

Carbon and Its Compounds

In the Chapter

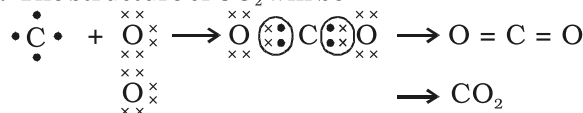
- Carbon is a versatile element which forms the basis for all living organisms and many of the things we use.
- Carbon forms covalent bonds with itself and other elements such as hydrogen, oxygen, sulphur, nitrogen and chlorine.
- This large variety of compounds is formed by carbon because of its tetravalency and the property of catenation that it exhibits.
- Covalent bonds are formed by the sharing of electrons between two atoms so that both can achieve a completely filled outermost shell.
- Carbon also forms compounds containing double and triple bonds between carbon atoms. These carbon chains may be in the form of straight chains, branched chains or rings.
- The functional groups such as alcohols, aldehydes, ketones and carboxylic acids bestow characteristic properties to the carbon compounds that contain them.
- Carbon and its compounds are some of our major sources of fuels.
- The ability of carbon to form chains gives rise to a homologous series of compounds in which the same functional group is attached to carbon chains of different lengths.
- Ethanol and ethanoic acid are carbon compounds of importance in our daily lives.
- The action of soaps and detergents is based on the presence of both hydrophobic and hydrophilic groups in the molecule and this helps to emulsify the oily dirt and hence its removal.

Intext Exercises

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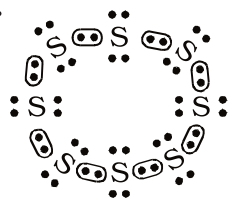
1. What would be the electron dot structure of carbon dioxide which has the formula CO_2 ?

Ans. The structure of CO_2 will be



2. What would be the electron dot structure of a molecule of sulphur which is made up of eight atoms of sulphur? (Hint – The eight atoms of sulphur are joined together in the form of a ring.)

Ans.

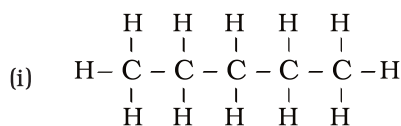


Eight atoms ($-S_8$) of sulphure molecule.

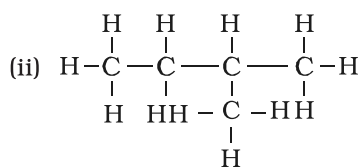
Page No. 68-69

1. How many structural isomers can you draw for pentane?

Ans. We can draw two structural isomers of pentane.



Normal pentane



Isopentane

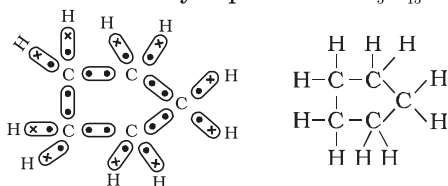
2. What are the two properties of carbon which lead to the huge number of carbon compounds we see around us?

Ans. The two properties of carbon are –

(a) Catenation and (b) Tetra Covalency of carbon atom.

3. What will be the formula and electron dot structure of cyclopentane?

Ans. The formula of cyclopentane is C_5H_{10} .



4. Draw the structures for the following compounds.

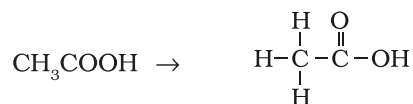
(i) Ethanoic acid

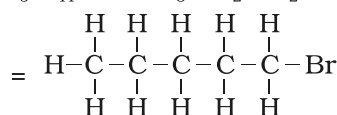
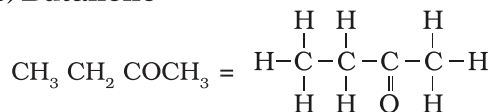
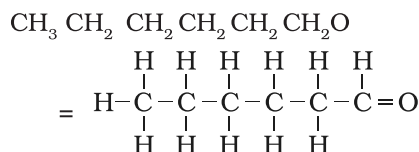
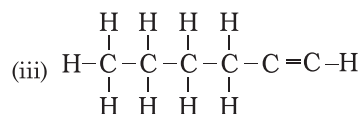
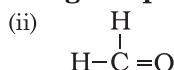
(ii) Bromopentane

(iii) Butanone (iv) Hexanal.

