# THE CATALYST

0805611[illegible]

# ORGANIC CHEMISTRY

# CH[illegible]102

NEW EDITION

**LECTURE NOTE WITH PAST QUESTIONS AND CAREFUL SOLUTIONS**

| | | | |
|---|---|---|---|
| alcohol | R—Ö—H | $CH_3CH_2OH$ | ethanol |
| ether | R—Ö—R' | $(C_2H_5)_2O$ | Diethyl ether |


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# ORGANIC CHEMISTRY


DEFINITION:

Although the original meaning of the term **organic chemistry** no longer applies, it has been retained because of wide usage and also because so many of the substances involved in organic chemistry do come directly or indirectly from living matter. The modern definition of organic chemistry says that;-

**Organic chemistry** is the study of carbon compounds.

NB: - there are several compounds of carbon which are not included in organic chemistry. They are not considered to be organic compounds, Examples;- carbon monoxide($CO$), carbon dioxide($CO_2$), carbon disulphide($CS_2$), carbonates($CO_3^{2-}$), bicarbonates($HCO_3^-$), cyanides($CN^-$), thiocyanates ($SCN^-$), cyanates($OCN^-$), carbides(eg.$CaC_2$).

## SOME SOURCES OF ORGANIC COMPOUNDS

There are many sources of organic compounds, both natural sources and artificial sources. Organic compounds can be gotten from living things. They can also come from crude oil (fossil remains), coal and fermentation process. etc.

Organic compounds can also be synthesized from inorganic compounds. Example is the production of urea $CO(NH_2)_2$ from ammonium cyanate ($NH_4CNO$) by a German chemist Friedrich Wohler in 1828.

$$NH_4CNO \rightarrow CO(NH_2)_2$$

## SOME PROPERTIES OF ORGANIC COMPOUNDS

- Most organic compounds have low boiling and melting points

Organic compounds are generally insoluble in water (except those that contain polar groups such as –OH, -COOH, $SO_3$) but they are soluble in organic solvents like benzene, ethoxyethane, trichlomethane (chloroform), 1,1,1-trichloroethane, etc.

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- Organic compound form covalent bonds.

## CLASSIFICATION OF ORGANIC COMPOUNDS

**ALIPHATIC COMPOUNDS:-** These are those organic compounds that have open chain structures.

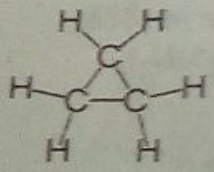
Examples:-

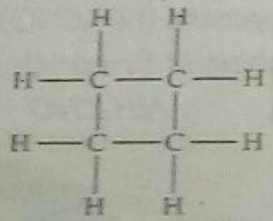
$CH_3-CH_2-CH_3$ and $CH_3 - CH_2 - CH_2-CH_3$

(n-propane) (n-butane)

*Where n stands for "normal"*

**ALICYCLIC COMPOUNDS:-** These are those organic compounds that have cyclic or ring structures. Examples:-



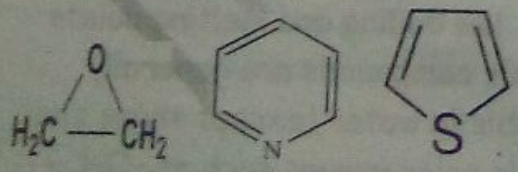


(cyclopropane) (cyclobutane)

NB:- the prefix "cyclo" is used to show that they have a cyclic shape.

**HETEROCYCLIC COMPOUNDS:**

These are those organic compounds in which a carbon atom in a cyclic ring is replaced with oxygen or nitrogen or sulphur atom. Examples;-



NB: it is called a heterocyclic compound only when the carbon atom replaced is among the carbons that form the cyclic ring. It is not heterocyclic if the carbon replaced is not among the ring carbons.

**AROMATIC COMPOUNDS:-** These are those organic compounds that behave like benzene. They are also known as benzene derivatives.

Examples; benzene, Aniline, naphthalene etc

Now, the question is; **what conditions must a given compound satisfy in order to be called an aromatic compound?**

### CONDITIONS FOR A COMPOUND TO BE AROMATIC

- The compound must be cyclic in structure
- The compound must be completely conjugated or all the carbon atoms in the ring must be $SP^2$ hybridized (having double bonds in an alternating manner, example; C-C=C-C=C-C=C)
- The compound must be planar (it must be flat)
- The compound must obey Huckel's rule of aromaticity.

### HUCKEL's RULE OF AROMATICITY

It states that; ***"for a compound to be aromatic, the compound must have a total of (4n + 2) pi-electrons"***. Where '**n**' is a positive whole number. More of this will be treated in CHM 204.

### HYDROCARBONS

Hydrocarbons are those organic compounds that contain only **hydrogen**

- Organic compound form covalent bonds.

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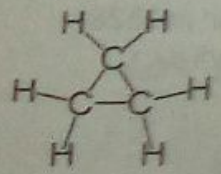

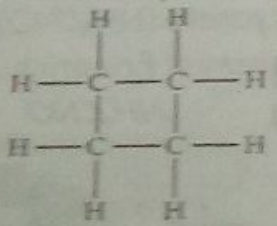

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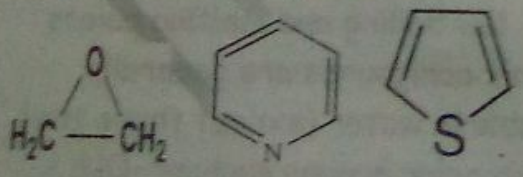

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### HYDROCARBONS

Hydrocarbons are those organic compounds that contain only **hydrogen**

and carbon. Example:- methane($CH_4$), ethene($C_2H_4$), ethyne ($C_2H_2$), etc.
NB:- methane is called a hydrocarbon because it contains only hydrogen and carbon in it.

## CLASSES OF HYDROCARBONS

The 3 classes of hydrocarbons are;-

- The alkanes
- The alkenes
- The alkynes
-

## EMPIRICAL AND MOLECULAR FORMULAR

Empirical formula of a compound is the simplest formula of the compound. Empirical formula of a compound can also be defined as the formula that shows the smallest ratio in which the atoms of a given compound can combine together.

*For instance:-* Since the molecula formular of benzene is $C_6H_6$, then empirical formula of benzene is CH (dividing through by 6).

Alternatively; if the molecular formula of a compound is given as $C_2H_4O_2$, then the empirical formula will be $CH_2O$ (dividing through with 2).

**Molecular formula** of a compound is the formula which shows the actual number of the individual atoms in one mole of the compound.

**Example:-** The molecular formula of benzene is $C_6H_6$. This means that one mole of benzene contains 6 atoms of carbon and 6 atoms of Hydrogen. Etc.

The structural formula of a compound is the formula that shows how the atoms of a compound are arranged within the compound or molecule.

***Now let us solve some questions on this.***

### QUESTION 1

A hydrocarbon Xi has a relative molecular mass of 56 and consists of 87.5% by mass of carbon. What is the molecular formula of Xi?

### Solution

*A hydrocarbon contains only hydrogen and carbon in it.*

Hydrocarbon = H + C

Since C = 87·5%,

Therefore, H = 100 − 87·5 = 12·5%

Before finding molecular formular, we need to find the empirical formula first.

Remember; [C=12, H=1]

| C | H | |
|---|---|---|
| $\frac{87·5}{12}$ | $\frac{12·5}{1}$ | ∴ Emp. formular = $CH_2$. |
| $\frac{7·292}{7·292}$ | $\frac{12·5}{7·292}$ | To find the molecular formular of the Compound, we say that |
| 1 : | 1·7 | |
| 1 : | 2 | |

[Empirical] n = Molar mass

$n = \frac{\text{Molar mass}}{[\text{Empirical}]} = \frac{56}{[12+2]}$

$n = \frac{56}{14} = 4$. Therefore,

molecular formular = $[CH_2] \times 4$

= $C_4H_8$.

## QUESTION 2

2.4mg of an organic acid gave 3.52mg and 1.44mg of $CO_2$ and $H_2O$ respectively on combustion.
What is the;
I) Empirical formula
ii) Molecular formula,
If the relative molecular mass is 60g.

## Solution

Total mass of compound = 2.4mg
Mass of $CO_2$ given = 3.52mg
Mass of $H_2O$ given = 1.44mg

In order to solve this problem, we need to find the mass of C and mass of H contained in 3.52mg of $CO_2$ and 1.44mg of $H_2O$ respectively.

**FINDING MASS OF C**

Molar mass of $CO_2$=12+32=44g
NB; Inside every 44g of $CO_2$, carbon is 12g [C=12]
We say that;

44g of $CO_2$ Contains → 12g of C
3.52mg of $CO_2$ will Contain → x of C

$44x = 12 \times 3.52$

$x = \frac{12 \times 3.52}{44} = 0.96mg$ of C

Therefore, the mass of C we will work with is 0.96mg

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**FINDING MASS OF H**

Molar mass of $H_2O$ =1(2) + 16 = 18g
NB; inside every 18g of $H_2O$, Hydrogen is 2g [H=1, O=16]
So we say that;

18g of $H_2O$ Contains → 2g of H
∴ 1.44mg of $H_2O$ will Contain → x g of H
Let us now find value of x

$\frac{18}{1.44} = \frac{2}{x} \Rightarrow 18x = 2 \times 1.44$

$x = \frac{2 \times 1.44}{18} = 0.16mg$ of H.

Now, mass of H = 0.16mg

Before we start finding the empirical formula we check if there will be oxygen or not.
Total mass given=2.4mg
Mass of C alone=0.96mg
Mass of H alone = 0.16mg

Sum of masses of C and H
=0.96+0.16=1.12mg.
**COMMENT:-** Since the sum of C and H is not equal to the total mass of the compound, we will use oxygen to complete it.
Mass of oxygen = Total mass - [C + H]
Mass of O=2.4-[0.96+0.16]
=2.4 - 1.12 = 1.28mg
Now we solve;

| C | H | O |
|---|---|---|
| $\frac{0.96}{12}$ | $\frac{0.16}{1}$ | $\frac{1.28}{16}$ |
| $\frac{0.08}{0.08}$ | $\frac{0.16}{0.08}$ | $\frac{0.08}{0.08}$ |
| 1 | 2 | 1 |

① Empirical formular = $CH_2O$.

II)

$[CH_2O]n = 60$

$n = \frac{60}{[CH_2O]} = \frac{60}{[12+1(2)+16]}$

$n = \frac{60}{30} = 2$. Therefore;

Molecular formular $= [CH_2O]n$

$= [CH_2O]2 = C_2H_4O_2$

## QUESTION 3

A sample of methane weighing 9.67mg produced 26.53mg of $CO_2$ and 21.56mg of $H_2O$.

Calculate the % compositions of carbon and hydrogen in it.

### Solution

Total mass = 9.67mg

Mass of $CO_2$ given = 26.53mg

Mass of $H_2O$ given = 21.56mg

We have to find the mass of carbon from $CO_2$ and find the mass of Hydrogen from water($H_2O$).

### FINDING MASS OF C

Molar mass of $CO_2 = C + 2(O)$

$= 12 + 2(16) = 44g$

44g of $CO_2$ Contains → 12g of C

26.53mg of $CO_2$ will Contain → $x$g of C

$\frac{44}{26.53} = \frac{12}{x} \Longrightarrow 44x = 12 \times 26.53$

$x = \frac{12 \times 26.53}{44} = 7.24$mg of C

### FINDING MASS OF H

Molar mass of $H_2O = H_2 + O$

$= 1(2) + 16 = 18g$

18g of $H_2O$ Contains → 2g of H

21.56mg of $H_2O$ will Contain → $x$ of H

$\frac{18}{21.56} = \frac{2}{x} \Longrightarrow 18x = 2 \times 21.56$

$\therefore x = \frac{2 \times 21.56}{18} = 2.396$mg of H

Sum of masses of C and H

= 7.24 + 2.396 = 9.64mg

It is the same with the total mass given in the question. Therefore, we can now go ahead and solve

$\%C = \frac{\text{mass of C}}{\text{Total mass}} \times \frac{100}{1}$

$= \frac{7.24}{9.67} \times \frac{100}{1} = 74.9\%$

$\%H = \frac{\text{mass of H}}{\text{Total mass}} \times \frac{100}{1}$

$= \frac{2.396}{9.67} \times \frac{100}{1} = 24.8\%$

## QUESTION 4

An organic compound contains 38.7% C and 9.75% H. What is its molecular formular if it has a molecular weight of 62.07g ?

### Solution

C = 38.7%

H = 9.75%

Sum of C and H = 38.7 + 9.75 = 48.45%

Since the sum of C and H is not up 100%, we will bring in Oxygen.

% of O = 100 - [C + H]

= 100 - 48.45

= 51.55%

Now, we can start solving

NB:[ C = 12, O = 16, H = 1 ]

| C | H | O |
|---|---|---|
| $\frac{38.7}{12}$ | $\frac{9.75}{1}$ | $\frac{51.55}{16}$ |
| $\frac{3.23}{3.22}$ | $\frac{9.75}{3.22}$ | $\frac{3.22}{3.22}$ |
| 1 : | 3 : | 1 |

Empirical formular $= CH_3O$

$[CH_3O]n = 62.07$

$\therefore n = \frac{62.07}{[CH_3O]} = \frac{62.07}{[12+3(1)+16]}$

$n = \frac{62.07}{31} = 2$

Molecular formular $= C_2H_6O_2$

## QUESTION 5

Determine the empirical and molecular formula of a compound containing Carbon, Hydrogen and Nitrogen given that C is 53.1% and H is 15.9%. [C = 12, H = 1, N = 14, R.M.M = 90].

### Solution

C = 53.1%, H = 15.95%

$\therefore$ N = 100 - [C + H]

= 100 - [53.1 + 15.95]

N = 30.95%

| C | H | N |
|---|---|---|
| $\frac{53.1}{12}$ | $\frac{15.95}{1}$ | $\frac{30.95}{14}$ |
| $\frac{4.425}{2.211}$ | $\frac{15.950}{2.211}$ | $\frac{2.211}{2.211}$ |
| 2 : | 7 : | 1 |

Empirical formular $= C_2H_7N$

$[C_2H_7N]n = 90$

$\therefore n = \frac{90}{[C_2H_7N]} = \frac{90}{12(2)+1(7)+14}$

$n = \frac{90}{45} = 2 \Longrightarrow [C_2H_7N]2$

Molecular formular $= C_4H_{14}N_2$

## QUESTION 6

A hydrocarbon contains 85.7%C by weight and it has a density of 1.25g/dm$^{-3}$ at S.T.P find the empirical and molecular formula of the compound.

### Solution

A hydrocarbon contains only C and H.

C = 85.7%

$\therefore$ H = 100 - 85.7 = 14.3%

| C | H |
|---|---|
| $\frac{85.7}{12}$ | $\frac{14.3}{1}$ |
| $\frac{7.142}{7.142}$ | $\frac{14.300}{7.142}$ |
| 1 : | 2 |

Empirical formular $= CH_2$

$[CH_2]n$ = molar mass

From $\boxed{\text{Density} = \text{mass/volume}}$

mass = Density x Volume

$= 1.25 \times 22.4 = 28g$

NB:- At S.T.P, Volume $= 22.4 dm^3$

$[CH_2]n = 28 \Longrightarrow n = \frac{28}{12+1(2)} = 2$

Therefore;-

Molecular formular $= C_2H_4$.


| C | H |
|---|---|
| $\frac{85.7}{12}$ | $\frac{14.3}{1}$ |
| $\frac{7.142}{7.142}$ | $\frac{14.300}{7.142}$ |
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$[CH_2]n = 28 \Longrightarrow n = \frac{28}{12+1(2)} = 2$

Therefore;-

Molecular formular $= C_2H_4$.

## QUESTION 7

If the empirical formula of a compound is given as CH. Find the molecular formula of the compound given that it's vapour density is 39.

Solution

$[CH]n$ = Molar mass

But molar mass = 2 × Vapour density

= 2 × 39

= 78

$[CH]n = 78 \therefore n = \frac{78}{[CH]}$

$n = \frac{78}{[12+1]} = \frac{78}{13} = 6$

$\Longrightarrow [CH]6$

Therefore;-

Molecular formular = $C_6H_6$

## QUESTION 8

The compound dioxane contains carbon, and oxygen only. 0.956g on analysis gave 1.91g of $CO_2$ and 0.782g of $H_2O$.

In another analysis of it, $6.04 \times 10^{-3}$ mol of the compound weighed 0.532g. Calculate it's molecular formular.

Solution

Total mass = 0.956g

Mass of $CO_2$ given = 1.91g

Mass of H2O given = 0.782g

## FINDING MASS OF C

Molar mass of CO2 = 44g

44g of CO2 — 12g of C

1.91g of CO2 — X of C

44/1.91 = 12/X

$44X = 12 \times 1.91$

$X = \frac{12 \times 1.91}{44} = 0.521g$ of C.

## FINDING MASS OF H

Molar mass of $H_2O$ = 18g

18g of $H_2O$ — 2g of H

0.782g of $H_2O$ — X of H

$18X = 2 \times 0.782$

$X = \frac{2 \times 0.782}{18} = 0.087g$ of H

Therefore;- C + H = 0.521 + 0.087

= 0.608g.

But total mass is given as 0.956g

**COMMENT:-** Since the sum of the mass of C and H is not equal to the total mass of the compound given in the Question, we will bring in oxygen to complete it.

Mass of O = Total - [C + H]

= 0.956 - 0.608

= 0.348g of O.

| C | H | O |
|---|---|---|
| 0.521 / 12 | 0.087 / 1 | 0.348 / 16 |
| 0.043 / 0.022 | 0.087 / 0.022 | 0.022 / 0.022 |

2 : 4 : 1

Empirical formular = $C_2H_4O$

$[C_2H_2O]n$ = Molar mass

Here, molar mass is not given, but mole and mass are given.

Therefore we can find the molar Mass.

$\text{Mole} = \frac{\text{mass}}{\text{Molar mass}}$

$\text{Molar mass} = \text{mass/mole} = \frac{0.532}{6.04\times10^{-3}}$

$\therefore$ Molar mass $= 88.08$

$[C_2H_4O]n = 88.08$

$n = \frac{88.08}{[C_2H_4O]} = \frac{88.08}{12(2)+1(4)+16}$

$n = \frac{88.08}{44} = 2$

$\Rightarrow [C_2H_4O]2$

Molecular formular $= C_4H_8O_2$

## QUESTION 9

5.24mg of an organic compound yielded 7.65mg and 1.56mg of $CO_2$ and $H_2O$ respectively on combustion and on further reaction with $AgNO_3$, 8.31mg of AgCl was precipitated. Calculate the empirical formular of the organic compound.

### Solution

Total mass = 5.24mg

Mass of $CO_2$ given = 7.65mg

Mass of $H_2O$ given = 1.56mg

Mass of AgCl given = 8.31mg

### FINDING MASS OF C

Molar mass of $CO_2 = 12 + 2(16) = 44$

$44g\ CO_2$ Contains $\rightarrow$ $12g$ of C

$7.65mg\ CO_2$ will Contain $\rightarrow$ $x$ of C

$x = \frac{12\times7.65}{44} = 2.09mg$ of C

### FINDING MASS OF H

Molar mass of $H_2O = 18g$

$18g\ H_2O$ Contains $\rightarrow$ $2g$ of H

$1.56mg\ H_2O$ will Contain $\rightarrow$ $x$ of H

$x = \frac{2\times1.56}{18} = 0.173mg$ of H

### FINDING MASS OF Cl

Molar mass of $AgCl = 108 + 35.5 = 143.5g$

$143.5g$ of AgCl Contains $\rightarrow$ $35.5g$ of Cl

$\therefore$ $8.31mg$ of AgCl will Contain $\rightarrow$ $x$ of Cl

$x = \frac{35.5\times8.31}{143.5} = 2.06mg$ of Cl.

### FINDING MASS OF O

Mass of O = Total mass - [ C + H + Cl ]

= 5.24 - [ 2.09 + 0.1731 + 2.06 ]

Mass of O = 0.917mg

| C | H | O | Cl |
|---|---|---|---|
| $\frac{2.09}{12}$ | $\frac{0.173}{1}$ | $\frac{0.917}{16}$ | $\frac{2.06}{35.5}$ |
| $\frac{0.174}{0.057}$ | $\frac{0.173}{0.057}$ | $\frac{0.057}{0.057}$ | $\frac{0.058}{0.057}$ |
| 3 : | 3 : | 1 : | 1 |

Empirical formular $= C_3H_3OCl$.

## BOND BREAKING AND BOND FORMATION

The reactions of organic compounds involve the breaking of existing bonds and formation of new bonds.This bond breaking involves the conversion of molecular orbitals (lower energy system) to atomic orbitals (higher energy system) by the action of heat or other agents. In order to break the molecular orbitals into atomic orbitals, energy is supplied to break the bond. There are two ways of breaking bonds, namely;-

(i). **HOMOLYTIC BOND BREAKING OR HOMOLYTIC FISSION** (HOMOLYSIS).

(ii). **HETEROLYTIC BOND BREAKING OR HETEROLYTIC FISSION** (HETEROLYSIS).

### HOMOLYTIC BOND BREAKING OR HOMOLYTIC CLEAVAGE (HOMOLYSIS).

In homolytic bond breaking, each of the two bonding atoms acquires one of the two bonding electrons after the breaking of the bond.

$A:B \rightarrow A^{\cdot} + B^{\cdot}$

The products of homolytic cleavage ($A^{\cdot}$ and $B^{\cdot}$) are called free radicals. The are electrically neutral and have one unpaired (odd) electron in them. Free radicals are very reactive due to the tendency of the unpaired electron to be paired. This type of bond breaking is common in vapour phase. Homolytic reactions are initiated by heat or light or peroxides.

### HETEROLYTIC BOND BREAKING OR HETEROLYTIC CLEAVAGE (HETEROLYSIS).

In this process, only one of the bonding atoms acquires the two bonding electrons alone when the bond is broken.

$A:B \rightarrow A^{+} + B^{-}$

The products of heterolytic fission are ion which possess electrical charges.Heterolytic cleavage occurs mainly with polar compounds in polar solvents.

## FUNCTIONAL GROUPS

INTRODUCTION: When you enter into a taxi as a traveller, you relax yourself on the passenger's seat while the taxi driver drives you to your destination.Let us imagine that the car is the chemical compound while you and the driver are the atoms present in the compound, then your destination is the finmjal product of the compound during a reaction. Now tell me, between you (the passenger) and the driver, **who controls the movement of the car from your initial position to your final destination?**

I believe you know that it is the driver. Now you see? Both you and the driver are present in the car but only the driver controls the movement of the car. This means that generally, in an organic compound, there is a particular atom or group of atoms that controls the reactions of the compound. This particular atom or group of atoms that control the reactions of the entire compound is

known as the **functional group**.
Therefore we can simply say that;-

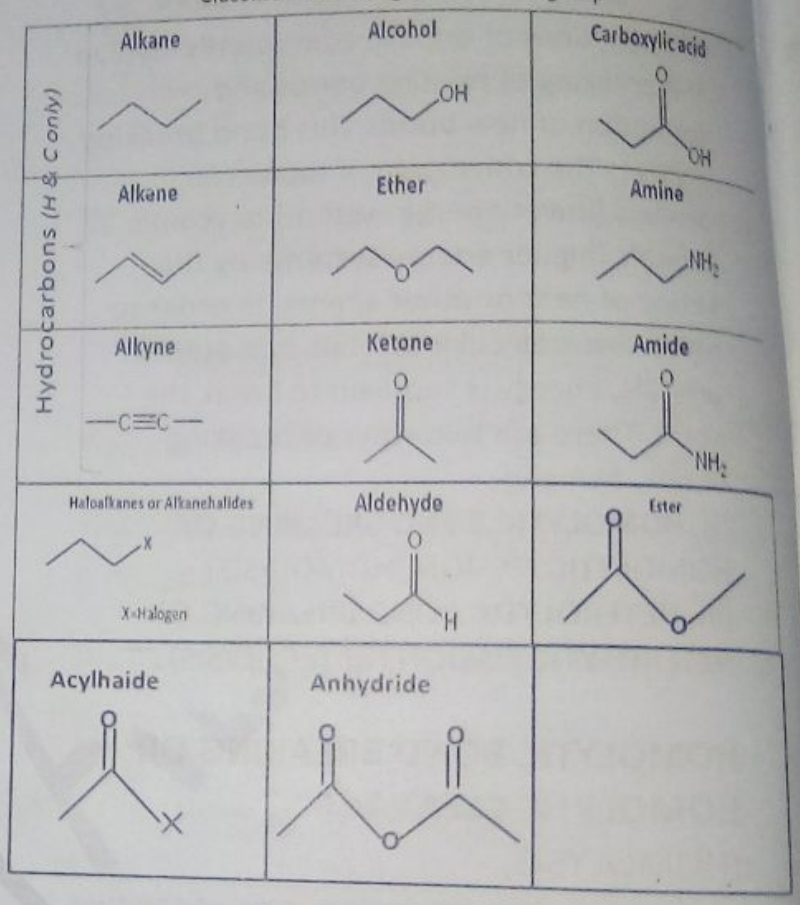
**A <u>functional group</u> is an atom or group of atoms responsible for the chemical reactions of a compound.**

The functional group is the **reactive site** of an organic molecule. It is the part of a molecule or compound where chemical reactions take place. The nature of the reaction an organic compound will undergo depends on the type of functional group present in the compound.

There are types of functional groups in organic compounds. Two or more compounds that have the same type of functional group in them are said to come from the same family and are called **homologues**. Below are some of the functional groups to be studied at this level.

## Types of Organic Compounds

Classified according to functional group




**FUTO 2014/2015 EXAM.**

The reactive portion of a molecule that undergoes predictable reactions is called -------?

**Ans = functional group**

# ALKANES

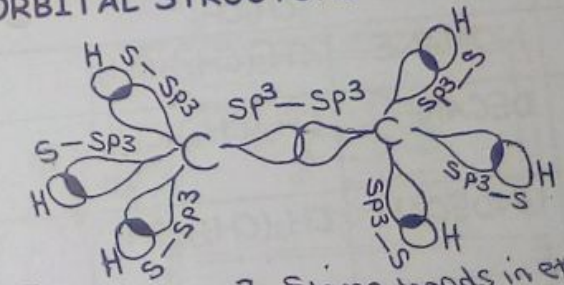
**Alkanes** are those hydrocarbons that contain **carbon-carbon single bond** (C-C). Alkanes are the simplest organic compounds made up of only hydrogen and carbon. The functional group present in an alkane is the **carbon to carbon single bond (C-C)**. The geometry or shape of the alkanes is **tetragonal** or **tetrahedral**. Alkanes have the bond angle of **109.5°** . The general molecular formular of alkanes is $C_nH_{(2n+2)}$ where **n** is the number of carbon atoms present in the alkane. Due to the presence of single bonds, alkanes are said to be saturated and **$SP^3$ hybridized**. Alkanes are called saturated hydrocarbon because each of the carbon atoms in an alkane is fully saturated with hydrogen atoms which makes alkanes to be inert or unreactive. Therefore alkanes are called **paraffins** which mean **little affinity**. The carbon-hydrogen(C-H) bond length in an alkane is approximately **1.09A°** while the carbon-carbon (C-C) bond length in an alkane is approximately **1.54A°**. Alkanes contain only sigma bonds and sigma(□) electrons in them. **NB;-** Alkanes do not have a π-bond because they do not have an unhybridized p-orbital's. Remember that the number of π-bonds in a compound is equal to the number of unhybridized p-orbital's in the compound because the unhybridized p-orbital's are used to form the π-bonds.

NOTE

Number of π-electrons = **2 x Number of π-bonds present.**

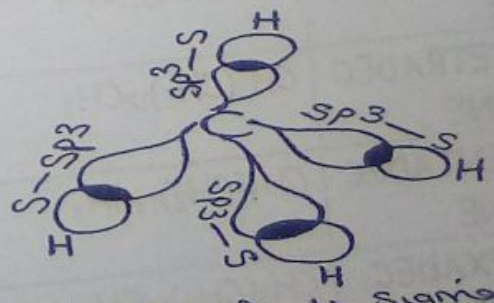
Number of □-electrons = **2 x Number of □ -bonds present.**

## ORBITAL STRUCTURE OF ETHANE




There are 7 Sigma bonds in ethane

## ORBITAL STRUCTURE OF METHANE




There are 4 Sigma bonds in methane

## NAMING OF ALKANES

The parent name of an alkane depends on the number of carbon atoms that make up the longest carbon-carbon chain. An alkanes that contains only one carbon atom is called methane. The alkane that contains two carbon atoms is called ethane. The one that contains three carbon atoms is called propane, etc. Below are formulae and names of the first-twenty alkanes

| | NAME | COMPOUND |
|---|---|---|
| 1 | METHANE | $CH_4$ |
| 2 | ETHANE | $CH_3CH_3$ |
| 3 | PROPANE | $CH_3CH_2CH_3$ |
| 4 | BUTANE | $CH_3CH_2CH_2CH_3$ |
| 5 | PENTANE | $CH3CH2CH2CH2CH_3$ |
| 6 | HEXANE | $CH_3CH_2CH_2CH_2CH_2CH3$ |
| 7 | HEPTANE | $CH_3CH_2CH_2CH_2CH_2CH_2CH_3$ |
| 8 | OCTANE | $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_3$ |
| 9 | NONANE | $CH_3(CH_2)_7CH_3$ |
| 10 | DECANE | $CH_3(CH_2)_8CH_3$ |
| 11 | UNDECANE | $CH_3(CH_2)_9CH_3$ |
| 12 | DODECANE | $CH_3(CH_2)_{10}CH_3$ |
| 13 | TRIDECANE | $CH_3(CH_2)_{11}CH_3$ |
| 14 | TETRADECANE | $CH_3(CH_2)_{12}CH_3$ |
| 15 | PENTADECANE | $CH_3(CH_2)_{13}CH_3$ |
| 16 | HEXADECANE | $CH_3(CH_2)_{14}CH_3$ |
| 17 | HEPTADANE | $CH_3(CH_2)_{15}CH_3$ |
| 18 | OCTADECANE | $CH_3(CH_2)_{16}CH_3$ |
| 19 | NONADECANE | $CH_3(CH_2)_{17}CH_3$ |
| 20 | EICOSANE | $CH_3(CH_2)_{18}CH_3$ |

## ALKYL GROUP

An **alkyl group** is formed when one hydrogen atom is removed from an alkane.

Alkyl group are named by replacing the last "ane" in the name of the alkane with "yl".EXAMPLE:-

| ALKANE | ALKYL GROUP |
|---|---|
| $CH_4$ Methane | $CH_3$ methyl |
| $C_2H_6$ Ethane | $C_2H_5$ Ethyl |
| $C_3H_8$ Propane | $C_3H_7$ Propyl |
| $C_4H_{10}$ Butane | $C_4H_9$ Butyl |

BELOW ARE THE FIRST-TWENTY ALKANE

Before naming any organic compound, we should always remember the rules that should be obeyed while naming an

organic compound according to the **IUPAC system**. The rules of naming organic compounds are as follows:-

**RULE 1.**

Identify the longest continuous carbon to carbon longest chain in the compound.

**RULE 2.**

Number only the carbon atoms in the longest chain starting from the side that would give the attachments or substituents or functional group a lower number

**NB;-** Attachments are those carbon branches which are not included as part of the longest chain in the compound.

**RULE 3.**

Locate the positions and names of the attachments or functional groups along the longest chain in the compound.

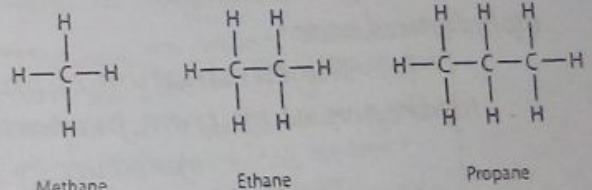
**RULE 4.**

When written the name of the compound, write the position and the name of the attachments first and then write the name of the longest chain.

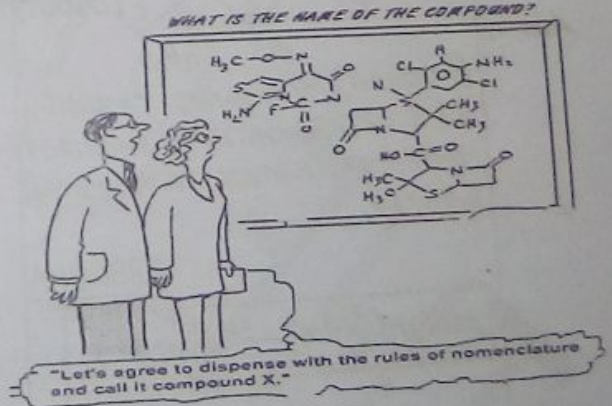
**NOTE**

- If there are more than one different attachments present in the compound, the name of the attachment that should be written first depends on the alphabetical order of their names. Example; **Ethyl** is written before **Methyl** because letter **E** comes first in the alphabets before letter **M**.
- If the same type of attachment is present twice in the compound, we use "**di**" but if it appears three times, we use "**tri**" and if four times, we use "**tetra**" etc.
  **Example**, if two methyl groups are attached to positions 2 and 4, we say **2,4-dimethyl**.

***NOW LET US NAME SOME ALKANES.***



Methane Ethane Propane



## TEST YOURSELF

*(1.)which of the following names is not correctly written?*

(A)2-Methylbutane (B)3-Ethylheptane (C)2-Methyl-3-Ethylheptane (D)3-Ethyl-2-Methylheptane.

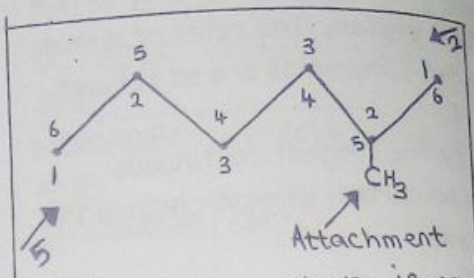
Ans = C.

