

SS 3: WEEK 1

ORGANIC CHEMISTRY

Organic Chemistry is the chemistry of carbon compounds.

Organic Compound are made up of few types of elements. They consist mainly of carbon, hydrogen (always present), oxygen, nitrogen, phosphorus and sometimes, metals.

HYDROCARBONS

These are compounds containing carbon and hydrogen only. They have the formula C_xH_y where x and y are whole numbers.

MAIN SOURCES OF HYDROCARBONS

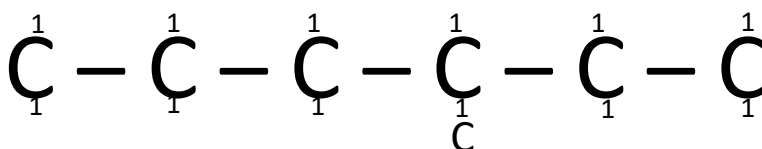
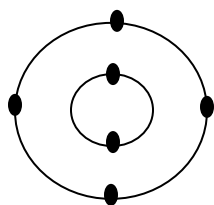
The natural sources of hydrocarbon include:

1. **Coal**:- Destructive distillation of coal gives coal-tar, which when fractional distillation is carried out yields organic compounds like phenol, toluene, benzene. These are used as starting materials for other products.
2. **Natural Gas**:- Contains mainly $C_1 - C_4$ compounds.
3. **Petroleum**.

CARBON

Carbon has atomic number 6. It has four electrons in the outer shell which could be involved in bonding. It forms mainly covalent bonds.

Carbon has the ability to combine with one another to form chains of carbon atoms. This is called Catenation.



Catenation

Electronic Structure of Carbon.

It is also possible for the 2 S Orbital to mix with the 2 P Orbitals during chemical reaction to form hybrids. Hence we have SP^3 , SP^2 or SP hybridisation.

GENERAL CHARACTERISTICS OF ORGANIC COMPOUNDS

1. Most organic compounds are entirely covalent – hence they are largely non polar and do not ionize in solution and are non conducting.
2. They are generally insoluble in water.
3. They are soluble in organic solvents like benzene, ether.
4. They have low M.P. and B.P. compared to inorganic compounds.
5. They are thermally unstable. Many are volatile.
6. Many organic compounds are highly inflammable.

7. Reactions of organic compounds are generally slow compared to inorganic compounds.

DETERMINATION OF FORMULA OF ORGANIC COMPOUNDS

1. The interest is on the structure and configuration of compounds obtained. We can also determine the elements present in the pure compound and their ratio; or the molecular masses.

An organic compound on analysis was found to contain 80% carbon and 20% hydrogen. Find: (a.) The empirical formula (b.) The molecular formula of the compound if the molecular mass is 30.

[C = 12, H = 1].

$$\begin{array}{rcl} \text{C} & = & \frac{80}{12} \\ & = & \frac{6.6}{6.6} \\ & = & 1 \\ \text{H} & = & \frac{20}{1} \\ & = & \frac{20}{6.6} \\ & = & 3 \\ \text{EF} & = & \text{CH}_3. \\ (\text{EF}) & = & \text{MF} \\ (\text{CH}_3)_n & = & 30 \\ (12+3)_n & = & 30 \\ 15n & = & 30 \\ n & = & \frac{30}{15} = 2 \\ (\text{EF})_n & = & \text{Mf} \quad (\text{CH}_3)_2 = \text{C}_2\text{H}_6. \end{array}$$

2. An organic compound contains carbon, hydrogen and oxygen. Analysis shows that it has 37.5% C and 12.5% Hydrogen. The rest is oxygen. If the molecular mass is 65, determine: (a.) Its empirical formula (b.) Its molecular formula. [H = 1, C = 12, O = 16].

3. A hydrocarbon on analysis consists of 92.3% carbon. If its vapour density is 39, determine molecular formula. [H = 1, C = 12].

NOMENCLATURE OF ORGANIC COMPOUNDS

_____IUPAC NOMENCLATURE

The basis of the IUPAC system of nomenclature is that every name consists of a root, a suffix and as many prefixes as necessary.

Root:- The root is generally an alphabetic hydrocarbon. All aliphatic compounds are regarded as being derived from this root hydrocarbon by (a) The replacement of hydrogen atoms by alkyl or functional groups.

(b.) The introduction of multiple bonds (double or triple)

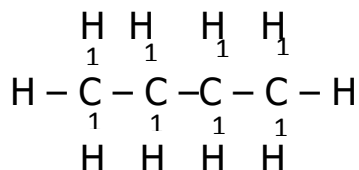
A suffix is added to the root to indicate the presence of the principal constituent which is usually also the principal functional group in the molecule.

CLASSIFICATION OF ORGANIC COMPOUNDS

Organic compounds can be classified into aliphatic and aromatic compounds according to their molecular structures i.e. the arrangement of atoms in the molecules.

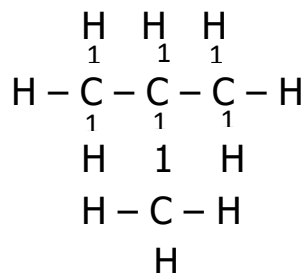
ALIPHATIC COMPOUNDS

Compounds whose molecules are composed of chains carbon atoms are known as aliphatic compounds. Eg:



Butane normal straight chain

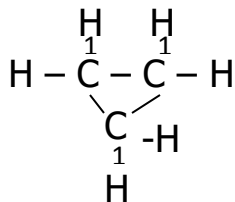
OR



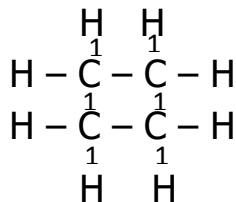
2-methyl propane

Branched chain

Sometimes, the end carbon atoms of an open aliphatic chain can also join together to form a closed system or ring. Such compounds are known as cyclic compounds.

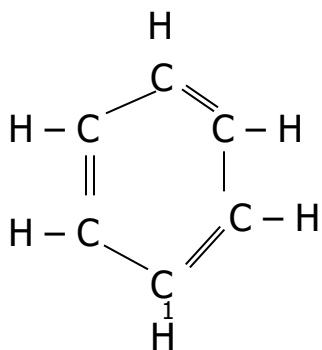


Cyclopropane.

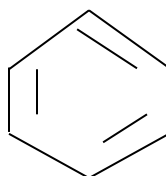


AROMATIC COMPOUNDS

Aromatic compounds are a special class of cyclic compounds based on benzene, C_6H_6 , a six numbered ring.



OR



HOMOLOGOUS SERIES

It is a series of compounds that contain a particular group of atoms called the functional group of the series. The functional group is responsible for giving the molecules in the family their chemical property.

A homologous series is a family of compounds (organic) with peculiar characteristics. These include:

1. All members of a homologous series share a general molecular formula e.g. the alkanes- C_nH_{2n+2} .
2. Each successive member differs from the next in molecular formula by the addition of a- CH_2 -gp or increase in molecular mass by 14.
3. The physical properties of the members change gradually as the number of carbon atoms increase. Graduation in physical properties e.g. M.P., B.P.
4. All members show similar chemical properties although they vary gradually in reactivity along the series. E.g. all alkenes burn in air to form carbon (iv) oxide and water.
5. All members can usually be prepared by using the same general method.

Examples of Homologous Series

Alkanes	_____	C_nH_{2n+2}
Alkenes	_____	C_nH_{2n}
Alkynes	_____	C_nH_{2n-2}
Alkanols	_____	$C_nH_{2n+1}OH$
Alkanoic Acids	_____	$C_nH_{2n+1}COOH$.

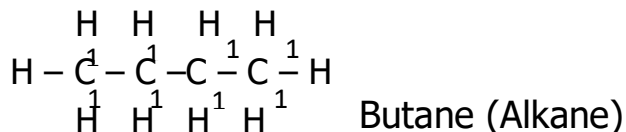
FUNCTIONAL GROUP

A functional group is an atom, a radical or a bond common to a homologous series and which determines the properties of the series.

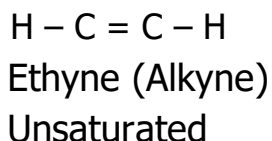
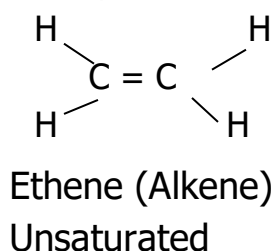
HOMOLOGUS SERIES	GENERAL FORMULA	FUNCTIONAL GROUP
Alkanes	$R - H$	—Single Bond
Alkenes	$C = C$	= Double Bond
Alkanols	$R - OH$	—OH
Alkanoic Acid	$R - C \begin{array}{l} \nearrow O \\ \searrow O-H \end{array}$	$C \begin{array}{l} \nearrow O \\ \searrow O-H \end{array}$
Primary Amines	$R - NH_2$	— NH_2
Alkanals	$R - C \begin{array}{l} \nearrow O \\ \searrow H \end{array}$	$—C \begin{array}{l} \nearrow O \\ \searrow H \end{array}$
Alkanone	$R \begin{array}{l} \nearrow \\ \searrow \end{array} C = O$	— $C = O$

SATURATED AND UNSATURATED COMPOUNDS

If an organic compound contains atoms joined by single bonds only the compound is said to be saturated. E.g. the Alkanes



If an organic compound contains carbon atoms joined by double or triple bonds the compound is said to be unsaturated.



WEEK 2

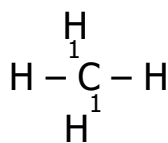
ALKANES

Alkanes form homologous series with the general formula $\text{C}_n\text{H}_{2n+2}$. Where $n = 1, 2, 3$, etc. Alkanes are saturated with single bonds between the carbon atoms. They are Sp^3 hybridized.

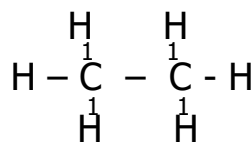
FORMULA OF ALKANES

Where $n = 1$	=	CH_4
$= 2 =$	C_2H_6	
C_3H_8		Propane
C_4H_{10}		Butane
C_5H_{12}		Pentane
C_6H_{14}		Hexane etc.

STRUCTURE OF ALKANES



Methane



Ethane

ALKYL GROUPS

Alkyl groups include all group derived from the alkanes by the loss of a hydrogen atom. Alkyl groups have a general formula C_nH_{2n+1} . They are named after the parent hydrocarbon by replacing the ending –ane by -yl.

PARENT ALKANE	ALKYL GROUP	FORMULA
Methane	Methyl	$CH_3 -$
Ethane	Ethyl	$C_2H_5 -$
Propane	Propyl	$C_3H_7 -$
Butane	Butyl	$C_4H_9 -$
Pentane	Pentyl	$C_5H_{11} -$

THE HALOGENS – NOMENCLATURE

F = Fluoro

Cl = Chloro

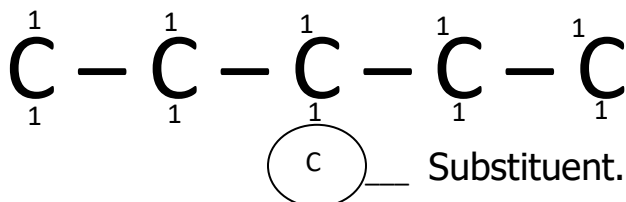
Br = Bromo

I = Iodo.

