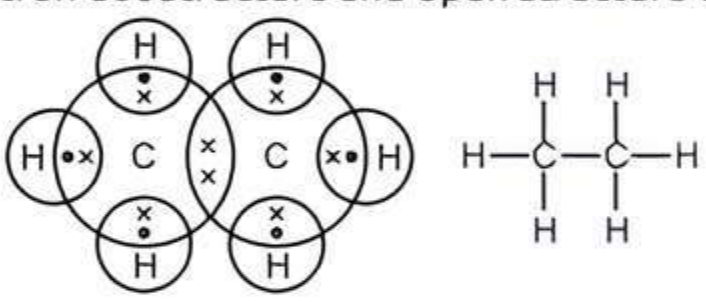
4 Carbon and its Compounds

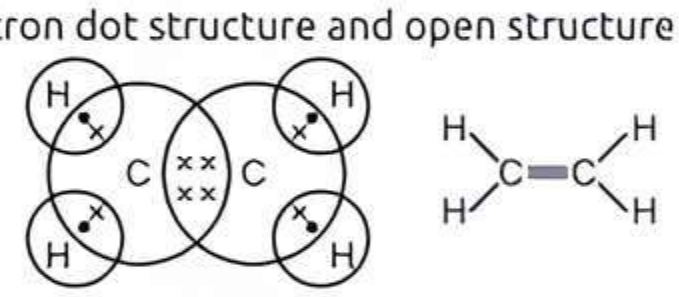
Fastrack Revision

- **Carbon:** Carbon is a non-metal whose atomic number is 6 and electronic configuration is 2, 4. All the living things, food, clothes, book etc. are made up of carbon based compounds. It is a versatile element and always forms strong covalent bonds (sharing of electron pairs) because of its small size. It is not easy for an atom of carbon to lose four electrons to gain stability because a large amount of energy will be required to do so. It is also not possible to gain all four electrons because it would be difficult for the nucleus with six protons to hold on to ten electrons.
- **Covalent Bond:** A chemical bond formed between two atoms by mutual sharing of electrons is called a covalent bond. The sharing of electrons takes place in such a way that each atom in the resulting molecule attains the noble gas configuration.
  - **Types of Covalent Bond:** The covalent bond can be of three types– **Single covalent bond** (sharing of **one pair** of electrons, *e.g.* Cl_2), **Double covalent bond** (sharing of **two pairs** of electrons, *e.g.* O_2) and **Triple covalent bond** (sharing of **three pairs** of electrons, *e.g.* N_2).
  - **Properties of Covalent Bonds:**
    (i) Covalently bonded molecules have low melting and boiling points due to weak intermolecular forces.
    (ii) These compounds are poor conductors of electricity since no charged particles are formed.
    (iii) Such compounds are insoluble in water and other polar solvents but soluble in organic solvents such as benzene.
- **Allotropy:** The property by virtue of which an element can exist in more than one form is referred to as allotropy. The various forms of an element which have similar chemical properties but different physical properties are called its allotropic forms or allotropes. Three allotropes of carbon are diamond, graphite and buckminsterfullerene.
- **Catenation:** The property of carbon atoms to form bonds with other atoms of carbon is called catenation. The compound thus formed may contain long chains, branched chains or even rings of carbon atoms.
- **Tetravalency:** Carbon has a valency of 4 and it is capable of bonding with atoms of oxygen, hydrogen, nitrogen, sulphur, chlorine and other elements. Carbon forms four covalent bonds, hence it is tetravalent.
- **Hydrocarbons:** The organic compounds which are made up of carbon and hydrogen atoms only are called hydrocarbons. For example, CH_4, C_2H_2, C_2H_4, C_2H_6, etc. The hydrocarbons are of two types:
  1. **Saturated Hydrocarbons:** The hydrocarbons having single (—) bond between carbon-carbon atoms are called saturated hydrocarbons (called alkanes, C_nH_{2n+2}). For example, Methane (CH_4), Ethane (C_2H_6), etc.
  2. **Unsaturated Hydrocarbons:** A hydrocarbon in which two carbon atoms are connected by a 'double bond' or a 'triple bond' is called an unsaturated hydrocarbon. The hydrocarbon in which the two carbon atoms are connected by a double bond is known as an alkene (C_nH_{2n}). For example, C_2H_4, C_3H_6 and in which the two carbon atoms are connected by a triple bond is called an alkyne (C_nH_{2n-2}) For example, C_2H_2, C_3H_4.

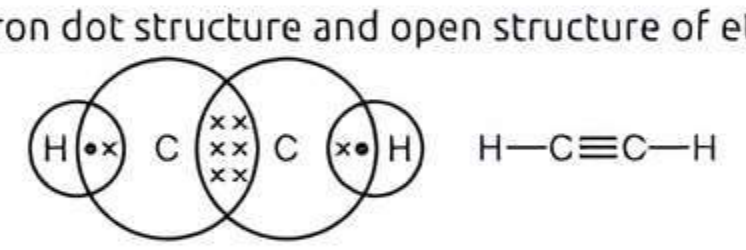
Electron dot structure and open structure of ethane



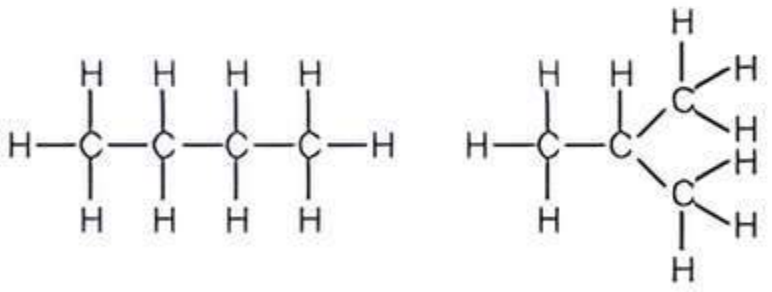
Electron dot structure and open structure of ethene



Electron dot structure and open structure of ethyne

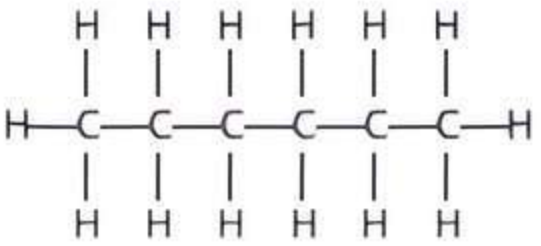


- **Isomerism:** Two or more organic compounds having the same molecular formulae but different structural formulae, are called **isomers** of each other and this phenomenon is called **isomerism**.
  For example,

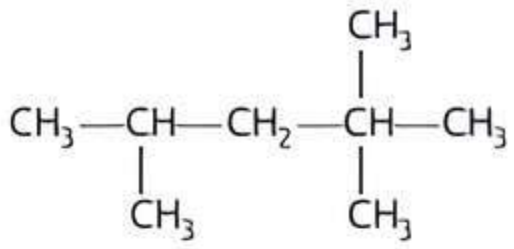


Two structures with formula C_4H_{10}

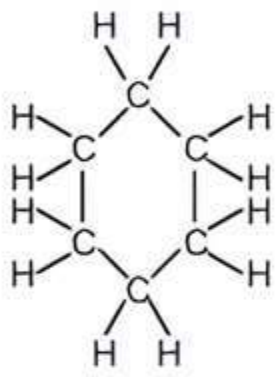
- **Chains, Branches and Rings:**
  1. **Straight Chain Compounds:** In these compounds, carbon atoms are arranged in linear fashion leading to a straight chain of carbon atoms.
     6 carbon atoms are arranged in a linear fashion in hexane.



2. **Branched Chain Compounds:** In these compounds, the carbon chain splits off in one or more directions. In the compound shown below the carbon chain has three branches, *i.e.*, the parent chain splits into three segments.

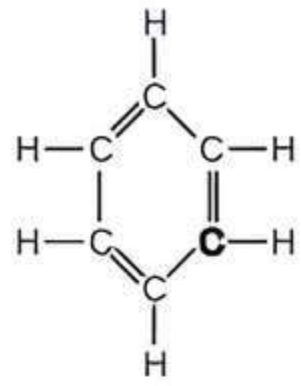


3. **Cyclic Compounds or Rings:** In these compounds, the carbon backbone is linked so as to form a ring or loop and the terminus of the backbone is not present.



Straight chain, branched chain and cyclic carbon compounds, all may be saturated and unsaturated.

For example, benzene (C_6H_6) is an unsaturated cyclic compound.



- **Homologous Series:** The series of organic compounds having the same functional group and similar chemical properties, is called homologous series. Each member differs from successive members by $—CH_2$ group. The difference in molecular weights of two successive members is 14 u.
- **Heteroatom and Functional Groups :** In hydrocarbon chains, one or more hydrogen atoms can be replaced by other atoms in accordance with their valencies. The element that replaces hydrogen is known as a **heteroatom**.

  These **heteroatoms** and the groups containing them impart chemical properties to the compound and hence are referred to as **functional groups.**

Nomenclature of Carbon Compounds

Prefix of the functional group	No. of C-atoms	Base name	Suffix 1	Suffix 2 of the functional group	Name of the organic compound
	1	Meth		-ol for alcohol	Prefix + Base name (for —Cl and —Br)
	2	Eth			
	3	Prop		-al for aldehyde	
	4	But			
Chloro for —Cl	5	Pent	-ane	-one for ketone	Base name + Suffix 1 + Suffix 2. (for —OH, —CHO, —CO— and —COOH)
	6	Hex	-ene		
Bromo for —Br	7	Hept	-yne	-oic acid for carboxylic acid	
	8	Oct			
	9	Non			
	10	Dec			

Note: If suffix 2 is to be used, then the name of the carbon chain is modified by deleting the final 'e' of ane, ene and yne.

MNEMONICS

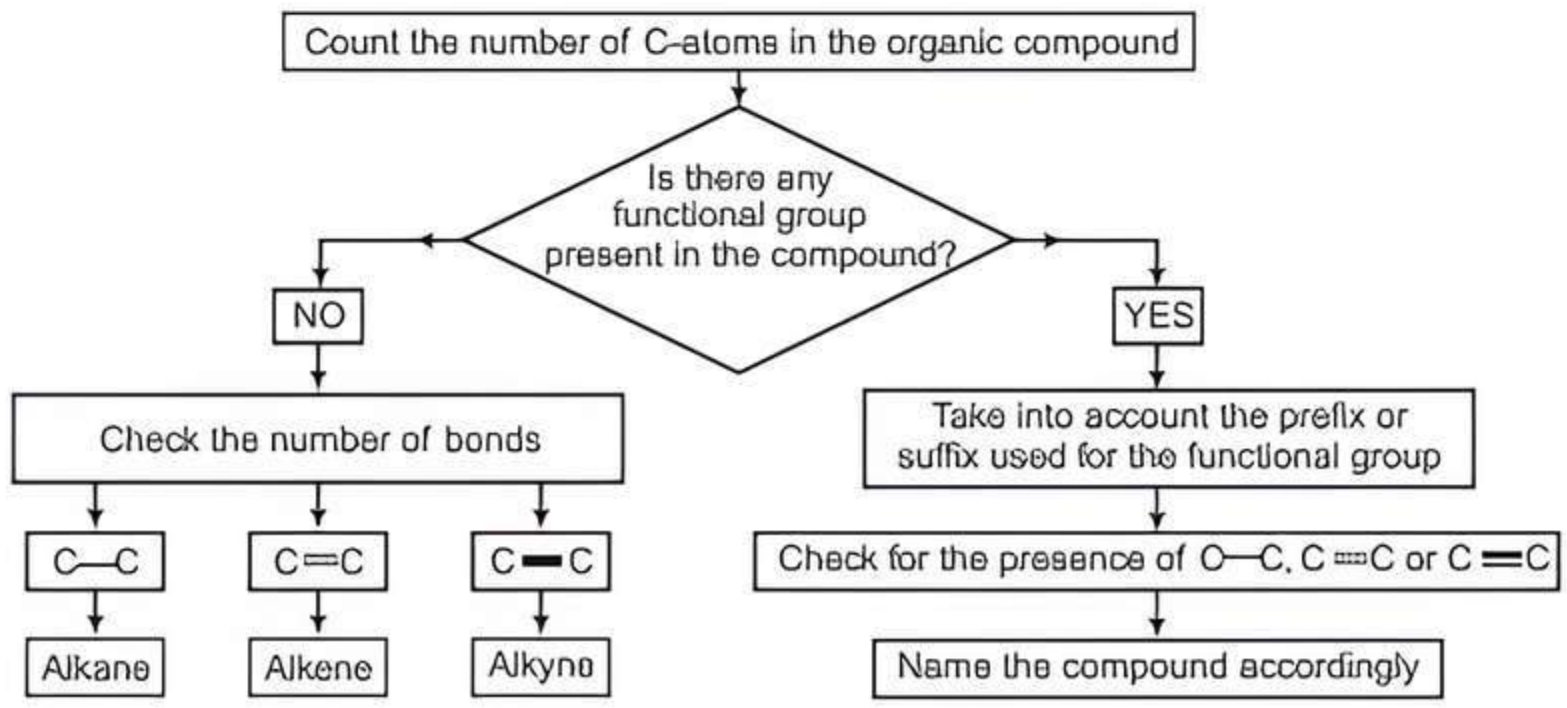
Concept: *How to remember order of base name ?*

Mnemonics: ***M****any* ***E****lderly* ***P****eople* ***B****uy* ***P****ent* ***H****ouses* ***H****igh* ***O****ver* ***N****orth* ***D****elhi*

Interpretation:

M – Meth-	*E – Eth-*	*P – Prop-*	*B – But-*	*P – Pent-*
H – Hex-	*H – Hept-*	*O – Oct-*	*N – Non-*	*D – Dec-*

- **Summary of Systematic Approach:**



▶ **Chemical Properties of Carbon Compounds:**

1. **Combustion:** Carbon compounds burn in air to give carbon dioxide along with the release of heat and light.

$$CH_4 + O_2 \longrightarrow CO_2 + H_2O + \text{heat and light}$$

Saturated hydrocarbons produce blue and non-sooty flame whereas unsaturated hydrocarbons produce yellow sooty flame.

