Unit 04

Stoichiometry

Descriptive Questions

Q.1 (Ex. Q.4 (i)) Which conditions must be fulfilled before writing a chemical equation for a reaction? 09204001

Ans. Representing a chemical change is called chemical equation. Chemical equation tell us element or compound which are reacting and those which are being produced as a result of chemical change. It is compulsory to write reactant on left hand side and products on right hand side. An arrow is drawn from reactants to product separate the two.

The following points must be kept in mind while writing a chemical equation.

i. A chemical equation must obey the law of conservation of mass. This means that no atom should be destroyed or produced during a chemical change. The total number and the type of atoms must remain the same during a chemical change.
ii. The formulas of elements and compounds must be written correctly.
iii. A chemical equation must determine the correct mole ratio between the reactants and the products.
iv. A chemical equation must also point out the direction in which the change is proceeding.
v. It is a usual practice to show the normal physical states of reactants and products. Solid, liquid and gas are symbolized as s, ℓ and g respectively. Aqueous (aq) represents the solvated ion.

Q.2 (Ex. Q.4 (ii)) Explain the concepts of Avogadro's numbers and mole. 09204002

Ans. Avogadro's Number:

The number of particles in one mole of a substance is called Avogadro's number. The value of this number is 6.02×10^{23}. It is represented as N_A. An Italian scientist Amaedo Avogadro discovered Avogadro's number.

Explanation:

In chemistry we deal with substances which are composed of atoms, molecules or formula units. The counting of these particles is not possible for the chemists. The concept of Avogadro's number facilitated the counting of particles contained in the given mass of a substance. Avogadro's Number is a collection of 6.02×10^{23} particles. It is represented by symbol N_A. Hence, the 6.02×10^{23} number of atoms, molecules or formula units are called Avogadro's number that is equivalent to one 'mole' of respective substance. In simple words 6.02×10^{23} particles are equal to one mole as twelve eggs are equal to one dozen. Following examples show the relationship between the Avogadro's number and the mole of a substance.

Examples:

6.02×10^{23} atoms of carbon are equivalent to one mole of carbon.
6.02×10^{23} molecules of H_2O are equivalent to one mole of water.
6.02×10^{23} formula units of NaCl are equivalent to one mole of sodium chloride.
Thus, 6.02×10^{23} atoms of elements or 6.02×10^{23} molecules of molecular compounds or 6.02×10^{23} formula units of ionic compounds are equivalent to 1 mole.

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For further explanation about number of atoms in molecular compounds or number of ions in ionic compounds, following two examples are given:

One molecule of water is made up of 2 atoms of hydrogen and 1 atom of oxygen, hence $2 \times 6.02 \times 10^{23}$ atoms of hydrogen and 6.02×10^{23} atoms of oxygen constitute one mole of water. So, total no of atoms in 1 mole of water are 18.06×10^{23} or 1.806×10^{24}

One formula unit of sodium chloride consists of one sodium ion and one chloride ion. So, there are 6.02×10^{23} number of Na^+ ions and 6.02×10^{23} Cl^- ions in one mole of sodium chloride.

Thus, the total number of ions in 1 mole of NaCl is 12.04×10^{23} or 1.204×10^{24}.

Mole (Chemist secret unit):

A mole is defined as *the amount (mass) of a substance that contains 6.02×10^{23} number of particles (atoms, molecules or formula units).* It is abbreviated as 'mol'.

It establishes a link between mass of a substance and number of particles.

Explanation:

We know that a substance may be an element or a compound (molecular or ionic). Mass of a substance is either one of the following: atomic mass, molecular mass or formula mass. These masses are expressed in atomic mass units (amu). But when these masses are expressed in grams, they are called as molar masses.

Scientists have agreed that Avogadro's number of particles are present in one molar mass of a substance.

Quantitative definition of mole:

The atomic mass, molecular mass or formula mass of a substance expressed in grams is called mole.

Examples:

Atomic mass of carbon expressed as 12g =1 mole of carbon
Molecular mass of H_2O expressed as 18g =1 mole of water
Molecular mass of H_2SO_4 expressed as 98g =1 mole of H_2SO_4
Formula mass of NaCl expressed as 58.5g =1 mole of NaCl

Relationship between Mole and Mass:

$$\text{No. of moles} = \frac{\text{Known mass of substance (g)}}{\text{Molar masss of the substance (g/mol)}}$$

Mass of substance (g) = number of moles x molar mass
Number of particles = number of moles x 6.02×10^{23}

Q.3 (Ex. Q.4 (iii)) How many grams of CO_2 will be produced when we react 10g of CH_4 with excess of O_2 according to the following equation? 09204003

$$CH_{4(g)} + 2O_{2(g)} \longrightarrow CO_{2(g)} + 2H_2O_{(l)}$$

Ans. Data:

mass of CH_4 = 10g

Molar Mass of CH_4 = C + 4H
= 12 + 4 (1)
= 12 + 4 = 16g/mol

Molar mass of CO_2 = C + 2O
12 = C + 2 (16)
= 12 + 32 = 44 g/mol

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To find:

Mass of CO_2= ?

Solution:

Firstly, we have to find no of moles of methane, then we will find no of moles of CO_2 through balance Chemical equation

$$\text{Moles of } CH_4 = \frac{\text{Mass}}{\text{Molar mass}}$$

$$= \frac{10}{16}$$

$$= 0.6 \text{ mol}$$

So,as per balance chemical equation

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

CH_4 : CO_2

0.6 : 0.6

So,0.6 moles of CO_2 will be produced as per equation.

Mass of CO_2 = moles x Molar mass

$= 0.6 \times 44$

$= 27.43$ g

27.43g of CO_2 will be produced

Q.4 (Ex. Q.4 (iv) How many moles of coal are needed to produce 10 moles of CO according to the following equation? 09204004

$$3C_{(s)} + O_{2(g)} + H_2O_{(l)} \longrightarrow H_2 + 3CO$$

Ans: Solution:

To find no. of moles of coal needed, we have to find molar ratio between coal and carbon monoxide through balance chemical equation.

$$3C + O_2 + H_2O \longrightarrow H_2 + 3CO$$

C : CO

3 : 3

1 : 1

10 : 10

So, 10 moles of Coal will be required to prepare 10 moles of CO.

