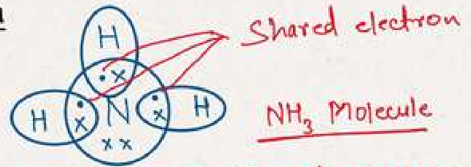
Carbon and its Compounds

Carbon is an element. It is a non metal 0.02% carbon in the form of minerals, 0.03%of carbon dioxide gas.

The covalent bond

Chemical bond form by the sharing of electrons between two atoms is known as a covalent bond.

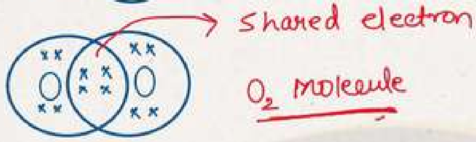
A molecule of Ammonia



H
|
H — N — H

Single Bond

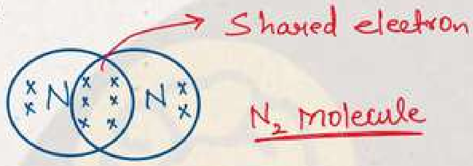
A molecule of Oxygen



O = O

Double Bond

A molecule of nitrogen



$N \equiv N$

Triple Bond

Properties of covalent Bond

- Covalent compounds are usually liquid or gases only some of them are solid.
- Covalent compounds have usually low melting and boiling point.
- Covalent compounds do not conduct electricity.
- Insoluble in water soluble in organic soluble.

Properties of carbon compound

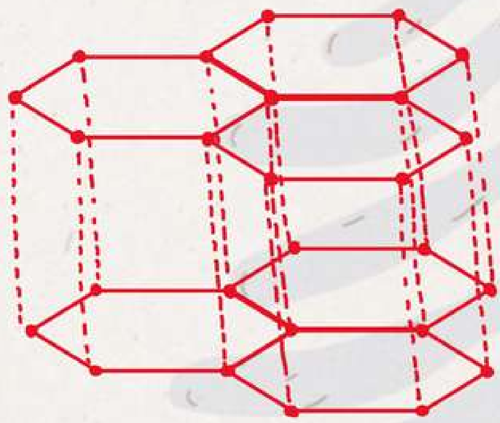
- Most carbon compound are poor conductor of electricity.
- Compounds have low melting and boiling point as compare to ionic compound.
- The force of attraction between the molecule are not very strong.
- The bonding in these compounds does not give rise to any ions.
- **Catenation:** The property of self combination of carbon atoms to form a long chain is called catenation. The compound may have long chain, branched chain, ring chain.
  Silicon also has this property.
- **Tetravalency:** Carbon atom has large valency of four, can form covalent bond with number of carbon atom as well as with a large number of other atom such as hydrogen chlorine and many more atoms.

Allotrophes of carbon

The various physical forms in which an element can exist are called allotropes of the element.

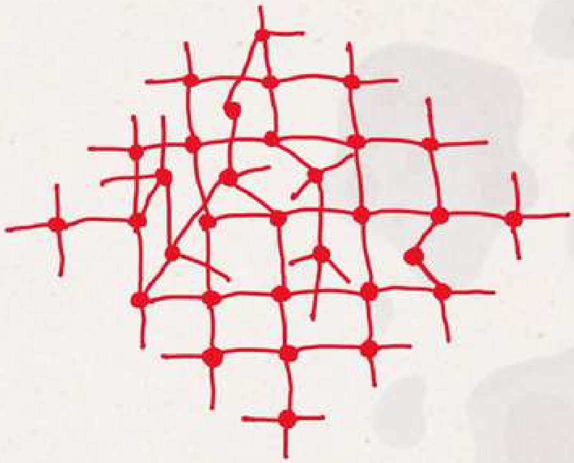
Graphite

- One carbon is attached to 3 other carbon
- Layer structure / Hexagonal structure
- 2-D figure
- No strong bond among layer
- Lubricant
- Soft solid and slippery
- Good conductor of electricity



Diamond

- One carbon attached to four carbon atom
- Network structure
- Strong bond between the atom
- 3-Dimensional
- Bad conductor of electricity



Buckminster fullerence

- Containing clusters of 60-carbon
- Formula 'C_{60}' (C-sixty)
- Football shaped-spherical
- Arrange in interlocking hexagonal and pentagonal rings of carbon.