NOMENCLATURE OF ALKANES - RULES

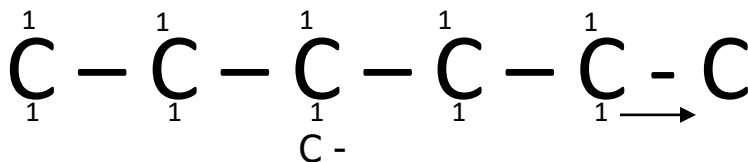
1. Take the longest continuous carbon chain as the root hydrocarbon and name it according to the number of carbon atoms it contains.

E.g.



Here the root hydrocarbon contains five carbon atoms and is a pentane.

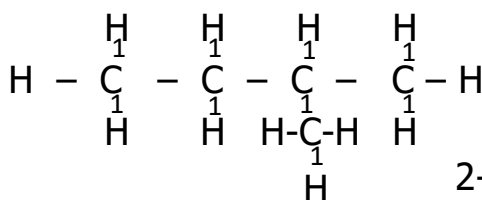
2. Number the carbonation in the root hydrocarbon from the end which will give the lowest number to the substituent e.g.



Here the substituent is given the number 3, not 4 (count from the left)

3. Indicate the other substituents by prefixes preceded by numbers to show their positions on the carbon chain

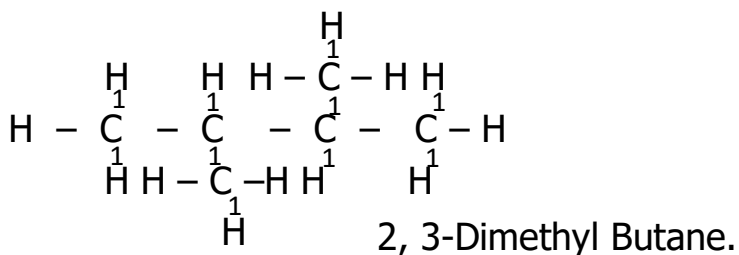
E.g.



2-methyl butane.

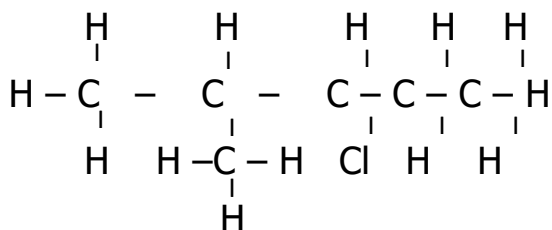
4. When more than one of the same substituent groups is present the multiplying prefixes di for two, tri for three, and tetra for four are used.

E.g.



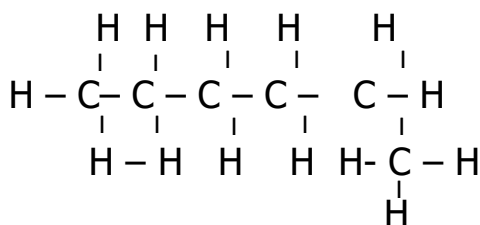
5. If more than one prefix is needed they are placed in alphabetical order

E.g.



3-Chloro, 2-Methyl, Pentane.

6. Where a carbon chain is joined at the first position ie. carbon atom no 1, the carbon chain becomes part of the compound, not a substituent:



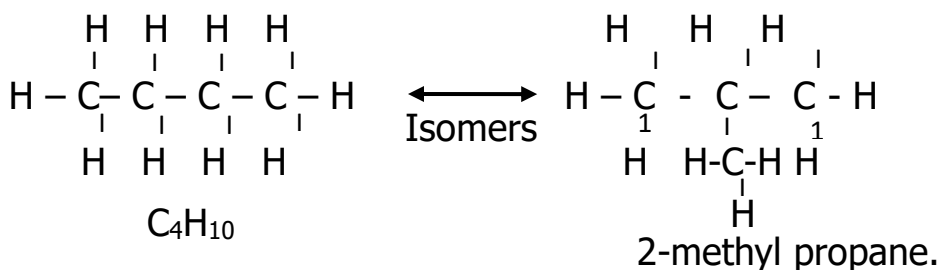
This is hexane and not 1-methylpentane.

Write the structure of

- a) 2, 3 - dimethyl hexane
- b) 2, 2 - dibromo butane
- c) 2 - chloro, 3 - methyl butane
- d) 2, 2, 4 - trimethyl pentane
- e) 2, 4 - dichloro, 3, 5 dimethyl octane
- f) 6 - ethyl 2, 4, 4 - trimethyl nonane

ISOMERISM IN ALKANES

Isomerism is the existence of two or more compounds with the same molecular formula but different molecular structures.



Assignment

1. Isomers of pentane

2. Isomers of hexane

Isomers could arise from (1) branching (2) existence of members as different homologous series

(3) positioning of functional groups (4) positioning of carbon-carbon multiple bonds.

ALKANES - PREPARATION OF METHANE

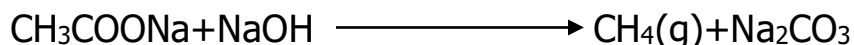
Methane is the major constituent of natural gas. It is given off from swamps - marsh gas. It is also found in coal mines - cause if explosion in mines.

LABORATORY PREPARATION

Methane is usually prepared by heating anhydrous sodium ethanoate with an alkali, usually soda lime. Soda lime is quicklime (CaO) slaked with concentrated solution of sodium hydroxide. It is used in preference to caustic soda (NaOH) because:

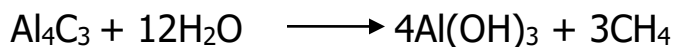
(a) It is not deliquescent (b) It does not attack glass easily.

Method: Ground equal mass of Sodium ethanoate and sodalime. Heat in a test tube (hard glass). Methane is given off.

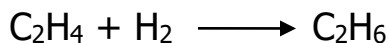


From Sodalime

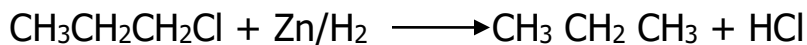
(2) Action of water on aluminum carbide



(3) Hydrogenation of Alkanes



(4) Reduction of Alkyl halide



PHYSICAL PROPERTIES OF ALKANES

1. Methane is a colourless and odourless gas

2. It is only slightly soluble in water (higher members are insoluble)

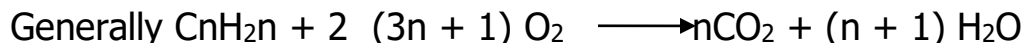
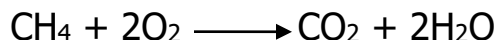
3. It is less dense than air I. Density = $16/2 = 8$

4. It has no action on litmus paper.

CHEMICAL PROPERTIES

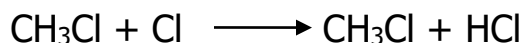
1. Combustion

Alkanes burn in air to form carbon (iv) oxide and steam

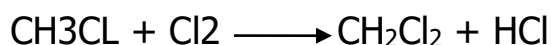


2. Substitution reaction (direct displacement of an atom or groups of atoms)

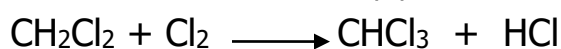
Methane reacts with chlorine in the presence of UV light to yield a variety of products in substitution reaction



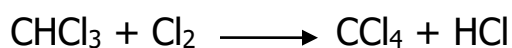
Chloromethane



I, I, dichloromethane



I, I, I, trichloromethane (chloroform)



I, I, I, I, tetrachloromethane

USES OF ALKANES (METHANE)

1. It is used as fuel mixed with other hydrocarbon
2. Used for producing trichloromethane, an anaesthetic
3. It is used for producing tetrachloromethane, an organic solvent.

WEEK 3

ALKENES (OLEFINS)

Alkenes form a homologous series with the general formula C_nH_{2n} where $n \neq 1$ but 2, 3, 4 etc.

They contain two hydrogen atoms less than the corresponding alkanes.

They are unsaturated

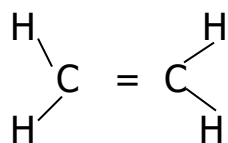
They are SP^2 hybridized.

They contain at least one double bond between two carbon atoms (contain one sigma and one P_1 bond) $\text{C} = \text{C}$

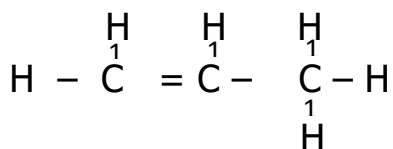
Members

$n = 2$	$=\text{C}_2\text{H}_4$	Ethene
	C_3H_6	Propene
	C_4H_8	butene
	C_5H_{10}	Pentene
	C_6H_{12}	Hexene

STRUCTURES



Ethene

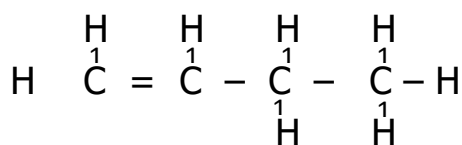


Propene.

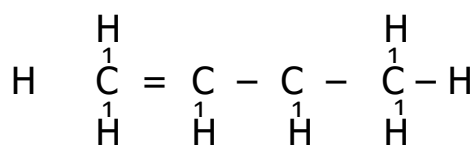
NOMENCLATURE

Alkenes are named using the same general rules as described for alkenes but adding the suffix (ending) - ene instead of - ane.

2. They are named in such a way that the lowest possible number is given to the double bond which is the functional group.
3. The position of the double bond is always indicated.

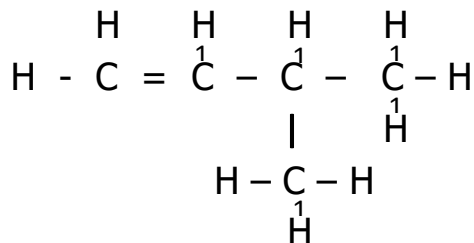


But - 1 - ene

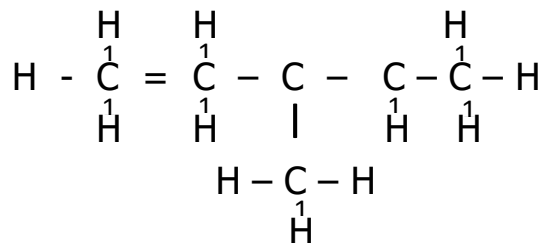


But - 2 - ene

STRUCTURAL ISOMERS

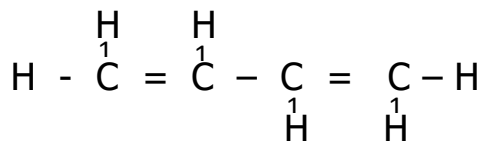


3 - methyl - but - 1 - ene



3 - methyl pent - 1 - ene.

There could be conjugated double bond

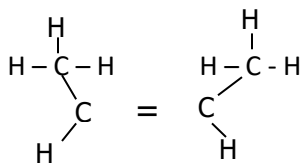


But - 1, 3 - diene.

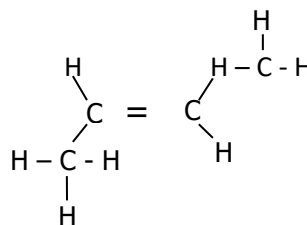
GEOMETRIC ISOMERISM

Geometric isomerism exists in alkenes. This type of isomerism exists in unsaturated compounds (double or triple bonds) where multiple bonds hinder rotation.

Where two similar groups are on the same side as the double bond the compound is called the Cis isomer (same (German)). When similar groups of atoms are on opposite side of the double bond the compound is called trans- (opposite) isomers.