Q.5 (Ex. Q.4 (v) How much SO_2 is needed in grams to produce 10 moles of Sulphur?

$$2H_2S_{(g)} + SO_{2(g)} \longrightarrow 2H_2O_{(\ell)} + 3S_{(s)}$$ 09204005

Ans:Data:

Moles of Sulphur = 10

Molar mass of SO_2 = S + 2(O)

= 32 + 2 (16)

= 32 + 32

= 64g/mol

To Find:

Mass of SO_2=?

Solution:

Firstly, we will find moles of SO_2 through molar ratio between reactant and product through balance chemical equation

$$2H_2S + SO_2 \longrightarrow 2H_2O + 3S$$

SO_2 : S

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1	:	3
$\frac{1}{3}$	:	1
$10 \times \frac{1}{3}$	:	10
3.33		

So, no. of moles by SO_2 = 3.33 mol

Mass of SO_2 = Moles x molar mass

= 3.33 x 64

= 213.12g

Result

213.12g of SO_2 will be required.

Q.6(Ex. Q.4 (vi) How much ammonia is needed in grams to produce 1kg of urea fertilizer? 09204006

$$2NH_{3(aq)} + CO_{2(g)} \longrightarrow CO(NH_2)_{2(aq)} + H_2O_{(l)}$$

Ans: Data:

Mass of urea = 1kg = 1000g

Molar mass of urea = $(NH_2)_2 CO$

$=2N+ 4H + C + O$

$=2 (14) + 4(1) + 12 +16$

$= 28 + 4 + 12 + 16$

$= 60g/mol$

Molar mass of $NH_3 = N + 3H$

$= 14 + 3 (1)$

$= 14 + 3$

$= 17g/mol$

To Find:

Mass of ammonia =?

Solution:

Firstly, we will find number of moles of urea, then we will find moles of ammonia through molar ratio given in balance chemical equation

$$\text{Moles of urea} = \frac{\text{Mass}}{\text{Molar Mass}}$$

$$= \frac{1000}{60}$$

$$= 16.66$$

To find no. of moles of ammonia, molar ratio will be compared through balance chemical equation

$$2NH_3 + CO_2 \longrightarrow NH_2CONH_2 + H_2O$$

NH_3	:	NH_2CONH_2
2	:	1
2 x 16.66	:	16.66
NH_3	:	NH_2CONH_2
33.32	:	16.66

So, no. of moles of NH_3 = 33.32 mol

Mass of NH_3 = Moles x Molar Mass

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$= 33.32 \times 17$

$= 567.77g$

Result

567.77 g of ammonia will be required.

Q.7 (Ex. Q.4 (vii)) Calculate the number of atoms in the following. 09204007

(a) 3g of H_2 (b) 3.4 moles of N_2 (c) 10g of $C_6H_{12}O_6$

Ans:

(a) Data:

Mass of $H_2 = 3g$

Molar mass of $H_2 = 2H$

$= 2\ (1.008)$

$= 2.016$ g/mol

To Find:

no. of atoms = ?

Solution:

Firstly no. of moles will be calculated as:

$$\text{Moles} = \frac{Mass}{Molar.mass}$$

$$= \frac{3}{2.016}$$

$= 1.48$ mol

Now, no. of molecules of H_2 will be calculated as:

no. of molecules = moles x N_A

$= 1.48 \times 6.02 \times 10^{23}$

$= 8.91 \times 10^{23}$

One molecule composed of two Hydrogen atoms

So, Total no of atoms $= 2 \times 8.91 \times 10^{23}$

$= 1.78 \times 10^{24}$

(b) Data:

Moles of $N_2 = 3.4$mol

To find

No of atoms = ?

Solution:

Firstly calculate no. of molecules

no. of molecules = moles x N_A

$= 3.4 \times 6.02 \times 10^{23}$

$= 2.05 \times 10^{24}$

One nitrogen molecules composed of two nitrogen atom, So

Total no. of atoms $= 2 \times 2.05 \times 10^{24}$

$= 4.10 \times 10^{24}$

(c) Data:

Mass of $C_6H_{12}O_6 = 10$ g

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Molar mass of glucose = $C_6H_{12}O_6$

$= 6(12) + 12(1) + 6(16)$

$= 72 + 12 + 96$

$= 180 g/mol$

To Find:

no. of atoms = ?

Solution:

Firstly we will find no. of moles

$$\text{no. of moles} = \frac{\text{Mass}}{\text{Molar mass}}$$

$$= \frac{10}{180}$$

$$= 0.055$$

Now calculate no. of molecules

no. of molecules = moles x N_A

$= 0.055 \times 6.02 \times 10^{23}$

$= 3.34 \times 10^{22}$

One glucose molecule composed of 6 carbon, 12 Hydrogen and 6 oxygen,

So, it becomes 24 atoms.

no. of atoms = $24 \times 3.34 \times 10^{22}$

$= 8.01 \times 10^{23}$

Investigative Questions

Q.1. (Ex. Q.5 (i)) It is generally believed that drinking eight glasses of water every day is required to keep oneself hydrated especially in the summer. If a glass occupies 400 cm^3 of water on the average, how many moles of water are needed for a single adult?

09204008

Ans: To calculate the number of moles of water needed for a single adult who drinks eight glasses of water a day, we can follow these steps:

If one glass occupies 400 cm^3, then for eight glasses:

Total volume = 8 glasses × 400 cm^3/glass

= 3200 cm^3

Since 1 liter = 1000 cm^3

Total volume in liters = 3200 cm^3 / 1000 = 3.2 liters.

The molar mass of water (H_2O) is approximately 18 g/mol. The density of water is about 1 g/cm^3, which means that 1 liter of water, has a mass of about 1000 grams.

Therefore, the number of moles in 3.2 liters of water can be calculated as follows:

Mass of water = 3.2 liters × 1000 g/liter

= 3200 grams.

