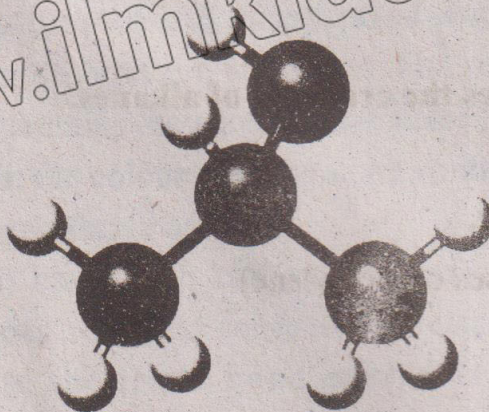


Student Learning Outcomes

After studying this chapter, students will be able to::

- Describe the manufacture of ethanol (This can be done by discussing fermentation of aqueous glucose at 25-35 °C in the presence of yeast and in the absence of oxygen catalytic addition of steam to ethene at 300°C and 6000kPa /6 atm in the presence of an acid catalyst including a comparison of the advantages and disadvantages of the two methods)
- Describe the combustion of alcohols
- Discuss the applications of alcohols as fuels, including their advantages and disadvantages over fossil fuels.
- Explain the role of alcohols in various industries such as pharmaceuticals, cosmetics, and fuel production.
- Discuss the impact of alcohols on daily life, including their use as solvents and disinfectants.



Subjective Type Questions

Long Questions prepared in the light of new Examination Techniques
(Knowledge, Understanding, Application, Analytical & Conceptual)

23.1**Manufacture of Ethyl Alcohol ($\text{CH}_3 - \text{CH}_2 - \text{OH}$)****23.2****Combustion of Alcohols**

Q.1: Describe the preparation of ethanol by fermentation process.

Ans. Ethanol:

Ethyl alcohol or ethanol is a very important member of homologous series of Monohydroxy alkanes or alcohols. It is manufactured on large scale by the fermentation

of glucose by yeast.

Fermentation of Glucose by Yeast:

Fermentation is a reaction in which a substance breaks down into simpler substances in the presence of enzymes present in yeast.

Examples:

Preparation of yogurt, bread and ethyl alcohol are some examples of the fermentation reactions.

The Chemical Process:

Glucose can be converted to ethyl alcohol in the presence of yeast at around 35°C and in a neutral or acidic solution.

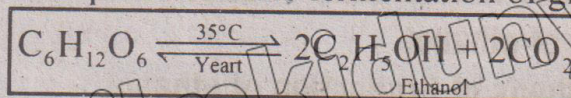
This fermentation reaction must be carried out in the absence of air (anaerobic conditions) to obtain ethanol.

Catalyst:

Yeast contains an enzyme which acts as a catalyst in this reaction.

Balanced Chemical Equation:

The balanced chemical equation for the fermentation of glucose is as follows:



Products of the Reaction:

Carbon dioxide gas comes out of the reaction mixture leaving behind a mixture of ethanol and water.

Conditions for Reaction:

Temperature Sensitivity:

The temperature of the process must be kept around 35°C to get the maximum yield of the product.

- A lower temperature decreases the rate of the reaction.
- The higher temperature makes the enzyme inactive in anaerobic conditions.

Exclusion of Oxygen:

Oxygen is excluded from the reaction because it converts the resulting ethanol into ethanoic acid.

Alcohol concentration:

Since ethanol is toxic to yeast in high concentration, yeast is made inactive when the concentration of ethanol in the reaction mixture exceeds 15%.

Q.2: Discuss the preparation of ethanol by hydration of ethene or Ethylene.

Ans. Preparation of Ethanol:

It is prepared in the industries on large scale by the hydration of Ethene or Ethylene which is discussed below.

Hydration of Ethene or Ethylene:

Hydration of ethene is an addition reaction. In this reaction water is added across

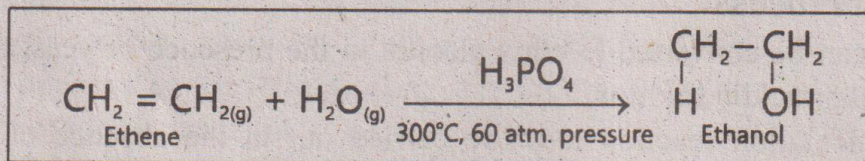
the double bond of the ethene.

The reaction is carried out by passing a mixture of ethene and steam over hot phosphoric acid (H_3PO_4), which acts a catalyst.

Mechanism:

Hydrogen atom of H_2O attaches itself to one carbon atom of ethene and the hydroxyl group to other atom. During this addition the double bond breaks down to give a saturated compound, ethanol.

Chemical Equation:



Gaseous ethanol obtained is then condensed into its liquid form.

Industrial Importance and Applications:

Hydration of ethene is an important industrial process because ethanol is a versatile compound. It has a wide range of applications from alcoholic drinks to fuels and as a solvent.

Q.3: Give a comparison of fermentation reaction and catalytic hydration of ethene for the preparation of ethanol.

