# Carbon and Its Compounds

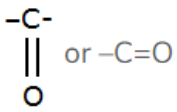
## Periodic Test

**Q.1. Give the formulae of the following functional groups:**

**(a) Aldehyde**

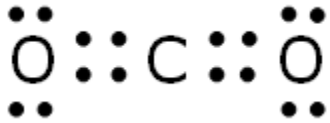
**(b) Ketone**

**Answer:** (a) –CHO

(b)  or –C=O

**Q. 2. Give the electronic dot structure of $CO_2$ molecule.**

**Answer:** The electronic dot structure of $CO_2$ is shown below.



**Q.3. What is the unique ability of carbon atom?**

**Answer:** Carbon has the ability of bond with other atoms of carbons forming large chains, branches or rings. This property is called catenation.

Also, carbon has a valency of four and can combine with other elements such as hydrogen, oxygen, nitrogen, etc. Due to its small size, the bonds formed by carbon with other elements are very strong. Hence, carbon forms a wide variety of compounds.

**Q.4. Silicon has same valence electrons like carbon but it do not show the property similar to carbon. Why?**

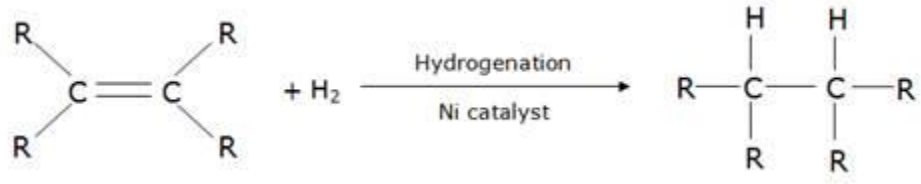
**Answer:** The size of silicon atom is larger than that of carbon atom causing a reduced force of attraction between electrons and the nucleus. In other words, the compounds formed by silicon are very reactive whereas the compounds formed by the carbon are very stable. That is why silicon does not exhibit the property similar to carbon.

**Q.5. Where in the nature you can find the products of esterification reaction?**

**Answer:** Ester is the product obtained from esterification reaction. These compounds are responsible for the pleasant smell of fruits. It is found in fruits such as apples, mangoes, pineapples, strawberries etc. Sometimes, esters are used as flavouring agents in food items and in perfumes as well.

**Q.6. What is the industrial application of hydrogenation?**

**Answer:** In industries, hydrogenation is used to reduce vegetable oils to vanaspati ghee. Vanaspati ghee is used as a substitute for ghee or butter containing animal fats which are harmful to our health and is cheaper than butter. Vegetable oils are unsaturated and they are hydrogenated in the presence of catalysts like nickel or palladium. The chemical reaction can be represented by the equation:




**Q.7. Give the name of:**

**(a) HCOOCH3**

**(b) HCHO**

**Answer:** (a) IUPAC name: Methyl methanoate

(b) IUPAC name: Methanal

**Q.8. What happens when ethanol gets oxidised? Name the type of oxidising agents used.**

**Answer:** Ethanol undergoes oxidation to yield ethanoic acid. This oxidation is done with the help of strong oxidizing agents like alkaline potassium permanganate ($KMnO_4$) and acidified potassium dichromate ($K_2Cr_2O_7$) in the presence of heat.

$$CH_3CH_2OH \xrightarrow[\text{Acidified } K_2Cr_2O_7 + \text{Heat}]{\text{Alkaline } KMnO_4 + \text{Heat}} CH_3COOH$$

**Q.9. What happens when ethanol is heated at 443 K with excess of conc. $H_2SO_4$?**

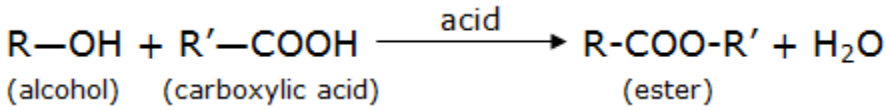
**Answer:** Concentrated sulphuric acid can act as a dehydrating agent. Hence, ethanol when heated at 443 K with excess conc. $H_2SO_4$ undergoes dehydration reaction to form ethene.