2. **Oxidation:** Alcohols can be converted to carboxylic acids by oxidizing them using alkaline potassium permanganate or acidified potassium dichromate (they add oxygen to the reactant, thus are called oxidizing agents).

$$CH_3—CH_2OH \xrightarrow[\text{Or acidified } K_2Cr_2O_7 + \text{Heat}]{\text{Alkaline } KMnO_4 + \text{Heat}} CH_3COOH$$

3. **Addition Reaction:** Unsaturated hydrocarbons add hydrogen in the presence of catalysts such as palladium or nickel to give saturated hydrocarbons.

$$\underset{\text{Ethene}}{CH_2 = CH_2} + H_2 \xrightarrow[573K]{Ni} \underset{\text{Ethane}}{CH_3—CH_3}$$

This reaction is commonly used in the hydrogenation of vegetable oils using a nickel catalyst.

4. **Substitution Reaction:** Saturated hydrocarbons undergo substitution reaction in the presence of sunlight.

$$CH_4 + Cl_2 \longrightarrow CH_3Cl + HCl$$

(in the presence of sunlight)

▶ **Chemical Properties of Ethanol:**

1. **Reaction with Sodium:** Ethanol reacts with sodium to form sodium ethoxide and hydrogen.

$$2Na + 2CH_3CH_2OH \longrightarrow \underset{\text{(Sodium ethoxide)}}{2CH_3CH_2O^-Na^+} + H_2\uparrow$$

2. **Reaction with acid:** When ethanol is heated with concentrated sulphuric acid (dehydrating agent) at 443K, it is dehydrated to ethene.

$$CH_3—CH_2OH \xrightarrow[H_2SO_4]{\text{Hot conc.}} CH_2 = CH_2 + H_2O$$

▶ **Chemical Properties of Ethanoic Acid:**

1. **Reaction with ethanol:** Ethanoic acid reacts with absolute ethanol in the presence of an acid catalyst to give an ester. Esters are sweet-smelling substances which are used in making perfumes and as flavouring agents. This reaction is called **esterification reaction**.

$$\underset{\text{Ethanoic acid}}{CH_3COOH} + \underset{\text{Ethanol}}{C_2H_5OH} \xrightarrow{\text{Conc. } H_2SO_4} \underset{\text{Ethyl ethanoate (Ester)}}{CH_3COOC_2H_5} + \underset{\text{Water}}{H_2O}$$

The ester gets converted back into alcohol and sodium salt of acid when treated with alkali like sodium hydroxide. This reaction is known as **saponification** because it is used in the preparation of soap.

$$CH_3COOC_2H_5 \xrightarrow{NaOH} C_2H_5OH + CH_3COONa$$

2. **Reaction with NaOH:** Ethanoic acid reacts with a base such as sodium hydroxide to give a salt (sodium ethanoate or commonly called sodium acetate) and water.

$$NaOH + CH_3COOH \longrightarrow CH_3COONa + H_2O$$

3. **Reaction with carbonates and hydrogen carbonates:** Ethanoic acid reacts with carbonates and hydrogen carbonates to give rise to a salt, carbon dioxide and water. The salt produced is commonly called sodium acetate.

$$2CH_3COOH + Na_2CO_3 \longrightarrow 2CH_3COONa + H_2O + CO_2\uparrow$$

$$CH_3COOH + NaHCO_3 \longrightarrow CH_3COONa + H_2O + CO_2\uparrow$$

▶ **Soaps and Detergents:**

1. Soaps are sodium or potassium salts of long chain carboxylic acids whereas detergents are the ammonium or sulphonate salts of long chain carboxylic acids.
2. Soaps are effective with soft water only because Ca^{2+} and Mg^{2+} present in hard water reacts with soap molecules to form insoluble substance (scum) that obstructs the cleansing action.
3. Detergents are effective with both soft as well as hard water.

▶ **Cleansing Action of Soaps:** When soap is dissolved in water, the hydrophilic end of soap interacts with water while the hydrophobic end interacts with oil (dirt). The soap molecules, thus form structures called **micelles** where one end of the molecules is towards the oil droplet while the hydrophilic end faces outside. This forms an emulsion in water and helps in dissolving the dirt when we wash our clothes.

Practice Exercise

Multiple Choice Questions ↘

Q 1. Which of the following statements are usually correct for carbon compounds?

(i) These are good conductors of electricity

(ii) These are poor conductors of electricity

(iii) They have strong forces of attraction between their molecules

(iv) They do not have strong forces of attraction between their molecules *(NCERT EXEMPLAR)*

a. (i) and (iii) b. (ii) and (iii)
c. (i) and (iv) d. (ii) and (iv)

Q 2. Carbon forms four covalent bonds by sharing its four valence electrons with four univalent atoms, *e.g.* hydrogen. After the formation of four bonds, carbon attains the electronic configuration of: *(NCERT EXEMPLAR)*

a. helium b. neon
c. argon d. krypton

Q 3. C^{4+} does not exist but Pb^{4+} exists although both belong to the same group. This is because:

(i) size of carbon is much smaller than Pb.

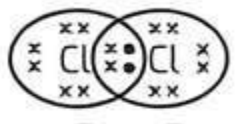
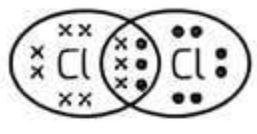
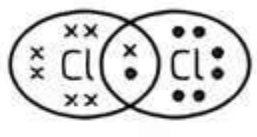
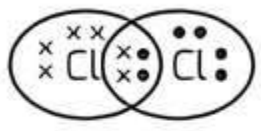
(ii) large amount of energy is needed in case of carbon.

(iii) of inert pair effect.
(iv) nucleus cannot hold such a large number of electrons.

The correct statement(s) is/are:

a. Only (I) b. (I) and (II)
c. Only (iii) d. (ii), (iii) and (iv)

Q 4. The electron dot structure of chlorine molecule is: *(CBSE 2023)*

a. 
b. 
c. 
d. 

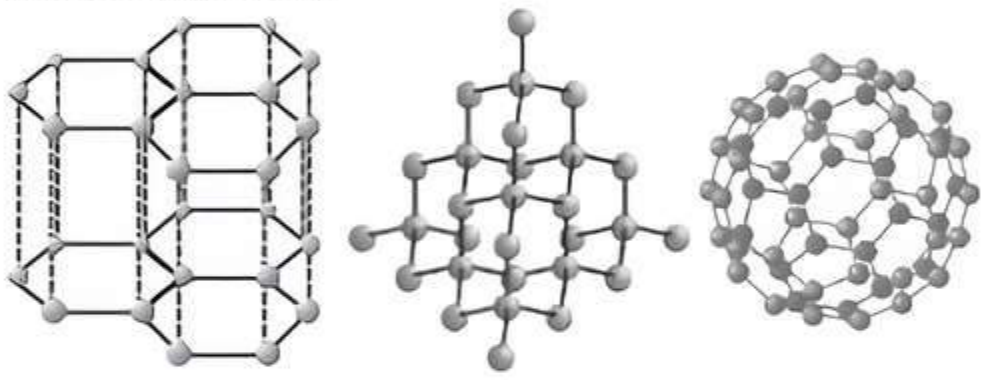
Q 5. Which of the following will contain covalent double bond between its atoms?

a. H_2 b. O_2 c. N_2 d. Cl_2

Q 6. A molecule of ammonia (NH_3) has: *(NCERT EXEMPLAR)*

a. Only single bonds
b. Only double bonds
c. Only triple bonds
d. Two double bonds and one single bond.

Q 7. Which three allotropes of carbon, do the given figures represent?



(I) (II) (III)

	(I)	**(II)**	**(III)**
a.	Diamond	Graphite	Buckminster-fullerene
b.	Graphite	Buckminster-fullerene	Diamond
c.	Diamond	Buckminster-fullerene	Graphite
d.	Graphite	Diamond	Buckminster-fullerene

Q 8. The property of self-linkage among identical atoms to form long chain compounds is known as:

a. catenation b. isomerisation
c. superposition d. halogenation

Q 9. Which of the following is not a straight chain hydrocarbon? *(NCERT EXEMPLAR)*

a. $H_3C—CH_2—CH_2—CH_2—CH(CH_3)$

b. $H_3C—CH_2—CH_2—CH_2—CH_2—CH_3$

c. $H_2C(CH_3)—H_2C—H_2C—CH_2(CH_3)$

d. $H_3C—CH(CH_3)—CH_2—CH_2—CH_3$

Q 10. Which among the following are unsaturated hydrocarbons?

(i) $H_3C—CH_2—CH_2—CH_3$

(ii) $H_3C—C\equiv C—CH_3$

(iii) $H_3C—CH(CH_3)—CH_3$

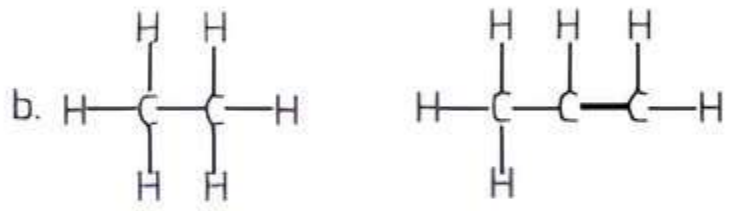
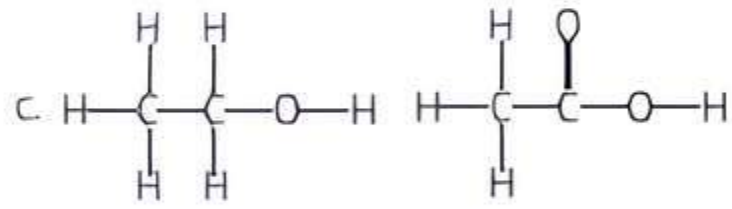
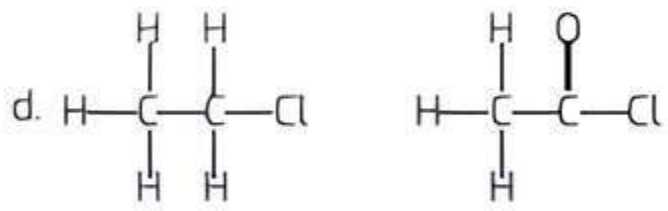
(iv) $H_3C—C(CH_3)=CH_2$

a. (i) and (iii) b. (ii) and (iii)
c. (ii) and (iv) d. (iii) and (iv)

Q 11. The total number of electrons shared in the formation of an ethyne molecule is: *(CBSE 2023)*

a. 6 b. 3
c. 10 d. 4

Q 12. Which of the following pairs of compounds have similar chemical properties?

a. 
b. 
c. 
d. 

Q 13. The heteroatoms present in $CH_3—CH_2—O—CH_2—CH_2Cl$ are:

(NCERT EXEMPLAR)

(i) oxygen (ii) carbon
(iii) hydrogen (iv) chlorine

a. (i) and (ii)
b. (ii) and (iii)
c. (iii) and (iv)
d. (i) and (iv)

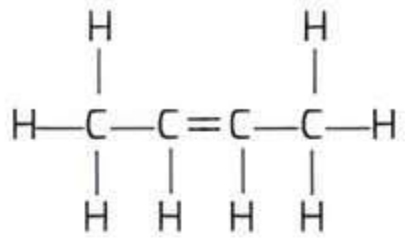
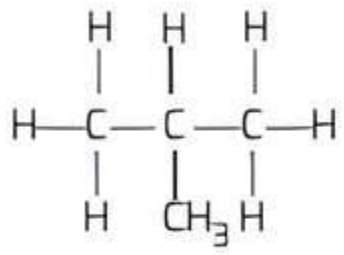
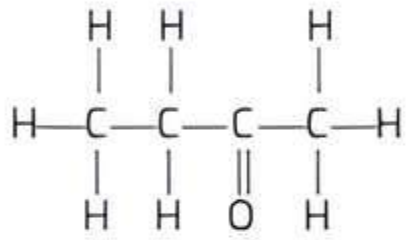
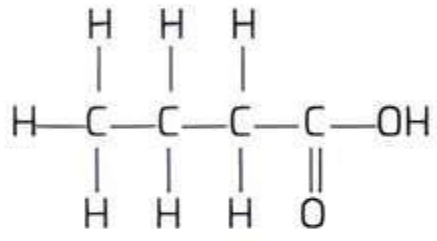
Q 14. Which of the following does not belong to the same homologous series? *(NCERT EXEMPLAR)*

a. CH_4 b. C_2H_6
c. C_3H_8 d. C_4H_8

Q 15. The correct IUPAC name for $CH_2=C(CH_3)—CH=CH_2$ is:

a. 2-methylbutane
b. 2-methyl. 1, 3-butadiene
c. 1, 3-pentadiene
d. 2-methylbutene

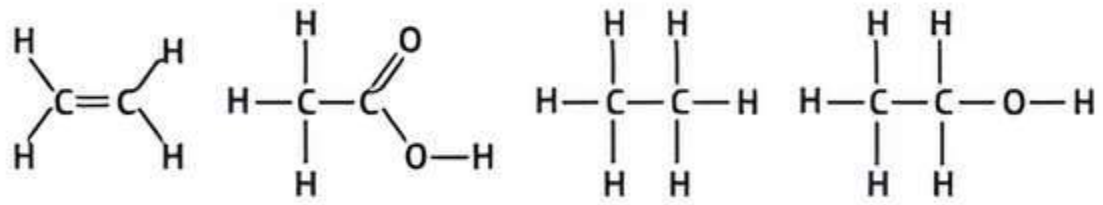
Q 16. Match the compounds given in column (A) with their appropriate structures given in column (B).