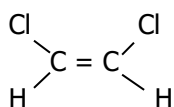


and

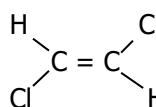


Cis – But – 2 – ene

Trans – But – 2 – ene



and



Cis – 1, 2 – dichloroethene

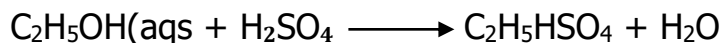
Trans- 1, 2 – dichloroethene

Note: Isomers have similar chemical properties but physical properties differ.

LABORATORY PREPARATION OF ETHENE

Ethene is prepared by heating ethanol with excess concentrated H_2SO_4 at 170°C . The reaction occurs in two stages:

1. On mixing the ethanol and the acid in a volume ration of 1:2 respectively.



Ethanol

Ethylhydrogen tetraoxosulphate (vi)

DIAGRAM

PHYSICAL PROPERTIES OF ALKENES

1. Ethene is a colourless gas with a faint sweetish smell.
2. There is a gradation in the properties of alkanes \longrightarrow 1st 3 are gases, $\text{C}_5 - \text{C}_{17}$ are liquid.
3. Boiling points rise with increase in molar mass
4. Ethene is only sparingly soluble in water
5. It is slightly less dense than air
6. It has no action on litmus
7. Alkenes tend to burn with a more luminous, smoky flame than the alkanes since they contain a higher percentage of carbon.

CHEMICAL TEST FOR ALKENES

1. Alkenes decolourless bromine water. This is the usual test for unsaturation.
2. They turn the purple colour of acidified KMnO_4 colourless

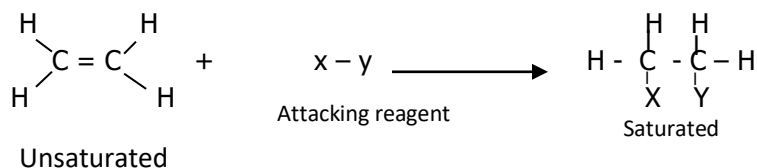
CHEMICAL PROPERTIES

1. Combustion: Ethene burns readily in oxygen with a smoky flame to produce water and carbon (iv) oxide



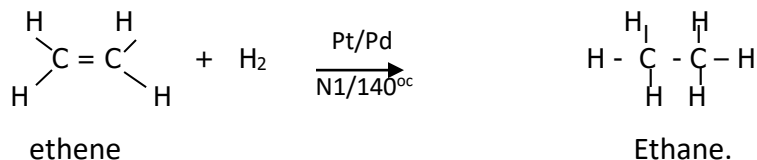
REACTIONS

Ethene undergoes mainly addition reactions. Addition reactions are characteristics of unsaturated compound. During an addition reaction, an unsaturated compound (alkene) is converted to a saturated one.

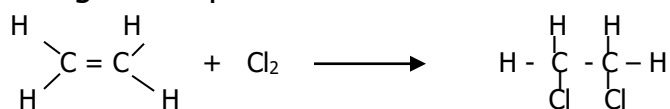


1. Addition of hydrogen (Hydrogenation)

When a mixture of ethene and hydrogen is passed on finely divided platinum or palladium as catalyst at room temperature or over nickel catalyst at 140°C a saturated compound is formed.

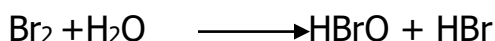


2. Addition of halogens (Halogenation). The halogens add on to ethene to form halogenated products.

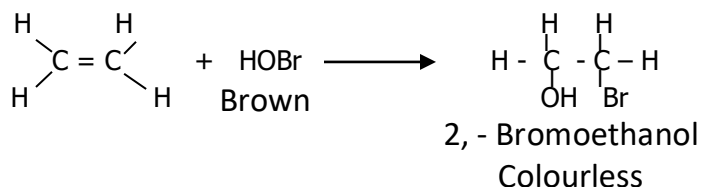


With Bromine we have 1, 2 – dibromoethane. Order of reactivity $\text{F} > \text{Cl} > \text{Br} > \text{I}$.

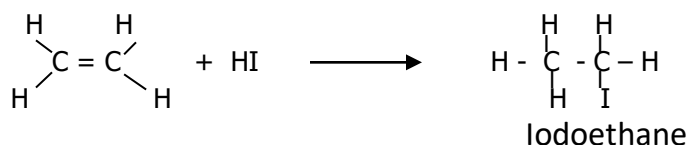
3. Addition of bromine water – Test for unsaturation



Oxobromate (1) acid (bromine water)

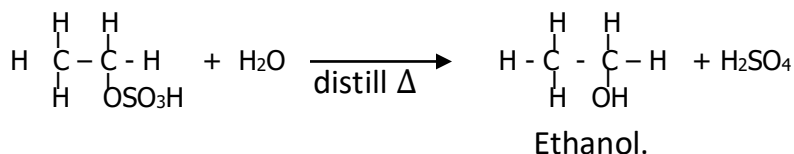
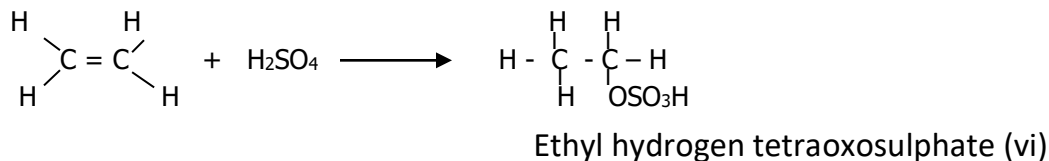


4. Reaction with Hydrogen Halide (HCl, HBr, HI, HF)

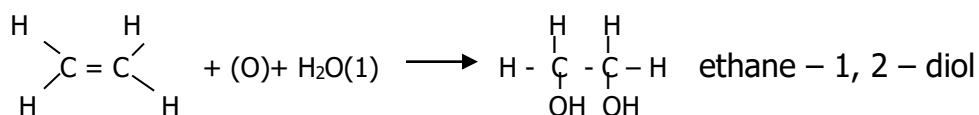


Order of reactivity is $\text{HI} > \text{HBr} > \text{HCl} > \text{HF}$.

5. Hydration: (Addition of water). This is indirectly carried out with fuming H_2SO_4 reactions is at room temperature. With conc. it is 70°C

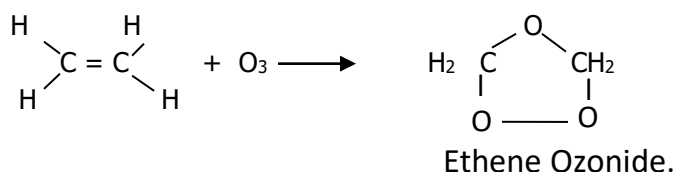


6. Oxidation: When ethene is bubbled through a dilute solution of KMnO_4 , oxidation occurs (ethylene glycol)



The purple colour of KMnO_4 changes to Colourless

7. Ozonolysis – Addition of ozone



8. POLYMERISATION: It is a process whereby 2 or more simple molecules are linked to form a larger molecule.

USES OF ETHENE

1. It is the main source of many organic compounds. - ethanol etc.
2. They are raw material for making plastics, pipes etc.
3. It is used in the manufacture of synthetic rubber
4. It is used for manufacture of detergent
5. Low concentrations of ethene are used to hasten the ripening of fruits

WEEK 4 AND 5

ALKYNES

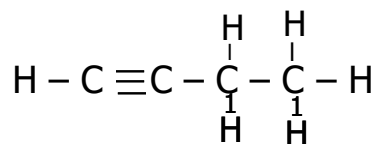
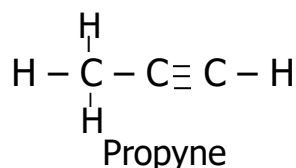
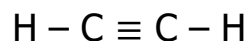
They form homologous series of unsaturated hydrocarbons. The functional group of alkynes is $\text{C} \equiv \text{C}$.

They possess a triple bond between two of the carbon atoms. They have a general formula $\text{C}_n\text{H}_{2n-2}$ where n is a positive whole number ≥ 2 .

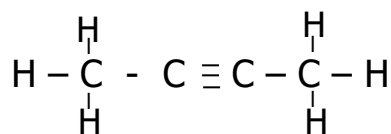
Each alkyne molecule has four hydrogens less than the corresponding alkane and two less than the corresponding alkene. Alkynes are sp hybridized. The first four members of the alkyne family are:

C_2H_2	$\text{CH} \equiv \text{CH}$	Ethyne	Acetylene
C_3H_4	$\text{CH} \equiv \text{CCH}_3$	Propyne	Methyl Acetylene
C_4H_6	$\text{CH} \equiv \text{CCH}_2\text{CH}_3$	Butyne	Ethyl Acetylene
C_5H_8	$\text{CH} \equiv \text{C}(\text{CH}_2)_2\text{CH}_3$	Pentyne	Propyl Acetylene

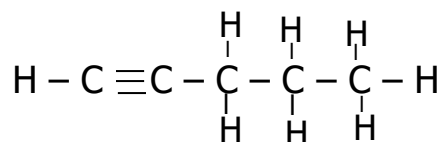
STRUCTURE



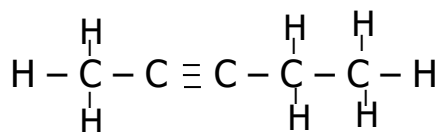
But – 1 – yne.



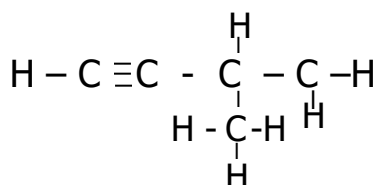
But – 2 – yne.



Pent – 1 – yne



Pent – 2 – yne.

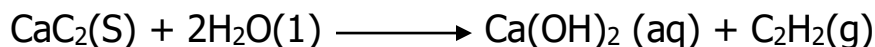


3 – methyl But – 1 – yne.

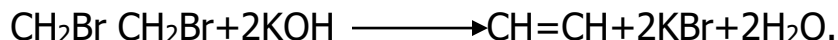
PREPARATION OF ETHYNE

DIAGRAM – 15 lines

Ethyne is usually prepared in the laboratory by the action of cold water on calcium carbide. The gas evolved is impure because it contains impurities from calcium carbide. These impurities such as calcium sulphide, calcium phosphide and calcium nitride react with water. On reacting with water these impurities yield gaseous impurities such as H_2S , PH_3 (phosphine) and NH_3 . The gaseous impurities are removed by bubbling the ensuring gas through aqueous $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$



Another method of preparing C_2H_2 is by dropping 1, 2-dibromoethane into boiling ethanolic solution of KOH .

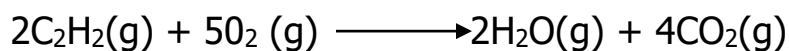


PHYSICAL PROPERTIES OF ETHYNE

1. Ethyne is a colourless gas with a sweet smell when pure
2. It is sparingly soluble in water
3. It is slightly less dense than air. Its V.D. is about $13 = \frac{\text{C}_2\text{H}_2}{\text{H}_2} = \frac{26}{2} = 13$
4. It is unstable and may explode on compression to a liquid. For storage purpose it is usually dissolved in propanone and kept in steel cylinders at about 12 atm.