P.Y.Qs

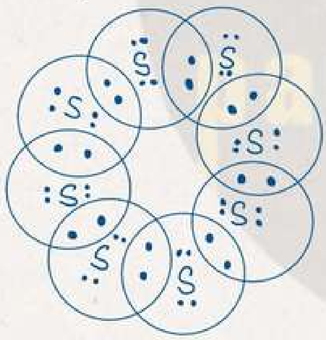
Question: Carbon does not form ionic compounds. Why?

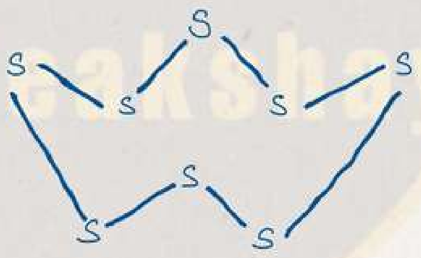
Answer: In order to form ionic bond carbon either should loose $4e^-$ or gain $4e^-$ to form C^{4+} or C^{4-} ion. Losing $4e^-$ needs large amount of energy and by gaining $4e^-$, it will have $10e^-$. It is difficult for 6 protons to hold $10e^-$. So C^{4+} and C^{4-} is not possible.

P.Y.Qs

Question: What would be the electron dot structure of a molecule of sulphur which is made up of eight atoms of sulphur?

Answer:

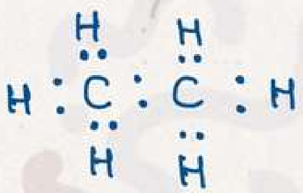




P.Y.Qs

Question: Draw the electron dot structure of ethane, C_2H_6.

Answer:



Saturated and unsaturated carbon compounds

Saturated: Compounds of carbon which are linked by only single bond between the carbon atoms.

Unsaurated: Compounds of carbon having double or triple bonds between the carbon atoms.

Open chained compound: Those compounds in which first carbon of the chain not combine with the last carbon and it not form closed structure.

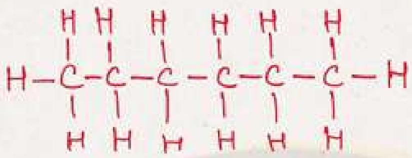
Saturated Hydrocarbon

Alkanes

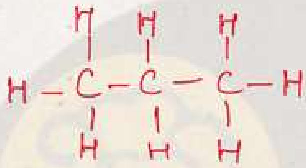
- General formula – C_nH_{2n+2}
- Suffix - ane
- It form tetrahedral structure
- Bond angle 109°28 min
- It show sp^3 hybridisation
- It give substitution reaction and elimination

C_1-Meth
C_2-Eth
C_3-Prop
C_4-But
C_5-pent
C_6-Hex
C_7-Hept
C_8-Oct

Example :-



Hexane



Propane

Derivation of alkane

When the hydrogen of alkane displaced by any functional group, the new compound is known as derivation of alkane.

functional group

Name	General Formula	Preffix	Suffix
Halo alkane (Alkyl halide)	R– X (F, Cl, Br, I) R- alkyl group R– C_nH_{2n+1} chloro - Cl Bromo – Br Iodo – I Fluro – F	Halo	
Alcohol	R–OH	Hydroxy	ol
Aldehyde	R–C(=O)–H	formyl / aldo	al
Ketone	R–C(=O)–R or R–C(=O)–R'	keto	One
Carboxylic acid	R–C(=O)–OH	Carboxy	Oic acid.