S.No.	Column (A)		Column (B)
A.	Butanone	(i)	
B.	2-Butene	(ii)	
C.	Butanoic acid	(iii)	
D.	2-methyl propane	(iv)	

Codes

	A	B	C	D
a.	(iv).	(i).	(iii).	(ii)
b.	(iii).	(ii).	(iv).	(i)
c.	(iii).	(i).	(iv).	(ii)
d.	(ii).	(iv).	(i).	(iii)

Q 17. The formulae of four organic compounds are shown below. Choose the correct option. *(CBSE SQP 2022-23)*



(A) (B) (C) (D)

a. *A* and *B* are unsaturated hydrocarbons
b. *C* and *D* are saturated hydrocarbons
c. Addition of hydrogen in presence of catalyst changes *A* to *C*
d. Addition of potassium permanganate changes *B* to *D*

Q 18. When ethanol reacts with sodium two products are formed? These products are: *(CBSE 2023)*

a. sodium ethanoate and oxygen
b. sodium ethanoate and hydrogen
c. sodium ethoxide and oxygen
d. sodium ethoxide and hydrogen

Q 19. Identify *X*, *Y* and *Z* respectively in the given reaction

$$X \xleftarrow[\Delta]{\text{Hot conc. } H_2SO_4} CH_3CH_2OH \xrightarrow[\Delta]{\text{Alk. } KMnO_4} Y$$

$CH_3CH_2OH \xrightarrow{\text{Acid}} Z$

a. CH_3COOH, $CH_2 = CH_2$, CH_3COOCH_3
b. $CH_2=CH_2$, CH_3COOH, $CH_3COOCH_2CH_3$
c. $HCHO$, CH_3CH_3, CH_3CH_2COOH
d. CH_3CH_3, $HCHO$, CH_3COOH

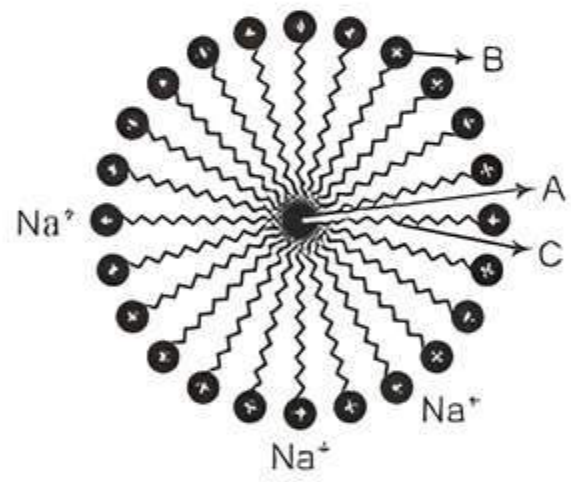
Q 20. Which of the following represents saponification reaction? *(NCERT EXEMPLAR)*

a. $CH_3COONa + NaOH \xrightarrow{CaO} CH_4 + Na_2CO_3$
b. $CH_3COOH + C_2H_5OH \xrightarrow{H_2SO_4} CH_3COOC_2H_5 + H_2O$
c. $2CH_3COOH + 2Na \longrightarrow 2CH_3COONa + H_2\uparrow$
d. $CH_3COOC_2H_5 + NaOH \longrightarrow CH_3COONa + C_2H_5OH$

Q 21. On adding acetic acid to solid sodium hydrogen-carbonate, a student observes the liberation of a:

a. greenish yellow gas with pungent smell
b. colourless and odourless gas
c. yellow coloured, odourless gas
d. colourless gas with smell of rotten eggs

Q 22. A diagram is given below:



The statement which defines the diagram and its parts is:

a. This is an ideal setting of micelle formation with *A* = hydrophilic end, *B* = oil droplet and *C* = hydrophobic end.
b. This is an ideal setting of micelle formation with *A* = hydrophobic end, *B* = hydrophilic end and *C* = oil droplet.
c. This is an ideal setting of micelle formation with *A* = oil droplet, *B* = hydrophilic end and *C* = hydrophobic end.
d. This is an ideal setting of micelle formation with *A* = oil droplet, *B* = hydrophobic end and *C* = hydrophilic end.

Q 23. Hard water does not easily produce lather with soap because it contains:

a. Only Mg^{2+} ions
b. Only Ca^{2+} ions
c. Both Mg^{2+} and Ca^{2+} ions
d. Both Na^{+} and K^{+} ions

Assertion & Reason Type Questions ↘

Directions (Q. Nos. 24-30): *Each of the following questions consists of two statements, one is Assertion (A) and the other is Reason (R). Give answer:*

a. Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

b. Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

c. Assertion (A) is true but Reason (R) is false.

d. Assertion (A) is false but Reason (R) is true.

Q 24. Assertion (A): Covalent compounds have generally low melting and boiling points.

Reason (R): Covalent compounds are soluble in water.

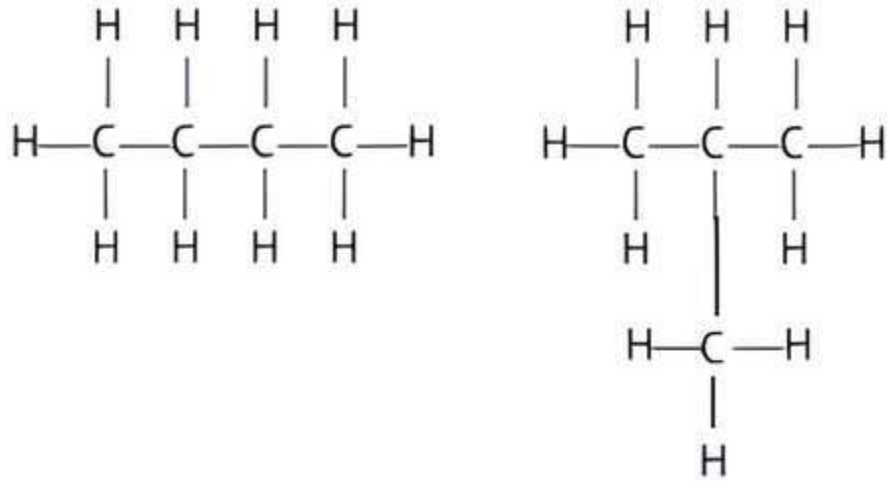
Q 25. Assertion (A): Diamond is a good conductor of electricity and heat.

Reason (R): In diamond, each carbon atom is bonded to four other carbon atoms forming a rigid 3-D structure.

Q 26. Assertion (A): Benzene is an unsaturated cyclic hydrocarbon.

Reason (R): Benzene has a six-carbon ring structure and has 3 carbon-carbon double bonds.

Q 27. Assertion (A): Following are the structural Isomers of butane.



Reason (R): Structural isomers have the same molecular formula, but they differ in their structures.

Q 28. Assertion (A): Alcohols have similar chemical properties.

Reason (R): All alcohols contains similar –OH functional group.

Q 29. Assertion (A): Following are the members of a homologous series:

$$CH_3OH, CH_3CH_2OH, CH_3CH_2CH_2OH$$

Reason (R): A series of compounds with same functional group, but differing by $—CH_2—$ unit is called a homologous series. *(CBSE 2020)*

Q 30. Assertion (A): Saturated hydrocarbons burn with a blue flame.

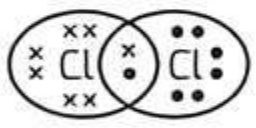
Reason (R): Saturated hydrocarbons contain less carbon content, so there is a complete combustion of these compounds.

Answers

1. (d) (ii) and (iv)

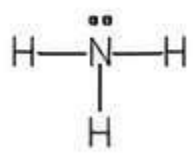
2. (b) neon

3. (b) 1 and 2

4. (c) 

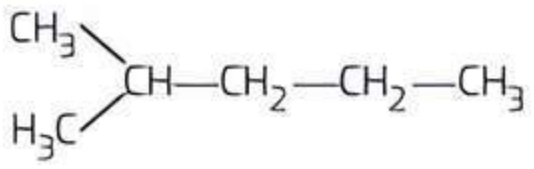
5. (b) O_2 contain double bond because an atom of oxygen has 6 electrons in its L shell and requires two more electrons to complete its octet. H_2 and Cl_2 forms a single covalent bond whereas N_2 forms a triple covalent bond.

6. (a) A molecule of ammonia has three single bonds between nitrogen and hydrogen and a lone pair of electrons.



7. (d) Graphite — Diamond — Buckminster-fullerene

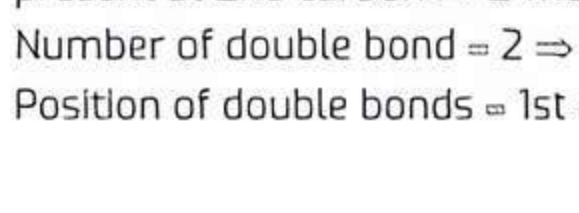
8. (a) catenation

9. (d) 

Option (d) is a branched chain hydrocarbon.

10. (c) (ii) and (iv) contain triple and double bonds respectively. hence they are unsaturated hydrocarbons.

11. (c) 6 electrons are shared between two 'C' atoms and 4 electrons are shared between two C—H bonds. Hence, 10 electrons are shared in formation of ethyne.

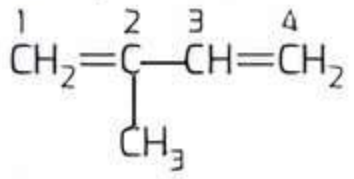
12. (a) 

They have the same functional group (—Cl group).

13. (d) The given compound has oxygen and chlorine atoms other than carbon and hydrogen. Thus, they are heteroatoms.

14. (d) CH_4, C_2H_6 and C_3H_8 belongs to the alkane (C_nH_{2n+2}) homologous series. C_4H_8 belongs to alkene (C_nH_{2n}) series.

15. (b) The given compound can be represented as:

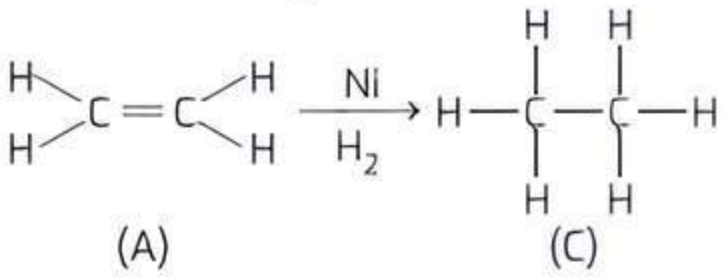


Number of carbon atoms = 4 ⇒ but Group present at 2nd carbon ⇒ 2-methyl

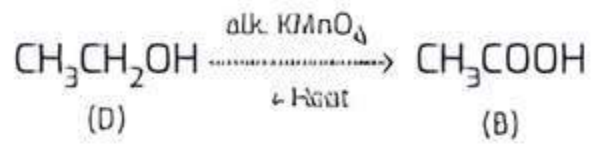
Number of double bond = 2 ⇒ diene

Position of double bonds = 1st and 3rd carbon.

16. (c) (iii), (i), (iv), (ii)
17. (c) *A* is an unsaturated hydrocarbon while *B*, *C* and *D* are saturated hydrocarbons.



(A) (C)



(D) (B)

18. (d) $2Na + 2CH_3CH_2OH \longrightarrow 2CH_3CH_2ONa + H_2$
Sodium, Ethanol, Sodium ethoxide, Hydrogen

19. (b) $CH_3CH_2OH \xrightarrow[H_2SO_4]{\text{Hot conc.}} CH_2 = CH_2 + H_2O$ (X)

$CH_3CH_2OH \xrightarrow[KMnO_4 + Heat]{\text{alk.}} CH_3COOH$ (Y)

$CH_3CH_2OH + CH_3COOH \xrightarrow{Acid} CH_3COOCH_2CH_3 + H_2O$ (Y) (Z)

20. (d) $CH_3COOC_2H_5 + NaOH \longrightarrow CH_3COONa + C_2H_5OH$

21. (b) $CH_3COOH + NaHCO_3 \longrightarrow CH_3COONa + H_2O + CO_2$
CO_2 is a colourless and odourless gas.

22. (c) This is an ideal setting of micelle formation with *A* = oil droplet. *B* = hydrophilic end and *C* = hydrophobic end.

23. (c) Both Mg^{2+} and Ca^{2+} ions

24. (c) Reason (R) is false because covalent compounds are soluble in organic solvents like benzene and insoluble in water.

25. (d) Assertion (A) is false because diamond is a bad conductor of electricity and good conductor of heat.

26. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

27. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

28. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

29. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

30. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

Case Study Based Questions

Case Study 1

Diamond, graphite and fullerenes (such as buckminsterfullerene) are three allotropes of pure carbon. In all three allotropes, the carbon atoms are joined by strong covalent bonds, but in such different arrangements that the properties of the allotropes are very different. Diamond is the hardest substance known in which each carbon atom is bonded to four other carbon atoms forming a rigid three-dimensional structure. Graphite is smooth and slippery and also a very good conductor of electricity. Graphite structure is formed by the hexagonal arrays being placed in layers one above the other.