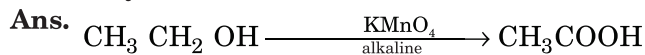
Are structural isomers possible for bromopentane?

Ans. (a) Ethanoic acid.



(b) Bromopentane**(c) Butanone****(d) Hexanal****5. How would you name the following compounds?****Ans.** (i) $\text{CH}_3-\text{CH}_2-\text{Br}$ 

(i) Bromo-ethane, (ii) Methanal, (iii) Hexanal.

Page No. 71**1. Why is the conversion of ethanol to ethanoic acid an oxidation reaction?**

Here, in this reaction, it is an oxidation reaction because there is a decrease in the number of hydrogen atoms in compound. Also number of oxygen atom has increased.

2. A mixture of oxygen and ethyne is burnt for welding. Can you tell why a mixture of ethyne and air is not used?**Ans.** Air contains nitrogen and other inactive gaseous contents which resist the sufficient supply of oxygen for burning of ethyne. Therefore, air is not used for combustion of ethyne.**Page No. 74****1. How would you distinguish experimentally between an alcohol and a carboxylic acid?****Ans.** We can distinguish experimentally between an alcohol and a carboxylic acid by using laboratory reagent Na_2CO_3 (solution.)

(i) When Na_2CO_3 is added to the test tube having CH_3COOH , CO_2 gas is evolved which turns lime water milky.

(ii) When Na_2CO_3 is added to the test tube having $\text{CH}_3\text{CH}_2\text{OH}$, then no gas is evolved.

2. What are oxidising agents?**Ans.** Oxidizing agents are the chemical substances which themselves undergo reduction and can oxidise the other species.

$\text{K}_2\text{Cr}_2\text{O}_7$ and KMnO_4 are the examples of oxidising agents.

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1. Would you be able to check if water is hard by using a detergent?

Ans. No, detergent is effective in both hard water and soft water.

2. People use a variety of methods to wash clothes. Usually after adding the soap, they 'beat' the clothes on a stone, or beat it with a paddle, scrub with a brush or the mixture is agitated in a washing machine. Why is agitation necessary to get clean clothes?

Ans. By the reaction of soap with the calcium and magnesium salts, foam is formed. This foam captures dust particles but also sticks to cloth. To remove them from cloth, agitation is necessary.

Exercise

1. Ethane, with the molecular formula C_2H_6 has

- (a) 6 covalent bonds.
- (b) 7 covalent bonds.
- (c) 8 covalent bonds.
- (d) 9 covalent bonds.

Ans. (b) 7 covalent bonds.

2. Butanone is a four-carbon compound with the functional group

- (a) carboxylic acid. (b) aldehyde.
- (c) ketone. (d) alcohol.

Ans. (c) ketone.

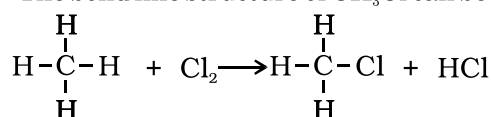
3. While cooking, if the bottom of the vessel is getting blackened on the outside, it means that

- (a) the food is not cooked completely.
- (b) the fuel is not burning completely.
- (c) the fuel is wet.
- (d) the fuel is burning completely.

Ans. (b) the fuel is not burning completely.

4. Explain the nature of the covalent bond using the bond formation in CH_3Cl .

The bond line structure of CH_3Cl can be written as –

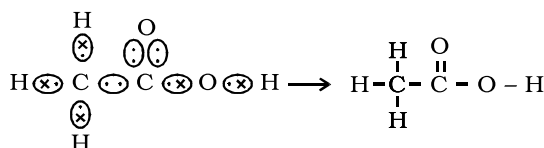


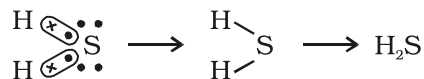
Here 3-hydrogen atoms are attached with C-atoms by single covalent bond. The bond between C and Cl atoms is covalent but because of higher value of electronegativity of Cl, the C–Cl bond is polar in nature.