Number of moles = mass (g) / molar mass (g/mol)

$$= \frac{3200\ g}{18\ g/mol}$$

= 177.78 moles.

Therefore, a single adult would need approximately 177.78 moles of water if they drink eight glasses of water every day.

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Q.2. (Ex. Q.5(ii)) **The chemical formula for sand is SiO_2 but the sand does not exist in the form of discrete molecules like H_2O. How has its formula been determined keeping in view its structure?** 09204009

Ans: In the chemical formula of sand, SiO_2, represents silicon dioxide, which is the primary component of most types of sand. However, unlike water (H_2O), which consists of discrete molecules, sand does not exist as individual SiO_2 molecules. Instead, sand is made up of a vast network of silicon and oxygen atoms that are bonded together in a solid structure.

Covalent Network Structure: In sand, each silicon atom is covalently bonded to four oxygen atoms in a tetrahedral arrangement. Each oxygen atom is, in turn, bonded to two silicon atoms. This creates a three-dimensional network of SiO_2 units that extends throughout the material.

Macroscopic Representation: The formula SiO_2 is a way to represent this network structure on a macroscopic scale. It indicates the ratio of silicon to oxygen in the compound, which is 1:2. This formula is useful for understanding the composition of sand, even though it does not reflect the discrete molecular structure like in covalent compounds.

Crystallinity: While some forms of sand can be crystalline, such as quartz, others can be amorphous. In both cases, the SiO_2 formula still applies because it describes the overall composition of the material, regardless of its structural arrangement.

SLO based Additional Long Question

Q.1. How Chemical Formula of Binary Ionic Compounds can be written? 09204010



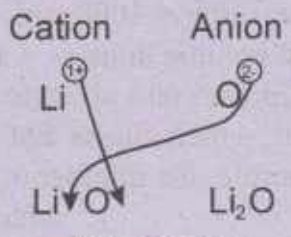
Ans. In order to write down the formula of an ionic compound, first identify the cations and anions and the number of charges present on them. Finally combine the two ions together to form an electrically neutral compound.

Steps:

If you know the name of binary ionic compound, you can write its chemical formula.

i. Start by writing symbol of cation with its charge.

ii. Then write the symbol of anion with its charge and find out how many of these ions are needed to give an electrically neutral compound.
For example, write down the formula of lithium oxide. The symbol of lithium cation with its single positive charge is Li^+. The symbol of anion is O^{2-}.



Example 1:

iii. Apply crisscross method to write the formula. In this method, the numerical value of each of the ion charges is crossed over to become the subscript of the other ion. Signs of the charges are then dropped.

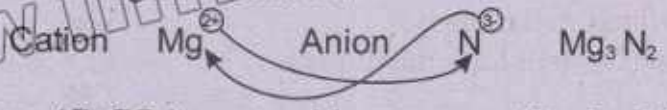
Example 2:

Write down the formula of Aluminium oxide.

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Example 3:
Write down the formula of Magnesium nitride.



Q.2. 25g of limestone ($CaCO_3$) reacts with an excess of hydrochloric acid according to the given equation. How much calcium chloride ($CaCl_2$) will be produced? 09204011

$$CaCO_{3(s)} + 2HCl_{(aq)} \longrightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_2$$

1 mole 2 moles 1 mole 1 mole 1 mole

100 g 73 g 111 g 18 g 44 g

Ans.

Solution: Mass of $CaCO_3 = 25g$ Molar mass of $CaCO_3 = 100\ g\ mol^{-1}$

Mass of $CaC\ell_2$ product = ? Molar mass of $CaC\ell_2 = 111\ g\ mol^{-1}$

According to the equation

100 g of limestone to produce calcium chloride = 111g

1 g of limestone will react to produce calcium chloride = $\frac{111}{100}g$

25g of limestone will react to produce calcium chloride = $\frac{111}{100} \times 25$

= 27.75g

Q.3. 1.80 moles of ethyl alcohol, when burnt in air completely, will utilize how many moles of oxygen gas? Also calculate the number of moles of CO_2 produced. 09204012

Ans. Solution: no. of moles of ethyl alcohol = 1.80

no. of moles of oxygen needed = ?

The balanced chemical equation for the reaction will be

$$C_2H_5OH_{(l)} + 3O_{2(g)} \longrightarrow 2CO_{2(g)} + 3H_2O_{(l)}$$

According to this equation

One mole of ethyl alcohol, when completely burnt, needs oxygen = 3 moles

1.8 moles of ethyl alcohol, upon burning, will need oxygen = $\frac{3}{1} \times 1.8$

= 5.4 moles

1 mole of ethyl alcohol produces moles of CO_2 = 2.0

1.8 mole of ethyl alcohol will produce = $\frac{2}{1} \times 1.8$

= 3.6 moles

Q.4. Aluminium metal reacts with oxygen to produce aluminium oxide. How many grams of oxygen will be required to react completely with 0.3 moles of aluminium? 09204013

Ans. Solution: Moles of $Al = 0.3$ moles Grams of O_2 used = ?

The balanced chemical equation for the reaction.

$$4Al_{(s)} + 3O_{2(g)} \longrightarrow 2Al_2O_{3(s)}$$

According to this equation

4 moles of aluminium need oxygen = 3.0 moles

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1.0 mole of aluminium will need oxygen = $\frac{3}{4}$

0.3 moles of aluminium will need oxygen = $\frac{3}{4} \times 0.3$

= 0.225 moles

1 mole of oxygen (O_2) has molar mass = 32g

0.225 mole of oxygen (O_2) will have molar mass = $32 \times .0225$

= 7.2g

Q.5. How many molecules of water will be produced if we react 5 g of hydrogen gas with excess of oxygen gas?

09204014

Ans. Solution: Mass of H_2 used = 5g

Molecules of water produced = ?

