CLASS -10
CHAPTER- 4
CARBON AND ITS COMPOUNDS

What do we know about carbon?
- Carbon is a versatile element.
Food, clothes, medicines, books, or many of the things, all based on the versatile carbon. All living structures are carbon based.
- The earth's crust has only 0.02% carbon in the form of minerals (like carbonates, hydrogen-carbonates and petroleum) and the atmosphere has 0.03% of carbon di-oxide.
Basics:-
- Carbon is a chemical element with the symbol C.
- Atomic number- 6, - Mass number-12
- Electronic configuration - 2, 4
Outmost shell's elections - 4 (Tetra valency)

- Group no – 14
- Period no – 2
- Bond - Covalent Bond
- Carbon is a poor conductor of electricity. Exception - Graphite.

Compound	Melting point (K)	Boiling point (K)
Acetic acid (CH_3COOH)	290	391
Chloroform ($CHCl_3$)	209	334
Ethanol (CH_3CH_2OH)	156	351
Methane (CH_4)	90	111

- Most of carbon compounds' melting points and boiling points are low.

Covalent Bond -

The atomic no. of carbon is 6 and electronic configuration of carbon is 2,4. It has four electrons in its outermost shell and needs to gain or lose four electrons to attain a noble gas configuration. If it were to gain or lose electrons-

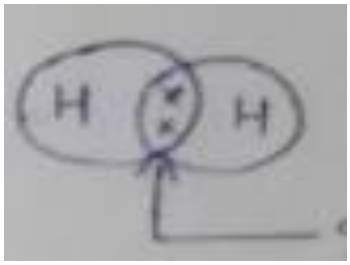
(i) It could gain four electrons forming C4 – anio. But it would be difficult for the nucleus with six protons to hold on to ten electrons. i.e. four extra electrons.

(ii) It could lose four electrons forming C4+ cation. But it would require a large amount of energy to remove four electrons leaving behind a carbon cation with six protons in its nucleus holding on to just two electrons.

Carbon overcomes this problem by sharing its valence electrons with other atoms of carbon or with atoms of other elements. This bond which is made by sharing electrons with the same or other elements is called a covalent bond.

Atoms of other elements like hydrogen, oxygen, nitrogen, and chlorine also show the sharing of valence electrons.

This type of bonding has three types-

(i) 

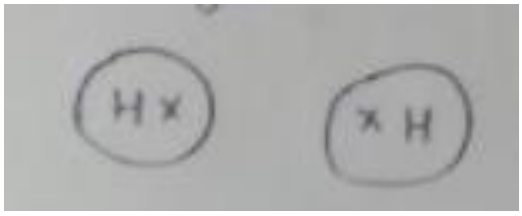
single covalent bond

(ii) Double covalent bond

(iii) Triple covalent bond

1. Single bond- One electron is shared by each atom giving rise to one shared pair of electrons.

1. Hydrogen atomic one no -1

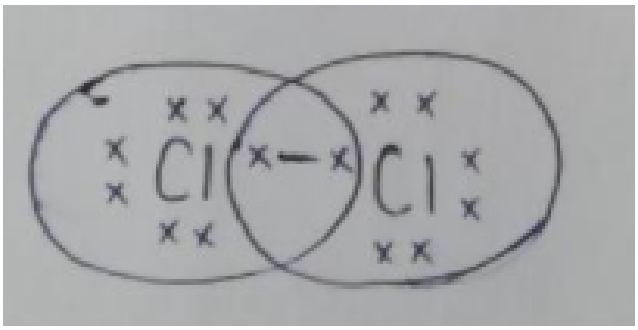


Hydrogen atoms

H_2 molecule

Shared electrons

H – H



↑

Covalent bond

The single bond between two hydrogen atoms.

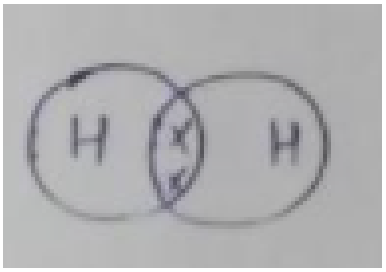
H_2 - That's why hydrogen is a diatomic molecule

2. Chlorine (Cl) Atomic No – 17
electronic configuration- 2, 8, 7
Outermost shell electrons -7

Electron-dot structure of [Cl_2]-
[7 electrons in the outermost shell]
CI – CI
Cl_2 (diatomic molecules) - Single bond between two chlorine atoms.

