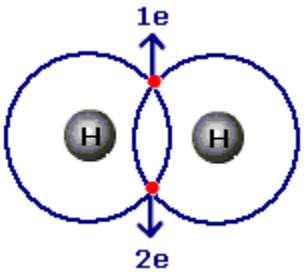
Carbon and its Compounds

Check Point 01

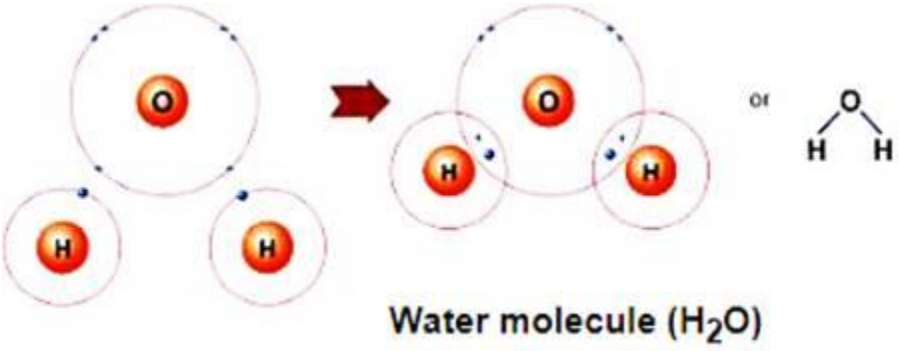
Q. 1. What do you mean by covalent bonding?

Answer: The bonding in which atoms mutually share the electron pair(s) to form molecules is called covalent bonding.

Example: Hydrogen molecule. In hydrogen molecule, both the electrons are shared to form a covalent bond.



Another very common example is the water molecule:



In water molecule, the two single hydrogen & oxygen bonds are formed.

Q. 2. An element X which has 6 electrons in its outermost shell, require 2 electrons to complete its octet for attaining noble gas configuration. X is an essential element for the survival of all living beings. What is X?

Answer: The element X is oxygen. The atomic number is 8, and its electronic configuration is 2,6. Oxygen is used for respiration by the living beings.

Q. 3. (i) The main constituent of marsh gas is …….
(ii) In case of a water molecule, hydrogen acquires a ……. configuration.

Answer: (i) Methane

Explanation:

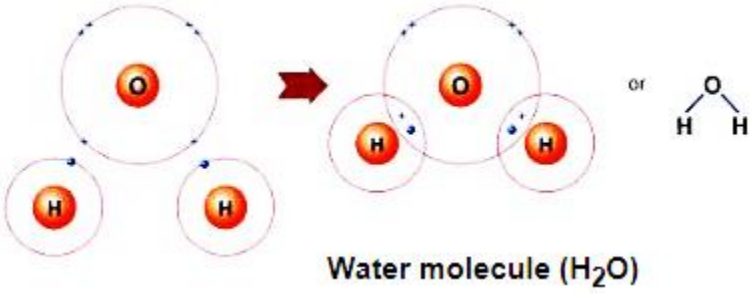
Marsh gas is a mixture of methane (CH_4), hydrogen sulfide (H_2S) and carbon dioxide (CO_2).

(ii) Single covalent bond configuration.

Explanation:

The water molecule is chemically written as:

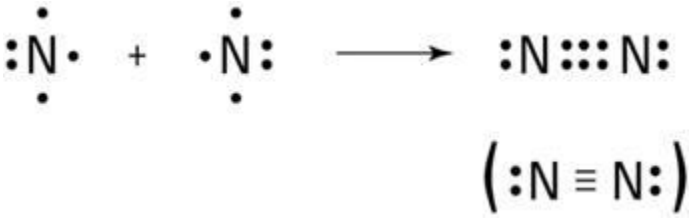
H—O—H



Water molecule (H_2O)

Q. 4. Write the covalent bonding in nitrogen.

Answer: Nitrogen has the electronic configuration 2, 5. It shares 3 of the outermost electrons with another nitrogen atom to form a triple-bonded N2 molecule, as shown below:



Q. 5. Why covalent compound are volatile in nature with low boiling and low melting point?

Answer: Covalent compounds have strong forces of attraction within the molecule, but the inter-molecular forces are very small due to which they are volatile. This results in the low melting and boiling point of compounds making them volatile.

Q. 6. Give two differences between ionic and covalent compounds.

Answer:

Ionic Compounds	Covalent Compounds
Formed by complete transfer of electrons from one atom to another	Formed by mutual sharing of electrons between atoms
High melting and boiling point	Low melting and boiling point
Example, NaCl (Sodium Chloride)	Example, CO_2 (carbon dioxide)

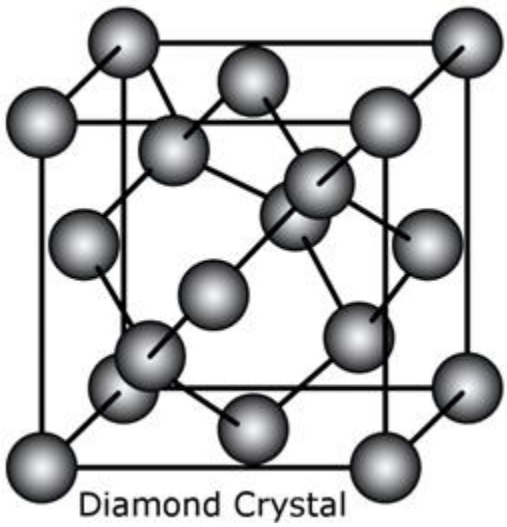
Check Point 02

Q. 1. Write the two examples of the crystalline form of carbon.

Answer: In the crystalline form of carbon, many atoms are bonded together in a repeating pattern. The arrangement of atoms in the crystal differs for each form of carbon. Two forms are:

i. Diamond.

Each carbon atom is covalently bonded to four other carbon atoms. The arrangement of carbon is shown below:



Diamond Crystal

ii. Fullerene:

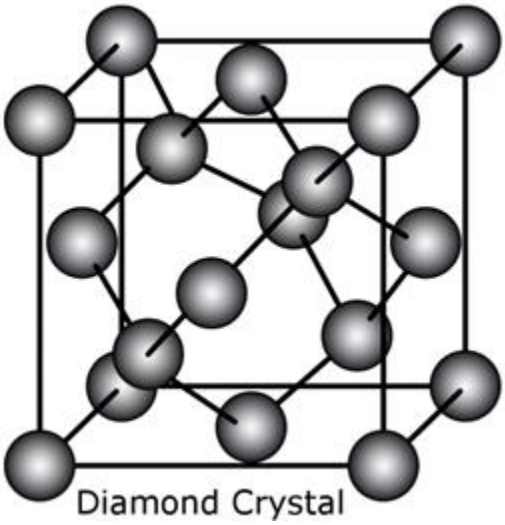
Each carbon atom is covalently bonded to four other carbon atoms. Each sphere contains 60 carbon atoms, and each carbon atom is bonded to three others by single covalent bonds.

Fullerene

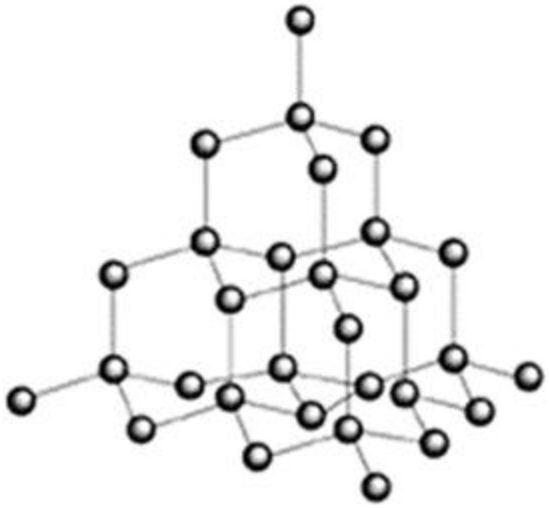
Q. 2. Draw the structure of diamond.