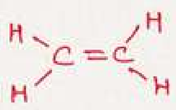
→If alkyl group similar in both direction then it is known as symmetrical Ketone – R–C(=O)–R

→If different alkyl group combine with carboxyl then it is known as unsymmetrical Ketone – R–C(=O)–R

Unsaturated Hydrocarbon

Alkene

- General formula – C_nH_{2n} (double band)
- Suffix – ene
- Bond angle 120°
- Structure – triagonal
- sp^2 hybridisation
- Give addition reaction
- First member – C_2H_4 /ethene/ ethlene



Alkane C_nH_{2n+2}

$\uparrow +2$

Alkene C_nH_{2n}

$\downarrow -2$

Alkyne C_nH_{2n-2}

Alkyne

- General formula – C_nH_{2n-2} (Triple bond)
- Suffix – yne
- Bond angle 180°
- Sp hybridisation
- Linear shape
- Give addition reaction
- First member C_2H_2 / ethyne / $H-C\equiv C-H$

Cyclic compound

Those compounds in which first carbon of the chain combine with last carbon to form a closed structure is known as Cyclic compound.

It is of two types:

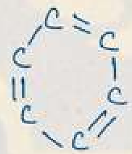
-Homocyclic

-Heterocyclic

Homocyclic

If all the atom of the closed chain are similar is known as homocyclic.

Example: Benzene, cyclopropane



Heterocarbon

If all the atom of the closed chain are not similar.

Example: pyride

Homocyclic compounds are of two types:

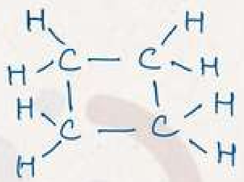
-Aliphatic

-Aerobatic

Aliphatic

It is also known as saturated cyclo-compound which is generally called cycloalkane.

Example: Cyclo-butane



Aerobatic

It is also known as unsaturated cyclo-compounds. In which a special type of smell is present

It is of two types:

-Benzenoid

-Non-Benzenoid

Benzenoid

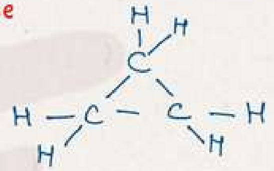
Those aerobatic compounds in which benzene ring is present is known as Benzenoid.

Example: phenol

Non-Benzenoid

Those aeromatic compound in which benzene ring are not present.

Example: Cyclopropane



Homologous series

Group of compound based on same general formula

Characteristics

- All the number of a homologous series can be represented by the same general formula.
- Any two adjacent homologous compounds differ by 1-C and 2-H atoms in their molecular formula.
- All the compounds of a homologous series show similar chemical properties.
- Two adjacent member of homologous series differ by 14u in molecular mass.
- Member of series have gradual change in their physical properties with increase in molecular mass.

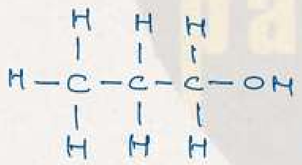
Functional group

Atoms or group of atoms which determine the chemical properties of compound is known as functional group. → all the functional group are mention in the above box

P.Y.Qs

Question: Write the name and structure of the alcohol with three carbon atoms in its molecules.

Answer: Propanol



or $CH_3CH_2CH_2OH$

P.Y.Qs

Question: The molecular formula of 'A' is $C_{10}H_{18}$ and 'B' is $C_{18}H_{36}$. Name the homologous series to which they belong.

Answer: 'A' belong to alkyne and 'B' belong to alkene.

P.Y.Qs

Question: Write molecular formula of alcohol which can be derived from butane.

Answer: $CH_3-CH_2-CH_2-CH_2-OH$ (Butanol)

P.Y.Qs

Question: write the name and molecular formula of an organic compound having its name suffixed with 'ol' and having two carbon atoms in its molecule. Write balance chemical equation to indicate what happens when these compound is heated with excess concentrated H_2SO_4 and the name of main product formed. Also state the role of concentrated H_2SO_4 in the reaction.

Answer: The compound is ethanol. It's formula is C_2H_5OH or C_2H_6O

$$C_2H_5OH \longrightarrow \underset{\text{Ethene}}{CH_2=CH_2} + H_2O$$

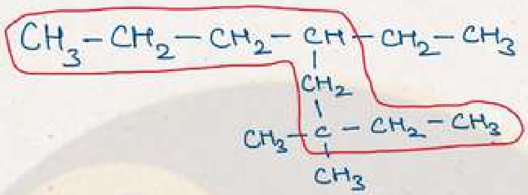
Conc. H_2SO_4 act as a dehydrating agent.