CHEMICAL PROPERTIES

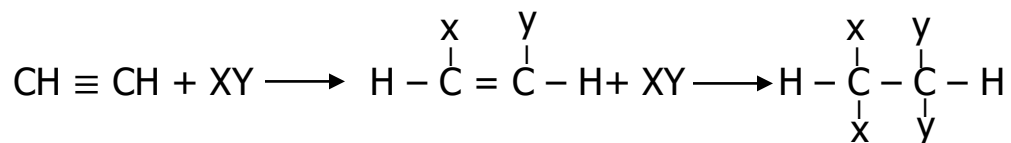
1. **Combustion:** Ethyne burns in air to give a very smoky and luminous flame owing to its high carbon content (92% by mass). A mixture of ethyne with air or oxygen may explode violently on ignition. In pure oxygen, ethyne burns with a non-luminous flame.



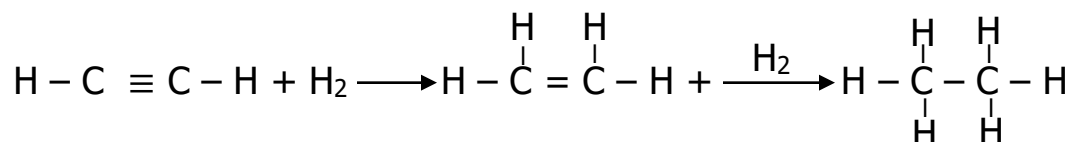
ADDITION REACTION

Ethyne is highly unsaturated containing a Carbon-Carbon triple bond in its structure. It hence undergoes addition reaction, combining with a maximum of four univalent atoms or radicals per molecule.

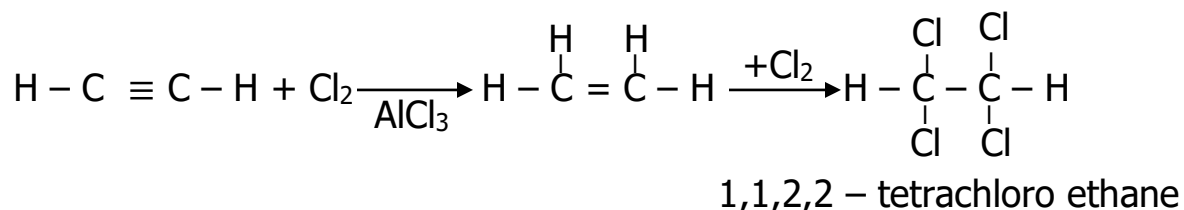
The reaction takes place in two stages. The 1st stage yields a product with a carbon double bond. The second converts this into a fully saturated compound with carbon-carbon single bond.



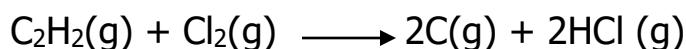
With Hydrogen: Ethyne reacts with twice its volume of hydrogen in the presence of an nickel catalyst at about 200^oc to give first ethene and then ethane.



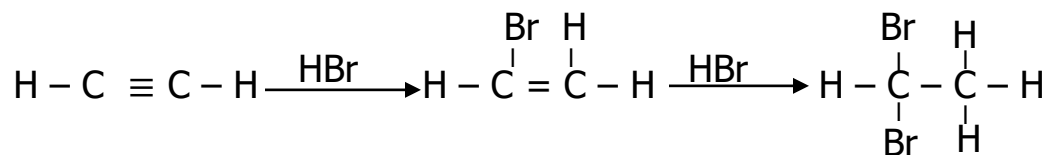
With The Halogens: Ethyne reacts with chlorine bromine in the presence of a metallic iodide catalyst (AlCl₃) at room temperature.



For chlorine, if pure ethyne and chlorine are used in the absence of a catalyst, carbon and hydrogen chlorine are formed. The reaction is explosive.



With Hydrogen Halides: Ethyne combines with HI at room temperature and HBr at 100^oc reaction with HCl is slow.

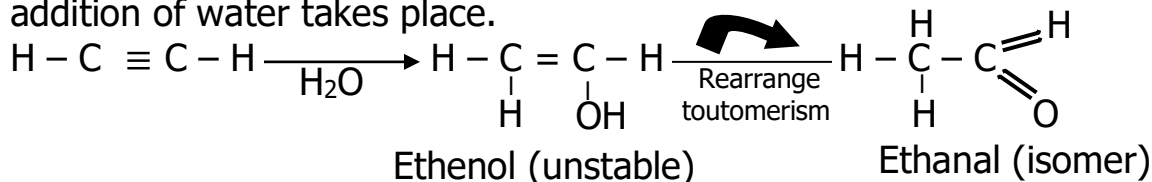


1,1,dibromo ethane.

This follows markownikoff's rule.

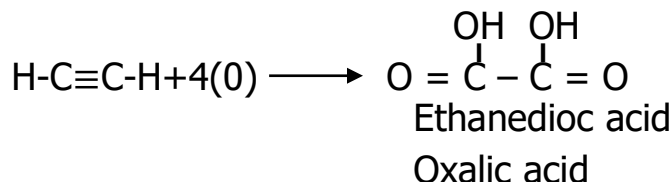
In the addition of a halogen acid to a halogenated compound, the halogen of the halogen acid adds to the carbon atom carrying the first halogen.

With Water: Pass ethyne through dil H_2SO_4 at 60°C with HgSO_4 as catalyst, addition of water takes place.



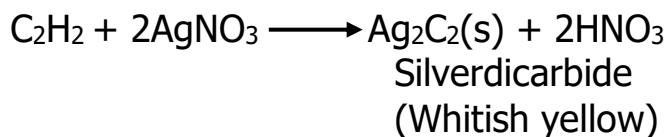
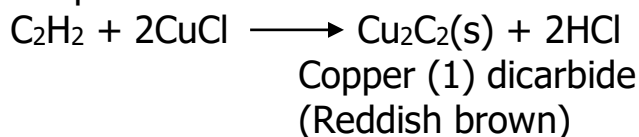
With Acidified KMnO_4

Ethyne decolourises acidified KMnO_4



SUBSTITUTION REACTION

Pass ethyne through ammoniacal solutions of CuCl and AgNO_3 at room temperature



This reaction distinguishes ethyne from ethene.

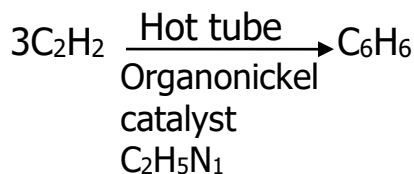
Note: Reaction is possible where the triple bond is at the end of the carbon chain ($\text{RH} = \text{CH}$)

The products give ethyne when warmed with a dilute acid



POLYMERIZATION

Ethyne polymerises to form the aromatic hydrocarbon benzene.



USES OF ETHYNE

- Used as fuel in lamps such as miners lamp
- When mixed with oxygen ethyne produces very hot flame known as oxyacetylene flame (oxyethyne flame) for welding
- It is a source of ethanol and some solvents like 1, 1, 2, 2,- tetrachloroethane used in dry cleaning industry.
- Polymerization of ethyne and its derivatives leads to series of products such as neoprene artificial rubber, dichloro ethene, plastics etc.

WEEK 6

AROMATIC COMPOUNDS - BENZENE

Aromatic compounds are a group derived from the parent hydrocarbon, C_6H_6 , benzene.

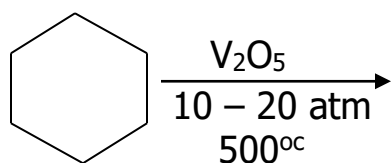
Their names are so derived as some have aromatic smell.

SOURCES

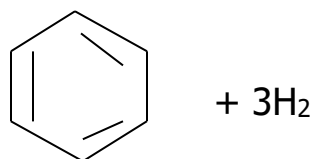
1. From coal tar: Together with phenol, toluene etc.
2. From petroleum hydrocarbons

OTHER SOURCES

- a. Hydroforming (catalytic reforming) - involves the conversion of straight chain to branched hydrocarbons and formation of benzene.

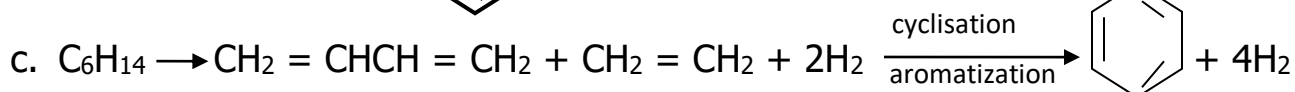
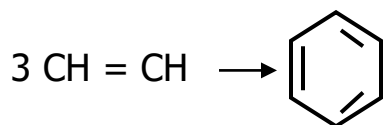


Cyclohexane (C_6H_{12})



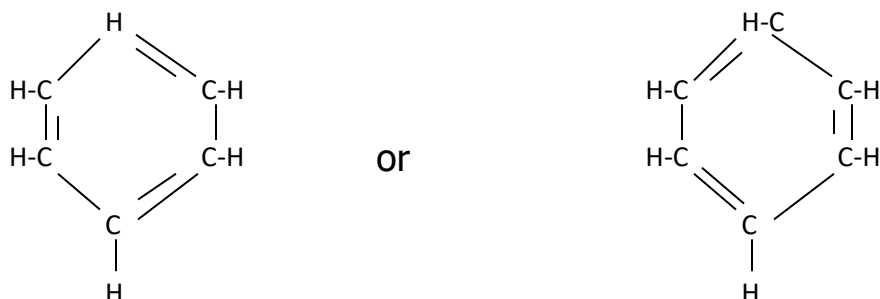
Benzene (C_6H_6)

- b. Polymerization of Ethyne
 $3CH \equiv CH$



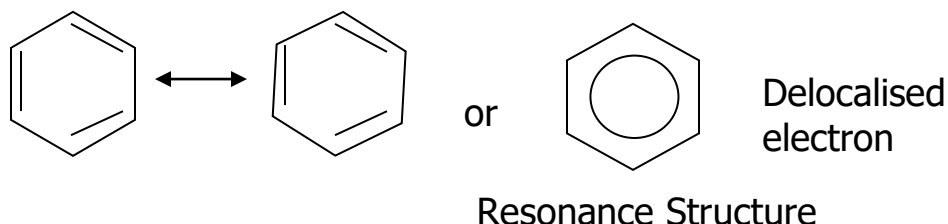
FORMULA/STRUCTURE OF BENZENE

It was difficult proposing a structure for benzene. In 1866, a French chemist, Kekulé proposed a ring structure represented by a regular hexagon with six (6) alternate single and double bond.



The structure explained a number of observed features in the chemistry of benzene.

Bonding is considered a delocalised electron cloud spread over the whole ring. The real structure is a **resonance**, oscillating between the carbon structures.

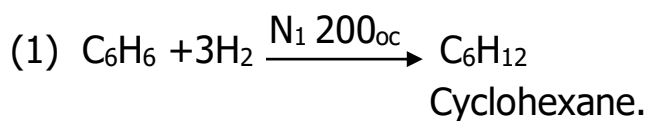


PHYSICAL PROPERTIES OF BENZENE

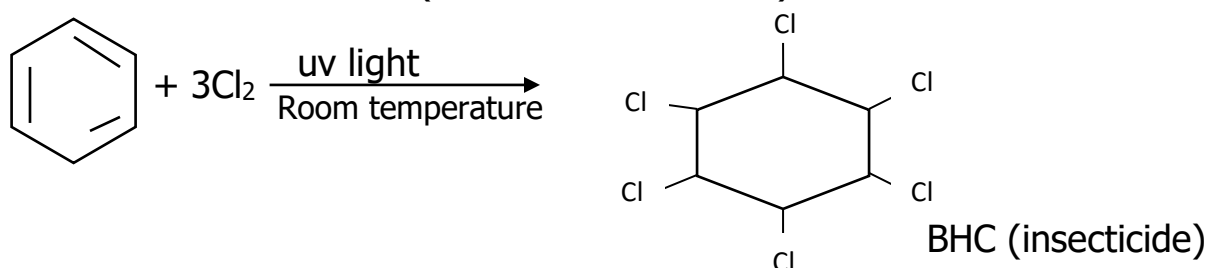
1. It is a colourless volatile liquid with a characteristic aroma.
2. It boils at 353(80°C) and freezes at 278.5K(5.5°C). It is immiscible with water but mixes with ethanol and toluene. It is a good solvent for fat, oils, etc.
3. It burns in air with a smoky flame due to its high carbon content.