Answer: In diamond, each carbon atom is covalently bonded to four other carbon atoms.

The crystal structure is shown below:

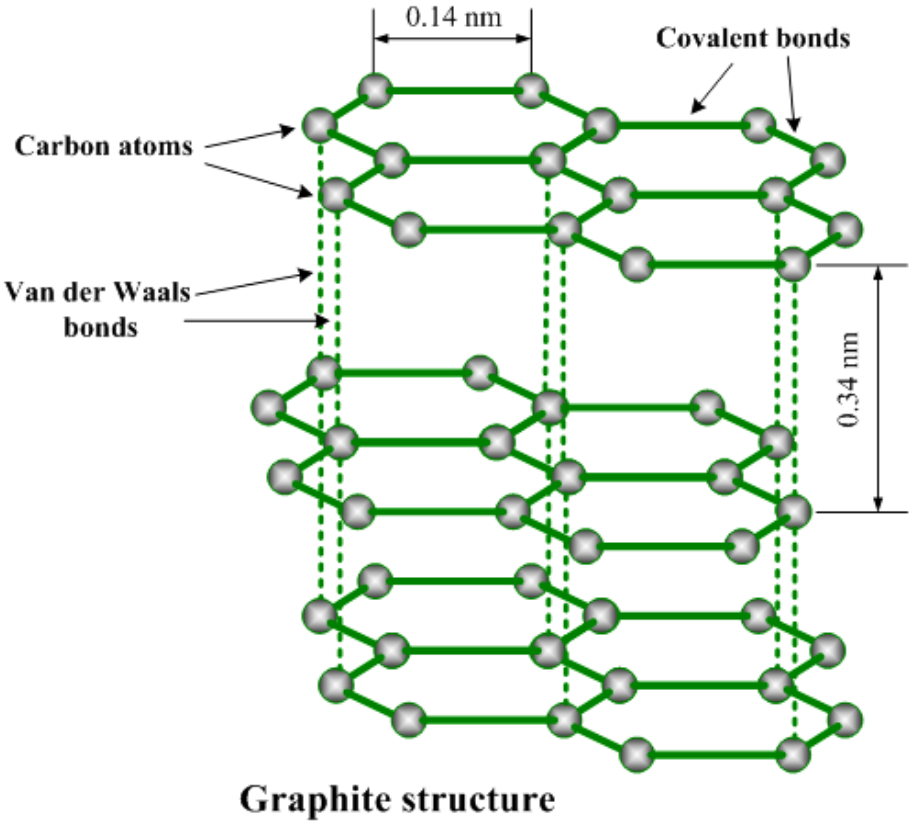


Diamond has a 3D structure.



Q. 3. Why is graphite smooth?

Answer: In graphite, each carbon atom is bonded to 3 other carbon atoms in the same plane giving rise to a hexagonal array. The structure of graphite is formed by stacking these hexagonal layers over one another and these layers have weak inter-molecular forces.



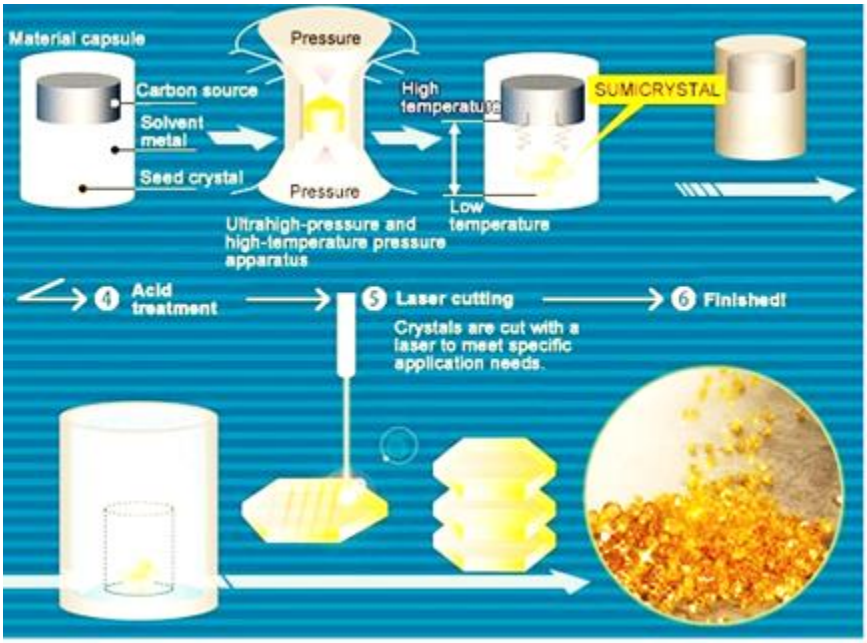
Graphite structure

This structure results in the smoothness of graphite.

Q. 4. How do diamond can be prepared artificially?

Answer: Artificial diamonds can be artificially prepared by subjecting pure carbon to a very high temperature and pressure.

Note: Here is a description of the complete process for extra knowledge.



Q. 5. Give two differences between ionic and covalent compounds.

Answer:

Ionic compounds	Covalent Compounds
High melting and boiling point	Low melting and boiling point
Conduct electricity in the aqueous or molten state	Do not conduct electricity in the aqueous or molten state

Q. 6. Diamond is a covalent solid, yet has a high melting point. Why?

Answer: Diamond has a rigid 3D structure in which each carbon atom is covalently bonded to 4 other carbon atoms. This structure involves a network of strong C-C bonds which requires high energy to break the bonds. Hence, the diamond has a high melting point.

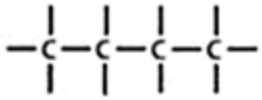
Check Point 03

Q. 1. What do you mean by catenation?

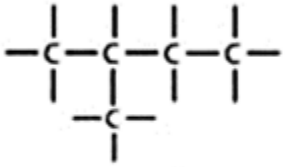
Answer: The ability of an element to form bonds with other atoms of the same element is called catenation.

The different types of bond chains are:

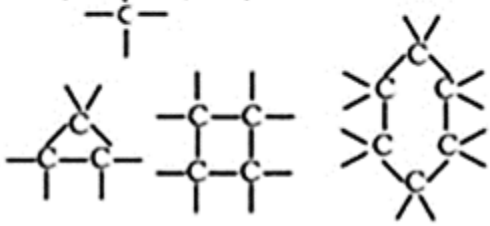
Straight Chain



Branched Chain



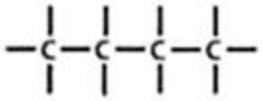
Closed Chain



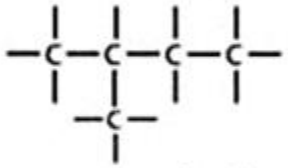
Q. 2. Why does carbon form a large number of compounds?

Answer: Carbon forms a large number of compounds because (a) Carbon exhibits catenation to a very large extent. It can form long chains, branched chains or ring structures.