IUPAC (Nomenclature of the compound)

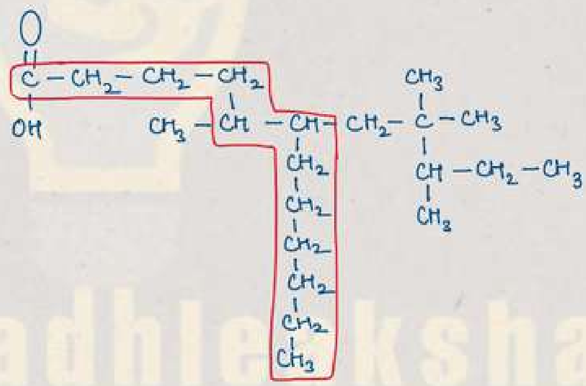
We can write it in 3 steps
- → Selection of parental chain
- → Numbering of carbon
- → Naming of the compound

Selection of parental chain

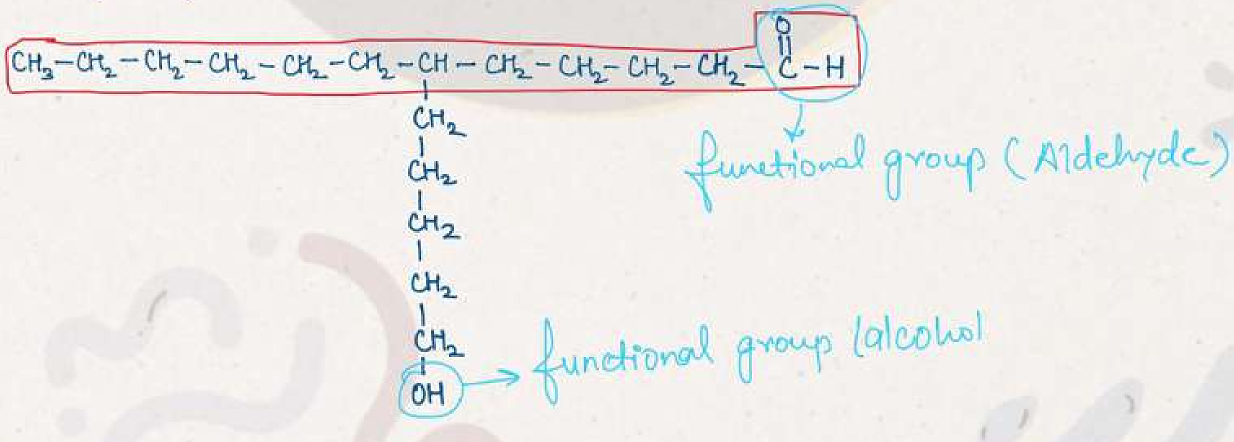
- Parental chain can be selected on the basis of maximum number of carbon in the Chain.



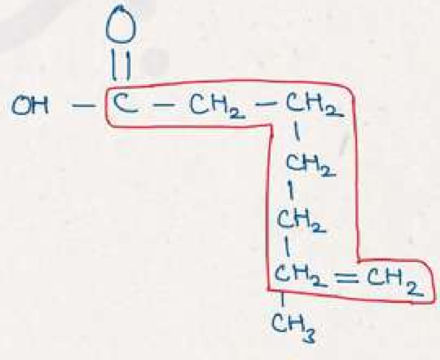
- If the functional group present in the compound and the number of longest chain is more than one in such case those carbon chain is selected in which functional group present.



- If more than one longest carbon chain with a functional group present in the compound in such case only Straight chain can be selected.

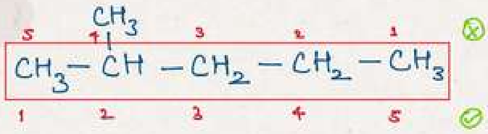


- If the multiple bond present in the compound in those longest carbon chain selected in which multiple bond present.

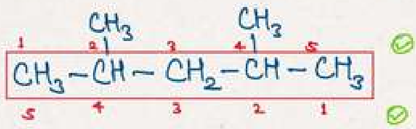


Numbering of Carbon

- Numbering is done in such a way so that branching (lateral chain) if present get the lowest number.