Read the above passage carefully and give the answer of the following questions:

Q 1. Which of the following is buckminsterfullerene?
a. C-40 b. C-50
c. C-60 d. C-70

Q 2. What type of bonding is present in diamond?
a. Ionic b. Metallic
c. van der Waals d. Covalent

Q 3. In graphite, the carbon atoms are arranged in layers of:
a. hexagonal arrays b. pentagonal arrays
c. heptagonal arrays d. octagonal arrays

Q 4. Which among the following is not a property of diamond?
(i) It is the hardest substance known
(ii) It is smooth and slippery
(iii) It is a poor conductor of electricity
(iv) It is used as a lubricant
a. (iii) and (iv) b. (ii) and (iv)
c. (i) and (iv) d. (ii), (iii) and (iv)

Q 5. Why is graphite soft and slippery?
a. Because of its layer-like structure
b. Because it is made of carbon
c. Because of its stronger tetrahedron pattern
d. Because it has free electrons

Answers

1. (c) C-60
2. (d) Covalent
3. (a) hexagonal arrays
4. (b) (ii) and (iv)
5. (a) Because of its layer-like structure

Case Study 2

Homologous series is a series of compounds with similar chemical properties and same functional group differing from the successive member by $-CH_2$ or 14 mass units. Members of a homologous series show a gradual change in the physical properties (such as melting point, boiling point etc.) with the increase in molecular formula in the series.

Read the above passage carefully and give the answer of the following questions:

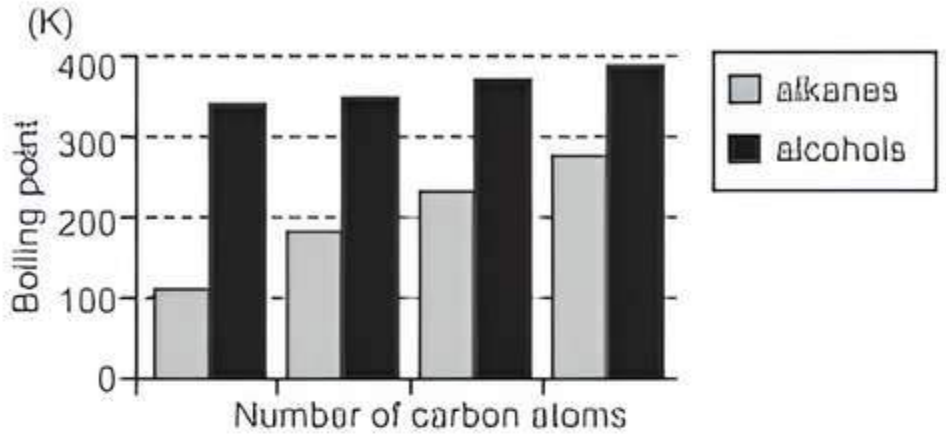
Q 1. What is the difference between two consecutive members in a homologous series in alkanes in terms of:
(i) Molecular mass
(ii) Number of atoms of elements?

Q 2. Write the formula and IUPAC name of the next homologue of CH_3CH_2OH.

Q 3. To which homologous series the compound $CH_3CH_2COCH_2CH_3$ belongs?

Q 4. Which two of the following organic compounds belong to the same homologous series?
$C_2H_6, C_2H_6O, C_2H_6O_2, CH_4O$

Q 5. Study the graph given given below that represents the boiling points of alcohols compared with alkanes.



What do you depict from the given graph?

Answers

1. (i) Molecular mass = 14 u
   (ii) Number of atoms of elements = CH_2
2. Formula: $CH_3CH_2CH_2OH$
   IUPAC name: Propan-1-ol
3. The compound $CH_3CH_2COCH_2CH_3$ belongs to Ketone homologous series.
4. C_2H_6O and CH_4O belongs to the same homologous series.
5. From the graph, we depict that alcohols possess higher boiling points as compared to those of corresponding alkanes.

Case Study 3

Chemistry in Automobiles:

For an internal combustion engine to move a vehicle down the road, it must convert the energy stored in the fuel into mechanical energy to drive the wheels. In your car, the distributor and battery provide this starting energy by creating an electrical "spark", which helps in combustion of fuels like gasoline. Below is the reaction depicting complete combustion of gasoline in full supply of air:

$$2C_8H_{18}(l) + 25O_2(g) \longrightarrow 16\,'X' + 18\,'Y'$$

Read the above passage carefully and give the answer of the following questions:

Q 1. **Which of the following are the products obtained from the reaction mentioned in the above case?**

	Product '*X*'	Product '*Y*'
a.	CO_2	H_2O_2
b.	H_2O	CO
c.	CH_3OH	H_2O
d.	CO_2	H_2O

Q 2. **Identify the types of chemical reaction occurring during the combustion of fuel:**

a. oxidation and endothermic reaction
b. decomposition and exothermic reaction
c. oxidation and exothermic reaction
d. combination and endothermic reaction

Q 3. **On the basis of evolution/absorption of energy, which of the following processes are similar to combustion of fuel?**

(i) Photosynthesis in plants
(ii) Respiration in the human body
(iii) Decomposition of vegetable matter
(iv) Decomposition of ferrous sulphate.

a. (ii) and (iii) b. (i) and (ii)
c. (iii) and (iv) d. (ii) and (i)

Q 4. **'A student while walking on the road observed that a cloud of black smoke belched out from the exhaust stack of moving trucks on the road.' Choose the correct reason for the production of black smoke:**

a. Limited supply of air leads to incomplete combustion of fuel.
b. Rich supply of air leads to complete combustion of fuel.
c. Rich supply of air leads to a combination reaction.
d. Limited supply of air leads to complete combustion of fuel.

Q 5. **'Although nitrogen is the most abundant gas in the atmosphere, it does not take part in combustion'. Identify the correct reason for this statement.**

a. Nitrogen is a reactive gas
b. Nitrogen is an inert gas
c. Nitrogen is an explosive gas
d. Only hydrocarbons can take part in combustion

Answers

1. (d) X-CO_2 . Y-H_2O
2. (c) oxidation and exothermic reaction
3. (a) (ii) and (iii)
4. (a) Limited supply of air leads to incomplete combustion of fuel.
5. (b) Nitrogen is an inert gas

Case Study 4

The table given below shows the hints given by the quiz master in a quiz.

S.No.	Hint
(i)	Substance 'C' is used as a preservative.
(ii)	'C' has two carbon atoms; 'C' is obtained by the reaction of 'A' in presence of alkaline Potassium permanganate followed by acidification.
(iii)	Misuse of 'A' in industries is prevented by adding Methanol, Benzene and Pyridine to 'A'.
(iv)	'F' is formed on heating 'A' in presence of conc. sulphuric acid.
(v)	'F' reacts with hydrogen gas in presence of Nickel and Palladium catalyst.

Based on the given hints answer of the following questions:

Q 1. Give the IUPAC names of A and F.

Q 2. Illustrate with the help of chemical equations the changes taking place. (A → C and A → F)

Or

Name the chemical reactions which occur in steps 2 and 5. Identify the compounds formed in these steps if 'A' is replaced with its next homologue. *(CBSE SQP 2023-24)*

Answers

1. A is Ethanol and F is Ethene.
2. **A → C :**

$$\underset{\text{(A) Ethanol}}{CH_3CH_2OH} \xrightarrow[+\text{Heat}]{\text{alk. } KMnO_4} \underset{\text{(C) Ethanoic acid (used as preservative in pickles)}}{CH_3COOH}$$

A → F :

$$\underset{\text{(A)}}{CH_3CH_2OH} \xrightarrow[H_2SO_4]{\text{Hot conc.}} \underset{\text{(F) Ethene}}{CH_2=CH_2} + H_2O$$

Or

Oxidation reaction occurs in step 2.
Addition reaction occurs in step 5.
Next homologue of 'A' (ethanol) is propanol ($CH_3CH_2CH_2OH$).

$$\underset{\text{Propanol}}{CH_3CH_2CH_2OH} \xrightarrow[+\text{Heat}]{\text{alk. } KMnO_4} \underset{\text{Propanoic acid}}{CH_3CH_2COOH}$$

$$\underset{\text{Propanol}}{CH_3CH_2CH_2OH} \xrightarrow[H_2SO_4]{\text{Hot conc.}} \underset{\text{Propene}}{CH_3CH=CH_2} + H_2O$$

∴ Propanoic acid and propene are formed in the given reactions.

Very Short Answer Type Questions ↘

Q 1. How are covalent bonds formed? *(CBSE 2020)*

Ans. Covalent bonds are formed by the mutual sharing of electrons between two or more atoms.

Q 2. Carbon is known to form compounds with many elements.

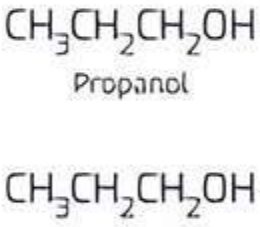
Write an example of a compound of carbon formed with

(i) chlorine **(ii) oxygen**

Ans. (i) Carbon tetrachloride (CCl_4).
(ii) Carbon dioxide (CO_2).

Q 3. Draw the electron dot structure of chlorine molecule. *(NCERT EXEMPLAR)*

Ans.



Q 4. Define catenation.

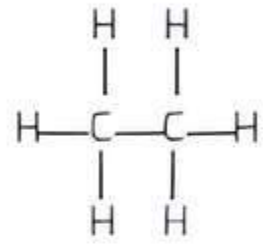
Ans. The property of carbon atoms to form bonds with other carbon atoms giving rise to large molecules is called catenation.

Q 5. 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 due to its smaller size which makes the C—C bonds strong and stable while the Si—Si bonds are comparatively weaker and reactive due to its large size.

Q 6. Write the number of covalent bonds in the molecule of ethane. *(CBSE 2015)*

Ans.



There are 7 covalent bonds in ethane.

Q 7. Select saturated hydrocarbons from the following:

C_3H_6, C_5H_{10}, C_4H_{10}, C_6H_{14}, C_2H_4. *(CBSE 2016)*

Ans. Saturated Hydrocarbons: C_4H_{10} and C_6H_{14}.

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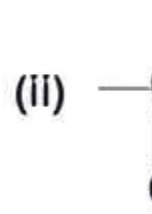
General formula of saturated hydrocarbons is C_nH_{2n+2}.

Q 8. Write the name of each of the following functional groups:

(i) —OH **(ii)** 

(CBSE 2015)

Ans. (i) —OH is alcohol (ii) —C(=O)— is a ketone

Q 9. Name the functional group present in each of the following organic compounds:

(i) CH_3COCH_3 **(ii) C_2H_5COOH**

Ans. (i) Ketone (ii) Carboxylic acid

Q 10. What is a homologous series of carbon compounds? *(CBSE 2016)*

Ans. Homologous series is a series of organic compounds which have the same functional group and similar chemical properties.

Q 11. Write the molecular formula of the 2nd and 3rd member of the homologous series where the first member is ethyne. *(CBSE 2017)*

Ans. Ethyne (C_2H_2) is the first member of alkyne series whose general formula is C_nH_{2n-2}, where n is the number of carbon atoms and $n = 2, 3, 4$ ..... etc.

The molecular formula of 2nd member ($n = 3$) of alkyne series is C_3H_4 and of the 3rd member ($n = 4$) is C_4H_6.

Q 12. Write the molecular formula of the first two members of the homologous series having functional group $>C=O$. *(CBSE 2017)*

Ans. The molecular formula of the first two members of the homologous series having functional group $>C=O$ is:

CH_3COCH_3 and $CH_3COC_2H_5$
(Propanone) (Butanone)

Q 13. Write molecular formula of alcohol which can be derived from butane. *(CBSE 2016)*

Ans. Butanol ($CH_3—CH_2—CH_2—CH_2—OH$).

Q 14. Write the name and structure of a carboxylic acid with three carbon atoms in its molecule.

Ans. IUPAC Name: Propanoic Acid
Structure : $CH_3—CH_2—COOH$

Q 15. Name the following compounds:

(i) $CH_3—CH_2—OH$ **(ii)** $CH_3—\overset{\overset{H}{|}}{C}=O$

(CBSE 2016)

Ans. (i) Ethanol (ii) Ethanal

Q 16. Which of the following will turn blue litmus solution red?

$CH_3OH, CH_3COOH, CH_3COOCH_3$

Ans. CH_3COOH will turn blue litmus solution red because it is an acid.

Q 17. Which of the following are carboxylic acids?

$C_2H_4O_2, C_2H_6O, C_3H_6O_2$

Ans. $C_2H_4O_2$ and $C_3H_6O_2$ are carboxylic acids.

Q 18. Write the chemical equation for combustion of ethanol.

Ans. $CH_3CH_2OH + 3O_2 \xrightarrow{\text{Combustion}} 2CO_2 + 3H_2O$ + heat and light.

Q 19. Name the process of converting vegetable oil to vegetable ghee.

Ans. Hydrogenation using nickel catalyst.

Q 20. Name the carbon compound which on heating with excess of conc. H_2SO_4 at 443 K gives ethene.

Ans. Ethanol on heating with excess of conc. H_2SO_4 at 443 K gives ethene.

Q 21. What is the role of reagents written on arrows in the given chemical reactions? *(NCERT EXEMPLAR)*

(i) $CH_3COOH + CH_3CH_2OH \xrightarrow{\text{Conc. } H_2SO_4} CH_3COOC_2H_5 + H_2O$

(ii) $CH_3CH_2OH \xrightarrow[\text{Heat}]{\text{Alk. } KMnO_4} CH_3COOH$

Ans. (i) Conc. H_2SO_4 acts as a catalyst.
(ii) Alkaline $KMnO_4$ acts as an oxidising agent.