Double bond -

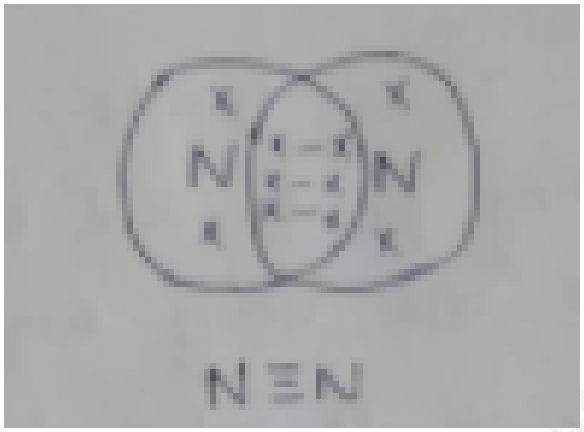
Two electrons contributed by each atom give rise to two shared pairs of electrons.
This is said to constitute a double bond between two atoms.
Example - Oxygen molecule, carbon dioxide molecule
Oxygen atoms - (O)- atomic no. - 8
Electronic configuration (2 ,6)
Outermost shell - 6 elections



O=O
[Double bond by sharing two pairs of electrons] (O2 molecule)
Double bond between two Oxygen atoms.

(3) Triple Bond-

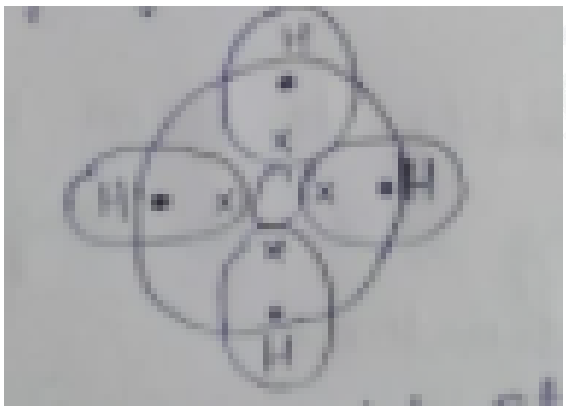
Three electrons contributed by each atom give rise to three shared pairs of electrons. (6 electrons in total). This is said to be a triple bond between two atoms.
Example - Nitrogen molecule.
Nitrogen atoms (N)- atomic No -7
Electronic configuration (2 ,5)
Outermost shell - 5 electrons



(Triple bond by sharing three pairs of electrons)

N_2 molecule
The triple bond between two Nitrogen atoms

Electron-dot structure of Methane $[CH_4]$
Carbon outmost elections - 4
Hydrogen outermost electrons – 1



Electron dot structure of Methane

Properties of covalent bonds
1. Covalently bonded molecules have low melting points and low boiling points.
2. They have weak intermolecular forces.
3. They are most cases poor conductor of electricity because it does not have charged particles.

Covalent bond vs Ionic bond

Covalent bonds	Iconic bonds

1. Melting points and boiling points are low.	Melting points and boiling points are high.
2. The force of attraction between molecules is weak.	Force of attraction between molecules is high.
3. Generally poor conductor of electricity.	3. Good conductor of electricity.

 # Versatile nature of Carbon -

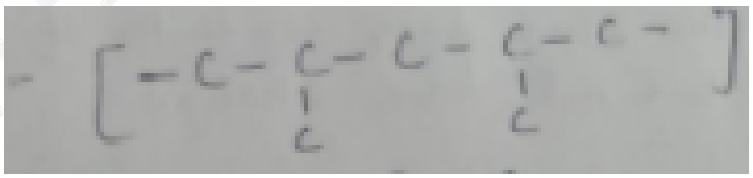
Two main factors enable carbon to form a large no of compounds.