Ans. Comparison of Methods of Production of ethanol:

Hydration of Ethene	Fermentation
Reaction is performed at high temperature and at high pressure.	It takes place at around 35°C and at atmospheric pressure.
Starting material for the process is obtained from crude oil, which is a non-renewable source.	Starting material for this method is a renewable source, such as cane-sugar.
Rate of reaction is high.	Rate of reaction is low. It may take days to complete.
The reaction produces relatively pure alcohol.	The reaction produces 15% alcohol which needs further distillation to increase the concentration. Distillation requires energy.
Ethanol produced in this method is expensive.	Ethanol produced in this process is cheap.

Q.4: Explain combustion of Alcohols.

(OR) Explain why the amount of heat evolved (ΔH) increases as you move from methanol to butanol in the homologous series.

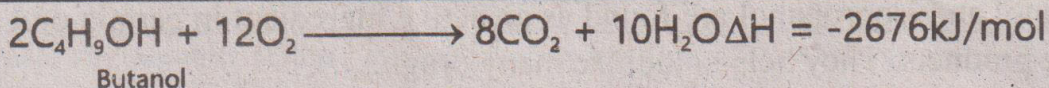
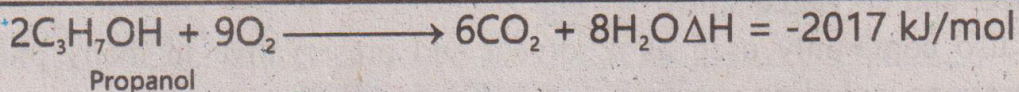
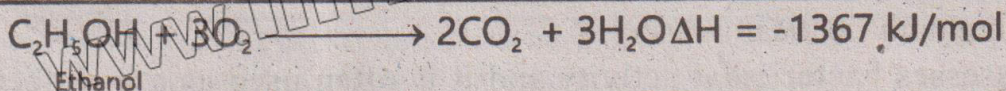
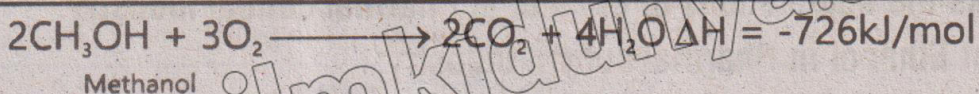
Ans. Combustion of Alcohols:

Alcohols are flammable, therefore, burn in air to produce CO_2 and H_2O evolving a large amount of heat.

Example:

Methanol, ethanol and 1-propanol, all burn completely in excess of air because they contain a hydrocarbon chain.

Balanced Chemical Equations:



Mechanism of Heat Evolution:

During combustion of alcohols:

- The weaker C-H bonds in C-H₂ groups break the stronger C=O and O-H bonds are formed in CO₂ and H₂O respectively.

This explains the reason due to which the amount of heat evolved increases with the addition of a -CH₂ group in the alcohol homologous series.

23.3

Applications of Alcohols as Fuels

23.4

Role of Ethanol in Industries

23.5

Impact of Alcohols on Daily Life

Q.5: Describe applications of Alcohols as fuels.

(OR) Describe advantages and disadvantages of alcohols as fuels.

Ans. Applications of Alcohols as Fuels:

Alcohols are also used as fuels instead of petrol and diesel to run an automobile.

The first four aliphatic alcohols namely methanol, ethanol, propanol and butanol have such properties which make them suitable to be used in internal combustion engines.

Advantages of Alcohols as Fuels:

- Alcohols are obtained from renewable sources.
- Burning of alcohols does not produce oxides of sulphur which makes them environmental friendly as compared to fossil fuels.
- Alcohols have higher fuel efficiency as compared to petrol or diesel fuels.

Disadvantages of Alcohols as Fuels:

- Alcohols have less energy per volume than gasoline. It means more fuel is needed to travel the same distance.
- Alcohols can increase wear and tear on engine components.
- Land is utilized to grow crops which then yield alcohols. This fact affects the

cultivation of food crops.

Q.6: Discuss the applications of ethanol in Pharmaceutical industry.

Ans. Role of Ethanol in Pharmaceutical Industry:

Ethyl alcohol serves as a very common ingredient in a variety of manufacturing processes in pharmaceutical industry.

- (i) It possesses bactericidal activity and it is often used as a disinfectant in hand sanitizer and ethylated spirit.
- (ii) It is also commonly used as a solvent and preservative in many pharmaceutical preparations including vaccines.
- (iii) Ethanol and isopropanol are found as an active ingredient in certain oral and topical drug products. They help solubilize many drugs.

Q.7: Describe the applications of ethanol in cosmetic industry.

Ans. Role of Ethanol in Cosmetic Industry:

Ethyl alcohol plays an important role in cosmetic industry because of its following properties:

- (i) Being highly volatile it evaporates in a very short time.
- (ii) Deodorizing and anti-inflammatory properties.
- (iii) Refreshing and antimicrobial properties.

Ethanol is an important part of such cosmetic and hygiene products as hair styling products, foundation creams, perfumes, deodorants and after shave lotions.

Q.8: Explain impact of alcohols on daily life.

