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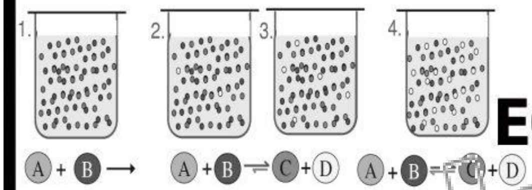
CHAPTER 9

CHEMICAL EQUILIBRIUM



INTRODUCTION

SHORT QUESTIONS

Q.1 What are chemical reactions? ***(Knowledge Base)***

Ans: **CHEMICAL REACTION**

Definition:

"The process in which chemical change occurs in nature and composition of substances is called chemical reaction".

Examples:

- Rusting of iron
- $2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(l)}$

Q.2 Differentiate between reactants and products. ***(Understanding Base)*** **(MTN 2016 G-I, FSD 2016 G-II)**

Ans: **DIFFERENTIATION**

The differences between reactants and products are as follows:

Reactants	Products
Definition	
• In a chemical reaction the substances that combine are called reactants.	• The new substances formed during a chemical reaction are called products.
Example	
• In a reaction $2H_{2(g)} + O_{2(g)} \longrightarrow 2H_2O_{(l)}$ H_2 and O_2 are reactants.	• In a reaction $2H_{2(g)} + O_{2(g)} \longrightarrow 2H_2O_{(l)}$ H_2O is product.

Q.3 What is complete reaction? How it is represented? ***(Understanding Base)*** **(LHR 2018)**

Ans: A reaction in which **all** the **reactants** are **converted** into **products** is called complete reaction.

Representation: It is represented by single arrow " $\longrightarrow$ "

Example: $\mathbf{2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(l)}}$

Q.4 Write down an example of equilibrium in nature. ***(Knowledge Base + Understanding Base)***

Ans: **EQUILIBRIUM IN NATURE**

Following examples describe the phenomenon of equilibrium in nature:

(i) Between O_2 and CO_2:

We owe our existence to equilibrium phenomenon taking place in atmosphere. We inhale oxygen and exhale carbon dioxide, while plants consume carbon dioxide and release oxygen. This natural process is responsible for the existence of life on the Earth.

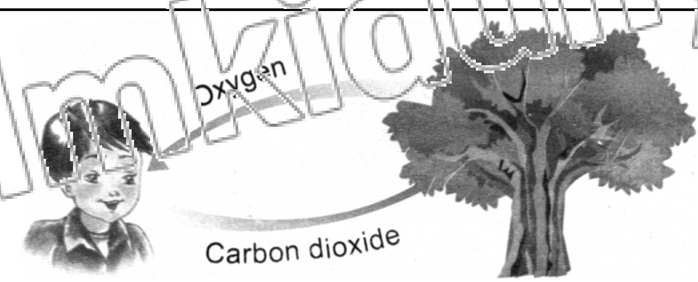


Figure: Showing Equilibrium Between O_2 and CO_2 in atmosphere

INTRODUCTION

MULTIPLE CHIOICE QUESTIONS

1. In chemical reactions the substances that combine are called: *(K.B)* **(FSD 2017 G-I)**
(A) Products (B) Reaction intermediates
(C) Reactants (D) Both A and C

2. Name the reactants in the equation, $2H_{2(g)} + O_{2(g)} \xrightarrow[\text{Heat}]{\text{Pt}} 2H_2O_{(l)}$ **: *(K.B)***
(A) Water (B) Hydrogen and oxygen
(C) Oxygen (D) None of these

3. The reactions in which all the reactants have been converted into products are known as: *(K.B)*
(A) Incomplete reactions (B) Complete reactions
(C) Continuous reactions (D) Reversible reactions

4. A complete reaction is one in which: *(U.B)* **(LHR 2016)**
(A) All the reactants convert into products
(B) All the reactants do not convert into products
(C) Half of the reactants convert into products
(D) Only 10% reactants convert into products

5. Plants consume carbon dioxide and release: *(K.B)*
(A) Oxygen (B) Water
(C) Carbon monoxide (D) Hydrogen

6. Human beings exhale: *(K.B)*
(A) Oxygen (B) Carbon monoxide
(C) Carbon dioxide (D) All of these

7. Name the products in the equation, $2H_{2(g)} + O_{2(g)} \xrightarrow[\text{Heat}]{\text{Pt}} 2H_2O_{(l)}$ **:*(K.B)***
(A) Water (B) Hydrogen and oxygen
(C) Oxygen (D) None of these

9.1 REVERSIBLE REACTION AND DYNAMIC EQUILIBRIUM

LONG QUESTIONS

Q.1 Explain in detail the reversible reaction with the help of suitable examples. *(Knowledge Base + Understanding Base)* **(Ex. Q.1)** **(SGD 2014)**

OR

Describe dynamic equilibrium with the help of examples. **(MTN 2017, RWP 2017)**

Ans:

REVERSIBLE REACTIONS

Definition:

"*The reactions in which the **products** can **recombine** to **form reactants** are called reversible reactions*".

Example 1:

(Reaction between H_2 and I_2):

Let us discuss a reaction between hydrogen and iodine. Because one of the reactant, **iodine is purple,** while the product **hydrogen iodide** is colorless, proceedings of the reaction are easily observable.

Forward Reaction:

On heating, hydrogen and iodine vapours in a closed flask, hydrogen iodide is formed. As a result, purple color of iodine fades as it reacts to form colorless hydrogen iodide.

$$\underset{\text{Colorless}}{H_2} + \underset{\text{Purple}}{I_2} \xrightarrow{\Delta} \underset{\text{Colorless}}{2HI}$$

Reverse Reaction:

When only hydrogen iodide is heated in a flask, purple colour appears because of formation of iodine vapours. Such as:

$$\underset{\text{Colorless}}{2HI} \dashrightarrow \underset{\text{Colorless}}{H_2} + \underset{\text{Purple}}{I_2}$$

In this case, hydrogen iodide acts as reactant and produces hydrogen and iodine vapours. This reaction is reverse of the above. Therefore, it is called reverse reaction.

At Equilibrium State:

When both of these reactions are written together as a reversible reaction, they are represented as:

$$2HI \rightleftharpoons H_2 + I_2$$

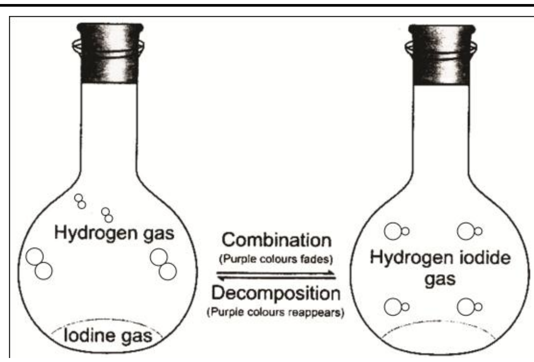


Figure: Showing Establishment of Reversible Reaction

Example 2:

(Reaction between Calcium Oxide and Carbon Dioxide):

(i) In Open Container:

When $CaCO_3$ is heated in an open flask, it decomposes to form calcium oxide and carbon dioxide. CO_2 escapes out and reaction goes to completion.

$$CaCO_3 \longrightarrow CaO + CO_2 \text{ (decomposition)}$$

In these two reactions, decomposition is reverse to combination or vice versa.

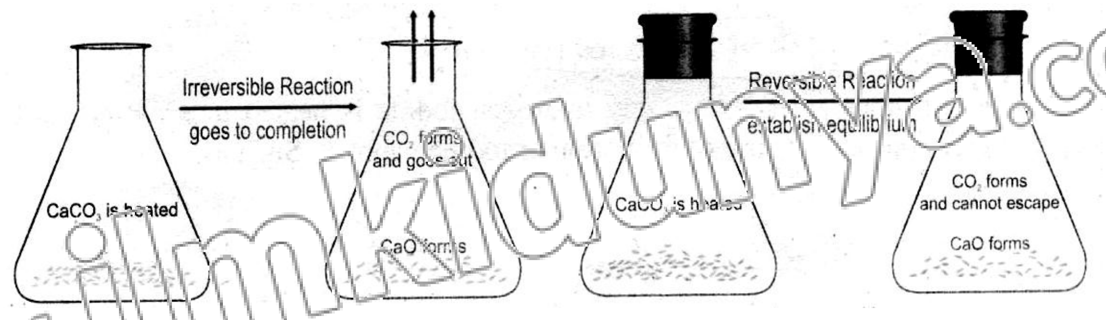
(ii) In Closed Container:

When calcium carbonate is heated in a **closed flask** so that **CO_2 cannot escape out,** following reaction takes place.

At Equilibrium:

In the beginning, **forward reaction is fast and reverse reaction is slow.** But eventually, the reverse reaction speeds up and both reactions go on at the same rate. At this stage decomposition and combination take place at the same rate but in opposite directions, as a result amounts of $CaCO_3$, CaO and CO_2 do not change. It is written as:

$$CaCO_3 \rightleftharpoons CaO + CO_2$$



$$CaCO_{3(s)} \xrightarrow{\text{Decomposition}} CaO_{(s)} + CO_{2(g)} \qquad CaCO_{3(s)} \underset{\text{Combination}}{\overset{\text{Decomposition}}{\rightleftharpoons}} CaO_{(s)} + CO_{2(g)}$$

Figure: Showing Establishment of Reversible Reaction

Q.2 What is chemical equilibrium? Explain its types with examples. ***(Knowledge Base)***

Ans:

CHEMICAL EQUILIBRIUM

Definition:

"When the rate of the forward reaction takes place at the rate of reverse reaction, the ***composition*** *of the* ***reaction mixture remains constant****, is called chemical equilibrium state".*

Types:

There are two types of chemical equilibrium:

(i) Static Equilibrium: ***(Test Yourself 9.1 Q(ii))***

"When reaction ***ceases*** *to proceed, it is called static equilibrium. This happens mostly in physical phenomenon".*

Example:

- A building remains standing rather than falling down because all the forces acting on it are balanced. This is an example of static equilibrium.

(ii) Dynamic Equilibrium:

"*When reaction does not stop only the* ***rates of forward and reverse reaction*** *become equal to each other but take place in* ***opposite directions****. This is called dynamic equilibrium state.*"

Note: Dynamic means reaction is still continuing at dynamic equilibrium state.

Example:

- $CaCO_3 \rightleftharpoons CaO + CO_2$

At equilibrium:

Rate of forward reaction = Rate of reverse reaction

Q.3 Explain graphical representation of dynamic equilibrium.

(Understanding+Application Base)

GRAPHICAL REPRESENTATION

In a reversible reaction, dynamic equilibrium is established before the completion of reaction. At initial stage the rate of forward reaction is very fast and reverse reaction is taking place at a negligible rate. But gradually forward reaction slows down and reverse reaction speeds up. Eventually, both reactions attain the same rate; it is called a dynamic equilibrium state.

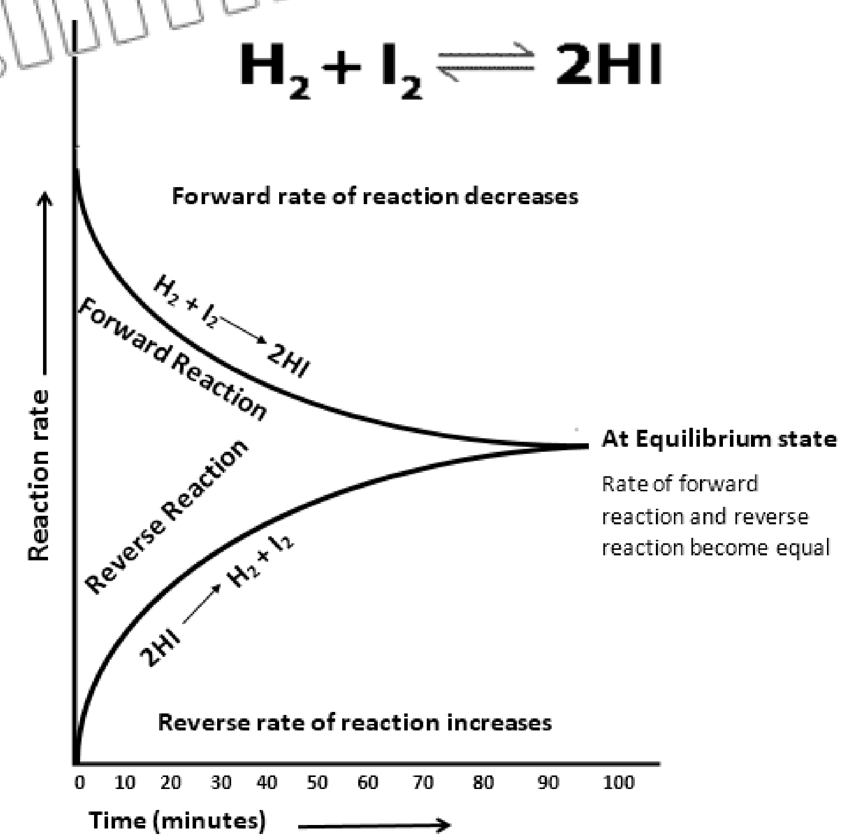


Figure: Graph Showing the Rate of Forward and Reverse Reactions and Establishment of Equilibrium State

Example:

In case of reaction between hydrogen and iodine vapors, some of the molecules react with each other to give hydrogen iodide.

$$H_{2(g)} + I_{2(g)} \longrightarrow 2HI_{(g)}$$

At the same time, some of the hydrogen iodide molecules decompose back to hydrogen and iodine.

$$2HI_{(g)} \longrightarrow H_{2(g)} + I_{2(g)}$$

Speed of Reaction:

In the beginning:

In the beginning, as the concentration of the reactants is higher than that of the products, the rate of the forward reaction is fast than the reverse reaction.

At Later Stage:

As the reaction proceeds, the concentration of reactants will gradually decrease while that of products will increase, consequently the rate of the forward reaction will go on decreasing and the reverse reaction will go on increasing and ultimately the two rates will become equal to each other. Thus, the equilibrium will set up and concentration of various species (H_2, I_2, HI) becomes constant. It is represented as:

$$H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$$

Q.3 Write down macroscopic characteristics of forward and reverse reactions. ***(Knowledge + Understanding Base)***

Ans: **DIFFERENTIATION** **(LHR 2016-2017, SGD 2017, FSD 2017)**

The differences between forward and reverse reaction are as follows:

Forward Reaction	Reverse Reaction
Definition	
• It is reaction in which reactants react to form products.	• It is reaction in which products react to produce reactants.
Direction	
• It takes place from left to right	• It takes place from right to left.
Rate of Reaction in the beginning	
• At initial stage the rate of forward reaction is very fast.	• In the beginning the rate of reverse reaction is negligible.
Rate of Reaction at later stage	
• It slows down gradually.	• It speeds up gradually.

Q.4 Write down macroscopic characteristics of dynamic equilibrium.

(Knowledge+Understanding Base)

(Ex-Q.2) (LHR 2014-16-17, SGD 2014, MTN 2016 G-II, 17, SWL 2017, FSD 2017, DGK 2016 G-II, BWP 2016, G-I)

Ans: **MACROSCOPIC CHARACTERISTICS**

Characteristics:

A few important characteristic features of dynamic equilibrium are given below:

(i) Closed System:

An equilibrium is achievable only in a closed system (in which substances can neither leave nor enter).

(ii) $R_f = R_r$:

At equilibrium state a reaction does not stop. Forward and reverse reactions keep on taking place at the same rate but in opposite direction.

(iii) Concentration of Substances:

At equilibrium state, the amounts (concentrations) of reactants and products do not change. Even physical properties like colour, density, etc. remain the same.

(iv) Attaining of Chemical Equilibrium:

An equilibrium state is attainable from either way, i.e. starting from reactants or from products.

(v) Re-establishment of Equilibrium after Disturbance:

An equilibrium state can be disturbed and again achieved under the given conditions of concentration, pressure and temperature.

9.1 REVERSIBLE REACTION AND DYNAMIC EQUILIBRIUM

SHORT QUESTIONS

Q.1 Differentiate between reversible and irreversible reactions. ***(Understanding Base)***

(LHR 2015-18-19)

Ans: **DIFFERENTIATION**

The differences between reversible and irreversible reactions are as follows:

Reversible Reaction	Irreversible Reaction
Definition	
• Reactions in which products recombine to form reactants are called reversible reactions and such reactions proceed in both directions.	• In most of the reactions the products do not recombine to form reactants, are called irreversible reactions and such reactions proceed in one direction only.
Completion	
• They never go to completion.	• They go to completion.
Representation	
• These are represented by a double arrow ($\rightleftharpoons$) between reactants and products.	• These are represented by a single arrow ($\rightarrow$) between reactants and products.

Q.2 Write down macroscopic characteristics of forward reactions. ***(Knowledge Base)***

(LHR 2019, MTN 2016 G-I, BWP 2017, DGK 2017)

Ans: **CHARACTERISTICS OF FORWARD REACTIONS**

Following are the characteristics of forward reactions:

- It is reaction in which reactants react to form products.
- It takes place from left to right.
- At initial stage the rate of forward reaction is very fast.
- It slows down gradually.

Q.3 Write down macroscopic characteristics of reverse reactions. ***(Knowledge Base)***

(GRW 2017, DGK 2017, SWL 2017, LHR 2013, 2014, 2015, GRW 2014)

Ans: **CHARACTERISTICS OF REVERSE REACTIONS**

Following are the characteristics of reverse reactions:

- It is reaction in which products react to produce reactants.
- It takes place from right to left.
- In the beginning the rate of reverse reaction is negligible.
- It speeds up gradually.

Q.4 Why reaction does not stop during equilibrium condition? ***(Understanding Base)***

(SGD 2016 G-I)

Ans: **REACTION AT EQUILIBRIUM**

The reaction does not stop during equilibrium condition because **products recombine** to form **reactants** again i.e. the forward and reverse reactions keep on occurring continuously.

$$A + B \underset{R_f}{\overset{R_r}{\rightleftharpoons}} C + D$$

Reactants Products

9.1 REVERSIBLE REACTION AND DYNAMIC EQUILIBRIUM

MULTIPLE CHIOICE QUESTIONS

1. **The reaction in which the products do not recombine to form reactants is known as:** ***(K.B)***
   (A) Reversible reaction (B) Decomposition reaction
   (C) Addition reaction (D) Irreversible reaction
2. **The reactions in which the products recombine to form reactants are called:** ***(K.B)*** **(SGD 2016 G-II, FSD 2017 G-II)**
   (A) Forward reactions (B) Reversible reactions
   (C) Irreversible reactions (D) Backward reactions
3. **Reversible reactions take place in:** ***(U.B)***
   (A) One direction (B) Both directions
   (C) Left to right (D) Right to left
4. **The characteristics of reversible reactions are the following except:** ***(U.B)***
   (A) They never complete
   (B) Products never recombine to form reactants
   (C) They have a double arrow between reactants and products
   (D) They proceed in both ways
5. **Irreversible reactions are represented by a ________ between reactants and products.** ***(K.B)***
   (A) Single arrow (B) K_c
   (C) Double arrow (D) Single line
6. **An irreversible reaction consists of:** ***(U.B)***
   (A) Forward reaction (B) Reverse reaction
   (C) Both forward and reverse reactions (D) None of these
7. **Which reaction is irreversible?** ***(U.B)*** **(MTN 2016 G-II)**
   (A) $N_2 + 3H_2 \longrightarrow 2NH_3$ (B) $H_2 + I_2 \longrightarrow 2HI$
   (C) $2H_2 + O_2 \longrightarrow 2H_2O$ (D) $N_2 + O_2 \longrightarrow 2NO$
8. **Reversible reaction is represented by:** ***(K.B)*** **(FSD 2017-G-I)**
   (A) $\longrightarrow$ (B) $\rightleftharpoons$
   (C) $\longleftarrow$ (D) $\overrightarrow{\longleftarrow}$
9. **The colour of hydrogen iodide (HI) is:** ***(K.B)*** **(GRW 2014, FSD 2017 G-II)**
   (A) Blue (B) Grey
   (C) Purple (D) Colourless
10. **The colour of iodine (I_2) is:** ***(K.B)*** **(LHR 2014, FSD G-I 2016, SWL 2016 G-I, 17, BWP 201 G-I)**
    (A) Purple (B) Green
    (C) Yellow (D) None of these

11. Dynamic means reaction: *(K.B)*
(A) Stops (B) Is still continuing
(C) In opposite direction (D) Both A and B

12. When reaction ceases to proceed it is called: *(K.B)* **(SGD G-II 2016)**
(A) Dynamic equilibrium (B) Static equilibrium
(C) Chemical equilibrium (D) None of these

13. Reaction in which reactants react to form products is called: *(K.B)*
(A) Forward reaction (B) Reverse reaction
(C) Reversible reaction (D) Backward reaction

14. At initial stage the rate of forward reaction is: *(K.B)*
(A) Low (B) Very low
(C) Very fast (D) All of these

15. Reverse reactions _________ gradually. *(U.B)*
(A) Speed up (B) Negligible
(C) Slow down (D) Do not speed up

16. Forward reaction takes place from: *(K.B)*
(A) Left to right (B) Right to left
(C) Both A and B (D) All of these

17. When CaO reacts with CO_2 they produce: *(U.B)*
(A) $CaCO_3$ (B) $CaCO_2$
(C) CaC_2 (D) CaO

18. In the beginning reverse reaction: *(K.B)* **(FSD 2017 G-I)**
(A) Is fast (B) Stops
(C) Is slow (D) Is very fast

19. When rate of forward reaction takes place at the rate of reverse reaction and the composition of the reaction mixture remains constant is called: *(K.B)*
(A) Static equilibrium (B) Neutral equilibrium
(C) Chemical equilibrium state (D) None of these

20. There are ________characteristics of dynamic equilibrium. *(K.B)*
(A) One (B) Two
(C) Three (D) Five

21. When a system is at equilibrium state then? *(U.B)* **(GRW 2015)**
(A) The concentration of reactants and products becomes equal
(B) The opposing reactions (forward and reverse) stop
(C) The rate of reverse reaction becomes very low
(D) The rates of forward and reverse reactions become equal

9.1 TEST YOURSELF

i. Why reversible reactions never complete? *(Understanding Base)* **(LHR 2013, SWL 2017)**

Ans: **<u>COMPLETION OF REVERSIBLE REACTIONS</u>**

The reversible reactions never complete because products recombine to form reactants again. The forward and reverse reactions keep on occurring continuously. e.g.

$$\underset{\text{Reactants}}{A + B} \underset{R_f}{\overset{R_f}{\rightleftharpoons}} \underset{\text{Products}}{C + D}$$

ii. What is a static equilibrium? Explain with an example. ***(Knowledge Base)***

(LHR 2015, GRW 2015)

Ans: Answer given on Page # 5

iii. Why the amounts of reactants and products do not change in reversible reaction? ***(Understanding Base)***

(GRW 2013)

Ans: **AMOUNTS OF REACTANTS AND PRODUCTS**

The amounts of reactants and products do not change in a reversible reaction because a state of **dynamic equilibrium** is established in reversible reaction. In dynamic equilibrium state the **rate of forward and reverse reaction** becomes **equal** and take place in **opposite direction** but amounts of reactants and products remain the same.

9.2 LAW OF MASS ACTION

LONG QUESTION

Q.1 State the Law of Mass Action and derive an expression for equilibrium constant for a general reaction. ***(Understanding Base + Application Base)*** **(Ex-Q.3)**

(DGK 2016 G-I, 17, RWP 2017, LHR 2015,2016,2017,2019, GRW 2015, 17, BWP 2017, SWL 2016 G-I, 17, SGD 2016 G-II, FSD 2016 G-I, 17)

Ans: **LAW OF MASS ACTION**

Introduction:

Law of Mass Action was given by C.M. Guldberg and P.Waage in 1869. They studied a lot of reversible reactions and put forward this law.

Definition:

"*The **rate** at which a substance reacts is **directly proportional** to its **active mass** and the **rate of a reaction** is **directly proportional** to the **product** of the **active masses** of the reacting substances".*

Active Mass:

Generally, an active mass is considered as the molar concentration in units of mol dm^{-3}, expressed as square brackets [ ].

DERIVATION OF EXPRESSION FOR EQUILIBRIUM CONSTANT

Consider a reversible reaction

$$A+B \underset{k_r}{\overset{k_f}{\rightleftharpoons}} C+D$$

Suppose [A], [B], [C] and [D] are the molar concentrations (mol dm^{-3}) of A, B, C and D respectively.

According to the Law of Mass Action:

Forward Reaction:

The rate of the forward reaction $\propto$ [A] [B]

$R_f = k_f$ [A] [B] **......(i)**

Similarly

Reverse Reaction:

The rate of the reverse reaction $\propto$ [C] [D]

$R_r = k_r$ [C] [D] **......(ii)**

Where k_f and k_r are the proportionality constant called specific rate constants of the forward and the reverse reactions respectively.

At Equilibrium State:

The rate of forward reaction = The rate of reverse reaction

$$R_f = R_r \quad \ldots\ldots\text{(iii)}$$

$$k_f[A][B] = k_r[C][D] \quad \textbf{By putting values of eq (i) and (ii) in (iii)}$$

$$\frac{k_f}{k_r} = \frac{[C][D]}{[A][B]}$$

$$\left(K_c = \frac{k_f}{k_r}\right)$$

Where,

K_c is called equilibrium constant. It is represented as:

$$K_c = \frac{[C][D]}{[A][B]}$$

Significance:

Law of Mass Action describes the relationship between active masses of the reactants and the rate of a reaction.

DERIVATION OF THE EXPRESSION FOR EQUILIBRIUM CONSTANT FOR GENERAL REACTION

Consider a general reaction.

$$aA + bB \rightleftharpoons cC + dD$$

This reaction consists of two reactions i.e. forward and backward.

According to Law of Mass Action:

*"The **rate** of a chemical reaction is **directly proportional** to the **product** of the **molar concentrations** of its **reactants** raised to power equal to their number of moles in the balanced chemical equation of the reaction".*

Derivation:

Forward Reaction:

In forward reaction A and B are the reactants whereas 'a' and 'b' are their number of moles. The rate of forward reaction is:

$$R_f \propto [A]^a[B]^b$$

$$R_f = k_f[A]^a[B]^b$$

Where k_f is the rate constant for the forward reaction while square brackets represent concentration in mol dm^{-3}.

Reverse Reaction:

The rate of the reverse reaction R_r is directly proportional to the product of $[C]^c[D]^d$, where 'c' and 'd' are the number of moles as given in the balanced chemical equation.

Thus,

$$R_r \propto [C]^c[D]^d$$

$$R_r = k_r[C]^c[D]^d$$

Where k_r is the rate constant for the reverse reaction

At Equilibrium State:

Rate of forward reaction = Rate of reverse reaction

Such as. $R_f = R_r$

By putting the values of R_f and R_r

$$k_f[A]^a[B]^b = k_r[C]^c[D]^d$$

By taking the constants on one side and the variables on other side of the equation, the above equation becomes:

$$\frac{k_f}{k_r} = \frac{[C]^c\,[D]^d}{[A]^a\,[B]^b}$$

Where,

$$\left[K_c = \frac{k_f}{k_r}\right]$$

$$K_c = \frac{[C]^c\,[D]^d}{[A]^a\,[B]^b}$$

Where K_c is called equilibrium constant.

Example 1:

When nitrogen reacts with oxygen to form nitrogen monoxide, the reversible reaction is as follows:

$$N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)}$$

The rate of forward reaction $R_f = k_f\,[N_2]\,[O_2]$

The rate of reverse reaction $R_r = k_r\,[NO]^2$

The equilibrium constant expression for this reaction is:

$$k_c = \frac{[NO]^2}{[N_2][O_2]}$$

Example 2:

For the reaction of nitrogen with hydrogen to form ammonia, the balanced chemical equation is:

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$$

For the reaction

The rate of forward reaction $R_f = k_f\,[N_2]\,[H_2]^3$

The rate of reverse reaction $R_r = k_r\,[NH_3]^2$

The expression for the equilibrium constant for this reaction is:

$$K_c = \frac{[NH_3]_2}{[N_2][H_2]^3}$$

9.2 LAW OF MASS ACTION

SHORT QUESTIONS

Q.1 What is significance of Law of Mass Action? ***(Knowledge Base)*** **(BWP 2016 G-II)**

Ans: **SIGNIFICANCE OF LAW OF MASS ACTION**

Law of Mass Action describes the relationship between active masses of the reactants and the rate of a reaction.

Q.2 Define specific rate constant. ***(Knowledge Base)***

Ans: **SPECIFIC RATE CONSTANT**

Definition:

"The rate constants at which concentrations of reactants and products are unity, are called specific rate constant".

Q.3 Find Kc for the reaction of nitrogen and hydrogen to form Ammonia?

Ans: See **Example 2** on Page # 13.

9.2 LAW OF MASS ACTION

MULTIPLE CHIOICE QUESTIONS

1. For the reaction $2A_{(g)} + B_{(g)} \rightleftharpoons 3C_{(g)}$ the expression for the equilibrium constant is: *(U.B)* **(BWP 2017)**

(A) $\frac{[2A][B]}{[3C]}$ (B) $\frac{[A]^2[B]}{[C]^3}$

(C) $\frac{[3C]}{[2A][B]}$ (D) $\frac{[C]^3}{[A]^2[B]}$

2. Which statement is not correct about active mass? *(U.B)*

(A) Rate of reaction is directly proportional to active masses

(B) Active mass is taken in molar concentration

(C) Active mass means total mass of substances

(D) Active mass expressed in square brackets

3. Name the scientist who presented Law of Mass Action: *(K.B)* **(GRW 2013)**

(A) Guldberg and Waage (B) Boyle

(C) Newton (D) Lavoisier

4. Point out the coefficients in the following hypothetical reaction: *(U.B)*

$$2A + 3\,D \longrightarrow 4C + 8D$$

(A) 2,3,4,5 (B) 2,3,4,3

(C) A, b, c, d (D) 2,3,4,8

5. An active mass is considered as the molar concentration in units of: *(K.B)*

(A) mol dm^{-3} (B) mol^{-3} dm

(C) mol^{-2} dm (D) mol^{-2} dm

6. The units of molar concentration: *(K.B)* **(LHR 2013, 17, GRW 2016)**

(A) mol dm^{-2} (B) mol dm^{-1}

(C) mol dm^{3} (D) mol dm^{-3}

7. Kc is always equal to: *(K.B)* **(LHR 2015, DGK 2017)**

(A) $\frac{R_f}{R_r}$ (B) $\frac{k_r}{k_f}$

(C) $\frac{k_f}{k_r}$ (D) $\frac{R_r}{R_f}$

8. Specific rate constant for forward reaction is represented by: *(K.B)* **(GRW 2017)**

(A) k_f (B) k_c

(C) k_r (D) k_b

9. Molar concentration (mol dm^{-3}) is expressed as: *(K.B)* **(GRW 2017)**

(A) { } (B) ( )

(C) [ ] (D) ϕ

9.2 TEST YOURSELF

i. Define the Law of Mass Action. ***(Knowledge Base)***
(LHR 2014-17-18, GRW 2014, MTN 2016 GII, 17, SWL 2016 G-II, 17, RWP 2017, FSD 2016 G-I, SGD 2016 G-II, DGK 2016 G-II)

Ans: **LAW OF MASS ACTION**

Definition:

*"The **rate** at which a substance reacts is **directly proportional** to its **active mass** and the **rate of a reaction** is **directly proportional** to the **product** of the **active masses** of the reacting substances."*

Rate of reaction ∝ active masses of reacting substances

$$A + B \underset{K_r}{\overset{K_f}{\rightleftharpoons}} C + D$$

$$K_C = \frac{[C][D]}{[A][B]}$$

ii. How the active mass is represented? ***(Knowledge Base)*** **(SGD 2017)**

Ans: **REPRESENTATION OF ACTIVE MASS**

An active mass is considered as the molar concentration in units of mol dm^{-3}. It is represented in square brackets, as [ ].

iii. What do you mean by equilibrium constant? (LHR 2015, BWP 2017, MTN 2017, SWL 2017)

Ans: **EQUILIBRIUM CONSTANT**

Definition:

"***Ratio*** *of the product of* ***concentration of products*** *raised to the power of coefficients to the product of* ***concentration of reactants*** *raised to the power of coefficients as expressed in the balanced chemical equation is called equilibrium constant."*

$$Kc = \frac{\text{Product of concentration of products raised to the power of coefficients}}{\text{Product of concentration of reactants raised to the power of coefficients}}$$

Importance of Kc:

- Equilibrium constant helps to predict the direction of a reaction and extent of a reaction.

iv. Point out the coefficients of each in the following hypothetical reactions: ***(Understanding Base)***

a. $2A + 3B \rightleftharpoons 4C + 2D$ **b. $4X \rightleftharpoons 2Y + 3Z$** **c. $2M + 4N \rightleftharpoons 5O$**

Ans: **COEFFICIENTS OF HYPOTHETICAL REACTIONS**

(a) $2A + 3B \rightleftharpoons 4C + 2D$

Reacting substances	A	B	C	D
Coefficients	2	3	4	2

(b) $4X \rightleftharpoons 2Y + 3Z$

Reacting substances	X	Y	Z
Coefficients	4	2	3

(c) $2M + 4N \rightleftharpoons 5O$

Reacting substances	M	N	O
Coefficients	2	4	5

v. Write the equilibrium constant expressions for the following reactions:

(Understanding Base)

a. $2NO_{2(g)} \rightleftharpoons N_2O_{4(g)}$ **b.** $PCl_{3(g)} + Cl_{2(g)} \rightleftharpoons PCl_{5(g)}$

c. $2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$

Ans: **<u>EQUILIBRIUM CONSTANT EXPRESSIONS</u>**

(a) $2NO_{2(g)} \rightleftharpoons N_2O_{4(g)}$ **(SWL 2016 G-I, DGK 2017)**

For this reaction

Rate of forward reaction = $R_f = k_f [NO_2]^2$

Rate of reverse reaction = $R_r = k_r [N_2O_4]$

Equilibrium constant expression

$$K_c = \frac{[N_2O_4]}{[NO_2]^2}$$

(b) $PCl_{3(g)} + Cl_{2(g)} \rightleftharpoons PCl_{5(g)}$ **(RWP 2017)**

For this reaction

Rate of forward reaction = $R_f = k_f [PCl_3] [Cl_2]$

Rate of reverse reaction = $R_r = k_r [PCl_5]$

Equilibrium constant expression

$$K_c = \frac{[PCl_5]}{[PCl_3][Cl_2]}$$

(c) $2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$

For this reaction

Rate of forward reaction = $R_f = k_f [SO_2]^2[O_2]$

Rate of reverse reaction = $R_r = k_r [SO_3]^2$

Equilibrium constant expression

$$K_c = \frac{[SO_3]^2}{[SO_2]^2[O_2]}$$

9.3 EQUILIBRIUM CONSTANT AND ITS UNITS

LONG QUESTIONS

Q.1 What is equilibrium constant? Explain its units. ***(Knowledge +Understanding Base)***

(BWP 2016 G-II)

Ans: **<u>EQUILIBRIUM CONSTANT</u>**

<u>Definition:</u>

"*Equilibrium constant is **ratio** of the **product of concentration** of **products** raised to the power of coefficients to the **product of concentration** of **reactants** raised to the power of coefficients as expressed in the balanced chemical equation*".

Formula:

$$K_c = \frac{\text{Product of concentration of products raised to the power of coefficients}}{\text{Product of concentration of reactants raised to the power of coefficients}}$$

Representation of Equilibrium Expression:

It is conventional to write the products side numerator and reactants denominator. By knowing the balanced chemical equation for reversible reaction we can write the equilibrium expression.

Determination of K_c Value:

We can calculate the numerical values by putting actual equilibrium concentrations of the reactants and products into equilibrium expression.

Dependence of Kc Value:

The value of **Kc depends only on temperature**, it does not depend on the initial concentrations of the reactants and the products.

UNITS OF K_c

There are two possibilities for units of K_c.

(i) No Unit of K_c: **(BWP 2017)**

Number of moles of reactants = Number of moles of products.

In a balance chemical equation.

This is because concentration units cancel out in the expression for K_c for the reaction.

Example:

$$H_2 + I_2 \rightleftharpoons 2HI$$

$$\text{Units} = \frac{\cancel{\left(\text{mol dm}^{-3}\right)^2}}{\cancel{\left(\text{mol dm}^{-3}\right)}\ \cancel{\left(\text{mol dm}^{-3}\right)}} = \text{no unit}$$

(ii) Some Unit of K_c:

Number of moles of reactants ≠ Number of moles of products.

In a balance chemical equation.

Example:

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

$$K_c = \frac{\left(\text{mol dm}^{-3}\right)^2}{\left(\text{mol dm}^{-3}\right)\left(\text{mol dm}^{-3}\right)^3} = \text{mol}^{-2}\text{dm}^6$$

NUMERICAL EXAMPLES

EXAMPLE 9.1

When hydrogen reacts with iodine at 25^{0}C to form hydrogen iodide by a reversible reaction as follows: ***(U.B +A.B)***

$$H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$$

The equilibrium concentrations are:

$[H_2] = 0.05\,moldm^{-3}$; $[I_2] = 0.06\,moldm^{-3}$.

$[HI] = 0.49\,moldm^{-3}$

Calculate the equilibrium constant for this reaction.

Solution:

Given Data:

Given equilibrium concentrations are:

$[H_2] = 0.05\,moldm^{-3}$

$[I_2] = 0.06\,moldm^{-3}$

$[HI] = 0.49\,moldm^{-3}$

To Find:

Equilibrium constant Kc = ?

Calculations:

Write the equilibrium constant expression as:

$$Kc = \frac{[HI]^2}{[H_2][I_2]}.$$

Now put the equilibrium concentration values in Kc. expression

$$Kc = \frac{[0.49]^2}{[0.05][0.06]} = \frac{0.2401}{0.0030} = 80$$

Result:

Thus equilibrium constant for the reaction= 80

EXAMPLE 9.2

For the formation of ammonia by Haber's process hydrogen and nitrogen react reversibly at 500 ^{0}C as follows: ***(U.B +A.B)***

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$$

The equilibrium concentrations of these gases are: nitrogen 0.602 mol dm^{-3}; hydrogen 0.420 mol dm^{-3} and ammonia 0.113 mol dm^{-3}. What is value of K_c?

Solution:

Given data:

The equilibrium concentrations are:

$[N_2] = 0.602\,moldm^{-3}$

$[H_2] = 0.420\,moldm^{-3}$

$[NH_3] = 0.113\,moldm^{-3}$

To Find:

Equilibrium constant Kc = ?

Calculations:

The equilibrium constant expression for this reaction is

$$Kc = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

No put the equilibrium concentration values into the equilibrium expression.

$$Kc = \frac{[0.113]^2}{[0.602][0.420]^3} = 0.286\,mol^{-2}dm^6$$

Result:

Thus equilibrium constant for the reaction = 0.286 mol^{-2}dm^6

EXAMPLE 9.3

For a reaction between PCl_3 and Cl_2 to from PCl_5, the equilibrium constant is 0.13 mol^{-1} dm^3 at a particular temperature. When the equilibrium concentrations of PCl_3 and Cl_2 are 10.0 and 9.0 mol dm^{-3} respectively, what is the equilibrium concentration of PCl_5? ***(U.B +A.B)***

Solution:

Given data:

The equilibrium concentrations are:

$[PCl_3] = 10\,moldm^{-3}$ $[Cl_2] = 9.0\,moldm^{-3}$

$Kc = 0.13\,mol^{-1}dm^3$

To Find:

$[PCl_5] = ?$

Solution:

Now write the balanced chemical equation and equilibrium constant expression:

$$PCl_{3(g)} + Cl_{2(g)} \rightleftharpoons PCl_{5(g)}$$

$$Kc = \frac{[PCl_5]}{[PCl_3][Cl_2]}$$

Now put the known values in above equation and rearrange.

$$0.13 = \frac{[PCl_5]}{[10.0][9.0]}$$

$$[PCl_5] = 0.13 \times 10.0 \times 9.0 = 11.7\,moldm^{-3}.$$

Result:

Thus molar concentration of PCl_5 = 11.7 moldm^{-3}

9.3 EQUILIBRIUM CONSTANT AND ITS UNITS
SHORT QUESTIONS

Q.1 What are the units of Kc? *(Understanding Base)*

Ans:

UNITS OF Kc

There are two possibilities for units of K_c.

i. No Unit of K_c: **(BWP 2017)**

Number of moles of reactants = Number of moles of products.

In a balance chemical equation.

This is because concentration units cancel out in the expression for K_c for the reaction. e.g.

$$H_2 + I_2 \rightleftharpoons 2HI$$

$$\text{Units} = \frac{\cancel{(\text{mol dm}^{-3})^2}}{\cancel{(\text{mol dm}^{-3})}\ \cancel{(\text{mol dm}^{-3})}} = \text{no unit}$$

ii. Some Unit of K_c:

Number of moles of reactants ≠ Number of moles of products.

In a balance chemical equation.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

$$K_c = \frac{(\text{mol dm}^{-3})^2}{(\text{mol dm}^{-3})(\text{mol dm}^{-3})^3} = \text{mol}^{-2}\text{dm}^6$$

9.3 EQUILIBRIUM CONSTANT AND ITS UNITS
MULTIPLE CHIOICE QUESTIONS

1. **For a reaction between PCl_3 and Cl_2 to form PCl_5 the units of Kc are: *(U.B)***
(GRW 2017, DGK 2017, MTN 2017)
(A) mol dm^{-3} (B) mol^{-1} dm^{-3}
(C) mol^{-1} dm^3 (D) mol dm^3
2. **When H_2 and O_2 combine they form: *(K.B)***
(A) H_2O (B) H and O
(C) HO_2 (D) None of these
3. **When H_2 and N_2 combine they form: *(K.B)***
(A) H_2O (B) NH_3
(C) I_2 (D) H_2 and I_2
4. **The ratio of product of concentration of products raised to power of coefficients to the product of concentration of reactants raised to the power of coefficients in a balanced chemical equation at equilibrium is known as: *(U.B)***
(A) Kc (B) Qc
(C) Kr (D) Kf
5. **Equilibrium constant is represented by: *(K.B)***
(A) Qc (B) Kc
(C) Kr (D) Kf
6. **What are units of Kc for the reaction? $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$ *(K.B)***
(GRW 2015, SWL 2017, RWP 2017)
(A) No units (B) mol dm^{-3}
(C) mol^2 dm^6 (D) mol^{-1} dm^3

7. The units of equilibrium constant Kc for the reaction in the balanced chemical equation $N_2 + 3H_2 \rightleftharpoons 2NH_3$ **are: *(K.B + U.B)***

(A) $mol^{-2}\ dm^{6}$ (B) $mol^{-1}\ dm^{-3}$
(C) $mol^{-1}\ dm^{3}$ (D) $mol\ dm^{3}$

8. For the reaction $H_2 + I_2 \rightleftharpoons 2HI$ **the expression for the equilibrium constant: *(U.B)*** **(SGD 2017)**

(A) $Kc = \frac{[HI]^2}{[H_2][I_2]}$ (B) $Kc = \frac{[H_2][I_2]}{[HI]^2}$

(C) $Kc = \frac{[2HI]}{[H_2][I_2]}$ (D) $Kc = \frac{[H_2][I_2]}{[2HI]}$

9. The value of equilibrium constant Kc depends only on: *(K.B)*(BWP 2016 G-II, DGK 2016 G-II)

(A) Temperature (B) Pressure
(C) Concentration (D) Density

10. When number of moles of both sides are equal in a reaction then the unit of Kc: *(K.B)* (DGK 2016 G-II)

(A) No units (B) $mol\ dm^{-3}$
(C) $mol^{2}\ dm^{6}$ (D) $mol^{-1}\ dm^{3}$

9.4 IMPORTANCE OF EQUILIBRIUM CONSTANT

LONG QUESTIONS

Q.1 What is the importance of equilibrium constant? *(Application Base)* **(Ex-Q.4)**
(GRW 2014, LHR 2015, SGD 2014, 17, BWP 2017)

Ans: **IMPORTANCE OF EQUILIBRIUM CONSTANT**

The numerical value of equilibrium constant of a chemical reaction helps in:

- Predicting Direction of a Reaction
- Predicting Extent of a Reaction

(i) Predicting Direction of a Reaction: **(MTN 2016 G-I)**

Direction of a reaction can be predicted by performing following steps:

Determination of K_c (Equilibrium Constant):

Direction of a reaction at a particular moment can be predicted by inserting the concentration of the reactants and products at that particular moment in the equilibrium expression.

Example:

- The reaction of hydrogen with iodine

$$H_2 + I_2 \rightleftharpoons 2HI \qquad K_C = 57.0 \text{ at } 700\text{ K}$$

Determination of Q_c (Reaction Quotient):

We withdraw the samples from the reaction mixture and determine the concentrations of H_2, I_2 and HI. Suppose concentrations of the components of the mixture are:

$[H_2]_t = 0.10\ mol\ dm^{-3}$ $[I_2]_t = 0.20\ mol\ dm^{-3}$ and $[HI]_t = 0.40\ mol\ dm^{-3}$

The subscript 't' with the concentration symbols means that the concentrations are measured at some time t, not necessarily at equilibrium. When we put these concentrations into the equilibrium constant expression, we obtain a value called the reaction quotient Q_c. The reaction quotient for this reaction is calculated as:

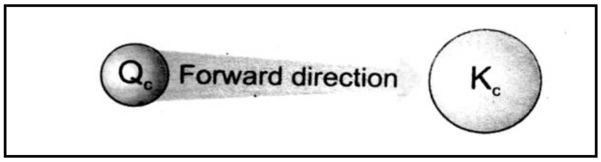
$$Q_c = \frac{[HI]_t^2}{[H_2]_t[I_2]_t} = \frac{(0.40)^2}{(0.10)(0.20)} = 8.0$$

As the numerical value of Q_c (8.0) is less than K_c (57.0), the reaction is not at equilibrium. It requires more concentration of products. Therefore, reaction will move in the forward direction. The reaction quotient Q_c is useful because it predicts the direction of the reaction by comparing the value of Q_c with K_c.

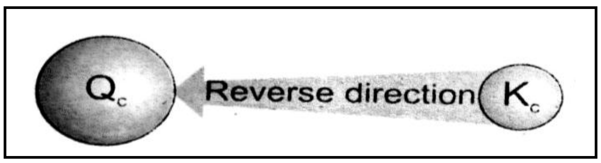
<u>Comparison of Q_c with K_c:</u>

Thus, we can make the following generalization about the direction of reaction.

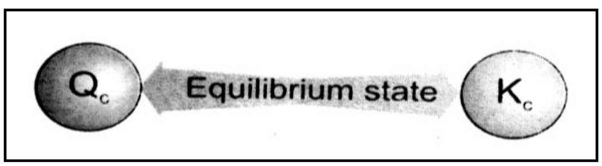
- If **$Q_c < K_c$;** the reaction goes from left to right, i.e., in **forward direction** to attain equilibrium.



- If **$Q_c > K_c$;** the reaction goes from right to left, i.e., in **reverse direction** to attain equilibrium.



- If **Qc = Kc;** forward and reverse reactions take place at equal rates i.e., **equilibrium** has been **attained**.



(ii) <u>Predicting Extent of a Reaction:</u> **(MTN 2017)**

*"**Numerical value** of the equilibrium constant **predicts the extent of a reaction**. It indicates to which extent reactants are converted to products"*

OR

*"It **measures how far a reaction proceeds** before establishing equilibrium state".*

<u>Possibilities:</u>

In general, there are three possibilities of predicting extent of reaction as explained below.

<u>Large Numerical Value of K_c:</u>

The large value of Kc indicates that at equilibrium position the reaction mixture consists of **almost all products** while **reactants are negligible.** The reaction has **almost gone to completion.**

Example:

Oxidation of carbon monoxide goes to completion at 1000 K.

$$2CO_{(g)} + O_{2(g)} \rightleftharpoons 2CO_{2(g)} \qquad Kc = 2.2 \times 10^{22}$$

Small Numerical Value of K_c:

The small value of kc indicates that the equilibrium has established with a very **small conversion of reactants to products**. At equilibrium position almost all reactants are present but amount of product is negligible. Such type of reaction **never goes to completion.**

Example:

$$2NH_{3(g)} \rightleftharpoons N_{2(g)} + 3H_{2(g)} \qquad Kc = 3.0 \times 10^{-9}$$

Numerical Value of Kc is Neither Small Nor Large:

The moderate value of Kc indicates that at equilibrium position the reaction mixture consists of **comparable amounts of reactants and products.**

Example:

$$N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)} \qquad Kc = 0.211$$

9.4 IMPORTANCE OF EQUILIBRIUM CONSTANT

SHORT QUESTIONS

Q.1 Define reaction quotient. ***(Understanding Base)***

Ans:

REACTION QUOTIENT

Definition:

"The ratio of product of concentration of products raised to the power of coefficients to the product of concentration of reactants raised to the power of co-efficients in a balanced chemical equation ***at any moment of the reversible reaction*** *is known as reaction quotient".*

Importance:

The reaction quotient Q_c is useful because it predicts the direction of the reaction by comparing the value of Q_c with K_c.

Q.2 Describe use of atmospheric gases in the manufacture of chemicals. ***(Knowledge Base)***

(Science, Technology and Society Pg. # 14)(LHR 2013, BWP 2017, RWP 2017)

Ans:

USES OF ATMOSPHERIC GASES

The two major components of atmosphere are nitrogen and oxygen gases. Both of these gases constitute 99% of the atmosphere.

- **Nitrogen:**
  Nitrogen is used to prepare **ammonia**, which is further used to manufacture nitrogenous fertilizers.
- **Oxygen:**
  Oxygen is used to prepare **sulphur dioxide** which is further used to manufacture **king of chemicals sulphuric acid.**

Q.3 Which chemical is called king of chemicals? *(Knowledge Base)*

(Science, Technology and Society Pg. # 14)

Ans: **KING OF CHEMICALS**

Sulphuric acid (H_2SO_4) is called king of chemicals because it is used in almost all chemical industries directly or indirectly.

Q.4 Write the names of two major gases of atmosphere. *(Knowledge Base)*

(Science, Technology and Society Pg. # 14)(GRW 2013)

Ans: **MAJOR GASES OF ATMOSPHERE**

The two major gases of atmosphere are:

- Nitrogen 78%
- Oxygen 21%

Both constitute 99% of the atmosphere.

Q.5 Write the importance of equilibrium constant. *(Application Base)* **(LHR 2014)**

Ans: **IMPORTANCE OF EQUILIBRIUM CONSTANT**

The importance of equilibrium constant is as follows:

- It is used to predict the direction of reaction i.e. forward or reverse
- It is used to predict the extent of reaction which means how much of the reactants are converted into products.

Q.6 Write the names of two chemicals in which nitrogen is used. *(Knowledge Base)*

Ans: **CHEMICALS INVOLVING NITROGEN**

Following are the chemicals in which nitrogen is used:

- Urea (H_2NCONH_2)
- Nitric acid (HNO_3)

9.4 IMPORTANCE OF EQUILIBRIUM CONSTANT

MULTIPLE CHOICE QUESTIONS

1. In direction of a reaction, if reaction proceeds forward then: *(K.B)*

(A) Qc < Kc (B) Qc > Kc
(C) Qc = Kc (D) None of them

2. In direction of a reaction, if reaction proceeds reverse then: *(K.B)*

(A) Qc < Kc (B) Qc > Kc
(C) Qc = Kc (D) All of these

3. In direction of a reaction, if reaction is at equilibrium then: *(K.B)*

(A) Qc < Kc (B) Qc > Kc
(C) Qc = Kc (D) Both a & b

4. In extent of reaction, the reaction which almost goes to completion has: *(U.B)*

(A) Very large Kc value (B) Very small Kc value
(C) Moderate Kc value (D) None of these

5. In extent of reaction, the reaction never goes to completion has: *(U.B)*

(A) Very large Kc value (B) Very small Kc value
(C) Moderate Kc value (D) Qc = Kc

6. There are _________ possibilities of predicting extent of a reaction. *(K.B)* (MTN 2017)
(A) 1 (B) 2
(C) 3 (D) 4

7. There are _________ major components of atmosphere. *(K.B)*
(A) 1 (B) 2
(C) 3 (D) 4

8. The two major components of atmosphere are: *(K.B)* (MTN 2017)
(A) Nitrogen and hydrogen gases (B) Oxygen and hydrogen gases
(C) Nitrogen and carbon dioxide gases (D) Nitrogen and oxygen gases

9. Nitrogen and oxygen constitute _____ of the atmosphere. *(K.B)* (GRW 2013)
(A) 99% (B) 98%
(C) 92% (D) 97%

10. Nitrogen is used to prepare: *(K.B)*
(A) Carbon dioxide (B) Ammonia
(C) Hydrogen (C) Sulphuric acid

11. Oxygen is used to prepare: *(K.B)*
(A) Ammonia (B) Nitrogen gas
(C) Oxygen (D) Sulphur dioxide

12. The percentage of nitrogen in atmosphere is: *(K.B)*
(A) 21 % (B) 78%
(C) 99% (D) 0.93%

13. Ammonia is used to manufacture: *(U.B)*
(A) Sulphuric acid (B) Hydrogen gas
(C) Nitrogenous fertilizers (D) Chlorine gas

14. Sulphur dioxide is used to manufacture: *(U.B)*
(A) Sulphuric dioxide (B) Ammonia
(C) Sulphuric acid (D) Nitrogenous fertilizers

15. Which is the king of chemicals? *(K.B)* (MTN 2017)
(A) Sulphur dioxide (B) Ammonia
(C) Nitrogen (D) Sulphuric acid

16. The value of Kc for the reaction $N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)}$ is: *(U.B)*
(A) 2.2×10^{22} (B) 0.211
(C) 3.5×10^{1} (D) None of these

17. The oxidation of carbon monoxides goes to completion at: *(K.B)*
(A) 2000K (B) 1000K
(C) 100K (D) 200K

18. The reaction quotient is useful because it predicts the direction of reaction by comparing the values of *(K.B)*
(A) Qc (B) Qc with Kc
(C) k_c (D) None of these

19. As the numeric value of Qc (3.0) is less than K_C (57.0) the reaction is: *(U.B)*
(A) In forward direction (B) At equilibrium
(C) In reverse direction (D) All of these

20. When $Qc < Kc$, then reaction goes in: *(U.B)* (SWL 2016 G-II, LHR 2016, SWL 2017)
(A) Forward (B) Reverse
(C) Equilibrium (D) None of these

9.3 TEST YOURSELF

i. What do you mean by the extent of reaction? ***(Knowledge Base)***

Ans: **EXTENT OF REACTION**

The extent of a reaction means the extent to which reactants are converted into products. In fact, it measures how far a reaction proceeds before establishing equilibrium state.

ii. Why the reversible reactions do not go to completion? ***(Understanding Base)***

Ans: **COMPLETION OF REVERSIBLE REACTIONS**

The reversible reactions do not go to completion because products recombine to form reactants and reaction occurs in both directions i.e. forward and reverse. At this state, the composition of reaction mixture remains constant.

$$\underset{\textit{Reactants}}{A + B} \underset{K_r}{\overset{K_f}{\rightleftharpoons}} \underset{\textit{Products}}{C + D}$$

iii. If a reaction has large value of K_c will it go to completion and why? ***(Understanding Base)*** **(SWL 2016)**

Ans: **LARGE K_c VALUE**

If a reaction has large value of K_c it indicates that reaction has almost gone to completion because at the equilibrium position the reaction mixture consists of almost all products and reactants are negligible.

Example:

$$2CO_{(g)} + O_{2(g)} \rightleftharpoons 2CO_{2(g)} \qquad K_c = 2.2 \times 10^{22}$$

iv. Which type of reactions do not go to completion? ***(Knowledge Base)*** **(RWP 2016 G-I)**

Ans: **REACTIONS WHICH DO NOT COMPLETE**

Reversible reactions do not go to completion. These reactions have very small value of K_c.

Examples:

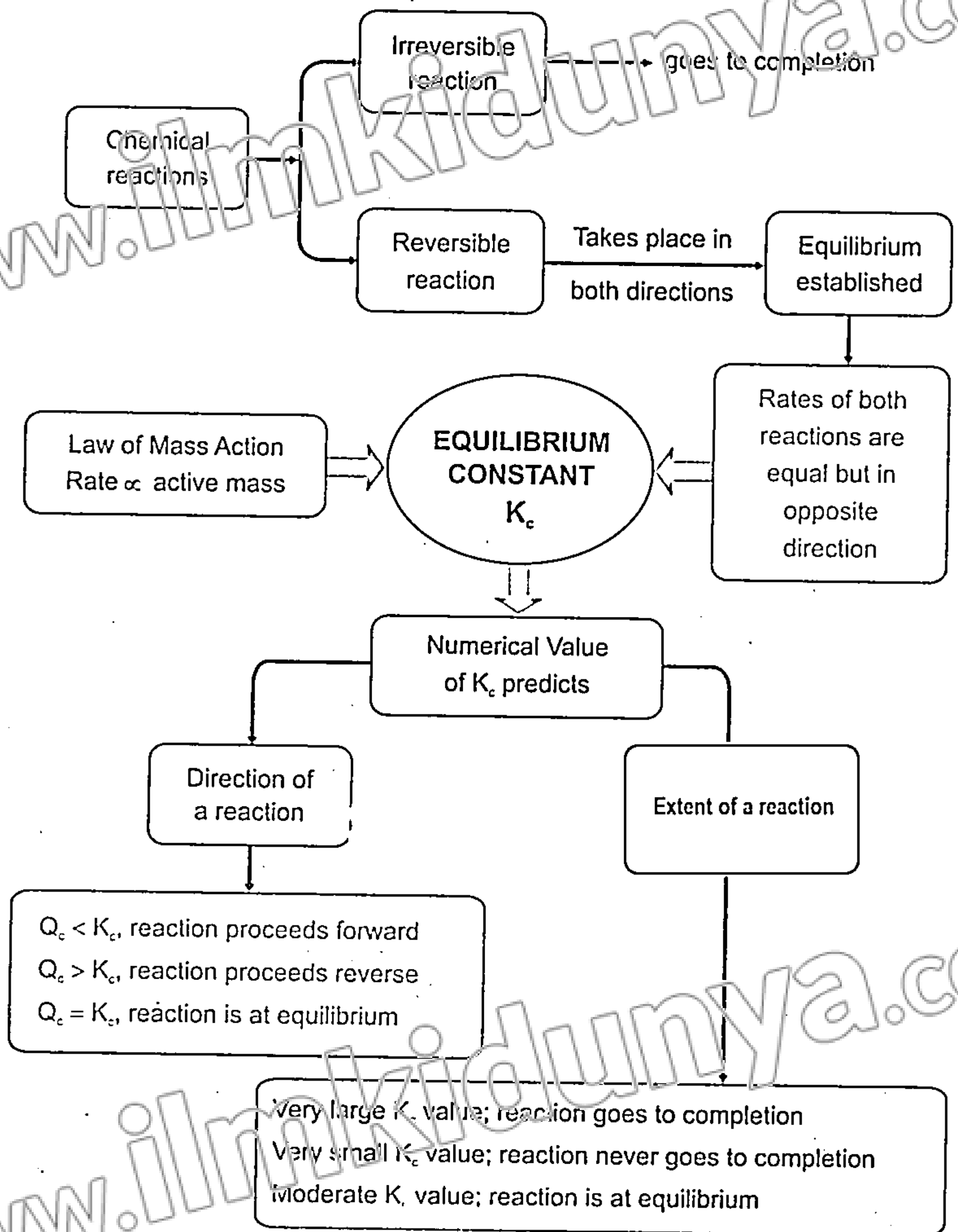
$$2NH_3 \rightleftharpoons N_2 + 3H_2 \qquad K_c = 3.0\times10^{-9}$$

v. Why the reaction mixture does not have 50% reactants and 50% products at equilibrium position? ***(Understanding Base)***

Ans: **50% REACTANTS AND 50% PRODUCTS**

The reaction mixture does not have 50% reactants and 50% products at equilibrium position because equilibrium **does not depend upon concentration** rather it is a state at which rate of forward and reverse reactions must be equal. So it is not necessary that reaction mixture contains 50% reactants and 50% products.

CONCEPT DIAGRAM



ANSWER KEY

MULTIPLE CHOICE QUESTIONS

INTRODUCTION

1	C	6	C
2	B	7	A
3	B		
4	A		
5	A		

9.1 CHEMICAL EQUILIBRIUM AND REVERSIBLE REACTIONS

1	D	6	A	11	B	16	A	21	D
2	B	7	C	12	B	17	A		
3	B	8	B	13	A	18	C		
4	B	9	D	14	C	19	C		
5	A	10	A	15	A	20	D		

9.2 LAW OF MASS ACTION

1	D	6	D
2	C	7	C
3	A	8	A
4	D	9	C
5	A		

9.3 EQUILIBRIUM CONSTANT AND ITS UNITS

1	C	6	A
2	A	7	A
3	B	8	A
4	A	9	A
5	B	10	A

9.4 IMPORTANCE OF EQUILIBRIUM CONSTANT

1	A	6	C	11	D	16	B
2	B	7	B	12	B	17	B
3	C	8	D	13	C	18	B
4	A	9	A	14	C	19	A
5	B	10	B	15	D	20	A

EXERCISE SOLUTION
MULTIPLE CHOICE QUESTIONS

1. The characteristics of reversible reactions are the following except: *(K.B)*
(a) Products never recombine to form reactants
(b) They never complete
(c) They proceed in both ways
(d) They have a double arrow between reactants and products

2. In the lime kiln, the reaction $CaCO_3(s) \longrightarrow CaO(s) + CO_2(g)$ goes to completion because: *(U.B)* (GRW 2013, 16, LHR 2015, SGD 2014, BWP 2017, MTN 2016 G-I, DGK 2016 G-I)
(a) Of high temperature
(b) CaO is more stable than $CaCO_3$
(c) CO_2 escapes continuously
(d) CaO is not dissociated

3. For the reaction, $2A_{(g)} + B_{(g)} \rightleftharpoons 3C_{(g)}$ the expression for the equilibrium constant is: *(K.B)*
(LHR 2013, 14, BWP 2017, RWP 2016 G-II, FSD 2017 G-II)
(a) $\frac{[2A][B]}{[3C]}$
(b) $\frac{[A]^2[B]}{[C]^3}$
(c) $\frac{[3C]}{[2A][B]}$
(d) $\frac{[C]^3}{[A]^2[B]}$

4. When a system is at equilibrium state: *(K.B)*
(a) The concentration of reactants and products becomes equal
(b) The opposing reactions (forward and reverse) stop
(c) The rate of the reverse reaction becomes very low
(d) The rates of the forward and reverse reactions become equal

5. Which one of the following statement is not correct about active mass? *(K.B)*
(a) Rate of reaction is directly proportional to active mass
(b) Active mass is taken in molar concentration
(c) Active mass is represented by square brackets
(d) Active mass means total mass of substances

6. When the magnitude of K_c is very large it indicates: *(U.B)*
(RWP 2017, SGD 2016 G-I, MTN 2016 G-I)
(a) Reaction mixture consists of almost all products
(b) Reaction mixture has almost all reactants
(c) Reaction has not gone to completion
(d) Reaction mixture has negligible products

7. When the magnitude of K_c is very small it indicates: *(U.B)*
(a) Equilibrium will never establish
(b) All reactants will be converted to products
(c) Reaction will go to completion
(d) The amount of products is negligible

8. Reactions which have comparable amounts of reactants and products at equilibrium state have: *(U.B)* **(RWP 2016 G-II, 17)**

(a) Very small K_c value
(b) Very large K_c value
(c) Moderate K_c value
(d) None of these

9. At dynamic equilibrium: *(K.B)* **(SGD 2016 G-I, II)**

(a) The reaction stops to proceed
(b) The amounts of reactants and products are equal
(c) The speeds of the forward and reverse reactions are equal
(d) The reaction can no longer be reversed

10. In an irreversible reaction dynamic equilibrium: *(K.B)* **(BWP 2016 G-II)**

(a) Never establishes
(b) Establishes before the completion of reaction
(c) Establishes after the completion of reaction
(d) Establishes readily

11. A reverse reaction is one that: *(K.B)*
(LHR 2013,2016, GRW 2016, DGK 2017, RWP 2016 G-I, MTN 2016 G-II, DGK 2016 G-I, II)

(a) Which proceeds from left to right
(b) In which reactants react to form products
(c) Which slows down gradually
(d) Which speeds up gradually

12. Nitrogen and hydrogen were reacted together to make ammonia: *(K.B + U.B)*
(GRW 2017, RWP 2017)

$$N_2 + 3H_2 \rightleftharpoons 2NH_3 \qquad K_c = 2.86\ mol^{-2}dm^6$$

What will be present in the equilibrium mixture?

(a) NH_3 only
(b) N_2, H_2 & NH_3
(c) N_2 & H_2
(d) H_2 only

13. For a reaction between PCl_3 and Cl_2 to form PCl_5 the units of K_c are: *(U.B)*
(GRW 2014, SGD 2016 G-I, 17, SWL 2016 G-I, RWP 2016 G-I, II)

(a) $mol\ dm^{-3}$
(b) $mol^{-1}\ dm^{-3}$
(c) $mol^{-1}\ dm^{3}$
(d) $mol\ dm^{3}$

ANSWER KEY

1	a	6	a	11	d
2	c	7	d	12	b
3	d	8	c	13	c
4	d	9	c		
5	d	10	a		

EXERCISE SHORT QUESTIONS

1. What are irreversible reactions? Give a few characteristics of them?
(Knowledge+Understanding Base) **(LHR 2013, RWP 2015, 2017, SGD 2017)**

Ans: **<u>IRREVERSIBLE REACTIONS</u>**

<u>Definition:</u>

*"The reactions, in which the products **do not recombine** to form reactants are called irreversible reactions".*

<u>Examples:</u>

- $2H_{2(g)} + O_{2(g)} \longrightarrow 2H_2O_{(l)}$
- $2Na + 2H_2O \longrightarrow 2NaOH + H_2$

<u>Characteristics:</u>

Following are the characteristics of irreversible reactions:

- These reactions proceed in one direction only.
- They are represented by single arrow ($\rightarrow$) between reactants and products.
- Reactants are completely converted into products at end of reaction.
- These reactions are generally fast.

2. Define chemical equilibrium state. *(Knowledge Base)*
(LHR 2013, BWP 2017, DGK 2016 G-II)

Ans: **<u>CHEMICAL EQUILIBRIUM STATE</u>**

<u>Definition:</u>

*"When the rate of the forward reaction takes place at the rate of reverse reaction, the **composition** of the **reaction mixture remains constant.** It is called a chemical equilibrium state".*

<u>Types:</u>

- Static equilibrium
- Dynamic equilibrium

3. Give the characteristics of reversible reaction. *(Knowledge+Understanding Base)*
(MTN 2017, RWP 2016 G-II, BWP 2016 G-II)

Ans: **<u>REVERSIBLE REACTIONS</u>**

<u>Definition:</u>

*"The reactions in which **products can recombine** to form **reactants** are called reversible reactions".*

<u>Example:</u>

- $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$ $K_c = 2.86\ mol^{-2}dm^6$

<u>Characteristics:</u>

- They are represented by double arrow ($\rightleftharpoons$) between reactants and products.
- They proceed in both ways.
- A reversible reaction never goes to completion.

4. How dynamic equilibrium is established? *(Understanding Base)*
(SGD 2016 G-II, 17, FSD 2017, GRW 2013, MTN 2016 G-II)

Ans: **<u>ESTABLISHMENT OF DYNAMIC EQUILIBRIUM</u>**

In a **reversible reaction,** dynamic equilibrium is established before the completion of reaction. At initial stage the rate of **forward reaction is very fast** and **reverse reaction** is taking place at a **negligible rate.** But gradually slows down and reaction speeds up. Eventually, **both reactions** attain the **same rate,** it is called a **dynamic equilibrium state.**

Example:

- $N_2 + 3H_2 \rightleftharpoons 2NH_3$ $K_c = 2.86\ mol^{-2}dm^6$

5. Why at equilibrium state reaction does not stop? *(Understanding Base)*
(BWP 2016 G-I, 17, MTN 2017)

Ans: **REACTION AT EQUILIBRIUM**

At equilibrium state, a reaction does not stop because forward and reverse reactions keep on taking place at the same rate but in opposite direction. Products recombine to from reactants.

Example:

$$H_2 + I_2 \rightleftharpoons 2HI \qquad K_c = 57.0 \text{ at } 700\ K$$

6. Why equilibrium state is attainable from either way? *(Understanding Base)*
(FSD 2016 G-I)

Ans: **ATTAINING OF EQUILIBRIUM STATE**

An equilibrium state is attainable from either way because it may start from reactants to give products or products can recombine to give reactants again.

$$\text{Reactants} \rightleftharpoons \text{Products}$$

$$A + B \rightleftharpoons C + D$$

Equilibrium state is established in a reversible reaction which proceeds in two direction.

7. What is relationship between active mass and rate of reaction? *(Knowledge Base)*
(SGD 2016 G-I, II)

Ans: **RELATIONSHIP**

According to Guldberg and Waage's Law of Mass Action, the rate of a reaction is **directly proportional** to the product of the active masses of reacting substances.

Rate of Reaction $\propto$ active masses of reacting substances.

8. Derive equilibrium constant expression for the synthesis of ammonia from nitrogen and hydrogen. *(Application Base)* **(GRW 2014)**

Ans: **EQUILIBRIUM CONSTANT EXPRESSION**

For the synthesis of ammonia from nitrogen and hydrogen the balanced chemical equation is:

$$N_{2(g)} + 3H_{2(g)} \underset{R_r}{\overset{R_f}{\rightleftharpoons}} 2NH_{3(g)}$$

The rate of forward reaction: $R_f = k_f[N_2][H_2]^3$
The rate of reverse reaction: $R_r = k_r[NH_3]^2$
At equilibrium state:

$$R_f = R_r$$

$$k_f[N_2][H_2]^3 = k_r[NH_3]^2$$

$$\frac{k_f}{k_r} = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

The equilibrium expression for this reaction is

$$K_c = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

9. Write the equilibrium constant expression for the following reactions:
(Application+Understanding Base) **(GRW 2014, SWL 2017, RWP 2017, FSD 2017)**

(i) $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$

(ii) $CO_{(g)} + 3H_{2(g)} \rightleftharpoons CH_{4(g)} + H_2O_{(g)}$

Ans: **EQUILIBRIUM CONSTANT EXPRESSIONS**

(i) $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$

The rate of forward reaction $R_f = k_f [H_2][I_2]$
The rate of reverse reaction $R_r = k_r [HI]^2$
The equilibrium constant expression:

$$K_c = \frac{[\text{Products}]}{[\text{Reactants}]}$$

$$\mathbf{K_c} = \frac{[HI]^2}{[H_2][I_2]}$$

(ii) $CO_{(g)} + 3H_{2(g)} \rightleftharpoons CH_{4(g)} + H_2O_{(g)}$:

The rate of forward reaction $R_f = k_f [CO] [H_2]^3$

The rate of reverse reaction $R_r = k_r [CH_4] [H_2O]$

The equilibrium constant expression:

$$K_c = \frac{[CH_4][H_2O]}{[CO]\,[H_2]^3}$$

10. How direction of a reaction can be predicted? *(Knowledge+Understanding Base)*
(SWL 2017, RWP 2017, SGD 2016 G-II, 17, LHR 2013)

Ans: **PREDICTION OF DIRECTION OF REACTION**

Direction of a reaction at particular moment can be predicted by comparing the value of Q_c (reaction quotient) with K_c (equilibrium constant) of a chemical reaction.

$$K_c = \frac{[\text{Molar concentration of product}]}{[\text{Molar concentration of reactatnt}]}$$

- **If $Q_c < K_c$;** the reaction goes from left to right, i.e., in **forward direction** to attain equilibrium.
- **If $Q_c > K_c$;** the reaction goes from right to left, i.e., in **reverse direction** to attain equilibrium.
- **If Qc = Kc;** forward and reverse reactions take place at equal rates i.e., **equilibrium** has been **attained.**

11. How can you know that a reaction has achieved an equilibrium state?
(Knowledge+Understanding Base)

Ans: **ACHIEVING OF EQUILIBRIUM STATE**

If $Q_c = K_c$, it indicates that forward and reverse reactions are taking place at equal rates i.e. equilibrium has been attained.

12. What are the characteristics of a reaction that establishes equilibrium state at once? *(Understanding Base)*

Ans: **CHARACTERISTICS OF A REACTION**

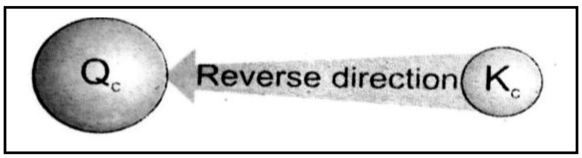
A reaction that establishes equilibrium state at once is called reversible reaction. Following are the characteristics of this type of reaction:

- These reactions never go to completion.
- These reactions are very fast.
- For these reactions the **value of K_c is small.**
- Closed flask $R_f = R_r$

13. If reaction quotient Qc of a reaction is more than Kc, what will be the direction of the reaction? *(Knowledge Base)* **(SGD 2013, BWP 2017, MTN 2017)**

Ans: **DIRECTION OF REACTION**

If reaction quotient, Q_c of a reaction is more than $\mathbf{K_c}$, the reaction proceeds from right to left i.e. in reverse direction to attain equilibrium.



14. An industry was established based upon a reversible reaction. It failed to achieve products on commercial level. Can you point out the basic reasons of its failure being a chemist? *(Application Base)*

Ans: **BASIC REASONS FOR FAILURE OF INDUSTRY**

An industry established based upon a reversible reaction failed to achieve products on commercial level due to the following reasons.

- Reaction is reversible so products recombine to form reactants and dynamic equilibrium is established.
- Equilibrium state is achieved at the initial stage of reaction and concentration of products is negligible.

EXERCISE LONG QUESTIONS

Q.1 Describe a reversible reaction with the help of an example and graph.

Ans: See LQ.1 (Topic 9.1)

Q.2 Write down the macroscopic characteristics of dynamic equilibrium.

Ans: See LQ.4 (Topic 9.1)

Q.3 State the Law of Mass Action and derive the expression for equilibrium constant for a general reaction

Ans: See LQ.1 (Topic 9.2)

Q.4 What is the importance of equilibrium constant?

Ans: See LQ.1 (Topic 9.4)

EXERCISE NUMERICALS

Q.1 For the decomposition of di-nitrogen oxide (N_2O) into nitrogen and oxygen reversible reaction takes place as follows

$$2N_2O \rightleftharpoons 2N_2 + O_2$$

The concentration of N_2O, N_2 and O_2 are 1.1 mol dm^{-3}, 3.90 mol dm^{-3} and 1.95 mol dm^{-3}, respectively at equilibrium. Find out K_c for this reaction.

Solution:

Given data:

The reversible reaction takes place as follows:

$$2N_2O \rightleftharpoons 2N_2 + O_2$$

The equilibrium concentration of:

$[N_2O]$ = 1.1mol dm^{-3}

$[N_2]$ = 3.90 mol dm^{-3}

$[O_2]$ = 1.95 mol dm^{-3}

The reversible reaction takes place as follows:

$$2N_2O \rightleftharpoons 2N_2 + O_2$$

To Find:

Equilibrium constant = K_c =?

Calculations:

The equilibrium constant expression for this reaction is

$$K_c = \frac{[N_2]^2[O_2]}{[N_2O]^2}$$

Putting the values

$$K_c = \frac{[3.90]^2[1.95]}{[1.1]^2}$$

$$= \frac{[15.21\,mol/dm^3][1.95\,mol/dm^3]}{[1.1\,moldm^3]^2}$$

$$K_c = 24.51 \text{ mol dm}^{-3}$$

Result:

Thus equilibrium constant for the reaction= 24.51 mol dm^{-3}

Q.2 Hydrogen iodide decomposes to form hydrogen and iodine. If the equilibrium concentration of HI is 0.078 mol dm^{-3}, H_2 and I_2 is same 0.011 mol dm^{-3}. Calculate the equilibrium constant value for this reversible reaction:

Solution:

Given data:

The equilibrium concentration of:

$[HI]$ = 0.078 mol dm^{-3}

$[H_2]$ = 0.011 mol dm^{-3}

$[I_2]$ = 0.011 mol dm^{-3}

The reversible takes place as follows:

$$2HI \rightleftharpoons H_2 + I_2$$

To Find:

Equilibrium constant = K_c = ?

Calculations:

The equilibrium constant expression for this reaction is

$$K_c = \frac{[H_2][I_2]}{[HI]^2}$$

Putting the values

$$K_c = \frac{[0.011][0.011]}{[0.078]^2}$$

$$= \frac{0.000121}{0.006084}$$

$$K_c = 0.01989$$

Result:

Thus equilibrium constant for the reaction= 0.01989

Q.3 For the fixation of nitrogen following reaction takes place:

$$N_2 + O_2 \rightleftharpoons 2NO$$

When the reaction takes place at 1500 K, the K_c for this is 1.1×10^{-5}. If equilibrium concentrations of nitrogen and oxygen are 1.7×10^{-3} mol dm^{-3} and 6.4×10^{-3} mol dm^{-3}, respectively, how much NO is formed?

Solution:

Given data:

Equilibrium concentrations of:

$[N_2] = 1.7 \times 10^{-3}$ mol dm^{-3}

$[O_2] = 6.4 \times 10^{-3}$ mol dm^{-3}

$K_c = 1.1 \times 10^{-5}$

The reversible takes place as follows:

$$N_2 + O_2 \rightleftharpoons 2NO$$

To Find:

Molar concentration of [NO] =?

Calculations:

The equilibrium constant expression for this reaction is

$$K_c = \frac{[NO]^2}{[N_2][O_2]}$$

Putting the values

$$1.1 \times 10^{-5} = \frac{[NO]^2}{[1.7\times10^{-3}\,moldm^{-3}][6.7\times10^{-3}\,moldm^{-3}]}$$

$[NO]^2 = (1.1 \times 10^{-5}) \times (1.7 \times 10^{-3} moldm^{-3}) \times (6.4 \times 10^{-3}\ moldm^{-3})$

$[NO]^2 = 11.96\times10^{-11}\ (moldm^{-3})^2$

$[NO]^2 = 1.96\times10^{-10}\ moldm^{-3}$

Taking square root on both sides

$$\sqrt{[NO]^2} = \sqrt{1.1968\times10^{-10}}$$

$[NO] = 1.09 \times 10^{-5}$ mol dm^{-3}

Result:

Thus molar concentration of NO = 1.09×10^{-3} mol dm^{-3}

Q.4 When nitrogen reacts with hydrogen to form ammonia, the equilibrium mixture contains 0.31 mol dm^{-3} and 0.50 mol dm^{-3} of nitrogen and hydrogen respectively. If the K_c is 0.50 mol dm^{-3} what is the equilibrium concentration of ammonia?

Solution:

Given data:

The equilibrium concentrations of:

$[N_2] = 0.31$mol dm^{-3}

$[H_2] = 0.50$ mol dm^{-3}

$K_C = 0.5$ mol^{-2}dm^{6}

The equilibrium constant expression for this reaction is

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

To Find:

Equilibrium concentration of ammonia= $[NH_3]$ = ?

Calculations:

The equilibrium constant expression for this reaction is

$$K_c = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

Putting the values

$$K_c = \frac{[NH_3]^2}{[0.31\,moldm^{-3}][0.50\,moldm^{-3}]^3}$$

$[NH_3]^2 = (0.50\,mol^{-2}dm^{6}) \times (0.31\,moldm) \times (0.50\,moldm)^3$

$[NH_3]^2 = \sqrt{0.019375}$

Taking square root on both sides

$[NH_3] = 0.1392$ mol dm^{-3}

$[NH_3] = 0.14$ mol.dm^{-3}

Result:

Thus equilibrium concentration of NH_3 = 0.14 mol dm^{3}

ADDITIONAL CONCEPTUAL QUESTIONS

Q.1 Why is equilibrium achievable only in closed system?

Ans: Equilibrium is only achievable in close system because dynamic equilibrium is only attained in reversible reactions and reversible reaction can only take place in closed system.

Q.2 How can we determine the value of Kc?

Ans: We can calculate the numerical values by putting actual equilibrium concentrations of the reactants and products into equilibrium expression.

Q.3 Why reaction quotient Qc is useful?

Ans: Qc is useful because it predicts the direction of a reaction by comparing the value of Qc with Kc.

Q.4 Differentiate between Qc and Kc.

Ans:

Qc	Kc
Definition: Ratio of product of concentration of products raised to the power of co-efficient to the product of concentration of reactants raised to the power of co-efficient in a balanced chemical equation, **at any time interval 't'** of reversible reaction	**Definition:** Ratio of product of concentration of products raised to the power of co-efficient to the product of concentration of reactants raised to the power of co-efficient in a balanced chemical equation. At the time of equilibrium.
Value: Its value can be obtained **before equilibrium state.**	**Value:** Its value can be obtained **only** at **equilibrium state.**
Formula: $Qc = \frac{[\text{Product}]_t}{[\text{Reactant}]_t}$	**Formula:** $Kc = \frac{[\text{Product}]}{[\text{Reactant}]}$

Q.5 Differentiate between Reverse and Reversible Reaction.

Ans:

Reverse Reaction	Reversible Reaction
Definition: It is reaction in which products react to produce reactants.	**Definition:** It is a reaction in which reactants react to produce products and products react to give reactants.
Direction: It takes place in one direction, i.e from right to left.	**Direction:** It takes place in both directions.

Q.6 Why at large numerical value of Kc concentration of products are high and reactants are low?

Ans: As we know

$$Kc = \frac{[Product]}{[Reactant]}$$

Which means **Kc** is **directly proportional** to concentration of **products** and inversely proportional to centration of reactants. If numerical value of Kc is large it means concentration of products are high as Kc is directly proportional to product and reaction has **almost** gone to completion.

Q.7 Why at small numerical value of Kc concentration of reactants are high and products are negligible?

Ans: As we know

$$Kc = \frac{[Product]}{[Reactant]}$$

Which means **Kc** is **directly proportional** to concentration of **products** and inversely proportional to centration of reactants. If numerical value of Kc small it means concentration of reactants are high as Kc is inversely proportional to the reactants and reaction will never go to completion.

Q.8 Explain why does the concentration of reactants decrease in forward reaction and increase in reverse reaction?

Ans: **In forward reaction reactants react and concentration of reactants decreases gradually** as they form products, as concentration decreases rate of forward reaction also decreases. On the other hand rate of reverse reaction increases and concentration of reactants also increases with time as products react to form reactants in reverse reaction. Therefore we can say that rate and concentration are directly proportional to each other.

$$\textbf{Rate of reaction} \propto \textbf{Concentration of reactants}$$

TERMS TO KNOW

Terms	Definitions
Chemical Reactions	The process in which chemical change occurs in nature and composition of substances is called chemical reaction.
Complete Reaction	A reaction in which all the reactants are converted into products is called complete reaction.
Irreversible Reactions	In most of the reactions the products do not recombine to form reactants, are called irreversible reactions and such reactions proceed in one direction only.
Reversible Reactions	Reactions in which products recombine to form reactants are called reversible reactions and such reactions proceed in both directions.
Chemical Equilibrium	When the rate of the forward reaction takes place at the rate of reverse reaction, the composition of the reaction mixture remains constant, is called chemical equilibrium state.
Static Equilibrium	When reaction ceases to proceed, it is called static equilibrium. This happens mostly in physical phenomenon.
Dynamic Equilibrium State	When reaction does not stop only the rates of forward and reverse reaction become equal to each other but take place in opposite directions. This is called dynamic equilibrium state.
Law of Mass Action	The rate at which a substance reacts is directly proportional to its active mass and the rate of a reaction is directly proportional to the product of the active masses of the reacting substances.
Active Mass	An active mass is considered as the molar concentration.
Equilibrium Constant	Ratio of the product of concentration of products raised to the power of coefficients to the product of concentration of reactants raised to the power of coefficients as expressed in the balanced chemical equation is called equilibrium constant.
Extent of a Reaction	Numerical value of the equilibrium constant predicts the extent of a reaction. It indicates to which extent reactants are converted to products. OR It measures how far a reaction proceeds before establishing equilibrium state.
Reaction Quotient	The ratio of product of concentration of products raised to the power of coefficients to the product of concentration of reactants raised to the power of co-efficients in a balanced chemical equation at any moment of the reversible reaction is known as reaction quotient.

CUT HERE

SELF TEST

Time: 35 Minutes **Marks: 25**

Q.1 Four possible answers (A), (B), (C) and (D) to each question are given, mark the correct answer. **(6×1=6)**

1. When the magnitude of K_c is very large it indicates:

(A) Equilibrium will never establish
(B) Reaction mixture has almost all products
(C) Reaction has not gone to completion
(D) Reaction mixture has negligible products

2. A reverse reaction is one that:

(A) Proceeds from left to right
(B) In which reactant react to form product
(C) Slows down gradually
(D) Speeds up gradually

3. The colour of hydrogen iodide is:

(A) Colourless
(B) Black
(C) Red
(D) Pink

4. Which gas is used to manufacture king of chemicals (sulphuric acid)?

(A) N_2
(B) O_2
(C) Cl_2
(D) CO_2

5. The units of molar concentration:

(A) $mol.dm^{-2}$
(B) $mol.dm^{-1}$
(C) mol.dm
(D) $mol.dm^{-3}$

6. If $Q_c < K_c$, the reaction goes in:

(A) Forward
(B) Reverse
(C) At equilibrium state
(D) None of the above

Q.2 Give short answers to the following questions. **(5×2=10)**

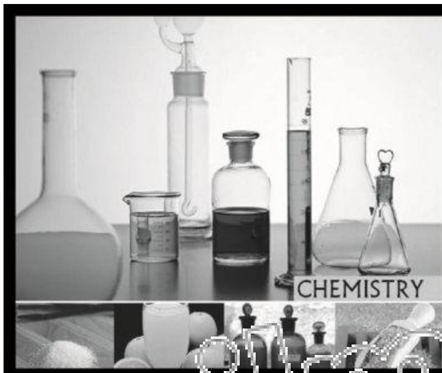
(i) Why reversible reactions never complete?
(ii) Define irreversible reaction.
(iii) Write use of atmospheric gases in manufacture of chemicals.
(iv) Define k_c and give its formula.
(v) How can you predict the direction of reaction?

Q.3 Answer the following questions in detail. **(5+4=9)**

(a) State law of mass action and explain derivation of expression for equilibrium constant for general reaction. **(5)**

(b) When nitrogen reacts with hydrogen to form ammonia, the equilibrium mixture contains 0.31 and 0.50 $mol.dm^{-3}$ of nitrogen and hydrogen respectively. If the K_c is 0.50 mol^{-2} dm^6, what is the equilibrium concentration of ammonia? **(4)**

NOTE: Parents or guardians can conduct this test in their supervision in order to check the skill of students.



CHAPTER 10

ACIDS, BASES & SALTS

INTRODUCTION

SHORT QUESTIONS

Q.1 What was the contribution of Jabir Bin Haiyan towards acids? *(Knowledge Base)*

Ans: **<u>CONTRIBUTION OF JABIR BIN HAIYAN</u>**

A famous Muslim Chemist Jabir Bin Haiyan prepared:
- Nitric acid (HNO_3)
- Hydrochloric acid (HCl)
- Sulphuric acid (H_2SO_4)

Q.2 What was the contribution of Lavoisier towards acids? *(Knowledge Base)*

Ans: **<u>CONTRIBUTION OF LAVOISIER</u>**

In 1787, Lavoisier named binary compounds of oxygen such as CO_2 and SO_2 as acids which on dissolution in water gave acidic solutions.

Q.3 Give the work of Sir Humphrey Davy towards acids. *(Knowledge Base)*

Ans: **<u>WORK OF SIR HUMPHREY DAVY</u>**

In 1815, Sir Humphrey Davy gave the following countributions:
- He discovered that there are certain acids which are without oxygen. For example, HCl.
- He proved the presence of hydrogen as the main constituent of all acids.

Q.4 Which acid is present in stomach and how is stomach acidity treated? (*Understanding+Application Base)*

Ans: **<u>ACID PRESENT IN STOMACH</u>**

We all have little concentration of hydrochloric acid in our stomach, which helps to break down the food. Sometimes the amount of stomach acid becomes too much, which causes acidity.

<u>Treatment of Stomach Acidity:</u>

Stomach acidity is easily treated by taking an alkaline medicine. The alkali neutralizes the acid, producing a harmless chemical called a salt.

MULTIPLE CHOICE QUESTIONS

1. Nitric acid was prepared by: *(K.B)*

(A) Bu Ali Sina (B) Jabir Bin Hayan
(C) Laviosier (D) Humphrey

2. The first acid known to man was: *(K.B)* **(SWL 2017)**

(A) Hydrochloric acid (B) Sulphuric acid
(C) Nitric acid (D) Acetic acid

3. The word acid is derived from: *(K.B)*

(A) Acidic (B) Acidus
(C) Acetic (D) Acetate

4. Humphrey Davy proved that main constituent of all acids is: *(K.B)*

(A) Nitrogen (B) Oxygen
(C) Hydrogen (D) Chlorine

5. CO_2 and SO_2 are: *(K.B)*

(A) Base (B) Acid
(C) Amphoteric compounds (D) Neutral compounds

6. **Which one gives acidic solution? *(K.B)***
(A) CO_2 (B) SO_2
(C) Both A and B (D) MgO

7. **Hydrochloric acid was prepared by: *(K.B)*** **(SGD 2016 G-II)**
(A) Alkhawarzmi (B) Ibnehashim
(C) Jabir Bin Hayan (D) Bu Ali Sina

8. **The meaning of Latin word acidus is: *(K.B)*** **(DGK 2016 G-II)**
(A) Sweet (B) Tasteless
(C) Sour (D) Salty

10.1 CONCEPTS OF ACIDS AND BASES

10.1.1 ARRHENIUS CONCEPT OF ACIDS AND BASES

LONG QUESTIONS

Q.1 What is the comparison between acids and bases? *(Knowledge Base)* **(DGK 2016 G-I)**

OR

Write down characteristic properties of acids and bases.

Ans: **<u>COMPARISON BETWEEN ACIDS AND BASES</u>**

Following are characteristics properties of acids and bases:

Acids	Bases
Taste	
• Acids have **sour** taste. e.g. unripe citrus fruits or lemon juice	• Bases have **bitter** taste and feel slippery. e.g. soap is slippery to touch
Effect on Litmus	
• They turn **blue litmus red**	• They turn **red litmus blue**
Nature	
• They are **corrosive** in concentrated form	• They are **non-corrosive** except concentrated forms of NaOH and KOH
Electrical Conductivity	
• Their aqueous solutions conduct electric current	• Their aqueous solutions conduct electric current
Examples	
• HCl, H_2SO_4, HNO_3 etc	• NaOH, KOH, $Ca(OH)_2$ etc

Q.2 Write in detail Arrhenius concept of acids and bases. *(Knowledge + Understanding Base)*

(LHR 2020, MTN 2016 G-II, 17, SGD 2016 G-II, 17, FSD 2016 G-I, 17)

Ans: **<u>ARRHENIUS CONCEPT</u>**

This concept was given by Arrhenius in 1787.

<u>Acid:</u>

*“Acid is a substance which **dissociates** in **aqueous solution** to give **hydrogen ions**”.*

<u>Examples:</u>

- Hydrochloric acid **(HCl)**
- Nitric acid **(HNO_3)**

- Sulphuric acid **(H_2SO_4)**
- Phosphoric acid **(H_3PO_4)**

General Reaction:

In general the ionization of acids, takes place as follows.

$$HA \rightleftharpoons H^+ + A^-$$

Explanation:

$$HCl \xrightleftharpoons{water} H^+ + Cl^-$$

$$HNO_3 \xrightleftharpoons{water} H^+ + NO_3^-$$

$$CH_3COOH \xrightleftharpoons{water} H^+ + CH_3COO^-$$

Base: **(BWP 2017)**

"Base is a substance which ***dissociates*** *in* ***aqueous solution*** *to give* ***hydroxide ions****".*

Examples:

- Sodium hydroxide **(NaOH)**
- Potassium hydroxide **(KOH)**
- Calcium hydroxide **[$Ca(OH)_2$]**
- Aluminium hydroxide **[$Al(OH)_3$]**

General Reaction:

The general ionization of bases takes place as follows;

Explanation:

$$BOH \xrightleftharpoons{water} B^+ + {}^-OH$$

$$NaOH \xrightleftharpoons{water} Na^+ + OH^-$$

Conclusion:

Thus, according to Arrhenius Concept:

Acid gives H^+ in water and base gives OH^- in water.

Limitations: **(LHR 2014, 2015, 2019, 2020)**

- **Aqueous medium:**

  This concept is applicable only in aqueous medium and **does not explain** nature of acids and bases in **non-aqueous medium**.

- **Nature of compounds:**

  According to this concept, acids and bases are only those compounds which contain hydrogen (H^+) and hydroxide (OH^-) ions, respectively. It **can't explain** the **nature** of compounds like **CO_2, NH_3** etc., which are acid and base, respectively. Although this concept has limited scope yet, it led to the development of more general theories of acid-base behaviour.

10.1 CONCEPTS OF ACIDS AND BASES

10.1.1 ARRHENIUS CONCEPT OF ACIDS AND BASES

SHORT QUESTIONS

Q.1 What are physical (characteristic) properties of acids? ***(Knowledge Base)***
(GRW 2014, 2016, DG. KHAN 2017, BWP 2016 G-II)

Ans: **PHYSICAL PROPERTIES OF ACIDS**

The physical properties of acids are as follows:

- Acids have **sour taste**. e.g. Unripe citrus fruits or lemon juices.
- They turn **blue litmus red.**
- They are **corrosive** in concentrated form.
- Their aqueous solutions conduct electric current.

Examples:

- Hydrochloric acid **(HCl)**
- Sulphuric acid **(H_2SO_4)**
- Nitric Acid **(HNO_3)**

Q.2 What are physical (characteristic) properties of bases? ***(Knowledge Base)*** **(GRW 2013, LHR 2015, BWP 2017)**

Ans: **PHYSICAL PROPERTIES OF BASES**

The physical properties of acids are as follows:

- Bases have **bitter taste** and feel slippery. e.g. Soap is slippery to touch.
- They turn **red litmus blue**.
- They are **non-corrosive except** concentrated forms of **NaOH and KOH**.
- Their aqueous solutions conduct electric current.

Examples:

- Sodium hydroxide **(NaOH)**
- Potassium Hydroxide **(KOH)**
- Calcium hydroxide **[$Ca(OH)_2$]**

Q.3 What are limitations of Arrhenius concept of acids and bases? ***(Understanding Base)***
(GRW 2014, 15, DGK 2016 G-II, 17, MTN 2017, RWP 2017, FSD 2016 G-II)

Ans: *Answer given on Page # 43* ***(limitations)***

10.1.1 MULTIPLE CHOICE QUESTIONS

1. **Formula of phosphoric acid is:** ***(K.B)***

(A) H_2PO_3 (B) H_4PO_3
(C) HPO_4 (D) H_3PO_4

2. **$Al(OH)_3$ is:** ***(K.B)***

(A) An acid (B) A base
(C) A salt (D) A non-metallic oxide

3. **The final product of Arrhenius concept is:** ***(U.B)***

(A) Salt +H_2O (B) An adduct
(C) A conjugate acid base pair (D) A salt only

4. Base turn red litmus to: *(K.B)*

(A) Blue (B) Red

(C) White (D) Yellow

5. Arrhenius concept was presented in: *(K.B)* **(BWP 2017)**

(A) 1234 (B) 1456

(C) 1787 (D) 1987

6. It is a substance which provides hydrogen ions: *(K.B)*

(A) Acid (B) Base

(C) Salt (D) Adduct

7. It is a substance which provides hydroxide ions: *(K.B)*

(A) Acid (B) Base

(C) Salt (D) Adduct

10.1.2 BRONSTED LOWRY CONCEPT

LONG QUESTIONS

Q.1 Explain Bronsted-Lowry Concept. Give its limitations. *(Knowledge + Understanding Base)* **(Ex-Q.1)(LHR 2019, FSD 2017)**

OR

Define an acid a base according to Bronsted-Lowry concept and justify with examples that water is an amphoteric compound.

Ans: **BRONSTED-LOWRY CONCEPT**

Introduction:

In 1923, the Danish Chemist Bronsted and the English Chemist Lowry independently presented their theories of acids and bases on the basis of proton transfer.

Acid:

*"An acid is a **substance** (molecule or ion) that can **donate a proton (H^+)** to another substance."*

Examples:

- Hydrocholoric acid **(HCl)**
- Acetic acid **(CH_3COOH)**
- Nitric acid **(HNO_3)**

Base:

*"A base is a **substance** that can **accept a proton (H^+)** from another substance."*

Examples:

- Ammonia **(NH_3)**
- Hydroxide **(OH^-)**

Explanation:

HCl acts as an acid while NH_3 acts as a base

$$\underset{\text{Acid} + \text{Base}}{HCl + NH_3} \rightleftharpoons \underset{\text{Conjugate acid}}{NH_4^+} + \underset{\text{Conjugate base}}{Cl^-}$$

<u>Water as an Amphoteric Substance:</u> (TEST YOURSELF 10.1 q iii)

(Understanding Base)

"*A substance that can act as an* ***acid as well as a base*** *is called amphoteric specie".*

- **<u>Water as a Base:</u>**

  When HCl dissolves in water; HCl acts as an acid and H_2O as a base.

$$\underset{\text{Acid} + \text{Base}}{HCl + H_2O} \rightleftharpoons \underset{\text{Conjugate acid}}{H_3O^+} + \underset{\text{Conjugate base}}{Cl^-}$$

- **<u>Water as an acid:</u>**

  When ammonia dissolves in water, H_2O acts as an acid and ammonia as a base.

$$\underset{\text{Acid}}{H_2O} + \underset{\text{Base}}{NH_3} \rightleftharpoons \underset{\text{Conjugate acid}}{NH_4^+} + \underset{\text{Conjugate base}}{OH^-}$$

<u>Explanation:</u>

It is a **reversible reaction**. In the forward reaction **HCl** is an acid as it **donates a proton**, whereas **H_2O** is a **base** as it **accepts a proton**. In the **reverse reaction Cl^- ion** is a base as it **accepts a proton** from acid **H_3O^+ ion**. Cl^- ion is called a conjugate base of acid HCl and **H_3O^+ ion is called a conjugate acid of base H_2O**. It means every acid produces a conjugate base and every base produces a conjugate acid such that there is conjugate acid-base pair.

<u>Conjugate Acid:</u>

"*A conjugate acid is a* ***specie*** *formed by* ***accepting*** *a* ***proton*** *by a* ***base****".*

<u>Conjugate Base:</u>

"*A conjugate base is a* ***specie*** *formed by* ***donating*** *a* ***proton*** *by an* ***acid****".*

<u>Examples:</u>

- Conjugate means joined together as pair.

$$\underset{\text{Acid}}{CH_3COOH} + \underset{\text{Base}}{H_2O} \rightleftharpoons \underset{\text{Conjugate acid}}{CH_3COO^-} + \underset{\text{Conjugate base}}{H_3O^+}$$

<u>Condition:</u>

According to Bronsted-Lowry concept, acid and base always, work together. That means, a substance can act as an acid (proton donor) only when another substance simultaneously behaves as a base (proton acceptor).

<u>Limitations:</u>

It has been observed that there are certain substances which behave as acids though they **do not** have the **ability** to **donate a proton**, e.g., **SO_3**. Similarly, **CaO behaves as a base but it cannot accept a proton**. These observations prove the limitations of Bronsted-Lowry concept of acids and bases.