(i) Catenation

(ii) Tetra Valency

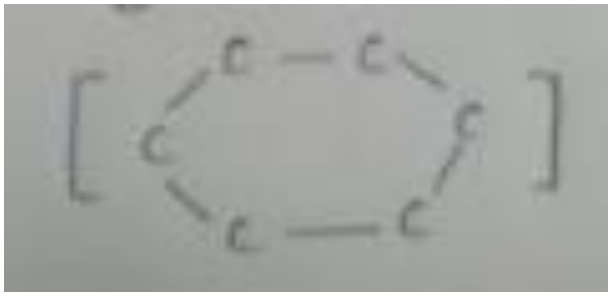
(i) Catenation- Carbon has the unique ability to form bonds with other atoms of carbon, giving rise to large molecules.

This property is called catenation.



Carton can concate by long chains, branched atoms of carbon or in ring forms.

[- C- C - C - C - C -] Chain form



Branch form

Ring form

Note-

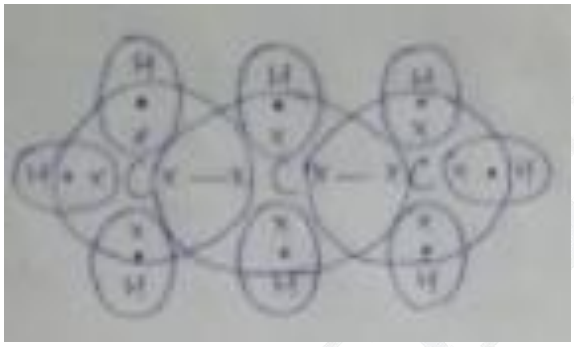
- Silicon also forms compounds with hydrogen which have chains of up to seven or eight atoms, but these compounds are very reactive.
- Carbon-carbon bond is very strong and hence stable.

(ii) Tetra Valency -

Carbon has a valency of four, it has the capability of bonding with four other atoms of carbon or atoms of some other mono-valent element.

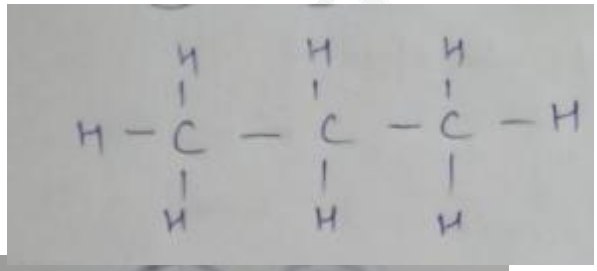
Note - The reason of strong bonds by carbon is its small size. This enables the nucleus to hold on to the shared pairs of electrons strongly, bonds formed by

elements of larger atoms are much weaker.



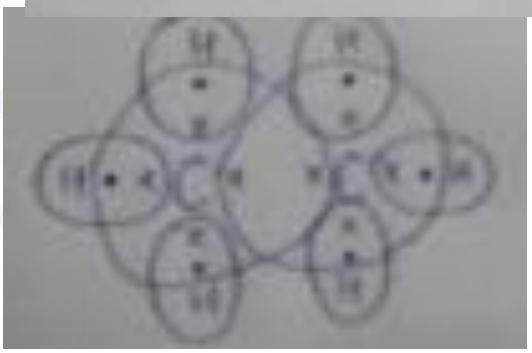
Saturated and unsaturated carbon compounds-

Saturated carbon compounds - Carbon compounds which are having single bond between the carbon atoms are known as saturated carbon compounds.
Example - ethane [C_2H_6) , propane (C_3 H_8) Electron-dot structure of ethane

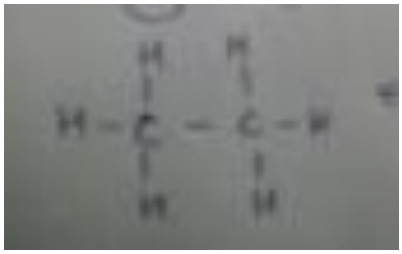


(single bond)

[C_2H6 , Ethane]



