CHAPTER 4

Carbon and its Compounds

TRY YOURSELF — ANSWERS

1. (i) CCl_4 : Covalent bond (ii) $CaCl_2$: Ionic bond
(iii) CH_4 : Covalent bond (iv) NH_3 : Covalent bond

2. (a) Electrovalent or ionic bond : Examples : Sodium chloride (NaCl), Magnesium chloride ($MgCl_2$) etc.

(b) Covalent bond : Examples : Chlorine molecule (Cl_2), Oxygen molecule (O_2), Hydrogen chloride gas (HCl) etc.

3. As the bond is formed by sharing of electrons between two atoms. Intermolecular forces of attraction are small between the covalent compounds. These bonds break easily.

4. Atomic number of carbon is 6. Therefore, its electronic configuration is 2, 4. Thus, carbon has 4 electrons in its outermost shell or the valence shell. Therefore, it should either lose 4 electrons or gain 4 electrons to attain noble gas configuration and become stable. It cannot lose electrons to form C^{4+} ion because this would require a large amount of energy to remove four electrons leaving behind a highly charged cation with six protons in the nucleus holding on to just two electrons. It also cannot gain four electrons to form C^{4-} ion since this ion is highly unstable because it is difficult for a nucleus with 6 protons to hold on to 10 electrons. Consequently, the only way by which it can complete is octet is by sharing of electrons. This explains why carbon forms compounds only by covalent bonding.

5. Urea is a covalent compound, therefore, its aqueous solution does not conduct electricity. In contrast, sodium or potassium chloride is an ionic compound, therefore, its aqueous solution conducts electricity.

6. The element of group 14 having two common allotropes is carbon. These two allotropes (*A* and *B*) of carbon element are diamond and graphite. This is confirmed by the fact that diamond is very hard and a non-conductor of electricity whereas graphite is soft to touch and a good conductor of electricity.

7. (a) It is a giant molecule containing a large number of carbon-carbon single covalent bonds (network structure). To break these covalent bonds, a large amount of energy is needed and hence diamond has a high melting point.

(b) Diamond is a good conductor of heat and is used for making cutting and drilling tools because the heat generated during cutting and drilling is easily absorbed by the network structure without overheating the diamond tool.

8. **Uses of Diamond :** Diamonds are used in cutting instruments like glass cutters and in rock drilling equipment. Diamonds are used for making Jewellery.

Uses of Graphite :

(i) Due to its softness, powdered graphite is used as a lubricant for the fast moving parts of machinery.

(ii) Graphite is a good conductor of electricity due to which graphite is used for making carbon electrodes or graphite electrodes in dry cells and electric arcs.

9. Carbon has atomic number 6.

It has 4 electrons in its valence shell (2, 4).

(i) All the organic compounds contain carbon. Carbon and its compounds are major sources of fuel.

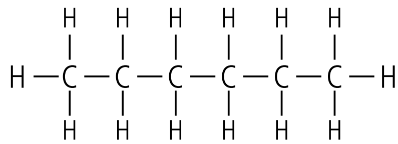
(ii) Carbon can form a large number of compounds due to :

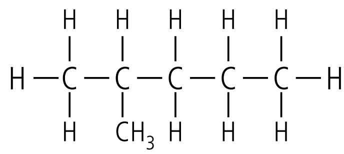
(a) its tetravalency

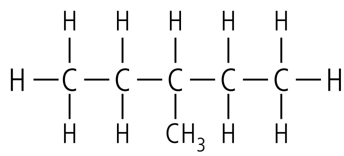
(b) catenation.

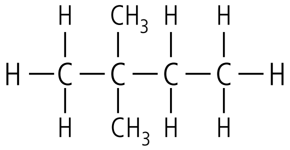
Carbon forms both saturated and unsaturated compounds. It can form open chain as well as ring compounds. The compounds of carbon are widely used in daily life, laboratories and industries.