The reaction involved is,

$$CH_3CH_2OH \xrightarrow[\text{conc. } H_2SO_4]{443\ K} CH_2{=}CH_2 + H_2O$$

**Q.10. What is meant by esterification reaction? Give equation to explain the process.**

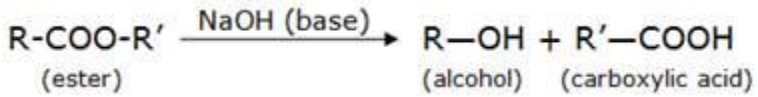
**Answer:** Esterification is the process of producing an ester from the reaction of an alcohol and a carboxylic acid. An acid is used as the catalyst. The general reaction can be expressed as:




The –OH part of alcohol and the –H present in acid get removed and form water as the byproduct. The nomenclature of ester is of the form “alkyl alkanoate” where the alkyl part is derived from the alcohol and the alkanoate part is derived from the carboxylic acid.

**Q.11. What is meant by saponification? Explain the process and its practical utility.**

**Answer:** Saponification is considered the reverse reaction of esterification. Esterification is the process of producing esters by the reaction of an alcohol and a carboxylic acid. Saponification is the process in which an ester upon hydrolysis in the presence of a base gives back the alcohol and the carboxylic acid.




This process is called saponification because this is used in the preparation of soap. Soaps are sodium or potassium salts of long chain carboxylic acids.

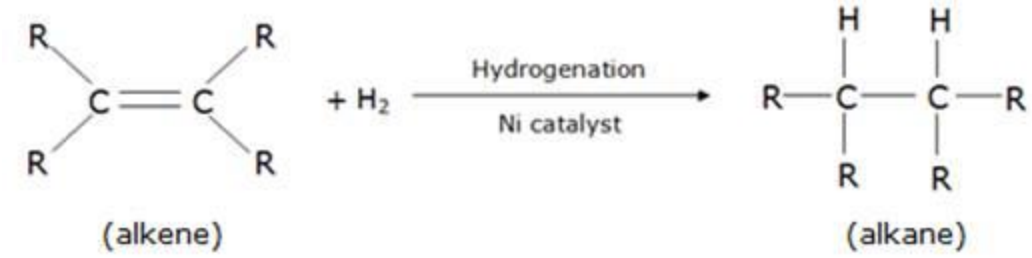
**Q.12. Differentiate between a soap and a detergent.**

**Answer:**

| **Soap** | **Detergent** |
|---|---|
| Sodium or potassium salts of long chain carboxylic acids (fatty acids). | Ammonium or sulphonate salts of long chain carboxylic acids. |
| Cleansing action is due to the formation of micelles | Cleansing action is due to the formation of micelles |
| Forms insoluble precipitates called scum after washing with water. | Does not form scum with water. |
| Uses: toilet soaps, washing soaps | Uses: shampoo, products for cleaning clothes |

**Q.13. What are addition reactions? Which category of compounds undergoes addition reactions? Explain.**

**Answer:** Addition reactions are reactions in which two or more molecules combine to form a larger molecule, with no other products. No atoms or molecules get eliminated in this reaction. An example of addition reaction is the hydrogenation of alkenes to form alkanes.




Unsaturated compounds i.e., compounds containing double or triple bond(s) undergo addition reactions very easily. To accommodate the new incoming atom(s) (in the case of hydrogenation, the incoming atom is hydrogen), the double/triple bond(s) gets cleaved and converted into single bonds such that all elements present in the compound get a stable electronic configuration.

**Q.14. What is a homologous series? Explain with an example.**

**Answer:** A series of compounds in which the same functional group substitutes for hydrogen in a carbon chain is called homologous series.

Consider the homologous series of alcohols – methanol, ethanol, etc. Note that methanol ($CH_3OH$) is obtained by replacing one of the H atoms with –OH group. Similarly, the –OH group replaces one of the H atoms of ethane ($CH_3CH_3$) to form ethanol

($CH_3CH_2OH$) and so on. The chemical properties of these compounds are similar. The successive members of the homologous series differ by a –CH2 unit.

For example, $CH_3OH$ and $CH_3CH_2OH$, $CH_3CH_2OH$ and $CH_3CH_2CH_2OH$ differ by a $–CH_2$ unit.