Electron-dot structure of Propane -

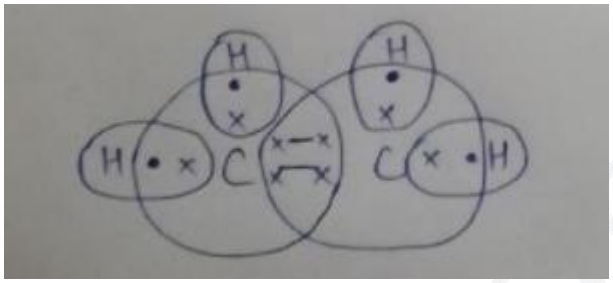


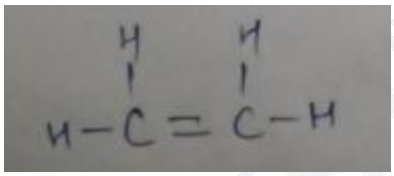
(single bond)

[C_3H8 Propane]

Unsaturated carbon compounds -

Such compounds of carbon having double or triple bonds between the carbon atoms are known as unsaturated carbon compounds.
These compounds are more reactive than the saturated carbon compounds.
Example - Ethene (C_2H_4), Propene (C_3H_6), Ethyne (C_2H_2)
Electron dot structure of Ethene (C_2H_4)

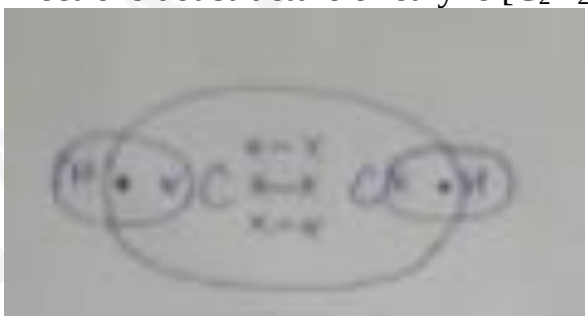




(double bond)

Ethene (C_2H_4)

Electrons dot structure of ethyne [C_2H_2]



H-C ≡ C-H [TRIPLE BOND]

Ethyne [c_2h_2]

Saturated carbons – alkanes: C_nH_{2n+2}

Examples – ethane, butane , pentane

Unsaturated carbons – alkene : C_nH_{2n}

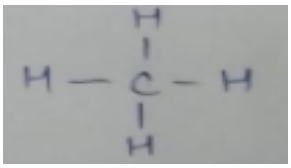
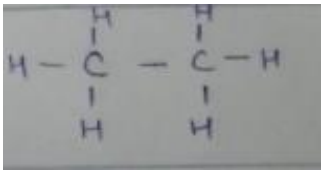
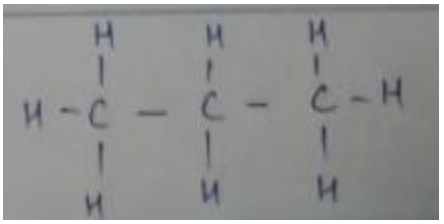
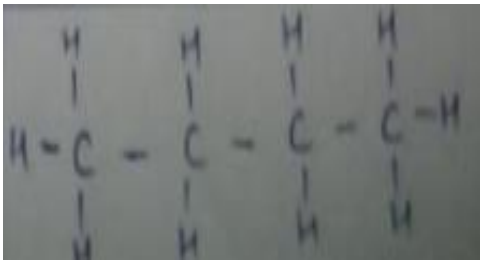
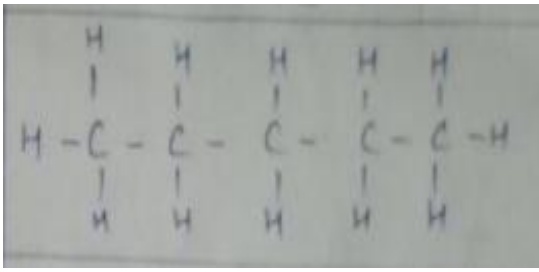
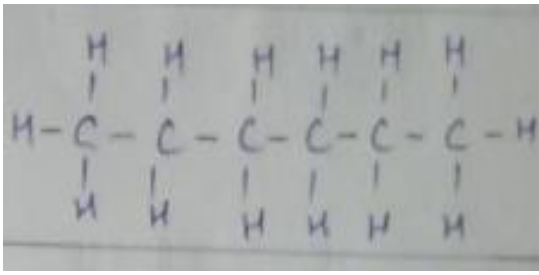
Example – ethene , butene , pentene