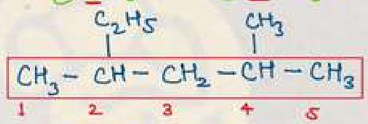


- If two similar alkyl group are attached with parental chain at the same number of carbon from any direction. Then numbering can be done in any direction.

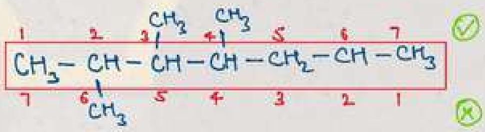


- If the two different alkyl group attached with a parental chain of the same number of carbon from two direction then numbering is done by alphabetically order.

Ethyl   Methyl



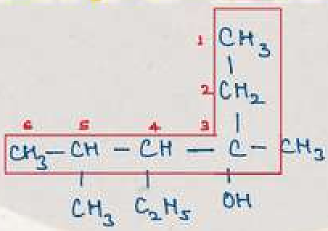
- When more than two similar of different alkyl group attached with parental Chain then the numbering can be done from the direction where the sum of position be lowest and this rule is called sum rule.



2+3+4 = 9
4+5+6 = 15

Naming of the compound

Priority — Carboxylic > ketone > Aldehyde > Alcohol > Halo alkanes



4 Ethyl 3,5 Dimethyl Hexane-3-al

- Main objective for numbering for multiple lateral chain and functional group is sum rule.
- When there is carbon functional group then without doubt do numbering from that side.

Activity 4.2

Answer:

Compounds	Difference in formula	Difference in molecular mass
CH_3OH & C_2H_5OH	$-CH_2-$	14U
C_2H_5OH & C_3H_7OH	$-CH_2-$	14U
C_3H_7OH & C_4H_9OH	$-CH_2-$	14U
C_4H_9OH & $C_5H_{11}OH$	$-CH_2-$	14U

Answer: Yes. They contain -OH group.

Answer: CH_3OH, C_2H_5OH, C_3H_7OH, C_4H_9OH

Yes. They are homologous series because they show a difference in $-CH_2$ group.

Answer: Chloro (-Cl) functional group: CH_3Cl, C_2H_5Cl, C_3H_7Cl, C_4H_9Cl

Aldehydes functional group: CH_3CHO, C_2H_5CHO, C_3H_7CHO, C_4H_9CHO

Ketone functional group: CH_2CO, C_2H_4CO, C_3H_6CO, C_4H_8CO

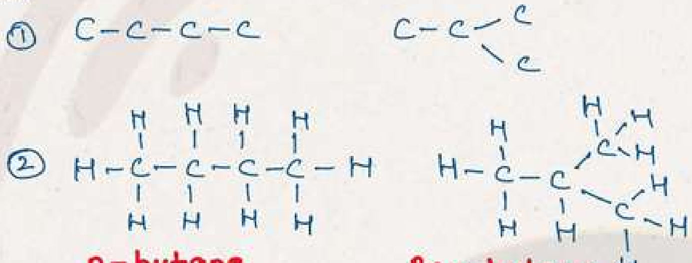
Carboxylic acids functional group: CH_2COOH, C_2H_4COOH, C_3H_6COOH, C_4H_9COOH

Isomerism

Compound having same molecular formula but different structural formula are called as isomers and this phenomena is known as isomerism.

Structural isomerism

If the compound have similar molecular formula but have different structure are called as structural isomerism.



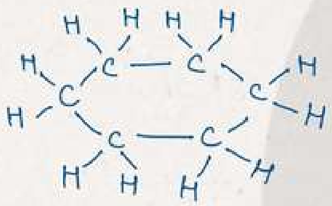
n-butane

iso-butane

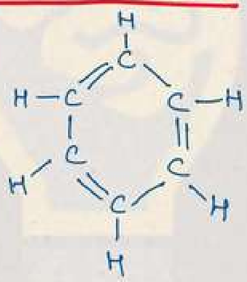
Pentane – 3 isomers
Hexane – 5 isomers
Bromopentane – 3 isomers

Cyclohexane

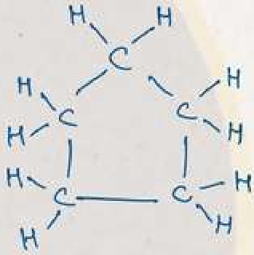
C_6H_{12}



Benzene C_6H_6



Cyclopentane



activity 4.3

Answer:

- Camphor & Naphthalene are unsaturated hydrocarbons. So they burn with yellow flame and leave residues.
- Alcohol is saturated and burns with clean blue flame.