Also, members of a homologous series can be represented using a general formula. In the case of alcohols, the general formula is $C_nH_{2n+1}O$, where ‘n’ is the number of carbon atoms.

**Q.15. Why scum is formed when soap is treated with hard water?**

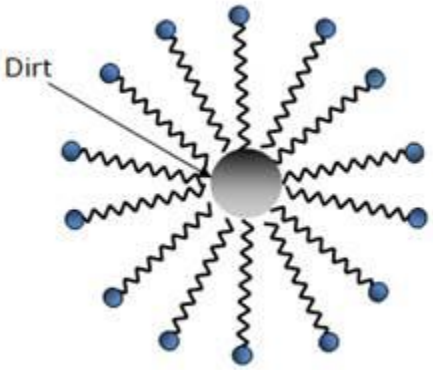
**Answer:** Scum is an insoluble precipitate formed due to the reaction of soap with calcium and magnesium salts present in hard water. As a result, soap does not form lather in hard water, making its cleansing action less effective in hard water.

**Q.16. Give only the mechanism of cleansing action of soaps.**

**Answer:** Soaps are sodium or potassium salts of long chain carboxylic acids. They contain two ends having different properties: the carboxylic acid part which is hydrophobic and the ionic end ($Na^+$ or $K^+$) which is hydrophilic.


Structure of a soap molecule

Dirt present in clothes is basically a hydrocarbon. When soap is used in water, the soap molecules tend to surround the dirt such that they form a cluster in which the hydrophobic tails are in the interior of the cluster and the hydrophilic part are on the surface of the cluster (see figure below). The hydrophilic part dissolves in water and the hydrophobic part dissolves in the hydrocarbon (dirt). This formation or cluster is called micelle.




Formation of micelle

Agitating the water by hand or brush forces the hydrophilic end to move along the direction of agitation of water, dragging the micelle holding the dirt out of the clothes and the dirt is rinsed away. In short, the cleansing action of soap is achieved by the formation of micelles.

**Q.17. A compound of carbon which has acidic characteristic is used as preservative of pickles. This compound reacts with carbonates and bicarbonates to release a colourless gas. Identify the compound and the gas. Give equations for the reactions also.**

**Answer:** The compound is ethanoic acid also known as acetic acid ($CH_3COOH$). It is a weak organic acid. $CH_3COOH$ reacts with carbonates and bicarbonates to release $CO_2$ which is a colourless gas. The reactions involved are:

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

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

**Q.18. How would you distinguish experimentally between an alcohol and a carboxylic acid?**

**Answer:** Alcohols can be distinguished from carboxylic acid using the sodium carbonate ($Na_2CO_3$) or sodium bicarbonate ($NaHCO_3$) test. Alcohols do not react with sodium carbonate or bicarbonate, whereas acid reacts with them to release carbon dioxide.

$2RCOOH + Na_2CO_3 \rightarrow 2RCOONa + CO_2\uparrow + H_2O$

$RCOOH + NaHCO_3 \rightarrow RCOONa + CO_2\uparrow + H_2O$

$Alcohol + Na_2CO_3 \rightarrow$ No reaction

**Q.19. How an ethanol and ethanoic acid be differentiated on the basis of their physical and chemical properties?**

**Answer:** Physical Properties:

Both Ethanol and ethanoic acid are liquids at room temperature and have distinct melting and boiling points.

| Physical Property | Ethanol | Ethanoic acid |
|---|---|---|
| Melting Point (in K) | 156 | 290 |
| Boiling Point (in K) | 351 | 391 |

Chemical Properties:

Ethanoic acid produces $CO_2$ when reacted with carbonates or bicarbonates. Ethanol does not react with carbonates or bicarbonates.

Ethanoic acid reacts with a base (say NaOH) to give salt and water:

$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$

Ethanol reacts very slightly with NaOH.

**Q. 20. How you can differentiate chemically between butter and cooking oil? What are substitution reactions? Explain giving a suitable example.**

**Answer:** Butter is basically made of animal fats which contain saturated fatty acids. Cooking oil on the other hand, contains long unsaturated fatty acids. This means that vegetable oils can be hydrogenated whereas butter cannot be hydrogenated.