Ans. Impact of Alcohols on Daily Life:

- (i) Ethyl alcohol is an essential part of first aid kit in every home in the form of methylated spirit.
Ethylated spirit is used as an antiseptic, for dressing of wounds. As an antidote for snake bites.
- (ii) In many parts of the world, ethanol is used as high efficiency fuel to drive vehicles.
- (iii) Ethanol is widely used as a solvent in perfumes.
- (iv) It is relatively safe and can be used to dissolve many organic compounds which are insoluble in water.

23.1 Quick Check!

1. What is the role of yeast in fermentation reaction?

Ans. Yeast acts as a biological catalyst. It contains enzymes (specifically Zymase) that provide the necessary chemical pathway to break down glucose into ethyl alcohol and carbon dioxide.

2. At which temperature enzymes present in yeast get inactive?

Ans. The enzymes present in yeast become inactive at temperatures higher than 35 °C.

23.2 Quick Check!

1. Why oxygen is excluded when the fermentation reaction is carried out?

Ans. Oxygen is excluded when the fermentation reaction is carried out because it converts the

resulting ethanol into ethanoic acid.

2. Which method for the preparation of ethene involves renewable source?

Ans. Fermentation is the method for the preparation of ethane that involves renewable source, such as cane-sugar.

23.3 Quick Check!

1. Why does butanol evolve a higher amount of heat than propanol when burnt in oxygen?

Ans. Butanol evolve more heat than propanol when burnt because butanol has a longer hydrocarbon chain more bonds to react, leading to the formation of more CO_2 and H_2O molecules, which releases more energy (heat).

23.4 Quick Check!

1. Why does the amount of heat evolved during burning of alcohols go on increasing from lower to higher alcohols?

Ans. The amount of heat evolved during burning of alcohols go on increasing from lower to higher alcohols due to the following reasons.

- Higher alcohols have more carbon and hydrogen atoms in their molecules. For example, Methanol has one carbon (CH_3OH), while Ethanol has two ($\text{C}_2\text{H}_5\text{OH}$).
- During combustion of alcohols the weaker C-H bonds in CH groups break and the stronger C=O and O-H bonds are formed in CO_2 and H_2O respectively. As the molecules size increases, there are more C-H and C-C bonds available to react.
- Each additional $\text{-CH}_2\text{-}$ group in the homologous series adds a consistent amount of energy to the total heat evolved. Therefore, the more fuel (Carbon and hydrogen) present per molecule, the more energy is released upon burning.

2. Why burning of alcohols does not produce oxides of sulphur unlike fossil fuels?

Ans. Alcohols are obtained from renewable sources consisting of carbon (C), hydrogen (H) and Oxygen (O). They do not contain sulphur. When these burn, they only produce CO_2 and H_2O . No oxides of sulphur are formed during their combustion.

On the other hand, fossil fuels are formed from ancient organic matter that often contains sulphur impurities. When these fossil fuels are burned, the sulphur reacts with oxygen to form sulphur dioxide (SO_2) or sulphur trioxide (SO_3) which causes pollution.

INTERESTING INFORMATION

- Alcohols are produced from plant materials which, in turn, are the result of the photosynthesis process using CO_2 of the atmosphere. The same CO_2 is generated when these bioalcohols are burnt in internal combustion engine. The overall process is considered to be carbon neutral because it does not increase the concentration of carbon dioxide gas in the atmosphere.
- Ethanol as a fuel reduces greenhouse gas emissions by 44 to 52% as compared to petrol. Besides this, ethanol also cuts down on other harmful pollutants like CO_x , NO_x and particulate matter.

DO YOU KNOW?

- Ethyl alcohol as a drink can cause hangover, alcohol poisoning, accidents and risky behaviour. Long-term use of alcohol is known to cause more than 200 different diseases.

Objective Type Questions

Additional MCQ's

Multiple Choice Questions prepared in the light of new Examination Techniques
(Knowledge, Understanding, Application, Analytical & Conceptual)

23.1

Manufacture of Ethyl Alcohol ($\text{CH}_3 - \text{CH}_2 - \text{OH}$)

23.2

Combustion of Alcohols

- What is the biological process of breaking down complex substances into simpler ones using yeast enzymes called?
(a) Fermentation (b) Oxidation (c) Distillation (d) Reduction
- Which of the following specific substance is converted into ethyl alcohol in the presence of yeast?
(a) Ethanoic acid (b) Glucose (c) Yogurt (d) Carbon dioxide
- What is the ideal temperature for the fermentation process to achieve the maximum yield?
(a) 15°C (b) 25°C (c) 35°C (d) 45°C
- Fermentation must be carried out in the absence of air, a condition known as:
(a) Aerobic (b) Acidic (c) Anaerobic (d) Basic
- According to the balanced chemical equation, what is the by product of fermentation along with ethanol?
(a) Water (b) Carbon dioxide (c) Oxygen (d) Nitrogen
- If oxygen is not excluded from the reaction, ethanol will be converted into:
(a) Ethanoic acid (b) Yeast (c) Glucose (d) methanol
- Why does the fermentation process stop when the alcohol concentration exceeds 15%.
(a) The glucose runs out (b) The temperature drops
(c) Ethanol becomes toxic to the yeast (d) Oxygen enters the mixture
- What happens to the yeast enzymes if the temperature of the process becomes too high?
(a) They work faster (b) They produce more gas
(c) They become inactive (d) They turn into glucose
- In what type of solution should the fermentation reaction be carried out?
(a) Strongly basic (b) Neutral or acidic (c) Highly alkaline (d) None of these
- What role does yeast play in the Chemical reaction?
(a) Reactant (b) Solvent (c) Catalyst (d) Product
- Which of the following is a specific example of a fermentation reaction?
(a) Preparation of bread (b) Melting ice