Short Answer Type-I Questions

Q 1. 'Carbon prefers to share its valence electrons with other atoms of carbon or with atoms of other elements rather than gaining or losing the valence electrons in order to attain noble gas configuration.' Give reasons to justify this statement. *(CBSE 2022 Term-2)*

Ans. Carbon has four electrons in its outermost shell. It could not gain four electrons forming C^{4-} anion because it would be difficult for nucleus with six protons to hold on ten electrons. It could not also lose four electrons forming C^{4+} cation because it would require a large amount of energy to remove four electrons.
Thus, carbon prefers to share its valence electrons with other atoms of carbon or with atoms of other elements.

Q 2. The table shows the electronic structures of four elements.

Element	Electronic Structure
P	2, 6
Q	2, 8, 1
R	2, 8, 7
S	2, 8, 8

(i) Identify which element(s) will form covalent bonds with carbon.
(ii) 'Carbon reacts with an element in the above table to form several compounds.' Give suitable reason. *(CBSE SQP 2021 Term-2)*

Ans. (i) As per the electronic configuration of given elements, *P* is oxygen, *Q* is sodium, *R* is chlorine and *S* is Argon. Sodium form ionic compounds and Argon is a noble gas. So, they does not form covalent bonds with carbon. Hence, P and R will form covalent bonds with carbon.

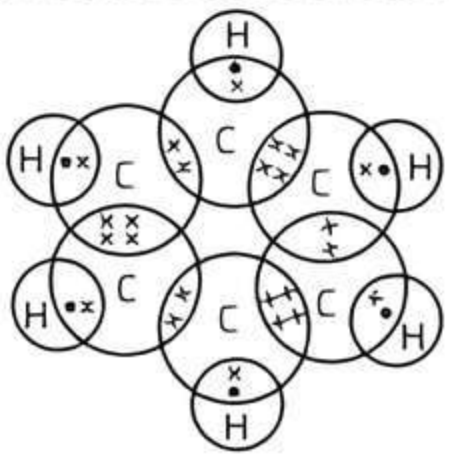
(ii) Several compounds are formed because of the following two properties:
(a) Tetravalency (b) Catenation

Q 3. State reasons to explain why covalent compounds:
(i) are bad conductors of electricity?
(ii) have low melting and boiling points?

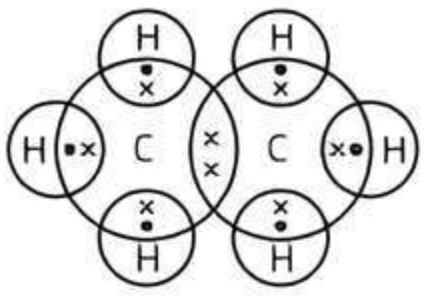
Ans. (i) Covalent compounds do not form ions, hence, they are bad conductor of electricity.
(ii) Covalent compound have weak intermolecular forces of attraction, therefore, have low melting and boiling points.

Q 4. Draw the electron dot structure of the following:
(i) Benzene (ii) Ethane *(CBSE 2022 Term-2)*

Ans. (i) Electron dot structure of Benzene:



(ii) Electron dot structure of ethane:

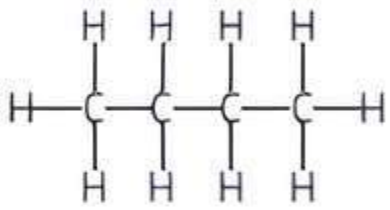


Q 5. (i) Write the name and draw the structure of a saturated hydrocarbon with four carbon atoms.

(ii) Write the number of single covalent bonds present in this compound. *(CBSE 2022 Term-2)*

Ans. (i) Butane is a saturated hydrocarbon with four carbon atoms.

Structure:



(ii) There are 13 covalent bonds present in butane.

Q 6. Write the structural formulae of any four isomers of hexane.

Ans.

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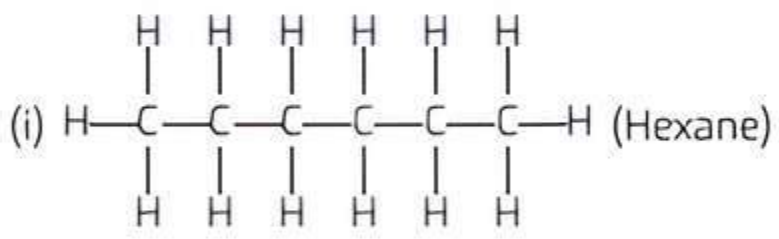
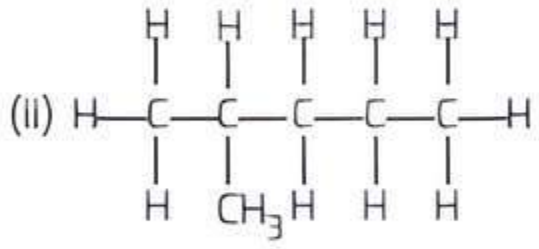
Understand the basic concept of isomerism. Drawing isomers and practicing them is mandatory.

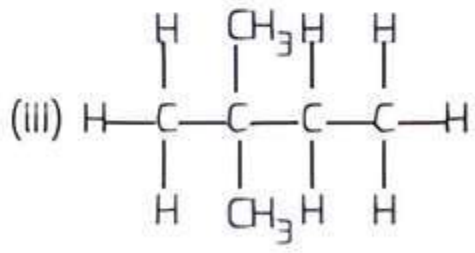
The structural formulae of isomers of hexane are:



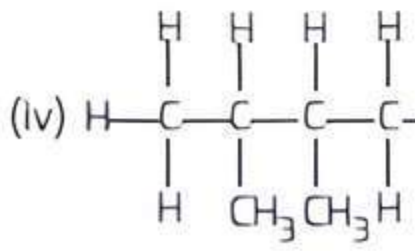
(i) (Hexane)



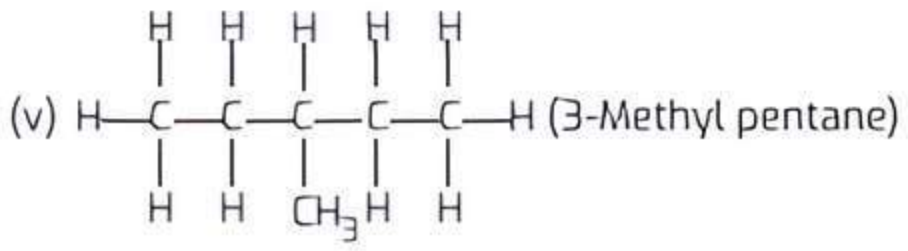
(ii) (2-Methyl pentane or isohexane)



(iii) (2. 2-Dimethyl butane or neohexane)



(iv) (2. 3-Dimethyl butane)

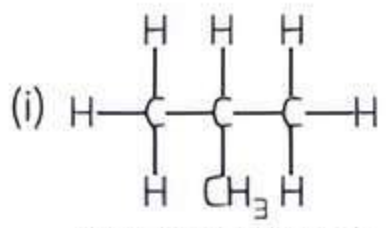


(v) (3-Methyl pentane)

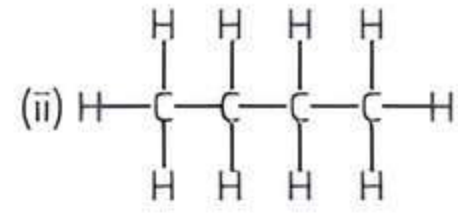
Q 7. Draw two structural isomers of butane.

(CBSE 2022 Term-2)

Ans. The structural isomers of butane are:



(i) (2-methyl propane)



(ii) (Butane)

Q 8. State any four characteristics of a homologous series.

Ans. Characteristics of a homologous series are as follows:

(i) Each member of the series can be represented by a general formula.

(ii) The successive members differ from each other in the molecular formula by $-CH_2$ unit.

(iii) The members of the homologous series have same functional group.

(iv) Members of homologous series have similar chemical properties.

Q 9. Write the chemical formula of two consecutive homologous of organic compounds having functional group—OH. What happens to the (i) boiling point and (ii) solubility of organic compounds of a homologous series as the molecular mass increases? *(CBSE 2022 Term-2)*

Ans. The chemical formula of two consecutive homologous of organic compounds having functional group —OH is:

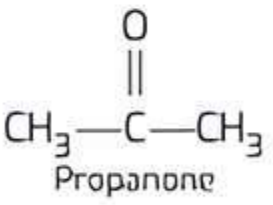
(a) CH_3OH and (b) C_2H_5OH

(i) The boiling point increases with increase in the molecular mass of members of homologous series.

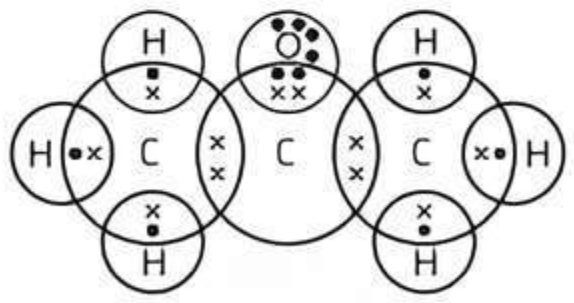
(ii) The solubility of organic compounds of a homologous series decrease with increase in molecular mass.

Q 10. Draw the possible isomers of the compound with molecular formula C_3H_6O and also give their electron dot structures.

Ans.

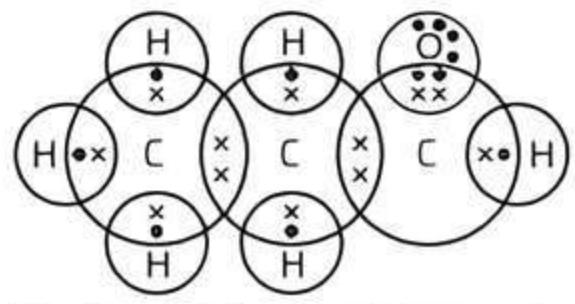


Propanone



Electron dot structure of propanone

Propanal



Electron dot structure of propanal

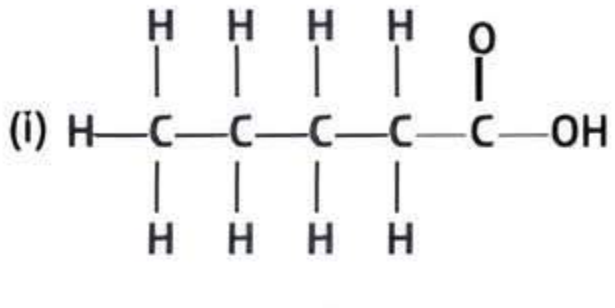
Q 11. Name the functional groups present in the following compounds:

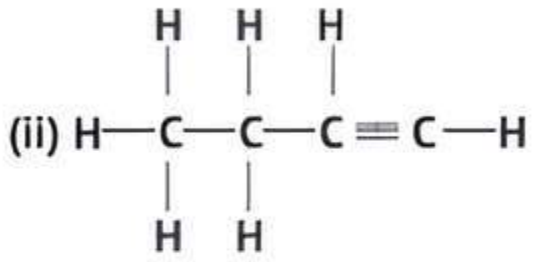
(i) $CH_3COCH_2CH_2CH_2CH_3$ (ii) $CH_3CH_2CH_2COOH$

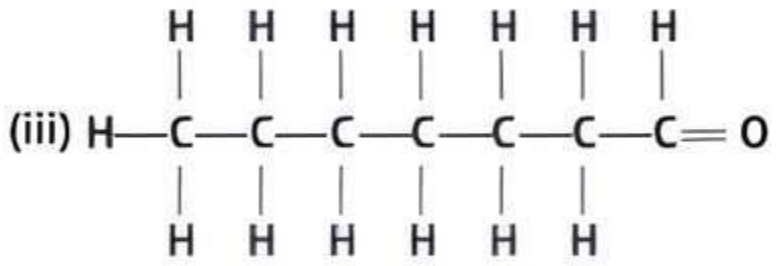
(iii) $CH_3CH_2CH_2CH_2CHO$ (iv) CH_3CH_2OH

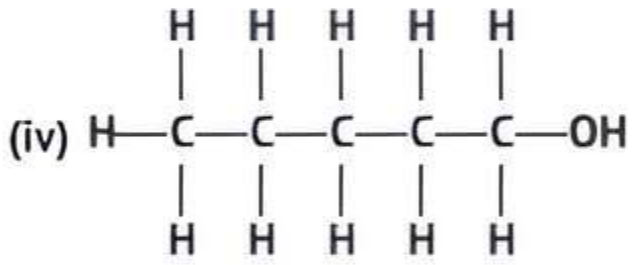
Ans. (i) Ketone (ii) Carboxylic acid
(iii) Aldehyde (iv) Alcohol

Q 12. Write the names of the following compounds:

(i)


(ii)


(iii)


(iv)


Ans. (i) Pentanoic acid (ii) Butyne
(iii) Heptanal (iv) Pentanol

COMMON ERROR

Mostly students commit errors in naming the organic compounds.

Q 13. Give the test to distinguish between ethane from ethene.

Ans. Ethane and ethene can be distinguished by subjecting them to the flame.
Ethane, being a saturated hydrocarbon, generally gives a clean flame while ethene, being an unsaturated hydrocarbon, gives a yellow flame with lots of black smoke.

Q 14. Rehmat classified the reaction between Methane and Chlorine in presence of sunlight as a substitution reaction. Support Rehmat's view with suitable justification and illustrate the reaction with the help of a balanced chemical equation.

(CBSE SQP 2023-24)

Ans. Rehmat's observation is correct as one hydrogen atom of methane has been substituted by heteroatom, *i.e.*, Cl atom in the presence of sunlight to form chloromethane and hydrogen chloride.

$$\underset{\text{Methane}}{CH_4} + \underset{\text{Chlorine}}{Cl_2} \longrightarrow CH_3Cl + HCl$$

(In the presence of sunlight)

Q 15. A gas is evolved when ethanol reacts with sodium. Name the gas evolved and also write the balanced chemical equation of the reaction involved.