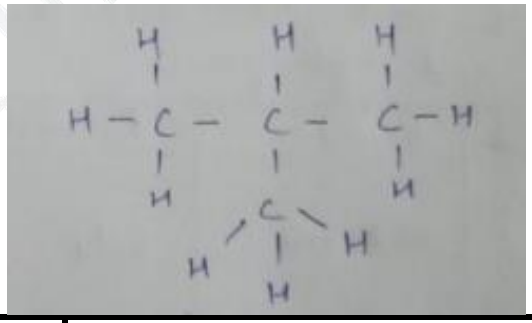
- alkyne : C_nH_{2n-2}

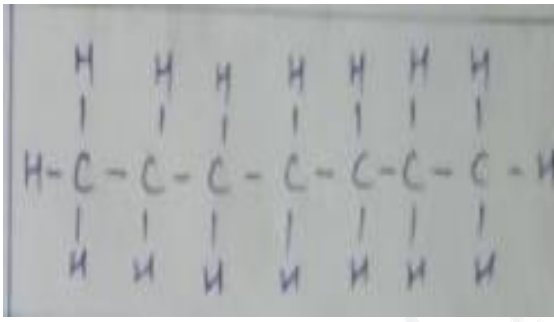
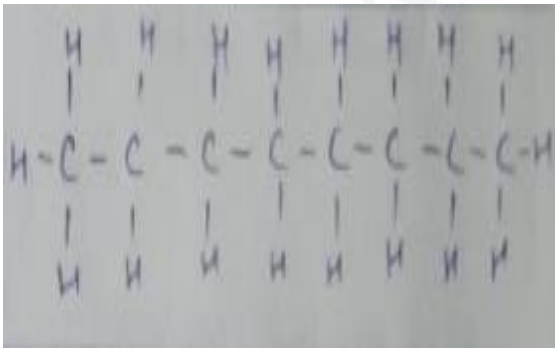
Example- ethyne , butyne , pentyne

Formula and structures of saturated compounds of carbon and hydrogen

No. Of carbon atoms	Name	Formula	Structure

1	Methane	CH_4	
2	Ethane	C_2H_6	
3	Propane	C_3H_8	
4	Butane	C_4H_{10}	
5	Pentane	C_5H_{12}	
6	Hexane	C_6H_{14}	



7	Heptane	C_7H_{16}	
8	Octane	C_8H_{18}	

#Structural Isomers

Compounds with identical molecular formulas but different structures are called isomers.

Example-[C_4H_{10}]

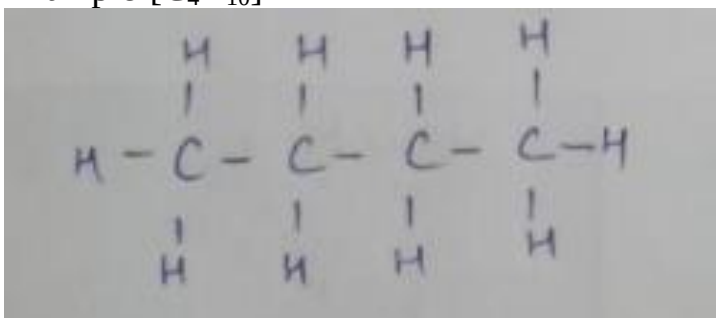


Fig –Two structures of formula C_4H_{10}

These are called structural isomers

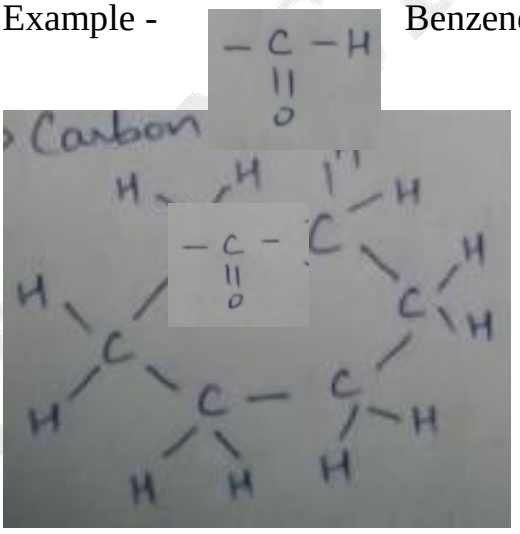
Carbon atoms can also be arranged in a ring form