The balanced chemical equation for the reaction:

$$2H_{2(g)} + O_{2(g)} \longrightarrow 2H_2O_{(l)}$$

2 moles + 1 mole → 2 moles

4g + 32 g → 36 g

According to this equation

4 g of hydrogen produce H_2O = 36g of H_2O

5 g of hydrogen will produce H_2O = $\frac{36}{4} \times 5$ = 45g of H_2O

36g (2 moles) of H_2O contain molecules = $6.02 \times 10^{23} \times 2$

$= 12.04 \times 10^{23}$

45g of H_2O contain = $\frac{45}{36} \times 12.04 \times 10^{23}$

$= 1.505 \times 10^{24}$ molecules

Exercise Short Questions

Q.1 Write down the chemical formula of barium nitride. 09204015

Ans: The chemical formula of barium nitride is Ba_3N_2.

Q.2 Find out the molecular formula of a compound whose empirical formula is CH_2O and its molar mass is 180. 09204016

Ans: Data:

Molar mass = 180 g/mol

Empirical formula = CH_2O

Empirical formula mass = C + 2H + O

= 12 + 2(1) + 16

= 12 + 2 + 16

= 30g

Solution:

To find molecules formula, we will find 'n' (n=0,1,2,3....) which will be multiplied with empirical formula to get molecules formula

$$n = \frac{molar\ mass}{Empirical\ formula\ mass}$$

$= \frac{180}{30}$

= 6

So,

Molecular formula = (Empirical formula)

$= (CH_2O)_6$

$= C_6H_{12}O_6$

Q.3 How many molecules are present in 1.5 g H_2O? 09204017

Ans. Data:

Mass of H_2O = 1.5g

Molar mass of H_2O = 2H+O

=2 (1) +16

= 2 + 16

= 18 g/mol

To Find:

No of molecules = ?

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Solution:

Firstly no. of moles will be calculated which will be multiplied with N_A to get no. of molecules

$$\text{Moles} = \frac{mass}{Molar\ mass}$$

$$= \frac{1.5}{18}$$

$$= 0.083$$

no. of molecules = moles × N_A

$$= 0.083 \times 6.02 \times 10^{23}$$

$$= 5.02 \times 10^{22}$$

Result:

5.02×10^{23} molecules of H_2O will be present in 1.5g of water.

Q.4 What is the difference between a mole and Avogadro's number? 09204018

Ans:

Mole	Avogadro's Number
• A mole is defined as the amount (mass) of a substance that contains 6.02×10^{23} number of particles (atoms, molecules or formula units). It is abbreviated as mol.	• Avogadro's number is a collection of 6.02×10^{23} particles. It is represented by symbol N_A. Hence, the 6.02×10^{23} number of atoms, molecules or formula units is called Avogadro's number that is equivalent to one mole of respective substance.
• Atomic mass of carbon expressed as 12g = 1 mole of carbon	• 6.02×10^{23} atoms of carbon = 1 mole of carbon.

Q.5 Write down the chemical equation of the following reaction. 09204019

Copper + Sulphuric acid → Copper sulphate + Sulphur dioxide + water

Ans: The chemical equation for the reaction between copper and sulphuric acid to form copper sulphate, sulphur dioxide, and water can be written as follows:

$$Cu + 2H_2SO_4 \rightarrow CuSO_4 + SO_2 + 2H_2O$$

This equation shows the reactants on the left side and the products on the right side.

Practice Exercise Questions

Q.6 How would you differentiate between the chemical formula of an element and that of a compound? Give examples. Write down the names of ionic and covalent compounds whose formulas have been given in this article. 09204020

Ans.

Chemical formula of an Element	Chemical formula of compound
i) This formula represent only one type of atoms	i) This formula represent two or more different types of atoms
ii) Example: O_2 for oxygen.	ii) Example:- H_2O for water.
iii) It has no type	iii) It has two types • Ionic compound = $NaCl$, KBr, $BaCl_2$ etc. represents formula units. • Covalent compound = NH_3, HCl, HF, H_2S, PH_3, H_2O_2, H_2SO_4, CO_2, CO, C_6H_6 etc. represents a molecule.

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Q.7 Give two examples of components which have some empirical and molecular formulas. 09204021

Ans. Molecular and empirical formula of water = H_2O

Molecular and empirical formula of Methane = CH_4

Q.8 Write down the names of three such compounds which have different empirical and molecular formulas. 09204022

Ans.

1. Molecular formula of Glucose= $C_6H_{12}O_6$

Empirical formula of Glucose = CH_2O

2. Molecular formula of Acetic Acid= CH_3COOH

Empirical formula of Acetic Acid = CH_2O

3. Molecular formula of benzene = C_6H_6

Empirical formula of benzene = CH

Q.9 The empirical formula of a compound is CH_2O. Its molar mass is $180gmol^{-1}$. Determine its molecular formula. 09204023

Ans. Empirical formula of compound = CH_2O

Empirical formula mass=$30gmol^{-1}$

Its molar mass = $180gmol^{-1}$

Its molecular formula will then be:

$$n = \frac{180}{30}$$

$$n = 6$$

Molecular formula $= (CH_2O)_6$

$= C_6H_{12}O_6$

Q.10 The empirical formula of a compound is CH_2O. Its molar mass is $60g\ mol^{-1}$. Determine its molecular formula. 09204024

Ans. Empirical formula of compound = CH_2O

Empirical formula mass=$30gmol^{-1}$

Its molar mass = $60gmol^{-1}$

Its molecular formula will then be:

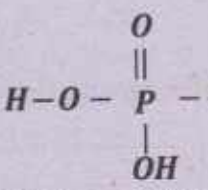
$$n = \frac{60}{30}$$

$n = 2$

Molecular formula $= (CH_2O)_2$

$= C_2H_4O_2$

Q.11 Find out the molecular formula of phosphoric acid, its structural formula is: 09204025



Ans: It has 3H, 1P and 4O atoms

Its molecular formula will be H_3PO_4.

Q.12 Determine the molecular formula of n-propyl alcohol. Its structural formula is CH_3-CH_2-CH_2-OH 09204026

Ans. It has 3C, 1O and 8H atoms.

Its molecular formula will be C_3H_8O

Q.13 Write down the formula of calcium carbonate. Its structural formula is: 09204027



Ans. It has 1Ca, 1C and 3O atoms.