CHEMICAL PROPERTIES

In most of its reactions benzene nucleus remains intact. It exhibits some unsaturated character. It undergoes some addition reaction.



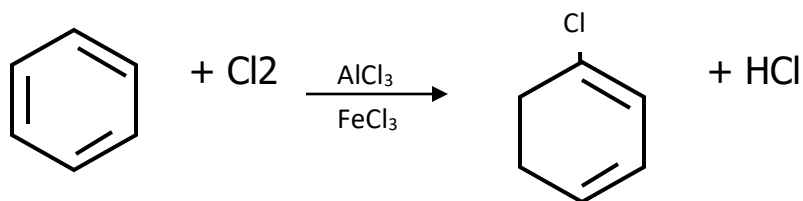
- (2.) In UV light, chlorine adds to benzene to form 1,2,3,4,5,6 hexachlorocyclohexane (benzenehexachlorine)



SUBSTITUTION REACTION

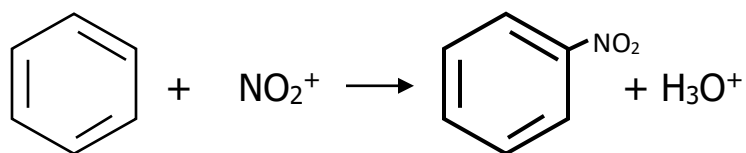
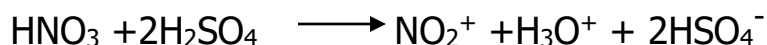
This is the main reaction of benzene.

(1.) with Chlorine/Bromine using a halogen carrier, we have



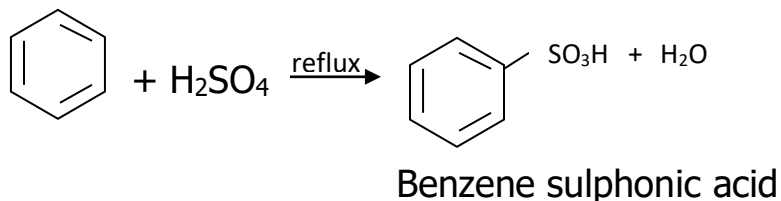
With Br/FeBr₃ we have bromobenzene.

(2.) Nitration:- This is carried out using a nitrating agent



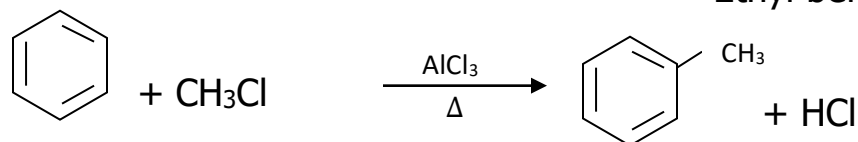
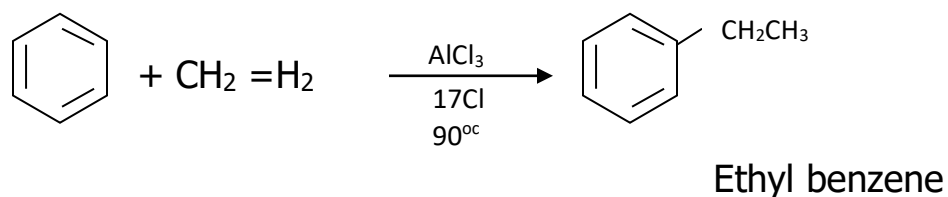
Could lead to C₆H₄(NO₂)₂ or C₆H₃(NO₂)₃, an explosive

Sulphonation:- If benzene is refluxed with conc H₂SO₄ for 12hrs benzene trioxosulphate(iv) (sulphonic acid) is formed.



OTHER REACTIONS

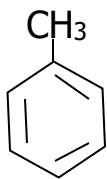
Friedel craft reaction- reaction with ethene



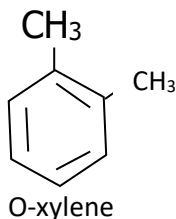
USES OF BENZENE

1. It is used as fuel, a solvent for oils and resin
2. It is used in manufacturing other chemicals like toluene, phenol etc.
3. It is a starting material for polystyrene.
(Packaging material).

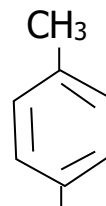
OTHER AROMATIC COMPOUNDS



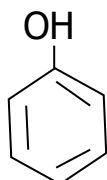
Methyl benzene (toluene)



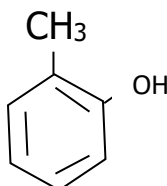
(dimethyl benzene)



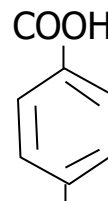
P-Xylene



Phenol
Hydroxy benzene



2-hydroxy benzene
Cresol



benzoic acid

WEEK 7

ALKANOLS

Alkanols are organic compounds containing the hydroxyl group-OH as the functional group. They can be considered as being derived from the corresponding Alkane by replacing the hydrogen atom with hydroxyl groups.

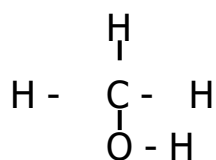
HOMOLOGOUS SERIES

Alkanols form homologous series with the general formula $C_nH_{2n+1}OH$ where $n=1,2,\text{etc.}$

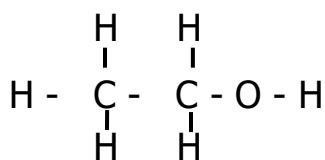
FORMULA OF THE FIRST FIVE(5) MEMBERS

$n=1$	CH_3OH	Methanol
$n=2$	C_2H_5OH	Ethanol
$n=3$	C_3H_7OH	Propanol
$n=4$	C_4H_9OH	Butanol
$n=5$	$C_5H_{11}OH$	Pentanol.

STRUCTURE OF ALKANOLS



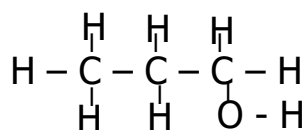
Methanol



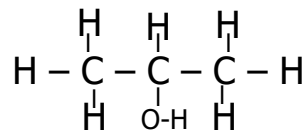
Ethanol.

NOMENCLATURE OF ALKANOLS

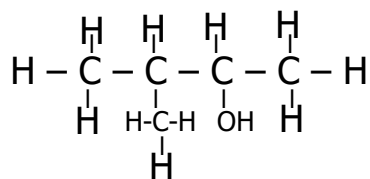
1. Select the longest straight chain of carbon atoms in the alkanol and name it as in the alkanes dropping the final-e and adding -OH
2. Indicate the position of the OH group and of any substituents by numbering the carbon atoms of the selected chain
3. The OH group is given top priority (given the lowest possible number).



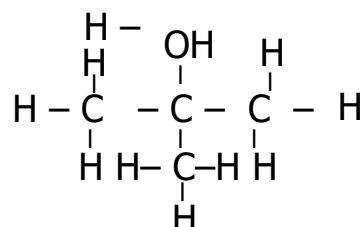
Propane – 1 - 01



Propane – 2 - 01



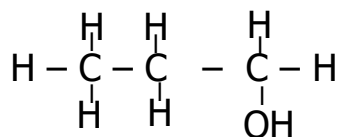
3-methyl butan-2-



2-methyl propane-2-01

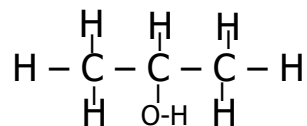
ISOMERISM IN ALKANOLS

For Propanol, we have



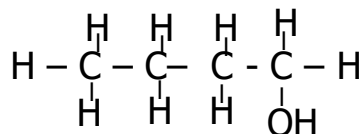
Propan-1-01

and

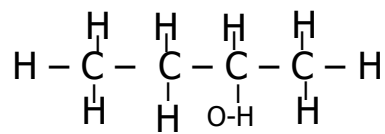


Propan-2-01.

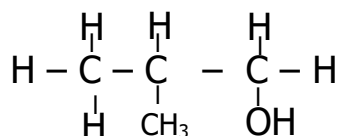
For Butanol, we have



Butan-1-01

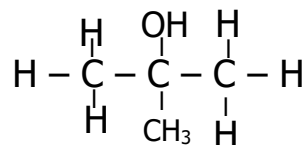


Butan-2-01



2-methyl propan-1-01

and

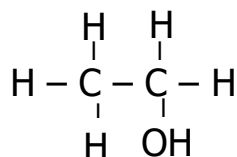


2-methyl propan-2-01

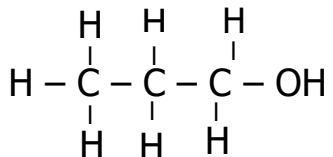
CLASSIFICATION OF ALKANOLS

Alkanols can be classified with respect to the number of hydroxyl groups in each molecule.

1. **MONOHYDRIC ALKANOLS:-** These contain one OH group e.g. ethanol, propanol, phenol.

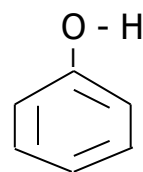


Ethanol



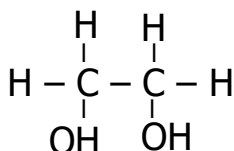
Propan-i-ol

Or

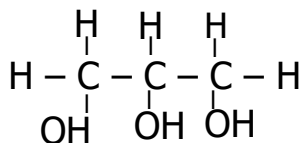


Phenol

2. **DIHYDRIC ALKANOL:-** These contain 2-OH groups per molecule e.g. ethane – 1, 2 – diol



3. **TRIHYDRIC ALKANOL:-** These contain 3 – OH groups per molecule e.g. propane – 1, 2, 3-triol

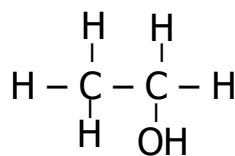


Alkanols containing more than three OH groups are called polyhydric alkanols.

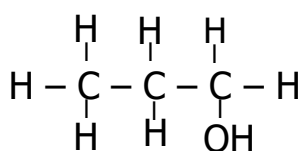
MORE CLASSIFICATION

Monohydric alkanols may be classified into primary, secondary and tertiary depending on the number of hydrogen atoms attached to the carbon atom carrying the OH group.

1. **PRIMARY ALKANOL:-** Here the carbon atom carrying the OH group has two hydrogen atoms attached to it e.g.

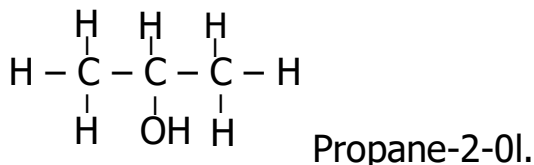


Ethanol

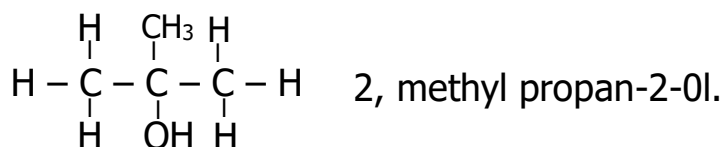


Propane-1-ol.