10. Isomers having similar molecular formula but differ in the nature of carbon chain or carbon skeleton is called chain isomers. Chain isomers of the hexane are :

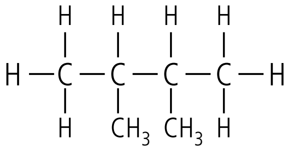
(i)

Hexane

(ii)

2-Methylpentane

(iii)

3-Methylpentane

(iv) 

2,2-Dimethyl butane

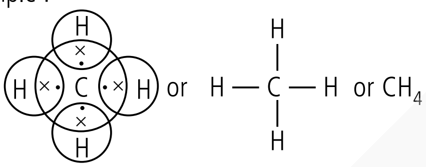
(v) 

2,3-Dimethyl butane

11. Saturated hydrocarbons have general formula, C_nH_{2n+2}. Among the given compounds only C_4H_{10} and C_6H_{14} satisfy the above formula. Thus, these are saturated hydrocarbons.

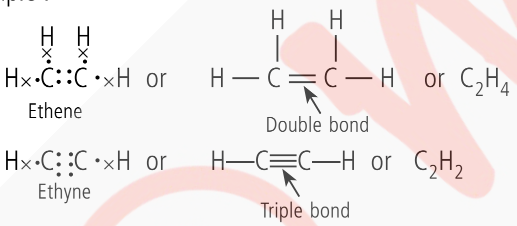
12. Saturated hydrocarbons: A hydrocarbon in which each carbon atom is attached to four other atoms, is known as saturated hydrocarbon. The bonds so formed are single covalent bonds. These hydrocarbons are also called alkanes.

Example :



Unsaturated hydrocarbons: Hydrocarbons containing either a carbon–carbon double bond (C=C) or a carbon-carbon triple bond (C≡C) in their molecules are called unsaturated hydrocarbons.

Example :



13. Hydrocarbons can be classified either on the basis of nature of bonds or nature of chains between carbon atoms.

(a) On the basis of bond, hydrocarbons are classified as

(i) Saturated hydrocarbons, *e.g.*, CH_4 (methane).

(ii) Unsaturated hydrocarbons, *e.g.*, C_2H_4 (ethene).

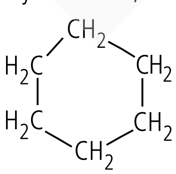
(b) On the basis of chains, hydrocarbons are classified as

(i) Straight chain hydrocarbons : *e.g.*, butane

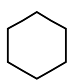
(ii) Branched chain hydrocarbon : *e.g.*, *iso*-butane, *neo*-pentane

(iii) Cyclic hydrocarbons : These contain rings of carbon atoms, *e.g.*, cyclohexane, benzene.

14. (a) Cyclohexane,

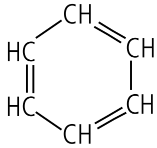


Condensed formula



Bond line notation

(b) Benzene,



Condensed formula

Bond line notation

15. The general formula of the alkane series is C_nH_{2n+2}. For fourth member of alkane series, $n = 4$

$\therefore$ $C_4H_{2\times4+2} = C_4H_{10}$ *i.e.*, butane.

16. (i) CH_4, C_2H_6, C_4H_{10} represent homologous series called alkanes (C_nH_{2n+2}).

(ii) C_2H_4, C_3H_6 represent homologous series called alkenes (C_nH_{2n}).

(iii) C_2H_2, C_3H_4 represent homologous series called alkynes (C_nH_{2n-2}).

17. (a) Alkenes with general formula C_nH_{2n}.

(b) Next homologue of compound (I) is C_3H_6 *i.e.*, propene and next homologue of compound (II) is C_5H_{10} *i.e.*, pentene.

18. (i) CH_3OH – Methyl alcohol

(ii) $CH_3—\underset{\displaystyle OH}{\underset{|}{CH}}—CH_3$ – *Iso*-propyl alcohol.