Its formula will be $CaCO_3$.

Q.14 Calculate the molar masses of the following compounds H_3PO_4, SiO_2, $C_{12}H_{22}O_{11}$, N_2O_4, $MgCO_2$ 09204028

Ans. Molar mass of H_3PO_4

Atomic mass of H=1g

Atomic mass of P=31g

Atomic mass of O=16g

Molar Mass = 1 (3) + 31 (1) + 16 (4)

= 3 + 31 + 64

= 98g/mol.

Molar mass of SiO_2

Atomic mass of Si=28g

Atomic mass of O=16g

Molar Mass = 28 (1) + 16 (2)

= 28 + 32 = 60g/mol

Molar mass of $C_{12}H_{22}O_{11}$

Atomic mass of C=12g

Atomic mass of H=1g

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Atomic mass of O = 16g
Molar Mass = 12 (12) + 1 (22) + 16 (11)
= 144 + 22 + 176
= 342 g/mol

Molar mass of N_2O_4
Atomic mass of N=14g
Atomic mass of O=16g
Molar Mass = 14 (2) + 16 (4)
= 28 + 64 = 92 g/mol

Molar mass of $MgCO_2$
Atomic mass of Mg=24g
Atomic mass of C=12g
Atomic mass of O = 16g
Molar mass = 24 (1) + 12 (1) + 16 (2)
= 24 + 12 + 32
= 68 g/mol

SLO based Additional Short Questions

Chemical Formula

Q.15 Define chemical formula. 09204029

Ans. A chemical formula is a symbolic representation of a chemical compound. It tell us about the type and no. of atoms present in a compound. **For example** chemical formula of water is H_2O. It is composed of two atom of hydrogen and one atom of oxygen.

Empirical Formula

Q.16 Define empirical formula with an example. 09204030

Ans. The type of formula which shows the simplest whole number ratio of atoms present in a compound is called empirical formula, e.g. glucose ($C_6H_2O_6$) has simplest ratio 1:2:1 of carbon, hydrogen and oxygen respectively. Hence its empirical formula is CH_2O.

Chemical Formula of Binary Ionic Compounds

Q.17 What is the significance of stoichiometry? 09204031

Ans. The composition of all the chemical products we use in our lives, such as shampoos, perfumes, soaps and fertilizers are formed using stoichiometric calculations. Without stoichiometry the chemical industry does not exist.

Q.18 Ho to write a chemical formula of an ionic compound? 09204032

Ans. In order to write down the formula of an ionic compound, first identify the cations and anions and the number of charges present on them. Finally combine the two ions together to form an electrically neutral compound.

Q.19 How can you differentiate between molecular formula and empirical formula? 09204033

Ans. Empirical Formula
It is the formula which shows the simplest whole number ratio of atoms present in a compound.
e.g. Glucose has simplest ratio 1:2:1 of carbon, hydrogen and oxygen respectively. Hence its empirical formula is CH_2O.

Molecular Formula
The formula which shows actual number of atoms of each element present in a molecule of that compound is called molecular formula, **e.g.** Molecular formula of benzene is C_6H_6.

Chemical Formula of Compounds

Q.20 How molecular formula of a compound can be found out? 09204034

Ans. Molecular formula of a compound can be found out if we know its empirical formula. To calculate the empirical formula of a compound, you need to determine the simplest whole-number ratio of atoms in the compound. This can be done by using experimental data on the mass percent composition of the compound. Molecular formula is then calculated by the following relationship.
Molecular formula = n (Empirical Formula)

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where, $n = \frac{\text{Molar Mass}}{\text{Empirical Formula mass}}$

For example, the empirical formula of hydrogen peroxide is HO. Its molar mass is 34. Its molecular formula will then be

$$n = \frac{34}{17} = 2$$

Molecular formula = $(HO)_2 = H_2O_2$

If for a compound the value of n is one, then its molecular formula is the same as its empirical formula.

Q.21 Empirical formula of a compound is CH. Its molar mass is 78 g mol^{-1}. Find out molecular formula? 09204035

Ans. Solution: Empirical Formula = CH

Empirical formula mass = 13 g mol^{-1}

Molar mass = 78 g mol^{-1}

Molecular formula = n(Empirical formula)

$$n = \frac{\text{molar mass}}{\text{empirical formula mass}}$$

$$= \frac{78}{13} = 6$$

Molecular Formula = $(CH)_6 = C_6H_6$

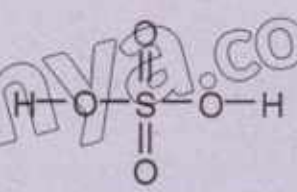
Deduce the molecular formula from the structural formula

Q.22 How to deduce the molecular formula of a compound from structural formula? 09204036

Ans. In order to deduce the molecular formula from the structural formula the following steps are taken.

i. Write down the structural formula of the compound.
ii. Count the number of atoms of each type in the structural formula.
iii. Write the symbols of all the elements.
iv. Write the total number of atoms of each kind as a subscript.
v. Remove the subscript 1.

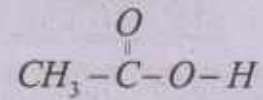
Q.23 Write down the molecular formula of sulphuric acid. Its structural formula is: 09204037



Ans. It has 2 H, 1 S and 4O atoms.

Its molecular formula will be H_2SO_4

Q.24 Write down the molecular formula of acetic acid. Its structure formula is: 09204038



It has 2C, 4H, 2O atoms

Its molecular formula will be $C_2H_4O_2$

Avogadro's Number (N_A)

Q.25 What is Avogadro's number? 09204039

Ans. Avogadro's number is a collection of 6.02×10^{23} particles. It is represented by symbol 'N_A'. Hence, the 6.02×10^{23} number of atoms, molecules or formula units are called Avogadro's number that is equivalent to one 'mole' of respective substance.

e.g. 6.02×10^{23} atoms of carbon = 1 mole of carbon.