2. **SECONDARY ALKANOL:-** Here the OH group is attached to a carbon atom carrying one hydrogen atom e.g.



3. **TERTIARY ALKANOL:-** Here the OH group is attached to the carbon atom without any free hydrogen atom e.g.



LABORATORY PREPARATION OF ALKANOLS

Ethanol can be prepared in the laboratory by several methods.

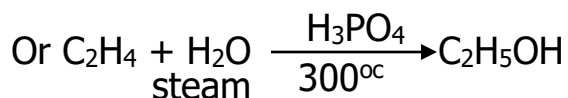
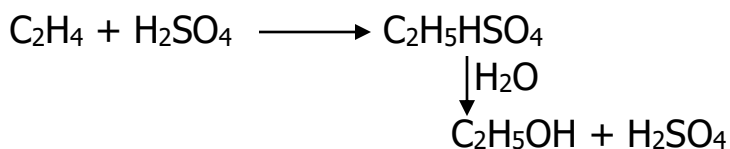
1. Hydrolysis of chloro or iodoethane using alkali

$$\text{C}_2\text{H}_5\text{I} + \text{NaOH} \longrightarrow \text{C}_2\text{H}_5\text{OH} + \text{NaI}$$
2. Alkaline hydrolysis of Alkanoates
3. Hydrolysis of ethene

COMMERCIAL PREPARATION

1. Fermentation process

From Ethene



PREPARATION BY FERMENTATION

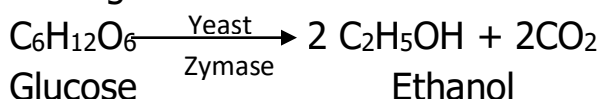
Ethanol can be prepared by fermentation of raw materials that contains starch and sugar.

FERMENTATION

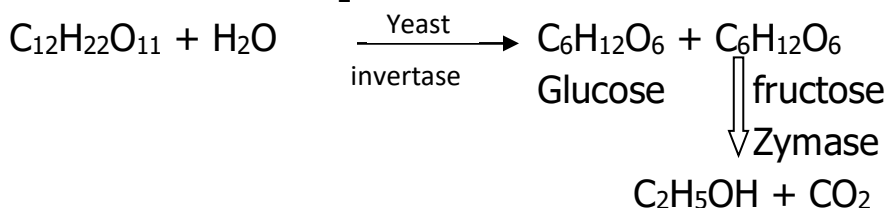
Fermentation is a chemical process in which microorganisms such as yeast act on carbohydrates to produce ethanol and carbon(iv)oxide.

A common micro organisms used is yeast. It contains a variety of enzymes that bring about the decomposition of starch and sugar.

1. From glucose

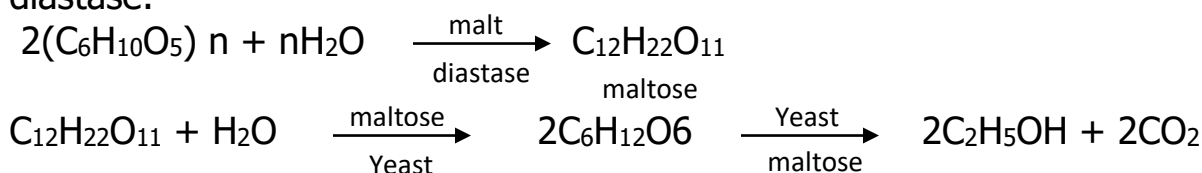


2. From molasses (cane sugar)/sucrose. The enzyme invertase in yeast acts upon sucrose to convert it to glucose and fructose which are both fermented into ethanol and CO₂



From starch (cassava, rice, corn, millet, potato)

The starch granule are first extracted, then treated with malt at 50^{0c} to give maltose. Malts is partially germinated barley which contain the enzyme diastase.



CONCENTRATION OF ETHANOL

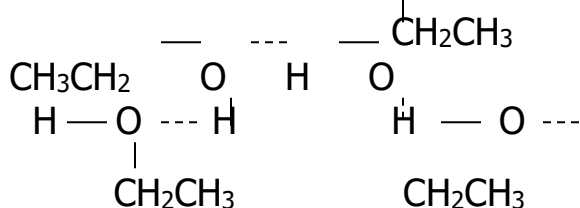
The ethanol from fermentation only has a maximum concentration of 18% as yeast cells die above this concentration. Further concentration and purification is done by fractional distillation.

TYPES OF ALCOHOLIC DRINKS

RAW MATERIAL	ALCOHOLIC DRINK	% ETHANOL	METHOD OF PREPARATION
Barley	Beer	3-8%	Fermentation
Grapes/Rice	Wines	3-8%	Fermentation
Barley	Whisky	30-60%	Fermentation and Distillation
Grapes	Brandy	30-60%	

PHYSICAL PROPERTIES OF ETHANOL

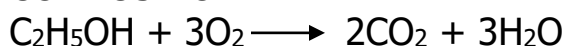
1. Ethanol is a colourless liquid with characteristics taste and smell
2. It is readily soluble in water in all proportions
3. It has a boiling point of 78°C
4. It has no action on litmus.



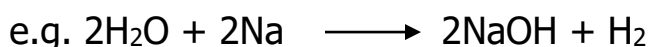
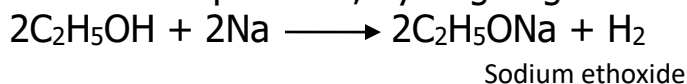
Hydrogen bonding in alkanols

CHEMICAL PROPERTIES

1. COMBUSTION

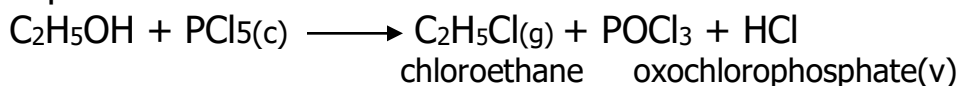


2. **REACTION WITH METAL:** If a small piece of sodium is added to ethanol at room temperature, hydrogen gas will be liberated.



3. REACTION WITH CHLORIDES OF PHOSPHORUS

Reaction is vigorous and fumes of hydrogen chloride and chloroethane vapour will be liberated.

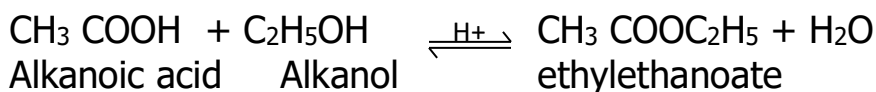
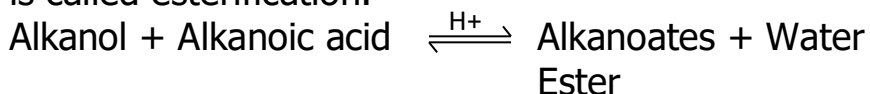


Also with phosphorus trichloride



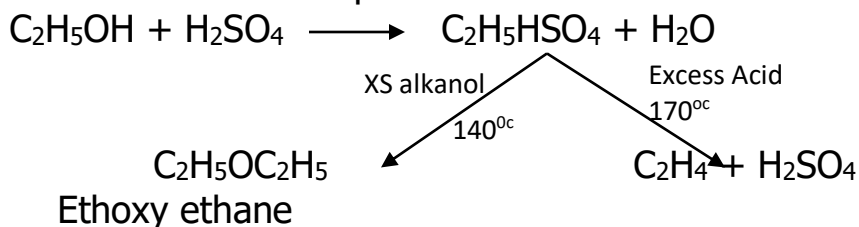
4. ESTERIFICATION

Ethanol reacts reversibly with acids forming alkanoates (esters). The process is called esterification.

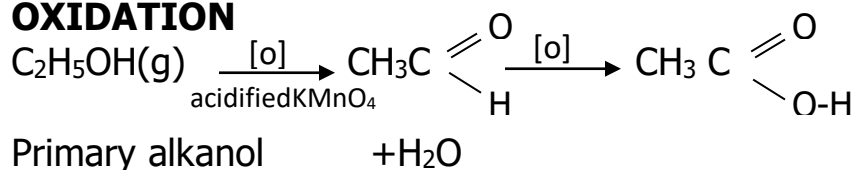


5. DEHYDRATION

In the presence of excess conc tetraoxosulphate (vi) acid above 170°C ethanol reacts and ethene is produced.

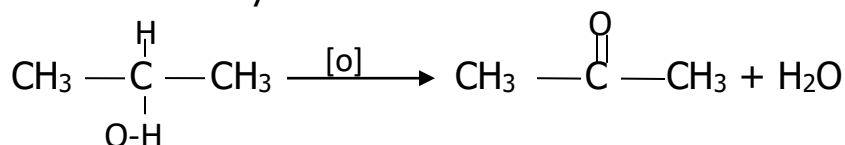


6. OXIDATION



The KMnO₄ is decolourised. If acidified K₂Cr₂O₇ is used, the orange colour changes to green.

With Secondary Alkanol



Further oxidation is not possible

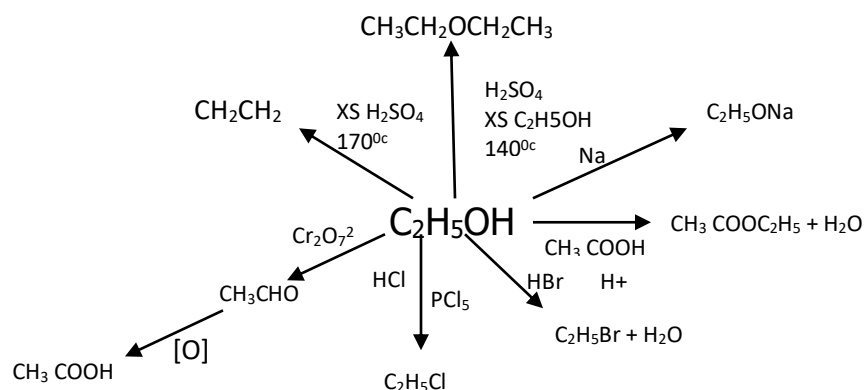
Tertiary alkanols do not undergo oxidation. Reason is that there are no free hydrogens.

Using diols



USES OF ALKANOLS (ETHANOL)

1. Ethanol is used as a fuel: in small motor vehicles
2. Ethanol is a good solvent for paints, perfumes etc.
3. Ethanol is used in alcoholic drinks
4. Ethanol is the main constituent of methylated spirit – a cleansing agent
85% ethanol 5% methanol
5. It is a raw material for the manufacture of other substances
6. It is used as an antifreeze in car radiators as the freezing point is (-117°C)



SUMMARY OF REACTIONS OF ALKANOLS

WEEK 8

SUBJECT: CHEMISTRY
TOPIC: ALKANOIC ACIDS
CLASS: SS 3
ABILITY: MIXED

OBJECTIVES: *At the end of the topic, the students should be able to:*

- Identify the functional group present in alkanoic acid:
- Give the general formula of alkanoic acids:
- Write names and structures of some alkanoic acids:
- State some physical properties of alkanoic acids:
- Write reactions for chemical properties of alkanoic acids:
- Give some uses of alkanoic acids.

PREVIOUS KNOWLEDGE: Students have knowledge of homologous series, isomerism in alkanols.

DEVELOPMENT

All alkanoic acids contains the carboxyl group – COOH as their functional group. Hence they are called carboxylic acids. They form homologous series with the general formula $C_nH_{2n+1}COOH$, where $n \geq 0$.