- (c) Burning wood (d) Boiling water
12. What is the effect of a lower temperature on the fermentation process?
(a) It makes the yeast toxic (b) It decreases the rate of the reaction
(c) It turns ethanol into glucose (d) It increases the yield of product
13. What is the state of the carbon dioxide as it leaves the mixture during fermentation?
(a) Solid (b) Liquid (c) Gas (d) Plasma
14. What remains behind in the mixture after carbon dioxide gas comes out during fermentation?
(a) Glucose (b) Yeast
(c) Ethanoic acid (d) Ethanol and water
15. What temperature is necessary for the yeast enzymes to remain active?
(a) Above 50 °C (b) Around 35 °C (c) Below 45 °C (d) At 75 °C
16. On burning in air, alcohols produce:
(a) Carbon dioxide (b) Water (c) Large amount of heat (d) All of these
17. How much heat is produced in the following reaction?
$$2\text{CH}_2\text{OH} + 3\text{O}_2 \longrightarrow 2\text{CO}_2 + 4\text{H}_2\text{O} \Delta H =$$

(a) 1367 kJ/mol (b) 2017 kJ/mol (c) 726 kJ/mol (d) 2676 kJ/mol
18. How much heat is produced when ethanol burns in excess of air?
(a) 1367 kJ/mol (b) 26 kJ/mol (c) 2017 kJ/mol (d) 726 kJ/mol
19. When propanol burns in excess of air; _____ energy is produced.
(a) 726 kJ/mol (b) 2017 kJ/mol (c) 1367 kJ/mol (d) 2676 kJ/mol
20. It is the energy produced when butanol burns in air.
(a) 726 kJ/mol (b) 1367 kJ/mol (c) 2017 kJ/mol (d) 2676 kJ/mol
21. It is a formula of ethanol.
(a) CH_2OH (b) $\text{C}_2\text{H}_5\text{OH}$ (c) $\text{C}_3\text{H}_7\text{OH}$ (d) $\text{C}_4\text{H}_8\text{OH}$
22. What type of chemical reaction occurs during the hydration of ethene to produce ethanol?
(a) Addition reaction (b) Substitution reaction
(c) Elimination reaction (d) Redox reaction
23. Which catalyst is essential for the industrial hydration of ethene?
(a) Nickel (Ni) (b) Phosphoric acid (H_3PO_4)
(c) Iron (Fe) (d) Manganese dioxide (MnO_2)
24. What are the standard industrial conditions for the hydration of ethene?
(a) 35 °C and 1 atm pressure (b) 300 °C and 60 atm pressure
(c) 100 °C and 200 atm pressure (d) 500 °C and 10 atm pressure
25. Comparing the cost and purity, which method produces expensive but pure ethanol?
(a) Combustion (b) Hydration of ethene
(c) Fermentation (d) Hydration of ethene

23.3**Applications of Alcohols as Fuels****23.4****Role of Ethanol in Industries****23.5****Impact of Alcohols on Daily Life**

26. What is the chemical name for H_3PO_4 ?
(a) Sulphuric acid (b) Phosphoric acid (c) Hydrochloric acid (d) Nitric acid
27. Hydration of ethane turns an unsaturated bond into a _____ compound.
(a) Saturated (b) Acidic (c) Basic (d) Gaseous
28. In the hydration reaction, ethane reacts with:
(a) Liquid water (b) Steam (gas) (c) Ice (Solid) (d) All of these
29. Which process is "Green" or uses renewable sources?
(a) Hydration (b) Fermentation (c) Combustion (d) Distillation
30. Ethanol made from crude oil is usually:
(a) Cheap (b) Free (c) Expensive (d) Unavailable
31. Which alcohol has the shortest carbon chain?
(a) Ethanol (b) Butanol (c) Methanol (d) Propanol
32. Which of the following alcohol has the longest carbon chain?
(a) Methanol (b) Ethanol (c) Propanol (d) Butanol
33. Select the alcohols which are commonly used in internal combustion engines.
(a) Methanol, ethanol (b) Propanol, butanol
(c) Pentanol, hexanol (d) a and b both
34. Which harmful pollutant, common in fossil fuels, is NOT produced when burning alcohols?
(a) Water vapour (b) Carbon dioxide
(c) Oxides of sulphur (d) Nitrogen oxides
35. How does the heat evolved during combustion change as you move from lower to higher alcohols?
(a) It decreases (b) It increases
(c) It disappears (d) It remain constant
36. Which of the following is used in hand sanitizers?
(a) Ethanol (b) Butanol (c) Propanol (d) Methanol
37. Ethanol is used in hand sanitizers primarily because of its:
(a) Colour (b) Smell
(c) Slow evaporation (d) Bactericidal activity
38. In the pharmaceutical industry, methylated spirit is often used as a/an.
(a) Antiseptic (b) Antibiotic (c) Vaccine (d) Painkiller
39. By what percentage ethanol can reduce greenhouse gas emissions compared to petrol?
(a) 10% to 20% (b) 90% to 100% (c) 44% to 52% (d) 30% to 49%