Answer: There is deposition in the case of naphthalene and camphor on the plate.

activity 4.4

Answer: If there is no sufficient supply of air, it results in incomplete combustion of even saturated hydrocarbons giving a yellow, sooty flame.

Answer: In presence of a sufficient supply of air with oxygen, it gives a blue flame.

activity 4.5

Answer: The purple colour of potassium permanganate disappears initially.

Answer: Because all the alcohol gets consumed and the reaction stops.

activity 4.6

Answer: It produces sodium ethoxide $(2CH_3CH_2O^-Na^+ \; \& \; H_2)$.

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

Answer: When a burning spitter is brought near to the gas, the gas burns with pop sound. A layer of moisture is formed inside the glass tube.

Chemical Properties Of Carbon Compounds

1.Combustion: The complete combustion of carbon compound in the air gives carbon dioxide, water, heat and light.

$\rightarrow CH_3CH_2OH(l) + O_2(g) \longrightarrow CO_2(g) + H_2O(l)$ + Heat and light

Carbon burns in air or oxygen to give Carbon dioxide and heat and light.

$\rightarrow C(s) + O_2(g) \longrightarrow CO_2(g)$ + Heat and light

Saturated hydrocarbons burn with a blue flame in the presence of a sufficient supply of air or oxygen.

$\rightarrow CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$ + Heat and light

When We burn:-

→ Saturated hydrocarbon — clean flame

→ Unsaturated hydrocarbon — Yellow flame + lot of Smoke (black)

2.Oxidation: Oxidation of ethanol in presence of oxidizing agents gives ethanoic acid.

$$\underset{\text{(Ethanol)}}{CH_3CH_2-OH} \xrightarrow[\text{or Acidified } K_2Cr_2O_7 + \text{Heat}]{\text{Alkaline } KMnO_4 + \text{Heat}} \underset{\text{(Ethanoic acid)}}{CH_3COOH}$$

Oxidising agent ← { $KMnO_4$ – Potassium permanganate; $K_2Cr_2O_7$ – Potassium dichromate }

3.Addition reaction: Addition of dihydrogen with unsaturated hydrocarbon in the presence of catalyst such as nickel or platinum or Palladium are known as Hydrogenation (addition) reaction.

$$R_2C=CR_2 + H_2 \xrightarrow{\text{Ni Catalyst}} R-\underset{R}{\overset{H}{C}}-\underset{R}{\overset{H}{C}}-R$$

$$\underset{\text{(Ethene)}}{CH_2=CH_2} + H_2 \xrightarrow{\text{Ni catalyst}} \underset{\text{(Ethane)}}{CH_3-CH_3}$$

→ Process of converting vegetable oil into solid fat (vegetable ghee) is called hydrogenation of oil. (vegetable oil + H_2)

→ Vegetable fat are saturated fat which are harmful for health.

→ Vegetable oil containing unsaturated fatty acids are good for health.

4.Substitution Reaction: Replacement of one or more hydrogen atom of an organic a molecule by another atom or group of the atom is known as substitution reaction.

$$\underset{\text{(Methane)}}{CH_4(g)} + Cl_2(g) \xrightarrow{\text{Sunlight}} \underset{\text{(Chloromethane)}}{CH_3Cl(g)} + HCl(g)$$

P.Y.Q

Question: What happens when a small piece of sodium is dropped into ethanol?

Answer: Hydrogen gas is evolved with the formation of sodium ethoxide.

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

Activity 4.7

Answer: Yes.

Answer: No.