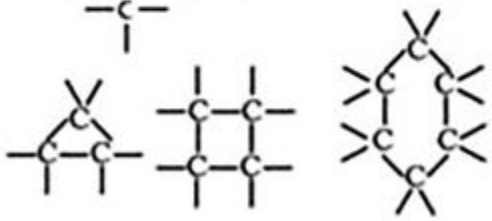
Straight Chain



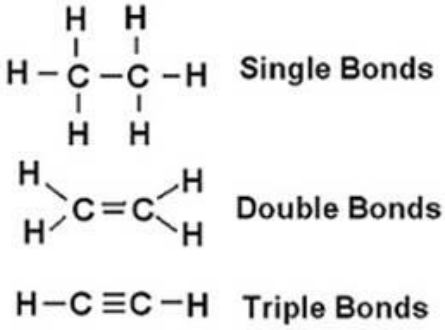
Branched Chain



Closed Chain



(b) Carbon has a valency of 4. It is satisfied by forming single, double or triple bonds with carbon or other elements such as oxygen, hydrogen, nitrogen etc. The bonds formed are strong and hence the compounds formed are stable.



Q. 3. Differentiate between saturated and unsaturated hydrocarbons.

Answer:

Saturated hydrocarbons	Unsaturated hydrocarbons
Compounds in which all the carbon-carbon bonds are single bonds	Compounds in which at least one carbon-carbon bond is a double or triple bond
Generally not very reactive. Shows substitution reaction(s)	More reactive than saturated hydrocarbons. Responds to addition reaction(s)
Burns with clean flame in sufficient amounts of oxygen	Burns with sooty flame in sufficient amounts of oxygen.

Q. 4. Write the electron dot structure of C_3H_8.

Answer: C_3H_8 contains 3 carbon atoms and 8 hydrogen atoms.

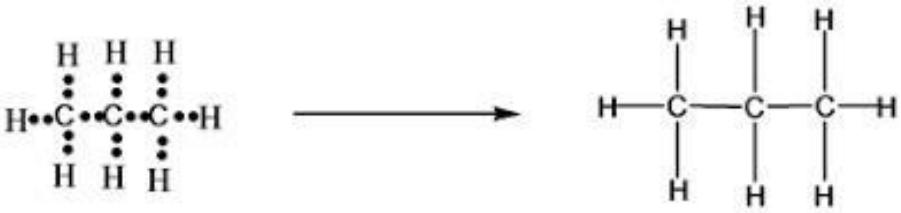
Now, each carbon atom has 4 electron and each hydrogen atom has 1 electron each.

So, in total 3×4 + 1×8 = 12 + 8 = 20 electrons.

And, 1 single bond = 2 electrons.

∴ 10 single bonds.

There now plot the electrons on the atoms as shown, and then jin the single bonds.



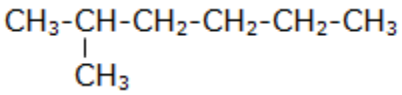
This is the final structure of propane i.e. C_3H_8

Check Point 04

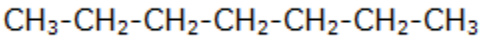
Q. 1. Write the structural formulae of all the isomers of an alkane with seven C-atoms (C_7H_{16})

Answer: There are 9 isomers for heptane (C_7H_{16}):

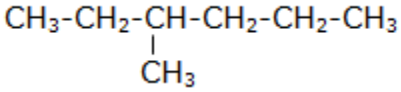
a. 2-methyl hexane (isoheptane)



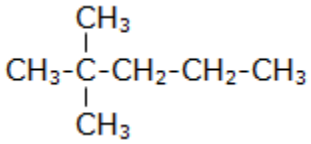
b. n-heptane



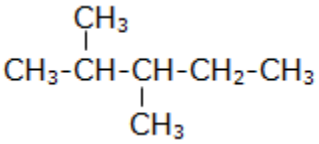
c. 3-methylhexane



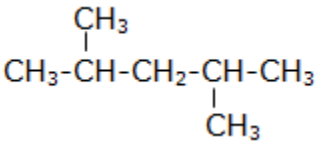
d. 2,2-dimethylpentane



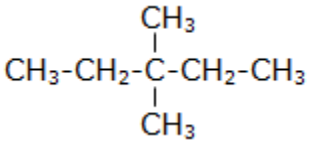
e. 2,3-dimethylpentane



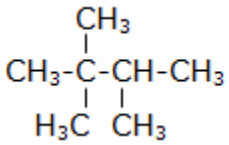
f. 2,4-dimethylpentane



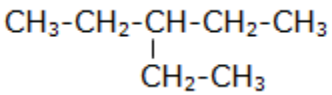
g. 3,3-dimethylpentane



h. 2,2,3-trimethylbutane



i. 3-ethylpentane



Q. 2. What is meant by homologous series?

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

Example: Methane (CH_4) and ethane (C_2H_8).

There are a part of homologous series & the difference among these molecules is that they have different numbers of CH_2 groups.

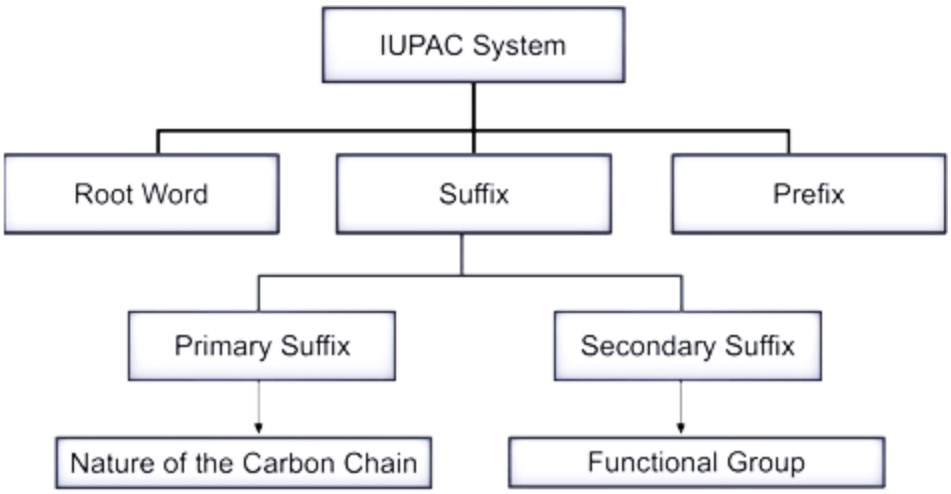
Q. 3. (i) The gradual change in the physical properties occurs with increase in the ……..
(ii) IUPAC stands for…..

Answer: (i) Molecular mass

(ii) International Union of Pure and Applied Chemistry

Q. 4. What are primary and secondary suffixes as applied to IUPAC nomenclature?

Answer: In IUPAC nomenclature, the following subdivision is followed for naming the compounds.



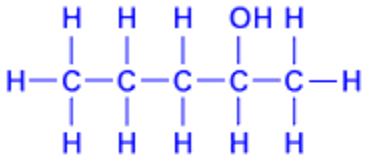
Primary suffixes are used to indicate the degree of unsaturation (i.e., presence of double or triple bonds) in a carbon compound.

e.g.: -ane (for alkanes), -ene (for alkenes), -yne (for alkynes)

Secondary suffixes are those suffixes which describe the main functional group of the compound. They are added after the primary suffix.

e.g.: -one (for ketones), -oic acid (for carboxylic acids)

Example:



Pentan-2-ol

Root Word	Primary Suffix	Secondary Suffix	Position of Functional Group
Pent	ane	ol	2

Check Point 05

Q. 1. Which type of hydrocarbon gives sooty flame after burning?

Answer: Unsaturated hydrocarbons give sooty flame after burning even in sufficient amount of oxygen. Saturated hydrocarbons may give sooty flame upon burning if there is limited supply of oxygen.