A reaction in which one atom or a group of atoms is replaced by another atom or another group of atoms is called substitution reaction. For example, consider the photochemical reaction of methane with chlorine. In the presence of sunlight, one of the H atoms is replaced by Cl atom. Gradually, each H gets replaced by Cl. The reaction can be represented by the equation:

$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$ (in the presence of sunlight)

$CH_3Cl + Cl_2 \rightarrow CH_2Cl_2 + HCl$ and so on.

**Q. 21. Give reason why:**

**(i) A mixture of ethyne and air is not used for welding whereas oxygen and ethyne mixture is preferred.**

**(ii) Carbon does not form $C^{4+}$ and $C^{4-}$ ions.**

**Answer:** (i) When a mixture of air and ethyne ($C_2H_2$) is used, incomplete combustion takes place and as a result a sooty flame is obtained, which is not effective for welding.

If ethyne is burned with oxygen, complete combustion takes place and gives a clean flame which is ideal for welding. This welding is also known as oxy-acetylene welding.

(ii) Carbon has 4 valence electrons. The two given situations can be analysed separately.

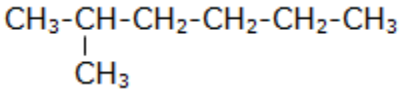
To form $C^{4+}$ cation, it has to lose 4 electrons, but an enormous amount of energy is required to remove the electrons, because of the strong nuclear force of attraction.

To form $C^{4-}$ anion, it has to gain 4 electrons, but it would be difficult for the nucleus with 6 protons to hold onto 10 electrons. In brief, the anion formed would not be stable.

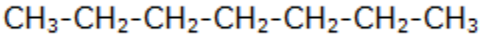
**Q.22. How many structural isomers you can draw for isoheptane?**

**Answer:** 9 structural isomers can be drawn for isoheptane ($C_7H_{16}$). They are listed below along with their structural formula.

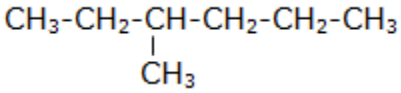
1. 2-methyl hexane (isoheptane)



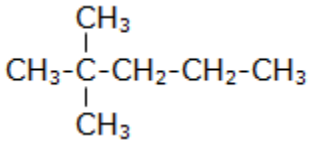
2. n-heptane



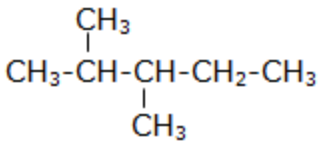
3. 3-methyl hexane



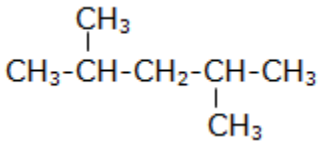
4. 2,2-dimethyl pentane



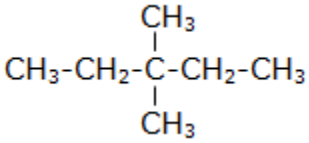
5. 2,3-dimethyl pentane



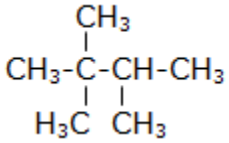
6. 2,4-dimethyl pentane



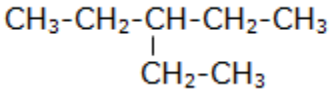
7. 3,3-dimethyl pentane



8. 2,2,3-trimethyl butane

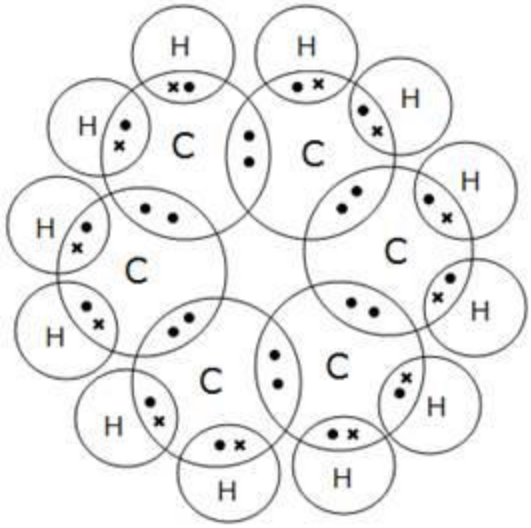


9. 3-ethyl pentane



**Q. 23. What will be the formula and electron dot structure of cyclohexane? Why diamond and graphite are so different from each other, although both of them are made-up of carbon atoms only?**

**Answer:** The formula of cyclohexane is $C_6H_{12}$. The structure is shown below:




Electron dot structure of cyclohexane

Even though diamond and graphite are made up of carbon atoms only, the molecular structure of diamond is different from that of graphite. Diamond has a 3D structure, whereas the structure of graphite consists of layers of carbon stacked above one another.