40. Which of these is a known long-term health risk of alcohol consumption?
 (a) Improve memory (b) Enhanced driving skills
 (c) Stronger immune system
 (d) Cause of more than 200 different diseases
41. Which of the following is also used as an antidote for snake bites?
 (a) Propanol (b) Butanol (c) Methanol (d) Ethanol
42. Ethanol evaporate very quickly when put on the skin because it is:
 (a) Very heavy (b) A solid (c) Highly volatile (d) Freezing cold
43. Which of the following is used in a first aid kit to clean wounds?
 (a) Cooking oil (b) Diesel
 (c) Petrol (d) Methylated spirit
44. Which gas is NOT made when you burn pure alcohol?
 (a) Water vapour (b) Oxides of sulphur
 (c) Carbon dioxide (d) Oxygen
45. In the pharmaceutical industry, ethanol is used as a preservatives in :
 (a) Bandages (b) Gauze (c) Vaccines (d) Pyodine
46. Ethanol and _____ help solubilize many drugs.
 (a) Isopropanol (b) Butanol (c) Propanol (d) Methanol
47. Alcohols have higher fuel efficiency as compared to:
 (a) Petrol (b) Diesel (c) Kerosene oil (d) a and b both

Answers

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

Additional Short Questions

Short Answer Questions prepared in the light of new Examination Techniques
 (Knowledge, Understanding, Application, Analytical & Conceptual)

23.1 Manufacture of Ethyl Alcohol ($\text{CH}_3 - \text{CH}_2 - \text{OH}$)

23.2 Combustion of Alcohols

1. What are Monohydroxy alkanes or alcohols?

Ans. Monohydroxy alkanes or alcohols are an important class of organic compounds.

2. How can Monohydroxy alkanes or alcohols be obtained?

Ans. Some of these alcohols can be obtained by the reactions in which living organisms

are used as catalysts. They can also be synthesized in the laboratory.

3. What is ethyl alcohol or ethanol?

Ans. Ethyl alcohol or ethanol is a very important member of homologous series of monohydroxy alkanes or alcohols.

4. How is ethyl alcohol or ethanol manufactured on large scale?

Ans. Ethyl alcohol or ethanol is manufactured on large scale by the following processes:

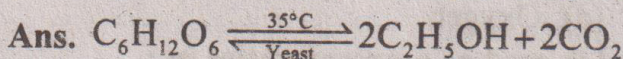
- Fermentation of Glucose by Yeast
- Hydration of Ethene or Ethylene

5. What is Fermentation?

Ans. Fermentation:

Fermentation is a reaction in which a substance breaks down into simpler substances in the presence of enzymes present in yeast.

6. Write the balanced chemical equation for the fermentation of glucose.



7. At which temperature enzymes present in yeast get inactive in fermentation reaction?

Ans. The enzymes present in yeast in fermentation reaction become inactive at temperatures higher than $35^\circ C$ in anaerobic conditions.

8. Name three common products produced through fermentation.

Ans. Three common products produced through fermentation are:

- Yogurt
- Bread
- Ethyl alcohol

9. What are the necessary conditions for the fermentation of glucose?

Ans. The reaction requires:

- A temperature of approximately $35^\circ C$
- A neutral or acidic solution
- Anaerobic conditions (the absence of air)

10. What is the role of yeast in fermentation reaction?

Ans. Yeast contains an enzyme which acts as a catalyst. In fermentation reaction, yeast speeds up the breakdown of glucose into ethanol and carbon dioxide.

11. Why is oxygen excluded from the fermentation mixture?

Ans. Oxygen is excluded from the fermentation mixture because it converts the resulting ethanol into ethanoic acid.

12. What happens when the concentration of ethanol in the reaction mixture exceeds 15%?

Ans. Ethanol is toxic to yeast in high concentration, yeast is made inactive when the concentration of ethanol in the reaction mixture exceeds 15%.

13. Which gas is released as a by-product during the fermentation of glucose?

Ans. Carbon dioxide (CO_2) is released as a by-product during the fermentation of glucose.

14. What remains in the mixture after the gas has escaped during the fermentation of glucose?

Ans. A mixture of ethanol and water remains in the mixture after the gas has escaped during the fermentation of glucose.

15. What is the main raw material used to make ethyl alcohol?

Ans. The main raw material used to make ethyl alcohol is glucose.

16. Which microorganism is used in the fermentation process?

Ans. Yeast is the microorganism in the fermentation process.

17. What is the ideal temperature for making ethanol?

Ans. The ideal temperature for making ethanol is 35°C.

18. Does fermentation require air?

Ans. No, it must be done in anaerobic conditions (without air).

19. What happens to the rate of fermentation reaction at low temperature?

Ans. A lower temperature decreases the rate of the reaction.

20. Write the chemical formula for Ethyl alcohol?

Ans. The Chemical formula for Ethyl Alcohol is $\text{CH}_3\text{—CH}_2\text{—OH}$.