Ethanol and Ethanoic acid

Ethanol

- It is liquid at room temperature.
- It is commonly called alcohol and is the active ingredient of all alcoholic drinks.
- It is also called used in medicine such as tincture iodine, cough syrups, and many tonics.
- Consumption of small quantities of dilute ethanol causes drunkeness.
- Intake of even an small quantity of pure ethanol can be lethal.

Reaction of ethanol

--- **Sodium**

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

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

→ $CH_3-CH_2OH \xrightarrow[H_2SO_4]{\text{Hot Conc}} CH_2=CH_2 + H_2O$

(sulphuric acid → dehydrating agent)

Ethanoic Acid

- It is commonly called acidic acid and belong to a group of acids called carboxylic acids.
- 5.8% solution of acetic acid in water is called vinegar – preservative of pickles.
- The melting point of pure ethanoic acid is 290K and boiling point is 391K.

Reaction of Ethanoic acid

--- **Esterification reaction**

→ $CH_3-COOH + CH_3-CH_2OH \rightleftharpoons CH_3-C-\underset{\underset{O}{||}}{C}-CH_2-CH_3 + H_2O$

(Ester)

- Easter are sweet smelling substance used in making perfumes and as flavour agents.
- → $CH_3COO_2H_5 \xrightarrow{NaOH} C_2H_5OH + CH_3COONa$ – saponification reaction
- On treating with sodium hydroxide,which is an alkali; the Easter Is converted back to alcohol and sodium salt of carboxylic acid.

--- **Reaction with base**

→ $NaOH + CH_3COOH \longrightarrow \underset{\text{(sodium acetate)}}{CH_3COONa} + H_2O$

--- **Reaction with carbonates and hydrogen carbonates**

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

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

activity 4.8

Answer: The resulting mixture is an ester. Esters have sweet smell.

activity 4.9

Answer: Following reaction occurs:

$$2CH_3COOH + Na_2CO_3 \longrightarrow \underset{\text{(sodium acetate)}}{2CH_3COONa} + CO_2 + H_2O$$

Answer: Lime-water turns milky. It means that the gas is CO_2.

Answer: Yes. The gas is CO_2.

Answer: Reaction with sodium hydrogen carbonate:

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

Soap and Detergent

Soap: Sodium or potassium salts of long chain fatty acids is called Soap.
General formula: $RCOO^-Na^+$

Detergent: Ammonium and sulphonate salts of long chain fatty acids are called Detergent.
Example: $CH_3-(CH_2)_{11}-C_6H_4-SO_3Na$

Hard and Soft Water: Water that does not produce lather with soap readily is called Hard water and which produces lather with soap is called Soft Water.
Hardness of water is due to the presence of bicarbonates, chlorides and sulphate salt of calcium and magnesium.

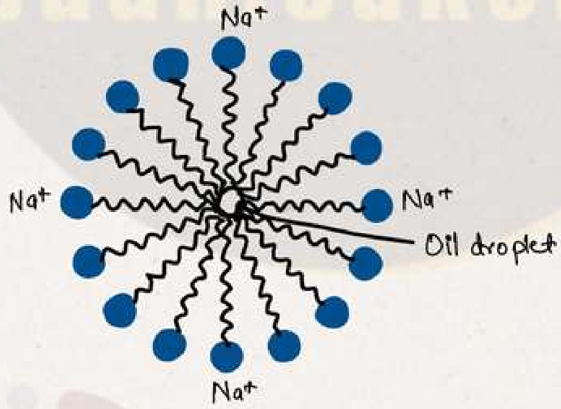
Advantage of Detergents: The main advantage of detergent over soaps is that soaps cannot be used in hard water for washing because hard water reacts with soap to form curdy white precipitate called Scum.

$$\underset{\text{Sodium stearate (Soap)}}{2C_{17}H_{25}COONa} + \underset{\text{Calcium chloride}}{CaCl_2} \longrightarrow \underset{\text{Calcium stearate (Scum)}}{(C_{17}H_{35}COO)_2Ca} + 2NaCl$$

Thus, in hard water, soap does not give lather while detergent does.