5. Draw the electron dot structures for

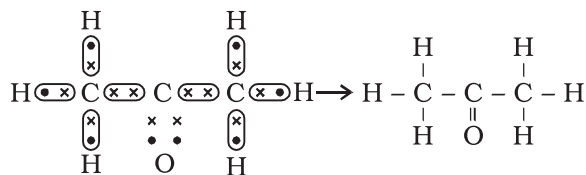
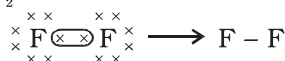
- (a) ethanoic acid. (b) H_2S .
- (c) propanone. (d) F_2 .

(a) Ethanoic acid



(b) H_2S .

(c) Propanone.

(d) F_2 **6. What is an homologous series? Explain with an example.**

Ans. A group of compounds of carbon having same general formula and same functional group is known as homologous series. The members of homologous series are termed as homologue. For example.

- (1) Methanol – CH_3OH
- (2) Ethanol – $\text{C}_2\text{H}_5\text{OH}$
- (3) Propanol – $\text{C}_3\text{H}_7\text{OH}$
- (4) Butanol – $\text{C}_4\text{H}_9\text{OH}$

7. How can ethanol and ethanoic acid be differentiated on the basis of their physical and chemical properties?

Ans. Difference between ethanal and ethanoic acid :

Physical properties: Ethanol

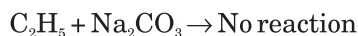
1. Ethanol has a pleasant smell.
2. Pure alcohol (95% or above) is known as rectified alcohol.

Ethanoic acid

1. It has typical vinegar smell.
2. Pure ethanoic acid is known as glacial acetic acid.

Chemical properties. Ethanol

1. Ethanol does not react with NaOH .
 $\text{C}_2\text{H}_5\text{OH} + \text{NaOH} \rightarrow \text{No reaction.}$
2. Ethanol does not react with Na_2CO_3 solution.



Ethanoic acid

1. Ethanoic acid reacts with NaOH to form sodium ethanoate.
 $\text{CH}_3\text{COOH} + \text{NaOH} \rightarrow \text{CH}_3\text{COONa} + \text{H}_2\text{O}$
2. Ethanoic acid reacts with Na_2CO_3 and produces CO_2 gas.
 $2\text{CH}_3\text{COOH} + \text{Na}_2\text{CO}_3 \rightarrow 2\text{CH}_3\text{COONa} + \text{CO}_2 + \text{H}_2\text{O}$

8. Why does micelle formation take place when soap is added to water? Will a micelle be formed in other solvents such as ethanol also?

Ans. Soap molecule consists of two parts – one part is hydrophobic and other part is hydrophilic. Hydrophobic part of soap is dissolved with dirt and hydrophilic part remains suspended in water. Thus, many more molecules of soap are attached to dirt having their one end

suspended in water. So, micelle is formed.

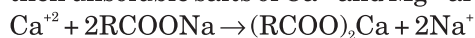
Since ethanol is not as polar as soaps, so, micelles will not be formed in other solvent such as ethanol also.

9. Why are carbon and its compounds used as fuels for most applications?

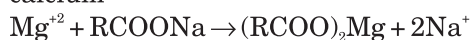
Ans. Carbon and its compounds give large amount of heat on combustion because of high percentage of carbon and hydrogen. These compounds contain optimum ignition temperature and are easy to handle. Their combustion can be controlled. So, carbon and its compounds are used as a fuel.

10. Explain the formation of scum when hard water is treated with soap.

Ans. Hard water contains soluble salts of Ca and Mg. When soap is dissolved in hard water, then insoluble salts of Ca^{+2} and Mg^{+2} are formed which are known as scum.



Salt of Soap Scum
calcium



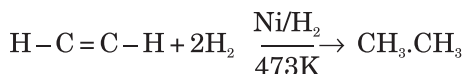
Salt of Soap Scum
Magnesium

11. What change will you observe if you test soap with litmus paper (red and blue)?

Ans. The litmus paper will turn red because of the basic nature of soap.