Q. 2. (i) Alcohols are converted into carboxylic acid only under …….
(ii) In partial oxidation; alcohols are converted into ……..

Answer: (i) complete oxidation (in the presence of strong oxidizing agents like acidified potassium dichromate)

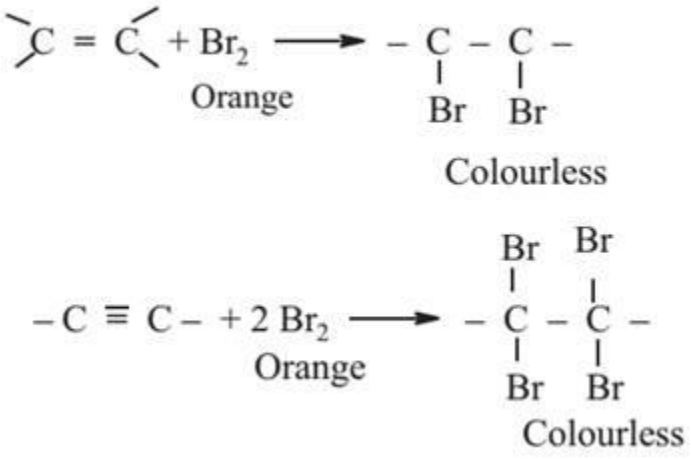
(ii) aldehydes

Q. 3. Give an example for the test of unsaturation.

Answer: Bromine water can be used for the test of unsaturation. If bromine water which is brown in colour is added to unsaturated compounds, then bromine water gets decolourised as a result of addition reaction.

Saturated compounds do not decolourise bromine water.

Example:



Q. 4. Why compounds like petrol, coal, etc generate heat or light or both on combustion?

Answer: Combustion is the process of burning of a substance in the presence of oxygen. The fuel (coal or petroleum) gets oxidized. As a result, the bonds present in the molecules of fuel break, releasing energy. Sometimes, the energy released falls in the visible range of the electromagnetic spectrum (which means the energy released is visible to human eye) which we call as light. Sometimes the energy released falls under infrared region, which we commonly call as heat. Basically, the compounds generate heat or light or both due to the release of energy from the breaking of molecular bonds.

Check Point 06

Q. 1. What happens when ethyl alcohol reacts with sodium metal?

Answer: When ethyl alcohol reacts with sodium metal, hydrogen gas is liberated along with the formation of sodium ethoxide.

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

Q. 2. Give any two examples of chemicals that are added to denature the alcohol.

Answer: Methanol and acetone are added to denature the alcohol to prevent the misuse of alcohol.

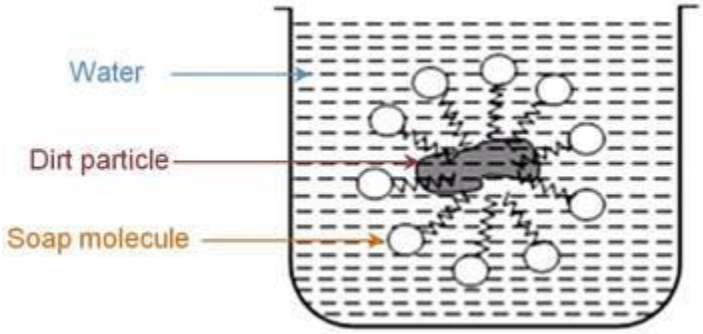
Q. 3. Mention two uses of ethanoic acid.

Answer: Ethanoic acid is used as a preservative in pickles.

It is also used in the production of esters which are used in making perfumes and as flavouring agents.

Q. 4. Why soap solution appears cloudy?

Answer: When soap is added to water, it forms clusters of molecules called micelles. These soap micelles are large enough to scatter light and therefore makes the soap solution cloudy.



Chapter Exercise

Q. 1. Which allotrope of carbon is soft, greasy and is used as solid lubricant for heavy machinery operating at a high temperature?

Answer: Graphite is the allotrope of carbon used for lubrication purposes.

Q. 2. Which property of diamond allows it to be used in knives for cutting marble?

Answer: Diamond is the hardest naturally occurring substance in the world. Its hardness is made use of in making knives to cut marbles.

Q. 3. Which of the following are alkenes?

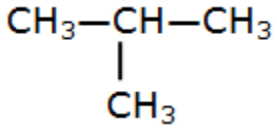
CH_4, C_2H_6, C_2H_4, C_3H_6 and C_3H_8

Answer: The general formula of alkenes is C_nH_{2n}, where 'n' is the number of carbon atoms.

Here, C_2H_4 and C_3H_6 are alkenes (put n=2, 3)

Q. 4. In order to form a branched organic compound, what should be the minimum number of carbon atoms?

Answer: The minimum number of carbon atoms to form a branched compound should be 4; 3 in the parent chain and 1 in the branched chain. The compound is 2-methylpropane (isobutane).



Q. 5. Which of the following two organic compounds belong to the same homologous series?

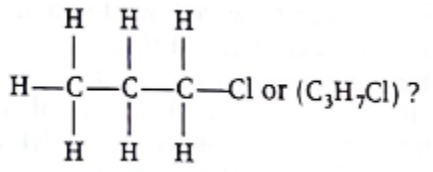
C_2H_6, C_2H_6O, $C_2H_6O_2$, CH_4O

Answer: CH_4O, C2H6O belong to the same homologous series as they differ only by a $–CH_2$ unit.

Q. 6. How two successive members of a homologous series differ from each other?

Answer: The successive members of a homologous series differ by a $–CH_2$ unit.

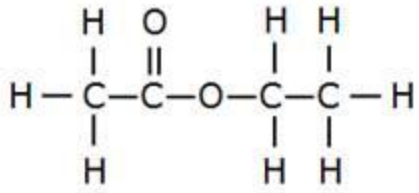
Q. 7. What is the common name of this compound



Answer: Propyl chloride

Q. 8. Draw the structural formula of ethyl ethanoate.

Answer:

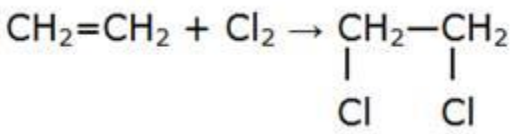


The molecular formula is $C_4H_8O_2$.

Q. 9. Complete the following reaction,

$CH_2=CH_2+Cl_2 \rightarrow$

Answer: This is an example of addition reaction.



Q. 10. Which functional group can be detected by using sodium hydrogen carbonate test?

Answer: Carboxylic acid (-COOH) can be detected by using sodium hydrogen carbonate ($NaHCO_3$) test. Treating a carboxylic acid with $NaHCO_3$ causes effervescence due to the liberation of carbon dioxide (CO_2). The reaction is as follows:

$R\text{-}COOH + NaHCO_3 \rightarrow R\text{-}COONa + CO_2 + H_2O$

Q. 11. Graphite is a covalent molecule but a good conductor of electricity. Why?

Answer: In graphite, each carbon is covalently bonded to 3 other carbon atoms in a hexagonal arrangement. That is 3 out of 4 valence electrons are used for covalent bonding. The remaining 1 electron from each carbon atom is free (or delocalized). This free electron helps in the conduction of electricity.

Q. 12. If water contains dissolved calcium hydrogen carbonate then out of soaps and synthetic detergents, which one will you use for cleaning the dirt of clothes?