## Comprehensive Exercises (MCQ)

**Q.1. Ethane, with the molecular formula $C_2H_6$ has:**

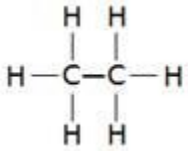
**A. 6 covalent bonds**

**B. 7 covalent bonds**

**C. 8 covalent bonds**

**D. 9 covalent bonds**

**Answer:** The structural formula of ethane is



Note that there are 6 C-H bonds and 1 C-C bond.

**Q.2. Butanone is a four carbon compounds with the functional group:**

**A. Carboxylic acid**

**B. Aldehyde**

**C. ketone**

**D. Alcohol**

**Answer:** Names of carbon compounds ending in '–one' have ketone (-C=O) as the functional group.

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

**A. The food is not cooked completely.**

**B. The fuel is not burning completely.**

**C. The fuel is wet**

**D. The fuel is burning completely.**

**Answer:** The bottom of the vessel is blackened due to the incomplete combustion of the fuel. Hence, one can say the fuel is not burning properly.

**Q.4. Alcohols may be represented by the general formula:**

**A. $C_nH_{2n}$ + 2 — OH**

**B. $C_nH_{2n}$ — OH**

**C. $C_nH_{2n+1}$ — OH**

**D. $C_nH_{2n-1}$ — OH**

**Answer:** One of the H atoms of alkanes (having the molecular formula $C_nH_{2n+2}$) is replaced by an –OH group to form alcohols.

Thus $C_nH_{2n+2}$ – (1 H) + (1 –OH) → $C_nH_{2n+1}$—OH

**Q.5. Ethanoic acid can be obtained from ethanol by the process of:**

**A. Reduction**

**B. Oxidation**

**C. Hydrolysis**

**D. Hydrogenation**

**Answer:** Oxidation of ethanol using alkaline $KMnO_4$ or acidified $K_2Cr_2O_7$ gives ethanoic acid.

**Q.6. Alkynes may be represented by the general formula:**

**A. $C_nH_{2n+2}$**

**B. $C_nH_{2n-2}$**

**C. $C_nH_{2n+1}$**

**D. $C_nH_{2n}$–1**

**Answer:** Alkynes are carbon compounds containing one or more C≡C bonds. One can generalize the formula from the examples $C_2H_2$, $C_3H_4$ etc.

**Q.7. The number of electron pairs shared by the two carbon atoms which are bonded by a triple bond are:**

**A. One pair**

**B. Two pairs**

**C. Three pairs**

**D. Six pairs.**

**Answer:** One bond is formed by sharing 2 electrons, and therefore a triple bond is formed by 6 electrons or 3 pairs of electrons.

**Q.8. The oxidizing agent which can oxidise ethanol to ethanoic acid is:**

**A. Alkaline $K_2Cr_2O_7$**

**B. Alkaline $KMnO_4$**

**C. Alkaline $KClO_3$**

**D. Alkaline $CrO_3$**

**Answer:**

$$CH_3CH_2OH \xrightarrow{\text{Alkaline } KMnO_4 + \text{Heat}} CH_3COOH$$

**Q.9. The class of organic compounds which gives effervescence with $NaHCO_3$ solution is:**

**A. Aldehydes**

**B. Alkanes**

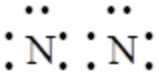
**C. Esters**

**D. Carboxylic acids**

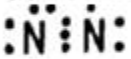
**Answer:** The effervescence is due to the formation of $CO_2$ when $NaHCO_3$ is treated with carboxylic acids.

$RCOOH + NaHCO_3 \rightarrow RCOONa + CO_2\uparrow + H_2O$

**Q.10. Which of the following is the correct representation of electron dot structure of nitrogen?**

A. 