21. Is the solution for fermentation basic or acidic?

Ans. The solution for fermentation should be neutral or acidic.

22. Define hydration of ethene.

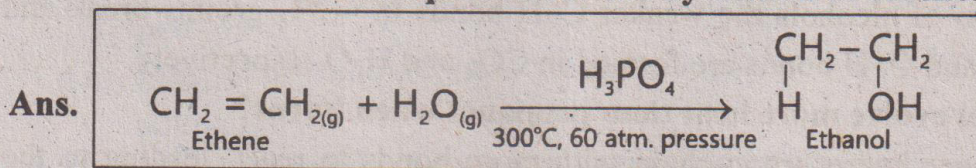
Ans. Hydration of Ethene: Hydration of ethene is an addition reaction. In this reaction water is added across the double bond of the ethene to produce ethanol.

23. What are the specific conditions required for the hydration of ethene?

Ans. The hydration of ethene requires:

- A temperature of 300 °C.
- A pressure of 60 atm.
- Phosphoric acid (H_3PO_4) as a catalyst.

24. Write the chemical equation for the hydration of ethene.



25. Name three industrial application of ethanol.

Ans. Ethanol has a wide range of application from alcoholic drinks to fuels as a solvent.

26. Why is hydration of ethene an important industrial process?

Ans. Hydration of ethene is an important industrial process because ethanol is a versatile compound.

27. Contrast the starting material used in hydration and fermentation.

Ans. Starting material for the process of hydration of ethene is obtained from crude oil, which is a non-renewable source.

Starting material for the process of fermentation is a renewable source, such as cane-sugar.

28. Which method of ethanol production is faster?

Ans. The rate of reaction of hydration of ethene is high, whereas the rate of fermentation reaction is low and it may take days to complete.

29. How does the purity of ethanol differ between the hydration of ethene and fermentation processes?

Ans. Hydration of ethene produces relatively pure alcohol. On the other hand, fermentation produces 15% alcohol which needs further distillation to increase the concentration.

30. Which method is more cost-effective for producing cheap ethanol?

Ans. Ethanol produced in hydration of ethene is expensive, whereas ethanol produced in fermentation is cheap.

31. Why are alcohols considered flammable?

Ans. Alcohols are flammable because they contain a hydrocarbon chain that burns in air to produce CO_2 and H_2O evolving a large amount of heat.

32. What is the general balanced equation for the combustion of methanol?

Ans. $2\text{C}_3\text{H}_7\text{OH} + 3\text{O}_2 \longrightarrow 2\text{CO}_2 + 4\text{H}_2\text{O}$ $\Delta H = -726 \text{ kJ/mol}$

33. Write a balanced equation for the combustion of ethanol?

Ans. $2\text{C}_3\text{H}_5\text{OH} + 3\text{O}_2 \longrightarrow 2\text{CO}_2 + 3\text{H}_2\text{O}$ $\Delta H = -136 \text{ kJ/mol}$

34. What is the general balanced equation for the combustion of propanol?

Ans. $2\text{C}_3\text{H}_7\text{OH} + 9\text{O}_2 \longrightarrow 6\text{CO}_2 + 8\text{H}_2\text{O}$ $\Delta H = -2017 \text{ kJ/mol}$

35. Write a balanced equation for the combustion of butanol.

Ans. $2\text{C}_3\text{H}_9\text{OH} + 12\text{O}_2 \longrightarrow 8\text{CO}_2 + 10 \text{H}_2\text{O}$ $\Delta H = -2676 \text{ kJ/mol}$

36. Explain why the heat evolved increases as you go down the alcohol homologous series.

Ans. During combustion of alcohols the weaker C-H bonds in $-\text{CH}_2$ groups break and the stronger C=O and O-H bonds are formed in CO_2 and H_2O respectively.

37. Why does butanol evolve more heat than propanol when burnt?

Ans. Butanol has a longer hydrocarbon chain with more bonds to react, leading to the formation of more CO_2 and H_2O molecules, which releases more energy.

38. What is added to ethene to make ethanol?

Ans. Water in the form of steam is added to ethene to make ethanol.

39. Which catalyst is used in the hydration of ethene?

Ans. Phosphoric acid (H_3PO_4) is used as a catalyst in the hydration of ethene.

40. What are the two main conditions for hydration of ethene or ethylene?

Ans. The two main conditions for hydration of ethene or ethylene are:

- High temperature (300°C).
- High pressure (60 atm).

41. Which alcohols are commonly used as fuels in internal combustion engines?

Ans. The first four aliphatic alcohols namely methanol, ethanol, propanol and butanol are commonly used as fuels in internal combustion engines.

42. From which sources are alcohols obtained?

Ans. Alcohols are obtained from renewable sources.

43. How are alcohols produced?

Ans. Alcohols are produced from plant materials which, in turn, are the result of the photosynthesis process using CO_2 of the atmosphere.

44. Why is bioalcohols considered "carbon netural"?

Ans. Bioalcohols is considered "carbon netural" because it does not increase the concentration of carbon dioxide gas in the atmosphere.

45. What is a socio-economic disadvantage of producing alcohol fuels?

Ans. Land is utilized to grow crops which then yield alcohols. This fact affects the cultivation of food crops.