12. What is hydrogenation? What is its industrial application?

Ans. The addition of hydrogen to unsaturated hydrocarbon in the presence of a catalyst is known as hydrogenation.



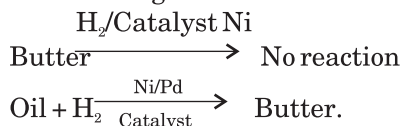
Its industrial application is that it is used in making vegetables ghee.

13. Which of the following hydrocarbons undergo addition reactions: C_2H_6 , C_3H_8 , C_3H_6 , C_2H_2 and CH_4 .

Ans. C_3H_6 and C_2H_2

14. Give a test that can be used to differentiate chemically between butter and cooking oil.

Ans. Butter is a saturated fat therefore it does not undergo catalytic hydrogenation but cooking oil being unsaturated hydrocarbon can be hydrogenated in the presence of catalyst. Hence, the following reactions can be used to differentiate between butter and cooking oil.



15. Explain the mechanism of the cleaning action of soaps.

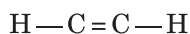
Ans. By the reaction of soap with the calcium and magnesium salts, foam is formed. This foam captures dust particles but also sticks to cloth. To remove them from cloth, agitation is necessary.

Additional Questions

1. Draw the electron dot structure of ethyne and also draw its structural formula.

Ans. $\text{H} : \text{C} : \text{C} : \text{H}$

Electron dot structure of ethyne (C_2H_2)



Structural formula of ethyne.

2. Why detergents are better cleansing agents than soaps? Explain

Ans. Detergents can be effectively used even in hard water whereas soaps cannot be used. The charged ends of detergents do not form insoluble precipitates with calcium and magnesium ions in hard water.

3. Intake of small quantity of methanol can be lethal. Comment.

Ans. Methanol is oxidised to methanal in the liver. Methanal reacts rapidly with the components of cells. It causes the protoplasm to coagulate. It also effects the optic nerve, causing blindness.

4. Catenation is the ability of an atom to form bonds with other atoms of the same element. It is exhibited by both carbon and silicon. Compare the ability of catenation of the two elements. Give reasons.

Ans. Carbon exhibits catenation much more than silicon or any other element due to its smaller size which makes the C — C bonds strong while the Si — Si bonds are comparatively weaker due to its large size.

5. Unsaturated hydrocarbons contain multiple bonds between the two C-atoms and show addition reactions. Give the test to distinguish ethane from ethene.

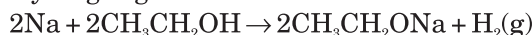
Ans. The two can be distinguished by subjecting them to the flame. Saturated hydrocarbons generally give a clear flame while unsaturated hydrocarbons give a yellow flame with lots of black smoke.

6. State two characteristic features of carbon which when put together give rise to a larger number of carbon compounds.

Ans. (i) Tetravalency. (ii) Catenation.

7. What happens when a small piece of sodium is dropped into ethanol?

Ans. Hydrogen gas is evolved and sodium ethoxide is produced.



8. Name the compound formed when ethanol is warmed with ethanoic acid in the presence of a few drops of conc. H_2SO_4 .

Ans. Ethyl ethanoate (an ester) is formed.

9. Name the carbon compound which on heating with excess of concentrated sulphuric acid at 443 K gives ethene.

Ans. Ethanol ($\text{C}_2\text{H}_5\text{OH}$)

10. What is meant by saturated hydrocarbon?

Ans. A hydrocarbon in which the two carbon atoms are connected by only single bonds is called a saturated hydrocarbon.

11. What is a homologous series?

Ans. A homologous series is a group of organic compounds having similar structures and similar chemical properties in which the successive compounds differ by CH_2 group.

12. Kerosene burns with a sooty flame. It is a saturated or an unsaturated compound?

Ans. Unsaturated.

13. How many covalent bonds are there in a molecule of ethane, C_2H_6 ?

Ans. Seven covalent bonds.

14. Name the by product of saponification reaction.

Ans. Glycerol.