Ans. Gas evolved is hydrogen.

$$2CH_3CH_2OH + 2Na \longrightarrow 2CH_3CH_2O^-Na^+ + H_2$$

Q 16. A compound '*X*' on heating with excess conc. sulphuric acid at 443 K gives an unsaturated compound '*Y*'. '*X*' also reacts with sodium metal to evolve a colourless gas '*Z*'. Identify '*X*', '*Y*' and '*Z*'. Write the equation of the chemical reaction of formation of '*Y*' and also write the role of sulphuric acid in the reaction. *(CBSE 2018)*

Ans. *X* is Ethanol (C_2H_5OH)
Y is Ethene (C_2H_4)
Z is Hydrogen gas (H_2)

Chemical Reaction Involved:

$$\underset{(X)}{CH_3CH_2OH} \xrightarrow[443\ K]{\text{Hot conc } H_2SO_4} \underset{(Y)}{CH_2=CH_2} + H_2O$$

Conc. H_2SO_4 acts as a dehydrating agent and removes water molecules from ethanol.

Q 17. What is saponification? Write the reaction involved in this process.

Ans. Saponification is the process of converting esters into salts of carboxylic acids and ethanol by treating them with a base.

$$CH_3COOC_2H_5 \xrightarrow{NaOH} CH_3COONa + C_2H_5OH$$

Q 18. In the three test tubes *A*, *B* and *C*, three different liquids namely, distilled water, underground water and distilled water in which a pinch of calcium sulphate is dissolved, respectively are taken. Equal amount of soap solution is added to each test tube and the contents are shaken. In which test tube will the length of the foam(lather) be longest? Justify your answer. *(CBSE 2019)*

Ans. In test tube *A* which contains distilled water, the length of the foam will be longest because it is soft water *i.e.* free from ions.
Underground water and distilled water in which a pinch of calcium sulphate is dissolved, are hard waters, so soap reacts with the salts present in them and form insoluble precipitate(scum), which is insoluble in water.

COMMON ERROR

Students often get confused between soft water and hard water and their action with soap.

Q 19. Why detergents are better cleansing agents than soaps? Explain.

Ans. Detergents work as cleansing agent both in hard and soft water. The charged ends of detergents do not form insoluble precipitates with calcium and magnesium ions in hard water.

Short Answer Type-II Questions

Q 1. What are covalent compounds? Why are they different from ionic compounds? List their three characteristic properties. *(CBSE 2016)*

Ans. Covalent compounds are those compounds which are formed by sharing of electrons.

They are different from ionic compounds because they do not contain ions.

The characteristic properties of these compounds are:

(i) They have low melting and boiling points.

(ii) They are insoluble in water but are soluble in organic solvents.

(iii) They do not conduct electricity in molten state or in the aqueous solutions.

Q 2. Explain, giving reason, why carbon neither forms C^{4+} cations nor C^{4-} anions, but forms covalent compounds which are bad conductors of electricity and have low melting point and low boiling point. *(CBSE 2017)*

Ans. The atomic number of carbon is 6. Its electronic configuration is 2.4. So, it has 4 electrons in its outermost shell. It cannot lose 4 electrons to form C^{4+} cations because a lot of energy is required to remove 4e^-. It also cannot gain 4e^- to form C^{4-} anions because it is difficult for 6 protons to hold on to 10e^-. Hence, it cannot form C^{4+} cation or C^{4-} anion and thus it shares 4e^- to form covalent compounds.

Since the electrons are shared by carbon so there are no charged particles and hence covalent compounds are bad conductors of electricity.

There are weak intermolecular forces in the molecules of covalent compounds so they have low melting and boiling points.

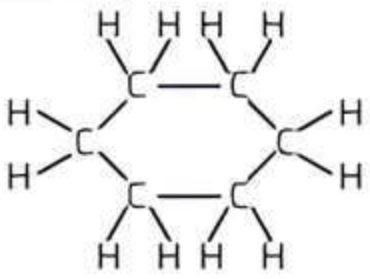
Q 3. (i) Why are most carbon compounds poor conductors of electricity?

(ii) Write the name and structure of a saturated compound in which the carbon atoms are arranged in a ring. Give the number of single bonds present in this compound. *(CBSE 2018)*

Ans. (i) Most carbon compounds are poor conductors of electricity because they form covalent bonds *i.e.* electrons are shared between atoms and no charged particles are formed.

(ii) **Name of Compound:** Cyclohexane (C_6H_{12})

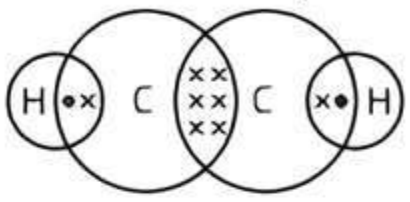
Structure: It is a saturated compound since there are only single covalent bonds present in it. The number of single bonds in the structure of this compound is 18.



Q 4. (i) Draw the electron dot structure for ethyne.

(ii) List two difference between the properties exhibited by covalent compounds and ionic compounds. *(CBSE 2022 Term-2)*

Ans. (I) Electron dot structure of ethyne:



(ii)

Basis of difference	Covalent compounds	Ionic compounds
Melting and Boiling points	They have low melting and boiling points.	They have high melting and boiling points.
Conduction of electricity	These compounds are non-conductors of electricity.	They conduct electricity in solution or in the molten state.

Q 5. What are hydrocarbons? Write the general formula of

(i) saturated hydrocarbons and

(ii) unsaturated hydrocarbons and draw the structure of one hydrocarbon of each type.

(CBSE 2017)

Ans. The organic compounds which are made up of carbon and hydrogen only are called hydrocarbons.

(i) General formula of saturated hydrocarbons: C_nH_{2n+2}.

where, n = number of carbon atoms.

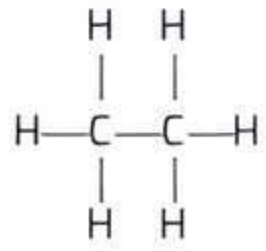
(ii) General formula of unsaturated hydrocarbons:

For Alkenes: C_nH_{2n} and for Alkynes: C_nH_{2n-2}.

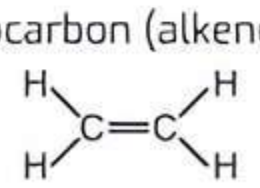
where, n = number of carbon atoms.

Structure:

Saturated Hydrocarbon: C_2H_6



Unsaturated Hydrocarbon (alkene): C_2H_4



Unsaturated Hydrocarbon (alkyne): C_2H_2

TiP

Learn the names of first few members of alkane, alkene and alkyne series with their formulae.

Q 6. What is meant by isomers? Draw the structures of two isomers of butane (C_4H_{10}). Explain why we cannot have isomers of first three members of alkane series. *(CBSE 2015)*

Ans. Isomers are the compounds having the same molecular formulae but different structural formulae.

$CH_3CH_2CH_2CH_3$ and $CH_3-\underset{\displaystyle CH_3}{\underset{|}{CH}}-CH_3$ are the two isomers of C_4H_{10}.

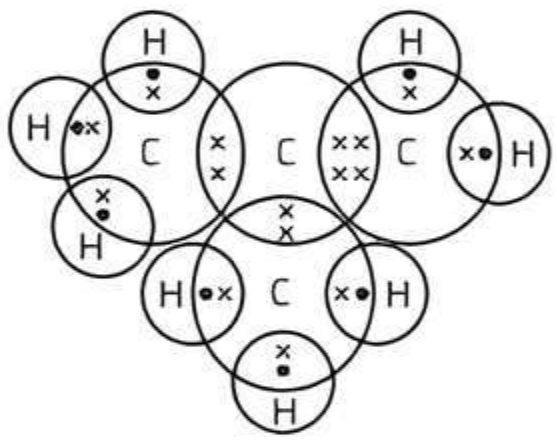
Isomers are not possible for the first three members of alkane series because there is no branching.

Q 7. (i) How many isomers are possible for the compound with the molecular formula C_4H_8? Draw the electron dot structure of branched chain isomer.

(ii) How will you prove the C_4H_8 and C_5H_{10} are homologous? *(CBSE SQP 2022 Term-2)*

Ans. (i) Five isomers are possible for the compound with the molecular formula C_4H_6.

Electron dot structure



(ii) C_4H_6 and C_5H_{10} are homologous because:

(a) they differ by a $-CH_2-$ unit.

(b) they can be represented by a general formula (C_nH_{2n}).

(c) difference in their molecular mass is 14 u.

Q 8. What is a homologous series? Find the difference in molecular mass between the two consecutive members of a homologous series. State how in a homologous series of carbon compounds the following properties vary will increase in molecular mass:

(i) Melting and boiling points

(ii) Chemical properties

Ans. Homologous series is a series of organic compounds having the same functional group and similar chemical properties. Any two consecutive members of a homologous series differ by a $-CH_2$ group and thus by a molecular mass of 14 u (12 + 2).

(i) With increase in molecular mass, van der Waals forces of attraction increases. So melting and boiling points of hydrocarbons increases with increase in molecular mass.

(ii) The chemical properties of members of a homologous series are same because they all have the same functional group.

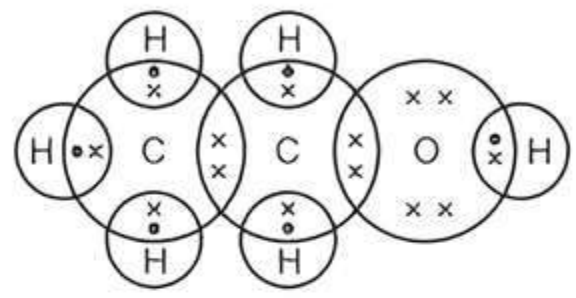
Q 9. A carbon compound 'A' having melting point 156 K and boiling point 351K, with molecular formula C_2H_6O is soluble in water in all proportions.

(i) Identify 'A' and draw its electron dot structure.

(ii) Give the molecular formulae of any two homologous of 'A'. *(CBSE SQP 2022 Term-2)*

Ans. (i) A is Ethanol (C_2H_5OH)

Electron dot structure of ethanol:

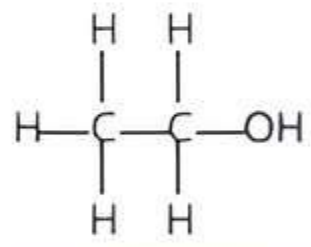
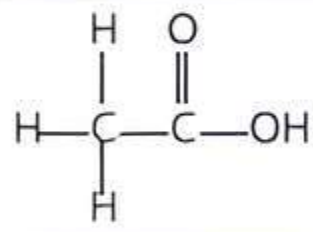


(ii) Molecular formula of two homologous of 'A' is $C_3H_8O(C_3H_7OH)$ and $C_4H_{10}O(C_4H_9OH)$.

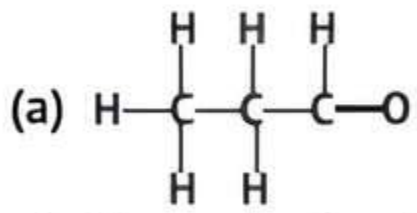
Q 10. What is meant by functional group in an organic compound? State in tabular form the structural formula and the functional groups present in:

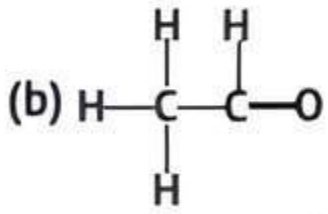
(i) Ethanol and (ii) Ethanoic acid *(CBSE 2015)*

Ans. An atom or a group of atoms which is the site of reactivity in the organic compound and which largely determines the properties of an organic compound is called functional group.

Name of the Compound	Structural Formula	Functional Group
Ethanol		Alcohol (— OH)
Ethanoic acid		Carboxylic acid (— COOH)

Q 11. Consider the following organic compounds:

(a) 

(b) 

(i) Name the functional group present in their compounds.

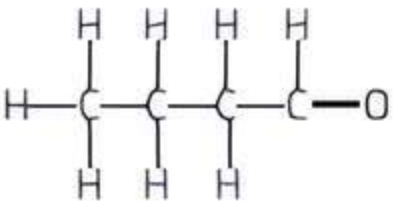
(ii) Write the general formula for the compounds of this functional group.

(iii) State the relationship between these compounds and draw the structure of any other compound having similar functional group. *(CBSE 2022 Term-2)*

Ans. (i) Aldehyde

(ii) The general formula of compounds of aldehyde group is $C_nH_{2n}O$ or $C_nH_{2n+1}CHO$.

(iii) These compounds show similar chemical properties and belong to homologous series of aldehydes.

Structure : 

Q 12. Two carbon compounds X and Y have the molecular formula C_4H_8 and C_5H_{12} respectively. Which one of these is most likely to show addition reaction? Justify your answer. Also give the chemical equation to explain the process of addition reaction in this case.

(CBSE 2017)

Ans.

TiP

Distinctly learn the molecular formula of saturated and unsaturated compounds. Lay stress on understanding the chemical properties of different carbon compounds.

C_4H_8 is an unsaturated hydrocarbon (C_nH_{2n}) and C_5H_{12} is a saturated hydrocarbon (C_nH_{2n+2}).

C_4H_8 will show addition reaction because of the presence of double bond (or it is an unsaturated hydrocarbon).

Chemical Equation : $C_4H_8 + H_2 \xrightarrow[473\ K]{Ni/Pd} C_4H_{10}$

Q 13. Name two oxidising agents that are used for the conversion of alcohols to acids. Distinguish between ethanol and ethanoic acid on the basis of (i) litmus test and (ii) reaction with sodium hydrogen carbonate.