Table 10.2 Conjugate Acid-Base Pairs of Common Species

Acid		Base		Conjugate Acid		Conjugate Base
$HNO_{3(aq)}$	+	$H_2O_{(l)}$	$\rightleftharpoons$	$H_3O^+_{(aq)}$	+	$NO_3^-{}_{(aq)}$
$H_2SO_{4(aq)}$	+	$H_2O_{(l)}$	$\rightleftharpoons$	$H_3O^+_{(aq)}$	+	$HSO_4^-{}_{(aq)}$
$HCN_{(aq)}$	+	$H_2O_{(l)}$	$\rightleftharpoons$	$H_3O^+_{(aq)}$	+	$CN^-_{(aq)}$
$CH_3COOH_{(aq)}$	+	$H_2O_{(l)}$	$\rightleftharpoons$	$H_3O^+_{(aq)}$	+	$CH_3COO_{(aq)}$
$H_2O_{(l)}$	+	$NH_{3(aq)}$	$\rightleftharpoons$	$NH_4^+{}_{(aq)}$	+	$OH^-_{(aq)}$
$H_2O_{(l)}$	+	$CO_3^{2-}{}_{(aq)}$	$\rightleftharpoons$	$HCO_3^-{}_{(aq)}$	+	$OH^-_{(aq)}$
$HCl_{(l)}$	+	$HCO_3^-{}_{(aq)}$	$\rightleftharpoons$	$H_2CO_{3(aq)}$	+	$Cl^-_{(aq)}$

PROBLEM 10.1

(Understanding + Application Base)

(a) What are conjugate bases of each of the following? **(DGK 2017, SWL 2017)**

$$HS^-, H_3O^+, H_2PO_4^-, HSO_4^-, HF, CH_3COOH, \left[Al\left(H_2O\right)_6\right]^{3+}$$

(b) Give the conjugate acids of the following?

$$OH^-, HCO_3^-, HPO_4^{2-}, CH_3NH_2, CO_3^{2-}, CH_3COOH.$$

(c) Which of the following behave both as Bronsted acids and Bronsted bases?

$$H_2O, HCO_3^-, H_2SO_4, H_3PO_4, HS^-.$$

NUMERICAL EXAMPLE

Solution:

(a) Conjugate Bases:

Species	**Conjugate Bases**
HS^-	S^{2-}
H_3O^+	H_2O
$H_2PO_4^-$	HPO_4^{2-}
HSO_4^-	SO_4^{2-}
HF	F^-
CH_3COOH	CH_3COO^-
$\left[Al\left(H_2O\right)_6\right]^{3+}$	$\left[Al\left(H_2O\right)_5 OH\right]^{2+}$

(b) Conjugate Acids:

Species	**Conjugate Acids**
OH^-	H_2O
HCO_3^-	H_2CO_3
HPO_4^{2-}	$H_2PO_4^-$
CH_3NH_2	$CH_3NH_3^+$
CO_3^{2-}	HCO_3^-
CH_3COOH	$CH_3COOH_2^+$.

(c) Bronsted Acids as Well as Bases:

- H_2O
- HCO_3^-
- HS^-

10.1.2 BRONSTED LOWRY CONCEPT
SHORT QUESTIONS

Q.1 What is conjugate acid and conjugate base? ***(Knowledge Base + Understanding Base)***
(GRW 2013,2014,2015)

Ans: **CONJUGATE ACID AND CONJUGATE BASE**

Conjugate Acid:

"*A conjugate acid is a **specie** formed by **accepting** a **proton** by a **base***".

Conjugate Base:

"*A conjugate base is a **specie** formed by **donating** a proton by an **acid***".

Examples:

- Conjugate means joined together as pair.

$$\underset{\text{Acid + Base}}{HCl + NH_3} \rightleftharpoons \underset{\text{Conjugate acid}}{NH_4^+} + \underset{\text{Conjugate base}}{Cl^-}$$

Q.2 What are limitations of Bronsted-Lowry concept of acids and bases? ***(Knowledge Base)***

Ans: *Answer given on Page # 46* ***(limitations)***

10.1.2 BRONSTED LOWRY CONCEPT
MULTIPLE CHOICE QUESTIONS

1. **Which one is amphoteric:** ***(U.B)***
   (A) HCl (B) NH_3
   (C) NaOH (D) H_2O
2. **Bronsted Lowry acid:** ***(K.B)***
   (A) Gives H^+ (B) Is an electron pair acceptor
   (C) Donates OH^- (D) Is an electron pair
3. **All Bronsted acids are:** ***(U.B)***
   (A) Arrhenius acids (B) Lewis acids
   (C) Lewis bases (D) Bronsted acids

4. Conjugate base of sulphuric acid is: *(U.B)* **(LHR 2014, BWP 2017)**

(A) SO_3^{2-} (B) SO^{2-}

(C) HSO_3^- (D) HSO_4^-

5. Acid is a substance that can donate a: *(K.B)*

(A) Proton (B) Electron

(C) Neutron (D) Positron

6. Bronsted-Lowry concept was presented in: *(K.B)* **(SWL 2017)**

(A) 1923 (B) 1787

(C) 1823 (D) 1943

7. Bronsted-Lowry concept is based on transfer of: *(K.B)*

(A) Proton (B) Electron

(C) Neutron (D) Positron

8. Base is a substance that can accept a: *(K.B)*

(A) Proton (B) Electron

(C) Neutron (D) Positron

9. Substances that can behave as acid as well as base are called: *(K.B)*

(A) Bases (B) Acids

(C) Amphoteric compounds (D) Salts

10. Which one is not an acid? *(K.B)* **(MTN 2016 G-II)**

(A) HCl (B) NH_3

(C) H_2CO_3 (D) H_2SO_4

10.1.3 LEWIS CONCEPT OF ACIDS AND BASES

LONG QUESTIONS

Q.1 Explain Lewis Concept of acids and bases with suitable examples. *(Knowledge Base + Understanding Base)* **(Ex-Q.2)**

(LHR 2013, 2014, 2019 GRW 2013, MTN 2016 G-I, 17, SGD 2017, BWP 2016 G-II)

Ans: **LEWIS CONCEPT OF ACIDS AND BASES**

Introduction:

The Arrhenius and Bronsted-Lowry concepts of acids and bases are limited to substances which contain protons. G.N. Lewis (1923) proposed a more general and broader concept of acids and bases. According to this concept:

Acid:

*"An acid is a substance (molecule or ion) which can **accept a pair of electrons**"*

Examples:

- Boron trifluoride **(BF_3)**
- Hydrogen ion **(H^+)**
- Sodium ion **(Na^+)**

- Aluminium trichloride **($AlCl_3$)**

Base:

"A base is a substance (molecule or ion) which can ***donate a pair of electrons****."*

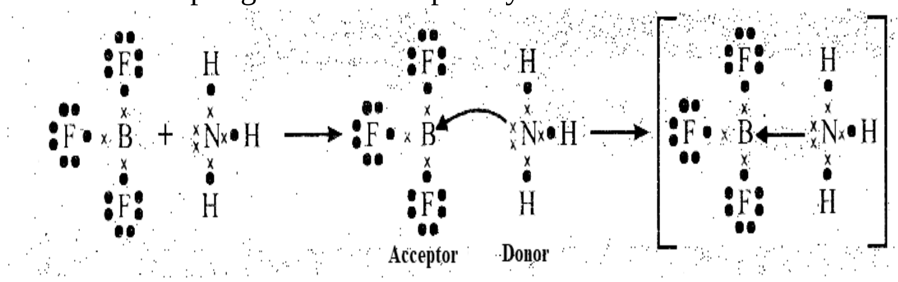
Examples:

- Ammonia **(NH_3)**
- Fluoride ion **(F^-)**
- Cyanide ion **(CN^-)**
- Alcohols **(ROH)**

Example 1:

(Reaction between Boron Trifluoride and Ammonia):

A reaction between ammonia and boron trifluoride takes place by forming a coordinate covalent bond between ammonia and boron trifluoride by donating an electron pair of ammonia and accepting that electron pair by boron trifluoride.

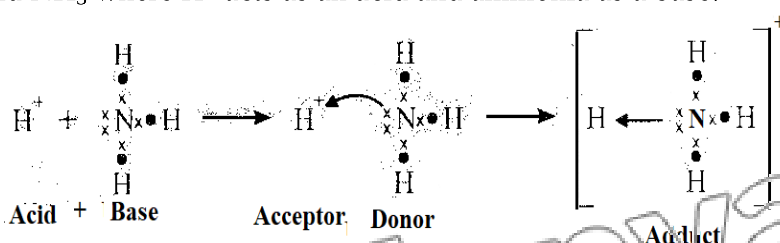


Boron trifluoride + Ammonia   Ammonia boron trifluoride (adduct)

Examples 2:

(Reaction between H^+ and Ammonia):

The cations (proton itself or metal ions) act as Lewis acids. For example, a reaction between H^+ and NH_3 where H^+ acts as an acid and ammonia as a base:



Adduct:

"The ***product*** *of any* ***Lewis acid-base*** *reaction is a* ***single specie****, called an adduct".*

Neutralization Reaction:

A **neutralization reaction** according to Lewis concept is **donation** and **acceptance** of an **electron pair** to **form** a **coordinate covalent bond** in an adduct.

Characteristics of Lewis Acids:

According to Lewis concept, the following species can act as Lewis acids:

(i) Central Atom With Incomplete Octet:

Molecules in which the **central atom** has **incomplete octet** are **Lewis acid**. The central atom has only six electrons around it, therefore, these can accept an electron pair.

Examples:
- BF_3
- $AlCl_3$
- $FeCl_3$

(ii) Simple Cations:
Simple cations can act as Lewis acids. All cations act as Lewis acids since they are deficient in electrons.

Little Tendency to Accept Electrons:
Some cataions have a very little tendency to accept electrons like:
- Na^+
- K^+
- Ca^{2+} etc.

Greater Tendency to Accept Electrons:
Some cataions have a greater tendency to accept electrons like:
- H^+
- Ag^+ etc.

Characteristics of Lewis Bases:
According to Lewis concept, the following species can act as Lewis bases:

(i) Electron Rich Species:
Neutral species having at least one lone pair of electrons act as Lewis bases because they contain a lone pair of electrons

Examples:
- Ammonia $\ddot{N}H_3$
- Aamines R- $\ddot{N}H_2$
- Alcohols R-$\ddot{\underset{..}{O}}$-H
- Water H-$\ddot{\underset{..}{O}}$-H.

(ii) Anions:
Negatively charged species or anions act as Lewis bases:

Examples:
- Chloride Cl^-
- Cyanide CN^{-1}
- Hydroxide ion OH^-

Q.2 Give brief idea about three concepts of acids and bases. ***(Knowledge Base)***

Ans:

CONCEPTS OF ACIDS AND BASES

A summary of three concepts of acids and bases is as follows:

Concept	Acid	Base	Product
• Arrhenius	It gives H^+ ion	It gives OH^-	Salt + H_2O
• Bronsted Lowry	It donates H^+	It accepts H^+	Conjugate acid base pair.
• Lewis	It is electron pair acceptor	It is electron pair donor	Adduct.

10.1.3 LEWIS CONCEPT OF ACIDS AND BASES

SHORT QUESTIONS

Q.1 What are types of Lewis bases? *(Knowledge Base)*

Ans:

<u>TYPES OF LEWIS BASES</u>

According to Lewis concept, the following species can act as Lewis bases:

(i) <u>Electron Rich Species:</u>

Neutral species having at least one lone pair of electrons act as Lewis bases because they contain a lone pair of electrons.

<u>Examples:</u>

- Ammonia $\ddot{N}H_3$
- Amines R- $\ddot{N}H_2$
- Alcohols R-$\ddot{\underset{..}{O}}$-H
- Water H-$\ddot{\underset{..}{O}}$-H.
- Ethers R-$\ddot{\underset{..}{O}}$-R

(ii) <u>Anions:</u>

Negatively charged species or anions act as Lewis bases:

<u>Examples:</u>

- Chloride Cl^-
- Cyanide CN^{-1}
- Hydroxide ion OH^-

Q.2 What is an adduct? *(Knowledge Base)* **(SWL 2016 G-I, II)**

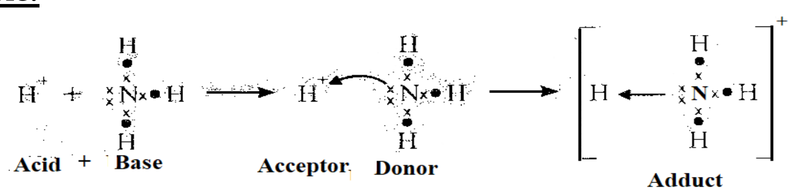
Ans:

<u>ADDUCT</u>

<u>Definition:</u>

*"The **product** of any **Lewis acid-base reaction** is a **single specie**, called an **adduct**".*

<u>Example:</u>



Q.3 All Bronsted bases are Lewis bases but all Bronsted acids are not Lewis acids. Justify. (*Understanding Base)* **(Do you know Pg. # 26)**

Ans:

<u>JUSTIFICATION</u>

It may be noted that all Bronsted bases are also Lewis bases but all Bronsted acids are not Lewis acids.

<u>Justification:</u>

According to Bronsted concept, a base is a substance which can accept a proton, while according to Lewis concept, a base is a substance which can donate a pair of electrons. Lewis bases generally contain one or more lone pair of electrons and, therefore, they can also accept a proton (Bronsted base). Thus, all Lewis bases are also Bronsted bases. On the other hand, Bronsted acids are those which can give a proton. For example, HCl, H_2SO_4 are not capable of accepting a pair of electrons. Hence, all Bronsted acids are not Lewis acids.

10.1.3 LEWIS CONCEPT OF ACIDS AND BASES

MULTIPLE CHOICE QUESTIONS

1. **The product of any Lewis acid base reaction is a single specie called: *(K.B)* (MTN 2017)**
   (A) A salt (B) An adduct
   (C) Salt +H_2O (D) Conjugate acid-base pair
2. **In a reaction between ammonia & boron trifluoride, BF_3 is: *(U.B)***
   (A) An acid (B) A base
   (C) A conjugate base (D) An adduct
3. **These can act as Lewis acids: *(K.B)***
   (A) Anions (B) Radicals
   (C) Cations (D) Molecule
4. **These can act as lewis bases: *(K.B)***
   (A) Cations (B) Anions
   (C) Cations & anions (D) Radicals
5. **Which is a Lewis base? *(K.B)* (GRW 2014, LHR 2015, 2016, DGK 2017)**
   (A) $AlCl_3$ (B) H^+
   (C) BF_3 (D) NH_3
6. **Molecules in which central atom has incomplete octet is called: *(U.B)***
   (A) Lewis base (B) Lewis acid
   (C) Amphoteric (D) Salt
7. **Substance which has unshared pair of electons act as: *(U.B)***
   (A) Lewis base (B) Lewis acid
   (C) Amphoteric (D) Salt
8. **Substances which have empty orbital that can accommodate an electron pair are called: *(U.B)***
   (A) Lewis base (B) Lewis acid
   (C) Amphoteric comopuds (D) Adduct
9. **Simple cations can act as: *(U.B)***
   (A) Lewis base (B) Lewis acid
   (C) Amphoteric (D) Adduct
10. **Ammonia, amines and alcohols are examples of: *(K.B)***
    (A) Lewis base (B) Lewis acid
    (C) Amphoteric (D) Arrhenius acid

10.1 TEST YOURSELF

i. What is the difference between Arrhenius base and Bronsted-Lowry base? (*Understanding Base*)

Ans: **DIFFERENTIATION**

The differences between Arrhenius base and Bronsted-Lowry base are as follows:

Arrhenius Base	Bronsted-Lowry Base
Definition	
• A base is a substance which dissociates in aqueous solution to give hydroxide ions (OH^-).	*A base is a substance that can accept a proton (H+) from another substance.*
Examples	
• NaOH • $Ca(OH)_2$ $NaOH \xrightarrow{H_2O} Na^+ + OH^-$	• NH_3 • $AlCl_3$ $\underset{Acid}{HCl} + \underset{Base}{NH_3} \longrightarrow NH_4^+ + Cl^-$

ii. What do you mean by neutralization reaction according to Arrhenius acid-base concept? (*Understanding Base*)

Ans: **NEUTRALIZATION**

According to Arrhernius acid base concept, during neutralization reaction hydrogen ions (H^+) combine with the equal number of hydroxide ions and both neutralize each other to form water.

$$HCl \longrightarrow H^+ + Cl^-$$

$$NaOH \longrightarrow Na^+ + OH^-$$

$$H^+ + OH^- \rightarrow H_2O$$

$$HCl + NaOH \xrightarrow{\text{In } H_2O} NaCl + H_2O$$

iii. Prove that water is an amphoteric specie. (*Understanding Base)*

Ans: *Answer given on Page # 46*

iv. How can you justify that NH_3 is Bronsted-Lowry base but not Arrhenius base? (*Understanding Base)*

Ans: **NH_3 AS BRONSTED-LOWRY BASE**

Ammonia (NH_3) is Bronsted –Lowry base because it has the ability to accept a proton (H^+ ion) but not Arrhenius base because it does not produce hydroxide ions (OH^-) in aqueous solution.

Example:

NH_3 accepts a proton from water

$$\underset{\text{Base}}{NH_3} + \underset{\text{Acid}}{H_2O} \rightleftharpoons \underset{\text{Conjugate acid}}{NH_4^+} + \underset{\text{Conjugate base}}{OH^-}$$

v. State and explain the neutralization reaction according to Lewis concept. *(Knowledge Base)*

Ans: **NEUTRALIZATION REACTION**

Definition:

"*A neutralization reaction according to Lewis concept is donation and acceptance of a electron pair to form a coordinate covalent bond in an adduct*".

Example:

$$\underset{\text{Electron pair Acceptor (acid)}}{BF_3} + \underset{\text{Electron pair Donor (base)}}{:NH_3} \longrightarrow \underset{\text{Adduct (Salt)}}{[BF_3 \leftarrow :NH_3]}$$

vi. Define and give the characteristics of Lewis acid. (*Understanding Base)*

Ans: **LEWIS ACID**

Definition:

"*An acid is a substance (molecule or ion) which can accept a pair of electrons*".

Examples:

- Boron trifluoride (BF_3)
- Hydrogen ion (H^+)
- Sodium ion (Na^+)

- Aluminium trichloride ($AlCl_3$)

Characteristics of Lewis Acids:

According to Lewis concept, the following species can act as Lewis acids:

(i) Central Atom With Incomplete Octet:

Molecules in which the central atom has incomplete octet are Lewis acid. The central atom as only six electrons around it, therefore, these can accept an electron pair.

Examples:

- BF_3
- $AlCl_3$
- $FeCl_3$

(ii) Simple Cations:

Simple cations can act as Lewis acids. All cations act as Lewis acids since they are deficient in electrons.

Little Tentdency to Accept Electrons:

Some cataions have a very little tendency to accept electrons like:

- Na^+
- K^+
- Ca^{2+} etc.

Greater Tendency to Accept Electrons:

Some cataions have a greater tendency to accept electrons like:

- H^+
- Ag^+ etc.

vii. What is an amphoteric specie according to Bronsted-Lowry concept? What is its nature according to Lewis concept? ***(Knowledge Base + Understanding Base)***

Ans: **AMPHOTERIC SPECIE**

Water is amphoteric specie according to Bronsted-Lowery concept because it behaves as an acid as well as base.

NATURE OF AMPHOTERIC SPEICE

According to Lewis concept water acts only as Lewis base because it has the ability to donate electron pair.

$$\underset{\text{Base}}{H_2\ddot{\underset{..}{O}}} + \underset{\text{Acid}}{H^+} \longrightarrow \underset{\text{Adduct}}{\left(H_2\ddot{\underset{..}{O}} \longrightarrow H\right)^+}$$

10.1.4 GENERAL PROPERTIES OF ACIDS

LONG QUESTIONS

Q.1 Explain the chemical properties of acids? ***(Understanding + Application Base)***

(LHR 2016, GRW 2014,2017, DGK 2017)

Ans: **CHEMICAL PROPERTIES OF ACIDS**

The chemical properties of acids are as follows:

(i) Reaction with Metals: **(LHR 2014)**

Acids react explosively with metals like sodium, potassium and calcium. However, dilute acids (HCl, H_2SO_4) react moderately with reactive metals like, Mg, Zn, Fe and Al form respective salts and **evolve hydrogen gas.**

$$Zn_{(s)} + H_2SO_{4(aq)} \longrightarrow ZnSO_4 + H_{2(g)} \uparrow$$

$$2Al_{(s)} + 6HCl_{(aq)} \longrightarrow 2AlCl_{3(aq)} + 3H_{2(g)} \uparrow$$

(ii) <u>Reaction with Carbonates and Bicarbonates:</u> ***(Test Yourself 10.2 q i)***

Acids react with carbonates and bicarbonates to form corresponding salts and **evolve carbon dioxide gas.**

$$\mathbf{CaCO_3 + 2HCl \longrightarrow CaCl_2 + CO_2 \uparrow + H_2O}$$

(Calcium carbonate)

$$\mathbf{2NaHCO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + 2CO_2 \uparrow + 2H_2O}$$

(Sodium Bicarbonate)

(iii)<u>Reaction with Bases:</u>

Acids react with bases (oxides and hydroxides of metal and ammonium hydroxide) to form **salts and water.** This process is called **neutralization.**

$$\mathbf{NaOH_{(aq)} + HCl_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}}$$

$$\mathbf{CuO_{(aq)} + H_2SO_{4(aq)} \longrightarrow CuSO_{4(aq)} + H_2O_{(l)}}$$

(iv)<u>Reaction with Sulphites and Bisulphites:</u> ***(Test Yourself 10.2 q ii)***

Acids react with sulphites and bisulphites to form salts with liberation of **sulphur dioxide gas.**

$$CaSO_{3(aq)} + 2HCl_{(aq)} \longrightarrow CaCl_{2(aq)} + SO_{2(g)} \uparrow + H_2O_{(l)}$$

(Calcium Sulphite)

$$NaHSO_{3(aq)} + HCl_{(aq)} \longrightarrow NaCl_{(aq)} + SO_{2(g)} \uparrow + H_2O_{(l)}$$

(Sodium Bisulphite)

(v) <u>Reaction with Sulphides:</u>

Acids react with metal sulphides to liberate **hydrogen sulphide gas.**

$$FeS_{(aq)} + H_2SO_{4(aq)} \longrightarrow FeSO_{4(aq)} + H_2S_{(g)} \uparrow$$

Q.2 Write down uses of acids. Give some naturally occuring acids and their sources.
(Knowledge Base) **(Do you know Pg. # 29) (FSD 2016 G-I, BWP 2016 G-I, GRW 2017)**

Ans: **<u>USES OF ACIDS</u>**

Following are the uses of some important acids:

<u>Sulphuric Acid (H_2SO_4):</u> ***(Test Yourself 10.2 q iii)***

It is used to manufacture fertilizers, ammonium sulphate, calcium superphosphate, explosives, paints, dyes, drugs. It is also used as an electrolyte in **lead storage batteries.**

<u>Nitric Acid (HNO_3):</u>

It is used in manufacturing of fertilizer (ammonium nitrate), explosives, paints, drugs and **etching designs on copper plates.**

<u>Hydrochloric Acid (HCl):</u>

It is used for cleaning metals, tanning and in printing industries.

<u>Benzoic Acid (C_6H_5COOH):</u>

It is used in preservation of food.

<u>Acetic Acid (CH_3COOH):</u>

It is used in food preservation & flavouring of food. It is also used to **treat stings of wasps.**

SOME NATURAL ACIDS AND THEIR SOURCES

Naturally accruing acid		
Sr. No.	**Acid**	**Source**
(i)	Citric acid	Citrus fruits i.e., lemon, orange
(ii)	Lactic acid	Sour milk
(iii)	Formic acid	Stings of bees and ants
(iv)	Butyric acid	Rancid butter
(v)	Tartaric aicd	Tamarind, grapes, apples
(vi)	Maleic acid	Apples
(vii)	Uric acid	Urine
(viii)	Stearic acid	Fats

10.1.4 GENERAL PROPERTIES OF ACIDS

SHORT QUESTIONS

Q.1 What are mineral acids? *(Knowledge Base)*
(Do you know Pg. # 28)(GRW 2015)

OR

Write down the names and formulae of three mineral acids.
(GRW 2015, DGK 2017, RWP 2017)

Ans: **MINERAL ACIDS**

Definitions:

"Acids having ***inorganic origin*** *are called mineral acids".*

Examples:

- Hydrochloric acid (HCl)
- Sulphuric acid (H_2SO_4)
- Nitric acid (HNO_3)

Q.2 How do acids react with metals? *(Application Base)* **(LHR 2014)**

Ans: **REACTION BETWEEN ACIDS AND METALS**

Acids react explosively with metals like sodium, potassium and calcium. However, dilute acids (HCl, H_2SO_4) react moderately with reactive metals like, Mg, Zn, Fe and Al to form respective salts and evolve hydrogen gas.

$$Zn_{(s)} + H_2SO_{4(aq)} \longrightarrow ZnSO_4 + H_{2(g)}$$

$$2Al_{(s)} + 6HCl_{(aq)} \longrightarrow 2AlCl_{3(aq)} + 3H_{2(g)}$$

Q.3 Write down uses of hydrochloric acid. *(Knowledge Base)*
(GRW 2013) (DGK 2017, RWP 2017)

Ans: **USES OF HYDROCHLORIC ACID**

It is used:

- For cleaning metals
- For tanning
- In printing industries.

Q.4 Write down sources of Maleic acid and Stearic acid. *(Knowledge Base)*

Ans: **SOURCES OF ACIDS**

Following are the sources of acids:

- Maleic acid : Apple
- Stearic acid : Fats

Q.5 Write sources of citric acid and lactic acid. *(Knowledge Base)* **(LHR 2014,2015)**

Ans: **SOURCES OF ACIDS**

The sources of citric acid and lactic acid are as follows:

- Citric acid : Citrus fruits i.e. lemon, orange.
- Lactic acid : Sour milk.

Q.6 Give the uses of sulphuric acid. *(Knowledge Base)* **(MTN 2016 G-I)**

Ans: **USES OF SULPHURIC ACID**

Sulphuric acid (H_2SO_4) is used:

- To manufacture fertilizers, ammonium sulphate, calcium superphosphate, etc.
- To prepare explosives, paints, dyes, drugs.
- As an electrolyte in lead storage batteries.

Q.7 Write down any two uses of acetic acid. *(Knowledge Base)* **(SWL 2016 G-I)**

Ans: **USES OF ACETIC ACID**

Acetic acid is used:

- In food preservation, flavouring of food.
- To treat stings of wasps.

Q.8 Give four uses of nitric acid. *(Knowledge Base)* **(DGK 2016 G-II)**

Ans: **USES OF NITRIC ACID**

It is used:

- In manufacturing of fertilizer (ammonium nitrate)
- In the manutectueing of explosives,
- To prepare of paints and drugs
- For etching designs on copper plates.

Q.9 Write the name of acid present in (a) Vinegar (b) Ant sting. *(Knowledge Base)* **(DGK 2016 G-I)**

Ans: **NAMES OF ACIDS**

The names of acids present in vinegar ant sting are:

- Vinegar : Acetic acid
- Ant Sting : Formic acid

10.1.4 GENERAL PROPERTIES OF ACIDS

MULTIPLE CHOICE QUESTIONS

1. **Neutralization is reaction of: *(U.B)***

(A) Acids with metals (B) Acids with sulphides
(C) Bases with acids (D) None of these

2. **Acid used for food preservation is: *(K.B)***

(A) Nitric acid (B) Benzoic acid
(C) Acetic acid (D) Both B and C

3. Maleic acid is found from: ***(K.B)***
(A) Apples (B) Grapes
(C) Sour milk (D) Fats

4. Acid reacts with metal sulphides to liberate: ***(U.B)***
(A) Hydrogen gas (B) Carbon dioxide
(C) Ammonia gas (D) Hydrogen sulphide gas

5. Formula of acetic acid is: ***(K.B)***
(A) CH_3COOH (B) CH_2O
(C) NaOH (D) CH_3OH

6. Which one is found in stings of bee's and ants? ***(K.B)***
(A) Lactic acid (B) Maleic acid
(C) Butyric acid (D) Formic acid

7. It is used to cure sting of wasps: ***(K.B)***
(A) Acetic acid (B) Benzoic acid
(C) Nitric acid (D) Sulphuric acid

8. When acids react with carbonates and bicarbonates, which gas evolves out? ***(U.B)*** **(LHR 2013,14, GRW 2014, SWL 2017)**
(A) H_2S (B) CO_3
(C) CO_2 (D) CO

9. Uric acid is present in: ***(K.B)*** **(FSD 2016 G-I, SGD 2016 G-I)**
(A) Fats (B) Citrus fruits
(C) Apples (D) Urine

10. When Na reacts with HCl the salt produced is: ***(U.B)***
(A) NaCl (B) NaOH
(C) H_2O (D) NH_3

11. Citric acid is found in: ***(K.B)*** **(BWP 2017, FSD 2016 G-II)**
(A) Urine (B) Fast
(C) Lemon (D) Sour milk

12. Acid present in sour milk is: ***(K.B)*** **(DGK 2016 G-I, 17)**
(A) Lactic acid (B) Formic acid
(C) Tartaric acid (D) Uric acid

13. Name the acid used in lead storage batteries: ***(K.B)*** **(MTN 2017, SGD 2017)**
(A) CH_3COOH (B) HCl
(C) HNO_3 (D) H_2SO_4

14. Lactic acid is found in: ***(K.B)*** **(GRW 2013, SWL 2017)**
(A) Citrus fruits (B) Sour milk
(C) Rancid butter (D) Apple

10.1.5 GENERAL PROPERTIES OF BASES

LONG QUESTIONS

Q.1 Describe the chemical properties of bases. ***(Understanding + Application Base)*** **(GRW 2014)**

Ans: **CHEMICAL PROPERTIES OF BASES**

The chemical properties of bases are as follows:

(i) Reaction with Acids:

Bases react with acids to form salt and water. It is a **neutralization reaction.**

$$2KOH_{(aq)} + H_2SO_{4(aq)} \longrightarrow K_2SO_{4(aq)} + 2H_2O_{(l)}$$

(ii) Reaction with Ammonium Salts:

Alkalies react with ammonium salts to liberate ammonia gas.

$$NH_4Cl_{(aq)} + NaOH_{(aq)} \longrightarrow NaCl_{(aq)} + NH_{3(g)}\uparrow + H_2O_{(l)}$$

$$(NH_4)_2SO_{4(aq)} + Ca(OH)_{2(aq)} \longrightarrow CaSO_{4(aq)} + 2NH_{3(g)}\uparrow + 2H_2O_{(l)}$$

(iii) Precipitation of Hydroxides (Reaction with Heavy Metal Salts): **(LHR 2013, 2020)**

Alkalies precipitate insoluble hydroxides when added to solutions of salts of heavy metals such as copper, iron, zinc, lead and calcium.

$$CuSO_{4(aq)} + 2NaOH_{(aq)} \longrightarrow Cu(OH)_{2(s)} + Na_2SO_{4(aq)}$$

Blue ppt.

$$ZnCl_{2(aq)} + 2NaOH_{(aq)} \longrightarrow Zn(OH)_{2(s)} + 2NaCl_{(aq)}$$

White ppt.

$$FeCl_{3(aq)} + 3NaOH_{(aq)} \longrightarrow Fe(OH)_{3(s)} + 3NaCl_{(aq)}$$

Brown ppt.

$$Pb(NO_3)_{2(aq)} + 2NaOH_{(aq)} \longrightarrow Pb(OH)_{2(s)} + 2NaNO_{3(aq)}$$

White ppt.

$$CaCl_{2(aq)} + 2NaOH_{(aq)} \longrightarrow Ca(OH)_{2(s)} + 2NaCl_{(aq)}$$

White ppt.

$$FeSO_{4(aq)} + 2NaOH_{(aq)} \longrightarrow Fe(OH)_{2(s)} + Na_2SO_{4(aq)}$$

Dirty Green ppt.

Q.2 Write down the uses of bases. ***(Knowledge Base)***

(LHR 2013, 2015, 2017, 2018, 2020, GRW 2014, 2015, BWP 2017 MTN 2017, DGK 2017, SWL 2016 G-I)

Ans: **USES OF BASES**

Following are the uses of some important bases:

Sodium Hydroxide (NaOH):

It is used for **manufacturing** of **soap**.

Calcium Hydroxide $Ca(OH)_2$:

It is used for manufacturing of **bleaching powder,** softening of hard water and **neutralizing acidic** soil and lakes due to acid rain.

Potassium Hydroxide (KOH):

It is used in alkaline batteries.

Magnesium Hydroxide $Mg(OH)_2$: **(LHR 2020)**

It is used as a base to **neutralize acidity in stomach.** It is also used for the **treatment of bee's stings.**

Aluminium Hydroxide $Al(OH)_3$:

It is used as foaming agent in **fire extinguishers.**

Ammonium Hydroxide (NH_4OH):

It is used to **remove grease** stains from clothes. **(BWP 2017)**

10.1.5 GENERAL PROPERTIES OF BASES
SHORT QUESTIONS

Q.1 What are the uses of magnesium hydroxide? *(Knowledge Base)* **(BWP 2016 G-I)**

Ans: **USES OF MAGNESIUM HYDROXIDE**

Magnesium hydroxide is used

- As a base to neutralize acidity in stomach
- For the treatment of bee's stings

Q.2 Write down four uses of bases. *(Knowledge Base)* **(LHR 2013) (GRW 2014,2015, MTN 2017)**

Ans: **USES OF BASES**

Bases are used for a number of purposes. The important uses of bases are:

- Potassium hydroxide is used in alkaline batteries and shaving creams.
- Magnesium hydroxide is used as a base to neutralize acidity in the stomach.
- Aluminum hydroxide is used as foaming agent in fire extinguishers.
- Ammonium Hydroxide (NH_4OH) is used to remove grease stains from clothes.

10.1.5 GENERAL PROPERTIES OF BASES
MULTIPLE CHOICE QUESTIONS

1. **$Fe(OH)_3$ is: *(K.B)***

(A) An acid (B) A base
(C) A salt (D) A non-metallic oxide

2. **It is used to treat bee's sting: *(K.B)***

(A) $Mg(OH)_2$ (B) $Ca(OH)_2$
(C) NaOH (D) KOH

3. **Which is found in alkaline batteries? *(K.B)*** **(SWL 2016 G-II)**

(A) $Mg(OH)_2$ (B) KOH
(C) NaOH (D) $Ca(OH)_2$

4. **Alkalies react with ammonium salts to liberate which gas? *(K.B)***

(A) Hydrogen (B) Sulphur dioxide
(C) Carbon dioxide (D) Ammonia

5. **Alkalies precipitate insoluble: *(K.B)***

(A) Oxides (B) Hydroxides
(C) Solvents (D) Salts

6. **Which is used as foaming agent in fire extinguishers. *(K.B)***

(A) Aluminium Hydroxide (B) Ammonium Hydroxide
(C) Potassium Hydroxide (D) Sodium Hydroxide

10.2 TEST YOURSELF

i. When acids react with carbonates and bicarbonates, which gas evolves out? *(Understanding + Application Base)*

Ans: *Answer given on Page # 56*

ii. Which types of salts produce SO_2 gas on reacting with acids? *(Understanding + Application Base)*

Ans: *Answer given on Page # 56*

iii. Give the uses of sulphuric acid. *(Knowledge Base)*

Ans: *Answer given on Page # 56*

iv. Write down the colours of the precipitates formed by reaction of aqueous caustic soda with solutions of copper, zinc and ferric salts. *(Knowledge Base)*

Ans: **<u>COLOURS OF PRECIPITATES</u>**

When caustic soda (NaOH) reacts with copper salt, it gives blue precipitate of cupric hydroxide.

$$CuSO_{4(aq)} + 2NaOH_{(aq)} \longrightarrow Cu(OH)_2 + Na_2SO_{4(aq)}$$

(Blue ppt.)

When caustic soda (NaOH) reacts with zinc salt, it gives white precipitate of zinc hydroxide.

$$ZnCl_2 + 2NaOH_{(aq)} \longrightarrow Zn(OH)_2 + 2NaCl_{(aq)}$$

(White ppt.)

When caustic soda (NaOH) reacts with ferric salt, it gives brown precipitate of ferric hydroxide.

$$FeCl_{3(aq)} + 3NaOH_{(aq)} \longrightarrow Fe(OH)_{3(s)} + 3NaCl_{(aq)}$$

(Brown ppt.)

v. Name an alkali used in alkaline batteries. *(Knowledge Base)*

Ans: **<u>ALKALI USED IN ALKALINE BATTERIES</u>**

Potassium hydroxide (KOH) is an alkali used in alkaline batteries.

Science, Technology and Society (STOMACH ACIDITY)

LONG QUESTION

Q.1 Write a detailed note on stomach acidity. ***(Knowledge Base)***

(Science, Technology and Society Pg. # 31)

Ans: **<u>STOMACH ACIDITY</u>**

<u>Definition:</u>

"Sometimes stomach produces too much acid. It causes stomach acidity also called hyperacidity."

<u>Composition of Stomach Secretions:</u>

Stomach secretes chemicals in a regular way to digest food. These chemicals mainly consist of hydrochloric acid along with other salts.

<u>Protection of Stomach from HCl:</u>

Although hydrochloric acid is highly corrosive, but stomach is protected from its effect because it is lined with cells that produce a base. The base neutralizes stomach acid.

Functions of Acid:

- The important function of this acid is to breakdown chemical bonds of foods in the digestion process. Thus big molecules of food are converted into small ones.
- It also kills the harmful bacteria of certain foods and drinks.

Symptoms of Hyperacidity:

- Feeling burning sensation throughout the gastro intestinal tract.
- The feelings of burning sensation sometimes extend towards the chest that is called heart burning.

Prevention of Hyperacidity:

The best prevention from hyperacidity is as follows:

- Avoiding over eating and staying away from the fatty acids and spicy foods.
- Simple and regular eating.
- Remaining in an upright position for 45 minutes after taking a meal
- Keeping the head elevated while sleeping.

Science, Technology and Society (STOMACH ACIDITY)

SHORT QUESTIONS

Q.1 How we can prevent hyperacidity? *(Knowledge Base)* **(SWL 2017)**

Ans: **PREVENTION OF HYPERACIDITY**

Hyperacidity can be prevented:

- Avoiding over eating and staying away from the fatty acids and spicy foods.
- Simple and regular eating.
- Remaining in an upright position for 45 minutes after taking a meal
- Keeping the head elevated while sleeping.

Q.2 What is hyperacidity? *(Knowledge Base)* **(DGK 2017)**

Ans: **HYPERACIDITY**

Definition:

"Sometimes stomach produces too much acid. It causes stomach acidity also called hyperacidity."

Symptoms of Hyperacidity:

- Feeling burning sensation throughout the gastro intestinal tract
- The feelings of burning sensation sometimes extend towards the chest that is called heart burning.

Q.3 Describe the process of etching in art and industry. *(Knowledge Base)*
(Science, Technology and Society Pg. # 32)

Ans: **ETCHING IN ART AND INDUSTRY**

The process of etching on glass is carried out by using a wax stencil.

Function Stencil:

Stencil is placed on areas of glass or mirror that are to be saved from acid.

Method of Etching:

Stencil is placed on the areas of glass or mirror. The glass or mirror is dipped into hydrofluoric acid. The acid dissolves the exposed part of the glass thus ething it.

Drawback:

This process has been very dangerous because the acid would damage the skin and tissues of artist's body.

Advantage:

Athough it is dangerous to deal with acid, yet etching done with acid is very attractive as compared to using other chemicals.

Science, Technology and Society (STOMACH ACIDITY)

MULTIPLE CHOICE QUESTIONS

1. **It is used in etching designs on copper plates:** ***(K.B)*** **(LHR 2013)**
   (A) Sulphuric acid (B) Acetic acid
   (C) Hydrochloric acid (D) Nitric acid
2. **In etching process, the glass or mirror is dipped into:** ***(K.B)***
   (A) Hydrochloric acid (B) Sulphuric acid
   (C) Nitric acid (D) Hydrofluoric acid
3. **Stomach acidity is also called:** ***(K.B)***
   (A) Acidity (B) Basicity
   (C) Hyperacidity (D) Hypoacidity

10.2 pH SCALE

LONG QUESTIONS

Q.1 What is autoionization of water? How it is used to establish the pH of water? ***(Knowledge + Understanding +Application Base)*** **(Ex-Q.3)**

OR

Write a note on pH scale.

Ans: **pH SCALE**

Definition:

"A logarithmic scale which is used to determine the pH of a solution is called pH scale". pH is the negative logarithm of molar concentration of the hydrogen ions".

Basis of pH Scale:

Concentration of hydrogen ions $[H^+]$ in pure water is the basis for pH scale.

pH:

"*pH is the **negative logarithm** of molar concentration of the **hydrogen ions**".*

$$pH = -\log [H^+]$$

Autoionization or Self Ionization:

*"Water is a **weak electrolyte** because it ionizes **very slightly** into ions in a process called autoionization or self ionization."*

DERIVATION OF DISSOCIATION CONSTANT OF WATER:

$$H_2O \rightleftharpoons H^+ + OH^-$$

The equilibrium expression of this reaction may be written as.

$$K_c = \frac{[H^+][OH^-]}{[H_2O]}$$

As concentration of water (H_2O) is almost constant the above equation may be written as,

$$K_c [H_2O] = [H^+][OH^-]$$

A new equilibrium constant known as ionic product constant of water 'K_w' is used instead of product of equilibrium constant and $[H_2O]$. Therefore,

$$K_w = [H^+][OH^-] = \mathbf{1.0 \times 10^{-14}\ at\ 25°C}$$

As we know, one molecule of water produces one H^+ ion and one OH^- ion on dissociation. Therefore,

$$[H^+] = [OH^-] \quad Or \Rightarrow \quad [H^+]^2 = [H^+][OH^-]$$

$$[H^+]^2 = (1.0 \times 10^{-14})^{1/2}$$

Taking square root on both sides

$$[H^+] = 1.0 \times 10^{-7}\ M \quad at\ 25°C$$

Thus in pure water

$$[H^+] = 1.0 \times 10^{-7}\ M$$

$$[OH^-] = 1.0 \times 10^{-7} M$$

<u>Conversion of Figures With Negative Exponents into Positive:</u>

As it is difficult to deal with such small figures having negative exponents, so it is convenient to convert these figures into a positive using a numerical system. It is taking the common (base-10) logarithm of the figure and multiplying it with –1.

<u>Meaning of 'p':</u>

'p' before a symbol means' negative logarithm of the symbol. So 'p' before H means negative logarithm of H^+.

Therefore, pH is the negative logarithm of molar concentration of the hydrogen ions. That is,

$$\mathbf{pH = -\log [H^+]}$$

<u>Range of pH Scale:</u>

With reference to above equation, a scale develops according to the molar concentration of H^+ ions that is called pH scale. It ranges from 0 to 14.

<u>To Prove That pH + pOH = 14:</u>

According to this scale, pH of water is calculated as:

$$\mathbf{pH = -\log [H^+]}$$

$$\mathbf{pH = -\log (1.0 \times 10^{-7}) = 7}$$

Similarly,

$$pOH = -\log [OH^-]$$

$$pOH = -\log (1.0 \times 10^{-7}) = 7$$

pH value normally varies from 0 to 14.

Therefore:

The sum of pH and pOH of the solution is always 14 at 25°C.

pH	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
pOH	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

<u>Identification of Acids and Bases by pH-Scale:</u>

pH scale can be used to identify the nature of solutions as acid and base. A solution of a compound of pH 7 or pOH 7 is considered a neutral solution. Solutions of pH less than 7 are acidic and more than 7 are basic.

<u>Conclusions:</u>

- pH of a neutral solution is always 7.
- Acidic solutions have pH less than 7.
- Basic solutions have pH value greater than 7.
- pH and pOH values range from 0 to 14.

	$[H_3O^+]$	pH	$[OH^-]$	pOH
	1×10^{-14}	14.0	1×10^{-0}	0.0
	1×10^{-13}	13.0	1×10^{-1}	1.0
	1×10^{-12}	12.0	1×10^{-2}	2.0
BASIC (More basic)	1×10^{-11}	11.0	1×10^{-3}	3.0
	1×10^{-10}	10.0	1×10^{-4}	4.0
	1×10^{-9}	9.0	1×10^{-5}	5.0
	1×10^{-8}	8.0	1×10^{-6}	6.0
NEUTRAL	1×10^{-7}	7.0	1×10^{-7}	7.0
	1×10^{-6}	6.0	1×10^{-8}	8.0
	1×10^{-5}	5.0	1×10^{-9}	9.0
	1×10^{-4}	4.0	1×10^{-10}	10.0
ACIDIC (More acidic)	1×10^{-3}	3.0	1×10^{-11}	11.0
	1×10^{-2}	2.0	1×10^{-12}	12.0
	1×10^{-1}	1.0	1×10^{-13}	13.0
	1×10^{-0}	0.0	1×10^{-14}	14.0

Figure: pH Scale Showing Relation Among $[H^+]$ and pH and pOH Scale Showing Relation Among $[OH^-]$ and pOH

10.2 pH SCALE

SHORT QUESTIONS

Q.1 What are uses of pH? *(Knowledge Base)* **(GRW 2017, SWL 2016 G-II, 17)**

Ans: **USES OF pH**

pH is used to:

- Determine acidic or basic nature of a solution.
- Produce medicines, culture at a microbiological particular concentration of H^+ ion.
- Prepare solutions of required concentrations necessary for certain biological reactions.

Q.2 What is pH scale? Give pH of pure water. *(Knowledge Base)* **(RWP 2016 G-II, 17)**

Ans: **pH SCALE**

Definition:

"A logarithmic scale which is used to determine the pH of a solution is called pH scale".

"pH is the negative logarithm of molar concentration of the hydrogen ions".

Basis of pH Scale:

Concentration of hydrogen ions $[H^+]$ in pure water is the basis for the pH scale.

pH of pure water:

pH of pure water is 7.

10.2 pH SCALE

MULTIPLE CHOICE QUESTIONS

1. Concentration of _________ in pure water is the basis for pH scale. ***(K.B)***
(A) Hydrogen ion (B) Sodium ion
(C) Potassium ion (D) Hydroxide ion

2. Water is:
(A) Weak electrolyte (B) Strong electrolyte
(C) Non-electrolyte (D) None of these

3. Water ionizes slightly into ions in a process called: ***(K.B)***
(A) Neutralization (B) Auto ionization
(C) Self ionization (D) Both B & C

4. "K_w" is known as: ***(K.B)***
(A) Equilibrium constant (B) Ionic product constant
(C) Specific rate constant (D) All of these

5. The negative logarithm of molar concentration of hydrogen ions is: ***(K.B)***
(A) pOH (B) p
(C) pH (D) None of these

6. The range of pH scale is from: ***(K.B)***
(A) 10-14 (B) 1-14
(C) 0-14 (D) 14-0

7. The sum of pH and pOH is always: ***(K.B)*** **(LHR 2014, GRW 2014, DGK 2016 G-II)**
(A) 14 at 26ºC (B) 14 at 25 ºC
(C) 13 at 25 ºC (D) 7 at 25 ºC

8. A solution of a compound of pH 7 or pOH 7 is considered a/an: ***(U.B)***
(A) Basic solution (B) Neutral solution
(C) Acidic solution (D) None of these

9. Solution of pH less than ________ is acidic. ***(K.B)*** **(RWP 2016 G-I)**
(A) 7 (B) 14
(C) 6 (D) 9

10. Solution of pH more than 7 is: ***(K.B)***
(A) Acidic (B) Neutral
(C) Basic (D) Strong acidic

11. pH =__________:***(K.B)***
(A) $-\log[OH^-]$ (B) $-\log[H^+]$
(C) $\log[H^+]$ (D) Both B & C

12. A solution of pH = 1 has _________ times higher concentration of H^+ than a solution of pH = 2: ***(U.B)***
(A) 14 times (B) 100 times
(C) 10 times (D) 20 times

13. pH of a neutral solution is always: ***(K.B)*** **(MTN 2017, SWL 2017)**
(A) 14 (B) 0
(C) 7 (D) 1

10.2.1 INDICATORS

LONG QUESTIONS

Q.1 Write a detailed note on the following. ***(Knowledge + Understanding Base)***

(LHR 2015, SGD 2014)

a. Indicators **b. Measuring pH of a solution**

Ans:

a. INDICATORS

Definition:

"The ***substances*** *which indicate the* ***completion of a chemical reaction*** *due to change in colour are called indicators".*

Properties of Indicators:

Indicators are the organic compounds. They have different colours in acidic and alkaline solutions.

Importance:

Indicators help in determining the acidic, basic and neutral nature of solutions.

Types of Indicators:

There are different types of indicators. Some of the indicators are given below:

(i) Litmus
(ii) Phenolphthalein
(iii) Methyl orange

(i) Litmus:

- Blue litmus turns red in acidic solution.
- Red litmus turns blue in alkaline solution.

(ii) Phenolphthalein:

- It is colourless in strongly acidic solution.
- It is red in strongly alkaline solution.
- It changes colour at pH about 9.
- Phenolphthalein is colourless in solution with pH less than 9.
- If the pH is above 9 then it gives pink colour.

(iii) Methyl Orange:

- It gives red colour at pH <4.
- It gives yellow colour from pH >4.

So, each indicator has a specific colour in acidic medium which changes at a specific pH to another colour in basic medium.

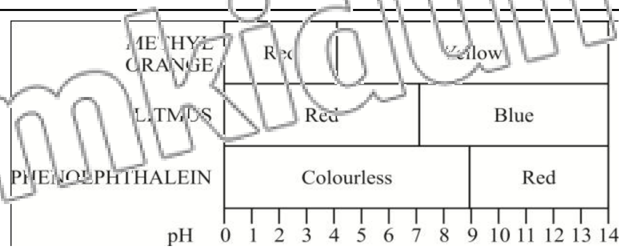


Figure: Colours of Indicators at Different pH Solutions

A few commonly used indicators in titrations are given in table 10.3.

Table: 10.3 Few Important Indicators

Indicator	Colour in Strongly Acidic Solution	pH at Which Colour Changes	Colour in Strongly Alkaline Solution
Methyl orange	Red	4	Yellow
Litmus	Red	7	Blue
Phenolphthalein	Colourless	9	Red

b. MEASURING pH OF A SOLUTION

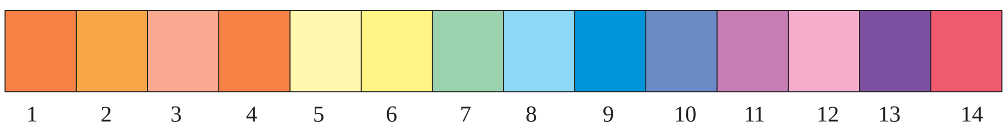
(i) Universal Indicator (pH indicator):

"The mixture of indicators which gives different colours at different pH values is called universal indicator or pH indicator".

It is used to measure the pH of a solution.

Procedure:

The pH of solution can be measured by dipping a piece of Universal Indicator paper in the solution. The pH is then found by comparing the colour obtained with a colour chart.



(ii) The pH Meter:

"A pH meter is an instrument which is used to measure the pH of a solution".

Construction:

It consists of a pH electrode connected to a meter.

Procedure:

The electrode is dipped into the solution and the meter shows the pH either on a scale or digitally.

Comparison with Universal Indicator:

It is much more reliable and accurate method of measuring pH than Universal Indicator paper, though the latter is often more convenient.

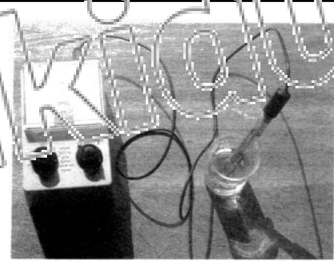


Figure: pH Meter

NUMERICAL EXAMPLE

PROBLEM 10.2 *(U.B+A.B)*

A solution of hydrochloric acid is 0.01M. What is its pH value?

Solution:

Given Data:

Molarity of HCl Solution = 0.01M

To Find:

pH of solution = ?

Calculations:

Hydrochloric acid is a strong acid so it ionizes completely that is:

$$HCl_{(aq)} \longrightarrow H^+_{(aq)} + Cl^-_{(aq)}.$$

So, its solution also contains 0.01M H^+ ions, i.e. 10^{-2} M.

$$pH = -\log\left[H^+\right]$$

By putting the values of H^+ ions in the above equation

$$pH = -\log 10^{-2}$$

$$pH = 2$$

Result:

Thus, pH of H_2SO_4 solution is 2.

PROBLEM 10.3 *(U.B+A.B)*

Find out the pH and pOH of 0.001M solution of KOH.

Solution:

Given Data:

Molarity of KOH solution = 0.001 M

To Find:

pH of solution = ?

pOH of solution = ?

Calculations:

Potassium hydroxide solution is a strong base. It ionizes completely such that one mole of KOH gives one mole of OH^- ions.

$$KOH_{(aq)} \longrightarrow K^+_{(aq)} + OH^-_{(aq)}$$

Therefore, 0.001 M or 10^{-3} M

$$\left[OH^-\right] = 10^{-3}\,M$$

$$pOH = -\log 10^{-3} = 3$$

$$pH = 14 - 3$$

$$pH = 11$$

$$pOH = 3$$

Result:

Thus pH and pOH of given solution are 11 and 3 respectively.

PROBLEM 10.4 *(U.B+A.B)*

Find the pH of 0.01M sulphuric acid.

Solution:

Given Data:

Sulphuric acid is a strong **dibasic acid**. It ionizes completely and its one mole produces 2 moles of hydrogen ions as presented in equation.

$$H_2SO_{4(eq)} \longrightarrow 2H^+_{(aq)} + SO_4^{2-}$$

Therefore; 0.01M sulphuric acid will produce $2 \times 0.01M$ hydrogen ions.

To Find:

pH of solution = ?

Calculations:

Hence hydrogen ions concentration is:

$$\left[H^+\right] = 2\times10^{-2}M$$

$$pH = -\log\left(2\times10^{-2}\right)$$

$$= -\left(\log2 + \log10^{-2}\right)$$

$$= -\log2 - \log10^{-2}$$

Where, $\left(-\log^{-2}10 = 2\right)$

Thus

$$pH = -\log2 + 2$$

$$= 2 - \log2$$

$$= 1.7$$

Result:

Thus pH of given solution is 1.7.

10.2.1 INDICATORS
SHORT QUESTIONS

Q.1 What are indicators? Write names of of any two indicators. ***(Knowledge Base)***
(DGK 2017, LHR 2015, RWP 2017)

Ans: *Answer given on Page # 68*

Q.2 What are universal indicators? ***(Knowledge Base)***

Ans: *Answer given on Page # 69*

Q.3 What are the areas of work for analytical chemists? ***(Knowledge Base)***
(Science and Technology Page#38)

Ans: **ANALYTICAL CHEMISTS**

Analytical chemist examines substances qualitatively and quantitatively.

Areas of work:

- They identify substances and evaluate their properties.
- They have a wide area for working ranging from basic research in laboratories to analytical research in industries.
- They work in almost all industries including manufacturing, pharmaceuticals, healthcare, forensics and public protection where they test air, water, industrial waste, drugs and food to make sure they are safe.
- They ensure the quality of the products in industry.

10.2.1 INDICATORS
MULTIPLE CHOICE QUESTIONS

1. **Indicators are:** ***(K.B)***
   (A) Inorganic compounds (B) Hydrocarbons
   (C) Organic compounds (D) Salts
2. **in acidic or basic solution indicators have colour:** ***(K.B)***
   (A) Same (B) Different
   (C) Light (D) Green
3. **It is a common indicator:** ***(K.B)***
   (A) Litmus (B) pH meter
   (C) pH scale (D) Both A and B
4. **In strong acidic solution litmus is:** ***(K.B)*** **(DGK 2017, BWP 2016 G-I)**
   (A) Blue (B) Normal
   (C) Red (D) Orange
5. **In strong alkaline solution litmus is:** ***(K.B)*** **(SGD 2016 G-II)**
   (A) Red (B) Blue
   (C) Yellow (D) Orange
6. **Colour of Phenolphthalein in acidic solution is:** ***(K.B)***
   (A) Red (B) Blue
   (C) Yellow (D) Colorless
7. **In alkaline solution methyl orange is:** ***(K.B)***
   (A) Red (B) Blue
   (C) Yellow (D) Orange

8. At which pH methyl orange changes color?

(A) 7 (B) 14
(C) 9 (D) 4

9. At which pH phenolphthalein changes color? *(K.B)*

(A) 7 (B) 4
(C) 9 (D) 0

10. pH meter consists of: *(K.B)*

(A) pH electrode (B) Positive electrode
(C) Negative electrode (D) None of these

11. It is much more reliable and accurate method of measuring pH: *(K.B)*

(A) Universal indicator (B) pH meter
(C) pH scale (D) Litmus

12. A solution of HCl is 0.001 M, what is its pH value? *(U.B)*

(A) 3 (B) 12
(C) 2 (D) 14

13. What is pOH value of 0.001 M solution of KOH? *(U.B)*

(A) 14 (B) 13
(C) 11 (D) 3

14. What is pH value of 0.01 M sulphuric acid? *(U.B)*

(A) 7.1 (B) 1.7
(C) 1.0 (D) 0.3

15. Ionic product constant depends on: *(K.B)*

(A) Temperature (B) Pressure
(C) Both (D) None of these

10.3 TEST YOURSELF

i. Why pure water is not a strong electrolyte? *(Understanding Base)*

(SGD 2016 G-II, RWP 2016 G-I)

Ans: **PURE WATER AS ELECTROLYTE**

Pure water is not a strong electrolyte because it ionizes very slightly into ions in a process called auto-ionization or self ionization.

$$H_2O \rightleftharpoons H^+ + OH^-$$

The concentration of ions is very small i.e.

$$[H^+] = [OH^-] = 1.0 \times 10^{-7} M.$$

ii. HCl and H_2SO_4 are strong acids. While their solutions are equimolar, they have different pH values as calculated in problem 10.2 and 10.4. Why they have different pH values? *(Understanding Base)*

Ans: **pH VALUES OF HCl AND H_2SO_4**

Equimolar solutions of HCl and H_2SO_4 have different pH values because when HCl ionized it produces one H^+ ion, it is monobasic acid.
While H_2SO_4 is dibasic acid it produces two H^+ ions.

$$HCl \longrightarrow H^+ + Cl^-$$

$$H_2SO_4 \rightleftharpoons 2H^+ + SO_4^{2-}$$

pH of HCl = – log $[H^+]$

pH of H_2SO_4 = – log $[2 \times H^+]$

iii. Why ionic-product constant of water is temperature dependent?

(Understanding Base)

Ans: **IONIC-PRODUCT CONSTANT OF WATER**

K_w is the ionic product constant of water.

$$K_w = [H^+][OH^-] = 1.0 \times 10^{-14} \text{ at } 25°C$$

Temperature dependence:

It is temperature dependent because it increases with the rise of temperature and vice versa.

iv. Differentiate between "p" and "pH". *(Understanding Base)*

Ans: **DIFFERENTIATION**

The difference between "p" and "pH" is as follows:

"p"	"pH"
"p" before the symbol means negative logarithm of the symbol. So 'p' before H means negative logarithm of H^+ (hydrogen ion).	pH is the negative logarithm of molar concentration of the hydrogen ions. pH = –log $[H^+]$

10.3 SALTS

10.3.1 PREPARATION OF SALTS

LONG QUESTIONS

Q.1 What are the salts? Write down characteristic properties of salt. *(Knowledge + Understanding Base)* **(Ex-Q.4)**

(GRW 2013, BWP 2017 DGK 2017, RWP 2017)

Ans: **SALTS**

Definition:

*"Salts are **ionic compounds** generally **formed** by the **neutralization** of an **acid** with a **base**".*

Composition of Salts:

$$HCl_{(aq)} + NaOH_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$$

Salts are made up of positive ions (cations) and negative ions (anions).

Basic Radical:

*"A **cation** is **metallic ion derived** from a **base**, therefore, it is called basic radical".*

Acid Radical:

*"An **anion** is **non-metallic ion derived** from **acid**, therefore, it is called acid radical".*

Salts are named from the name of the metal and the respective acid. **(SGD 2017)**

Nomenclature:

A salt gets its name from the name of the metal and the acid as shown in the following.

Metal	Acid	Salt Name
• **Sodium (Na)**	Hydrochloric acid (HCl)	Sodium Chloride (NaCl)
• **Potassium (K)**	Nitric Acid (HNO_3)	Potassium nitrate (KNO_3)
• **Zinc (Zn)**	Sulphuric acid (H_2SO_4)	Zinc sulphate ($ZnSO_4$)
• **Calcium (Ca)**	Phosphoric acid (H_3PO_4)	Calcium phosphate $Ca_3(PO_4)_2$
• **Silver (Ag)**	Acetic acid (CH_3COOH)	Silver acetate (CH_3COOAg)

Characteristic Properties of Salts: **(DGK 2016 G-I)**

The characteristic properties of salts are as follows:

Ionic Compounds:

Salts are ionic compounds found in crystalline form.

Melting and Boiling Points:

They have high melting and boiling points.

Water of Crystallization:

Most of the salts contain water of crystallization which is **responsible** for the **shape of the crystals**. The number of molecules of water is specific for each salt and they are written with the chemical formula of a salt.

Example:

Copper sulphate $\mathbf{CuSO_4.5H_2O}$; Calcium sulphate $\mathbf{CaSO_4.2H_2O}$ **(Gypsum)**

Neutral Compound: ***(Test Yourself 10.4 q iii)***

Salts are neutral compounds. Although, they **do not** compose of equal **number** of **positive** and **negative ions,** but have **equal number** of **positive** and **negative charges.**

$$NaCl \longrightarrow Na^{+} + Cl^{-}$$

$$CaCl_2 \longrightarrow Ca^{2+} + 2Cl^{-}$$

Q.2 Explain with examples that how soluble salts are prepared? Describe preparation of insoluble salts as well. ***(Understanding Base + Application Base)***

(Ex-Q.5) (SGD 2014, LHR 2021)

Ans:

PREPARATION OF SOLUBLE SALTS

Salts may be water soluble or insoluble. The methods used for the preparation of salts are based on their solubility in water.

General Methods for the Preparation of Salts:

There are five general methods for the preparation of salts. Four methods make soluble salts but one prepares insoluble salts.

(i) Preparation of Soluble Salts:

Soluble salts are often prepared in water. Therefore, they are **recovered** by **evaporation or crystallization.**

(a) By the Reaction of an Acid and a Metal (Direct Displacement Method):

This is direct displacement method in which hydrogen ion of acid is replaced by a reactive metal such as calcium, magnesium, zinc and iron

Examples:

$$\text{Acid} + \text{Metal} \longrightarrow \text{Salt} + \text{Hydrogen gas}$$

$$HCl_{(aq)} + Mg_{(s)} \longrightarrow MgCl_{2(aq)} + H_{2(g)}$$

(b) By the Reaction of An Acid And a Base (Neutralization Method):

It is a neutralization reaction in which acid and base react to produce a salt and water.

Example:

$$\text{Acid} + \text{Base} \longrightarrow \text{Salt} + \text{Water}$$

$$HCl_{(aq)} + NaOH_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$$

(c) By the Reaction of an Acid and Metallic Oxide:

Mostly the insoluble metallic oxides react with dilute acids to form salt and water.

$$\text{Acid} + \text{Metallic oxide} \longrightarrow \text{Salt} + \text{water}$$

$$H_2SO_{49aq)} + CuO_{(aq)} \longrightarrow CuSO_{4(aq)} + H_2O_{(aq)}$$

(d) By the Reaction of an Acid and a Carbonate:

Dilute acids react with metallic carbonates to produce salts, water and carbon dioxide gas.

$$2HNO_{3(aq)} + Na_2CO_{3(aq)} \longrightarrow NaNO_{3(aq)} + H_2O_{(l)} + CO_2 \uparrow_{(g)}$$

(ii) Preparation of Insoluble Salts:

In this method, usually **solutions of soluble salts** are mixed. During the reaction exchange of ionic radicals (i.e., metallic radicals exchange with acidic radicals) takes place to produce two new salts. **One of the salts is insoluble and the other is soluble.** The insoluble salt precipitates (solidify in solution).

$$AgNO_{3(aq)} + NaCl_{(aq)} \longrightarrow \mathbf{AgCl_{(s)}} + NaNO_{3(aq)}$$

$$Na_2CO_{3(aq)} + CuSO_{4(aq)} \longrightarrow Na_2SO_{4(aq)} + \mathbf{CuCO_{3(s)}}$$

10.3 SALTS

SHORT QUESTIONS

Q.1 Write names of any two methods for the preparation of salts. ***(Knowledge Base)*** **(LHR 2014)**

Ans: **PREPARATION OF SALTS**

Two important methods for the preparation of salts are as follows:

- Direct displacement method
- Neutralization method

Q.2 Complete and balance the equation. ***(Understanding Base)*** **(LHR 2013)**

$$Al + HCl \longrightarrow$$

Ans: **COMPLETE AND BALANCED EQUATION**

$$2Al_{(s)} + 6HCl_{(aq)} \longrightarrow 2AlCl_{3(s)} + 3H_{2(g)}$$

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10.3 SALTS

MULTIPLE CHOICE QUESTIONS

1. **Salts are: *(K.B)***
   (A) Organic compounds (B) Inorganic compounds
   (C) Ionic compounds (D) Polar compounds
2. **A cation is derived from: *(K.B)***
   (A) Acid (B) Base
   (C) Molecule (D) Compound
3. **Metallic oxides are: *(K.B)***
   (A) Bases (B) Acids
   (C) Salts (D) Organic compounds
4. **An anion is derived from: *(K.B)***
   (A) Acid (B) Base
   (C) Molecule (D) All of these
5. **When K reacts with HCl the salt produced is: *(K.B)***
   (A) KCl (B) NaOH
   (C) H_2O (D) NH_3
6. **Salts have: *(K.B)***
   (A) High M.P and low B.P (B) High M.P and B.P
   (C) Low M.P and low B.P (D) Low M.P and high B.P
7. **Copper sulphate has water of crystallization: *(K.B)***
   (A) 5 (B) 2
   (C) 6 (D) 24
8. **Calcium sulphate has water of crystallization: *(K.B)***
   (A) 5 (B) 2
   (C) 6 (D) 24
9. **Salts may be: *(K.B)***
   (A) Water soluble (B) Water insoluble
   (C) Both A and B (D) None of these
10. **Reaction of acid and a metal is called reaction: *(K.B)***
    (A) Partial displacement (B) Direct displacement
    (C) Incomplete displacement (D) All of these
11. **Mostly soluble metallic oxides form salt and water when they are treated with: *(K.B)***
    (A) Dilute acids (B) Concentrated acids
    (C) Dilute bases (D) None of these
12. **In preparation of insoluble salts which are mixed? *(K.B)***
    (A) Insoluble salts (B) Soluble salts
    (C) Insoluble and soluble salts (D) None of these
13. **When Mg reacts with HCl the salt produced is: *(K.B)***
    (A) $MgCl_2$ (B) NaOH
    (C) H_2O (D) NH_3
14. **Soluble salts are recovered by: *(K.B)***
    (A) Evaporation (B) Crystallization
    (C) Both 'A' and 'B' (D) Boiling
15. **There are _______ general methods for preparation of salts. *(K.B)***
    (A) 5 (B) 4
    (C) 3 (D) 2

10.4 TEST YOURSELF

i. How the salts are named? *(Understanding Base)*

Ans: **NOMENCLATURE OF SALTS**

A salt gets its name from the names of the metal and the acid from which they are made of.

Examples:

Metal	Acid	Salt Name
Sodium (Na)	Hydrochloric acid (HCl)	Sodium chloride (NaCl)
Potassium (K)	Nitric acid (HNO_3)	Potassium nitrate (KNO_3)

ii. Name the salts which are formed when Zn metal reacts with following acids.

(Understanding Base)

(A) Nitric acid (B) Phosphoric acid (C) Acetic acid

Ans: **NAMES OF SALTS**

$$\text{Zn + nitric acid} \longrightarrow \text{Zinc nitrate}$$

$$\text{Zn + phosphoric acid} \longrightarrow \text{Zinc phosphate}$$

$$\text{Zinc + acetic acid} \longrightarrow \text{Zinc acetate}$$

iii. How will you justify salts are neutral compounds? *(Understanding Base)*

Ans: *Answer given on page 74.*

iv. How many water of crystallization are present in $CuSO_4.5H_2O$ and $CaSO_4$. $2H_2O$?

(Understanding Base)

Ans: **WATER OF CRYSTALLIZATION**

In $CuSO_4.5H_2O$, there are 5 water molecules and in $CuSO_4.2H_2O$ there are 2 water molecules attached with $CuSO_4$ and $CaSO_4$, respectively as water of crystallization.

v. Name the type of reaction that takes place between an acid and a metal. Which gas would evolve in the reaction? Explain with an example. *(Understanding Base)*

Ans: **REACTION BETWEEN ACID AND METAL**

When acid reacts with metal, salt and hydrogen gas are produced. This type of reaction is called direct displacement reaction.

Representation:

$$\text{Acid + Metal} \longrightarrow \text{Salt + Hydrogen gas}$$

Gas Evolved:

The gas produced due to reaction between acid and metal will be hydrogen gas.

Example:

$$2HCl_{(aq)} + Mg_{(s)} \longrightarrow MgCl_{2(aq)} + H_{2(g)} \uparrow$$

10.3.2 TYPES OF SALTS

LONG QUESTIONS

Q.1 Name the classes of salts? Explain them with the help of examples.
(Knowledge + Understanding + Application Base) **(RWP 2017)**

Ans: **TYPES OF SALTS**

The main classes of salts are as follows:

(i) Normal salts
(ii) Basic salt
(iii) Mixed salts
(iv) Acidic salts
(v) Double salts
(vi) Complex salts

(i) Normal or Neutral Salts: **(LHR 2015)**

*"A salt formed by the **total replacement of ionizable H^+** ions of an acid by a **positive metal ion or NH_4^+** ions, is called normal or neutral salt".*

Examples:

$$HCl_{(aq)} + KOH \longrightarrow KCl + H_2O_{(l)}$$
$$H_2SO_4 + ZnO \longrightarrow ZnSO_4 + H_2O_{(l)}$$
$$H_3PO_4 + 3NaOH \longrightarrow Na_3PO_4 + 3H_2O_{(l)}$$
$$HNO_3 + NH_4OH \longrightarrow NH_4NO_3 + H_2O_{(l)}$$

Properties:

Normal salts are neutral to litmus and have no effect on blue or red litmus paper.

(ii) Acidic Salts: **(LHR 2015, 2016, MTN 2017)**

*"These salts are formed by **partial replacement of a replaceable H^+** ions of an acid, **by a positive metal ion".***

$$H_2SO_4 + KOH \longrightarrow KHSO_4 + H_2O$$
$$H_3PO_4 + NaOH \longrightarrow NaH_2PO_4 + H_2O$$

Properties:

Aqueous solutions of these salts turn blue litmus red.
Acidic salts react with bases to form normal salts.

$$KHSO_{4(aq)} + KOH_{(aq)} \longrightarrow K_2SO_{4(aq)} + H_2O_{(l)}$$
$$NaH_2PO_{4(aq)} + 2NaOH_{(aq)} \longrightarrow Na_3PO4_{(aq)} + 2H_2O_{(l)}$$

(iii) Basic Salts: **(LHR 2016, DGK 2016 G-II)**

*"Basic salts are formed by the **incomplete neutralization** of a **polyhydroxy base** by an **acid**".*

$$Al(OH)_3 + HCl \longrightarrow Al(OH)_2Cl + H_2O$$
$$Pb(OH)_2 + CH_3COOH \longrightarrow Pb(OH)CH_3COO + H_2O$$
$$Zn(OH)_2 + HNO_3 \longrightarrow Zn(OH)NO_3 + H_2O$$

Properties:

Aqueous solutions of these salts turn red litmus blue.

These salts further react with acids to form normal salts.

$$Al(OH)_2Cl + HCl \longrightarrow Al(OH)Cl_2 + HCl$$

$$Al(OH)Cl_2 + H_2O \longrightarrow AlCl_3 + H_2O$$

$$Pb(OH)CH_3COO + CH_3COOH \longrightarrow Pb(CH_3COO)_2 + H_2O$$

$$Zn(OH)NO_3 + H_2O \longrightarrow Zn(NO_3)_2 + HNO_3$$

(iv) Double Salts:

"Double salts are formed by ***two normal salts*** *when they are* ***crystallized*** *from a mixture of* ***equimolar saturated solutions****".*

Properties:

The individual salt components retain their properties. The anions and cations give their respective tests.

Examples:

- Mohr's salt $FeSO_4\cdot(NH_4)_2SO_4.6H_2O$
- Potash alum $K_2SO_4.Al_2(SO_4)_3.24H_2O$
- Ferric alum $K_2SO_4\cdot Fe_2(SO_4)_3\cdot 24H_2O$

(v) Mixed Salts:

"Mixed salts contain more than one basic or acid radicals".

Example:

- Bleaching powder $Ca(OCl)Cl$

(vi) Complex Salts:

"Complex salts on dissociation provide a ***simple cation and a complex anion*** *or vice versa".*

Only the simple ions yield the characteristic test for cation or anion.

Example:

- Potassium ferrocyanide $K_4[Fe(CN)_6]$ gives on ionization, a simple cation (K^+) and complex anion $[Fe(CN)_6]^{-4}$.

10.3.2 TYPES OF SALTS

SHORT QUESTIONS

Q.1 What are normal salts? *(Knowledge Base)* **(GRW 2017, MTN 2016 G-II, 17)**

Ans: **NORMAL OR NEUTRAL SALTS**

"A salt formed by the total replacement of ionizable H^+ ions of an acid by a positive metal ion or NH_4^+ ions, is called normal or neutral salt".

Examples:

$$HCl_{(aq)} + KOH \longrightarrow KCl + H_2O_{(l)}$$

$$H_2SO_4 + ZnO \longrightarrow ZnSO_4 + H_2O_{(l)}$$

Q.2 Define acidic salts? Write one chemical equation of their reaction with bases. *(Understanding Base)*

(GRW 2015) (LHR 2015)

Ans: **ACIDIC SALTS**

These salts are formed by partial replacement of H^+ ions of an acid by a positive metal ion.

Examples:

- Potassium hydrogen sulphate : $KHSO_4$
- Sodium hydrogen sulphate : $NaHSO_4$

Chemical Equation:

Acidic salts react with bases to form normal salts.

$$KHSO_{4(aq)} + KOH_{(aq)} \rightarrow K_2SO_{4(aq)} + H_2O_{(l)}$$

Q.3 Define double salts. Give two examples. *(Knowledge Base)* **(GRW 2013)**

Ans: **DOUBLE SALTS**

Definition:

"Double salts are formed by two normal salts when they are crystallized from a mixture of equimolar saturated solutions."

Examples:

- Mohr's salt $FeSO_4.(NH_4)_2SO_4.6H_2O$
- Potash Alum $K_2SO_4.A\ell_2(SO_4)_3.24H_2O$

Q.4 Give formulas of potash alum and ferric alum. *(Knowledge Base)* **(SWL 2017)**

Ans: **FORMULAS OF SALTS**

The formulas of potash alum and ferric alum are as follows:

- Potash alum $K_2SO_4.Al_2(SO_4)_3.24H_2O$
- Ferric alum $K_2SO_4 \cdot Fe_2(SO_4)_3 \cdot 24H_2O$

Q.5 Name any four types of slats. *(Knowledge Base)* **(SWL 2016 G-I)**

Ans: **FOUR TYPES OF SALTS**

Following are the four types of salts:

(i) Normal salts

(ii) Basic salt

(iii) Mixed salts

(iv) Acidic salts

10.3.2 TYPES OF SALTS

MULTIPLE CHOICE QUESTIONS

1. $HCl + KOH \longrightarrow KCl + H_2O$ is an example of: *(U.B)*

(A) Neutral salt (B) Acidic salt

(C) Basic salt (D) Complex salt

2. $H_3PO_4 + 2NaOH \longrightarrow Na_2HPO_4 + 2H_2O$ is an example of: *(U.B)*

(A) Acidic salt (B) Basic salt

(C) Double salt (D) Normal salt

3. Which litmus turns into red in acidic salts? *(K.B)*
(A) Blue (B) Orange
(C) Yellow (D) Green

4. $FeSO_4.(NH_4)_2\ SO_4.6H_2O$ is: *(K.B)*
(A) Mohr's salt (B) Potash alum
(C) Ferric alum (D) Chrome alum

5. Double salts are formed by two: *(K.B)*
(A) Acidic salts (B) Neutral salts
(C) Basic salts (D) Mixed salts

6. The formula of bleaching powder is: *(K.B)*
(A) CaCl (B) Ca(OCl)Cl
(C) $CaCl_2$ (D) Ca(OCl)

7. Washing soda has water of crystallization: *(K.B)*
(A) 24 (B) 6
(C) 5 (D) 10

8. There are how many types of salts? *(K.B)*
(A) 4 (B) 6
(C) 5 (D) 7

9. $HBr + KOH \longrightarrow KBr + H_2O$ is an example of formation of: *(K.B)*
(A) Neutral salt (B) Acidic salt
(C) Basic salt (D) Complex salt

10. Which litmus turn into blue in basic salts? *(K.B)*
(A) Blue (B) Orange
(C) Yellow (D) Red

11. $K_2SO_4.Fe_2(SO_4)_3.24H_2O$ is: *(K.B)*
(A) Mohr's salt (B) Potash alum
(C) Ferric alum (D) Chrome alum

12. A neutral salt is not composed of: *(K.B)* **(GRW 2015)**
(A) A metallic cation (B) Non-metallic anion
(C) An anion of a base (D) An anion of an acid

13. Which one of the following is acidic salt? *(K.B)* **(LHR 2016)**
(A) $KHSO_4$ (B) $Al(OH)_2Cl$
(C) NaCl (D) Ca(OCl)Cl

14. Bleaching powder is an example of: *(K.B)* **(MTN 2017)**
(A) Mixed Salt (B) Acidic Salt
(C) Double Salt (D) None of these

15. Ca(OCl)Cl is an example of: *(K.B)* **(FSD 2017 G-I)**
(A) Normal salts (B) Double salts
(C) Mixed salts (D) Complex salts

10.3.3 USES OF SALTS

LONG QUESTIONS

Q.1 Write down the uses of salts. ***(Knowledge Base)***

Ans:

USES OF SALTS

Salts have vast applications in industries and in our daily life. Some common salts and their uses are given below:

Name of Salts	Common and Industrial Uses
Sodium chloride (NaCl) (GRW 2017)	It is commonly used as a table salt and for **cooking purposes**. It is also used for **de-icing roads** in winter and for the **manufacture of sodium metal**, caustic soda, washing soda.
Sodium carbonate(Na_2CO_3) Soda ash	It is used for the manufacture of glass, detergents, pulp, paper and other chemicals.
Sodium carbonate ($Na_2CO_3.10H_2O$) Washing soda	It is used as cleaning agent for domestic and commercial purposes, for **softening of water**, in **manufacture** of chemicals like **caustic soda (NaOH),** borax, glass, soap and paper.
Sodium sulphate (Na_2SO_4)	It is used for the manufacture of glass, paper and detergents
Sodium silicate (Na_2SiO_3)	It is used for the manufacture of detergents, cleaning agents and adhesives.
Sodium chlorate ($NaClO_3$)	It is used for manufacture of explosives, plastics and other chemicals.
Sodium tetraborate ($Na_2B_4O_7.10H_2O$)	It is used for manufacture of **heat resistance glass (pyrex),** glazes and enamels, in leather industry for soaking and cleaning hides.
Calcium chloride ($CaCl_2$)	It is used for **de-icing roads in winter**, as a **drying agent of chemical reagents** and as freezing agent.
Calcium oxide (CaO) Quick lime	It is used as drying agent for gases and alcohol and in steel making, after treatment and other chemicals like slaked lime, bleaching powder, calcium carbide. **Soda Lime:** For purification of sugar, a mixture of CaO and NaOH called soda lime is used to remove carbon dioxide and water vapours from air.
Calcium sulphate ($CaSO_4.2H_2O$)	**Gypsum** is used as fertilizer, to **prepare plaster of Paris** which is used for making statues, casts, etc.
Potassium Nitrate (KNO_3)	It is used as fertilizer and for the manufacture of flint glass.

Q.2 What are neutralization reactions? *(Knowledge Base)* **(RWP 2016 G-I, 2017)**

Ans: **NEUTRALIZATION REACITONS**

Definition:

*"A reaction between an **acid** and a **base** is called a **neutralization** reaction. It produces a **salt and water**."*

Examples:

A few balanced chemical reactions are given here:

$$\text{Acid} + \text{Base} \longrightarrow \text{Salt} + \text{Water}$$

$$HCl_{(aq)} + NaOH_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$$

$$H_2SO_{4(aq)} + 2NaOH_{(aq)} \longrightarrow Na_2SO_{4(aq)} + 2H_2O_{(l)}$$

$$CH_3COOH_{(aq)} + NaOH_{(aq)} \longrightarrow CH_3COONa_{(aq)} + H_2O_{(l)}$$

10.3.3 USES OF SALTS

SHORT QUESTIONS

Q.1 What are uses of calcium sulphate? *(Knowledge Base)* **(RWP 2017)**

Ans: **USES OF CALCIUM SULPHATE**

Calcium sulphate (Gypsum) is used:

- As fertilizer
- To prepare Plaster of Paris which is used for making statues, casts, etc.

Q.2 What are uses of washing soda? *(Knowledge Base)*

Ans: **USES OF WASHING SODA**

Washing soda ($Na_2CO_3.10H_2O$) also called sodium carbonate is used:

- As cleaning agent for domestic and commercial purposes
- For softening of water
- In manufacture of chemicals like caustic soda (NaOH), borax, glass, soap and paper.

Q.3 Write down the use of sodium chlorate ($NaClO_3$). *(Knowledge Base)* **(LHR 2014)**

Ans: **USES OF SODIUM CHLORATE**

It is used for manufacture of:

- Explosives
- Plastics and other chemicals.

Q.4 Give the uses of calcium chloride ($CaCl_2$). *(Knowledge Base)* **(GRW 2013)**

Ans: **USES OF CALCIUM CHLORIDE**

It is used:

- For de-icing roads in winter
- As a drying agent of chemical reagents
- As freezing agent

Q.5 Write uses of CaO. *(Knowledge Base)* **(SWL 2017, RWP 2017, SGD 2017)**

Ans: **USES OF CaO**

The four uses of CaO are as follows:

(i) As drying agent for gases and alcohol

(ii) In steel making, after treatment and other chemicals like slaked lime, bleaching powder, calcium carbide.

(iii) For preparation of bleaching powder

Q.6 Write down the use of sodium chloride. ***(Knowledge Base)*** **(SGD, 2016 G-I)**

Ans:

USES OF SODIUM CHLORIDE

It is commonly used:

- As a table salt and for cooking purposes
- It is also used for de-icing roads in winter
- For the manufacture of sodium metal, caustic soda, washing soda.

Q.7 How acid rain is formed? Give effects of acid rain. ***(Knowledge Base)***

(Science and Technology Page#44)

Ans:

FORMATION OF ACID RAIN

Acid rain is formed by dissoving acidic air pollutants like oxides of sulphur and nitrogen by rain water.

Effects:

- pH of the rain water decreases and it becomes too acidic.
- When this acid rain falls down, it damages animals, plants, buildings, water bodies and even soil.

10.3.3 USES OF SALTS

MULTIPLE CHOICE QUESTIONS

1. Which salt is used to dry the gas: ***(K.B)*** **(LHR 2014, 2015, BWP 2017)**

(A) $CaCl_2$ (B) NaCl
(C) CaO (D) Na_2SiO_3

2. Gypsum is also known as: ***(K.B)***

(A) Calcium carbonate (B) Calcium chloride
(C) Calcium sulphate (D) Calcium bi-carbonate

3. $Na_2CO_3.10H_2O$ is called: ***(K.B)***

(A) Baking soda (B) Washing soda
(C) Detergent (D) Soda ash

4. Na_2CO_3 is called: ***(K.B)***

(A) Baking soda (B) Washing soda
(C) Detergent (D) Soda ash

5. It is used as fertilizer and for the manufacture of flint glass: ***(K.B)***

(A) Potassium nitrate (B) Sodium silicate
(C) Calcium chloride (D) Soda ash

6. A reacton between an acid and a base is called: ***(K.B)***

(A) Displacement (B) Decomposition
(C) Hydrolysis (D) Neutralization

7. Soda lime is a mixture of: ***(K.B)***

(A) $CaCl_2$, KOH (B) NaOH, CaO
(C) NaCl, CaO (D) $Ca(OH)_2$, CaO

10.5 TEST YOURSELF

i. Name the types of salts. ***(Knowledge Base)*** **(DGK 2016 G-I)**

Ans: **TYPES OF SALTS**

Following are the main types of salts:

- Normal salts
- Basic salt
- Mixed salts
- Acidic salts
- Double salts
- Complex salts

ii. H_3PO_4 is a weak acid but its salt (Na_3PO_4) with strong base NaOH is neutral. Explain it. ***(Understanding Base)***

Ans: **NEUTRAL SALT OF H_3PO_4**

Three moles of strong base (NaOH) release 3 OH^- ions that neutralize acid H_3PO_4. So neutral salt is obtained.

$$\underset{(\text{weak acid})}{H_3PO_{4(aq)}} + \underset{(\text{strong base})}{3NaOH_{(aq)}} \longrightarrow \underset{(\text{Neutral salt})}{Na_3PO_{4(aq)}} + \underset{(\text{water})}{3H_2O_{(l)}}$$

iii. How the basic salts turn into normal salts? Explain with an example. ***(Understanding Base)***

Ans: **BASIC SALTS FORM NORMAL SALTS**

Basic salts turn into normal salt by the removal of OH group when they are treated with acid.

Example:

$$\underset{(\text{Basic salt})}{Zn(OH)NO_3} + \underset{(\text{Acid})}{HNO_3} \longrightarrow \underset{(\text{Normal salt})}{Zn(NO_3)_2} + \underset{(\text{Water})}{H_2O}$$

iv. What are complex salts? ***(Knowledge Base)*** **(SGD 2017)**

Ans: **COMPLEX SALTS**

Definition:

"*Complex salts on dissociation produce a simple cation and a complex anion or visa versa.*"

These are the simple ions which give characteristic test for cation or anion.

Example:

Potassium ferrocyanide, $K_4[Fe(CN)_6]$ gives on ionization, a simple cation (K^+) and complex anion $(Fe(CN)_6]^{-4}$.

v. Na_2SO_4 is a neutral salt. What are its uses? ***(Knowledge.Base)***

Ans: **USES OF Na_2SO_4**

Na_2SO_4 is used for the manufacture of:

- Glass
- Paper
- Detergents

Science, Technology and Society (PRESERVATIVES IN FOOD)

LONG QUESTIONS

Q.1 What are preservatives? Why preservatives are used in food? *(Knowledge Base)*

(Science, Technology and Society Pg. # 44)

Ans: **FOOD PRESERVATIVES**

*"Those chemicals which are used to **prevent food spoilage** are called preservatives."*

Cause of Food Spoilage:

Food spoiling may be due to **microbial actions** or chemical reactions.

Principle of preservatives:

Preservatives serve as **anti-microbial or antioxidants.**

Uses:

The important uses of preservatives are as follows:

- Manufacturers add preservatives to prevent spoilage during transportation and storage of foods for a long period of time.
- Natural food preservatives efficiently control the growth of bacteria in food. They are used to preserve meat and fish. Natural preservatives include salts, sugar, alcohol, vinegar.

Science, Technology and Society (PRESERVATIVES IN FOOD

SHORT QUESTIONS

Q.1 Why tears, perspiration and blood taste salty? *(Knowledge Base)*

(Interesting Information Pg. # 43)

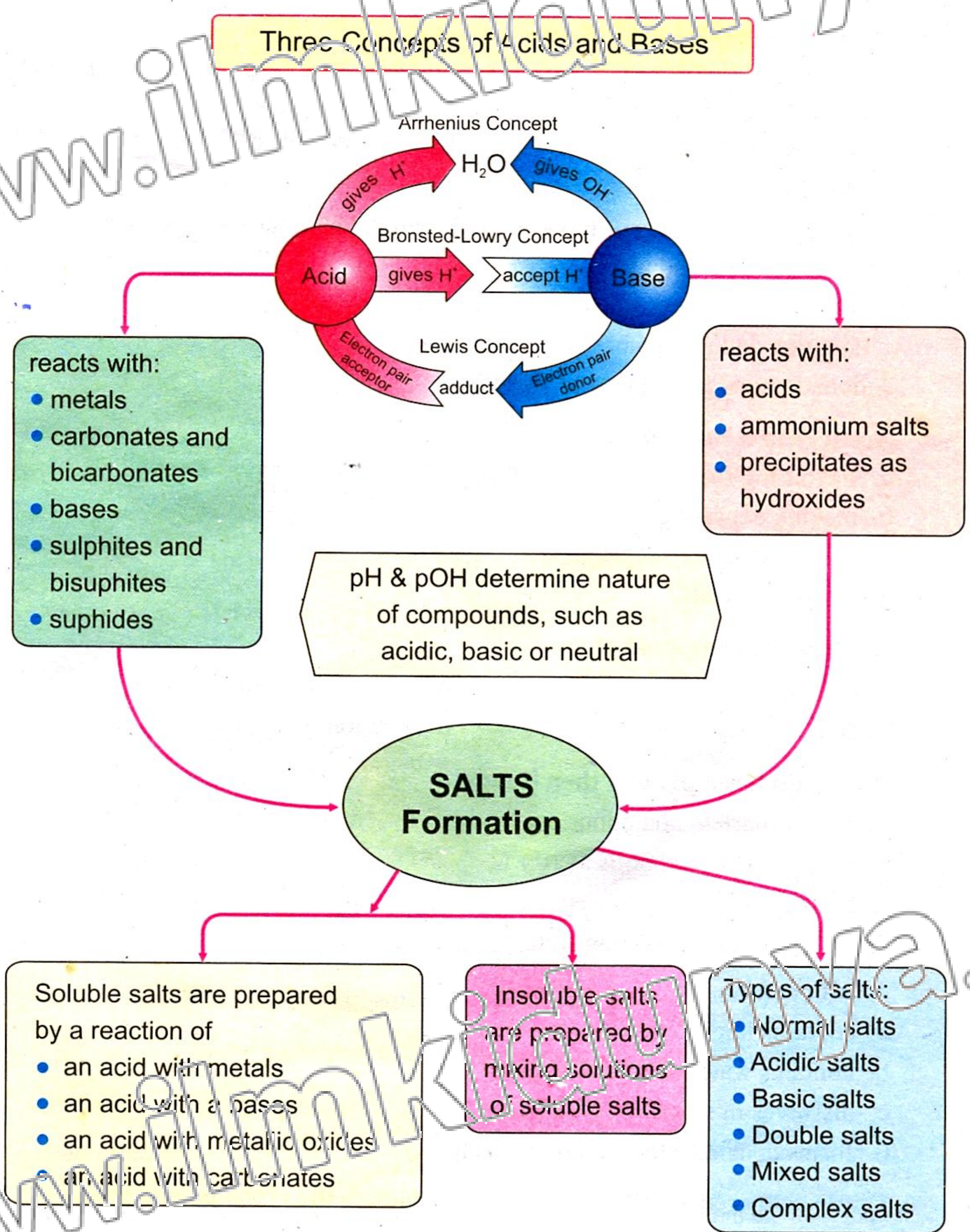
Ans: **TASTE OF TEARS, PERSPIRATION AND BLOOD**

There are many kinds of salt solutions inside our body, which come from the food we eat as a result of chemical reactions. So, tears, perspiration and blood are salty because they contain slat in solution.

MULTIPLE CHOICE QUESTIONS

1. **The substances used to preserve food are called: *(K.B)***
   (A) Preservatives (B) Oxidants
   (C) Microbial (D) Degradative
2. **Natural food preservatives added to food efficiently control the growth of: *(K.B)***
   (A) Bacteria (B) Plants
   (C) Algae (D) Vertebrates
3. **Tears, perspiration and blood taste salty because of: *(K.B)***
   (A) Hydrochloric acid (B) Sodium chloride and other salts
   (C) Sulphuric acid (D) Sugar
4. **Which pollutants decrease the pH of rain water? *(K.B)***
   (A) Basic oxides (B) Normal oxides
   (C) Acidic oxides (D) None of these
5. **Preservatives serve as: *(K.B)***
   (A) Oxidants (B) Anti-oxidants
   (C) Anti-microbial (D) Both B and C

CONCEPT DIAGRAM



ANSWER KEY

MULTIPLE CHOICE QUESTIONS

INTRODUCTION

1	B	6	C
2	D	7	C
3	B	8	C
4	C		
5	B		

10.1.1 ARRHENIUS CONCEPT OF ACIDS AND BASES

1	D	6	A
2	B	7	B
3	A		
4	A		
5	C		

10.1.2 BRONSTED LOWRY CONCEPT

1	D	6	A
2	A	7	A
3	A	8	A
4	D	9	C
5	A	10	B

10.1.3 LEWIS CONCEPT OF ACIDS AND BASES

1	B	6	B
2	A	7	A
3	C	8	B
4	B	9	B
5	D	10	A

10.1.4 GENERAL PROPERTIES OF ACIDS

1	C	6	D	11	C
2	D	7	A	12	A
3	A	8	C	13	D
4	D	9	D	14	B
5	A	10	A		

10.1.5 GENERAL PROPERTIES OF BASES

1	B	6	A
2	A		
3	B		
4	D		
5	B		

STOMACH ACIDITY

1	D
2	D
3	C

10.2 pH SCALE

1	A	6	C	11	B
2	A	7	B	12	C
3	D	8	B	13	C
4	B	9	A		
5	C	10	C		

10.2.1 INDICATORS

1	C	6	D	11	B
2	B	7	C	12	A
3	A	8	D	13	D
4	C	9	C	14	B
5	B	10	A	15	A

10.3 SALTS

10.3.1 PREPARATION OF SALTS

1	C	6	A	11	A
2	B	7	A	12	B
3	A	8	B	13	A
4	A	9	C	14	C
5	A	10	B	15	A

10.3.2 TYPES OF SALTS

1	A	6	B	11	C
2	B	7	D	12	C
3	A	8	C	13	A
4	A	9	A	14	A
5	B	10	D	15	C

10.3.3 USES OF SALTS

1	C	6	D
2	C	7	B
3	B		
4	D		
5	A		

PRESERVATIVES IN FOOD

1	A
2	A
3	B
4	C
5	D

EXERCISE SOLUTION

MULTIPLE CHOICE QUESTIONS

1. **A base is a substance which neutralizes an acid. Which of these substances is not a base? *(K.B)*** **(GRW 2013, RWP 2017, mtn 2016 G-I)**
   (a) Aqueous ammonia (b) Sodium chloride
   (c) Sodium carbonate (d) Calcium oxide

2. **Lewis acid-base concept has the following characteristics except: *(K.B)***
   (a) Formation of an adduct (b) Formation of a co-ordinate covalent bond
   (c) Donation and acceptance of an electron pair (d) Donation and acceptance of a proton

3. **Acetic acid is used for: *(K.B)*** **(RWP 2016 G-I, 17, FSD 2016 G-I, BWP 2016 G-I)**
   (a) Flavouring food (b) Making explosive
   (c) Etching designs (d) Cleaning metals

4. **A salt is not composed of: *(K.B)***
   (a) A metallic cation (b) Non-metallic anion
   (c) An anion of a base (d) An anion of an acid

5. **If a liquid has a pH of 7 then it must:** **(RWP 2016 G-II, GRW 2015)**
   (a) Be a colourless and odourless liquid (b) Freeze at 0^oC and boil at 100^oC
   (c) Be neutral (d) Be a solution containing water

6. **A salt always: *(K.B)***
   (a) Contains ions (b) Contains water of crystallization
   (c) Dissolves in water (d) Forms crystals which conduct electricity

7. **Dilute acids react with carbonates to produce the given products except: *(K.B)*** **(LHR 2013, GRW 2013, DGK 2017, MTN 2016 G-II)**
   (a) Salt (b) Water
   (c) Carbon dioxide (d) Hydrogen

8. **In the preparation of insoluble salts, which one of the facts is incorrect? *(U.B)***
   (a) Two soluble salts are mixed (b) Two soluble salts are produced
   (c) One of the salts produced is insoluble (d) Both of the salts produced are insoluble

9. **A reaction between an acid and base produces: *(K.B)*(SGD 2014, RWP 2017, FSD 2017 G-I)**
   (a) Salt and water (b) Salt and gas
   (c) Salt and an acid (d) Salt and a base

10. **The conjugate acid of HPO_4^{-2} is: *(U.B)*** **(LHR 2015,2017)**
   (a) PO_4 (b) H_2PO^-
   (c) $H_2PO_4^-$ (d) H_3PO_4

11. **What is the pOH of 0.02 M $Ca(OH)_2$? *(U.B)*** **(GRW 2014)**
   (a) 1.698 (b) 1.397
   (c) 12.31 (d) 12.61

12. **Which one of the following species is not amphoteric? *(U.B)*** **(LHR 2013, FSD 2016 G-II)**
   (a) H_2O (b) NH_3

(c) HCO_3^- (d) SO_4^{2-}

13. The product of Lewis acid-base reaction is called adduct. The bond between the adduct specie is: *(K.B)*

(a) Ionic (b) Covalent
(c) Metallic (d) Coordinate covalent

14. The water of crystallization is responsible for the: *(K.B)*

(a) Melting points of crystals (b) Boiling points of crystals
(c) Shapes of crystals (d) Transition point of crystals

15. You want to dry a gas which one of the following salt you will use: *(K.B)*
(LHR 2013, 14, 15, BWP 2016 G-I, 17, FSD 2017 G-II, SWL 2016 G-I, MTN 2016 G-I, DGK 2016 G-I)

(a) $CaCl_2$ (b) NaCl
(c) CaO (d) Na_2SiO_3

16. Ferric hydroxide $Fe(OH)_3$ is precipitated out of solution when aqueous sodium hydroxide solution is added to ferric chloride ($FeCl_3$): *(K.B)*

$$FeCl_{3\,(aq)} + 3NaOH_{(aq)} \longrightarrow Fe(OH)_{3(s)} + 3NaCl_{(aq)}$$

Colour of the precipitate is:

(a) Green (b) Blue
(c) Dirty green (d) Brown

17. Which ion is the conjugate base of sulphuric acid? *(K.B)*
(LHR 2014, BWP 2016 G-I, 2017, SWL 2016 G-I, II)

(a) SO_3^{-2} (b) S^{-2}
(c) HSO_3^{-1} (d) HSO_4^{-1}

18. Which one of the following is a Lewis base? *(K.B)*
(GRW 2014, LHR 2015, SGD 2014, 16 G-I RWP 2017, SWL 2016 G-II, FSD 2017 G-II)

(a) NH_3 (b) BF_3
(c) H^+ (d) $AlCl_3$

19. According to the Lewis concept, acid is a substance which can: *(K.B)* (LHR 2014)

(a) Donate a proton (b) Donate a pair of electron
(c) Accept a proton (d) Accept a pair of electron

20. Given $K_c = [H^+][OH^-] = 1.0 \times 10^{-14}$ at 25°C. What is the concentration of H^+ in pure water at 25°C? *(K.B)* **(SGD 2017)**

(a) 1×10^{-7} mol dm^{-3} (b) 1×10^{7} mol dm^{-3}
(c) 1×10^{-14} mol dm^{-3} (d) 1×10^{14} mol dm^{-3}

ANSWER KEY

1	b	6	a	11	b	16	d
2	d	7	d	12	d	17	d
3	a	8	b	13	d	18	a
4	c	9	a	14	c	19	d
5	c	10	c	15	c	20	a

EXERCISE SHORT QUESTIONS

1. Name three common household substances having *(Knowledge Base)*
(a) pH value greater than
(b) pH value less than 7
(c) pH value equal to 7

Ans: **COMMON HOUSEHOLD SUBSTANCES**

(a) pH Value Greater Than 7:
White wash, soap, shampoo, detergent etc

(b) pH Value Less Than 7:
Vinegar, citrus fruits, butter, apple etc

(c) pH Value Equal to 7:
Water, sodium chloride, sugar etc

2. Define a base and explain all alkalies are bases, but all bases are not alkalies. ***(Understanding Base)***

Ans: **BASE**

Definition:
***"**A base is a substance that can **release OH⁻** ions in **aqueous solution**, **accepts a proton** or **donates an electron pair** is called base".*

Examples:
- Sodium hydroxide : NaOH
- Potassium hydroxide : KOH

All Alkalies are Bases but All Bases are not Alkalies:
Water soluble base is called an alkali but some bases are not soluble in water, so all alkalies are bases but all bases are not alkalies.

3. Define Bronsted-Lowry base and explain with an example that water is a Bronsted Lowry base. *(Knowledge Base)* **(SGD 2017, FSD 2017)**

Ans: **BRONSTED-LOWRY BASE**

Definition:
***"**Bronsted Lowry base is a substance that can accept a proton (H^+) from another substance".*

Water as Bronsted-Lowry Base:
When HCl dissolves in water HCl acts as an acid and H_2O as a base because it takes proton from HCl. In this reaction water is a base.

$$HCl_{(aq)} + H_2O_{(aq)} \rightleftharpoons H_3O^+_{(aq)} + Cl^-_{(aq)}$$

4. How can you justify that Bronsted-Lowry concept of acid and base is applicable to non-aqueous solutions? *(Application Base)*

Ans: **APPLICATION OF BRONSTED-LOWRY CONCEPT**

According to Bronsted-Lowry concept

Acids:
"An acid is a substance that can donate a proton (H^+)".