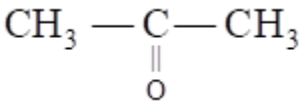
Answer: The given sample of water contains calcium ions and hence is hard water. Soaps are not effective in hard water as they produce scum (insoluble precipitate) with calcium ions. Therefore, synthetic detergents must be used to clean the dirt of clothes in hard water.

Q. 13. Write the names of the next homologues of CH_3CH_2OH and HCOOH.

Answer: Homologues of CH_3CH_2OH: $CH_3CH_2CH_2OH$ (propanol), $CH_3CH_2CH_2CH_2OH$ (butanol),...

Homologues of HCOOH: CH_3COOH (ethanoic acid), CH_3CH_2COOH (propanoic acid),...

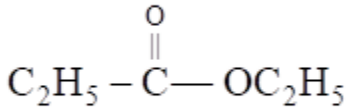
Q. 14. Write the names of the following compounds.



Answer: (i) Propanone (ii) ethyne

Q. 15. Identify the functional groups in the following compounds and name them.

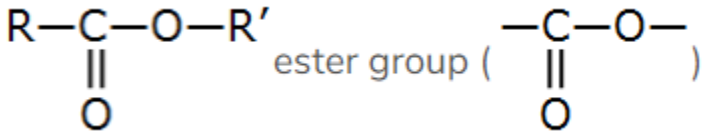
(i) $C_2H_5CO\overset{-}{O}\overset{+}{N}a$

(ii) 

(iii) $CH_3CH_2CH_2OH$

(iv) HCHO

Answer: (i) –COO- group (carboxylic acid; the anion is called carboxylate ion)

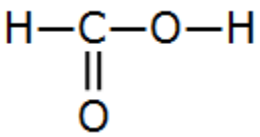
(ii) 

(iii) –OH group – alcohol

(iv) –CHO group – aldehyde

Q. 16. Mention the number of double bonds between carbon and oxygen in methanoic acid. Write its general formula.

Answer: Methanoic acid contains 1 C=O bond and 1 C-O bond.

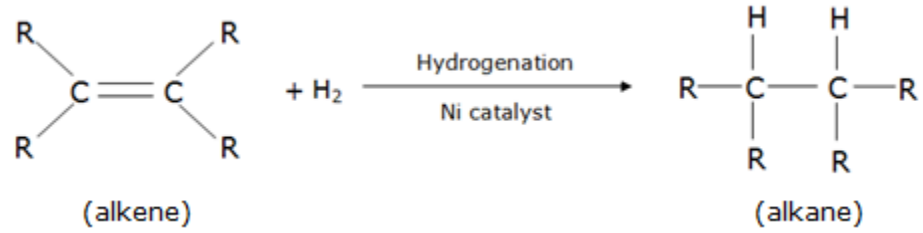


The general molecular formula of a carboxylic acid is $C_nH_{2n}O_2$.

Q. 17. Why vegetable oils are considered healthy as compared to vegetable ghee? How are they converted into ghee? What name is given to the reaction?

Answer: Vegetable oils contain unsaturated fatty acids which are good for the health, whereas vegetable ghee contains saturated fatty acids which are harmful to our health.

Vegetable oils are converted into ghee by the process of hydrogenation. Hydrogen is added to unsaturated compounds in the presence of a catalyst (such as nickel) to produce saturated compounds. The reaction is illustrated as:



Q. 18. How is glacial acetic acid different from acetic acid provided to you in laboratory? Write its one characteristic which resembles its name.

Answer: The water content present in acetic acid provided in the laboratory is higher than that of glacial acetic acid.

Pure ethanoic acid is often called glacial acetic acid because it freezes to form ice-like crystals when kept in cold surroundings (the melting point is 290K).

Q. 19. The gas/kerosene stoves used at home have inlets for air. What is the purpose of these inlets? What will happen, if these inlets are not provided?

Answer: Inlets are provided to supply air to ensure that the fuel burns completely and give a clean flame. If the inlets are absent, then the fuel may not burn completely and produce sooty flame. This will also result in wastage of fuel.

Q. 20. How would you predict whether a given water sample is of hard water or soft water? Give chemical equation.

Answer: To determine whether a given water sample is of hard water or soft water, one can use soap.

Soap produces lather in soft water whereas soap does not produce lather in hard water due to the formation of scum (insoluble precipitate). Scum is a result of reaction of soap with calcium and magnesium ions present in the hard water.

$$2RCOONa + Ca^{2+} \rightarrow \underset{\text{(scum)}}{(RCOO)_2Ca\downarrow} + 2Na^{+}$$

Q. 21. Soaps are prepared by treating the esters of fatty acid with alkali. Sometimes common salt is also added to it. Why is common salt added during this process?

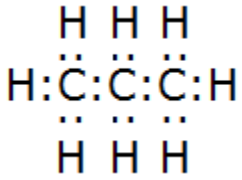
Answer: In the reaction of esters with alkali to prepare soap (saponification reaction), the product (soap) is obtained in a suspension form. To precipitate the soap out of the suspension form, common salt (NaCl) is added to it. This process is often referred to as “salting out” of soap.

Q. 22. Scientists detect the presence of sodium bicarbonate in a water sample. Can this water be used for washing clothes with soap? Justify your answer.

Answer: Yes, soap can be used for washing clothes in water containing sodium bicarbonate, as sodium ion will not contribute to the hardness of water.

Q. 23. Compound A has three carbon atoms, which burns with non-sooty flame. Predict what is A? Write its electron dot structure.

Answer: Non-sooty flame can be interpreted as clean flame. Clean flame is given out by burning of saturated compounds. Hence, A is propane (C_3H_8).



Q. 24. Two non-metals A and B combine with each other by sharing of electron to form compound C.

(i) What is the nature of compound C?
(ii) Will it dissolve in water or organic solvents? Give reason for your answer.

Answer: (i) C is a covalent compound, as the combining atoms form a bond by sharing of electrons.

(ii) Using “like dissolves like” rule, polar molecules dissolve in polar solvents, whereas non-polar molecules dissolve in non-polar solvents. C and organic solvents are both covalent (non-polar) in nature, but water is a polar solvent. Hence C will dissolve in organic solvents.

Q. 25. Account for the following.

(i) Sunlight is necessary for the substitution reactions of saturated hydrocarbons.
(ii) Ethyne burns with a yellow flame and lots of black smoke.

Answer: **(i)** Saturated hydrocarbons undergo substitution reaction through a mechanism called “free radical mechanism”, where the initial step of reaction is the formation of free radicals. Generation of free radicals requires sunlight, without which the reaction does not get initiated. So, sunlight is necessary for the substitution reactions of saturated hydrocarbons.

(ii) Ethyne (HC≡CH) is an unsaturated compound, and unsaturated compounds produce yellow sooty flame with lots of black smokes. This is due to incomplete combustion of ethyne in air.

Q. 26. Give reasons for the following.

(i) Ethanoic acid is used in the preservation of pickles.
(ii) CO_2 is released on burning diamond as well as graphite.

Answer: (i) Ethanoic acid provides an acidic environment where bacteria cannot survive, preserving the pickles for a longer time.

(ii) Both diamond and graphite are allotropes of the same element carbon. The only difference is in their physical properties due to the difference in their structure. The chemical properties remain the same. Carbon when burnt in the presence of oxygen gives carbon dioxide (CO_2). Since, diamond and graphite are chemically carbon, both release CO_2 upon burning.