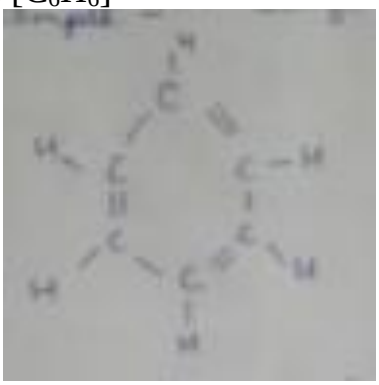
Cyclohexane
Formula [C_6H_{12}]

Structure of Cyclohexane

Unsaturated cyclical carbon compounds

Example - Benzene [C_6H_6]





Structure of Benzene [C_6H_6]

Hydrocarbons -

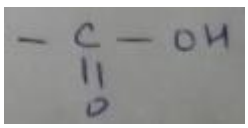
All carbon compounds that contain just carbon and hydrogen are called hydrocarbons.

Functional groups -

In a hydrocarbon chain, one or more hydrogens can be replaced by other elements such as halogens, oxygen, nitrogen, and Sulphur, such that the Valency of carbon remains satisfied, The element which replaces hydrogen is called heteroatoms. These heteroatoms are called functional group.

For example- [Chloro -Cl], [Bromo - Br] [Alcohol - OH] ,
[Aldehyde]

[ketone]

[carboxylic Acid] 

Homologous Series-

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

For example CH_3OH, C_2H_5OH, C_3H_7OH, and C_4H_3OH are all very similar.

The successive members differs by one – CH_2, unit and 14 units of molecular mass.
- As molecular masses increase physical properties change and melting points and boiling points increase.

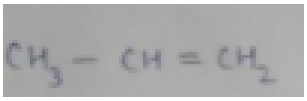
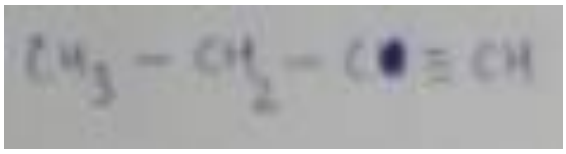
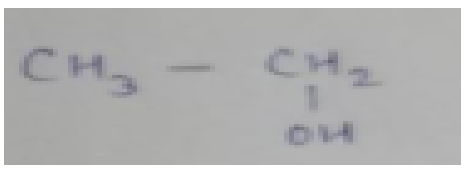
Nomenclature - Giving name to the carbon compounds with functional groups.

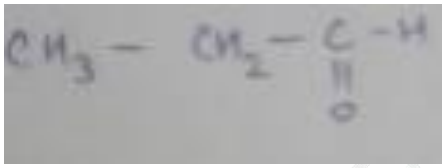
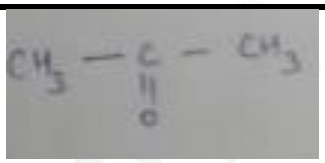
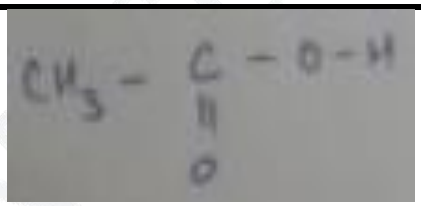
Functional group ***prefix/suffix***

1. **Halogen** **Prefix-chloro, bromo etc.**

2. **Alcohol** **suffix –ol**
3. **Aldehyde suffix –al**
4. **Ketone suffix – one**
5. **Carboxylic acid suffix –oic acid**
6. **Double bond suffix –ene**
7. **Triple bond suffix – yne**

EXAMPLES:

SR NO.	STRUCTURE	NOMENCLA -TURE	REASON
1		**Ethene**	**Double bond**
2		**Ethyne**	**Triple bond**
3		**Propene**	**3 carbon (prop) & double bond(ene)**
4		**Butyne**	**4 carbon (but) And triple bond (yne)**
5		**Ethanol**	**2 carbon (Eth) &Alcohol Functional group in (suffix-ol)**

6		**Propanl**	**3 carbon (prop) & Aldehyde functional group in (suffix -al)**
7		**Propanone**	**3 carbon (prop) & ketone functional group (suffix-one)**
8		**Ethanoic acid**	**2 carbon (eth) & carboxylic acid functional group (suffix-oic acid)**

Chemical properties of carbon compounds –

1. Combustion

— Carbon, in all its allotropic forms, burns in oxygen to give carbon dioxide along with the heat and light.