Q.26 What is importance of mole? 09204040

Ans. Mole is important because atoms and molecules are so small. The mole concept allows us to count atoms and molecules by weighing macroscopically small amounts of matter.

The Mole and Molar Mass

Q.27 Define molar mass. 09204041

Ans. The mass of one mole of a substance is called as molar mass.

e.g. Molar mass of O-atom = 16 g.

Q.28 What is mole? 09204042

Ans. A mole is defined as the amount (mass) of a substance that contains 6.02×10^{23} number of particles (atoms, molecules or formula units). It is abbreviated as 'mol'.

e.g. 1 mole of carbon = 12 g = 6.02×10^{23} atoms of carbon.

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Q.29 Determine the molar masses of the following compounds in g mol^{-1}. 09204043

(a) H_2SO_4 (Sulphuric acid)

(b) $C_6H_{12}O_6$ (Glucose)

Ans. (a)H_2SO_4

Atomic mass of H=1

Atomic mass of S= 32

Atomic mass of O = 16

Molar mass

$= 2(1) + 1(32) + 4(16) = 98$ g mol^{-1}

(b) $C_6H_{12}O_6$

Atomic mass of C = 12

Atomic mass of H=1

Atomic mass of O = 16

Molar mass

$= 6(12) + 12(1) + 6(16) = 180$ g mol^{-1}

Chemical Equations and Chemical Reactions

Q.30 What is chemical equation? 09204044

Ans. The chemists have developed a very suitable way of representing a chemical change in terms of symbols of elements and formulas of compound. Representing a chemical change in this way is called a chemical equation.

Q.31 Write names of compounds which have same empirical formula but different molecules formula. 09204045

Ans. Molecular formula of Benzene = C_6H_6

Molecular formula of Acetylene= C_2H_2

But Both have same empirical formula = CH

Q.32 Differentiate between reactants and products. 09204046

Ans.

Reactants	Products
In a chemical reaction, the substances that combine or decompose to form products are called reactants.	In a chemical reaction, the new substances which are formed by the combination or decomposition of reactants are called products.
e.g. $2H_2 + O_2 \xrightarrow[\Delta]{h\nu} 2H_2O$ (Reactants)	(Product)

Q.33 Define reversible reaction. 09204047

Ans. Sometimes a chemical reaction moves both ways. In other words, the reactants react to give the products and the products, in turn, react to give the reactants back. Such reactions are called as reversible reactions and are indicated by($\rightleftharpoons$) **e.g.**

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

Calculations Based on Chemical Equation

Q.34 What information do we get from balanced chemical equation? 09204048

Ans. A complete and balanced chemical equation tells us the mole ratio or molar mass ratio between the reactants and the products. With the help of this ratio, we can find out the molar masses of the products provided we know the molar masses of the reactants. Similarly the molar masses of the reactants can also be found out if we know the molar masses of the products.

For example, the following equation tells us that one mole (100 g) of calcium carbonate reacts with two moles (73 g) of hydrochloric acid to produce one mole (111 g) of $CaCl_2$, one mole (18 g) of water and one mole (44 g) of carbon dioxide.

$$CaCO_{3(s)} + 2HCl_{(aq)} \longrightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_2$$

1 mole	2 moles	1 mole	1 mole	1 mole
100 g	73 g	111 g	18 g	44 g

The total masses of the reactants are equal to the total masses of the products.

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Constructed Response Question

Q.1 (Ex. Q.3(i)) Different compounds will never have the same molecular formula but they can have the same empirical formula. Explain. 09204049

Ans: Different compounds can indeed have the same empirical formula but different molecular formulae. The empirical formula represents the simplest whole number ratio of atoms of each element in a compound.

For example, the empirical formula for both glucose and formaldehyde is CH_2O. This means that both compounds contain the same ratio of carbon, hydrogen, and oxygen atoms, but they differ in the actual number of those atoms.

On the other hand, the molecular formula provides the actual number of each type of atom in a molecule. In the case of glucose, the molecular formula is $C_6H_{12}O_6$, while for formaldehyde, it is CH_2O.

Q.2 (Ex. Q.3(ii)) Write down the chemical formulas of the following compounds. 09204050

Calcuim phosphate, Aluminium nitride, Sodium acetate, Ammonium carbonate and Bismuth sulphate.

Ans: Here are the chemical formulas for the compounds:

1. Calcium phosphate: $Ca_3(PO_4)_2$
2. Aluminium nitride: AlN
3. Sodium acetate: CH_3COONa
4. Ammonium carbonate: $(NH_4)_2CO_3$
5. Bismuth sulphate: $Bi_2(SO_4)_3$

Q.3 (Ex. Q.3(iii)) Why does Avogadro's number have an immense importance in chemistry? 09204051

Ans: Avogadro's number, which is approximately 6.022×10^{23} no. of particles, is immensely important in chemistry for several reasons.

Firstly, it provides a bridge between the microscopic world of atoms and molecules and the macroscopic world we can measure. When chemists work with substances, they often deal with grams and liters but the reactions and interactions occur at the atomic or molecular level. Avogadro's number allows chemists to convert between the number of particles and the amount of substance in grams, making it easier to calculate and understand chemical reactions.

Secondly, it helps in determining the molar mass of substances. The molar mass is the mass of one mole of a substance, and knowing Avogadro's number enables chemists to relate the mass of a sample to the number of moles it contains. This is crucial for stoichiometric calculations in chemical reactions, where the ratios of reactants and products need to be precisely measured.

Q.4 (Ex. Q.3(iv)) When 8.657g of a compound were converted into elements, it gave 5.217g of carbon, 0.962g of hydrogen and 2.478g of oxygen. Calculate the percentage of each element present in this compound. 09204052

Ans: To calculate the percentage of each element in the compound, the following formula can be used:

Percentage of an element = (mass of the element / total mass of the compound) × 100

- **Carbon (C):**

- Mass of carbon = 5.217 g
- Total mass of the compound = 8.657 g
- Percentage of carbon = (5.217 g / 8.657 g) × 100
- Percentage of carbon = 60.3%

- **Hydrogen (H):**
  - Mass of hydrogen = 0.962 g
  - Percentage of hydrogen = (0.962 g / 8.657 g) × 100
  - Percentage of hydrogen = 11.1%
- **Oxygen (O):**
  - Mass of oxygen = 2.478 g

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- Percentage of oxygen = (2.478 g / 8.657 g) × 100
- Percentage of oxygen = 28.6%

Q.5 (Ex. Q.3(v)) How can you calculate the masses of the products formed in a reversible reaction? 09204053

Ans: The following example to illustrate how to calculate the masses of products formed in a reversible reaction.