Base:
"A base is substance that can accept a proton (H^+)".

This concept does not require an aqueous medium for an acid and base to ionize. This concept requires only two substances. One acts as an acid and the other acts as a base. It means an acid and base work together to transfer a proton.

$$HCl_{(aq)} + NH_{3(aq)} \rightarrow NH^+_{4(aq)} + Cl^-_{(aq)}$$

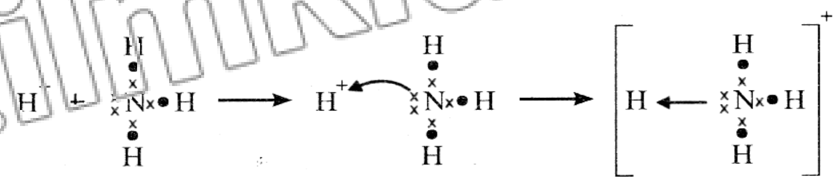
5. Which kind of a bond forms between a Lewis acid and a base? ***(Understanding Base)***

Ans: **KIND OF BOND**

Coordinate covalent bond is formed between Lewis acid and base to form an adduct.

In this case **Lewis base donates an electron pair** and **Lewis acid accepts** that **electron pair.**

Example:

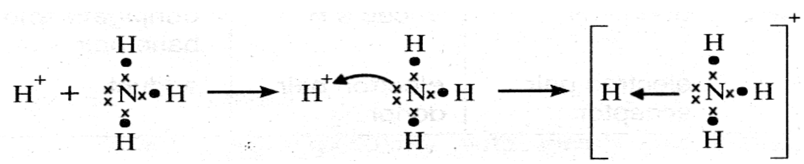


Lewis acid Lewis base Adduct

6. Why H^+ ion acts as a Lewis acid? ***(Understanding Base)*** **(SGD 2017, MTN 2016 G-II)**

Ans: **H^+ ION ACTS AS A LEWIS ACID**

H^+ ion acts as a Lewis acid because it has an **empty orbital** that can accommodate a **pair of electron.**



Lewis acid Lewis base Adduct

7. Name two acids used in the manufacture of fertilizers. ***(Knowledge Base)***

(FSD 2016 G-II, SGD 2016 G-I)

Ans: **ACIDS TO MANUFACTURE OF FERTILIZERS**

Acids used in the manufacture of fertilizers are:

(i) Nitric acid HNO_3

(ii) Sulphuric acid H_2SO_4

8. Define pH. What is the pH of pure water? ***(Knowledge Base)***

(LHR 2013, BWP 2017, SGD 2017, FSD 2017, MTN 2016 G-I, II)

Ans: **pH**

Definition:

"pH is the ***negative logarithm*** *of* ***molar concentration*** *of the* ***hydrogen ions****".*

Mathematically,

$$pH = -\log[H^+]$$

pH of Pure Water:

The pH of pure water is 7

9. How many times a solution of pH = 1 will be stronger than that of a solution having pH = 2? ***(Understanding Base)*** **(LHR 2013)**

Ans: **STRENGTH OF SOLUTION**

A solution of pH = 1 will be stronger than that of a solution having pH = 2 because the pH scale is logarithmic. A solution of pH = 1 has 10 times higher concentration of $[H^+]$ than that of a solution of pH =2.

10. Define the following: ***(Knowledge Base)*** **(LHR 2013)**

i. Normal salt ii. Basic salt

Ans: **DEFINITIONS**

(i) Normal Salt:

"A salt formed by the ***total replacement of ionizable H⁺*** *ions of an acid by a* ***positive metal ion or*** NH_4^+ *ion is called normal or neutral salt".*

These salts have no effect on litmus paper.

Example:

$$HCl_{aq} + KOH_{aq} \longrightarrow KCl_{aq} + H_2O$$

Acid Base Salt Water

(ii) Basic Salt:

"*A salt formed by the* ***incomplete neutralization*** *of a* ***polyhydroxy base*** *by an* ***acid.****"*

Example:

$$Al(OH)_{3(aq)} + HCl_{aq} \longrightarrow Al(OH)_2Cl_{(aq)} + H_2O$$

Base Acid Salt Water

11. Na_2SO_4 is a neutral salt while $NaHSO_4$ is an acid salt. Justify. ***(Understanding Base)***

Ans: **NEUTRAL SALT AND ACIDIC SALT**

Justification:

Na_2SO_4 is a neutral salt because it is formed by complete replacement of H^+ ions from an acid while $NaHSO_4$ is an acidic salt because it has one H^+ ion and is formed by the partial replacement of H^+ ions from an acid.

12. Give a few characteristic properties of salts. ***(Knowledge Base)***

(BWP 2016 G-II, DGK 2016 G-I)

Ans: **PROPERTIES OF SALTS**

The characteristic properties of salts are as follows:

Ionic Compounds:

Salts are ionic compounds found in crystalline form.

Melting and Boiling Points:

They have high melting and boiling points.

Water of Crystallization:

Most of the salts contain water of crystallization which is **responsible for the shape of the crystals**. The number of molecules of water is specific for each salt and they are written with the chemical formula of a salt.

Example:

Copper sulphate $CuSO_4.5H_2O$; Calcium sulphate $CaSO_4.2H_2O$

13. How the soluble salts are recovered from water? ***(Understanding Base)***

Ans: **RECOVERY OF SOLUBLE SALTS**

The soluble salts are **recovered** from water by **evaporation** and **crystallization.** When salt solution is evaporated, water vaporizes leaving behind salt.

14. How the insoluble salts are prepared? *(Knowledge Base)*
(SGD 2017, FSD 2016 G-II, BWP 2016 G-I)

Ans: **PREPARATION OF INSOLUBLE SALTS**

Insoluble slats are prepared by mixing **solutions of soluble salts**. During reaction exchange of ionic radicals takes place to produce **two new salts**. One of the salt is insoluble and other is soluble. The insoluble salt precipitates (solidifies in solution).

Example:

$$AgNO_{3(aq)} + NaCl_{(aq)} \longrightarrow \mathbf{AgCl_{(s)}} + NaNO_{3(aq)}$$

15. Why a salt is neutral, explain with an example? *(Understanding Base)* (FSD 2016 G-I)

Ans: **SALT IS NEUTRAL**

Salts are neutral compounds although they do not contain equal member of positive and negative ions but they have positive and negative charges e.g.

$$NaCl \longrightarrow Na^{+} + Cl^{-}$$

$$CaCl_2 \longrightarrow Ca^{2+} + 2Cl^{-}$$

16. Name an acid used in the preservation of food. *(Knowledge Base)* (SGD 2017, FSD 2016 G-I)

Ans: **ACID TO PRESERVE FOOD**

These are the acids used in preservation of food.

- Benzoic acid is used for food preservation
- Acetic acid is also used for preservation of food i.e. in pickles.

17. Name the acids present in: *(Knowledge Base)* (FSD 2017, SGD 2017 G-I)

i. Vinegar ii. Ant sting iii. Citrus fruit iv. Sour milk

Ans: **SOURCES OF ACIDS**

Following are the sources of acids:

Sr.No.	Source	Acid
(i)	Vinegar	Acetic acid
(ii)	Ant sting	Formic acid
(iii)	Citrus fruit	Citric acid
(iv)	Sour milk	Lactic acid

18. How can you justify that $Pb(OH)NO_3$ is a basic salt? *(Application Base)* (SGD 2016 G-1)

Ans: **$Pb(OH)NO_3$ IS A BASIC SALT**

$Pb(OH)NO_3$ is a basic slat because it is formed by the incomplete neutralization of a polyhydroxy base by an acid and it contains replaceable OH^{-1} ions.

Examples:

$$Pb(OH)_{2(aq)} + HNO_{3(aq)} \longrightarrow Pb(OH)NO_3 + H_2O$$

$$Pb(OH)NO_3 + HNO_3 \longrightarrow Pb(NO_3)_2 + H_2O$$

19. You are in a need of an acidic salt. How can you prepare it? *(Application Base)*

Ans: **PREPARATION OF AN ACIDIC SALT**

An acidic salt is formed by partial replacement of replaceable H^{+} ions of an acid by a positive metal ion.

Examples:

$$H_2SO_{4(aq)} + KOH_{(aq)} \longrightarrow KHSO_{4(aq)} + H_2O_{(l)}$$

$$H_3PO_{4(aq)} + NaOH_{(aq)} \longrightarrow NaH_2PO_{4(aq)} + H_2O_{(l)}$$

20. Which salt is used to prepare Plaster of Paris? *(Knowledge Base)*
(SGD 2016 G-II, 17, FSD 2016 G-I, 17)

Ans: **SALT USED FOR PLASTER OF PARIS**

Calcium sulphate or gypsum ($CaSO_4.2H_2O$) is used to prepare plaster of paris.

EXERCISE LONG QUESTIONS

Q.1 Define an acid and a base according to Bronsted-Lowry concept and justify with examples that water is an amphoteric compound.

Ans: See the LQ.1 (Topic 10.1.2)

Q.2 Explain the Lewis concept of acids and bases

Ans: See the LQ.1 (Topic 10.1.3)

Q.3 What is auto-ionization of water? How is it used to establish the pH of water?

Ans: See the LQ.1 (Topic 10.2)

Q.4 Define a salt and give the characteristic properties of salts.

Ans: See the LQ.1 (Topic 10.3)

Q.5 Explain with examples that how soluble salts are prepared?

Ans: See the LQ.2 (Topic 10.3.1)

Q.6 Give the characteristics of an acidic salt.

Ans: See the LQ.1 (Topic 10.3.2)

Q.7 Give four uses of calcium oxide.

Ans: See the SQ.1 (Topic 10.3.3)

Q.8 You are having a strong acid (HNO_3) and strong base (NaOH) on mixing

a. What type of salt you will have?

b. What type of this reaction will be?

c. Will it be soluble or insoluble?

d. If it is soluble, how it will be recovered?

Ans: **a.** When strong acid (HNO_3) and strong base (NaOH) react together normal or neutral slat is formed.

$$HNO_3 + NaOH \longrightarrow NaNO_3 + H_2O$$

b. This reaction will be neutralization reaction.

c. It will be a soluble salt.

d. This salt can be recovered by evaporation and crystallization process.

Q.9 Explain why:

a. HCl forms only one series of salts.

b. H_2SO_4 from two series of salts.

c. H_3PO_4 form three series of slats.

Give necessary equations.

Ans: **a.** HCl forms only one series of salts because it contains one ionizeable hydrogen ion.

$$HCl_{(aq)} \longrightarrow H^+_{(aq)} + Cl^-$$

$$HCl_{(aq)} + NaOH_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$$

b. H_2SO_4 forms two series of salts because it contains two ionizeable hydrogen ions.

$$H_2SO_{4(aq)} \longrightarrow H^+_{(aq)} + HSO^-_{4(aq)}$$

$$HSO^-_{4(aq)} \longrightarrow H^+_{(aq)} + SO^{-2}_{4(aq)}$$

<u>**Examples:**</u>

$$KOH_{(aq)} + H_2SO_{4(aq)} \longrightarrow KHSO_{4(aq)} + H_2O_{(l)}$$

$$KHSO_{4(aq)} + KOH_{(aq)} \longrightarrow K_2SO_{4(aq)} + H_2O_{(l)}$$

c. HCl forms only one series of salts because it contains one ionizeable hydrogen ion.

$$H_2PO_{4(aq)} \longrightarrow H^+_{(aq)} + H_2PO^-_{4(aq)}$$

$$H_2PO^-_{4(aq)} \longrightarrow H^+_{(aq)} + HPO^{-2}_{4(aq)}$$
$$HPO^{-2}_{4(aq)} \longrightarrow H^+_{(aq)} + PO^{-3}_{4(aq)}$$

Examples:

$$NaOH_{(aq)} + H_3PO_{4(aq)} \longrightarrow NaH_2PO_{4(aq)} + H_2O_{(l)}$$
$$NaH_2PO_{4(aq)} + NaOH_{(aq)} \longrightarrow Na_2HPO_{4(aq)} + H_2O_{(l)}$$
$$Na_2HPO_{4(aq)} + NaOH_{(aq)} \longrightarrow Na_3PO_{4(aq)} + H_2O_{(aq)} + H_2O_{(l)}$$

Q.10 Classify the following salts as soluble or insoluble salts:
(i) Sodium chloride (ii) Silver nitrate (iii) Lead chloride (iv) Copper sulphate
(v) Barium sulphate (vi) Ammonium chloride
(vii) Sodium carbonate (viii) Calcium carbonate
(ix) Ferric chloride (x) Magnesium sulphate

Ans:

Sr. No.	Name of Salt	Solubility in Water
(i)	Sodium chloride	Soluble
(ii)	Silver nitrate	Soluble
(iii)	Lead chloride	Insoluble
(iv)	Copper sulphate	Soluble
(v)	Barium sulphate	Insoluble
(vi)	Ammonium chloride	Soluble
(vii)	Sodium carbonate	Soluble
(viii)	Calcium carbonate	Insoluble
(ix)	Ferric chloride	Soluble
(x)	Magnesium sulphate	Soluble

Q.11 Complete and balance the following equations:

- **Aluminium + Hydrochloric acid. $\longrightarrow$ Aluminium chloride + Hydrogen gas**
- **Copper oxide + Sulphuric acid. $\longrightarrow$ Copper sulphate + water**
- **Iron sulphide + Sulphuric acid. $\longrightarrow$ Iron sulphate + hydrogen sulphide**
- **Ammonium chloride + Sodium hydroxide. $\longrightarrow$ Sodium chloride + water + ammonia gas**
- **Ferric chloride + Sodium hydroxide. $\longrightarrow$ Ferric hydroxide + sodium chloride**

Ans:

- Aluminium + Hydrochloric acid. $\longrightarrow$ Aluminium chloride + Hydrogen gas
  $2Al + 2HCl \longrightarrow 2AlCl_3 + H_2\uparrow$
- Copper oxide + Sulphuric acid $\longrightarrow$ Copper sulphate + water
  $CuO + H_2SO_4 \longrightarrow CuSO_4 + H_2O$
- Iron sulphide + Sulphuric acid $\longrightarrow$ Iron sulphate + hydrogen sulphide
  $FeS + H_2SO_4 \longrightarrow FeSO_4 + H_2S\uparrow$
- Ammonium chloride + Sodium hydroxide $\longrightarrow$ Sodium chloride + water + ammonia gas
  $NH_4Cl + NaOH \longrightarrow NaCl + NH_3\uparrow + H_2O$
- Ferric chloride + Sodium hydroxide $\longrightarrow$ Ferric hydroxide + sodium chloride
  $FeCl_{3(aq)} + 3NaOH_{(aq)} \longrightarrow Fe(OH)_3 + 3NaCl_{(aq)}$

EXERCISE NUMERICALS

(i) Calculate the pH and pOH of 0.2 M H_2SO_4.

Solution:

Given Data:

Molarity of H_2SO_4 solution = 0.2M

To Find:

pH of H_2SO_4 solution = ?

pOH of H_2SO_4 solution = ?

Calculations:

Ionization of H_2SO_4 in aqueous solution is as:

$$H_2SO_{4(aq)} \longrightarrow 2H^+_{(aq)} + SO^{-2}_{4\,(aq)}$$

1M 2M 2M

Therefore, 0.2 M sulphuric acid will produce 2× 0.02 M hydrogen ions.

Hence molar concentration of H^+ ions,

$= [H^+]$

$= 2\times0.2$ M

$= 2\times 2 \times 10^{-1}$M

$= 4\times10^{-1}$M

To find pH

$pH = -\log [H^+]$

$= -\log 4\times10^{-1}$

$= -\log 4 + \log 10^{-1}$

$= -\log 4 - \log^{-1} 10$

$= -\log 4+1$

$= 1-0.602$

pH = 0.398

To find pOH

pH + pOH = 14

pOH = 14 – PH

= 14 – 0.398

pOH = 13.602

Result:

Thus pH and pOH of solution are 0.398 and 13.602 respectively.

(ii) Calculate the pH of 0.1 M KOH?

Solution:

Given Data:

Molarity of KOH solution = 0.1M

To find:

pH = ?

Calculations:

Ionization of KOH in aqueous solution is as follows.

$$KOH \longrightarrow K^+ + OH^{-1}$$

1M 1M 1M

Concentration of KOH = 0.1M

Concentration of OH^{-1} = 0.1M

$= 1\times10^{-1}$M

In case of alkali or base first we have to calculate pOH of solution and then we calculate pH of solution.

$pOH = -\log [OH^-]$

$= -\log 1\times 10^{-1}(0.1)$

$= -\log 10^{-1}$

$pOH = -(-1) \log 10$

pOH = 1

To find pH

pH + pOH = 14

pH = 14 – pOH

pH = 14 – 1

pH = 13

Result:

Thus pH of solution is 13.

(iii) Calculate the pOH of 0.004 M HNO_3

Solution:

Given Data:

Molarity of HNO_3 solution = 0.004M

To find:

pOH = ?

Calculations:

Ionization of HNO_3 in aqueous solution is as follows:

$$HNO_3 \longrightarrow H^+ + NO_3^{-1}$$

1M 1M 1M

Therefore, 0.004 M HNO_3 will produce 1×0.004M H^+ ions.

$[HNO_3]$ = 0.004 M

$= 4 \times 10^{-3}$ M

$[H^+]$ = 0.004M or

$= 4 \times 10^{-3}$ M

In case of an acid first we have to calculate the pH of solution.

$pH = -\log [H^+]$

$= -\log [4 \times 10^{-3}]$

$= -(\log 4 + \log 10^{-3})$

$= -\log 4 - \log 10^{-3}$

$= -\log 4 + 3 \log^{10}$

$= -\log 4 + 3$

$= 3 - \log 4$

$= 3 - 0.602$

pH = 2.398

To find pOH

pH + pOH= 14

pOH = 14 – PH

= 14 – 2.398

pOH = 11.602

Result:

Thus pOH of solution is 11.602.

(iv) Complete the following table.

Sr. No	Solution concentration	$[H^+]$	$[OH^-]$	pH	pOH
(i)	0.15 M HI	——	——	——	——
(ii)	0.040 M KOH	——	——	——	——
(iii)	0.020 M $Ba(OH)_2$	——	——	——	——
(iv)	0.00030 M $HClO_4$	——	——	——	——
(v)	0.55 M NaOH	——	——	——	——
(vi)	0.055 M HCl	——	——	——	——
(vii)	0.055 M $Ca(OH)_2$	——	——	——	——

Ans:

(i) 0.15 M HI:

Solution:

Given Data:

Molarity of HI solution = 0.15M

To find:

$[H^+]$ = ?

pH = ?

pOH = ?

Calculations:

Ionization of HI in aqueous solution as follows.

$$HI \longrightarrow H^+ + I^-$$

1M 1M 1M

Hydrogen iodide produce one H+ ion.

To find $[H^+]$

$[H^+]$ = 0.15M

$= 15 \times 10^{-2}$M

To find pH

$pH = -\log [H^+]$

$= -\log [15 \times 10^{-2}]$

$= -(\log 15 + \log 10^{-2})$

$= -\log 15 - \log 10^{-2}$

$= -\log 15 + 2 \log 10$

$= \log 15 + 2$

$= 2 - \log 15$

pH = 2 – 1.18

pH = 0.82

To find pOH

pH + pOH = 14

pOH = 14 – POH

= 14 – 0.82

pOH = 13.12

Result:

Thus $[H^+]$ is 15×10^{-2}M and its pH and pOH values are 0.82 and 13.12, respectively.

(ii) <u>0.040 M KOH</u>

<u>Solution:</u>

<u>Given Data:</u>

Molarity of KOH solution = 0.040M

<u>To find:</u>

$[H^+]$ = ?

$[OH^-]$ = ?

pH = ?

pOH = ?

<u>Calculations:</u>

Ionization of KOH in aqueous solution is as follows.

$$\begin{array}{ccccc} KOH & \rightarrow & K^+ & + & OH^- \\ 1M & & 1M & & 1M \end{array}$$

Therefore 0.040 M KOH produces $1 \times 0.040M\ OH^-$ ions

To find $[OH^{-1}]$

$[KOH] = 0.040M$

$[OH^{-1}] = 0.040M$ or 4.0×10^{-2} M

To find pOH

$pOH = -\log [OH^-]$

$= -\log [4 \times 10^{-2}]$

$= -(\log 4 + \log 10^{-2})$

$= -\log 4 - \log 10^{-2}$

$= -\log 4 + 2$

$2 - \log 4$

$pOH = 2 - 0.602$

$pOH = 1.40$

To find pH

$pH + pOH = 14$

$pH = 14 - pOH$

$= 14 - 1.40$

$pH = 12.60$

<u>Result:</u>

Thus $[OH^{-1}]$ 0.040M or 4.0×10^{-2} M and its pH and pOH values are 12.60 and 1.40, respectively.

(iii) <u>0.020 M $Ba(OH)_2$:</u>

<u>Solution:</u>

<u>Given Data:</u>

Molarity of $Ba(OH)_2$ solution = 0.020M

<u>To find:</u>

$[OH^-]$ = ?

pH = ?

pOH = ?

<u>Calculations:</u>

Ionization of $Ba(OH)_2$ in aqueous solution is as follows.

$$Ba(OH)_2 \rightarrow Ba^{2+} + OH^-$$

Therefore 0.020 M $Ba(OH)_2$ produces $1 \times 0.020M\ OH^-$ ions.

To find $[OH^-]$

$[Ba(OH)_2] = 0.020$ M

$[OH^-] = 2 \times 2.0 \times 10^{-2}$

$= 4 \times 10^{-2}$

To find pOH

$pOH = -\log [OH^-]$

$= -\log [4 \times 10^{-2}]$

$= -(\log 4 + \log 10^{-2})$

$= -\log 4 - \log 10^{-2}$

$= -\log 4 + 2$

$= 2 - \log 4$

$pOH = 2 - 0.602$

$pOH = 1.40$

To find pH

$pH + pOH = 14$

$pH = 14 - pOH$

$= 14 - 1.40$

$pH = 12.60$

<u>Result:</u>

Thus $[OH^{-1}]$ is 4×10^{-2} M and its pH and pOH values are 12.60 and 1.40, respectively.

(iv) $0.00030\ M\ HClO_4$:

Solution:

Given Data:

Molarity of $HClO_4$ solution = 0.00030M

To find:

$[H^+]$ = ?

pH = ?

pOH = ?

Calculations:

Ionization of $HClO_4$ in aqueous solution is as follows.

$$HClO_4 \rightarrow H^+ + ClO_4^-$$

1M 1M 1M

Therefore 0.00030 M $HClO_4$ produces $1 \times 0.00030M\ H^+$ ions

To find $[H^+]$

$[H^+]$ = 0.00030 M

$= 3 \times 10^{-4}$ M

To find pOH

$pH = -\log [H^+]$

$= -\log [3 \times 10^{-4}]$

$= -(\log 3 + \log 10^{-4})$

$= -\log 3 - \log 10^{-4}$

$= -\log 3 + 4 \log 10$

$= \log 3 + 4$

$= 4 - 0.4771$

pH = 3.5229

To find pOH

pH + pOH = 14

pOH = 14 – pH

pOH = 14 – 3.5229

pOH = 10.4771

Result:

Thus $[H^+]$ is 0.00030 M or 3×10^{-4} M and its pH and pOH values are 3.5229 and 10.4771, respectively.

(v) 0.55 M NaOH:

Solution:

Given Data:

Molarity of NaOH solution = 0.55M

To find:

$[OH^-]$ = ?

pH = ?

pOH = ?

Calculations:

Ionization of NaOH in aqueous solution is as follows.

$$NaOH \rightarrow Na^+ + OH^-$$

Therefore 0.55 M NaOH produces 0.55 M OH^- ions

To find $[OH^-]$

$[OH^-]$ = 0.55 M

$OH^- = 0.55 \times 10^{-2}$

To find pOH

$pOH = -\log [OH^-]$

$= -\log [55 \times 10^{-2}]$

$= -(\log 55 + \log 10^{-2})$

$= -\log 55 - \log 10^{-2}$

$= -\log 55 + 2$

$= 2 - \log 55$

pOH = 2 – 1.74

pOH = 0.26

To find pH

pH + pOH = 14

pH = 14 – pOH

= 14 – .26

pH = 13.74

Result:

Thus $[OH^-]$ of solution is 0.55×10^{-2} M and its pH and pOH values are 13.74 and 0.26, respectively.

(vi) 0.055 M HCl:

Solution:

Given Data:

Molarity of HCl solution = 0.055M

Fo Find:

$[H^+]$ = ?

pH = ?

pOH = ?

Calculations:

Ionization of HCl in aqueous solution is as follows.

$$\underset{1M}{HCl} \rightarrow \underset{1M}{H^+} + \underset{1M}{Cl^-}$$

Therefore 0.055 M HCl produces 0.055 M H^+ ions

Hydrochloric acid produces one H+ ion.

To find $[H^+]$

$[H^+] = 0.055$ M

$= 5.5 \times 10^{-2}$ M

To find pH

$pH = -\log [H^+]$

$= -\log [5.5 \times 10^{-2}]$

$= -(\log 5.5 + \log 10^{-2})$

$= -\log 5.5 - \log 10^{-2}$

$= -\log 5.5 + 2 \log 10$

$= \log 5.5 + 2$

$= 2 - 0.74$

$pH = 1.26$

$pH = 1.26$

To find pOH

$pH + pOH = 14$

$pOH = 14 - pH$

$pOH = 14 - 1.26$

$pOH = 12.74$

Result:

Thus $[OH^-]$ of solution is 0.55×10^{-2} M and its pH and pOH values are 1.26 and 12.74, respectively.

(vii) 0.055M $Ca(OH)_2$:

Solution:

Given Data:

Molarity of $Ca(OH)_2$ solution = 0.055M

To find:

$[OH^-]$ = ?

pH = ?

pOH = ?

Calculations:

Ionization of $Ca(OH)_2$ in aqueous solution is as follows.

$$Ca(OH)_2 \rightarrow Ca^{2+} + OH^-$$

Therefore 0.055 M $Ca(OH)_2$ produces 0.055 M OH^- ions

To find $[OH^-]$

$[Ca(OH)_2] = 0.055$ M

$[OH^-] = 2 \times 5.5 \times 10^{-2}$

$= 11 \times 10^{-2}$ M

To find pOH

$pOH = -\log [OH^-]$

$= -\log (11 \times 10^{-2})$

$= -(\log 11 + \log 10^{-2})$

$= -\log 11 - \log 10^{-2}$

$= -\log 11 + 2$

$= 2 - \log 11$

$pOH = 2 - 1.04$

$pOH = 0.96$

To find pH

$pH + pOH = 14$

$pH = 14 - pOH$

$= 14 - 0.96$

$pH = 13.04$

Result:

Thus $[OH^-]$ of solution is 11×10^{-2} and its pH and pOH values are 13.04 and 0.96, respectively.

ADDITIONAL CONCEPTUAL QUESTIONS

Q.1 Why it is preferable to use pH meter over universal indicator?

Ans: **Preference to pH meter**

Althrough universal indicator is often more convenient preference is given to pH meter because it is much more reliable and accurate method of measuring pH. The pH meter consists of pH electrode connected to meter which shows pH either on scale or digitally when dipped into the solution and give precise value.

Q.2 Why HCl can make only one type of salt whereas H_2SO_4 can make two series of salts?

Ans: **HCl vs H_2SO_4**

HCl is a **monobasic acid** i.e it has only one replaceable H^+ ion, therefore it gives only one type of salt.

$$HCl \rightleftharpoons H^+ + Cl^-$$

For example. $$HCl + KOH \rightarrow H_2O + KCl$$

Conversely, H_2SO_4 is **dibasic acid** i.e. it has two replaceable H^+ ions. It dissocates in two stages.

$$(i)\ H_2SO_{4(aq)} \rightleftharpoons H^+ + HSO_4^-$$

$$(ii)\ HSO^-_{4(aq)} \rightleftharpoons H^+ + SO_4^{-2}$$

Hence, it gives two series of salts.

Example: $$H_2SO_{4(aq)} + KOH_{(aq)} \rightarrow KHSO_4 + H_2O$$

(Acidic salt)

$$KHSO_{4(aq)} + KOH_{(aq)} \rightarrow K_2SO_{4(aq)} + H_2O$$

(Normal salt)

Q.3 Why NaOH can make only one type of salt whereas $Al(OH)_3$ can make three series of salts?

Ans: **NaOH vs $Al(OH)_3$**

NaOH has only "1" replaceable hydroxide ion (OH^-) which results in formation of one type of salt.

$$NaOH \rightleftharpoons Na^+ + OH^-$$

Eg. $$NaOH + HCl \rightarrow NaCl + H_2O$$

Conversely, $Al(OH)_3$ is a polyhydroxy base. It has 3 replaceable OH^- ions. It dissociates as follows:

$$Al(OH)_3 \rightleftharpoons Al^{+3} + 3OH^-$$

Therefore, it gives three series of salts.

$$Al(OH)_3 + HCl \rightarrow Al(OH)_2Cl + H_2O$$

Basic Salt

$$Al(OH)_2Cl + HCl \rightarrow Al(OH)Cl_2 + H_2O$$

Basic Salt

$$Al(OH)Cl_2 + HCl \rightarrow AlCl_3 + H_2O$$

Normal Salt

Q.4 Why the precipate of same heavy metal give different colours?

Ans: Heavy metals are transition elements. There hydroxides give different colours of precipitates at **different oxidation states**.

E.g

$$FeSO_{4(aq)} + 2NaOH_{(aq)} \rightarrow Na_2SO_{4(aq)} + Fe(OH)_{2(s)}$$

Dirty green ppt.

$$FeCl_{3(aq)} + 3NaOH_{(aq)} \rightarrow 3NaCl_{(aq)} + Fe(OH)_{3(s)}$$

Brown ppt.

Q.5 Differentiate between Acid and Basic radical.

Ans: **DIFFERENTIATE**

Acid Radical	Basic Radical
Definition: An anion is non-metallic ion derived from acid, therefore, it is called acid radical.	**Definition:** A cation is metallic ion and derived from a base, therefore, it is called basic radical.
Example: $NaOH + HCl \rightarrow NaCl + H_2O$ In this reaction Cl^- is an acid radical.	**Example:** $NaOH + HCl \rightarrow NaCl + H_2O$ In this reaction Na^+ is a basic radical.

Q.6 Why Bronsted acids are not lewis acids?

Ans: Bronsted acids can donate a proton to another substance whereas lewis acids are those that can accept a pair of electrons. All bronsted acids are not lewis acids because all proton donating species do not have tendency to accept electron pair.

Example:

- H_2SO_4
- HNO_3
- HCl

They can dissociate to give proton but cannot accept an electron pair.

Q.7 Find pH of 0.01M of H_2SO_4 and 0.001M of H_2SO_4. Which solution is more concentrated and why?

Ans: **pH of H_2SO_4**

Given Data
(i) 0.01M H_2SO_4
(ii) 0.001M H_2SO_4
Required: pH = ?

Calculation:

(i) For 0.01M H_2SO_4

$$H_2SO_4 \rightarrow 2H^+ + SO_4^{-2}$$
$$2[H^+] = 2\times 0.01 = 2\times 10^{-2}\,M$$
$$pH = -\log[H^+]$$
$$= -\log[2\times 10^{-2}]$$
$$= -\log 2 + 2\log 10$$
$$= 2\log 10 - \log 2$$
$$= 2 - \log 2$$
= 2-0.3010
= 1.7

(ii) For 0.001M H_2SO_4

$$H_2SO_4 \rightarrow 2H^+ + SO_4^{-2}$$
$$2[H^+] = 2\times 0.001 = 2\times 10^{-3}\,M$$
$$pH = -\log[H^+]$$
$$= -\log[2\times 10]^{-3}$$
$$= -\log 2 + 3\log 10$$
$$= 3\log 10 - \log 2$$
$$= 3 - 0.3010$$
= 2.7

Conclusion

- 0.01 M H_2SO_4 is more concentrated due to larger value of molarity compared to 0.001M solution.
- Smaller value of pH of 0.01M H_2SO_4 make it more concentrated then 0.001M H_2SO_4.

Q.8 Differentiate between to the Acidic Salt and Basic Salt.

Ans: **DIFFERENTIATE**

Acidic Salt	Basic Salt
Definition: These salts are formed by partial replacement of replaceable H^+ ions of an acid by a positive metal ion.	**Definition:** These salts are formed by the incomplete neutralization of polyhydroxy base by an acid.
Presence of Ion: H^+ ion is present in it.	**Presence of Ion:** OH^- ion is present in it.
Example: • $KHSO_4$ • $NaHPO_4$	**Example:** • $Al(OH)_2Cl$ • $Zn(OH)NO_3$

Q.9 Differentiate between to the Double Salt and Complex Salt.

Ans: **DIFFERENTIATE**

Double Salt	Complex Salt
Definition: These salts are formed by two normal salts when they are crystallized from a mixture of equimolar saturated solution.	**Definition:** The salts which on dissociation provides a simple cation and complex anion or vice versa.
Example: • $K_2SO_4.Al_2(SO_4)_3.24H_2O$ • $K_2SO_4.Fe_2(SO_4)_3.24H_2O$	**Example:** • Potassium Ferrocyanide $K_4[Fe(CN)_6]$

Q.10 Why salts have high melting and boiling points?

Ans: Salts have high melting and boiling points because there exist strong electrostatic force of attraction between opposite charged ions.

Q.11 What is Soda lime? For what purpose it is used?

Ans: Mixture of CaO and NaOH is called Soda lime. For purification of sugar, it is used to remove carbon dioxide and water vapours from air.

Q.12 Differentiate between Conjugate Acid and Conjugate Base.

Ans: **DIFFERENTIATE**

Conjugate Acid	Conjugate Base
Definition: A conjugate acid is a specie formed by accepting a proton by a base. **Example:** • $HCl + H_2O \rightleftharpoons H_3O^+ + Cl^-$ Acid Base Conjugate Acid	**Definition:** A conjugate base is a specie formed by donating a proton by an acid. **Example:** • $HCl + H_2O \rightleftharpoons H_3O^+ + Cl^-$ Acid Base Conjugate Base

NOTE: *Every acid produces a Conjugate Base and every base produces a conjugate acid.*

Q.13 Why HS^{-1} is amphoteric but SO_4^{2-} is not?

Ans: Amphoteric substance can act as acid as well as base. HS^{-1} is amphoteric because it can act as acid by donating H^+ ion and become S^{2-} whereas, it can also accept H^+ ion and act as base to form H_2S, on the other hand SO_4^{2-} cannot donate a proton therefore it cannot act as an acid. It can only act as a base therefore it is not amphoteric substance.

Q.14 Give conjugate base of $[Al(H_2O)_6]^{3+}$ and conjugate acid of HPO_4^{2-}.

Ans:

Conjugate Base of $[Al(H_2O)_6]^{3+}$: $[Al(H_2O)_5OH]^{2+}$

Conjugate Acid of HPO_4^{2-} : $H_2PO_4^{1-}$

Q.15 Justify bronsted bases are also lewis bases.

Ans: Bronsted bases are also lewis bases, For example $NH_3.NH_3$ is bronsted base as it can accept a proton, it is also lewis base as NH_3 contains lone pair of electrons and according to lewis concept, base is a substance which cn donate a pair of electrons, hence we can say that all bronsted bases are also lewi bases.

Q.16 Define water of crytallization.

Ans: The number of water molecules present in the crystals of a substance are called water of crystallization.

Example: $CaSO_4.2H_2O$

Q.17 How acidic salts are turned into normal salts?

Ans: Acidic salts are turned into normal salts by the reaction of acidic salts with its parent base.

$$KHSO_{4(aq)} + KOH_{(aq)} \rightarrow K_2SO_{4(aq)} + H_2O_{(l)}$$

TERMS TO KNOW

Terms	Definitions
Arrhenius Acid	Acid is a substance which dissociates in aqueous solution to give hydrogen ions.
Arrhenius Base	Base is a substance which dissociates in aqueous solution to give hydroxide ions.
Bronsted-Lowry Acid	An acid is a substance (molecule or ion) that can donate a proton (H^+) to another substance.
Bronsted-Lowry Base	A base is a substance that can accept a proton (H^+) from another substance.
Amphoteric Specie	A substance that can act as an acid as well as a base is called amphoteric specie.
A Conjugate Acid	A conjugate acid is a specie formed by accepting a proton by a base.
A Conjugate Base	A conjugate base is a specie formed by donating a proton by an acid.
Lewis Acid	An acid is a substance (molecule or ion) which can accept a pair of electrons
Lewis Base	A base is a substance (molecule or ion) which can donate a pair of electrons.
Lewis Concept of Neutralization	A neutralization reaction according to Lewis concept is donation and acceptance of a electron pair to form a coordinate covalent bond in an adduct.
pH Scale	A logarithmic scale which is used to determine the pH of a solution is called pH scale. pH is the negative logarithm of molar concentration of the hydrogen ions.
pH	pH is the negative logarithm of molar concentration of the hydrogen ions.
Autoionization	Water is a weak electrolyte because it ionizes very slightly into ions in a process called autoionization or self ionization.
Universal Indicator	The mixture of indicators which gives different colours at different pH values is called universal indicator or pH indicator.
pH Meter	A pH meter is an instrument which is used to measure the pH of a solution.
Salts	Salts are ionic compounds generally formed by the neutralization of an acid with a base.
Basic Radical	A cation is metallic and derived from a base, therefore, it is called basic radical.
Acid Radical	An anion is derived from acid, therefore, it is called acid radical.
Acidic Salt	These salts are formed by partial replacement of a replaceable H^+ ions of an acid, by a positive metal ion.
Double Salts	Double salts are formed by two normal salts when they are crystallized from a mixture of equimolar saturated solutions.
Mixed Salts	Mixed salts contain more than one basic or acid radicals.
Complex Salts	Complex salts on dissociation provide a simple cation and a complex anion or vice versa.

SELF TEST

Time: 35 Minutes **Marks: 25**

Q.1 Four possible answers (A), (B), (C) and (D) to each question are given, mark the correct answer. **(6×1=6)**

1. Acetic acid is used for:

(A) Flavouring food (B) Making explosives

(C) Etching designs (D) Cleaning metals

2. What is the pOH of 0.02 M $Ca(OH)_2$?

(A) 1.698 (B) 1.397

(C) 12.31 (D) 12.61

3. Which one is a Lewis acid?

(A) BF_3 (B) $AlCl_3$

(C) $FeCl_3$ (D) All of above

4. pH value normally varies from:

(A) 0 – 14 (B) 1 – 14

(C) 7 – 14 (D) 10 – 14

5. Which salt is used as a table salt?

(A) NaCl (B) $NaCO_3$

(C) Na_2SiO_3 (D) $NaHCO_3$

6. Which is used as cleaning agent for domestic and commercial purposes?

(A) NaCl (B) $Na_2CO_3.10H_2O$

(C) $NaHCO_3$ (D) Na_2SiO_3

Q.2 Give short answers to the following questions. **(5×2=10)**

(i) Prove that water is an amphoteric specie.

(ii) How can you prepare hydrogen sulphide gas?

(iii) Describe the reaction of bases with ammonium salts.

(iv) Define the pH. What is pH of pure water?

(v) What H^+ act as Lewis acids?

Q.3 Answer the following questions in detail. **(5+4=9)**

(i) Explain the preparation of salts. **(5)**

(ii) Explain the Lewis concept of acids and bases. **(4)**

NOTE: Parents or guardians can conduct this test in their supervision in order to check the skill of students.

CHAPTER 11
ORGANIC CHEMISTRY

INTRODUCTION

LONG QUESTIONS

Q.1 What was vital force theory? How it was rejected? ***(Knowledge Base)***

(DGK 2017, GRW 2013, BWP 2016 G-II)

Ans: **VITAL FORCE THEORY**

Introduction:

In early 19th century, Swedish chemist Jacob Berzellius put forward the "Vital Force Theory" in 1815.

Definition:

*"According to this theory organic compounds **could not be prepared in laboratories** because they were supposed to be **synthesized** under the **influence of a mysterious force** called Vital Force, **inherent** only in **living things".***

Rejection of Vital Force Theory

(i) F. Wohler (1828): **(DGK 2017)**

The Vital Force Theory suffered death blow in 1828 when Wohler synthesized the first organic compound urea from inorganic substance by heating ammonium cyanate (NH_4CNO).

$$NH_4CNO \xrightarrow[\text{Rearrangement}]{\text{Heat}} \underset{\text{(Urea)}}{H_2NCONH_2}$$

(ii) Kolbe (1845):

In **1845 Kolbe** also rejected vital force theory, when he **prepared acetic acid in laboratory.**

SHORT QUESTIONS

Q.1 What was early concept of scientists about organic chemistry? ***(Knowledge Base)***

Ans: **EARLY CONCEPT OF SCIENTISTS ABOUT ORGANIC CHEMISTRY**

Initially (before 1828), the name organic chemistry was given for the chemistry of compounds obtained from plants and animals, i.e., from living organisms.

"The word organic signifies life"

Q.2 What was Lavoiser's concept about composition of plants and animals? ***(Knowledge Base)***

Ans: **COMPOSITION OF PLANTS AND ANIMALS**

Plants:

Lavoiser showed that compounds obtained from plants were often made of C, H and O elements.

Animals:

He showed that compounds obtained from animals contain elements C, H, N, O, S, P etc.

Q.3 Give examples of some important organic compounds. ***(Knowledge Base)***

Ans: **IMPORTANT ORGANIC COMPOUNDS**

Some important organic compounds are as follows:

- They range from simple to complex compounds

- They are present in drugs and medicines
- Flavours and fragrances
- Plastics and paints
- Detergents, insecticides and pesticides
- Carbohydrates
- Proteins
- Lipids
- Enzymes
- Vitamins

Q.4 How was vital force theory rejected? ***(Knowledge Base)***

Ans: *Answer given on pg # 110*

MULTIPLE CHOICE QUESTIONS

1. The vital force theory suffered rejection in: ***(K.B)***

(A) 1892 (B) 1882
(C) 1889 (D) 1828

2. Who put forth Vital Force Theory? ***(K.B)***

(A) Berzellius (B) Jabir Bin Hayan
(C) Dalton (D) Wohler

3. Vital Force Theory was further negated by: ***(K.B)***

(A) Kolbe, 1845 (B) Farat, 1545
(C) Divan, 1435 (D) Derek, 348

4. Who rejected Vital Force Theory? ***(K.B)***

(A) Wohler (B) Farat
(C) Divan (D) Derek

5. According to Lavoiser the compounds obtained from plants were often made of: ***(K.B)***

(A) C, H, N, O, S and P (B) C, H and O
(C) H, C, N, and O (D) C and H

11.1 ORGANIC COMPOUNDS

LONG QUESTIONS

Q.1 Explain the types of formulae of organic compounds. ***(Knowledge +Understanding Base)***

(GRW 2014, DGK 2017, MTN 2016 G-I)

Ans: **<u>TYPES OF FORMULAE OF ORGANIC COMPOUNDS</u>**

There are four types of formulae of organic compounds:

(i) Molecular formula
(ii) Structural formula
(iii) Condensed formula
(iv) Dot and cross formula

(i) <u>Molecular Formula:</u>

"The formula which represents the ***actual number of atoms*** *in one molecule of the organic compound is called the molecular formula".*

Example:

Molecular formula of butane is **C_4H_{10}.** It shows:

- **Butane** is made up of **carbon** and **hydrogen atoms**.
- Each molecule of butane consists of **4 carbon** atoms and 10 **hydrogen atoms.**

(ii) Structural Formula:

*"Structural formula of a compound represents the **exact arrangement** of the **different atoms** of various elements present in a molecule of a substance".*

Representation of Bonds:

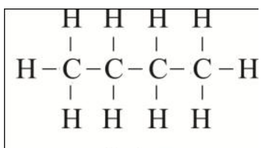
In a structural formula the bonds between bonded atoms are shown as follows:

- Single bond is represented by a single line (–)
- Double bond by two lines (=)
- Triple bond by three lines (≡)

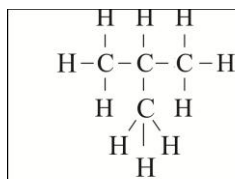
Organic compounds may have same molecular formulae but different structural formulae.

Example:

Structural formulae of butane (C_4H_{10}) are:



n-butane



isobutane

(iii) Condensed Formula:

*"The formula that indicates the **group of atoms joined together** to each carbon atom in a straight chain or a branched chain is called the condensed formula".*

Examples:

$$H_3C-CH_2-CH_2-CH_3$$

n-Butane

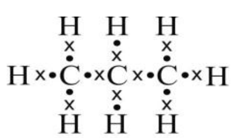
$$\begin{array}{l} H_3C-CH-CH_3 \\ \qquad\quad\;\; | \\ \qquad\;\;\; CH_3 \end{array}$$

isobutane

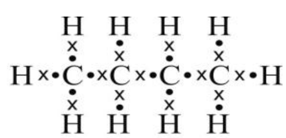
iv. Electronic or Dot and Cross Formula:

*"The formula which shows the **sharing of electrons** between various atoms in one molecule of the organic compound is called dot and cross formula or electronic formula".*

Examples:



Propane



n-butane

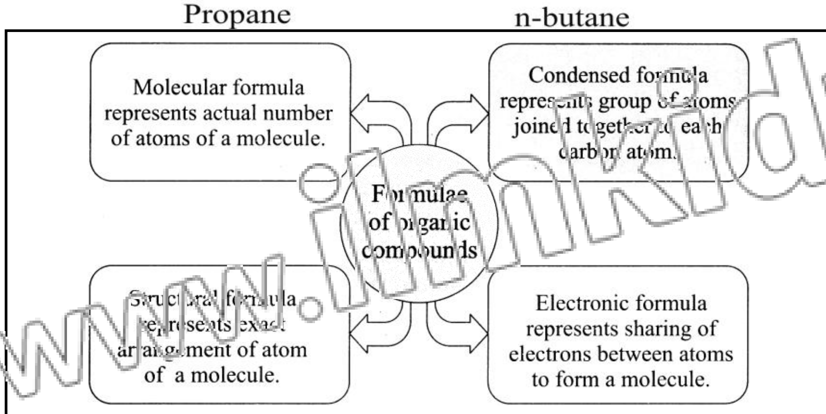


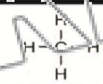
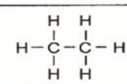
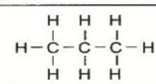
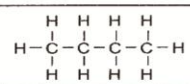
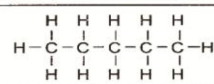
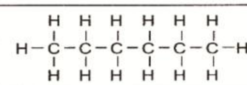
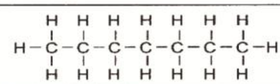
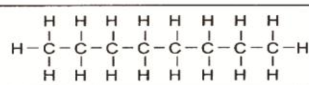
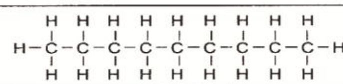
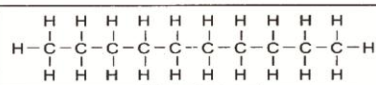
Figure: Summary of the Formulas of Organic Compounds

Q.2 Write the names, molecular, condensed and structural formulae of the first ten hydrocarbons. ***(Knowledge + Understanding Base)***

Ans:

<u>**FIRST TEN HYDROCARBONS**</u>

Following are the names, molecular, condensed and structural formulae of the first ten hydrocarbons:

Name	Molecular Formula	Condensed Formula	Structural Formula
Methane	CH_4	CH_4	
Ethane	C_2H_6	H_3CCH_3	
Propane	C_3H_8	$H_3CCH_2CH_3$	
Butane	C_4H_{10}	$H_3C\,(CH_2)_2CH_3$	
Pentane	C_5H_{12}	$H_3C(CH_2)_3CH_3$	
Hexane	C_6H_{14}	$H_3C(CH_2)_4CH_3$	
Heptane	C_7H_{16}	$H_3C(CH_2)_5CH_3$	
Octane	C_8H_{18}	$H_3C(CH_2)_6CH_3$	
Nonane	C_9H_{20}	$H_3C(CH_2)_7CH_3$	
Decane	$C_{10}H_{22}$	$H_3C(CH_2)_8CH_3$	

11.1 ORGANIC COMPOUNDS

SHORT QUESTIONS

Q.1 What are the organic compounds? ***(Knowledge Base)*** **(GRW 2017, SGD 2016 G-I)**

Ans:

<u>**ORGANIC COMPOUNDS**</u>

<u>**Definition:**</u>

*"Organic compounds are **hydrocarbons** (compounds of carbon and hydrogen) and their derivatives, in which covalently bonded **carbon is an essential constituent**".*

<u>**Examples:**</u>

- Glucose ($C_6H_{12}O_6$)
- Methane (CH_4)
- Alcohol (C_2H_5OH)

Number of Organic Compounds:

Today, there are about ten millions of organic compounds and thousands of new organic compounds are being prepared every year.

Q.2 What is organic chemistry? *(Knowledge Base)* **(LHR 2013, DGK 2016 G-I)**

Ans: **ORGANIC CHEMISTRY**

Definition:

"The branch of chemistry which deals with the study of hydrocarbons and their derivatives is known as organic chemistry".

Scope:

In this branch we study petroleum, petrochemicals, pharmaceuticals etc.

Q.3 Which are inorganic compounds yet they contain carbon? *(Knowledge Base)*

Ans: **INORGANIC COMPOUNDS CONTAINING CARBON**

Following are inorganic compounds yet they contain carbon:

- The oxides of carbon like carbon monoxide and carbon dioxide. (CO,CO_2)
- Carbonates ($CaCO_3$)
- Bicarbonates ($NaHCO_3$)
- Carbides. (CaC_2)

They are not treated as organic compounds because their properties are quite different from those of organic compounds.

Q.4 Define molecular formula? *(Knowledge + Understanding Base)* (LHR 2013, FSD 2017, SGD 2016 G-I, DGK 2016 G-I)

Ans: *Answer given on Page # 111*

Q.5 What is electronic or dot and cross formula? *(Knowledge + Understanding Base)*
(SWL 2017)

Ans: *Answer given on Page # 112*

Q.6 Define structural formula. Draw the structural formulae of n-butane and isobutane. *(Knowledge + Understanding Base)*
(MTN 2017, SWL 2016 G-II)

Ans: *Answer given on Page # 112*

Q.7 Define condensed formula. *(Knowledge + Understanding Base)* (FSD 2016 G-II, MTN 2016 G-I)

Ans: *Answer given on Page # 112*

Q.8 What are characteristics of naphthalene? Give its uses. *(Knowledge Base)*
(Interesting Information Book Pg. # 53)

Ans: **CHARACTERISTICS OF NAPHTHALENE**

Naphthalene is an organic compound. It decomposes at room temperature giving out very strong smell.

Uses:

It is used in moth balls to keep insects away from clothes.

11.1 ORGANIC COMPOUNDS

MULTIPLE CHOICE QUESTIONS

1. **The branch of chemistry which deals with hydrocarbons and their derivatives is called: *(K.B)***
   (A) Inorganic Chemistry (B) Analytical Chemistry
   (C) Organic Chemistry (D) Biochemistry

2. **The chemical formula of octane is: *(K.B)***
   (A) C_5H_{12} (B) C_3H_8
   (C) C_2H_6 (D) C_8H_{18}

3. **Organic compounds have: *(K.B)***
   (A) Ionic bond (B) Covalent bond
   (C) Electrovalent bond (D) Coordinate covalent bond

4. **How many types of formula of organic compound? *(K.B)***
   (A) 4 (B) 5
   (C) 3 (D) 2

5. **Formula which represents the actual number of atoms in one molecule of organic compound is: *(U.B)***
   (A) Structural formula (B) Condensed formula
   (C) Dot and cross formula (D) Molecular formula

6. **Condensed formula of propane is: *(U.B)***
   (A) H_3CCH_3 (B) $H_3C(CH_2)_2CH_3$
   (C) $H_3CCH_2CH_3$ (D) CH_4

7. **It represents group of atoms joined together to each carbon atom: *(U.B)***
   (A) Molecular formula (B) Structural formula
   (C) Condensed formula (D) Electronic formula

8. **The molecular formula of pentane is: *(K.B)***
   (A) CH_4 (B) C_3H_3
   (C) C_5H_{12} (D) C_4H_{10}

9. **Naphthalene is an. *(K.B)***
   (A) Organic compound (B) Inorganic compound
   (C) Covalent compound (D) Ionic compound

11.1.1 CLASSIFICATION OF ORGANIC COMPOUNDS

LONG QUESTIONS

Q.1 Write a detailed note on classification of organic compounds.
(Knowledge +Understanding Base) **(Ex Q.14)**

OR

How organic compounds are classified? Explain with the help of examples.

Ans: **Classification of Organic Compounds:**

All known organic compounds have been broadly divided into two categories depending upon their carbon skeleton. These are:

(i) Open chain or acyclic compounds
(ii) Closed chain or cyclic compounds

(i) Open Chain or Acyclic or Aliphatic Compounds: **(SWL 2017)**

"*Open chain compounds are those in which the* ***end carbon atoms are not joined*** *with each other in this way they form a long chain of carbon atoms".*

Open chain compounds are also called aliphatic compounds.

Types of Open Chain Compounds:

There are two types of open chain compounds.

a. Straight chain compounds
b. Branched chain compounds

a. Straight Chain Compounds:

"Straight chain compounds are those in which carbon atoms link with each other through a ***single, double or triple bond*** *forming a straight chain".*

Examples:

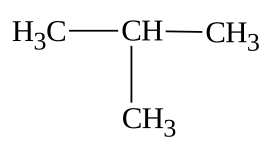
$$H_3C-CH_2-CH_2-CH_3$$

Straight chain (n – Butane)

b. Branched Chain Compounds:

"Branched chain compounds are those in which there is a ***branch along straight chain****".*

Examples:



Branched chain (isobutane)

(ii) Closed Chain or Cyclic Compounds: **(GRW 2014, 2015, LHR 2014)**

"Closed chain or cyclic compounds are those in which the carbon atoms at the ***end of chain are not free****. They are linked to form a ring".*

Types of Closed Chain Compounds:

They are further divided into two classes.

a. Homocyclic or carbocyclic compounds.
b. Heterocyclic compounds.

a. Homocyclic or Carbocyclic Compounds: **(LHR 2014, GRW 2013, 15)**

"Homocyclic or carbocyclic compounds contain rings which are made up of ***only one kind of atoms, i.e., carbon atoms*** *are called homocyclic compounds".*

These are further divided into two classes:

- Aromatic compounds
- Alicyclic compounds

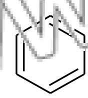
Aromatic Compounds:

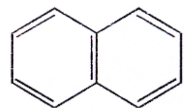
*These organic compounds contain **at least one benzene ring** in their molecule. They are also called **benzenoid compounds.***

Benzene Ring:

*A benzene ring is made up of **six carbon atoms** with **three alternating double bonds**. They are **called aromatic** because of **aroma or smell** they have.*

Examples:

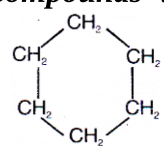

Benzene


Naphthalene

Alicyclic or Non-benzenoid Compounds:

*"**Carbocyclic compounds** which **do not have benzene ring** in their molecules are called **alicyclic or non- benzenoid compounds**".*

Examples:

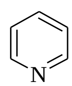

Cyclo-hexane

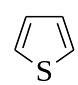
CH_2 — CH_2
| |
CH_2 — CH_2 (Cyclobutane)

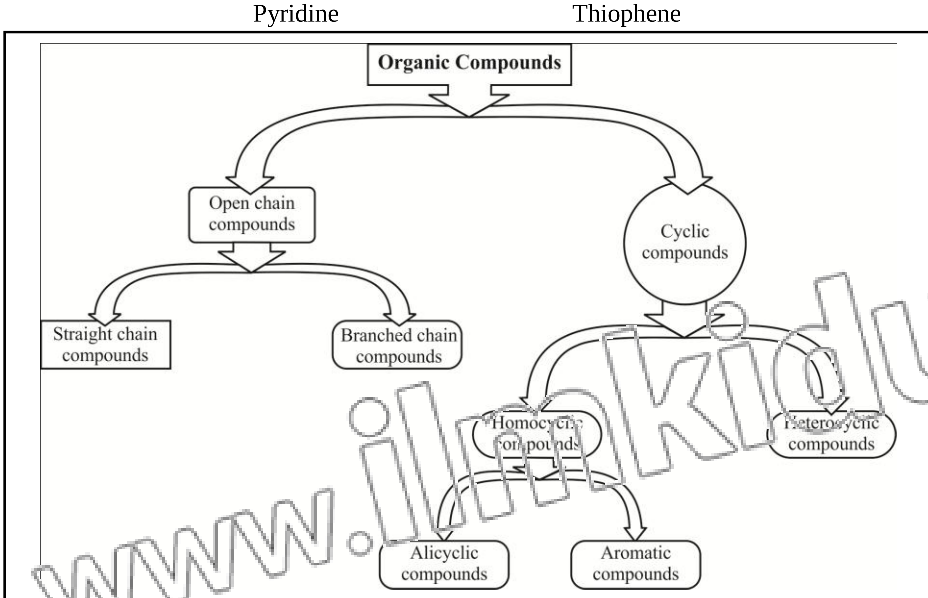
b. Heterocyclic Compounds:

*"**Cyclic compounds** that contain **one or more atoms other than** that of **carbon atoms** in their rings are called heterocyclic compounds".*

Examples:


Pyridine


Thiophene



11.1.1 CLASSIFICATION OF ORGANIC COMPOUNDS

SHORT QUESTIONS

Q.1 What are aromatic compounds? *(Knowledge Base)* **(MTN 2016 G-I, 17)**

Ans: *Answer given on Page # 117*

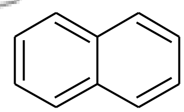
Q.2 What is Benzene Ring? *(Knowledge Base)*

Ans: **<u>Benzene Ring</u>**

*"A benzene ring is made up of **six carbon atoms with three alternating double bonds.***

<u>Examples</u>:

Benzene



Naphthalene

Q.3 Define open chain or acyclic compounds. *(Knowledge Base)* **(SWL 2017)**

Ans: *Answer given on Page # 116*

Q.4 What are alicyclic or non benzenoid compounds? *(Knowledge Base)*

Ans: *Answer given on Page # 117*

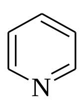
Q.5 Define heterocyclic compounds. Give two examples. *(Knowledge Base)*
(DGK 2017, FSD 2016 G-I BWP 2016 G-I)

Ans: **<u>HETEROCYCLIC COMPOUNDS</u>**

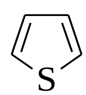
<u>Definition:</u>

*"The **cyclic compounds** that contain **one or more atoms other than** that of **carbon atoms** in their rings are called heterocyclic compounds".*

<u>Examples:</u>



Pyridine



Thiophene

Q.6 Write names of any two closed chain or cyclic chain hydrocarbons. *(Knowledge Base)*
(SWL 2014, GRW 2014)

Ans: **<u>CYCLIC HYDROCARBONS</u>**

Following are the names of two closed chain or cyclic chain hydrocarbons:

(i) Benzene

(ii) Naphthalene

Q.7 Write down two properties of naphthalene. *(Knowledge Base)* **(BWP 2016 G-II)**

Ans: **<u>PROPERTIES OF NAPHTHALENE</u>**

Following are the two properties of naphthalene:

(i) It is used as laboratory reagent.

(ii) It is used in moth balls to keep insects away from clothes.

11.1.1 CLASSIFICATION OF ORGANIC COMPOUNDS

MULTIPLE CHOICE QUESTIONS

1. A benzene ring is made of carbon atoms: ***(K.B)***

(A) 4 (B) 2
(C) 6 (D) 3

2. $-\overset{|}{\underset{|}{C}}-\overset{|}{\underset{|}{C}}-\overset{|}{\underset{|}{C}}-\overset{|}{\underset{|}{C}}-$ **is a:** ***(K.B)***

(A) Straight Chain (B) Closed Chain
(C) Branched Chain (D) Cyclic Chain

3. Aromatic compounds are also called: ***(K.B)***

(A) Benzenoid (B) Carbonoids
(C) Acyclic (D) Heterocyclic

4. Homocyclic compounds are of types: ***(K.B)***

(A) 4 (B) 3
(C) 2 (D) 1

11.1.2 DIVERSITY AND MAGNITUDE OF ORGANIC COMPOUNDS

LONG QUESTION

Q.1 Explain the diversity and magnitude of organic compounds.
(Knowledge + Understanding Base) **(Ex-Q.8)**

OR

Why organic compounds are numerous? **(Ex-Q.8)**

Ans: **<u>DIVERSITY AND MAGNITUDE OF ORGANIC COMPOUNDS</u>**

There are a total of 118 elements known today. The number of organic compounds (carbon compounds) is more than ten million. This number is far more than the number of compounds of all the remaining elements taken together.

<u>Reason for Large Number of Organic Compounds:</u>

Following are the reasons for large number of organic compounds:

- Catenation
- Isomerism
- Strength of covalent bonds of carbon
- Multiple bonding

(i) <u>Catenation:</u> **(RWP 2017, DGK 2017)**

"*The **ability of carbon atoms** to link with other carbon atoms to form **long chains** and **large rings** is called catenation.*"

<u>Explanation:</u>

Main reason for the existence of a large number of organic compounds is that carbon atoms can link with one another by means of covalent bonds to form long chains or rings of carbon atoms. The chains can be straight or branched. The **ability** of **carbon atoms** to **link** with **other carbon atoms** to form **long chains** and **large rings** is called catenation.

<u>Conditions:</u> **(DGK 2017)**

Two basic conditions for an element to exhibit catenation are,

(a) Valency:

Element should have valency **two** or **greater than two**.

(b) Bonds:

Bonds made by an element with its own atoms should be stronger than the bonds made by the element with other atoms especially oxygen.

Example:

$$H_3C—CH_2—CH_2—CH_3$$

n-butane

Carbon Shows Catenation Whereas Silicon does not:

Both silicon and carbon have similar electronic configurations but carbon shows catenation whereas silicon does not.

Reasons:

- It is mainly due to the reason that **C–C bonds** are much stronger **(355 kJ mol^{-1})** than **Si–Si (200 kJ mol^{-1})** bonds.
- On the other hand, **Si–O** bonds are much stronger **(452 kJ mol^{-1})** than **C–O** bonds **(351kJ mol^{-1})** Hence, silicon occurs in the form of silica and silicates in nature.

(ii) Isomerism:

*"The compounds having the **same molecular formula** but different arrangement of atoms in their molecules or **different structural formulae** are called isomers and this **phenomenon** is called **isomerism**".*

Examples:

Molecular formula **C_5H_{12}** can be used to draw the structures of isomers of pentane, represented by **three different structures**. Thus, **C_5H_{12} has three isomers.**

$CH_3—CH_2—CH_2—CH_2—CH_3$

n-pentane

$$\begin{array}{c} CH_3—CH_2—CH—CH_3 \\ \quad\quad\quad\quad | \\ \quad\quad\quad\quad CH_3 \end{array}$$

(Iso-pentane)

$$\begin{array}{c} CH_3 \\ | \\ CH_3 — C — CH_3 \\ | \\ CH_3 \end{array}$$

(Neo-pentane)

Note:

Number of **isomers increases with the increase in number of carbon atoms** in the given molecular formula.

(iii) Strength of Covalent Bonds of Carbon:

Due to its **very small size**, carbon can form very **strong covalent bonds** with other carbon atoms, hydrogen, oxygen, nitrogen and halogens. This enables it to form a large number of compounds.

(iv) Multiple Bonding:

In order to satisfy its **tetravalency**, carbon can make **multiple bonds (i.e., double and triple bonds)**. This further adds to the possible number of structures.

Example:

- Two carbon atoms in ethane are linked by a single covalent bond, by a double covalent bond in ethylene and a triple covalent bond in acetylene.

11.1.2 DIVERSITY AND MAGNITUDE OF ORGANIC COMPOUNDS

SHORT QUESTIONS

Q.1 Why does silicon occur in the form of silica and silicates? ***(Knowledge Base)*** **(GRW 2015)**

Ans: **OCCURRENCE OF SILICON**

Silicon occurs in form of silica and silicates because **Si – Si bonds** are much weaker **(200kJ/mol)** whereas **Si–O bonds** are much stronger **(452kJ/mol)** that is why silicon prefers to make compound with oxygen.

Q.2 Define isomerism. Give an example. ***(Knowledge Base)*** **(GRW 2014, SWL 2017, FSD 2017)**

Ans:

ISOMERISM

"The compounds having the same molecular formula but different arrangement of atoms in their molecules or different structural formulae are called isomers and this phenomenon is called isomerism".

Examples:

$CH_3—CH_2—CH_2—CH_2—CH_3$
n-pentane

$CH_3—CH_2—CH—CH_3$
$\qquad\qquad\quad |$
$\qquad\qquad CH_3$
(Iso-pentane)

11.1.2 DIVERSITY AND MAGNITUDE OF ORGANIC COMPOUNDS

MULTIPLE CHOICE QUESTIONS

1. How many carbon atoms are present in heptane? ***(K.B)***
(A) 5 (B) 6
(C) 8 (D) 7

2. C-C bond is stronger than: ***(K.B)***
(A) Si-Si (B) C-O
(C) Both (A) and (B) (D) None of these

3. Number of isomers increases with increase in number of atoms of: ***(K.B)***
(A) Hydrogen (B) Nitrogen
(C) Carbon (D) Oxygen

4. Energy of C-C bonds is: ***(K.B)***
(A) 355 kJ/mol (B) 351 kJ/mol
(C) 452 kJ/mol (D) 200 kJ/mol

5. Energy of Si-Si bonds is: ***(K.B)***
(A) 452 kJ/mol (B) 355 kJ/mol
(C) 200 kJ/mol (D) 351 kJ/mol

6. Energy of C-O bonds is: ***(K.B)***
(A) 452 kJ/mol (B) 355 kJ/mol
(C) 200 kJ/mol (D) 351 kJ/mol

11.1.3 GENERAL CHARACTERISTICS OF ORGANIC COMPOUNDS

LONG-QUESTION

Q.1 What are the general characteristics of organic compounds? ***(Knowledge Base)*****(Ex-Q.13)**
(GRW 2016, BWP 2016 G-I, MTN 2016 G-II, 17, DGK 2016 G-II)

Ans:

GENERAL CHARACTERISTICS OF ORGANIC COMPOUNDS

Organic compounds have the following general charcteristics:

(i) Origin:

Naturally occurring **organic compounds** are obtained from **plants and animals**. On the other hand, **inorganic compounds** are obtained from **minerals and rocks**.

(ii) <u>Composition:</u>

Carbon is an essential constituent of all organic compounds. They are made up of few elements such as carbon, hydrogen, nitrogen, oxygen, halogen, sulphur, etc. On the other hand, inorganic compounds are made up of almost all the elements of the Periodic Table known so far.

(iii) <u>Covalent Linkage:</u>

Organic compounds contain **covalent bonds** that may be **polar** or **non-polar**, while the inorganic compounds mostly contain ionic bonds.

(iv) <u>Solubility:</u>

Organic compounds having **non-polar linkages** are generally soluble in **organic solvents** like alcohol, ether, benzene, carbon disulphide etc. On the other hand, the inorganic compounds with **ionic bonds** are soluble in **polar solvents like water**.

(v) <u>Electrical Conductivity:</u>

Due to the **presence of covalent bonds**, organic compounds are **poor conductor** of electricity, whereas inorganic compounds being **ionic** in nature, are **good conductors** of electricity in **molten state** are in **aqueous solution**.

(vi) <u>Melting and Boiling Points:</u>

Generally **organic compounds** have **low melting and boiling points** and are **volatile** in nature. **Inorganic compounds**, on the other hand, have comparatively **high melting and boiling points.**

(vii) <u>Stability:</u>

Since organic compounds have low melting and boiling points, they are less stable than inorganic compounds.

(viii) <u>Combustibility:</u>

Organic compounds with **high percentage of carbon** are generally combustible. On the other hand, **inorganic compounds** are mostly **non-combustible.**

(ix) <u>Isomerism:</u>

A main characteristic of organic compounds which differentiates them from inorganic substances is their tendency to exhibit the phenomenon of isomerism. Isomerism is rare in inorganic substances.

(x) <u>Rate of reaction:</u>

Due to the presence of covalent linkages, the reactions of organic compounds are molecular in nature. They are often **slow** and require specific **conditions such as temperature, pressure or catalyst.**

11.1.3 GENERAL CHARACTERISTICS OF ORGANIC COMPOUNDS

SHORT QUESTIONS

Q.1 What is origin of organic compounds? ***(Knowledge Base)***

Ans: **<u>ORIGIN OF ORGANIC COMPOUNDS</u>**

Organic compounds are obtained from plants and animals. On the other hand, inorganic compounds are obtained from minerals and rocks.

Q.2 What do you know about solubility of organic compounds? ***(Knowledge Base)***

Ans: **<u>SOLUBILITY OF ORGANIC COMPOUNDS</u>**

Organic compounds having non-polar linkages are generally soluble in organic solvents like alcohol, ether, benzene, carbon disulphide etc. On the other hand, the inorganic compounds with ionic bonds are soluble in polar solvents like water.

11.1.3 GENERAL CHARACTERISTICS OF ORGANIC COMPOUNDS

MULTIPLE CHOICE QUESTIONS

1. **Organic compounds have:** ***(K.B)***
   (A) Low% of carbon (B) High% of carbon
   (C) Both A and B (D) None of these
2. **Organic compounds are obtained from:** ***(K.B)***
   (A) Plants and animals (B) Minerals
   (C) Air (D) Sun
3. **Organic compounds are soluble in:** ***(K.B)***
   (A) Organic solvent (B) Polar solvent
   (C) Inorganic solvent (D) Both A and B
4. **The ability of carbon atoms to form chain is called:** ***(K.B)*** **(LHR 2014)**
   (A) Isomerism (B) Catenation
   (C) Resonance (D) Condensation
5. **Rates of reactions of organic compounds are usually:** ***(K.B)***
   (A) Slow (B) Fast
   (C) Moderate (D) Very fast

11.1 TEST YOURSELF

i. Why and how carbon completes its octet? ***(Knowledge Base)***

Ans: **<u>COMPLETION OF OCTET</u>**

<u>Reason:</u>

Carbon completes its octet in order to become stable.

<u>Method:</u>

Carbon atom satisfies its tetravalancy by making single bond and also multiple bonds (double or triple bond). These multiple bonds are formed itself between carbon atoms or sometimes by simple sharing (covalent bond) with hydrogen atoms.

<u>Examples:</u>

$$\begin{array}{ccc} & H & \\ & | & \\ H - & C & - H \\ & | & \\ & H & \end{array}$$

CH_4	Methane
$H_2C = CH_2$	Ethene
$HC \equiv CH$	Ethyne

ii. Point out the properties of carbon which are responsible for formation of long chains of carbon atom compounds? *(Understanding Base)*

Ans: **REASONS FOR CATENATION**

The properties of carbon which are the responsible for long chain of carbon compounds are as follows:

- Carbon has the valency more than two.
- Bonds formed between carbon carbon (C–C) atoms is stronger (355kJmol^{-1}) than the bond formed between carbon and other elements e.g. C – O (351kJmol^{-1})

iii. Why the melting and boiling points of organic compounds are low? *(Understanding Base)*

Ans: **MELTING AND BOILING POINTS**

The melting and boiling points of organic compounds are generally low because:

- These are non-polar
- Intermolecular forces between the organic molecules are weak.

iv. Why the organic compounds are poor conductors of electricity? *(Understanding Base)*
(GRW 2015)

Ans: **CONDUCTIVITY OF ORGANIC COMPOUNDS**

The organic compounds are poor conductors of electricity because:

- They consist of molecules having covalent bonds between atoms rather than ions.
- They do not have free electrons for electric conduction.
- The covalent bonds is between non-metals which itself are poor conductor of heat and electricity.

v. What are the reasons for the formation of millions of organic compounds?
(Knowledge Base)

Ans: **MILLIONS OF ORGANIC COMPOUNDS**

The reasons for formation of millions of organic compounds are:

- Catenation
- Isomerism
- Strength of covalent bond between carbon atoms
- Multiple bonding

11.2 SOURCES OF ORGANIC COMPOUNDS

11.2.1 COAL

LONG QUESTIONS

Q.1 Describe important sources of organic compounds. *(Knowledge Base)*

Ans: **SOURCES OF ORGANIC COMPOUNDS**

Organic compounds are naturally prepared by animals and plants.

(A) Animals:

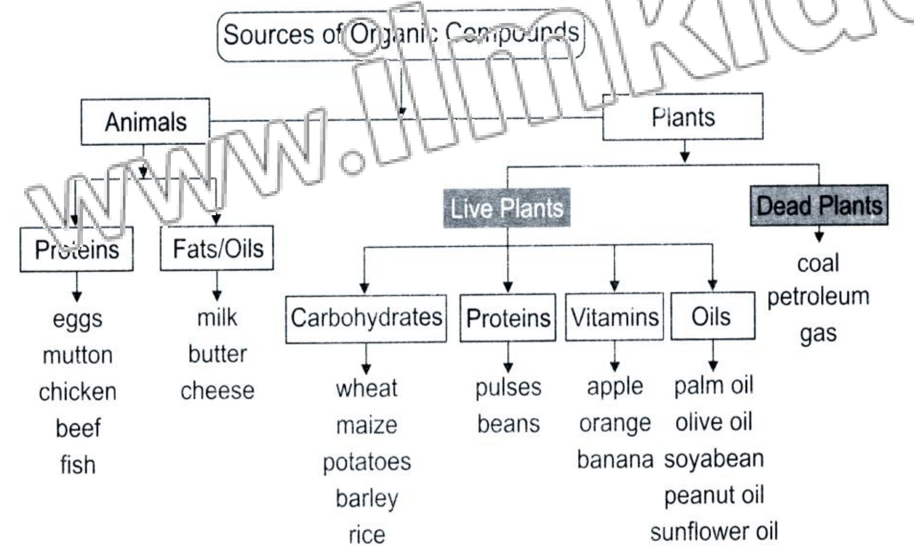
Animals synthesize two main groups of organic compounds.

(i) Proteins: e.g meat, mutton, chicken, eggs etc.

(ii) Fats/Oils. Fats are present in milk, butter, cheese etc.

(B) <u>Plants:</u>

Plants synthesize four main groups of organic compounds. More over dead plants burried under Earth's crust are converted through biochemical processes to coal, petroleum and natural gas. These materials are the main sources of organic compounds. We can get thousands of organic compounds by the destructive distillation of coal and fractional distillation of petroleum.



<u>Figure: Sources of Organic Compounds</u>

Q.2 How coal is formed? What are different types of coal?
(Knowledge Base+Understanding Base) **(Ex-Q.1) (LHR 2014)**

OR

Write down composition and uses of different types of coal.
(Knowledge Base+Understanding Base) **(Ex-Q.2)**

Ans:

<u>FORMATION OF COAL</u>

<u>Definition:</u>

*"Coal is **blackish, complex mixture** of compounds of **carbon, hydrogen and oxygen.** It also consists of **small amounts** of **nitrogen and sulphur** compounds".*

<u>Formation of Coal:</u>

Coal was formed by the decomposition of dead plants burried under the Earth's crust millions of years ago.

<u>Carbonization:</u>

"The conversion of wood into coal is called carbonization".

It is a very slow bio-chemical process. It takes place in the absence of air under high pressure and high temperature over a long period of time (about 500 millions of years).

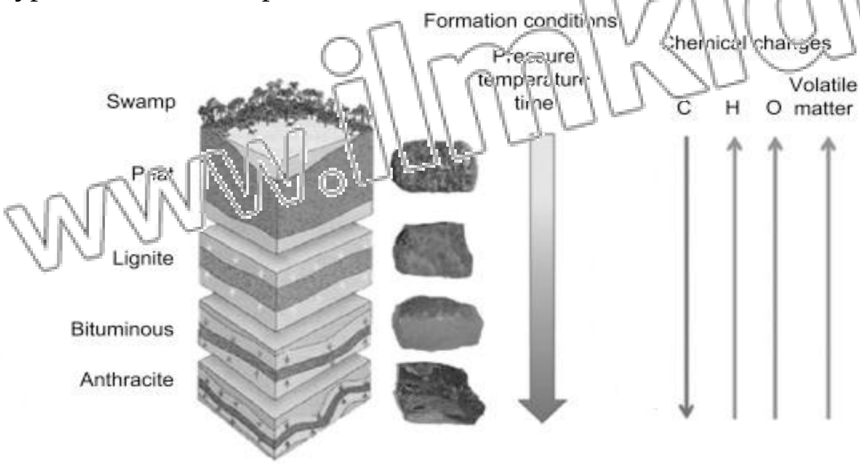
$$\underset{\text{about 500 millions years ago}}{\textit{Dead plants}} \longrightarrow \textit{Burried under Earth's crust} \xrightarrow[\text{Presence of high temp.\& press.}]{\text{Absence of air}} \textit{Coal}$$

Types of Coal: **(Ex-Q.2)**

Wood contains about **40% carbon**, so depending upon the **extent of carbonization** process, **four types of coal** are found.

Basis of Difference in Types of Coal:

These types differ with respect to carbon content, volatile matter and moisture.



Different Types of Coal: **(DGK 2016 G-I)**

Composition and uses of different types of coal are as follows:

Type of Coal	Carbon Content	Uses
Peat	**60%**	It is inferior quality coal used in kiln.
Lignite	**70%**	It is soft coal used in thermal power stations.
Bituminous	**80%**	It is common variety of coal used as household coal.
Anthracite	**90%**	It is superior quality hard coal that is used in industry.

Q.3 Which products can be obtained by the destructive distillation of coal?
(Knowledge Base+Understanding Base) **(Ex-Q.3&4)**

OR

What is destructive distillation of coal? *(Knowledge Base+Understanding Base)*(Ex-Q.2)

OR

Name the different types of products obtained by the destructive distillation of coal.
(Knowledge Base+Understanding Base) **(Ex-Q.2)**

Ans: **DESTRUCTIVE DISTILLATION OF COAL**

*"The **strong heating** of coal in the **absence of air** is called destructive distillation".*

Composition of Coal:

Coal contains elements like:

- Carbon
- Hydrogen
- Oxygen
- Nitrogen
- Sulphur

So, destructive distillation of coal provides large number of organic compounds along with a few inorganic compounds.

Products of Destructive Distillation of Coal:

(i) Coal Gas:

"Coal gas is mixture of ***hydrogen, methane and carbon monoxide*** *produces heat when burnt in air".*

Uses:

- It is mainly used as a **fuel** in industry.
- It is also used to provide an inert or **reducing atmosphere** in various **metallurgical processes**.

(ii) Ammonical Liquor:

"Ammonical liquor is a solution of ***ammonia gas in water****".*

Uses:

- It is used to prepare **nitrogenous fertilizers**. For example, when it is treated with sulphuric acid, it produces **ammonium sulphate**, fertilizer.

(iii) Coal Tar:

"*Coal tar is a thick* ***black liquid****. It is a mixture of more than* ***200 different organic compounds, mostly aromatic****".* They are separated by **fractional distillation** of Coal Tar. Some of the important aromatic compounds are benzene, phenol, toluene, aniline, etc.

Uses:

These compounds are used to synthesize:

- Drugs
- Dyes
- Explosives
- Paints
- Varnishes
- Plastic
- Synthetic fibre
- Pesticides

Pitch:

"*The black* ***residue*** *of the* ***coal tar*** *is called pitch".*

Use:

- It is **used** for surfacing of **roads** and **roofs**.

(iv) Coke: **(BWP 2017)**

"*When* ***coal*** *is subjected to* ***destructive distillation****, it loses all its volatile components and leaves behind a solid residue called coke. Coke is* ***98% carbon****".*

Uses:

- It is mainly used as a **reducing agent** in the extraction of metals especially iron.
- It is also used as **fuel**.

11.2 SOURCES OF ORGANIC COMPOUNDS

11.2.1 COAL

SHORT QUESTIONS

Q.1 Write down names of different types of coal. ***(Knowledge Base)*** **(RWP 2017)**

Ans: **TYPES OF COAL**

Following are the names of different types of coal:

- Peat 60% C
- Lignite 70% C
- Bituminous 80% C
- Anthracite 90% C

Q.2 Write carbon content and use of peat and lignite. ***(Knowledge Base)***

Ans: **PEAT AND LIGNITE**

Following are the carbon content and uses of peat and lignite:

Type of Coal	Carbon Contents	Uses
Peat	60%	It is inferior quality coal used in kiln.
Lignite	70%	It is soft coal used in thermal power stations.

Q.3 Write any four sources of organic compounds. ***(Knowledge Base)***

Ans: **SOURCES OF ORGANIC COMPOUNDS**

Following are the four sources of organic compounds:

- Plants
- Animals
- Petroleum
- Natural gas

Q.4 Define pitch give its uses. ***(Knowledge Base)***

Ans: *Answer given on Page # 127*

Q.5 How scientists are trying to mine coal in the future? ***(Application Base)***

(Interesting Information Pg. # 69) (BWP 2016 G-II)

Ans: **MINING OF COAL IN FUTURE**

Scientists are working one ways to convert coal into gas underground so that it will not have to be mined. This will allow us to use small seams of coal or seams that are dangerous to mine because of weaknesses in the surrounding rocks.

MULTIPLE CHOICE QUESTIONS

1. Amount of carbon content in lignite is: ***(K.B)***

(A) 70% (B) 90%

(C) 80% (D) 60%

2. Vitamins are found in: ***(K.B)***

(A) Apple (B) Pulses

(C) Citrus fruits (D) Both A and C

3. Name the gas which is not found in coal gas: ***(K.B)***

(A) Hydrogen (B) Nitrogen
(C) Methane (D) Carbon monoxide

4. Coal is of types: ***(K.B)***

(A) 1 (B) 3
(C) 2 (D) 4

5. Dead plants produce all of these products except: ***(K.B)***

(A) Coal (B) Gas
(C) Petroleum (D) Carbohydrate

6. Which one is used as reducing agent? ***(K.B)***

(A) Ammonical liquor (B) Coal gas
(C) Coal tar (D) Coke

7. Which one provides inert atmosphere in metallurgical process? ***(K.B)***

(A) Ammonical liqour (B) Coke
(C) Coal gas (D) Coal tar

8. Which one is soft coal? ***(K.B)***

(A) Peat (B) Bituminous
(C) Lignite (D) Anthracite

9. Which type of coal is used as household coal: ***(K.B)***

(A) Lignite (B) Peat
(C) Anthracite (D) Bituminous

10. Wood contains carbon about: ***(K.B)*** **(GRW 2014)**

(A) 10% (B) 20%
(C) 30% (D) 40%

11. Which one of the following is not a fossil fuel? ***(K.B)*** **(LHR 2015)**

(A) Coal (B) Natural gas
(C) Bio gas (D) Petroleum

12. The %age of carbon in anthracite is: ***(K.B)*** **(DKG 2016 G-II)**

(A) 90% (B) 80%
(C) 70% (D) 60%

11.2 TEST YOURSELF

i. Name the gases which are found in coal gas? ***(Knowledge Base)***

Ans: **GASES FOUND IN COAL GAS**

The gases which are found in coal gas are hydrogen, methane and carbon monoxide.

ii. Is coal tar a compound? What is importance of coal tar? ***(Understanding Base)***

Ans: **COAL-TAR AS A COMPOUND**

No, Coal-tar is not a compound. It is a mixture of more than 200 different organic compounds, mostly aromatic. Some of the important aromatic compounds are benzene, phenol, toluene, aniline etc.

Importance:

These chemicals are used to synthesize drugs, dyes, explosives, paints, varnishes, polishes, synthetic fibre and pesticides.

iii. What is coke? For what purpose it is used? ***(Understanding Base)*** **(BWP 2017)**

Ans: **COKE**

Coke is **98% carbon**. It is left behind **residue of coal**.

Uses:

Coke is mainly used as **reducing agent** in the extraction of metals especially iron.
It is also used as **fuel**.

iv. Which is the best quality of coal? *(Knowledge Base)* **(SWL 2016 G-I)**

Ans: **BEST QUALITY COAL**

Anthracite is considered as **superior quality** of coal containing **90% carbon content**. It is used in industry.

v. What is destructive distillation? *(Knowledge Base)* **(SWL 2016 G-I)**

Ans: **DESTRUCTIVE DISTILLATION**

Definition:

*"The **strong heating of coal** in the **absence of air** is called destructive distillation"*.

Importance:

Coal contains elements like carbon, hydrogen, oxygen nitrogen and sulphur. So destructive distillation of coal provides large number of organic compounds along with a few inorganic compounds.

11.2.2 PETROLEUM

11.2.3 NATURAL GAS

11.2.4 PLANTS

11.2.5 SYNTHESIS IN LABORATORY

LONG QUESTIONS

Q.1 Write a short note on petroleum and natural gas. *(Knowledge Base+Understanding Base)*

Ans: **PETROLEUM**

Definition:

*"Petroleum is a **dark brownish** or **greenish black** coloured **viscous liquid**. It is a complex mixture of several solid, liquid or gaseous hydrocarbons in water mixed with salts and earth particles"*.

Fractional Distillation:

*"Separation of fractions or components from a mixture **depending upon** their **boiling point ranges** is called fractional distillation"*.

Petroleum is a **main source** of **organic compounds**. It consists of several compounds mainly hydrocarbons. These compounds are separated by fractional distillation.

Composition of a Fraction:

Each fraction of a petroleum is not a single compound, rather each of it consists of different organic compounds.

NATURAL GAS

*"It is a **mixture** of **low molecular mass** hydrocarbons"*.

Composition:

The main component about **85%** is **methane**, along with other gases: ethane, propane and butane.

Uses: **(BWP 2017)**

Nautral gas is used:

- As fuel in homes as well as in industries.
- As fuel in automobiles as compressed natural gas (CNG).
- To make carbon black and fertilizers.

Origin:

Its origin is similar to that of coal and petroleum. Therefore, it is found with their deposits.

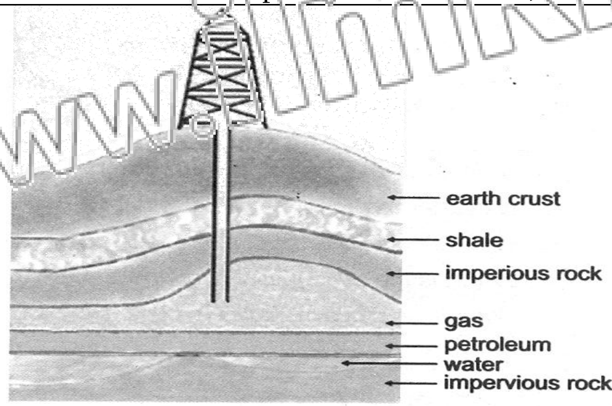


Figure: Occurrence and Drilling of Gas

Q.2 What types of compounds are synthesized by plants? ***(Knowledge Base)***

OR

Explain living plants as a source of organic compounds.

Ans:

SYNTHESIS OF COMPOUNDS BY PLANTS

Living plants synthesize macro-molecules, like carbohydrates, proteins, oils, vitamins etc.

(i) Carbohydrates:

The basic unit of all types of carbohydrates is glucose which is synthesized by plants through photosynthesis. Glucose then further polymerizes to form sucrose, starch and cellulose.

(ii) Proteins:

Proteins are found in the pulses and beans.

Preparation:

Proteins are prepared by fixation of nitrogen by bacteria found on the roots of plants.

(iii) Oils:

Oils are found in the seeds of plants such as:

- Sunflower
- Rapeseed
- Palm
- Coconut
- Ground-nut

(iv) Vitamins:

Vitamins are found in apple and citrus fruits.

Other Substances Drived From Plants:

Besides these major food items, plants also give us substances like:

- Gums
- Rubber
- Medicines, etc.

11.2.2 PETROLEUM

11.2.3 NATURAL GAS

SHORT QUESTIONS

Q.1 What is composition of natural gas? *(Knowledge Base)*

Ans: *Answer given on Page # 130*

Q.2 What is meant by fractional distillation? *(Understanding Base)*

Ans: *Answer given on Page # 130*

MULTIPLE CHOICE QUESTIONS

1. Petroleum is a dark brownish ___________ liquid. *(K.B)*

(A) Viscous (B) Light
(C) Heavy (D) Transparent

2. Main component of natural gas is: *(K.B)* **(LHR 2016)**

(A) Methane (B) Propane
(C) Butane (D) Propyne

3. Natural gas is a mixture of ___________molecular mass hydrocarbons. *(K.B)*(GRW 2016)

(A) Low (B) High
(C) Both A and B (D) Very high

4. Which one is main source of organic compounds? *(K.B)*

(A) Petroleum (B) Natural gas
(C) Coal (D) Ammonical liquor

5. Living plants synthesize: *(K.B)*

(A) Macromolecules (B) Micromolecules
(C) Plasmid (D) Inorganic compound

6. What percent of natural gas consists of methane (CH_4)? *(K.B)* **(LHR 2014)**

(A) 82% (B) 83%
(C) 84% (D) 85%

11.3 USES OF ORGANIC COMPOUNDS

LONG QUESTION

Q.1 Give some uses of organic compounds in our daily life. *(Knowledge Base)* **(Ex-Q.6)**
(FSD 2016 G-I, BWP 2016 G-II, SWL 2016 G-II)

Ans: **USES OF ORGANIC COMPOUNDS**

Organic compounds are part of everything, from food we eat to the various items we use in daily life to fulfill our needs. Organic compounds are prepared naturally as well as synthetically by chemists.

(i) Uses as Food:

The food we eat daily such as milk, eggs, meat, vegetables contain carbohydrates, proteins, fats, vitamins, etc. are all organic stuff.

(ii) Uses as Clothing:

All types of clothing (we wear, we use as bed sheets etc.) are made up of natural fibres (cotton, silk and wool, etc.) and synthetic fibres (nylon, dacron and acrylic etc.) all these are organic compounds.

(iii) Uses as Houses:

Wood is cellulose (naturally synthesized organic compound). It is used for making houses and furniture of all kinds.

(iv) Uses as Fuel:

The fuels we use for automobiles and domestic purposes are coal, petroleum and natural gas. These are called fossil fuels. All of these are organic compounds.

(v) Uses as Medicines:

A large number of organic compounds (naturally synthesized by plants) are used as medicines by us. Most of the life saving medicines and drugs such as antibiotics (inhibit or kill microorganisms which cause infectious diseases) are synthesized in laboratories.

(vi) Uses as Raw Material:

Organic compounds are used to prepare a variety of materials, such as rubber, paper, ink, drugs, dyes, paints, varnishes, pesticides, etc.

11.3 USES OF ORGANIC COMPOUNDS

SHORT QUESTIONS

Q.1 Describe use of organic compounds for clothing. ***(Knowledge Base)***

Ans: **ORGANIC COMPOUNDS AS CLOTHING**

All types of clothing (we wear, we use as bed sheets etc.) are made up of natural fibres (cotton, silk and wool, etc.) and synthetic fibres (nylon, dacron and acrylic etc.) all these are organic compounds.

Q.2 Describe two uses of organic compounds. ***(Knowledge Base)*** **(GRW 2017)**

Ans: **USES OF ORGANIC COMPOUNDS**

The two uses of organic compounds are as follows:

(i) Uses as Food:

The food we eat daily such as milk, eggs, meat, vegetables contain carbohydrates, proteins, fats, vitamins, etc. are all organic stuff.

(ii) Uses as Clothing:

All types of clothing (we wear, we use as bed sheets etc.) are made up of natural fibres (cotton, silk and wool, etc.) and synthetic fibres (nylon, dacron and acrylic etc.) all these are organic compounds.

Q.3 How organic compounds can be used as fuel? ***(Knowledge Base)***

Ans: *Answer given above*

Q.4 How organic compound can be used as medicines? ***(Knowledge Base)***

Ans: *Answer given above*

11.3 TEST YOURSELF

i. Define Petroleum. ***(Knowledge Base)*** **(GRW 2015)**

Ans: **PETROLEUM**

Definition:

"Petroleum is a dark brownish or greenish black coloured viscous liquid. It is a complex mixture of several solid, liquid, or gaseous hydrocarbons mixed with water, salt and earth particles".

Importance:

- Petroleum is a main source of organic compounds.
- It consists of several compounds mainly hydrocarbons.

ii. What types of compounds are synthesized by plants? ***(Knowledge Base)***

Ans: **COMPOUNDS SYNTHESIZED BY PLANTS**

Living plants synthesize macromolecules.

Examples:

Following are the important the compounds sysnthesized by plants:

- Carbohydrates
- Proteins
- Oils
- Vitamins

iii. What is the basic unit of carbohydrates and how it is synthesized? ***(Knowledge Base)***

Ans: **BASIC UNIT OF CARBOHYDRATES**

The basic unit of all types of carbohydrates is glucose.

Synthesis of Glucose:

Glucose is synthesized by plants through photosynthesis.

$$6CO_2 + 6H_2O \xrightarrow[\text{Sunlight}]{\text{Chlorophyl}} C_6H_{12}O_6 + 6O_2 + \text{Energy}$$

iv. CNG stands for? ***(Knowledge Base)***

Ans: **CNG STANDS FOR**

CNG stands for compressed natural gas, which is used as fuel in automobiles.

v. Our existence owe to organic compounds, comment. ***(Knowledge Base)***

Ans: **OWING OF OUR EXISTENCE**

Our existence owes to organic compounds because organic compounds are the part of everything from food we eat to the various items we use in daily life to fulfill our needs.

11.3 USES OF ORGANIC COMPOUNDS
MULTIPLE CHOICE QUESTIONS

1. Which one of the following is synthetic fibre? ***(K.B)***

(A) Cotton (B) Dacron
(C) Wool (D) Silk

2. Which one of the following is not fossil fuel? ***(K.B)***

(A) Dacron (B) Petroleum
(C) Natural gas (D) Coal

3. Which one of the following is natural fibre? ***(K.B)***

(A) Nylon (B) Dacron
(C) Wool (D) Acrylic

11.4 ALKANES AND ALKYL RADICALS

LONG QUESTIONS

Q.1 Define the homologous series. Write down its properties.

(Knowledge Base+Understanding Base)

(Ex-Q.7)(LHR 2015, FSD 2016 G-II)

OR

Write down the chracteristics of homologous series. **(Ex-Q.7)**

Ans: **<u>HOMOLOGOUS SERIES</u>**

*"The **group** of **similar compounds** in which each member differs from the adjacent member by –CH_2– group and have **same functional group** is called homologous series".*

<u>Examples:</u>

- Alkane series
- Alkene series
- Alkyne series

<u>Most Important Homologous Series:</u>

Alkanes from the most important homologous series of compounds. **Alkanes are saturated hydrocarbons** or paraffins (para means little, affin means affinity). Their general formula is $\mathbf{C_nH_{2n+2}}$, where 'n' is number of carbon atoms. In case of alkanes 'n' ranges from 1 to 40. In this way, alkanes form the most important homologous series of compounds.

<u>Properties of Homologous Series:</u>

Organic compounds are divided into groups of compounds having similar chemical properties. Each group is known as a homologous series. Organic compounds of the same homologous series have the following properties in common.

(i) <u>General Formula:</u>

All members of a series can be represented by a general formula.

<u>Examples:</u>

- General formula of Alkanes : C_nH_{2n+2}
- General formula of Alkenes : C_nH_{2n}
- General formula of Alkynes : C_nH_{2n-2}

(ii) <u>Difference Between Successive Members:</u>

Successive members of the series differ by one unit of **–CH_2–** and **14** units in their **relative molecular mass**.

(iii) <u>Chemical Properties:</u>

They have **similar chemical properties** (because they contain the same functional group).

(iv) <u>Physical Properties:</u>

There is a **regular change** in their **physical properties**; the **melting** and **boiling** points **increase** gradually with the **increase** of **molecular masses**.

(v) <u>Methods of Preparation:</u>

They can be prepared by similar general methods.

Q.2 What is alkyl radical? How alkyl radical can be formed?

(Knowledge Base+Understanding Base)

Ans: **ALKYL RADICAL**

Definition:

"The group of atoms formed by the removal of one of the hydrogen atom of an alkane is called alkyl radical".

General Formula:

Their general formula is $\mathbf{C_nH_{2n+1}}$

Formation:

Alkyl radicals are **derivatives** of **alkanes**. They are **formed** by the **removal** of one of the **hydrogen atoms** of an alkane and are **represented** by a letter **'R'.**

Nomenclature:

Their name is written by replacing 'ane' of alkane with "yl".

Examples:

(i) Alkyl Radicals of Propane:

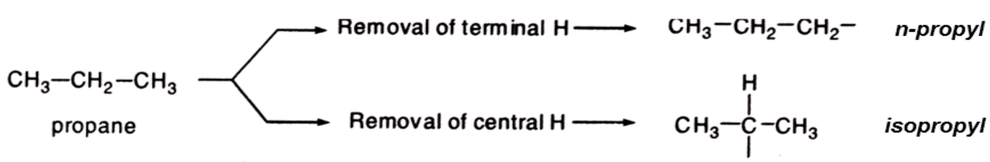
Following are two alkyl radicals of propane:

n-Propyl:

Propane has a straight chain structure. When **terminal H is removed** it is called **n-propyl.**

Iso-propyl:

When **hydrogen from central carbon** is removed it is called **isopropyl**, as explained below:



(ii) Alkyl Radicals of Butane:

Similarly, different structures of butyl radicals are explained:

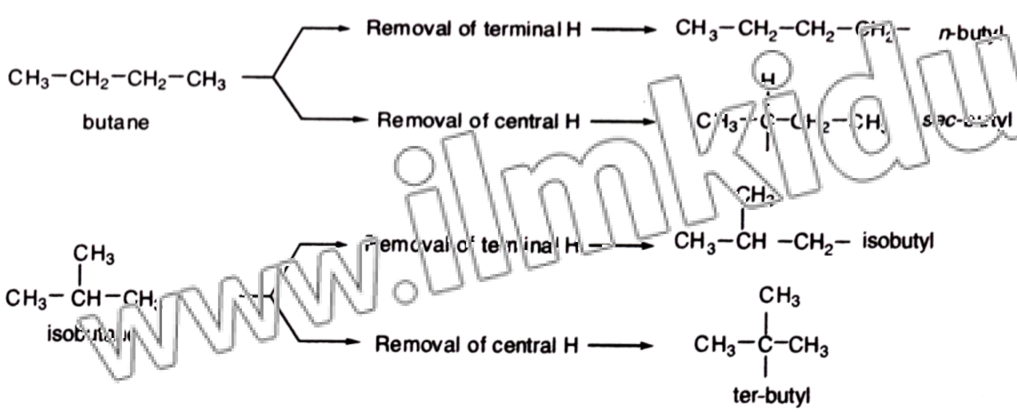


Table: Names and Molecular Formulae of Alkanes and their Alkyl Radicals

Alkane	Molecular Formula	Alkyl radical	Name
Methane	CH_4	CH_3 –	Methyl
Ethane	C_2H_6	C_2H_5 –	Ethyl
Propane	C_3H_8	C_3H_7 –	Propyl
Butane	C_4H_{10}	C_4H_9 –	Butyl
Pentane	C_5H_{12}	C_5H_{11} –	Pentyl
Hexane	C_6H_{14}	C_6H_{13} –	Hexyl
Heptane	C_7H_{16}	C_7H_{15} –	Heptyl
Octane	C_8H_{18}	C_8H_{17} –	Octyl
Nonane	C_9H_{20}	C_9H_{19} –	Nonyl
Decane	$C_{10}H_{22}$	$C_{10}H_{21}$ –	Decyl

11.4 ALKANES AND ALKYL RADICALS

SHORT QUESTIONS

Q.1 Define homologous series. ***(Knowledge Base)*** **(SGD 2016 G-I, II, MTN 2016 G-II, SWL 2016 G-II)**

Ans: **RADICALS OF BUTANE**

Definition:

"A group of similar compounds in which each member differs from the adjacent member by –CH_2– group and have same functional group is called homologous series".

Examples:

- Alkane series
- Alkene series
- Alkyne series

Q.2 Why hydrocarbons are regarded as parent organic compounds? ***(Knowledge Base)***

Ans: **PARENT ORGANIC COMPOUNDS**

Hyrocarbons are regarded as parent organic compounds because all other compounds are considered to be derived from them by substituting one or more hydrogen atoms of a hydrocarbon by one or more reactive atom or group of atoms.