Q. 27. An organic compound X of molecular formula $C_2H_4O_2$ turns blue litmus to red and gives brisk effervescence with Na_2CO_3 and $NaHCO_3$. Identify X and name of the gas responsible for effervescence.

Answer: X is ethanoic acid (CH_3COOH). It is acidic and hence turns blue litmus red. It releases carbon dioxide (CO_2) when treated with Na_2CO_3 and $NaHCO_3$ which is responsible for effervescence.

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

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

Q. 28. (i) Why does carbon form largest number of compounds? Give two reasons.

(ii) Why are some of these called saturated and the other unsaturated compounds?
(iii) Which one of these two is more reactive and why?

Answer: (i) Carbon has the ability to form long, branched chains or ring structures with other carbon atoms. This self-linking capacity is referred to as catenation.

Also carbon has a valency of 4 and combines with 4 other monovalent atoms or shares its outermost electrons with different elements through single, double or triple bonds. The bonds formed are highly strong and stable. Hence carbon forms a large variety of compounds.

(ii) Compounds of carbon which are linked by only single bonds between the carbon atoms are called saturated compounds.

Compounds of carbon having double or triple bonds between the carbon atoms are called unsaturated compounds.

(iii) Unsaturated compounds are more reactive than saturated compounds because of the presence of double or triple bonds present in them. These bonds tend to break in the presence of some reacting species to become saturated compounds which are highly stable. The relative stability of hydrocarbons in the decreasing order is given by:

alkanes > alkenes > alkynes

Q. 29. Write the molecular formula of ethene and also give three succeeding members with their names.

Answer: The molecular formula of ethene is C_2H_4. The three succeeding members in this homologous series are:

Propene (C_3H_6), Butene (C_4H_8), Pentene (C_5H_{10})

Q. 30. Give reasons for the following.

(i) Unsaturated hydrocarbons show addition reaction.
(ii) Alcohol supplied for industrial purpose is mixed with copper sulphate.

Answer: (i) A + B → C

The above reaction occurs because the stability of C is higher than the stability of A and B. Molecules always tend to attain the most stable configuration in a reaction.

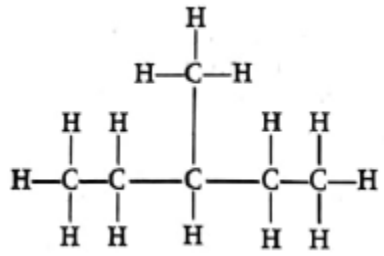
Here saturated compounds are more stable than unsaturated compounds. The double/triple bonds present in the unsaturated compound break to form single bonds by combining with the reactant to attain a highly stable product. Therefore, unsaturated hydrocarbons show addition reaction.

(ii) Alcohol supplied for industrial purpose is mixed with chemicals like methanol to prevent the misuse of it. It is a common practice to overuse this alcohol for recreational purposes, and addition of these chemicals would help prevent the misuse to an extent.

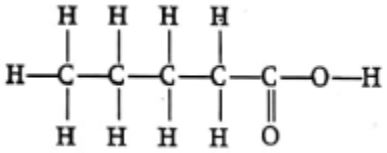
To identify such mixtures of alcohols, dyes or coloured substances are added to colour the alcohol blue. In this case, the coloured substance added is copper sulphate.

Q. 31. Name the following compounds.

(i)



(ii)



Answer: (i) 3-methylpentane

(ii) Pentatonic acid

Q. 32. (i) What is black gold and how is it formed? (ii) Why coal and petroleum are considered as air pollutants?

Answer: (i) Petroleum or crude oil is called black gold and it is formed from the remains of plants and animals that lived in the sea millions of years ago. The dead remains along with the silt which settled in the sea bed are attacked by bacteria and got converted to crude oil and gas under high pressure conditions. Slowly the silt compressed into rocks and the oil seeped into the porous parts of the rocks.

(ii) Fossil fuels such as coal and petroleum contain some amount of nitrogen and sulphur in them. The combustion of these fuels in air results in the formation of oxides of nitrogen and sulphur which are major pollutants of the environment. Therefore, coal and petroleum are considered to be pollutants of air.

Q. 33. A substance (X) be oxidised to acetic acid (CH_3COOH)? Name substance (X) and write two tests to demonstrate acidic nature of acetic acid.

Answer: The substance X is ethanol (C_2H_5OH).

The acidic nature of acetic acid can be shown using:

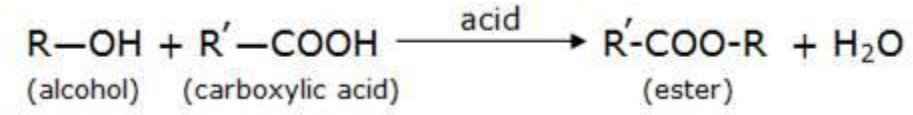
(a) Litmus test – Chemicals which are acidic in nature turn blue litmus red

(b) Sodium carbonate test – Acids when treated with sodium carbonate gives effervescence due to the liberation of carbon dioxide. Acetic acid also produces CO_2 in this reaction.

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

Q. 34. Explain giving chemical equation, how are esters prepared? Specify any one property and one use of esters.

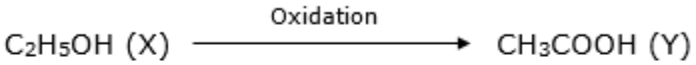
Answer: Esters are prepared by the reaction of an acid and an alcohol in the presence of an acid catalyst. The reaction is called esterification reaction.

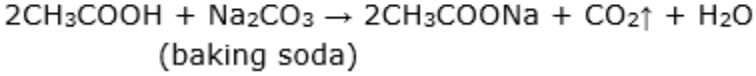


Esters are sweet smelling substances and hence are used in making perfumes and as flavouring agents.

Q. 35. An organic compound X which is sometimes used as an antifreeze has the molecular formula C_2H_6O. X on oxidation gives a compound Y which gives effervescence with a baking soda solution. Identify X and Y. Write the chemical equation of reaction.

Answer: X is ethanol (C_2H_5OH) and Y is ethanoic acid ($C_2H_4O_2$)





Q. 36.A. Give a detailed explanation on the following.

Properties of acetic acid

Answer: Acetic acid (CH_3COOH) is a weak acid and belongs to the family of carboxylic acids.

<u>Physical Properties:</u>

Acetic acid exists in liquid state at room temperature. Pure acetic acid has a melting point of 290K and often freezes when kept in cold climates.

Chemical Properties:

(a) Reaction with alcohol:

Acetic acids react with alcohols in the presence of an acidic medium to form esters. Esters are sweet smelling substances and are often used in perfumes and as flavouring agents.

$$CH_3COOH + R\text{-}OH \xrightarrow{\text{Acid}} CH_3COOR + H_2O$$

(b) Reaction with base:

Like other acids, acetic acid reacts with base to form salt and water. The reaction is called neutralization reaction.

$$\underset{\text{(base)}}{CH_3COOH + NaOH} \rightarrow \underset{\text{(salt)}}{CH_3COONa} + H_2O$$

(c) Reaction with carbonates and bicarbonates:

Acetic acid reacts with carbonates and bicarbonates to form salt, carbon dioxide and water.

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

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

Q. 36.B. Give a detailed explanation on the following.

Versatile nature of carbon

Answer: The versatility of carbon can be explained in the following ways:

(a) Catenation:

The self-linking capacity of an element is referred to as catenation. Carbon can form long straight chains, branched chains, or ring structures by bonding with other carbon atoms. No other element exhibits catenation up to this extent. Carbon can link with other carbon atoms using single, double or triple bonds.