***REASON:-*** *ethyl should be written before methyl according to alphabetical order.*

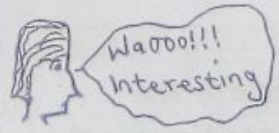
*(2). The elimination of one hydrogen atom from propane produces --?*

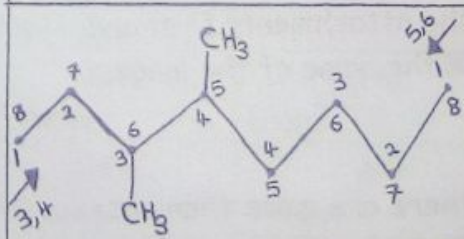
*(A)methyl (B)propyl (C)propane (D)butyl*

*Ans =B*




In this structure above, if we number from the left hand side, the attachment will be at position 5, but if we number from the right hand side, the attachment will be at position 2.
Since 2 is smaller than 5, we will number from the right hand side according to the rule. Therefore;
LONGEST CHAIN = 6 (Hexane)
POSITION OF ATTACHMENT = 2
NAME OF ATTACHMENT = methyl
ANSWER:- 2-Methylhexane



Here, if we number from the right, attachments will be at positions 5 and 6 which is 56. If we number from the left, attachments will be at positions 3 and 4 which is 34. Therefore we

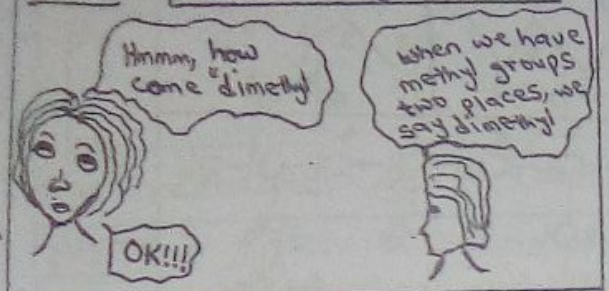
2 will number from the left since 34 is lower than 56. Therefore;

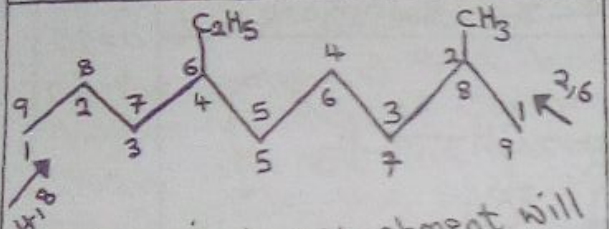
LONGEST CHAIN = 8 (Octane)

POSITIONS OF ATTACHMENT = 3 $ 4

NAME OF ATTACHMENTS = dimethyl

ANSWER: **3,4-Dimethyl Octane**




From the right, attachment will be at positions 2 and 6 which is 26.

From the left, attachments will be at positions 4 and 8 which is 48.

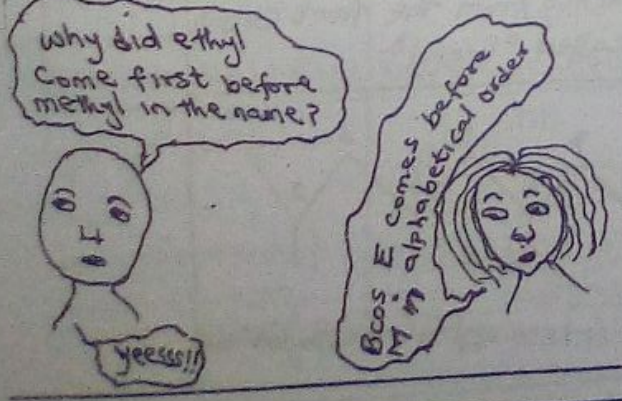
Since 26 is smaller than 48, we will number from the right.

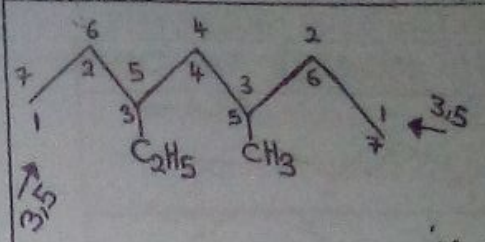
LONGEST CHAIN = 9 (Nonane).

POSITIONS OF ATTACHMENTS = 2 $ 6

NAMES OF ATTACHMENTS → Ethyl $ methyl

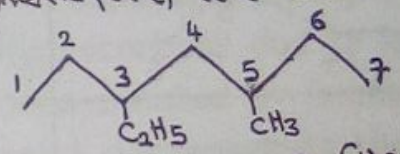
ANSWER:- **6-Ethyl-2-methyl nonane**




In this compound above, if we number the chain from the right hand side, the attachments will be at positions 3 $ 5. If we number from the left, the attachments will be at positions 3 $ 5. Since the attachments will have the same positions from both sides, we will consider the alphabetical order of the different attachments. $C_2H_5$ is ethyl while $CH_3$ is methyl

We have to start numbering from the side of ethyl because letter "e" comes before letter "m" in alphabetical order. Therefore, we have




LONGEST CHAIN = 7 (Heptane)

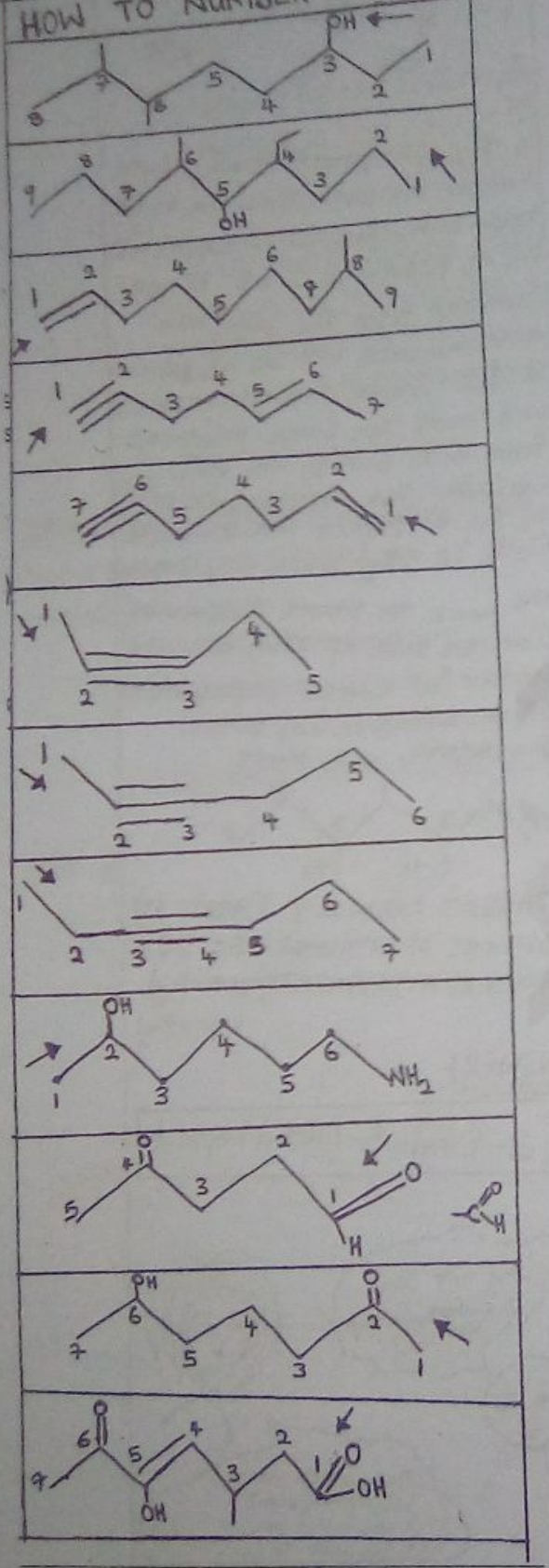
POSITIONS OF ATTACHMENTS = 3 $ 5

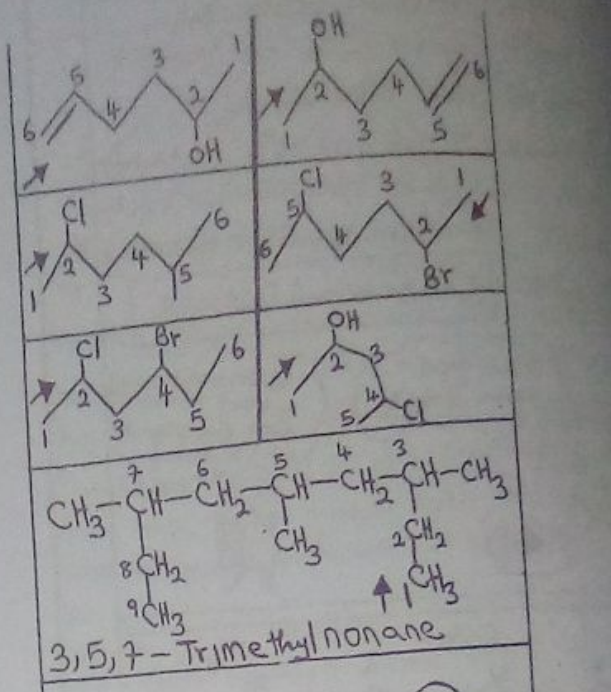
NAMES OF ATTACHMENTS → ethyl, methyl

ANSWER:-

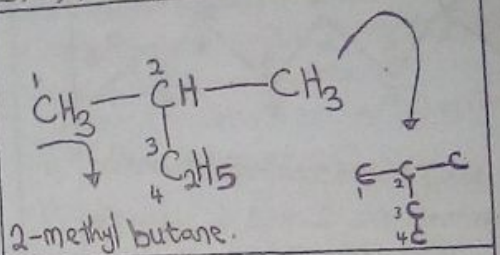
**3-Ethyl-5-methyl heptane**

## HOW TO NUMBER THE CHAIN

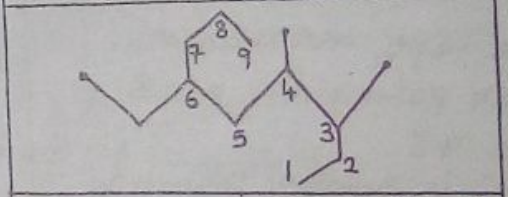


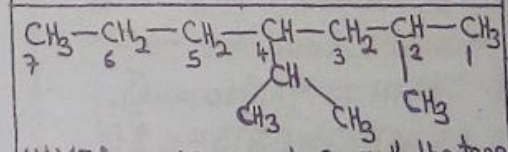


3,5,7-Trimethylnonane



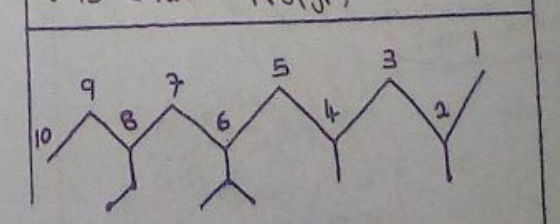
2-methyl butane.





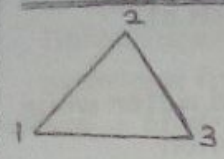
NAME:- 4-Isopropyl-2-methylheptane

If propyl is attached to a compound from it's second carbon, it is called "Isopropyl" but if it is attached from the front carbon, it is called "Propyl".

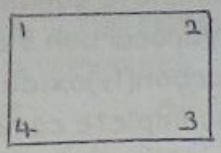


8-Ethyl-6-isopropyl-2,4-dimethyldecane

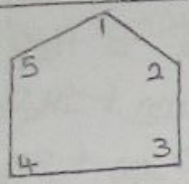
## NAMING OF CYCLO ALKANES



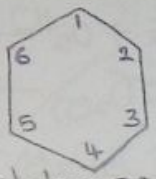

Cyclopropane




Cyclobutane



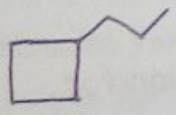

Cyclopentane




Cyclohexane

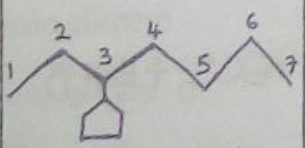
**NOTE**:- When a cyclo alkane is joined together with an open chain alkane, the side of the compound that has higher number of carbon chain will be the parent chain while the side that has lower number of carbon chain will be the attachment. Also, the part that carries the functional group is the parent chain.

Examples:-



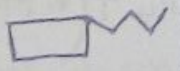
Propyl Cyclobutane

Cyclopropyl butane

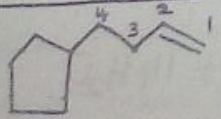



3-Cyclopentyl heptane

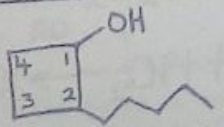
If both side have equal carbons, the cyclo part will be the parent.



Butyl Cyclobutane




4-Cyclopentyl but-1-ene.




2-Pentyl Cyclo-butanol.

## PHYSICAL PROPERTIES OF ALKANES

- From methane to butane are colourless gases at room temperature.

$C_5$-$C_7$ are liquids. Above $C_{17}$ are solids.

- The boiling and melting points of alkane's increases as the molecular weight increases.
- The density of alkanes is about $0.7 g/cm^3$. It means that the density of alkanes is lower than the density of water.

NB; If two or more alkanes have equal number of carbon and hydrogen atoms, the one that has more branches will have a lower boiling point. Branched hydrocarbons have lower boiling points than their corresponding straight chain hydrocarbons due to lower surface area created by branching. Boiling point decreases as the number of branches increases.

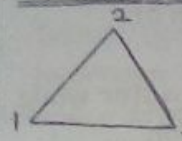
**FUTO PAST QUESTION 2015/2016**

Arrange the following isomeric alkanes in order of decreasing boiling points:- pentane, 2,2-dimethyl propane, and 2-methyl butane

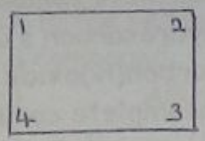
**ANSWER=** pentane > 2-methyl butane > 2,2-dimethyl propane.

- Alkanes are insoluble in water, but they dissolve in organic

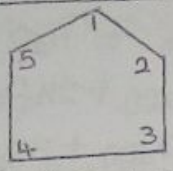
## NAMING OF CYCLO ALKANES




Cyclopropane




Cyclobutane




Cyclopentane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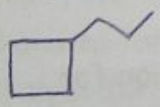
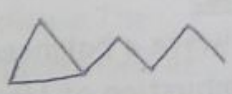
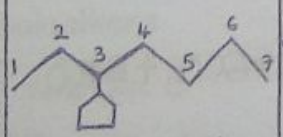


Propyl Cyclobutane

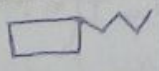


Cyclopropyl butane

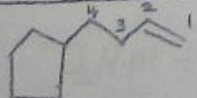



3-Cyclopentyl heptane

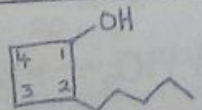
If both side have equal carbons, the cyclo part will be the parent.



Butyl Cyclobutane




4-Cyclopentyl but-1-ene.




2-Pentyl cyclo-butanol.

## PHYSICAL PROPERTIES OF ALKANES

- From methane to butane are colourless gases at room temperature.

$C_5$-$C_7$ are liquids. Above $C_{17}$ are solids.

- The boiling and melting points of alkane's increases as the molecular weight increases.
- The density of alkanes is about $0.7 g/cm^3$. It means that the density of alkanes is lower than the density of water.

NB: If two or more alkanes have equal number of carbon and hydrogen atoms, the one that has more branches will have a lower boiling point. Branched hydrocarbons have lower boiling points than their corresponding straight chain hydrocarbons due to lower surface area created by branching. Boiling point decreases as the number of branches increases.

**FUTO PAST QUESTION 2015/2016**

Arrange the following isomeric alkanes in order of decreasing boiling points:- pentane, 2,2-dimethyl propane, and 2-methyl butane

ANSWER= pentane > 2-methyl butane > 2,2-dimethyl propane.

- Alkanes are insoluble in water, but they dissolve in organic

solvents such as benzene and ether.

- Viscosity of alkanes increase as the number of carbon atoms increases.
- The density of the n-alkanes is around 0.7g/ml. It means that the density of water is higher than the density of the alkanes.

NB:- the density of alkane's increases as the number of carbon atom increases. It means that, ethane is denser than methane because ethane has more carbon atoms than methane.

## TEST YOURSELF

*rrange the following in their ecreasing order of boiling oints;*

$H_4$, $C_3H_3$, $C_8H_{18}$, $C_5H_{12}$, $C_2H_6$

## ANSWER

more the number of carbon atoms, the more the ng point.

NSWER=$C_8H_{18}$>$C_5H_{12}$>$C_3H_8$>$C_2H_6$>C

## CHEMICAL PROPERTIES OF ALKANES

Alkanes are generally unreactive. is is because alkanes are highly urated.

der certain conditions, alkanes erally undergo substitution ction;

- **COMBUSTION REACTION**

Combustion of alkane is the reaction of an alkane with oxygen gas. The products of complete combustion of hydrocarbon s are carbon(iv)oxide and water while incomplete combustion produces carbon(ii)oxide and water,

$$\text{Alkane} + O_2 \longrightarrow CO_2 + H_2O$$

$$CH_{4(g)} + 2O_{2(g)} \longrightarrow CO_{2(g)} + 2H_2O_{(g)}$$

$$C_2H_{6(g)} + \tfrac{7}{2}O_{2(g)} \longrightarrow 2CO_{2(g)} + 3H_2O_{(g)}$$

OR

$$2C_2H_6 + 7O_2 \longrightarrow 4CO_2 + 6H_2O$$

If you are asked to balance the equation of combustion reaction of an alkane, use this formula;

$$C_xH_y + \left(x + \tfrac{y}{4}\right)O_2 \longrightarrow xCO_2 + \tfrac{y}{2}H_2O$$

Where X = number of carbon Atoms present.

Y = numbers of hydrogen atoms present.

Example;

Let us write a balanced equation for the combustion of Hexane.

Hexane => $C_6H_{14}$

Here, X = 6 and Y = 14

$$C_6H_{14} + \left(6 + \tfrac{14}{4}\right)O_2 \longrightarrow 6CO_2 + \tfrac{14}{2}H_2O$$

$$C_6H_{14} + \tfrac{19}{2}O_2 \longrightarrow 6CO_2 + 7H_2O$$

OR

$$2C_6H_{14} + 19O_2 \longrightarrow 12CO_2 + 14H_2O$$

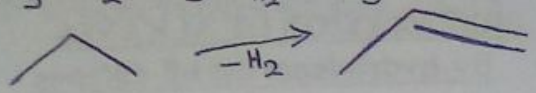
- **DEHYDROGENATION REACTION**

Dehydrogenation is the removal of hydrogen from a compound.

**Alkane - Hydrogen → Alkene**

$CH_3-CH_3 \xrightarrow{-H_2} CH_2=CH_2$

$CH_3-CH_2-CH_3 \xrightarrow{-H_2} CH_3-CH=CH_2$



**NB;** Dehydrogenation is the removal of hydrogen.

- **NITRATION OF ALKANES**

This is the addition of a nitro group ($NO_2$) to a substance. In nitration of alkanes, a hydrogen atom is substituted with a nitro group ($NO_2$).

$CH_3CH_3 \xrightarrow[400°C]{HNO_3} CH_3CH_2NO_2$

Ethane → Nitroethane

- **HALOGENATION OF ALKANES**

This is the addition of a halogen to an alkane to form haloalkane. The catalyst for the halogenations of alkane is the ultra-violet light.

**Alkane+Halogen → Haloalkane**

$CH_4 + Cl_2 \xrightarrow{U.V} CH_3Cl + HCl$ (Excess)

$CH_4 + 2Cl_2 \longrightarrow CCl_4 + 2H_2$ (Excess)

$Cl_2 \xrightarrow{U.V} Cl^{\cdot} + Cl^{\cdot}$ (free radicals)

Heat can also be used to generate the free radicals in the absence of U.V light.

**When the alkane is in excess, chloromethane is produced but when the chlorine is in excess, tetrachloromethane is produced.**

**NB;** Halogenations of alkanes occur through series of radical mechanism called "Chain reaction".

There are 3 stages in the halogenations of alkanes namely;-

- **Initiation Stage**

This is the stage at which the halogen is activated to its free radicals with the use of light.

$Cl_2 \xrightarrow{U.V} Cl^{\cdot} + Cl^{\cdot}$

free radicals.

- **Chain propagation stage**

This is the stage at which the free radicals start attacking the alkane.

$Cl^{\cdot} + CH_4 \longrightarrow {}^{\cdot}CH_3 + HCl$

$Cl^{\cdot} + CH_3CH_2CH_3 \longrightarrow CH_3{}^{\cdot}CHCH_3 + HCl$

- **TERMINATION STAGE**

This is the stage at which the reaction stops. This happens when free radicals combine.

$Cl^{\cdot} + {}^{\cdot}CH_3 \longrightarrow CH_3Cl$

$Cl^{\cdot} + CH_3{}^{\cdot}CHCH_3 \longrightarrow CH_3CHClCH_3$

$Cl^{\cdot} + Cl^{\cdot} \longrightarrow Cl_2$

$^{\cdot}CH_3 + {}^{\cdot}CH_3 \longrightarrow CH_3CH_3$

**NB;** Ultraviolet light (U.V) acts as the Catalyst here and halogenations of

alkanes will not take place in a dark condition (absence of light).
NOTE;- halogenations of alkanes occur through a free radical mechanism

5. SULFONATION OF ALKANES

This is the addition of SO3H to alkanes.

NB: $H_2SO_3$ is used (fuming)

$$CH_3CH_3 \xrightarrow{H_2SO_4} CH_3CH_2SO_3H$$

- CRACKING OF ALKANES

Cracking is the breaking down of higher molecular weight hydrocarbons into smaller fractions.
Cracking is also called pyrolysis.

$$\text{Alkane} \xrightarrow[(400^\circ - 600^\circ)]{\Delta} \text{Smaller alkane} + \text{alkene} + H_2$$

$$CH_3CH_3 \xrightarrow{\Delta} CH_4 + CH_2{=}CH_2 + H_2$$

- ISOMERIZATION OF ALKANES

This is the conversation of a normal alkane into its branched chain isomer in the presence of aluminum chloride ($AlCl_3$) and HCl at 25°C.

$$CH_3CH_2CH_2CH_3 \xrightarrow[HCl]{AlCl_3} CH_3\underset{\displaystyle CH_3}{\underset{|}{C}}HCH_3$$

n-butane — isobutane

- AROMATIZATION OF ALKANES

This is the conversion of an alkane into a cyclic benzene or benzene derivative in the presence of $Cr_2O_3/Al2O_3$.

$$CH_3CH_2CH_2CH_2CH_2CH_3 \xrightarrow[600^\circ C]{Cr_2O_3/Al_2O_3} \text{C}_6\text{H}_6 + 4H_2$$

## SOURCES OF ALKANES

The two major sources of alkanes are:
-Natural gas
-Petroleum

## PREPARATION OF ALKANES

- By hydrogenation of alkenes

$$CH_2{=}CH_2 + H_2 \xrightarrow[\Delta]{Ni} CH_3CH_3$$

Ethene — Ethane

$$\text{C}_6\text{H}_{10} + H_2 \xrightarrow[\Delta]{Ni} \text{C}_6\text{H}_{12}$$

Ethane

NB:- The catalysts used in hydrogenation are Nickel (Ni), Platinum (Pt) and Palladium (Pd).

- By complete hydrogenation of an alkyne

$$CH{\equiv}CH \xrightarrow[Ni,\Delta]{2H_2} CH_3CH_3$$

In order to prevent complete hydrogenation of an alkyne, we use Palladium poisoned with Calcium Carbonate in Quinoline. This is called LINDLAR'S CATALYST. we shall see this reaction in the reactions of alkynes.

- By reduction of alkyl halides

$$CH_3CH_2Cl + 2H^+ \rightarrow CH_3CH_3 + HCl$$

By decarboxylation of Carboxylic acid salts.

This is the removal of $CO_2$ from an alkanoate salt to produce an alkane.

NB;- Decarboxylation of ethanoate produces methan. Decarboxylation of propanoate produces ethane. Decarboxylation of butanoate produces propane, etc.

$$CH_3COONa + NaOH \rightarrow CH_4 + Na_2CO_3$$

$$CH_3CH_2COONa + NaOH \rightarrow CH_3CH_3 + Na_2CO_3$$

FUTO PAST QUESTION

The decarboxylation of sodium ethanoate produces...? (A)methanol (B)ethane (C)methane (D)ethanoic acid

ANSWER = C

- By Wurtz reaction

$$2CH_3Br + 2Na \xrightarrow{Ether} CH_3CH_3 + 2NaBr$$

- By hydrolysis of Grignard reagent

$$CH_3CH_2MgCl + H_2O \rightarrow CH_3CH_3 + MgCl(OH)$$

- By Kolbe's synthesis

$$2CH_3COONa \xrightarrow{H_2O} CH_3CH_3 + 2NaOH + H_2$$

# ALKENES

Alkenes are the unsaturated hydrocarbons that contains carbon to carbon double bond along the chain. Alkenes have the general molecular formula $C_nH_{2n}$ (n = number of carbon atoms).

Alkanes have two hydrogen atoms more than their corresponding alkenes.

Alkenes are SP2-hybridized.

Alkenes have trigonal or planar shape with a bond angle of 120°.

Alkenes are also called olefins which mean oil formers. The double bond in an alkene is made up of one sigma bond and one pi-bond.

NB; One pi-bond contains two pi-electrons.

The first member of the alkenes family is Ethene.

## NOMENCLATURE OF ALKENES

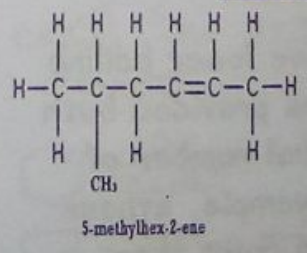
We follow the same rules of naming as in alkanes.

In naming alkenes, we number the carbon atoms in the longest chain in a way that will give the double bond the smallest number.

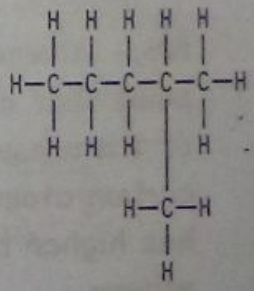
The position of the double bond in the longest chain should be indicated when writing the name of the alkene.

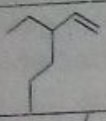
- The last "ane" in the name of an alkane is replaced with "ene" for an alkene.

**Examples**



5-methylhex-2-ene



| Bond-line Structure | IUPAC Name |
|---|---|
|  | Pent-1-ene |
|  | 3-Methylcyclopent-1-ene |
|  | 4-Methylhex-1-ene |
|  | 3-Ethylhex-1-ene |
|  | 2-Methylbut-2-ene |
|  | 2,4-DimethlPent-2-ene |

NB; When both a cyclo and an open chain compounds are joined together, the part that carries the functional group is taken to be the parent.

## PHYSICAL PROPERTIES OF ALKENES

- From $C_2$-$C_4$ are gases $C_5$-$C_{17}$ are liquids while from $C_{18}$ and above are solids at room temperature.
- Alkenes are not completely soluble in water because alkenes are non polar.
- Boiling and melting points of alkenes as well as their viscosity increase as the number of carbon atoms increases.

NB;- Alkenes have lower boiling point that alkanes provided both of them have equal number of carbon atoms. Example, ethane has higher boiling point than ethene.

## STABILITY AND REACTIVITY OF ALKENES

More substituted alkenes are more stable than the less substituted alkenes. Example, but-2-ene is more stable than but-1-ene.

Less substituted alkenes are more reactive than the more substituted alkenes. Example, but-1-ene is more reactive than but-2-ene. It means that, the lower the position of the double bond, the more reactive the alkene.

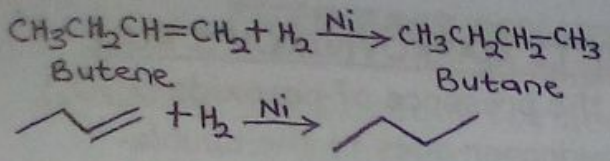
## CHEMICAL PROPERTIES OF ALKENES

Generally, alkenes are more reactive than alkanes. This is due to the presence of pi-electrons (electron cloud) present in alkenes.

- Hydrogenation of alkenes

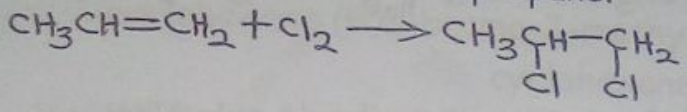
  Hydrogenation is the addition of hydrogen to a substance. The hydrogenation of an alkene produces an alkane. Example, hydrogenation of ethane produces ethane. Hydrogenation of butane produces butane.

  NB;- The catalysts used in hydrogenation of alkenes are Nickel, palladium and Platinum.




- **Halogenation of alkenes**

Halogenation of alkene produces dihaloalkane. Example;- chlorination of prop-1-ene will produce 1,2-dichloropropane.



**FUTO PAST QUESTION 2016/2017**

What is the product formed by the bromination of 2-methyl pent-1-ene?

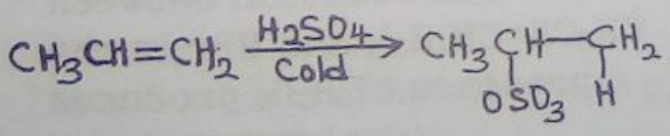
(a) 2,2-dibromo-2-methyl heptane (b) 1,2-dibromo-2-methyl pentane (c) 2-bromo-2-methyl pent-1-ene (d) 1-bromo-2-methyl pent-1-ene

ANSWER = B

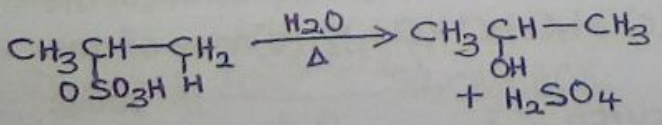
- **Reaction with $H_2SO_4$**

The reaction of an alkene with $H_2SO_4$ has two stages. The final product is an alcohol.

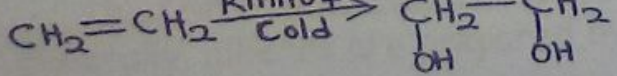
**Stage 1**



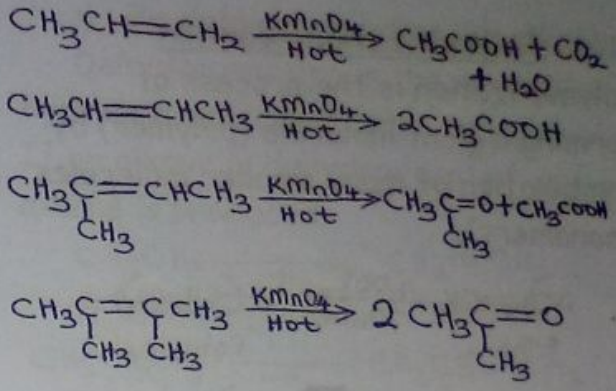
**Stage 2**



- **Reaction with $KMnO_4$**



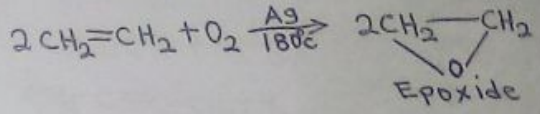
**NB;** Cold and hot conditions of alkene with $KMnO_4$ gives different products.

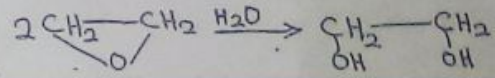


- **Reaction with oxygen**

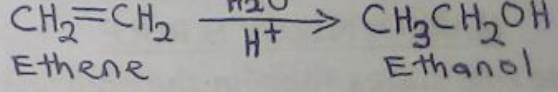
This is comburstion reaction.

=> In the presence of silver, a different product is formed.



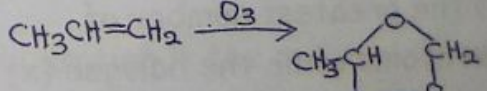



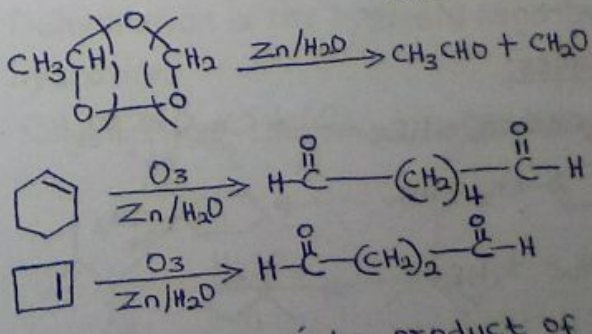
- **Hydration of alkenes**




**Reaction with Ozone ($O_3$)**

**The reaction of an alkene with ozone is called ozonolysis.**



**NB:-** the intermediate product of ozonolysis is called ozonide

- **Polymerization reaction**

Polymerization is the process of forming a giant molecule (polymer) by combination of many smaller molecules (monomers).

$$n CH_2=CH_2 \xrightarrow[70\,atm]{400^\circ C} n(CH_2-CH_2)$$

Ethene → Polyethene

where $n = (3,000 \rightarrow 15,000)$ molecules

- **Hydrohalohenation of alkenes**

**Hydrohalogenation is the addition of hydrogen and halogen to a substance**

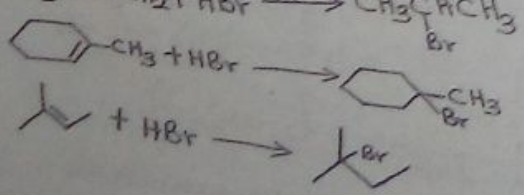
$$CH_2=CH_2 + HBr \longrightarrow CH_3CH_2Br$$

## MARKOVNIKOV'S RULE

The rule states that "in the addition of a hydrogen halide (Hx) to an unsymmetric alkene, the H of the Hx goes to the double-bonded carbon that has the greatest number of hydrogen atoms while the halogen (x) joins the carbon with Smaller number of hydrogen atoms".

**Examples;**

$$CH_3CH=CH_2 + HBr \longrightarrow CH_3\underset{Br}{C}HCH_3$$



## ANTI MARKOVNIKOV'S RULE

In the presence of peroxide ($H_2O_2$), the hydrogen goes to the double-bonded carbon with smaller number of hydrogen atoms while the halogen goes to the one with more hydrogen atom.

$$CH_3CH=CH_2 \xrightarrow[H_2O_2]{HBr} CH_3CH_2-CH_2Br$$

*NB; Anti markovnikov's rule also occurs in the presence of diakyl, diacyl and alkyl.

**FUTO PAST QUESTION 2016/2017**

Predict the product of pent-1-ene and excess HCl in the presence of hydrogen peroxide (a) 1.2-dichloropentane (b) 1,2-dichloropentane (c)2,2-dichloropentene (d) 2-chloro-1-pentene

ANSWER = B

**FUTO PAST QUESTION 2016/2017**

The reaction between $CH_3CH=C(CH_3)_2$ and HBr in the presence of $H_2O_2$ produces (a)$CH_3CHBrCH(CH_3)_2$ (b)$CH_3CH_2CBr(CH_3)_2$ (c)$CH_3CH_2CH(CH_3)_2$ (d)none of the above

ANSWER = A

**FUTO PAST QUESTION 2016/2017**

What is the product formed in the peroxide catalysed hydrobromination of 1-methylcyclohexene?

(a)4-bromo-1-methylcyclohexane (b) 2-bromo-1-methyl-1-methyl cyclohexane (c) 1-bromo-1-methyl cyclohexane (d)5-bromo-2-methyl cyclohexane

**ANSWER** = 1-bromo-2-methyl cyclohexane (no correct option).

*NB; There is a reaction known as *Oxymercuration of alkenes.*

The final product of this oxymercuration of alkene is an alcohol.

$$3CH_3(CH_2)_3CH=CH_2 \xrightarrow{BH_3} [CH_3(CH_2)_4CH_2]_3B$$

$$[CH_3(CH_2)_4CH_2]_3B \xrightarrow[H_2O_2]{OH^-} 3CH_3(CH_2)_4CH_2OH$$

OR

$$3CH_3(CH_2)_3CH=CH_2 \xrightarrow[OH^-,\ H_2O_2]{BH_3} 3CH_3(CH_2)_4CH_2OH$$

There is also another reaction of alkenes called hydroboration of alkenes.