46. Why does the heat evolved during combustion increase from lower to higher alcohols?

Ans. Higher alcohols have more carbon and hydrogen atoms per molecule, meaning more chemical bonds are broken and reformed releasing more energy.

47. What does make the alcohols environmental friendly as compared to fossil fuels?

Ans. Burning of alcohols does not produce oxides of sulphur which makes them environmental friendly as compared to fossil fuels.

48. By what percentage can ethanol reduce greenhouse gas emissions compared to petrol?

Ans. Ethanol as a fuel reduces greenhouse gas emissions by 44 to 52% as compared to petrol.

49. What harmful pollutants ethanol cuts down?

Ans. Ethanol cuts down harmful pollutants like CO_x , NO_x and particulate matter.

50. How is ethanol used in the pharmaceutical industry?

Ans. Ethanol is used as a disinfectant in hand sanitizer and methylated spirit. It is also commonly used as a solvent and preservative in many pharmaceutical preparations including vaccines.

51. What property makes ethanol useful in hand sanitizers?

Ans. Ethanol possesses bactericidal activity, meaning it can kill bacteria. This property makes ethanol useful in hand sanitizer.

52. What do help many drugs solubilize?
Ans. Ethanol and isopropanol are found as an active ingredient in certain oral and topical drug products. They help solubilize many drugs.
53. Name some cosmetic products that contain ethanol.
Ans. Ethanol is an important part of such cosmetic and hygiene products as hair styling products, foundation creams, perfumes, deodorants and after shave lotions.
54. What is methylated spirit and how is it used in first aid?
Ans. Methylated spirit is a form of ethyl alcohol. It is used as an antiseptic, for dressing of wounds and as an antidote for snake bites.
55. Why is ethanol widely used in the perfume industry?
Ans. Ethanol is an effective solvent that can dissolve many organic compounds that are insoluble in water. This is why it is used in the perfume industry.
56. What are the immediate health risks of consuming alcohol?
Ans. Ethyl alcohol as a drink can cause hangover, alcohol poisoning, accidents and risky behaviour.
57. What is the long-term impact of alcohol consumption?
Ans. Long-term use of alcohol is known to cause more than 200 different diseases.
58. What can be used in cars instead of petrol or diesel to run as automobile?
Ans. Alcohols can be used instead of petrol and diesel to run as automobile.
59. What is the common name for alcohol used in a first aid kit?
Ans. Methylated spirit is the common name for alcohol used in a first aid kit.
60. What is one use of methylated spirit besides cleaning wounds?
Ans. Methylated spirit is used as an antidote for snake bites.
61. What part of the car can be damaged by using alcohols?
Ans. Alcohols can increase wear and tear on engine components.
62. Why does ethanol evaporate quickly on the skin?
Ans. Ethanol evaporates quickly on the skin because it is highly volatile.
63. Why is ethanol added to afters have or foundation creams?
Ans. Ethanol is added to aftershave or foundation creams for its refreshing, antimicrobial, and deodorizing properties.
64. How does ethanol help in making medicine?
Ans. Ethanol is used as a solvent and preservative in many pharmaceutical preparations including vaccines.
65. Can ethanol dissolve things that water cannot?
Ans. Yes, ethanol dissolves many organic compounds that are insoluble in water.

Exercise Questions (Solved)

A. Multiple Choice Questions

☆ Choose and tick the correct answer from the given choices.

1. Which conditions are considered best for the fermentation of glucose?
(a) 35 °C, fresh yeast, absence of oxygen (b) 45 °C, yeast

- (c) 45 °C, absence of oxygen (d) 35 °C, fresh yeast
- Which catalyst other than H_3PO_4 can also be used for hydration of alkenes?
(a) NaOH (b) H_2SO_4 (c) CH_3COOH (d) Ni
 - Alcohol which has the maximum heat of combustion is:
(a) $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$ (b) $\text{CH}_3\text{CH}_2\text{OH}$
(c) CH_3OH (d) $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$
 - The most environment friendly fuel is:
(a) coal (b) kerosene oil (c) ethanol (d) wood
 - Which property or properties of ethanol make it suitable to be used in cosmetic industry?
(a) Easily Flammable (b) Highly volatile and deodorizing
(c) Antipyretic (d) Sedative
 - Which is the correct name of the following alcohol:

$$\begin{array}{ccccccc} \text{CH}_3 & - & \text{CH} & - & \text{CH}_2 & - & \text{CH} & - & \text{CH}_3 \\ & & | & & & & | & & \\ & & \text{OH} & & & & \text{CH}_3 & & \end{array}$$

(a) 2-Methylpentan-4-ol (b) 4-Methylpentan-2-ol
(c) Hexan-2-ol (d) Hexan-4-ol
 - Which property of ethanol makes it suitable for cleaning wounds?
(a) Good solvent (b) Volatility (c) Antiseptic (d) Deodorizing
 - Which alcohol is used to accomplish all the following tasks:
It is added in petrol to improve combustion. It serves as a feed stock to prepare vinegar and many other organic compounds.
(a) Propanol (b) Propan-2-ol (c) Ethanol (d) Methanol

Answers

1. (a) 2. (b) 3. (d) 4. (c) 5. (b) 6. (b) 7. (c)
8. (c)

B. Short Answer Questions

23.1 Give two advantages of burning of alcohols over the burning of fossil fuel?

Ans. Advantages of Alcohols as Fuels:

- Alcohols are obtained from renewable sources.
- Burning of alcohols does not produce oxides of sulphur which makes them environmental friendly as compared to fossil fuels.
- Alcohols have higher fuel efficiency as compared to petrol or diesel fuels.