(CBSE 2017)

Ans. The two oxidising agents are:

(i) alkaline potassium permanganate ($KMnO_4$)

(ii) acidified potassium dichromate ($K_2Cr_2O_7$)

(a) Litmus Test: Ethanoic acid is acidic in nature and therefore it changes blue litmus to red whereas ethanol which is neutral in nature does not change the colour of litmus paper.

(b) Reaction with Sodium Hydrogen Carbonate: Ethanol does not react with sodium hydrogen carbonate whereas ethanoic acid reacts with sodium hydrogen carbonate to give brisk effervescence with the evolution of carbon dioxide gas.

TiP

Students should learn the chemical properties of carbon compounds and different agents/catalysts required for these reactions. Also, lay stress on properties of ethanol and ethanoic acid.

Q 14. Complete the following chemical equations:

(i) $CH_3COOC_2H_5 + NaOH \longrightarrow$

(ii) $CH_3COOH + NaOH \longrightarrow$

(iii) $C_2H_5OH + CH_3COOH \xrightarrow{Conc.\ H_2SO_4}$

(CBSE 2017)

Ans. (i) $CH_3COOC_2H_5 + NaOH \longrightarrow CH_3CH_2OH + CH_3COONa$

(ii) $CH_3COOH + NaOH \longrightarrow CH_3COONa + H_2O$

(iii) $C_2H_5OH + CH_3COOH \xrightarrow{Conc.\ H_2SO_4} CH_3COOC_2H_5 + H_2O$

Q 15. Complete the following chemical equations:

(CBSE 2017)

(i) $CH_3COOH + Na_2CO_3 \longrightarrow$

(ii) $CH_4 + O_2 \longrightarrow$

(iii) $C_2H_5OH + Na \longrightarrow$

Ans. (i) $2CH_3COOH + Na_2CO_3 \longrightarrow 2CH_3COONa + H_2O + CO_2 \uparrow$

(ii) $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$ + heat and light

(iii) $2C_2H_5OH + 2Na \longrightarrow 2C_2H_5ONa + H_2 \uparrow$

Q 16. Write the structural formula of ethanol. What happens when it is heated with excess of conc. H_2SO_4 at 443 K? Write the chemical equation for the reaction stating the role of conc. H_2SO_4 in this reaction.

(CBSE 2017)

Ans.

TiP

Ethanol contains the word root 'eth' so we can say that ethanol contains two carbon atoms. –ol suffix represent the presence of alcohol functional group in ethanol.

Structural formula of Ethanol is:

When ethanol is heated with excess of conc. H_2SO_4 at 443 K, ethene is formed due to dehydration of ethanol.

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

In the above reaction, conc. H_2SO_4 acts as a dehydrating agent which removes water from ethanol.

Q 17. Distinguish between esterification and saponification reactions with the help of the chemical equations for each. State one use of each (i) esters and (ii) saponification process. *(CBSE 2017)*

Ans.

Basis of Difference	Esterification Reaction	Saponification Reaction
Process	In this reaction, an acid reacts with alcohol in the presence of an acid catalyst to give sweet- smelling substances called esters.	In this reaction, an ester reacts with an alkali (NaOH) to form sodium salt of carboxylic acid and alcohol
Example	$CH_3—COOH + CH_3—CH_2OH \xrightarrow{Acid}$ Ethanoic acid, Ethanol $CH_3—\underset{\underset{O}{\|}}{C}—O—CH_2—CH_3 + H_2O$ Ester	$CH_3COOC_2H_5 \xrightarrow{NaOH} C_2H_5OH + CH_3COONa$ Ester, Ethanol, Sodium salt of carboxylic acid
Use	Esters are used in making perfumes and as flavouring agents.	This reaction is used in the preparation of soap.

Q 18. What are detergents chemically? List two merits and two demerits of using detergents for cleansing. State the reason for the suitability of detergents for washing, even in the case of water having calcium and magnesium ions.

Ans. Detergents are chemically ammonium or sulphonate salts of long chain carboxylic acids.

Merits of Using Detergents for Cleansing:

(i) They can work effectively even in hard water.

(ii) They have better cleansing action than soaps.

Demerits of Using Detergents for Cleansing:

(i) They are non-biodegradable and thus harm the aquatic life.

(ii) They are prepared from petroleum hydrocarbons.

Detergents can work effectively even if calcium and magnesium ions are present in water. Since the charged ends of detergents do not form insoluble precipitate called scum with hard water, so they clean the clothes more effectively than soaps.

Long Answer Type Questions

Q 1. (i) It is observed that covalent compounds are bad conductors of electricity. Give reason.

(ii) Carbon can neither from C^{4+} cation nor C^{4-} anion. Why?

(iii) Draw electron dot structure of Ethanol.

(iv) Identify heteroatom(s) in the following compounds:

(a) $CH_3CH_2—\underset{\underset{O}{\|}}{C}—CH_3$

(b) CH_3CH_2Cl *(CBSE 2023)*

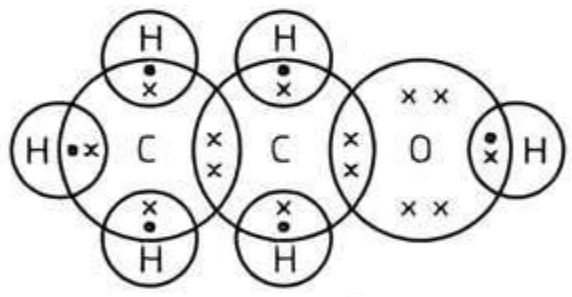
Ans. (i) Covalent compounds are bad conductors of electricity because electrons are shared between atoms and no charged particles are formed.

(ii) Carbon can neither form C^{4+} cation nor C^{4-} anion because:

(a) it could not lose four electrons as it would require a large amount of energy to remove four electrons.

(b) it could not gain four electrons as it would be difficult for the nucleus with six protons to hold on to ten electrons.

(iii) **Electron dot structure of ethanol:**



(iv) (a) oxygen (b) chlorine

COMMON ERROR

Students often make mistake while drawing electron dot structures.

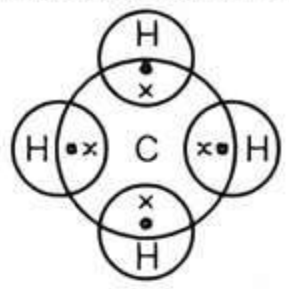
Q 2. (I) Name the simplest saturated hydrocarbon. Draw its electron dot structure. Which type of bonds exist in this compound?

(ii) Name any two mixtures of the carbon compound used as a fuel in daily life, of which the above mentioned compound is an important component.

(iii) In which homologous series of carbon compounds can this compound be placed? Write the general formula of the series.

(iv) Which type of flame is produced on burning it? *(CBSE 2023)*

Ans. (I) The simplest saturated hydrocarbon is methane.
Electron dot structure of methane (CH_4):



Covalent bonds exist in methane

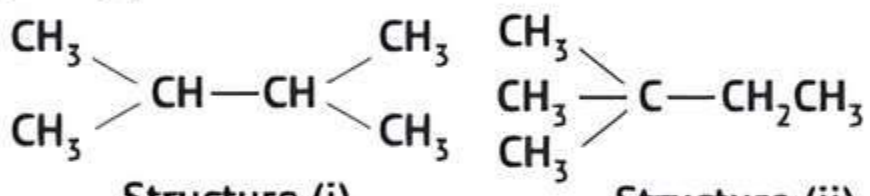
(ii) Bio-gas and Compressed Natural Gas (CNG).

(iii) Homologous series: Alkane
General formula : C_nH_{2n+2}, where n = no. of carbon atoms.

(iv) Methane on burning produces a blue and non-sooty flame.

Q 3. (i) Draw the structure of the following compounds:
(a) Butanoic acid (b) Chloropentane

(ii) How are structure (i) and structure (ii) given below related to one another? Give reason to justify your answer.

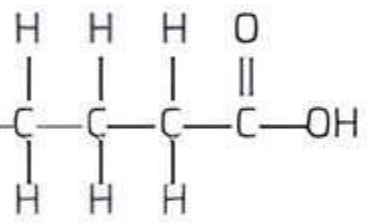


Structure (i) **Structure (ii)**

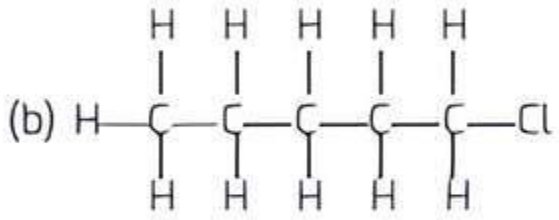
Draw one more possible structure for above case.

(iii) Differentiate between saturated and unsaturated carbon compounds on the basis of their general formula? *(CBSE 2023)*

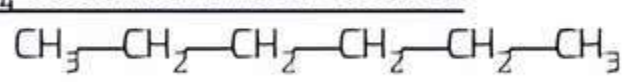
Ans. (i) (a)



(b)

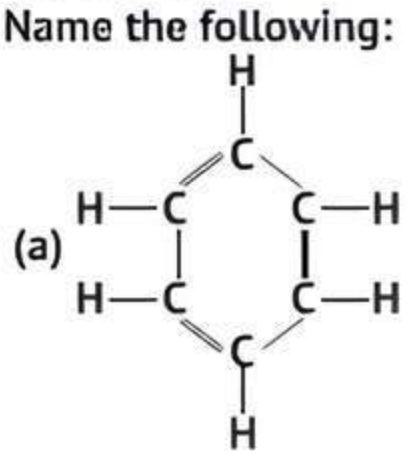


(ii) Structure (I) and (II) are structural isomers because they have the same molecular formula C_6H_{14} but different structures.



(iii) The general formula of saturated hydrocarbons is C_nH_{2n+2} where n is the number of carbon atoms. The general formula of unsaturated hydrocarbons is C_nH_{2n} or C_nH_{2n-2} where n is the number of carbon atoms.

Q 4. (i) Draw two structural isomers of butane.
(ii) Draw the structures of propanol and propanone.
(iii) Name the third homologue of:
(a) alcohols (b) aldehydes
(iv) Name the following:



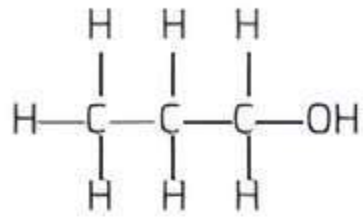
(b) $CH_3—CH_2CH=CH_2$

(v) Show the covalent bond formation in nitrogen molecule. *(CBSE 2023)*

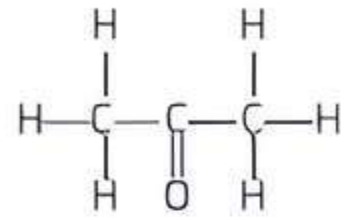
Ans. **(I) Structural isomers of butane:**

(a) $CH_3—CH_2—CH_2—CH_3$ (b) $CH_3CH(CH_3)CH_3$

(II) Propanol:



Propanone:



(iii) (a) Propanol (b) Propanal

(iv) (a) Benzene (b) Butene

(v) :N≡N:

Q 5. Write the chemical equation for the following:
(i) Combustion of methane
(ii) Oxidation of ethanol
(iii) Hydrogenation of ethene
(iv) Esterification Reaction
(v) Saponification Reaction *(CBSE 2023)*

Ans. (i) $CH_4 + O_2 \longrightarrow CO_2 + H_2O$ + heat and light

(ii) $CH_3CH_2OH \xrightarrow[\text{+ Heat}]{\text{alk. } KMnO_4} CH_3COOH$

(iii) $CH_2=CH_2 \xrightarrow[H_2]{Ni} CH_3CH_3$

(iv) $CH_3COOH + CH_3CH_2OH \xrightarrow{Acid} CH_3COOC_2H_5 + H_2O$

(v) $CH_3COOC_2H_5 \xrightarrow{NaOH} C_2H_5OH + CH_3COONa$

Q 6. Write the chemical formula and name of the compound which is the active ingredient of all alcoholic drinks. List its two uses. Write chemical equation and name of the product formed when this compound reacts with:
(i) sodium metal
(ii) hot concentrated sulphuric acid *(CBSE 2019)*

Ans. Ethanol is the active ingredient of all alcoholic drinks and its chemical formula is C_2H_5OH or CH_3CH_2OH

Uses of ethanol:

- It is used in medicines such as tincture iodine, cough syrups and many tonics.
- It is used in hand sanitizers.

Chemical equation and products:

(i) $2Na$ (Sodium) $+ 2CH_3CH_2OH$ (Ethanol) $\longrightarrow 2CH_3CH_2O^-Na^+$ (Sodium ethoxide) $+ H_2\uparrow$ (Hydrogen)

The products formed are sodium ethoxide and hydrogen gas.

(ii) CH_3CH_2OH (Ethanol) $\xrightarrow[H_2SO_4]{\text{Hot conc.}} CH_2=CH_2$ (Ethene) $+ H_2O$ (Water)

The products formed are ethene and water.

Q 7. (i) What is the role of concentrated Sulphuric acid when it is heated with Ethanol at 443 K. Give the reaction involved.