The end-product of hydroboration of alkene is an alcohol.

It is a two step reaction.

$$CH_3CH=CH_2 \xrightarrow[H_2O]{Hg(O-C(=O)-CH_3)_2} CH_3\underset{OH}{C}HCH_3$$

## PREPARATION OF ALKENES

Generally, alkenes are prepared by **elimination reaction.**

- **By dehydrogenation of alkanes**

Dehydrogenation is the removal of hydrogen molecule from a substance. If an alkane is dehydrogenated, an alkene is produced.

$$\underset{\text{Ethane}}{CH_3CH_3} \xrightarrow{-H_2} \underset{\text{Ethene}}{CH_2=CH_2}$$

$$\underset{\text{Propane}}{CH_3CH_2CH_3} \xrightarrow{-H_2} \underset{\text{Propene}}{CH_3CH=CH_2}$$

- **By hydrogenation of alkynes**

Hydrogenation of a substance is the addition of hydrogen molecule to the substance.

The addition of hydrogen molecule ($H_2$) is an alkyne.

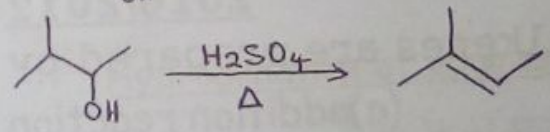
$$CH\equiv CH + H_2 \xrightarrow[\text{Quinoline}]{Pd-CaCO_3} CH_2=CH_2$$

$$CH_3-C\equiv C-CH_3 + H_2 \xrightarrow[\text{Quinoline}]{Pd-CaCO_3} \underset{\text{trans}}{\text{(trans-2-butene)}}$$

- **By dehydration of alcohols**

$$CH_3CH_2OH \xrightarrow[\Delta]{H_2SO_4} CH_2=CH_2 + H_2O$$

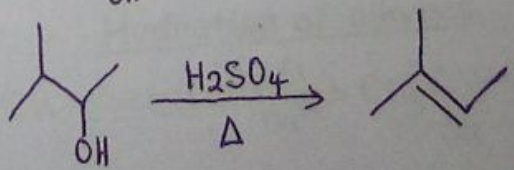
$$CH_3CH_2\underset{OH}{C}HCH_3 \xrightarrow[\Delta]{H_2SO_4} CH_3CH=CHCH_3$$



Dehydration is the removal of water molecule from a substance.

Dehydration is the opposite of hydration.

$$CH_3CH_2\underset{OH}{C}HCH_3 \xrightarrow[\Delta]{H_2SO_4} CH_3CH=CHCH_3$$



- **By dehydrohalogenation of haloalkanes**

Dehydrohalogenation is the removal of a molecule of hydrogen halide from a substance.

A haloalkane is an alkane that contains a halogen.

**FUTO PAST QUESTION 2016/2017**

The loss of a halide atom to generate an alkene is known as (a) dehydro-halogenation (b) dehydration (c) reduction (d) oxidation

**ANSWER = A**

$$CH_3CH_2CH_2Cl \xrightarrow[Alcohol]{KOH} CH_3CH=CH_2 + KCl + H_2O$$

- **By cracking of alkane**

$$CH_3CH_2CH_3 \xrightarrow[\Delta]{600^\circ C} CH_2=CH_2 + CH_4$$

**FUTO PAST QUESTION 2016/2017**

Alkenes are prepared by (a)addition reaction (b)substitution reaction (c)elimination reaction (d)free radical reaction

ANSWER = C

# Alkynes

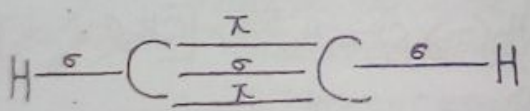
Alkynes are hydrocarbons that contain carbon to carbon triple bond.

Alkynes have the general molecular formula $C_nH_{2n-2}$.

Alkynes are SP-hybridizated.

Alkynes have Linear shape with bond angle of 180°.

The triple bonds of an alkyne is made up of one sigma bond and two pi-bonds.




Ethyne

NOTE

**Alkynes whose triple bonds are located at position one are called TERMINAL ALKYNES and they are more reactive than other alkynes.**

## NOMENCLATURE OF ALKYNES

Alkynes are named in this manners are alkenes.

In naming alkynes, the the last "ane" of alkane is replaced with "yne" for an alkyne.

The triple bond position is given the smallest number when numbering the carbon atoms in the longest chain.

Ethyne is the first member of the alkynes.

| | | |
|---|---|---|
| | $H-C\equiv C-H$ | |
| | $H-C\equiv C-\underset{H}{\overset{H}{C}}-H$ | |

$$HC\equiv C-CH_2-CH_2-CH_2-CH_3$$
Hex-1-yne

$$CH_3-C\equiv C-CH_2-CH_2-CH_3$$
Hex-2-yne

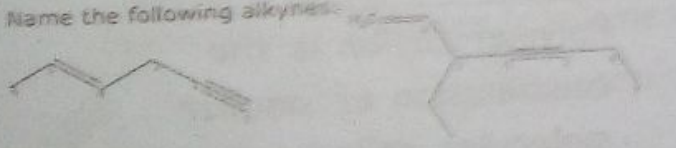
$$CH_3-CH_2-C\equiv C-CH_2-CH_3$$
Hex-3-yne

$$HC\equiv C-\underset{\displaystyle CH_3}{\underset{|}{CH}}-CH_2-CH_3$$
3-Methylpent-1-yne

## ALKYNES

**IUPAC naming system:**

Name the following alkynes:

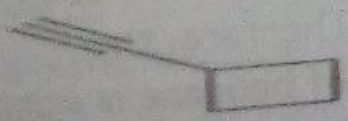


hex-4-en-1-yne

3-ethylhept-1-en-4-yne

*Alkenes are ordered first in the name, and the "e" ending is dropped.*

*Generally, double bonds and triple bonds have equal numbering priority* (aim to get the lowest numbers).*



cylobutylethyne

## PHYSICAL PROPERTIES OF ALKYNES

- Boiling and melting points of alkynes increases as the number of carbon atoms increases.

**NB;- alkynes have higher boiling points than alkenes and alkanes of the same number of carbon atoms. For boiling points,**

**ALKYNE > ALKANE > ALKENE**

- Alkynes are slightly polar and therefore are slightly soluble in water but they dissolve in organic solvents.
- From $C_1$-$C_3$ alkynes are gases, $C_4$-$C_{11}$ are liquids while others are solids at room temperature.

## CHEMICAL PROPERTIES OF ALKYNES

- **Comburstion reaction**

$$HC\equiv CH + 5/2\,O_2 \longrightarrow 2CO_2 + H_2O$$

- **Hydrogenation of alkynes**

$$HC\equiv CH + H_2 \xrightarrow{Ni} H_2C=CH_2$$

- **Halogenation of alkynes**

$$H_3CC\equiv CH \xrightarrow[SiO_2]{Cl_2} H_3C-\underset{Cl}{C}=\underset{Cl}{CH}$$

- **Hydration of alkynes**

$$CH_3C\equiv CH \xrightarrow[Hg^{2+}]{H_2O} CH_3-\underset{OH}{C}=CH_2$$

- **Hydrohalohenation of alkynes**

$CH_3C\equiv CH \xrightarrow{HCl} CH_3C(Br)=CH(H)$

$CH_3C\equiv CH + 2HBr \rightarrow CH_3CBr_2CH_3$

- **Oxidation of alkynes**

$CH_3C\equiv CH \xrightarrow{KMnO_4} CH_3COOH + CO_2$

$CH_3C\equiv CCH_3 \xrightarrow{KMnO_4} 2CH_3COOH$

$HC\equiv CCH_3 \xrightarrow[\text{Liq. ammonia}]{NaNH_2} C\equiv C$

$\rangle\!\equiv \xrightarrow{NaNH_2} \rangle\!\equiv Na$

$CH_3C\equiv CH \xrightarrow[\text{Liq } NH_3]{NaNH_2} CH_3C\equiv CNa$

- **Formation of salts (Acetylides)**

Hydrogen atom bonded to a carbon carrying a triple bond is called an **acidic hydrogen**. acidic hydrogens are very reactive. Acidic hydrogen in alkynes are usually substituted by metals like sodium, silver, copper.

***NB:** Alkynes that have acidic hydrogens (terminal alkynes) are more reactive than those without acidic hydrogen.

**FUTO PAST QUESTION 2016/2017**

Which of the following is more acidic

(a) 1-butyne (b) 2-butyne (c) 1-butene (d) butane

**ANSWER = A**...(a terminal alkyne).

$CH_3C\equiv CH \xrightarrow{KMnO_4} CH_3COOH + CO_2$

$CH_3C\equiv CCH_3 \xrightarrow{KMnO_4} 2CH_3COOH$

$HC\equiv CCH_3 \xrightarrow[\text{Liq. ammonia}]{NaNH_2} C\equiv C$

$\rangle\!\equiv \xrightarrow{NaNH_2} \rangle\!\equiv Na$

$CH_3C\equiv CH \xrightarrow[\text{Liq } NH_3]{NaNH_2} CH_3C\equiv CNa$

Cu

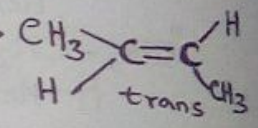
$Na, NH_3$

$CH_3C\equiv CH + AgNO_3 \xrightarrow{NH_4OH} CH_3C\equiv CAg$

$HC\equiv C-H \xrightarrow[NH_4OH]{2AgNO_3} AgC\equiv CAg$ (white ppt)

$CH_3C\equiv CCH_3 \xrightarrow[NH_4OH]{AgNO_3}$ No reaction

$HC\equiv CH \xrightarrow[NH_4OH]{Cl_2} CuC\equiv CCu$

$CH_3C\equiv CCH_3 \xrightarrow{Na}$ 

trans

- **Production of Vinyl chloride**

$HC\equiv CH \xrightarrow{HCl} H_2C=CH$

Vinyl chloride

- **Polymerization of Ethyne**

**Polymerization is the combination of smaller molecules called monomers to produce a giant molecule called polymer.** Example, when molecules of ethyne combine together, they form benzene molecule. Therfore, the monomer of benzene is ethyne.

$3HC\equiv CH \rightarrow$ 

Benzene

## PREPARATION OF ALKYNES

- **By dehydrogenation of alkanes or alkenes.**

$$CH_3CH_3 \xrightarrow{-H_2} CH_2=CH_2 \xrightarrow{-H_2} HC\equiv CH$$

Ethane Ethene Ethyne

- **From dehydrohalogenation of haloalkenes.**

$$CH_3\underset{Br}{C}=CH_2 \xrightarrow[-HBr]{NaNH_2} CH_3C\equiv CH$$

- **From coke**

$$CaO + 3C \xrightarrow[2000^\circ C]{\Delta} CaC_2 + CO$$

$$CaC_2 + 2H_2O \longrightarrow C_2H_2 + Ca(OH)_2$$

- **By thermal cracking of alkanes**

$$2CH_4 \xrightarrow[\Delta]{1500^\circ C} C_2H_{2(g)} + 3H_{2(g)}$$

**FUTO PAST QUESTION. 2016/2017.**

$CaC_2$ on hydrolysis gives ?
(a)alkanes (b)alkenes (c)alkynes (d)alcohols

ANSWER = alkynes...C

## TEST FOR ALKANES, ALKENES AND ALKYNES

Alkanes do not change the colour of bromine water because alkanes are saturated.

Alkenes and alkynes decolourise bromine water because they are unsaturated.

Akenes and alkynes also change the purple colour of KMnO4 to colourless.

Alkynes react with a solution of silver trioxonitrate(v) while alkenes do not react with it.

## HOMOLOGOUS SERIES

Homologous series is a series of compounds in which each member differs from it's successive member by a constant amount.
Members of a homologous series are called "homologous".A given homologous series is made up of compounds of the same family or functional group.

### CHARACTERISTICS OF HOMOLOGOUS SERIES

- They differ from each successive member by $CH_2$ or 14g (C=12, H= 1)
- They have similar chemical properties.
- Their physical properties gradually vary on going down the series.
- Boiling and melting points as well as viscosity increases down the series.

**Example:**

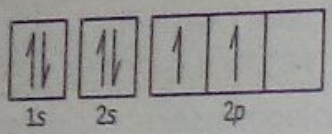
- $CH_4$
- $C_2H_6$
- $C_3H_8$ etc

# HYBRIDIZATION

Hybridization is the process of mixing of two or more pure different orbitals to form new equivalent orbital.

Now, let us take a look at the electronic configuration of carbon atom.

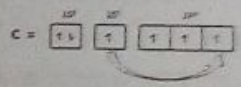
C $1s^2 2s^2 2p^2$




If energy is applied to this ground state configuration of carbon, one electron will be transferred from 2S-orbital to the empty P-orbital (Pz).

We then have the excited state configuration of carbon atom as;

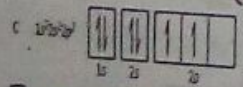
[redacted]



[redacted]

## $SP^3$ HYBRIDIZATION

Ground state(C)



Excited state

[redacted]

In other to produce four identical bonds, carbon must contribute a set of four equivalent orbitals.

This is done when the 2S orbital and the three 2P-orbitals in the excited state of carbon are mixed together or hybridized to form four new equivalent orbitals. These new orbitals are known as $SP^3$ hybrid orbitals.

**HYBRID ORBITALS are those new equivalents orbitals formed by mixing up of two or more different orbitals.**

***N/B:-** $SP^3$ orbitals are formed when one S-orbital ($S^1$) mixes up with three P-orbital ($P^3$).

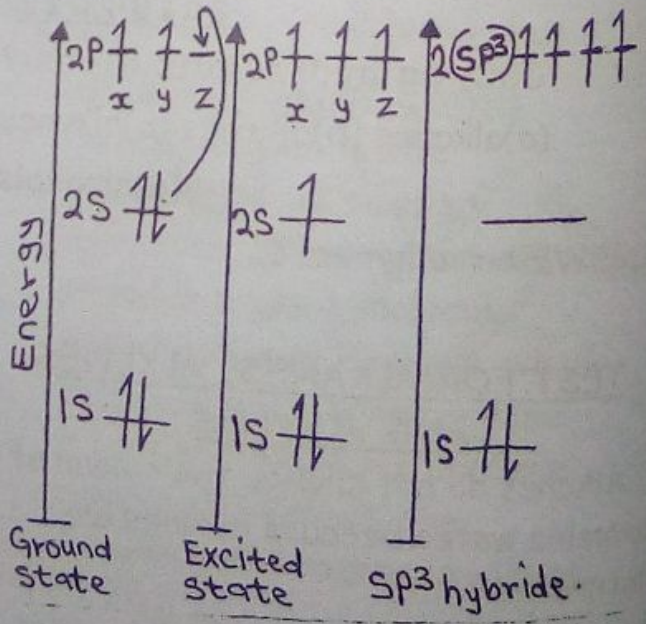
It is just like when you mix one liter of a pure red paint with three Liters of white paint and you form four liters of pink paint ( Red +white=pink)

i.e $S^1 + P^3$ $SP^3$

The electronic configuration of $SP_3$ of carbon becomes;

$1S^2$ $2(SP^3)^1$ $2(SP^3)^1$ $2(SP^3)^1$ $2(SP^3)^1$

Now, let us take a look at the formation of $SP^3$ hybrids in terms of energy levels,



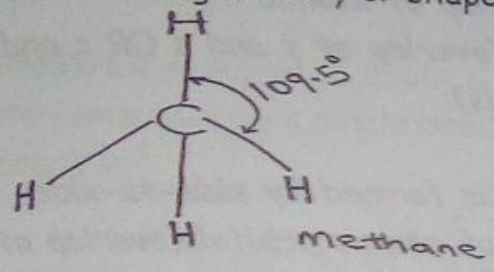
In $SP^3$

$$\%S = \frac{S}{SP^3} \times \frac{100}{1} = \frac{1}{1+3} \times \frac{100}{1} = 25\%$$

$$\%P = \frac{P^3}{SP^3} \times \frac{100}{1} = \frac{3}{1+3} \times \frac{100}{1} = 75\%$$

NB:- The higher percentage S-character, the more acidic the compound

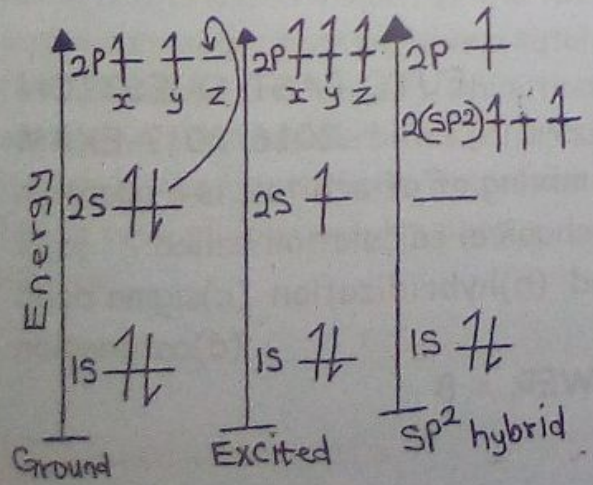
The shape of an $SP^3$ hybrid orbital is tetrahedral. Examples, alkanes are $SP^3$ hybridized and they have tetrahedral geometry or shape.




***N/B:** The tetrahedral shape is obtained because the electrons move as far as possible away from each other because they are like charges.

## $SP^2$ HYBRIDIZATION

In $SP^2$ hybridization, one electron of 2S-orbital mixes up with two from 2P_orbital leaving one of P-orbital unhybridized.




The configuration in $SP^2$ is;

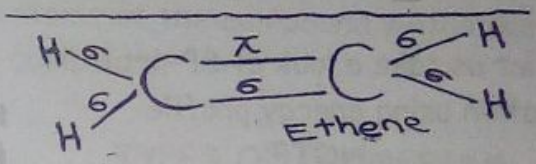
$1S^2\ 2(SP^2)^1\ 2(SP^2)^1\ 2(SP^2)^1\ 2P^1$

*Unhybridized*

The bond angle in an $SP^2$ hybrid is 120° and it has a trigonal shape. $SP^2$ hybridization is found in alkenes.

The unhybridized orbital in P-orbital ($P_z$) is used to form a pi-bond. Since only one is unhybridized, one pi-bond ($\pi$) is found in a simple alkene.

EXAMPLE;




$\pi$ pi-bond

$\sigma$ sigma bond

The percentage S and P in $SP^2$ are as follows;

In $SP^2$

$$\%S = \frac{S}{SP^2} \times \frac{100}{1} = \frac{1}{1+3} \times \frac{100}{1} = 33.3\%$$

$$\%P = \frac{P^2}{SP^2} \times \frac{100}{1} = \frac{2}{3} \times \frac{100}{1} = 66.7\%$$

## SP HYBRIDIZATION

Here, only one orbital of the P-orbital is hybridized.

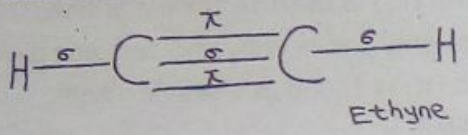
SP-hybrid orbital is formed when one electron from the 2S-orbital of carbon atoms mixes up with only one orbital of 2P-orbital.

The other two orbitals in P-orbital ($P_y$ and $P_z$) are left unhybridized.

The two unhybridized orbitals are used to form pi-bond.Simple alkynes

have two pi-bonds because there are two unhybridized p-orbitals in alkynes (SP).
There two pi-bonds in this case.
SP-hybridization is found in alkynes.
They have Linear shape with a bond angle of 180°

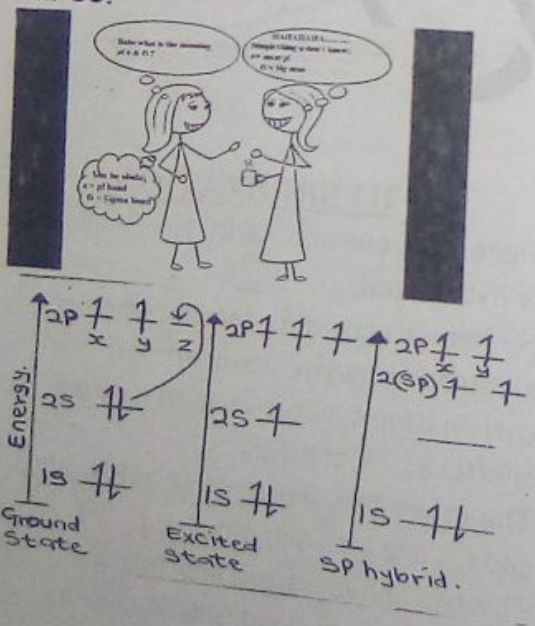
**EXAMPLE:**




Now let us take a look at SP-orbitals formation using energy profile.

NOTE

**SP hybridization is more acidic followed by $SP^2$ hybridization and then $SP^3$ hybridization because SP hybridization is more electronegative. The more the electronegativity, the more acidic it will be.**




The %S and %P in SP hybrid are as follows;

In SP

$$\%S = \frac{S}{SP} \times \frac{100}{1} = \frac{1}{1+1} \times \frac{100}{1} = 50\%$$

$$\%P = \frac{P}{SP} \times \frac{100}{1} = \frac{1}{1+1} \times \frac{100}{1} = 50\%$$

***NB:** Sigma bond is stronger than pi-bond.

NOTE

***Sigma bond is formed by end-to-end overlap of atomic orbitals(overlap of s and s OR s and p orbitals).***

***Pi-bond is formed by side-to-side overlap of atomic orbitals(overlap of p-orbitals)***

**2016/2017 EXAM**

Which compound contains an sp hybridized C atom?
(a)$CH_3CO_2H$ (b)$CH_3HO$ (c)$CH_3CN$ (d)$CH_3NH_2$
ANSWER = C...( this is due to the presence of triple bond in between C and N in the compound $CH_3CN$ )

**FUTO PAST QUESTION 2016/2017 EXAM**

The mixing of of orbitals is a quantum mechanical calculation called ? (a)pi bond (b)hybridization (c)sigma bond (d)catenation

**ANSWER = B**

## FUTO PAST QUESTION
**2016/2017 EXAM**

Pi bonds are formed by (a)overlap of two s-orbital (b)overlap of an s and a p orbital (c)End to end overlap of two p orbitals (d)side to side overlap of two p orbitals

ANSWER = D

**FUTO EXAM 2016/2017**

What orbitals are involved in C -O bond in alcohols? (a)C $sp^2$, O $sp^2$ (b)C sp, O $sp^2$ (c)C $sp^2$, O $sp^2$ (d)C $sp^3$, O $sp^3$

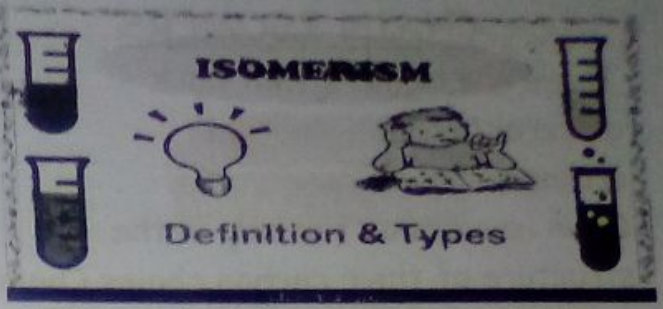
ANSWER = D. in alcohols, C and O are connected by a single bond which means $sp^3$

## FUTO PAST QUESTION
**2016/2017 EXAM**

Which atomic orbital overlap to form the carbon-carbon triple bond (a)$sp^2$+$sp^2$, sp+sp, p+p (b)s+s, sp+sp, p+p (c)sp+sp, p+p, p+p (d)sp+sp, sp+sp, p+p

ANSWER = C

In a carbon to carbon triple bond system, we have SP hybridization. In each of the two carbon atoms involved, only one p-obital is hybridized in each of the two carbons.It means that we have a total of two hybridized orbitals(SP), while there are two unhybridized orbitals (P) present in each of the two carbons.Therefore we have a total of four unhybridized p-orbitals.




This is the phenomenon in which two or more different compounds have the same molecular formula but with different structures,

Isomerism is caused as a result of the different arrangement of the atoms of the compound within the compound.

## TYPES OF ISOMERISM

There are two main types of isomerism;

- Structural or constitutional isomerism
- Steroisomerism

## STRUCTURAL ISOMERISM

Structural isomers are compounds that have the same molecular formula but differ in their structures. Another name for structural isomerism is constitutional isomerism.

Structural isomerism occurs as a result of difference in the method of arrangement of atoms within the molecule of the given compound. There are five types of structural isomerism namely;

(a)Chain Isomerism (b)Positional isomerism

(c) Functional group Isomerism

(d)Metamerism

FUTO PAST QUESTION
**2016/2017 EXAM**

Pi bonds are formed by (a)overlap of two s-orbital (b)overlap of an s and a p orbital (c)End to end overlap of two p orbitals (d)side to side overlap of two p orbitals

ANSWER = D

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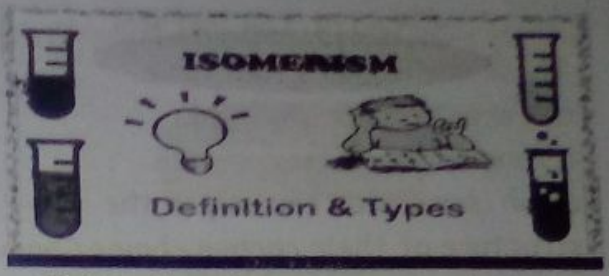
FUTO PAST QUESTION
**2016/2017 EXAM**

Which atomic orbital overlap to form the carbon-carbon triple bond (a)$sp^2$+$sp^2$, sp+sp, p+p (b)s+s, sp+sp, p+p (c)sp+sp, p+p, p+p (d)sp+sp, sp+sp, p+p

ANSWER = C

In a carbon to carbon triple bond system, we have SP hybridization. In each of the two carbon atoms involved, only one p-obital is hybridized in each of the two carbons.It means that we have a total of two hybridized orbitals(SP), while there are two unhybridized orbitals (P) present in each of the two carbons.Therefore we have a total of four unhybridized p-orbitals.

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(a)Chain Isomerism (b)Positional isomerism

(c) Functional group Isomerism

(d)Metamerism

(e)Tautomerism

## CHAIN ISOMERS

These are isomers that have different carbon skeletal arrangement.

Chain isomers differ only in the structure of their carbon chains.Chain isomers have different carbon to carbon longest chain.

**NB:** The more the number of carbon branches in a compound, the lower the boiling point of the compound.

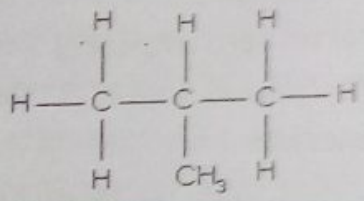
Examples of chain Isomers:

$CH_3—CH_2-CH_2-CH_3$

$CH_3CH_2CH_2CH_3$

**Butane ($C_4H_{10}$)**

And

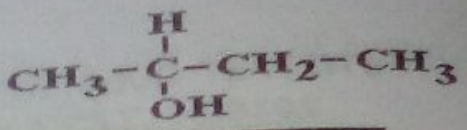


**2-methyl propane (C4H10)**

The two compounds above are isomers because they have equal number of total atoms of H and C in them ($C_4H_{10}$) which means they have the same molecular formular.

They are called chain isomers because the difference between them is only the method in which their carbon chains are arranged.

Another example of chain Isomers;



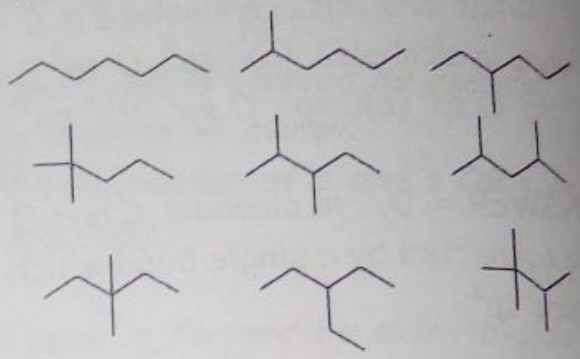
**Butan-2-ol (C4H10O)**

And

**2-methyl propan-2-ol (C4H10O)**

## STRUCTURAL ISOMERS

Draw all of the structural isomers of heptane using line structures: $C_7H_{16}$



## POSITIONAL ISOMERISM

These are those isomers that differ only in the position of their attachments or substituent on the carbon chain. **EXAMPLE:**

$CH_3-CH_2-CH_2Br$ and $CH_3-CHBr-CH_3$

**1-Bromo Propane** **[$C_3H_7Br$]**

**2-Bromo Propane** **[$C_3H_7Br$]**

the difference between the two compounds above is the position of the attachment (Br) on the carbon chains.Another example;

$CH_3CHCH_2CH_2CH_3$

$CH_3$

**2-methyl pentane**

**[C4H8]**

And

$CH_3CH_2CHCH_2CH_3$
$CH_3$

[redacted]-methyl pentene

$[C_4H_8]$

**NOTE**

**Chain isomers belong to the same family. Also, positional isomers belong to the same family.**

**FUTO PAST QUESTION 2016/2017**

Pent-1-ene and Pent-2-ene are examples of

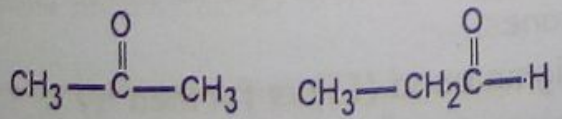
(A)enantiomers (B)constitutional isomers (c)stereoisomers (d) E-(Z)-isomers of pentene

ANSWER = B (constutional is the same as structural)

## FUNCTIONAL GROUP ISOMERISM

These are those isomers that have different functional groups in them. Functional group isomers do not belong to the same family.

**Examples;**



Propanone Propanal

$(C_3H_6O)$

**Also;**

$CH_3\text{-}CH_2OH$ and $CH_3\text{-}O\text{-}CH_3$

[redacted]

[redacted]

## METAMERISM

This is the type of isomerism caused as a result of unequal distribution of carbon atoms on either side of the functional group. Metamers belong to the same homologous series.

**Examples;**

$CH_3CH_2\text{-}O\text{-}CH_2CH_3$ and $CH_3\text{-}O\text{-}CH_2CH_2CH_3$

Diethyl ether [Ethoxyethane] and Methyl propylether [Methoxypropane]

**Also;**

$CH_3CH_2\text{-}NH\text{-}CH_2CH_3$ ( 2 : 2 arrangement)

Diethylamine

*and*

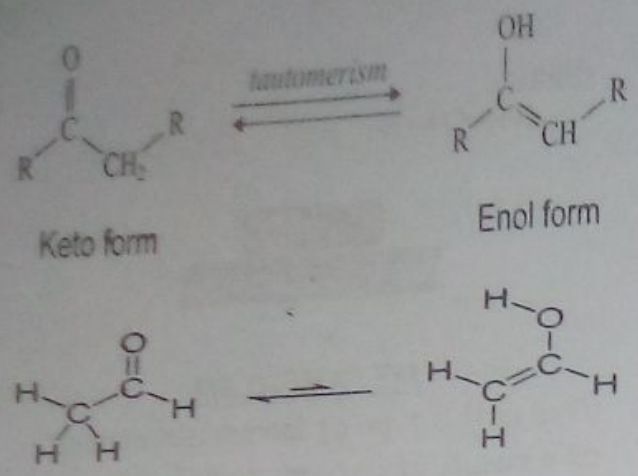
$CH_3\text{-}NH\text{-}CH_2\text{-}CH_2CH_3$ (1 : 3 arrangement)

Methypropylamine

## TAUTOMERISM

This is a form of functional group isomerism in which the isomers are in dynamic equilibrium with each other. The two forms of tautomerism are (i) keto form and (ii) enol form

**EXAMPLE: Ethanal and Ethenol**




NB; They are called tautomers.

Tautomers are formed as a result of the movement of a proton ($H^+$) or a pi electron within the compound.

## STEREOISOMERISM

**This is the phenomenon whereby isomers have the same link but with different arrangement in space.** Molecules that have the same number of atoms in them or the same molecular formular but different structures or arrangement in space are called **stereoisomers**

Stereoisomerism is divided into;

- Geometric Isomers and
- Optical Isomerism.
- Enantiomers
- Diastereomers

**FUTO PAST QUESTION 2016/2017**

Stereoisomers are ?

(a)molecules with the same number of atoms but different structures (b)molecules with the same structure (c)linear molecules with single bonded carbon atoms (d)molecules with different conformations due to a double bond

ANSWER = A

**FUTO PAST QUESTION 2016/2017**

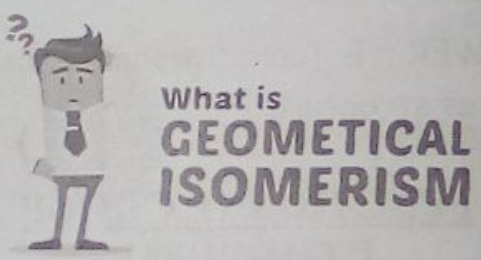
Propane and 2-propanone are……

(a)positional isomeres (b)functional group isomers (c) a dnd c (d) none of the above

ANSWER = D

Propane ($CH_3CH_2CH_3$) and propanone ($CH_3COCH_3$) are not isomers because they do not have the same molecular formular.

## GEOMETRIC ISOMERISM




This is the type of isomerism caused as a result of the lack of rotation around a double bond.Free rotation is not allowed around a carbon to carbon double bond. Geometric isomerism is mainly possible in alkenes and some cycloalkanes.

NB;- Sigma bond (□) is formed by the overlap of $SP^2$ hybrid orbitals while pi-bond (π) is formed by the overlap of the P-orbital.

Geometric isomerism is also called Cis-trans Isomerism.

## NOTE THIS

*Cis and trans isomerism is only possible in alkenes in which the two carbon atoms carrying the double bond are bonded to two different atoms or groups. If both or one of the carbon atoms carrying the double bond has the same type of atoms or groups bonnded to it, then such compound will not exhibit cis and trans isomerism.* Example, *$CH_3CH=CH_2$ will not show geometric isomerism* because among the two carbon atoms carrying the double bond, one of the carbons has two different attachments on it ($CH_3$ and H), but the other carbon carrying the double bond has two same atoms (H and H) attached to it. Since one of those two carbons carrying the double bond has two same atoms attached to it, the compound will not show geometric isomerism

## FUTO PAST QUESTION 2016/2017

Which of the following compounds does not have cis/trans isomers?