15. Name the raw materials required for making soap.

Ans. Vegetable oil, sodium hydroxide and common salt.

16. What type of synthetic detergents are biodegradable ?

Ans. Synthetic detergents having linear alkyl chains are biodegradable.

17. What is saponification reaction ?

Ans. Esters react in the presence of an acid or a base to give back the alcohol and carboxylic acid. This reaction is called saponification reaction.

18. A soap molecule is made up of two parts : a long hydrocarbon chain and a short ionic end.

(a) Which of these parts dissolves in water?

(b) Which of these parts dissolves in oils?

Ans. (a) The ionic end dissolves in water.

(b) The hydrocarbon chain dissolves in oil.

19. Soap does not work well with hard water. Name the class of compounds which can be used as cleansing agents in place of soap. Write the name of one such compound. Explain in brief the mechanism of its cleansing action when used in hard water.

Ans. Detergents can be used as cleansing agents in place of soap.

The name of such compound is sodium dodecyl benzene sulphonate.

A detergent works by making the oil and grease particles of dirty clothes dissolve in water through the formation of micelles.

20. What happens when hydrogen gas is passed through mustard oil in presence of nickel ? Mention one difference between physical property of mustard oil and the product so obtained.

Ans. Mustard oil changes into solid fat upon hydrogenation in presence of nickel.

Physical difference between mustard oil and the product fat is while the former is a liquid and the latter is a solid.

21. Acetic acid reacts with ethyl alcohol in the presence of conc. H_2SO_4 producing a sweet smelling compound. For the reaction:

(i) Name the main product.

(ii) Write the chemical equation.

Ans. (i) The main product in the reaction is ethyl acetate or ethyl ethanoate.

(ii) The chemical reaction involved is : $CH_3COOH + C_2H_5OH \rightarrow CH_3COOC_2H_5 + H_2O$

22. Explain why soaps are not effective cleansing agents in hard water.

Ans. Hard water contains hydrogen carbonates, chlorides and sulphates of calcium and magnesium. These salts react with soap to form scum (precipitate). For example

Calcium chloride + Sodium stearate \rightarrow Sodium chloride + Calcium stearate

(Soap)

(Scum)

The scum formed hinders in the cleansing action of soap.

23. Why carbon forms compounds by sharing of electrons and not by formation of ions ?

Ans. Carbon is tetravalent in nature. If it gains 4 electrons to form C^{4-} ions, then it will be difficult for 6 electrons to hold on to 10 electrons while formation of C^{4+} ions i.e., loss of 4 electrons requires considerable amount of energy. Hence, it forms bond by sharing of electrons.

24. Give an important difference between saturated and unsaturated hydrocarbons. Give one example of each also.

Ans. In a saturated hydrocarbon all the carbon atoms in a compound are linked to other carbon atoms by single covalent bonds while in an unsaturated hydrocarbons, there is a presence

of a double/triple covalent bond between the carbon atoms.

Example: Ethane is a saturated hydrocarbon while ethene is an unsaturated hydrocarbon.

25. Why the compounds formed by carbon are exceptionally stable?

Ans. The stability of carbon compounds is attributed to the small size of carbon atom. Due to the small size of carbon atom, the nucleus holds the shared pair of electron more effectively. Thus, making the bond stronger.

26. Give the structure of diamond and explain one property based upon structure.

Ans. The structure of diamond is as shown in figure.

In diamond, each carbon atom is bonded to four other carbon atoms by covalent bonds resulting in the formation of a three dimensional network structure. Due to the presence of strong covalent bonds, diamond is hard and has high melting point.

27. Two non-metal atoms combine with each other by the sharing of electrons to form a compound A.

(i) What type of chemical bond is present in A ?

(ii) State whether A will have high melting point and boiling point.

(iii) Will it be a good conductor of electricity or not ?

(iv) Will it dissolve in organic solvents or not ?

Ans. (i) In the compound A, the atoms are linked by covalent bonds because sharing of electrons has taken place.

(ii) As A is a covalent compound, it will not have high melting point and boiling point.

(iii) A will not be a good conductor of electricity because electric current cannot pass through the solution of covalent compound.