19. (i) The general formula of alkyl halides is $C_nH_{2n+1}X$, where X is the halogen atom (F, Cl, Br, I).

(ii) Longest carbon chain is chosen and the alkyl halide is named by adding the prefix : Fluoro (F), Chloro (Cl), Bromo (Br) and Iodo (I) before the alkane of the main chain.

(iii) The position of halogen atom is indicated by a number assigned to the carbon atom to which it is attached.

(iv) The prefixes *di-* or *tri-* are used if 2 or 3 halogen atoms of the same element are attached to the main carbon chain.

20. (i) The functional group in CH_3COCH_3 is carbonyl group or ketonic group ($—\underset{|}{C}=O$).

(ii) CH_3COCH_3 contains a total of 3 carbon atoms and is therefore to be named as derivative of propane, C_3H_8.

(iii) Since the compound is a ketone, the suffix-*e* of propane is replaced by suffix-*one*. Therefore, the IUPAC name of CH_3COCH_3 is propanone.

21. (i) $CH_3—CH_2—CH_2—Cl$ contains 3 carbon atoms so its parent chain is propane. It contains chloro group so its IUPAC name will be chloro + propane = chloropropane.

(ii) $CH_3—CH_2—CH_2—OH$ contains 3 carbon atoms in its parent chain so its parent alkane is propane. It contains —OH (hydroxyl) group as the functional group. The numbering of the parent chain is done, so that the functional group *i.e.*, —OH group gets the lowest number.

$\overset{3}{C}H_3—\overset{2}{C}H_2—\overset{1}{C}H_2—OH$

Its IUPAC name is written as 1+ propane $-e+ol=$ 1-propanol

(iii) CH_3CHO contains 2 carbon atoms in its parent chain, so its parent alkane is ethane. It also contains —CHO (aldehyde) group as the functional group.

$\overset{2}{CH_3}—\overset{1}{CHO}$

Its IUPAC name is written as ethane $-e+al=$ ethanal

22. Addition of oxygen or removal of hydrogen from any substance is called oxidation. *e.g.*,

Ethanol on burning in presence of oxygen or air produces carbon dioxide and water along with release of heat.

$CH_3CH_2OH + 3O_2 \longrightarrow 2CO_2 + 3H_2O + \text{Heat}$

However when ethanol is heated with alkaline $KMnO_4$ it gives ethanoic acid.

$CH_3CH_2OH + 2[O] \xrightarrow[KMnO_4]{Alk.} CH_3COOH + H_2O$

Both these reactions are oxidation reactions because in both cases oxygen has been added or hydrogen has been removed. But complete oxidation of compound to form CO_2 and H_2O is called combustion which is generally accompanied by evolution of heat energy. While only partial oxidation of a compound is called oxidation.

23. Methane burns in air to give carbon dioxide and water.

$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O + \text{Heat energy}$

24. (i) $\underset{\text{Ethanol}}{2CH_3CH_2OH} + 2Na \longrightarrow \underset{\text{Sodium ethoxide}}{2CH_3CH_2ONa} + H_2\uparrow$

(ii) $\underset{\text{Ethanoic acid}}{CH_3COOH} + \underset{\text{Ethanol}}{CH_3CH_2OH} \xrightarrow[\text{Warm}]{\text{Conc. } H_2SO_4} \underset{\text{Ethyl ethanoate}}{CH_3COOCH_2CH_3} + H_2O$

(iii) $\underset{\text{Ethanol}}{CH_3CH_2OH} \xrightarrow[443\text{ K}]{\text{Conc. } H_2SO_4} \underset{\text{Ethene}}{CH_2{=}CH_2} + H_2O$

25. 5-8% solution of acetic acid is called vinegar. Glacial acetic acid is pure acetic acid (100%). It often freezes during winter to form colourless, ice-like solid (which looks like glacier), hence its name is glacial acetic acid.