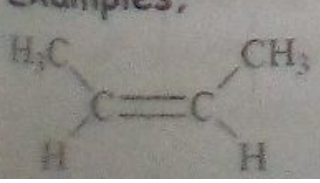
(a)$CH_3CH=CHCH_3$ (b)$ClCH=CHCl$

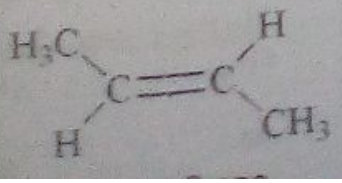
(c)$H_2C=CHC_2H_5$ (d)$CH_3CH=CHCH_3$

**ANSWER = C...**

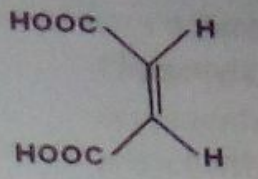
(One of the carbons carrying the double band has the same thing attached to it, i.e. H and H)

Examples;

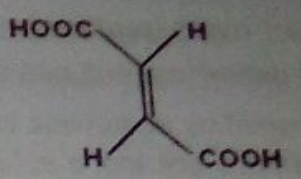




NB; when the same group is located on the same side, it is called "**Cis**" but when the same group is located on opposite side, it is called "trans"




**cis-butenedioic (maleic acid)**

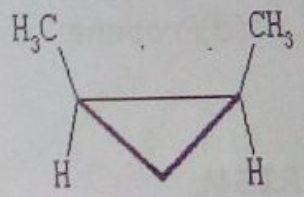



**trans-butenedioic acid (fumaric acid)**

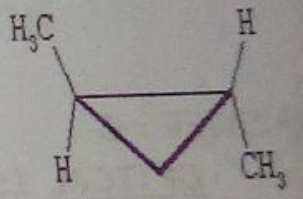
NB; "**Cis**" isomers are stronger acids than "**trans**" Isomers.

Geometric isomerism is also possible in some cyclic compounds.

Example;




*cis*-1,2-dimethylcyclopropane (bp 37°C)




*trans*-1,2-dimethylcyclopro (bp 29°C)

***NB;** Trans isomerism does not exist in cycloalkenes whose carbon atoms are less than 8 due to angle strain. therefore, the smallest cycloalkene that has a trans isomer is **cyclooctene** (trans cycloalkene).

***NB;-trans isomers** have higher melting point than their **cis isomer while cis isomer has higher boiling point than the trans isomer.**

Also, trans isomers are more stable than their cis isomers due to the lesser force of repulsion between like charges in trans isomers...

Cis and trans isomers have almost equal densities, but not exactly equal.

Cis isomers are more soluble than their trans isomers. Another name for geometric isomerism is CIS and TRANS isomerism.

**FUTO PAST QUESTION ON STEREOISOMERISM 2016/2017**

Which compound has stereoisomer?

(a)Butane (b)Propyne (c)But-2-ene (d)Propene

ANSWER = C

## OPTICAL ISOMERISM

these are those isomers that have the ability to rotate the direction of a plane-polarised light.

NB; A substance is said to be "**optically active**" if the substance has the ability to rotate the direction of a plane-polarised light.

The substance is said to be "**optically inactive**" if it cannot rotate a plane-polarised light.

A substance that rotates light to the right (clockwise) is said to be **dextro-rotatory** while the one that rotates light to the left (anticlockwise) is said to be **Levorotatory**.

*NOTE

The instrument used to measure optical activity in a molecule is called POLARIMETER.

## RACEMIC MIXTURE

A racemic mixture is a mixture which contains equal amount of enantiomers (dextro and levo).

*N/B; A racemic mixture is **optically inactive** because the components of a racemic mixture oppose the action of the other in the mixture.

A racemic mixture is also defined as a mixture of two enantiomers.

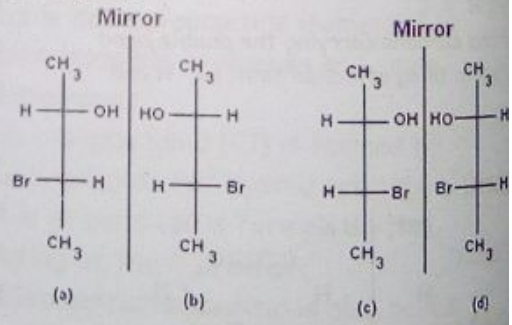
*NB; The process of separating a racemic mixture is known as RESOLUTION.

The process of producing a racemic mixture is known as RACEMIZATION.

## ENANTIOMERS

Enantiomers are isomers that are mirror images of each other. Enantiomers are not superimposable to each other.

Example;

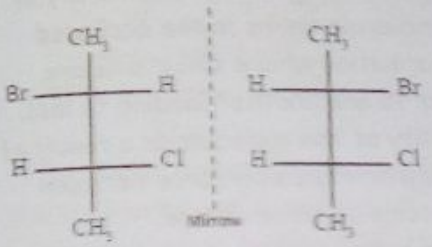


## DIASTEREOMERS

Diastereomers are isomers that are [redacted] of each other. Diastereomers are not superimposable on each other. Diastereomers have more than one chiral centre.

*Example of Diastereomers;*

Diastereomers




NB; The condition for a compound to be optically active is that the compound must be dissymmetric (unsymmetric) which means that the compound must have a chiral centre.

# CONFORMATION

Conformation is defined as the different spatial arrangement of a molecule that can be obtained by the rotation around carbon to carbon single bond.

Free rotation is possible around carbon to carbon single bond.

NB;- molecules that have different conformations due to the presence of single bond are called conformers.

## TYPES OF CONFORMATION

The two major types of conformation are;

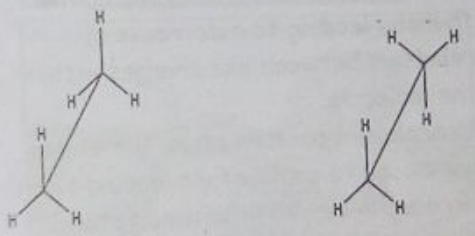
- Staggered conformation and
- Ecclipsed conformation

These two conformations can be represented as sawhorse or Newman projections.

## CONFORMATIONS OF ETHANE

The carbon atoms in ethane are not frozen in space. The two methyl groups in ethane can rotate about the C-C bond. As a result of the free rotation, different arrangements of ethane can be obtained.

## SAWHORSE REPRESENTATION OF ETHANE




In sawhorse eclipsed conformation, the two H atoms are located opposite to each other just like in trans isomerism (up and down) while in sawhorse staggered conformation, the two H atoms are on the same side just like in cis isomerism (up, up or down, down).

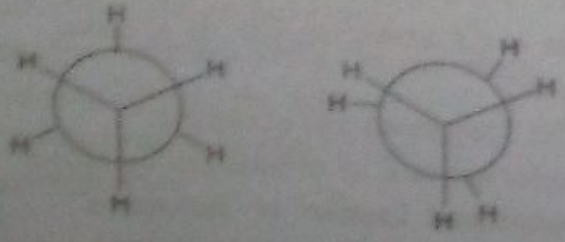
The staggered and ecclipsed conformations of ethane can be called "**Rotational Isomer**" or "**Rotamers**" because staggered and ecclipsed

conformations can be converted into one another by rotation about C-C bond.
A 60° rotation converts a staggered conformation into an ecclipsed conformation and vice versa.

**NB:- the two types of hydrogens in cyclohexan conformation are axial hydrogen (vertical position) and equatorial hydrogen (horizontal position).**

*NB: The staggered conformation is more stable than the ecclipsed conformation. This is because, in staggered conformation, the similar atoms are far apart from one another thereby leading to a decrease in repulsion between like charges within the molecule.
In ecclipsed conformation, the atoms are closer to one another leading to an increase in repulsion between atoms of same charge.
NB: The points of intersection of lines in sawhorse representation is carbon atom position.

## NEWMAN REPRESENTATION OF ETHANE

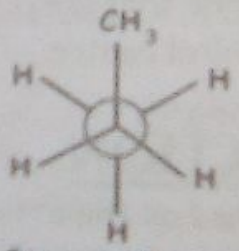


In Newman projection, a circle is used to represent the carbon atom at the back while the point of intersection of the lines at the centre represents the front carbon atom.

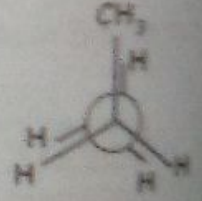
As shown in sawhorse projection, in the staggered conformation of Newman projection, the atoms are far apart from one another leading to higher stability of the molecule unlike in the ecclipsed conformation where the atoms are closer to one another leading to less stability of the molecule as a result of the higher repulsion force between the atoms of same charge.

In summary, the staggered conformation is more stable than the ecclipsed conformation.

## CONFORMATIONS OF PROPANE



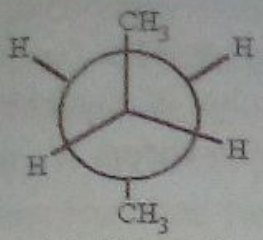

Staggered propane



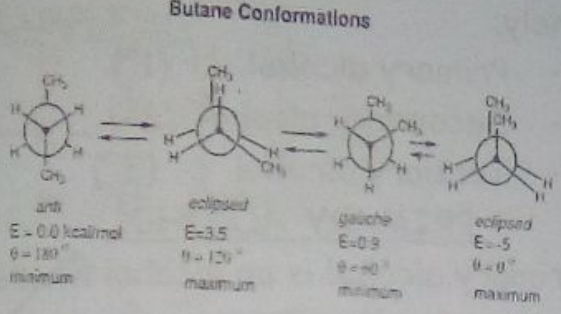

Ecliped propane

The above two structures are the staggered and ecclipsed conformations of propane ($C_3H_8$=>$CH_3$-$CH_2$-$CH_3$)

## CONFORMATIONS OF BUTANE



Anti (Staggered)
Dihedral Angle = 180 degrees



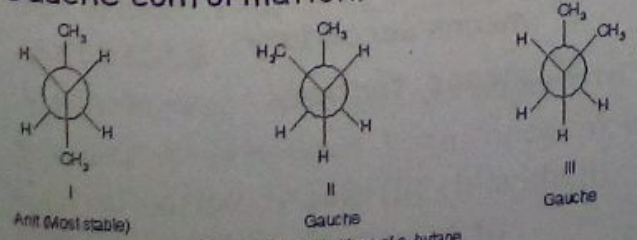

The above two structures represent the staggered and ecclipsed conformations of butane ($CH_3$-$CH_2$-$CH_3$-$CH_3$).

There are two forms of staggered ecclipsed conformations of butane know as "Anti" and "Gauche" conformations.

The staggered conformation in which the methyl groups are closer to each other is known as Gauche conformation.

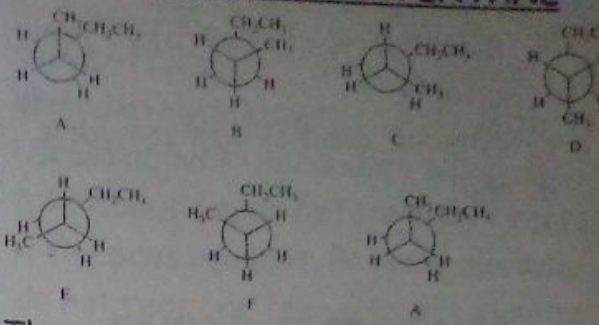
The one in which the methyl groups are far from each other is known as Anti conformation.

NB; Anti conformation is more stable. Energy is highest in the ecclipsed Gauche conformation.




Staggered conformations of n-butane

## CONFORMATIONS OF PENTANE



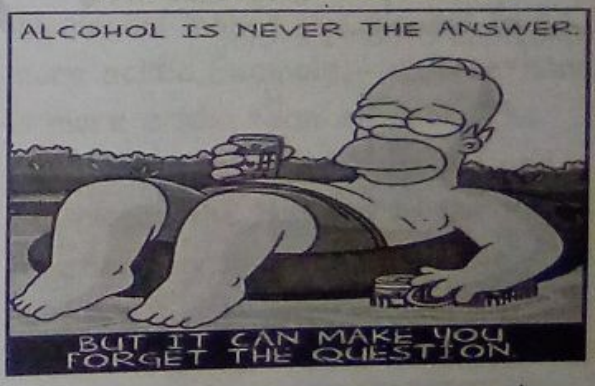
The staggered form is more stable.

### FUTO PAST QUESTION ON CONFORMATION 2013/2014 EXAM

Different arrangement of atoms that can be converted into other form by the rotation about single bond is called...?

ANSWERS = Conformation

# ALCOHOLS




These are organic compounds that have the hydroxyl functional group (-OH).

They have the general molecular formula $C_nH_{(2n+1)}OH$ where n represents the number of carbon atoms present.

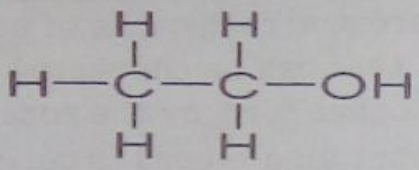
## TYPES OF ALCOHOLS

- Monohydric alcohol (b)Dihydric alcohol

c)Trihydric alcohol (d)Polyhydric alcohol.

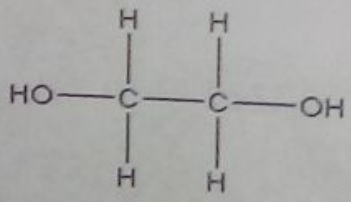
## MONOHYDRIC ALCOHOL

A Monohydric alcohol is an alcohol that has only one hydroxyl group in it. An example of a Monohydric alcohol is ethanol.



## DIHYDRIC ALCOHOL

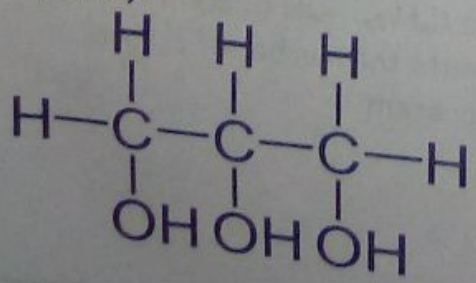
A dihydric alcohol is an alcohol that has only two hydroxyl groups in it. Example is Ethan-1,2-diol.



Ethan-1,2-diol (Glycol)

## TRIHYDRIC ALCOHOL

This is an alcohol that contains three hydroxyl groups in it.
Example is propan-1,2,3-triol (Glycerol)



Propan-1,2,3-triol (Glycerol)

A polyhydric alcohol is an alcohol that contains more than three hydroxyl groups in it.

## CLASSES OF ALCOHOLS

There are three classes of Alcohols namely;

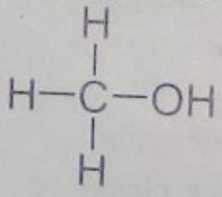
- Primary alcohol. (1°)
- Secondary alcohol (2°)
- Tertiary alcohol. (3°)

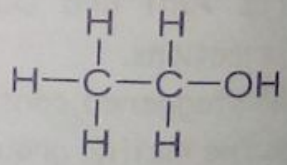
## PRIMARY ALCOHOL

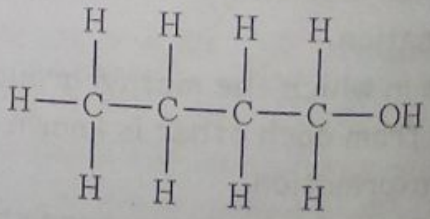
A primary alcohol is an alcohol whose -OH group is attached to a primary carbon.

NB:- A primary carbon is a carbon atom in a compound that has only one or no other carbon atom or alkyl group directly bonded to it.

EXAMPLES:-







(n-butanol)

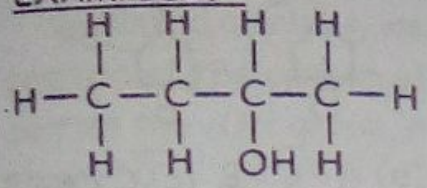
NB:- 1° means primary
2° means secondary
3° means tertiary

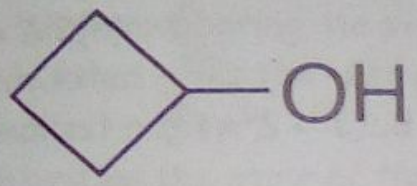
## SECONDARY ALCOHOL

A secondary alcohol is an alcohol whose -OH group is attached to a secondary carbon.

**NB;** A secondary carbon is a carbon atom that has two other carbon atoms or two alkyl group directly bonded to it.

**EXAMPLES;-**



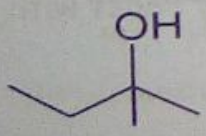


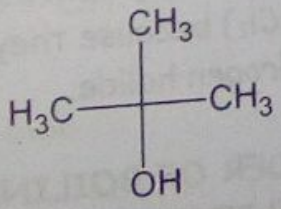

## TERTIARY ALCOHOL

A tertiary alcohol is an alcohol whose -OH group is attached to a tertiary carbon in a compound.

**NB;** A tertiary carbon is a carbon atom that has tthree other carbon atoms or two alkyl group directly bonded to it.

**Examples:-**




## TEST USED TO DISFFERENCIATE BETWEEN THE 3 CLASSES OF ALCOHOLS

Alcohols react with Lucas reagent to produce alkyl halides. Lucas reagent is a combination of zinc (ii) chloride in HCl ($ZnCl_2$/HCl). It is used to differenciate the 3 classes of alcohols where $ZnCl_2$ serves as the catalyst.. Tertiary alcohols react immediately and very rapidly with Lucas reagent. Secondary alcohols take about 5mins before they reacts with Lucas reagent. Primary alcohols do not react or take a longer time to reacts with Lucas reagent at a temperature above room temperature. Therefore, the decreasing order of reactivity of the classes of alcohols with Lucas reagent is

**tertiary > secondary > primary.**

## ACIDITY OF ALCOHOLS

**primary > secondary > tertiary**

**NB;- the presence of a halogen in an alcohol makes the alcohol to be more acidic. Example;- chloroethanol is more acidic than ethanol. The more the number of halogens and the closer the halogen to the functional group, the more the acidity.**

## SOLUBITY OF ALCOHOLS AND DEGREE OF HYDROGEN BONDING IN ALCOHOLS

**Primary > secondary > tertiary**

NB;- the lesser the number of carbon atoms in an alcohol, the more soluble the alchol will be. It means that methanol is more soluble than butanol.

NOTE

the more the number of atoms of a halogen present in an clcohol, the more acidic the alcohol will be.

RATE OF DEHYDRATION OF THE 3 CLASSES OF ALCOHOLS.

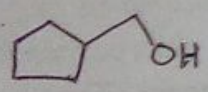
Tertiary > Secondary > Primary

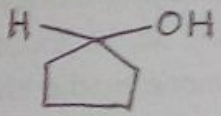
REACTIVITY OF THE 3 CLASSES OF ALCOHOLS TOWARDS HX (X= halogen)

tertiary > secondary > primary.

FUTO PAST QUESTION 2012/2013 EXAM

Classify each of the following alcohols as $1^0$, $2^0$, $3^0$.





(III).$(CH_3)_3C$-OH

(IV).CH3CH2CH(OH)CH3

ANSWERS

(I) is a primary alcohol (II) is a secondary alcohol (III) is a tertiary alchol.

(IV) is secondary alcohol.

FUTO PAST QUESTIONS 2016/2017

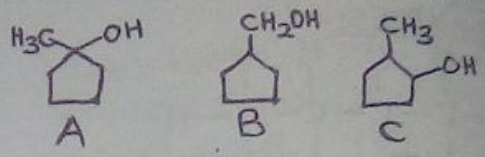
Which of the following alcohols is most acidic?

(a)1-chloroethanol (b)ethanol (c)1,1-dichloroethanol (d) 2-chloroethanol

ANSWER = C (it has more halogen atoms)

FUTO PAST QUESTION 2016/2017 EXAM

Arrange the following alcohols in order of their decreasing reactivity with HBr (most reactive).



(a)A > B > C (b) A > C > B (c) C > A > B (d)B>C >A

ANSWER = B...($3^0 > 2^0 > 1^0$)

FUTO PAST QUESTION 2016/2017 EXAM

For reacting with HCl, the alcohol which does not require $ZnCl_2$ is (a) $CH_3CH_2OH$ (b)$CH_3CH(CH_3)CH_2OH$ (c)$CH_3CH(CH_3)OH$ (d)$(CH_3)_3C$-OH

ANSWER = $(CH_3)_3C$-OH...D

this is becausetertiary alcohols react with HX (x=halogen) fastest. Tertiary alcohols may not require the catalyst ($ZnCl_2$) because they easily react with hydrogen halide.

ORDER OF BOILING POINT AND ABILITY TO FORM HYDROGEN BONDING HYDROGEN BOND FOR THE 3 CLASSES OF ALCOHOLS.

Primary > Secondary > Tertiary

FUTO PAST QUESTION 2015/2016

Arrange the following in the decreasing order of ease of dehydration, $2^0$, $1^0$, $3^0$ alcohols.

ANSWER = $3^0 > 2^0 > 1^0$

## NOMENCLATURE OF ALCOHOL

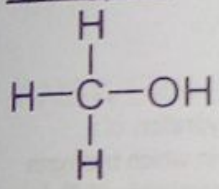
Alcohols are named in the same manner as alkanes, alkenes and alkynes.

In naming alcohols, we show the position of the carbon atom that carries the -OH group in the longest chain.

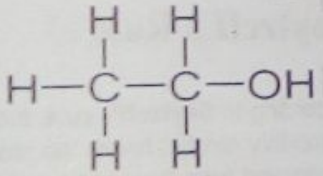
When numbering, we start from the side kthat gives the -OH group the smallest number.

In writing the name of the alcohol, we replace the last "e" in the name of the corresponding alkane with "ol".

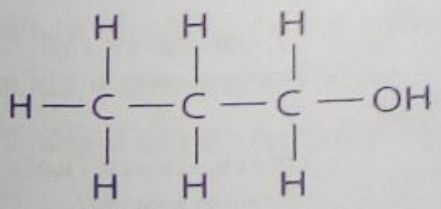
**Examples;**



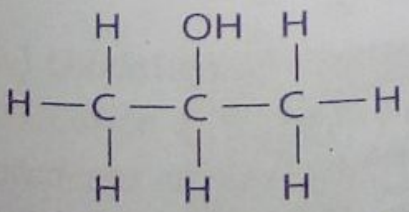
**Methanol**



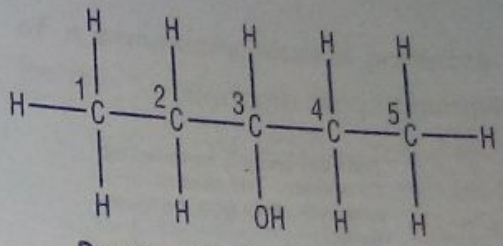
**Ethanol**



**1-Propanol (*n*-propanol)**



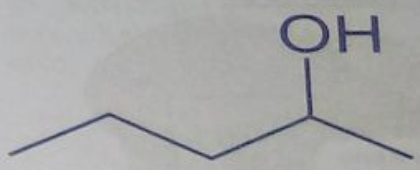
**2-Propanol (isopropanol)**

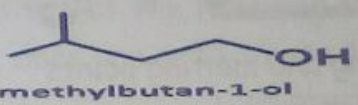


**Pentan-3-ol OR 3-pentanol.**

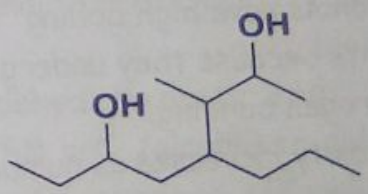
$CH_3CH_2CH(OH)CH_2CH_2CH_3$

**Hexan-3-ol**

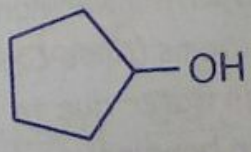




**3-methylbutan-1-ol**

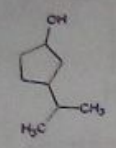


3-methyl-4-propyl-octane-2,6-dio



**Cyclopentanol**

## Naming cyclic alcohols




The –OH group is assigned the C1 position. The second substituent then gets the lowest number.

The name of the compound is **3-isopropyl-cyclopentanol**

## PHYSICAL PROPERTIES OF ALCOHOLS


- Boiling and melting points increases as the number of carbon atoms increases.
- Alcohols have high boiling points because they undergo hydrogen bonding.
- Viscosity increases as number of carbon atoms increases while volaticity decreases as number of carbon atoms increases.
- Alcohols with lower number of carbon atoms ($C_1$ to $C_4$) are soluble in water due to hydrogen bonding.

## CHEMICAL PROPERTIES OF ALCOHOL

### i) Reactions with active metals

(i) $2CH_3CH_2OH + 2Na \rightarrow 2CH_3CH_2ONa + H_2$

### ii) Dehydration of alcohol at 180°C

When alcohols are dehydrated with $H_2SO_4$ at a temperature of 180°C, alkenes are produced

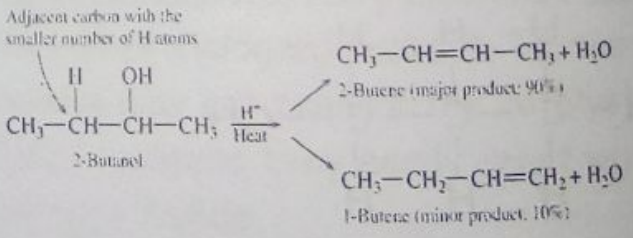
$$CH_3CH_2OH \xrightarrow[-H_2O]{H_2SO_4} CH_2=CH_2$$

**At a temperature of about 170°C to 180°C, alcohols react with $H_2SO_4$ to produce alkene but at 140°C, it produces an ether.**

NB;- $POCl_3$ (phosphorus oxychloride) is also used to dehydrate alcohols to forl alkene. $POCl_3$ is used in order to prevent the decomposition in the presence of strong acids like $H_2SO_4$.

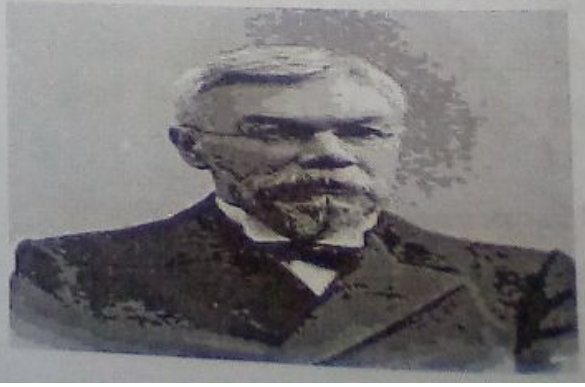
## Saytzeff's Rule

According to Saytzeff's rule, the dehydration of a secondary alcohol favors the product in which hydrogen is removed from the carbon atom in the chain with the smaller number of H atoms







NB;- A reaction is said to be **regioselective** if a particular product of the reaction predominates over the other product. Example of a regioselective reaction is the Saytzeff reaction above in which 2-butene predominates over 1-butene because 2-butene produced was 90% while 1-butene was 10% which means that 2-butene is preferred over 1-butene.

**FUTO PAST QUESTION 2016/2017**

A regioselective reaction is one in which

(a) A single product is form (b)multiple products are made in equal amounts (c)multiple products are made with one in excess of the other (d)involves oxidation

ANSWER = C

iii) **Reaction with carboxylic acid. (Esterification reaction)**

When alcohols react with carboxylic acids, esters are formed. The reaction is called esterification reaction.

$$CH_3CH_2OH + CH_3COOH \overset{H^+}{\rightleftharpoons} CH_3-\underset{\underset{O}{\|}}{C}-O-CH_2CH_3$$

iv) **Oxidation of alcohols**

Oxidation of a primary alcohol produces an aldehyde. Partial **oxidation of a primary alcohol produces an aldehyde while complete oxidation of a primary alcohol produces carboxylic acid. Oxidation of a secondary alcohol produces a keton.**

$$CH_3CH_2OH \xrightarrow[-H_2]{PCC} CH_3CHO$$
Ethanol — Ethanal

$$CH_3CH_2CH_2OH \xrightarrow[-H_2]{[O]} CH_3CH_2CHO$$
Propanol — Propanal

NB:- when a mild oxidizing agent such as Pyridinium chloro-chromate (PCC) is used to oxidize an alcohol, an aldehyde will be produced.
If a strong oxidizing agent such as $K_2Cr_2O_7$ or $Na_2Cr_2O_7$ or $KMnO_4$ is used to oxidize an alcohol, a carboxylic acid will be produced.

**FUTO PAST QUESTION 2016/2017**

For which of the following oxidations does one need to use pyridinium chlorochromate?

(a) Methanol to formic acid (b) Ethanol to acetic acid (c) Ethanol to acetaldehyde (d) Acetaldehyde to acetic acid

**ANSWER = C...(alcohol to aldehyde)**

NB;- acetaldehyde is ethanal.

**oxidation of secondary alcohols**

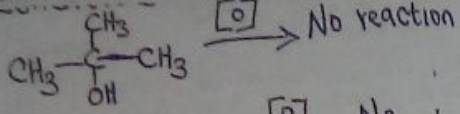
oxidation of secondary alcohols products a ketone.

$$CH_3-\underset{\underset{OH}{|}}{CH}-CH_3 \xrightarrow[-H_2]{[O]} CH_3-\underset{\underset{O}{\|}}{C}-CH_3$$
Propan-2-ol — Propan-2-one

$$CH_3CH_2CH(OH)CH_3 \xrightarrow[-H_2]{[O]} CH_3CH_2COCH_3$$
Butan-2-ol — Butan-2-one

**Oxidation Of Tertiary Alcohols**

Tertiary alcohols are not easily oxidized at normal conditions.



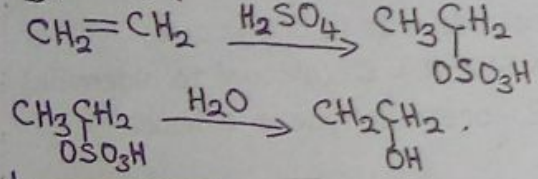

$CH_3C(CH_3)(OH)CH_3 \xrightarrow{[O]}$ No reaction.

[O] Means oxidization or oxidizing agent.

## PREPARATION OF ALCOHOLS.

- **By hydration of alkanes.**

Reaction of an alkene with steam (water at 100°C) produces an alcohol. The reaction occur in two stages.




**In summary:**

$$CH_2=CH_2 \xrightarrow[H_2O]{H_2SO_4} CH_3CH_2OH$$

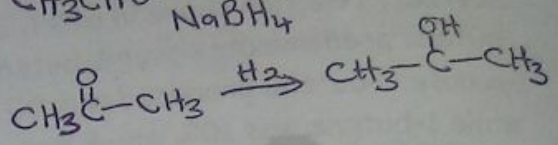
ii) **By hydrolysis of esters.**

$$CH_3COOCH_3 + H_2O \xrightarrow{H^+} CH_3COOH + CH_3OH$$

iii) **By reduction of aldehydes and ketones.**

$LiAlH_4$ and $NaBH_4$ (reducind agents) are used to reduce aldehydes and ketones (carbonyl compounds).

$$CH_3CHO \xrightarrow[NaBH_4]{H_2} CH_3CH_2OH$$




iv) **By hydrolysis of alkyl halide**

$$CH_3Br + NaOH \rightarrow CH_3OH + NaBr$$

**FUTO PAST QUESTIONS 2016/2017 EXAM**

The product of the reaction of alcohols with $H_2SO_4$ at 140°C (a)an ether (b)an alkene (c)an alkane (d)an aldehyde

ANSWER = A

vi) **By fermentation of glucose**

$$C_6H_{12}O_6 \xrightarrow{Enzyme} 2CH_3CH_2OH + 2CO_2$$

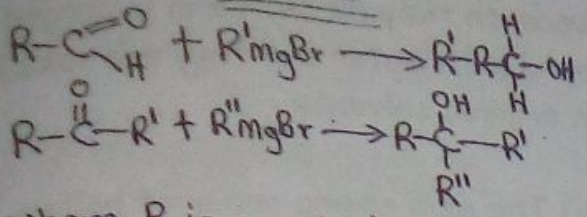
vii) **By adding of Grignard reagent to aldehyde and ketone.**

NOTE

$CH_3CHO + CH_3MgBr \rightarrow CH_3CH_2CH_2OH$

$CH_3COCH_3 \xrightarrow{CH_3MgBr} CH_3C(OH)(CH_3)CH_3$

NOTE



where R is an alkyl group.

Where R Alkyl group.

**NB;- whwn Grignard reagent reacts with an aldehyde, a secondary alcohol is produced but when Grignard reagent reacts with a ketone, a tertiary alcohol is produced.**

# ALKYL HALIDES OR HALOAKANES (R-X).

Alkyl halides are o X is a halogen (x = f or Cl or Br or I).rganic compounds in which a halogen (X) is attached to carbon atom. They have the general molecular formula $C_nH_{2n+1}X$ where "n" is the number of carbon atoms present while

## CLASSES OF ALKYL HALIDES

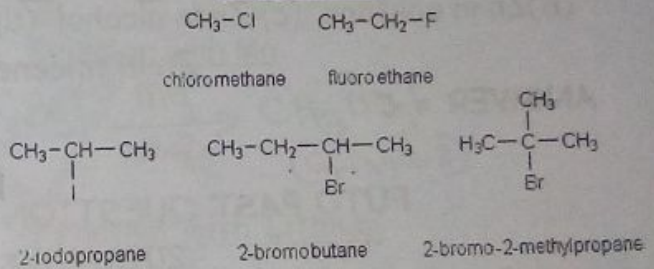
There are 3 classes of alkyl halides namely
(a)primary alkyl halides (b)secondary alkyl halides (c)tertiary alkyl halides.

**A primary alkyl halide** is an alkyl halide in which the halogen is bonded to a primary carbon, example is 1-Bromopropane ($CH_3CH_2CH_2Br$).

**A secondary alkyl halide** is an alkyl halide in which the halogen is bonded to a secondary carbon, example 2-Bromopropane ($CH_3CHBrCH_3$).

**A tertiary alkyl halide** is an alkyl halide in which the halogen is bonded to a tertiary carbon, example 2-Bromo-2-methylpropane $CH_3CBr(CH_3)CH_3$.

## NONMENCLATURE OF ALKYL HALIDES




### NOTE THIS

An alkyl halide that contains two halogen atoms is called a ***dihalide***.
The two types of dihalides are (i) geminal dihalide and (ii) vicinal dihalide
**gem-dihalide** is one in which the two halogen atoms are attached to the same carbon atom, Example; $CH_3CHBr_2$ (1,1-dibromoethane) while a **vic-dihalide** is one in which the two halogen atoms are attach to adjacent cabon atoms, Example; $CH_2BrCH_2Br$ (1,2-dibromoethane).