Consider the reversible reaction of nitrogen gas (N_2) with hydrogen gas (H_2) to form ammonia (NH_3):

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

- **Chemical Equation:** First of all, write the balanced chemical equation.
- **Identify Known Quantities:** Suppose we start with 28 g of nitrogen (N_2) and 6 g of hydrogen (H_2).
- **Calculate Moles of Reactants:**
  - Molar mass of N_2 = 28 g/mol
  - Molar mass of H_2 = 2 g/mol
  Moles of N_2 = 28 g / 28 g/mol = 1 mol
  Moles of H_2 = 6 g / 2 g/mol = 3 mol
- **Use Stoichiometry:** According to the balanced equation, 1 mole of N_2 reacts with 3 moles of H_2 to produce 2 moles of NH_3. We have exactly 1 mol of N_2 and 3 mol of H_2, which means we have enough hydrogen to react completely with nitrogen.
- **Calculate Moles of Products:**
  From the balanced equation:
  1 mol of N_2 produces 2 mol of NH_3.
  Therefore, 1 mol of N_2 will produce 2 mol of NH_3.
- **Calculate Mass of Products:**
  Molar mass of NH_3 = 14 g/mol (N) + 3 g/mol (H) = 17 g/mol
  Moles of NH_3 produced = 2 mol
  Mass of NH_3 = 2 mol × 17 g/mol = 34 g

In this example, starting with 28 g of nitrogen and 6 g of hydrogen, we can produce 34 g of ammonia.

Multiple Choice Questions (Exercise)

1. **How many atoms are present in one gram of H_2O?** 09204054
   (a) 1002×10^{23} atoms
   (b) 6.022×10^{23} atoms
   (c) 0.334×10^{23} atoms
   (d) 2.004×10^{23} atoms
2. **Which is the correct formula of calcium phosphide?** 09204055
   (a) CaP (b) CaP_2
   (c) Ca_2P_3 (d) Ca_3P_2
3. **How many atomic mass units (amu) are there in one gram?** 09204056
   (a) 1 amu
   (b) 10 amu
   (c) 6.022×10^{23} amu
   (d) 6.022×10^{22} amu
4. **Structural formula of 2-hexene is $CH_3–CH=CH-(CH_2)_2CH_3$. What will be its empirical formula?** 09204057
   (a) C_2H_2 (b) CH
   (c) C_6H_{12} (d) CH_2
5. **How many moles are there in 25 g of H_2SO_4?** 09204058
   (a) 0.765 moles
   (b) 0.51 moles
   (c) 0.255 moles
   (d) 0.4 moles
6. **A necklace has 6g of diamonds in it. What are the number of carbon atoms in it?** 09204059
   (a) 6.02×10^{23}
   (b) 12.04×10^{23}
   (c) 1.003×10^{23}
   (d) 3.01×10^{23}
7. **What is the mass of Al in 204g of aluminium oxide, Al_2O_3?** 09204060
   (a) 26g (b) 27g
   (c) 54g (d108g

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8. **Which one of the following compounds will have the highest percentage of the mass of nitrogen?** 09204061
(a) $CO(NH_2)_2$ (b) N_2H_4
(c) NH_3 (d) NH_2OH

9. **When one mole of each of the following compounds is reacted with oxygen, which will produce the maximum amount of CO_2?** 09204062
(a) Carbon (b) Diamond
(c) Ethane (d) Methane

10. **What mass of 95% $CaCO_3$ will be required to neutralize 50 cm^3 of 0.5M HCl solution?** 09204063
(a) 9.5g (b) 1.25g
(c) 1.32g (d) 1.45g

SLO Based Additional MCQ's

Chemical Formula

11. **Formula of ozone is:** 09204064
(a) O_2 (b) O_3
(c) S_8 (d) CO_2

12. **Avogadro was a scientist:** 09204065
(a) Greek (b) German
(c) Italian (d) African

13. **Which of the following is insoluble salt** 09204066
(a) NaCl (b) $CaCl_2$
(c) AgCl (d) KCl

14. **Stoichiometric calculators are used to prepare** 09204067
(a) Soaps
(b) Shampoo
(c) Perfumes
(d) All of these

15. **Without stoichiometry which industry cannot exist** 09204068
(a) Chemical (b) Petroleum
(c) Leather (d) Meta Energy

16. **Which law is obeyed in chemical calculations?** 09204069
(a) Law of conservation of mass
(b) Law of definite proportion
(c) Law of mass action
(d) both a & b

Empirical Formula

17. **Empirical formula of sand is:** 09204070
(a) SiO_3 (b) SiO_2
(c) SiO_4 (d) SiO_3

18. **Empirical formula of glucose is:** 09204071
(a) CH_2O (b) CHO
(c) CHO_2 (d) C_2HO

19. **Empirical formula of acetic acid (CH_3COOH) is:** 09204072
(a) CHO (b) CH_2O
(c) CH (d) None of these

20. **Which of the following represents sand?** 09204073
(a) SiO_2 (b) H_2O
(c) NaCl (d) $CaCO_3$

21. **Empirical formula of hydrogen peroxide is:** 09204074
(a) HO (b) CHO
(c) CH (d) CO

22. **Empirical formula of Benzene is:** 09204075
(a) CH_2O (b) CH
(c) CH_2 (d) C_2H

Chemical Formulas of Binary Ionic Compounds

23. **Which compound has same molecular and empirical formula?** 09204076
(a) $C_6H_{12}O_6$ (b) C_6H_6
(c) H_2O_2 (d) H_2O