MULTIPLE CHOICE QUESTIONS

1. **The molecular formula of pentane is:** ***(K.B)***
   (A) CH_4 (B) C_3H_8
   (C) C_5H_{12} (D) C_4H_{10}
2. **Which of the following are derived from alkanes?** ***(K.B)***
   (A) Alkyl radical (B) Alkane radical
   (C) Alkene radical (D) Alkyne radical
3. **How many carbons are present in octane?** ***(K.B)***
   (A) 5 (B) 6
   (C) 8 (D) 7

4. **The chemical formula of butane is:** ***(K.B)***
(A) C_5H_{12} (B) C_3H_8
(C) C_2H_6 (D) C_4H_{10}

5. **General formula of alkyl radical is:** ***(K.B)*** **(GRW 2017)**
(A) C_nH_{2n+2} (B) C_nH_6
(C) C_nH_{2n+1} (D) C_nH_8

6. **Paraffins means:** ***(K.B)***
(A) Little affinity (B) Very high affinity
(C) High affinity (D) None of these

7. **The removal of terminal hydrogen from the straight chain of propane is called:** ***(K.B)***
(A) n-propyl (B) Propane
(C) Isopropyl (D) Propene

8. **Alkanes are hydrocarbons:** ***(K.B)***
(A) Saturated (B) Unsatruated
(C) Cyclic (D) Very reactive

9. **When one hydrogen atom is removed from alkane it gives:** ***(K.B)***
(A) Ethene (B) Alkynes
(C) Alkyl radical (D) Aromatic compound

10. **Each member of homologous series differs from the successive member by:** ***(K.B)***
(A) CH_3 – group (B) – CH_2 – group
(C) – OH group (D) – CHO – group

11.5 FUNCTIONAL GROUPS

11.5.1 Functional Groups Containing Carbon, Hydrogen and Oxygen

11.5.2 Functional Groups Containing Carbon, Hydrogen and Nitrogen

11.5.3 Functional Groups Containing Carbon, Hydrogen and Halogen

11.5.4 Double and Triple Bond

LONG QUESTION

Q.1 Define the functional group. Explain functional groups containing carbon, hydrogen and oxygen with examples. ***(Knowledge+Understanding+Application Base)***

(Ex-Q.5)(SGD 2016 G-II)

OR

Write a detailed note on functional groups of alkenes and alkynes. How they are identified from other compounds? **(Ex-Q.5)**

Ans: **FUNCTIONAL GROUP**

Definition:

*"An **atom** or **group of atoms** or presence of **double** or **triple bond** which **determines** the **characteristic properties** of an organic compound is known as functional group".*

Alkyl Radical:

"The remaining part of the organic molecule (other than functional group) mainly determines the physical properties such as melting point, boiling point, density, etc and is called alkyl part or alkyl radical".

Examples:

- – OH group is the functional group of alcohols, which gives characteristics properties of alcohols.
- – COOH group is the functional group of carboxylic acids.

FUNCTIONAL GROUPS CONTAINING CARBON, HYDROGEN AND OXYGEN

The organic compounds containing carbon, hydrogen and oxygen as functional group are alcohols, ethers, aldehydes, ketones, carboxylic acids and esters.

(i) Alcoholic Group: **(GRW 2014, SGD 2014, SWL 2016, 17) (Ex-Q.10)**

*"The **functional group -OH** is called Alcoholic group".*

The functional group of alcohols is –OH.

General Formula:

Their **general formula** is **ROH**, where R is any alkyl group.

Exmaples:

H_3C-OH Methyl Alcohol

H_3C-CH_2-OH Ethyl Alcohol

$H_3C-CH_2-CH_2-OH$ n-propyl Alcohol

(ii) Ether Linkage: **(LHR 2015)**

*"The functional group **C– O – C** is called ether linkage".*

The functional group of ether is C– O – C.

General Formula:

Their general formula is **R -O- R'**. Where R and R' are alkyl groups. R and R' may be same or different.

Examples:

$H_3C-O-CH_3$ Dimethyl ether

$H_3C-CH_2-O-CH_2-CH_3$ Diethyl ether

$H_3C-O-C_2H_5$ Ethyl methyl ether

(iii) Aldehydic Group: **(Ex-Q.11)**

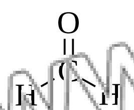
The functional group $-\overset{O}{\overset{\|}{C}}-H$ *is called aldehydic group".*

Aldehydes family consists of functional group $-\overset{O}{\overset{\|}{C}}-H$.

General Formula:

Their general formula is **RCHO**. Where **R** stands for **H** or some **alkyl group**.

Examples:



Formaldehyde

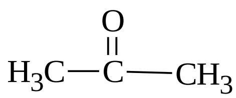
$H_3C-\overset{O}{\overset{\|}{C}}-H$

Acetaldehyde

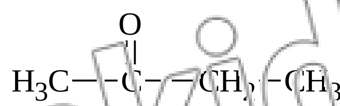
(iv) Ketonic Group: (LHR 2015) (Ex-Q.11)

*"The functional group **C=O** is called ketonic group".*

The compound containing **C=O** functional group are called ketones.



Dimethyl ketone



Ethyl methyl ketone

They have the general formula $\mathbf{R-\overset{\overset{O}{\|}}{C}-R'}$. Where **R and R'** are alkyl groups. They may be **same or different**.

(v) Carboxyl Group: (MTN 2016 G-II)

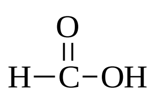
"*The functional group **–COOH** is called carboxyl group".*

The compounds containing –COOH as functional group are called carboxylic acids.

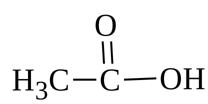
General Formula:

Their general formula is **R-COOH**. Where, **R stands for H** or some **alkyl group.**

Examples:



Formic acid



Acetic acid

(vi) Ester Linkage: (LHR 2015)

"The functional group $\mathbf{-\overset{\overset{O}{\|}}{C}-O-}$ *is called ester linkage or ester functional group".*

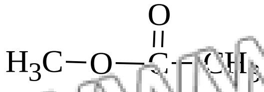
Organic compounds consisting of $\mathbf{-\overset{\overset{O}{\|}}{C}-O-}$ functional group are called esters.

General Formula:

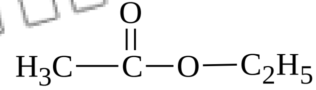
There general formula is **RCOOR'**.

Where **R and R'** are alkyl groups. They may be **same or different**, such as:

Examples:



Methyl acetate



Ethyl acetate

FUNCTIONAL GROUPS CONTAINING CARBON, HYDROGEN AND NITROGEN

(Ex-Q.9)

Amines:

*"The organic compounds containing **carbon, hydrogen and nitrogen** as functional group are called as amines".*

Functional Group:

Their functional group is $-\ddot{N}H_2$

General Formula:

Their general formula is $R-\ddot{N}H_2$

Examples:

$H_3C-\ddot{N}H_2$
Methylamine

$H_3C-\ddot{N}H-CH_3$
Dimethylamine

$(H_3C)_2\ddot{N}-CH_3$
Trimethylamine

Table 11.4 Functional Groups containing carbon, hydrogen and oxygen

Class Name	Functional Group	Class Formula	Examples
Alcohols			
Primary	$-CH_2-OH$	$R-CH_2-OH$	H_3C-CH_2-OH
Secondary	$>CH-OH$	R_2CH-OH	$(H_3C)_2CH-OH$
Tertiary	$-\overset{\vert}{\underset{\vert}{C}}-OH$	R_3C-OH	$(H_3C)_3C-OH$
Ethers	$-O-$	$R-O-R$	$H_3C-O-CH_3$
Aldehydes	$-\overset{O}{\overset{\Vert}{C}}-H$	$R-\overset{O}{\overset{\Vert}{C}}-H$	$H_3C-\overset{O}{\overset{\Vert}{C}}-H$
Ketones	$-\overset{O}{\overset{\Vert}{C}}-$	$R-\overset{O}{\overset{\Vert}{C}}-R$	$H_3C-\overset{O}{\overset{\Vert}{C}}-CH_3$
Carboxylic acids	$-\overset{O}{\overset{\Vert}{C}}-OH$	$R-\overset{O}{\overset{\Vert}{C}}-OH$	$H_3C-\overset{O}{\overset{\Vert}{C}}-OH$
Esters	$-\overset{O}{\overset{\Vert}{C}}-OR$	$R-\overset{O}{\overset{\Vert}{C}}-OR$	$H_3C-\overset{O}{\overset{\Vert}{C}}-OC_2H_5$

FUNCTIONAL GROUP CONTAINING CARBON, HYDROGEN AND HALOGENS

*"The organic compounds having **functional group** containing **carbon**, **hydrogen** and **halogens** are called **alkyl halides".***

Functional Group:

Their functional group is **– X.**

General Formula:

There general formula is **R – X.** Where X = F, Cl, Br or I)

Table 11.4 Functional Groups containing carbon, hydrogen and oxygen

Class Name	Functional Group	Class Formula	Examples
Alkyl Halides a. Primary	$-CH_2-X$	$R-CH_2-X$	H_3C-CH_2-X Ethyl halide
b. Secondary	$>CH-X$	R_2CH-X	$(H_3C)_2CH-X$ *sec*-Propyl halide
c. Tertiary	$-\overset{\vert}{\underset{\vert}{C}}-X$	R_3C-X	$H_3C-C(CH_3)_2-X$ *ter*-Butyl halide

DOUBLE AND TRIPLE BOND

(i) Alkenes:

"Hydrocarbon compounds consisting of double bonds between two carbon atoms in their molecules are called alkenes".

Examples:

$H_2C = CH_2$ Ethene

$H_3C - HC = CH_2$ Propene

(ii) Alkynes:

"Hydrocarbon compounds consisting of triple bonds between two carbon atoms in their molecules are called alkynes".

Examples:

$HC \equiv CH$ Ethyne

$H_3C - C \equiv CH$ Propyne

11.5 FUNCTIONAL GROUPS

SHORT QUESTIONS

Q.1 Write the general formula of aldehydic group. **(SWL 2016 G-II)**

Ans: **ALDEHYDIC GROUP**

The general formula of aldehydic group is $R - \overset{\overset{\large O}{\Vert}}{C} - H$.

Q.2 What is composition of perfume? Give functional groups present in geraniol.

(Interesting Information Pg. # 69)

Ans: **COMPOSITION OF PERFUME**

Perfumes often contain rose oil, which consists of distinct smell giving organic compound geraniol.

Functional Groups of Geraniol:

Geraniol consists of two functional groups; carbon-carbon double bond and the hydroxyl group.

Q.3 How dogs recognize the characteristic smell of human sweat?

(Interesting Information Pg. # 69)

Ans: **SMELL OF HUMAN SWEAT**

A sniffing dog can recognize the **characteristic smell** of **human sweat**. Each person's sweat contains a unique blend of **carboxylic acids.**

11.5 FUNCTIONAL GROUPS
MULTIPLE CHOICE QUESTIONS

1. **Functional group – OH is found in:** ***(K.B)***
   (A) Alcohols (B) Carboxylic acids
   (C) Ethers (D) Esters
2. **Perfumes contain:** ***(K.B)***
   (A) Sunflower oil (B) Rose oil
   (C) Soya bean oil (D) Palm oil
3. **Functional group C-O-C is found in:** ***(K.B)***
   (A) Alcohols (B) Carboxylic acids
   (C) Ethers (D) Esters
4. **$CH_3–O–CH_3$ is called:** ***(K.B)***
   (A) Dimethyl ether (B) Diethyl ether
   (C) Ethyl methyl ether (D) Propyl ether
5. **The characteristics of carboxylic acids are due to the presence of group:** ***(K.B)***
   (A) $-\overset{\overset{\displaystyle O}{\|}}{C}-$ (B) –COOH
   (C) –OH (D) C–O–C

6. Which one contains double bond? *(K.B)*

(A) Alkene (B) Alkyne
(C) Alkane (D) Alkyle

7. Which one contains triple bond? *(K.B)*

(A) Alkyne (B) Alkyle
(C) Alkane (D) Alkene

8. Organic compounds containing carbon, hydrogen and halogens are called: *(K.B)*

(A) Alkyl halides (B) Alkene
(C) Amines (D) Halides

9. Organic compounds containing – NH_2 are called: *(K.B)*

(A) Thiophene (B) Alkyne
(C) Amines (D) Alkane

10. Geraniol consists of _________ functional group. *(K.B)*

(A) 2 (B) 4
(C) 3 (D) 5

11. Organic compounds consisting of $-\overset{\overset{\large O}{\|}}{C}-O-$ functional group are called *(K.B)*

(A) Ethers (B) Ketones
(C) Esters (D) Carboxylic acids

12. Members of a homologous series have same: *(K.B)*

(A) Chemical properties (B) Physical properties
(C) Melting point (D) Density

13. The functional group —COOH is found in: *(K.B)* **(GRW 2014)**

(A) Carboxylic acids (B) Aldehydes
(C) Alcohols (D) Esters

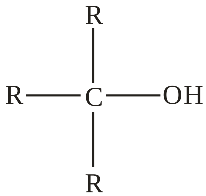
14. Which one is carboxylic group? *(K.B)* **(GRW 2015)**

(A) $\rangle C=OH$ (B) $-\overset{\overset{\large O}{\|}}{C}-OH$

(C) $-\overset{\overset{\large O}{\|}}{C}-H$ (D) $R-\overset{\overset{\large O}{\|}}{C}-OR$

15. Class formula of primary alcohols is: *(K.B)* **(GRW 2015)**

(A) $R-CH_2-OH$ (B) $\begin{matrix}R\\R\end{matrix}\rangle CH-OH$

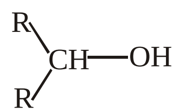
(C)  (D) R - O – R

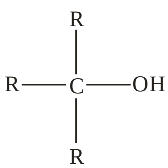
16. **Which one of the following compounds is ketone? *(K.B)*** **(GRW 2016)**

(A) $(CH_3)_2CHOH$ (B) $(CH_3)_2CO$

(C) $(CH_3)_2NH$ (D) $(CH_3)_2CHC\ell$

17. **Formula of tertiary alcohols is. *(K.B)*** **(RWP 2016 G-II)**

(A) R – CH_2 - OH (B) 

(C)  (D) R - O – R

11.6 TESTS FOR FUNCTIONAL GROUPS

LONG QUESTIONS

Q.1 **Give the tests for functional groups. *(Knowlegde+Understanding+Application Base)***

Ans: **<u>TESTS FOR FUNCTIONAL GROUPS</u>**

a. <u>Tests for Unsaturation</u>: $>C=C<$ or $-C\equiv C-$

(i) <u>Bromine Water Test:</u>

Dissolve a **pinch** of the given **organic compound** in **2.0 cm^3 of carbon tetrachloride (CCl_4)**. Add **2 cm^3** of **bromine water** in it and shake.

<u>Result:</u>

Bromine will be **decolourised.**

(ii) <u>Baeyer's Test:</u>

Dissolve about **0.2 g** of the **organic compound** in water. Add to it **2-3 drops** of **alkaline $KMnO_4$ solution and shake.**

<u>Result:</u>

Pink colour will disappear.

b. <u>Tests for Alcoholic Group –OH:</u> **(Ex-Q.10) (SWL 2016 G-I)**

(i) <u>Sodium Metal Test:</u>

Take about **2-3 cm^3** of the given **organic liquid** in a **dry test tube** and add a **piece** of **sodium metal.**

<u>Result:</u>

Hydrogen gas will evolve.

(ii) <u>Ester Formation Test:</u>

Heat about **1.0 cm^3** of the **organic compound** with **1.0 cm^3** of **acetic acid** and **1-2 drops** of concentrated **sulphuric acid**.

Result:
Fruity smell will be given out.

c. Tests for Carboxylic Group –COOH:

(i) Litmus Test:
Shake a **pinch** of the **given compound** with water and add a drop of **blue litmus solution**.
Result:
Litmus paper (solution) will turn red.

(ii) $NaHCO_3$ Solution Test:
Take about **2.0 cm^3 of 5% $NaHCO_3$** solution and add a **pinch** of **given compound**.
Result:
CO_2 gas with effervescence evolves.

d. Detection of Aldehydic Group –CHO : **(Ex-Q.12)**

$$\begin{array}{c} O \\ \| \\ -C-H \end{array}$$

(i) Sodium Bisulphite Test:
Shake about **0.2 g or 0.5 cm^3** of the given compound with **1-2 cm^3** of **saturated solution** of **sodium bisulphite**.
Result:
A crystalline white precipitate will be formed.

(ii) Fehling's Solution Test:
Mix **equal volumes** of **Fehling's solution A and B** in a test tube. Add a pinch of organic compound and **boil for five minutes**.
Result:
Red precipitate will be formed.

e. Tests for Ketonic Group: **(Ex-Q.12)**

(i) Phenyl Hydrazine Test:
Shake a pinch of the given **organic compound** with about **2.0 cm^3** of **phenyl hydrazine solution.**
Result:
Orange red precipitate will be formed.

(ii) Sodium Nitroprusside Test:
Take about **2.0 cm^3 of sodium nitroprusside** solution in a test tube and add **2-3 drops of NaOH solution**. Now add a pinch of the given compound and shake.
Result:
Red colour will be formed.

(iii) Fehling's Solution Test:
No reaction

f. Tests for Primary Amino Group ($-NH_2$): **(Ex-Q.9)**

Carbyl Amine Test:
Heat about **0.2 g** of the **given compound** and add **0.5 cm^3 of chloroform** and add **2-3 cm^3**

of alcoholic KOH.

<u>Result:</u>

Extremely unpleasant odour will be given out.

g. <u>Tests for Esters:</u>

They are recognized by their fruity smell.

11.6 TESTS FOR FUNCTIONAL GROUPS

SHORT QUESTIONS

Q.1 **What is carbyl amine test? *(Knowledge Base+Understanding Base)***

Ans: *Answer given on Page # 146*

Q.2 **What is Baeyer's test? *(Knowledge Base+Understanding Base)***

Ans: *Answer given on Page # 145*

Q.3 **How can aldehydic group be identified? *(Knowledge Base+Understanding Base)*** **(Ex-Q.12)**

Ans: *Answer given on Page # 146*

Q.4 **What is bromine water test? *(Knowledge Base+Understanding Base)*** **(SWL 2017)**

OR

Which reaction is used to identify the unsaturation of an organic compound?

Ans: *Answer given on Page # 145*

Q.5 **Pharmaceutical chemists work towards the partial and total synthesis of effective drugs. Comment. *(Understanding Base)*** **(Science, Technology and Society Pg. # 73)**

Ans: **<u>WORK OF PHARMACEUTICAL CHEMISTS</u>**

Synthesis of effective drugs to control the epidemics and fatal diseases is the need of the society. The responsibility to synthesize effective drugs is of pharmaceutical chemists. They can evaluate the efficiency and safety of these drugs. They make the drugs more and more effective by reducing their side effects and enhancing potency.

11.4 TEST YOURSELF

i. **What is the functional group of an ester? *(Knowledge Base+Understanding Base)*** **(LHR 2013)**

Ans: **<u>FUNCTIONAL GROUP OF AN ESTER</u>**

Esters have $\mathbf{R-\overset{O}{\overset{\|}{C}}-OR'}$ general formula where R and R' are the alkyl groups that may or may not be same.

Thus,

Functional group of an ester $\mathbf{-\overset{O}{\overset{\|}{C}}-OR'}$

<u>Example:</u> $\mathbf{[CH_3-\overset{O}{\overset{\|}{C}}-O-CH_3]}$

Methyl Acetate

ii. What is the difference between aldehydes and ketones?

(Knowledge Base+Understanding Base)

Ans: **DIFFERENTIATION**

The differences between aldehydes and ketones are as follows:

Aldehydes	Ketones
Functional Group	
• Aldehydes have functional group $-\overset{\overset{\large O}{\|}}{C}-H$	• Ketones have functional group $-\overset{\overset{\large O}{\|\|}}{C}-$
General Formula	
• Their general formula is RCHO $R-\overset{\overset{\large O}{\|\|}}{C}-H$	• Their general formula is $R-\overset{\overset{\large O}{\|\|}}{C}-R'$
Examples	
• $H-\overset{\overset{\large O}{\|\|}}{C}-H$	• $H_3C-\overset{\overset{\large O}{\|\|}}{C}-CH_3$

iii. Give the functional groups of alkenes and alkynes?

(Knowledge Base+Understanding Base)

Ans: **FUNCTIONAL GROUPS**

Folowing are the functional groups of alkenes and alkynes:

Alkenes: $>C=C<$

Alkynes: $-C\equiv C-$

iv. How an alcohol is tested? ?*(Knowledge Base+Understanding Base)* **(SGD 2016 G-II)**

Ans: **TESTS FOR ALCOHOL**

Alcoholic group is tested by sodium metal test and ester formation test.

(i) Sodium Metal Test

Take 2 – 3 cm^3 of the given organic compound in dry test tube and add a piece of sodium metal.

Result:

Hydrogen gas will evolve.

(ii) Ester Formation Test

Take about 2–3cm^3 of given organic compound with 1.0 cm^3 of acetic acid and 1-2 drops of concentrated sulphuric acid.

Result:

Fruity smell will be given out.

v. **How a ketonic group is tested? *(Knowledge Base+Understanding Base)***

Ans: **TESTS FOR KETONIC GROUP**

Ketonic group is tested by following tests.

(i) Phenyl Hydrazine Test:

Shake a pinch of the given organic compound with 2.0 cm^3 of phenyl hydrazine solution.

Result:

Orange red precipitate will be formed.

(ii) Sodium Nitroprusside Test:

Take about 2.0 cm^3 of sodium nitroprusside solution in test tube and add 2-3 drops of NaOH solution. Now add a pinch of organic compound and shake it.

Result:

Red colour will be formed.

(iii) Fehling's Solution Test:

No reaction

11.6 TESTS FOR FUNCTIONAL GROUPS

MULTIPLE CHOICE QUESTIONS

1. **Baeyer's test results in disappearance of colour: *(K.B)***

(A) Pink (B) Red
(C) Orange red (D) White

2. **Esters are recognized by their: *(K.B)***

(A) Fruity smell (B) Fruity taste
(C) Fruity colour (D) Unpleasant smell

3. **Fehling's solution test gives colour precipitate of: *(U.B+K.B)***

(A) Red colour (B) White colour
(C) Black colour (D) Orange red colour

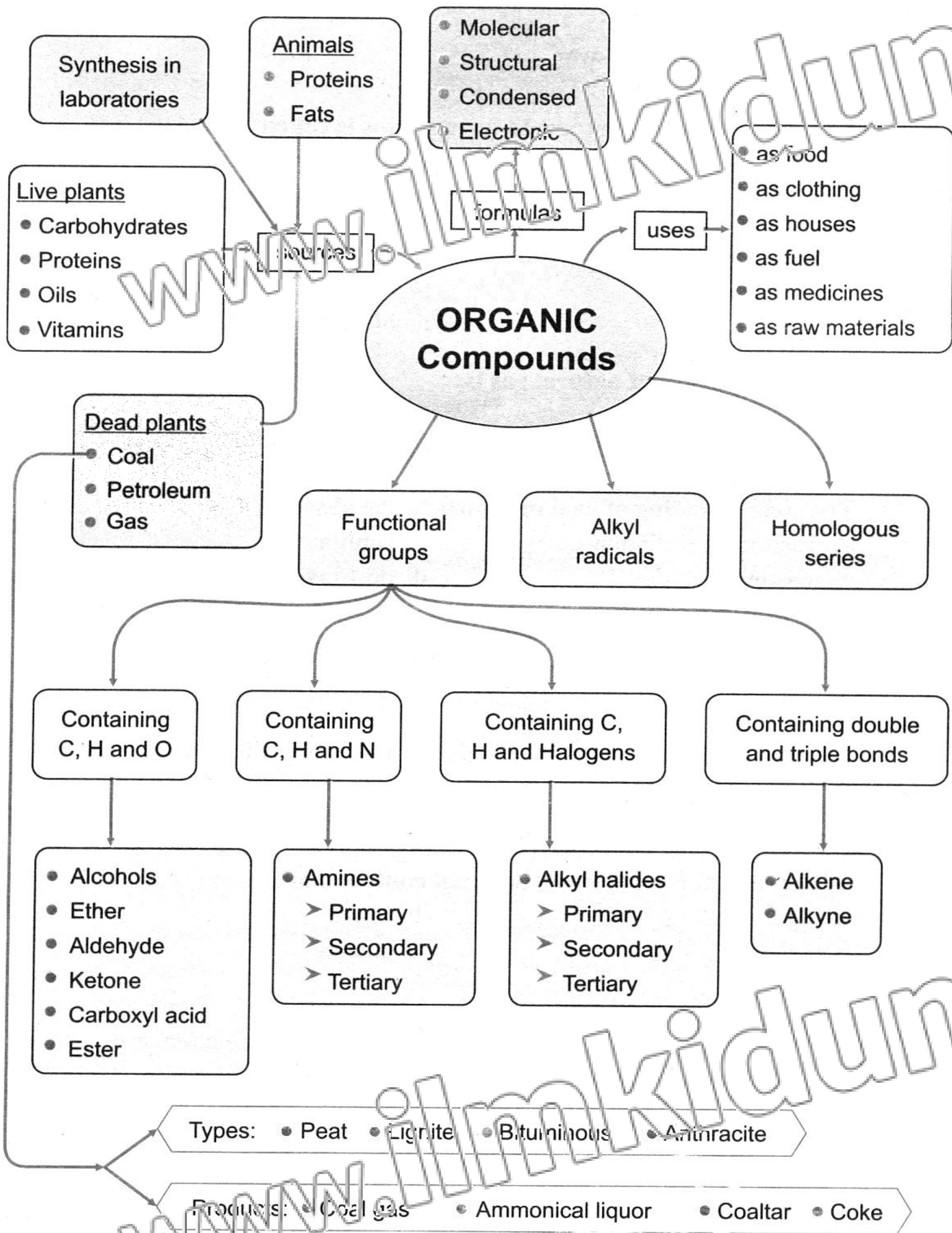
4. **Extremely unpleasant smell will be given out for test: *(K.B)***

(A) Carbyl amine (B) Fehling solution
(C) Sodium sulphite (D) Litmus

5. **Phenylhydrazine reacts with ketones and forms: *(A.B)***

(A) Orange red ppt (B) Brown ppt.
(C) White ppt. (D) Red ppt.

CONCEPT DIAGRAM



ANSWER KEY
MULTIPLE CHOICE QUESTIONS
INTRODUCTION

1	D
2	A
3	A
4	A
5	B

11.1 ORGANIC COMPOUNDS

1	**C**	6	**C**
2	**D**	7	**C**
3	**B**	8	**C**
4	**A**	9	**A**
5	**D**		

11.1.1 CLASSIFICATION OF ORGANIC COMPOUNDS

1	C
2	A
3	A
4	C

11.1.2 DIVERSITY AND MAGNITUDE OF ORGANIC COMPOUNDS

1	D
2	C
3	C
4	A
5	C
6	D

11.1.3 GENERAL CHARACTERISTICS OF ORGANIC COMPOUNDS

1	B
2	A
3	A
4	B
5	A

11.2 SOURCES OF ORGANIC COMPOUNDS

1	A	6	B	11	C
2	D	7	C	12	A
3	B	8	A		
4	D	9	D		
5	B	10	D		

11.2.2 PETROLEUM To 11.2.5 SYNTHESIS IN LABORATORY

1	A	6	D
2	A		
3	A		
4	A		
5	A		

11.3 USES OF ORGANIC COMPOUNDS

1	B
2	A
3	C

11.4 ALKANES AND ALKYL RADICALS

1	C	6	A
2	A	7	A
3	C	8	A
4	D	9	C
5	C	10	B

11.5 FUNCTIONAL GROUPS

1	A	6	A	11	C	16	B
2	B	7	A	12	A	17	C
3	C	8	A	13	A		
4	A	9	C	14	B		
5	B	10	A	15	A		

11.6 TESTS FOR FUNCTIONAL GROUPS

1	A
2	A
3	A
4	A
5	A

EXERCISE SOLUTION
MULTIPLE CHOICE QUESTIONS

1. **The ability of carbon atoms to form chains is called: *(K.B)***
(GRW 2013, LHR 2014, SGD 2014, FSD 2016 G-II, SWL 2017 G-I)
(a) Isomerism (b) Catenation
(c) Resonance (d) Condensation

2. **Coal having 90% carbon contents is called: *(K.B)*** **(DGK 2017, MTN 2017, SGD 2017)**
(a) Peat (b) Lignite
(c) Anthracite (d) Bituminous

3. **Main component of natural gas is: *(K.B)*** **(GRW 2013, LHR 2015, RWP 2017, MTN 2016 G-I, II)**
(a) Methane (b) Propane
(c) Butane (d) Propene

4. **The strong heating of coal in retorts in the absence of air is called: *(K.B)***
(a) Fractional distillation (b) Sublimation
(c) Roasting (d) Destructive distillation

5. **Pitch is black residue of: *(K.B)*** **(SGD 2016 G-I, SWL 2016 G-II, BWP 2016 G-II)**
(a) Coke (b) Coal tar
(c) Coal (d) Coal gas

6. **Natural gas is 85% methane. It is used to make the following except: *(K.B)***
(a) Carbon black (b) Coke
(c) Coal tar (d) Coal gas

7. **Which one of the following does not contain starch? *(K.B)***
(a) Sugar cane (b) Maize
(c) Barley (d) Potatoes

8. **Petroleum is refined by: *(K.B)***
(a) Destructive distillation (b) Fractional distillation
(c) Simple distillation (d) Dry distillation

9. **In laboratory urea was prepared by: *(K.B)*** **(SGD 2016 G-II, MTN 2016, G-II)**
(a) Wohler (b) Rutherford
(c) Berzellius (d) Dalton

10. **General formula of alkyl radical is: *(K.B)*** **(SGD 2017, BWP 2016 G-I)**
(a) C_nH_{2n+2} (b) C_nH_{2n-2}
(c) C_nH_{2n+1} (d) C_nH_{2n}

11. **Identify which one of the following compounds is a ketone? *(K.B)***
(a) $(CH_3)_2CHOH$ (b) $(CH_3)_2CO$
(c) $(CH_3)_2NH$ (d) $(CH_3)_2CHCl$

12. **The functional group -COOH is found in: *(K.B)*** **(GRW 2014)**
(a) Carboxylic acid (b) Aldehydes
(c) Alcohols (d) Esters

13. Which one of the following statements is not true about fossil fuels? *(K.B)*

(a) They all contain carbon (b) They are renewable
(c) They produce pollutants when burnt (d) They cause acid rain

14. Which one of the following is the hardest coal? *(K.B)* **(DGK 2017, SWL 2016 G-I)**

(a) Peat (b) Lignite
(c) Bituminous (d) Anthracite

15. In which of the following groups, oxygen is attached on both sides with carbon atoms?*(U.B)*

(a) Ketone (b) Ether
(c) Aldehyde (d) Ester

16. Carbonization process is the conversion of: *(K.B)*

(a) Coal into coal gas (b) Coal into wood
(c) Wood into coal (d) Wood into coal tar

17. Coal gas is a mixture of: *(K.B)* **(FSD 2016 G-I)**

(a) CO and CH_4 (b) CO, CH_4, CO_2
(c) CO, CH_4, H_2 (d) CO, H_2 and CO_2

18. Which one of the following is a synthetic fibre? *(K.B)*

(a) Cotton (b) Wool
(c) Nylon (d) Silk

19. Which one of the following is not a fossil fuel? *(K.B)*

(a) Coal (b) Natural gas
(c) Biogas (d) Petroleum

20. Which one of the following does not contain protein? *(K.B)*

(a) Pulses (b) Potatoes
(c) Beans (d) Eggs

21. Conversion of dead plants into coal by the action of bacteria and heat is called: *(K.B)* **(DGK 2016 G-I)**

(a) Carbonization (b) Catenation
(c) Hydrogenation (d) Cracking

22. Which one of the following compounds is an aldehyde? *(K.B)*

(a) CH_3-CH_2-OH (b) CH_3-COOH
(c) CH_3CHO (d) CH_3COCH_3

23. Formula of acetaldehyde is:

(a) CH_3-CH_2OH (b) $CH_3-\overset{\overset{O}{\|}}{C}-OH$
(c) $CH_3-\overset{\overset{O}{\|}}{C}-H$ (d) $H-\overset{\overset{O}{\|}}{C}-H$

ANSWER KEY

1	b	**6**	a	**11**	b	**16**	c	**21**	a
2	c	**7**	a	**12**	a	**17**	c	**22**	c
3	a	**8**	b	**13**	b	**18**	c	**23**	c
4	d	**9**	a	**14**	d	**19**	c		
5	b	**10**	c	**15**	b	**20**	b		

EXERCISE SHORT QUESTIONS

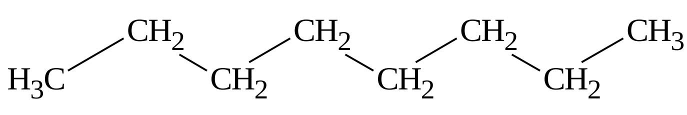
1. What is meant by the term catenation? Give an example of a compound which displays catenation. ***(Knowledge Base)*** **(GRW 2014, SWL 2016 G-I, DGK 2016 G-II)**

Ans: **CATENATION**

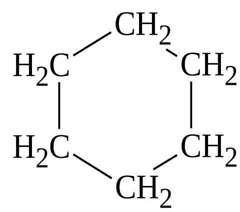
Definition:

"*The ability of carbon atoms to link with other carbon atoms to form long chains and large rings is called catenation*".

Examples:



n-octane



cyclohexane

2. How coal is formed? ***(Knowledge+Understanding Base)***

Ans: **FORMATION OF COAL**

Coal is formed by the decomposition of dead plants burried under the Earth's crust millions of years ago. It is very show bio-chemical process. Coal is formed by carbonization of wood. It takes place in the absence of air under high pressure and high temperature over a long period of time (about 500 millions of years).

$$\underset{40\%\,C}{\textbf{Wood}} \xrightarrow[\text{Biochemical}]{\text{Bacterial}} \underset{60\%\,C}{\textbf{Peat}} \xrightarrow[\text{Press}]{\text{High temperature}} \underset{70\%\,C}{\textbf{Lignite}} \xrightarrow{\text{Pressure}} \underset{80\%\,C}{\textbf{Bituminous}} \xrightarrow{\text{Pressure}} \underset{90\%\,C}{\textbf{Anthracite}}$$

3. What is importance of natural gas? ***(Knowledge Base)*** **(BWP 2016 G-I)**

Ans: **IMPORTANCE OF NATURAL GAS**

Natural gas is used:

- As fuel in homes as well as in industries.
- As fuel in automobiles as compressed natural gas (CNG).
- To make carbon black and fertilizer.

4. Justify that organic compounds are used as food. ***(Knowledge Base)***
(GRW 2014, MTN 2017, DGK 2016 G-I)

Ans: **ORGANIC COMPOUNDS AS FOOD**

Organic compounds are used as food because the food we eat daily such as milk, eggs, meat, vegetables etc. contains carbohydrates, proteins, fats, vitamins etc. are all organic stuff.

5. How alkyl radicals are formed? Explain with examples. ***(Knowledge Base)***

(FSD 2016 G-I)

Ans: **FORMATION OF ALKYL RADICALS**

Alkyl radicals are the derivatives of alkanes. They are formed by the removal of one hydrogen atom of an alkane and are represented by a letter "R".

Example:

Alkyl Radicals of Propane:

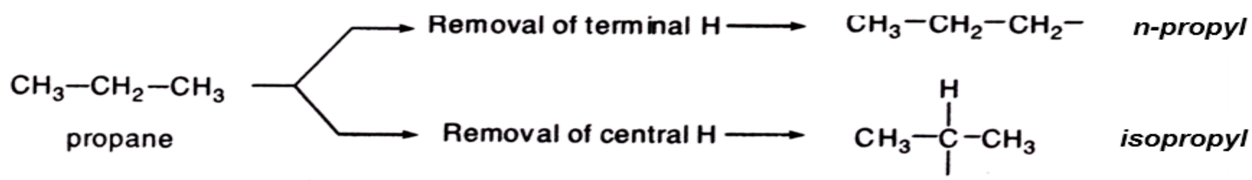
Following are two alkyl radicals of propane:

n-Propyl:

Propane has a **straight chain** structure. When **terminal H** is **removed** it is called **n-propyl.**

Iso-propyl:

When **hydrogen** from central carbon is **removed** it is called **isopropyl**, as explained below:



6. What is the difference between n-propyl and isopropyl?

(Knowledge+Understanding Base) **(LHR 2015, FSD 2016G-II, MTN 2016 G-II)**

Ans: **DIFFERENTIATION**

The differences between n-propyl and isopropyl are as follows:

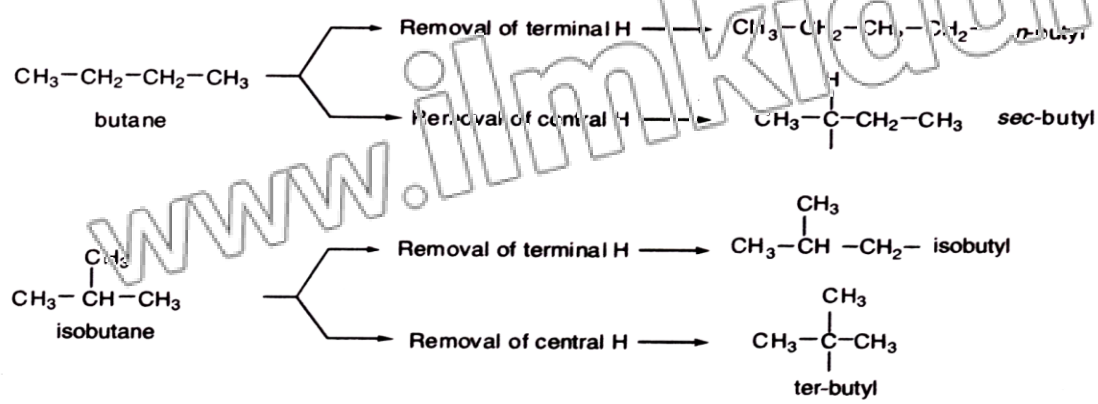
n-Propyl	Isopropyl
Definition	
When **terminal hydrogen** is **removed** from the structure of n-propane, n propyl is obtained. n-propyl is the radical of propane.	When **central hydrogen** is **removed** from the structure of n-propane, it is called isopropyl. Isopropyl is also the radical of propane.
Formation	
$CH_3-CH_2-CH_3 \rightarrow$ Removal of terminal "H" $\downarrow$ $CH_3-CH_2-CH_2-$ n-propyl	$CH_3-CH_2-CH_3 \rightarrow$ Removal of Central "H" $\downarrow$ H CH_3-C-CH_3 Iso–propyl

7. Explain different radicals of butane. *(Knowledge Base)* **(RWP 2017, SGD 2016 G-II)**

Ans: **<u>RADICALS OF BUTANE</u>**

Butane has two isomers, n-butane and isobutane.

Different radicals of butane which are possible, are as follows.



8. Define functional group with an example. *(Knowledge Base)*
(LHR 2014, 15, GRW 2013M, SGD 2016 G-II, DGK 2016 G-II)

Ans: **<u>FUNCTIONAL GROUP</u>**

<u>Definition:</u>

*"An **atom** or **group of atoms** or presence of **double or triple bond** which determines the **characteristic properties** of an **organic compound** is known as the **functional group**".*

<u>Examples:</u>

- **Alcoholic functional group: (–OH)** present in alcohols
- **Carboxylic functional group: (–COOH)** present in carboxylic acids

9. What is an ester group? Write down the formula of ethyl acetate. *(Knowledge Base)*
(LHR 2013, FSD 2016 G-II)

Ans: **<u>ESTER GROUP</u>**

<u>Definition:</u>

"The functional group $-\overset{\overset{\displaystyle O}{\|}}{C}-O-$ *is called ester group"*

<u>General Formula:</u>

General formula of esters is $R-\overset{\overset{\displaystyle O}{\|}}{C}-O-R'$.

Where R and R' are alkyl groups. They may be same or different.

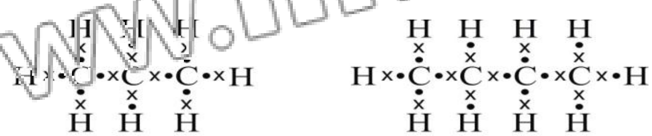
<u>Formula of Ethyl Acetate:</u>

Formula of ethyl acetate is $CH_3COOCH_2CH_3$.

10. Write down the dot and cross formulae of propane and n-butane? *(Knowledge Base)*

Ans: **<u>DOT AND CROSS FORMULAE</u>**

The dot and cross formulae of propane and n-butane are as follows:.



Propane n-butane

11. Define structural formula. Draw the structural formulae of n-butane and isobutane.
(Knowledge Base) **(BWP 2017, MTN 2017, SWL 2016 G-I)**

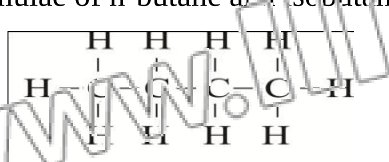
Ans: **STRUCTURAL FORMULA**

Definition:

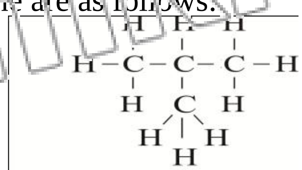
*"Structural formula of a compound represents the **exact arrangement** of **different atoms** of **various elements** present in a molecule of a substance".*

Structural formulae:

Structural formulae of n-butane and isobutane are as follows:



n-butane



isobutane

12. Write down classification of coal. *(Knowledge Base)*

Ans: **CLASSIFICATION OF COAL**

Following are the different classes of coal:

Type of Coal	Carbon Contents	Uses
Peat	**60%**	It is inferior quality coal used in kiln.
Lignite	**70%**	It is soft coal used in thermal power stations.
Bituminous	**80%**	It is common variety of coal used as household coal.
Anthracite	**90%**	It is superior quality hard coal that is used in industry.

13. What are heterocyclic compounds? Give two examples. *(Knowledge Base)*

(DGK 2017, FSD 2016 G-I, BWP 2016 G-I)

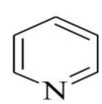
Ans: **HETEROCYCLIC COMPOUNDS**

Definition:

*"The **cyclic compounds** that contain **one** or **more atoms other than** that of **carbon** atoms in their rings are called heterocyclic compounds"*

.**Examples:**

Thiophene



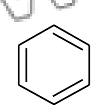
Pyridine

14. Why benzene and other homologous compounds of benzene are called aromatic compounds?
(Knowledge Base) **(DGK 2016 G-II)**

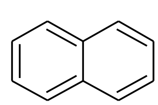
Ans: **AROMATIC COMPOUNDS**

These compounds are called aromatic because of **aroma or smell** that these compounds have. These compounds are also called benzenoid compounds.

Examples:



Benzene



Naphthalene

EXERCISE LONG QUESTIONS

Q.1 How is coal formed? What are the different types of coal?
Ans: See LQ.2 (Topic 11.2)
Q.2 Write down the composition and uses of different types of coal.
Ans: See LQ. 2 (Topic 11.2)
Q.3 What is destructive distillation of coal?
Ans: See LQ.3 (Topic 11.2)
Q.4 Name the different types of the products obtained by the destructive distillation of coal.
Ans: See LQ.3 (topic 11.2)
Q.5 Write a detailed note on functional groups of alkenes and alkynes. How they are identified from other compounds? ***(Knoowlegde+Understanding Base)***
Ans:

FUNCTIONAL GROUPS

Alkenes:
*"Hydrocarbon compounds consisting of **double bonds** between **two carbon atoms** in their molecules are called alkenes".*

Examples:
- $H_2C = CH_2$ **Ethene**
- $H_3C - HC = CH_2$ **Propene**

Alkynes:
*"Hydrocarbon compounds consisting of **triple bonds** between **two carbon atoms** in their molecules are called alkynes".*

Examples:
- $HC \equiv CH$ **Ethyne**
- $H_3C - C \equiv CH$ **Propyne**

IDENTIFICATION OF ALKENES AND ALKYNES

Alkenes and alkynes are identified form other organic compoudns by the following tests:

(i) Bromine Water Test:
Dissolve a pinch of the given organic compound in 2.0 cm^3 of carbon tetrachloride (CCl_4). Add 2 cm^3 of bromine water in it and shake.

Result:
Bromine will be decolourised.

(ii) Baeyer's Test:
Dissolve about 0.2 g of the organic compound in water. Add to it 2-3 drops of alkaline $KMnO_4$ solution and shake.

Result:
Pink colour will disappear.

Q.6 Give some uses of organic compounds in our daily life.
Ans: See LQ.1 (Topic 11.3)
Q.7 Write down the characteristics of homologous series.
Ans: See LQ.1 (Topic 11.4)
Q.8 Why organic compounds are numerous?
Ans: See LQ.1 (Topic 11.1.2)
Q.9 What are amines? Explain the different types of amines giving an example of each

type. How primary amino group is identified?

Ans:

AMINES:

"The organic compounds containing carbon, hydrogen and nitrogen as functional group are called as amines".

Functional Group:

Their functional group is $-\ddot{N}H_2$

General Formula:

Their general formula is $R-\ddot{N}H_2$

TYPES OF AMINES

Following are the types of amines:

Primary Amines:

"The amines in which one carbon atom is attached directly to the nitrogen atom of amino ($-\ddot{N}H_2$) *group are called primary amines."*

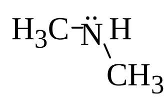
Example: $CH_3-\ddot{N}H_2$

Methyl Amine

Secondary Amines:

*"The amines in which **two carbon atoms** are attached directly to the nitrogen atom of amino* ($-\ddot{N}H_2$) *group are called secondary amines."*

Example:

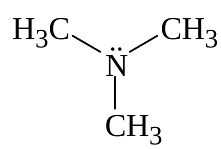


Dimethylamine

Tertiary amines:

*"The amines in which **three carbon atoms** are attached directly to the nitrogen atom of amino* ($-\ddot{N}H_2$) *group are called tertiary amines."*

Example:



Trimethylamine

IDENTIFICATION OF PRIMARY AMINO GROUP

Carbyl Amine Test is used for the indentification of primary amino group. Heat about 0.2 g of the given compound and add 0.5 cm^3 of chloroform and add 2-3 cm^3 of alcoholic KOH.

Result:

Extremely unpleasant odour will be given out.

Q.10 Describe the functional group of an alcohol. How alcoholic groups are identified?

Ans: **(GRW 2014, SGD 2014, SWL 2016, 17)(Ex.Q.10)**

ALCOHOLIC GROUP

*"The functional group of **alcohols is –OH**".*

Their **general formula is ROH**, where R is any alkyl group.

H_3C-OH	H_3C-CH_2-OH	$H_3C-CH_2-CH_2-OH$
Methyl Alcohol	Ethyl Alcohol	n-propyl Alcohol

Identification of Alcoholic Group –OH: **(Ex-Q.10) (SWL 2016 G-I)**

(i) Sodium Metal Test:

Take about 2-3 cm^3 of the given organic liquid in a dry test tube and add a piece of sodium metal.

Result:

Hydrogen gas will evolve.

(ii) Ester Formation Test:

Heat about 1.0 cm^3 of the organic compound with 1.0 cm^3 of acetic acid and 1-2 drops of concentrated sulphuric acid.

Result:

Fruity smell will be given out.

Q.11 Differentiate between aldehydic and ketonic functional groups. How both are identified from each other?

Ans: **DIFFERENTIATION**

The differences between aldehydes and ketones are as follows:

Aldehydes	Ketones
Functional Group	
• The aldehydic $-\overset{\overset{O}{\|}}{C}-H$ functional group is present in aldehydes.	• The ketonic $-\overset{\overset{O}{\|}}{C}-$ functional group is present in ketones
Examples	
• $H-\overset{\overset{O}{\|}}{C}-H$	• $H_3C-\overset{\overset{O}{\|}}{C}-CH_3$

IDENTIFICATION

Tests for Aldehydic Group: **(Ex-Q.12)**

$$-\overset{\overset{O}{\|}}{C}-H$$

(i) Sodium Bisulphite Test:

Shake about 0.2 g or 0.5 cm^3 of the given compound with 1-2 cm^3 of saturated solution of sodium bisulphite.

Result:

A crystalline white precipitate will be formed.

(ii) Fehling's Solution Test:

Mix equal volumes of Fehling's solution A and B in a test tube. Add a pinch of organic compound and boil for five minutes.

Result:

Red precipitate will be formed.

Tests for Ketonic Group: **(Ex-Q.12)**

(i) Phenyl Hydrazine Test:

Shake a pinch of the given organic compound with about 2.0 cm^3 of phenyl hydrazine solution.

Result:

Orange red precipitate will be formed.

(ii) Sodium Nitroprusside Test:

Take about 2.0 cm^3 of sodium nitroprusside solution in a test tube and add 2-3 drops of NaOH solution. Now add a pinch of the given compound and shake.

Result:

Red colour will be formed.

(iii) Fehling's Solution Test:

No reaction

Q.12 Encircle the functional groups in the following compounds. Also give the names of the functional groups?

$CH_3-\overset{O}{\overset{\|}{C}}-CH_3$ $\quad$ $CH_3-\overset{O}{\overset{\|}{C}}-H$ $\quad$ $HO-\overset{O}{\overset{\|}{C}}-CH_2-CH_3$ $\quad$ $H-\overset{O}{\overset{\|}{C}}-CH_2-CH_3$

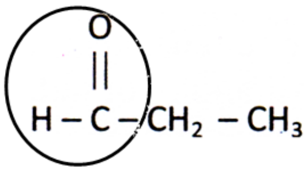
$CH_3-O-\overset{O}{\overset{\|}{C}}-CH_3$ $\quad$ $H_2C=CH-CH_3$

Ans:

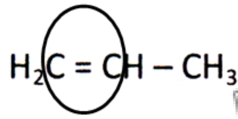
$CH_3-\overset{O}{\overset{\|}{C}}-CH_3$ (i)Ketonic group

$CH_3-\overset{O}{\overset{\|}{C}}-H$ (ii) Aldehydic group

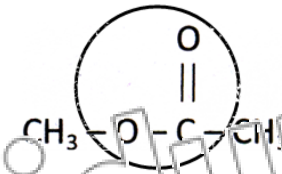
$HO-\overset{O}{\overset{\|}{C}}-CH_2-CH_3$ (iii) Carboxylic group



(iv) Aldehydic group



(v) Double bond



(vi) Ester group

Q.13 What are general properties of organic compounds?

Ans: See Q.NO.1 for the topic 11.1.3

Q.14 Write a detailed note on classification of organic compounds.

Ans: See Q.NO.1 for the topic 11.1.1

ADDITIONAL CONCEPTUAL QUESTIONS

Q.1 Differentiate between Carbonization and Destructive distillation.

Ans: **DIFFERENTIATION**

The differences between Carbonization and Destructive distillation are as follows:

Carbonization	Destructive Distillation
Definition: The conversion of wood into coal is called carbonization.	**Definition:** The strong heating of coal in the absence of air is called destructive distillation.
Products: • Peat • Lignite • Bituminous • Anthracite	**Products:** • Coal gas • Coal tar • Coke • Ammonical liquor

Q.2 Why silicon does not show catenation whereas carbon does?

Ans: **Carbon Shows Catenation Whereas Silicon does not**

Both silicon and carbon have similar electronic configurations but carbon shows catenation whereas silicon does not.

Reasons:

- It is mainly due to the reason that C-C bonds are much stronger (355 kJ mol^{-1}) than Si-Si (200kJ mol^{-1}) bonds.
- On the other hand, Si-O bonds are much stronger (452 kJ mol^{-1}) than C-O bonds (351 kJ mol^{-1}) Hence, silicon occurs in the form of silica and silicates in nature.

Q.3 Differentiate between Alkene and Alkynes.

Ans:

DIFFERENTIATION

Alkenes	Alkynes
Definition: "Hydrocarbon compounds, consisting of double bonds between two carbon atoms in their molecules are called alkenes." **Example:** • $H_2C=CH_2$ Ethene $H_3C-HC=CH_2$ Propene	**Definition:** "Hydrocarbon compunds consisting of triple bonds between two carbon atoms in their molecules are called alkynes." **Example:** $HC\equiv CH$ Ethyne $H_3C-C\equiv CH$ Propyne

Q.4 Differentiate between open chain and closed chain compounds.

Ans:

DIFFERENTIATION

Open Chain Compounds	Closed Chain Compounds
Definition: Open chain or Aliphatic compounds are those in which end carbon atoms are not joined with each other in this way they form a long chain of carbon atoms. **Types:** • Straight chain • Branched chain **Example:** • $CH_3-CH_2-CH_2-CH_3$ n-butane	**Definition:** Closed chain or cyclic compunds are those in which carbon atoms at the end of the chain are not free. They are linked to form a ring. **Types:** • Homocylic • Heterocyclic **Example:** CH_2-CH_2 • $\vert \quad \vert$ CH_2-CH_2 Cyclo Butane

Q.5 Differentiate between pitch and coke.

Ans:

DIFFERENTIATION

Pitch	Coke
Definition: It is the black residue of coal tar. **Uses:** • It is used for surfacing of roads and roofs.	**Definition:** It is the left behind residue of coal. **Uses:** • It is mainly used as reducing agent in the extraction of metals especially iron.

Q.7 Differentiate ether and esters.

Ans:

DIFFERENTIATION

Ethers	Esters
Definition: • Its functional group is – O – • Its general formula is $R-O-R'$ **Example:** • $CH_3-O-C_2H_5$ Ethyl Methyl Ether	**Definition:** • Its functional group is $-\overset{\overset{\large O}{\parallel}}{C}-OR$ • Its general formula is $R-\overset{\overset{\large O}{\parallel}}{C}-OR'$ **Example:** • $CH_3-\overset{\overset{\large O}{\parallel}}{C}-OC_2H_5$ Ethyl Acetate

Q.8 Write down formulas of sec-propyl Alcohol and Tertiary Butyl chloride.

Ans:

Sec propyl Alcohol	Tertiary Butyl chloride
$CH_3-\underset{\underset{\large CH_3}{\vert}}{CH}-OH$	$CH_3-\underset{\underset{\large CH_3}{\vert}}{\overset{\overset{\large CH_3}{\vert}}{C}}-Cl$

TERMS TO KNOW

Terms	Definitions
Vital Force Theory	According to this theory organic compounds could not be prepared in laboratories because they were supposed to be synthesized under the influence of a mysterious force called Vital Force, inherent only in living things.
Molecular Formula	The formula which represents the actual number of atoms in one molecule of the organic compound is called the molecular formula.
Structural Formula	Structural formula of a compound represents the exact arrangement of the different atoms of various elements present in a molecule of a substance.
Condensed Formula	The formula that indicates the group of atoms joined together to each carbon atom in a straight chain or a branched chain is called the condensed formula.
Dot and Cross Formula	The formula which shows the sharing of electrons between various atoms in one molecule of the organic compound is called dot and cross formula or electronic formula".
Organic Compounds	Organic compounds are hydrocarbons (compounds of carbon and hydrogen) and their derivatives, in which covalently bonded carbon is an essential constituent".
Organic Chemistry	The branch of chemistry which deals with the study of hydrocarbons and their derivatives is known as organic chemistry.
Open Chain Compounds	Open chain compounds are those in which the end carbon atoms are not joined with each other in this way they form a long chain of carbon atoms.
Straight Chain Compounds	Straight chain compounds are those in which carbon atoms link with each other through a single, double or triple bond forming a straight chain.
Branched Chain Compounds	Branched chain compounds are those in which there is a branch along straight chain.
Closed Chain or Cyclic Compounds	Closed chain or cyclic compounds are those in which the carbon atoms at the end of chain are not free. They are linked to form a ring.
Homocyclic or Carbocyclic Compounds	Homocyclic or carbocyclic compounds contain rings which are made up of only one kind of atoms, i.e., carbon atoms are called homocyclic compounds.
Benzene Ring	A benzene ring is made up of six carbon atoms with three alternating double bonds. They are called aromatic because of aroma or smell they have.
Aromatic Compounds	These organic compounds contain at least one benzene ring in their molecule are called aromatic compounds. They are also called benzenoid compounds.
Heterocyclic Compounds	The cyclic compounds that contain one or more atoms other than that of carbon atoms in their rings are called heterocyclic compounds.
Catenation	The ability of carbon atoms to link with other carbon atoms to form long chains and large rings is called catenation.
Isomerism	The compounds having the same molecular formula but different arrangement of atoms in their molecules or different structural formulae are called isomers and this phenomenon is called isomerism.

Destructive Distillation	The strong heating of coal in the absence of air is called destructive distillation.
Coal Gas	Coal gas is mixture of hydrogen, methane and carbon monoxide, produces heat when burnt in air.
Ammonical Liquor	Ammonical liquor is a solution of ammonia gas in water.
Coal Tar	Coal tar is a thick black liquid. It is a mixture of more than 200 different organic compounds, mostly aromatic. They are separated by fractional distillation of Coal Tar. Some of the important aromatic compounds are benzene, phenol, toluene, aniline, etc.
Pitch	The black residue of the coal tar is called pitch.
Coke	When coal is subjected to destructive distillation, it loses all its volatile components and leaves behind a solid residue called coke. Coke is 98% carbon.
Petroleum	Petroleum is a dark brownish or greenish black coloured viscous liquid. It is a complex mixture of several solid, liquid or gaseous hydrocarbons in water mixed with salts and earth particles.
Fractional Distillation	Separation of fractions or components from a mixture depending upon their boiling point ranges is called fractional distillation.
Natural Gas	It is a mixture of low molecular mass hydrocarbons.
Homologous Series	The group of similar compounds in which each member differs from the adjacent member by $-CH_2-$ group and have same functional group is called homologous series.
Alkyl Radical	The group of atoms formed by the removal of one of the hydrogen atom of an alkane is called alkyl radical or alkyl group.
Functional Group	An atom or group of atoms or presence of double or triple bond which determines the characteristic properties of an organic compound is known as functional group.
Amines	The organic compounds containing carbon, hydrogen and nitrogen as functional group are called as amines.
Alkyl Halides	The organic compounds having functional group containing carbon, hydrogen and halogens are called alkyl halides.
Alkenes	Hydrocarbon compounds consisting of double bonds between two carbon atoms in their molecules are called alkenes.
Alkynes	Hydrocarbon compounds consisting of triple bonds between two carbon atoms in their molecules are called alkynes.
Esters	Organic compounds consisting of' functional group $-\overset{\overset{\displaystyle O}{\|}}{C}-O-$ are called esters.
Aldehydes	Aldehydes have functional group $-\overset{\overset{\displaystyle O}{\|}}{C}-H$.
n-Propyl	When terminal hydrogen is removed from the structure of propane, n propyl is obtained.

CUT HERE

SELF TEST

Time: 35 Minutes **Marks: 25**

Q.1 Four possible answers (A), (B), (C) and (D) to each question are given, mark the correct answer. **(6×1=6)**

1. Vital Force Theory was further negated by:

(A) Kolbe, 1845 (B) Farat, 1545

(C) Divan, 1435 (D) Derek, 348

2. Octane has molecular formula:

(A) C_8H_{19} (B) C_8H_{18}

(C) C_8H_{23} (D) C_8H_{16}

3. Energy of C-O bonds is:

(A) 452 kJ/mol (B) 355 kJ/mol

(C) 200 kJ/mol (D) 351 kJ/mol

4. The percentage of machine in natural gas is:

(A) 87 (B) 85

(C) 89 (D) 90

5. –CHO is functional group of:

(A) Aldehydes (B) Ketones

(C) Ethers (D) Esters

6. Perfumes often contain:

(A) Rose oil (B) Olive oil

(C) Kerosene oil (D) None of these

Q.2 Give short answers to the following questions. **(5×2=10)**

(i) Differentiate between open chain and closed chain compounds.

(ii) Which factors influence catenation?

(iii) What is pitch?

(iv) Explain ammonical liquor?

(v) How organic compounds are used for fuel?

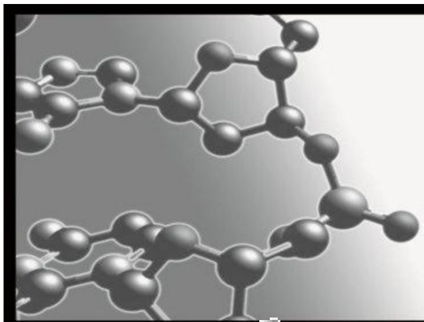
Q.3 Answer the following questions in detail. **(5+4=9)**

(i) Explain briefly types of formulae of organic compounds. **(5)**

(ii) Explain the tests for the following functional groups. **(4)**

(i) Aldehydic group (ii) Carboxylic group

NOTE: Parents or guardians can conduct this test in their supervision in order to check the skill of students.



CHAPTER 12

HYDROCARBONS

INTRODUCTION

SHORT QUESTIONS

Q.1 What are hydrocarbons? ***(Knowledge Base)***

Ans: **HYDROCARBONS**

Definition:

"*The organic compounds which consist of carbon and hydrogen only are called hydrocarbons*".

Examples:

- Methane (CH_4)
- Ethane (C_2H_6)
- Propane (C_3H_8)

Q.2 Which elements form stable and extended chains? ***(Knowledge Base)***

Ans: **FORMATION OF STABLE AND EXTENDED CHAINS**

Carbon is the only element capable of forming stable, extended chains of atoms bonded through single, double, or triple bonds.

Q.3 What are general classes of hydrocarbons? ***(Knowledge Base)***

Ans: **GENERAL CLASSES OF HYDROCARBONS**

Hydrocarbons are divided into four general classes, depending upon the nature of bonds present in the molecules. Each carbon atom of a hydrocarbon has four bonds.

The general classes of hydrcabons include:

- Alkanes
- Alkenes
- Alkynes
- Aromatics

Hydrocarbons are further classified as saturated and unsaturated.

Q.4 What are general properties of hydrocarbons? ***(Knowledge Base)***

Ans: **GENERAL PROPERTIES OF HYDROCARBONS**

The general properties of hydrocarbons are as follows:

Different Chemical Properties:

The members of these classes have different chemical properties because of different nature of bonds present in them.

Similar Physical Properties:

Physical properties of hydrocarbons are similar because of comparable electro-negativities of carbon and hydrogen.

Solubility:

They are almost non-polar and insoluble in water. They dissolve readily in non-polar solvents.

Physical State:

They are gases or volatile liquids and their volatility decreases with the increase of molecular mass. That is the reason low molecular mass hydrocarbons are gases at room temperature, such as: CH_4 and C_2H_6. Moderate molecular mass hydrocarbons are liquids, such as, C_6H_{14}; while higher molecular mass hydrocarbons are solids.

Q.5 What is importance of hydrocarbons? ***(Knowledge Base)***

Ans: **IMPORTANCE OF HYDROCARBONS**

The importance of hydrocarbons is as follows:

As Fossil Fuels:

Fossil fuels are hydrocarbons. They are not only major sources of energy but also are raw materials used to make thousands of consumer products.

As Starting Materials:

Hydrocarbons are the starting materials for the synthesis of organic chemicals of commercial importance.

Other Uses:

These chemicals are essential for making:

- Plastics
- Synthetic rubbers
- Synthetic fibres
- Fertilizers

INTRODUCTION
MULTIPLE CHOICE QUESTIONS

1. The simplest class of organic compounds is: ***(K.B)***
(A) Carbides (B) Hydrocarbons
(C) Carbonates (D) Nitrates

2. Hydrocarbons are divided into classes: ***(K.B)***
(A) 4 (B) 3
(C) 2 (D) 1

3. Each carbon atom of hydrocarbon has bonds: ***(K.B)***
(A) 4 (B) 3
(C) 2 (D) 1

4. Hydrocarbons are ________ and _______ in water. ***(K.B)***
(A) Polar, insoluble (B) Non-polar, insoluble
(C) Polar, soluble (D) Non-polar, soluble

5. These are hydrocarbons: ***(K.B)***
(A) Fossil fuels (B) Coals
(C) Petroleum (D) All of these

HYDROCARBONS
LONG QUESTIONS

Q.1 Describe the types of hydrocarbons? ***(Knowledge Base)*** **(DGK 2016 G-II)**

OR

Define and classify hydrocarbons. **(MNT 2016 G-II)**

OR

Explain saturated and unsaturated hydrocarbons with exmaples. **(BWP 2016 G-II)**

Ans: **HYDROCARBONS**

Definition:

"*The organic compounds which consist of carbon and hydrogen only are called hydrocarbons".*

Types of Hydrocarbons:

On the basis of structure, hydrocarbons are divided into two main classes.

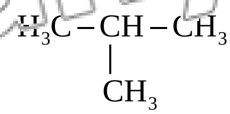
1. Open Chain or Aliphatic Hydrocarbons:

"These are compounds in which first and the last carbon atom are not joined directly to each other. The open chain may be straight or branched".

Examples:

$H_3C-CH_2-CH_2-CH_3$

Straight chain (n-butane)



Branched chain (isobutane)

Types of Open Chain Hydrocarbons:

Open chain hydrocarbons have been further subdivided into saturated and unsaturated hydrocarbons.

(a) Saturated Hydrocarbons:

*"The hydrocarbon in which all the **four valencies** of **carbon atoms** are fully **satisfied** (saturated) by **single bonds** with other carbon atoms and hydrogen atoms are called saturated hydrocarbons".*

Saturated hydrocarbons are also called alkanes. Thus, an alkane is a hydrocarbon in which the carbon atoms are connceted by only single covalent bond (there are no double or triple bonds in alkanes).

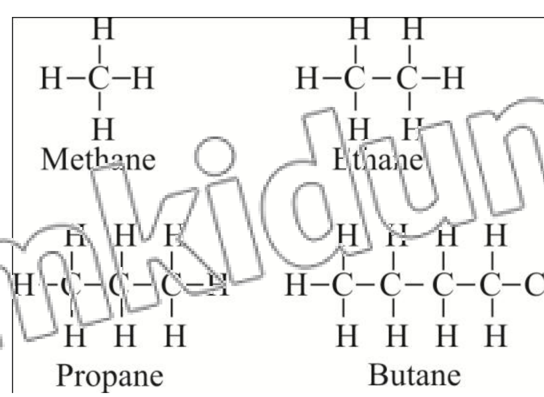
General Formula:

The general formula of saturated hydrocarbons is $\mathbf{C_nH_{2n+2}}$, where n is the number of carbon atoms in one molecule of the alkane.

Examples:

- Methane (CH_4),
- Ethane (C_2H_6),
- Propane (C_3H_8) and
- Butane (C_4H_{10})

All these are saturated hydrocarbons because they contain only carbon-carbon single bonds as follows:



(b) Unsaturated Hydrocarbons:

"*The hydrocarbons in which **two carbon** atoms are linked by a **double or a triple** bond are called unsaturated hydrocarbons."*

Classification:

Unsaturated hydrocarbons are classified into two groups

(i) Alkenes

(ii) Alkynes

(i) Alkenes:

*"The compounds in which **two carbon atoms** are linked by a **double bond** are called alkenes."*

General Formula:

These compounds have general formula C_nH_{2n}.

Functional Group:

Functional group of alkenes is $>C=C<$

Examples:

$H_2C=CH_2$	$H_3C–CH=CH_2$
Ethene	Propene

(ii) Alkynes:

*"The hydrocarbons in which **two carbon atoms** are linked **by a triple bond** are called alkynes".*

General Formula:

They have general formula C_nH_{2n-2}.

Functional Group:

Functional group of alkynes is $–C \equiv C–$.

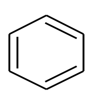
Examples:

$HC\equiv CH$	$H_3C–C\equiv CH$
Ethyne	Propyne

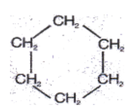
2. Closed Chain or Cyclic Hydrocarbons:

"*Compounds having rings of carbon atoms in their molecules are called closed chain or cyclic hydrocarbons*".

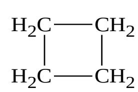
Examples:



Benzene



Cyclohexane



Cyclobutane

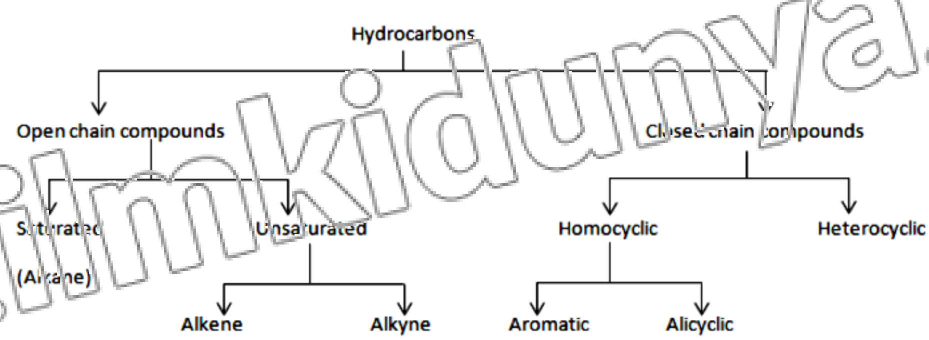


Figure: Summary of Classification of Hydrocarbons

HYDROCARBONS
SHORT QUESTIONS

Q.1 What are aliphatic hydrocarbons? *(Knowledge Base)*

Ans: **ALIPHATIC HYDROCARBONS**

"These are the compounds in which the first and the last carbon are not directly joined to each other".

These may be straight or branched chain hydrocarbons.

Examples:

$H_3C—CH_2—CH_2—CH_3$

n-butane

$$\begin{array}{c} H_3C-CH-CH_3 \\ | \\ CH_3 \end{array}$$

Branched chain (isobutane)

Q.2 Define saturated hydrocarbons. *(Knowledge Base)* **(GRW 2017, FSD 2016 G-I, II)**

Ans: *Answer given on Page # 172*

Q.3 Write the general formulas of alkanes, alkenes and alkynes. *(Knowledge Base)*
(BWP 2016 G-I)

Ans: **GENERAL FORMULAS**

The general formulas of alkanes, alkenes and alkynes are as follows:

- Alkanes: C_nH_{2n+2}
- Alkenes: C_nH_{2n}
- Alkynes: C_nH_{2n-2}

HYDROCARBONS
MULTIPLE CHOICE QUESTIONS

1. Which one is saturated hydrocarbon? *(K.B)* **(LHR 2014), (GRW 2017)**

(A) C_2H_4 (B) C_3H_6
(C) C_4H_8 (D) C_5H_{12}

2. Which one is unsaturated hydrocarbon? *(K.B)* **(LHR 2014)**

(A) $CH_2 = CH_2$ (B) $CH_3 – CH_3$
(C) $CH_3 – CH_2 – CH_3$ (D) Both A and C

3. General formula of alkanes is: *(K.B)* **(GRW 2014)**

(A) C_nH_{2n-2} (B) C_nH_{2n+2}
(C) C_nH_{2n} (D) C_nH_{2n+1}

4. The formula of butane is: *(K.B)* **(GRW 2014)**

(A) C_9H_{18} (B) C_4H_{10}
(C) C_8H_{20} (D) C_9H_{20}

5. The general formula of saturated hydrocarbons is: *(K.B)* **(LHR 2015)**

(A) C_nH_{2n+2} (B) C_nH_{2n}
(C) C_nH_{2n-2} (D) C_nH_{2n+1}

6. Carbon has valency: *(K.B)*

(A) 3 (B) 4
(C) 5 (D) 6

7. Which of the following property is not present in hydrocarbons? *(K.B)*

(A) High melting point (B) Non-polar property
(C) Solubility in non-polar solvent (D) Poor conductivity

8. Hydrocarbons having high molecular mass are: *(K.B)*

(A) Gases (B) Liquid
(C) Solids (D) All of these

9. Hydrocarbons having double bond are: *(K.B)*

(A) Alkane (B) Alkene
(C) Alkyne (D) Alkyl

10. What is the formula of methane? *(K.B)*

(A) CH_3 (B) CH_4
(C) CH_2 (D) C_2H_5

11. Which of the following is not an example of open chain hydrocarbon? *(K.B)*

(A) CH_4 (B) C_3H_8
(C) C_2H_6 (D) C_6H_6

12. Number of bonds present in methane: *(K.B)*

(A) 2 (B) 3
(C) 4 (D) 5

13. The compounds having at least one benzene ring are called: *(K.B)*

(A) Aromatics (B) Alkanes
(C) Alkenes (D) Alkynes

14. Alkynes form: *(K.B)*

(A) Single bond (B) Double bond
(C) Triple bond (D) Ionic bond

15. The molecular formula of ethane is: *(K.B)* **(LHR 2013)**

(A) C_2H_6 (B) C_3H_8
(C) $C_{10}H_{16}$ (D) $C_{10}H_{20}$

12.1 TEST YOURSELF

i. Why hydrocarbons are considered as parent organic compounds? *(Understanding Base)* **(GRW 2015)**

Ans: **PARENT ORGANIC COMPOUNDS**

Hydrocarbons are regarded as the parent organic compounds since other organic compounds are considered to be derived from them by replacement of one or more hydrogen atoms by other atoms or group of atoms.

Example:

CH_3OH is obtained by replacement of H – atom of CH_4 with OH.

ii. What is the difference between a straight and a branched chain hydrocarbon?

(Knowledge Base)

Ans: **<u>DIFFERENTIATION</u>**

The differences between straight chain and branched chain hydrocarbons are as follows:

Straight Chain Hydrocarbons	Branched Chain Hydrocarbons
Definition	
• Straight chain hydrocarbons are those in which carbon atoms link with each other through single, double or triple bond forming a straight chain.	• Branched chain hydrocarbons are those in which there is a branch along straight chain.
Examples	
• $H_3C - CH_2 - CH_2 - CH_3$ Straight chain (n-butane)	• $CH_3 - CH - CH_3$ | CH_3 Branched Chain (iso-butane)

iii. Give the general formulae of saturated and unsaturated hydrocarbons.

(Knowledge Base)

Ans: **<u>GENERAL FORMULAE</u>**

<u>Saturated Hydrocarbons:</u>

Alkanes are saturated hydrocarbons. The general formula of saturated hydrocarbons is C_nH_{2n+2}.

<u>Unsaturated Hydrocarbons:</u>

Alkenes and alkynes are unsaturated hydrocarbons. The general formula of alkenes is C_nH_{2n} and that of alkynes is C_nH_{2n-2}.

iv. Define unsaturated hydrocarbons with examples. ***(Knowledge Base)***

(LHR 2015, GRW 2013), (MTN 2017)

Ans: **<u>UNSATURATED HYDROCARBONS</u>**

<u>Definition:</u>

"The hydrocarbons in which two carbon atoms are linked by a double or a triple bond are called unsaturated hydrocarbons".

<u>Examples:</u>

There are two types of unsaturated hydrocarbons:

(i) Alkenes	**(ii)** Alkynes
$H_2C = CH_2$	$HC \equiv CH$
(Ethene)	(Ethyne)
$H_3C - CH = CH_2$	$H_3C - C \equiv CH$
(Propene)	(Propyne)

12.1 ALKANES

LONG QUESTIONS

Q.1 What are the alkanes? Give the sources of alkanes. *(Knowledge Base)*

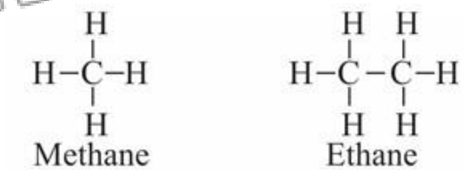
Ans:

ALKANES

Definition:

"The hydrocarbons in which all the carbon-carbon bonds are single covalent are called alkanes".

Examples:



Alkanes are Called Paraffins: **(BWP 2017)**

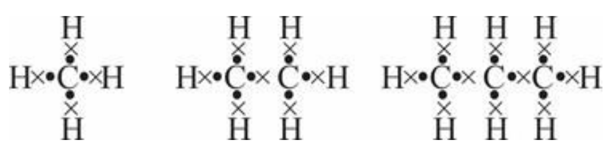
The simplest hydrocarbons are alkanes. In these compounds all the bonds of carbon atoms are single that means valencies of carbon atoms are saturated. Therefore, they are least reactive. That is the reason, alkanes are called paraffins (para means less, and affins means affinity or reactivity).

Alkanes as Homologous Series:

Alkanes form a homologous series of compounds in which each successive member of the series differes by a CH_2 group but they have similar structures amnd similar chemical properties.

Memebers of Alkane Series:

The first member of the series is methane (CH_4). Next ethane (C_2H_6), then next propane (C_3H_8) and so on. The electron cross and dot sturctures of simple alkanes are presented as follows:



Sources of Alkanes: **(SGD 2017)**

Following are the sources of alkanes:

(i) Petroleum and Natural Gas:

- **The main sources of alkanes are petroleum and natural gas.**
- **Methane** forms about **85%** of natural gas.
- All the alkanes can be obtained commercially by the **fractional distillation** of crude petroleum.

(ii) Marsh Gas:

- Marsh gas is obtained by the bacterial decay of vegetable matter contains mostly methane.

(iii) Fuel Gases:

- Fuel gases obtained from coal gas contain alkanes in small amounts.

(iv) <u>Gobar Gas, Sewage Gas and Bio Gas:</u>

- Methane occurs in gobar gas, sewage gas and bio-gas which are formed by the decomposition of cattle dung, excreta and plant wastes.

Q.2 How alkanes can be prepared in laboratory? *(Knowledge + Understanding+ Application Base)* **(GRW 2013)**

Ans:

PREPARATION OF ALKANES

Alkanes form a series of homologous compounds. So, their methods of preparation and chemical properties are similar. There are many methods of preparation but only two methods are as follows:

(i) <u>Hydrogenation of Alkenes and Alkynes:</u>

*"Hydrogenation means **addition of molecular hydrogen (H_2)** in alkenes and alkynes".*

Alkenes and alkynes are unsaturated compounds, so they have the capacity to add up atoms in them.

<u>Reaction Conditions:</u>

This reaction is carried out in the presence of **nickel catalyst at 250°C to 300 °C.** However, in the presence of catalyst platinum or palladium, the reaction takes place at room temperature.

<u>Reactions:</u>

$$H_2C{=}CH_2 + H_2 \xrightarrow[250\text{ - }300\ ^{o}C]{Ni} H_3C{-}CH_3$$

$$HC{\equiv}CH + H_2 \xrightarrow[250\text{ - }300\ ^{o}C]{Ni} H_2C{=}CH_2$$

$$H_2C{=}CH_2 + H_2 \xrightarrow[250\text{ - }300\ ^{o}C]{Ni} H_3C{-}CH_3$$

(ii) <u>Reduction of Alkyl Halides:</u> **(GRW 2017)**

*"Reduction means **addition of nascent hydrogen".***

In fact, it is a replacement of a halogen atom with a hydrogen atom.

<u>Reaction Conditions:</u>

This reaction takes place in the presence of **Zn metal and dilute HCI.**

<u>Reactions:</u>

$$H_3C-Br \quad + \quad 2[H] \xrightarrow{Zn/dil.HCl} CH_4 \quad + \quad HBr$$

$$CH_3CH_2Br \quad + \quad 2[H] \xrightarrow{Zn/dil.HCl} CH_3-CH_3 \quad + \quad HBr$$

Q.3 Write down the physical properties of alkanes. *(Knowledge Base)* **(MTN 2017, SWL 2016 G-II)**

Ans:

PHYSICAL PROPERTIES OF ALKANES

The physical properties of alkanes are as follows:

(i) <u>Physical State:</u>

Alkanes form a homologous series of compounds. First four members of the series are gases. The alkanes consisting of **C_5 to C_{10}** are **liquids** while **higher members** of the series are **solids**.

(ii) <u>Solubility:</u>

They are **nonpolar**, therefore, they are **insoluble** in **water** but soluble in organic solvents.

(iii) <u>Density:</u>

The density of alkanes **increases** gradually with the increase of **molecular size**.

(iv) Melting and Boiling Points:

The melting and boiling points' of alkanes **increase** regularly with the **increase of molecular sizes**. This is because of increase of attractive forces between the molecules of alkanes.

(v) Viscosity:

The alkanes become more viscous as their molecular sizes increase.

(vi) Combustion:

Alkanes become **less flammable**, i.e. more difficult to burn with the increase of molecular sizes.

Q.4 Write down the chemical properties of alkanes. ***(Knowledge +Understanding+Application Base)*** **(Ex-Q.1)**

OR

What type of reactions are given by alkanes? Explain with reference to halogenation of alkanes? **(GRW 2013), (LHR 2013, 2015)**

Ans:

CHEMICAL PROPERTIES OF ALKANES

Reactivity:

Alkanes are least reactive compounds being saturated hydrocarbons. However, they give reactions at high temperatures.

(i) Halogenation: **(GRW 2016)**

Alkanes give only substitution reactions which are:

"A reaction in which one or more hydrogen atoms of a saturated compound are replaced with some other atoms (halogen) is called a substitution reaction".

Reaction in Dark:

In dark there is **no reaction** of alkanes with halogens.

Reaction in Bright Sunlight:

In direct sunlight, reaction is explosive and carbon is deposited.

$$CH_4 + 2Cl_2 \xrightarrow{\text{Bright sunlight}} C + 4HCl$$

Reaction in Diffused Sunlight:

Alkanes react fairly with halogens in diffused sunlight. In diffused sunlight, a series of reactions take place and at each step one hydrogen atom is substituted by halogen atoms, so that all the hydrogen atoms are substituted one by one by halogen atoms.

$$CH_4 + Cl_2 \xrightarrow[\text{Sunlight}]{\text{Diffused}} CH_3Cl + HCl$$

Chloromethane

$$CH_3Cl + Cl_2 \xrightarrow{\text{Diffused sunlight}} CH_2Cl_2 + HCl$$

Dichloromethane

$$CH_2Cl_2 + Cl_2 \xrightarrow{\text{Diffused sunlight}} CHCl_3 + HCl$$

Trichloromethane

(Chloroform)

$$CHCl_3 + Cl_2 \xrightarrow{\text{Diffused sunlight}} CCl_4 + HCl$$

Tetrachloromethane

(Carbon tetrachloride)

(ii) Combustion: **(Ex-Q.2)**

In Excess Supply of Oxygen:

Alkanes burn in the presence of excess of air or oxygen to produce a lot of heat, carbon dioxide and water.

Applications:

This reaction takes place in automobile combustion engines, domestic heaters and cooking appliances. It is highly exothermic reaction and because of it alkanes are used as fuel.

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O + \text{Heat}$$

In Limited Supply of Oxygen:

In the limited supply of oxygen, there is incomplete combustion.

Disadvantage:

As a result, carbon monoxide is produced that creates suffocation and causes death.

$$3CH_4 + 4O_2 \longrightarrow 2CO + C + 6H_2O$$

Q.5 What are the uses of alkanes? *(Knowledge Base)* **(SGD 2016 G-II)**

Ans: **USES OF ALKANES**

The uses of alkanes (methane and ethane) are as follows:

(i) Natural gas that is chiefly methane is used as domestic fuel.

(ii) Compressed natural gas (CNG) is used as automobile fuel.

(iii) These gases are used in the manufacture of chemicals such as carbon black, methyl alcohol, ethyl alcohol, chloroform, carbon tetrachloride, formaldehyde and acetaldehyde.

Use of Products of Alkanes:

The products of alkanes are used in daily life such as:

- Carbon black is used in the manufacture of shoe polishes, printers ink and as filler in rubber industry.
- Chloroform is used as a solvent for rubber, waxes, etc., and for anesthesia.
- Carbon tetrachloride is used as an industrial solvent and in dry cleaning.

12.1 ALKANES

SHORT QUESTIONS

Q.1 Why orchids produce alkanes? *(Knowledge Base)* **(Instersting Information Pg. # 87) (GRW 2014)**

Ans: **PRODUCTION OF ALKANES BY ORCHIDS**

Orchids are beautiful ornamental and colourful flowers. Some orchids produce alkanes to attract bees to pollinate their flowers.

Q.2 What is use of butane and propane? *(Knowledge Base)*

Ans: **USES OF BUTANE AND PROPANE**

Propane and butane burn with very hot flames and are sold as liquefied petroleum gas (LPG).They are kept as liquids under pressure, but they vapourize easily when the pressure is released. Butane is also used in portable torches and gas lighters.

Q.3 What is marsh gas? *(Knowledge Base)*

Ans: **MARSH GAS**

Marsh gas is obtained by the bacterial decay of vegetable matter contains mostly methane.

Q.4 How orchids attract bees to pollinate their flowers? *(Knowledge Base)*

(Insterting Information Pg # 87)

Ans: **ORCHIDS ATTRACT BEES**

Orchids produce alkanes to attract bees to pollinate their flowers

12.1 ALKANES

MULTIPLE CHOICE QUESTIONS

1. The formula of pentane is: *(K.B)* **(LHR 2014)**

(A) C_5H_{12} (B) C_5H_{10}

(C) C_5H_8 (D) C_5H_{14}

2. How many percent of natural gas is consisted of methane (CH_4)? *(K.B)* **(LHR 2014)**

(A) 82% (B) 83%

(C) 84% (D) 85%

3. General formula of alkanes is: *(K.B)* **(GRW 2014)**

(A) C_nH_{2n-2} (B) C_nH_{2n+2}

(C) C_nH_{2n} (D) C_nH_{2n+1}

4. The formula of octane is: *(K.B)* **(GRW 2014)**

(A) C_9H_{18} (B) C_8H_{18}

(C) C_8H_{20} (D) C_9H_{20}

5. The number of hydrogen atoms in butane is: *(K.B)* **(LHR 2015)**

(A) 10 (B) 6

(C) 8 (D) 4

6. The reduction of alkyl halides takes place in the presence of: *(K.B)* **(LHR 2015)**

(A) Cu / HCl (B) Mg / HCl

(C) Na / HCl (D) Zn / HCl

7. Which one is methyl radical? *(K.B)* **(GRW 2015)**

(A) $–CH_2–$ (B) $CH_3–$

(C) CH_4 (D) $CH_3 – CH_3$

8. Which one of these is a saturated hydrocarbon? *(K.B)* **(GRW 2016)**

(A) C_2H_4 (B) C_3H_6

(C) C_4H_8 (D) C_5H_{12}

9. The chemical formula of chloroform: *(K.B)* **(GRW 2016)**

(A) CH_3Cl (B) CH_2Cl_2

(C) $CHCl_3$ (D) CCl_4

10. The density of alkanes increases with the increase of: *(K.B)*

(A) M.P (B) B.P

(C) Molecular size (D) Bonds

11. Which one is the characteristic property of alkanes? *(K.B)*

(A) Displacement reactions (B) Double displacement reaction

(C) Substitution reactions (D) Redox reaction

12. Incomplete combustion of alkanes produces: ***(K.B)***
(A) Carbon dioxide (B) Oxygen
(C) Chlorine gas (D) Carbon monoxide

13. What is the formula of butane? ***(K.B)*** **(BWP 2017), (RWP 2017),**
(A) C_3H_8 (B) C_4H_{10}
(C) C_5H_{12} (D) C_6H_{14}

14. Which of the following is not a function of chloroform? ***(K.B)***
(A) Solvent in rubber (B) Dry cleaning
(C) Solvent in waxes (D) Anaesthesia

15. Due to which property alkanes are used a fuel? ***(K.B)***
(A) Combustion (B) Halogenation
(C) Oxidation (D) Reduction

16. Paraffins means: ***(K.B)***
(A) Highly reactive (B) Less reactive
(C) Oil forming (D) None of these

17. Which one of the following is a substitution reaction? ***(K.B)***
(A) Halogenation of alkane (B) Dehydration of alkane
(C) Hydrolysis of alkane (D) Hydrogenation

18. Liquid alkanes have carbon atoms ranging form: ***(K.B)***
(A) C_4 to C_6 (B) C_5 to C_{10}
(C) C_8 to C_{18} (D) Both A and B

19. Substitution reaction is the property of: ***(K.B)*** **(BWP 2017)**
(A) Alkanes (B) Alkenes
(C) Alkynes (D) None of these

20. CNG stands for: ***(K.B)*** **(DGK 2017, RWP 2016 G-I)**
(A) Combustion natural gas (B) Carbon natural gas
(C) Compressed natural gas (D) Cooled natural gas

12.2 TEST YOURSELF

i. Which is the simplest alkane? ***(Knowledge Base)***

Ans: **SIMPLEST ALKANE**

The simplest alkane is methane having formula CH_4.

ii. Give the structure of following compounds: isopentane and isobutane.
(Understanding Base)

Ans: **STRUCTURES OF ISOPENTANE AND ISOBUTANE**

- Isopentane:

$$\begin{array}{l} H_3C-\underset{\displaystyle CH_3}{\underset{|}{CH}}-CH_2-CH_3 \end{array}$$

- Isobutane:

$$\begin{array}{l} H_3C-\underset{\displaystyle CH_3}{\underset{|}{CH}}-CH_3 \end{array}$$

iii. Why the burning of alkanes requires sufficient supply of oxygen?
(Understanding Base)

Ans: **SUFFICIENT OXYGEN FOR BURNING**

The burning of alkanes requires sufficient supply of oxygen because complete burning of alkanes requires sufficient supply of oxygen to form CO_2, H_2O and heat. Otherwise alkanes undergo incomplete combustion in the limited supply of oxygen, as a result carbon monoxide is produced which is poisonous gas and causes air pollution.

$$3CH_4 + 4O_2 \longrightarrow 2CO + C + 6H_2O$$

iv. What do you mean by halogenation? Give the reaction of methane with chlorine in bright sunlight. *(Knowledge Base)*

Ans: **<u>HALOGENATION</u>**

"*Addition of halogen to a substance is called halogenation".*

OR

"A reaction in which one or more hydrogen atoms of a saturated compound are replaced with some other atoms like halogen atom is called halogenation".

<u>Reaction of Methane with Chlorine</u>

In direct sunlight reaction is explosive and carbon is deposited.

$$CH_4 + 2Cl_2 \xrightarrow[\text{Sunlight}]{\text{Bright}} C + 4HCl$$

12.2 ALKENES

LONG QUESTIONS

Q.1 Define the alkenes. How alkenes can be prepared in laboratory?
(Knowledge+Understanding+Application Base) **(SGD 2014)**

Ans: **<u>ALKENES</u>**

<u>Definition:</u>

"*The hydrocarbons in which two carbons atoms are linked by a double bond are called alkenes".*

<u>General Formula:</u>

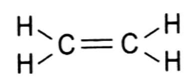
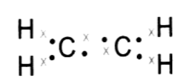
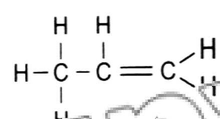
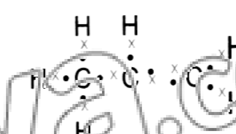
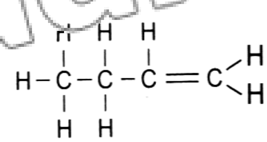
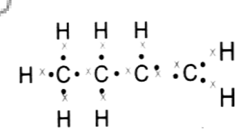
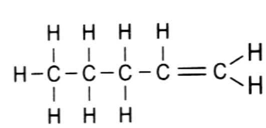
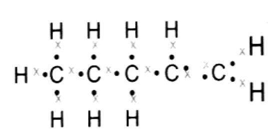
They have general formula $\mathbf{C_nH_{2n}}$ and functional group $>C=C<$

<u>Simplest Alkene:</u>

The simplest alkene is ethene having formula C_2H_4.

<u>Why Alkenes are Called Olefins?</u> (Ex. Short Question # 9)

These compounds are also known as olefins (a Latin word meaning oil forming) because first members form oily products when react with halogens.

Name	Molecular formula	Condensed formula	Structural formula	Cross and dot formula
(i) Ethylene or ethene	C_2H_4	$H_2C=CH_2$		
(ii) Propylene or propene	C_3H_6	$H_3C-HC=CH_2$		
(iii) Butylene or butene	C_4H_8	$H_3C-H_2C-HC=CH_2$		
(iv) Pentene	C_5H_{10}	$H_3C-CH_2-CH_2CH=CH_2$		

Occurrence:

Occurrence of alkenes is as follows:

(i) Alkenes being more reactive than alkanes, seldom occur free in nature.

(ii) Lower alkenes occur in coal gas in minute quantities.

(iii) Ethylene is present in natural gas some times to the extent of **20%.**

(iv) Alkenes are produced in large amounts by cracking of petroleum.

Preparation of Alkenes: (Ex. Short Question # 7)

Alkenes are prepared by the removal of small atoms (H, OH, X) from the adjacent carbon atoms of the saturated compounds, so as to create a double bond between carbon atoms.

(i) Dehydration of Alcohols:

Dehydration:

"The removal of water from a substance is called dehydration".

Preparation of Alkenes:

Ethene is prepared by heating a mixture of ethanol and excess of concentrated sulphuric acid at **180°C.** In first step, ethyl hydrogen sulphate is formed which decomposes on heating to produce ethane, which is collected over water.

$$H_3C-CH_2-OH+H_2SO_4\xrightarrow{180^{o}C}CH_3CH_2-OSO_3H$$

$$CH_3CH_2-OSO_3H\xrightarrow{heat}H_2C=CH_2+H_2SO_4$$

(ii) Dehydrohalogenation of Alkyl Halides:

Dehydrohalogenation:

"The ***removal of hydrogen and halogen*** *from adjacent carbon atoms to create a double bond is called dehydrohalogenation".*

Preparation of Alkenes:

On heating, ethyl bromide with alcoholic KOH, ethene is formed and removal of hydrogen and halogen takes place from adjacent carbon atoms to create a double bond.

$$H_3C-CH_2Br+KOH_{(Alcoholic)}\xrightarrow{Heat}H_2C=CH_2+KBr+H_2O$$

Q.2 Write down the physical properties of alkenes. ***(Knowledge Base)***

(GRW 2015, 2017, FSD 2016 G-I, SGD 2016 G-II)

Ans:

PHYSICAL PROPERTIES OF ALKENES

The physical properties of alkenes are as follows:

(i) Physical State and Color:

The first member of the alkenes is ethene. It is a **colourless gas** with **pleasant odour.**

(ii) Solubility:

Alkenes are **nonpolar,** therefore, they are **insoluble** in **water** but soluble in organic solvents.

(iii) Density:

The first member of the series ethene is **slightly less dense than air**.

(iv) Nature of Flame:

Alkenes are flammable hydrocarbons. On complete combustion, they form carbon dioxide and water with release of energy. However, their **flame** is **smokier than alkanes** having a **similar number of carbon atoms.**

(v) Melting and Boiling Points:

Their melting and boiling points gradually increase with the increase of molecular sizes of the compounds in the series.

Q.3 Write down the chemical properties of alkenes.
(Knowledge+Understanding+Application Base) **(DGK 2017)**

Ans: **<u>CHEMICAL REACTIONS OF ALKENES</u>**

<u>Reactivity of Alkenes:</u> (Test Yourself 12.3 q.i)

Alkenes a reactive compound because the electrons of the double bond a easily available for reaction. These compounds have tendency to react readily by adding other atoms to become saturated compounds. As a result, the double bond is converted into a single bond that is more stable.

Adition reactions are characteristic property of unsaturated compounds.

<u>Addition Reactions:</u>

"These are the reactions in which the products are formed by the addition of some reagents like H_2, Cl_2, etc., to an unsaturated organic compound".

In the process, one of the bonds of a double bond gets broken and two new single bonds are formed.

(i) <u>Hydrogenation of Alkenes:</u> **(MTN 2017)**

"Hydrogenation means addition of molecular hydrogen to an unsaturated hydrocarbon in the presence of a catalyst (Ni, Pt) to form saturated compound".

$$H_2C{=}CH_2 + H_2 \xrightarrow[250\ -\ 300\ ^oC]{Ni} H_3C{-}CH_3$$

<u>Application:</u>

On industrial scale, this reaction is used to convert vegetable oil into margarine (Banaspati ghee)

$$\text{Oil} + H_2 \longrightarrow \text{Margarine (Banaspati ghee)}$$

(ii) <u>Halogenation of Alkenes:</u> **(GRW 2015), (MTN 2017)**

"Halogenation means addition of halogen like chlorine or bromine".

Bromination of alkenes is very important reaction. When bromine water (a solution of bromine in water having red-brown colour) is added to ethene in an inert solvent like carbon tetrachloride, its colour is discharged at once.

$$H_2C = CH_2 + Br_2 \longrightarrow \underset{\displaystyle Br}{\underset{|}{H_2C}} - \underset{\displaystyle Br}{\underset{|}{CH_2}}$$

1, 2 – Dibromoethane

<u>Application:</u>

In the reaction, double bond of ethene is converted into a single bond by addition of a molecule of bromine. This reaction is used to identify the unsaturation of an organic compound.

(iii) <u>Hydrohalogenation of Alkenes:</u>

*"The **addition of hydrogen and halogen** to a substance is called hydrohalogenation".*

Dry gaseous hydrogen halides (HI, HBr and HCl) react with alkenes to produce alkyl halides.

$$H_2C = CH_2 + HX \longrightarrow H_3C - CH_2X$$

$$H_2C = CH_2 + HBr \longrightarrow H_3C - CH_2Br$$

The order of reactivity of hydrogen halides is HI > HBr > HCl.

(iv) <u>Oxidation of Alkenes with $KMnO_4$:</u> **(LHR 2013)**

Alkenes decolourize the pink colour of acidified dilute solution of potassium permanganate because the double bond electrons react with MnO_4^- ion, which further goes on to form MnO_2 and ethene glycol **(l, 2–ethanediol).** Such as there is addition of two hydroxyl groups at the double bond.

This reaction is also used to test the unsaturation in an organic compound.

$$3H_2C{=}CH_2 + 2KMnO_4 + 4H_2O \longrightarrow 3H_2\underset{\substack{|\\ OH}}{C}-\underset{\substack{|\\ OH}}{C}H_2 + 2MnO_2 + 2KOH$$

Ethene Glycol

Q.4 What are the uses of ethene? *(Knowledge Base)*

Ans: **<u>USES OF ETHENE</u>**

The uses of alkenes are as follows.

(i) For artificial ripening of fruits.

(ii) As a general anaesthetic.

(iii) For the manufacture of polythene. Polythene is a plastic material used in packaging, toys, bags, etc.

(iv) As a starting material for the manufacture of a large number of compounds such as ethylene oxide, ethyl alcohol, ethylene glycol, diethyl ether, etc.

(v) Ethylene oxide is used as a fumigant.

(vi) Ethylene glycol is used as an antifreeze, diethlyl ether and ethyl alcohol are used as solvent.

(vii) For making poisonous mustard gas which is used in chemical warfare.

12.2 ALKENES

SHORT QUESTIONS

Q.1 What are alkenes? Give their general formula. *(Knowledge Base)*

Ans: **<u>ALKENES</u>**

Alkenes are unsaturated hydrocarbons having double bond between two carbon atoms.

<u>Examples:</u>

- Ethene : $H_2C = CH_2$
- Propene : $H_3C - C = CH_2$

<u>General Formula:</u>

General formula of alkenes is C_nH_{2n}.

Q.2 Give a test to identify ethene ($H_2C = CH_2$). *(Understanding Base)* **(GRW 2015)**

Ans: **<u>TEST TO IDENTIFY ETHENE</u>**

Ethene ($H_2C = CH_2$) can be identified using bromine-water test. It decolorizes bromine water which is the indication of the presence of a double bond in the compound.

Q.3 Why bananas are stored away from rest of the fruits? *(Knowledge Base)*
(Interesting Information Pg. # 90) (GRW 2015)

Ans: **<u>STORAGE OF BANANAS</u>**

Ripening bananas produce ethene gas that makes fruits ripen fastly and lead to food spoilage. That is the reason bananas are stored away from rest of the fruits.