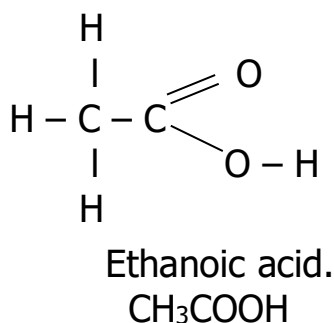
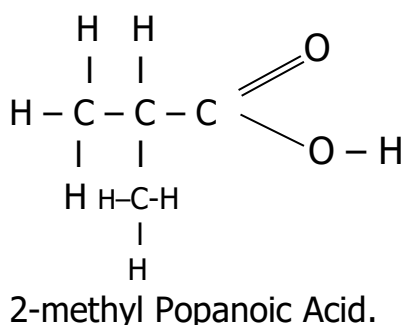
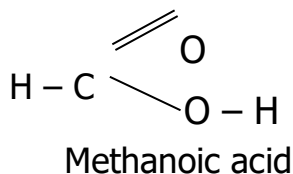
They are sometimes called fatty acids because some of them are found in natural fats and oils

IUPAC NOMENCLATURE

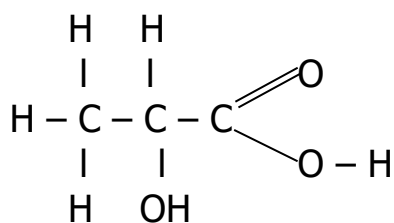
The IUPAC nomenclature for alkanoic acids involve changing the ending 'e' of the alkane and adding – OIC acid.

FORMULA	IUPAC NAME	COMMON NAME
HCOOH	Methanoic acid	Formic acid (ant-formica)
CH ₃ CH ₂ COOH	Ethanoic acid	Acetic acid (vinegar)
CH ₃ CH ₂ CH ₂ COOH	Butanoic acid	Butyric acid (spoilt butter)

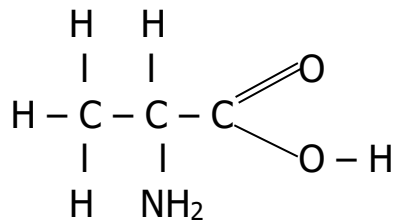
STRUCTURE OF ALKANOIC ACIDS



Some monocarboxylic acids have other additional functional groups e.g. OH and NH₂ groups.



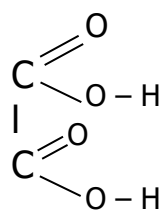
2-hydroxy propanoic acid
(lactic acid) (sour milk)



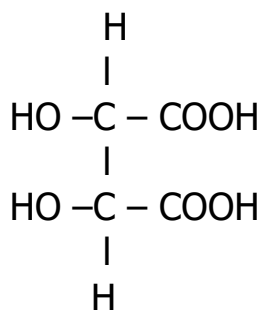
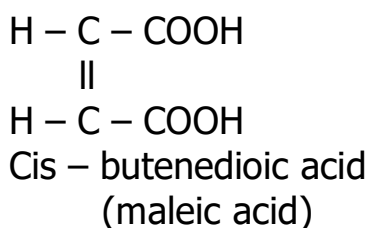
2-amino propanoic acid
Alanine (Amino acid)

DICARBOXYLIC ACIDS

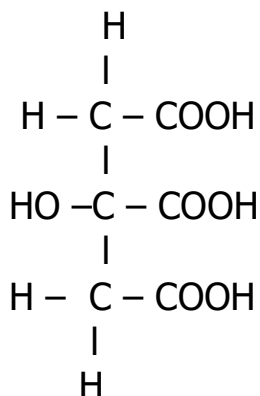
Some acids contain more than one carboxylic acid group e.g.



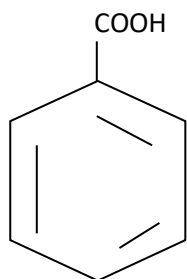
ethanedioic acid (oxalic)



2,3-dihydroxybutanedioic acid
Tartaric acid (grape fruit)

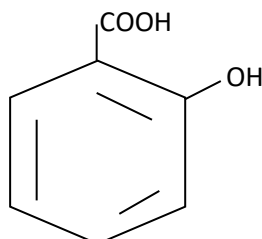


2-dihydroxypropane-
1,2,3-tricarboxylic acid
citric acid (lemon)



Benzoic acid

ORGANIC ACIDS (AROMATIC)

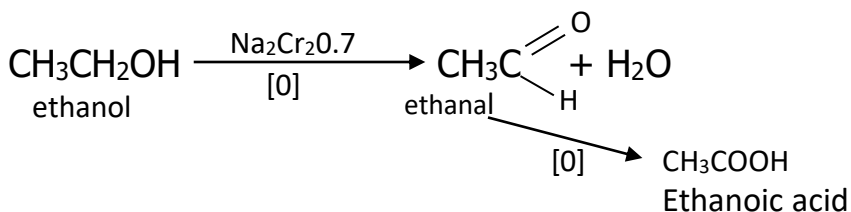


2-hydroxy benzoic acid
(salicylic acid)
Aspirin.

PREPARATION OF ETHANOIC ACID

Ethanoic acid can be prepared by the complete oxidation of ethanol by acidified sodium heptaoxodichromate (VI), ($\text{Na}_2 \text{Cr}_2\text{O}_7$)

- Ethanol undergoes oxidation first to ethanal



The ethanal is oxidised further to ethanoic acid.

Note: The ethanol is dropped into a large excess of the oxidizing agent and distilled under reflux so that the reactants are brought into close and prolonged contact.

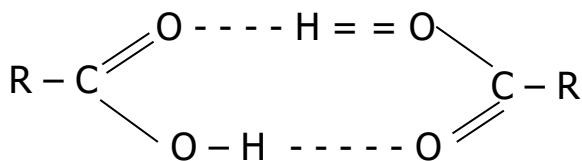
Assignment: Students to write the procedure for the process.

PHYSICAL PROPERTIES OF ETHANOIC ACID

1. Ethanoic acid is a colourless liquid with a characteristic sharp and pungent smell.
2. The dilute solution has a sour taste.
3. It is very soluble in water.
4. The pure anhydrous ethanoic acid is called glacial ethanoic acids because it freezes into ice-like crystals at temperatures below 17°C .
5. It has a boiling point of 118°C .
6. It turns blue litmus paper red.

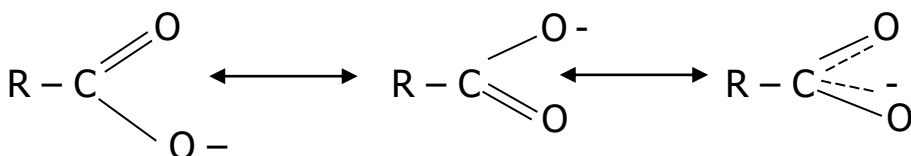
DIMERISATION

The boiling point of ethanoic acid is higher than expected due to formation of hydrogen bonds. They form dimers

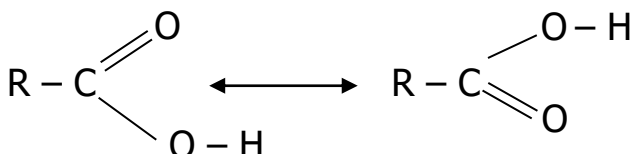


CHEMICAL PROPERTIES

The carboxyl group is a resonance structure.



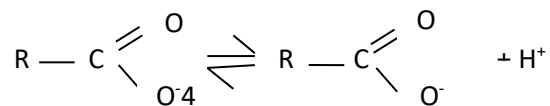
OR



The 2 C – O bonds are of equal length and identical. The double bond character is equally distributed.

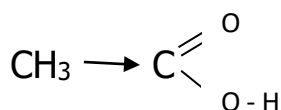
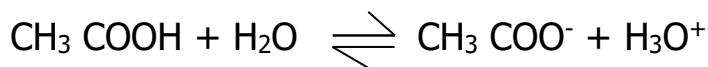
ACID STRENGTH

They are weak acids. They turn blue litmus paper faintly red.

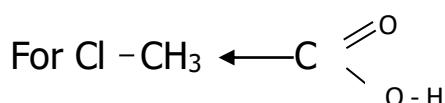


That is

Alkanoate ion



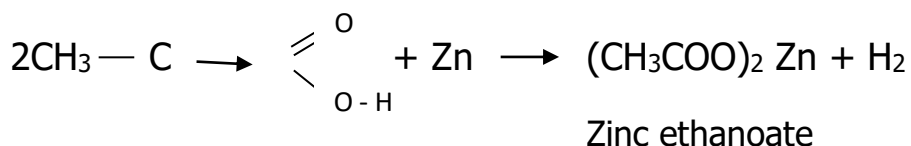
Very weak as CH_3 pushes in electron to the group and $\text{O}-\text{H}$ bond get stronger. Hydrogen cannot leave easily.



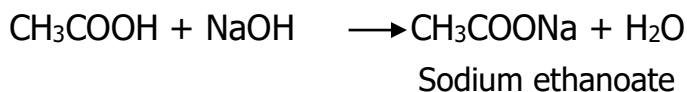
Cl^- withdraws electrons to itself and weakens the OH group. Chloroethanoic acid is a strong acid.

OTHER REACTIONS

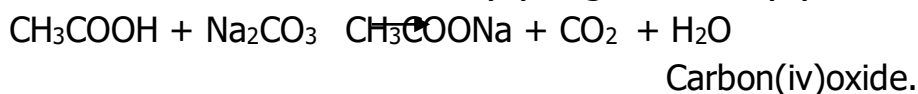
1. Reaction with Metals: Ethanoic acid reacts with highly electropositive metals to liberate hydrogen gas.



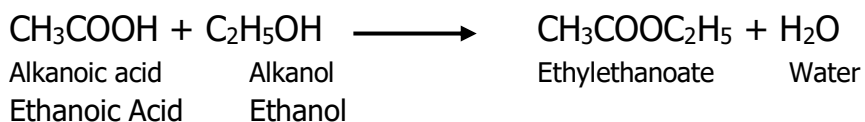
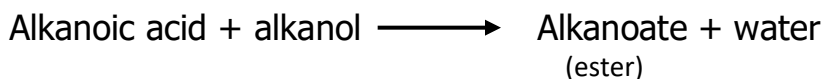
2. Neutralization: Ethanoic acid reacts with alkali to give organic salt and water.



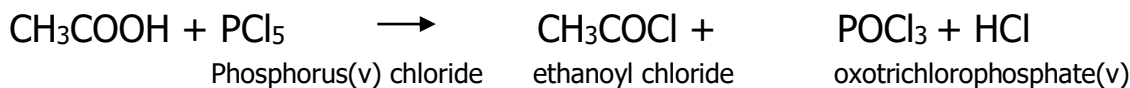
3. Reaction with Trioxcarbonates (IV) to give carbon(IV) oxide.



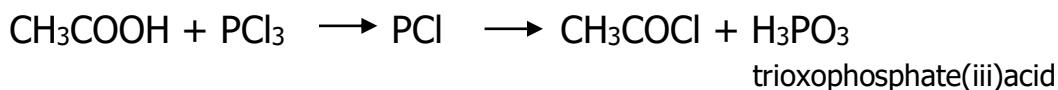
4. Esterification: This is the reaction between an alkanol and an alkanoic acid to give an alkanoate and water only.