26. Ethyl alcohol contains hydroxyl group (–OH) which gets bonded to water molecules readily through hydrogen bonding. So it is miscible with water in all proportions.

27. The following tests show presence of ethanoic acid :

(i) Sodium bicarbonate test – To a small amount of organic compound add a pinch of solid sodium bicarbonate. Evolution of carbon dioxide with brisk effervescence shows presence of ethanoic acid (carboxylic acid).

$\underset{\text{Ethanoic acid}}{CH_3COOH} + \underset{\text{Sodium bicarbonate}}{NaHCO_3} \longrightarrow \underset{\text{Sodium ethanoate}}{CH_3COONa} + CO_2\uparrow + H_2O$

(ii) Ester test – Warm the organic compound with some ethanol and a few drops of conc. H_2SO_4. A sweet smell due to formation of an ester shows presence of ethanoic acid (carboxylic acid).

$\underset{\text{Ethanoic acid}}{CH_3COOH} + \underset{\text{Ethanol}}{C_2H_5OH} \xrightarrow[\text{Heat}]{\text{Conc. } H_2SO_4} \underset{\text{Ester (Sweet smell)}}{CH_3COOC_2H_5} + H_2O$

28. An antifreeze is a mixture of ethanol (C_2H_5OH) and ethylene glycol ($OH-CH_2-CH_2-OH$).

It is used in car radiators. In foreign countries, during the sub-zero weather conditions, it is mixed with coolants to stop freezing of these coolants.

29. Hard water contains hydrogen carbonates, chlorides and sulphates of calcium and magnesium. When soap is added to hard water it reacts with these salts to form scum which is insoluble in water and floats on the top of the water surface. The scum is formed due to the formation of insoluble calcium or magnesium salts of fatty acids.

$\underset{\text{Sodium stearate (soap)}}{2C_{17}H_{35}COONa} + \underset{\text{(From hard water)}}{Ca^{2+}} \longrightarrow \underset{\text{Calcium stearate (ppt. or scum)}}{(C_{17}H_{35}COO)_2Ca} + 2Na^+$

30. Temporary hardness can be removed if hard water is heated with sodium salt or boiled.

31. Disadvantages of excessive use of synthetic detergents :

(a) Synthetic detergents are non-biodegradable and therefore, can cause water pollution in lakes and rivers. This affects the fish and other aquatic organisms because phosphatic salts present in detergents can cause rapid growth of algae in water bodies which further leads to decrease in the dissolved oxygen content of these water bodies, resulting in the death of certain aquatic organisms which require high oxygen content for their survival.

(b) Synthetic detergents are also known to affect the texture and colour of the fabrics.

32. Detergents are the sodium salts of a long chain benzene sulphonic acid or a long chain alkyl hydrogen sulphate. Most of the detergents have C_8 to C_{12} hydrocarbon chains (a non-polar group) and a polar group $SO_3^-Na^+$. Example :

Sodium lauryl sulphate $CH_3—(CH_2)_{10}—CH_2SO_4^-Na^+$

33. Advantages of synthetic detergents :

(i) Use of vegetable oils (which can be used as food articles) is minimised.

(ii) They can be used even with hard water.

(iii) They have better cleansing properties.

34. Soaps are the sodium or potassium salts of the long chain carboxylic acids (Fatty acids). The ionic group in soap is $-COO^-Na^+$, whereas detergents are ammonium or sulphate salts of long chain carboxylic acids. The ionic group in a detergent is $-SO_3^-Na^+$ or $-SO_4^-Na^+$.

35. A soap molecule has two ends with different properties, one end is polar *i.e.*, water soluble or hydrophilic while other end is non-polar *i.e.*, water insoluble or hydrophobic. When soap is added to water, the polar ends get dissolve in water and non-polar ends get dissolve in each other and directed towards the centre. As a result, a spherical ionic molecule known as micelles, formation takes place. Since, soaps are soluble in ethanol, therefore, micelles formation does not occur.