Q.4 Write a note on occurrence of alkenes. *(Knowledge Base)* **(DGK 2016 G-I)**

Ans: *Answer is given on Page # 134*

MULTIPLE CHOICE QUESTIONS

1. Alkenes are prepared from alcohols by a process called: *(K.B)* **(LHR 2016, MTN 2017)**

(A) Dehydrogenation	(B) Dehalogenation
(C) Dehydration	(D) Dehydohalogenation

2. Oxidation of alkene with $KMnO_4$ produces: *(U.B)* **(LHR 2016, MTN 2017)**
(A) Glyoxal (B) Oxalic acid
(C) Glycol (D) Formic acid

3. Dehydrohalogenation of alkyl halides takes place in the presence of: *(K.B)*
(A) Alcoholic KOH (B) Aqueous NaCl
(C) Alcoholic NaCl (D) Aqueous KOH

4. A solution of bromine in water having colour: *(K.B)*
(A) Dark brown (B) Purple
(C) Red-brown (D) Voilet

5. Alkenes are also called: *(K.B)* **(SWL 2017)**
(A) Paraffins (B) Olefins
(C) Acetylenes (D) All of above

6. Ethanol reacts with H_2SO_4 at temperature of: *(K.B)*
(A) 150^oC (B) 16^oC
(C) 180^oC (D) 253 K

7. Banaspati ghee is also called: *(K.B)*
(A) Vegetable oil (B) Margarine
(C) Cooking oil (D) Coconut oil

8. Ethylene oxide is used as: *(K.B)*
(A) Anti-freeze (B) Solvent
(C) Fumigant (D) Poisonous mustard gas

9. Banana when riped produces gas: *(K.B)*
(A) Ethene (B) Methane
(C) Noble gas (D) Oxygen gas

10. Number of bonds in propene is: *(K.B)*
(A) 6 (B) 7
(C) 8 (D) 9

11. Butene is also called: *(K.B)*
(A) Ethylene (B) Acetylene
(C) Methane (D) Butylene

12. Alkenes are insoluble in: *(K.B)*
(A) Organic solvent (B) Alcohol
(C) Water (H_2O) (D) Both B and C

12.3 TEST YOURSELF

i. Why alkenes are reactive? *(Knowledge+Understanding Base)*

Ans: **REACTIVITY OF ALKENES**

Alkenes are reactive compounds because the electrons of the double bond are easily available for reaction. These compounds have the tendency to react readily by adding other atoms to become saturated compounds. As a result, the double bond is converted into a single bond that is more stable.

ii. How can you prepare propene from propyl alcohol? *(Understanding+Application Base)*

Ans: **PREPARATION OF PROPENE**

Propene can be prepared from propyl alcohol by heating a mixture of propyl alcohol and excess of concentrated sulphuric acid at 180°C.

$$\underset{\text{(Propyl alcohol)}}{CH_3-CH_2-\underset{|\atop OH}{CH_2}} \xrightarrow[180^oC]{H_2SO_4} CH_3-CH=CH_2+H_2O$$

iii. Give a test used to identify unsaturation of an organic compound.
(Knowledge+Application Base)

Ans: **<u>TEST FOR UNSATURATION</u>**

When unsaturated compounds are oxidized with $KMnO_4$ the pink colour is discharged.

<u>Process:</u>

Dissolve about 0.2g of the organic compound in water. Add to it 2 to 3 drops of alkaline $KMnO_4$ solution and shake.

<u>Examples:</u>

- **<u>Reaction with Alkene:</u>**

$$3CH_2 = CH_2 + 2KMnO_4 + 4H_2O \longrightarrow 3\underset{\large OH}{\underset{|}{H_2C}}-\underset{\large OH}{\underset{|}{CH_2}} + 2MnO_2 + 2KOH$$

This reaction is used to identify unsaturation of an organic compound.

iv. Give a few uses of ethene. ***(Knowledge Base)***

(LHR 2015, SGD 2017, BWP 2017, FSD 2016 G-II, SWL 2016 G-I)

Ans. *Answer given on Page # 186*

12.3 ALKYNES

LONG QUESTIONS

Q.1 Define the alkynes. How alkynes can be prepared in laboratory? ***(Knowledge+Understanding+Application Base)***

Ans: **<u>ALKYNES</u>**

<u>Definition:</u>

"*The hydrocarbons in which two carbon atoms are linked by a* ***triple bond*** *are called alkynes".*

<u>Examples</u>: Ethyne and propyne.

<u>General Formula:</u>

They have general formula $\mathbf{C_nH_{2n-2}}$ and functional group – **C≡C–.**

<u>Simplest Alkyne:</u>

The simplest alkyne is acetylene, with molecular formula $\mathbf{C_2H_2}$**.**

<u>Why are Alkynes Called Acetylenes?</u> (Test Yourself 12.4 q.i) **(BWP 2017)**

Alkynes are also called acetylenes because of the name of the first member of the series is acetylene.

<u>Important Alkynes:</u>

Molecular, condensed, structural and dot and cross formulae of a few alkynes are given below:

Name	Molecular formula	Condensed formula	Structural formula	Cross and dot formula
(i) Acetylene (ethyne)	C_2H_2	$HC \equiv CH$	$H-C\equiv C-H$	$H \times\!\cdot C \vdots\vdots C \cdot\!\times H$
(ii) Methyl Acetylene (propyne)	C_3H_4	$H_3C-C\equiv CH$	$H-\underset{H}{\overset{H}{C}}-C\equiv C-H$	$H\times\!\cdot\underset{H}{\overset{H}{C}}\cdot\!\times C \vdots\vdots C\cdot\!\times H$
(iii) Dimethyl Acetylene (butyne)	C_4H_6	$H_3C-C\equiv C-CH_3$	$H-\underset{H}{\overset{H}{C}}-C\equiv C-\underset{H}{\overset{H}{C}}-H$	$H\times\!\cdot\underset{H}{\overset{H}{C}}\cdot\!\times C \vdots\vdots C\cdot\!\times\underset{H}{\overset{H}{C}}\cdot\!\times H$

Occurrence

Acetylene does not occur free in nature. Traces of acetylene are present in coal gas (about **0.06%)**

Preparation of Alkynes: **(DGK 2017)**

Alkynes are prepared by the following methods:

(i) Dehydrohalogenation of Vicinal Dihalides:

*"The **removal of hydrogen and halogen** from an alkyl halide is called dehydrohalogenation".*

Process:

When a vicinal dihalide is heated with alcoholic KOH, two hydrogen along with two halogen atoms are removed from two adjacent carbon atoms with formation of a triple bond between the adjacent carbons.

$$\begin{array}{c} \mathrm{Cl}\quad \mathrm{H} \\ |\qquad | \\ \mathrm{H-C-C-H} \\ |\qquad | \\ \mathrm{H}\quad \mathrm{Cl} \end{array} + 2KOH \xrightarrow[100^{o}C]{\text{Alcoholic}} \underset{\text{ethyne}}{HC \equiv CH} + 2KCl + 2H_2O$$

(ii) Dehalogenation of Tetrahalides:

*"The **removal of halogen** from a substance is called dehalogenation".*

Process:

When alkyl tetrahalides are heated with zinc dust, the elimination of halogen atoms takes place to form ethyne.

$$\begin{array}{c} \mathrm{Cl}\quad \mathrm{Cl} \\ |\qquad | \\ \mathrm{H-C-C-H} \\ |\qquad | \\ \mathrm{Cl}\quad \mathrm{Cl} \end{array} + 2Zn_{(dust)} \xrightarrow{\text{Heat}} HC \equiv CH + 2ZnCl_2$$

Q.2 Write down the physical properties of alkynes. *(Knowledge Base)*

(LHR 2014, DGK 2017, SWL 2016 G-II)

Ans: **PHYSICAL PROPERTIES**

The physical properties of alkynes are as follows:

(i) Alkynes also form a series of compounds. Its first member is acetylene. It is a **colourless** gas with **faint garlic odour**.

(ii) Acetylene is **slightly soluble in water** but soluble in organic solvents such as benzene, alcohol, acetone, ether, etc.

(iii) Acetylene is **slightly lighter than air.**

(iv) Alkynes are also flammable. They produce **smokier flames than those of alkanes and alkenes.**

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Q.3 Write down the chemical properties of alkynes.
(Knowledge+Understanding+Application Base) **(BWP 2016 G-II)**

Ans: **CHEMICAL PROPERTIES**

Reactivity of alkynes:

Reason:

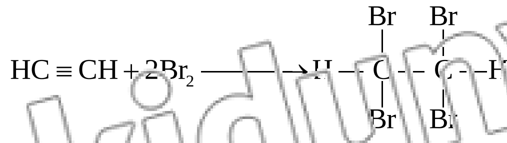
Alkynes are reactive compounds because of presence of a triple bond. A triple bond consists of two weak bonds and a strong bond.

Mechanism:

When alkynes react with other substances, two weak bonds are readily broken one by one and addition takes place easily. The addition reactions of alkynes resemble to those of alkenes.

(i) Addition of Halogen:

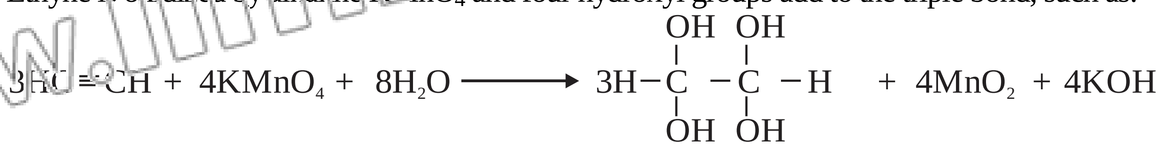
Chlorine and bromine add to acetylene to form tetrachloroethane and tetrabromoethane, respectively. When bromine water is added to acetylene, red brown colour of bromine water is discharged rapidly due to formation of colourless tetrabromoethane.



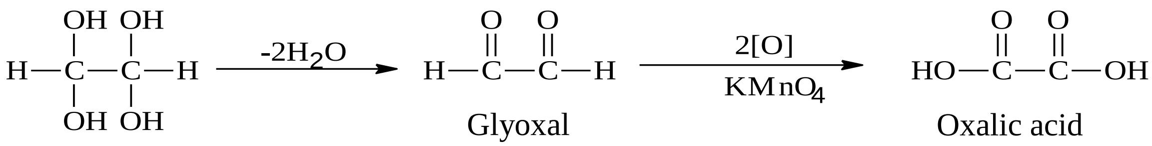
Tetrabromoethane

(ii) <u>Oxidation with $KMnO_4$:</u> **(Ex-Q.4) (LHR 2013, 2015)**

Ethyne is oxidized by alkaline $KMnO_4$ and four hydroxyl groups add to the triple bond, such as:



This intermediate product eliminates water molecules to form glyoxal, which is further oxidized to form oxalic acid.



Q.4 What are the uses of alkynes? ***(Knowledge Base)***
(LHR 2016, GRW 2014, DGK 2017, MTN 2016 G-I, 17, SGD 2017, FSD 2016 G-II, SWL 2016 G-I, II)

Ans: **<u>USES OF ACETYLENE</u>**

The uses of alkynes are as follows:

(i) Acetylene produces **oxy-acetylene flame** with oxygen. It is a **highly exothermic** reaction. Heat released is used for **welding purposes.**

(ii) Acetylene is used to prepare other chemicals, such as alcohols, acetaldehyde and acids.

(iii) It is used for the **ripening of fruits.**

(iv) It is used for the **manufacturing of polymer products** like polyvinyl chloride, polyvinyl acetate and synthetic rubber like neoprene.

(v) It is **polymerized to form benzene** which is used as raw material to form a variety of organic compounds.

12.3 ALKYNES
SHORT QUESTIONS

Q.1 Define the alkynes. Give their general formula. ***(Knowledge Base)*** **(GRW 2014)**

Ans: **<u>ALKYNES</u>**

<u>Definition:</u>

"*The hydrocarbons in which two carbon atoms are linked by a triple bond are called alkynes".*

<u>Examples:</u>

Ethyne and propyne.

<u>General Formula:</u>

General formula of alkynes is C_nH_{2n-2}.

Q.2 Write down molecular and structural formulas of ethyne.
(Knowledge+Understanding Base) **(MTN 2016 G-II)**

Ans: **FORMULAS OF ETHYNE**

Molecular and structural formulas of ethyne are as follows:

Molecular formula:

C_2H_2

Structural formula:

$H - C \equiv C - H$

12.3 ALKYNES

MULTIPLE CHOICE QUESTIONS

1. **Traces of acetylene are present in coal gas about: *(K.B)***
   (A) 0.06% (B) 0.07%
   (C) 0.08% (D) 0.09%
2. **Which one is used for ripening of fruits? *(K.B)***
   (A) Ethyne (B) Butane
   (C) Buane (D) Propane
3. **Which compound is used for welding process? *(K.B)***
   (A) CH_4 (B) $KMnO_4$
   (C) Acetylene (D) Ethylene
4. **Which of the following does not occur free in nature? *(K.B)***
   (A) Ethylene (B) Acetylene
   (C) Propylene (D) Pentene
5. **Alkynes form ______ bonds between carbon and hydrogen atoms. *(K.B)***
   (A) Triple bond (B) Double bond
   (C) Single bond (D) Ionic bond
6. **Di-methyl acetylene is also called: *(K.B)***
   (A) Ethyne (B) Propyne
   (C) Butyne (D) Hexyne
7. **Alkynes are also called: *(K.B)*** **(DGK 2017)**
   (A) Olefins (B) Parraffins
   (C) Acetylenes (D) Ethanes
8. **General formula of alkynes is: *(K.B)*** **(BWP 2016 G-I, II)**
   (A) C_nH_{2n} (B) C_nH_{2n+2}
   (C) C_nH_{2n+1} (D) C_nH_{2n-2}

12.4 TEST YOURSELF

i. Why the alkynes are called acetylenes? ***(Knowledge Base)***

Ans: *Answer given on Page # 188*

Answer given on Page # 188

ii. How is tetrabromoethane prepared from acetylene? ***(Understanding+Application Base)***

Ans: **PREPARATION OF TETRABROMOETHANE**

When bromine water is added to acetylene, red brown colour of bromine water is discharged rapidly due to formation of colourless tetrabromoethane.

$$\underset{\text{(Acetylene)}}{HC\equiv CH} + 2Br_2 \longrightarrow \underset{\text{(Tetrabromoethane)}}{H-\overset{Br}{\underset{Br}{C}}-\overset{Br}{\underset{Br}{C}}-H}$$

This reaction is used to identify the unsaturation of alkynes.

iii. How can you prepare acetylene from tetrachloroethane? ***(Understanding+Application Base)***

iv. Ans: **PREPARATION OF ACETYLENE**

Acetylene can be prepared by dehalogenation of tetrahalides or tetrachloroethane. When tetrachloroethane is heated with zinc dust, the elimination of halogen atoms takes place to form acetylene.

$$H-\overset{Cl}{\underset{Cl}{C}}-\overset{Cl}{\underset{Cl}{C}}-H + \underset{\text{(Dust)}}{2Zn} \xrightarrow{\text{Heat}} \underset{\text{(Acetylene)}}{HC\equiv CH} + 2ZnCl_2$$

v. What is difference between glycol and glyoxal? ***(Knowledge Base)***

Ans: **DIFFERENTIATION**

Glycol	Glyoxal
Functional Group	
• The functional group in glycol is hydroxyl group (OH).	• The functional group in glyoxal is a aldehyde group. $-\overset{O}{\overset{\Vert}{C}}-H$
Chemical Formula	
• The formula of a glycol is $\underset{OH}{H_2C}-\underset{OH}{CH_2}$ • It belongs to alcohol family.	• The formula of a glyoxal is $H-\overset{O}{\overset{\Vert}{C}}-\overset{O}{\overset{\Vert}{C}}-H$ • It does not belong to aldehyde family.

vi. Write the formula of oxalic acid. ***(Knowledge Base)*** **(BWP 2016 G-II)**

Ans: **FORMULA OF OXALIC ACID**

The formula of oxalic acid is $C_2H_2O_4$ or $(COOH)_2$, which can also be represented as:

$$\begin{array}{c} \;\;\;O \;\;\; O \\ \;\;\;\| \;\;\;\; \| \\ HO-C-C-OH \end{array}$$

Oxalic Acid

HYDROCARBONS AS FEED STOCK IN INDUSTRY

LONG QUESTIONS

Q.1 Write down the applications of hydrocarbons. ***(Application Base)***

(Science, Technology and Society Pg. # 94)

Ans: **HYDROCARBONS AS FEED STOCK IN INDUSTRY**

Hydrocarbons are not only used as fuel in automobiles or industries, they are also used as raw materials in many industries.

(i) Petrochemical Industry

"The organic compounds prepared from hydrocarbons (petroleum and natural gas) are called petrochemicals."

Examples:

Some of the important petrochemicals are:

- Methyl alcohol
- Ethyl alcohol
- Formic acid
- Chloroform
- Carbon tetrachloride
- Ethylene
- Butadiene
- Benzene
- Toluene etc.

(ii) Plastic Industry:

Hydrocarbons are used as raw materials for the preparation of a large variety of synthetic polymers, called plastics like polythene, polyester.

Properties of Synthetic Polymers:

These can be given any shape when soft, and on hardening make a durable article to be used in common life.

Examples:

- Crockery items (cups, glass, jug, plates, spoons)
- Furniture items (chair, table, stool)
- Automobile parts
- Electric and sewage items
- A lot of other household items

(iii) Rubber Industry:

Hydrocarbons are used to prepare synthetic rubber such as acetylene is used to prepare butadiene rubber used for making footwear, tyres and toys. Similarly, a good quality rubber neoprene is prepared from chloroprene.

(iv) Synthetic Fiber Industry:

Hydrocarbons are used to prepare synthetic fibres like nylon, rayon, polyesters.

Properties of Fibres:

- These fibres have better qualities like greater strength, good elasticity, and resistance to wear and tear.
- Clothes made of synthetic fibres are long lasting than that of natural fibres.

(v) Synthetic Detergents:
Long chain hydrocarbons obtained from petroleum are used to make synthetic detergents and washing powders.

Properties:
- These detergents are sodium salts of alkyl hydrogen sulphate.
- These detergents have better and stronger cleaning properties than that of soaps.
- They can be used even in hard water.

HYDROCARBONS AS FEED STOCK IN INDUSTRY

SHORT QUESTIONS

Q.1 How hydrocarbons are used as a fuel? ***(Knowledge+Application Base)***
(Science, Technology and Society Pg. # 94)

OR

Describe combustion process and give chemical equation.

Ans: **HYDROCARBONS AS FUEL**

The main constituents of fuels (coal, petroleum and natural gas) are hydrocarbons. When hydrocarbons are burnt in air the reaction is called combustion. It is highly exothermic reaction, i.e. it produces a lot of heat. The basic combustion reaction is:

$$CH_4 + O_2 \longrightarrow CO_2 + H_2O + \text{heat}$$

Significance of Heat Produced:
The heat energy thus produced is used to meet needs of energy in:
- Homes
- Transportation
- Industries

Q.2 Describe use of hydrocarbons in synthetic fibre industry. ***(Knowledge Base)***

Ans: **HYDROCARBONS IN SYNTHETIC FIBRE INDUSTRY**

Hydrocarbons are used to prepare synthetic fibres like nylon, rayon, polyesters.

Preperties of Fibres:
- These fibres have better qualities like greater strength, good elasticity, and resistance to wear and tear.
- Clothes made of synthetic fibres are long lasting than that of natural fibres.

MULTIPLE CHOICE QUESTIONS

1. Due to which property alkanes are used as fuel? ***(K.B)***
(A) Combustion (B) Halogenation
(C) Oxidation (D) Reduction

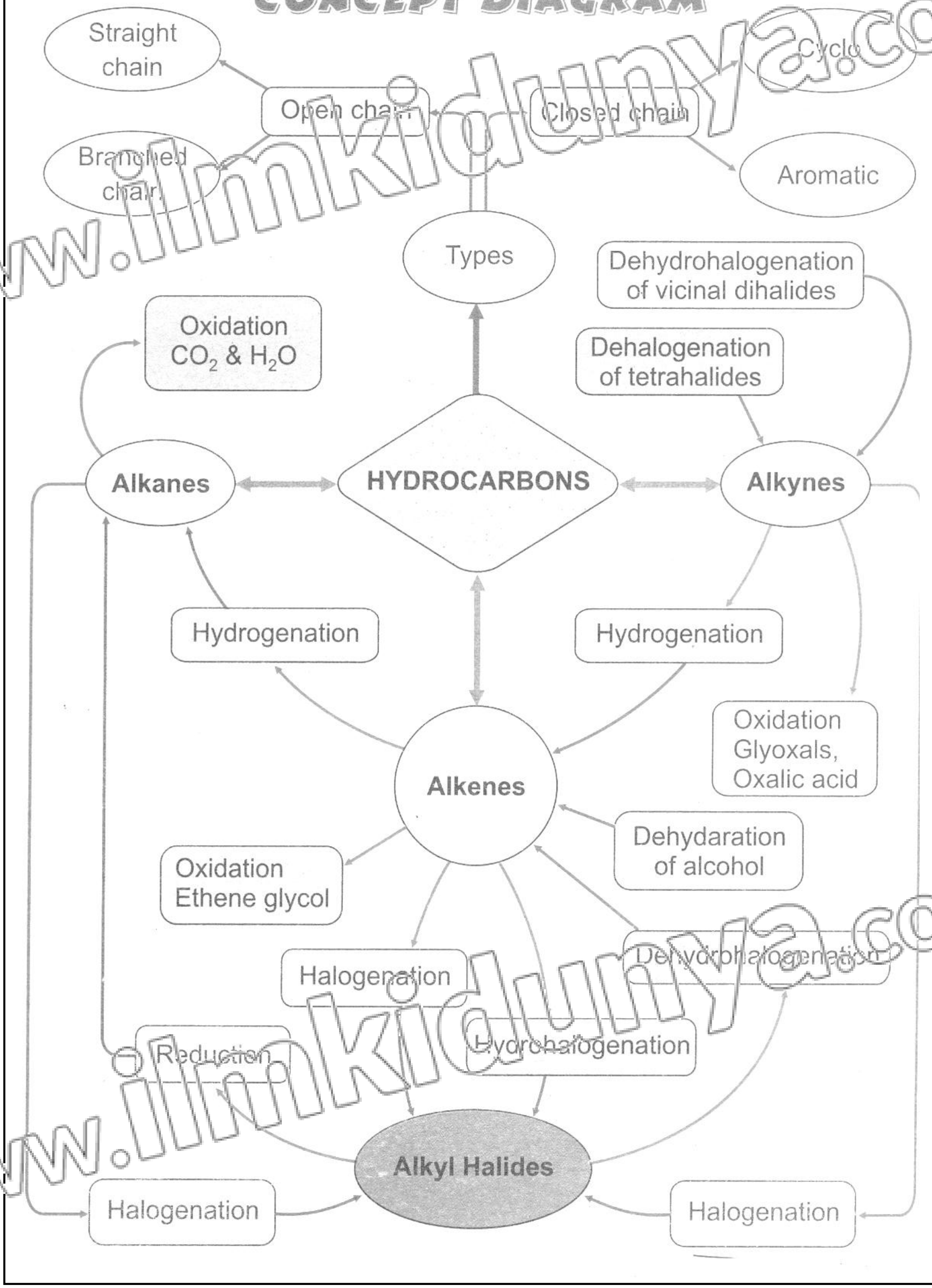
2. The organic compounds prepared from hydrocarbons (petroleum and natural gas) are called: ***(K.B)***
(A) Petrochemicals (B) Petroleum
(C) Pharmaceuticals (D) None of these

3. Which one of the following is synthetic polymer? ***(K.B)***
(A) Toluene (B) Silk
(C) Benzene (D) Polyester

4. Which one is petrochemical? ***(K.B)***
(A) Acetylene (B) Rayon
(C) Nylon (D) Polyester fibres

5. Neoprene is prepared from: ***(K.B)***
(A) Benzene (B) Chloroprene
(C) Chloroform (D) Carbon tetrachloride

CONCEPT DIAGRAM



ANSWER KEY

MULTIPLE CHOICE QUESTIONS

INTRODUCTION

1	B
2	C
3	A
4	B
5	D

HYDROCARBONS

1	D	6	B	11	B
2	A	7	A	12	C
3	B	8	C	13	A
4	B	9	B	14	C
5	A	10	B	15	A

12.1 ALKANES

1	A	6	D	11	C	16	B
2	D	7	B	12	A	17	A
3	B	8	D	13	B	18	B
4	B	9	C	14	D	19	A
5	A	10	C	15	A	20	C

12.2 ALKENES

1	C	6	C	11	D
2	C	7	B	12	C
3	A	8	C		
4	C	9	A		
5	B	10	A		

12.3 ALKYNES

1	A	6	C
2	A	7	C
3	C	8	D
4	B		
5	C		

HYDROCARBONS AS FEED STOCK IN INDUSTRY

1	A
2	A
3	D
4	A
5	B

EXERCISE SOLUTION

MULTIPLE CHOICE QUESTIONS

1. **Which one of these hydrocarbon molecules would have no effect on an aqueous solution of bromine? *(U.B)*** **(LHR 2013, GRW 2013, RWP 2017, BWP 2016 G-I)**
(a) CH_4 (b) $C_{10}H_{20}$
(c) C_2H_4 (d) C_2H_2

2. **If an organic compound has 4 carbon atoms, all singly bonded, it will have the following characteristics except one: *(K.B)***
(a) It will be saturated hydrocarbon (b) It will have 8 hydrogen atoms
(c) Its name will be n-butane (d) It will be least reactive

3. **The reduction of alkyl halides takes place in the presence of: *(K.B)*** **(LHR 2015, BWP 2016 G-I)**
(a) Zn/HC*I* (b) Na/HC*l*
(c) Mg/HC*l* (d) Cu/HC*l*

4. **Halogenation of methane does not produce which one of the following? *(K.B)*(SGD 2014)**
(a) Carbon tetrachloride (b) Chloroform
(c) Carbon black (d) Chloromethane

5. **Incomplete combustion of alkanes produces: *(K.B)*** **(GRW 2013)**
(a) Carbon dioxide only (b) Carbon monoxide only
(c) Carbon monoxide and carbon black (d) Carbon dioxide and carbon black

6. **Alkenes are prepared from alcohols by a process called: *(K.B)***
(a) Dehydrogenation (b) Dehalogenation
(c) Dehydration (d) Dehydrohalogenation

7. **Dehydrohalogenation takes place in the presence of: *(K.B)***
(a) NaOH aqueous (b) Alcoholic KOH
(c) Aqueous KOH (d) Alcoholic NaOH

8. **Oxidation of ethene with $KMnO_4$ produces: *(K.B)*** **(MTN 2017)**
(a) Oxalic acid (b) Glyoxal
(c) Ethene glycol (d) Propene glycol

9. **Which one of these is a saturated hydrocarbon? *(K.B)*** **(LHR 2014, FSD 2016 G-I, II, SGD 2016 G-II, MTN 2016 G-II)**
(a) C_2H_4 (b) C_3H_6
(c) C_4H_8 (d) C_5H_{12}

10. **A hydrocarbon has molecular formula C_8H_{14}. What is the molecular formula of the next member of the same homologous series? *(U.B)*** **(SWL 2016 G-II)**
(a) C_9H_{18} (b) C_9H_{16}
(c) C_9H_{20} (d) C_9H_{22}

11. **The molecular formulae of the first three members of the alkane hydrocarbons are CH_4, C_2H_6 and C_3H_8. What is the molecular formula for the eighth alkane member, octane, which is found in petrol? *(K.B)***
(a) C_8H_{12} (b) C_8H_{14}
(c) C_8H_{18} (d) C_8H_{20}

12. **One of the hydrocarbons reacts with one mole of hydrogen to form a saturated hydrocarbon. What formula could be of the X? *(U.B)***
(a) C_3H_8 (b) C_6H_{l2}
(c) C_4H_{10} (d) C_7H_{l6}

13. Dehydration of alcohols can be carried out with: *(K.B)*(GRW 2013, SWL 2016 G-II, FSD 2017 G-II)

(a) NaOH
(b) KOH
(c) H_2SO_4
(d) HCl

14. The end product of oxidation of acetylene is: *(K.B)* **(GRW 2013)**

(a) Oxalic acid
(b) Glycol
(c) Glyoxal
(d) None of these

15. Dehalogenation of tetrahalides produces acetylene. This reaction takes place in the presence of: *(K.B)*

(a) Sodium metal
(b) Zinc metal
(c) Magnesium metal
(d) Potassium metal

16. Substitution reaction is the characteristic of: *(K.B)*

(a) Alkanes
(b) Alkenes
(c) Alkynes
(d) None of these

17. Halogenation of methane in the presence of diffused sunlight takes place: *(K.B)*

(a) Suddenly, only in one step
(b) Slowly in one step
(c) In a series of four steps
(d) Fastly in two steps

18. Which one of the following is a substitution reaction? *(K.B)*

(a) Halogenation of alkynes
(b) Halogenation of alkenes
(c) Halogenation of alkanes
(d) Bromination of alkenes

19. The order of reactivity of hydrogen halides with alkenes is: *(K.B)*

(SGD 2016 G-I, 17, DGK 20156 G-I)

(a) HI > HBr
(b) HBr > HI
(c) HCl> HBr
(d) HBr < HCl

20. Oxidation of alkenes produces: *(K.B)* **(GRW 2013, BWP 2017, FSD 2017 G-1)**

(a) Glyoxal
(b) Oxalic acid
(c) Glycol
(d) Formic acid

ANSWER KEY

1	a	6	c	11	c	16	a
2	b	7	b	12	b	17	c
3	a	8	c	13	c	18	c
4	c	9	d	14	a	19	a
5	c	10	b	15	b	20	b

EXERCISE SHORT QUESTIONS

Q.1 Differentiate between saturated and unsaturated hydrocarbons. ***(Knowledge Base)***

(GRW 2017, RWP 2016 G-I, MTN 2016 G-I, II)

Ans: **DIFFERENTIATION**

The differences between saturated and unsaturated hydrocarbons are as follows:

Saturated Hydrocarbons	Unsaturated Hydrocarbons
Definition	
• *The compounds in which all the four valencies of carbon atoms are fully satisfied by single bonds with other carbon atoms and hydrogen atoms are called saturated hydrocarbons.*	• *The compounds in which two carbon atoms are linked by a double or triple bond are called hydrocarbons.*
Other Name	
• Saturated hydrocarbons are also called alkanes.	• Unsaturated hydrocarbons are also called alkenes (with double covalent bond) and alkynes (with triple covalent bond).
General Formula	
• Their general formula is C_nH_{2n+2}.	• Their general formula is C_nH_{2n} for alkenes and C_nH_{2n-2} for alkynes.
Examples	
• CH_4 (Methane) $H_3C–CH_3$ (Ethane)	• $H_2C = CH_2$ (Ethene) $HC \equiv CH$ (Ethyne)

Q.2 A compound consisting of four carbon atoms has a triple bond in it. How many hydrogen atoms are present in it? ***(Understanding Base)***

Ans: **NUMBER OF H-ATOMS**

A compound consisting of four carbons atoms with a triple bond will have following structure. $H_3C-C\equiv C-CH_3$ $H_3C\text{-}CH_2\text{-}C\equiv CH$

Thus there are six hydrogen atoms in it.

Q.3 Why the alkanes are called paraffins? ***(Knowledge Base)***

(GRW 2015), (SGD 2017), (BWP 2017), (FSD 2017)(RWP G-I,II 2017)

Ans: **ALKANES ARE PARAFFINS**

Para means 'less' and affin means 'affinity' or reactivity, Alkanes are least reactive compounds. In these compounds all the bonds of carbon atoms are single, that means all valencies of carbon atoms are fully satisfied.

Q.4 What do you know about hydrogenation of alkenes? ***(Knowledge+Application Base)***

(BWP 2016 G-I, II)

Ans: **HYDROGENATION OF ALKENES**

Hydrogenation means **addition of molecular hydrogen** to an unsaturated hydrocarbon in the presence of a catalyst (Ni, Pt) to form saturated compound.

$$H_2C{=}CH_2 + H_2 \xrightarrow[250\text{-}300^0C]{Ni} H_3C\text{-}CH_3$$

On industrial scale this reaction is used to convert vegetable oil into margarine (ghee).

Q.5 How alkyl halides are reduced? *(Knowledge+Application Base)*

(GRW 2013, RWP 2016 G-II)

Ans: **<u>REDUCTION OF ALKYL HALIDES</u>**

When alkyl halides are treated with HCl in the presence of Zn, they are reduced.

$$CH_3Br + 2[H] \xrightarrow{Zn/dil.HCl} CH_4 + HBr$$

$$CH_3CH_2Br + 2[H] \xrightarrow{Zn/dil.HCl} H_3C{-}CH_3 + HBr$$

Q.6 Why the alkanes are used as fuel? *(Understanding+Application Base)* **(GRW 2014)**

Ans: **<u>USE OF ALKANES AS FUELS</u>**

Alkanes are used as fuel because they burn easily in excess of air or oxygen to produce a lot of heat, CO_2 and water then heat is produced.

$$CH_4 + O_2 \longrightarrow CO_2 + H_2O + Heat$$

Q.7 How can you prepare ethene from alcohol and ethyl bromide? *(Knowledge+Application Base)*

Ans: **<u>PREPARATION OF ALKENES</u>**

Alkenes are prepared by the removal of small atoms (H, OH, X) from the adjacent carbon atoms of the saturated compounds, so as to create a double bond between carbon atoms.

(i) <u>Dehydration of Alcohols:</u>

"The removal of water from a substance is called dehydration".

<u>Process:</u>

Ethene is prepared by heating a mixture of ethanol and excess of concentrated sulphuric acid at **180°C**. In first step, ethyl hydrogen sulphate is formed which decomposes on heating to produce ethane, which is collected over water.

$$H_3C-CH_2-OH + H_2SO_4 \xrightarrow{180^{o}C} CH_3CH_2-OSO_3H + H_2O$$

$$CH_3CH_2-OSO_3H \xrightarrow{heat} H_2C = CH_2 + H_2SO_4$$

(ii) <u>Dehydrohalogenation of Alkyl Bromide:</u> **(LHR 2014)**

"The removal of hydrogen and halogen from a substance is called dehydrohalogenation".

<u>Process:</u>

On heating, ethyl bromide with alcoholic KOH, ethene is formed. Removal of hydrogen and halogen takes place from adjacent carbon atoms to create a double bond.

$$H_3C-CH_2Br + KOH_{(Alcoholic)} \xrightarrow{Heat} H_2C = CH_2 + KBr + H_2O$$

Q.8 Identify propane from propene with a chemical test.

Ans: **<u>IDENTIFICATION OF PROPANE</u>**

To identify propane from propene, pass the two gases (propane and propene) through bromine water separately. Propene will decolourise reddish brown colour of bromine but propane cannot.

$$CH_3-CH_2=CH_2+Br_2 \longrightarrow CH_3-\underset{\displaystyle Br}{\underset{|}{CH}}-\underset{\displaystyle Br}{\underset{|}{CH_2}}$$

Colourless

Q.9 Why the alkenes are called olefins? *(Knowledge Base)*

(FSD 2017, SWL 2016 G-II, MTN 2016 G-I)

Ans: **ALKENES CALLED OLEFINS**

Alkenes are also known as olefins because lower members of the series form oily products when react with halogens. Olefins is a Latin word which means oil forming.

Q.10 Why alkanes can't be oxidized with $KMnO_4$ solution? *(Understanding Base)* (GRW 2013)

Ans: **OXIDATION OF ALKANES WITH $KMnO_4$**

Alkanes cannot be oxidized with KMnO4 solution because they are saturated hydrocarbons and are least reactive due to presence of all C – C single bonds.

$$\text{Alkane}+KMnO_4+H_2O \longrightarrow \text{No reaction}$$

Q.11 What are the addition reactions? Explain with an example. *(Knowledge Base)*

(LHR 2015, GRW 2013)

Ans: **ADDITION REACTIONS**

Definition:

"These are the reactions in which the products are formed by the addition of some reagents like H_2, Cl_2 etc. to an unsaturated organic compound".

Mechanism:

In the process, one of the bonds of double bonds gets broken and two new single bonds are formed.

Example:

- Addition of molecular hydrogen to an unsaturated hydrocarbon in the presence of a catalyst (Ni, Pt) to form saturated compounds takes place.

$$H_2C{=}CH_2-H_2 \xrightarrow[250\text{-}300^o]{Ni} H_3C-CH_3$$

Q.12 Justify that alkanes give substitution reactions. *(Understanding Base)*

Ans: **ALKANES GIVE SUBSTITUTION REACTIONS**

"Substitution reaction is a reaction in which one or more hydrogen atoms of a saturated compound are replaced with some other atoms like halogens is called a substitution reaction".

These reactions are a characteristic property of alkanes.

Example:

In diffused sunlight, a series of reactions take place and at each step one hydrogen atom is substituted by halogen atoms, so that all the hydrogen atoms are substituted one by one by halogen atoms

$$CH_4 + Cl_2 \xrightarrow[\text{Sunlight}]{\text{Diffused}} CH_3Cl + HCl$$
Chloromethane

$$CH_3Cl + Cl_2 \xrightarrow{\text{Diffused sunlight}} CH_2Cl_2 + HCl$$
Dichloromethane

$$CH_2Cl_2 + Cl_2 \xrightarrow{\text{Diffused sunlight}} CHCl_3 + HCl$$
Trichloromethane
(Chloroform)

$$CHCl_3 + Cl_2 \xrightarrow{\text{Diffused sunlight}} CCl_4 + HCl$$
Tetrachloromethane
(Carbon tetrachloride)

Q.13 Both, alkenes and alkynes are unsaturated hydrocarbons. State the one 'most significant difference between them. *(Understanding Base)* (FSD 2017)

Ans: **<u>MOST SIGNIFICANT DIFFERENCE</u>**

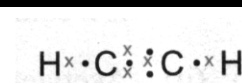
The most significant differences between alkenes and alkynes are as follows:

Alkenes	Alkynes
Nature of Bond	
• *In alkenes two carbon atoms are linked by a double bond.*	• *In alkynes two carbon atoms are linked by a triple bond.*
Functional Group	
• Their functional group is $-\underset{\vert}{C}=\underset{\vert}{C}-$	• Their functional group is $-C\equiv C-$
Examples	
• $H_2C=CH_2$ (Ethene) $H_3C-CH=CH_2$ (Propene)	• $HC\equiv CH$ (Ethyne) $H_3C-C\equiv CH$ (Propyne)

Q.14 Write the molecular, dot and cross and structural formulas of ethyne.
(Knowledge Base)

Ans: **<u>FORMULAS OF ETHYNE</u>**

The molecular, dot and cross and structural formulas of ethyne are as follows:

Name	Molecular Formula	Structural Formula	Cross and dot Formula
Ethyne	C_2H_2	$H-C\equiv C-H$	

Q.15 Why hydrocarbons are soluble in organic solvents? *(Knowledge Base)*

(SGD 2016 G-II, DGK 2016 G-I)

Ans: **SOLUBILITY OF HYDROCARBONS**

We know that

"Like Dissolves Like"

Therefore, hydrocarbons being non-polar in character are more soluble in non polar organic solvents such as ether, carbon tetrachloride etc.

Example:

- Petrol is dissolved in kerosene oil.

Q.16 Give the physical properties of alkanes. *(Knowledge Base)* **(MTN 2017, BWP 2016 G-I)**

Ans: **PHYSICAL PROPERTIES OF ALKANES**

The physical properties of alkanes are as follows:

(i) Physical state:

Alkanes form a homologous series of compounds. The first four members of the series are gases. The alkanes consisting of C_5 to C_{10} are liquids while higher members of the series are solids.

(ii) Solubility:

They are non-polar, therefore, they are insoluble in water but soluble in organic solvents.

(iii) Density:

The density of alkanes increases gradually with the increase of molecular size.

(iv) Melting and Boiling Points:

The melting and boiling points of alkanes increase regularly with the increase of molecular sizes. This is because of increase of attractive forces between the molecules of alkanes.

(v) Viscosity:

The alkanes become more viscous as their molecular sizes increase.

(vi) Nature of Flame:

Alkanes become less flammable, i.e. more difficult to burn with the increase of molecular sizes.

Q.17 How can you identify ethane from ethene? *(Understanding Base)* **(SGD 2016 G-I)**

Ans: **IDENTIFICATION OF ETHANE**

For the identification of ethane from ethene, bromine water is added to both ethane and ethene in the presence of an inert solvent like carbon tetrachloride. Ethene will give reaction with bromine water but ethane will not react with it.

Examples:

$$H_2C{=}CH_2 + Br_2 \longrightarrow Br{-}CH_2{-}CH_2{-}Br$$

(Ethene)

$$H_3C{-}CH_3 + Br_2 \longrightarrow \text{No reaction}$$

(Ethane)

Bromination is an important reaction for checking of unsaturation in organic compounds.

Q.18 Why colour of bromine water discharges on addition of ethene in it? ***(Understanding +Application Base)***

Ans: **COLOUR OF BROMINE WATER**

Colour of bromine water discharges on addition of ethene in it because double bond of ethene is converted into a single bond and nature of bromine is changed.

Example:

$$H_2C=CH_2 + Br_2 \longrightarrow Br–CH_2–CH_2–Br$$

This reaction is used to identify the unsaturation of an organic compound.

Q.19 State one important use of each: ***(Knowledge Base)***

(i) Ethene **(ii)** Acetylene **(iii)** Chloroform **(iv)** Carbon tetrachloride

Ans: **IMPORTANT USES**

(i) Ethene:

Oxy-ethylene flame is used for welding purposes.

(ii) Acetylene:

It is used for the manufacturing of polymer products like polyvinyl chloride, polyvinyl acetate and synthetic rubber like neoprene.

(iii) Chloroform:

Chloroform is used as a solvent for rubber, waxes etc. and for anaesthesia.

(iv) Carbon Tetrachloride:

Carbon tetrachloride is used as an industrial solvent and in dry cleaning.

EXERCISE LONG QUESTIONS

Q.1 What types of reactions are given by alkanes? Explain with reference to halogenations of alkanes. ***(Knowledge Base)***

Ans: See LQ.4 (Topic 12.1)

Q.2 Alkanes are a source of heat. Explain it. ***(Application Base)***

Ans: See LQ.1 (Topic *Application of Hydrocarbons)

Q.3 Prepare the following as directed: ***(Understanding+Application Base)***

(a) Ethane from ethene

(b) Acetylene from tetrahalide

(c) Carbon tetracholride from methane

(d) Ethylene glycol from ethene

(e) 1,2-dibromoethane from ethene

(f) Glyoxal from acetylene

Ans. **PREPARATIONS AS DIRECTED**

(a) Ethane From Ethene:

When hydrogen is passd through ethene in presence of heated nickel catalyst, ethane is formed.

$$H_2C = CH_2 + H_2 \xrightarrow[250\text{-}300^\circ C]{Ni} H_3C - CH_3$$

(b) Acetylene From Tetrahalide:

When alkyl tetrahalides are heated with zinc dust, the elimination of halides takes place to form alcetylene.

$$\begin{array}{c} \quad\; Cl \;\; Cl \\ \quad\;\, | \quad\; | \\ H-C-C-H \\ \quad\;\, | \quad\; | \\ \quad\; Cl \;\; Cl \end{array} + 2Zn_{dust} \longrightarrow \underset{\text{ethyne}}{HC \equiv CH} + 2ZnCl_2$$

(c) Carbon Tetracholride From Methane:

Carbon tetrachloride is prepared by the substitution reaction of methane with chlorine in diffused sunlight.

In diffused sunlight, a series of reactions take place and at each step one hydrogen atom is substituted by halogen atoms, so that all the hydrogen atoms are substituted one by one by halogen atoms.

$$CH_4 + Cl_2 \xrightarrow[\text{Sunlight}]{\text{Diffused}} \underset{\text{Chloromethane}}{CH_3Cl} + HCl$$

$$CH_3Cl + Cl_2 \xrightarrow{\text{Diffused sunlight}} \underset{\text{Dichloromethane}}{CH_2Cl_2} + HCl$$

$$CH_2Cl_2 + Cl_2 \xrightarrow{\text{Diffused sunlight}} \underset{\substack{\text{Trichloromethane} \\ \text{(Chloroform)}}}{CHCl_3} + HCl$$

$$CHCl_3 + Cl_2 \xrightarrow{\text{Diffused sunlight}} \underset{\substack{\text{Tetrachloromethane} \\ \text{(Carbon tetrachloride)}}}{CCl_4} + HCl$$

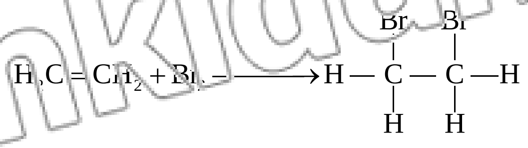
(d) Ethylene Glycol From Ethene:

Ethylene glycol is prepared by the reaction of ethane with acidified dilute solution of $KMnO_4$

$$3H_2C = CH_2 + 2KMnO_4 + 4H_2O \longrightarrow \underset{\text{Ethylene glycol}}{3\,\underset{OH}{\underset{|}{H_2C}} - \underset{OH}{\underset{|}{CH_2}}} + 2MnO_2 + 2KOH$$

(e) <u>1,2-dibromoethane From Ethene:</u>

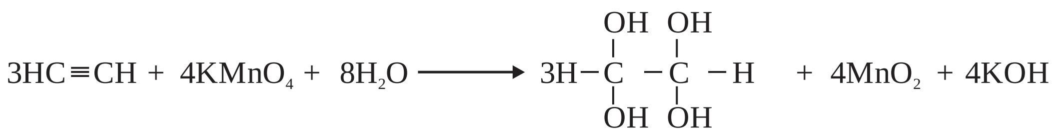
When bromine water is added to ethene in an inert solvent like carbon tetrachloride it decolourizes to form 1, 2-dibromoethane. This reaction is used to identify the unsaturation of an organic compound.



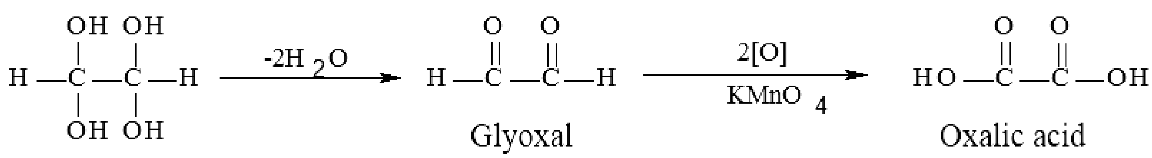
1, 2 – dibromoethane

(f) <u>Glyoxal From Acetylene:</u>

Acetylene is oxidized by alkaline $KMnO_4$ and four hydroxyl groups add to the triple bond.



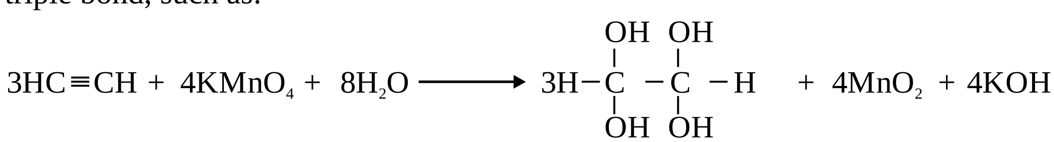
This intermediate product eliminates water molecules to form glyoxal, which is further oxidized to form oxalic acid.



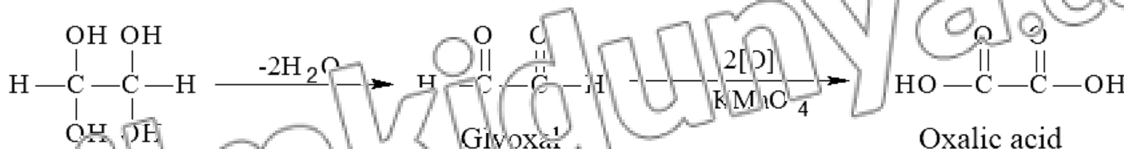
Q.4 Explain the oxidation of acetylene. ***(Knowledge+Understanding Base)***

Ans. **<u>OXIDATION OF ACETYLENE</u>**

Acetylene (ethyne) is oxidized by alkaline $KMnO_4$ and four hydroxyl groups add to the triple bond, such as:



This intermediate product eliminates water molecules to form glyoxal, which is further oxidized to form oxalic acid.



Q.5 Write balanced chemical equations for the following reactions. Also name the products that are formed. ***(Knowledge+Understanding Base)***

(i) A mixture of ethyne and hydrogen is passed over heated nickel

(ii) Ethyne is treated with chlorine

(iii) Ethyne is burnt in air

(iv) Ethyne is passed through bromine water

Ans. **BALANCED EQUATIONS AND NAMES OF PRODUCTS**

The balanced chemical equations for the reactions along with names of proudcts are as follows:

(i) Reaction Between Ethyne and Hydrogen:

$$HC \equiv CH + H_2 \xrightarrow[250\text{-}300^\circ C]{Ni} H_2C = CH_2$$

$$H_2C = CH_2 + H_2 \xrightarrow[250\text{-}300^\circ C]{Ni} H_3C - CH_3$$

(ii) Reaction Between Ethyne and Chlorine:

$$HC \equiv CH + 2Cl_2 \longrightarrow \begin{array}{c} \quad Cl \quad Cl \\ \quad | \quad\;\; | \\ H - C - C - H \\ \quad | \quad\;\; | \\ \quad Cl \quad Cl \end{array}$$

Tetrachloroethane

(iii) Burning of Ethyne in Air:

$$2HC \equiv CH + 5O_2 \longrightarrow 4CO_2 + 2H_2O + Heat$$

(iv) Reaciton Between Ethyne and Bromine Water:

$$HC \equiv CH + 2Br_2 \longrightarrow \begin{array}{c} \quad Br \quad Br \\ \quad | \quad\;\; | \\ H - C - C - H \\ \quad | \quad\;\; | \\ \quad Br \quad Br \end{array}$$

Tetrabromoethane

Q.6 Explain briefly: ***(Knowledge+Understanding Base)***

(i) Why butane undergoes substitution reactions?
(ii) There are millions of organic compounds.
(iii) Acetylene undergoes addition reactions in two stages.
(iv) Alkynes are more reactive than alkanes.

Ans. **JUSTIFICATION**

(i) Substitution Reactions of Butane:

Butane is saturated hydrocarbon (alkane). Like other alkanes it gives substitution reactions by replacing its hydrogen atoms with some other atoms. Also it cannot underge addition reacitons.

(ii) Millions of Organic Compounds:

There are millions of organic compounds due to the following four properties:

- Catenation
- Isomerism
- Strength of covalent bonds of carbon
- Multiple bonding

Moreover, the number of organic compounds is very large because they are derived from hydrocarbons (parent organic compounds).

(iii) Addition Reactions of Acetylene:

Alkynes are reactive compounds because of presence of a triple bond. A triple bond consists of two weak bonds (π-bonds) and a strong bond (σ-bond).

When alkynes react with other substances, two weak bonds are readily broken one by one and addition takes place easily. The addition reactions of alkynes resemble to those of alkenes.

$$HC \equiv CH + H_2 \xrightarrow[250\text{-}300°C]{Ni} H_2C = CH_2$$

$$H_2 = CH_2 + H_2 \xrightarrow[250\text{-}300°C]{Ni} H_3C - CH_3$$

(iv) <u>More Reactivity of Alkynes:</u>

Alkynes are more reactive compounds than alkanes because of presence of a triple bond. A triple bond consists of two weak bonds (π-bonds) and a strong bond (σ-bond). When alkynes react with other substances, two weak bonds are readily broken one by one and addition takes place easily. The addition reactions of alkynes resemble to those of alkenes.

ADDITIONAL CONCEPTUAL QUESTIONS

Q.1 Differentiate between Glyoxal and Oxalic Acid. ***(Understanding Base)***

Ans: **<u>DIFFERENTIATION</u>**

Glyoxal	Oxalic Acid
<u>Definition:</u> • Glyoxal is dialdehyde compound. **<u>Functional Group:</u>** • It has aldeyhydic functional group (-CHO) **<u>Structure:</u>** $H-\overset{\overset{O}{\parallel}}{C}-\overset{\overset{O}{\parallel}}{C}-H$	**<u>Definition:</u>** • Oxalic acid is dicarboxylic compound. **<u>Functional Group:</u>** • It has carboxylic functional group (-COOH) **<u>Structure:</u>** $HO-\overset{\overset{O}{\parallel}}{C}-\overset{\overset{O}{\parallel}}{C}-OH$

Q.2 How alkyl halides are produced fom alkenes? ***(Understanding Base)***

Ans: Alkyl Halides can be prepared from Alkenes by Hydrohalogenation (Addition of hydrogen and halogens). Dry gaseous halides react with alkene to produce alkyl halides.

$$H_2C = CH_2 + HX \rightarrow H_3C - CH_2X$$

$$H_2C = CH_2 + HBr \rightarrow H_3C - CH_2Br$$

Q.3 What is the difference between 1-butyne and 2-butyne or Dimethyl Acetylene?

Ans: **<u>DIFFERENTIATION</u>**

1-Butyne	2-Butyne (Dimethyl Acetylene)
<u>Definition:</u> • The carbon-carbon triple bond is at end of carbon chain. **<u>Common Name:</u>** • Its common name is ethyl Acetylene **<u>Structure:</u>** $H_3C-CH_2-C\equiv CH$	**<u>Definition:</u>** • The carbon-carbon triple bond is at middle of carbon chain. **<u>Common Name:</u>** • Its common name is dimethyl Acetylene **<u>Structure:</u>** $H_3C-C\equiv C-CH_3$

Q.4 How can you prepare 1-2, dichloroethene?

Ans: Ethene will undergo an addition reaction with Cl_2 to give 1-2 dichloroethane.

$$CH_2 = CH_2 + Cl_2 \rightarrow \begin{array}{c} \quad\;\; Cl \quad Cl \\ \quad\;\; | \quad\;\; | \\ H - C = C - H \\ \quad\;\; | \quad\;\; | \\ \quad\;\; H \quad\; H \end{array}$$

1-2 dichloroethane

Q.5 How can you prepare butane from butyl Alcohol?

Ans: Butene can be prepared by dehydration of butyl Alcohol.

$$C_4H_9OH + H_2SO_4 \longrightarrow C_4H_9OSO_3H + H_2O$$

$$C_4H_9OSO_3H \xrightarrow{\Delta} C_4H_8 + H_2SO_4$$

Q.6 Convert ethyl chloride into ethene?

Ans: Ethyl chloride can be converted into ethene by the process of dehydrhalogenetion (removal of hydrogen and halogen).

$$CH_3 - CH_2 - Cl + KOH_{(alcholic)} \longrightarrow CH_2 = CH_2 + KCl + H_2O$$

Q.7 Give condensed and structural formula of Propylene and Methyl Acetylene.

Ans:

<u>PROPYLENE</u>

Molecular formula: C_3H_6

Structural formula:

$$\begin{array}{c} \quad\;\; H \qquad\quad H \\ \quad\;\; | \qquad\quad\; | \\ H - C - C = C \\ \quad\;\; | \quad\;\; | \quad\;\; | \\ \quad\;\; H \quad H \quad H \end{array}$$

Condensed formula: $CH_3 - CH = CH_2$

<u>Methyl Acetylene</u>

Molecular formula: C_3H_4

Structural formula:

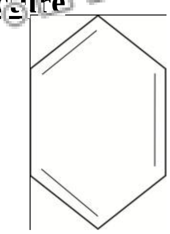
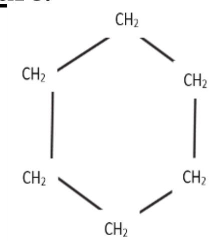
$$\begin{array}{l} \quad\;\; H \\ \quad\;\; | \\ H - C - C \equiv C - H \\ \quad\;\; | \\ \quad\;\; H \end{array}$$

Condensed formula: $H_3C - C \equiv CH$

Q.8 What is the difference between Benzene and Cyclohexane?

Ans:

DIFFERENTIATION

Benzene	Cyclohexane
Definition: • Benzene is an aromatic compound. **Description:** • It has alternating double and single bonds in its ring. **Molecular Formula:** **C_6H_6** **Structure:** 	**Definition:** • Cyclohexane is an alicyclic or non-benzenoid compound. **Description:** • It has six carbon atoms linked through single bonds only. **Molecular Formula:** **C_6H_{12}** **Structure:** 

Q.9 What is the relationship between flammability and Molecular size?

Ans: The smaller the carbon chain, the better is its flammability and vice versa. Therefore, there exist inverse relationship between flammability and molecular size.

$$\text{Flammability} \times \frac{1}{\text{Molecular Size}}$$

Q.10 Why density of acetylene is slightly lighter than air?

Ans: Density of acetylene is slightly lighter than air because air molecular weight is 28.5g/mol. While acetylene molecular weight is 26 g/mol. As density is directly proptional to mass and inversely proportional to volume, so we can say that acetylene is slightly lighter than air.

Q.11 What is the difference between Hydrogenation and Reduction?

Ans:

Hydrogenation	Reduction
Definition: • It is the addition of molecular hydrogen in unsaturated hydrocarbon. **Example:** $CH_2 = CH_2 + H_2 \xrightarrow[250-300^\circ C]{Ni} CH_3 - CH_3$	**Definition:** • reduction is addition of hydrogen or removal of oxygen or gain of electrons **Example:** $2FeO + C \longrightarrow CO_2 + 2Fe$

Q.12 How can we distinguish between alkene and alkyne?

Ans: We can distinguish between alkene and alkyne using $KMnO_4$ test. Oxidation of alkene with $KMnO_4$ gives ethylene glycol and Oxidation of alkyne with $KMnO_4$ gives glyoxal.

Q.13 Is this a substitution reaction?

$$CH_4 + 2Cl_2 \underset{\text{sunlight}}{\overset{\text{bright}}{\rightarrow}} C + 4HCl$$

Ans: No, this is not a substitution reaction because the hudrogen atom are replaced by halogen atom but removed

Q.14 What is vicinal dihalide?

Ans: Compounds which has two halogen atoms on the adjacent carbon atoms is called vicinal dihalide

TERMS TO KNOW

Terms	Definitions
Hydrocarbons	The organic compounds which consist of carbon and hydrogen only are called hydrocarbons.
Open Chain Compounds	These are compounds in which first and the last carbon atom are not joined directly to each other. The open chain may be straight or branched.
Aliphatic Hydrocarbons	These are the compounds in which the first and the last carbon are not directly joined to each other.
Saturated Hydrocarbons	The hydrocarbon in which all the four valencies of carbon atoms are fully satisfied (saturated) by single bonds with other carbon atoms and hydrogen atoms are called saturated hydrocarbons.
Unsaturated Hydrocarbons	The hydrocarbons in which two carbon atoms are linked by a double or a triple bond are called unsaturated hydrocarbons.
Alkanes	The hydrcarbons in which all the carbon-carbon bonds are single covalent are called alkanes.
Alkenes	The compounds in which two carbon atoms are linked by a double bond are called alkenes.
Alkynes	The hydrocarbons in which two carbon atoms are linked by a triple bond are called alkynes.
Closed Chain Hydrocarbons	Compounds having rings of carbon atoms in their molecules are called closed chain or cyclic hydrocarbons.
Straight Chain Hydrocarbons	Straight chain hydrocarbons are those in which carbon atoms link with each other through single, double or triple bond forming a straight chain.
Branched Chain Hydrocarbons	Branched chain hydrcarbons are those in which there is a branch along a straight chain.
Substitution Reaction	A reaction in which one or more hydrogen atoms of a saturated compound are replaced with some other atoms (halogen) is called a substitution reaction.
Halogenation	Addition of halogen to a substance is called halogenation.

Dehlogenation	Removal of halogen from a substance is called dehalogenation.
Hydration	Addition of water to a substance is called hydration.
Dehydration	Removal of water from a substance is called dehydration.
Addition Reacitons	These are the reactions in which the products are formed by the addition of some reagents like H_2, Cl_2, etc., to an unsaturated organic compound.
Hydrogenation	Hydrogenation means addition of molecular hydrogen to an unsaturated hydrocarbon in the presence of a catalyst (Ni, Pt) to form saturated compound.
Bromination	Addition of bromine to a substance is called bromination.
Dehydrogenation	Removal of hydrogen from a substance is called dehydrogenation.
Dehydrohalogenation	Removal of hydrogen and halogen from an alkyl halide is called dehydrohalogenation.
Dehalogenation	Removal of halogen from a substance is called dehalogenation.
Hydroxyl Group (OH)	The functional group in glycol is hydroxyl group (OH).
Petrochemicals	The organic compounds prepared from hydrocarbons (petroleum and natural gas) are called petrochemicals.
Paraffins	Paraffins means less affinity. Alkanes are called paraffins due to their less reactivity.
Olefins	Olefins means oil forming. Alkenes are called olefins due to their property of forming oily products on reaction with lower halogens.
Marsh Gas	The gas (major compounent is methane) produced from marshy places due to anaerobic decomposition of dead organic matter is called marsh gas.

CUT HERE

SELF TEST

Time: 35 Minutes **Marks: 25**

Q.1 Four possible answers (A), (B), (C) and (D) to each question are given, mark the correct answer. **(6×1=6)**

1. One of the hydrocarbons reacts with one mole of hydrogen to form a saturated hydrocarbon. What formula could be of the X?

(A) C_3H_8 (B) C_6H_{12}

(C) C_4H_{10} (D) C_7H_{16}

2. Traces of acetylene are present in coal gas about:

(A) 0.06% (B) 0.08%

(C) 1.1% (D) 90%

3. Which one is the formula of chloromethane?

(A) CH_2Cl_2 (B) CCl_4

(C) $CHCl_3$ (D) CH_3Cl

4. In dry cleaning which chemical is used:

(A) Chloroform (B) Carbon tetrachloride

(C) Acetaldehyde (D) Ethanol

5. Dehydration means removal of:

(A) Water (B) Halogen

(C) Hydrogen (D) All of these

6. General formula of alkanes is:

(A) C_nH_{2n-2} (B) C_nH_{2n}

(C) C_nH_{2n+2} (D) C_nH_{2n+1}

Q.2 Give short answers to the following questions. **(5×2=10)**

(i) What are saturated hydrocarbons? Give an example.

(ii) Give reactions of methane with chlorine in diffused light?

(iii) Why alkenes are called "olefins"?

(iv) What is meant by hydrogenation?

(v) Write sources of alkenes.

Q.3 Answer the following questions in detail. **(5+4=9)**

(i) Write down the chemical properties of alkynes? **(5)**

(ii) How alkanes are prepared? **(4)**

NOTE: Parents or guardians can conduct this test in their supervision in order to check the skill of students.

CHAPTER 13

BIOCHEMISTRY

INTRODUCTION

SHORT QUESTIONS

Q.1 What is biochemistry? *(Knowledge Base)* **(BWP 2017)**

Ans: **<u>BIOCHEMISTRY</u>**

<u>Definition:</u>

"The branch of chemistry that deals with the study of structure, composition, and chemical reactions of substances found in living organisms is called biochemistry."

<u>Scope:</u>

It deals with the naturally occurring macromolecules such as carbohydrates, proteins, lipids, nucleic acids and vitamins.

<u>Importance:</u>

Biochemistry is a field that has a great importance today in various fields like:

- Medicine
- Agriculture
- Pharmaceuticals

Q.2 How are macromolecules synthesized? Why are they important? *(Knowledge Base)*

Ans: **<u>SYNTHESIS OF MACROMOLECULES</u>**

These macromolecules are synthesized by living organisms from simple molecules present in the environment.

<u>Examples:</u>

- Carbohydrates
- Lipids
- Proteins
- Nucleic acids

<u>Importance:</u>

- Macromolecules are essential for us as they are reservoirs of energy.
- They not only provide us energy but also form new bones and muscular bones.
- They protect us against the diseases.
- They are responsible for transmitting genetic information from generation to generation.

Q.3 What are functions of macromolecules? *(Knowledge Base)*

Ans: **<u>FUNCTIONS OF MACROMOLECULES</u>**

Some important functions of macromolecules are as follows:

(i) <u>Carbohydrates:</u>

Carbohydrates we eat, provide us energy.

(ii) <u>Lipids:</u>

Lipids are major source of energy. They are stored in the body to provide emergency energy supplies. They help us to work during tough times.

(iii) <u>Proteins:</u>

Proteins not only provide us energy, they help us stay strong by forming new bones and muscular tissues. Moreover, proteins protect us against the diseases.

(iv) <u>Nucleic Acids:</u>

Nucleic acids are responsible for transmitting genetic information from generation to generation.

MULTIPLE CHOICE QUESTIONS

1. **It is responsible for the transmission of genetic information:** ***(K.B)***
   (A) Nucleic acid (B) Acetic acid
   (C) Carbonic acid (D) Oxalic acid
2. **Carbohydrates are synthesized by plants through:** ***(K.B)***
   (A) Photosynthesis (B) Respiration
   (C) Oxidation (D) Breathing
3. **Carbohydrates are molecules:** ***(K.B)***
   (A) Macromolecules (B) Micromolecules
   (C) Homomolecules (D) Monomolecule
4. **The major source of energy are:** ***(K.B)***
   (A) Proteins (B) Carbohydrates
   (C) Nucleic acids (D) Lipids

13.1 CARBOHYDRATES

LONG QUESTIONS

Q.1 What are carbohydrates? How monosaccharides are prepared? Give their characteristics. ***(Knowledge+Understanding Base)*** **(Ex-Q.1)**

Ans:

CARBOHYDRATES

Definition:

*"Carbohydrates are macromolecules defined as **polyhydroxy aldehydes or ketones**".*

General Formula:

They have general formula $\mathbf{C_n(H_2O)_n}$.

Classification of Carbohydrates:

Carbohydrates are classified as:

- Monosaccharides
- Oligosaccharides
- Polysaccharides

SYNTHESIS OF CARBOHYDRATES/MONOSACCHARIDES

Carbohydrates are synthesized by plants through photosynthesis process from carbon dioxide and water in the presence of sunlight and green pigment chlorophyll.

$$6CO_2 + 6H_2O \xrightarrow[\text{chlorophyll}]{\text{sunlight}} \underset{\text{(Glucose)}}{C_6H_{12}O_6} + 6O_2$$

The **glucose** is further **polymerized** to form **starch** and **cellulose**.

MONOSACCHARIDES

*"Monosaccharides are the simplest sugars which cannot be hydrolyzed. They consist of **3** to **9 carbon atoms**".*

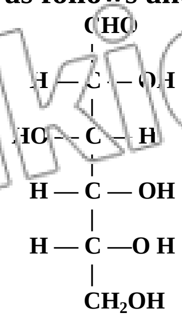
Classification of Monosaccharides (On the Basis of No. of C-atoms)

They are classified according to the number of carbon atoms in their molecules as:

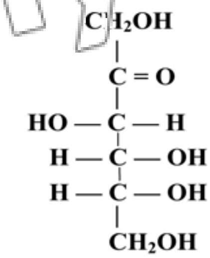
- Trioses (Monosaccharides made up of 3 carbon atoms)
- Tetroses (Monosaccharides made up of 4 carbon atoms)
- Pentoses (Monosaccharides made up of 5 carbon atoms)
- Hexoses etc. (Monosaccharides made up of 6 carbon atoms)

Examples:

The important monosaccharides are **hexoses like glucose and fructose.**
Glucose is a pentahydroxy aldehyde while fructose is pentahydroxy ketone having the open chain structures as follows and general formula $C_6H_{12}O_6$



Glucose



Fructose

Characteristics:

The characteristics of monosaccharides are as follows:

- Monosaccharides are **white crystalline solids.**
- They are soluble in water and have **sweet taste.**
- They cannot be hydrolyzed.
- They are **reducing in nature**, therefore, these are called **reducing sugars.**

Q.2 Explain oligosaccharides in detail. ***(Knowledge+Understanding Base)***

(SWL 2016 G-I)(Ex-Q.2)

Ans: **OLIGOSACCHARIDES**

Definition:

*"The carbohydrates which give **2 to 9 units of monosaccharide** on hydrolysis are called oligosaccharides".*

Classification:

Depending upon the number of units they produce on hydrolysis, they are classified as:

- Disaccharides
- Trisaccharides
- Tetrasaccharides etc.

Examples:

The most important oligosaccharides are disaccharides like sucrose. Another example of disaccharide is lactose.

Hydrolysis of Sucrose:

On hydrolysis, sucrose produces one unit of glucose and one unit of fructose.

$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow[\text{Heat}]{\text{Dilute HCl}} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

Properties of Oligosaccharides:

The characteristics of oligosaccharides are as follows:

- These carbohydrates are **white crystalline solids.**
- They are easily **soluble in water.**
- They are also **sweet in taste.**
- They may be **reducing or non-reducing.**

Q.3 What are polysaccharides? Give their properties. ***(Knowledge + Understanding Base)***
(GRW 2015)(Ex-Q.3)

Ans:

POLYSACCHARIDES

Definition:

"Polysaccharides are macromolecular carbohydrates consisting of hundreds to thousands of monosaccharides".

Examples:

- Starch
- Cellulose
- Glycogen

PROPERTIES OF POLYSACCHARIDES

The properties of polysaccharides are as follows:

- They are **amorphous solids.**
- They are **tasteless and insoluble in water.**
- They are **non-reducing in nature.**

Q.4 Explain the sources and uses of carbohydrates. ***(Knowledge Base)***
(GRW 2015, LHR 2015, 17)

Ans:

SOURCES AND USES OF CARBOHYDRATES

Carbohydrates range from simple to complex ones. They have varied sources and uses.

Sources:

(i) Simple Sugars:

- **Glucose, fructose** and **galactose** are found in fruits, vegetables, honey and cereals.

(ii) Disaccharides:

- **Sucrose** is found in sugar beet, sugar cane, and fruits.
- **Lactose** consisting of **glucose and galactose** is the main sugar in milk and dairy products.
- **Maltose,** a disaccharide of **two glucose molecules,** is found in cereals.

(iii) Polysaccharides:

- **Starch** is found in cereal crops; wheat, barley, maize, rice, etc.
- **Cotton** is pure cellulose.

USE OF CARBOHYDRATES

Source of energy **(MTN 2016 G-II)**

(i) Glucose is the only form of carbohydrates that is used directly by muscles for energy.
(ii) It is important to note that brain needs glucose as an energy source, because it cannot use fat for this purpose.

Other than Energy:

Besides, the energy providing materials, carbohydrates also provide the following usage in our body.

(i) They regulate the amount of sugar level in our body. Low sugar level in body results in **hypoglycemia.**
(ii) They provide **essential nutrients** for bacteria in intestinal tract that helps in digestion.
(iii) Dietary fiber helps to keep the **bowel functioning** properly.
(iv) Fiber helps in lowering of cholesterol level and **regulates blood pressure.**
(v) Carbohydrates protect our muscles from cramping.

Q.5 What is dextrose? Describe its composition and uses. ***(Knowledge Base)***

(Science, Technology and Society Pg. # 104)

Ans: **DEXTROSE**

Definition:

"***Dextrose is crystallized glucose*** *(natural sugar found in starchy foods). It provides* ***simple carbohydrates*** *to the body that can be* ***easily broken down and processed."***

Dextrose Solution:

Dextrose solution is available in several concentrations. For example, five percent dextrose solution (D5W) consists of **5 grams of dextrose in each 100 ml** of solution. It is used to provide fluid replacement and energy to the body.

Importance of Dextrose:

- **Source of Energy:**

It contains approximately **170 calories of energy,** but does not contain electrolytes. Therefore, electrolytes are added according to requirements in solution.

- **Use in Drips:**

It is commonly called **drip system**. It is the fastest way to deliver fluids, electrolytes and medications throughout the body. It prevents air entering into blood stream.

Nature of Therapy:

Dextrose is given to patients directly into vein called **intravenous (IV) therapy.**

13.1 CARBOHYDRATES

SHORT QUESTIONS

Q. 1 Give the characteristics of oligosaccharides. ***(Knowledge Base)*** **(FSD 2016 G-I)**

Ans: **CHARACTERISTICS OF OLIGOSACCHARIDES**

The characteristics of oligosaccharides are as follows:

- These carbohydrates are white, crystalline solids easily soluble in water.
- They are also sweet in taste.
- They may be reducing or non-reducing.

Q. 2 Describe the sources of sucrose and starch. ***(Knowledge Base)*** **(DGK 2016 G-I)**

Ans: **SOURCES OF SUCROSE AND STARCH**

The sources of sucrose and starch are as follows:

Sucrose:

Sucrose is found in:

- Sugar beet
- Sugar cane
- Fruits

Starch:

Starch is found in:

- Cereal crops
- Wheat
- Barley
- Maize
- Rice etc.

Q. 3 What are monosaccharides? ***(Knowledge Base)*** **(BWP 2016 G-II)**

Ans:

MONOSACCHARIDES

Definition:

"Monosaccharides are the simplest sugars which cannot be hydrolyzed. They consist of 3 to 9 carbon atoms".

Examples:

- Glucose
- Fructose etc.

Classification:

They are classified according to the number of carbon atoms in their molecules as:

- Trioses
- Tetroses
- Pentoses
- Hexoses etc.

13.1 CARBOHYDRATES
MULTIPLE CHOICE QUESTIONS

1. **The glucose is further polymerized to form** ***(K.B)***
   (A) Starch and cellulose (B) Starch and protein
   (C) Lipids and carbohydrates (D) Carbohydrates
2. **Carbohydrates are:** ***(K.B)***
   (A) Crystalline solid (B) Amorphous solid
   (C) Semisolid (D) Both A and B
3. **Monosaccharides consist of number of carbon atoms:** ***(K.B)***
   (A) 3 to 9 (B) 3 to 6
   (C) 4 to 8 (D) 6 to 8
4. **Monosaccharides cannot be:** ***(K.B)***
   (A) Dehydrolyzed (B) Evaporated
   (C) Condensed (D) Hydrolyzed
5. **Maltose is a disaccharide of two molecules of:** ***(K.B)***
   (A) Glucose (B) Starch
   (C) Fructose (D) Sucrose
6. **Nature of polysaccharides is:** ***(K.B)***
   (A) Non-reducing (B) Reducing
   (C) Oxidizing (D) Non oxidizing
7. **It is pure cellulose:** ***(K.B)***
   (A) Nylon (B) Silk
   (C) Ebonite (D) Cotton
8. **Carbohydrates is directly used by:** ***(K.B)***
   (A) Bones (B) Muscles
   (C) Cartilages (D) Heart
9. **Energy provided by carbohydrates is:** ***(K.B)***
   (A) 17 kJ/g (B) 18 kJ/g
   (C) 34 kJ/g (D) 436 kJ/g

10. Dextrose solution contains how many calories of energy? *(K.B)*

(A) 170 (B) 180
(C) 350 (D) 10

11. Molecular formula of fructose is: *(K.B)* **(LHR 2014, DGK 2017, MTN 2017, RWP 2017)**

(A) $C_{12}H_{22}O_{11}$ (B) C_2H_5OH
(C) $C_6H_{12}O_6$ (D) C_6H_6

12. Glucose and fructose combine to form: *(K.B)* **(GRW 2014)**

(A) Starch (B) Cellulose
(C) Sucrose (D) Glycogen

13. General formula of carbohydrates is: *(K.B)* **(SWL 2016 G-I)**

(A) C_nH_{2n} (B) $C_n(H_2O)_n$
(C) $C_n(OH)_n$ (D) None of these

14. Which one of the following is crystalline solid? *(K.B)* **(DGK 2016 G-I)**

(A) Glucose (B) Starch
(C) Cellulose (D) Glycogen

15. Polyhydroxy ketone is called: *(K.B)* **(FSD 2017 G-I)**

(A) Glucose (B) Starch
(C) Sucrose (D) Fructose

13.1 TEST YOURSELF

(i) Define carbohydrates. *(Knowledge Base)* **(LHR 2013, FSD 2016 G-II)**

Ans: **CARBOHYDRATES**

Definition:

"*Carbohydrates are macromolecules defined as polyhydroxy aldehydes or ketones".*

General Formula:

They have general formula $C_n(H_2O)_n$.

Examples:

- Glucose
- Fructose
- Starch etc.

(ii) Give the characteristics of disaccharides. *(Knowledge Base)*

Ans: **CHARACTERISTICS OF DISACCHARIDES**

The characteristics of disaccharides are as follows:

- On hydrolysis disaccharides give 2 to 9 units of monosaccharides.
- Disaccharides are easily soluble in water.
- They are white crystalline solids.
- They have sweet taste.
- They may be reducing (lactose, maltose) or non-reducing sugars (sucrose)

(iii) Give the balanced equation for the formation of glucose. *(Knowledge Base)*
(LHR 2013, GRW 2013)

Ans: **FORMATION OF GLUCOSE**

Glucose is formed from carbon dioxide and water in the presence of sunlight and green pigment chlorophyll.

Reaction:

$$6CO_2 + 6H_2O \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} \underset{\text{Glucose}}{C_6H_{12}O_6} + 6O_2$$

(iv) Draw the structure of glucose. ***(Knowledge Base)*** **(GRW 2014, 2015)**

Ans: **<u>STRUCTURE OF GLUCOSE</u>**

$$\begin{array}{ccc} & CHO & \\ & | & \\ H - & C & - OH \\ & | & \\ HO - & C & - H \\ & | & \\ H - & C & - OH \\ & | & \\ H - & C & - OH \\ & | & \\ & CH_2OH & \end{array}$$

(Glucose)

(v) Give the balanced equation for the hydrolysis of sucrose.
(Knowledge+Understanding Base)

Ans: **<u>HYDROLYSIS OF SUCROSE</u>**

The balanced equation for the hydrolysis of sucrose is as follows:

$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow[\text{Heat}]{\text{Dil.HCl}} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

13.2 PROTEINS

LONG QUESTIONS

Q.1 Define proteins and explain their properties. ***(Knowledge+Understanding Base)***

Ans: **<u>PROTEINS</u>**

<u>Definition:</u>

*"Proteins are highly **complicated nitrogenous compounds** made up of amino acids".*

<u>Example:</u>

- Albumen
- Gelatin

<u>Composition:</u>

Proteins consist of **carbon, hydrogen, oxygen, nitrogen and sulphur.** They are **polymers of amino acids.** Amino acids are linked with each other through **peptide linkage**. Protein has more than **10,000 amino acids.**

<u>Hydrolysis of Proteins:</u>

All proteins yield amino acids upon hydrolysis.

$$\underset{\text{Peptide linkage}}{-\underset{\underset{O}{\|}}{C}-NH-}$$

<u>Occurrence of Proteins in Living Organisms:</u>

Occurrence of proteins in living organisms is as follows:

(i) Proteins are **present** in all **living organisms.**
(ii) They make up bulk of the non-bony structure of the animal bodies.
(iii) They are major component of all cells and tissues of animals.
(iv) About 50% of the dry weight of cell is made up of proteins.
(v) They are found in muscles, skin, hair, nails, wool, feathers, etc.
(vi) Proteins make up more than 50% of the dry weight of animals.

Q.2 What are amino acids? Explain, amino acids are the building blocks of proteins.
(Knowledge+Understanding Base)
(GRW 2016, MTN 2017)

Ans: **AMINO ACIDS**

Definition:

*"Amino acids are organic compounds consisting of **both amino and carboxyl groups".***

General formula:

They have the general formula

$$\text{(side chain)}\ \mathbf{R\text{-}\underset{\substack{|\\ NH_2\ \text{(amino group)}}}{CH}\text{-}COOH}\ \text{(carboxylic group)}$$

Side chain 'R' is different for different amino acids.

Types of Amino Acids:

There are 20 amino acids. These amino acids are classified into major classes on the basis of their synthesis.

(i) Non-Essential Amino Acids:

"Ten out of twenty amino acids can be synthesized by human body. These amino acids are called non-essential amino acids".

(ii) Essential Amino Acids:

"The ten amino acids which cannot be synthesized by our bodies are called essential amino acids".

Essential amino acids are required by our bodies and must be supplied through diet.

Amino Acids are Building Blocks of Proteins:

Two amino acids link through peptide linkage. Peptide linkage (bond) is formed by the elimination of water molecule between the amino group of one amino acid and carboxyl acid group of another.

$$\underset{1^{st}\ Amino\ Acid}{H_2N-\underset{\substack{|\\R}}{CH}-COOH} + \underset{2^{nd}\ Amino\ Acid}{HNH-\underset{\substack{|\\R}}{CH}-COOH} \xrightarrow{-H2O} H_2N-\underset{\substack{|\\R}}{CH}-\overset{\substack{O\\ \|}}{C}-NH-\underset{\substack{|\\R}}{CH}-COOH$$

When thousands of amino acids polymerize they form protein.

Q.3 Explain the sources and uses of proteins. ***(Knowledge Base)*** **(Ex-Q.4)**
(LHR 2013-15, DGK 2017, SWL 2017, FSD 2016 G-I, BWP 2016 G-I)

Ans: **SOURCES AND USES OF PROTEINS**

Proteins make up more than 50% of the dry weight of animals. Each protein has its source and carries out a specific function.

Sources and uses of protein are as follows:

(i) Animal Proteins:

Sources:

Sources of animal's proteins are:

- Meat
- Mutton
- Chicken
- Fish
- Egg

Uses:

- These are used as food by human beings as they are essential for the formation of protoplasm.

(ii) Enzymes are Proteins:

Production:

Enzymes are proteins that are produced by the living cells.

Functions:

- They **catalyze** the **chemical reactions** taking place in the bodies.
- They are **highly specific and have extraordinary efficiency.**
- Many enzymes are used as **drugs**.
- They **control** the **bleeding and treat blood cancer.**

(iii) Hides are Proteins:

These are used to make leather by tanning. Leather is used to make shoes, jackets, sports items, etc.

(iv) Proteins in Bones:

Proteins are found in bones. When bones are heated they give **gelatin. Gelatin is used to make bakery items.**

(v) Plant Proteins:

Sources:

Plants also synthesize proteins, such as pulses, beans, etc.

Uses:

These are used as food.

13.2 PROTEINS

SHORT QUESTIONS

Q.1 What are essential and non-essential amino acids? *(Knowledge Base)* **(MTN 2016 G-II)**

Ans: *Answer given on Page # 223*

Q.2 Define protein and name its basic unit. *(Knowledge Base)* **(FSD 2017)**

Ans: *Answer given on Page #* 222

MULTIPLE CHOICE QUESTIONS

1. **Amino acids are linked with each other through: *(K.B)*** **(BWP 2016 G-I)**
   (A) Peptide linkage (B) Covalent linkage
   (C) Hydrogen bond (D) Ionic bond
2. **Percentage of protein in dry weight of cell is: *(K.B)***
   (A) 50 % (B) 90 %
   (C) 60% (D) 40%
3. **Protein are essential for the formation of: *(K.B)***
   (A) Cytoplasm (B) Protoplasm
   (C) Ectoplasm (D) Endoplasm
4. **These are proteins: *(K.B)***
   (A) Hides (B) Hooves
   (C) Bones (D) Caudals
5. **It is found in bones: *(K.B)***
   (A) Lipids (B) Proteins
   (C) Carbohydrates (D) Organic acids

6. **Gelatin is used in: *(K.B)***

(A) Bakery items (B) Plastic

(C) Glass items (D) Gems

7. **Basic building units of proteins are : *(K.B)*** **(LHR 2014, 2016, MTN 2017)**

(A) Carbohydrates (B) Amino acids

(C) Fatty acids (D) Monosaccharides

8. **Number of amino acids in proteins is: *(K.B)***

(A) 1000 (B) More than 1000

(C) Less than 10000 (D) More than 10000

9. **Which one of the following does not contain protein? *(K.B)*** **(RWP 2017, FSD 2016)**

(A) Pulses (B) Potatoes

(C) Beans (D) Eggs

13.2 TEST YOURSELF

i. **Which elements are found in proteins? *(Knowledge base)***

Ans: **ELEMENTS FOUND IN PROTEINS**

The elements found in proteins are:

- Carbon
- Hydrogen
- Oxygen
- Sulphur
- Nitrogen

ii. **How amino acids are bonded with each other? *(Knowledge+Understanding base)***

Ans: **BONDING OF AMINO ACIDS**

Amino acids are basic building blocks of proteins. Two Amino acids are bonded through peptide linkage. Peptide linkage (bond) is formed by the elimination of water molecule between the amino group of an amino acid and carboxyl group of another such as:

$$H_2N-\underset{\substack{|\\ R}}{C}H-COOH + HNH-\underset{\substack{|\\ R}}{C}H-COOH \xrightarrow[\text{Dehydration}]{-H_2O} H_2N-\underbrace{\left[\underset{\substack{|\\ R}}{C}H-\overset{\substack{O\\ \|}}{C}-NH\right]}_{\text{Peptide linkage}}-\underset{\substack{|\\ R}}{C}H-COOH$$

When thousands of amino acids polymerize they form protein.

iii. **Give the general formula of amino acids. *(Knowledge base)*** **(FSD 2016 G-II, SWL 2016 G-II)**

Ans: **GENERAL FORMULA OF AMINO ACIDS**

The general formula of amino acids is given below.

$$\text{(Side chain) } R-\underset{\substack{|\\ NH_2\\ \text{(Amino group)}}}{CH}-COOH \text{ (Carboxylic group)}$$

Side chain "R" is different for different 20 kinds of amino acids.

iv. **What do you mean by non-essential amino acids? *(Knowledge base)*** **(MTN 2016 G-I)**

Ans: **NON-ESSENTIAL AMINO ACIDS**

***"**Non-essential amino acids are those amino acids which our body itself can produce or synthesize".*

Synthesis by Human Body:

Ten out of twenty amino acids can be synthesized by human body and thus are called non- essential amino acids.

13.3 LIPIDS

LONG QUESTIONS

Q.1 What are lipids? Explain their properties. *(Knowledge+Understanding base)*

(MTN 2017)

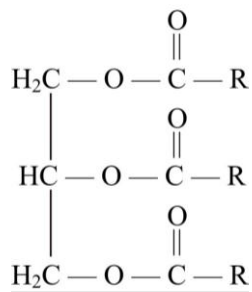
Ans: **LIPIDS**

Definition:

*"Lipids are **macromolecules** made up of **fatty acids**. Lipids include oils and fats".*

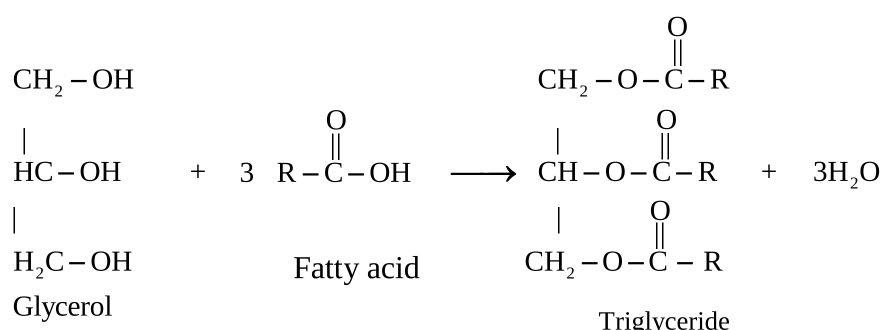
General formula:

General formula of triglycerides is as under:



Composition:

The esters are made of three fatty acids therefore, they are called triglycerides.



Major Types of Lipids:

The major types of lipids are as follows:

(i) Oils:

Oils exist in **liquid form** at room temperature. They are triglycerides of **unsaturated fatty acids.**

(ii) Fats:

Fats exist in **solid form** at room temperature. They are triglycerides of **saturated fatty acids.**

Fatty Acids: **(MTN 2017, SWL 2017)**

"Fatty acids are building blocks of lipids. They are long chain saturated and unsaturated carboxylic acids."

Examples:

- Palmitic acid: $C_{15}H_{31}COOH$ (Saturated)
- Stearic acid: $C_{17}H_{35}COOH$ (Saturated)
- Oleic acid: $C_{17}H_{33}COOH$ (Unsaturated)

These acids form esters (oils or fats) with glycerol in the presence of mineral acids.

Q.2 Explain the source and uses of lipids. ***(Knowledge base)***

(GRW 2013, 14, FSD 2017, BWP 2017, BWP 2017, DGK 2017, MTN 2016 G-I 17, SWL 2017, RWP, 2017)

Ans:

SOURCES OF LIPIDS

Fats and oils are synthesized naturally by animals, plants and marine organisms.

(i) Animal Fats:

Source:

Animal fats are found in adipose tissue cells. Animals secrete milk from which butter and ghee is obtained.

Uses:

Butter and ghee are used for cooking and frying of food, for preparing bakery products and sweets.

(ii) Animal fats are used in soap industry.

(iii) Plant Oils:

Sources:

Plants synthesize oils and store them in seeds, such as, sunflower oil, coconut oil, groundnut oil.

Uses:

These oils are used as vegetable oils or ghee for cooking and other purposes.

(iv) Marine Animals Oils:

Sources:

Marine animals like salmon and whales are also source of oils.

Uses:

These oils are used as medicines e.g., cod liver oil.

USES OF LIPIDS

The uses of lipids are as follows:

(i) Fats and oils are high energy foods.

(ii) They are source of vitamins A, D and E.

(iii) They are used to build brain cells, nerve cells and cell membranes.

(iv) They are insoluble in water but soluble in organic solvents.

(v) The fats stored in the body insulate it as these are poor conductor of heat and electricity.

13.3 LIPIDS

SHORT QUESTIONS

Q.1 How margarine can be prepared? ***(Application Base)*** **(Interesting Information Pg. #107)**

Ans:

PREPARATION OF MARGARINE

Margarine is produced by **adding hydrogen to vegetable oil** at **200^0**C in the presence of catalyst. Greater the amount of hydrogen added, the more solid the margarine becomes.

$$\textbf{Vegetable oil} + \textbf{H}_2 \xrightarrow[\text{Catalyst}]{200^\circ C} \textbf{Margarine}$$

Q.2 What is the smell of rancid butter and its cause? ***(Knowledge Base)***

(Interesting Information Pg. # 107)

Ans:

SMELL OF RANCID BUTTER

Rancid butter has a foul smell because of **butanoic acid**. However, the esters of butanoic acid have fruity smell. For example, methyl butanoate smells like apples and ethyl **butanoate smells like pineapple**.

Q.3 What is meant by hydrogenation of vegetable oil? *(Application Base)*

(Science, Technology and Society Pg. # 107)(BWP 2017)

Ans: <u>**HYDROGENATION OF VEGETABLE OIL**</u>

Vegetable oils are triesters of glycerol and fatty acids of unsaturated long chains. These oils are hydrogenated in the presence of nickel catalyst at **250 to 300 °C** to form vegetable ghee.

$$\textbf{Vegetable oil} + \mathbf{H_2} \xrightarrow[250^0 C]{Ni} \textbf{Vegetable ghee}$$

(Unsaturated triester) (Saturated triester)

Q.4 What are fatty acids? *(Knowledge Base)*

Ans: *Answer given on Page # 226*

13.3 LIPIDS

MULTIPLE CHOICE QUESTIONS

1. **It is poor conductor of heat: *(K.B)***
   (A) Acids (B) Lipids
   (C) Carbohydrates (D) Proteins
2. **Butter and fats are obtained from: *(K.B)***
   (A) Milk (B) Eggs
   (C) Meat (D) Fish
3. **Plants synthesize: *(K.B)***
   (A) Oil (B) Ghee
   (C) Custard (D) Yogurt
4. **Salmon and whale oil is used as: *(K.B)***
   (A) Bar. B.Q. (B) Medicine
   (C) Food (D) Lemonoid
5. **Which gas is passed through vegetable oil to get margarine? *(K.B)***
   (A) Nitrogen (B) Chlorine
   (C) Hydrogen (D) Carbon
6. **Esters of butanoic acids have smell: *(K.B)***
   (A) Pungent (B) Rotten egg
   (C) Foul (D) Fruity
7. **Ethyl butanoate smells like: *(K.B)***
   (A) Apple (B) Pineapple
   (C) Cherry (D) Guava
8. **Fat soluble vitamins are: *(K.B)***
   (A) A, E, D, C (B) B, C
   (C) A, B, C (D) K, D, E
9. **Which of the following is monosaccharide? *(K.B)***
   (A) Lactose (B) Glucose
   (C) Fructose (D) Both B and C
10. **Formula of palmitic acid is: *(K.B)*** **(RWP 2016 G-I)**
    (A) $C_{15}H_{31}COOH$ (B) $C_{15}H_{35}COOH$
    (C) $C_{15}H_{32}COOH$ (D) $C_{17}H_{36}COOH$

13.3 TEST YOURSELF

i. What is difference between ghee and oil? ***(Understanding Base)***
(LHR 2015, GRW 2017, MTN 2017, FSD 2016 G-I, SWL 2016 G-II, DGK 2016 G-II, BWP 2016 G-II)

Ans: **DIFFERENTIATION**

The differences between ghee and oil are as follows:

Ghee	Oil
Physical State	
• It exists in solid form at room temperature.	• It exists in liquid form at room temperature.
Nature	
• These are the triglycerides of **saturated fatty acids.**	• These are the triglycerides of **unsaturated fatty acids.**

ii. Give the characteristics of fats. ***(Knowledge Base)***

Ans: **CHARACTERISTICS OF FATS**

The characteristics of fats are as follows:

(i) Fats exist is solid form at room temperature.
(ii) Fats are the triglycerides of saturated fatty acids.
(iii) They are lighter than water.
(iv) They are insoluble in water.
(v) They are poor conductors of heat and electricity and serve excellent insulator for the animal body.

iii. Give the sources and uses of animal fats. ***(Knowledge Base)*** **(GRW 2017, SGD 2017)**

Ans: **SOURCES AND USES OF ANIMAL FATS**

Sources:

Animal fats are found in adipose tissue cells. Butter and ghee is obtained from milk which is secreted by animals.

Uses:

- Animal fats are used in soap industry.
- Butter and ghee (animal fat products) are used for cooking and frying of food for preparing bakery products and sweets.

iv. Plants are the source of oil, justify. ***(Understanding Base)***

Ans: **PLANTS AS SOURCE OF OIL**

Justification:

Plants synthesize oils and store them in seeds such as: sunflower oil, coconut oil, ground nut oil, corn oil. These oils are used as vegetable oils or ghee for cooking and other purposes.

13.4 NUCLEIC ACIDS

LONG QUESTIONS

Q.1 What are nucleic acids? Explain their types in detail.
(Knowledge + Understanding Base)

Ans: **NUCLEIC ACIDS**

Definition:

"Nucleic acids are essential components of every living cell. They are generally long chain molecules made up of nucleotides".

Components of Nucleic Acids:

Each nucleotide consists of three components.

(i) Nitrogenous base
(ii) Pentose sugar
(iii) Phosphate group

Types of Nucleic Acids:

There are two types of nucleic acids.

(i) Deoxyribonucleic Acid (DNA)
(ii) Ribonucleic acid (RNA)

(i) Deoxyribonucleic Acid (DNA): **(DGK 2016 G-I)**

"The type of nucleic acid which contains deoxyribose sugar in its nucleotides is called DNA."

Discovery:

DNA consists of **deoxyribose sugar**. Its structure was discovered by **J. Watson and F. Crick in 1953.**

Structure of DNA: **(BWP 2017)**

It is long double stranded molecule consisting of two chains. Each chain is made up of sugar, phosphate group and a base. The sugar and phosphate groups make the backbone of the chains and two chains are linked through bases. The chains are wrapped around each other in a double helix form.

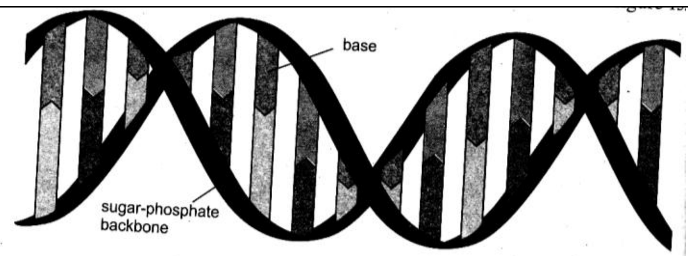


Figure: DNA Structure

Functions of DNA:

The functions of DNA are as follows:

- DNA is the permanent storage place for genetic information in the nucleus of a cell.
- It carries and stores all genetic informations of the cell.
- It passes the information as instructions from generation to generation how to synthesize particular proteins from amino acids.
- DNA carries genes that control the synthesis of RNA.

What are Instructions?

These instructions are genetic code of life. They determine whether an organism is a man or a tree or a donkey and whether cell is a nerve cell or a muscle cell.

Sequence of Nitrogenous Base:

The sequence of nitrogenous bases in DNA determines the protein development in new cells.

Function of Double Helix:

The function of the double helix formation of DNA is ensuring that no disorder takes place. DNA carries genes that control the synthesis of RNA.

Genetic Disease:

Errors introduced into the genes synthesize faulty RNA. It synthesizes faulty proteins that do not function the way they are supposed to. This disorder causes genetic diseases.

(ii) <u>Ribonucleic Acid (RNA):</u>

"The type of nucleic acid which contains ribose sugar in its nucleotides is called RNA."

<u>Structure:</u>

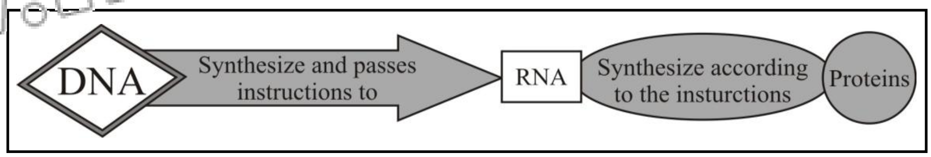
It consists of ribose sugar. It is a single stranded molecule.

<u>Function:</u>

It is responsible for putting the genetic information to work in the cell to build proteins.

<u>RNA as a Messenger:</u>

Its role is like a messenger. RNA is synthesized by DNA to transmit the genetic information. RNA receives, reads, decodes and uses the given information to synthesize new proteins. Thus RNA is responsible for directing the synthesis of new proteins.



13.4 NUCLEIC ACIDS

SHORT QUESTIONS

Q.4 What are nucleic acids? *(Knowledge Base)* **(BWP 2016 G-I, 17)**

Ans: *Answer given on Page # 229*

Q.5 What is cause of cancer and how it can be cured? *(Knowledge + Understanding Base)*
(Interesting Information Pg. # 109)

Ans: **<u>CAUSE AND CURE OF CANCER</u>**

<u>Cause:</u>

Cancer is caused by damage to DNA or interfering with the mechanism of its replication or passing informations.

<u>Cure:</u>

By understanding the mechanism of action of DNA, cancer can be cured.

MULTIPLE CHOICE QUESTIONS

1. It is responsible for decoding of genetic information present in DNA: *(K.B)*

(A) RNA (B) Acetic acid
(C) DNA (D) Nucleic acid

2. DNA structure was discovered in: *(K.B)*

(A) 1953 (B) 1919
(C) 1983 (D) 1913

3. RNA stands for: *(K.B)*

(A) Deoxyribonucleic acid (B) Stearic acid
(C) Ribonucleic acid (D) Nucleic acid

4. RNA acts as: *(K.B)*

(A) Synthesizer (B) Messenger
(C) Transporter (D) All of the above

5. Which scientist discovered the structure of DNA? *(K.B)* **(GRW 2015)**

(A) Hopkins (B) John
(C) Watson and Crick (D) Robert Hooke

6. **Basic structural unit of nucleic acid is:** ***(K.B)*** **(GRW 2014)**

(A) Amino acid (B) Glucose

(C) Nucleoside (D) Nucleotide

13.5 VITAMINS

LONG QUESTIONS

Q.1 What are vitamins? Explain their types and importance in detail.

(Knowledge + Understanding Base)

(LHR 2013, 14 SWL 2017, SGD 2017, BWP 2016 G-II)

Ans: **VITAMINS**

Definition:

"Organic compounds essential to health that must be supplied in small amounts in the diet are called vitamins".

Historical Background:

- In **1912 Hopkins** noticed that in addition to carbohydrates, proteins and fats there are other substances needed for normal growth. Although these substances were needed in small quantity, yet these substances were called "Accessory Growth Factors."
- Later Funk proposed the name **'Vitamin'** for these substances. He discovered **Vitamin B_1 (Thiamin).**

Types of Vitamins: **(BWP 2017)**

Vitamins are divided into two types:

(i) Fat Soluble Vitamins:

"The vitamins which dissolve in fats are called fat soluble vitamins".

Examples:

- Vitamin A
- Vitamin D
- Vitamin E
- Vitamin K

Effects of Accumulation:

They are stored in the liver and fatty tissues of the body. If these vitamins are taken in large quantity, they accumulate in the body and cause diseases.

Example:

- Accumulation of vitamin D in the body causes bone-pain and bone-like deposits in the kidney.

Effects of Deficiency:

However, their deficiency also causes diseases.

Sources, Uses and Diseases:

Sources, uses and diseases due to deficiency of fat soluble vitamins are as follows:

Sr.No.	Vitamin	Sources	Uses	Diseases
i.	Vitamin A	Dairy products, eggs, oils, fats and fish. It can also be obtained from the beta-carotene found in green vegetables, carrots and liver.	Maintains the health of the epithelium and acts on the retina's dark adaptation mechanism.	**Night blindness.** **Eye inflammation.**
ii.	Vitamin D	Fish liver, dairy products, oils and fats. Vitamin D is formed in the skin when it is exposed to sunlight.	Has a role in the absorption of calcium which is essential for the maintenance of healthy bones.	**Rickets**

(ii) <u>Water Soluble Vitamins:</u> **(GRW 2013)**

"The vitamins that dissolve in water are called water soluble vitamins".