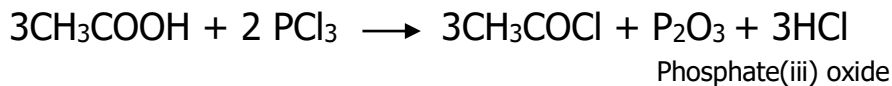
5. Formation of Acyl chloride



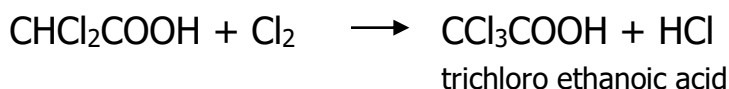
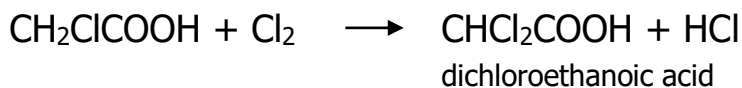
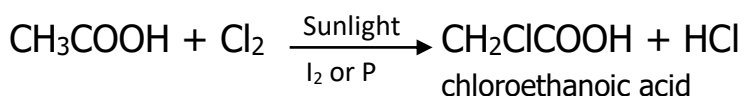
Using Phosphorus III chloride



or

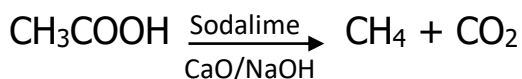


6. Formation of chloro alkanoic acid. (substitution reaction)

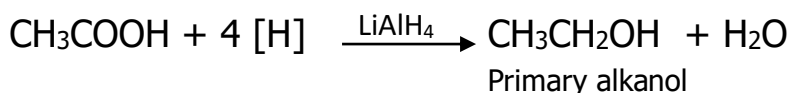


Note that the hydrogen of the methyl group is gradually replaced.

7. De Carboxylation: if acid is heated strongly with sodalime, methane will be produced.



8. Reduction: Ethanoic acid can be reduced to primary alkanol using lithium tetrahydride aluminate(iii)



USES OF ETHANOIC ACID

- Ethanoic acid is used in making compounds like:
 - Ethanoic anhydride which is used in making aspirin
 - Cellulose ethanoate which is used for packing cigarette filters etc.
 - For producing dyes.
- Ethanoic acid is an important organic solvent
- It is used in the food industry as vinegar for preserving food.
- It can be used for coagulating rubber latex.

WEEK 9

ALKANOATES (ESTERS)

Alkanoates are formed by the reaction between alkanoic acids and alkanols. The alkanoates are usually referred to as esters and the reaction for their formation is known as Esterification. Esters are the main constituents of many naturally occurring fats and oils. Many of them have pleasant smells and are largely responsible for the fragrance of flowers and the flavor of fruits. Eg.

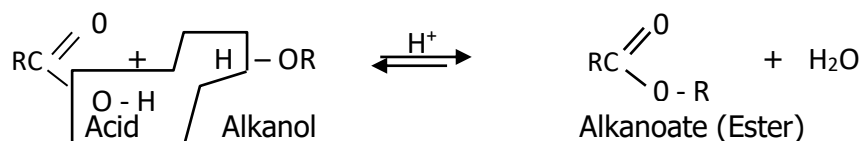
HCOOC_2H_5 used as Rum flavouring

$\text{CH}_3\text{COOC}_2\text{H}_5$ Perfume

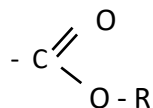
$\text{CH}_3\text{COOC}_5\text{H}_{11}$ Odour of banana (banana oil)

$\text{CH}_3\text{COOC}_8\text{H}_{17}$ Smell of oranges

$\text{C}_3\text{H}_7\text{COOC}_2\text{H}_5$ Pineapple flavouring



Alkanoates have the general formula $\text{C}_n\text{H}_{2n+1}\text{COO C}_m\text{H}_{2m+1}$ or R COOR^1 where R and R^1 where R and R^1 are whole numbers. The functional group in alkanoate is $-\text{COOR}$ or



PREPARATION OF ETHYL ETHANOATE

In a dry round bottomed flask add a mixture of ethanol 25cm^3 and 25cm^3 of tetraoxosulphate (vi) acid. Setup a distilling flask. Add an equal volume of ethanoic acid through a dropping funnel.

As the oil bath gets to 150°C the ethyl ethanoate distills over. The distillate contains impurities like ethanol, acids, water and ethoxy ethane, apart from ethyl ethanoate.

PURIFICATION OF THE ETHYL ETHANOATE

1. Shake the distillate in a separating funnel with Conc. Na_2CO_3 to remove the acidic impurities.
2. $\text{Na}_2\text{CO}_3 + 2\text{CH}_3\text{COOH} \rightarrow 2\text{CH}_3\text{COONa} + \text{H}_2\text{O} + \text{CO}_2$.
3. Discard the lower aqueous layer and shake with Conc. CaCl_2 solution to remove the ethanol
4. Add anhydrous Calcium chloride to remove water
5. Finally, filter the mixture, distill it over a water bath and collect the fraction which over between 74 to 79°C

DIAGRAM FOR PREPARATION OF ETHYL ETHANOATE

Fifteen lines for diagram

PHYSICAL PROPERTIES

1. Ethyl Ethanoate is a colourless volatile liquid with a pleasant smell.
2. It is slightly soluble in water but readily soluble in organic solvent examples benzene, ethanol, etc.
3. It has a boiling point of about 76°C

CHEMICAL PROPERTIES

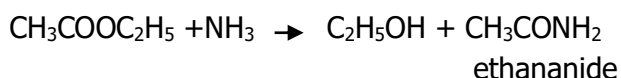
1. HYDROLYSIS



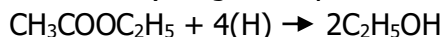
With Alkali,



2. With Ammonia



3. Reduction (using tetrahydrido Aluminate (iii))



NAMING OF ALKANOATES

Note convention used in writing the formula of Alkanoates. The alkyl group on the right of the formula indicates the alkanol end, while the Alkyl group on the left of the formula indicates the acid from which it is derived. In naming, name the alkanol end first.

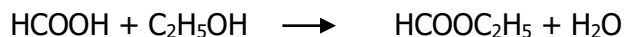
HCOOC_2H_5 — Ethyl methanoate

$\text{C}_2\text{H}_5\text{COOC}_2\text{H}_3$ — Methyl Propanoate

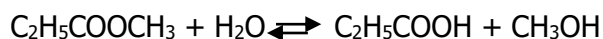
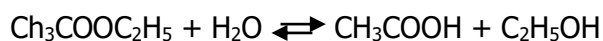
Acid end Alkanol end

$\text{C}_3\text{H}_7\text{COOC}_2\text{H}_5$ Ethyl butanoate

Pairs of this compound yield different products on hydrolysis



Acid end Alkanol end



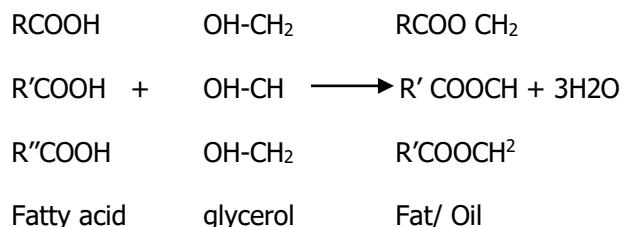
Alkanoates may be Isomeric with Alkanoic acids e.g.

$\text{CH}_3\text{COOCH}_3$ is isomeric with $\text{C}_2\text{H}_5\text{COOH}$ and both are isomeric with HCOOC_2H_5

FATS AND OILS

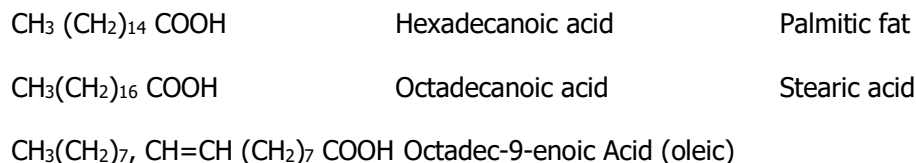
Animals fats, vegetables oils like palm oil, G.N oil, palm kernel oil are esters (alkanoates) occurring naturally in plants and animals. They are derived from

Propan -1,2,3- trio and a fatty acid



FATTY ACIDS

The fatty acids commonly found in fats and oil are the higher fatty acids

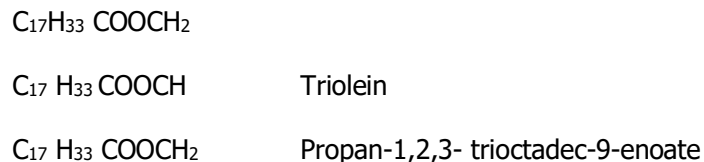


In case of solid fat, the fatty acid is a straight chain saturated fatty acid

E.G



A typical liquid fact or oil is derived from glycerol but the acid contains 2hydrogen atoms fewer per molecule ($C_n H_{2n-1} COOH$). This normally contains the unsaturated grouping $-CH=CH-$. Taking olic acid



Fats are solids whereas oils are liquid under the same condition. If the esterification product of fatty acids and glycerol contain a high proportion of low MP unsaturated fatty acids they are generally liquids at room temperature, and called oils. If the esterification product contains a high percentage of saturated fatty acids they are severally solid or semi solid at room temperature and are classified as fats. Generally fats are glycerides of saturated fatty acids and oils are glycerides of unsaturated fatty acid.

HYDROGENATION OF OILS

An oil can be changed into fat by hydrogenation. E.g margarine

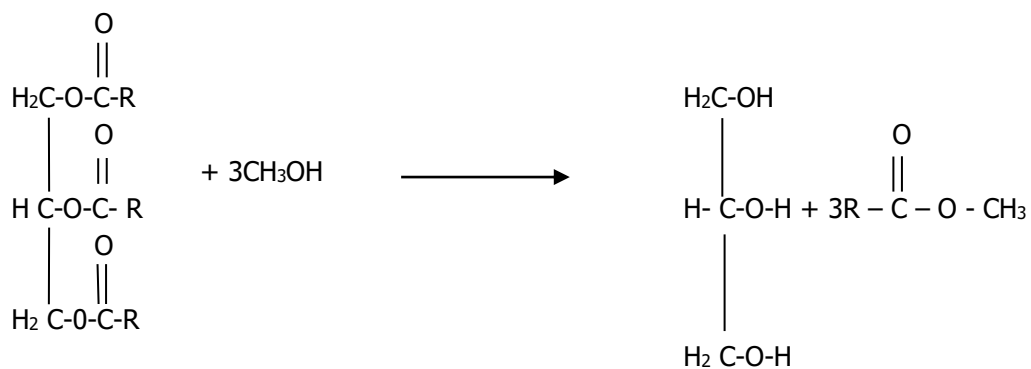
Oil $\xrightarrow[N_2 \text{ 5at}]{N_1 \text{ 180}}$ fats. The hydrogen is added across the double bond in the unsaturated chain. The hardened oils are then mixed with salt, vitamin, skimmed milk and other fats to form margarine.

PHYSICAL PROPERTIES OF FATS AND OILS

- (a) They are insoluble in water
- (b) They have low densities. They float in water
- (c) They have lubricating properties.

CHEMICAL PROPERTIES

REDUCTION: For reduction to occur, fats and oils are first converted to simpler alkanoates by reaction with methanol



These alkanoate are then reduced to alkanols under high pressure with copper(II) pentaoxochromate(III) as catalyst



HYDROLYSIS

Fats and oils can be hydrolyzed by water to form glycerol and corresponding fatty acids. Reaction is the reverse of esterification. A dilute acid is used to catalyse the reaction.