B. 

C. 

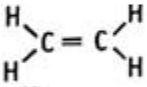
D. 

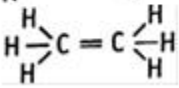
**Answer:** Nitrogen atoms share 3 pairs of electrons to form a triple bond (N≡N) to attain stable electronic configuration.

**Q.11. Structural formula of ethyne is:**

A. $H-C\equiv C-H$

B. $H_3-C\equiv C-H$

C. 

D. 

**Answer:** Ethyne is the alkyne consisting of 2 carbons with a triple bond between them.

**Q.12. Chlorine reacts with saturated hydrocarbons at room temperature in the:**

**A. absence of sunlight**

**B. presence of sunlight**

**C. presence of water**

**D. presence of hydrochloric acid**

**Answer:** Chlorine reacts rapidly with saturated hydrocarbons in the presence of sunlight. One such reaction is,

$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$ (in the presence of sunlight)

**Q.13. 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:**

**A. helium**

**B. neon**

**C. argon**

**D. krypton**

**Answer:** Carbon atom has 2 electrons in its innermost shell and 4 valence electrons. When it forms covalent bonds with 4 univalent atoms, it gets an additional 4 electrons as a result of sharing them. Now there are 8 electrons in its outermost shell. This resembles the electronic configuration of neon, which has the electronic configuration 2, 8.

**Q.14. The correct electron dot structure of a water molecule is:**

A. 

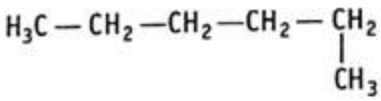
B. 

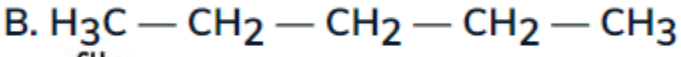
C. 

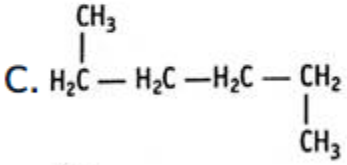
D. H : O : H

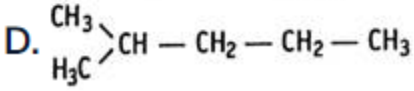
**Answer:** Oxygen forms single covalent bonds with hydrogen. Having 6 valence electrons, 2 of them contribute to the covalent bond. After bond formation oxygen would have 2 shared pairs of electrons and 2 lone pairs of electrons.

**Q.15. Which of the following is not a straight chain hydrocarbon?**

A. 

B. 

C. 

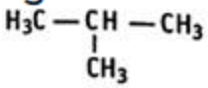
D. 

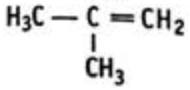
**Answer:** Mark the longest chain of the given compound. If no carbon atoms are remaining after marking the chain, then the compound is not branched. If one or more carbon atoms are not marked in the longest chain, then they are said to be branches.

**Q.16. 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) 

(iv) 

A. (i) and (iii)

B. (ii) and (iii)

C. (ii) and (iv)

D. (iii) and (iv)

**Answer:** Unsaturated hydrocarbons are compounds of carbon and hydrogen which contain double bonds and/or triple bonds.

**Q.17. Pentane has the molecular formula C5H12. It has:**

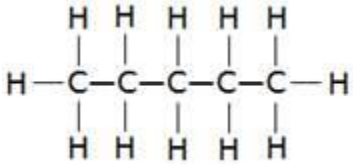
**A. 5 covalent bonds**

**B. 12 covalent bonds**

**C. 16 covalent bonds**

**D. 17 covalent bonds**

**Answer:** There are 4 C-C bonds and 12 C-H bonds.



**Q.18. Ethanol reacts with sodium and forms two products. These are:**

**A. sodium ethanoate and hydrogen**

**B. sodium ethanoate and oxygen**

**C. sodium ethoxide and hydrogen**

**D. sodium ethoxide and oxygen**

**Answer:** $Na + CH_3CH_2OH \rightarrow CH_3CH_2ONa + H_2$

**Q.19. Vinegar is a solution of:**

**A. 50% – 60% acetic acid in alcohol**

**B. 5% – 8% acetic acid in alcohol**

**C. 5%–8% acetic acid in water**

**D. 50%–60% acetic acid in water**

**Answer:** 5%–8% acetic acid in water

**Q.20. Which of the following does not belong to the same homologous series?**

**A. $CH_4$**

**B. $C2H_6$**

**C. $C3H_8$**

**D. $C4H_8$**

**Answer:** The other three compounds form a homologous series of alkanes ($C_nH_{2n+2}$), whereas $C_4H_8$ is an alkene ($C_nH_{2n}$).