23.2 Which properties of ethyl alcohol make it useful for cosmetic industry?

Ans. Role of Ethanol in Cosmetic Industry: Ethyl alcohol plays an important role in cosmetic industry because of its following properties:

- Being highly volatile it evaporates in a very short time.
- Deodorizing and anti-inflammatory properties.

(iii) Refreshing and antimicrobial properties.

Ethanol is an important part of such cosmetic and hygiene products as hair styling products, foundation creams, perfumes, deodorants and after shave lotions.

23.3 How is ethyl alcohol important for pharmaceutical industry?

Ans. Role of Ethanol in Pharmaceutical Industry: Ethyl alcohol serves as a very common ingredient in a variety of manufacturing processes in pharmaceutical industry.

- (i) It possesses bactericidal activity and it is often used as a disinfectant in hand sanitizer and ethylated spirit.
- (ii) It is also commonly used as a solvent and preservative in many pharmaceutical preparations including vaccines.
- (iii) Ethanol and isopropanol are found as an active ingredient in certain oral and topical drug products. They help solubilize many drugs.

23.4 Give any two disadvantages of fermentation reactions.

Ans. Disadvantages of Fermentation: Two disadvantages of fermentation are:

- (i) Fermentation produces 15% alcohol which needs further distillation to increase the concentration.
- (ii) Rate of fermentation is low. It may take days to complete.

23.5 Write the conditions involved in the hydration of ethene.

Ans. To convert ethene into ethanol, the following conditions are required:

- **Catalyst:** Phosphoric acid (H_3PO_4).
- **Temperature:** Approximately 300°C .
- **Pressure:** High pressure (60 atmospheres).

C. Constructed Response Questions

23.1 How ethanol is obtained as a by-product in sugar industry?

Ans. Obtaining Ethanol as by-Product in Sugar Industry: Ethanol is produced from molasses, which is the thick, dark brown liquid left over after sugar crystals have been extracted from sugarcane juice. Molasses contains about 15% to 50% fermented sugar.

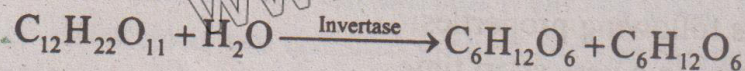
It is done by the process of fermentation.

Fermentation: It is a reaction in which a substance breaks down into simpler substances in the presence of enzymes present in yeast.

Following steps are involved in the process of fermentation.

- (i) **Dilution:** Molasses is diluted with water to reduce the sugar concentration to about 10% to 12%
- (ii) Yeast (*Saccharomyces cerevisiae*) is added to the mixture.
- (iii) Enzymes in the yeast (invertase and zymase) break down the sucrose into glucose and fructose, and then into ethanol and carbon dioxide.

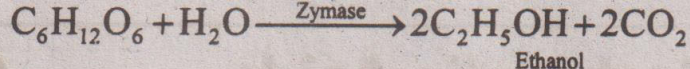
Chemical Equation:



Sucrose

Glucose

Fructose



23.2 Why do we get relatively impure alcohol in the fermentation process?

Ans. The alcohol obtained directly from fermentation is relatively impure (usually 10 % – 15% concentration) for two main reasons.

- Yeast is a living organism. When the concentration of ethanol reaches about 14% – 15%, It becomes toxic to the yeast, deactivating the enzymes and stopping the fermentation process.
- Along with ethanol, the process produces water, left over sugars, and small amounts of other organic compounds (like glycerol or higher alcohols), which remain mixed in the solution.
- Along with ethanol, the process produces water, left over sugars, and small amounts of other organic compounds (like glycerol or higher alcohols), which remain mixed in the solution.
- To obtain pure alcohol, the mixture must undergo fractional distillation.

23.3 How do properties of ethyl alcohol help us to utilize it as fuel?

Ans. Ethyl alcohol (ethanol) has several chemical and physical properties that make it an effective fuel or fuel additive. These properties are discussed below:

- It burns with a clear, blue, smokeless flame, producing a significant amount of heat energy.



- Ethanol has a high octane number, which helps prevent "engine knocking" and allows engines to run more efficiency at higher compression ratios.
- Since ethanol contains Oxygen in its molecular structure, it promotes more complete combustion of the fuel blend, reducing toxic emissions.
- Unlike fossil fuels, it is a renewable energy source because it is derived from crops like sugarcane and corn.

D. Descriptive Questions

23.1 Give a comparison of fermentation reaction and catalytic hydration of ethene for the preparation of ethanol.

Ans. For answer see Q3.

23.2 Describe the preparation of ethanol by fermentation process.

Ans. For answer see Q1.

23.3 Describe the applications of ethanol in pharmaceutical and cosmetic industries?

Ans. For answer see Q6 + Q7.