(b) Tetravalency:

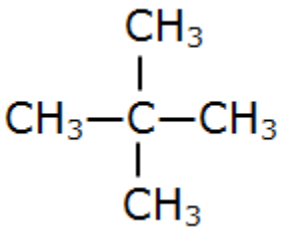
Carbon has a valency of 4. It is satisfied by forming bonds with 4 other monovalent atoms. Carbon can also form multiple bonds (double or triple bonds) with atoms like

oxygen and nitrogen. The bonds formed are highly stable and thus forms stable compounds.

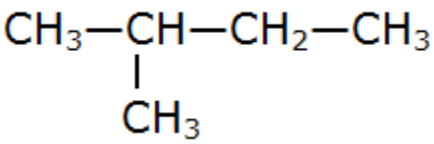
Q. 37. How are the following pairs related?

(i) 2, 2-dimethylpropane and 2-methylbutane
(ii) Ethane and propane
(iii) C_2H_5C1 and C_3H_7Cl
(iv) C_3H_4 and C_2H_4

Answer: (i) The structural formula of the two compounds are shown below.



2,2-dimethylpropane



2-methylbutane

Note that both compounds have the same molecular formula C_5H_{12}. Since they have same molecular formula but different structural formula, they are isomers.

(ii) Ethane (C_2H_6) and propane (C_3H_8) can be represented by the general formula C_nH_{2n+2} where 'n' is the number of carbon atoms. Also they differ by a $–CH_2$ unit. Hence they are homologues.

(iii) C_2H_5Cl and C_3H_7Cl differ by a $–CH_2$ unit. Also these 2 can be represented by the formula $C_nH_{2n+1}Cl$. Therefore they are homologues.

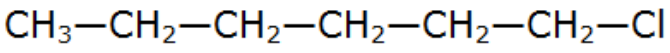
(iv) C_3H_4 is an alkyne and C_2H_4 is an alkene. Both the compounds contain double or triple bonds. Therefore, they belong to the family of unsaturated compounds.

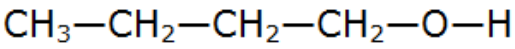
Q. 38. Draw the structures of

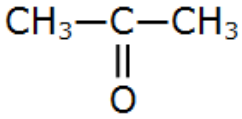
(i) chlorohexane (ii) butanol
(iii) propanone (iv) sodium ethanoate

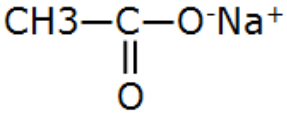
(v) butanoic acid (vi) butyraldehyde
(vii) sodium ethoxide (viii) sodium stearate
(ix) glycerol (x) sodium acetate

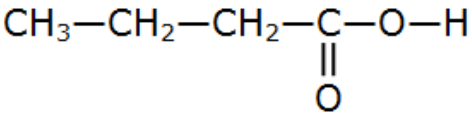
Answer:

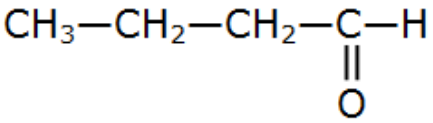
(i) 

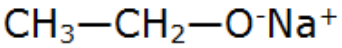
(ii) 

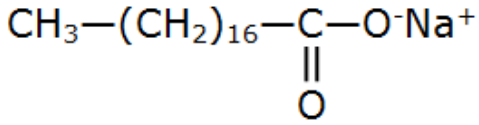
(iii) 

(iv) 

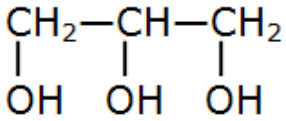
(v) 

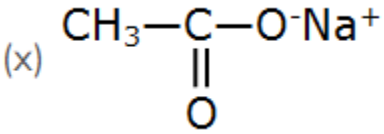
(vi) 

(vii) 

(viii) 

(ix) Glycerol is propane-1,2,3-triol

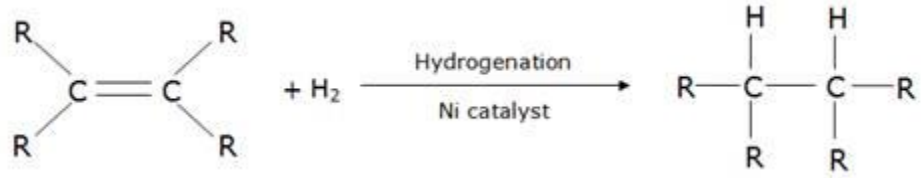


(x) 

Q. 39. Give the reaction for the hydrogenation of unsaturated carbon compounds. Define the term catalyst and name the catalyst used in this reaction. Which oil should be chosen for cooking and why?

Answer: Hydrogenation is the process of addition of hydrogen to compounds containing double/triple bonds to form saturated compounds.

The hydrogenation of unsaturated carbon compounds is given by the reaction:



Catalyst is a substance which alters the rate of a chemical reaction, without undergoing any change to itself. Nickel, palladium can be used as the catalyst for hydrogenation.

Vegetable oil must be chosen for cooking as it contains unsaturated fatty acids which are good for health.

Q. 40. Give account of chemical properties?

(i) combustion of ethanol
(ii) oxidation of ethanol
(iii) reaction of C_2H_5OH with sodium metal
(iv) dehydration of C_2H_5OH
(v) reaction of C_2H_5OH with ethanoic acid

Answer: (i) Ethanol upon combustion gives carbon dioxide and water.

$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$

(ii) Ethanol is oxidized to ethanoic acid when treated with oxidizing agents like acidified potassium dichromate

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

(iii) Ethanol reacts with sodium metal to liberate hydrogen gas.

$2C_2H_5OH + 2Na \rightarrow 2C_2H_5O^-Na+ + H^2$

(iv) Ethanol when dehydrated using conc. H_2SO_4 forms ethene.

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

(v) Ethanol (C_2H_5OH) reacts with ethanoic acid (CH_3COOH) in the presence of acidic medium to produce ethyl ethanoate which is an ester.

$$CH_3COOH + CH_3CH_2OH \xrightarrow{\text{acid}} CH_3COOCH_2CH_3$$

Q. 41. An organic compound A with molecular form $C_4H_8O_2$ on alkaline hydrolysis gives two compound B and C. C on acidification with dil. HCl gives D. Oxidation of B with $K_2Cr_2O_7/H_2SO_4$ also gives D. Identify A, B, C and D and explain all the reactions involved.

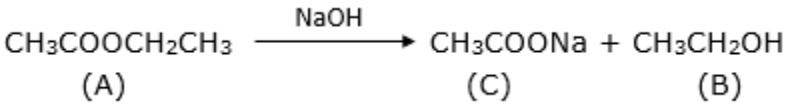
Answer: A – ethyl ethanoate

B – ethanol

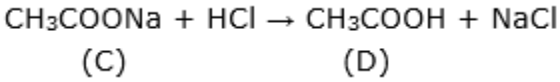
C – sodium ethanoate

D – ethanoic acid

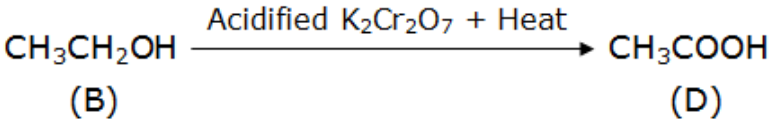
Esters upon alkaline hydrolysis gives back the carboxylic acid and the alcohol. The acid is initially obtained in its salt form. The reaction is called saponification.



The salt (sodium ethanoate) is treated with dil HCl to obtain the carboxylic acid.