**Q.21. The name of the compound**

**$CH_3$ — $CH_2$ — CHO is:**

**A. Propanal**

**B. Propanone**

**C. Ethanol**

**D. Ethanal**

**Answer:**

The compound contains 3 carbons. The alkane with 3 carbons is “propane”. There is a –CHO group (aldehyde) in this compound. Hence the name would contain the suffix “-al”.

The IUPAC name would then be:

Propane – ‘e’ + ‘-al’ → Propanal

**Q.22. The heteroatoms present in**

**$CH_3$ — $CH_2$ — O — $CH_2$ — $CH_2$Cl are:**

**(i) oxygen (ii) carbon**

**(iii) hydrogen (iv) chlorine**

**A. (i) and (ii)**

**B. (ii) and (iii)**

**C. (iii) and (iv)**

**D. (i) and (iv)**

**Answer:** Heteroatoms are the elements which replace hydrogen in a hydrocarbon. In the given compound, H is replaced by oxygen and chlorine.

**Q.23. The first member of alkyne homologous series is:**

**A. ethyne**

**B. ethane**

**C. propyne**

**D. methane**

**Answer:** Alkynes are carbon compounds containing one or more triple bonds. The lowest member (or the first member) is formed by 2 carbon atoms, which is ethyne.

## Comprehensive Exercises (T/F)

**Q.1. Write true or false for the following statements:**

**Scum is formed due to the reaction of soap with calcium and magnesium salts present in hard water.**

**Answer:** True

**Q.2. Write true or false for the following statements:**

**Alcohols react with sodium leading to the evolution of carbon dioxide.**

**Answer:** False

Alcohols react with sodium to evolve hydrogen gas, along with the formation of sodium alkoxides.

Alcohol + Na $\rightarrow$ Sodium alkoxide + $H_2$

**Q.3. Write true or false for the following statements:**

**Heating ethanol at 443 K with excess concentrated sulphuric acid results in the dehydration of ethanol to give ethene.**

**Answer:** True

**Q.4. Write true or false for the following statements:**

**Esters are most commonly formed by reaction of an aldehyde with ketones.**

**Answer:** False

Esters are formed as a result of reaction between an alcohol and a carboxylic acid.

**Q.5. Write true or false for the following statements:**

**Esters react in the presence of an acid or a base to give back the alcohol and carboxylic acid.**

**Answer:** True

**Q.6. Write true or false for the following statements:**

**Carbon, in its all allotropic forms, burns in oxygen to give nitrogen dioxide along with the release of heat and light.**

**Answer:** False

Carbon in its allotropic forms under suitable conditions, burns in oxygen to produce carbon monoxide or carbon dioxide depending on the extent of combustion. Incomplete combustion results in the evolution of carbon monoxide, whereas complete combustion would result in the formation of carbon dioxide.

**Q.7. Write true or false for the following statements:**

**Saturated hydrocarbons will generally give a clean flame while unsaturated carbon compounds will give a yellow flame with lots of black smoke.**

**Answer:** True

**Q.8. Write true or false for the following statements:**

**Animal fats generally contain saturated fatty acids which are said to be good for health.**

**Answer:** False

Animal fats contain saturated fatty acids which are harmful for our health. Vegetable oils on the other hand, contain unsaturated fatty acids which are good for our health.

**Q.9. Write true or false for the following statements:**

**Two pairs of electrons are shared between two nitrogen atoms to form a nitrogen molecule**

**Answer:** False

Nitrogen molecule is formed by the sharing of 3 pairs of electrons.

The electron dot structure of N2 is shown:

**Q.10. Write true or false for the following statements:**

**Like mineral acids, ethanoic acid reacts with a base such as sodium hydroxide to give salt (sodium ethanoate or sodium acetate) and water.**

**Answer:** True