**NB;- in order to remove the two halogen atoms (dehalogenation) from a vic-dihalide, we use zinc dust in acetic acid.**

**Also, reaction of a vic-dihalide with excess $NaNH_2$ produces an alkyne but when $NaNH_2$ is not in excess, alkene is produces. This reaction is called DEHYDROHALOGENATION reaction because hydrogen halide is removed during the reaction.**

**FUTO PAST QUESTION 2016/2017**

What conditions are best for dehalogenation of vicinal dibromide? (a) Zn in acetic acid (b)Zn in acetone (c) Zn in alcohol (d) Zn in toluene

ANSWER = C

FUTO PAST QUESTION 2016/2017

The major product of the reaction of1,2-dibromobutane and excess $NaNH_2$ is (a) 2-bromo-1-butyne (b) 1-bromo-1-butene (c) 1-butyne (d) 1,2-butadiene

ANSWER = C...(when $NaNH_2$ is in excess, alkyne is produced).

## PHYSICAL PROPERTIES OF ALKYL HALIDES

i) Haloalkanes or alkyl halides with only one carbon atom is gaseous at room temperature.

Other alkyl halides up to $C_{18}$ are colourless liquids. Those greater than $C_{18}$ are colourless solids.

ii) Alkyl halides are insoluble in water because they do not form hydrogen bond with water but they are soluble in organic solvents.

iii) The decreasing order of boiling points of alkyl halides is;

$$RI > RBr > RBr > RF$$

where R is alkyl group.

## CHEMICAL PROPERTIES OF ALKYL HALIDES

- **Reaction with aqueous KOH**

$$CH_3I + KOH \xrightarrow[\Delta]{H_2O} CH_3OH + KI$$

- **Reaction with moist silver oxide**

$$CH_3CH_2Br \xrightarrow{AgOH} CH_3CH_2OH + AgBr$$

- **Reaction with sodium alkoxide**

$$CH_3CH_2Br + NaOCH_2CH_3 \rightarrow CH_3CH_2OCH_2CH_3 + NaBr$$

- **Reaction with dry $Ag_2O$**

$$2CH_3I + Ag_2O \xrightarrow{\Delta} CH_3OCH_3 + 2AgI$$

(NaBr)

- **Reaction with Ammonia**

$$CH_3CH_2Br + NH_3 \rightarrow CH_3CH_2NH_2 + HBr$$

(in ethanol)

- **Reaction with amine**

$CH_3CH_2Br + CH_3CH_2NH_2 \rightarrow (CH_3CH_3)_2NH + HBr$

$CH_3CH_2Br + (CH_3CH_2)_2NH \rightarrow (CH_3CH_2)_3N + HBr$

$CH_3CH_2Br + (CH_3CH_2)_3N \rightarrow (CH_3CH_2)_4NBr$

Tetraethylammonium bromide

- **Reaction with NaCN**

$CH_3CH_2Br \xrightarrow[ethanol, \Delta]{NaCN} CH_3CH_2CN + NaBr$

- **Reaction with RCOOAg**

$CH_3CH_2Br \xrightarrow[ethanol, \Delta]{CH_3COOAg} CH_3COOC_2H_5 + AgBr$

**Reaction with acetylides**

$CH_3Br + CH{\equiv}CNa \longrightarrow CH{\equiv}CCH_3 + NaBr$

- **Reaction with KSH**

$CH_3CH_2I \xrightarrow[ethanol, \Delta]{KSH} CH_3CH_2SH + KI$

- **Reaction with K2S**

$2CH_3CH_2I + K_2S \rightarrow CH_3CH_2{-}S{-}CH_2CH_3 + KI$

- **Reaction with AgNO2**

$CH_3CH_2I + AgNO_2 \rightarrow CH_3CH_2NO_2 + AgI$

nitroethane

- **Reaction with alcoholic KOH**

This reaction is known as dehydrohalogenation of alkyl halides.

$CH_3CH_2Br \xrightarrow[ethanol, \Delta]{KOH} CH_2{=}CH_2 + KBr + H_2O$

$CH_3CHBrCH2Br + KOH/Zn$ dust in alcohol $CH_3CH{=}CH_2 + 2KBr + H_2O$

- **Reduction with hydrogen**

$CH_3CH_2Br + H_2 \xrightarrow{Ni} CH_3CH_3 + HBr$

NB:- This reaction occurs in the presence of reducing agents such as Zn + HCl or $LiAlH_4$ or $H_2$ or Ni or Pd.

$CH_3\overset{Br}{C}HCH_3 + 2[H] \xrightarrow[Ether]{LiAlH_4} CH_3\overset{H}{C}HCH_3 + HBr$

- **Reaction with Mg**

$CH_3I \xrightarrow[ether]{Mg} CH_3MgI$ (Grignard)

- **Reaction with Lithium**

$CH_3CH_2Br \xrightarrow[ether]{Mg} CH_3CH_2MgBr$

Ethylmagnesium bromide

$CH_3CH_2Br \xrightarrow{2Li} CH_3CH_2Li + LiBr$

ethyl Lithium

- **Wurtz reaction**

In Wurtz reaction, the carbon longest chain of the product is always twice that of the reactant.

$2CH_3CH_2Br + 2Na \xrightarrow{ether} CH_3CH_2CH_2CH_3 + 2NaBr$

$2CH_3I \xrightarrow[ether]{2Na} CH_3CH_3 + 2NaI$

- **Halogenation of alkyl halide**

$$CH_3Cl + Cl_2 \xrightarrow{U.V} CH_2Cl_2 \xrightarrow{Cl_2} CHCl_3 \xrightarrow{Cl_2} CCl_4$$

- **Friedel-crafts Alkylation**
  The catalyst used in Friedel craft alkylation is Aluminium trihalide ($AlCl_3$)

$$CH_3CH_2Br + \bigcirc \xrightarrow{AlCl_3} \bigcirc\!\!-\!\!CH_2CH_3 + HBr$$

OR

$$CH_3CH_2Br + C_6H_6 \xrightarrow{AlCl_3} C_6H_5CH_2CH_3 + HBr$$

## PREPARATION OF ALKYL HALIDES

i) **By halogenation of alkanes**

$$CH_4 \xrightarrow[U.V]{Cl_2} CH_3Cl + HCl$$

ii) **By addition of halogen acids to alkenes**

$$CH_3CH{=}CH_2 \xrightarrow{HBr} CH_3\overset{Br}{C}H{-}CH_3$$

iii) **By action of halogen acids on alcohols**

$$CH_3OH \xrightarrow{HBr} CH_3Br + H_2O$$

$$CH_3CH_2OH \xrightarrow{HCl} CH_3CH_2Cl + H_2O$$

iv) **By the action of phosphorus halides on alcohols**

$$2CH_3CH_2OH \xrightarrow{PCl_5} 2CH_3CH_2Cl + POCl_3 + H_2O$$

$$3CH_3OH \xrightarrow{PCl_3} 3CH_3Cl + H_3PO_3$$

$$3CH_3OH \xrightarrow{PI_3} 3CH_3I + H_3PO_3$$

v) **By the action of thionyl chloride on alcohols.**

$$CH_3CH_2OH \xrightarrow[Pyridine]{SOCl_2} CH_3CH_2Cl + SO_2 + HCl$$

vi) **By halogen exchange reaction.**

$$CH_3CH_2Br \xrightarrow[Acetone]{NaI} CH_3CH_2I + NaBr$$

$$2CH_3Cl \xrightarrow{Hg_2F_2} 2CH_3F + Hg_2Cl_2$$

## ORDER OF LEAVING GROUP ABILITY

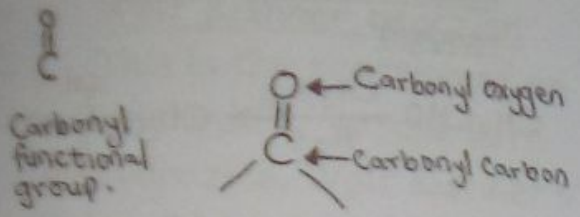
Alkyl halides are leaving groups.

[redacted] $I^- > Br^- > Cl^- >> F^- > CH_3C(=O)O^- > OH^-$ [redacted]

# ALDEHYDES AND KETONES

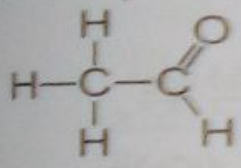
Both aldehydes and ketones have the carbonyl functional group. Both aldehydes and ketones are jointly called **carbonyl compounds.**

**NB:** A carbonyl group is a carbon-oxygen double bond present in a compound.

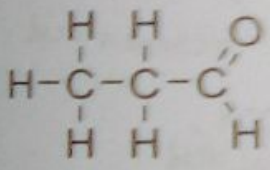



Aldehydes and ketones are jointly called carbonyl compounds.

In aldehydes, only one alkyl group (or carbon atom) is directly bonded to the carbonyl carbon and the carbonyl functional group is located in front of the compound (R-CHO) Examples;



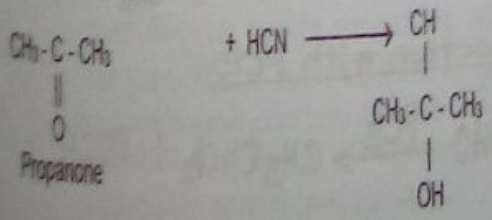
Ethanal

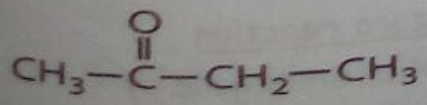


Propanal

In ketones, two alkyl groups (or carbon atoms) are directly attached to the carbonyl carbon and the carbonyl functional group is located inside the compound.

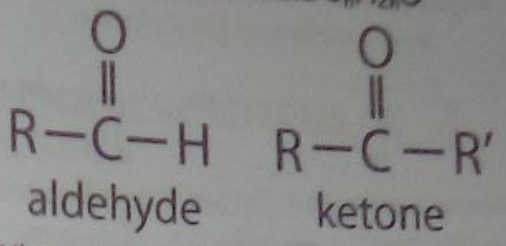
**Example;**



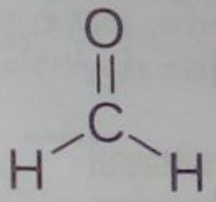
**Butanone**

Both aldehydes and ketones have the same molecular formula $C_nH_{2n}O$

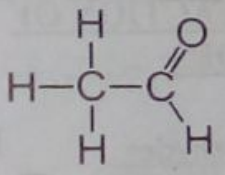



Where R and R' are alkyl groups.

## NOMENCLATURE OF ALDEHYDES AND KEYTONES

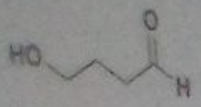


**Methanal**

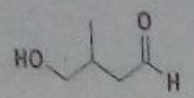


**Ethanal**

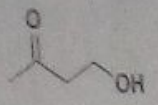
In naming aldehydes and keytones, the carbonyl carbon is given the smallest number when numbering the chain. In writing the name of an aldehyde, we replace the Last "*ane*" in the of the corresponding alkane with "*nal*". The position of the aldehyde functional group (CHO) is not shown when writing the name of an aldehyde because it is always at position one along the carbon chain. In writing the name of ketone, we give the smallest number to the ketone group and show the position if the functional group in the chain. The position of the ketone functional group (CO) is indicated when writing the name of the ketone.



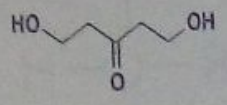
4-hydroxybutanal



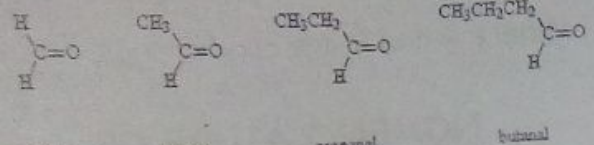
4-hydroxy-3-methylbutanal



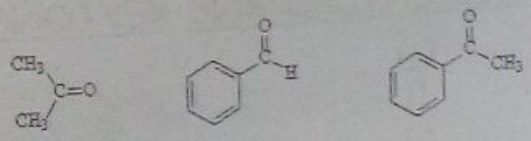
4-hydroxy-2-butanone



1,5-dihydroxy-3-pentanone



methanal ethanal propanal butanal



acetone (propanone) benzaldehyde acetophenone

## CHEMICAL REACTION OF ALDEHYDES

- **Reduction of aldehydes**

$$CH_3CHO + H_2 \longrightarrow CH_3CH_2OH$$

NB; Reduction of aldehydes produces primary alcohols.

- **Addition of water**

$$HCHO + H_2O \longrightarrow HCH(OH)_2$$

formalin

Formalin is used as a preservative.

- **Reaction with cyanide**

$$CH_3CHO + HCN \rightarrow CH_3CH(OH)CN$$

cyanohydrin

NB; The product has one carbon atom greater than the reaction.

- **Reaction with Grignard reagent**

$$CH_3CHO \xrightarrow[H_2O]{CH_3MgI} CH_3-\underset{CH_3}{\overset{OH}{\underset{|}{\overset{|}{C}}}}-H$$

$$CH_3CHO + RMgI \longrightarrow A \xrightarrow{H_2O} B + C$$

$$A = CH_3-\underset{R}{\overset{H}{\underset{|}{\overset{|}{C}}}}-OMgI$$

$$B = CH_3-\underset{R}{\overset{H}{\underset{|}{\overset{|}{C}}}}-OH$$

$$C = MgI(OH)$$

- **Oxidation of aldehyde**

$$HCHO \xrightarrow{[O]} HCOOH$$

methanal — methanoic acid

$$CH_3CHO \xrightarrow{[O]} CH_3COOH$$

Ethanal — Ethanoic acid.

- **Wittig reaction**

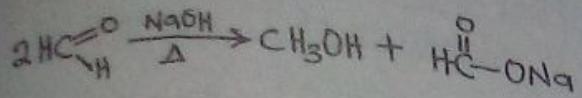
$$CH_3C(=O)H + CH_3\underset{CH_3}{\overset{|}{C}}=P(C_6H_5)_3 \rightarrow C_6H_5P=O + CH_3\underset{H}{\overset{|}{C}}=\underset{CH_3}{\overset{|}{C}}-CH_3$$

- **Reaction with PCl5**

$$CH_3CHO \xrightarrow{PCl_5} CH_3CHCl_2 + POCl_3$$

- **Cannizzaro reaction**

This is a reaction undergone by aldehydes that lack alpha hydrogen



- **Wolf Kishner reaction**

This is the reaction of an aldehyde or ketone with hydrazine. Wolf Kishner's reagent is known as hydrazine ($H_2N.NH_2$).

$CH_3CHO + H_2N.NH_2$
$CH_3CH=NOH$( oxime) $+ H_2O$

**FUTO PAST QUESTION 2016/2017**

The reaction between aldehydes and ketones with hydrazine in the presence of KOH is called?

(a)Clemmensen reduction
(b)Wolf Kishner reduction
(c)hydrogenation
(d)condensation

ANSWER = B

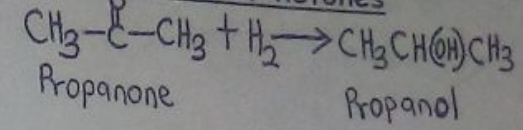
***.ALDOL CONDENSATION***

This is the reaction of an aldehyde with another aldehyde to produce an ALDOL (an aldol is a compound that contains both the alcohol functional group and an aldehyde functional group).

The two types of aldol condensation reactions are *(i) self (the same aldehyde) and (ii) mixed aldol(different aldehydes) condensation.*

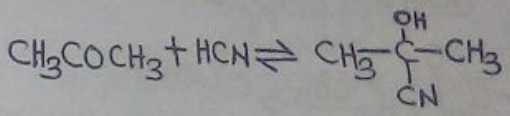
**CHEMICAL REACTIONS OF KETONES**

- **Reduction of ketones**

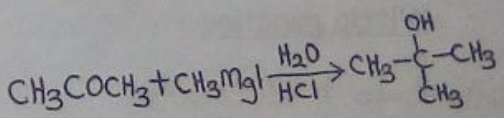



NOTE:- $LiAlH_4$ and $NaBH_4$ are used to reduce carbonyl compounds (aldehydes and ketones).

- **Reaction with hydrogen cyanide**

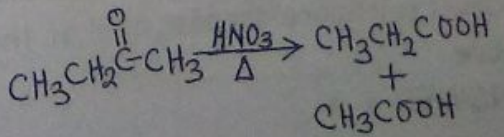


- **Reaction with Grignard reagent**



- **Oxidation of ketones by strong acids**

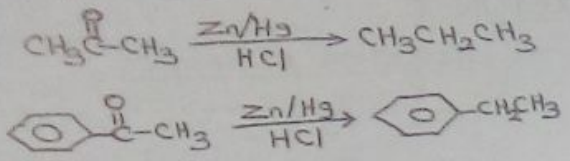
**Ketones are not easily oxidized. Only very strong oxidizing agents like $HNO_3$ can do so.**



NB; Bond breaking can occur from any side of the functional group.

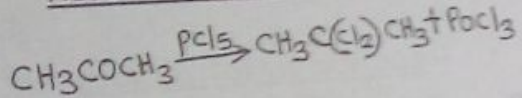
- **Clemmensen reduction of ketones**

Reaction of Clemmensen reagent (Zn/Hg.HCl) reacts with a ketone, an alkane is produced.

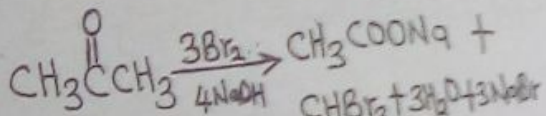


Zn/Hg.HCl is called clemmensen reagent, used to convert a ketone to an alkane.

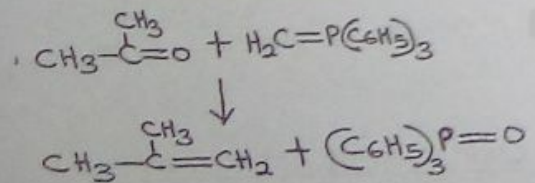
- **Reaction with PCl5**



- **Haloform reaction**



- **Wittig reaction**



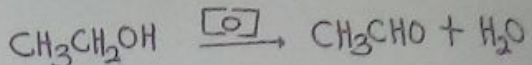
**FUTO PAST QUESTION 2016/2017**

$LiAlH_4$ and $NaBH_4$ are used to
(a)reduce carbonyl groups (b)reduce alkenes (c)reduce arenes (d)all of the above

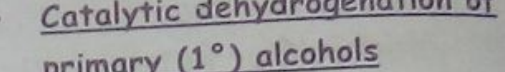
**ANSWER = A**

## PREPARATION OF ALDEHYDES

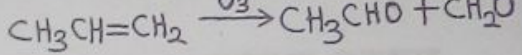
- **Oxidation of 1° alcohols**



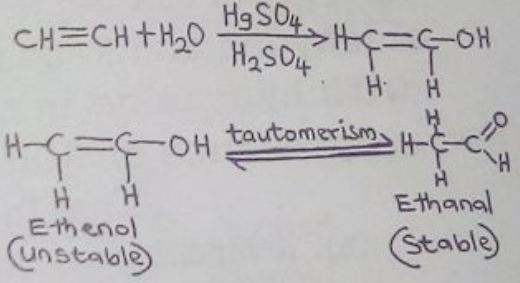
- **Catalytic dehydrogenation of primary (1°) alcohols**



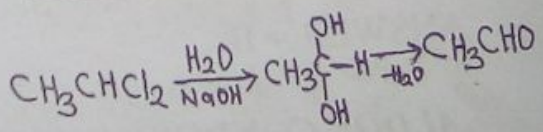
- **Oxidation of alkenes (ozonolysis)**



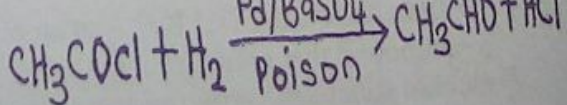
- **Hydrolysis of Ethyne**




- **Hydrolysis of gem-dihalide**

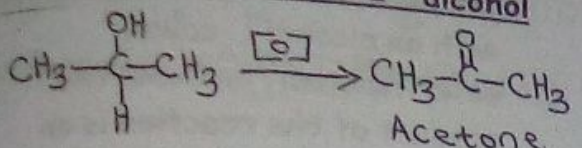


- **Reduction of acid chloride**



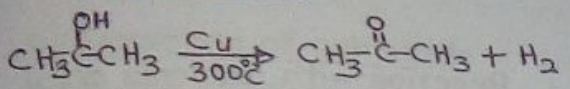
## PREPARATION OF KETONES

- **By Oxidation of 2° alcohol**

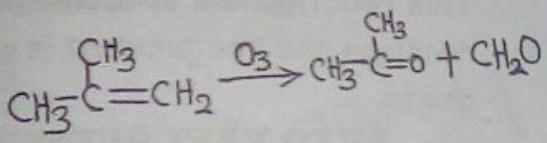


Acetone
or
Propanone.

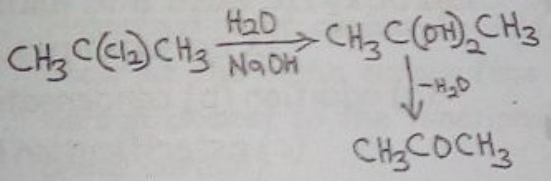
- **By catalytic dehydrogenation of 2° alcohol**



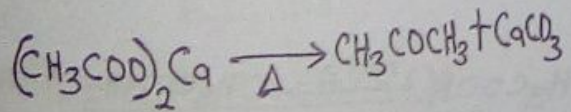
- **By Ozonolysis**



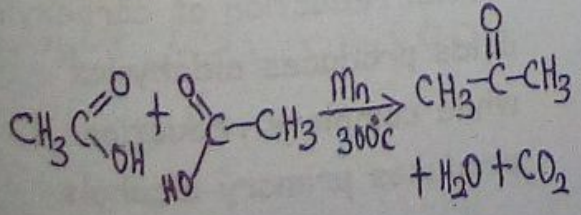
- **By hydrolysis of gem-dihalide**



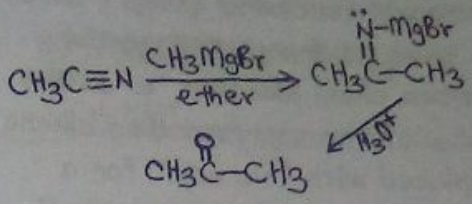
- **Pyrolysis of calcium salts of acids**



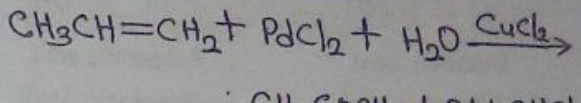
- **Catalytic decomposition of acids.**



- **From Nitide and Grignard reagent**



- **By wacker process.**



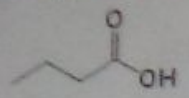
# CARBOXYLIC ACIDS

Carboxylic acids are organic compounds that contains the carboxyl functional group [-COOH].

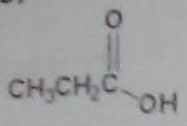
Carboxylic acids have the general molecular formula $C_nH_{2n}O_2$.

## NOMENCLATURE OF CARBOXYLIC ACIDS

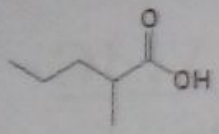
In naming carboxylic acids, the carboxyl functional group (-COOH) is given number one in the carbon chain. The last "e" in the name of the corresponding alkane is replaced with "oic acid" for a carboxylic acid. Examples:



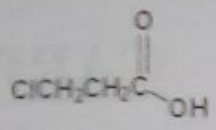
Butanoic acid
(Butyric Acid)



Propanoic acid
(Propionic Acid)



2-Methylpentanoic acid



3-Chloropropanoic acid

*TEST FOR CARBOXYLIC ACIDS(COOH group).*

*When carboxylic acids react with sodium bicarbonate ($NaHCO_3$), carbon(ii)oxide gas is released.*

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

## CHEMICAL PROPERTIES OF CARBOXYLIC ACIDS

- **Reaction with sodium metal**

$$CH_3COOH + Na \longrightarrow CH_3COONa$$

- **Neutralization reaction**

$$CH_3COOH \xrightarrow{NaOH} CH_3COONa + H_2O$$

- **Reaction with alcohol (esterification)**

This reaction of carboxylic acid with an alcohol is called esterification reaction. The product of the reaction is an ester.

$$CH_3COOH \underset{H_2SO_4}{\overset{CH_3OH}{\rightleftharpoons}} CH_3COOCH_3 + H_2O$$

- **Reaction with ammonia or amine**

This reaction is a condensation reaction and the product is an amide.

**FUTO PAST QUESTION 2016/2017**

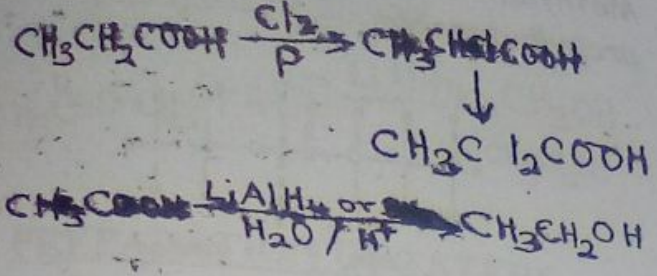
The reaction between carboxylic acid and amine is an example of
(a) addition (b) condensation
(c) esterification (d) hydrogenation

*ANSWER = B (water is lost during the reaction)*

$$CH_3COOH \xrightarrow{NH_3} CH_3CONH_2 + H_2O$$

- **Reduction of carboxylic acids**

Partial reduction of carboxylic acids produces aldehydes while complete reduction produces primary alcohols.

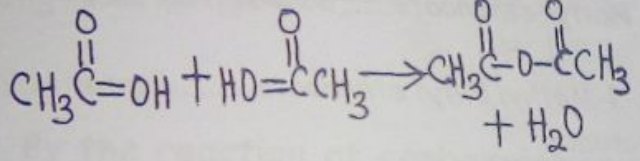


- **Formation of acyl halide**

$$CH_3COOH + PCl_5 \longrightarrow CH_3COCl$$

- **Formation of anhydride**

When two molecules of carboxylic acide combine together, an anhydride is formed.



- **Halogenation**

Halogenation of carboxylic acids occur at the alpha carbon (the carbon closest to the functional group carbon).

- **Reduction with diborane**

$$CH_3COOH \xrightarrow[H_2O,\ HCl]{BH_3,\ THF} CH_3CH_2OH$$

## PREPARATION OF CARBOXYLIC ACIDS

- **By oxidation of primary alcohol**

$$CH_3CH_2OH \xrightarrow{[O]} CH_3COOH$$

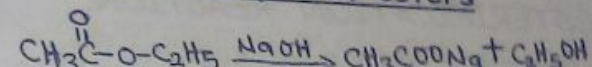
- **By oxidation of alkenes**

$$CH_3CH{=}CH_2 \xrightarrow[H_2O/H^+]{KMnO_4/OH^-} CH_3COOH + HCOOH$$

- **By hydrolysis of Nitriles**

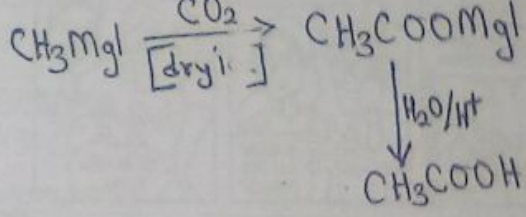
$$CH_3C{\equiv}N \xrightarrow{H_2O/H^+} CH_3COOH + NH_4^+$$

- **By hydrolysis of esters**



$$CH_3COONa + HCl \rightarrow CH_3COOH + NaCl$$

- **By grignard method**



- **By carboxylation of alkenes**

$$CH_2{=}CH_2 + CO + H_2O \xrightarrow[400^\circ C]{H_3PO_4} CH_3CH_2COOH$$

- **By oxidation of aldehyde**

$$CH_3CHO \xrightarrow{[O]} CH_3COOH$$

Carboxylation acids have high boiling points due to their ability to undergo hydrogen bonding they dissolve in water.

# ESTERS

Esters are organic compounds with the functional group -CO-O-C

Esters are formed by the reaction between a carboxylic acid and and alcohol. This reaction between a carboxylic acid and an alcohol to produce an esters in known as *ESTERIFICATION REACTION.*

Esters are formed by replacing the -OH of a carboxylic acid with "-OR" where R is an alkyl group.Esters have sweet smell.


## NOMENCLATURE OF ESTERS

When naming an ester, we call the name of the alkyl group part first followed by the name of the alkanoate part. Examples;

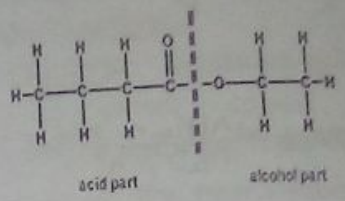
$HCOOCH_3$
*Methylmethanoate*
*(Methyl formate)*

$CH_3COOCH_2CH_3$
*Ethylethanoate*

$CH_3COOCH_3$
*Ethyl methanoate*
*(ethyl acetate)*

$CH_3OOCCH_3$

$C_3H_7OOCC_3H_7$
*Methylethanoate*
*propylbutanoate*




Ethylbutanoate

**Many esters of simple carboxylic acids have fragrance, fruity smells and they are used as flavouring agents.** Examples;-

*(a). Pentyl ethanoate.....Banana fragrance*

*(b). 3-Methyl butyl ethanoate.....Banana fragrance*

*(c). Ethyl butanoate....Pineapple fragrance*

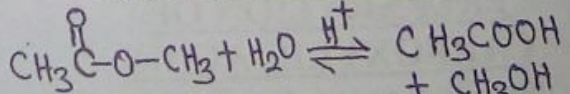
*(c). Octyl ethanoate.....Orange gragrance*

*(e). Methyl butanoate.....Apple fragrance*

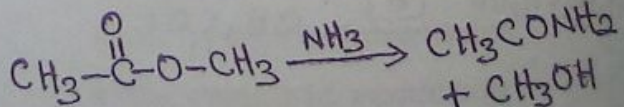
*(f). Ethyl formate.....Rum(wine) fragrance*

## CHEMICAL PROPERTIES OF ESTERS

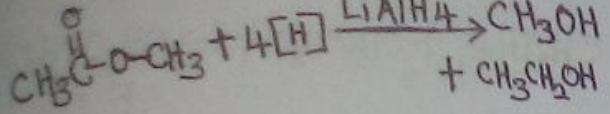
- **Hydrolysis of esters**




- **Reaction with ammonia**

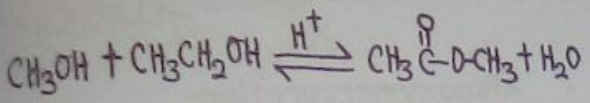


- **Reduction to alcohol**

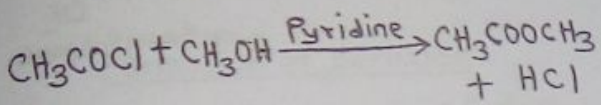


## PREPARATION OF ESTERS

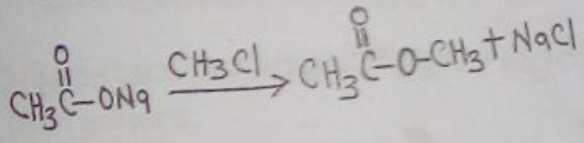
- **By esterification reaction**



- **Reaction of acid chloride with alcohol**



- **By the reaction of carboxylation salt with an alkyl halide**



**NOTE**

*The process by which an ester is converted into another ester is known as* **TRANSESTERIFICATION.**

Transesterification occurs when an ester reacts with excess alcohol.Examples,

Methylpropanoate + butanol → butylpropanoate + methanol

Methylpropanoate + propanol → propylpropanoate + methanol

Ethylpentanoate + propanol → propylpentanoate + ethanol

Propylethanoate + butanol → butylethanoate + propanol.

# ETHERS

Ethers are organic compounds with the functional group C-O-C
The oxygen atom of an ether is bonded to two alkyl groups.

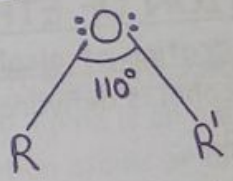
If the two alkyl groups of an ether are same, the ether is said to be symmetric. If the two alkyl groups are not the same, it is said to be non-symmetric.

Ethers are $SP^3$ hybridized.

**Example;**

CH3-O-CH3. *Symmetric.*

CH3-O-CH2CH3 *Non-symmetric*




R is an alkyl group.

## NOMENCLATURE OF ETHERS

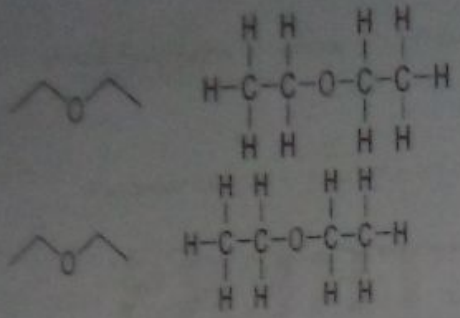
Ethers are named as alkoxyalkanes. The longer of the two alkyl groups is taken to be the alkane.

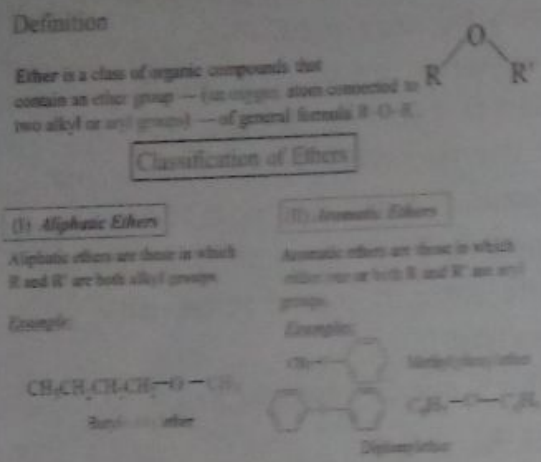
*For instance;*

Diethyl ether $C_2H_5OCH_3$

**Methoxyethane**

**$C_2H_5OCH_3$**






## PREPARATION OF ETHERS

- **By dehydration of alcohol**

when excess alcohol is dehydrated, an ether is formed.

$$2CH_3CH_2OH \xrightarrow[140^\circ C]{H_2SO_4} CH_3CH_2-O-CH_2CH_3 + H_2O$$

- **Passing alcohol vapour over hot $Al_2O_3$.**

$$2CH_3CH_2OH \xrightarrow[250^\circ C]{Al_2O_3} CH_3CH_2-O-CH_2CH_3 + H_2O$$

- **Heating alkyl halides with dry silver oxide**

$$2CH_3CH_2Cl + Ag_2O \xrightarrow{\Delta} CH_3CH_2OCH_2CH_3 + 2AgCl$$

- **Williamson ether synthesis**

$$CH_3ONa + CH_3CH_2Cl \longrightarrow CH_3OCH_2CH_3 + NaCl$$

- **Alkaoxymercuration-demercuration**

$$CH_3CH=CH_2 \xrightarrow[NaBH_4]{Hg(OAc)_2,\ CH_3OH} CH_3-\underset{\underset{CH_3}{|}}{\overset{O}{CH}}-CH_3$$

2-methoxy Propane

- **Action of diazomethane on alcohols**

$$CH_3OH + CH_2N_2 \xrightarrow{HBF_4} CH_3OCH_3 + N_2$$

$$CH_3CH_2OH + CH_3N_2 \xrightarrow{HBF_4} CH_3CH_2OCH_3 + N_2$$

## CHEMICAL PROPERTIES OF ETHERS

- **Halogenation of ethers**

$$CH_3CH_2OCH_2CH_3 \xrightarrow[dark]{Cl_2} CH_3\underset{Cl}{CH}O\underset{Cl}{CH}CH_3$$

- **Reaction with $H_2SO_4$**

$$CH_3CH_2OCH_2CH_3 + H_2O \xrightarrow[dilute]{H_2SO_4} 2CH_3CH_2OH$$

- Reaction with $PCl_5$

$$CH_3CH_2OCH_3 \xrightarrow[\Delta]{PCl_5} CH_3CH_2Cl + CH_3Cl + POCl_3$$

- **Cleavage by acid**

$$CH_3OCH_2CH_3 \xrightarrow{HCl} CH_3OH + CH_3CH_2Cl$$

- **Reaction with Acyl Chloride**

$$CH_3CH_2OCH_3 \xrightarrow[ZnCl_2, \Delta]{CH_3COCl} CH_3CH_2Cl + CH_3COOCH_3$$

- **Formation of peroxide**

$$CH_3CH_2OCH_2CH_3 + O_2 \xrightarrow{\text{Long Contact}} CH_3CH_2OCHCH_3$$
$$\text{OOH}$$

(hydroperoxide of diethyl ether)

NB: Esters have higher boiling points than ethers.