<u>Examples:</u>

- Vitamin B complex (this includes 10 vitamins)
- **Vitamin C (Ascorbic acid).**

<u>Advantages:</u>

Water soluble vitamins are rapidly excreted from the body. Hence these vitamins are not toxic even if taken in large quantity. However, their deficiency causes diseases.

<u>Sources:</u>

Sources of water soluble vitamins are:

- Grains
- Green vegetables
- Milk
- Cheese
- Curd
- Fish
- Egg etc.

<u>IMPORTANCE OF VITAMINS</u> (GRW 2017, RWP 2017)

The importance of vitamins is as follows:

(i) Each vitamin plays an important role in the **healthy development** of our body.

(ii) Natural vitamins are organic food substances **found only in plants and animals**. Our body is unable to synthesize vitamins. Because of this, they must be supplied either directly in the diet or by way of dietary supplements. They are **absolutely necessary for our normal growth**.

(iii) Vitamins **cannot be assimilated without ingesting food.** This is why, it is suggested that vitamins **must be taken with meal.**

(iv) They help to **regulate our body's metabolism.**

13.5 VITAMINS

SHORT QUESTIONS

Q.1 Give the uses of vitamins? (*Knowledge Base*) **(GRW 2017, 14)**

Ans: **USES OF VITAMINS**

The uses of vitamins are as follows:

- Vitamins play an important role in the healthy development of our body.
- Vitamins help to regulate our body's metabolism.
- They assist the food for formation of bones and tissues.
- Vitamins are absolutely necessary for our normal growth.

Q.2 What is role of vitamin A in body? (*Knowledge Base*)

Ans: **ROLE OF VITAMIN A**

Vitamin A performs various functions in the body like:

- It maintains the health of epithelium.
- It controls (affects) the retina's dark adaptation mechanism.

Q.3 Write down diseases born by the deficiency of vitamin A. (*Knowledge Base*)(LHR-2015)

Ans: **DEFICIENCY OF VITAMIN A**

The diseases born by the deficiency of vitamin A are as follows:

- Night blindness
- Eye inflammation.

Q.4 Describe the sources and uses of vitamin D. (*Knowledge Base*) (GRW 2017, BWP 2016 G-II)

Ans: **SOURCE AND USES OF VITAMIN D**

Sources:

The sources of vitamin D are as follows:

- Fish liver
- Dairy products
- Oils and fats
- Vitamin D is formed in the skin when it is exposed to sunlight.

Uses:

- Vitamin D helps in the absorption of calcium which is essential for the maintenance of healthy bones.

Q.5 What are vitamins? (*Knowledge Base*) **(FSD 2016 G-I, BWP 2017)**

Ans: *Answer given on Page # 232*

13.5 VITAMINS

MULTIPLE CHOICE QUESTIONS

1. Vitamins were discovered in: *(K.B)*

(A) 1912	(B) 1914
(C) 1932	(D) 1924

2. Accessory growth factors later named vitamins by: *(K.B)*

(A) Drude	(B) Loren
(C) Funk	(D) De'duve

3. **Funk discovered vitamin: *(K.B)***
(A) B_1(thiamin) (B) C (creatinin)
(C) B (sucrose) (D) Urea

4. **Vitamin C is also called: *(K.B)***
(A) Nucleic acid (B) Carlic acid
(C) Ascorbic acid (D) Maleic acid

5. **Which vitamin is fat soluble? *(K.B)*** **(LHR 2014, 2016; GRW 2016)**
(A) A (B) E
(C) K (D) All of these

6. **Which one of the following vitamins is water soluble? *(K.B)*** **(GRW 2015, MTN 2017)**
(A) Vitamin D (B) Vitamin E
(C) Vitamin A (D) Vitamin C

7. **Deficiency of which vitamin causes night blindness? *(K.B)*** **(GRW 2016, DGK 2017)**
(A) Vitamin D (B) Vitamin C
(C) Vitamin E (D) Vitamin A

8. **Eye inflammation is caused by the deficiency of vitamin: *(K.B)*** **(LHR 2014, DGK 2017)**
(A) Vitamin D (B) Vitamin C
(C) Vitamin B (D) Vitamin A

9. **Rickets disease is caused by the deficiency of: *(K.B)*** **(SGD 2017)**
(A) Vitamin D (B) Vitamin A
(C) Vitamin E (D) Vitamin B

10. **Who proposed the name of vitamin? *(K.B)*** **(SWL 2016 G-I)**
(A) Funk (B) Watson
(C) F.Crick (D) Lewis

13.4 TEST YOURSELF

i. What are the disadvantages of fat soluble vitamins? *(Knowledge Base)* **(SWL 2016 G-I)**

Ans: **DISADVANTAGES**

If these vitamins are taken in large quantity, they accumulate in the body and cause diseases.

ii. What are advantages of water soluble vitamins? *(Knowledge Base)*

Ans: **ADVANTAGES**

Water soluble vitamins are rapidly excreted from the body. Hence, these vitamins are not toxic even if taken in large quantity.

Examples:

- Vitamin B complex
- Vitamin C

iii. Give examples of fat soluble vitamins. *(Knowledge Base)*

Ans: **FAT SOLUBLE VITAMINS**

The examples of the fat soluble vitamins are:

- Vitamin A
- Vitamin D
- Vitamin E
- Vitamin K

iv. What are the components of nucleotide? *(Knowledge Base)* **(FSD 2017)**

Ans: **COMPONENTS OF NUCLEOTIDE**

Each nucleotide consists of three components:

(i) Nitrogenous base
(ii) A pentose sugar
(iii) A phosphate group

Pentose sugar and phosphate group make the backbone of the chain and two chains are link through bases.

v. What is the function of DNA? ***(Knowledge Base)***

(RWP 2014, 16 G-I, FSD 2017, SWL 2016 G-I, II, SGD 2016 G-I, GRW 2013)

Ans: **<u>FUNCTIONS OF DNA</u>**

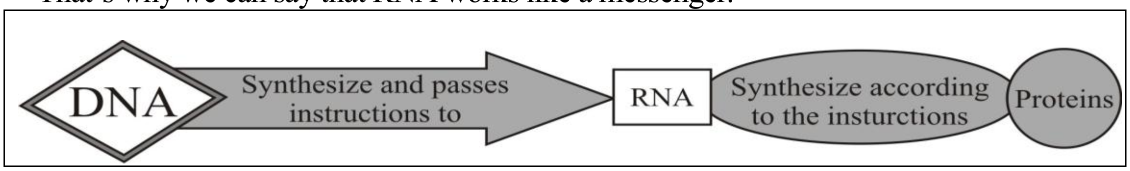
The functions of DNA are as follows:

- DNA is the permanent storage place for genetic information in the nucleus of a cell.
- It carries and stores all genetic information of the cell.
- It passes the information as instructions from generation to generation how to synthesize particular proteins from amino acids.
- DNA carries genes that control the synthesis of RNA.

vi. Why RNA is called a messenger? ***(Understanding Base)***

Ans: **<u>RNA AS A MESSENGER</u>**

The whole activity of DNA depends upon the RNA. DNA stores genetic information and passes this information to RNA, then RNA reads, decodes and uses this given information to synthesize new proteins. Thus RNA is responsible for directing the synthesis of new proteins. That's why we can say that RNA works like a messenger.



COMMERCIAL USES OF ENZYMES

LONG QUESTION

Q.1 Write down the commercial uses of enzymes. ***(Knowledge Base)***

(Science, Technology and Society Pg. # 111)

Ans: **<u>COMMERCIAL USES OF ENZYMES</u>**

<u>Enzymes:</u>

"*The substances which are used to catalyze the reactions in living organisms are called enzymes"*.

<u>Examples:</u>

- Protease
- Amylase
- Lipase

<u>Common Types of Enzymes and Their Commercial Uses:</u>

Enzymes are used on commercial scale for different purposes. Common types of enzymes and their role in industry is described as:

(i) <u>Fermentation of Molasses and Starch:</u>

Enzymes present in the yeast are commercially used for the fermentation of molasses and starch to produce alcohol (Ethanol).

<u>Examples:</u>

- Diastase
- Invertase
- Zymase

(ii) <u>Detergent Industry:</u>

Microbial enzymes are used in detergents (powder or liquid).

<u>Examples:</u>

- Lipases decompose fats into more water soluble compounds.
- Amylase removes starch based stains.
- Cellulose degrades cellulose to glucose, a water soluble compound.
- Bacterial proteases break down protein stains on the clothes.

Thus enzymes containing detergents clean effectively and remove all stains and dirt.

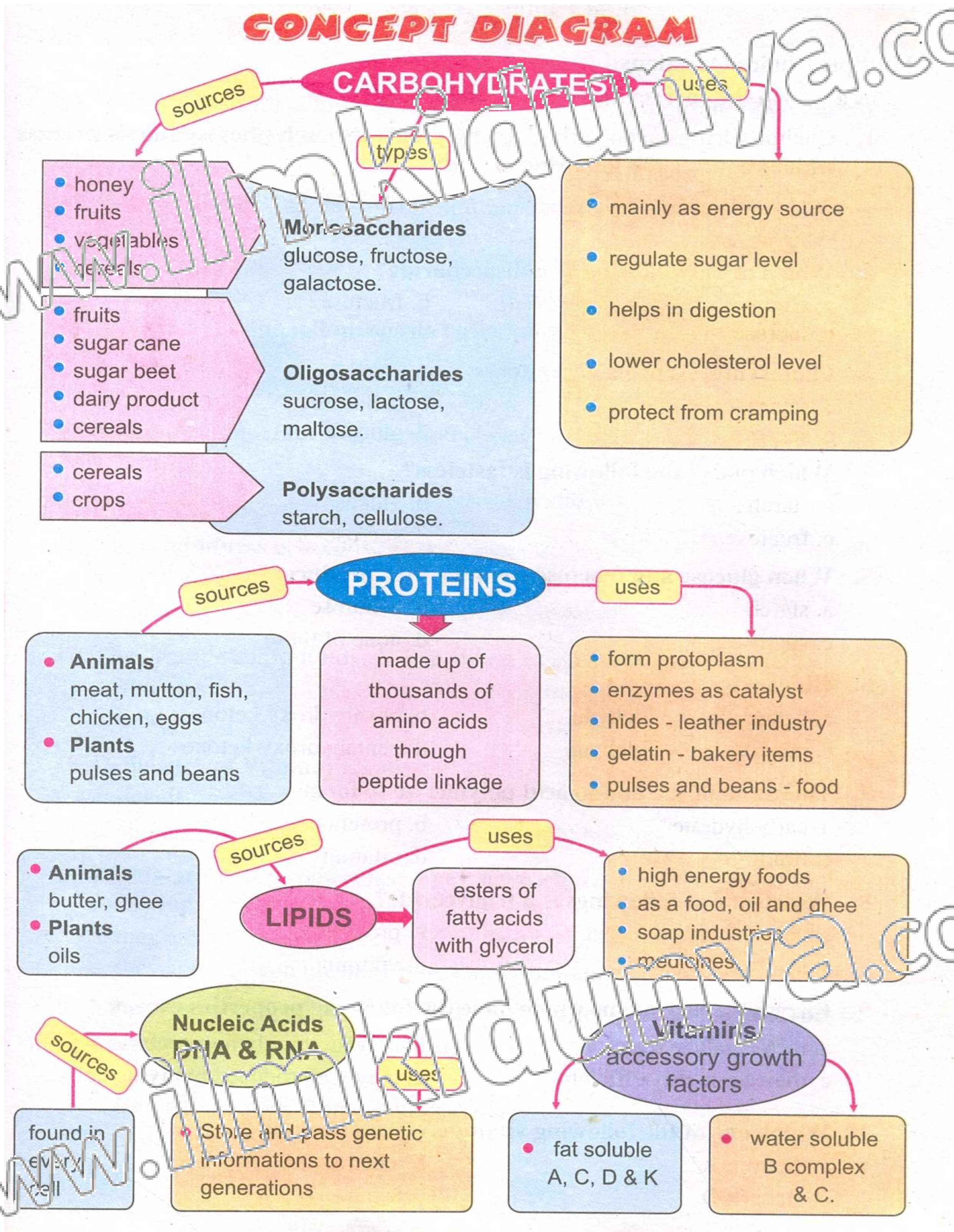
(iii) <u>Purification of Fruit Juices:</u>
Enzymes are used for the purification of fruit juices. They are added to fruit that has been crushed like grapes. This increases the yield of the juice extracted by removing suspended particles. It also improves the colour derived from the fruit skins.
(iv) <u>Bread making:</u>
Amylase enzymes are used in bread making because they can yield more starch of the flour. Even they are efficient enough to convert starch to sweet glucose syrup. This can be used as sweetener in the food as well as bread making.
(v) <u>Sweetness ice cream:</u>
Lactose in milk is broken down to galactose and glucose, which are sweeter than lactose.
<u>Example:</u>
Lactase enzyme is used to increase sweetness in ice cream.
(vi) <u>Enzymes in Dairy Industry:</u>
In the dairy industry some enzymes are used for the production of cheeses, yogurt and other dairy products while others are used to improve texture or flavours of the products.

COMMERCIAL USES OF ENZYMES
SHORT QUESTIONS

Q.1 How we can check the solubility of starch and sugar? *(Knowledge Base)*
(Skills Pg. # 112)
Ans: **<u>SOLUBILITY OF STARCH AND SUGAR</u>**
Solubility of starch and sugar in water can be checked in laboratory as well as at home. Starch is insoluble in water while sugar is soluble in water forming a clear solution in water.
Q.3 Give a commercial uses of enzymes *(Knowledge Base)*
Ans: **<u>COMMERCIAL USES OF ENZYMES</u>**
Two commercial uses of enzymes are as follows:
(i) <u>Fermentation of Molasses and Starch:</u>
Enzymes present in the yeast are commercially used for the fermentation of molasses and starch to produce alcohol (Ethanol).
<u>Examples:</u>
- Diastase
- Invertase
- Zymase

COMMERCIAL USES OF ENZYMES
MULTIPLE CHOICE QUESTIONS

1. Which one of the following is used in bread making? *(K.B)*
(A) Lactase (B) Amylase
(C) Urease (D) Ligase
2. Alcohol is obtained mainly by the fermentation of: *(K.B)*
(A) Molasses (B) Proteins
(C) Starch (D) Both A and C
3. Which one of the following decomposes fats into more water soluble compounds? *(K.B)*
(A) Lactase (B) Amylase
(C) Lipase (D) Protease
4. Which one of the following decomposes protein stains on the clothes? *(K.B)*
(A) Lactase (B) Amylase
(C) Lipase (D) Protease
5. Cellulase degrades cellulose to: *(K.B)*
(A) Fructose (B) Glucose
(C) Lactose (D) Ribose


CONCEPT DIAGRAM
CARBOHYDRATES
sources
types
uses
honey
fruits
vegetables
cereals
Monosaccharides
glucose, fructose, galactose.
fruits
sugar cane
sugar beet
dairy product
cereals
Oligosaccharides
sucrose, lactose, maltose.
cereals
crops
Polysaccharides
starch, cellulose.
mainly as energy source
regulate sugar level
helps in digestion
lower cholesterol level
protect from cramping
PROTEINS
sources
uses
Animals
meat, mutton, fish, chicken, eggs
Plants
pulses and beans
made up of thousands of amino acids through peptide linkage
form protoplasm
enzymes as catalyst
hides - leather industry
gelatin - bakery items
pulses and beans - food
Animals
butter, ghee
Plants
oils
sources
LIPIDS
uses
esters of fatty acids with glycerol
high energy foods
as a food, oil and ghee
soap industries
medicines
sources
Nucleic Acids
DNA & RNA
uses
found in every cell
Store and pass genetic informations to next generations
Vitamins
accessory growth factors
fat soluble
A, C, D & K
water soluble
B complex
& C.

ANSWER KEY

MULTIPLE CHOICE QUESTIONS

INTRODUCTION

1	A	3	A
2	A	4	D

13.1 CARBOHYDRATES

1	A	6	A	11	C
2	D	7	D	12	C
3	A	8	B	13	B
4	D	9	A	14	A
5	A	10	A	15	D

13.2 PROTEINS

1	A	6	A
2	A	7	B
3	B	8	D
4	A	9	B
5	B		

13.3 LIPIDS

1	B	6	D
2	A	7	B
3	A	8	D
4	B	9	D
5	C	10	A

13.4 NUCLEIC ACIDS

1	A	6	D
2	A		
3	C		
4	B		
5	C		

13.5 VITAMINS

1	A	6	D
2	C	7	D
3	A	8	D
4	C	9	A
5	D	10	A

COMMERCIAL USES OF ENZYMES

1	B	4	D
2	D	5	B
3	C		

EXERCISE SOLUTION

MULTIPLE CHOICE QUESTIONS

1. **Carbohydrates are synthesized by plants through photosynthesis process which requires the following except: *(K.B)***
   (a) CO_2 and water (b) Presence of sunlight
   (c) O_2 (d) Chlorophyll
2. **Which of the following is a disaccharide? *(K.B)***
   (GRW 2013, 15, FSD 2016 G-I, II, LHR 2015, SWL 2017)
   (a) Glucose (b) Fructose
   (c) Sucrose (d) Starch
3. **Photosynthesis process produces: *(K.B)*** **(LHR 2015)**
   (a) Starch (b) Cellulose
   (c) Sucrose (d) Glucose
4. **Which one of the following is tasteless? *(K.B)***
   (LHR 2014, GRW 2013, DGK 2017, RWP 2016 G-II, 17, MTN 2016 G-I, 17, FSD 2016 G-I, SGD 2017, G-II)
   (a) Starch (b) Glucose
   (c) Fructose (d) Sucrose
5. **When glucose and fructose combine they produce: *(K.B)***
   (GRW 2013, DGK 2017, MTN 2016 G-II)
   (a) Starch (b) Cellulose
   (c) Sucrose (d) None of these
6. **Glucose is: *(K.B)*** **(LHR 2014, SGD 2017)**
   (a) Hexahydroxy aldehyde (c) Pentahydroxy aldehyde
   (b) Hexahydroxy ketone (d) Pentahydroxy ketone
7. **Thousands of the amino acids polymerize to form: *(K.B)***
   (GRW 2014, LHR 2014, 16, SGD 2016 G-I, MTN 2017, RWP 2017, FSD 2017)
   (a) Carbohydrates (b) Proteins
   (c) Lipids (d) Vitamins
8. **Which one of following is a triglyceride? *(K.B)***
   (SWL 2016 G-II, LHR 2015, 16, BWP 2016 G-I, 17)
   (a) Carbohydrates (b) Proteins
   (c) Lipids (d) Vitamins
9. **Enzymes are proteins which have the following properties except: *(K.B)***
   (a) They catalyze reaction (b) They are highly non specific
   (c) They are highly efficient (d) They are produced by living cells
10. **Which one of the following vitamins is water soluble? *(K.B)***
    (SGD 2017, DGK 2016 G-II, 17, GRW 2016, BWP 2016 G-II, FSD 2017 G-II)
    (a) Vitamin A (b) Vitamin C
    (c) Vitamin D (d) Vitamin E
11. **Which one of the following is a fat soluble vitamin? *(K.B)***
    (GRW 2013, LHR 2014, BWP 2017, SWL 2017, RWP 2016 G-II, SWL 2016 G-II MTN 2016 II)
    (a) A (b) E
    (c) K (d) All of these

12. Which one of the following is not the characteristic of monosaccharide? *(K.B)*

(a) White crystalline solids (b) Soluble in water
(c) Hydrolysable (d) Reducing in nature

13. Which one of the following statements about glucose and sucrose is incorrect? *(K.B)*

(a) Soluble in water (b) Naturally occurring
(c) Carbohydrates (d) Disaccharides

14. Which one of the following is a reducing sugar? *(K.B)*
(FSD 2016 G-II, SWL 2016 G-II, DGK 2016 G-II)

(a) Glucose (b) Maltose
(c) Sucrose (d) Starch

15. The most important oligosaccharide is: *(K.B)* **(SGD 2016, G-I,17, GRW 2016 G-II)**

(a) Sucrose (b) Glucose
(c) Fructose (d) Maltose

16. Night blindness is because of deficiency of: *(K.B)* **(MTN 2017, RWP 2017, BWP 2017 G-I)**

(a) Vitamin A (b) Vitamin E
(c) Vitamin C (d) Vitamin D

17. The organic compounds used as drugs to control bleeding are: *(K.B)*
(LHR 2013, SWL 2017, SGD 2016 G-II)

(a) Vitamins (b) Proteins
(c) Lipids (d) Glycerides

18. Deficiency of Vitamin E causes: *(K.B)* **(GRW 2017,MTN 2016 G-I)**

(a) Rickets (c) Anemia in babies
(b) Scurvy (d) Night blindness

19. Lipids are macromolecules. They have characteristics except one of the following: *(K.B)*

(a) They are high energy foods (b) They are soluble in water
(c) They are poor conductor of heat (d) They are esters of fatty acids

20. Vitamins are Accessory Growth Factors. They play important role in our body like: *(K.B)*

(a) Provide energy to the body (b) Insulate our body from electric shock
(c) Build brain cells (d) Regulate metabolic process

ANSWER KEY

1	c	6	c	11	d	16	a
2	c	7	b	12	c	17	b
3	d	8	c	13	d	18	c
4	a	9	b	14	a	19	b
5	c	10	b	15	a	20	d

EXERCISE SHORT QUESTIONS

1. How plants synthesize carbohydrates? *(Knowledge Base)*

(DGK 2017, SGD 2016 G-II, RWP 2016 G-II, MTN 2016 G-II)

Ans: **SYNTHESIS OF CARBOHYDRATES**

Carbohydrates are synthesized by plants through photosynthesis process, from carbon dioxide and water in the presence of sunlight and green pigment chlorophyll.

$$6CO_2 + 6H_2O \xrightarrow[\text{chlorophyll}]{\text{sunlight}} C_6H_{12}O_6 + 6O_2$$

The glucose is further polymerized to form starch and cellulose.

2. Give the characteristics of monosaccharides. *(Knowledge Base)*

(DGK 2016 G-II, SGD 2016 G-I, 17, RWP 2016 G-II, MTN 2016 G-I)

Ans: **CHARACTERISTICS OF MONOSACCHARIDES**

The characteristics of monosaccharaides are as follows:

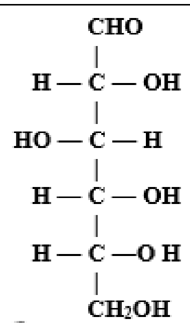
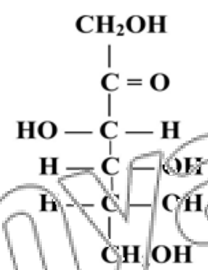
- Monosaccharides are the **simplest sugars** which cannot be hydrolyzed.
- They are usually **white crystalline solids**.
- They are **soluble in water**.
- They have **sweet taste**.
- Monosaccharides are **reducing in sugar** therefore they are called **reducing sugars**.

3. What is difference between glucose and fructose? *(Knowledge+Understanding Base)*

(GRW 2014, LHR 2015, FSD 2017, SGD 2016, FSD 2016-G-I,II, DGK 2016 G-I)

Ans: **DIFFERENTIATION**

The differences between glucose and fructose are as follows:

Glucose	Fructose
Definition	
• Glucose is pentahydroxy aldehyde in nature.	• Fructose is pentahydroxy ketone in nature.
Functional Group	
• It has aldehydic functional group. (Aldose)	• It has ketonic functional group. (Ketose)
Structure	
 Glucose	 Fructose

4. Give an example of a disaccharide. How it is hydrolyzed into monosaccharides? *(Knowledge Base)*

(BWP 2016 G-I)

Ans: **DISACCHARIDES**

The most common example of disaccharide is sucrose. When it hydrolyses it produces one unit of glucose and one unit of fructose.

$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \rightarrow \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

5. Give the characteristics of polysaccharides. (*Knowledge Base)*
(GRW 2015, SWL 2017, SGD 2017, MTN 2016 G-II, DGK 2016 G-II)

Ans: **CHARACTERISTICS OF POLYSACCHARIDES**

Definition:
"Polysaccharides are ***macromolecular carbohydrates*** *consisting of* ***hundreds to thousands*** *of monosaccharides".*
The characteristics of polysaccharides are as follows:
- These are **amorphous solids**.
- These are **non-reducing in nature**.
- They are **insoluble in water.**
- They are **tasteless.**

Examples:
- Starch
- Cellulose
- Glycogen

6. Where the proteins are found? (*Knowledge Base)* **(SGD 2016 G-I, II, RWP 2016 G-I)**

Ans: **OCCURRENCE OF PROTEINS**

Proteins occur as follows:
(i) Animal Proteins:
Sources:
Sources of animal's proteins are:
- Meat
- Mutton
- Chicken
- Fish
- Egg

Uses:
- These are used as food by human beings as they are essential for the formation of protoplasm.

(ii) Enzymes are Proteins:
Production:
Enzymes are proteins that are produced by the living cells.
Functions:
- They **catalyze the chemical reactions** taking place in the bodies.
- They are **highly specific** and have **extraordinary efficiency**.
- Many enzymes are used as **drugs**.
- They **control** the **bleeding and treat blood cancer**.

(iii) Hides are Proteins:
These are used to make leather by tanning. Leather is used to make shoes, jackets, sports items, etc.
(iv) Proteins in Bones:
Proteins are found in bones. When bones are heated they give gelatin. Gelatin is used to make bakery items.
(v) Plant Proteins:
Sources:
Plants also synthesize proteins, such as pulses, beans, etc.
Uses:
These are used as food.

7. Describe the uses of carbohydrates. (*Knowledge Base)* **(RWP 2016, MTN 2016 G-I)**

Ans: **USE OF CARBOHYDRATES**

The uses of carbohydrates are as follows:

As Source of Energy:

- Glucose is the only form of carbohydrates that is used directly by muscles for energy.
- It is important to note that brain needs glucose as an energy source, because it cannot use fat for this purpose.

Uses Other Than Energy:

Besides, the energy providing materials, carbohydrates also provide the following usage in our body.

(i) They regulate the amount of sugar level in our body. Low sugar level in body results in hypoglycemia.

(ii) They provide essential nutrients for bacteria in intestinal tract that helps in digestion.

(iii) Dietary fiber helps to keep the bowel functioning properly.

(iv) Fiber helps in lowering of cholesterol level and regulates blood pressure.

(v) Carbohydrates protect our muscles from cramping.

8. Lactose is disaccharide; which monosaccharide is present in it? (*Knowledge Base)*(GRW 2013)

Ans: **MONOSACCHARIDES PRESENT IN LACTOSE**

Two monosaccharides glucose and galactose are present in lactose.

$$\underset{\text{Lactose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow[\text{Enzymes}]{\text{Lactose}} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Galactose}}{C_6H_{12}O_6}$$

9. Why the ten amino acids are essential for us? (*Knowledge Base)* **(BWP 2016 G-I)**

Ans: **ESSENTIAL AMINO ACIDS**

Ten amino acids called essential amino acids cannot be synthesized by our body. Thus these amino acids must be supplied through diet to fulfill the requirement of our body.

10. How proteins are formed? (*Knowledge + Understanding Base)* **(RWP 2017)**

Ans: **FORMATION OF PROTEINS**

Amino acids are the building blocks of proteins. Two amino acids link through peptide linkage is formed by the elimination of water molecule between the amino group of one amino acid and carboxyl acid group of another amino acid.

$$H_2N-\underset{\displaystyle R}{\underset{|}{C}}H-COOH + HNH-\underset{\displaystyle R}{\underset{|}{C}}H-COOH \xrightarrow[\text{(Dehydration)}]{-H_2O} H_2N-\left[\underset{\displaystyle R}{\underset{|}{C}}H-\overset{\displaystyle O}{\overset{\|}{C}}-NH\right]\underset{\displaystyle R}{\underset{|}{C}}H-COOH$$

When thousands of amino acids polymerize they form proteins.

11. How gelatin is obtained? (*Knowledge Base)* **(RWP 2014, SGD 2017, DGK 2016 G-II)**

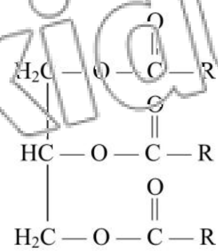
Ans: **PREPARATION OF GELATIN**

Proteins are found in bones. Gelatin is obtained on heating bones.

12. Give the general formula of the lipids. (*Knowledge Base)*

Ans: **<u>GENERAL FORMULA OF LIPIDS</u>**

The general formula of the lipids is as follows:



(Triester)

13. Name two fatty acids with their formulae. (*Knowledge Base)*

(GRW 2013,14,15, MTN2017)

Ans: **<u>FATTY ACIDS</u>**

Following are the names of two fatty acids with their formulae:

Plamitic acid : $C_{15}H_{31}COOH$

Stearic acid : $C_{17}H_{35}COOH$

14. Give the types of vitamins. (*Knowledge Base)* **(RWP 2016, G-I MTN 2016 G-I, II)**

Ans: **<u>TYPES OF VITAMINS</u>**

Vitamins are divided into two types:

(i) Fat Soluble Vitamins:

"*The vitamins which dissolve in fats are called fat soluble vitamins"*.

<u>Example:</u>

- Vitamin A
- Vitamin D
- Vitamin E
- Vitamin K

(ii) Water Soluble Vitamins:

"*The vitamins that dissolve in water are called water soluble vitamins"*

<u>Example:</u>

- Vitamin B complex
- Vitamin C (Ascorbic acid).

15. What is the significance of vitamins? (*Knowledge Base)* **(SGD 2016 G-I)**

Ans: **<u>SIGNIFICANCE OF VITAMINS</u>**

The significance of vitamins is as follows:

- Vitamins play an important role in the healthy development of our body.
- Vitamins help to regulate our body's metabolism.
- They assist the food for formation of bones and tissues.
- Vitamins are absolutely necessary for our normal growth.

16. Describe the sources and uses of vitamin A. (*Knowledge Base)*

(GRW 2015, RWP 2016 G-II, 17, SWL 2016 G-I, BWP 2016 G-I)

Ans: **SOURCES AND USES OF VITAMIN A**

The sources and uses of vitamin A are as follows:

Sources:

- Dairy products
- Eggs
- Oils fats
- Fish
- Beta carotene found in green vegetables, carrots and liver

Uses: **(MTN 2017)**

- It maintains the health of epithelium.
- It controls (affects) the retina's dark adaptation mechanism.

17. Justify water soluble vitamins are not injurious to health. (*Knowledge Base)*

(GRW 2017, LHR 2015, SWL 2017)

Ans: **WATER SOLUBLE VITAMINS**

Justification:

Water soluble vitamins are rapidly excreted from the body (environment of body is aqueous) hence, these are not toxic even if taken in large quantity. However, their deficiency causes diseases.

Examples:

- Vitamin B complex
- Vitamin C (Ascorbic acid)

18. What do you mean by genetic code of life? (*Knowledge Base)* **(BWP 2016 G-I)**

Ans: **GENETIC CODE OF LIFE**

*"**Genetic Code of Life**" means those **specific instructions** which pass from **generation to generation**, to synthesize the **particular proteins from amino acids**."*

Importance:

It determines whether an organism is a man, a tree, or a donkey. DNA is considered the genetic code of life.

19. What is the function of DNA? (*Knowledge Base)*

(GRW 2013, SGD 2016 G-I, RWP 2016 G-I, SWL 2016 G-I, II, FSD 2017, RWP 2014, DGK 2016 G-I, II)

Ans: **FUNCTIONS OF DNA**

The functions of DNA are as follows:

- DNA is the permanent storage place for genetic information in the nucleus of a cell.
- It carries and stores all genetic information of the cell.
- It passes the information as instructions from generation to generation how to synthesize particular proteins from amino acids.
- DNA carries genes that control the synthesis of RNA.

20. How you justify RNA works like a messenger? (*Knowledge Base)*

Ans: **RNA AS A MESSENGER**

The whole activity of DNA depends upon the RNA. DNA stores genetic information and passes this information to RNA. RNA receives, reads, decodes and uses the given information to synthesize new proteins. Thus RNA is responsible for directing the synthesis of new proteins. That's why we can say that RNA works like a messenger.

EXERCISE LONG QUESTIONS

Q.1 What are carbohydrates? How monosaccharides are prepared? Give their characteristics.

Ans: See LQ.1 (Topic 13.1)

Q.2 Explain oligosaccharides.

Ans: See LQ.2 (Topic 13.1)

Q.3 What are polysaccharides? Give their properties.

Ans: See LQ.3 (Topic 13.1)

Q.4 Explain the sources and uses of proteins.

Ans: See LQ.3 (Topic 13.2)

Q.5 Explain that amino acids are building blocks of proteins.

Ans: See LQ.2 (Topic 13.2)

Q.6 Explain the sources and uses of lipids.

Ans: See LQ.2 (Topic 13.3)

Q.7 Give the importance of vitamins.

Ans: See LQ.1 (Topic 13.5)

Q.8 Describe the sources, uses and deficiency symptoms of water soluble vitamins.

Ans: **SOURCES, USES AND DEFICIENCY SYMPTOMS OF WATER SOLUBLE VITAMINS**

Vitamin	Sources	Uses	Diseases
Vitamin B (Thiamine)	Yeast, egg yolk, liver, wheat, nuts, red meat and whole cereals	Carbohydrate metabolism	Fatigue, irritability, loss of appetite
Vitamin B_2 (riboflavin)	Liver, eggs, whole cereals, fruits and yeasts	Intracellular metabolism	Glossitis (inflammation of tongue) anemia dermatitis.
Vitamin B_{12}	Liver, red meat, dairy products and fresh vegetables	Essential for manufacturing of genetic material in cells, involved in production of WBC's	Pernicious anemia, retarted growth
Vitamin C (Ascorbic acid)	Green vegetables, citrus fruits	Essential for maintenance of bones, teeth, gums and ligaments	Scurvey (bleeding of gums)

ADDITIONAL CONCEPTUAL QUESTIONS

Q. 1 Carbohydrates are a source of energy, comment.

(Science, Technology and Society Pg. # 194) (GRW 2014, SWL 2017)

Ans:

CARBOHYDRATES AS SOURCE OF ENERGY

Carbohydrates provide 17 kilo joules of energy per gram. We take carbohydrates as food.

Mechanism:

Long chains of starch (carbohydrates) are broken down into simple sugars (glucose) by digestive enzymes. The glucose is absorbed directly by small intestine into the blood stream. Blood stream transports the glucose to its place of use, e.g., muscles.

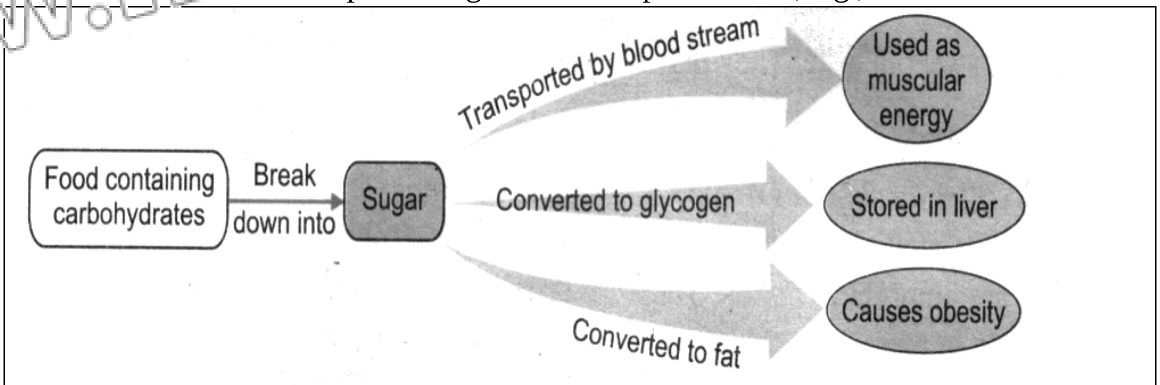


Figure: Showing Carbohydrates as a Source of Energy

Q. 2 Differentiate between monosaccharides and oligosaccharides. **(BWP 2016 G-II)**

Ans:

DIFFERENTIATION

The differences between monosaccharides and oligosaccharides are as follows:

Monosaccharides	Oligosaccharides
Definition: Monosaccharides are the simplest sugars which cannot be hydrolyzed. They consist of 3 to 9 carbon atoms.	**Definition:** The carbohydrates which give 2 to 9 units of monosaccharide on hydrolysis are called oligosaccharides.
Classification: They are classified according to the number of carbon atoms in their molecules as trioses, tetroses, pentoses, hexoses, and so on.	**Classification:** They are classified as disaccharides, trisaccharides, tetrasaccharides, etc. depending upon the number of units they produce on hydrolysis.
Examples: • Glucose • Fructose	**Examples:** • Sucrose • Lactose

Q. 3 Differentiation between fat soluble and water soluble vitamins.

Ans: **DIFFERENTIATION**

The differences between fat soluble vitamins and water soluble vitamins are as follows:

Fat Soluble Vitamins	Water Soluble Vitamins
Definition: • The vitamins which dissolve in fats are called fat soluble vitamins.	**Definition:** • The vitamins that dissolve in water are called water soluble vitamins.
Examples: • Vitamin A • Vitamin D • Vitamin E • Vitamin K	**Examples:** • Vitamin B-complexes • Vitamin C (Ascorbic acid).

Q. 4 What is meant by denaturation of proteins?

Ans: **DENATURATION OF PROTEINS**

"Denaturing of protein means precipitation or coagulation of protein."

Method:

It can be carried out by heating or changing pH.

Example:

A simple common method for denaturing of protein is boiling of an egg. White viscous fluid (albumen) present in an egg is protein. When egg is boiled for a few minutes, albumen coagulates i.e., solidifies.

Q. 5 How can you distinguish between DNA and RNA?

Ans: **DIFFERENCE**

DNA	RNA
Definition: The type of nucleic acid which contains deoxyribose sugar in its nucleotides is called DNA.	**Definition:** The type of nucleic acid which contains ribose sugar in its nucleotides is called RNA.
Structure: It is a double stranded molecule	**Structure:** It is a single stranded molecule.
Function: DNA is the permanent storage place for genetic information in the nucleus of a cell	**Function:** RNA is responsible for putting the genetic information to work in the cell to build proteins.

Q. 6 How esters are formed?

Ans: Fatty acids formed esters (oil or fats) with glycerol in the presence of mineral acids.

TERMS TO KNOW

Terms	Definitions
Biochemistry	The branch of chemistry that deals with the study of structure, composition and chemical reactions of substances found in living organisms is called biochemistry.
Carbohydrates	Carbohydrates are macromolecules defined as polyhydroxy aldehydes or ketones.
Monosaccharides	Monosaccharides are the simplest sugars which cannot be hydrolyzed. They consist of 3 to 9 carbon atoms.
Polysaccharides	The carbohydrates which give a large number of monosaccharides on hydrolysis are called polysaccharides.
Dextrose	Dextrose is crystallized glucose (natural sugar found in starchy foods). It provides simple carbohydrates to the body that can be easily broken down and processed.
Oligosaccharides	The carbohydrates which give 2 to 9 units of monosaccharide on hydrolysis are called oligosaccharides. OR Oligosaccharides give 2 to 9 units of monosaccharaides on hydrolysis.
Proteins	Proteins are highly complicated nitrogenous compounds made up of amino acids.
Amino Acids	Amino acids are organic compounds consisting of both amino and carboxyl groups.
Essential Amino Acids	Ten out of twenty amino acids can be synthesized by human body. These amino acids are called non-essential amino acids.
Lipids	Lipids are macromolecules made up of fatty acids. Lipids include oils and fats. OR Esters of long chain carboxylic (fatty) acids with glycerol are called lipids.
Fatty Acids	Fatty acids are building blocks of lipids. They are long chain saturated and unsaturated carboxylic acids.
Fat	It exists in solid form at room temperature.
Oil	It exists in liquid form at room temperature.
Nucleic Acids	Nucleic acids are essential components of every living cell. They are generally long chain molecules made up of nucleotides.
Genetic Code of Life	Genetic Code of Life" means those specific instructions which pass from generation to generation, to synthesize the particular proteins from amino acids.
Vitamins	Organic compounds essential to health that must be supplied in small amounts in the diet are called vitamins.
Fat Soluble Vitamins	The vitamins which dissolve in fats are called fat soluble vitamins.
Water Soluble Vitamins	The vitamins that dissolve in water are called water soluble vitamins.
Enzymes	The substances which are used to catalyze the reactions in living organisms are called enzymes.
Denaturation of Protein	Denaturation of protein means precipitation or coagulation of protein.

CUT HERE

SELF TEST

Time: 35 Minutes **Marks: 25**

Q.1 Four possible answers (A), (B), (C) and (D) to each question are given, mark the correct answer. **(6×1=6)**

1. Which one is found in sugar?

(A) Sucrose (B) Lactose
(C) Maltose (D) Starch

2. One gram carbohydrate provides energy:

(A) 17 KJ (B) 18 KJ
(C) 21 KJ (D) 30 KJ

3. Lipids include oils and:

(A) Acids (B) Fats
(C) Fatty Acids (D) Bases

4. In industry, margarine is produced by adding:

(A) Nitrogen (B) Oxygen
(C) Carbon (D) Hydrogen

5. It is caused by damage to DNA:

(A) Hepatitis (B) Tetanus
(C) Cancer (D) Headache

6. These are fat soluble vitamins:

(A) A, D (B) C, D
(C) D, B (D) B, C

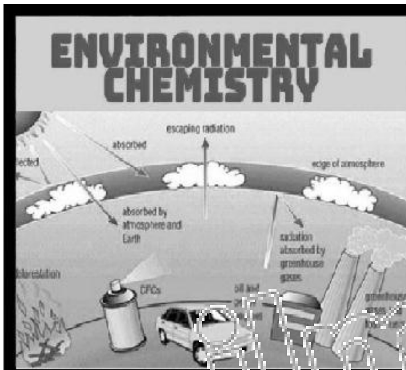
Q.2 Give short answers to the following questions. **(5×2=10)**

(i) Differentiate between glucose and fructose.
(ii) Define polysaccharides?
(iii) Give general formula of lipids
(iv) What is hydrogenation of vegetable oil?
(v) Why RNA acts like a messenger?

Q.3 Answer the following questions in detail. **(5+4=9)**

(i) What are Carbohydrates? How monosaccharides are prepared? **(5)**
(ii) Define vitamins. Explain fat soluble and water soluble vitamins. **(4)**

NOTE: Parents or guardians can conduct this test in their supervision in order to check the skill of students.



CHAPTER 14

ENVIRONMENTAL CHEMISTRY - I THE ATMOSPHERE

INTRODUCTION

SHORT QUESTIONS

Q.1 What are natural systems of the earth? *(Knowledge Base)* **(BWP 2017)**

Ans: **NATURAL SYSTEMS OF EARTH**

Our planet the Earth has four natural systems: lithosphere, hydrosphere, atmosphere and biosphere.

(i) Lithosphere:

"*Rigid rocky part of the Earth is called lithosphere".*

(ii) Hydrosphere:

"*The part of environment which includes all water bodies is called hydrosphere".*

Examples:

- Oceans
- Rivers
- Lakes
- Glaciers

(iii) Atmosphere:

"*The envelope of gases around the Earth is called atmosphere".*

(iv) Biosphere:

"*The part of environment which can support life is called biosphere".*

Examples:

- Lower atmosphere
- Ocean
- Rivers
- Soils etc.

Q.2 What is the significance of study of composition of atmosphere? *(Knowledge Base)*

Ans: **SIGNIFICANCE OF STUDY OF COMPOSITION OF ATMOSPHERE**

The study of composition of atmosphere provides us the knowledge about the gases present in atmosphere and their significance.

MULTIPLE CHOICE QUESTIONS

1. In how many natural systems Earth is divided? *(K.B)*

(A) 4 (B) 3

(C) 2 (D) 1

2. The layer of gases around the earth is called: *(K.B)*

(A) Troposphere (B) Stratosphere

(C) Atmosphere (D) Thermosphere

3. The part of environment which can support life is called: *(K.B)*

(A) Lithosphere (B) Biosphere

(C) Atmosphere (D) Hydrosphere

14.1 COMPOSITION OF ATMOSPHERE

14.2 LAYERS OF ATMOSPHERE

LONG QUESTION

Q.1 What is atmosphere? Explain the composition of dry atmosphere. ***(Knowledge+Understanding Base)***

(FSD 2016 G-I, MTN 2016 G-II)

Ans: **ATMOSPHERE**

Definition:

*"Atmosphere is the **envelope of different gases** around the Earth".*

Location:

It extends continuously from the Earth's surface outwards without any boundary.

Composition:

About **99% of atmospheric mass** lies within **30 kilometres** of the surface and **75%** lies within the **lowest 11 kilometres.**

Table: Composition of Dry Air

Gas	% By Volume
Nitrogen	78.09
Oxygen	20.94
Argon	0.93
Carbon dioxide	0.03

Q.2 Describe the layers of atmosphere in detail. ***(Knowledge+Understanding Base)***

Ans: **LAYERS OF ATMOSPHERE**

Atmosphere consists of four spheres (layers) extending from the surface of the Earth upwards.

Change in Concentration of Gases:

The concentration of the component gases decreases gradually upwards, that results in gradual decrease of pressure.

Change in Temperature:

Temperature of the atmosphere does not change in a gradual way. It varies in a complex way.

Region of Atmosphere:

Depending upon the temperature variation, atmosphere is divided into four regions.

(i) Troposphere

(ii) Stratosphere

(iii) Mesosphere

(iv) Thermosphere

(i) <u>Troposphere:</u>

*"The **region of** the **atmosphere** from earth's surface upto **12 km** above is called troposphere"*

<u>Characteristics:</u>

- It is lowest region of the atmosphere in which we live.
- Temperature decreases from **17°C** to **-58°C** regularly in the lowest layer extending upto **12 km.**

(ii) <u>Stratosphere:</u>

*"The **region of** the **atmosphere** which is **up to 50 km** is called stratosphere"*

<u>Characteristics:</u>

- In this layer temperature rises upto 2°C.
- Ozone is present in this layer at a height of about 25 km.

(iii) <u>Mesosphere:</u>

*"The **region of** the **atmosphere** between **50–85 kilometers** is called mesosphere"*

<u>Characteristic:</u>

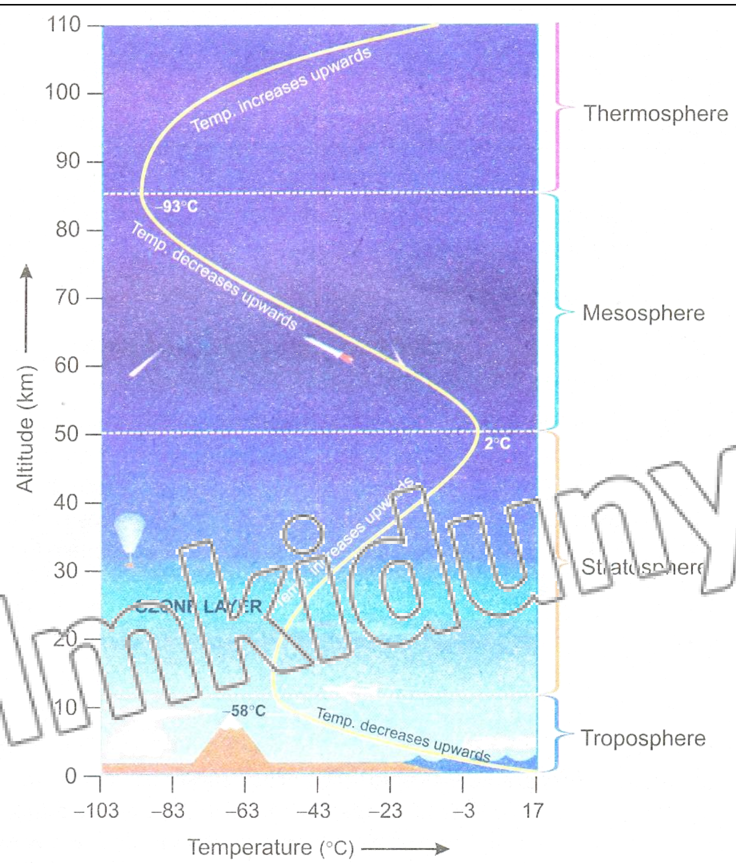
- In this region again **temperature decreases** down to **-93°C.**

(iv) <u>Thermosphere:</u>

*"The **region of** the **atmosphere** between **85–120 kilometers** is called thermosphere"*

<u>Characteristic:</u>

- In this region temperature goes on increasing upwards.



<u>Figure: Different Spheres of Atmosphere</u>

Characteristics of Regions of the Atmosphere:

The characteristics of four regions of atmosphere are as follows:

Name of Region	Height Above the Earth's Surface	Temperature Range and Trend
Troposphere	0km –12km	17°C – -58°C (decreases)
Stratosphere	12km – 50km	-58°C – 2°C (increases)
Mesosphere	50km – 85 km	2°C – -93°C (decreases)
Thermosphere	85kms –120km	> –93°C (increases)

Distribution of atmospheric mass:

- About 99% of the atmospheric mass lies within 30 kilometers of the surface
- 75% of the mass lies within the lowest 11 km.
- Similarly, about 50% of the atmospheric mass lies within 5–6 cm of surface.

Q.3 Give the characteristics of troposphere. Why temperature decreases upwards in this sphere? *(Knowledge+Understanding Base)*

(Ex-Q.2) (SGD 2014, FSD 2016 G-I, II, SGD 2016 G-II, BWP 2016 G-II)

Ans: **TROPOSPHERE**

Definition:

"The region of the atmosphere from the earth surface upto 12km is called troposphere"

Characteristics:

The characteristics of troposphere are as follows:

- It is the lowest region of the atmosphere in which we live.
- It is the region in which most of the earth weather or phenomenon occurs.
- Almost all air crafts fly in this region.

Major Components:

The major constituents of troposphere are nitrogen and oxygen gases. Nitrogen and oxygen form 99% by volume of the earth's atmosphere.(No role in temperature maintenance)

Concentration of CO_2 and Water Vapours and their Role:

Although concentration of carbon dioxide and water vapours is negligible in atmosphere, yet they play a significant role in maintaining temperature of the atmosphere.

Temperature Maintenance:

Both of these gases (CO_2 and water vapours) allow visible light to pass through but absorb infrared radiations emitted by the Earth's surface. Therefore, these gases absorb much of the outgoing radiations and warm the atmosphere.

DECREASE IN TEMPERATURE UPWARD

As the concentration of gases decreases gradually with the increase of altitude, correspondingly temperature also decreases in troposphere at a rate of 6 °C per kilometer.

Q.4 What are the characteristics of stratosphere? Why temperature increases upwards in this sphere? **(Ex-Q.3) (GRW 2015, LHR 2014, FSD 2016 G-II)**

Ans: **STRATOSPHERE**

Definition:

"The region of atmosphere which is present upto 50 km is called stratosphere".

Rise in Temperature:

The presence of ozone (due to absorption of radiation) in this region is responsible for the rise of temperature in stratosphere.

Within this region, temperature increases as altitude increases, such as lower layer temperature is about **-58°C and upper layer is about 2°C.**

The fate of ozone and different regions of stratosphere can be described as follows:

(i) Ozone in Upper Stratosphere (Destruction of Ozone):

Since ozone in the upper layer absorbs high energy ultraviolet radiations from the Sun, it breaks down into monoatomic (O) and diatomic oxygen (O_2).

$$O_{3(g)} \longrightarrow O_{2(g)} + O_{(g)}$$

(ii) Ozone in the Mid Stratosphere: (Formation of Ozone): **(GRW 2014)**

The mid stratosphere has less UV light passing through it. Here O and O_2 recombine to form ozone which is an exothermic reaction. Ozone formation in this region results in the formation of ozone layer. Thus, ozone layer exists in mid stratosphere.

$$O_{2(g)} + O_{(g)} \longrightarrow O_{3(g)}$$

(iii) Ozone in the Lower Stratosphere:

The lower stratosphere receives very low UV radiations, thus monoatomic oxygen is not found here and ozone is not formed here.

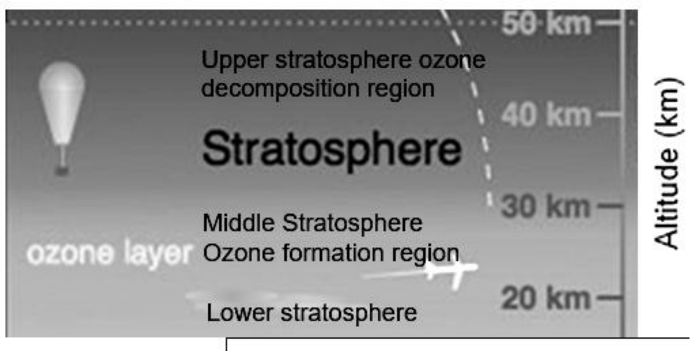


Figure: Stratosphere Regions

14.1 COMPOSITION OF ATMOSPHERE

SHORT QUESTIONS

Q.1 What do you know about wavelength of solar radiations? ***(Knowledge Base)*** **(Do you know Pg. # 118)**

Ans: **WAVELENGTH OF SOLAR RADIATIONS**

Sunlight has short wavelength radiations. Solar energy absorbed by the Earth surface is transformed into heat energy which is of longer wavelength.

Q.2 What do you know about reflection and absorption of solar radiations by the earth? ***(Knowledge Base)*** **(Do you know Pg. # 118)**

Ans: **REFLECTION AND ABSORPTION OF SOLAR RADIATIONS**

Reflection:

On the average there is total 32% reflection of light out of which:

- 6% being reflected from the Earth's surface
- 26% being reflected back into space because of clouds, gases and dust particles in the atmosphere.

Absorption:

- 18% of sunlight is absorbed by atmospheric gases.
- The remaining 50% reaches upto the Earth and is absorbed by it.

Fate of Heat Energy Radiated From Earth:

- The energy is radiated as heat energy of longer wavelength which is absorbed by water vapours and CO_2 in atmosphere.

Q.3 How is ozone produced in troposphere? *(Knowledge Base)*(Interesting Information Pg. # 121)

Ans: **PRODUCTION OF OZONE**

Ozone is quite a well-known gas. Photocopiers and any other source of static electricity can cause it to form from oxygen. You may have noticed a strange bitter smell near photocopiers; this is ozone. It is a poisonous gas and is formed on hot days in badly polluted cities.

Q.4 What are the major components of troposphere? *(Knowledge Base)*

Ans: *Answer given on Page # 256*

Q.5 Name the layers of atmosphere. *(Knowledge Base)*

Ans: **LAYERS OF ATMOSPHERE**

Depending upon the temperature variation, atmosphere is divided into four regions.

- Troposphere
- Stratosphere
- Mesosphere
- Thermosphere

Q.6 How is ozone formed in stratosphere? *(Knowledge Base)*

Ans: **FORMATION OF OZONE IN STRATOSPHERE**

The mid stratosphere has less UV light passing through it. Here O and O_2 recombine to form ozone which is an exothermic reaction. Ozone formation in this region results in the formation of ozone layer. Thus, ozone layer exists in mid stratosphere.

$$O_{2(g)} + O_{(g)} \longrightarrow O_{3(g)}$$

14.1 COMPOSITION OF ATMOSPHERE
14.2 LAYERS OF ATMOSPHERE
MULTIPLE CHOICE QUESTIONS

1. % of sunlight absorbed by atmospheric gases is: *(K.B)* **(SGD 2014, DGK 2017)**
(A) 19 (B) 18
(C) 20 (D) 30

2. Percentage of argon in atmosphere by volume is: *(K.B)*
(A) 0.93 (B) 0.03
(C) 0.21 (D) 78.09

3. Percentage of carbon dioxide in atmosphere by volume is: *(K.B)*
(A) 0.93 (B) 0.21
(C) 0.03 (D) 78.09

4. Solar energy absorbed by Earth is converted into: *(K.B)*
(A) Heat energy (B) Light energy
(C) Both A and B (D) None of these

5. How much energy is absorbed by Earth? *(K.B)*
(A) 6% (B) 23%
(C) 50% (D) 32%

6. How much energy is reflected from Earth's surface? ***(K.B)***

(A) 32% (B) 23%
(C) 50% (D) 6%

7. Percentage of nitrogen in the composition of atmosphere by volume is : ***(K.B)***

(A) 78.09% (B) 20.94%
(C) 0.03% (D) 0.93%

8. About 99% atmosphere mass lies within: ***(K.B)*** **(SWL 2017)**

(A) 35km (B) 30km
(C) 15km (D) 11km

9. Temperature decreases from 17°C to -58°C regularly in the lowest layer extending upto kilometers: ***(K.B)***

(A) 12 (B) 13
(C) 14 (D) 15

10. Height above the Earth surface of troposphere is: ***(K.B)***

(A) 12-50km (B) 0-12km
(C) 50-85km (D) 85-120km

11. Height above the Earth surface of stratosphere is: ***(K.B)***

(A) 12-50km (B) 50-85km
(C) 85-120km (D) 120-130km

12. Temperature of atmosphere decreases by ______ °C per kilometer as the concentration of gases decreases gradually with the increase of altitude. ***(K.B)***

(A) 4 (B) 2
(C) 3 (D) 6

13. Formula of ozone is: ***(K.B)*** **(LHR 2014, MTN 2017)**

(A) O (B) O_2
(C) SO_3 (D) O_3

14. A group of gases that maintains the temperature of atmosphere is: ***(K.B)***

(A) Carbon dioxide and water vapours (B) Nitrogen and carbon dioxide
(C) Oxygen and water vapours (D) Nitrogen and oxygen

15. The Earth's atmosphere is getting hotter because of increasing concentration of: ***(K.B)***

(A) CO (B) CO_2
(C) O_2 (D) SO_2

16. Temperature range of troposphere is: ***(K.B)***

(A) 10°C – -80°C (B) 17°C – -58°C
(C) -58°C – 2°C (D) 2 – -93°C

17. Stratosphere extends upto: ***(K.B)***

(A) 12 km (B) 50 km
(C) 85 km (D) 110 km

18. The major constituents of troposphere are: ***(K.B)***

(A) O_2 & N_2 (B) CO_2 & CO
(C) SO_2 & SO_3 (D) NO_x

19. Which is responsible for rise in temperature in stratosphere? ***(K.B)***

(A) O_3 (B) CO_2
(C) CO (D) O_2

20. Mid of stratosphere contains: ***(K.B)***

(A) O_3 (B) CO_2

(C) CO (D) H_2SO_4

14.1 TEST YOURSELF

i. What do you mean by atmosphere? *(Knowledge Base)* (GRW 2013, LHR 2013, SWL 2017)

Ans: **ATMOSPHERE**

"Atmosphere is the envelope of different gases around the Earth".

Layers of atmosphere:

Atmosphere consists of four layers extending from the surface of the Earth upwards which are as follows:

- Troposphere
- Stratosphere
- Mesosphere
- Thermosphere

ii. What is difference between atmosphere and environment?
(Knowledge+Understanding Base) **(LHR 2014)**

Ans: **DIFFERENTIATION**

The differences between atmosphere and environment are as follows:

Atmosphere	Environment
Definition	
• Atmosphere is the envelope of different gases around the Earth. It extends continuously from the Earth's surface outwards without any boundary.	• Environment is the sum of all social, biological, physical and chemical factors which constitutes the surroundings of man.
Composition	
• It consists of four layers i.e., troposphere, stratosphere, mesosphere, thermosphere.	• It consists of air, water, food and sunlight.

iii. Name the major constituents of troposphere? *(Knowledge Base)*(LHR 2015, MTN 2016 G-I)

Ans: **MAJOR CONSTITUENTS**

The major constituents of troposphere are:

- Nitrogen (78 %)
- Oxygen (21 %)

Both Nitrogen and oxygen constitute 99 % of atmosphere by volume.

iv. How the temperature of atmosphere is maintained? *(Knowledge Base)* (GRW 2015)

Ans: **MAINTENANCE OF TEMPERATURE**

CO_2 and water vapours maintain the temperature of atmosphere. Both these gases allow visible light to pass through but absorb infrared radiations emitted by the Earth's surface. So, temperature of atmosphere is maintained.

v. Where the ozone layer exists? *(Knowledge Base)*

Ans: **EXISTENCE OF OZONE LAYER**

Ozone layer exists in mid of stratosphere about 25 to 30 kilometers away from the Earth surface. In this region formation of ozone takes place.

$$O_2 + O \longrightarrow O_3$$

vi. Why the temperature of upper stratosphere is higher? *(Knowledge Base)*

Ans: **TEMPERATURE OF UPPER STRATOSPHERE**

The temperature of upper stratosphere is higher due to the presence of ozone in this region.

Mechanism:

Ozone absorbs ultraviolet radiations coming from the sun. As the altitude increases the temperature also increases from **–58°C** to **2°C.**

14.3 POLLUTANTS

LONG QUESTIONS

Q.1 Write a note on pollutants. *(Knowledge Base)* **(GRW 2015)**

OR

What is meant by pollutants? Write down the type and sources of pollutants. **(SGD 2016 G-II)**

Ans: **POLLUTANTS**

Definition:

"*A pollutant is a **waste material** that pollutes air, water or soil (environment) and this phenomenon is called pollution*".

Characteristics:

The characteristics of pollutants are as follows:

- They make the environment (air, water or soil) harmful to life.
- They cause pollution.
- The contaminants are those substances that make something impure.
- A beneficial substance beyond a specific concentration may be harmful.

Air Pollutants: **(DGK 2016 G-II)**

"*The harmful substances present in air are called air pollutants*".

Effects:

Air pollutants have following effects:

- Change the weather
- Badly affect the human health
- Damage the plants
- Destroy buildings

Factors Affecting Severity of a Pollutant:

Three factors determine the severity of a pollutant.

- Chemical nature of pollutant
- Concentration of pollutant
- Persistence of pollutant.

Types of Pollutants:

Major air pollutants are classified as:

(i) Primary pollutants

(ii) Secondary pollutants.

Primary Pollutants: **(MTN 2017)**

"*Primary pollutants are the **waste** or **exhaust products** driven out because of **combustion** of **fossil fuels** and organic matter*".

Examples:

- Oxides of sulphur (SO_2 and SO_3)
- Oxides of carbon (CO_2 and CO)
- Oxides of nitrogen (specially nitric oxide NO)
- Hydrocarbon (CH_4)
- Ammonia
- Compounds of fluorine etc.

(ii) Secondary Pollutants:

*"Secondary pollutants are produced by **various reactions of primary pollutants**".*

Examples:

- Sulphuric acid
- Carbonic acid
- Nitric acid
- Hydrofluoric acid
- Ozone
- **Peroxy acetyl nitrate (PAN) etc.**

Sources of Air Pollutants:

99% of atmosphere consists of N_2 and O_2. Although other gases are minor constituents they can have major effects on our environment. Because atmosphere determines the environment in which we live. So, these minor constituents are safe up to concentration limit. But human activities disrupt the environment. So, limit has been crossed considerable during the last 60 years.

Different sources of air pollutants are described as:

- Carbon oxides
- Sulphur compounds
- Nitrogen compounds
- Ozone

Q.2 State the major sources of CO and CO_2 emission. *(Knowledge Base)* **(Ex-SQ. 3)**
(GRW 2015, 16, MTN 2017, FSD 2016 G-I, DGK 2016 G-II)

Ans: **SOURCES OF OXIDES OF CARBON (CO_2 AND CO)**

Sources of oxides of carbon (CO and CO_2) are as follows:

(i) Volcanic Eruption:

These gases are emitted due to volcanic eruption.

(ii) Decomposition of Organic Matter:

These gases are also emitted due to decomposition of organic matter.

(iii) Combustion of Fossil Fuels:

The major source for the emission of these gases is combustion of fossil fuels (coal, petroleum and natural gas). Fossil fuels burnt in combustion engine of any type of automobile, kiln of any industry, or open air fires emit CO_2 and CO.

(iv) Forest Fires and Burning of Wood:

Forest fires and burning of wood also emit CO_2 and CO. Especially, when supply of oxygen is limited, emission of CO dominates.

Q.3 Compounds of sulphur are air pollutants. Describe the sources of these compounds along with their effects. *(Knowledge Base)* **(Ex-Q.7) (GRW 2014)**

Ans: **SOURCES AND EFFECTS OF SULPHUR COMPOUNDS**

Sources:

a. Natural Production of Sulphur Compounds:

Naturally occurring sulphur containing compounds are emitted in the

- Bacterial decay of organic matter
- In volcanic gases
- Forest fires

b. Production of Sulphur Compounds due to Human Activities:

These compounds are emitted by fossil fuel combustion in automobiles and industrial units.

Comparison of SO_2 Production Naturally and By Combustion of Fossil Fuels:

The concentration of sulphur containing compounds in the atmosphere because of natural sources is very small as compared to the concentration of those compounds emitted by fossil fuel combustion in automobiles and industrial units. About 80% of the total SO_2 is released by the combustion of coal and petroleum products.

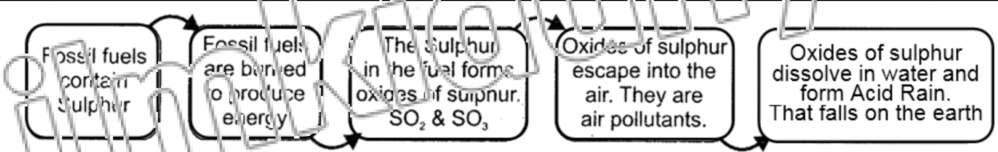


Figure: Formation of SO_3 and SO_2 on Combustion of Fossil Fuels and Causing Air Pollution

Effects of SO_2: **(RWP 2017)**

(i) Respiratory Problems:

SO_2 is a colourless gas having irritating smell. It causes suffocation, irritation and severe respiratory problems to asthmatic people.

(ii) Sulphuric Acid:

SO_2 forms sulphuric acid which damages buildings and vegetations.

Control of Sulphur Pollution:

To control pollution because of SO_2, it is necessary to remove sulphur from fossil fuels before they are burnt.

Q.4 Oxides of nitrogen cause air pollution. Describe the sources of these compounds. *(Knowledge+Understanding Base)*

(SWL 2016 G-I)

Ans: **SOURCES OF NITROGEN COMPOUNDS (NOx)**

(i) Production of NO:

Natural Production:

Naturally occurring **oxides of nitrogen, mainly nitric oxide (NO),** is produced by the electrical lightening in air.

Combustion of Fossil Fuels:

Combustion of fossil fuels in internal combustion engines, in thermal power stations and factories where huge amount of coal is burnt, NO is formed by the direct combination of nitrogen and oxygen.

$$N_2 + O_2 \rightarrow 2NO$$

(ii) Production of NO_2:

NO quickly reacts with air to form nitrogen dioxide. **NO is highly toxic gas.**

$$2NO + O_2 \rightarrow 2NO_2$$

Effects of NO_x:

Mixture of these gases represented as NOx, enter in the air through automobile exhaust and chimneys of thermal power stations and factories. These gases have following effects:

- It irritates breathing passage.
- These oxides form nitric acid combining with water vapours in air.
- Nitric acid is a component of acid rain.
- Acidic gases (pollutants) from nearby industrial units contribute to the wearing away of the famous marble building the Taj Mahal in India.

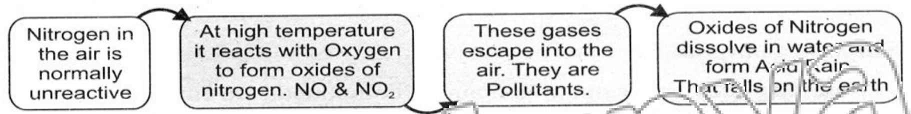


Figure: Formation of NO and NO_2 on Combustion of Fossil Fuels and Causing Air Pollution

Q.5 Write a complete note on greenhouse effect and global warming.
(Knowledge+Understanding Base) **(SWL 2016 G-II)**

OR

CO_2 is necessary for plants but why its increasing concentration is alarming for?
(Ex-Q.4)(LHR 2015, BWP 2016 G-I)

Ans: **GREEN HOUSE EFFECT**

Definition:

*"The **concentration** of **CO_2** in air increases, less heat energy is lost from the surface of the Earth. Therefore, the average temperature of the surface gradually increases. This is called greenhouse effect".*

Explanation:

The CO_2 forms a layer around the Earth like an envelope. It allows the heat rays of the Sun to pass through it and reaches upto the Earth. These rays are reflected from the Earth surface and go back to upper atmosphere.

Importance of CO_2 Layer Around the Earth:

Normal concentration of CO_2 layer retains enough heat to keep the atmosphere warm. So, normal concentration of CO_2 is necessary and beneficial for keeping the temperature warm. Otherwise, the Earth would have been uninhabitable. The Earth's average temperature would be about -20°C, rather than presently average temperature 15°C.

Recycling of CO_2 and O_2:

CO_2 is not an air pollutant. Rather, it is an essential gas for plants as O_2 is essential for animals. Plants consume CO_2 in photosynthesis process and produce O_2.While animals use O_2 in respiration and give out CO_2. In this way, a natural balance exists between these essential gases as represented here.

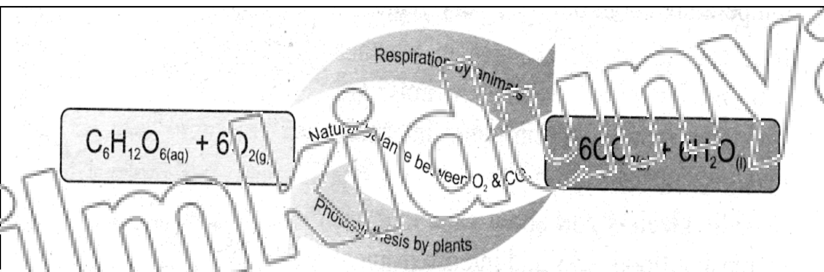


Figure: Recycling of CO_2 And O_2

Disturbance in Balance of CO_2 in Atmosphere:

But this balance is being disturbed by emitting more and more CO_2 in air through different human activities.

Role of CO_2 in Global Warming (CO_2 as Glass Wall in Atmosphere):

(Ex Q.4)(LHR 2015)

(i) Disadvantage:

CO_2 is not a poisonous gas, yet its increasing concentration due to burning of fossil fuels in different human activities is alarming because CO_2 in the atmosphere acts like a glass wall of a green house.

Mechanism of Global Warming:

CO_2 in the atmosphere acts like a glass wall of a green house. It allows UV radiations to pass through it but does not allow the IR radiations to pass through it. It traps some of the infrared radiations emitted by the Earth. Hence, increased concentration of CO_2 layer absorbs the infrared radiations emitted by the Earth's surface and prevents heat energy escaping from the atmosphere.

(ii) Advantage:

It helps to stop surface from cooling down during night.

GLOBAL WARMING

"The increase in average temperature of Earth's atmosphere and oceanic temperature due to green house effect (resulting especially due to pollution) is called global warming".

Relationship between CO_2 and Green House Effect:

Green house effect $\propto$ amount of CO_2 in air

If the concentration of CO_2 in air increases, less heat energy is lost from the surface of the Earth. Therefore, the average temperature of the surface gradually increases. This is called greenhouse effect. This effect is proportional to amount of CO_2 in air. Trapping of heat or warming is greater with increase of CO_2. This phenomenon due to increased warming is also called global warming.

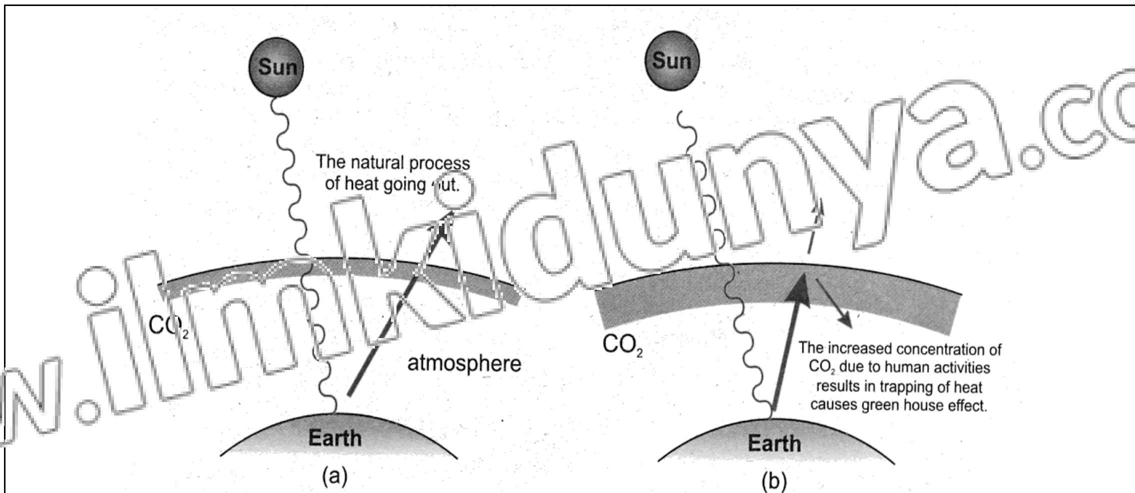


Figure: Greenhouse Effect

Effects of Global Warming:

(GRW 2014, DGK 2017, MTN 2016 G-II, BWP 2016 G-I-II, DGK 2016 G-I)

The effect of global warming are as follows:

(i) Rising of Temperature:

Accumulation of carbon dioxide in air is resulting in increasing atmospheric temperature about **0.05 °C** every year.

(ii) Weather Changes:

It is causing major changes in weather patterns. Extreme weather events are occurring more commonly and intensely than previously.

(iii) Melting of Glaciers and Snow Caps:

It melts glaciers and snow caps that are increasing flood risks and intense tropical cyclones.

(iv) Rise of Sea Level:

Sea-level is rising due to which low lying areas are liable to be submerged, turning previously populated areas no longer habitable.

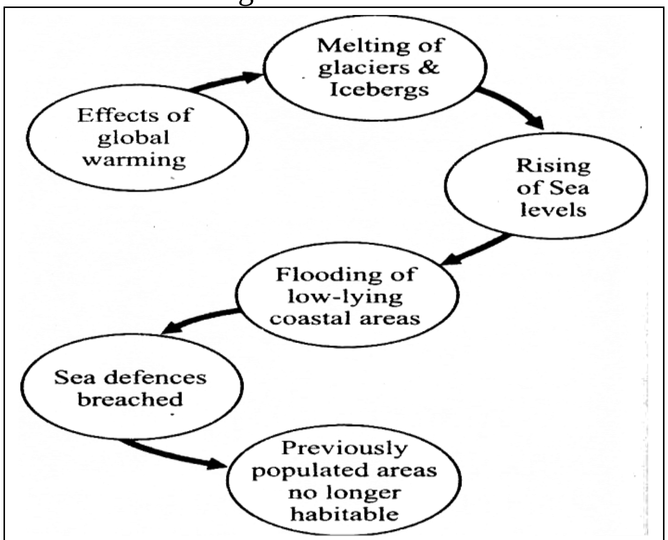


Figure: Effects of Global Warming

14.3 POLLUTANTS

SHORT QUESTIONS

Q.1 CO_2 is the life gas for plants and animals. Comment it. ***(Knowledge Base)***

(Interesting Information Pg. # 125)

Ans: **CO$_2$ AS LIFE GAS**

CO_2 is the life gas for plants as well as for the human beings and animals.

Comments:

CO_2 absorbs infrared radiations emitted by the Earth. Although CO_2 is negligible as compared to N_2 and O_2, yet its heat retaining capacity is tremendous. Without CO_2, life on earth would have been impossible.

Q.2 What are catalytic converters? *(Knowledge Base+Application Base)*

(Do you know Pg. # 124)

Ans: **CATALYTIC CONVERTERS**

Definition:

*"An instrument which is used to **convert harmful gases (CO, NO_x hydrocarbons etc) present in automobile exhaust into harmless substances (CO_2, N_2 and H_2O),** in the presence of some catalyst like Pd, Cd etc is called catalytic converter".*

Importance:

Converters should be used in automobile exhaust so that they convert **CO to CO_2** and oxides of nitrogen **NO_x to N_2** before it enters in air. Catalytic converters are attached to automobile exhausts.

Q.3 Describe working of catalytic converters. *(Application Base)* **(Do you know Pg. # 124)**

Ans: **WORKING OF CATALYTIC CONVERTERS**

When hot gases pass through the converters, harmful pollutants are converted to harmless substances.

Examples:

- Carbon monoxide is oxidized to carbon dioxide.
- Unburnt hydrocarbons are oxidized to carbon dioxide and water, while oxides of nitrogen are reduced to nitrogen.

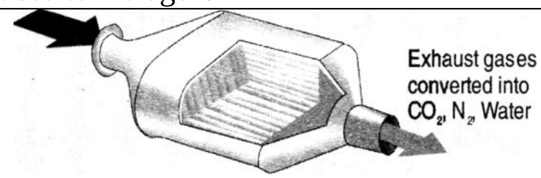


Figure: Catalytic Converter Used in Automobile Vehicle

Q.4 What are effects of SO_2? *(Knowledge Base)* **(RWP 2017)**

Ans: *Answer Given on Page # 263*

Q.5 Define global warming? *(Knowledge Base)* **(RWP 2016 G-II)**

Ans: **GLOBAL WARMING**

Definition:

"The increase in average temperature of earth's atmosphere and oceanic temperature due to green house effect (resulting especially due to pollution) is called global warming".

Effects of Global Warming:

- Rising of temperature
- Weather changes
- Melting of glaciers and snow caps
- Rise of sea level

Q.6 What are life gases for plants and animals? *(Knowledge Base)*

(Interesting Information Pg. # 125)

Ans: **LIFE GASES**

- CO_2 is the life gas for plants used for photosynthesis.
- O_2 is for the respiration of human beings and animals.

Q.7 How CO_2 is responsible for existance of life on earth? *(Knowledge Base)*

(Interesting Information Pg. # 125)

Ans: **ROLE OF CO_2**

CO_2 is responsible for existance of life on earth. It absorbes infrared radiations emitted by the Earth. Although CO_2 is negligible as compared to N_2 and O_2 yet its heat retaining capacity is tremendous. Without CO_2, life on Earth would have been impossible.

14.3 POLLUTANTS

MULTIPLE CHOICE QUESTIONS

1. A group of gases that maintains the temperature of atmosphere is: *(K.B)*
(A) Carbon dioxide and water vapours (B) Nitrogen and carbon dioxide
(C) Oxygen and water vapours (D) Nitrogen and oxygen

2. Which one is primary pollutant? *(K.B)*
(A) HNO_3 (B) CH_4
(C) O_3 (D) H_2SO_4

3. Which one of the following is a greenhouse effect? *(K.B)*
(A) Increasing atmosphere temperature (B) Both A and C
(C) Increasing flood risks (D) None of these

4 Formula of nitrogen dioxide is: *(K.B)*
(A) H_2SO_4 (B) NO_2
(C) HNO_3 (D) NO

5. Infrared radiations emitted by the Earth are absorbed by: *(K.B)*
(A) CO_2 and H_2O (B) N_2 and O_2
(C) CO_2 and N_2 (D) O_2 and CO_2

6. Cause of global warming is: *(K.B)* **(LHR 2014, GRW 2014, MTN 2017)**
(A) CO_2 (B) SO_2
(C) NO_2 (D) SO_3

7. The harmful substances present in air are called: *(K.B)*
(A) Air pollutants (B) Ozone
(C) Carbondioxide (D) Water

8. Which is not a primary pollutant? *(K.B)*
(A) SO_3 (B) CO_2
(C) CH_4 (D) O_3

9. Which is not a secondary pollutant? *(K.B)*
(A) H_2SO_4 (B) HNO_3
(C) PAN (D) NH_3

10. When wood burns in limited supply of oxygen which gas is produced? *(K.B)*
(A) CO_2 (B) CO
(C) SO_2 (D) SO_3

11. PAN is the abbreviation of: *(K.B)*
(A) Perhydroxy acetyle nitrate (B) Polyhydroxy acetyle nitrite
(C) Polyalkyl nitrate (D) Perhydroxyle acetyle nitrite

12. Which pollutant is not found in car exhaust gases? *(K.B)* **(LHR 2014)**
(A) CO (B) O_3
(C) NO_2 (D) SO_2

13. Which gas is inert? *(K.B)* **(GRW 2014, LHR 2016)**
(A) O_2 (B) CO
(C) N_2 (D) O_3

14. Photosynthesis process produces: *(K.B)* **(GRW 2015)**
(A) Starch (B) Cellulose
(C) Sucrose (D) Glucose

15. Carbon monoxide gas is harmful to us because: *(K.B)* **(DGK 2016 G-I)**
(A) It paralysis the lungs
(B) It damages lung tissues
(C) It reduces oxygen carrying ability of hemoglobin
(D) It makes the blood coagulate

14.2 TEST YOURSELF

i. What do you mean by an air pollutant? *(Knowledge Base)* **(BWP 2016 G-II, SGD 2017)**

Ans: **AIR POLLUTANT**

"*The harmful substances present in air are called air pollutants*".

Examples:

- H_2SO_4
- HNO_3
- SO_2
- CO etc.

ii. Name three primary air pollutants. *(Knowledge Base)*

Ans: **THREE PRIMARY AIR POLLUTANTS**

Following are the names of three primary air pollutants:

- Sulphurdioxide : SO_2
- Sulphur trioxide : SO_3
- Carbon monoxide : CO etc.

iii. Identify as primary or secondary air pollutants. SO_2, CH_4, HNO_3, NH_3, H_2SO_4, O_3. *(Knowledge Base)*

Ans: **IDENTIFICATION OF AIR POLLUTANTS**

The primary and secondary air pollutants are as follows:

Primary Pollutants	Secondary Pollutants
NH_3	HNO_3
CH_4	H_2SO_4
SO_2	O_3

iv. Why CO_2 is called a greenhouse gas? *(Knowledge Base)*

(LHR 2013, DGK 2016 G-I, GRW 2017)

Ans: **CO_2 AS A GREENHOUSE GAS**

Carbon dioxide is called as a greenhouse gas because it acts like a glass wall of green house.

Mechanism:

It allows UV radiations to pass through it but does not allow the IR radiations to pass through it. As concentration of CO_2 increases, less heat is lost from the surface. So, average temperature of earth's surface gradually increases. This is called green house effect.

v. Why the flood risks are increasing? *(Knowledge Base)* **(SWL 2016 G-II)**

Ans: **INCREASING FLOOD RISKS**

Flood risks are increasing because Global Warming is melting the glaciers and snow caps.

vi. Comment burning in open air is preferred. *(Knowledge Base)*

Ans: **BURNING IN OPEN AIR IS PREFERRED**

Burning in open air is preferred because in open air, burning produces CO_2 gas which is not poisonous and becomes part of atmosphere where as in closed places, CO is produced due to limited supply of oxygen, CO is poisonous gas and can be fatal.

vii. How sulphur containing compounds are emitted naturally? ***(Knowledge Base)***

Ans: **EMISSION OF SULPHUR COMPOUNDS**

Sulphur containing compounds are emitted naturally in the following ways:

- Bacterial decay of organic matter
- Volcanic gases
- Forest fires

viii. How combustion of fossil fuels in internal combustion engine produces oxides of nitrogen? ***(Knowledge Base)***

Ans: **COMBUSTION OF FOSSIL FUELS**

Combustion of fossil fuels in internal combustion engines, in thermal power stations and factories where huge amount of coal is burnt, NO is formed by the direct combination of nitrogen and oxygen. NO combines with O_2 to form NO_2.

$$N_{2(g)} + O_{2(g)} \longrightarrow 2NO_{(g)}$$

$$2NO + O_2 \longrightarrow 2NO_2$$

ROLE OF GOVERNMENT TO CONTROL POLLUTION

LONG QUESTIONS

Q.1 What is the role of government to control pollution? ***(Application Base)***

(Science, Technology and Society Book Pg. # 127)

Ans: **ROLE OF GOVERNMENT TO CONTROL POLLUTION**

Causing air pollution through auto exhaust is almost the most common air polluting act which an average citizen commits daily for hours without considering its consequences. One is poisoning the air, creating a big problem that has local, regional and global effects.

Responsibility of Government:

Government should do short term as well as long term planning to preserve the natural world. Because without a healthy natural environment, there will be no healthy human, plant, or animal.

Quality of Fuel:

Quality of fuel must be improved by adding anti-knocking agents in fuels. At the same time, automobiles combustion engines must be efficient so that they should burn the fuel completely. No unburned hydrocarbon molecules (fuel) should come out of the exhaust. So government must guide the people to use converters in auto exhausts.

(i) Alternative Fuels:

Fossil fuels produce a number of air pollutants because of impurities and complex molecule and nature of hydrocarbons

Examples:

Government should promote the use of alternative fuels such as:

- Methanol
- ethanol
- Bio-diesel

Advantages:

- These fuels are less polluting than hydrocarbons fuel, as their molecules are simple, and burn completely in the engine.
- Their burning produces less carbon monoxide, soot and other pollutants.

(ii) <u>Bettery Powdered Electric Vehicles:</u>

The government must plan to avoid using carbon dioxide producing fuels as it is a greenhouse gas. It should go to battery-powered electric vehicles.

(iii) <u>Efficient Transport:</u>

Government should provide efficient transport in the big cities, so that people should avoid using their own vehicles.

ROLE OF GOVERNMENT TO CONTROL POLLUTION

SHORT QUESTIONS

Q.1 How can we improve the quality of fuel? *(Knowledge+Application Base)*

Ans: **<u>TO IMPROVE THE QUALITY OF FUEL</u>**

Quality of fuel must be improved by adding anti-knocking agents in fuels. At the same time, automobiles combustion engines must be efficient so that they should burn the fuel completely. No unburned hydrocarbon molecules (fuel) should come out of the exhaust. So government must guide the people to use converters in auto exhausts.

Q.2 What are alternative fuels? Give their advantages. *(Knowledge+Application Base)*

Ans: **<u>ALTERNATIVE FUELS</u>**

The fuels produced by human other than fossil fuels are called alternative fuels.

<u>Examples:</u>

- Methanol
- ethanol
- Bio-diesel

<u>Advantages:</u>

- These fuels are less polluting than hydrocarbons fuel, as their molecules are simple, and burn completely in the engine.
- Their burning produces less carbon monoxide and other pollutants.

MULTIPLE CHOICE QUESTIONS

1. The government must plan to avoid using the fuels which produce greenhouse gas called: *(K.B+A.B)*

(A) CO_2 (B) CO
(C) NO (D) NO_2

2. No unburned __________ molecules (fuel) should come out of the exhaust. *(K.B+A.B)*

(A) Hydrocarbon (B) Ethanol
(C) O_2 (D) N_2

3. Which fuels are less polluting than hydrocarbon fuel? *(K.B+A.B)*

(A) Ethanol (B) Methanol
(C) Bio-diesel (D) All of these

4. Quality of fuel must be improved by adding: *(K.B+A.B)*

(A) Water (B) Hydrocarbon
(C) Acid (D) Anti-knocking agents

14.4 ACID RAIN AND ITS EFFECTS

LONG QUESTIONS

Q.1 Explain how rain water is acidic and what are the effects of acidic rain?
(Knowledge+Understanding Base)

How rain water is acidic?

OR

Define acid rain. How it forms and what are its effects? **(Ex-Q.6) (LHR 2014, 15)**

Ans:

ACID RAIN

Definition:

*"A rain having a pH lower than that of **normal rain water** due to the presence of H_2SO_4 and HNO_3 is called acid rain".*

Formation of Acid Rain:

Burning of fossil fuels produces oxides of sulphur and nitrogen in air. Rain water converts SO_2 into H_2SO_4 and NO_x to HNO_2 and HNO_3.

$$H_2O + SO_2 \longrightarrow H_2SO_4$$
$$NO_2 + H_2O \longrightarrow HNO_2 + HNO_3$$

Normal Rain Water: Normal rain water is weakly acidic because it consists of dissolved CO_2 of the air. Its pH is about **5.6 to 6.**

Acid Rain Water:

Rain water on dissolving air pollutants (acids) becomes more acidic and its **pH reduces to 4**. Thus, acid rain is formed on dissolving acidic air pollutants such as sulphur dioxide and nitrogen dioxide by rain water. These oxides dissolve in rain water and damage soil, animals and aquatic life.

$$H_2O + SO_2 \longrightarrow H_2SO_4$$
$$H_2O + CO_2 \longrightarrow H_2CO_3$$
$$NO_2 + H_2O \longrightarrow HNO_2 + HNO_3$$

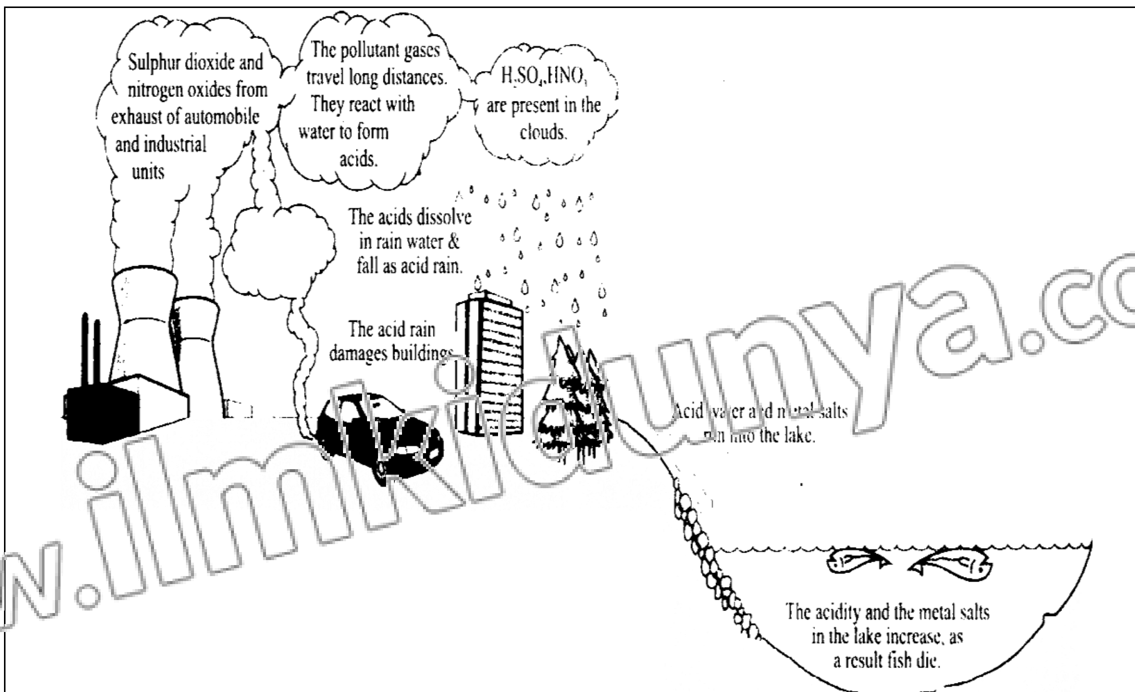


Figure: Acid Rain Formation And Its Effects

Effects of Acid Rain: **(SWL 2016 G-I, MTN 2016 G-II, DGK 2016 G-I)**

The effects of acid rain are as follows:

(i) Leaching of Soil:

Acid rain on soil and rocks leaches heavy metals (Al, Hg, Pb, Cr, etc) with it and discharges these metals into rivers and lakes.

Effect on Humans:

This water is used by human beings for drinking purpose. These metals accumulate in human body to toxic level.

Effect on Aquatic Life:

Aquatic life present in lakes also suffers because of high concentration of these metals. Especially high concentration of aluminum metal clogs the fish gills. It causes suffocation and ultimate death of fish.

(ii) Effect on Marble and Limestone of Buildings:

Acid rain attacks the calcium carbonate present in the marble and limestone of buildings and monuments. Thus, these buildings are getting dull and eroded day by day.

(iii) Increase in Acidity of Soil:

Acid rain increases the acidity of the soil. Many crops and plants cannot grow properly in such soil. It also increases the toxic metals in the soil that poison the vegetation. Even old trees are being affected due to acidity of soil. Their growth is retarded. They get dry and die.

(iv) Effect on Growth of Plants:

Acid rain directly damages the leaves of trees and plants, thus limiting their growth. Depending upon the severity of the damage, plants growth can be hampered. Plants ability to bear cold or diseases reduces and ultimately die.

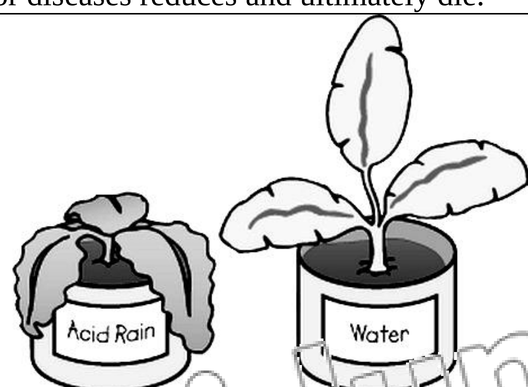


Figure: Effects of Acid Rain on Plants

14.4 ACID RAIN AND ITS EFFECTS

SHORT QUESTIONS

Q.1 What is meant by acid rain? ***(Knowledge Base)***

Ans: **ACID RAIN**

Definition:

"A rain having a pH lower than that of natural rain due to the presence of H_2SO_4 and HNO_3 is called acid rain".

Formation:

Burning of fossil fuels produces oxides of sulphur and nitrogen in air. Rain water converts SO_2 into H_2SO_4 and NO_x to HNO_2 and HNO_3.

Q.2 How does aluminium harm the fish? *(Knowledge Base)* (FWP 2017)

Ans: **HARM OF ALUMINIUM TO THE FISH**

High concentration of aluminium metal clogs fish gills. It causes suffocation and ultimately death of fish.

14.4 ACID RAIN AND ITS EFFECTS

MULTIPLE CHOICE QUESTIONS

1. Which one is heavy metal? *(K.B)*

(A) Na (B) Hg
(C) K (D) Both A and C

2. Buildings are being damaged by acid rain because it attacks: *(K.B)* (SWL 2017)

(A) $CaSO_4$ (B) $Ca(NO_3)_2$
(C) $CaCO_3$ (D) CaC_2O_4

3. pH of normal rain water is: *(K.B)*

(A) 5.6 to 6 (B) 6 to 7
(C) 8 (D) 9

4. pH of acid rain is: *(K.B)*

(A) 7 (B) 5
(C) 6 (D) 4

5. Acid rain attacks on: *(K.B)*

(A) $CaCO_3$ (B) K_2CO_3
(C) Na_2CO_3 (D) HNO_3

14.3 TEST YOURSELF

i. How acid rain is produced? *(Knowledge Base)* (GRW 2013, SWL 2016 G-I, 17, SGD 2017)

Ans: **PRODUCTION OF ACID RAIN**

Definition:

"*Acid rain means the presence of excessive acids in rain waters*".

Production:

This rain is produced when normal rain water dissolves oxides of sulphur and nitrogen in air. The rain water converts SO_2 into H_2SO_4, NOx into HNO_2 and HNO_3.

ii. Why acid rain damages buildings? *(Knowledge Base)* (GRW 2014, FSD 2016 G-II)

Ans: **ACID RAIN DAMAGES BUILDINGS**

Acid rain attacks the calcium carbonate present in the marble and limestone of buildings and monuments. Thus, these buildings are getting dull and eroded day by day.

iii. How aquatic life is affected by acid rain? *(Knowledge Base)*

Ans: **EFFECTS OF ACID RAIN**

Acid rain on soil and rocks dissolves heavy metals (Al, Hg, Pb, Cr, etc.) with it and discharges these metals into rivers and lakes. The high concentration of these metals, especially high concentration of aluminium metal clogs the fish gills. It causes suffocation and ultimately death of fish.

iv. Why plants are dying day by day? Comment. ***(Knowledge Base)***

OR

How acid rain affect the trees and plants? **(GRW 2017)**

Ans: **DYING OF PLANTS DAY BY DAY**

Acid rain directly damages the leaves of trees and plants, thus limiting their growth. Depending upon the severity of the damage plants growth can be hampered. Plants capability to bear cold or diseases reduces and ultimately die.

14.5 OZONE DEPLETION AND ITS EFFECTS

LONG QUESTION

Q.1 (a) What is ozone layer? Explain the functions of ozone layer in stratosphere.
(Knowledge Base+Understanding Base)

(b) How ozone layer is depleted and what are the effects of ozone depletion?
(GRW 2014)

Ans: (a) **OZONE LAYER**

Definition:

"The region of stratosphere (25-30 kilometers away from the earth surface) in which there is maximum concentration of ozone is called ozone layer."

Ozone:

"*An allotropic form of oxygen consisting of tri-atomic molecules is called ozone*".

Formation of Ozone in Atmosphere:

It is formed in atmosphere by the association of an oxygen atom with an oxygen molecule in the mid of stratosphere.

$$O_{2(g)} + O_{(g)} \longrightarrow O_{3(g)}$$

Maximum Concentration of Ozone (Ozone Layer): **(MTN 2017)**

Ozone is present throughout the atmosphere. But its maximum concentration called ozone layer lies in stratosphere region about 25 to 30 km away from the Earth's surface.

FUNCTIONS OF OZONE LAYER

Ozone layer surrounds the globe and protects Earth like a shield from harmful ultraviolet radiations of sunlight. Otherwise, ultraviolet radiations would cause skin cancer. Thus ozone layer in stratosphere is beneficial for life on the Earth.

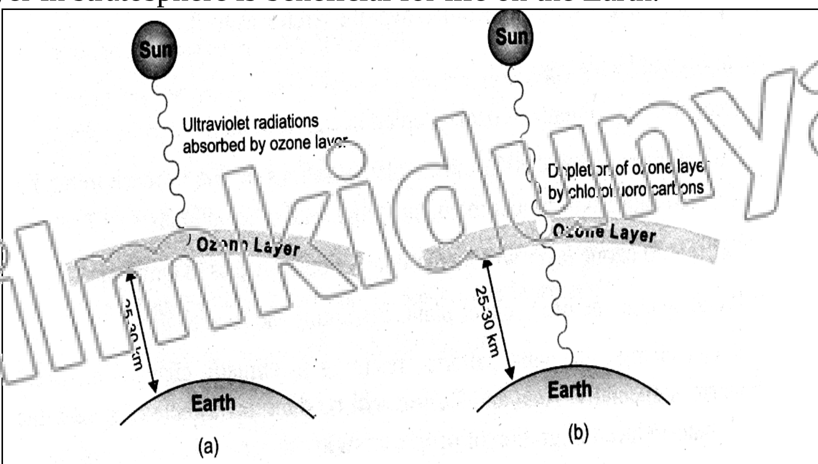


Figure: (a) Ozone Layer (b) Depletion of Ozone Layer

Maintenance of Balance of Ozone Concentration:

Under normal conditions ozone concentration in stratosphere remains nearly constant through a series of complex atmospheric reactions. Two reactions that maintain a balance in ozone concentrations are as follows:

$$O_{2(g)} + O_{(g)} \longrightarrow O_{3(g)} \quad \text{(formation)}$$

$$O_{3(g)} \longrightarrow O_{2(g)} + O_{(g)} \quad \text{(decomposition)}$$

(b) DEPLETION OF OZONE LAYER

Following are ways in which ozone is being depleted:

(i) Solar Radiations:

The ozone molecule absorbs solar radiations and dissociates readily, i.e., self dissociation of ozone takes place.

(ii) Chlorofluorocarbons:

Chlorofluorocarbons (CFCs) (used as refrigerants in air conditioners and refrigerators) are major cause of depletion of ozone layer. These compounds leak in one way or other escape and diffuse to stratosphere. These ultraviolet radiations break the **C-Cl bond in CFCs** and generate chlorine free radicals as:

$$CFCl_3 \xrightarrow{UV} CFCl_2 + \dot{Cl}$$

These free radicals are very reactive. They react with ozone to form oxygen.

$$O_{3(g)} + \dot{Cl} \longrightarrow O_{2(g)} + O\dot{Cl}$$

$$O\dot{Cl} \longrightarrow \dot{O} + \dot{Cl}$$

$$\dot{O} + \dot{O} \longrightarrow O_{2(g)}$$

A single chlorine free radical released by the decomposition of CFCs is capable of destroying upto many lacs of ozone molecules.

Ozone Hole:

"The region in which ozone layer depletes is called ozone hole".

Signs of Ozone Depletion:

Signs of ozone depletion were first noticed over Antarctica in 1980s. Since1990s ozone depletion have also been recorded over the Arctic.

EFFECTS OF OZONE DEPLETION

(GRW 2016, DGK 2016, MTN 2016 G-II)

Even minor problems of ozone depletion can have major effects. The major effects of ozone depletion are as follows:

(i) Skin Cancer:

Depletion of ozone enables ultraviolet radiations of Sun to reach to the Earth that can cause skin cancer to human beings and other animals.

(ii) Infectious Diseases:

Decreased ozone layer will increase infectious diseases like malaria.