24. **Formula of sulphate radical is:** 09204077
(a) SO_3^{2-} (b) SO_4^{2-}
(c) HSO_4 (d) HSO_3^-

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Avogadro's Number (N_A)

25. Value of Avogadro's number is: 09204078

(a) 6.02×10^{23}
(b) 1.32×10^{23}
(c) 6.6×10^{-20}
(d) 6.00×10^{24}

The Mole and Molar Mass

26. 1 gram formula of $NaCl$ contains grams: 09204079

(a) 100 g (b) 32 g
(c) 58.5 g (d) 49 g

27. 1-gram atom of carbon contains how many moles? 09204080

(a) 2 moles (b) 12 moles
(c) 1 mole (d) 6 moles

28. Formula of common salt is: 09204081

(a) $AgCl$ (b) $LiCl$
(c) $NaCl$ (d) KCl

Chemical Equations and Chemical Reactions

29. Formula mass of K_2SO_4 is: 09204082

(a) 174 amu (b) 180 amu
(c) 110 amu (d) 145 amu

30. Molecular mass of acetic acid is: 09204083

(a) 43 amu (b) 70 amu
(c) 60 amu (d) 80 amu

31. No. of formula units present in 58.5 g of $NaCl$ are: 09204084

(a) $2 \times 6.02 \times 10^{23}$
(b) 6.02×10^{23}
(c) $3 \times 6.02 \times 10^{23}$
(d) $58.5 \times 6.02 \times 10^{23}$

32. Number of hydrogen atoms present in 18g of water: 09204085

(a) $2 \times N_A$ (b) N_A
(c) $3 \times N_A$ (d) $\frac{1}{2} N_A$

33. The mass number of sodium is: 09204086

(a) 19 (b) 23
(c) 27 (d) 31

Calculations Based on Chemical Equation

34. Total number of ions present in one mole of sodium chloride is: 09204087

(a) $\frac{1}{2} \times 6.02 \times 10^{23}$
(b) 6.02×10^{23}
(c) 1.204×10^{24}
(d) None of these

35. Limestone is another name of: 09204088

(a) Sodium hydroxide
(b) Calcium Carbonate
(c) Sodium Carbonate
(d) Silicon dioxide

36. Mass of 3 moles of oxygen atoms is: 09204089

(a) 48 g (b) 32 g
(c) 64 g (d) 16 g

37. How many molecules of water will be present in half mole of water? 09204090

(a) 6.02×10^{23}
(b) 3.01×10^{23}
(c) 6.02×10^{24}
(d) 1.66×10^{-2}

38. Number of moles in $29.25g$ $NaCl$ is: 09204091

(a) 0.25 (b) 0.21
(c) 0.50 (d) 0.75

39. How many atoms of carbon are present in one molecule of glucose? 09204092

(a) 11 (b) 12
(c) 6 (d) 22

40. How many atoms are present in one gram atomic mass of a substance? 09204093

(a) 6.20×10^{24}
(b) 12.04×10^{23}
(c) 6.02×10^{23}
(d) 6.2×10^{-2}

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41. 40 g of H_3PO_4 contains number of moles: 09204094
(a) $0.58g$
(b) $0.408g$
(c) $4.8g$
(d) $5.8g$

42. A compound with chemical formula Na_2CX_3 has formula mass $106amu$. Atomic mass of the element X is: 09204095
(a) 106 (b) 23
(c) 12 (d) 16

43. How many moles of molecules are there in 16g oxygen: 09204096
(a) 1 (b) 0.5
(c) 0.1 (d) 0.05

44. What is the mass of 4 moles of hydrogen gas? 09204097
(a) 8.064g (b) 4.032g
(c) 1g (d) 1.008g

45. Which term is the same for one mole of oxygen and one mole of water? 09204098
(a) volume (b) molecules
(c) mass (d) atoms

46. If one mole of carbon contains x atoms, what is the number of atoms contained in 12g of Mg. 09204099
(a) x (b) $0.5x$
(c) $2x$ (d) $1.5\,x$

47. The mass of one molecule of water is: 09204100
(a) 18 amu (b) 18 g
(c) 18 mg (d) 18 kg

48. The molar mass of H_2SO_4 is: 09204101
(a) 98 g (b) 98 amu
(c) 9.8 g (d) 9.8 amu

49. Which one of the following is molecular mass of O_2 in amu? 09204102
(a) $32\ amu$
(b) $53.12 \times 10^{-24}\ amu$
(c) $1.92 \times 10^{-25}\ amu$
(d) $192.64 \times 10^{-25}\ amu$

50. How many number of moles are equivalent to 8 grams of CO_2? 09204102
(a) 0.15 (b) 0.18
(c) 0.21 (d) 0.24

51. Which one of the following pairs has the same number of ions? 09204103
(a) 1 mole of $NaCl$ and 1 mole of $MgCl_2$
(b) $\frac{1}{2}$ mole of $NaCl$ and $\frac{1}{2}$ mole of $MgCl_2$
(c) $\frac{1}{2}$ mole of $NaCl$ and $\frac{1}{3}$ mole of $MgCl_2$
(d) $\frac{1}{3}$ mole of $NaCl$ and $\frac{1}{2}$ mole of $MgCl_2$

52. Which one of the following pairs has the same mass? 09204104
(a) 1 mole of CO and 1 mole of N_2
(b) 1 mole of CO and 1 mole of CO_2
(c) 1 mole of O_2 and 1 mole of N_2
(d) 1 mole of O_2 and 1 mole of CO_2

Answer Key

1	c	2	d	3	c	4	d	5	c
6	d	7	d	8	b	9	c	10	c
11	b	12	c	13	c	14	d	15	a
16	a	17	b	18	a	19	b	20	a
21	a	22	b	23	d	24	b	25	a
26	c	27	c	28	c	29	a	30	c
31	b	32	a	33	b	34	c	35	b
36	a	37	b	38	c	39	c	40	c
41	b	42	d	43	b	44	a	45	b
46	b	47	a	48	a	49	a	50	b
51	c	52	a						

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