# AMINES

Amines are derivatives of ammonia in which one or more hydrogen atoms of ammonia ($NH_3$) have been replaced by alkyl group or groups.

Amines have the functional group of the $-NH_2$. Amines are basic. Tertiary anmines are more basic than secondary amines while primary amine are the least basic.

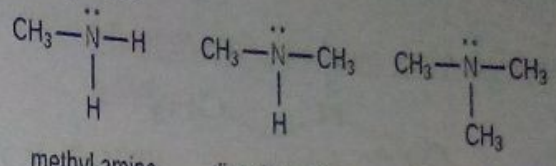
## CLASSES OF AMINES

- Primary amine. (1°)
- Secondary amine (2°)
- Tertiary amine. (3°)

## PRIMARY AMINE (1°)

A primary amine is an amine that has only one carbon atom or alkyl group directly attached to the nitrogen atom of the amine.

***Examples;***

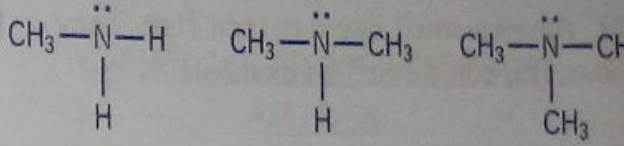


methyl amine dimethyl amine trimethyl amine

## SECONDARY AMINE

A secondary amine is an amine that has two carbon atoms or alkyl groups directly attached to the nitrogen atom of the amine.

***Examples;***

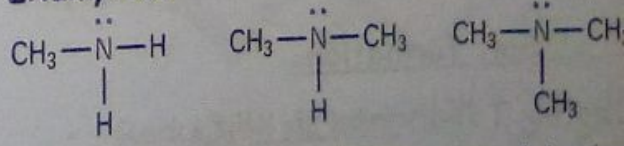


methyl amine dimethyl amine trimethyl amin

## TERTIARY AMINE

A tertiary amine is an amine that has three carbon atoms or alkyl groups directly attached to the nitrogen atom of the amine.

***Examples;***

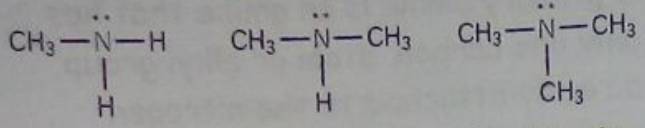


methyl amine dimethyl amine trimethyl amine

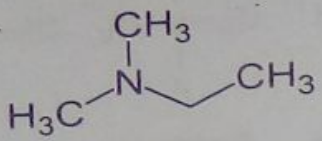
## NOMENCLATURE OF AMINES

Amines are named by naming the alkyl groups attached to the nitrogen atom followed by the ending "**amine**".

**Examples:**



methyl amine dimethyl amine trimethyl amine



## PHYSICAL PROPERTIES OF AMINES

I. Amines undergo hydrogen bonding and therefore are soluble in water, but alcohols undergo hydrogen bonding more than amines. Therefore, the O-H bond undergoes hydrogen bonding more than the N-H bond.

II. Amines smell like a rotten fish. They have the same smell as ammonia.

## CHEMICAL PROPERTIES OF AMINES

Amines are generally basic in nature due to the presence lone of lone pair of electron on the nitrogen atom of amines.

***INCREASING ORDER OF BASICITY OF AMINE.***

$$NH_3 < 1^0 < 2^0 < 3^0$$

- **Salt formation**

$$CH_3NH_2 + HCl \longrightarrow CH_3NH_3Cl$$

methyl ammonium chloride

**Reaction with nitrous acid**

$$CH_3CH_2NH_2 \xrightarrow[HCl]{NaNO_2} CH_3CH_2\overset{+}{N}\equiv N + H_2O + OH^-$$

$(0-5)^\circ C$

- **Reaction with acid chloride (Acylation)**

$$CH_3NH_2 + CH_3COCl \longrightarrow CH_3CON(H)CH_3 + HCl$$

## PREPARATION OF AMINES

$$CH_3CH_2Cl + NH_3 \longrightarrow CH_3CH_2NH_2 + HCl$$

- **By reduction of alkyl halides with ammonia**

$$CH_3CH_2NO_2 + 3H_2 \xrightarrow{Pt} CH_3CH_2NH_2 + 2H_2O$$

- **By reduction of nitro alkanes**
- **By reduction of amides**

$$CH_3CH_2CONH_2 + 4[H] \xrightarrow[H_2O]{LiAlH_4} CH_3CH_2NH_2 + H_2O$$

- **By reduction of nitriles**

$$CH_3C\equiv N + 4[H] \xrightarrow[H_2O]{LiAlH_4} CH_3CH_2NH_2$$

- **Reduction of oximes**

$$CH_3CH{=}NOH + 4[H] \xrightarrow{LiAlH_4} CH_3CH_2NH_2 + H_2O$$

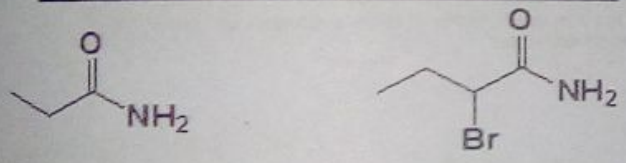
**N/B:** In naming priority of a poly-functional group compound in which there are multiple functional groups present, $-NH_2 > =$

but. $-OH > NH_2 > =$

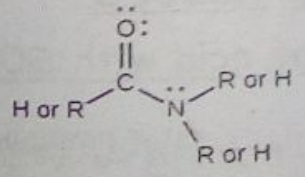
# AMIDES

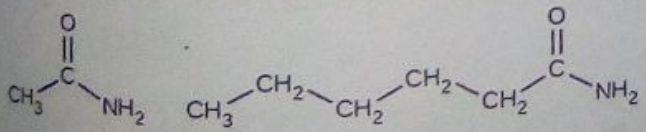
Amides are organic compounds that contains the functional group as - CONH2. Amides are formed by replacing the OH group in the carboxylic acid functional group with $NH_2$ group. Therefore, amides are carboxylic acid derivatives. Amides are the most stable derivatives of carboxylic acides because they are unreactive like other carboxylic acid derivatives. The stability of amides is as a result of resonance in amides. Amides are obtained principally from the reaction of carboxylic acid and ammonia. Amides are acidic.

## NOMENCLATURE OF AMIDES



Propanamide 2-Bromobutanamide





acetamide hexanamide

## PREPARATION OF AMIDES

- **Reaction of acid with NH3**

$$CH_3COOH + NH_3 \longrightarrow CH_3CONH_2 + H_2O$$

- **Reaction of eathers with $NH_3$**

$$CH_3COOCH_3 + NH_3 \longrightarrow CH_3CONH_2 + CH_3OH$$

- **Controlled hydrolysis of nitrile**

$$CH_3C{\equiv}N + H_2O \longrightarrow CH_3CONH_2$$

- **Heating ammonium salt of the acid.**

$$CH_3COONH_3 \xrightarrow{\Delta} CH_3CONH_2 + H_2O$$

- **Reaction of acid chloride with $NH_3$**

$$CH_3COCl + NH_3 \longrightarrow CH_3CONH_2 + HCl$$

## CHEMICAL PROPERTIES OF AMIDES

*Generally, amides are stable and unreactive. Amides are the least reactive compared to the other derivatives of carboxylic acids. Amides are acidic.*

- **Hydrolysis of amindes**

$$CH_3CONH_2 + H_2O + HCl \longrightarrow CH_3COOH + NH_4Cl$$

- **Reduction of amindes**

$$CH_3CONH_2 \xrightarrow{LiAlH_4} CH_3CH_2NH_2$$

- **Hoffman degradation**

$$CH_3CONH_2 + Br_2 \xrightarrow{NaOH} CH_3NH_2 + 2NaBr + 2H_2O + Na_2CO_3$$

- **Dehydration with P2O5**

$$CH_3CONH_2 \xrightarrow[-H_2O]{P_2O_5} CH_3C\equiv N$$

acetonitrile

- **Reduction using nitrous acid**

$$CH_3CONH_2 + HNO_2 \rightarrow CH_3COOH + N_2 + H_2O$$

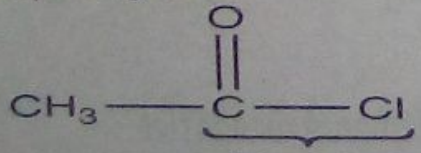
# ACYL HALIDES


Acyl halides are organic compounds with the functional group of -COX where x is a halogen. Acyl halides are carboxylic acide derivatives. Acyl halides are formed by replacing the -OH group of a carboxylic acid with a halogen.

Acyl halides are formed by replacing the -OH group of a carboxylic acid with a halogen.

Acyl halides are insoluble in water but they dissolve slowly in water due to hydrolysis.

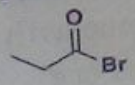
Acyl halides have lower boiling points compared to their corresponding acids.



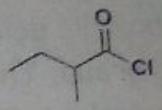

acid chloride group

## NOMENCLATURE OF ACYL HALIDES.

In naming acyl halides, the last "e" in the name of the corresponding alkane is replaced with "oyl" followed by the name of the halogen present.

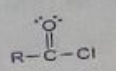



Propanoyl Bromide

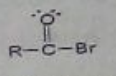



2-Methylbutanoyl chloride

### Acid Halides




acid chloride (acyl chloride)




acid bromide (acyl bromide)

- Also called *acyl halides*.
- These are more reactive than carboxylic acids, so they are used to synthesize other acid derivatives such as esters and amides.
- Used in the Friedel–Crafts acylation to make acylbenzenes.

Chapter 21 14

## PREPARATION OF ACYLHALIDES

- **Reaction of acid with SOCl2**

$$CH_3COOH + SOCl_2 \rightarrow CH_3COCl + HCl + SO_2$$

- **Reaction of acid with PCl3**

$$CH_3COOH + PCl_3 \rightarrow CH_3COCl + H_3PO_3$$

- **Reaction with $PCl_5$**

$CH_3COOH + PCl_5 \rightarrow CH_3COCl + POCl_3 + HCl$

## CHEMICAL PROPERTIES OF ACYL HALIDES

- **Hydrolysis**

$CH_3COCl + H_2O \rightarrow CH_3COOH + HCl$

- **Reaction with alcohol**

$CH_3COCl + CH_3OH \rightarrow CH_3COOCH_3 + HCl$

- **Reaction with $NH_3$**

$CH_3COCl + NH_3 \rightarrow CH_3CONH_2 + HCl$

- **Reaction with amine**

$CH_3COCl + CH_3NH_2 \rightarrow CH_3CONHCH_3 + HCl$

$CH_3COCl + CH_3NHCH_3 \rightarrow CH_3CON(CH_3)_2 + HCl$

- **Reaction with carboxylic acid salts**

$CH_3COCl + CH_3COONa \rightarrow CH_3C(=O)OC(=O)CH_3 + NaCl$

Anhydride

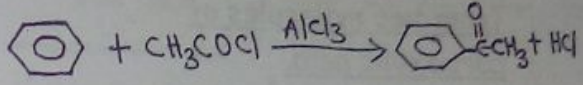
- **Reduction of Acyl halide**

$CH_3COCl + H_2 \xrightarrow[BaSO_4]{Pd} CH_3CHO + HCl$

- **Reaction with organoculerate compounds**

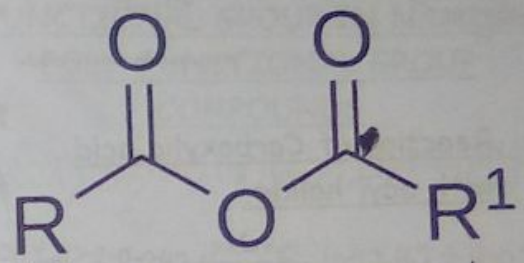
$CH_3CH_2COCl + (CH_3)_2CuLi \xrightarrow{ether} CH_3CH_2COCH_3$

- **Friedel craft acylation**



$C_6H_6 + CH_3COCl \xrightarrow{AlCl_3} C_6H_5COCH_3 + HCl$

# ANHYDRIDES



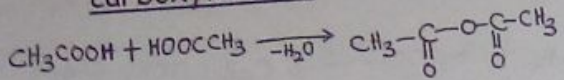
Anhydrides are organic compounds having two compounds having two carbonyl groups joined together by a single oxygen atom. Anhydrides are carboxylic acid derivatives.
Anhydrides are derived by the loss of water molecule between two molecules of carboxylic acid.Anhydrides combines with water to produce acids.
Anhydrides have the functional group **-COOOC-**
Anhydrides are insoluble in water and they have higher boiling points than the acids from which they are derived.

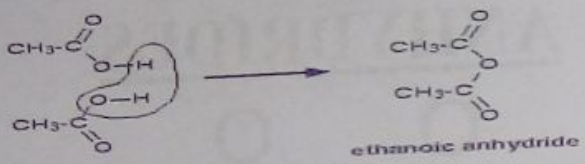
**NOTE**
*Anhydrides have higher boiling points than their corresponding carboxylic*

acides due to the large size of anhydrides and presence of Van Der Waal's interaction in them.

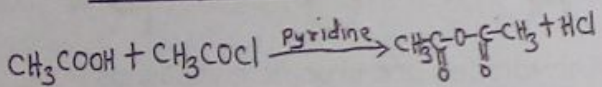
## PREPARATION OF ANHYDRIDES

- By removing of water molecule from two molecules of carboxylic acid.

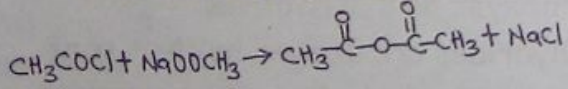





- Reaction of Carboxylic acid with acyl halide.

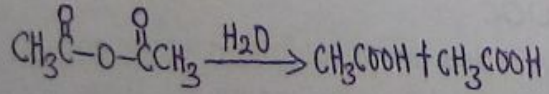


- Reaction of acid halide with a salt of Carboxylic acid.

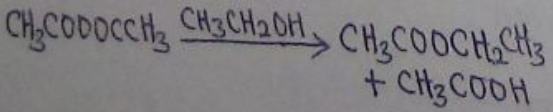


## CHEMICAL PROPERTIES OF ANHYDRIDES

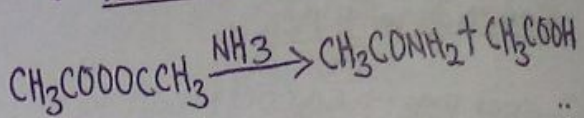
- Hydrolysis



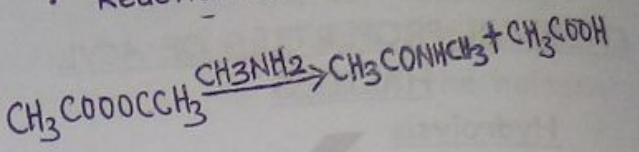
- Reaction with alcohol



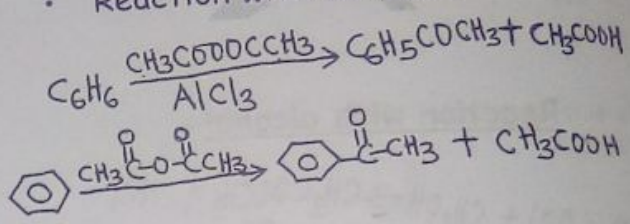
- Reaction with $NH_3$



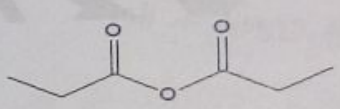
- Reaction with amines



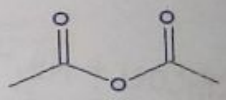
- Reaction with Benzene



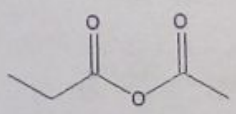
## NOMENCLATURE OF ANHYDRIDES



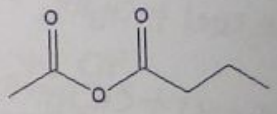
Propanoic anhydride
(Propionic anhydride)



Ethanoic anhydride
(Acetic anhydride)



Ethanoic propanoic anhydride
(Acetic propionic anhydride)



Butanoic ethanoic anhydride
(Acetic butyic anhydride)

**NOTE**

**The derivatives of carboxylic acids are,**

*Amides (least reactive of them)*
*Esters*
*Acyl halides*
*Anhydrides*

**NOTE**

- **Alkanes undergo mainly substitution reaction.**
- **Alkenes undergo mainly addition reaction.**

- Alkynes undergo mainly addition reaction.
- Benzene undergo mainly substitution reaction.

## SOME REAGENTS

- Grignard reagent _ RMgX
  R=alkyl group
  X=halogen
- Baeyer's reagent_ $KMnO_4$ (used to test for unsaturation)
- Clemmensen reagent__$ZnCl_2$/HCl
- Wolf Kishner reagent__$H_2N.NH_2$ (Wolf Kisher reagent is hydrazine)
- Lucas reagent _ $ZnCl_2$/HCl

(Anhydrous ZnCl2 in concentrated HCl)

## SAYTZEFF RULE

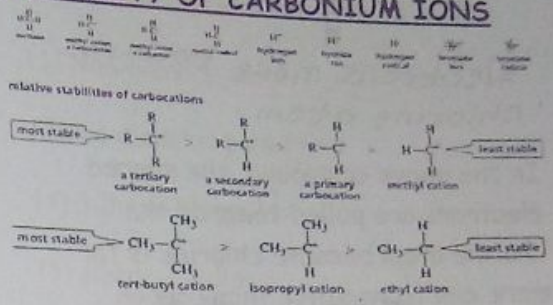
"In the reaction of an alkyl halide with alcoholic KOH, the main product is the most substituted alkene"

## DICARBOXYLIC ACIDS

Dicarboxylic acids are those carboxylic acids that contain teo carboxylic acid functional groups in them.Dicarboxylic acids are **dibasic acids** because they produce two hydrogen ions on ionization.Examples,

**Ethanedioic acid (Oxalic acid)….HOOC-COOH**
**Malonic acid….$HOOC-CH_2-COOH$**
**Succinic acid_ $HOOC-(CH_2)_2-COOH$**
**Glutaric acid_ $HOOC-(CH_2)_3-COOH$**
**Adipic acid_$HOOC-(CH_2)_4-COOH$,**
**etc.**

## STABILITY OF CARBONIUM IONS




## PRIORITY OF CITATION OF FUNCTIONAL GROUP IN NAMING POLY-FUNCTIONAL GROUP COMPOUNDS

$COOH > CHO > CO > OH > NH_2 > = > \equiv >$ Halide > Alkyl group.

## ORDER OF LEAVING GROUP ABILITY AND RATE OF REACTIVITY TOWARDS ALCOHOL

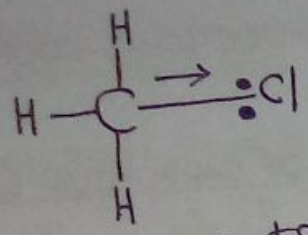
$I^- > Br^- > Cl^- > F^-$

## RATE OF DEHYDRATION OF ALCOHOLS.

$3° > 2° > 1°$

## INDUCTIVE EFFECT

This is the pull of electron density through sigma bonds caused by the electronegativity difference between atoms.
Example;



Electrons move towards chlorine atom.

In the above compound, the shared electrons are pulled towards the chorine atom because chlorine is far more electronegative than carbon atom.

Atoms that draw electrons away from carbon are said to have -1 effect while those that loose electrons towards carbon are said to have +1 effect.

Examples;

-1 effect : $-NO_2$, $F^-$, $Cl^-$, $Br^-$, $I^-$, $OH^-$ etc

+1 effect; $-COO^-$, $-CH_3$, $O^-$, etc

## MESOMERIC EFFECT

This is the polarity produced in a molecule as a result of the interaction between two π-bond or a π-bond and a lone pair of electrons.

Atoms that draw electrons away from carbon have -M effect while loosing to carbon is +M effect.

## NUCLEOPHILE

A nucleophile is an electron rich substance that donates a pair of electrons to an electron deficient substance forming a covalent bond.

Example is of nucleophiles;

$OH^-$, $NH3^-$, $I^-$, $Br^-$, $Cl^-$, $H_2O^-$, $CH_3O^-$ (methoxide ion), etc


## ELECTROPHILE

An electrophile is an electron deficient substance that can accept a pair of electrons from a nucleophile forming a covalent bond.

NB; Lewis acids are electrophiles

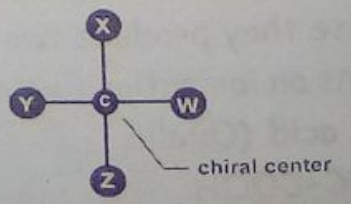
Examples; $H^+$, $NO_2^+$, $Bf_3$, $BH_3$, $AlCl_3$, $Cl+$, $Br^+$, $I^+$ etc

### FUTO PAST QUESTION ON ELECTROPHILES 2016/2017

Which of the following act as an electrophile? (a)$HO^-$ (b)$(CH_3)N$ (c)$Cl^-$ (d)*$BH_3$

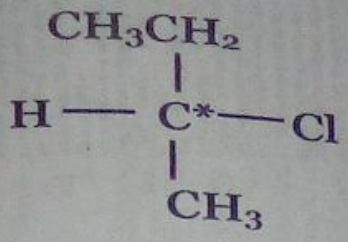
ANSWER = D

## CHIRAL CARBON




A chiral carbon is a carbon atom that is bonded to four other non-identical

groups.Another name for a chiral centre is stereogenic centre.
Example;




**FEDERAL UNIVERSITY OF TECHNOLOGY OWERRI**
**DEPARTMENT OF CHEMISTRY**
**CHM102 GENERAL CHEMISTRY 11**
**TEST 2016/2017**
**TIME: 50 Minutes**
**INSTRUCTIONS: ANSWER ALL QUESTIONS, SOLVE YOUR QUESTIONS AT THE BACK OF THE QUESTION PAPER.**

1) The compound ethylene glycol is often used as an antifreeze, it contains 38.7% carbon, 9.75% hydrogen and the rest oxygen. The molecular weight of ethylene glycol is 62.07g. What is the molecular Formula of ethylene glycol.

2) Why does propanol boil at higher temperature than the corresponding hydrocarbons.
3) Markovnikov's rule states that.....
4) Terminal alkynes are alkyne.....
5) Tautomerism is defined as;.....
6) Catenation is defined as;.....
7) Tertiary cabrbocation is .....
8) Hybridization in Organic Chemistry is define as .....
.....

**GIVE THE STRUCTURE OF THE FOLLOWING COMPOUNDS.**

9) 2-Chloro-4-ethyl-heptanes

10) 2,3-dimethyl pentane

11) Non-6-ene-3-yne

12) 4,4-dimethyl pent-1-yne

14) 5-fluoro hexan-3-ol

15) ethane-1,2-diol

# SOLUTION TO 2016/2017 CHM102 TEST.

**1** C = 38.7%, H = 9.75%

O = 100 − (38.7 + 9.75) = 51.55%

| C | H | O |
|---|---|---|
| 38.7 / 12 | 9.75 / 1 | 51.55 / 16 |
| 3.225 / 3.222 | 9.750 / 3.222 | 3.222 / 3.222 |
| 1 | 3 | 1 |

Empirical formular = $CH_3O$

$[CH_3O]_n = 62.07$

$n = \frac{62.07}{CH_3O} = \frac{62.07}{12+(1\times3)+16}$

$n = \frac{62.07}{31} = 2$

Molecular formular = $[CH_3O]_n = [CH_3O]_2 = C_2H_6O_2$

**2** Propanol boils at a higher temperature than the corresponding hydrocarbon (Propane) due to hydrogen bonding in propanol.

**3** Markovnikoff's rule states that "during the the addition of hydrogen halide(HX) to an unsymmetric alkene, the H atom goes to the carbon that has higher hydrogens while the halogen (X) bonds to the carbon with lower number of hydrogens"

**4** Terminal alkyne is an alkyne whose triple bond is at position one along the carbon chain.

**5** Tautomerism is defined as the phenomenon by which isomers or tautomers are in dynamic equilibrium with each other as a result of movement of Proton and π-bond or π-electron.

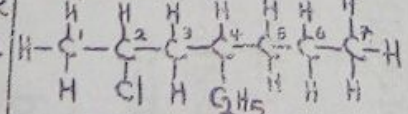
**6** Catenation is the process by which carbon atom bonds with other carbon atoms forming chains of different lengths and shapes.

**7** Tertiary carbocation is a carbonium ion in which the positively charged carbon is directly bonded to three alkyl groups.

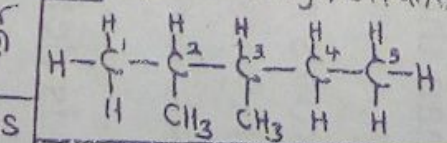
$R-\overset{+}{C}(R'')-R'$ or $(R)_3C^+$

**8** Hybridization in organic chemistry is defined as the combination of two or more atomic orbitals to produce an entirely new equivalent orbital

**9** 2-chloro-4-ethyl heptane



**10** 2,3-dimethylPentane



THE CATALYST

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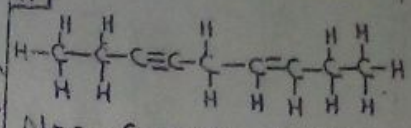
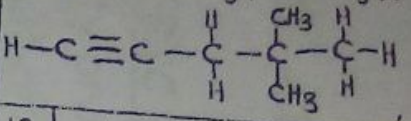
**11**



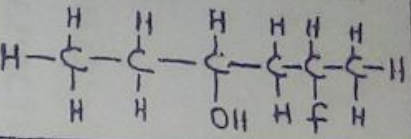
Non-6-ene-3-yne.

**12** 4,4-dimethylpent-1-yne

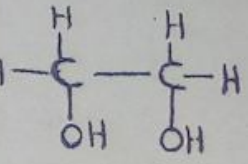


**13** No Question No:13

**14** 5-fluoro-hexan-3-ol

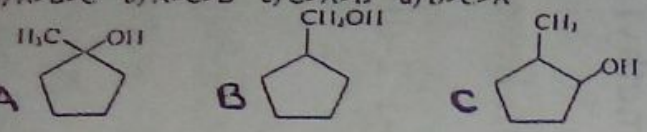


**15** Ethane-1,2-diol



FEDERAL UNIVERSITY OF TECHNOLOGY OWERRI
DEPARTMENT OF CHEMISTRY
CHM 102 GENERAL CHEMISTRY II
2016/2017 SESSION. TIME ALLOWED: 1 HR 30 MINUTES
INSTRUCTION: ANSWER ALL QUESTIONS. DO NOT DETACH THE QUESTION PAPER FROM THE OMR TYPE 2

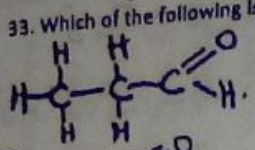
1) $CaC_2$ on hydrolysis gives
a) alkanes b) alkenes c) alkynes d) alcohols
2) For reacting with HCl, the alcohol which does not require $ZnCl_2$ is
a) $CH_3CH_2OH$ b) $CH_3CH(CH_3)CH_2OH$
c) $CH_3CH(CH_3)OH$ d) $C(CH_3)_3C\text{-}OH$
3) Arrange the following alcohols in order of decreasing reactivity with HBr (most reactive first).
a) A>B>C b) A>C>B c) C>A>B d) B>C>A

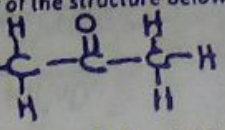



4) Which of the following compound contains an sp hybridized C atom?
a) $CH_3CO_2H$ b) $CH_3CHO$ c) $CH_3CN$ d) $CH_3NH_2$
5) Which compound has stereoisomers?
a) Butane b) Propyne c) But-2-ene d) Propene
6) Pent-1-ene and pent-2-ene are examples of
a) enantiomers b) constitutional isomers
c) stereoisomers d) (E)-and (Z)-isomers of pentane
7) Which of the following can act as an electrophile?
a) $HO^-$ b) $(CH_3)_3N$ c) $Cl^-$ d) $BH_3$
8) Pi ($\pi$) bonds are formed by the?
a) overlap of two orbitals b) overlap of an s and p orbital c) end-to-end overlap of two orbitals d) side-to-side overlap of two p orbitals
9) Stereoisomers are a) molecules with the same numbers of atoms but different structures
b) molecules with the same structure
c) linear molecules with single bonded carbon atoms
d) molecules with different conformation due to a double bond
10) A regio selective reaction is one which?
a) a single product is produced b) multiple products are made in equal ainounts c) multiple products are made with one in excess of the others d) involves an oxidation
) $LiAlH_4$ and $NaBH_4$ are used to?
a) reduce carbonyl groups b) reduce alkenes
c) reduce arenes d) all of the above
) Alkenes are prepared by?
a) addition reactions b) substitution reactions
c) elimination reactions d) free radical reactions
The loss of a halide atom to generate an alkene is known as? a) a dehydrohalogenation b) a dehydration
c) a reduction d) an oxidation
$LiAH_4$ and $NaBH_4$ are used to _____
a) reduce carbonyl groups b) reduce alkenes
c) reduce arenes d) reduce amines
The reaction between a carboxyl acid and an amine is an example of this type of reaction
a) addition b) condensation c) esterification
d) hydrogenation
The mixing of orbitals, which is quantum mechanical calculation process is termed
a) pi bond b) hybridization c) sigma bond d) catenation
17) Propane and 2-propanone are _____
a) positional isomers b) functional group isomers
c) a and b d) none of the above
18) The reaction between aldehydes and ketones with hydrazine in the presence of KOH is called_____.
a) Clemmenson's reduction b) Wolf Kisher s reduction
c) hydrogenation d) condensation
19) The product of the reaction of alcohols with $H_2SO_4$ at 140°C is _____ a) an ether b) an alkene c) an alkane d) an aldehyde
20) The reaction between $CH_3CH{=}C(CH_3)_2$and HBr in the presence of $H_2O_2$ produces
a) $CH_3CHBrCH(CH_3)_2$ b) $CH_3CH_2CBr(CH_3)_2$
c) $CH_3CH_2CH(CH_3)_2$ d) none of the above
21) Which of the following statements is false?
a) alkanes have lower density than water
b) the density of alkanes increases with increasing number of carbon atoms c) cis/trans isomerism affects density slightly d) for compounds with same number of carbon atoms alkenes have higher boiling points than alkanes
22) Which of the following compounds does not have cis/trans isomers?
a) $CH_3CH{=}CHCH_3$ b) $ClCH{=}CHCl$
c) $H_2C{=}CHC_2H_5$ d) $CH_3CH{=}CHCH_3$
23) What conditions are best for dehalogenation of vicinal dibromide
a) Zn in acetic acid b) Zn in acetone
c) Zn in alcohol d) Zn in toluene
24) What product is obtained from the oxidation of Hex-2-ene with warm conc. potassium solution
a) acetate and butanone b) acetaldehyde and butanoate
c) acetaldehyde and butanal c) acetate and butanoate
25) What is the product formed by, bromination of 2-methyl pent-1-ene?
a) 2,2- dibromo-2-methyl heptanes
b) 1,2-dibromo-2-methyl pentane
c) 2-bromo-2-methyl pen-1-ene
d) 1-bromo-2-methyl pent-1-ene
26) What is the product formed in the peroxide catalyzed hydrobromination of 1-methylcyclohexene
a) 4-bromo-1-methyl cyclohexane
b) 2-bromo-1-methyl cyclohexane
c) 1-bromo-1-methylcyclohexane
d) 5-bromo-1-cyclohexane
27) Which atomic orbital overlap to form the carbon triple bond a) $sp^2+sp^2$, sp + sp , p+ p b) s+ s, sp+ sp p+ p c) sp + sp, p + p, p+ p d) sp + sp, sp + sp, p+ p
28) The major product of the reaction of 1,2 dibromobutane and excess $NaNH_2$
a) 2-bromo-1-butyne b) 1-bromo-1-butene
c) 1-butyne d) 1,2-butadiene
29) Which of the following is more acidic?
a) 1-butyne b) 2-butyne c) 1-butene d) butane
30) Predict the product of the reaction of pent-1-ene and excess HCl in the presence of hydrogen peroxide
a) 1,2-dichloropentane b) 1,2-dichloropentane
c) 2,2-dichloropentane d) 2-chloro-1-pentane
31) Which neuclophile is required to convert 1-bromobutane to butyl methyl ether?
a) ethoxide ion b) methoxide ion
c) butoxide ion d) hydroxide ion

32) What type of orbitals are involved in C=O bond in alcohols? a) C $sp^3$, O $sp^2$ b) C$sp$, O$sp^2$ c) C $sp^2$ d) C$sp^3$O, $sp^3$

33. Which of the following is is an isomer of the structure below



(A) 

(B) $CH_3C(=O)H$

(C) $CH_3CH_2CH_2OH$

(D) $CH_3CH_2COOH$

34. A specific arrangement of atoms which gives characteristic properties of an organic molecule is known as a(an) ..... (A) carbonyl group (B) functional group (C) group (D) alkyl group

35. The compound $C_4H_9OH$ is an isomer of (A)$C_3H_7OCH_3$ (B) $C_3H_7OC_2H_5$ (C) $CH_3COOC_3H_5$ (D)$CH_3COOH$

36. Molecules of 1-propanol and 2-propanol have different (A) percentage composition (B) molecular mass (C) molecular formular (A) structural formular

37. Which of the following is not a catalyst for the hydrogenation of an alkene? (A) Pd (B)Pt (C) Na (D) Ni

38. The angle formed between any two carbon-hydrogen bonds in a molecule of an organic compound is a(an) (A) dihedral angle (B)right angle (C)acute angle (D) tetrahedral angle

39. Which alcohol has the lowest solubility in water ? (A) pentanol (B) methanol (C) butanol (D) ethanol

40. Which of the following alcohols cannot be oxidized to a carbonyl compound? (A) 3-methyl-3-pentanol (B) propanol (C) 2-butanol (D) 2-pentanol

41. Which product is formed in the catalytic hydrogenation of 2,2-dimethy-4-pentenol? (A) 2,2-dimethyl-1-pentanol (B) 2,2-dimethyl-4-pentanol (C) 2,2-dimethylpentanal (D) none of the above

42. Which of the following aldehydes used alone can undergo Aldol condensation? (A)formaldehyde (B) butanal (C) benzaldehyde (D) none of the above

43. An unknown compound on ozonolysis gave acetaldehyde and benzophenone. What is the name of the compound? (A) 1,2-diphenylpropane (B) 1,1-diphenylpropene (C) 2-phenyl-2-hexene (D) 1,2-diphenylhexane

44. Which of the following acid derivatives is the most stable? (A) acid chlorides (B) esters (C) amides (D) anhydrides

45. Which of the following compounds does not form an imine upon reaction with an amine? (A) benzaldehyde (B) benzamide (C) acetophenone (D) benzophenone

46. What conditions are best for dehalogenation of vicinal dibromide? (A)Zn in acetic acid (B) Zn in acetone (C) Zn in alcohol (D) Zn in toulene

47. What is the product of the reaction of acid chloride with primary amine? (A) an amine (B) an ester (C) amides (D) a secondary amine

49. The type of substitution reaction that takes place when methane is treated with $Cl_2$ in the presence of light is (A) ionic (B) electrophilic (C) nucleophilic (D) radical

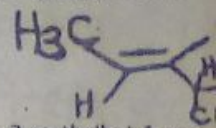
50. When the same group are on the same or opposite sides of the bonds in alkenes, the isomerism is called (A) chain isomerism (B) geometrical isomerism (C) positional isomerism (D) optical isomerism

51. Which of the following best describes the carbon-chlorine bond of an alkyl chloride? (A) nonpolar, no dipole (B) polar, $d^+$ at carbon and $d^-$ at chlorine (C) ionic (D) none of the above

52. Which of the following alcohols is the most acidic? (A) 1-chloroethanol (B) ethanol (C) 1,1-dichloroethanol (D) 2-ethanol

53. An alkene reacts with ozone to form (A) alkyne (B) alcohol (C) ketone (D) aldehyde

54. The IUPAC name for this compound is



(A) 4-bromopent-2-ene (B) 3-bromo-2-methylbut-1-ene (C) 4-bromo-3-methylpent-2-ene (D) 1-bromo-2-mtheylbut-2-ene

55. How many structural isomers of heptanes exist? (A) 2 (B) 4 (C) 6 (D) 8 (E) 9

56. Which of the following groups of products is formed when methane and chlorine reacts in the dark? (A) $CH_3Cl$, $CH_2Cl_2$, $CHCl_3$ and $CCl_4$ (B) $CH_3Cl$ and HCl (C) $CCl_4$ and HCl (D) no product formed

57. The hybridization indicated by (*) in $CH_3$-*$CH_2$-$CH_3$, *$CH$=$CH_2$ and *$CHCCH_3$ respectively (A) $sp^3$, $sp^2$, sp (B) $sp^3$, sp, $sp^2$ (C) sp, $sp^2$, $sp^3$ (D) $sp^2$, $sp^3$, sp

58. Which of these is the most stable? (A)acyl halides (B) esters (C) amides (D) acid anhydrides

59. The hybridization of the central carbon in $CH_3CN$ and the bond angle respectively are (A) $sp^3$, 180° (B) sp, 180° (C) $sp^2$, 120° (D) $sp^3$, 109°

60. . An unknown compound on ozonolysis gave acetaldehyde and benzophenone. What is the name of the compound? (A) 1,2-diphenylpropane (B) 1,1-diphenylpropene (C) 2-phenyl-2-hexene (D) 1,2-diphenylhexane

# SOLUTIONS TO 2016/2017 EXAM QUESTIONS.

**1** Hydrolysis of $CaC_2$ means the addition of water to it.

$$CaC_2 + H_2O \longrightarrow C_2H_2 + CaO$$

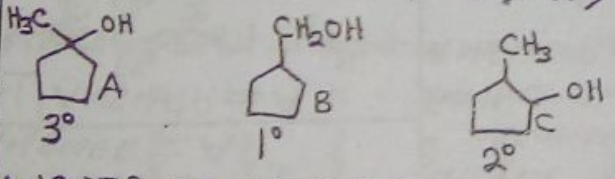
NB:- $C_2H_2$ is ethyne $H-C\equiv C-H$ which belongs to alkyne family

ANSWER = Alkyne.