Cleansing Action of Soaps and Detergents: Both soaps and detergents contains two parts. A long hydrocarbon part which is hydrophobic (water repelling) in nature and a short ionic part which is hydrophilic (water attracting) in nature

The hydrocarbon part of the soap molecule links itself to the oily (dirt) drop and ionic end orients itself towards water and forms a spherical structure called micelles. The soap micelles helps in dissolving the dirt in water and wash our clothes.



Miscelle formation

activity 4.10

Answer: No.
Answer: Yes. The oil layer separates out in both test tubes. But this happens first in test tube A.

activity 4.11

Answer: In the test tube containing distilled water.
Answer: In the test tube containing hard water.

activity 4.12

Answer: No. The test tube containing detergent has more foam.
Answer: In the test tube containing soap.

Question: Oils on treating with hydrogen in the presence of palladium or nickel catalyst form fats. This is an example of
(a) Addition reaction
(b) Substitution reaction
(c) Displacement reaction
(d) Oxidation reaction
Answer: (a) Addition reaction

Question: In which of the following compounds -OH is the functional group?
(a) Butanone
(b) Butanol
(c) Butanoic acid
(d) Butanal
Answer: (b) Butanol

Question: The soap molecule has a
(a) hydrophilic head and a hydrophobic tail
(b) hydrophobic head and a hydrophilic tail
(c) hydrophobic head and a hydrophobic tail
(d) hydrophilic head and a hydrophilic tail
Answer: (a) hydrophilic head and a hydrophobic tail

Question: In the soap micelles
(a) the ionic end of soap is on the surface of the cluster while the carbon chain is in the interior of the cluster.
(b) ionic end of soap is in the interior of the cluster and the carbon chain is out of the cluster.
(c) both ionic end and carbon chain are in the interior of the cluster
(d) both ionic end and carbon chain are on the exterior of the cluster
Answer: (a) the ionic end of soap is on the surface of the cluster while the carbon chain is in the interior of the cluster.

Question: Pentane has the molecular formula C5 H12. It has
(a) 5 covalent bonds
(b) 12 covalent bonds
(c) 16 covalent bonds
(d) 17 covalent bonds
Answer: (c) 16 covalent bonds

Question: (a) How will you bring about following reactions? Write the concerned chemical equation
(I) Ethanol to Ethene
(ii) Ethanol to Ethanoic acid
(b) Give one example with chemical equation for the following reactions
(I) Substitution reaction
(ii) Saponification reaction
(iii) Combustion Reaction
Answer: (a) (i) $CH_3CH_2OH \xrightarrow[\text{conc-}H_2SO_4]{443K} CH_2=CH_2$
$CH_3CH_2OH \xrightarrow{\text{alk. }KMnO_4} CH_3COOH$
(b) (i) $CH_4 + Cl_2 \xrightarrow[\text{sunlight}]{} CH_3Cl + HCl$
(ii) $CH_3COOC_2H_5 \xrightarrow{NaOH} C_2H_5OH + CH_3COOH$
(iii) $CH_4 + O_2 \longrightarrow CO_2 + H_2O$

Question: What are soapes chemically? How do they differ from synthetic detergent? Explain the mechanisms and the cleansing action of soapes.

Answer: (i) Soap It is sodium or potassium salt of fatty acid.
Detergent are ammonium or sulphonate salts of long chain carboxylic acids.
(ii) Due to miscelle formation, ionic - ionic repulsion.
Micelle It is a structure formed when soap molecule get arranged and align along the surface of water with the ionic end in water and the hydrocarbon 'tail' protruding out of water.

Question: **(a) Different between soap and detergent.**
(b) Explain why, soaps form scum with hard water whereas detergents do not.
Answer:

SOAPS	DETERGENT
(i)Soaps are sodium or potassium salts of long chain carboxylic acids. (ii)Soaps have lesser cleansing action or quality as compared to detergents. (iii) Soaps are made from animal or plant fats. (iv) Soaps are more are biodegradable.	(i) Detergent are ammonium or sulphonate salts of long chain carboxylic acids. (ii) Detergent have better cleansing actio as compared to soaps. (iii) Detergent are made from petrochemical. (iv) Detergent are less biodegradable.