(iii) Disruption of Food Chain:

It can change the life cycle of plants disrupting the food chain.

(iv) Climatic Change:

It can change the wind patterns, resulting in climatic changes all over the world. Especially, Asia and Pacific will be the most affected regions, facing climate-induced migration of people crisis.

Q.2 What is incineration? Describe its advantages and disadvantages. *(Application Base)*

(Science, Technology and Society Pg. #131)

Ans: **INCINERATION**

Definition:

*"Incineration is a waste treatment process that involves the **burning of solid waste** at high temperatures between **650^oC to 1100^oC** in incinerators".*

ADVANTAGES

Incinerators reduce the solid mass of the original waste by **80-85%** and convert the waste materials into ash, flue gas and heat.

DISADVANTAGES

Although, the volume of solid waste is reduced effectively by incineration, it produces highly poisonous gases and toxic ash. The flue gas includes, dioxins, furans, sulphur dioxide, carbon dioxide, carbon monoxide, hydrochloric acid and a large amount of particulate matter.

14.5 OZONE DEPLETION AND ITS EFFECTS

SHORT QUESTIONS

Q.1 What is incineration? *(Application Base)* **(Science, Technology and Society Book Pg. #131) (SWL 2016 G-I)**

Ans: *Answer given above*

Q.2 What are disadvantages of incineration? *(Knowledge Base)*

(Science, Technology and Society Book Pg. # 131)(GRW 2014)

Ans: *Answer given above*

Q.3 Write composition of flue gas produced during incineration of waste material. *(Knowledge Base)* **(Science, Technology and Society Book Pg. # 131)**

Ans: **COMPOSITION OF FLUE GAS**

The flue gas includes:

- Dioxins
- Furans
- Sulphur dioxide
- Carbon dioxide
- Carbon monoxide
- Hydrochloric acid
- Large amount of particulate matter

Q.4 Define ozone and ozone layer. *(Knowledge Base)* **(MTN 2016 G-II)**

Ans: *Answer given on Page# 275*

MULTIPLE CHOICE QUESTIONS

1. Ozone is beneficial for us as it absorbs: *(K.B)*
(A) Infra radiations (B) Ultra violet radiations
(C) Chlorofluorocarbons (D) Air pollutants

2. Decreased ozone layer will increase infectious disease like: *(K.B)*
(A) Fever (B) Cholera
(C) Malaria (D) Headache

3. Ozone is an allotropic form of: *(K.B)*
(A) Carbon (B) Oxygen
(C) Sulphur (D) Chlorine

4. The region in which ozone layer depletes is called: *(K.B)*
(A) Ozone wall (B) Ozone hole
(C) Ozone deficiency (D) Ozone downfall

5. It destroys ozone molecules: *(K.B)*
(A) Chlorocarbons (B) Trichlorocarbons
(C) CFCs (D) PAN

6. A strange bitter smell noticed near photocopier machine is of: *(K.B)* (DGK 2016 G-II)
(A) H_2S (B) SO_2
(C) O_3 (D) O_2

14.4 TEST YOURSELF

i. Justify, ozone is beneficial for human kinds. *(Understanding Base)*(GRW 2015, FSD 2017)

Ans: **BENEFITS OF OZONE**

It protects from harmful ultraviolet radiations of sun. It protect us from skin cancer.

ii. Why ozone is depleting in atmosphere? *(Knowledge Base)*

Ans: **OZONE DEPLETION**

Following are ways in which ozone is being depleted:

(i) Solar Radiations: The ozone molecule absorbs solar radiations and dissociate readily, i.e., self dissociation of ozone takes place.

(ii) Chlorofluorocarbons: Chlorofluorocarbons (CFCs) (used as refrigerants in air conditioners and refrigerators) are major cause of depletion of ozone layer. These compounds leak in one way or other escape and diffuse to stratosphere. These ultraviolet radiations break the C-Cl bond in CFCs and generate chlorine free radicals as:

$$CFCl_3 \xrightarrow{UV} CFCl_2 + \dot{Cl}$$

These free radicals are very reactive. They react with ozone to form oxygen.

$$O_{3(g)} + \dot{Cl} \longrightarrow O_{2(g)} + O\dot{Cl}$$

$$O\dot{Cl} \longrightarrow \dot{O} + \dot{Cl}$$

$$\dot{O} + \dot{O} \longrightarrow O_{2(g)}$$

A single chlorine free radical released by the decomposition of CFCs is capable of destroying upto many lacs of ozone molecules.

iii. What do you mean by ozone hole? Where was it noticed first? *(Knowledge Base)*

(GRW 2017, FSD 2016 G-II, 17)

Ans: **OZONE HOLE**

"*The region in which ozone layer is depleted is called ozone hole"*

Signs of Ozone Depletion:

Signs of ozone depletion were first noticed over Antarctica in 1980s. Since, 1990s depletion have also been recorded over the Arctic, as well.

iv. Where the ozone layer is found? *(Knowledge Base)*

(FSD 2016 G-I, SGD 2016 G-II, SWL 2016 G-II, MTN 2017)

Ans: **OCCURRENCE OF OZONE LAYER**

Ozone layer lies in stratosphere region from 25–30 km from earth's surface.

Skills

Q.1 What is meant by filtration? Describe process for filtration of suspended impurities.

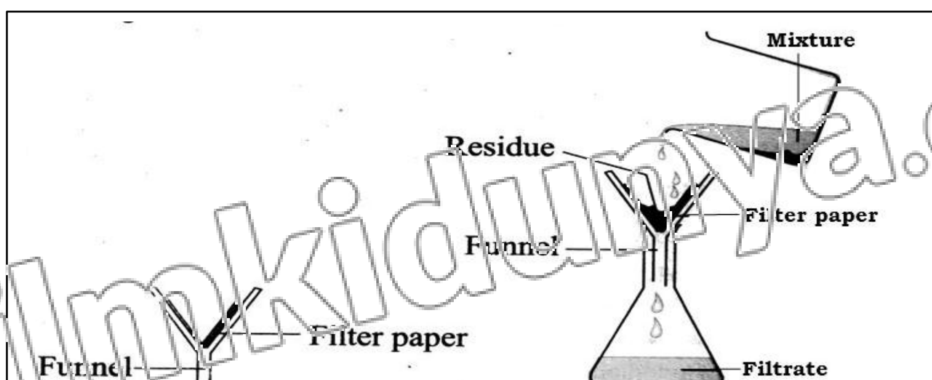
Ans: **FILTRATION**

"Filtration is separation of insoluble solid particles (sand, clay, dust or precipitates) from a liquid."

It is carried out by filtering a mixture.

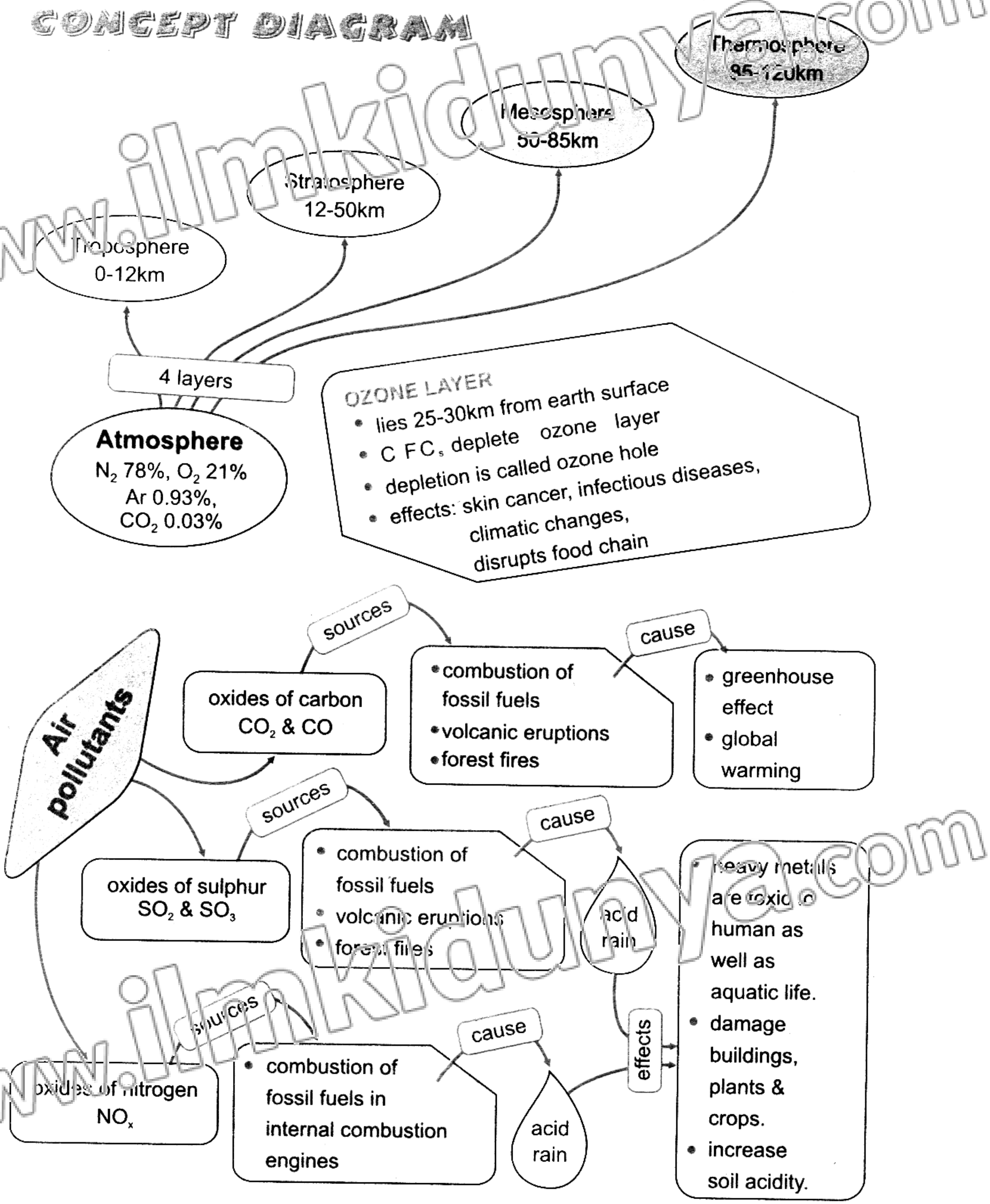
FILTRATION OF SUSPENDED IMPURITIES

Filtration is separation of insoluble solid particles (sand, clay, dust or precipitates from a liquid. It is carried out by filtering a mixture. A filter paper is first folded half way, then another fold is made, so that a filter paper gets four folds. This folded filter paper is placed in a filter funnel in such a way that on one side are three layers and on the other side is one layer as shown in figure. The mixture (sand in water or chalk in water) is poured into the filter paper as shown in figure.



Filtrate passes through the filter paper and is collected in a conical flask. The solid particles (residue) deposit on the filter paper. It is then dried.

Concept Diagram



ANSWER KEY

MULTIPLE CHOICE QUESTIONS

INTRODUCTION

1	A
2	C
3	B

14.1 COMPOSITION OF ATMOSPHERE
14.2 LAYERS OF ATMOSPHERE

1	B	6	D	11	A	16	B
2	A	7	A	12	D	17	B
3	C	8	B	13	D	18	A
4	A	9	A	14	A	19	A
5	C	10	B	15	B	20	A

14.3 POLLUTANTS

1	A	6	A	11	A
2	B	7	A	12	B
3	B	8	D	13	C
4	B	9	D	14	D
5	A	10	B	15	C

ROLE OF GOVERNMENT TO CONTROL POLLUTION

1	A
2	A
3	D
4	D

14.4 ACID RAIN AND ITS EFFECTS

1	B
2	C
3	A
4	D
5	A

14.5 OZONE DEPLETION AND ITS EFFECTS

1	B	6	C
2	C		
3	B		
4	B		
5	C		

EXERCISE SOLUTION

MULTIPLE CHOICE QUESTIONS

1. About 99% atmosphere's mass lies within: *(K.B)*

(LHR 2013, FSD 2016 G-I&II, 2017 G-II, DGK 2017, SWL 2017)

(a) 30 kilometres (b) 35 kilometres
(c) 15 kilometres (d) 11 kilometres

2. Depending upon temperature variation, atmosphere is divided into how many regions? *(K.B)*

(GRW 2013, BWP 2016 G-II, MTN 2016 G-II, SGD 2017, FSD 2017 G-I)

(a)One (b) Two
(c) Four (d) Three

3. **Just above the Earth's surface is: *(K.B)*** **(LHR 2014, SWL 2016 G-II, MTN 2017, RWP 2017)**
(a) Mesosphere (b) Stratosphere
(c) Thermosphere (d) Troposphere

4. **A group of gases that maintains temperature of atmosphere is: *(K.B)***
(a) Carbon dioxide and water vapours (b) Nitrogen and carbon dioxide
(c) Oxygen and water vapours (d) Nitrogen and oxygen

5. **The Earth's atmosphere is getting hotter because of: *(K.B)***
(a) Increasing concentration of CO (b) Increasing concentration of CO_2
(c) Increasing concentration of O_3 (d) Increasing concentration of SO_2

6. **Which one of the following is not a Greenhouse Effect? *(K.B)***
(a) Increasing atmospheric temperature (b) Increasing food chains
(c) Increasing flood risks (d) Increasing sea-level

7. **Normally rain water is weakly acidic because of: *(K.B)***
(LHR 2015, SGD 2016 G-II, MTN 2016 G-I, GRW 2017)
(a) SO gas (b) CO_2 gas
(c) SO_2 gas (d) NO_2 gas

8. **Buildings are being damaged by acid rain because it attacks: *(K.B)*** **(SWL 2017)**
(a) Calcium sulphate (b) Calcium nitrate
(c) Calcium carbonate (d) Calcium oxalate

9. **Acid rain affects the aquatic life by cloging fish gills because of: *(K.B)***
(SGD 2016 G-II, RWP 2016 G-I)
(a) Lead metal (b) Chromium metal
(c) Mercury metal (d) Aluminium metal

10. **Ozone is beneficial for us as it: *(K.B)***
(a) Absorbs infrared radiations (b) Absorbs ultraviolet radiations
(c) Absorbs chloroflourocarbons (d) Absorbs air pullutants

11. **Which one of the following is not an air pollutant? *(K.B)***
(a) Nitrogen (b) Carbon monoxide
(c) Nitrogen dioxide (d) Ozone

12. **Iron and steel structures are damaged by: *(K.B)*** **(GRW 2014, LHR 2014)**
(a) Carbon monoxide (b) Sulphur dioxide
(c) Methane (d) Carbon dioxide

13. **Infrared radiations emitted by the Earth are absorbed by: *(K.B)***
(a) CO_2 and H_2O (b) $N_2$and O_2
(c) CO_2 and N_2 (d) O_2 and CO_2

14. **Global warming causes rising of the sea level. The cause of global warming is: *(K.B)***
(a) CO_2 gas (b) SO_2 gas
(c) NO_x gases (d) O_3 gas

15. Which gas protects the Earth's surface from ultraviolet radiations? ***(K.B)***

(LHR 2014, BWP 2017. RWP 2017, SGD 2017)

(a) CO_2 (b) CO
(c) N_2 (d) O_3

16. Effects of ozone depletion are following except the one: ***(K.B)*** **(GRW 2014)**

(a) Increases infectious diseases (b) Increases crops production
(c) Can cause skin cancer (d) Can cause climatic changes

17. Which one of these pollutants are not found in car exhaust fumes? ***(K.B)***

(a) CO (b) O_3
(c) NO_2 (d) SO_2

18. The process by which atmospheric nitrogen is turned into nitrates in the soil is called: ***(K.B)***

(a) Nitration (b) Oxidation
(c) Fixing (d) Reduction

19. Global warming is because of: ***(K.B)***

(a) Absorption of infrared radiations emitted by the Earth's surface
(b) Absorption of infrared radiations coming from the Sun
(c) Absorption of ultraviolet radiation coming from the Sun
(d) Emission of ultraviolet radiation from the Earth's surface

20. Carbonmonoxide is harmful to us because: ***(K.B)***

(a) It paralyses
(b) It damages lung tissues
(c) It reduces oxygen carrying ability of haemoglobin
(d) It makes the blood coagulate

ANSWER KEY

1	a	**6**	b	**11**	a	**16**	b
2	d	**7**	b	**12**	b	**17**	b
3	d	**8**	c	**13**	a	**18**	b
4	a	**9**	d	**14**	a	**19**	a
5	b	**10**	b	**15**	d	**20**	c

EXERCISE SHORT QUESTIONS

1. Explain the phenomenon of decreasing temperature in troposphere.
(Knowledge Base) **(LHR 2013)**

Ans: **DECREASING OF TEMPERATURE**

In troposphere the concentration of gases (CO_2 and water vapours) decreases gradually with the increase of altitude, correspondingly temperature also decreases at a rate 6k per kilometer. This is the region where all weather occurs and air crafts fly in this region.

2. Differentiate between primary and secondary air pollutants. ***(Understanding Base)***
(LHR 2013, RWP 2016 G-I, MTN 2016 G-II, SWL 2017)

Ans: **DIFFERENTIATION**

The differences between primary pollutants and secondary pollutants are as follows:

Primary Pollutants	Secondary Pollutants
Definition	
• Primary pollutants are those wastes and exhaust products driven out because of combustion of fossil fuels and organic matter.	• Secondary pollutants are produced by various reactions of primary pollutants.
Examples	
• Oxides of sulphur (SO_2 & SO_3) • Oxides of carbon (CO, CO_2) • Oxides of nitrogen (NO_x)	• Sulphuric acid • Carbonic acid • Nitric acid • Ozone, Peroxy acetyl nitrate etc.

3. State the major sources of CO and CO_2 emission. ***(Knowledge Base)*** **(Ex-SQ. 3)**
(GRW 2015, 16, MTN 2017, FSD 2016 G-I, DGK 2016 G-II)

Ans: **SOURCES OF OXIDES OF CARBON (CO_2 AND CO)**

Sources of oxides of carbon (CO and CO_2) are as follows:

(i) Volcanic Eruption:
These gases are emitted due to volcanic eruption.

(ii) Decomposition of Organic Matter:
These gases are also emitted due to decomposition of organic matter.

(iii) Combustion of Fossil Fuels:
The major source for the emission of these gases is combustion of fossil fuels (coal, petroleum and natural gas). Fossil fuels burnt in combustion engine of any type of automobile, kiln of any industry, or open air fires emit CO_2 and CO.

(iv) Forest Fires and Burning of Wood:
Forest fires and burning of wood also emit CO_2 and CO. Especially, when supply of oxygen is limited, emission of CO dominates.

4. CO_2 is responsible for heating up atmosphere, how? ***(Knowledge+Understanding Base)***
(LHR 2013, GRW 2013, 14, DGK 2016 G-II)

Ans: **HEATING UP OF ATMOSPHERE**

Carbon dioxide is called as a greenhouse gas because it acts like a glass wall of green house.

Mechanism:
It allows UV radiations to pass through it but does not allow the IR radiations to pass through it. As concentration of CO_2 increases, less heat is lost from the surface. So, average temperature of Earth's surface gradually increases. This is called green house effect.

5. CO is a hidden enemy, explain its action. ***(Understanding Base)***

(LHR 2013, GRW 2013, 14, BWP 2017, FSD 2017, MTN 2017)

Ans: **CO AS A HIDDEN ENEMY AND ITS ACTION**

Hidden Enemy:

CO is an air pollutant. It is a health hazard being a highly poisonous gas. Being a colourless and odourless. Its presence cannot be noticed easily and readily.

Action and Effects of CO:

- When inhaled it binds with hemoglobin most strongly than oxygen thus hindering the supply of oxygen in body.
- Exposure to the higher concentration of CO causes headache and fatigue.
- If inhaled for the longer time it results in breathing difficulties and ultimately death.

6. What threats are to human health due to SO_2 gas as air pollutant?

(Knowledge Base) **(GRW 2014)**

Ans: **THREATS DUE TO SO_2**

SO_2 is a colorless gas having irritating smell. It has following threats to human health:

- Irritation
- Suffocation
- Severe respiratory problems to asthmatic patients

7. Which air pollutant is produced on anaerobic decomposition of organic matter?

(Knowledge Base) **(LHR 2015)**

Ans: **AIR POLLUTANT FROM ANAEROBIC DECOMPOSITION**

CH_4 is an air pollutant produced on anaerobic decomposition of organic matter.

8. How acid rain increases the acidity of soil? ***(Knowledge Base)***

(BWP 2016 G-I, 17, SGD 2016 G-II, RWP 2016 G-I, MTN 2016 G-II)

Ans: **INCREASE IN ACIDITY OF SOIL**

Acid rain increases the acidity of the soil due to the presence of a number of acids like H_2SO_4, HNO_3 and H_2SO_3 present in it. These acids decrease the pH and increase the acidity of soil.

9. Point out two serious effects of ozone depletion. ***(Knowledge Base)***

(GRW 2014, LHR 2015, SWL 2016 G-II, MTN 2016 G-I, BWP 2016 G-I)

Ans: **TWO SERIOUS EFFECTS OF OZONE DEPLETION**

Two serious effects of ozone depletion are as follows:

(i) Decreased ozone layer will increase infectious diseases like malaria.

(ii) It can change the life cycle of plants disrupting the food chain.

10. How ozone layer forms in stratosphere? ***(Knowledge Base)***

(GRW 2014, LHR 2015, RWP 2016 G-I & II, SWL 2016 G-I)

Ans: **FORMATION OF OZONE LAYER**

Ozone layer forms in atmosphere by the association of an oxygen atom with an oxygen molecule in the mid of stratosphere.

$$O_{(g)} + O_{2(g)} \longrightarrow O_{3(g)} \quad \text{(exothermic reaction)}$$

11. Why the 75% of the atmospheric mass lies within the troposphere?

(Understanding Base) **(LHR 2013, 15, GRW 2014)**

Ans: **ATMOSPHERIC MASS IN TROPOSPHERE**

About 75% of the atmospheric mass lies within the troposphere which extends 11 kilometers from earth surface and this is due to gravitational force of attraction of Earth.

12. How ozone layer is being depleted by chloroflourocarbon? *(Knowledge Base)*

(LHR 2013, SGD 2016 G-II, BWP 2016 G-II, FSD 2017)

Ans: **DEPLETION OF OZONE LAYER BY CFCs**

Chlorofluorocarbons (CFCs) (used as refrigerants in air conditioners and refrigerators) are major cause of depletion of ozone layer. These compounds leak in one way or other escape and diffuse to stratosphere. These ultraviolet radiations break the C–Cl bond in $CFCl_3$ and generate chlorine free radicals as.

$$CFCl_3 \xrightarrow{uv} CFCl_2 + \dot{Cl}$$

$$O_{3(g)} + \dot{Cl} \longrightarrow O_{2(g)} + O\dot{Cl}$$

$$O\dot{Cl} \longrightarrow \dot{O} + \dot{Cl}$$

$$\dot{O} + \dot{O} \longrightarrow O_{2(g)}$$

A single chlorine free radical released by the decomposition of CFCs is capable of destroying upto many lacs of ozone molecules.

Ozone Hole:

"The region in which ozone layer depletes is called ozone hole".

EXERCISE LONG QUESTIONS

Q.1 Write down the significance of atmospheric gases. *(Knowledge Base)* **(SGD 2014)**

Ans: **SIGNIFICANCE OF ATOMOSPHEREIC GASES**

Atmosphere:

"Atmosphere is the envelope of different gases around the Earth. It extends continuously from the earth's surface outwards without any boundary."

Atmosphere Gases:

The percentage composition of atmosphere by volume is as follows:

Gas	%by Volume
Nitrogen	78.09
Oxygen	20.94
Argon	0.93
Carbon dioxide	0.03

Significance of Atmospheric Gases:

(i) Nitrogen:

78% of atmosphere is nitrogen. It is necessary for the safety of life on earth. It controls the fire and combustion processes, otherwise all the things around us could burn with a single flame.

(ii) Oxygen:

Oxygen is a life gas for animals. Animals take in oxygen during respiration. It is necessary for burning process.

(iii) CO_2:

The CO_2 forms a layer around the Earth like an envelope. It allows the heat rays of the Sun to pass through it and reaches upto the earth. These rays are reflected from the Earth surface and go back to upper atmosphere.

Normal concentration of CO_2 layer retains enough heat to keep the atmosphere warm. So, normal concentration of CO_2 is necessary and beneficial for keeping the temperature warm. Otherwise, the Earth would have been uninhabitable. The Earth's average temperature would be about –20°C, rather than presently average temperature 15°C.

It is a life gas for plants because they synthesize their food by using CO_2

(iv) Ozone:

Ozone layer surrounds the globe and protects Earth like a shield from harmful ultraviolet radiations of sunlight which can cause skin cancer.

Q.2 Give the characteristics of troposphere. Why temperature increases upwards in this sphere?

Ans: See LQ.3 (Topic 14.2)

Q.3 What are the characteristics of stratosphere? Why temperature increases upwards in this sphere?

Ans: See LQ.4 (Topic 14.2)

Q.4 CO_2 is necessary for plants but why its increasing concentration is alarming for us?

Ans: See LQ.5 (Topic 14.3)

Q.5 Why CO is considered a health hazard?

Ans: See SQ.12 (Topic 14.3)

Q.6 Define acid rain. How it forms and what are its effects?

Ans: See LQ. 1 (Topic 14.4)

Q.7 Compounds of sulphur are air pollutants. Describe the sources of these compounds along with their effects.

Ans: See LQ. 3 (Topic 14.3)

Q.8 Where does ozone layer lie in atmosphere? How it is depleting and how we can prevent its depletion?

Ans: See LQ.1 (Topic 14.5)

Q.9 Oxides of nitrogen cause air pollution. Describe the sources of these compounds.

Ans: See LQ.4 (Topic 14.3)

ADDITIONAL CONCEPTUAL QUESTIONS

Q.1 What is a relationship between green house effect and carbondioxide?

Ans: Green house effect and carbondioxide are directly proportional to each other, Greater the carbondioxide, more the green house effect. If the concentration of CO_2 in air increase, less heat energy is lost from the surface of the Earth. Therefore, the average temperature of the surface gradually increases.

Green house effect $\propto$ Amount of CO_2 in air.

Q.2 How can we determine the severity of a pollutant?

Ans: Three factors determine the severity of a pollutant.

- Chemical nature of pollutant
- Concentration of pollutant.
- Persistence of pollutant.

Q.3 Why normal rain water pH is 5.6-6?

Ans:

NORMAL RAIN WATER

Normal rain water is weakly acidic because it consists of dissolved CO_2 of the air. Its pH is about 5.6 to 6. When CO_2 dissolve with water it produces carbonic acid (H_2CO_3) which itself is a weak acid therefore it reduces the pH of water from 7 to 5.6-6.

Q.4 Why is the pH of acid rain is reduced to 4?

Ans:

ACID RAIN WATER

Rain water on dissolving air pollutants (acids) becomes more acidic and its pH reduces to 4. Thus, acid rain is formed on dissolving acidic air pollutants such as sulphur dioxide and nitrogen dioxide by rain water. These oxides dissovlve in rain water and reduces its pH to 4.

Q.5 What do you know about leaching of soil?

Ans: Acid rain on soil and rocks leaches heavy metals (Al, Hg, Pb, Cr, etc) with it and discharges these metals into rivers and lakes. This water is used by human beings for drinking purpose which causes diseases.

TERMS TO KNOW

Terms	Definitions
Environmental Chemistry	Branch of chemistry which deals with the chemicals and other pollutants in the environment is called environmental chemistry.
Atmosphere	Atmosphere is the envelope of different gases around the Earth.
Troposphere	The region of the atmosphere from Earth's surface upto 12 km above is called troposphere.
Stratosphere	The region of the atmosphere which is up to 50 km is called stratosphere.
Mesosphere	The region of the atmosphere between 50–85 kilometers is called mesosphere.
Thermosphere	The region of the atmosphere between 85–120 kilometers is called thermosphere.
Pollution	A pollutant is a waste material that pollutes air, water or soil and this phenomenon is called pollution.
Pollutant	The harmful substances present in environment (air) are called air pollutants.
Primary Pollutants	Primary pollutants are the waste or exhaust products driven out because of combustion of fossil fuels and organic matter.
Secondary Pollutants	Secondary pollutants are produced by various reactions of primary pollutants.
Green House Effect	The concentration of CO_2 in air increases, less heat energy is lost from the surface of the Earth. Therefore, the average temperature of the surface gradually increases. This is called greenhouse effect.
Global Warming	The increase in average temperature of Earth's atmosphere and oceanic temperature due to green house effect (resulting especially due to pollution) is called global warming.
Catalytic Converter	An instrument which is used to convert harmful gases (CO, NO_x hydrocarbons etc) present in automobile exhaust into harmless substances (CO_2, N_2 and H_2O), in the presence of some catalyst like Pd, Cd etc is called catalytic converter.
Acid Rain	A rain having a pH lower than that of natural rain due to the presence of H_2SO_4 and HNO_3 is called acid rain.
Ozone Layer	The region of stratosphere (25-30 kilometers away from the earth surface) in which there is maximum concentration of ozone (10ppm) is called ozone layer.
Ozone	An allotropic form of oxygen consisting of tri-atomic molecules is called ozone.
Incineration	Incineration is a waste treatment process that involves the burning of solid waste at high temperatures between 650°C to 1100°C in incinerators.
Ozone Hole	The region in which ozone layer is depleted is called ozone hole.

SELF TEST

Time: 35 Minutes **Marks: 25**

Q.1 Four possible answers (A), (B), (C) and (D) to each question are given, mark the correct answer. **(6×1=6)**

1. Normally rain water is weakly acidic because of:

(A) SO_3 gas (B) CO_2 gas
(C) SO_2 gas (D) NO_2 gas

2. Infrared radiations emitted by the Earth are absorbed by:

(A) CO_2 and H_2O (B) N_2 and O_2
(C) CO_2 and N_2 (D) O_2 and CO_2

3. The percentage of sunlight absorbed by atmospheric gases is:

(A) 2% (B) 10%
(C) 18% (D) 25%

4. Which gas is also known as life gas for plants?

(A) CO (B) O_2
(C) CO_2 (D) NO_2

5. The range of temperature in burning solid waste in incinerators is:

(A) 650°C to 1000°C (B) 650°C to 1100°C
(C) 1000°C to 2000°C (D) 500°C to 1000°C

6. The stratosphere layer above the Earth's surface is at the height of:

(A) 85 – 120 km (B) 50 – 85 km
(C) 12 – 50 km (D) 0 – 12 km

Q.2 Give short answers to the following questions. **(5×2=10)**

(i) Write the composition of air?
(ii) Why CO_2 is called a green house gas?
(iii) CO is an hidden enemy, explain its action.
(iv) What are the effects of SO_2?
(v) Differentiate between primary and secondary air pollutants.

Q.3 Answer the following questions in detail. **(5+4=9)**

(i) Define Acid Rain how it forms and what are its effects? **(5)**
(ii) What are the effects of global warming? **(4)**

NOTE: Parents or guardians can conduct this test in their supervision in order to check the skill of students.

CHAPTER 15
ENVIRONMENTAL CHEMISTRY - II WATER

INTRODUCTION

SHORT QUESTIONS

Q.1 What is importance of water? ***(Knowledge Base)***

Ans: **REASONS FOR IMPORTANCE OF WATER**

Throughout history, importance and significance of water has been recognized by mankind. Its importance is because of following reasons.

- It is an essential and major component of each and every living cell. For example, human body consists of about **70% water.**
- It provides an environment for animals and plants that live in water. So, all living organisms owe their life because of water.
- We use water in daily life for drinking, cooking and washing purposes. →

Q.2 How does ground water pollution occur? ***(Knowledge Base)***

Ans: **GROUND WATER POLLUTION**

Quality of drinking water has remained a major factor in determining human health and welfare since ages.

- Since World War II, there has been a rapid production and use of synthetic chemicals.
- Many of these chemicals (fertilizers and pesticides run off from agriculture lands and industrial discharge from industrial units) have polluted water supplies.
- Besides this, there is also a threat to ground water from waste chemical dumps and landfills. Currently, waterborne toxic chemicals pose the greatest threat to the supplies of water especially in urban areas.

Q.3 Why it is necessary to understand the sources and effects of water pollution? ***(Knowledge Base)***

Ans: **SOURCES AND EFFECTS OF WATER POLLUTION**

Use of polluted water is causing water borne diseases. So, use of polluted water is a concern of every citizen. Therefore, understanding the sources and effects of water pollution is essential for controlling this alarming threat.

Q.4 What do you mean by ground water pollution? ***(Knowledge Base)***

Ans: **GROUND WATER POLLUTION**

"The contamination of ground water due to undesirable and harmful substances is called ground water pollution."

Disadvantage:

Use of this polluted water is causing water borne diseases.

Q.5 Write a note on occurrence of water. ***(Knowledge Base)*** **(SWL 2016 G-I)**

Ans: **OCCURRENCE OF WATER**

The occurrence of water is as follows:

(i) The oceans contain about **97%** of world water.

(ii) The rest **3%** of water is in the form of:

- Glaciers and ice caps **(2.1 %)**
- Ground water **(0.6%)**
- Inland water (river, lakes, and streams) about **0.2%**
- Atmospheric water (water vapours) about **0.001%**

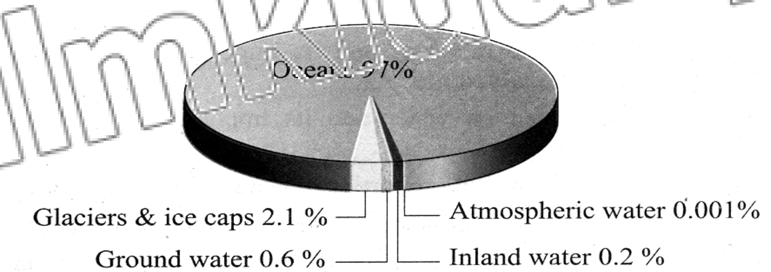


Figure: Distribution of Water

INTRODUCTION
MULTIPLE CHOICE QUESTIONS

1. **Human body consists of ________ __ % water *(K.B)***
   (A) 70 (B) 60
   (C) 40 (D) 30
2. **The ocean contains about ________% of world water: *(K.B)*** **(BWP 2017)**
   (A) 97 (B) 98
   (C) 90 (D) 97.1
3. **Water is also present in the atmosphere in form of: *(K.B)***
   (A) Rain drops (B) Dew
   (C) Water vapors (D) Rivers
4. **Only _________ % of the total water on the earth is potable: *(K.B)*** **(LHR 2013)**
   (A) 0.6 (B) 0.9
   (C) 0.2 (D) 2
5. **The amount of ground water is: *(K.B)***
   (A) 0.6 % (B) 0.9 %
   (C) 0.2 % (D) 2 %

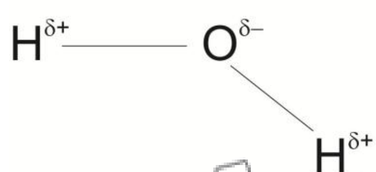
15.1 PROPERTIES OF WATER
15.2 WATER AS A SOLVENT
LONG QUESTIONS

Q.1 Write a detailed note on properties of water: *(Knowledge+Understanding Base)*
(LHR 2015, GRW 2016, SWL 2017, FSD 2016 G-I&II, MTN 2016 G-I & II)

Ans: **<u>PROPERTIES OF WATER</u>**

<u>Structure of Water Molecules:</u>

Water is composed of two elements: oxygen and hydrogen. One atom of oxygen combines with two atoms of hydrogen to form one molecule of water.



<u>Properties:</u>

The properties of water are as follows.

- Pure water is a **clear, colourless, odourless and tasteless liquid**.
- It is **neutral** to litmus.(i.e pH = 7)
- Its **freezing point is 0°C** and **boiling point is 100°C** at sea level.
- Its maximum density is **1 gcm^{-3} at 4°C.**
- It is an **excellent solvent** for ionic as well as molecular compounds i.e polar compounds.
- It has usually high that of **heat capacity about 4.2 Jg^{-1}K^{-1}**, which is about **six times greater than that of rocks**. This specific property of water is responsible for keeping the Earth's temperature within limits. Otherwise, day time

temperature would have been too high to bear and night time temperature would have been too low to freeze everything.

- It has **high surface tension**. This unique property of water is responsible for its high capillary action.

Capillary Action:

"Capillary action is the process by which water rises up from the roots of plants to leaves".

Significance:

This process is vital for the survival of the land plants.

Q.2 Why water is called universal solvent? (*Knowledge+Understanding Base)*

(GRW 2014, SGD 2016 G-II)

OR

How polarityof water molecule plays its role to dissolve the substances?

OR

Explain the reasons, water is considered a universal solvent.

Ans: **WATER AS A UNIVERSAL SOLVENT**

Water is the universal solvent because it can dissolve almost all the minerals. Its ability to dissolve substances is because of two unique properties of water:

(i) Polarity of water molecule.

(ii) Exceptional hydrogen bonding ability.

(i) Polar Nature of Water (Dissolution by Hydration): **(GRW 2014)**

Water molecule has a polar structure, i.e. **one end of the molecule is partially positive while the other end is partially negative because of electronegativity difference between oxygen and hydrogen atoms.**

Solubility of Polar Substances in Water: **(DGK 2017)**

All other polar substances are soluble in water, because the **positive end** of the **substance** is attracted by the **negative end ($O^{\delta-}$)** of the water and **negative end** of the **substance** is attracted by the **positive end ($H^{\delta+}$)** of the water. The **electrostatic attraction among the ions** is overcomed by the **ion-dipole** forces of attraction between ion and water molecules. In this way, positive and negative ions of the compounds are pulled apart. Ultimately, these oppositely charged ions are surrounded by water molecules, thus separated and kept in solution.

Examples:

Most of the salts are soluble in water like:

- NaCl
- KCl
- Na_2SO_4, etc.

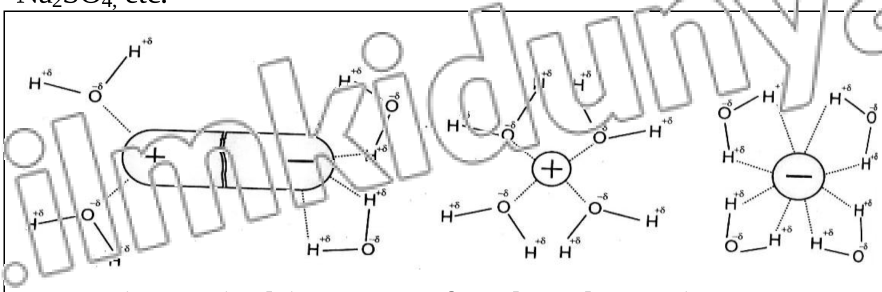


Figure: Dissolving Process of a Polar Substance in Water

Insolubility of Non Polar Substances in Water: **(FSD 2017)**

Many covalent substances which **do not have polar ends** or bonds are not attracted by water molecule. Therefore, non-polar compounds do not dissolve in water.

Exmaples:

- Benzene
- Ether
- Octane etc.

(ii) Extensive Hydrogen Bonding Ability:

"The attractive force present between partial positive hydrogen end of one molecule and partial negative end of more electronegative atom of other molecule is called Hydrogen bonding".

Mechanism of Dissolution:

Water molecule is composed of oxygen and hydrogen atoms. Because of **two O-H bonds and two lone pairs**, one H_2O molecule can develop hydrogen bonding with four other H_2O molecules, which are arranged like tetrahedral around the water (H_2O) molecule.

This unique behavior of water enables it to dissolve many polar non-ionic compounds having hydroxyl group (-OH).

Examples:

- Alcohols
- Organic acids
- Glucose
- Sugar etc.

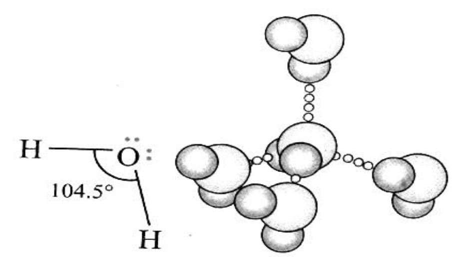


Figure: Hydrogen Bonding of Water Molecule

15.1 PROPERTIES OF WATER

15.2 WATER AS A SOLVENT

SHORT QUESTIONS

Q.1 What is the significance of heat capacity of water? (*Knowledge+Understanding Base*)

Ans: **HEAT CAPACITY OF WATER**

Water has unusually high heat capacity about **4.2 $Jg^{-1}K^{-1}$**, which is about **six times greater than that of rocks.**

Importance:

This specific property of water is responsible for keeping the Earth's temperature within limits. Otherwise, day time temperature would have been too high to bear and night time temperature would have been too low to freeze everything.

Q.2 What happens if a lump of cesium is dropped to water? (*Knowledge Base*)

(Interesting Information Pg. # 140)

Ans: **REACTION OF CESIUM WITH WATER**

If you add a lump of cesium to water in a glass trough, the reaction is so vigorous that the trough will shatter into small pieces.

Q.3 Why water is considered to be a universal solvent? (*Knowledge Base)*

(GRW 2014, FSD 2014, DGK 2017)

Ans: **WATER AS UNIVERSAL SOLVENT**

Water is a universal solvent because it can dissolve almost all the minerals. Its ability to dissolve substances is due to two unique properties of water:

(i) Polarity of water molecules

(ii) Exceptional hydrogen bonding ability

Q.4 Explain why non polar compounds are insoluble in water? (*Understanding Base)*

(FSD 2016 G-I,17)

Ans: **INSOLUBILITY OF NON POLAR COMPOUNDS**

Many covalent substances which do not have polar ends or bonds are not attracted by water molecule. Therefore, non-polar compounds do not dissolve in water.

Exmaples:

- Benzene
- Ether
- Octane etc.

15.1 PROPERTIES OF WATER

15.2 WATER AS A SOLVENT

MULTIPLE CHOICE QUESTIONS

1. **Water is composed of: *(K.B)***
(A) Oxygen, hydrogen (B) Nitrogen, Hydrogen
(C) Nitrogen, Oxygen (D) Oxygen, Hydrogen, Carbon

2. **The freezing point of water at sea level is: *(K.B)*** **(SWL 2017)**
(A) 0ºC (B) 20ºC
(C) 100ºC (D) 1ºC

3. **The boiling point of water at sea level is: *(K.B)***
(A) 100 ºC (B) 0 ºC
(C) 50 ºC (D) 101

4. **The maximum density of water at 4ºC is: *(K.B)*** **(MTN 2017, FSD 2016 G-II)**
(A) 3 g/cm^3 (B) 1 gm^3
(C) 1 g/cm^2 (D) 1 gcm^{-3}

5. **Water is excellent solvent for: *(K.B)***
(A) Ionic compounds (B) Polar compounds
(C) Both A and B (D) None of these

6. **Surface tension of water is: *(K.B)***
(A) High (B) Low
(C) Moderate (D) Comparable

7. **The bond angle between H–O–H in water is: *(K.B)*** **(GRW 2016, BWP 2016 G-II)**
(A) 104.5º (B) 104.6º
(C) 104.7º (D) 104.8º

8. **Water is a universal: *(K.B)***
(A) Solvent (B) Solute
(C) Both A and B (D) Donor

9. Structure of water molecule is: *(K.B)* **(DGK 2016 G-II)**

(A) Polar (B) Non-polar
(C) Both A and B (D) Diatomic

10. Water dissolves non-ionic compounds by: *(U.B)*

(A) Ion-ion forces (B) Ion-dipole forces
(C) Hydrogen bonding (D) Covalent bonds

11. Conductivity of pure water is: *(K.B)*

(A) High (B) Very low
(C) Very high (D) None of these

15.1 TEST YOURSELF

i. What is capillary action? *(Knowledge Base)* **(GRW 2017, FSD 2016 G-I, RWP 2016 G-II, MTN 2016 G-II)**

Ans: **<u>CAPILLARY ACTION</u>**

<u>Definition:</u>

"*Capillary action is the process by which water rises up from the roots of plants to leaves".*

<u>Importance:</u>

This process is vital for the survival of land plants.

ii. Point out two properties of water that make it an excellent solvent. ***(Knowledge Base)***

Ans: **<u>WATER AS EXCELLENT SOLVENT</u>**

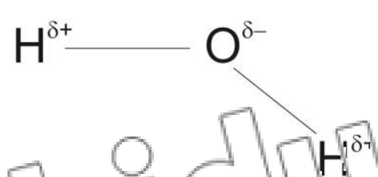
The two properties of water that make it an excellent solvent are:

(i) Polarity of water molecules
(ii) Exceptional hydrogen bonding ability

iii. Why the water molecule is polar? *(Understanding Base)*

Ans: **<u>POLAR NATURE OF WATER MOLECULE</u>**

Water molecule has a polar structure i.e., one end of the molecule is partially positive while the other end is partially negative because of electro negativity difference between oxygen and hydrogen atoms.



iv. Explain why non-ionic polar compounds are soluble in water? *(Understanding Base)* **(FSD 2017)**

Ans: **<u>SOLUBILITY OF NON-IONIC POLAR COMPOUNDS IN WATER</u>**

Non-ionic polar compounds are soluble in water due to hydrogen bonding. This hydrogen bonding is due to hydroxyl group i.e. OH^-, which is responsible for solubility

<u>Example:</u>

- Glucose
- Sugar

15.3 SOFT AND HARD WATER

LONG QUESTIONS

Q.1 What is soft and hard water? Write down the causes of hardness. ***(Knowledge +Understanding Base)***

OR

How is hardness caused in water?

(GRW 2014, 15, SGD 2014, MTN 2017, SWL 2016 G-II, BWP 2016 G-I)

Ans: **SOFT WATER AND HARD WATER**

Soft Water:

"Soft water is that which ***produces good lather with soap****."*

Hard Water:

"Hard water is that which ***does not produce lather with soap****."*

CAUSES OF HARDNESS IN WATER

The rain water while coming down absorbs **carbon dioxide** from the atmosphere. The water mixed with carbon dioxide, when passes through the beds of the soil, converts insoluble carbonates of calcium and magnesium into soluble bicarbonates. It may also dissolve chlorides and sulphates of calcium and magnesium.

These salts make the water hard.

$$\underset{\text{(limestone)}}{\mathbf{CaCO_{3(s)}}} + \mathbf{CO_{2(g)}} + \mathbf{H_2O_{(l)}} \longrightarrow \mathbf{Ca(HCO_3)_{2(aq)}}.$$

$$\mathbf{MgCO_{3(s)}} + \mathbf{CO_{2(g)}} + \mathbf{H_2O_{(l)}} \longrightarrow \mathbf{Mg(HCO_3)_{2(aq)}}$$

Ions/Salts Present in Rain Water:

The rain water dissolves many salts of divalent cations like $\mathbf{Mg^{2+}}$, $\mathbf{Ca^{2+}}$, and anions like $\mathbf{Cl^{1-}}$, $\mathbf{SO_4^{2-}}$, $\mathbf{HCO_3^{1-}}$ **and** $\mathbf{CO_3^{2-}}$.

Important Salts:

- Gypsum ($CaSO_4.2H_2O$)
- Limestone ($CaCO_3$)

Gypsum is sparingly soluble in water, while **limestone is insoluble in water**. However, in the presence of carbon dioxide small quantity of limestone is soluble in water according to the above chemical reaction. These salts make the water hard.

Q.2 What are the types of hardness of water? Explain the methods for the removal of hardness in water. ***(Knowledge+Understanding+Application Base)***

(LHR 2016, 15, 17, DGK 2016 G-II, SWL 2016 G-I)

OR

Explain the methods of removing permanent hardness of water.

Ans: **TYPES OF HARDNESS OF WATER**

Hardness of water is of two types:

(i) Temporary Hardness:

"*It is because of presence of* ***bicarbonates*** *of* ***calcium and magnesium****."*

(ii) Permanent Hardness:

"*It is because of presence of* ***sulphates and chlorides*** *of* ***calcium and magnesium****."*

METHODS OF REMOVING HARDNESS

The removal of Mg^{2+} and Ca^{2+} ions which are responsible for the hardness is called **water softening.**

(i) Removal of Temporary Hardness: (DGK 2017, FSD 2017)

(a) By Boiling:

Temporary hardness of water is easily removed by boiling water. On boiling, calcium bicarbonate $Ca(HCO_3)_2$ **decomposes** to produce **insoluble calcium carbonate**, which precipitates out of the solution.

$$Ca(HCO_3)_{2(aq)} \xrightarrow{heat} CaCO_{3(s)} + CO_{2(g)} + 2H_2O_{(l)}$$

(b) Clark's Method:

A **chemical method** to remove temporary hardness is by the **addition of slaked lime** $Ca(OH)_2$. A calculated amount of lime water is added to temporary hard water.

$$Mg(HCO_3)_{2(aq)} + Ca(OH)_{2(aq)} \longrightarrow MgCO_{3(s)} + CaCO_{3(s)} + H_2O_{(l)}$$

$$Ca(HCO_3)_{2(aq)} + Ca(OH)_{2(aq)} \xrightarrow{heat} 2CaCO_{3(s)} + 2H_2O_{(l)}$$

Thus, once the magnesium and calcium ions precipitate out water becomes soft.

(ii) Removal of Permanent Hardness:

(Ex.Q.2)(GRW 2013, LHR 2013, MTN 2017, RWP 2017)

Permanent hardness can only be removed by using chemicals. Calcium ions (Ca^{2+}) and magnesium ions (Mg^{2+}) are removed as insoluble salts by adding **washing soda (Na_2CO_3)** or **Na_2-zeolite.**

(a) By Using Washing Soda (Na_2CO_3): **(SWL 2016 G-I, BWP 2016 G-I)**

The addition of washing soda removes the calcium and magnesium ions as the insoluble calcium and magnesium carbonates respectively.

$$Na_2CO_{3(aq)} + CaSO_{4(aq)} \longrightarrow CaCO_{3(s)} + Na_2SO_{4(aq)}$$

$$Na_2CO_{3(aq)} + MgSO_{4(aq)} \longrightarrow MgCO_{3(s)} + Na_2SO_{4(aq)}$$

(b) Using Sodium Zeolite (An Ion Exchanger): **(BWP 2016 G-II)**

Sodium zeolite is naturally occurring resin of **sodium aluminum silicate $NaAl(SiO_3)_2$** which can also be prepared artificially.

Uses of Sodium Zeolite:

It is used for softening of water at domestic as well as on industrial scale. When water is passed through resin, sodium ions of the resin are exchanged with the unwanted calcium and magnesium ions of the hard water.

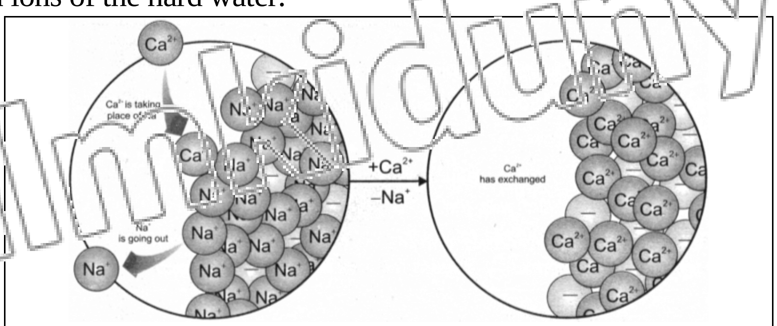


Figure: Ion Exchange For Removal of Hard Water Ions

$$Na_2\,zeolite + CaSO_{4(aq)} \longrightarrow Ca\,zeolite + Na_2SO_{4(aq)}$$

Regeneration of Sodium Zeolite:

When resin is fully used up it can be regenerated by flushing it with **concentrated solution of NaCl**. The reverse process takes place' because of **high concentration of sodium ions**.

$$\text{Ca zeolite} + 2NaCl \longrightarrow Na_2\,\text{zeolite} + CaCl_2$$

Q.3 What are the disadvantages of hardness of water? *(Knowledge Base)*

(GRW 2013, 14, SGD 2014, BWP 2016 G-I, DGK 2016 G-II, 2017, MTN 2016 G-II)

OR

Give some disadvantages of hardness of water?

Ans: DISADVANTAGES OF HARD WATER

Following are the disadvantages of hard water:

Consumption of More Soap:

Hard water **consumes large amount of soap** in washing purposes.

Stomach Disorders:

Drinking hard water causes **stomach disorders**.

Scales Formation:

Hard water is unfit for use in steam engines, boilers and turbines because insoluble calcium and magnesium salts are deposited inside which is called **scales**. They are bad conductors of heat and hence more fuel is used.

Insoluble calcium and magnesium sulphates not only **reduce the efficiency of the engine but also cause the boiler to burst.**

15.3 SOFT AND HARD WATER
SHORT QUESTIONS

Q.1 Define soap? *(Knowledge Base)* **(Science, Technology and Society Pg. # 144)**

Ans: SOAP

Soap is the **sodium salt** of a long chain **carboxylic acid** (fatty acid).

Q.2 What is scum? *(Knowledge Base)* **(DGK 2016 G-I, SGD 2017)**

Ans: SCUM

Hard water contains salts of magnesium and calcium. These ions react with the soap molecules to form an **insoluble precipitates of calcium and magnesium salts of fatty acids** called **scum**.

Q.3 How limestone dissolves in water? *(Knowledge Base)* **(MTN 2017)**

Ans: DISSOLUTION OF LIMESTONE

The rain water while coming down absorbs carbon dioxide from the atmosphere. The water mixed with carbon dioxide, when passes through the beds of the soil, converts insoluble carbonates of calcium and magnesium into soluble bicarbonates. It may also dissolve chlorides and sulphates of calcium and magnesium. These salts make the water hard.

$$CaCO_{3(s)} + CO_{2(g)} + H_2O_{(l)} \longrightarrow Ca(HCO_3)_{2(aq)}$$

$$MgCO_{3(s)} + CO_{2(g)} + H_2O_{(l)} \longrightarrow Mg(HCO_3)_{2(aq)}$$

Q.4 Explain chemistry of removing hardness of water by Clark's method. ***(Knowledge Base)***

Ans: *Answer given on page # 300*

Q.5 Discuss briefly two types of hardness of water. *(Knowledge Base)* **(BWP 2016 G-II)**

OR

Differentiate between temporary and permanent hardness. **(SGD 2016 G-II)**

Ans: *Answer given on page # 300*

MULTIPLE CHOICE QUESTIONS

1. Soft water produces lather with soap: *(K.B)*

(A) Good (B) Bad
(C) Rough (D) Fine

2. $CaCO_3 + CO_2 + H_2O \longrightarrow$: *(K.B)*

(A) $Ca(HCO_3)_2$ (B) $Mg(HCO_3)_2$
(C) $Ca_2(HCO_3)_2$ (D) Ca_2CO_3

3. $MgCO_3 + CO_2 + H_2O \longrightarrow$: *(K.B)*

(A) $Mg(HCO_3)_2$ (B) $Mg(HCO)_2$
(C) $Mg(HCO_3)$ (D) $MgCl$

4. In water gypsum is sparingly: *(K.B)*

(A) Soluble (B) Insoluble
(C) None of these (D) Both A and B

5. HCO_3 makes the water: *(K.B)*

(A) Hard (B) Soft
(C) Clean (D) Waxy

6. Temporary hardness is because of presence of bicarbonates of magnesium and: *(K.B)*

(A) Calcium (B) Potassium
(C) Gypsum (D) Copper

7. The removal of which ions is responsible for the hardness of water: *(K.B)*

(A) Mg^{2+} (B) K
(C) Na^{1+} (D) Cu^{2+}

8. In washing purposes hard water consumes large amount of: *(K.B)*

(A) Soap (B) Power
(C) Slaked lime (D) Detergents

9. Drinking hard water causes disorders: *(K.B)*

(A) Blood (B) Heart
(C) Stomach (D) Kidney

10. It is sodium salt of a long chain carboxylic acid: *(K.B)*

(A) Acid (B) Soap
(C) Lime (D) Sodium chloride

11. Hard water contains salts of: *(K.B)*

(A) Magnesium, calcium (B) Magnesium, potassium

(C) Calcium, potassium (D) Ca, Cu

12. A large number of soap is wasted in formation of: *(K.B)*

(A) Scum (B) Detergents
(C) Soda (D) None of these

13. Hardness is of how many types? *(K.B)* **(GRW 2017)**

(A) Four (B) Two
(C) Three (D) Five

14. Permanent hardness because of Mg^{2+} and Ca^{2+}: *(K.B)*

(A) SO_4^{2-} (B) Cl^-
(C) Both A and B (D) Phosphates

15. Sodium zeolite is resin of: *(K.B)* **(LHR 2014)**

(A) $NaAl(SiO_3)_2$ (B) $KAl(SiO_3)_2$
(C) $LiAl(SiO_3)_2$ (D) $RbAl(SiO_3)_2$

15.2 TEST YOURSELF

i. Which salts are responsible for hardness of water? *(Knowledge Base)* **(GRW 2015)**

Ans: **SALTS RESPONSIBLE FOR HARDNESS**

Calcium and magnesium salts like bicarbonates, sulphates and chlorides present in water cause hardness in water.

Examples:

- Gypsum ($CaSO_4.2H_2O$)
- Limestone ($CaCO_3$)

ii. Explain the chemistry of removing the temporary hardness by boiling water. *(Knowledge Base)*

Ans: **REMOVAL OF TEMPORARY HARDNESS**

On boiling, calcium and magnesium bicarbonates present in temporary hard water decompose to produce insoluble carbonates, which are precipitated out of the solution.

$$Ca(HCO_3)_2\,(aq) \xrightarrow{\Delta} CaCO_{3(s)} + CO_{2(g)} + H_2O_{(l)}$$

iii. What is the principle of removing permanent hardness of water? *(Knowledge Base)*

Ans: **PRINCIPLE TO REMOVE PERMANENT HARDNESS**

The permanent hardness can only be removed by using chemicals. Calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions are removed as "insoluble salts" by adding washing soda (Na_2CO_3) or sodium zeolite.

iv. How addition of Na_2CO_3 removes permanent hardness of water? *(Knowledge Base)* **(SGD 2016 G-II)**

Ans: **USES OF Na_2CO_3**

The addition of washing soda removes the calcium and magnesium ions as the insoluble calcium and magnesium carbonates respectively.

$$Na_2CO_{3(aq)} + CaSO_{4(aq)} \longrightarrow CaCO_{3(s)} + Na_2SO_{4(aq)}$$

$$Na_2CO_{3(aq)} + MgSO_{4(aq)} \longrightarrow MgCO_{3(s)} + Na_2SO_{4(aq)}$$

v. How sodium zeolite softens water? *(Understanding+Application Base)*

Ans: **WATER SOFTENING PROCESS**

When hard water is passed through sodium zeolite, sodium ions of the resin are exchanged with the unwanted calcium and magnesium ions of the hard water to form insoluble calcium zelite.

$$Na_2zeolite + CaSO_{4(aq)} \longrightarrow Na_2SO_{4(aq)} + CaZeolite_{(s)}$$

vi. What do you mean by boilers scale? How are they removed? ***(Understanding+Application Base)***

(GRW 2014, LHR 2015, FSD 2016 G-II, SGD 2016 G-II, RWP 2016 G-I)

Ans: **BOILERS SCALE**

The hard layer of carbonates of calcium and magnesium salts deposited in industrial boilers is called boiler scales. They can be removed by washing the boilers with washing soda, slaked lime or sodium zeolite.

15.4 WATER POLLUTION

LONG QUESTIONS

Q.1 What is water pollution? Describe the effects of using polluted water. ***(Knowledge+Understanding+Application Base)***

(GRW 2017, BWP 2017, SWL 2017, SGD 2017, FSD 2016 G-II, 2017, DGK 2016 G-I) (Ex-Q.8)

Ans: **WATER POLLUTION**

Definition:

"*Water pollution is a **contamination of water bodies** (e.g. lakes, rivers, oceans and ground water)".*

Reason:

Water pollution occurs when pollutants are discharged directly or indirectly into water bodies without adequate treatment to remove harmful compounds.

EFFECTS OF WATER POLLUTION

The effects of water pollution are as follows:

(i) It is **hazardous to human health**. Drinking polluted water can cause cholera, typhoid and diarrhea.

(ii) The use of polluted water is not only devastating for people but also for **animals and birds**.

(iii) It causes **rapid growth of algae**. Death and decomposition of algae causes deficiency of oxygen in water that affects other organism living in water.

(iv) It is damaging aquatic life, thus breaking a link in **food chain**.

(v) It reduces the **aesthetic quality** of lakes and rivers.

(vi) It is **unfit for cleaning** or washing purposes.

Q.2 Explain the water pollution because of industrial waste.

(Knowledge+Application Base) **(Ex-Q.5)**

Ans: **INDUSTRIAL EFFLUENTS**

"*The waste water of industries is called industrial effluents".*

Purpose of Industries:

Industrial units are installed to produce the desired substances on commercial scale to meet the needs of the society.

Examples:

- Chemicals
- Cloth
- Leather goods

- Paper
- Plastic items
- Petrochemicals
- Rubber items

Disadvantages of industries:

Unfortunately all the industrial units discharge their wastes (chemicals and solid materials) either to open ground or to water channels. This is called industrial effluent.

Composition of Industrial Effluents:

The industrial effluents may be:

- Highly toxic organic chemicals
- Inorganic salts
- Heavy metals
- Mineral acids
- Oil
- Greases
- All kinds of toxic chemicals and detergents

Water used as cleaning agent in industries is directly discharged out. This water contains all kinds of toxic chemicals and detergents

Forms of Industrial Effluents:

When these effluents or used water enters lakes, streams, rivers or oceans, they are present in the following forms:

- Either get dissolved
- Float suspended in water
- Even they get deposited on the bed

Effects of Industrial Effluents on Water:

Results:

The effects of industrial effluents on water are as follows:

(i) Quality of Water:

They **deteriorate** the quality of water.

(ii) Quantity of Dissolved Oxygen

They reduce the quantity of dissolved oxygen, ultimately affect **aquatic life and ecosystem**.

(iii) Human Health:

They can also seep down and affect the ground water deposits. They contaminate the water deposits. When this water is used by human beings, it **causes serious diseases like cancer and gastro.**

(iv) Damage to Soil and Living Organisms:

This polluted water damages soil, crops, plants and animals.

(v) Effects of Heavy Metals:

Heavy metals like cadmium, lead and mercury are toxic and health hazards for human beings.

- **Acute cadmium poisoning** causes **high blood pressure**, **kidney damage** and **destruction of red blood cells.**
- **Acute lead poisoning** causes **dysfunction of kidney, liver, brain, central nervous system and reproductive system.**
- **Mercury poisoning** causes **neurological damage**.

Q.3 Justify the statement: household water is the reason of water pollution. ***(Knowledge+Understanding Base)*** **(Ex-Q.4)**
(GRW 2017, BWP 2017, DGK 2017)

Ans: **DOMESTIC EFFLUENTS**

Definition:

"The waste water of domestic sources is called domestic effluents" household water is also a domestic effluent.

Composition of Domestic Sewage: **(Ex-Q.4)**

Domestic sewage contains a wide variety of dissolved and suspended impurities. They include:

- Detergents
- Food and vegetable waste
- Garbage
- Cans
- Bottles

All these substances add to water pollution.

Advantages of Detergents:

- **Use of detergents is increasing day by day** for cleaning purposes in houses and industries. **It is because; detergents have strong cleaning action** than that of soap even in hard water.
- They **can work even in acidic solutions.**

Disadvantages of Detergents:

- They have a major disadvantage over the soaps, as some of the detergents are **non-biodegradable** (cannot be decomposed by microorganisms like bacteria).
- The detergent remains in the water for a long time and makes the water unfit for aquatic life.
- Use of detergent affects **aquatic life**. When household water containing these detergents is discharged in streams, ponds, lakes and rivers, it causes water pollution.

Effect of Detergents on Aquatic Life:

The **phosphate salts** present in detergents **cause rapid growth of algae** in water bodies, which floats over the surface of water. These plants ultimately die and decay. Decaying plants **being biodegradable consume oxygen gas present in water**. Thus, depletion of oxygen gas results in death of aquatic life.

Q.4 Explain agricultural effluents are fatal for aquatic life.

Ans: **AGRICULTURAL EFFLUENTS**

Definition:

"The waste water of agricultural sources is called agricultural effluents".

Major Pollutants:

Water pollution due to agricultural waste is because of use of **fertilizers and pesticides**.

Fertilizers:

Fertilizers are used to make up the **deficiency of nitrogen, phosphorus**, etc. of the soil because of **intensive cultivation of crops** in the recent years.

Pesticides:

The pesticides are used either directly to **kill or control the growth of pests**. Pests may be weeds, herbs, insects, fungi, viruses, etc. They all damage crops and transmit diseases both to human beings and animals.

Effects of Agricultural Effluents on Water:

Agricultrual effluents have dual effects:

(i) Ground Water Pollution:

Intensive cultivation of crops causes these chemicals from fertilizers and pesticides to **seep into the ground water** commonly called **leaching process**. The high nitrate contents in ground water is mainly because of irrigation run-off from agricultural fields.

(ii) Run-off Water:

Run-off from the agricultural land (where fertilizers and pesticides have been used) enters into ponds, streams or rivers. This water **contains nitrate (NO_3^-) and phosphate (PO_4^{3-}) salts**. These substances result in a **rapid growth of algae**, floating over the surface of water. They prevent the sunlight and air (oxygen) to reach upto aquatic life. **When algae dies, bacteria consume oxygen of the water for decomposition of algae. As a result oxygen depletes in the water**. Aquatic animals feel suffocation and ultimately die due to insufficient supply of oxygen.

15.4 WATER POLLUTION
SHORT QUESTIONS

Q.1 What is role of fluorine for protection of teeth?
(Knowledge+Understanding+Application Base) **(Interesting Information Pg. # 146)**

OR

Why tooth pastes contain fluorine compounds?

Ans: **FLUORINE AND TEETH PROTECTION**

In some parts of the world, the water supply contains small amounts of compounds of fluorine. It was found that, in these areas, people did not suffer much from tooth decay. This is because compounds of fluorine protect teeth from decay. This is why many tooth-pastes contain fluorine compounds.

Q.2 Which industrial effluents cause water pollution? *(Knowledge Base)*

Ans: **INDUSTRIAL EFFLUENTS**

Industrial effluents are one of the main causes of water pollution.

Composition:

Industrial effluents include:

- High toxic organic chemicals
- Inorganic salts
- Heavy metals
- Mineral acids
- Oil and greases, etc.

Q.3 Explain agricultural effluents are fatal for aquatic life. *(Knowledge Base)* **(GRW 2014)**

Ans: *Answer given on page # 307*

Q.4 Define industrial effluents. ***(Knowledge Base)*** **(SGD 2016 G-II, SWL 2016 G-II)**

Ans: *Answer given on page # 305*

What is meant by water pollution? (RWP 2016 G-II) ***(Knowledge Base)***

Ans: **WATER POLLUTION**

Definition:

"*Water pollution is a contamination of water bodies (e.g. lakes, rivers, oceans and ground water)*".

Water pollution occurs when pollutants are discharged directly or indirectly into water bodies without adequate treatment to remove harmful compounds.

15.4 WATER POLLUTION

MULTIPLE CHOICE QUESTIONS

1. Water pollution is contamination of water: ***(K.B)***
(A) Bodies (B) Molecules
(C) Compounds (D) Prices

2. Water pollution causes rapid growth of: ***(K.B)***
(A) Bacteria (B) Algae
(C) Chemicals (D) Pollutants

3. Water pollution is unfit for following purposes: ***(K.B)***
(A) Cleaning (B) Washing
(C) Both A and B (D) Drinking

4. In some parts of the world, the water supply contains small amount of compounds of: ***(K.B)***
(A) Chlorine (B) Bromine
(C) Fluorine (D) Iodine

5. Lack of proper sanitation facilities is the main cause of rapidly spreading ______ diseases. ***(K.B)***
(A) Water borne (B) Water pollution
(C) Hepatitis (D) Heart

6. Water pollution due to agriculture waste is because of use of the: ***(K.B)***
(A) Fertilizers (B) Pesticide
(C) Both A and B (D) Insecticide

7. Fertilizers are used to make up deficiency of: ***(K.B)***
(A) Nitrogen (B) Phosphorus
(C) Both A and B (D) Calcium

8. Aquatic animals feel suffocation and ultimately die due to insufficient supply of: ***(K.B)***
(A) Oxygen (B) Hydrogen
(C) Carbon dioxide (D) None of these

9. Heavy metals like Cadmium, Lead and Mercury are toxic and health hazards for: ***(K.B)***
(A) Humans (B) Animals
(C) Both A and B (D) Plants

10. Use of detergents is increasing day by day for cleaning purposes in: ***(K.B)***
(A) Houses (B) Industries
(C) Both A and B (D) Classes

11. Detergents can work even in solutions: ***(K.B)***
(A) Acidic (B) Basic
(C) Both A and B (D) Alkaline

12. Which salt present in detergents causes rapid growth of algae in water? *(K.B)*
(A) Nitrate (B) Phosphate
(C) Magnesium (D) Both A and B

13. Used water is called: *(K.B)*
(A) Waste water (B) Sewage
(C) Both A and B (D) None of these

14. Good quality water is colorless and: *(K.B)*
(A) Odorless (B) Tasteless
(C) Both A and B (D) Softly

15.3 TEST YOURSELF

i. What is an industrial waste? *(Knowledge Base)* **(LHR 2014, 2015)**

Ans: **INDUSTRIAL WASTE**

Definition:

"The waste materials (particles) which are discharged by industrial units are called industrial waste".

Disadvantages:

- Water pollution deteriorate the quality of water.
- It reduce the quantity of dissolved oxygen, ultimately affect aquatic life and ecosystem.
- It causes serious diseases like cancer and gastro.
- This polluted water damages soil, crops, plants and animals.

Examples:

Inorganic salts, heavy metals, mineral acids, oil and grease etc.

ii. How water used as a cleaning agent in industries causes pollution? ***(Knowledge Base)***

Ans: **POLLUTION DUE TO WATER AS CLEANING AGENT**

Water used as cleaning agent in industries is directly discharged out. This water contains all kinds of toxic chemicals and detergents. When these effluents or used water enter lakes, streams, rivers or oceans, they either get dissolved or float suspended in water. Even they get deposited on the bed. This results in the pollution of water.

iii. Why use of detergents is increasing day by day? *(Knowledge Base)*

Ans: **INCREASING USE OF DETERGENTS**

The use of detergents is increasing day by day in houses and industries because of following reasons:

- Detergents have strong cleaning action than that of soap even in hard water.
- They work in acidic solution as well.

iv. How decaying plants consume oxygen? *(Knowledge Base)*

Ans: **DECAYING PLANTS CONSUME OXYGEN**

Decaying plants consume oxygen present in water thus depletion of oxygen results in death of aquatic life for the biodegradation.

v. What is function of fertilizers? *(Knowledge Base)* **(LHR 2014)**

Ans: **FUNCTION OF FERTILIZERS**

Fertilizers are used to make up the deficiency of nitrogen, phosphorous etc. of the soil because of intensive cultivation of crops in the recent years.

vi. How pesticides cause water pollution? *(Knowledge Base)* **(GRW 2013)**

Ans: **WATER POLLUTION BY PESTICIDES**

Pesticides are used to kill or control the pests. Pesticides cause water pollution by adding poisonous chemicals in it.

15.5 WATERBORNE INFECTIOUS DISEASES

LONG QUESTIONS

Q.1 Write a detailed note on water borne diseases. *(Knowledge+Understanding Base)* **(Ex-Q.6)**

OR

What are water borne infectious dieases? Explain five important water borne dieases. How can they by prevented? **(GRW 2013, BWP 2017)**

Ans: **WATER BORNE DISEASES**

Definition:

*"Diseases that **spread because** of **drinking polluted water** or eating **food prepared** with **polluted water** are called waterborne infectious diseases".*

Causes of Water Pollution:

Water pollution may be due to toxins or microorganisms.

(i) Toxins:

Toxins are arsenic, mercury, lead and many organic chemicals.

(ii) Microorganisms:

Microorganisms are viruses, bacteria, protozoa and worms.

Main Cause of Waterborne Infectious Diseases:

Lack of proper sanitation facilities is the main cause of rapidly spreading waterborne diseases.

WATER BORNE DISEASES

A few common diseases are mentioned here:

(i) Diarrheal Diseases:

Intestinal diseases, such as cholera, that may cause dangerous dehydration.

Causative Organisms:

- Viruses
- Bacteria
- Parasites

(ii) Dysentery:

Dysentery is an **intestinal disease**. It is characterized by **severe diarrhea** that may be accompanied by blood or mucous.

Causative Organisms:

It is typically caused by certain bacteria or parasites.

(iii) Cholera: **(SGD 2016 G-I)**

Cholera is **an acute infection**. It causes severe diarrhea and can be fatal.

Causative Organisms:

It is caused by the bacteria ***Vibrios cholerae*** which may be found in **water contaminated** by human feaces.

(iv) Cryptosporidiosis: **(DGK 2016 G-I)**

Waterborne disease that causes **gastrointestinal effects** including diarrhea and vomiting.

Causative Organisms:

- **Protozoa**

These tiny pathogens are found in surface water sources like reservoirs, lakes and rivers.

(v) Fluorosis:

Fluorosis is a disease caused by the **consumption** of **excess fluoride**. Fluorosis can cause bones and teeth damage.

(vi) Hepatitis:

It is **liver inflammation**.

Causative Organisms:

It is commonly caused by one of five viruses called hepatitis A, B, C, D, and E. Hepatitis **A and E can be transmitted by contaminated water.**

(vii) Hookworm:

Effects:

Hookworm is a **parasitic worm** that infects the **small intestine**. Severe cases can result in anemia and stunted growth in children.

Transmission:

Hookworm larvae enter the body through the skin, often via the feet. Spread by poor sanitary conditions, hookworms infect about one billion people worldwide per annum.

(viii) Jaundice: **(RWP 2017)**

Jaundice is caused by an **excess of bile pigments** in the blood. **Liver ceases to function** and eyes turn yellow. Patient feels weakness and fatigue.

(ix) Typhoid:

A dangerous bacterial disease often spread by contaminated water or by food prepared with contaminated water.

Causative Organisms:

- Bacteria

Q.2 What are the remedial parameters to avoid water borne diseases? *(Knowledge Base)* **(Ex-Q.6)**

Ans: **PREVENTION OF WATER BORNE DISEASES**

Waterborne diseases can be prevented by taking the following measures:

(i) Provision of Safe Water:

Drinking water must be properly treated and purified.

(ii) Disposal of Sewage:

There must be adequate sanitary disposal of sewage, any type of waste must not be thrown or discharged directly in water supplies or reservoirs.

(iii) Control of Toxic Chemicals:

Chemical contamination can cause acute illness, but often toxic contaminants are slow poisons and carcinogens. There must be a strict control over the use of pesticides and other chemicals.

15.5 WATERBORNE INFECTIOUS DISEASES

SHORT QUESTIONS

Q.1 What are waterborne infectious diseases? *(Knowledge Base)* **(DGK 2017)**

Ans: *Answer given on Page # 311*

Q.2 How jaundice is caused? Write its symptoms. *(Knowledge Base)* **(RWP 2017)**

Ans: *Answer given on Page # 312*

MULTIPLE CHOICE QUESTIONS

1. ***Vibrios cholerae* may be found in water contaminated by: *(K.B)***
   (A) Human feaces (B) Animal feaces
   (C) Both A and B (D) Human urine
2. **Fluorosis is a disease caused by the consumption of excess: *(K.B)* (LHR 2014, SWL 2017)**
   (A) Chlorine (B) Bromine
   (C) Fluoride (D) Astatine
3. **Which of the following disease causes liver inflammation? *(K.B)***
   (A) Typhoid (B) Cholera
   (C) Hepatitis (D) Jaundice
4. **Hepatitis _____and______ can be transmitted by contaminated water. *(K.B)***
   (A) B, C (B) A, E
   (C) A, D (D) B, A
5. **Hookworm infects the: *(K.B)***
   (A) Small intestine (B) Large intestine
   (C) Stomach (D) Liver
6. **Hookworm infects about how many billion people worldwide per annum? *(K.B)***
   (A) 1 (B) 2
   (C) 4 (D) 5
7. **Diarrhea may be caused by viruses: *(K.B)***
   (A) Bacteria (B) Parasites
   (C) Both a and b (D) Fungal infections
8. **Dysentery is a disease of: *(K.B)***
   (A) Intestine (B) Stomach
   (C) Heart (D) Liver
9. **Cholera is an acute infection caused by bacteria: *(K.B)***
   (A) *Cholerae* (B) *Vibrious cholerae*
   (C) Both a and b (D) None of these
10. **Water borne diseases: *(K.B)***
    (A) Dysentery (B) Cholera
    (C) Both A and B (D) Pneumonia
11. **Jaundice is caused by an excess of _________ in blood. *(K.B)***
    (A) Bile pigments (B) RBC's
    (C) WBC's (D) Thrombocytes
12. **Patient feels weakness and fatigue in: *(K.B)***
    (A) Jaundice (B) Hepatitis
    (C) Cryptosporidiosis (D) Cholera
13. **Typhoid is a dangerous disease: *(K.B)***
    (A) Intestinal (B) Bacterial
    (C) Infections (D) Fungal
14. **Chlorine kills: *(K.B)***
    (A) Bacteria (B) Micro-organisms
    (C) Both A and B (D) Germs

15. **Swimming pools are cleaned by:** ***(K.B)***
(A) Chlorination (B) Fluorination
(C) Bromination (D) Both B and C

16. **A disease that causes bone and tooth damage:** ***(K.B)*** **(LHR 2015, GRW 2017)**
(A) Jaundice (B) Fluorosis
(C) Hepatitis (D) Asthma

17. **Which gas is used to destroy harmful bacteria in water?** ***(K.B)*****(GRW 2015, MTN 2017, DGK 2017)**
(A) Iodine (B) Chlorine
(C) Fluorine (D) Bromine

15.4 TEST YOURSELF

i. **Define water borne diseases.** ***(Knowledge Base)***

Ans: **WATER BORNE DISEASES**

Definition:

"*Diseases that spread because of drinking polluted water or eating food prepared with polluted water are called water borne diseases".*

Examples:

- Cholera
- Dysentery
- Hepatitis

These diseases spread because of lack of sanitation arrangements.

ii. **What is dysentery?** ***(Knowledge Base)***

Ans: **DYSENTERY**

Definition:

"Dysentery is an intestinal disease which is typically caused by certain bacteria or parasites".

Symptoms:

It is characterized by severe diarrhea that may be accompanied by blood or mucous.

iii. **Which of the bacteria causes the cholera?** ***(Knowledge Base)***

Ans: **BACTERIA CAUSING CHOLERA**

Cholera is an acute infection caused by the bacteria "*Vibrious chloerae*".

iv. **What do you mean by fluorosis?** ***(Knowledge Base)*** **(RWP 2017)**

Ans: **FLUOROSIS**

Definition:

"Fluorosis is a disease caused by the consumption of excess fluoride".

Symptoms:

Flurorosis can cause bones and teeth damage.

v. **What is hepatitis?** ***(Knowledge Base)*** **(SWL 2017)**

Ans: **HEPATITIS**

Definition:

"It is liver inflammation commonly caused by one of five viruses called hepatitis A, B, C, D and E".

Transmission:

Hepatitis A and E can be transmitted by contaminated water.

SKILLS

Quality of Water:

Good quality water is colourless, odourless and tasteless. Hardness of water can be checked by washing. Soft water produces lather with water. Pure water has least conductivity.

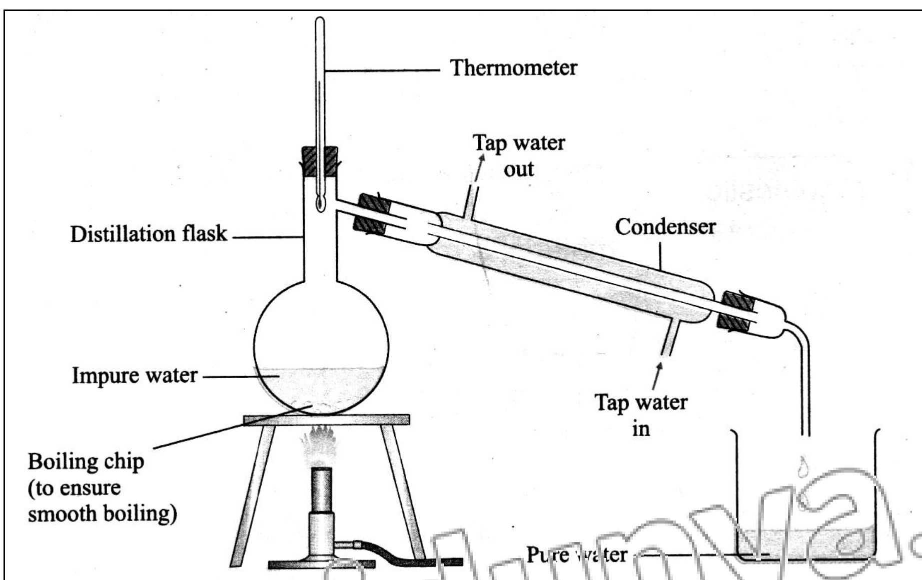
Boiling point of water:

Water boils at 100°C.

Distillation of Impure water:

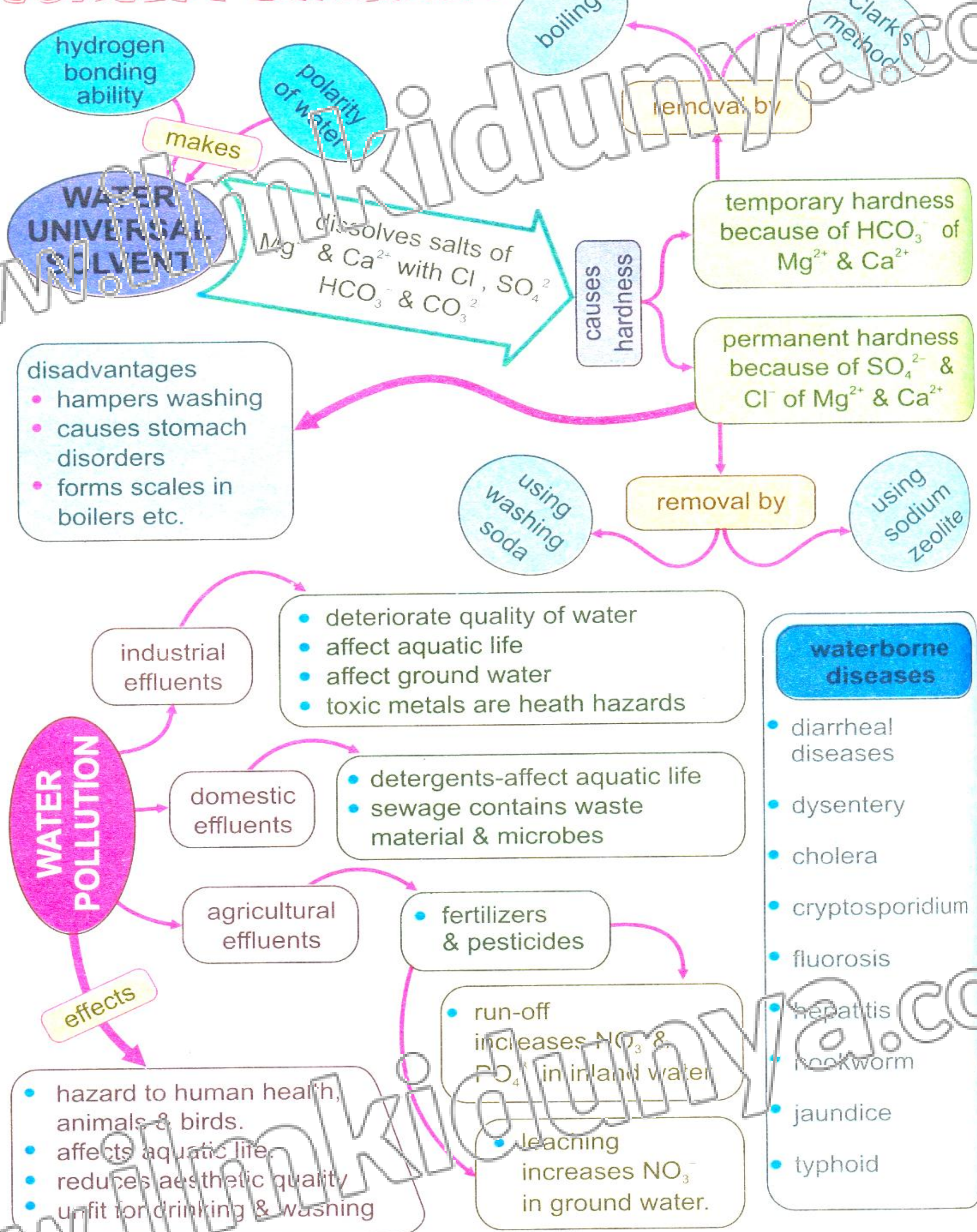
Impure water can be purified by simple distillation apparatus as shown in figure.

Distillation process involves boiling of a liquid and then condensing the vapours.



Impure water is taken in a distillation flask. It is boiled. Water vapours rise and enter the condenser. The vapours condense while passing through condenser. Thus they are changed back into pure water, which is called distillate (distilled water). The distillate is collected in a beaker. The impurities remain behind in the distillation flask.

CONCEPT DIAGRAM



ANSWER KEY

MULTIPLE CHOICE QUESTIOS

INTRODUCTION

1	A
2	A
3	C
4	C
5	A

15.1 PROPERTIES OF WATER
15.2 WATER AS SOLVENT

1	A	6	A	11	B
2	A	7	A		
3	A	8	A		
4	D	9	A		
5	C	10	C		

15.3 SOFT AND HARD WATER

1	A	6	A	11	A
2	A	7	A	12	A
3	A	8	A	13	B
4	A	9	C	14	C
5	A	10	B	15	A

15.4 WATER POLLUTION

1	A	6	C	11	A
2	B	7	C	12	B
3	D	8	A	13	C
4	C	9	A	14	C
5	A	10	C		

15.5 WATER BORNE INFECTIOUS DISEASES

1	A	6	A	11	A	16	B
2	C	7	C	12	A	17	B
3	C	8	A	13	B		
4	B	9	B	14	C		
5	A	10	C	15	A		

EXERCISE SOLUTION

MULTIPLE CHOICE QUESTIONS

1. Which one of the following properties of water is responsible for rising of water in plants? *(K.B)* **(LHR 2015, DGK 2016 G-II, SGD 2017)**

(a) Specific heat capacity (b) Surface tension
(c) Excellent solvent action (d) Capillary action

2. Specific heat capacity of water is: *(K.B)*

(GRW 2014,17 SGD 2014, RWP 2016 G-ILHR 2017, BWP 2017, SWL 2017, MTN 2017)

(a) 4.2 $kJg^{-1}K^{-1}$ (b) 4.2 $Jg^{-1}K^{-1}$
(c) 2.4 $kJg^{-1}K^{1}$ (d) 2.4 $Jg^{-1}K^{1}$

3. Water dissolves non-ionic compound by: *(K.B)* **(GRW 2014, SWL 2017)**

(a) Ion-ion forces (b) Ion-dipole forces
(c) Dipole-dipole forces (d) Hydrogen bonding

4. Temporary hardness is because of: *(K.B)*

(GRW 2013,14,17, LHR 2015, BWP 2016 G-II, FSD 2016 G-I, SGD 2016 G-II, RWP 2016 G-II, SWL 2016 G-I, DGK 2017)

(a) $Ca(HCO_3)_2$ (b) $CaCO_3$
(c) $MgCO_3$ (d) $MgSO_4$

5. Temporary hardness is removed by adding: *(K.B)* **(SGD 2016 G-I, GRW 2015, MTN 2017)**

(a) Quick lime (b) Slaked lime
(c) Limestone (d) Lime water

6. Permanent hardness is removed by adding: *(K.B)* **(GRW 2014, DGK 2016 G-I, BWP 2017)**

(a) Na_2 zeolite (b) Soda lime
(c) Lime water (d) Quick lime

7. Which one of the following salts makes the water permanently hard? *(K.B)*

(LHR 2014, 15, GRW 2014, 15, 16, SWL 2016 G-II, MTN 2016 G-II, RWP 2016 G-I, 17)

(a) Na_2CO_3 (b) $NaHCO_3$
(c) $Ca(HCO_3)_2$ (d) $CaSO_4$

8. Rapid growth of algae in water bodies is because of detergent having: *(K.B)* **(DGK 2017)**

(a) Carbonate salts (b) Sulphonic acid salts
(c) Sulphate salts (d) Phosphate salts

9. Depletion of O_2 from water is not because of: *(K.B)*

(a) Decaying of aquatic plants (b) Biodegradation of aquatic plants
(c) Rapid growth of aquatic plants (d) Decomposition of aquatic plants

10. Which one of the following diseases causes liver inflammation? *(K.B)*

(FSD 2016 G-II, 17, MTN 2016 G-I, SWL 2016 G-II, LHR 2014,15, SGD 2017)

(a) Typhoid (b) Jaundice

(c) Cholera (d) Hepatitis

11. Which one of the following diseases causes severe diarrhea and can be fatal? *(K.B)*

(SGD 2016 G-I, BWP 2017, RWP 2017)

(a) Jaundice (b) Dysentery

(c) Cholera (d) Typhoid

12. Which one of the following gases is used to destroy harmful bacteria in water? *(K.B)*

(DGK 2017, SGD 2016 G-II, 17, MTN 2016 G-I)

(a) Iodine (b) Chlorine

(c) Fluorine (d) Bromine

13. Which one of the following ions does not cause hardness in water? *(K.B)*

(LHR 2014, 16, MTN 2016, G-II, DGK 2016 G-I, SWL 2016 G-II, FSD 2017 G-I, RWP 2017, GRW 2017)

(a) Ca^{2+} (b) Mg^{2+}

(c) SO_4^{2-} (d) Na^+

14. A disease that causes bone and tooth damage is: *(K.B)*

(GRW 2013, LHR 2013, 15, RWP 2016 G-II, 17, SGD, 2017)

(a) Fluorosis (b) Hepatitis

(c) Cholera (d) Jaundice

15. Ionic compounds are soluble in water due to: *(K.B)* **(RWP 2016 G-II)**

(a) Hydrogen bonding (b) Ion-dipole forces

(c) Dipole-dipole forces (d) Dipole-induced dipole forces

16. The chemicals used to kill or control pests are called pesticides. They are: *(K.B)*

(a) Dangerous inorganic chemicals (b) Dangerous organic chemicals

(c) Beneficial inorganic chemicals (d) Beneficial organic chemicals

ANSWER KEY

1	D	6	a	11	c	16	b
2	B	7	d	12	b		
3	d	8	d	13	d		
4	a	9	c	14	a		
5	b	10	d	15	b		

EXERCISE SHORT QUESTIONS

1. How water rises in plants by capillary action? *(Knowledge Base)*
(RWP 2016 G-I, DGK 2016 G-I & II)

Ans: **WATER RISE IN PLANTS**

Water rises in plants by capillary action. Capillary action is the process by which water rises up from the roots of plants to leaves. This process is vital for the survival of land plants.

2. Which forces are responsible for dissolving polar substances in water?
***(Knowledge Base)*(GRW 2013, MTN 2016 G-I&II)**

Ans: **FORCES RESPONSIBLE FOR DISSOLUTION**

Dipole forces (Dipole-dipole forces and H-bonding) are responsible for dissolving polar substances in water because positive end of polar substance is attracted by negative end of polar substance and vice versa.

3. Why non-polar compounds are insoluble in water?
***(Knowledge+Understanding Base)*(LHR 2013, SWL 2016 G-I&II)**

Ans: **INSOLUBILITY OF NON POLAR COMPOUNDS**

The non-polar compounds do not have polar ends or bonds and are not attracted by water molecules. Therefore, non-polar compounds do not dissolve in water.

Examples:

- Benzene
- Ether
- Octane etc.

4. How water dissolves sugar and alcohols? *(Understanding Base)* (LHR 2013)

Ans: **DISSOLUTION OF SUGAR AND ALCOHOLS**

Water dissolves sugar and alcohols through H-bonding. Both sugar and alcohols contain hydroxyl groups $(-OH)$ having polar ends which are attached by positive and negative ends of water molecules.

5. How limestone dissolves in water? *(Knowledge+Understanding Base)* (GRW 2015)

Ans: **DISSOLVING OF LIMESTONE**

The water which has limestone is insoluble in water but carbon dioxide dissolved in it, convert the insoluble lime stone (calcium carbonate) into soluble calcium bicarbonate. In this way, lime stone dissolves in water.

$$CaCO_{3(s)} + H_2O + CO_2 \longrightarrow Ca(HCO_3)_{2(aq)}$$

6. Differentiate between soft and hard water. *(Knowledge Base)*
(GRW 2015, LHR 2013, BWP 2016 G-I, FSD 2016 G-I, DGK 20196 G-II, SWL 2017)

Ans: **DIFFERENTIATION**

The differences between soft water and hard water are as follows:

Soft Water	Hard Water
Definition	
• Soft water is that which produced good lather with soap.	• Hard water is that which does not produce lather with soap.
Importance	
• It does not affect the cleaning action of soap.	• It decreases the cleaning reaction of soap.
Scum formation	

• It does not form scum with soap	• It forms scum with soap.

7. What are the causes of hardness in water? ***(Knowledge+Understanding Base)***

(GRW 2015, LHR 2014, 15, RWP 2016 G-II, MTN 2016 G-II)

Ans: **CAUSES OF HARDNESS**

The rain water while coming down absorbs carbon dioxide from the atmosphere. The water mixed with carbon dioxide, when passes through the beds of the soil, converts insoluble carbonates of calcium and magnesium into soluble bicarbonates. It may also dissolve chlorides and sulphates of calcium and magnesium.

$$CaCO_{3(s)} + H_2O + CO_2 \longrightarrow Ca(HCO_3)_{2(aq)}$$

$$MgCO_{3(s)} + CO_2 + H_2O \longrightarrow Mg\left(HCO_3\right)_{2(aq)}$$

8. What are the effects of temporary hardness in water? ***(Knowledge Base)*** **(LHR 2013)**

Ans: **EFFECTS OF TEMPORARY HARDNESS**

Temporary hardness is because of presence of bicarbonates of calcium and magnesium.

Effects:

- Hard water consumes large amount of soap in washing purposes.
- Drinking hard water causes stomach disorders.
- Hard water is unfit for use in steam engines, boilers and turbines because insoluble calcium and magnesium salts are deposited inside, which is called scales. They are bad conductors of heat and hence more fuel is used. Insoluble calcium and magnesium sulphates not only reduce the efficiency of the engine but also cause the boiler to burst.

9. Mention the disadvantages of detergents. ***(Knowledge Base)***

(GRW 2014, LHR 2015, SWL 2016 G-I, DGK 2016 G-I, BWP 2017, DGK 2017)

Ans: **DISADVANTAGES OF DETERGENTS**

The disadvantages of detergents are as follows:

- Detergents have a major disadvantage over the soaps as some of the detergents are non-biodegradable (cannot be decomposed by micro-organisms like bacteria).
- Detergents cause water pollution.
- The detergents remain in the water for a long time and make the water unfit for aquatic life.
- The phosphate salts present in detergents cause rapid growth of algae.

10. What is difference between biodegradable and non-biodegradable substances? ***(Knowledge Base)*** **(GRW 2014, MTN 2016 G-II, 17)**

Ans: **DIFFERENTIATION**

The differences between biodegradable substances and non-biodegradable substances are as follows:

Biodegradable Substances	Non-Biodegradable Substances
Definition	
• The substance which can be decomposed by microrganisms like bacteria are called bio-degradable substances.	• The substances which cannot be decomposed by microorganism like bacteria are called non-biodegradable substances.
Examples	

• Dead bodies of living organisms like plants and animals	• Plastics • Rubber

11. How detergents make the water unfit for aquatic life? *(Understanding Base)*

(GRW 2015, RWP 2017, SGD 2017, FSD 2017)

Ans: **<u>DETERGENTS AND AQUATIC LIFE</u>**

Detergents make the water unfit for aquatic life because:

(i) <u>Non-biodegradable:</u>

The detergents are non-biodegradable, so they remain in the water for a long time and make the water unfit for aquatic life.

(ii) <u>Phosphate Salts:</u>

The phosphate salts present in detergents cause rapid growth of algae in water bodies, which floats over the surface of water. These plants ultimately die and decay. Decaying plants being biodegradable consume O_2 present in water. Thus, depletion of O_2 results in death of aquatic life.

12. Why pesticides are used? *(Knowledge Base)* **(SWL 2016 G-II, MTN 2016 G-I)**

Ans: **<u>USE OF PESTICIDES</u>**

Pesticides are used either directly to kill or control the growth of pests. Pests may be weeds, herbs, insects, fungi, viruses, etc. they all damage crops and transmit diseases both to human beings and animals.

13. What is the reason of waterborne diseases? *(Knowledge Base)*

(GRW 2014, 2015, MTN 2016 G-I)

Ans: **<u>CAUSE OF WATERBORNE DISEASES</u>**

The reason of waterborne diseases are as follows:

- "**Toxins**" like arsenic, mercury lead and many organic chemicals.
- "**Microorganisms**" like viruses, bacteria, protozoa and worms present in water.

The main cause of waterborne diseases is lack of proper sanitation facilities.

14. How waterborne diseases can be prevented? *(Application Base)*

(SGD 2016 G-I, DGK 2016 G-II)

Ans: **<u>PREVENTION OF WATERBORNE DISEASES</u>**

The waterborne diseases can be prevented by the following methods:

- Provision of safe water
- Disposal of sewage
- Control of toxic chemicals
- Drinking water must be properly treated and purified
- There must be adequate sanitary disposal of waste.
- Chemical contamination can cause acute illness but often toxic contaminants are

slow poisons and carcinogens. There must be strict control over the use of pesticides and other chemicals.

EXERCISE LONG QUESTIONS

1. How polarity of water molecule plays its role to dissolve the substances?
Ans: See LQ. 2 (Topic 15.2)
2. Explain the methods of removing permanent hardness.
Ans: See LQ. 2 (Topic 15.3)
3. Explain the water pollution because of industrial waste.
Ans: See LQ. 2 (Topic 15.4)
4. Justify the statement: household water is the reason of water pollution.
Ans: See LQ.3 (Topic 15.4)
5. Explain agricultural effluents are fatal for aquatic life.
Ans: See LQ. 4 (Topic 15.4)
6. Explain five important waterborne diseases. How can these be prevented?
Ans: See LQ. 1 (Topic 15.5)
7. Give some disadvantages of hard water.
Ans: See LQ. 3 (Topic 15.3)
8. What is water pollution? Describe the effects of using polluted water.
Ans: See LQ. 1 (Topic 15.4)
9. Explain the reasons, water is considered a universal solvent.
Ans: See LQ. 2 (Topic 15.2)
10. Write a note on the treatment of sewage water.
(Understanding+Application Base)

Ans: **SEWAGE TREATMENT**

Definition:

"Sewage treatment is the process of removing contaminants from wastewater, primarily from household sewage".

Methods:

It includes physical, chemical, and biological processes to remove these contaminants and produce environmentally safe treated wastewater (or treated effluent).

STEPS INVOLVED

Sewage treatment generally involves three stages, called primary, secondary and tertiary treatment.

1. Primary Treatment:

"It consists of temporarily holding the sewage in a quiescent basin where heavy solids can settle to the bottom while oil, grease and lighter solids float to the surface. The settled and floating materials are removed and the remaining liquid may be discharged or subjected to secondary treatment".

Some sewage treatment plants that are connected to a combined sewage system have a bypass arrangement after the primary treatment unit. This means that during very heavy rainfall events, the secondary and tertiary treatment systems can be bypassed to protect them from hydraulic overloading, and the mixture of sewage and storm water only receives primary treatment.