**2** $ZnCl_2$ in HCl ($ZnCl_2/HCl$) is called lucas reagent used to differenciate between the three classes of alcohols. Tertiary alcohol reacts fastest with Lucas reagent while secondary alcohol takes little time about 5mins to react with it. Primary alcohol react very slow with it.

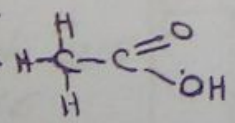
ANSWER = $(CH_3)_3C-OH$ ($3^o$ alcohol)

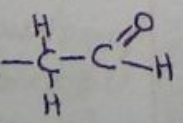
**3** In terms of reactivity of alcohols with HBr, $3^o > 2^o > 1^o$

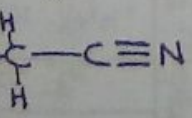


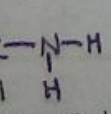

ANSWER = A > C > B

**4** SP hybridization is present in a compound that has a triple bond.

$CH_3CO_2H \longrightarrow$ 

$CH_3CHO \longrightarrow$ 

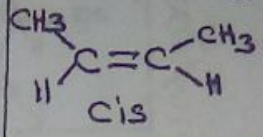
$CH_3CN \longrightarrow$ 

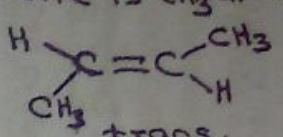
$CH_3NH_2 \longrightarrow$ 

NB:- Carbon always have four bonds round it while nitrogen has three.

ANSWER = $CH_3CN$.

**5** A compound that has stereoisomer is the one that can exist as "cis" and "trans" isomers. But-2-ene is $CH_3CH=CHCH_3$




ANSWER = But-2-ene.

**6** The difference between pent-1-ene and pent-2-ene is the position of their double bonds. Therefore, both of them are called positional isomers.

NB:- Positional isomerism is part of structural isomers and another name for structural isomers is constitutional isomers.

ANSWER = Constitutional isomers.

**7** Electrophiles are electron defficient substances.

ANSWER = $BH_3$

**8** Pi bonds ($\pi$) are formed by the side by side overlap of p-orbitals.

ANSWER = Side by side overlap of two p-orbitals.

**9** A

**10** C

**11** To reduce Carbonyl groups.

**12** Elimination reaction.

Example;- If we eliminate (remove) two hydrogen atoms from ethane, we form ethene.

$$CH_3-CH_3 \xrightarrow{-H_2} CH_2=CH_2$$

**13** Dehydrohalogenation is the removal of hydrogen halide from a haloalkane to form an alkene.

ANSWER = reduction.

14 Reduce Carboonyl groups.

15 $CH_3COOH + CH_3NH_2 \rightarrow CH_3CONHCH_3 + H_2O$

Since water is given out in the reaction of a carboxylic acid and amine, it is a condensation reaction.

16 Hybridization

17 Propane $CH_3CH_2CH_3$ and Propanone $CH_3COCH_3$ are not isomers because they do not have the same number of atoms of the same elements in them.

ANSWER = none of the above.

18 Wolf Kishner's reduction

19 At a temperature of 140°C $H_2SO_4$ reacts with alcohols to produce ethers.

At 180°C, the produce is an alkane.

ANSWER = Ether.

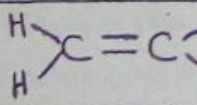
20 In the presence of $H_2O_2$ (peroxide), it will follow the Anti-Markovnikov's rule.

$CH_3CH=C(CH_3)_2 \xrightarrow[H_2O_2]{HBr} CH_3CH(Br)-C(H)(CH_3)_2$

ANSWER = $CH_3CHBrCH(CH_3)_2$.

21 D

22 C



23 Zinc in acetic acid or zinc in alcohol.

$Zn + CH_3CHBrCHBrCH_3 \xrightarrow{\text{Acetic acid}} ZnBr_2 + CH_3C(H)=C(H)CH_3$

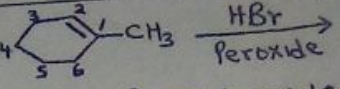
24 Acetate and Butanoate

$CH_3CH_2CH_2CH=CHCH_3 \xrightarrow{\text{Conc } KMnO_4} CH_3CH_2CH_2COO^- + CH_3COO^-$

25 $CH_3CH_2CH_2C(CH_3)=CH_2 \xrightarrow{Br_2} CH_3CH_2CH_2C(CH_3)(Br)CH_2Br$

ANSWER = 1,2-dibromo-2-methyl Pentane

26



ANSWER = 2-Brono-1-methyl Cyclohexane

27 In a Carbon–Carbon triple bond system (C≡C) each of the two carbon atoms contributes one SP orbital and two P-orbitals. It means that will be a total of two SP orbitals and four P-orbitals.

ANSWER = SP+SP, P+P, P+P

28 $CH_3CH_2CH(Br)CH_2Br + NaNH_2 \rightarrow CH_3CH_2C\equiv CH$ (excess)

ANSWER = 1-Butyne or But-1-yne

29 Acidic hydrogen is present in an alkyne whose triple bond is at position one, along the carbon chain.

ANSWER = 1-Butyne

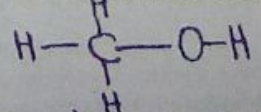
30 $CH_3CH_2CH_2CH=CH_2 + HCl \xrightarrow[\text{Peroxide}]{\text{(excess)}} CH_3CH_2CH_2C(Cl)HCH_2Cl$

ANSWER = 1,2-dichloro Pentane

31 $CH_3CH_2CH_2CH_2Br \xrightarrow{CH_3O^-} CH_3CH_2CH_2CH_2OCH_3 + Br^-$ (methoxide ion)

ANSWER = methoxide ion.

32



In alcohol, we have only single bonds all over.

ANSWER = C, $sp^3$, O, $sp^3$

33 ANSWER = A.

34 ANSWER = B

35 ANSWER = A

36 ANSWER = D

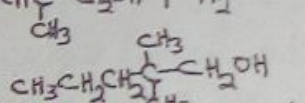
37 ANSWER = C

38 ANSWER = D

39 The higher the number of carbon atoms in a compound, the lower the solubility of the compound.
ANSWER = A

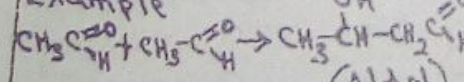
40 Tertiary alcohols are not easily oxidized
ANSWER = A

41 ANSWER = A



2,2-dimethylpentan-1-ol

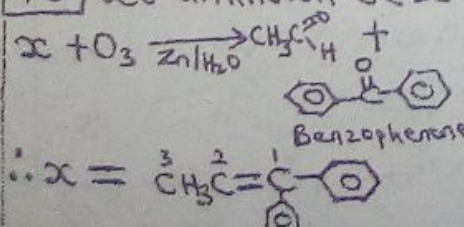
42 Aldehydes that contain alpha hydrogens undergo self addition forming an aldol. This reaction is known as "Aldol Condensation". It occurs in the presence of a base.
Aldol = Aldehyde + Alcohol
Example



(Aldol)

ANSWER = B

43 Let unknown be x.



Benzophenone

$\therefore x = CH_3C=C$ (with Ph, Ph)

x = 1,1-diphenylpropene

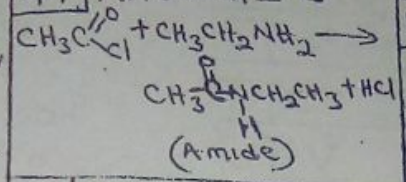
ANSWER = B.

44 Amides are the most stable acid derivatives because they are not very reactive.
ANSWER = C

45 ANSWER = B

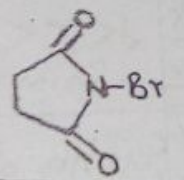
46 ANSWER = A
Zn in acetic acid.

47 ANSWER = C



(Amide)

48 N-Bromosuccinimide (NBS) is used to supply bromine to allylic systems because NBS prevents further chain reaction
ANSWER = B



NBS

49 ANSWER = D

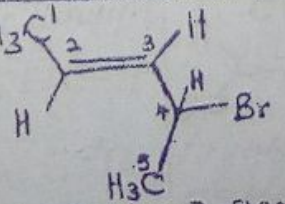
50 ANSWER = B
It is "trans isomerism"

51 ANSWER = B

52 The the halogen atoms, the more the acidity
ANSWER = C

53 ANSWER = D

54



4-Bromo-Pent-2-ene

ANSWER = A

55 ANSWER = E.
Check the note on isomerism. You will see a table of isomers of $C_7H_{16}$

56 Halogenation of alkanes does not take place in the dark.
ANSWER = D

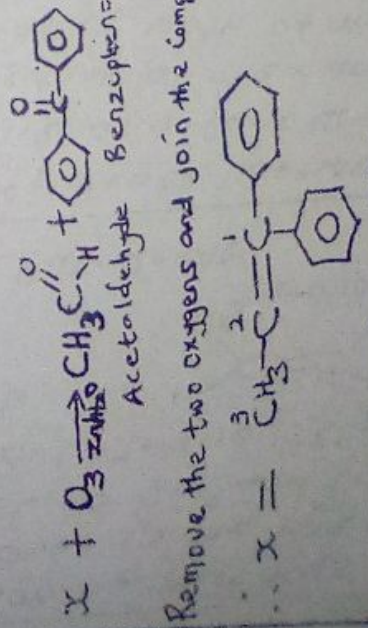
57 ANSWER = A
— $sp^3$ = $sp^2$ ≡ sp

58 ANSWER = C
Amides are stable as a result of resonance in them.

59 $CH_3-\dot{C}\equiv N$
The central carbon atom is the carbon with a dot on it. It has triple bond which is sp hybridizaton (180°)
ANSWER = B

60 ANSWER = B
Repeated Question.

This is Ozonlysis of alkenes.



Acetaldehyde Benzophenone

Remove the two oxygens and join the compds.

x = 1,1-diphenylpropene.

**FEDERAL UNIVERSITY OF TECHNOLOGY OWERRI, DEPARTMENT OF CHEMISTRY** TEST

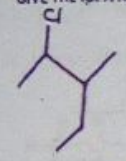
Rain semester 2011/2012 session

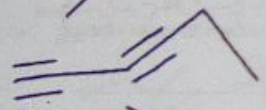
CHM 102: GENERAL CHEMISTRY II time: 1hr. Date: 29/08/12

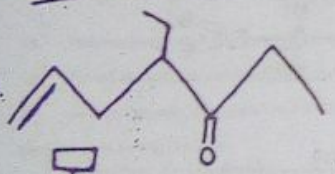
Instruction: Answer all questions in the spaces provided.

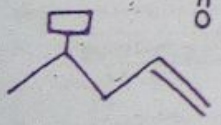
Name: _____ Reg No: _____

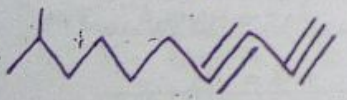
GIVE THE IUPA NAMES OF THE FOLLOWING ORGANIC STRUCTURES.

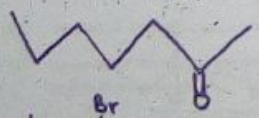
1.  2-Chloro-3-methylPentane

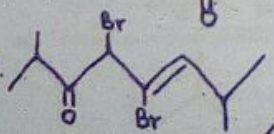
2.  Hex-1,3-diyne

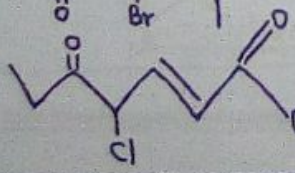
3.  4-Ethylhept-6-ene-3-one

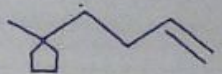
4.  4-Cyclobutylpent-1-ene

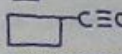
5.  9-methyldec-1,3-diyne

6.  Heptan-2-one OR 2-Heptanone.

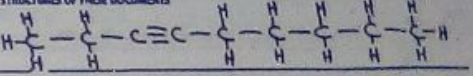
7.  4,5-dibro-2,7-dimethyl Oct-5-ene-3-one

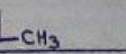
8.  4-chloro-2-ene-5-one-heptanoic acid. OR 4-chloro-5-one-2-heptenoic acid.

9.  5-Cyclopentylhex-1-ene

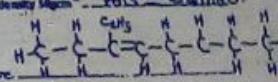
10.  1-Cyclobutylethyne OR Cyclobutylethyne

GIVE THE STRUCTURES OF THESE DOCUMENTS

11. Non-3-yne 

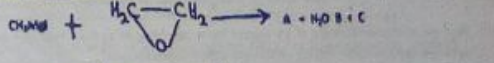
12. 4-methyl-cyclobut-1-enol 

13. Find the molecular formula of an organic liquid consisting of carbon, hydrogen and oxygen with the following composition C:55%, H: 13.59%, and vapour density 44gcm$^{-3}$. Ans = $C_4H_{10}O$.

14. Write a possible structure of this compound: 3-ethyl-oct-3-ene. 

15. How many π-bonds in the compound: $CH_3CH_2CH_2COOH$ One π-bond

16. Complete the following chemical reactions:



What are A: $CH_3CH_2CH_2OMgCl$

B: $CH_3CH_2CH_2OH$

C: $Mg(OH)_2$

17. $CH_3CH{=}CHCH_3 \xrightarrow[Hot]{KMnO_4}$ $CH_3COOH + CH_3COOH$

18. $CH_3CH=CH_2 + PCl_5 \longrightarrow ?$ $CH_3CHCl_2$

19. $CH_3CH=CH_2 + HI \longrightarrow ?$ $CH_3CHICH_3$

20. $(CH_3)_2COH + SOCl_2 \longrightarrow ?$ $(CH_3)_3C-Cl$

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**Federal University of Technology Owerri, Department of Chemistry**

**Rain Semester Examination 2011/2012 Session**

CHM 102: General Chemistry II Time: 2hrs Date: 16/02/12

Instructions: Answer all questions in the spaces provided.

Complete the following reactions.

1. $CH_3CH(CH_3)_2$ _____

2. ? + $KOH \xrightarrow[-HBr]{}$ $CH_3CH_2CH{=}CH_2 + H_2O$. Ans = $CH_3CH_2CHBrCH_3$

23. $(CH_3)_2CO^-H^+ \xrightarrow{LiAlH_4}$ Ans = $(CH_3)_2CH(OH)$

24. $CH_3COCl + C_6H_6 \xrightarrow{AlCl_3}$ Ans = $C_6H_5COCH_3$

25. $CH_3NH_2 + (CH_3CO)_2O \longrightarrow$ Ans = $CH_3CONHCH_3 + CH_3C$

26. $CH_3COCl + C_6H_5NH_2 \longrightarrow$ Ans = $CH_3CONHC_6H_5$

27. $CH_3CH_2OH \xrightarrow[170°C]{Conc\ H_2SO_4}$ Ans = $H_2C{=}CH_2$

Ans = $CH_3COOH + CH_3C$


4-chloro-5-one-2-heptenoic acid.

## Federal University of Technology Owerri, Department of Chemistry

**Rain Semester Examination 2011/2012 Session**

CHM 102: General Chemistry II  Time: 2hrs  Date: 18/09/12

Instructions: Answer all questions in the spaces provided.

Complete the following reactions.

1. $CH_3CH(CH_3)_2$ _____

2. ? $\xrightarrow{KOH,\ -HBr}$ $CH_3CH_2CH{=}CH_2 + H_2O$. Ans = $CH_3CH_2CHBrCH_3$

3. $(CH_3CH_2)_3CBr \xrightarrow{H_2O}$ ? Ans = $(CH_3CH_2)_3C{-}OH$

4. $CH_3CH_2\underset{CH_3}{C}{=}CHCH_3 \xrightarrow[Zn/ACOH]{O_3}$ ? Ans = $CH_3CH_2\underset{CH_3}{C}{=}O + CH_3\underset{H}{C}{=}O$

5. $HC{\equiv}CCH_3 + NaNH_2 \xrightarrow{NH_3}$ ? Ans = $NaC{\equiv}CCH_3$

6. $CH_3CH_2Cl + CH_3CH_2ONa \longrightarrow$ ? Ans = $CH_3CH_2OCH_2CH_3$

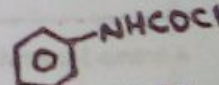
7. $CH_3CH_2Br + NaOH \longrightarrow$ ? Ans = $CH_3CH_2OH$

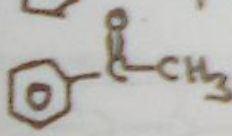
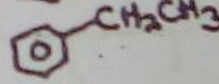
8. $CH_3CH_2CH_2OH + KCN \longrightarrow$ ? Ans = $CH_3CH_2CH_2CN$

9. $CH_3CH_2CH_2Br \xrightarrow[dry\ ether]{Mg}$ ? Ans = $CH_3CH_2CH_2MgBr$

10. $CH_3OH + CH_3CH_2COCl \longrightarrow$ ? Ans = $CH_3CH_2COOCH_3$

11. $CH_3CH_2CH_2OH + HCl \longrightarrow$ ? Ans = $CH_3CH_2CH_2Cl$.

12.  + $CH_3COCl \longrightarrow$ ? Ans = 

13.  $\xrightarrow[Conc\ HCl]{Zn/Hg}$ ? Ans = 

14. $CH_3CH_2CHO + Br_2 \xrightarrow{NaOH}$ ? Ans = $CH_3CHBrCHO$.

15. _____ $\xrightarrow{KmnO_4}$ $CH_3CH_2COOH$ ? Ans = $CH_3CH_2CHO$

16. $C_2H_5OH + CH_2{=}CH_2$ ? Ans = $CH_3CH_2CH_2CH_2OH$

17. $CH_3CH_2NO_2 \xrightarrow{LiAlH_4}$ ? Ans = $CH_3CH_2NH_2$

18. $CH_3COOCH_3 \xrightarrow{NH_3}$ ? Ans = $CH_3CONH_2 + CH_3OH$

19. $CH_2BrCH_2Br \xrightarrow{Zn}$ ? Ans = $CH_2{=}CH_2$

20. $CH_3{-}C{\equiv}C{-}CH_2CH_3 + Br_2 \longrightarrow$ ? Ans = $CH_3CBr{=}CBrCH_2CH_3$

21. $CH_3CH_2CH{=}CH_2 + HBr \xrightarrow{H_2O_2}$ ? Ans = $CH_3CH_2CH_2CH_2Br$

22. $C_6H_5CH_3 \xrightarrow{KMnO_4}$ ? Ans = $C_6H_5COOH$

23. $(CH_3)_2CO^-H^+ \xrightarrow{LiAlH_4}$ Ans = $(CH_3)_2CH(OH)$

24. $CH_3COCl + C_6H_6 \xrightarrow{AlCl_3}$ Ans = $C_6H_5COCH_3$

25. $CH_3NH_2 + (CH_3CO)_2O \longrightarrow$ Ans = $CH_3CONHCH_3 + CH_3COOH$

26. $CH_3COCl + C_6H_5NH_2 \longrightarrow$ Ans = $CH_3CONHC_6H_5$

27. $ClCH_2CH_2OH \xrightarrow[170°C]{Conc\ H_2SO_4}$ Ans = $H_2C=CH_2$

28. $CH_3COOCH_2CH_3 \xrightarrow[heat]{NaOH}$ Ans = $CH_3COOH + CH_3CH_2OH$

29. $NH_2OH + CH_3CHO \longrightarrow$ Ans = $CH_3CONH_2$

30. $ClCH_2CHO + HCN \longrightarrow$ Ans = $CH_3CH_2CH_2CH(OH)CN$

31. How many π-bonds has ethane? Ans = Zero. It doesn't have π-bonds.

32. Write a balanced equation of this combustion reaction: $C_2H_6 + O_2 \rightarrow CO_2 + H_2O$ Ans = $C_2H_6 + \frac{7}{2}O_2 \rightarrow 2CO_2 + 3H_2O$

33. What type of geometry has ethane Ans = Tetrahedral

34. How many pi-bonds ethane Ans = Zero.

35. Arrange the following amines in order of increasing basicity: $(CH_3)_3N$, $NH_3$, $(CH_3)_2NH$, and $CH_3NH_2$
1° < 2° < 3° Ans = $NH_3 < CH_3NH_2 < (CH_3)_2NH < (CH_3)_3N$.

36. Chloromethane reacts with an alloy of sodium and lead to produce a liquid compound of the following composition: C=29.7%, H=6.2%, Pb=64.1%. Give the empirical formula of this compound. Ans = $C_8H_{20}Pb$

Distinguish between the following pairs of compound

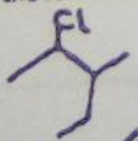
37. $CH_3CH_2C\equiv CH$ and $CH_3C\equiv CCH_3$ Ans = They are positional isomers.

38. Hexene and Hexane Ans = They have different functional groups.

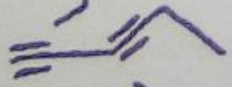
39. Ethanoic acid and phenol Ans = They have different functional groups

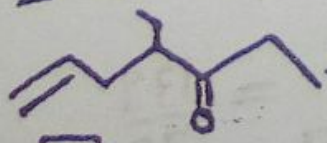
40. $CH_3COOH$ and HCOOH Ans = They differ in there longest chain.

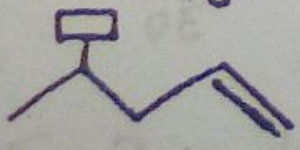
Give the IUPAC names of the following structure:

41. 

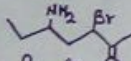
Ans = 2-chloro-3-methylpentane

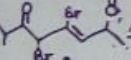
42. 
Ans = Hex-1,3-diyne.

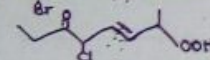
43. 
Ans = 4-Ethylhept-6-ene-3-one

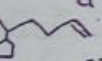
44. 
Ans = 4-Cyclobutylpent-1-ene.

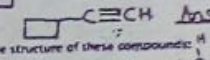
45.  Ans = 9-methyl-dec-7-ene-13-diyne

46.  Ans = 5-Amino-3-bromohept-2-one.

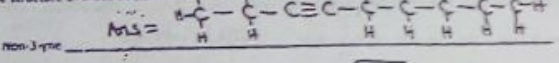
47.  Ans = 4,5-dibromo-2,7-dimethyl Oct-5-ene-3-one.

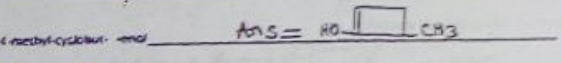
48.  Ans = 5-chloro-2-methyl-3-ene-6-oxo-Octanoic acid.

49.  Ans = 5-Cyclopentyl hex-1-ene.

50.  Ans = 1-Cyclobutylethyne or Cyclobutyl ethyne.

Give the structure of these compounds:

51. Non-3-yne Ans = 

52. 4-methyl-cyclohex-enol Ans = 

53. Find the molecular formula of an organic halide consisting of carbon, hydrogen and oxygen with the following compositions: 65%, H: 13.51% and vapour density 37gcm$^3$ Ans = $C_4H_{10}O$

54. Write a possible structure of this compound: 3-ethyl-oct-1-ene

55. How many σ-bonds are in this compound: $CH_3CH_2CH_2COOH$ Ans = 13.

56. Complete the following chemical reactions:

$CH_3MgI + H_3C-C\equiv CH \rightarrow A + H_2O \rightarrow B + C$

What are A: Ans = $CH_3CH_2CH_2OMgI$

B: Ans = $CH_3CH_2CH_2OH$

C: Ans = MgI(OH).

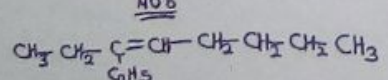
57. $CH_3CH + CHCH_3 \xrightarrow{KMnO_4}$ Ans = $CH_3COOH + CH_3COOH$

58. $CH_3CH=O + PCl_5 \rightarrow$ Ans = $CH_3CHCl_2$

59. $CH_3CH + CH_3 + HI \rightarrow$ Ans = $CH_3CHICH_3$

60. $(CH_3)_3COH + SOCl_2 \rightarrow$ Ans = $(CH_3)_3CCl$.

NOB



FEDERAL UNIVERSITY OF TECHNOLOGY OWERRI, DEPARTMENT OF CHEMISTRY

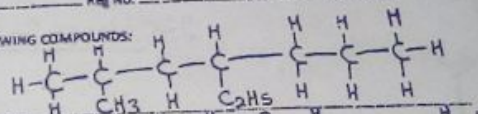
RAIN SEMESTER EXAMINATION 2012/2013 SESSION TEST

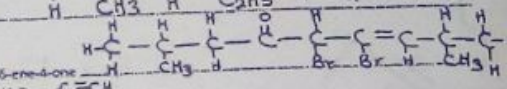
CHM 102: GENERAL CHEMISTRY II: TIME: 45 MINS DATE: 12/06/13

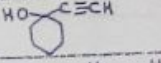
INSTRUCTION: ANSWER ALL QUESTIONS IN THE SPACES PROVIDED.

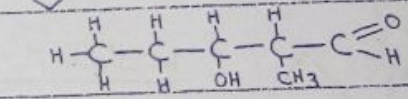
Name: ..... Reg No: .....

GIVE THE STRUCTURE OF THE FOLLOWING COMPOUNDS:

1. 4-Ethyl-2-methylheptane 

2. 5,6-dibromo-2, 8-dimethylnon-5-ene-4-one 

3. 1-Ethynylcyclohexanol 

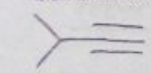
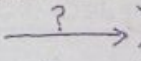
4. 3-Hydroxy-2-ethylpentanal 

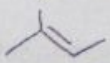
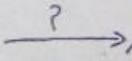
Give the IUPAC name of the following structures:

5. $CH_3CH_2C\equiv C-CH_2(CH_2)_2CH_3$ Ans = Non-3-yne

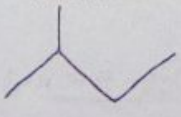
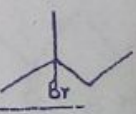
6. $CH_3CH(CH_3)CH_2CH(Cl)CO(CH_2)CH_3$ Ans = 4-Chloro-6-methylheptan-3-one

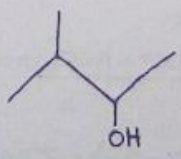
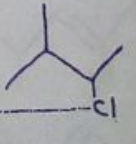
WHAT IS THE BEST REAGENT TO MAKE THE FOLLOWING PRODUCT?

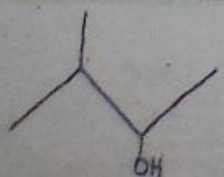
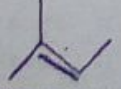
7.  ?  Ans = $NaNH_2$/Liquid

8.  ?  Ans = $H_2$

WHAT IS THE MAJOR PRODUCT OF THE FOLLOWING REACTION?

9.  $\xrightarrow[Light]{Br_2}$ ? Ans = 

10.  $\xrightarrow[Pyridine]{SOCl_2}$ ? Ans = 

 $\xrightarrow[Heat]{H_2SO_4}$ ? Ans = 

Federal University of Technology Owerri, Department of Chem

Rain Semester Examination 2012/2013 Session

CHM 102: General Chemistry II: Time: 1hr 30mins Date: 21/01/14

Instruction: Answer all questions in the spaces provided.

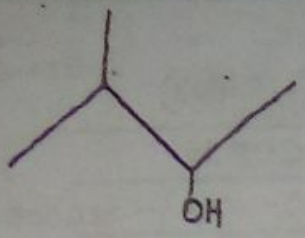
Name

59 $CH_3CH=CH_2 + HI \longrightarrow$

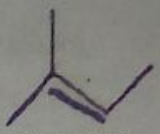
60 $(CH_3)_2CHOH + SOCl_2 \longrightarrow (CH_3)_3CCl$

NO 8

$CH_3CH_2\underset{C_6H_5}{\overset{}{C}}=CH-CH_2CH_2CH_2CH_3$

11. 


$\xrightarrow[\text{Heat}]{H_2SO_4}$ ?

Ans= 

GIVE THE NAME AND THE STRUCTURE OF THE MAIN PRODUCTS OR STARTING MATERIAL FOR THE FOLLOWING REACTIONS

12. $CH_3CH_2CH=CH_2 + HBr \xrightarrow{H_2O_2}$ ? Ans= $CH_3CH_2CH_2CH_2Br$

13. $CH_3CH=CH_2 + HI \longrightarrow$ ? Ans= $CH_3CHICH_3$

14. $CH_3CH_2OH + PCl_5 \longrightarrow$ ? Ans= $CH_3CH_2Cl$

15. ? + $\xrightarrow[H_2O,\ NaBH_4]{HgO_2CCH_3}$ $CH_3(CH_2)_3\overset{OH}{C}HCH_3$ Ans= $CH_3(CH_2)_3\overset{OH}{C}H=CH_2$

16. $CH_3\overset{O}{\overset{\|}{C}}CH_3 + CH_3CH_2CH_2MgO \longrightarrow$ ? Ans= $CH_3-\overset{OH}{\overset{|}{C}}H_2-CH_2CH_2CH_3$

17. $CH_3COCl + CH_3NH_2 \longrightarrow$ ? Ans= $CH_3CONH_2 + CH_3Cl$

18. Write a balanced equation for the complete combination of hexane

Ans= $C_6H_{14} + 19/2\,O_2 \longrightarrow 6CO_2 + 7H_2O$

19. Rank the following ions in terms of their leaving group reactivity: $Br^-$, $Cl^-$, $I^-$, $F^-$

Ans= $I^- > Br^- > Cl^- > F^-$

20. The empirical formula of compound X is $CH_2O$ and its molecular Formula is 179±5. Calculate the molecular formula of compound X.

$$[CH_2O]_n = \frac{[179+5] + [179-5]}{2}$$

$$[CH_2O]_n = 179$$

$$\therefore n = \frac{179}{[CH_2O]} = \frac{179}{[12+(1\times2)+16]} = \frac{179}{30}$$

$n = 6$ // $\therefore$ Molecular formular $= [CH_2O]_n$

$= C_6H_{12}O_6$ //

OH

# Federal University of Technology Owerri, Department of Chemistry

## Rain Semester Examination 2012/2013 Session

CHM 102: General Chemistry II: Time: 1hr 30mins Date: 21/01/14

Instruction: Answer all questions in the spaces provided.