(iv) A will dissolve in organic solvents because covalent compounds normally dissolve in organic solvents.

28. Why do covalent molecules have definite shapes?

Ans. A covalent bond is formed by the sharing of electrons between the atoms. The bonds are represented by dashes (-) and are directional in nature. The directional nature of the covalent bonds gives covalent molecules having two or more such bonds of a definite shape. This is also called definite geometry of the covalent molecule. Thus, the geometry of a covalent molecule may be defined as the arrangement of the different atoms with respect to each other.

29. Give the structure of graphite and explain its one property based upon structure.

Ans. The structure of graphite is as shown in figure. In graphite each C-atom is bonded to three other carbon atoms to form hexagonal rings which are held together by weak van der Waals' forces of attraction. Therefore, graphite has a two dimensional sheet-like structure. Due to the presence of one free electron left with each C - atom, graphite is a good conductor of electricity.

30. Describe the structure of Fullerenes.

Ans. Fullerenes are also allotropes of carbon, for example, the fullerene, C₆₀ has carbon atoms arranged in the form of a football and it looked like the geodesic dome designed by the US architect Buckminster Fuller, the molecule was named fullerene.

31. Describe two tests to detect carboxylic acid group in an organic compound.

Ans. The carboxylic acids can be tested by the following tests :

1. Litmus test. Add a small amount of blue litmus solution to the given compound. If the blue litmus solution turns red, it indicates that the organic compound is a carboxylic acid.

2. Sodium bicarbonate tests : To small portion of the organic compound in a test tube, add a pinch of solid sodium bicarbonate. Evolution of carbon dioxide with brisk effervescence shows the presence of carboxylic acid.

Multiple Choice Questions

1. Which is not an allotrope of carbon :

- (a) diamond (b) graphite
(c) buckminsterfullerene (d) dry ice.

Ans. (d) dry ice.

2. A molecule of water (H₂O) has :

- (a) only single bond (b) only double bonds
(c) only triple bonds (d) one double bond and one single bond.

Ans. (a) only single bond

3. Which of the following compounds contains –COOH as the functional groups?

- (a) Butanone (b) Ethanol
(c) Butanoic acid (d) Butanol.

Ans. (c) Butanoic acid

4. Structural formula of ethene is :

- (a) $\text{H}-\text{C}=\text{C}-\text{H}$ (b) $\text{CH}_2=\text{CH}_2$
(c) $\text{CH}=\text{CH}$ (d) $\text{CH}_3-\text{CH}=\text{CH}_3$.

Ans. (b) $\text{CH}_2=\text{CH}_2$

5. Structural formula of ethane is :

- (a) CH_3-CH_3 (b) $\text{CH}_2=\text{CH}_2$
(c) $\text{CH}=\text{CH}$ (d) $\text{CH}_2-\text{CH}-\text{CH}_3$

Ans. (a) CH_3-CH_3

6. Chlorine reacts with unsaturated hydrocarbons at room temperature in the :

- (a) absence of sunlight (b) presence of sunlight
(c) presence of water (d) presence of hydrochloric acid.

Ans. (c) presence of water

7. Identify the unsaturated compounds from the following :

- (i) Ethane (ii) Propene
(iii) Propyne (iv) Propane.
(a) (i) and (iii) (b) (ii) and (iv)
(c) (i) and (iv) (d) (iii) and (iv).

Ans. (a) (i) and (iii)

8. Sodium reacts with ethyl alcohol to give:

- (a) Sodium ethoxide and hydrogen (b) Sodium ethoxide and oxygen
(c) Sodium ethanol and hydrogen (d) Sodium ethanol and oxygen.

Ans. (a) Sodium ethoxide and hydrogen

9. The carbon atom has a covalency of :

- (a) 2 (b) 4
(c) 6 (d) 1.

Ans. (b) 4

10. Any two adjacent members of a homologous series differ by:

- (a) CH_3 unit (b) CH_2 unit
(c) CH unit (d) C_2H_4 unit

Ans. (b) CH_2 unit

11. Chemically rust is :

- (a) FeZO_3 (b) FeO
(c) $\text{FeZO}_3 \cdot x\text{H}_2\text{O}$ (d) Fe_3O_4 .