2. Secondary Treatment:

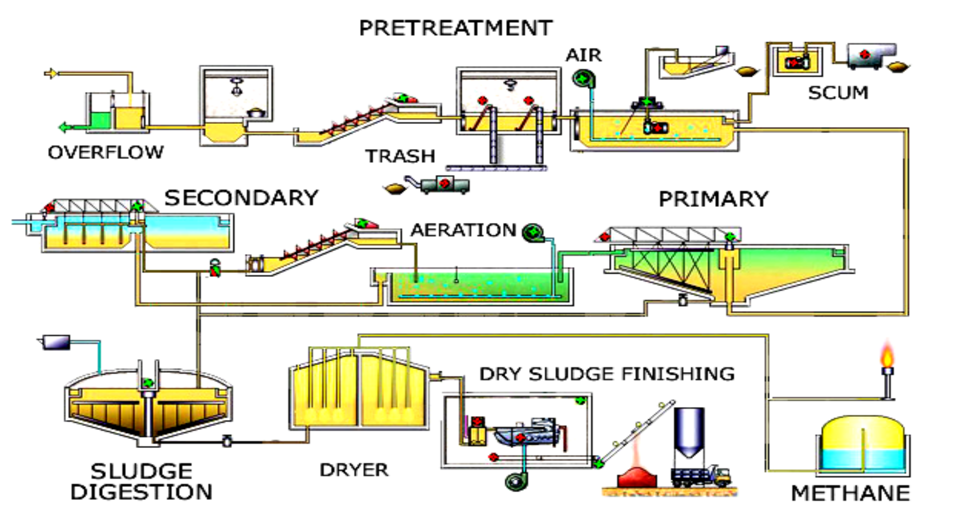
"Secondary treatment removes dissolved and suspended biological matter. Secondary treatment is typically performed by indigenous, water-borne micro-organisms in a managed habitat".

Secondary treatment may require a separation process to remove the micro-organisms from the treated water prior to discharge or tertiary treatment.

3. <u>Tertiary Treatment:</u>

"Tertiary treatment is sometimes defined as anything more than primary and secondary treatment in order to allow rejection into a highly sensitive or fragile ecosystem (estuaries, low-flow rivers, coral reefs)".

Treated water is sometimes disinfected chemically or physically (for example, by lagoons and microfiltration) prior to discharge into a stream, river, bay, lagoon or wetland, or it can be used for the irrigation of a golf course, green way or park. If it is sufficiently cleaned, it can also be used for groundwater recharge or agricultural purposes.



<u>Figure: Simplified process flow diagram for a typical large-scale treatment plant</u>

ADDITIONAL CONCEPTUAL QUESTIONS

Q.1 What is chlorination process of water?

(Science, Technology and Society Pg. # 148)

Ans: **<u>CHLORINATION OF WATER</u>**

<u>Definition:</u>

"*The process of passing of chlorine through water to kill bacteria and other micro-organisms is called chlorination".*

<u>Mechanism of Chlorination of Water:</u>

Swimming pools are cleaned by **chlorination process.** It is the addition of chlorine solution in swimming' pools. Chlorine kills bacteria and other micro-organisms. Cl_2 itself does not kill rather it dissociates in water to form **hypoclorous acid (HOCl)** and hydrochloric acid.

$$Cl_{2(g)} + H_2O_{(l)} \longrightarrow HOCl_{(aq)} + H^+_{(aq)} + Cl^-_{(aq)}$$

HOCl further ionizes to produce **hypochlorite** and proton.

$$HOCl_{(aq)} \longrightarrow H^+_{(aq)} + OCl^-_{(aq)}$$

Both the products HOCI and OCl^- kill bacteria and micro-organisms.

Q.2 What is difference between hepatitis and jaundice? **(LHR 2015)**

Ans:

DIFFERENTIATION

Hepatitis	Jaundice
Effects	
• It is liver inflammation.	• In this disease, liver ceases to function and eyes turn yellow. Patient feels weekness and fatigue.
Cause	
• It is caused by one of five viruses called hepatitis A, B, C, D and E.	• It is caused by an excess of bile pigments in the blood.

Q.3 Differentiate between temporary hardness and permanent hardness.

Ans:

DIFFERENTIATION

Temporary Hardness	Permanent Hardness
Definition	
• It is because of presence of bicarbonates of calcium and magnesium.	• It is because of presence of sulphates and chlorides of calcium and magnesium.
Removal	
• It can be removed by physical as well as chemical method.	• It can only be removed by chemical method.

Q.4 Why sea water is unfit for drinking and agricultural purposes? ***(Knowledge Base)***

Ans:

SEA WATER IS UNFIT

Sea water is unfit for drinking and agricultural purposes due to high percentage of dissolved salts. **Only 0.2% of the total water on the Earth is potable, i.e. fit for drinking purposes.**

Q.5 What is meant by heat capacity of water?

Ans: Heat capacity is defined as, "The amount of heat required to raise the temperature of one gram of water by 1 ^oC". Water has a high heat capacity meaning it takes more energy to increase the temperature of wataer compared to other substances.

TERMS TO KNOW

Terms	Definitions
Ground Water Pollution	The contamination of ground water due to undesirable and harmful substances is called ground water pollution.
Capillary Action	Capillary action is the process by which water rises up from the roots of plants to leaves. This process is vital for the survival of the land plants.

Hydrogen Bonding	The attractive force present between partial positive hydrogen end of one molecule and partial negative end of more electronegative atom of other molecule is called Hydrogen bonding.
Soft Water	Soft water is that which produces good lather with soap.
Hard Water	Hard water is that which does not produce lather with soap.
Temporary Hardness	It is because of presence of bicarbonates of calcium and magnesium.
Permanent Hardness	It is because of presence of sulphates and chlorides of calcium and magnesium.
Water Pollution	Water pollution is a contamination of water bodies (e.g. lakes, rivers, oceans and ground water).
Agricultural Effluents	The waste water of agricultural sources is called agricultural effluents.
Industrial Effluents	The waste materials (particles) which are discharged by industrial units are called industrial waste or industrial effluents.
Waterborne Infectious Diseases	Diseases that spread because of drinking polluted water or eating food prepared with polluted water are called waterborne infectious diseases.
Chlorination	The process of passing of chlorine through water to kill bacteria and other micro-organisms is called chlorination.
Dysentery	Dysentery is an intestinal disease which is typically caused by certain bacteria or parasites. It is characterized by severe diarrhea that may be accompanied by blood or mucous.
Fluorosis	Fluorosis is a disease caused by the consumption of excess fluoride. Flurorosis can cause bones and teeth damage.
Hepatitis	It is liver inflammation commonly caused by one of five viruses called hepatitis A, B, C, D and E.
Bio-degradable Substances	The substance which can be decomposed by micro-organisms like bacteria are called bio-degradable substances.

CUT HERE

SELF TEST

Time: 35 Minutes **Marks: 25**

Q.1 Four possible answers (A), (B), (C) and (D) to each question are given, mark the correct answer. **(6×1=6)**

1. The %age of drinkable water on earth is:
(A) 2.0% (B) 0.02%
(C) 0.2% (D) 5%

2. The heat capacity of water is:
(A) 4.3 K/gk (B) 4.2 $Jg^{-1}K^{-1}$
(C) 4.4 $Jg^{-1}k^{-1}$ (D) 4.1 $Jg^{-1}K^{-1}$

3. Water molecule has a structure:
(A) Polar (B) Non-polar
(C) Both (D) None of these

4. It is sparingly soluble in water:
(A) Limestone (B) Benzene
(C) Ether (D) Gypsum

5. The disease that causes bones and teeth damage:
(A) Fluorosis (B) Hepatitis
(C) Cholera (D) Jaundice

6. Temporary hardness is removed by adding:
(A) Quick lime (B) Slaked lime
(C) Limestone (D) Lime water

Q.2 Give short answers to the following questions. **(5×2=10)**

(i) What is the distribution of water?

(ii) Differentiate between soft and hard water?

(iii) Write two disadvantages of hard water?

(iv) What is the function of fertilizer?

(v) What do you mean by fluorosis?

Q.3 Answer the following questions in detail. **(5+4=9)**

(i) Explain water pollution because of industrial wastes? **(5)**

(ii) Write two methods used for removal of permanent hardness of water. **(4)**

NOTE: Parents or guardians can conduct this test in their supervision in order to check the skill of students.

CHAPTER 16
CHEMICAL INDUSTRIES

INTRODUCTION

LONG QUESTION

Q.1 (A) What is importance of chemical industries in Pakistan? *(Knowledge Base)*
(B) Explain historical background of industries in Pakistan.

Ans: (A)

IMPORTANCE OF CHEMICAL INDUSTRIES

Chemical industries are established to meet the needs of modern societies.

(i) Metals:

Metallurgy is the science of extracting metals form ores. Metals have played a major role in progress of societies. Since ages metals are used for making tools, machines and other items. In the modern age, although polymers have taken the place of metals, yet the importance of metals cannot be ignored.

(ii) Polymers:

In a number of cases polymers have taken the place of metals.

(iii) Baking and Washing Soda:

Baking soda ($NaHCO_3$) and washing soda (Na_2CO_3) are used in daily life for different purposes.

(iv) Fertilizers:

Fertilizers are vital for the growth and development of plants and crops. One of the important fertilizers urea, is used to enhance the productivity of crops.

(v) Petroleum Industry:

In the modern age of communication, petroleum industry has a great significance.

Use of Petroleum proudcts:

Petroleum products are used as fuel, solvent and lubricants.

Use of petrochemicals:

Petrochemicals are used to manufacture a variety of household items, plastics, detergents, rubber etc.

HISTORICAL BACKGROUND OF INDUSTRIES

Pakistan Industrial Base:

Pakistan industrial base was very weak at the time of independence.

Total Industries in India:

At the time of partition, there were 921 big industrial units in India.

Pakistan's Share:

Out of these only 34 came to the share of Pakistan.

Measures Taken to Develop Industry:

- After the independence, government made a lot of policies and encouraged the private sector to establish industrial units.
- A lot of steps and measures are taken to set up corporations to facilitate loans and technical know-how for the rapid development of industries.
- Chemical industry was rapidly developed because the chemicals are used for the manufacturing of ammunitions, fertilizers and other substances of daily use.

Industrial Products of Pakistan:

Pakistan is now producing a lot of products like:

- Chemicals
- Fertilizers
- Cement
- Steel
- Heavy engineering machines and tools.

INTRODUCTION

SHORT QUESTIONS

Q.1 How are chemical industries important to us? *(Knowledge Base)*

Ans: *Answer given on Page # 330 (Industrial Products of Pakistan)*

Q.2 Give chemical formulas of baking and washing soda? *(Knowledge Base)*

Ans: **CHEMICAL FORMULAS**

The chemical formulas of baking and washing soda are as follows:

- Baking soda : $NaHCO_3$
- Washing soda : $Na_2CO_3.10H_2O$

Q.3 What was Pakistan's industrial base at the time of independence? *(Knowledge Base)*

Ans: **PAKISTAN INDUSTRIAL BASE**

Pakistan industrial base was very weak at the time of independence.

Total Industries in India:

At the time of partition, there were 921 big industrial units in India.

Pakistan's Share:

Out of these only 34 came to the share of Pakistan.

MULTIPLE CHOICE QUESTIONS

1. **Fertilizer urea is used to enhance: *(K.B)***
   (A) Variety of items (B) Both A and C
   (C) Productivity of crops (D) None of these
2. **These are used as fuel, solvent and lubricants: *(K.B)***
   (A) Petrochemicals (B) Fertilizers
   (C) Petroleum products (D) Ores
3. **Big industries in India at the time of partition: *(K.B)***
   (A) 989 (B) 924
   (C) 926 (D) 921
4. **How many industries came in share of Pakistan? *(K.B)***
   (A) 36 (B) 33
   (C) 34 (D) 30
5. **Chemical formula of baking soda is: *(K.B)***
   (A) $NaHCO_3$ (B) Na_2CO_3
   (C) $CaCO_3$ (D) $Na_2CO_3.10H_2O$
6. **Chemical formula of washing soda is: *(K.B)***
   (A) $NaHCO_3$ (B) Na_2CO_3
   (C) $CaCO_3$ (D) $Na_2CO_3.2H_2O$

16.1 BASIC METALLURGICAL OPERATIONS

LONG QUESTIONS

Q.1 Define the terms. *(Knowledge Base)*

(LHR 2015, RWP 2016 G-II, MTN 2016 G-I, BWP 2016 G-I)

(i) Mineral (ii) Ore (iii) Gangue.

Ans: **DEFINITIONS**

MINERALS:

(LHR 2015, RWP 2016 G-II, MTN 2016 G-I, BWP 2016 G-I)

*"The **solid natural materials** found **beneath** the **Earth's surface,** which contain **compounds of metals** in the combined state **along with earthly impurities**, are called minerals".*

Examples:

- Rocks salt
- Gypsum

ORES: **(LHR 2015, SWL 2017, RWP 2017, DGK 2016 G-II)**

"*Those **minerals** from which the **metals** are **extracted commercially** at a comparatively **low cost** with minimum effort are called ores of the metals".*

All ores of the metals are minerals, but all minerals are not ores.

Examples:

- Copper glance (Cu_2S)
- Chalcopyrite ($CuFeS_2$)

GANGUE: **(GRW 2014, SGD 2016 G-I)**

*The **earthly** and other **impurities associated** with the **minerals** are known as gangue.*

Examples:

- Soil
- Clay
- Sand

Q.2 Define metallurgy. Describe different steps involved in the metallurgy.
(Knowledge+Understanding+Application Base)

(DGK 2017, BWP 2017)

Ans: **METALLURGY**

Definition:

*"The process of extraction of a metal in **pure state** on a **large scale** from its **ore** by **physical** or **chemical means** is called metallurgy".*

STEPS INVOLVED

The processes involved in metallurgy for extraction of a metal in the pure state from its ore are:

(i) Concentration of the ore
(ii) Extraction of the metal
(iii) Refining of the metal

(i) Concentration of the Ore: **(MTN 2017) (Ex-Q.1)**

*"The process of **removal of gangue** from the ore is technically known as concentration and the **purified ore** is called the **concentrate**".*

Methods to Concentrate an Ore:

Concentration of the crushed ore is carried out by the following methods:

(a) Gravity Separation: **(SGD 2016 G-I, MTN 2016 G-I)**

*Gravity separation is based on the **differences** in **densities** of the **metallic ore** and the **gangue particles**.*

Working:

In the process, the **powdered heavy metal** bearing **ore settles down** on agitation in a stream of water, while the **lighter gangue particles** are carried away by the water.

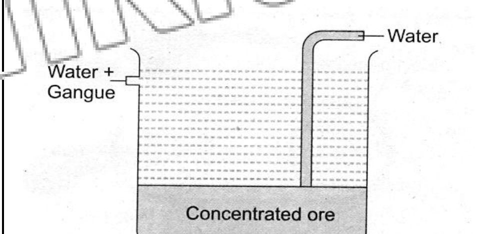


Figure: Gravity Separation

(b) Froth Flotation Process: **(GRW 2014, 17, SGD 2016 G-II)**

*"Froth flotation process is based on the **wetting characteristic** of the ore and the **gangue** particles with **oil and water**, **respectively**."*

Working:

The **ore particles** are **preferentially wetted by oil** and the **gangue particles** by the **water**. The whole mixture is **agitated** with compressed air. Hence, oil coated particles being **lighter** come to the surface in the form of a **froth** that can be skimmed.

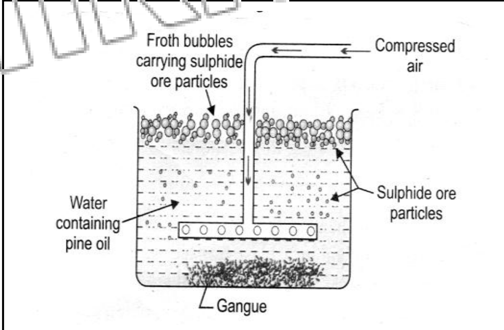


Figure: Froth Flotation Process

(c) Electromagnetic Separation: **(LHR 2014; GRW 2014, SGD 2016 G-II, RWP 2016 G-I)**

*Electromagnetic separation is based on the **separation of magnetic ores** from **the non-magnetic impurities** by means of electro-magnets or magnetic separators.*

Working:

The **powdered ore is dropped** over a **leather belt** moving over **two rollers**, one of which is magnetic. The ore gets attracted and is collected nearer to the magnet while the non-magnetic impurities fall further away.

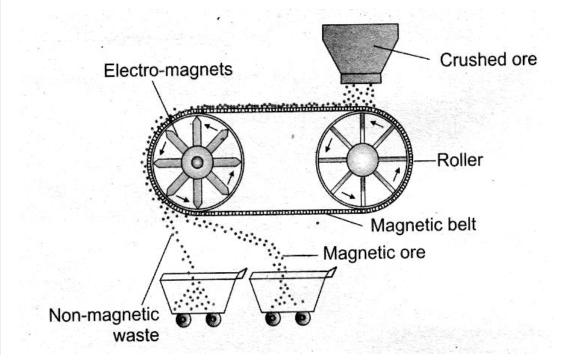


Figure: Magnetic Separation

(ii) Extraction of the Metal From the Concentrated Ore:

The metal is isolated from the concentrated ore by chemical reduction or electrolytic processes. Chemical methods of reduction of ore involves following methods:

(a) Roasting: **(LHR 2013, SWL 2017)**

*It is a process of **heating** the **concentrated ore** to a **high temperature** in excess of **air**.*

Example:

Copper pyrite ($CuFeS_2$) is strongly heated in excess of air to convert it into a mixture of cuprous sulphide and ferrous sulphide (Cu_2S + FeS). While impurities react with oxygen to form volatile oxides.

$$2CuFeS_{2(s)} + O_{2(g)} \longrightarrow 2FeS_{(s)} + Cu_2S_{(s)} + SO_{2(g)} \uparrow$$

(b) <u>Smelting:</u>

(GRW 2014, 2015, 2016, BWP 2016 G-II, 17, DGK 2016 G-I & II, RWP 2017) (Ex.Q 7)

*It is further **heating** the **roasted ore** with **sand flux** and **coke** in the presence of **excess** of **air** in a blast furnace.*

<u>Process</u>:

It is **highly exothermic process**, therefore a **small amount of coke** is required in the process. In the process, **first ferrous sulphide oxidizes** to form ferrous oxide which reacts with sand to form iron silicate slag ($FeSiO_3$). It being lighter rises to the top and is removed from the upper hole.

$$\mathbf{2FeS_{(s)} + 3O_{2(g)} \longrightarrow 2\,FeO_{(s)} + 2SO_{2(g)} \uparrow}$$

$$\mathbf{FeO_{(s)} + SiO_{2(g)} \longrightarrow FeSiO_{3(s)}}$$

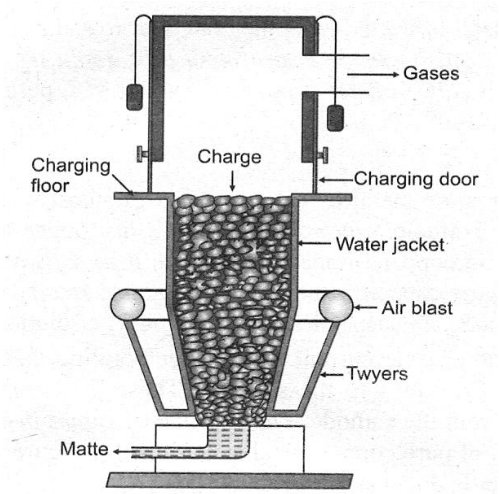
Cuprous sulphide also **oxidizes** to form **cuprous oxide** which reacts with unreacted ferrous sulphide to form ferrous oxide and cuprous sulphide.

<u>Matte:</u>

Cuprous sulphide and ferrous sulphide form a mixture **($Cu_2S.FeS$)**. **This molten mixture is called matte.** It is withdrawn from the lower hole. It contains about **45%** of copper.

$$\mathbf{2Cu_2S_{(l)} + 3O_{2(g)} \longrightarrow 2Cu_2O_{(l)} + 2SO_{2(g)}}$$

$$\mathbf{Cu_2O_{(l)} + FeS_{(l)} \longrightarrow Cu_2S_{(l)} + FeO_{(l)}}$$



<u>Figure: Blast Furnace For Smelting of Copper</u>

(c) <u>Bessemerization:</u>

(GRW 2014, 15, WL 2016 G-I, DGK 2017, MTN 2016 G-I & II, 17, RWP 2017)

"It *is the further **heating** of the **molten matte** in a pear shaped **bessemer converter.**"*

<u>Bessemer Converter:</u>

Bessemer converter is the furnace which is used to performed bessemerizaiton. It is fixed on a pivot, so that it can be tilted in any direction.

<u>Process:</u>

Molten matte is mixed with **sand** and **heated** with a **hot blast** of **air** through tuyers. Ferrous sulphide is oxidized to form ferrous oxide which reacts with sand to form slag ($FeSiO_3$) that floats on the top.

$$2FeS_{(s)} + 3O_{2(g)} \longrightarrow 2FeO_{(s)} + 2SO_{2(g)}$$

$$FeO_{(s)} + SiO_{2(s)} \longrightarrow FeSiO_{3(slag)}$$

Cuprous sulphide is oxidized to form cuprous oxide, which again reacts with remaining cuprous sulphide to form metallic copper.

$$2Cu_2S_{(s)} + 3O_{2(g)} \longrightarrow 2Cu_2O_{(l)} + 2SO_{2(g)} \uparrow$$

$$2Cu_2O_{(s)} + Cu_2S_{(s)} \longrightarrow 6Cu_{(l)} + SO_{2(g)} \uparrow$$

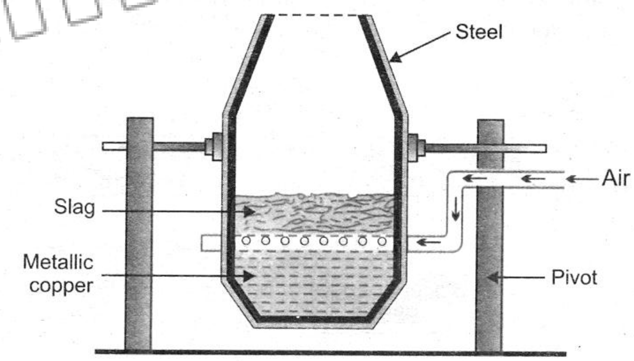


Figure: Bessemer Converter Used For Bassemerization of Copper

Blister Copper:

*"The **molten metal** is **shifted** from the **converter to sand moulds** and is allowed to **cool**. The dissolved **gases escape** out forming **blisters** on the surface of the solid copper. Therefore, it is called blister copper. It is about **98% pure copper**. It is further refined by electrolysis".*

(iii) Refining or Purification of the Metal: **(LHR 2015)**

*Refining the **impure metal by electrolysis** is the most widely used process of refining metals.*

Example:

Electrolytic refining of copper is carried out in an electrolytic tank.

Electrolytic Cell:

The concentration and working of electrolytic cell is as follows:

Electrode:

There are two copper electrodes:

- **Anode:** Impure copper metal acts as anode.
- **Cathode:** Pure copper metal acts as cathode

Both electrodes are suspended in electrolytic solution.

Electrolyte:

Copper sulphate solution is used as an electrolyte.

Working:

On passing the electric current through the solution, anode (impure copper) dissolves to provide Cu^{2+} ions to the solution. These Cu^{2+} ions are discharged by gaining of electrons from the cathode. Thereby copper atoms deposit on the cathode, making it thick block of pure copper metal.

Impurities Obtained:

The impurities like gold and silver settle down as anode mud.

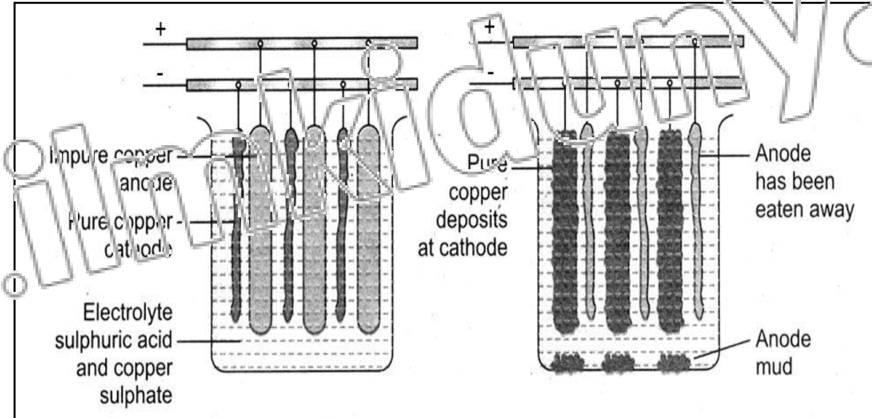


Figure: Electro-refining of Copper

Net Result:

In this process, impure copper from the anode dissolves and goes into the copper sulphate solution. Side by side, pure copper ions from the solution deposit on the cathode. Thus, cathode becomes a pure copper metal. The impurities like gold and· silver settle down as anode mud.

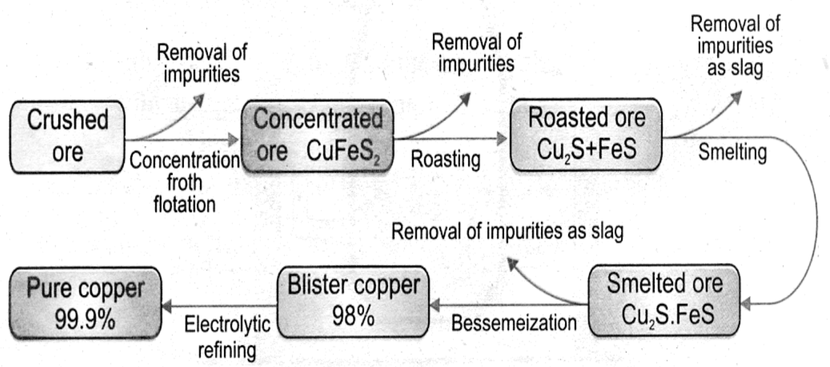


Figure: Flow Sheet Diagram for Extraction of Copper 3

16.1 BASIC METALLURGICAL OPERATIONS

SHORT QUESTIONS

Q.1 Define matte. ***(Knowledge Base)***

Ans:

MATTE

Definition:

"During smelting of copper ore cuprous sulphide and ferrous sulpide form a mixture ($Cu_2S.FeS$). This molten mixture is called matte".

Withdrawl of matte:

It is withdrawn from lower hole. It contains about 45% of copper.

$$2Cu_2S + 3O_2 \longrightarrow 2Cu_2O + 2SO_2$$

Q.2 What is metallurgy? ***(Knowledge Base)***

(DGK 2017, FSD 2016 G-II, 17, RWP 2016, G-II RWP 2017)

Ans: *Answer given on Page # 332*

Q.3 Describe froth flotation process. ***(Knowledge+Application Base)***

(GRW 2014, 17, FSD 2016 G-I, SWL 2016 G-II)

Ans: *Answer given on Page # 333*

Q.4 Write the formula of copper glance and chalcopyrite. ***(Knowledge Base)***

(SGD 2016 G-II)

Ans: **FORMULAS**

The formulas of copper glance and chalcopyrite are as follows:

- **Copper glance** : Cu_2S
- **Chalcopyrite** : $CuFeS_2$

Q.5 What is gangue? Also write chemical formula of copper glance. ***(Knowledge Base)***

(GRW 2014, SGD 2016 G-I, RWP 2016 G-II)

Ans: *Answer given on Page # 332*

Q.6 How concentration of ore is done by gravity separation and electromagnetic separation? ***(Knowledge+Application Base)*** **(DGK 2016 G-I)**

Ans: **CONCENTRATION OF ORE**

Concentration of ore is done by the following methods:

Gravity Separation:

In the process, the powdered heavy metal bearing ore settles down on agitation in a stream of water, while the lighter gangue particles are carried away by the water.

Electromagnetic Separation:

The powdered ore is dropped over a leather belt moving over two rollers, one of which is magnetic. The ore gets attracted and is collected nearer to the magnet while the non-magnetic impurities fall further away.

Q.7 Why hair colour of different people is different? ***(Knowledge Base)***

(Interesting Information Pg. # 56)

Ans: **HAIR COLOUR OF PEOPLE**

The colour of hair is cuased by the presence of transition metal compounds in the hair.

- **Brown hair** contains **iron** or **copper** compounds
- **Blonde hair** contains compounds of **titanium**
- **Redhead hair** is because of the presence of **molybdenum** compounds

16.1 BASIC METALLURGICAL OPERATIONS

MULTIPLE CHOICE QUESTIONS

1. **Science of extracting metals from ores is called:** ***(K.B)***
   (A) Gangue (B) Metallurgy
   (C) Bessemerization (D) Calcination
2. **Blister copper contains:** ***(K.B)***
   (A) 95% pure copper (B) 99% pure copper
   (C) 98% pure copper (D) 92% pure copper

3. Cuprous sulphide oxidizes to form: *(K.B)*
(A) Cuprous sulphate (B) Cupric oxide
(C) Cuprous oxide (D) Cupric sulphate

4. Matte contains ___________% copper: *(K.B)*
(A) 30 (B) 35
(C) 40 (D) 45

5. Molten mixture of $Cu_2S.FeS$ is called: *(K.B)*
(A) Ore (B) Matte
(C) Soil (D) Petroleum

6. First process involved in metallurgy is: *(K.B)*
(A) Extraction of metals (B) Smelting
(C) Froth flotation (D) Concentration of ore

7. Process based on wetting characteristics of ore is called: *(K.B)*
(A) Electrolytic separation (B) Smelting
(C) Froth flotation (D) Gravity separation

8. Separation of magnetic ore from non magnetic is called: *(K.B)*
(A) Gravity separation (B) Electromagnetic separation
(C) Concentrate (D) Matte

9. Brown hair contains: *(K.B)*
(A) Titanium (B) Molybdenum
(C) Iron or copper compounds (D) Alkali metals

10. Blonde hair contains: *(K.B)*
(A) Titanium (B) Molybdenum
(C) Iron or copper compounds (D) Alkali metals

11. Red hair contains: *(K.B)*
(A) Titanium (B) Molybdenum
(C) Iron or copper compounds (D) Alkali metals

12. Process of extraction of metal in pure state is: *(K.B)*
(A) Gangue (B) Gravity separation
(C) Metallurgy (D) Electromagnetic Separation

13. Process of removal of gangue from ore is called: *(K.B)*
(A) Concentrate (B) Metallurgy
(C) Concentration (D) Ores

14. Minerals are those solid natural materials which contain: *(K.B)*
(A) Compounds of non-metals (B) Compounds of metals
(C) Both A and B (D) None of these

15. Example of ores is:
(A) $NaHCO_3$ (B) Cu_2S
(C) NaCl (D) Both B and C

16. Cause of color of hair is due to presence of:
(A) Alkali Metal (B) Halogens
(C) Transition element (D) Noble Gases

17. The chemical formula of chalcopyrite is: *(K.B)* **(GRW 2016)**
(A) Cu_2S (B) $CuFeS_2$
(C) CuS (D) FeS

16.1 TEST YOURSELF

i. Define concentration process used in metallurgy of copper. *(Knowledge Base)*

Ans: **CONCENTRATION OF ORE**

Definition:

"The process of removal of gangue from the ore is technically known as concentration and the purified ore is called the concentrate."

Methods:

Concentration of crushed ore is carried out by following methods:

- Gravity separation
- Electromagnetic separation
- Froth flotation process

ii. Why a small amount of coke is required in the smelting process? *(Knowledge Base)*

Ans: **USE OF COKE**

A small amount of coke is required in the smelting process because smelting is further heating the roasted ore with sand flux and coke in the presence of excess of air in a blast furnace. It is highly exothermic process. More over the coke initiates the reaction.

Reaction:

$$2FeS_{(s)} + 3O_{2(g)} \longrightarrow 2FeO_{(s)} + 2SO_{2(g)}\uparrow$$

$$FeO_{(s)} + SiO_{2(g)} \longrightarrow FeSiO_{3(s)}$$

iii. Why lime is added in the smelting process? *(Knowledge Base)*

Ans: **ADDITION OF LIME**

Lime ($CaCO_3$) is added to remove excess of SiO_2. Lime decomposes to form CaO, which reacts with sand to form slag.

$$CaCO_3 \longrightarrow CaO + CO_2$$

$$CaO + SiO_2 \longrightarrow CaSiO_{3(Slag)}$$

Slag is removed from the upper hole.

iv. How slag and matte are removed from the blast furnance? *(Knowledge Base)*

Ans: **REMOVAL OF SLAG AND MATTE**

Slag:

Slag ($FeSiO_3$) being lighter rises to the top and forms upper layer, which is removed from the upper hole.

Matte:

Matte is a mixture of cuprous sulphide along with some unreacted ferrous sulphide ($Cu_2S.FeS$) forms a lower layer. It is withdrawn from the lower hole.

v. What is difference between slag and matte? *(Knowledge Base+Understanding Base)*
(SGD 2017)

Ans: **DIFFERENTIATION**

The differences between slag and matte are as follows:

Slag	Matte
Definition	
• *When flux combines with gangue it will form slag which being lighter in weight and floats on the molten metal.*	• *Blast furnace cuprous sulphide and ferrous sulphide form a mixture (Cu_2S, FeS). This molten mixture is called matte.*
Density	
• *It is lighter than the metal*	• *It is heavier than the metal*

vi. Mention the chemical reaction for the formation of metallic copper in the bessemerization process. ***(Knowledge Base)***

Ans: **<u>FORMATION OF METALLIC COPPER</u>**

The chemical reactions for the formation of metallic copper in the bessemerization process are given as follows:

$$2FeS_{(s)} + 3O_{2(g)} \longrightarrow 2FeO_{(s)} + 2SO_{2(g)}$$

$$FeO_{(s)} + SiO_{2(s)} \longrightarrow FeSiO_{3(slag)}$$

$$2Cu_2S_{(s)} + 3O_{2(g)} \longrightarrow 2Cu_2O_{(l)} + 2SO_{2(g)}\uparrow$$

$$2Cu_2O_{(s)} + Cu_2S_{(s)} \longrightarrow 6Cu_{(l)} + SO_{2(g)}\uparrow$$

vii. What is blister copper? ***(Knowledge Base)***

Ans: **<u>BLISTER COPPER</u>**

<u>Definition:</u>

"The molten metal is shifted from the converter to sand moulds and is allowed to cool. The dissolved gases escape out forming blisters on the surface of the solid copper. Therefore, it is called blister copper".

<u>Composition:</u>

- It is about 98% pure copper.

<u>Refining:</u>

- It is further refined by electrolysis.

viii. Why anode is eaten up in electro-refining process? ***(Understanding Base)***

Ans: **<u>EATING UP OF ANODE</u>**

The anode is eaten up in electro-refining process becuase impure copper from the anode dissolves and goes into the copper sulphate solution. Side by side, pure copper ions from the solution deposit on the cathode. Thus, cathode becomes a pure copper metal. The impurities like gold and silver settle down as anode mud.

ix. What do you mean by anode mud? ***(Knowledge Base)*** **(MTN 2016 G-II)**

Ans: **<u>ANODE MUD</u>**

In electro-refining process, the impurities like gold and silver settle down under the anode and are called anode mud.

16.2 MANUFACTURE OF SODIUM CARBONATE BY SOLVAY'S PROCESS

LONG QUESTIONS

Q.1 Explain the industrial preparation of soda ash.
(Knowledge+Understanding+Application Base)

OR

Explain Solvay's Process for the manufacture of sodium carbonate.
(GRW 2013, LHR 2015, DGK 2017, MTN 2017, SWL 2017, BWP 2016 G-II RWP 2017)

OR

Write a detailed note on Ammonia Solvay's process. **(Ex-Q.3)**

Ans: **<u>SOLVAY'S PROCESS</u>**

<u>Principle:</u>

Principle of Solvay's process *lies in the* ***low solubility*** *of* ***sodium bicarbonate*** *at low temperature i.e. at 15°C. When CO_2 is passed through an ammonical solution of NaCl* *called ammonical brine, only $NaHCO_3$ precipitates.*

$$Na^{+}_{(aq)} + HCO_3^{-}{}_{(aq)} \longrightarrow NaHCO_{3(s)}$$

Raw Materials:

The raw materials needed for this process are cheap and easily available. They are in abundance such as,

- **Sodium chloride (NaCl) or brine**
- **Limestone ($CaCO_3$)**
- **Ammonia gas (NH_3)**

Basic Reactions/Steps Involved:

The process consists of the following steps:

(i) Preparation of Ammonical Brine:

First of all **ammonical brine** is prepared by dissolving **ammonia gas in sodium chloride** solution (brine).

(ii) Carbonation of Ammonical Brine: **(MTN 2016 G-I)**

Ammonical brine is fed **into carbonating tower** and **carbon dioxide** is passed through it. Following reactions take place in the carbonating tower.

$$CO_{2(g)} + NH_{3(g)} + H_2O_{(l)} \longrightarrow NH_4HCO_{3(aq)}$$

$$NH_4HCO_{3(s)} + NaCl_{(brine)} \longrightarrow NaHCO_{3(aq)} + NH_4Cl$$

The temperature of the mixture is **lowered to 15°C** and **precipitates** of **$NaHCO_3$** are obtained.

(iii) Filtration of Precipitates:

The milky solution from the carbonating tower is filtered to get sodium bicarbonate. It is used as a baking soda.

(iv) Calcination:

Sodium **bicarbonate** is heated to get sodium carbonate.

$$2NaHCO_{3(l)} \xrightarrow{heat} Na_2CO_{3(s)} + CO_{2(g)} + H_2O_{(l)}$$

CO_2 is again used in tower. It is about half of CO_2 needed in the process.

(v) Preparation of Carbon Dioxide and Slaked Lime:

CO_2 is prepared by heating limestone in a lime kiln. Then it is carried to carbonating tower.

$$CaCO_{3(s)} \xrightarrow{heat} CaO_{(s)} + CO_{2(g)}$$

Quick lime (CaO) formed in lime kiln is slaked with water. Then it is pumped to the ammonia recovery tower.

$$CaO_{(s)} + H_2O_{(l)} \xrightarrow{heat} \underset{\text{(slaked lime)}}{Ca(OH)_{2(aq)}}$$

(vi) Ammonia Recovery Tower:

Ammonia is recovered in this tower from **ammonium chloride** solution produced in the carbonated tower and calcium hydroxide formed in lime kiln.

$$2NH_4Cl_{(s)} + Ca(OH)_{2(l)} \longrightarrow 2NH_{3(g)} + CaCl_{2(s)} + 2H_2O_{(l)}$$

In fact, all **ammonia is recovered** in this tower and is **reused in the process**. There are minor losses of ammonia in the process which are compensated by using some fresh ammonia.

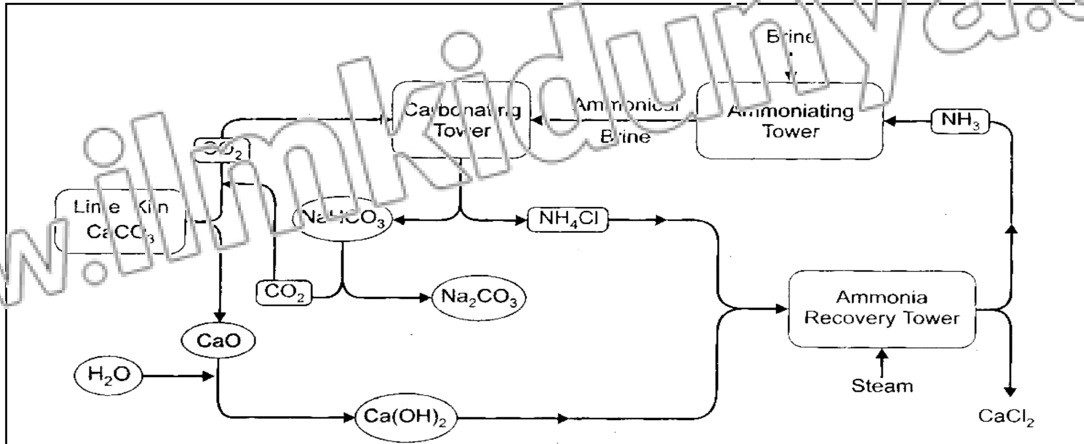


Figure: Flow Sheet Diagram of Solvay's Process for the Manufacturing of Sodium Carbonate

Advantages of Solvay's Process: **(LHR 2014, GRW 2015, BWP 2017, MTN 2017, RWP 2017)**

The advantages of Solvay's process are as follows:

(i) It is a **cheap process** as raw materials are available at very low prices.
(ii) Carbon dioxide and ammonia are **recovered and reused.**
(iii) Process is **pollution free,** because the only waste is calcium chloride solution.
(iv) Sodium carbonate of very **high purity** is obtained.
(v) Consumption of **fuel** is very less since no solution is to be evaporated.

Q.2 What are the important industries of soda ash in Pakistan? ***(Knowledge Base)***

Ans: **IMPORTANT INDUSTRIES OF SODA ASH**

The important industries of soda ash in Pakistan are as follows:

(i) Imperial Chemical Industries (ICI) Khewra (Jhelum):

Pakistan is self-sufficient as far as demand of sodium carbonate is concerned. **Imperial Chemical Industries (ICI)** Khewra **(Jhelum)** is producing enough **sodium carbonate.** This unit was established in 1944 in Khewra because abundant raw material sodium chloride is available here.

(ii) Sindh Alkali Limited:

A **Sindh Alkali Limited** was **established** near **Karachi** in **1966**. Sodium carbonate and sodium bicarbonate are important industrial chemicals and are used by many industries.

16.2 MANUFACTURE OF SODIUM CARBONATE BY SOLVAY'S PROCESS

SHORT QUESTIONS

Q.1 What do you mean by calcination? ***(Knowledge Base)***

(LHR 2015, MTN 2017, SGD 2016 G-I)

Ans: **CALCINATION**

Calcination is a process of thermal decomposition by heating a substance at high temperature below its melting point.

Example:

Sodium bicarbonate is heated to get sodium carbonate in the sovlay's process.

$$2NaHCO_{3(l)} \xrightarrow{heat} Na_2CO_{3(s)} + CO_{2(g)} + H_2O_{(l)}$$

Q.2 Write down two important compounds with their formulae which are used in the manufacture of sodium carbonate. ***(Knowledge Base)*** **(RWP 2016 G-II)**

Ans: **COMPOUNDS AND THEIR FORMULAS**

The two important compounds with their formulae which are used in the manufacture of sodium carbonate are as follows:

(i) Sodium chloride NaCl

(ii) Limestone $CaCO_3$

Q.3 What is role of technology in the production of common chemcials?
(Knowledge Base) **(Science, Technology and Society Pg. # 163)**

Ans: **ROLE OF TECHNOLOGY**

"Technology is considered a consequence of science and engineering".

Role:

- Technology began to influence human efforts to produce common chemicals since people began using different tools and machineries.
- Now it is because of use of technology that needs of people are being fulfilled.
- Use of technology has increased the production with improved quality of proudcts.

Examples:

Common chemcials are being produced on commercial scale by chemists or chemical engineers since centruies. Important example are:

- Alkalies
- Salts
- Soaps
- Detergents etc.

16.2 MANUFACTURE OF SODIUM CARBONATE BY SOLVAY'S PROCESS

MULTIPLE CHOICE QUESTIONS

1. Pakistan is self-sufficient for the demand of: ***(K.B)***
(A) Sodium carbonate (B) Sodium bicarbonate
(C) Sodium chloride (D) Sodium hydroxide

2. In Solvay's process, $CaCl_2$ solution is a material: ***(K.B)***
(A) Need (B) Waste Product
(C) Raw Material (D) Reactant

3. Solvay's process involves recovery and reuse of CO_2 and: ***(K.B)***
(A) Ammonia (B) Aluminium
(C) Sodium (D) NaCl

4. Sodium hydrogen carbonate decomposes to liberate gas. ***(K.B)***
(A) H_2 (B) SO_2
(C) CO_2 (D) N_2

5. **Solvay's process is: *(K.B)***
(A) Expensive process (B) Hydrogen free
(C) Pollution free (D) None of these

6. **"ICI" stands for: *(K.B)***
(A) International chemical industries (B) Imperial chemical industry
(C) International Compound Industry (D) None of these

7. **Sodium bicarbonate heated to get: *(K.B)***
(A) Lime kiln (B) Calcium hydroxide
(C) Sodium carbonate (D) Ammonia

8. **Quick lime reacts with water to form: *(K.B)***
(A) Lime water (B) Limestone
(C) Salt water (D) Slaked lime

9. **$NaHCO_3$ on heating produces: *(K.B)***
(A) NaOH (B) Na_2CO_3
(C) NaCl (D) $NaCO_3$

16.2 TEST YOURSELF

i. Why only $NaHCO_3$ precipitates, when CO_2 is passed through the ammonical brine? *(Knowledge Base)*

Ans: **PRECIPITATION OF $NaHCO_3$**

When CO_2 is passed through the ammonical brine, a mixture of NH_4Cl and $NaHCO_3$ is obtained. The temperature of the mixture is lowered to 15^oC and precipitates of $NaHCO_3$ are formed because $NaHCO_3$ is insoluble in water at low temperature.

ii. Which raw materials are required for the formation of sodium carbonate? *(Knowledge Base)*

Ans: **RAW MATERIALS**

The raw materials required for the formation of sodium carbonate are as follows?

- Sodium chloride (NaCl) or brine
- Limestone ($CaCO_3$)
- Ammonia gas (NH_3

These raw materials are cheap and easily available. They are in abundance.

iii. How CO_2 is prepared in the Solvay's process? *(Knowledge Base)* **(LHR 2013)**

Ans: **PREPARATION OF CO_2**

CO_2 is prepared by heating limestone in a lime kiln. Then it is carried to carbonating tower.

Reaciton:

$$CaCO_{3(s)} \xrightarrow{\Delta} CaO_{(s)} + CO_{2(g)}$$

iv. Give the reaction of formation of ammonia in the process? *(Knowledge Base)*

Ans: **FORMATION OF AMMONIA**

Ammonia is formed in ammonia recovery tower from ammonium chloride solution produced in the carbonated tower and calcium hydroxide formed in lime kiln.

Reaciton:

$$2NH_4Cl_{(s)} + Ca\,(OH)_{2(l)} \longrightarrow 2NH_{3(g)} + CaCl_{2(s)} + 2H_2O_{(l)}$$

v. Give the advantages of Solvay's process. ***(Knowledge Base)***

(LHR 2014, GRW 2015, SWL 2017)

Ans: *Answer given on Page # 342*

16.3 MANUFACTURE OF UREA

LONG QUESTIONS

Q.1 How urea is manufactured on industrial scale? ***(Knowledge Base)***

(SWL 2017, SGD 2017, FSD 2017, GWP 2016 G-I)

OR

How urea is manufactured? **(SGD 2017, FSD 2016 G-I)**

Ans: **MANUFACTURE OF UREA**

Properties of Urea:

- Urea is **nitrogenous fertilizer.**
- It consists of **46.6% nitrogen.**
- It is **white crystalline compound**
- Highly soluble in water.
- It is used for the manufacturing of important chemicals, but its major **(about 90%) use is as a fertilizer.**

Raw Materials: **(GRW 2015, 17)**

The raw materials for the manufacturing of urea are:

- **Ammonia (NH_3)**
- **Carbon dioxide (CO_2)**

Haber's Process: **(SWL 2017)**

Ammonia is prepared by the "Haber's process". One volume of nitrogen **(from air)** and three volumes of hydrogen (obtained by passing **methane** and **steam** over heated **nickel catalyst)** is passed over **iron catalyst** at **450°C** and **200 atm pressure.**

$$N_{2(g)} + 3H_{2(g)} \xrightleftharpoons[200atm]{450°C} 2NH_{3(g)}$$

- Nitrogen is taken from air.
- Hydrogen is obtained by passing methane and steam over heated nickel catalyst.

Process / Steps Involved:

Manufacturing of urea involves three stages:

(i) Reaction of Ammonia and Carbondioxide:

Carbon dioxide is passed through liquid **ammonia** under **high pressure** to form **ammonium carbamate.**

$$2NH_{3(g)} + CO_{2(g)} \xrightarrow{heat} NH_2COONH_4$$

Ammonium Carbamate

(ii) Urea Formation: **(SGD 2017)**

When ammonium carbamate is evaporated with the help of steam, it dehydrates to form urea.

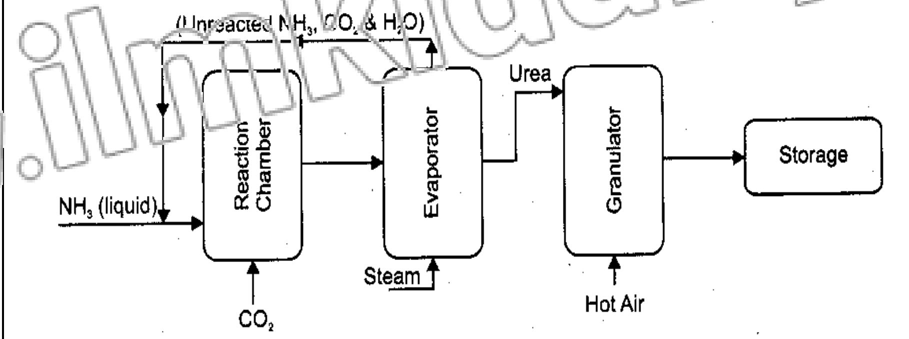
$$NH_2COONH_4 \longrightarrow NH_2CONH_2 + H_2O\uparrow$$

Ammonium Carbamate (Urea)

(iii) **<u>Granulation of Urea</u>**:

At this stage, liquid urea is evaporated to form granules. When liquid urea is sprayed from top of a tower under pressure and a hot current of air is introduced from the base, it evaporates to form granules.

This is stored to be marketed.



<u>Figure: Flow Sheet Diagram of Urea</u>

Q.2 What is the importance of urea? Explain its industries in Pakistan.
(Knowledge Base) **(SGD 2014, LHR 2015, GRW 2017, RWP 2017, SWL 206 G-II, BWP 2016 G-I)**

Ans:

<u>IMPORTANCE AND STATUS OF UREA</u>

It is white crystalline organic compound. Its importance is because of following usage.

(i) <u>Agriculture Sector:</u>

Urea is widely used world over in the **agriculture sector** both as a **fertilizer** and **animal feed additive.** About **90% of urea** is used as **fertilizer**. It has the highest nitrogen percentage, i.e. much higher than other **nitrogenous fertilizers**. It is harmless and is useful for all types of crops and soils.

(ii) <u>Safe Storage:</u>

It is **non-toxic**, **non-explosive**, therefore, can be stored safely but it is **very soluble** in **water** and **hygroscopic**, therefore, storage requires better packing.

(iii) <u>As a Raw Material:</u>

It is used as a **raw material** for the **manufacture** of many important **compounds**.

(iv) <u>To Make Explosives:</u>

It is used to make **explosives**.

(v) <u>Reduction of NO_x Pollutants:</u>

It is **used** in **automobile** systems to **reduce the NO_x** pollutants in exhaust gases.

<u>INDUSTRIAL UNITS OF UREA</u>

There are about six urea manufacturing units in Pakistan. The major four are

- Fauji Fertilizer company
- Engro Chemicals
- Fauji fertilizer
- Bin Qasim, Dawood Hercules company

Fauji Fertilizer is the biggest fertilizer manufacturer with 59% market shares.

<u>Subsidy to Promote Urea Manufacturing:</u>

Government provides an indirect subsidy to manufacturers but this industry is still facing supply shortfall problems. The price of urea has grown since the last years.

16.3 MANUFACTURE OF UREA

SHORT QUESTIONS

Q.1 What is the importance and status of urea in agricultural sector? *(Knowledge Base)*

Ans: *Answer given on Page # 346*

Q.2 What are industrial units of urea in Pakistan? *(Knowledge Base)*

Ans: *Answer given on Page # 346*

Q.3 Write formula of urea and ammonium carbamate. *(Knowledge Base)* (BWP 2016 G-I)

Ans: **FORMULAS**

The formulas of urea and ammonium carbamate are as follows:

- Urea : NH_2CONH_2
- Ammonium carbamate : $H_2NCOONH_4$

Q.4 Why fertilizers are added to the soil for crops? *(Knowledge Base)*

(Interesting Formation Pg. # 165)

Ans: **ROLE OF FERTILIZERS**

Crops need phosphorus and nitrogen to grow well. Athough, there is 78% nitrogen in air yet it can not be assimilated directly by plants. Therefore, fertilizers are used to provide these essential elements to soil and ultimately plants.

MULTIPLE CHOICE QUESTIONS

1. Urea is a fertilizer: *(K.B)*
(A) Phosphate (B) Nitrogenous
(C) Pottasium (D) Sulphar

2. Percentage of nitrogen in urea: *(K.B)*
(A) 46.2 % (B) 48%
(C) 41% (D) 46.6%

3. Urea is a compound: *(K.B)*
(A) White-crystalline (B) Transparent
(C) Blue crystalline (D) Non crystalline

4. Urea is highly soluble in: *(K.B)*
(A) Toulene (B) Water
(C) Benzene (D) CCl_4

5. Urea is used for manufacturing of: *(K.B)*
(A) Crude oil (B) Slaked lime
(C) Important chemicals (D) None of these

6. Which of the following %age of urea is used as fertilizers? *(K.B)*
(A) 90% (B) 93%
(C) 90.4% (D) 94%

7. Ammonia is prepared by: *(K.B)*
(A) Solvay's process (B) Electromagnetic separation
(C) Haber's process (D) Electrolysis

8. Volume of nitrogen in Haber's process is obtained from: *(K.B)*
(A) Water (B) Air
(C) Carbon dioxide (D) None of these

9. Nitrogen reacts with hydrogen to form ammonia at: *(K.B)*
(A) 250 atm (B) 235 atm
(C) 300 atm (D) 200 atm

10. Temperature required for the production of ammonia is: *(K.B)*

(A) 400ºC (B) 450 ºC

(C) 425 ºC (D) 500 ºC

11. Urea is used to make: *(K.B)*

(A) Fire extinguisher (B) Explosives

(C)Automobiles (D) None of these

12. There are how many urea manufacturing units in Pakistan? *(K.B)*

(A) Six (B) Nine

(C) Twelve (D) Seven

13. The biggest fertilizer manufacturer in Pakistan is: *(K.B)*

(A) Engro Chemicals

(B) Dawood Hercules compony

(C) Bin Qasim

(D) Fauji Fertilizers compony

14. Fauji fertilizer contributes with market shares: *(K.B)*

(A) 55% (B) 61%

(C) 56% (D) 59%

15. The gas prepared by Haber's process is: *(K.B)* **(SWL 2017)**

(A) CO_2 (B) SO_2

(C) HI (D) NH_3

16.3 TEST YOURSELF

i. What happens when ammonium carbamate is heated with steam? *(Knowledge Base)* (SGD 2017)

Ans: **<u>HEATING OF AMMONIUM CARBAMATE</u>**

When ammonium carbamate is evaporated with the help of steam, it dehydrates to form urea.

$$\underset{\text{Ammonium carbamate}}{NH_2COONH_4} \longrightarrow \underset{\text{(Urea)}}{NH_2CONH_2} + H_2O\uparrow$$

ii. How many stages are involved in the formation of urea? *(Knowledge Base)*

Ans: **<u>STAGES INVOLVED</u>**

Three stages are involved in the manufacture of urea.

- Reaction of ammonia and carbon dioxide.
- Urea formation
- Granulation of urea.

iii. What is the percentage of nitrogen in urea? *(Knowledge Base)*

Ans: **<u>PERCENTAGE OF NITROGEN IN UREA</u>**

The percentage of nitrogen in urea is **46.6%.**

NATURAL FERTILIZERS ARE BETTER THAN SYNTHETIC FERTILIZERS

LONG QUESTIONS

Q.1 Describe in detail that natural fertilizers are better than chemical or synthetic fertilizers ***(Knowledge Base)*** **(Science, Technology and Society Pg. 166)**

OR

Explain that the natural fertilizers are better than synthetic fertilizers. (LHR 2014)

Ans:

FERTILIZER

Definition:

"Fertilizer is a substance added to soil to improve plants growth and yield".

Types of fertilizes:

Following are two major types of fertilizers:

(i) Natural Fertilizers

(ii) Chemical fertilizers

(i) Natural Fertilizers:

"Natural fertilizers contain all natural, biodegradable materials from livestock and human waste and foliage of plants".

These materials are decomposed by bacteria. Decomposed materials contain useful nutrient for plants. Organic matter is essential part of fertile soil. Uses of natural fertilizers return the nutrients and organic matter of soil.

Advantages:

The advantages of natural fertilizers are as follows:

- They improve the soil condition to support plant growth.
- They improve the porosity of the soil to make it capable of absorbing water, thus improve crops production.
- They improve the structure of soil which in turn allows more air to get to plant roots.
- The chance of water shortage because of the moisture holding capacity of soil increases.
- Natural fertilizers practically do not contain toxic chemicals. Thus, they do not damage the soil and crops yield increases.

(ii) Chemical Fertilizers:

"*Chemical Fertilizers include one or more of the three elements most important for plant nutrition; nitrogen, phosphorus and potassium*".

Advantages:

The advantages of chemical fertilizers are as follows:

- They release the nutrients very fastly.

Disadvantages:

- Their effects are short lived, so they are required again and again, after short intervals, may be 4 to 6 times in a year.
- Use of synthetic fertilizers may cause over fertilization resulting in burning of plants instead of greening them.

NATURAL FERTILIZERS ARE BETTER THAN SYNTHETIC FERTILIZERS

SHORT QUESTIONS

Q.1 What are natural fertilizers? *(Knowledge Base)* **(FSD 2017)**

Ans: *Answer given on Page # 349*

Q.2 What are disadvantages of chemical fertilizers? *(Knowledge Base)*

Ans: *Answer given on Page # 349*

Q.3 What is fertilizer? *(Knowledge Base)*

Ans: *Answer given on Page # 349*

MULTIPLE CHOICE QUESTIONS

1. Natural fertilizers contain natural Bio-degradable from: *(K.B)*

(A) Nitrogen (B) Phosphorous
(C) Livestock (D) Potassium

2. Chemical fertilizers release very fastly: *(K.B)*

(A) Minerals (B) Gases
(C) Nutrients (D) Both A and C

3. Natural fertilizers improve the structure of: *(K.B)*

(A) Soil (B) Ores
(C) Minerals (D) Metals

4. Natural fertilizers are decomposed by: *(K.B)*

(A) Fungi (B) Algae
(C) Bacteria (D) Ferns

5. Natural fertilizers practically do not contain: *(K.B)*

(A) Nitrogenous chemicals (B) Ionic chemicals
(C) Non-ionic chemicals (D) Toxic chemicals

16.4 PETROLEUM INDUSTRY

LONG QUESTIONS

Q.1 What are the characteristics of petroleum? Explain the origin of petroleum.
(Knowledge Base) **(GRW 2017)**

Ans: **PETROLEUM**

Definition:

"*It is a **complex mixture** of several gaseous, liquid and solid **hydrocarbons** having water, salts and earth particles with it*".

CHARACTERISTICS OF PETROLEUM

The characteristics of petroleum are as follows:

- Petroleum is a **natural product** found under the Earth's crust trapped in rocks.
- Petroleum means **rock oil.**
- It is lighter than water and is insoluble in it.

ORIGIN OF PETROLEUM

Petroleum was formed by the decomposition of dead plants and animals burried under earth's crust millions of years ago. It is believed that millions of years ago living plants and animals in the seas died. Their bodies sunk and burried under mud and sand. Then decomposition process took place in the absence of air because of high pressure, temperature and bacterial effects. This process took millions of years for completion.

Crude Oil:

Remains of dead plants and animals were converted into dark brownish viscous crude oil.

Trapping of Petroleum:

Petroleum was trapped between two layers of impervious rocks.

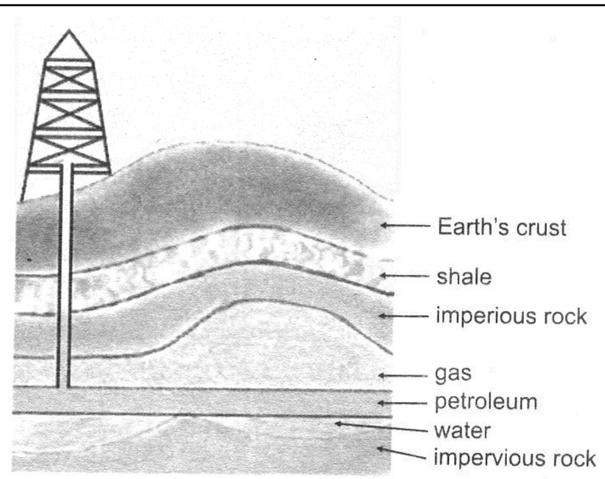


Figure: Occurrence of Petroleum

Being lighter and insoluble in water it floats over the water and forms an oil trap. The gaseous products accumulated over the petroleum are found as natural gas.

Extraction of Petroleum: **(SWL 2016 G-I)**

Petroleum is extracted by drilling holes (oil wells) into Earth's crust where the oil is found. When a well is drilled through the rocks, natural gas comes first with a great pressure. For some time crude oil also comes out by itself due to gas pressure. When gas pressure subsides, then crude oil is pumped out.

Refining of Petroleum:

The **crude oil** is **refined** in the **refineries**. Refining process is the **separation** of **crude oil mixture** into various useful products (fractions). It is carried out by process called **fractional distillation**.

Q.2 Write a note on fractional distillation of petroleum.

(Knowledge+Understanding+Application Base) **(Ex-Q.4) (GRW 2017)**

OR

Write a note on refining of crude oil. **(GRW 2014, LHR 2013, SGD 2014,13, MTN 2017)**

Ans: **FRACTIONAL DISTILLATION**

Definition:

*"The process of **separating a mixture** into its **fractions** by **evaporation** and **condensation** on the basis of **difference in their boiling points** is called fractional distillation".*

Principle:

The **principle of fractional distillation** is based upon **separation of substances** depending upon their **boiling points**. The substances having **low boiling points boil out first** and leave the others behind. Then **next fraction** of **slightly higher boiling point boils out.** This process remains continue until a residue is left behind. The vapours of each fraction are collected and condensed separately.

Apparatus:

The fractional distillation of petroleum is carried out in a tall fractionating tower (Oil Refinery).

Steps Involved:

The steps involved in the fractional distillation of petroleum are as follows:

(i) Heating of Crude Oil:

The **crude oil** is **heated** in a **furnace** upto a temperature of **400°C** under **high pressure**.

(ii) Evaporation:

Then vapours are passed through a fractionating column from near its bottom. The hot vapours rise up in the column and gradually cool down and condense.

(iii) Condensation: The vapours of higher boiling point fraction (350-400°C) condense first in the lower part of the tower, while vapours of medium and lower boiling point fractions rise upward in the tower and condense gradually with respect to their boiling points at different levels.

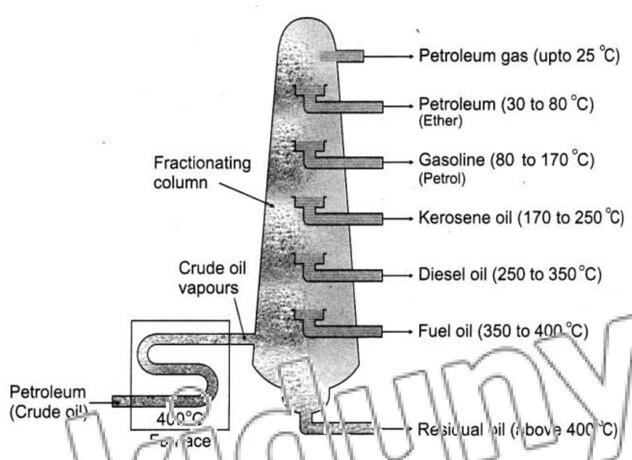


Figure: Fractional Distillation of Petroleum

Number of Fractions:

The crude oil is separated into **six hydrocarbon fractions.**

Composition of Single Fraction:

Each fraction is not a single compound. Rather each one is a mixture of hydrocarbons having different number of carbon atoms in it. Each fraction has its specific boiling range, composition and uses.

IMPORTANT FRACTIONS OF PETROLEUM

(GRW 2014, FSD 2016 G-II)

The important fractions of petroleum, their composition, boiling range and uses are as follows:

Name	Composition	Boiling Range	Uses
Petroleum Gas	**C_1 to C_4**	**up to 25°C**	As a fuel, as such in the form of LPG, used for the production of carbon black (needed in tyre industry) and hydrogen gas (needed to form NH_3 used to manufacture fertilizer).
Petroleum Ether	**C_5 to C_7**	**30 to 80°C**	Used as laboratory solvent and for dry cleaning purpose.
Gasoline or Petrol	**C_7 to C_{10}**	**80 to 170°C**	Used as fuel in motor cycles, motor cars and other light vehicles. It is more volatile than kerosene oil. It is also used for dry cleaning.
Kerosene oil	**C_{10} to C_{12}**	**170 to 250°C**	Used as domestic fuel, a special grade of it is used as jet fuel.
Diesel oil	**C_{13} to C_{15}**	**250°C to 350°C**	Fuel for buses, trucks railway engines, tubewell engines and other heavy vehicles.
Fuel oil	**C_{15} to C_{18}**	**350°C to 400°C**	Used in ships and industries to heat boilers and furnaces.

Residual Oil:

Definition:

"The left behind residue obtained after the fractional distillation of crude oil which does not vapourize at 400°C is called residual oil".

Distillation:

The residual oil, which does not vapourize under these conditions is collected and heated above 400°C for further fractional distillation.

Fractions:

The four fractions of residual oil are:

(i) Lubricants
(ii) Paraffin wax
(iii) Asphalt
(iv) Petroleum coke

16.4 PETROLEUM INDUSTRY

SHORT QUESTIONS

Q.1 What is composition of diesel fuel sold in summer and winter? *(Knowledge Base)*

(Interesting Information Pg. # 170)

Ans: **COMPOSITION OF DIESEL FUEL**

The diesel fuel sold in winter is different mixture of hydrocarbons from the mixture sold in summer. This is because diesel sets rather like Vaseline at a little below 0°C and will not work as a fuel. More of the lighter fractions are added in winter to prevent this.

Q.2 What are the fractions obtained due to fractional distillation of residual oil? ***(Knowledge Base)***

Ans: *Answer given on Page # 353*

Q.3 Describe uses of diesel oil. ***(Knowledge Base)*** **(RWP 2016 G-I)**

Ans: *Answer given on Page # 353*

Q.4 Write uses of petroleum ether. ***(Knowledge Base)*** **(DGK 2016 G-I)**

Ans: *Answer given on Page # 353*

16.4 PETROLEUM INDUSTRY

MULTIPLE CHOICE QUESTIONS

1. In fractional distillation crude oil is heated up to: ***(K.B)*** **(MTN 2017)**

(A) 400ºC (B) 500 ºC
(C) 450 ºC (D) 425ºC

2. Crude oil is separated into hydrocarbon fractions: ***(K.B)***

(A) 7 (B) 6
(C) 8 (D) 5

3. Boiling point of gasoline or petrol is: ***(K.B)***

(A) 50 to 100 ºC (B) 30 to 80ºC
(C) 40 to 90 ºC (D) 80 to 170 ºC

4. Petroleum ether boils at: ***(K.B)***

(A) 350 to 400 ºC (B) 60 to 140 ºC
(C) 40 to 90 ºC (D) 30 to 80 ºC

5. Boiling range of fuel oil is : ***(K.B)***

(A) 250-350ºC (B) 350-400 ºC
(C) 400-500 ºC (D) 200-250 ºC

6. Kerosene oil is used as: ***(K.B)***

(A) Laboratory solvent (B) To form NaCl
(C) Jet fuel (D) In ships

7. Composition of petroleum ether is: ***(K.B)***

(A) C_1 to C_{10} (B) C_5 to C_7
(C) C_{13} to C_{15} (D) C_1 to C_4

8. Which one is used as jet fuel? ***(K.B)***

(A) Kerosene oil (B) Lubricating oil
(C) Fuel oil (D) Diesel oil

9. Composition of diesel oil is: ***(K.B)***

(A) C_1 to C_{10} (B) C_5 to C_7
(C) C_{13} to C_{15} (D) C_1 to C_4

10. Boiling point of diesel oil is: ***(K.B)***

(A) 250 to 350ºC (B) 60 to 140 ºC
(C) 40 to 90 ºC (D) 80 to 170 ºC

11. The composition of carbon in fuel oil is: ***(K.B)*** **(GRW 2017, RWP 2016 G-I)**

(A) C_7 to C_{10} (B) C_{10} to C_{12}
(C) C_{13} to C_{15} (D) C_{15} to C_{18}

12. Which one of the following is used as laboratory solvent? ***(K.B)*** **(SWL 2017)**

(A) Kerosene oil (B) Diesel oil
(C) Petrolum ether (D) Fuel oil

13. Which fraction of petroleum is used in ships and industries as fuel? *(K.B)*

(A) Petroleum gas (B) Petrol
(C) Diesel oil (D) Fuel oil

16.4 TEST YOURSELF

i. Define petroleum. *(Knowledge Base)* **(LHR 2015, GRW 2016 G-II, MTN 2016 G-I)**

Ans: **PETROLEUM**

Definition:

"It is a complex mixture of several gaseous, liquid and solid hydrocarbons having water, salts and soil particles with it."

Characteristics:

- The petroleum is a natural product found under the Earth's crust trapped in rocks.
- Petroleum means "rock oil".
- It is lighter than water and is insoluble in it.

ii. How petroleum is extracted? *(Knowledge Base)* **(LHR 2015)**

Ans: **EXTRACTION OF PETROLEUM**

Petroleum is extracted by drilling holes (oil wells) into Earth's crust where the oil is found. When a well is drilled through the rocks, natural gas comes first with a great pressure.

For some times crude oil also comes out by itself due to gas pressure. When gas pressure subsides, then crude oil is pumped out.

iii. What is principle of fractional distillation? *(Knowledge Base)* **(SWL 2016 G-I)**

Ans: **PRINCIPLE OF FRACTIONAL DISTILLATION**

The principle of fractional distillation is based upon separation of substances depending upon their boiling points. The substances having low boiling points, boil out first and leaving behind other. Then next fraction of slightly higher boiling point boils out. This process remains continue until a residue is left behind.

iv. In how many fractions crude oil is separated? *(Knowledge Base)*

Ans: **FRACTIONS OF CRUDE OIL**

The crude oil is separated into six fractions:

(i) Petroleum gas
(ii) Petroleum (ether)
(iii) Gasoline (petrol)
(iv) Kerosene oil
(v) Diesel oil
(vi) Fuel oil

Residual oil is another left behind residue of fractional distillation of petroleum.

v. What do you mean by a fraction of petroleum? *(Knowledge Base)* **(FSD 2016 G-I)**

Ans: **FRACTION OF PETROLEUM**

Fraction of petroleum means a part of petroleum. Each fraction is not a single compound rather each one is a mixture of hydrocarbons having different number of carbon atoms in it. Each fraction has its specific boiling range, composition and uses.

DIFFERENT TYPES OF FIRE REQUIRE DIFFERENT METHODS TO EXTINGUISH

LONG QUESTIONS

Q.1 What are the things needed to start and sustain fire? Describe methods to put out fire. *(Knowledge Base)* **(Science, Technology and Society Pg. 170)**

Ans: **THINGS TO START AND SUSTAIN FIRE**

The things needed to start and sustain fire are as follws:

(i) Fuel:

The substance that burns in the combustion process, e.g. wood, oil and electricity.

(ii) Heat:

The energy component of the fire when it comes in contact with fuel, it provides the energy necessary for ignition and sustaining combustion process.

(iii) Air (Oxygen):

It is essential component for combustion process.

Self Sustained Chemical Chain Reaction:

"A self sustained chemical chain reaction is a complex reaction that requires fuel, oxygen and heat energy to come together in a very specific way".

METHODS TO PUT OUT FIRE

Fire can be put out by taking away any of the components like fuel, heat and air (oxygen). When fuels are different, they require different techniques to put them out.

(i) Wood Fire:

Wood fire can be extinguished by throwing water on it. Water uses large amount of heat for evaporation process, so it absorbs huge amount of heat and deprive the wood fire of heat and it is not possible for fire to be sustained.

(ii) Oil Fires:

Oil fires can't be put out with water because oil and water do not mix. Oil being lighter than water, floats and spreads over it. The fire also spreads along with water. To put out oil fire, oxygen needs to be cut off. This can be controlled by throwing sand, table salt or baking soda on the flames.

(iii) Electric Fire:

Electric fire is much stronger than other fires because its source of heat is electrical energy. It requires cut off oxygen supply to put it out. Oxygen supply can be controlled by using fire extinguishers.

DIFFERENT TYPES OF FIRE REQUIRE DIFFERENT METHODS TO EXTINGUISH

SHORT QUESTIONS

Q.1 What is self sustained chemical chain reaction? *(Knowledge Base)*

Ans: *Answer given on Page # 356*

Q.2 Name the things needed to start and sustain fire? *(Knowledge Base)*

Ans: **<u>THINGS TO START AND SUSTAIN FIRE</u>**

The things needed to start and sustanin fire are:

- Fuel
- Heat
- Air (oxygen)

MULTIPLE CHOICE QUESTIONS

1. Which fire could be extinguished by water? *(K.B)*

(A) Wood fire (B) Oil fire
(C) Electric fire (D) Fat fire

2. Which fire is the strongest of all? *(K.B)*

(A) Wood fire (B) Oil fire
(C) Electric fire (D) Fat fire

3. Which fire can not be extingiushed with water? *(K.B)*

(A) Wood fire (B) Oil fire
(C) Electric fire (D) Both A and C

4. The energy necessary for ignition and sustanining combustion process is provided by: *(K.B)*

(A) Fuel (B) Heat
(C) Air (D) Oxygen

5. To put out oil fire_____ needs to be cut off. *(K.B)*

(A) Oxygen (B) Nitrogen
(C) Hydrogen (D) Carbondioxide

CHEMISTRY AS A CAREER IN INDUSTRY

LONG QUESTIONS

Q.1 Write a detailed note on chemistry as a career in industry. *(Knowledge Base)*

(Science, Technology and Society Pg. 170)

Ans: **<u>CHEMISTRY AS A CAREER IN INDUSTRY</u>**

<u>Chemist:</u>

By studying chemistry, one can be a professional chemist.

<u>Functions of a Chemist:</u>

- He studies the composition and properties of available chemicals.
- He develops methods to manufacture new substances on commercial scale to meet the needs of society.
- He designs and develops instruments and techniques to make the production more and more economical.

<u>Career of a Chemist:</u>

Chemists can have working opportunities in almost all fields of industry depending upon their areas of specialization.

(i) <u>Organic Chemists:</u>

Organic chemists have career in pharmaceutical, petroleum, petrochemicals, cosmetics, polymers and plastic industries.

(ii) <u>Inorganic Chemists:</u>

Inorganic chemists work in:

- Metallurgical industries
- Manufacturing industries like textile, cement, sugar
- Chemicals
- Manufacturing plants like fertilizer, acids and caustic soda.

(iii) <u>Physical Chemists:</u>

Physical chemists have working opportunities in energy transformation industries. They develop new and better energy sources. They explore renewable energy fields.

(iv) <u>Analytical Chemists:</u>

Analytical chemists work in almost all fields of industry.

- They identify the materials, measure their quantities and control the quality of the products.
- They evaluate the efficiency and devise techniques to enhance the production.
- They have working scope from food and beverage industry to paints and varnish industry.
- They work even in generating units.

(v) <u>Other Types of Chemists:</u>

The other types of chemists are:

- Biochemists
- Food chemists
- Material chemists etc.

CHEMISTRY AS A CAREER IN INDUSTRY
SHORT QUESTIONS

Q.1 Good communication skills promote the sale while poor communication skills often result in inefficiency. *(Knowledge Base)* **(Science, Technology and Society Pg. # 171)**

Ans: **<u>COMMUNICATION</u>**

<u>Definition:</u>

"Communication is the exchange of information to others through audio, video, print or electronic media".

<u>Good Communication Skills:</u>

Good communication skills help to ensure the efficient operation of all levels of an organization, from lowest to highest.

<u>Poor Communication Skills:</u>

Poor communication skills often result in inefficiency. Successful business leaders know, inefficiency equals a loss of productivity and consequently, a loss of profits.

Moreover, communication can make the difference between success and failure for a company. Therefore, in the field of chemical industry good communication skills are also vital.

Q.2 What is the work of an inorganic chemist? *(Knowledge Base)*

Ans: *Answer given above.*

CHEMISTRY AS A CAREER IN INDUSTRY
MULTIPLE CHOICE QUESTIONS

1. **Organic chemist has career in:** ***(K.B)***
   (A) Pharmaceuticals (B) Cement
   (C) Energy (D) Caustic soda
2. **Inorganic chemist has career in:** ***(K.B)***
   (A) Fertilizers (B) Petroleum
   (C) Pharmaceuticals (D) Cosmetics
3. **Which one of the following has career in almost all fields of industry?** ***(K.B)***
   (A) Organic chemist (B) Inorganic chemist
   (C) Physical chemist (D) Analytical chemist
4. **Which one of the following explores renewable energy fields?** ***(K.B)***
   (A) Organic chemist (B) Inorganic chemist
   (C) Physical chemist (D) Analytical chemist

ANSWER KEY
MULTIPLE CHOICE QUESTIONS
INTRODUCTION

1	C	6	B
2	C		
3	D		
4	C		
5	A		

16.1 BASIC METALLURGICAL OPERATIONS

1	B	6	D	11	B	16	C
2	C	7	C	12	C	17	B
3	C	8	B	13	C		
4	D	9	C	14	B		
5	B	10	A	15	B		

16.2 MANUFACTURE OF SODIUM CARBONATE BY SOLVAY'S PROCESS

1	A	6	B
2	B	7	C
3	A	8	D
4	C	9	B
5	C		

16.3 MANUFACTURE OF UREA

1	B	6	B	11	B
2	D	7	C	12	A
3	B	8	B	13	D
4	B	9	D	14	D

5	C	10	A	15	D

NATURAL FERTILIZERS ARE BETTER THAN SYNTHETIC FERTILIZERS

1	C
2	D
3	A
4	C
5	D

16.4 PETROLEUM INDUSTRY

1	A	6	C	11	D
2	B	7	B	12	C
3	D	8	A		
4	D	9	C		
5	B	10	A		

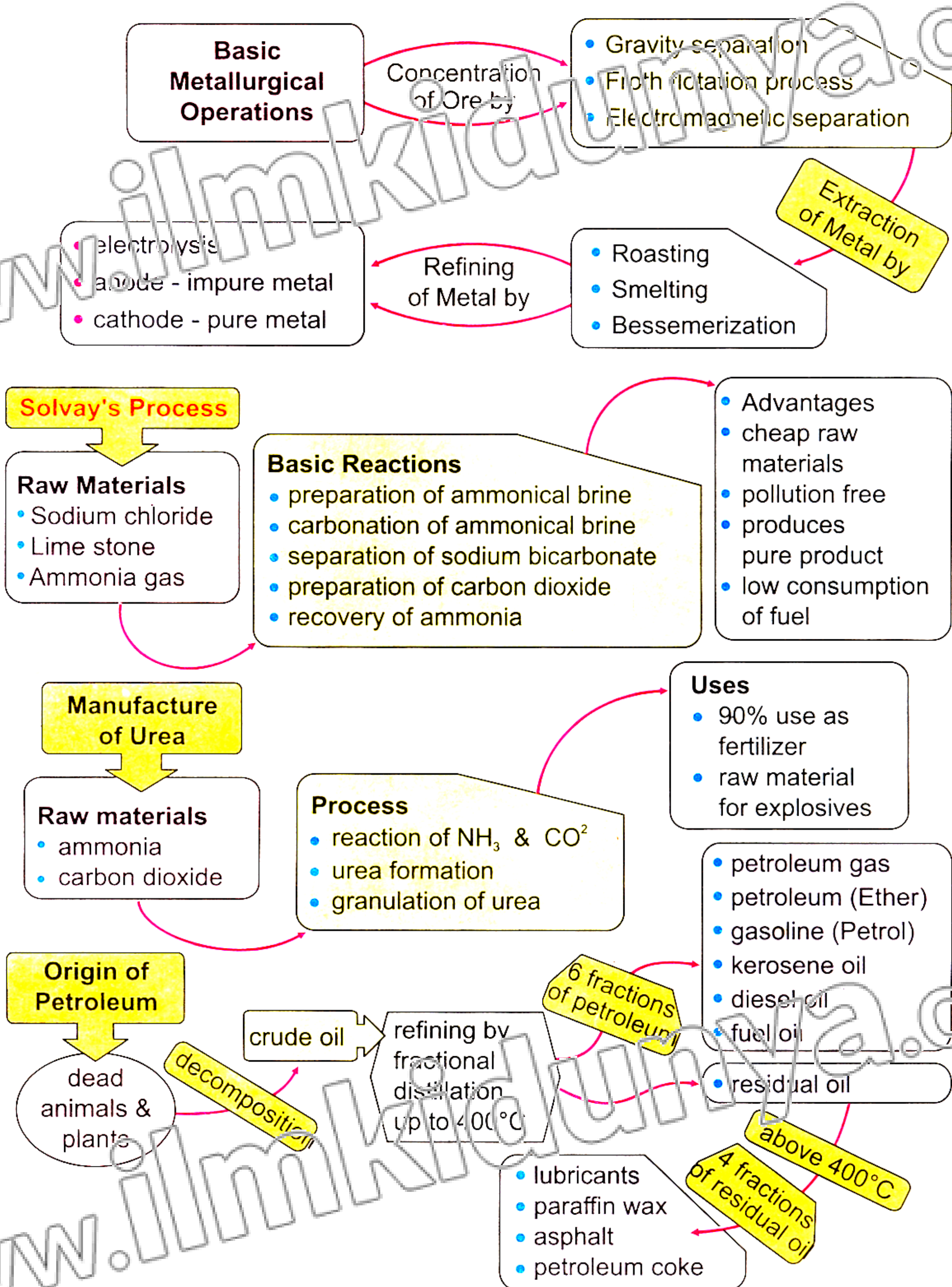
DIFFERENT TYPES OF FIRE REQUIRE DIFFERENT METHODS TO EXTINGUISH

1	A
2	C
3	B
4	B
5	A

CHEMISTRY AS A CAREER IN INDUSTRY

1	A
2	A
3	D
4	C

CONCEPT DIAGRAM



EXERCISE SOLUTION

MULTIPLE CHOICE QUESTIONS

1. Concentration is a: *(K.B)* **(GRW 2014, SGD 2017, FSD 2016 G-I,II)**
(a) Mixing technique (b) Separating technique
(c) Boiling technique (d) Cooling technique

2. Froth flotation process is used to concentrate the ore on: *(K.B)* **(SGD 2017)**
(a) Density basis (b) Concentration basis
(c) Wetting basis (d) Magnetic basis

3. Matte is a mixture of: *(K.B)* **(LHR 2014,15, SWL 2017)**
(a) FeS and CuS (b) Cu_2O and FeO
(c) Cu_2S and FeS (d) CuS and FeO

4. In the bessemerization process: *(K.B)*
(a) Roasted ore is heated (b) Molten matte is removed
(c) Molten matte is heated (d) Molten matte is added

5. Concentration of the copper ore is carried out by: *(K.B)*
(LHR 2013, GRW 2013, RWP 2017)
(a) Calcinations (b) Roasting
(c) Froth flotation (d) Distillation

6. When CO_2 is passed through the ammonical brine the only salt that precipitates is: *(K.B)*
(a) $NaHCO_3$ (b) NH_4HCO_3
(c) Na_2CO_4 (d) $(NH_4)_2CO_3$

7. In Solvay's process slaked lime is used to: *(K.B)*
(a) Prepare CO_2 (b) Prepare quick lime
(c) Recover ammonia (d) Form Na_2CO_3

8. When $NaHCO_3$ is heated it forms: *(K.B)* **(DGK 2017)**
(a) CO_2 (c) $CaCO_3$
(b) NH_2COONH_2 (d) CaO

9. Formula of urea is: *(K.B)* **(GRW 2013, LHR 2013,14, SGD 2017)**
(a) NH_2COONH_4 (b) NH_2COONH_2
(c) NH_2CONH_4 (d) NH_2CONH_2

10. Crude oil is heated in the fractionating furnace upto: *(K.B)*
(MTN 2016 G-I 17, FSD 2016 G-II, SWL 2016 G-I)
(a) 300°C (b) 350°C
(c) 400°C (d) 450°C

11. When crude oil is heated in the fractionating tower: *(K.B)*
(a) Vapours of higher boiling point fraction condense first in the lower part of the tower
(b) Vapours of lower boiling point fraction condense first in the lower part of tower
(c) Vapours of higher boiling point condense later in the upper part of tower
(d) Vapours of higher boiling point never condense

12. Which one of the following is used as jet fuel? *(K.B)*
(a) Kerosene oil (b) Lubricating oil
(c) Fuel oil (d) Diesel oil

13. Which one of the following is not fraction of crude oil? *(K.B)*

(a) Paraffin wax (b) Asphalt
(c) Fuel oil (d) Petroleum coke

14. Which one of the following is not a fraction of petroleum? *(K.B)*
(RWP 2016 G-II, FSD 2017 G-II)

(a) Kerosene oil (b) Diesel oil
(c) Alcohol (d) Petrol

15. The nitrogen present in urea is used by plants to synthesize: *(K.B)*
(GRW 2014, RWP 2017, DGK 2016 G-I)

(a) Sugar (b) Proteins
(c) Fats (d) DNA

16. Which one of the following organic compound is found in gasoline? *(K.B)*
(DGK 2017, MTN 2016 G-II, FSD 2017 G-I)

(a) C_2H_4 (b) C_3H_8
(c) C_8H_{18} (d) $C_{12}H_{26}$

ANSWER KEY

1	b	6	a	11	a	16	c
2	c	7	c	12	a		
3	c	8	a	13	c		
4	c	9	d	14	c		
5	c	10	c	15	b		

EXERCISE SHORT QUESTIONS

1. What role is played by pine oil in the froth flotation process? *(Knowledge Base)*
(DGK 2016 G-II)

Ans: **<u>ROLE OF PINE OIL</u>**

The role played by pine oil in the forth flotation process is that the pine oil coated ore particles being lighter come to the surface in the form of froth that can be skimmed easily.

2. Name the various metallurgical operations. *(Knowledge Base)* **(GRW 2014, LHR 2015)**

Ans: **<u>METALLURGICAL OPERATIONS</u>**

The various metallurgical operations are as follows:

- Concentration of the ore
- Extraction of the metal
- Refining of the metal

3. How roasting is carried out? *(Knowledge+Application Base)*
(BWP 2016 G-II, GRW 2014, LHR 2013, 15, SWL 2015, 16 G-I, II)

Ans: **<u>ROASTING</u>**

"*It is a process of heating the concentrated ore to a high temperature in excess of air.*"

<u>Example:</u>

Copper pyrite ($CuFeS_2$) is strongly heated in excess of air to convert it into a mixture of cuprous sulphide and ferrous sulphide (Cu_2S + FeS), while impurities react with oxygen to form volatile oxides.

$$2CuFeS_{2(s)} + O_{2(g)} \longrightarrow 2\,FeS_{(s)} + Cu_2S_{(s)} + SO_{2(g)}\uparrow$$

4. Explain process of electro-refining. ***(Knowledge+Application Base)***

(FSD 2016 G-I, SGD 2016 G-II, MTN 2016 G-II, DGK 2016 G-II)

Ans: *Answer given on Page # 335*

5. What are advantages of Solvay's process? *(Knowledge Base)*

(DGK 2016 G-II, 17, FSD 2016 G-I, LHR 2014, GRW 2015, SWL 2017, MTN 2016 G-II)

Ans. **ADVANTAGES OF SOLVAY'S PROCESS**

The advantages of Solvay's process are as follows:

(i) It is a cheap process, as raw materials are available at very low prices.
(ii) Carbon dioxide and ammonia are recovered and reused.
(iii) Sodium carbonate of very high purity is obtained.
(iv) It is pollution free because the only waste is calcium chloride solution.
(v) Consumption of fuel is very less since no solution to be evaporated.

6. What is the principle of Solvay's process? *(Knowledge Base)*

(SWL 2016 G-II)

Ans: **PRINCIPLE OF SOLVAY'S PROCESS**

Principle of Solvay's process lies in the low solubility of sodium bicarbonate at low temperature i.e., at 15^0C. When CO_2 is passed through an ammonical solution of NaCl called ammonical brine only $NaHCO_3$ precipitates.

$$Na^+_{(aq)} + HCO^+_{3(aq)} \longrightarrow NaHCO_{3(s)}\ .$$

7. What happens when ammonical brine is carbonated? *(Knowledge Base)*

Ans: **CARBONATION OF AMMONICAL BRINE**

When CO_2 is passed through an ammonical solution of NaCl called ammonical brine only $NaHCO_3$ precipitates. Following reactions take palce in the carbonating tower.

$$CO_2 + NH_3 + H_2O \longrightarrow NH_4HCO_{3(aq)}$$

$$NH_4 + HCO_3 + NaCl \longrightarrow NaHCO_3 + NH_4Cl_{(aq)}$$

$$CO_2 + NH_3 + H_2O + NaCl \longrightarrow NaHCO_{3(s)} + NH_4Cl_{(aq)}$$

$$Na^+_{(aq)} + HCO^{-1}_{3(aq)} \longrightarrow NaHCO_{3(s)}$$

The temperature of the mixture is lowered to 15°C and precipitates of $NaHCO_3$ are obtained.

8. How $NaHCO_3$ is converted to Na_2CO_3? *(Knowledge Base)*

(GRW 2014, SGD 2017, DGK 2016 G-II)

Ans: **CONVERSION OF $NaHCO_3$ TO Na_2CO_3**

By heating sodium bicarbonate ($NaHCO_3$), it can be converted in to sodium carbonate (Na_2CO_3). This process is called calcination.

$$2NaHCO_{3(l)} \xrightarrow{\Delta} Na_2CO_{3(s)} + CO_{2(g)} + H_2O_{(l)}$$

9. How ammonia is recovered in the Solvay's process? *(Knowledge Base)*

(LHR 2014, 2015)

Ans: **AMMONIA RECOVERY**

Ammonia is recovered in ammonia recovery tower from ammonium chloride solution produced in the carbonated tower and calcium hydroxide formed in lime kiln.

$$2NH_4Cl_{(s)} + Ca(OH)_2 \longrightarrow 2NH_{3(g)} + CaCl_2 + 2H_2O$$

In fact, all ammonia is recovered in this tower and is reused in the process.

10. How ammonia is prepared for the synthesis of urea? *(Knowledge Base)*

(GRW 2014, SWL 2016 G-I)

Ans. **PREPARATION OF AMMONIA**

Ammonia is prepared by the "Haber's process". One volume of nitrogen (from air) and three volumes of hydrogen (obtained by passing methane and steam over heated nickel catalyst) is passed over iron catalyst at 450^0C and 200 atm pressure.

$$N_{2(g)} + 3H_{2(g)} \xrightarrow[200\,atm]{450^0C} 2NH_{3(g)}$$

11. Describe the formation of petroleum. *(Knowledge Base)* **(LHR 2015, MTN 2017)**

Ans: **FORMATION OF PETROLEUM**

Organic Theory:

According to the organic theory, millions of years ago living plants and animals in the seas died. Their bodies sank and burried under mud and sand. Then decomposition process took place in the absence of air because of high pressure, temperature and bacterial effects. This process took millions of years for completion. Thus, remains of dead plants and animals were converted into a dark brownish viscous crude oil.

12. What is refining of petroleum and how it is carried out? *(Knowledge Base)*

(FSD 2016 G-I)

Ans: **REFINING OF PETROLEUM**

"*Refining process is the separation of crude oil mixture into various useful products (fractions)."*

Method:

It is carried out by a process called "fractional distillation". Fractional distillation is the process of separating a mixture into its fractions on the basis of differences in their boiling points by evaporation and condensation.

13. Give a use of kerosene oil. *(Knowledge Base)*

(MTN 2016 G-II, 17, GRW 2017, BWP 2016 G-I, 17, SGD 2017)

Ans. **USE OF KEROSENE OIL**

Kerosene oil is used as domestic fuel, a special grade of it is used as jet fuel.

14. Describe the difference between diesel oil and fuel oil. *(Knowledge Base)* (LHR 2013)

Ans: **DIFFERENTIATION**

The differences between diesel oil and fuel oil are as follows:

Diesel Oil	Fuel Oil
Number of Carbons Atoms	
• The number of carbon atoms in diesel oil ranges from C_{13} to C_{15}.	• The number of carbon atoms in fuel oil ranges from C_{15} to C_{18}.
Boiling Range	
• Its boiling range is 250^0C to 350^0C	• Its boiling range is 350^0C to 400^0C.
Uses	
• It is used as fuel for buses, trucks, railway engines, ships etc.	• It is used in industries to heat boilers and furnace.

15. Write down the names of four fractions obtained by the fractional distillation of residual oil. ***(Knowledge Base)*** **(GWL 2016 G-II)**

Ans: **FRACTIONS OF RESIDUAL OIL**

The four fractions obtained by the fractional distillation of residual oil are:

- Petroleum gas
- Petroleum ether
- Diesel oil
- Fuel oil

16. What is the difference between crude oil and residual oil? ***(Knowledge Base)***

(BWP 2017, SGD 2016 G-II, 17)

Ans: **DIFFERENTIATION**

The difference between crude oil and residual oil are as follows:

Crude Oil	Residual Oil
Definition	
• It is dark brownish viscous liquid which is formed by decomposition of dead plants and animals in absence of air	The left behind residue of crude oil when it is heated at 400°C under high pressure.
Products of Distillation	
• It gives residual oil on fractional Distillation.	• On heating at 400°C it gives further four fractions: **(i)** Lubricants **(ii)** Parrafin wax **(iii)** Asphalt **(iv)** Petroleum coke

17. Which petroleum fraction is used in dry cleaning?

(LHR 2013, SGD 2016 G-I, II, FSD 2017 MTN 2016 G-II)

Ans: **PETROLEUM FRACTION USED IN DRY CLEANING**

Gasoline or petrol and petroleum ether is used in dry cleaning.

EXTENSIVE LONG QUESTIONS

Q.1 Describe in detail the various processes involved in the concentration of ore. Explain your answer with the help of diagrams.

Ans: See LQ. 2 (Topic 16.1)

Q.2 Explain the process of roasting with reference to copper.

Ans: See LQ.2 (Topic 6.1)

Q.3 Write a detailed note on Ammonia Solvay's process.

Ans: See LQ.1 (Topic 16.2)

Q.4 Write a note on fractional distillation of petroleum.

Ans: See LQ.2 (Topic 16.4)

Q.5 How urea is manufactured? Explain showing the flow sheet diagram.

Ans: See LQ.1 (Topic 16.3)

Q.6 How crude oil is refined? Explain two important fractions of petroleum along with their usage.

Ans: See LQ.2 (Topic 16.4)

Q.7 Write a note in detail on smelting and bessemerization, giving a specific example.

Ans: See LQ.2 (Topic 16.1)

ADDITIONAL CONCEPTUAL QUESTIONS

Q.1 What is meant by flux?

Ans: A substance introduced in smelting process to promote fluidity and to remove impurities in form of slag.

Q.2 What is difference between mineral and ore? *(K.B)* (SGD 2016 G-II)

Ans: **DIFFERENTIATION**

The differences between mineral and ore are as follows:

Mineral	Ore
Definition	
• *"The solid natural materials found beneath the Earth's surface, which contain compounds of metals in the combined state along with earthly impurities, are called minerals".*	• *"Those minerals from which the metals are extracted commercially at a comparatively low cost with minimum effort are called ores of the metals".*
Nature	
• All minerals are not ores.	• All ores of the metals are minerals.
Examples	
• Rocks salt, hematite, gypsum etc.	• Ores of copper are; copper glance (Cu_2S) and chalcopyrite ($CuFeS_2$).

Q.3 Describe the difference between gasoline and kerosene oil. *(Knowledge Base)*

Ans: **DIFFERENTIATION**

Gasoline	Kerosene
Number of Carbons Atoms	
• The number of carbon atoms in diesel oil ranges from C_7 to C_{10}.	• The number of carbon atoms in fuel oil ranges from C_{10} to C_{12}.
Boiling Range	
• Its boiling range is 80^0C to 170^0C	• Its boiling range is 170^0C to 250^0C
Uses	
• Used as fuel in motor cycles, motor cars and other light vehicles. It is more volatile than kerosene oil. It is also used for dry cleaning.	• Used as domestic fuel, a special grade of it is used as jet fuel.

TERMS TO KNOW

Terms	Definitions
Minerals	The solid natural materials found beneath the Earth's surface which contain compounds of metals in the combined state along with earthly impurities, are called minerals.
Ores	Those minerals from which the metals are extracted commercially at a comparatively low cost with minimum effort are called ores of the metals.
Gangue	The earthly and other impurities associated with the minerals are known as gangue.
Metallurgy	The process of extraction of a metal in pure state on a large scale from its ore by physical or chemical means is called metallurgy.
Concentrate	The process of removal of gangue from the ore is technically known as concentration and the purified ore is called the concentrate.
Gravity Separation	Gravity separation is based on the differences in densities of the metallic ore and the gangue particles.
Froth Flotation Process	Froth flotation process is based on the wetting characteristic of the ore and the gangue particles with oil and water, respectively.
Electromagnetic Separation	Electromagnetic separation is based on the separation of magnetic ores from the non-magnetic impurities by means of electro-magnets or magnetic separators.
Roasting	It is a process of heating the concentrated ore to a high temperature in excess of air.
Smelting	It is further heating the roasted ore with sand flux and coke in the presence of excess of air in a blast furnace.
Bessemerization	It is the further heating of the molten matte in a pear shaped bessemer converter.
Blister Copper	The molten metal is shifted from the converter to sand moulds and is allowed to cool. The dissolved gases escape out forming blisters on the surface of the solid copper. Therefore, it is called blister copper. It is about 98% pure copper. It is further refined by electrolysis.
Electrolytic Refining of Metal	Refining the impure metal by electrolysis is the most widely used process of refining metals.
Matte	During smelting of copper ore cuprous sulphide and ferrous sulpide form

	a mixture (Cu_2S .FeS). This molten mixture is called matte.
Concentration	The process of removal of gangue from the ore is technically known as concentration and the purified ore is called the concentrate.
Slag	When flux combines with gangue it will form slag which being lighter in weight and floats on the molten metal.
Principle of Solvay's Process	Principle of Solvay's process lies in the low solubility of sodium bicarbonate at low temperature i.e. at 15°C. When CO_2 is passed through an ammonical solution of NaCl called ammonical brine, only $NaHCO_3$ precipitates.
Technology	Technology is considered a consequence of science and engineering.
Fertilizer	Fertilizer is a substance added to soil to improve plants growth and yield.
Natural Fertilizers	Natural fertilizers contain all natural, biodegradable materials from livestock and human waste and foliage of plants.
Chemical Fertilizers	Chemical Fertilizers include one or more of the three elements most important for plant nutrition; nitrogen, phosphorus and potassium.
Petroleum	It is a complex mixture of several gaseous, liquid and solid hydrocarbons having water, salts and earth particles with it.
Fractional Distillation	The process of separating a mixture into its fractions by evaporation and condensation on the basis of difference in their boiling points is called fractional distillation.
Residual Oil	The left behind residue obtained after the fractional distillation of crude oil which does not vapourize at 400°C is called residual oil.
Self Sustained Chemical Chain Reaction	A self sustained chemical chain reaction is a complex reaction that requires fuel, oxygen and heat energy to come together in a very specific way.
Communication	Communication is the exchange of information to others through audio, video, print or electronic media.
Diesel Oil	The number of carbon atoms in diesel oil ranges from C_{13} to C_{15}.

CUT HERE

SELF TEST

Time: 35 Minutes **Marks: 25**

Q.1 Four possible answers (A), (B), (C) and (D) to each question are given, mark the correct answer. **(6×1=6)**

1. Red hair contains:

(A) Titanium compounds (B) Molybdenum compounds
(C) Iron or copper compounds (D) Alkali metals

2. Blister copper contains pure copper:

(A) 95% (B) 99%
(C) 98% (D) 92%

3. Formula of urea is:

(A) NH_2COONH_4 (B) NH_2COONH_2
(C) NH_4CONH_2 (D) NH_2CONH_2

4. Temperature required for the production of ammonia is:

(A) 400°C (B) 450°C
(C) 425°C (D) 500°C

5. Fauji fertilizers contributes market shares:

(A) 55% (B) 61%
(C) 56% (D) 59%

6. Composition of petroleum ether is:

(A) C_2 toC_{10} (B) C_5 to C_7
(C) C_{13} to C_{15} (D) C to C_4

Q.2 Give short answers to the following questions. **(5×2=10)**

(i) What do you mean by gangue?
(ii) What is the difference between slag and matte?
(iii) Give reaction for the formation of ammonia?
(iv) What do you mean by calcination?
(v) What is the principle of solvay's process?

Q.3 Answer the following questions in detail. **(5+4=9)**

(i) Describe bessemerization along with diagram? **(5)**
(ii) Write a note on manufacture of urea. **(4)**

NOTE: Parents or guardians can conduct this test in their supervision in order to check the skill of students.