— Most carbon compounds also related a large amount of heat and light on burning.

→ $C + O_2 \rightarrow CO_2$ + Heat and light

→ $CH_4 + O_2 \rightarrow CO_2 + H_2O$ + Heat and light

→ $CH_3CH_2OH + O_2 \rightarrow Co_2 + H_2O$ + Heat and light

- Saturated Hydrocarbon will generally give a clean flame while unsaturated carbon compounds will give a yellow flame with lots of black smoke which gives a sooty deposit on the metal plate.

— Limiting the supply of air results in incomplete combustion of saturated Hydrocarbon giving a Sooty flame.

— The gas / kerosene store used at home and inlets of air so that a sufficiently oxygen-rich mixture in burnt to give a clean flame.

2. Oxidation –

Carbon compounds can be easily oxidised on combustion. In addition to this complete oxidation, alcohols are converted to carboxylic acids –

$$CH_3 - CH_2OH \xrightarrow[\text{Acidified Or } K_2Cr_2O_4 + \text{Heat}]{\text{Alkaline } KMnU_4 + \text{Heat}} CH_3COOH$$

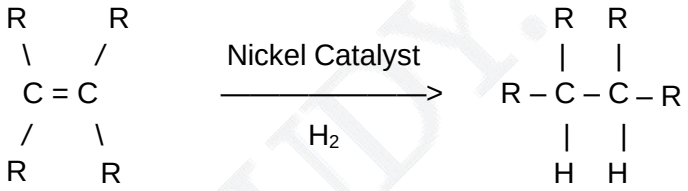
We see that some substances are capable of adding oxygen to others. These substances are known as oxidising agents.

Alkaline potassium permanganate or acidified potassium dichromate are oxidizing alcohol to acids.

3. Addition Reaction

Unsaturated hydrocarbon and hydrogen in the presence of catalysts such as palladium or nickel to give saturated Hydrocarbons.

Catalyts are substances that cause a reaction to occur or proceed at a different rate without there action itself being affected.



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

Substitution Reaction

Saturated hydrocarbon are fairly unreactive and are inert in the presence of most reagents. However, in the presence of Sunlight chlorine is added to hydrocarbon in a very fast reaction.

$$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl \text{ (in the presence of Sunlight)}$$

some important carbon compound –

* Ethanol –

– Ethanol is a liquid at room temperature commonly known as alcohol and is actively ingredient of all alcoholic drinks.

– Alcohol is a good solvent, used in medicines such as tincture iodine, cough syrups and many tonics.

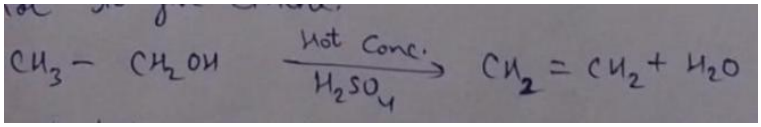
Reaction of ethanol –

(i) Reaction with sodium

$$2Na + 2CH_3CH_2OH \rightarrow 2CH_3\ CH_2O^-Na^+ + H_2$$

(Sodium ethoxide)(ii) Reaction to give unsaturated hydrocarbons

Heating ethanol at 443k with excess concentrated sulpuric acid result in the dehydration of ethanol to give ethene.



Concentrated H_2SO_4 is dehydrating agent with remove water from ethanol.