Ans. (c) $\text{FeZnO}_3 \cdot x\text{H}_2\text{O}$

12. While cooking if the bottom of the vessel is getting blackened on the outside, it means that: .

- (a) the food is not cooked completely
- (b) the fuel is wet
- (c) the fuel is not burning completely
- (d) the fuel is burning completely.

Ans. (c) the fuel is not burning completely

13. Which of the following does not belong to the same homologous series ?

- (a) C_2H_2
- (b) C_2H_4
- (c) C_2H_4
- (d) C_4H_6 .

Ans. (b) C_2H_4

14. Ethanol has the functional group:

- (a) $-\text{OH}$
- (b) $-\text{CHO}$
- (c) $-\text{COOH}$
- (d) $>\text{C}=\text{O}$.

Ans. (b) $-\text{CHO}$

15. Propane has covalent bonds :

- (a) 10
- (b) 8
- (c) 6
- (d) 4.

Ans. (c) 6

16. Vinegar is :

- (a) 25% acetic acid
- (b) 6-8% acetic acid
- (c) Pure acetic acid
- (d) 50% acetic acid.

Ans. (b) 6-8% acetic acid

17. Ethanol has the functional group:

- (a) $-\text{OH}$
- (b) $-\text{CHO}$
- (c) $-\text{COOH}$
- (d) $\begin{array}{c} \text{O} \\ || \\ -\text{C}- \end{array}$

Ans. (a) $-\text{OH}$

18. Out of $\text{C}_2\text{H}_5\text{OH}$ and CH_3COOH , which is a stronger acid?

- (a) $\text{C}_2\text{H}_5\text{OH}$
- (b) CH_3COOH
- (c) Both are of equal strength
- (d) None of the above.

Ans. (b) CH_3COOH

19. Acetic acid turns :

- (a) Blue litmus solution red
- (b) Red litmus solution blue
- (c) Decolorise red litmus solution
- (d) None of the above.

Ans. (a) Blue litmus solution red

20. The combustion of methane is :

- (a) An exothermic reaction
- (b) An endothermic reaction
- (c) Reversible reaction
- (d) None of the above.

Ans. (a) An exothermic reaction

21. Glacial acetic acid is :

- (a) An aqueous solution of alcohol
- (b) 100% pure acetic acid
- (c) An aqueous solution of acetic acid
- (d) 50% aqueous solution of acetic acid.

Ans. (b) 100% pure acetic acid

22. The water which readily gives lather with soap is :

- (a) Soft water
- (b) River water
- (c) Hard water
- (d) None of the above.

Ans. (a) Soft water

23. Propanone has :

- (a) 7 covalent bonds
- (b) 8 covalent bonds
- (c) 9 covalent bonds
- (d) 10 covalent bonds.

Ans. (d) 10 covalent bonds.

24. The property of catenation is more marked in case of

- (a) silicon
- (b) hydrogen
- (c) oxygen
- (d) carbon

Ans. (d) carbon

25. Alkenes and alkynes are

- (a) saturated aliphatic hydrocarbons
- (b) unsaturated aliphatic hydrocarbons
- (c) unsaturated aromatic hydrocarbons
- (d) cyclic hydrocarbons

Ans. (b) unsaturated aliphatic hydrocarbons

25. The chlorinations of methane, is an example of

- (a) addition reaction
- (b) reduction reaction
- (c) elimination reaction
- (d) substitution chain reaction

Ans. (d) substitution chain reaction

26. Micelles are

- (a) Soap molecules in clean water
- (b) drops of oil or dirt that surrounds the molecule
- (c) a tadpole shaped fatty acid
- (d) cluster of soap molecules surrounding the dirt particles.

Ans. (d) cluster of soap molecules surrounding the dirt particles.

28. Detergents are sodium salts of

- (a) Sulphonic acids
- (c) Carbonic acids
- (c) Carboxylic Acids
- (d) None of these

Ans. (a) Sulphonic acids