(ii) Reshu by mistake forgot to label the two test tubes containing Ethanol and Ethanoic acid. Suggest an experiment to identify the substances correctly? Illustrate the reactions with the help of chemical equations. *(CBSE SQP 2022-23)*

Ans. (i) Sulphuric acid acts as dehydrating agent which removes water from ethanol.

$$C_2H_5OH \xrightarrow{\text{Conc. } H_2SO_4,\ 443K} C_2H_4 + H_2O$$

(ii) Add sodium carbonate or sodium hydrogen carbonate solution in both the test tubes. The test tube which will produce brisk effervescence of CO_2 gas will contain ethanoic acid. Ethanol do not evolve CO_2 gas when reacted with Na_2CO_3 or $NaHCO_3$.

$$2CH_3COOH + Na_2CO_3 \longrightarrow 2CH_3COONa + H_2O + CO_2$$

or

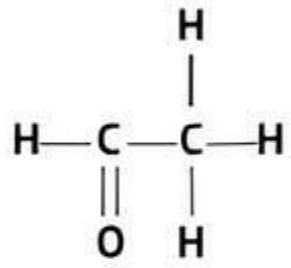
$$CH_3COOH + NaHCO_3 \longrightarrow CH_3COONa + H_2O + CO_2$$

Q 8. (i) Compare soaps and detergents on the basis of their composition and cleansing action in hard water.

(ii) What happens when ethanol is treated with sodium metal? State the behaviour of ethanol in this reaction.

(iii) Draw the structure of cyclohexane.

(iv) Name the following compound. *(CBSE 2020)*



Ans. (i)

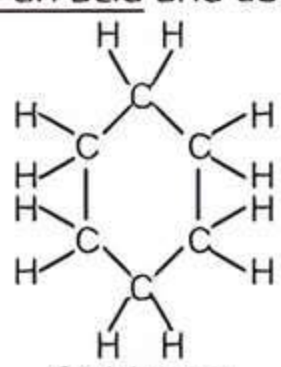
Basis of Difference	Soaps	Detergents
Composition	Soaps are sodium or potassium salts of long-chain carboxylic acids.	Detergents are ammonium or sulphonate salts of long chain carboxylic acids.
Cleansing action in hard water	Soap produces scum in hard water.	Detergents do not form scum in hard water.

(ii) When ethanol is treated with sodium metal Sodium ethoxide and hydrogen gas are formed.

$$\underset{\text{Ethanol}}{2C_2H_5OH} + 2Na \longrightarrow \underset{\text{Sodium ethoxide}}{2C_2H_5ONa} + H_2\uparrow$$

Ethanol acts as an acid and liberates hydrogen gas.

(iii) Structure:



Cyclohexane

(iv) Ethanal

TiP

The given compound is an aldehyde as –CHO group is present in it.

IUPAC name of aldehyde

= Name of parent alkane -e + al

= Ethane -e + al = Ethanal

Q 9. (i) What are soaps? Explain the mechanism of cleansing action of soap with the help of a labelled diagram.

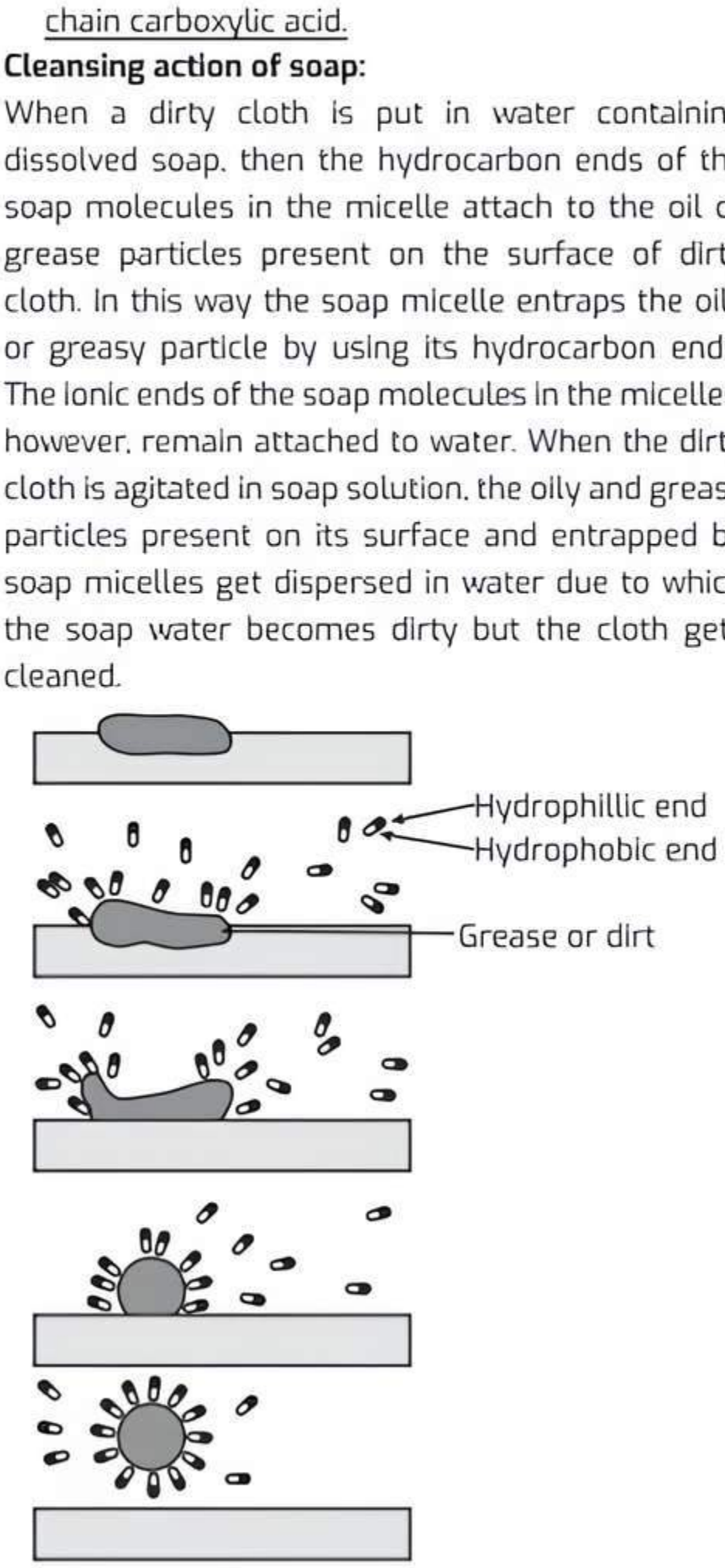
(ii) Detergents are better than soaps. Justify.

(CBSE 2023)

Ans. (i) Soaps are sodium or potassium salts of long chain carboxylic acid.

Cleansing action of soap:

When a dirty cloth is put in water containing dissolved soap, then the hydrocarbon ends of the soap molecules in the micelle attach to the oil or grease particles present on the surface of dirty cloth. In this way the soap micelle entraps the oily or greasy particle by using its hydrocarbon ends. The ionic ends of the soap molecules in the micelles, however, remain attached to water. When the dirty cloth is agitated in soap solution, the oily and greasy particles present on its surface and entrapped by soap micelles get dispersed in water due to which the soap water becomes dirty but the cloth gets cleaned.



(ii) Detergents are better than soaps because:

(a) Detergents can be used even with hard water whereas soaps are not suitable for use with hard water.

(b) Detergents have a stronger cleansing action than soaps.

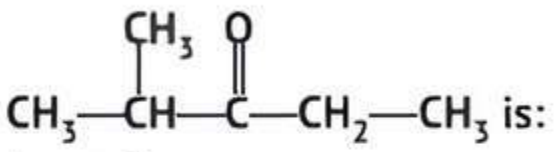
Chapter Test

Multiple Choice Questions

Q 1. Which of the following pairs of compounds of carbon will undergo combustion as well as addition reactions?

a. CH_4 and C_2H_6
b. C_2H_6O and C_3H_8O
c. $C_2H_4O_2$ and C_3H_6O
d. C_2H_2 and C_3H_6

Q 2. The IUPAC name of:



is:

a. 2-methylpent-3-one
b. 4-methylpent-3-one
c. 4-methyl pentane-2-ol
d. hexanone

Q 3. Which of the following molecules has all its atoms joined together by double covalent bonds?

a. Methane
b. Water
c. Carbon dioxide
d. Nitrogen trichloride

Q 4. A student takes about 5 ml distilled water in four test tubes marked *P, Q, R* and *S*. He dissolves sodium chloride in *P*, potassium chloride in *Q*, calcium chloride in R and magnesium chloride in *S*. After that he adds equal amount of soap solution in each test tube. On shaking these test tubes he would observe a good amount of lather in the test tubes marked:

a. *P* and *Q*
b. *Q* and *R*
c. *R* and *S*
d. *P* and *S*

Assertion and Reason Type Questions

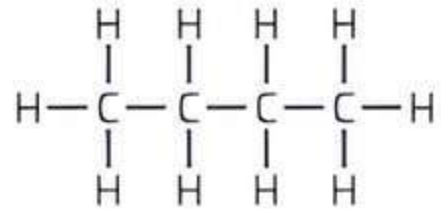
Directions (Q. Nos. 5-6): *Each of the following questions consists of two statements, one is Assertion (A) and the other is Reason (R). Give answer:*

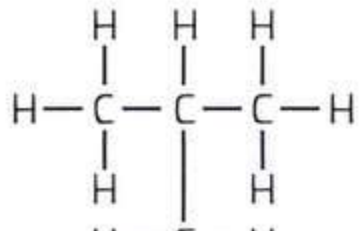
a. Both Assertion (A) and Reason (R) are true and Reason (R) is a correct explanation of Assertion (A).
b. Both Assertion (A) and Reason (R) are true but Reason (R) Is not a correct explanation of Assertion (A).
c. Assertion (A) is true but Reason (R) is false.
d. Assertion (A) is false but Reason (R) is true.

Q 5. Assertion (A): Carbon shows maximum catenation property in the periodic table.

Reason (R): Carbon has small size and thus, forms strong C—C bond.

Q 6. Assertion (A): Following are the structural isomers of butane.





Reason (R): Structural isomers have the same molecular formula but they differ in their structures.

Case Study Based Question

Q 7. The table shows some information about compounds in homologous series.

Name of Compound	Molecular Formula	Molecular Mass	Boiling Point
Methanoic acid	HCOOH	46	100.8°C
Ethanoic acid	CH_3COOH	60	118°C
Propanoic acid	C_2H_5COOH	74	141°C
Butanoic acid	C_3H_7COOH	88	163°C
Pentanoic acid	C_4H_9COOH	102	186°C

Based on the above table, answer of the following questions:

(i) **Predict the molecular mass of the compound in the same series which has six carbon atoms in one molecule.**
(ii) **Write the general formula for a compound in this homologous series.**
(iii) **Draw the structural formula of propanoic acid.**
(iv) **Why ethanoic acid is called glacial acetic acid?**

Very Short Answer Type Questions

Q 8. Write the molecular formula of first two members of homologous series having functional group —Br.

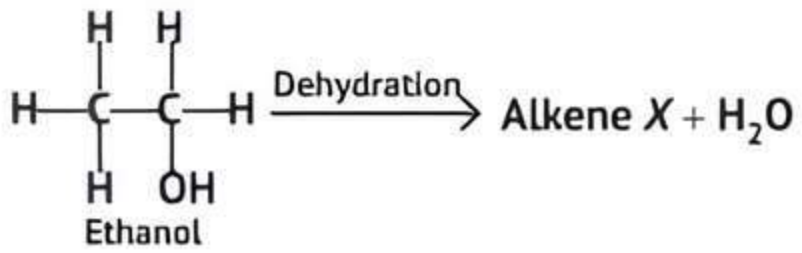
Q 9. Will micelle formation take place when soap is dissolved in organic solvent?

Short Answer Type-I Questions

Q 10. (i) The molecular formula of alkenes *X* and *Y* are C_XH_8 and $C_{10}H_Y$ respectively. What are the relative molecular masses of *X* and *Y*?
(ii) Draw the structure of simplest ketone.

Q 11. Give four major differences between soaps and detergents.

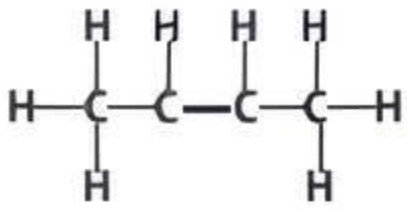
Q 12. (i) Predict the alkene *X*, obtained when ethanol undergoes dehydration.



(ii) — CHO group cannot be present in the middle of a chain. Justify.

Short Answer Type-II Questions

Q 13. A hydrocarbon molecule has the structure given below:



(i) Write the equation for the combustion of this hydrocarbon molecule in oxygen.

(ii) The given molecule can be hydrogenated to produce an alkane molecule. Name it.

(iii) Give the reaction conditions for the above conversion.

Q 14. An aldehyde as well as ketone can be represented by the same molecular formula say C_3H_6O. Write their structures and name them. State the relationship between two in language of science.

Q 15. (i) Name the property of ethanol which makes it useful in medicines.

(ii) Name the organic compound which is used in pickles. Mention its composition.

(iii) What is meant by denatured alcohol?

Long Answer Type Questions

Q 16. You are given balls and stick model of six carbon atoms and fourteen hydrogen atoms and sufficient number of sticks. In how many ways one can join the models of six carbon atoms and fourteen hydrogen atoms to form different molecules of C_6H_{14}.

Q 17. Raina while doing certain reactions observed that heating of substance '*X*' with vinegar like smell with a substance '*Y*' (which is used as an industrial solvent) in presence of conc. Sulphuric acid on a water bath gives a sweet-smelling liquid '*Z*' having molecular formula $C_4H_8O_2$. When heated with caustic soda (NaOH), '*Z*' gives back the sodium salt of and the compound '*Y*'.

Identify '*X*', '*Y*' and '*Z*'. Illustrate the changes with the help of suitable chemical equations.

(CBSE SQP 2023-24)