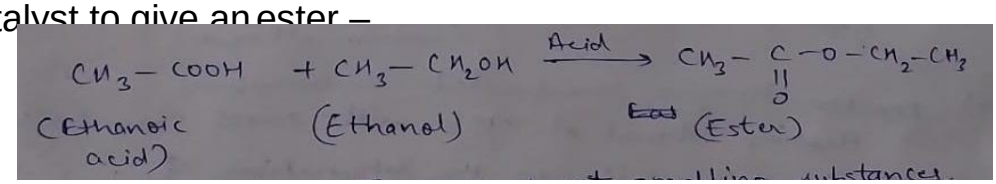
* Ethanoic Acid

– Commonly known as acetic acid
– Belongs to a group of acids called carboxylic acids.
– 5 - 8 % solution of acetic acid in water is called vinegar and is used widely as a preservative in pickles.
– The melting point to pure ethanoic acid is 290k and hence after freezing during winter in cold climates it is also called glacial acidic acid.

Reactions of ethanoic acid –(i) Esterification reaction –

Esters are formed by reaction of an acid and alcohol.

Ethanoic acid reacts with absolved ethanol in the presence of an acid catalyst to give an ester –



Use of esters - they are sweet smelling substances.

They are used in making perfumes and as flavoring agents.

When ester reacts with base, we will find alcohol and acetic acid back.

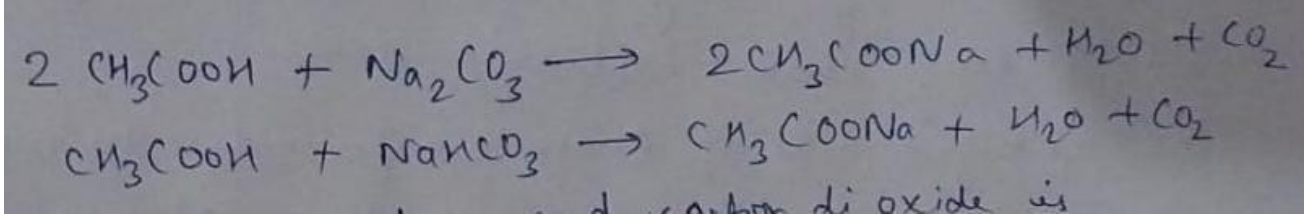
This reaction is also known as Saponification.

(ii) Reaction with water

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

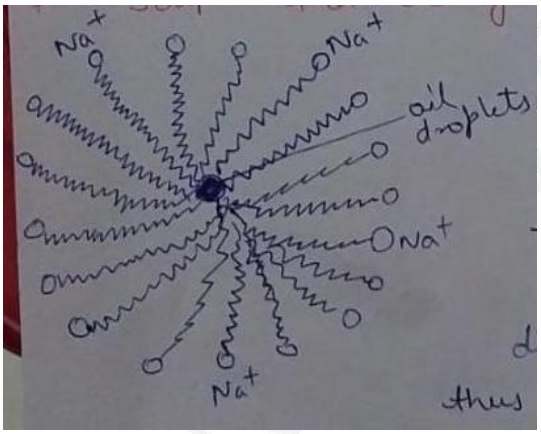
$$NaOH + CH3COOO \rightarrow CH3COONa + H_2O$$

(iii) Reaction with carbonates and hydrogencarbonates.



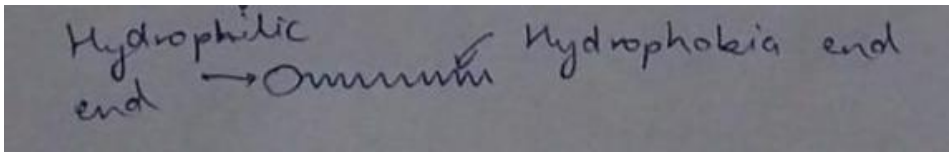
Salt, water and carbon dioxide is produced in this reaction.

The salt produced is commonly called sodium acetate.



– The molecules of soap are sodium or potassium salt of long–chain carboxylic acid.

– The iconic end of soap dissolves in water while the carbon chain dissolves in oil. the soap molecules thus form structures called micelles. Where one end of the molecules is towards the oil droplet while the iconic – end faces outside. This forms an emulsion in water.



The reaction of soap with the calcium and magnesium salt which causes the hardness of the water.

The hardness of water is overcome by using another class of compounds called detergents cleansing agents.

– Detergents are generally ammonium or sulphonate salt 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. Detergents are usually used to make shampoos and products for cleaning clothes.