Ethanol is oxidized to ethanoic acid in the presence of acidified potassium dichromate. Here, the acid used for acidification is H_2SO_4.



Q. 42. Have you ever observed while cleaning cloth that foam is formed with difficulty and an insoluble substance (scum) remains after washing with water? This is caused by the reaction of soap with the calcium and magnesium salts, which cause the hardness of water. Hence, you need to use a larger amount of soap. This problem is overcome by using another class of compounds called detergents as cleansing agents. Detergents are generally ammonium or sulphonate salts of long chain carboxylic acids. The charged ends of these compounds do not form insoluble precipitates with the calcium and magnesium ions in hard water. Thus, they remain effective in hard water. Detergents are usually used to make shampoos and products for cleaning clothes.

(i) How will you test the hardness of water?
(ii) Why soap forms scum (insoluble substance) with hard water?
(iii) How one can overcome the problem of scum formation? What values do you identify in this context?

Answer: (i) The hardness of water can be determined using soap.

If the given amount of soap has difficulty in producing foam (lather) and produces an insoluble precipitate (scum) instead, in the water then the water is hard.

If the soap produces foam easily in the water, then the water is soft.

(ii) Hard water contains calcium and magnesium ions. Scum is formed as a result of reaction between calcium or magnesium ions with soap.

$$2RCOONa + Mg^{2+} \rightarrow \underset{\text{(scum)}}{(RCOO)_2Mg\downarrow} + 2Na^+$$

(iii) The problem of scum formation can be avoided by using detergents. The charged ends of these compounds do not form insoluble precipitates with calcium or magnesium ions in hard water which makes detergents effective in hard water.

From this, one can learn that soaps are ineffective in hard water (water containing calcium and magnesium ions) as they do not produce foam in hard water. This is rectified by the usage of another class of compounds called detergents. Thus one must not use soaps in hard water, as it will be a waste of time and money. At the same time one must also realize that detergents are non-biodegradable. These compounds cannot be degraded by bacteria and therefore can potentially harm the environment.

Challengers

Q. 1. Consider the following statements related to diamond and graphite.

I. Both diamond and graphite are used as abrasives.
II. Diamond and graphite have different arrangements of carbon atoms.
III. The carbon atoms in graphite have a different number of neutrons from those in diamond.
IV. The carbon atoms in both graphite and diamond have four single covalent bonds. The incorrect statement(s) is/are

A. I and III
B. II and IV
C. I, III and IV
D. All of these

Answer: Graphite is commonly used as an abrasive, but diamond is not used.

The number of neutrons in carbon atoms present in both graphite and diamond are the same. It only depends upon the nature of the element, and both are allotropes of the same element carbon.

In diamond, each carbon is covalently bonded to 4 other carbon atoms whereas in graphite, each carbon is covalently to 3 other carbon atoms.

Q. 2. What would happen if graphene is heated in sufficient supply of air?

A. It aggregates to form graphite

B. It gets converted into diamond

C. Carbon dioxide gas is released

D. It becomes a non-conductor

Answer: Graphene is an allotrope of carbon. Like diamond, and graphite, when subjected to sufficient supply of air, it burns to release carbon dioxide.

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

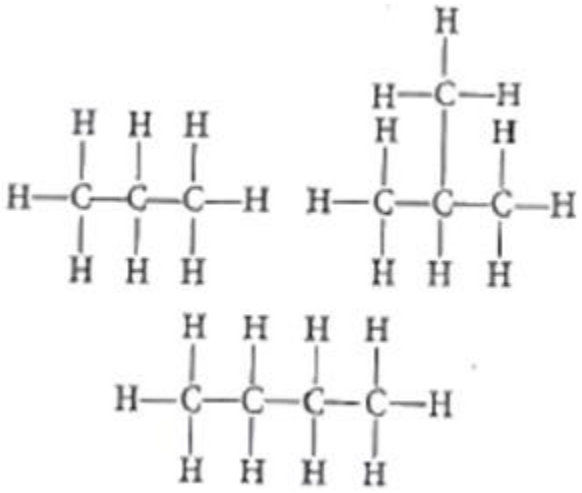
I. size of carbon is much smaller than Pb.
II. large amount of energy is needed in case of carbon.
III. of inert pair effect.
IV. nucleus cannot hold such a large number of electrons.

The correct statement(s) is/are

A. Only I
B. I and II
C. Only III
D. II, III and IV

Answer: As you go down a group, the size of the atom increases and the ionization enthalpy decreases due to the shielding of outermost electrons by the inner electrons.

Q. 4. The structures of three hydrocarbons are given below

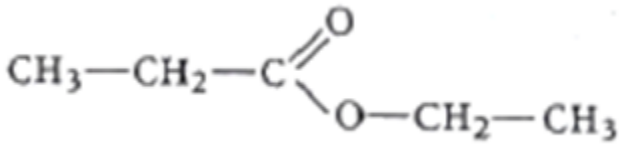


Which statement is correct for all the above three compounds?

A. They are isomers of each other
B. They have the same general formula
C. They have the same physical properties
D. They react with aqueous bromine

Answer: All the three compounds are alkanes and can be generally represented by C_nH_{2n+2}, where 'n' is the number of carbon atoms.

Q. 5. The diagram shows the molecule, ethyl propanoate.



How many bonding pairs of electrons are there in the molecule?

A. 13
B. 16
C. 17
D. 20

Answer: Number of C-H bonds = 10 = 10 bond pairs (bp) of electrons

Number of C-C bonds = 3 = 3 bp of electrons

Number of C-O bonds = 2 = 2 bp of electrons

Number of C=O bonds = 1 = 2 bp of electrons

Total number of bp = 10+3+2+2 = 17

Q. 6. Which compound has an addition reaction with - chlorine?

A. C_2H_4
B. C_2H_5OH
C. C_2H_6
D. CH_3CO_2H

Answer: C_2H_4 is an alkene which is an unsaturated compound. It gives addition reaction.

Q. 7. One mole of a hydrocarbon X reacted completely with one mole of hydrogen gas in the presence of a heated catalyst. What could be the formula of X?

A. C_2H_6
B. C_5H_{10}
C. C_3H_8
D. C_7H_{16}

Answer: C_5H_{10} is an alkene which is an unsaturated hydrocarbon. Only unsaturated hydrocarbons react with hydrogen to form saturated hydrocarbons.

Q. 8. Compound X is a six carbon compound. When it is burnt, light is generated. Here, the colour of the flame is yellow because of the presence of carbon particles. Compound X cannot be

A. C_6H_{12}
B. C_6H_{14}
C. C_6H_6
D. C_6H_{10}

Answer: Only unsaturated carbon compounds produce yellow (and sooty) flame. C_6H_{14} is a saturated compound (hexane) and it will always produce clean blue flame (not yellow) when burnt in sufficient amount of oxygen.

Q. 9. A reaction scheme is shown below:

$$\text{Ethene} + \text{Steam} \xrightarrow{\text{Catalyst}} X \xrightarrow[\text{Potassium dichromate (VI)}]{\text{Acidified}} Y \xrightarrow{x} Z$$

What is the final product Z?

A. A carboxylic acid
B. An alcohol
C. An alkene
D. An ester

Answer:

$$\text{Ethene + Steam} \xrightarrow{\text{Catalyst}} \text{Ethanol} \xrightarrow{\text{Acidified } K_2Cr_2O_7} \text{Ethanoic acid}$$

$$\xrightarrow{\text{Ethanol}} \text{Ethyl ethanoate (ester)}$$