Name _____ Reg. No.: _____

1. Determine the molecular formula of an organic compound with the following composition: Carbon 65%, Hydrogen 13.9% and vapour density 38gcm$^{-3}$ NB:- Molar mass = 2x Vapour density

Ans = $C_4H_{10}O$

2. Write a balanced equation for the complete combustion of hexane.

Ans: $C_6H_{14} + 19/2\,O_2 \rightarrow 6CO_2 + 7H_2O$ OR $2C_6H_{14} + 19O_2 \rightarrow 12CO_2 + 14H_2O$

3. Name the product that will be obtained from the reaction of acetone and $CH_3CH_2CH_2MgCl$ followed by treatment with acid? Ans = 3-methyl Pentan-2-ol.

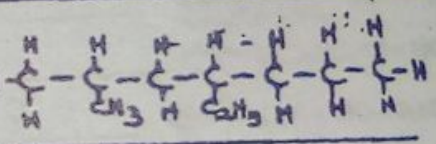
4. In the reaction of propan-2-ol with HCl, the leaving group is? Ans = $H_2O$

5. What would be the major product of the reaction of butanoic with $SOCl_2$, Et3N? Ans = $CH_3CH_2CH_2COCl$

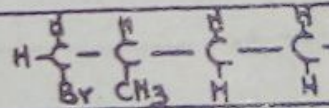
6. The Geometry of the carbon atoms in an alkyne are? Ans = Linear Shape.

*Give the structure of the following compounds:*

7. 4-Ethyl-2-methylheptane Ans =

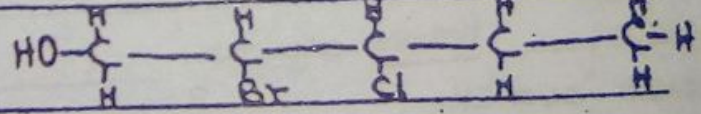


8. 4-bromo-3-methylbutanol Ans =



9. 5-cyclopentyl-1-hexene. Ans =

10. 2-Bromo-3-chloro pentanol



*Give the IUPAC name of the following structures:*

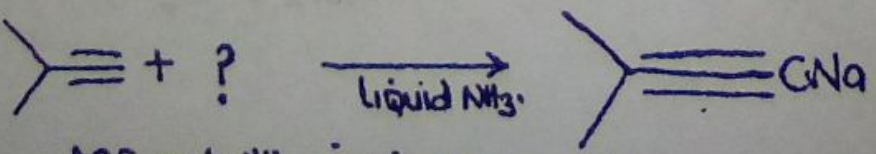
11. $CH_3CH_2C{\equiv}CCH_2(CH_2)_2CH_3$ Ans = Non-3-yne

12. $CH_3CH(CH_3)CH_2CH(Cl)COCH_2CH_3$ Ans = 4-chloro-6-methylhept-3-one

13. State the order of stability in the following carbonium ions: $CH_3H_2C^+$, $(CH_3)_2HC^+$, $(CH_3)_3C^+$

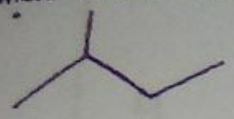
Ans = $(CH_3)_3C^+ > (CH_3)_2HC^+ > CH_3H_2C^+$

14. What is the best reagent to make the following product?

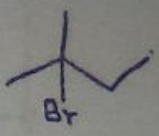



Ans = $NaNH_2$ in Liquid ammonia

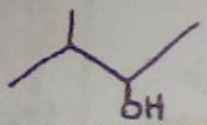
15. What is the major product of the following reaction?



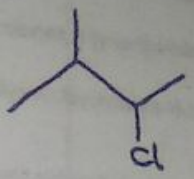
$\xrightarrow[\text{Light}]{Br_2}$ ? Ans=




16. What is the major product of the following reaction?




$\xrightarrow[\text{Pyridine}]{SOCl_2}$ ? Ans=

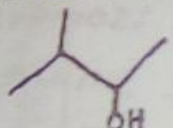



17. What is the best reagent to make the following product?

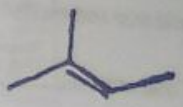


$+ H_2 \longrightarrow$ ? Ans=

18. What is the major product of the following reaction?




$\xrightarrow[\text{heat}]{H_2SO_4}$ ? Ans =



19. How many isomeric structures are possible in $C_5H_{12}$ Ans = Nine.

20. The loss of a halide to generate an alkene is known as Ans = Dehalogenation

21. Rank the following ions in terms of their leaving group reactivity: $Br^-$, $Cl^-$, $I^-$, $F^-$. Ans = $I^- > Br^- > Cl^- > F^-$

Complete the following reactions:

22. $CH_3CH_2CH=CH_2 + HBr \xrightarrow{H_2O_2}$ ? Ans = $CH_3CH_2CH_2CH_2Br$

23. $CH_3CH=CH_2 + HI \longrightarrow$ ? Ans = $CH_3CHICH_3$

24. _____ $+ PCl_5 \longrightarrow CH_3CH_2Cl + HCl + POCl_3$ Ans = $CH_3CH_2OH$.

25. _____ $\xrightarrow[H_2O/NaBH_4]{Hg(O_2CCH_3)_2} CH_3(CH_2)_2CHCH_3$ (OH) Ans = $CH_3(CH_2)_3CH=CH_2$

26. $CH_3CCH_3 + CH_3CH_2CH_2MgCl \xrightarrow[\text{acid treatment}]{}$ ? Ans = $CH_3-C(OH)(CH_3)-CH_2CH_2CH_3$

27. $CH_3COCl + CH_3NH_2 \longrightarrow$ ? Ans = $CH_3CONHCH_3$

28. The empirical formula of compound X is $CH_2O$ and its molecular formula is 179±5. Calculate the molecular formula of compound X. $[CH_2O]n = \frac{(179+5)+(179-5)}{2}$ ∴ $[CH_2O]n = 179$, $n = \frac{179}{30} = 6$. ∴ Ans = $C_6H_{12}O_6$.

29. Calculate the percentage of nitrogen in Morphine, $C_{17}H_{19}NO_3$.

$$\%N = \frac{N}{C_{17}H_{19}NO_3} \times \frac{100}{1}$$

$$\%N = \frac{14}{(12\times17)+(1\times19)+14+(16\times3)} \times \frac{100}{1} = 4.9\%.$$

30. The combustion of a ... empirical formula of ...

31. A compound with e... $[CH_2]n = 5$...

32. The Chlorination ... [a] an $S_N1$ reaction ...

33. How many π (pi) a...

34. The compound C... material? _____

[a] 2-methylpropa...

35. Ethyl butanoate, ...

[a] Ethanol and p... and butanoic acid

36. What is the perc...

37. Arrange the follo... (d) $CH_3CH_2SH$ ...

38. Arrange the fol... (c) propanal (d) ...

39. Which alkyl hal... _____

Classify each of the fol...

40. $(CH_3)_3COH$ ...

42. $CH_3CH_2N(CH_3)_2$

44. 


46. 


48. 


50 

30. The combustion of 6.51g of an organic compound yields 8.36g of $H_2O$ and 20.47 of $CO_2$. Determine the empirical formula of the compound. [C = 12, H = 1, O = 16]. Ans = $CH_2$.

31. A compound with empirical formula as $CH_2$ has a molecular weight of 56g. What is the molecular formula

$[CH_2]n = 56 \therefore n = \frac{56}{14} = 4.$ $\therefore$ Ans = $C_4H_6$

32. The Chlorination of an alkane is _____
[a] an $S_N1$ reaction [b] an $S_N2$ rxn [c] a free radical rxn [d] an oxidation rxn Ans = C

33. How many π (pi) are present in the molecule $CH_3CH_2CH = CHCH_2CH \equiv CH$? Ans = 6 π-electrons.

34. The compound $CH_3CH_2COOH$ was produced by oxidation. Which one of the following is likely starting material? Ans = Propan-1-ol.

[a] 2-methylpropanol [b] Butan-2-ol [c] Propan-1-ol [d] propan-2-ol.

35. Ethyl butanoate, the pineapple flavor, can be prepared by esterification of: _____

[a] Ethanol and pentanoic acid [b] Methanol and butanoic acid [c] Ethanol and ethanoic acid [d] Ethanol and butanoic acid. Ans = D

36. What is the percentage character in an $sp^2$ hybridized carbon atom? $\%S = \frac{S}{Sp^2} \times \frac{100}{1} = \frac{1}{1+2} \times \frac{100}{1} = 33.3\%$

37. Arrange the following compounds in order of increasing acidity: (a) $CH_3CO_2H$ (b) $CCl_3CO_2H$ (c) $CH_3CH_2OH$ (d) $CH_3CH_2SH$ Ans = c < d < a < b

38. Arrange the following compounds in order of increasing boiling point: (a) Chloroethane (b) propanol (c) propanal (d) propanone Ans = a < c < d < b

39. Which alkyl halide has the most polar alkyl-halogen bond? (a) RF (b) RCl (c) RBr (d) RI

Ans = RF

Classify each of the following compounds as primary, secondary or tertiary alcohols/amines

40. $(CH_3)_3COH$ 3° alcohol

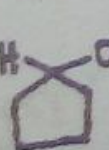
41. $CH_3CH_2CH(OH)CH_3$ 2° alcohol

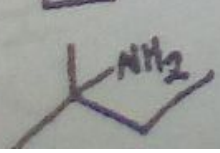
42. $CH_3CH_2N(CH_3)_2$ 3° amine

43. $CH_3CH_2CH_2NHCH_3$ 2° amine

44.  2° amine

46.  1° alcohol

48.  2° alcohol

50  1° amine

NB:- 1° = Primary
2° = Secondary.
3° = Tertiary.

FEDERAL UNIVERSITY OF TECHNOLOGY, OWERRI

DEPARTMENT OF CHEMISTRY

RAIN SEMESTER 2013/2014 SESSION

TEST ON CHM 102-GENERAL CHEMISTRYII DATE. 20\08\2014

INSTRUCTION; ATTEMPT ALL THE QUESTIONS AND GIVE THE ANSWER IN THE SPACE PROVIDED.

Time allowed;45mins

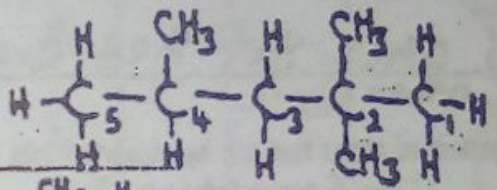
1. A hydrocarbon X has a relative molecular mass of 56 and consists of 87.5% by mass of carbon and 12.5% of hydrogen. What is the molecular formula of X $C_4H_8$

2. Write a balanced equation for the complete combustion of propane

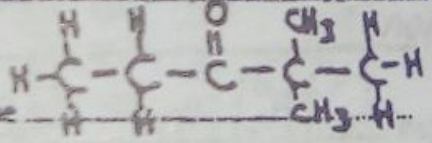
$$C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O.$$

Draw the structures for the following compounds;

3. 2,2,4-Trimethyl pentane



4. 2,2,- Dimethyl pentan-3-one

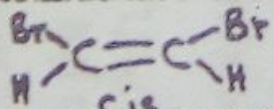
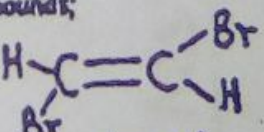


5. Indicate the hybridization of the carbon atoms in a benzene structure

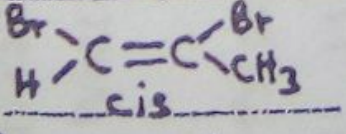
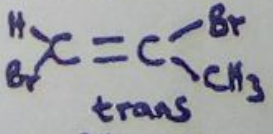
 ⇨ $sp^2$

Draw and name the geometrical isomers of the following compounds;

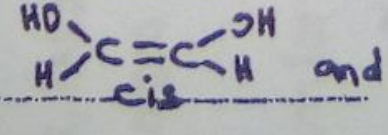
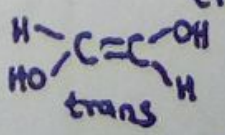
6. 1,2- Dibromoethene

 cis and  trans

7. 2,3,-Dibromopropene

 cis and  trans

8 Ethene-1,2-diol

 cis and  trans

9. Enantiomers are molecules that are mirror images of each other and are not superimposable on each other.

10. The metal catalyst for the hydrogenation of an alkene is Nickel or Paladium

11. A liquid of molecular weight of 60g was found to contain 40% carbon and 6.7% Hydrogen what is the molecular formula of the compound..... Ans = $C_2H_4O_2$

12. A qualitative analysis of papaverine an alkaloid, showed 70.8% carbon. 6.2% Hydrogen and 4.1% Nitrogen calculate the empirical formula of papaverine $C_{20}H_{21}O_4N$

13. The percentage composition of ethanol is 52.2%C 13%H 34.8%O.

14. The number of sigma electrons and shape of bonding orbitals in Ethyne are 6 and Linear respectively.

15. Isomerism is defined as Phenomenon by which different compounds have molecular formular but different molecular structures.

16. _____ and _____ are the two main types of isomerism in organic chemistry.
Ans = Structural and Stereoisomerism.

17. An alkene $C_6H_{12}$ on ozonolysis yielded two products-acetone and propanal. Give the structure of the alkene.....

Ans = $CH_3-\underset{CH_3}{C}=\underset{H}{C}-C_2H_5$

Complete the following equation of reaction

18. $CH_3CH_2CH_2CH=CH_2 + HBr \longrightarrow$ Ans = $CH_3CH_2CH_2\overset{Br}{C}H-\overset{H}{C}H_2$

19. Why is the boiling point of a branched chain compound lower than that of its straight chain isomer. This is due to the lower Surface area created by branching and lower intermolecular force of ↓ attraction.

20. In a free radical reaction, the following step;

$Cl^- + CH_3CH_2CH_3 \longrightarrow CH_3\dot{C}HCH_3 + HCl$ is called?..... Ans = Propagation.

FEDERAL UNIVERSITY OF TECHNOLOGY, OWERRI

DEPARTMENT OF CHEMISTRY

RAIN SEMESTER EXAMINATION 2013/2014 SESSION

CHM 102-GENERAL CHEMISTRY II

DATE; 30/09/2014

Instruction; Provide the solution to the each of the following questions in the appropriate space.

Time allowed; 2 hours

1. The combustion of 8.00mg of squalene sample produced 25.6mg $CO_2$ and 8.75mg H2O. Calculate the empirical formular of squalene if it has a molecular weight of 410g. $C_4H_{12}O$

2. Calculate the percentage of each element in quinine $C_{20}H_{24}O_2$ C=74.07%, H=7.41% N=8.64%, O=9.88%

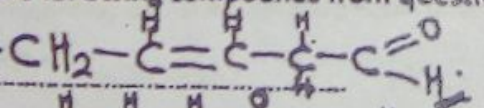
3. A hydrocarbon X has a relative molecular formula of x

4. A balanced equation for the complete combustion of butane is written as;

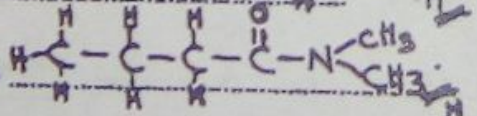
$$C_4H_{10(g)} + 13/2\,O_{2(g)} \longrightarrow 4CO_{2(g)} + 5H_2O_{(l)}$$

Draw the structures for the following compounds from questions 5-12.

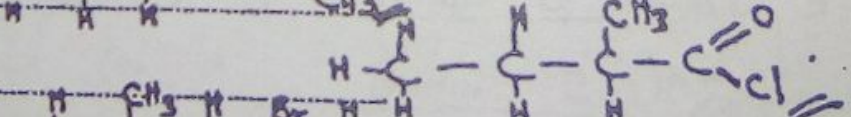
5. Hex-3-enal



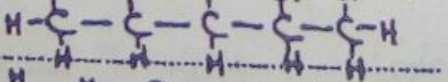
6. N,N-Dimethylbutanamide



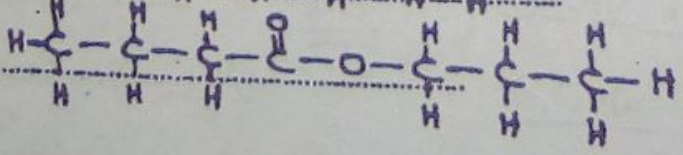
7. 2-Methylbutanoyl chloride

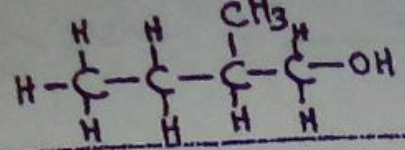


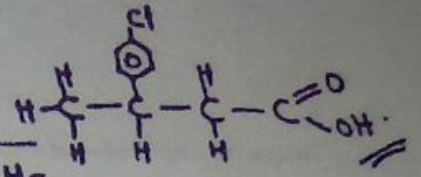
8. 2-Bromo-4-methyl pentane

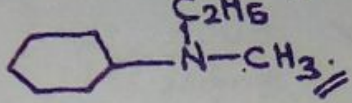


9. Propylbutanoate



10. 2-Methylbutanol 

11. 3-(p-Chlorophenyl butanoic acid 

12. N-Ethyl-N-methylcyclohexylamine 

Indicate the type of relationship that exists between the following pair of compounds;

13. Buten-2-ol and 2-methyl- propan-2-ol Chain isomers.

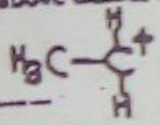
14. Propanoic acid and methyl ethanoate Functional group isomers.

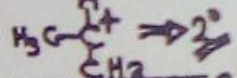
15. Ethenol and ethanal Tautomers [Equilibrium isomers].

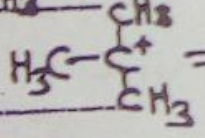
16. The two structures of 2-methylbutanol are:- They are enantiomers.

17. Carbonium ions are classified as 1°, 2° and 3°.

Illustrate each of the above classes with a structure of your choice

18.  ⇒ 1°

19.  ⇒ 2°

20.  ⇒ 3°

21. The addition of HBr to 2-butene is called: Hydrohalogenation.

22. Calculate the percentage composition of an organic compound with its empirical formula given as $C_{20}H_{21}O_4N$: C = 70.8%, H = 6.2%, N = 4.1%, O = 18.9%.

23. The percentage composition of chlorine in Propylchloride is 45.2%.

Propyl chloride = $CH_3CH_2CH_2Cl$

$$\%Cl = \frac{Cl}{CH_3CH_2CH_2Cl} \times \frac{100}{1}$$

[Cl = 35.5, C = 12, H = 1]

24. What orbital's are used for the formation of C-H bonds in a propane compound.....

$Sp^2$ from C and S from H.

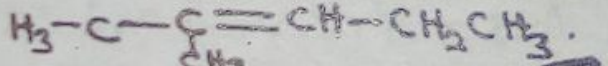
OR

C($Sp^2$), H(S).

25. The number of sigma electrons in $CH_3CH=CH_2$ is given as 8x2 = 16 Sigma electrons.

26. How can propane be distinguished from propane. Propene decolourises cold Solution of $KMnO_4$ (Purple) or $Br_2/CCl_4$ Solution (Pink) but Propane does not.

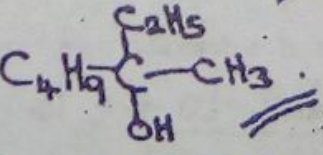
27. An alkene $C_6H_{12}$ on ozonolysis yielded two products- acetone and propanal. Give the structure of the alkene.....



Complete the following equation of reactions;

28. $CH_3CH_2CH_2CH=CH_2 + H_2SO_4 \xrightarrow[\Delta]{H_2O} CH_3CH_2CH_2CH(OSO_3H)-CH_2 \longrightarrow CH_3CH_2CH_2CH(OH)-CH_2$.

29. $CH_3CH_2C\equiv CH + 2H_2 \xrightarrow[\text{Quinoline}]{CaCO_3} CH_3CH_2CH_2CH_3$.

30. $C_6H_5COC_2H_5 \xrightarrow[2.\ H_3O^+]{1.\ CH_3MgCl}$ 

31. $C_3H_7COOH + CH_3OH \xrightarrow[\text{Reflux}]{\text{Conc } H_2SO_4} C_3H_7COOCH_3$.

32. $CH_3C\equiv CCH_2CH_2CH_3 + Cu^{2+} \longrightarrow$ No reaction. (Non-terminal alkyne)

33. Why is the boiling point of a branched chain compound lower than that of its straight chain isomer..... This is because of the small surface area created by branching.

34. The major product of the chlorination of methane in large excess of methane is given as; $CH_3Cl$

35. The major product of the chlorination of methane in lager excess of chlorine is given as $CCl_4$

36. The reagent for wolff-kishner reaction is _____

37. The order of reactivity for the dehydration of $1^\circ$, $2^\circ$ and $3^\circ$ alcohols is given as $3^\circ > 2^\circ > 1^\circ$

38. Enantiomers are molecules that are mirror images of each other yet they are not superimposable on each other.

39. Different arrangement of atoms that can be converted into by rotation about single bonds are called Conformation.

40. What is the chemical combination of Lucas reagent HCl and $ZnCl_2$

FEDERAL UNIVERSITY OF TECHNOLOGY OWERRI

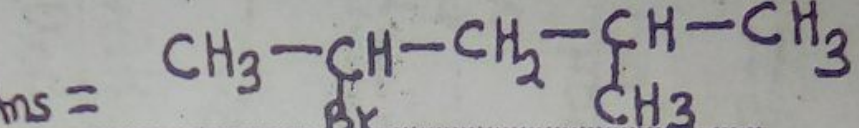
DEPARTMENT OF CHEMISTRY CHM102 TEST 2014/2015 ACADEMIC SESSION

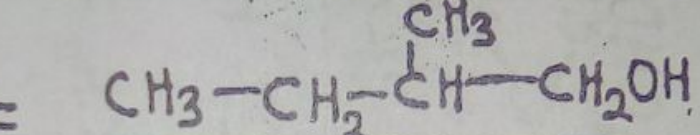
1. An hydrocarbon $X_1$ has a relative molecular mass of 56g and consist of 87.8% by mass of carbon and 12.5% of hydrogen. What is the molecular formular of $X_1$ ? .....

Ans = $C_4H_8$.

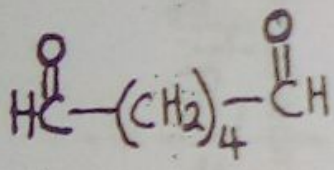
2. A balanced equation for the complete combustion of HEXANE is written as :

Ans = $C_6H_{14} + {}^{19}/_{2}O_2 \rightarrow 6CO_2 + 7H_2O$

3. 2-Bromo-4-methyl pentane Ans = 

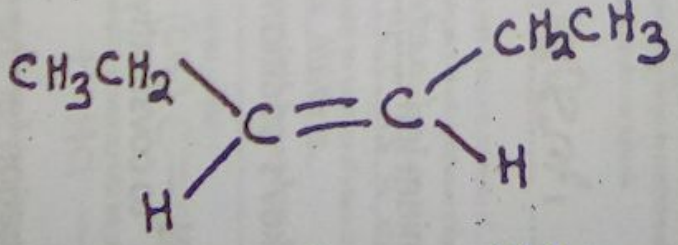
4. 2-methylbutanol Ans = 

5. Predict the structure of a hydrocarbon($C_6H_{10}$) that produces

 after ozonolysis ?

Ans = 

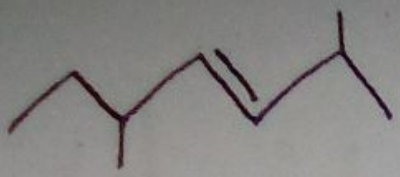
6. write the structural formular cis-hex-3-ene

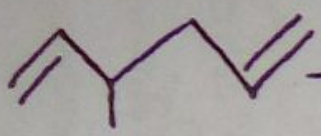
Ans = 

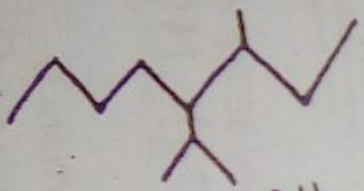
7. Why are alkene insoluble in water? Ans = Alkenes are non-Polar.

8. What are hybrid orbitals in a carbon compound?

Ans = Hybrid orbitals are those new equivalent orbitals formed by mixing up of the S and P orbitals of carbon atoms.

9.  Ans = 2,5-dimethylhept-3-ene.

10.  Ans = 3-methylhex-1,5-diene.

11.  Ans = 4-isopropyl-3-methyl Octane

12. $CH_3\underset{CH_3}{C}HCH_2OH$ Ans = 2-methylPropan-1-ol

13. $H_2C=\underset{OH}{C}-CH_2CH_3$ Ans = But-1-ene-2-ol.

14. $CH_3-\underset{C_2H_5}{\overset{CH_3}{C}}-C\equiv C-\underset{CH_3}{\overset{CH_3}{C}}-H$ Ans = 2,5,5-Trimethylhept-3-yne.

**GIVE THE STRUCTURAL FORMULAR FOR A COMPOUND THAT REPRESENT EACH CLASS OF ORGANIC COMPOUND IN QUESTION 14 AND 15**

15. Tertiary alcohol ..... Ans = $H_3C-\underset{CH_3}{\overset{CH_3}{C}}-OH$

16. Terminal alkyne ..... Ans = $CH_3-C\equiv C-H$

NB:- Tripple bond is at position one in a terminal alkyne.

**INDICATE THE TYPE OF RELATIONSHIP THAT EXIST BETWEEN THE FOLLOWING PAIR OF COMPOUNDS**

17. Butanol-2-ol and 2-methyl-propan-2-ol ..... Ans = Chain isomers.

18. Propanoic acid and methyl ethanoate ..... Ans = functional group isomers.

19. Ethenol and Ethanal ..... Ans = Tautomers.

20. Carbonium ions are classified as ..... Primary, Secondary, and tertiary.

FEDERAL UNIVERSITY OF TECHNOLOGY

# 2014/2015 CHM102 RAIN SEMESTER EXAMINATION

1. A compound x contains carbon, hydrogen and possibly oxygen. Combustion analysis of 6.24mg X gave 10.766mg of $CO_2$ and 3.684mg of $H_2O$. Analysis of 3.669mg of X gave 6.850mg of silver chloride. What is the emprical formular of X ? .....

2. A hydrocarbon Y has a relative molecular mass of 56 and contains 87.8% by mass of carbon and 12.5% of hydrogen. What is the molecular formular of Y ? ..... Ans = $CH_2$.

3. What is the percentage composition of *Na* in the compound $NaHCO_3$ ?

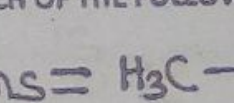
Ans = $\%Na = \frac{Na}{NaHCO_3} \times \frac{100}{1} = \frac{23}{23+1+12+16(3)} \times \frac{100}{1} = 27.38\%$.

4. A organic compound was said to have 42.90%C, 2.4%H, 16.7%N and 38%O. What is its emprical formular ? ..... Ans = $C_3H_2NO_2$.

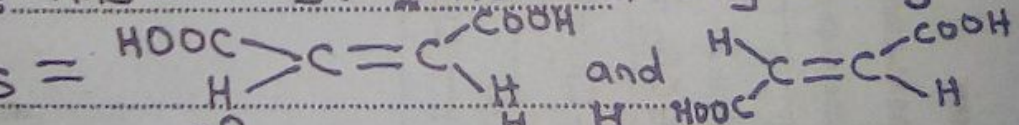
5. The reactive portion of a molecule that undergoes predictable reactions is Called..... Ans = functional group.

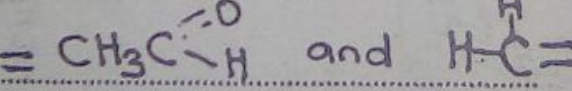
6. What are free radicals..... Ans = They are the reactive molecular fragments with an unpaired electron.

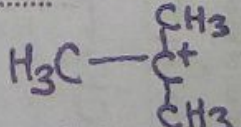
**DRAW THE STRUCTURES OR EQUATIONS THAT REPRESENTS EACH OF THE FOLLOWING.**

7. Tertiary amine ..... Ans = 

8. Functional group isomers ..... Ans = $CH_3CH_2CHO$ and $CH_3COCH_3$

9. Stereoisomers ..... Ans = 

10. Tautomers ..... Ans = 

11. Tertiary carbonium ion ..... Ans = 

12. Anti-markovnikov's addition Ans = $CH_3CH=CH_2 \xrightarrow[H_2O_2]{HBr} CH_3\overset{H}{C}H-\overset{Br}{C}H_2$

13. Carbon's ability to covalently bond with itself to form straight long chains is called Ans = Catenation.

14. A balanced equation for the complete combustion of nonane is written as

Ans = $C_9H_{20} + 14O_2 \longrightarrow 9CO_2 + 10H_2O$

15. What is hybridization Ans = Hybridization is the mixing up of two or more different orbitals to form entirely new equivalent orbitals.

16. Illustrate the definition in question 15 above with carbon atom

$_6C$ = $1s^2$ $2s^2$ $2p^2$ (unhybridized) Ans = $1s^2$ $2s^1$ $2p^3$ (Hybridized)

17. The side to side overlap of p-orbitals in phase gives .....
Ans = π-bonding molecular orbitals.

18. The geometric shape and bond angle of ethyne are ..... and .....
Ans = Linear and 180°

19. Why are alkenes insoluble in water? .....
Ans = Because alkenes are non-polar.

20. Write the equation of reaction for the commercial production acetylene from methane
Ans = $2CH_4 \xrightarrow{1500°C} HC\equiv CH + 3H_2$

DRAW THE STRUCTURES OF EACH OF THE ORGANIC COMPOUNDS IN QUESTION 21 TO 27.

21. Trans but-2-ene Ans = $CH_3CH=CHCH_3$ (trans)

22. Sodium pentanoate Ans = $CH_3-CH_2-CH_2-CH_2-C(=O)-ONa$

23. 2,5,5-trimethyl hept-3-yne Ans = $CH_3-CH(CH_3)-C\equiv C-C(CH_3)_2-CH_2-CH_3$

24. Propoxybutane Ans = $CH_3-CH_2-CH_2-O-CH_2-CH_2-CH_2-CH_3$

25. 3-methyl-4-(isopropyl) octane Ans = $CH_3-CH_2-CH(CH_3)-CH(CH(CH_3)_2)-CH_2-CH_2-CH_2-CH_3$

26. 2-iodo-2-methylpropane Ans = $CH_3-C(I)(CH_3)-CH_3$

27. 2,2-dimethylpentan-3-one .....
Ans = $CH_3-C(CH_3)_2-C(=O)-CH_2-CH_3$

PROVIDE THE REQUIRED REAGENTS OR PRODUCTS TO COMPLETE THE FOLLOWING CHEMICAL REACTIONS BELOW:

28. $CH_3CH_2CH(OH)CH_3 \xrightarrow[Cr_2O_7^{2-}]{H^+/MnO_4^{2-}} ?$ Ans = $CH_3CH_2C(=O)CH_3$

29. $CH_3CH_2CH_2CH=CH_2 \xrightarrow[2.\ H_2O,\ \Delta]{1.\ Conc.\ H_2SO_4} ?$
Ans = $CH_3CH(OH)CH_2CH_2CH_3$

30. $CH_3-C(=O)-Cl$

31. $CH_3C(=O)CH_2CH_3$

32. $CH_3CH_2CHBr$

33. $CH_3C\equiv C$

34. $CH_3C\equiv C$

35. $3CH_3CH$

36. $C_2H_5O$

37. $CH_3$ $CH_3$ C

38. $CH_3$ $CH_3$ C

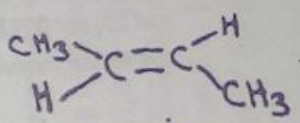
39. $C_2H_5C$

30. $CH_3-\overset{O}{\overset{\|}{C}}-Cl + H_2 \xrightarrow{Pb/BaSO_4} ?$ Ans = $CH_3-\overset{O}{\overset{\|}{C}}-H + HCl$

31. $CH_3\overset{O}{\overset{\|}{C}}CH_2CH_3 + NH_2OH \longrightarrow ?$ Ans = $CH_3\overset{NOH}{\overset{\|}{C}}CH_2CH_3$

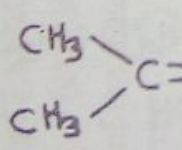
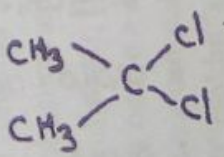
32. $CH_3CH_2CHBrCHBrCH_3 \xrightarrow[Liq.\ NH_3]{2NaNH_2} ?$ Ans = $CH_3CH_2C\equiv CCH_3$

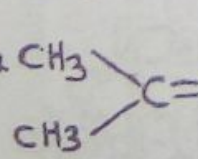
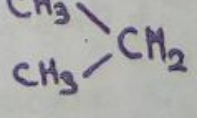
33. $CH_3C\equiv CCH_3 \xrightarrow{O_3/H_2O} ?$ Ans = $CH_3\overset{O}{\overset{\|}{C}}-\overset{O}{\overset{\|}{C}}CH_3$

34. $CH_3C\equiv CCH_3 \xrightarrow{Na,\ NH_3} ?$ Ans = 
trans isomer.

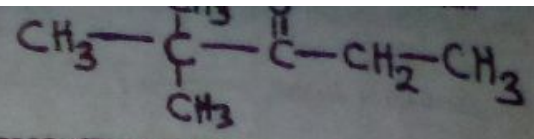
35. $3CH_3CH_2CH_2OH + PBr_3 \longrightarrow ?$ Ans = $3CH_3CH_2CH_2Br$

36. $C_2H_5ONa + C_3H_7Cl \longrightarrow ?$ Ans = $C_2H_5OC_3H_7$

37.  $+ PCl_5 \longrightarrow ?$ Ans = 

38.  $+ 4[H] \xrightarrow[Conc.\ HCl]{Zn/Hg} ?$ Ans = 

39. $C_2H_5COOH + NaOH \longrightarrow ?$ Ans = $C_2H_5COONa$

Ans = 

PROVIDE THE REQUIRED REAGENTS OR PRODUCTS TO COMPLETE THE FOLLOWING CHEMICAL REACTIONS BELOW:

28. $CH_3CH_2CH(OH)CH_3 \xrightarrow[Cr_2O_7^{2-}]{H^+/MnO_4^{2-}} ?$ Ans = $CH_3CH_2C(=O)CH_3$

29. $CH_3CH_2CH_2CH=CH_2 \xrightarrow[2.\ H_2O,\ \Delta]{1.\ Conc.\ H_2SO_4} ?$

Ans = $CH_3CH(OH)CH_2CH(OH)CH_3$

DRAW THE STRUCTURE OF THE FOLLOWING COMPOUNDS IN QUESTIONS 40 AND 41

40. 2-Methylbutanoyl chloride _____ Ans = $CH_3-CH_2-CH(CH_3)-C(=O)Cl$

41. N,N-Dimethylbutanamide Ans = $CH_3-CH_2-CH_2-N(CH_3)-CH_3$

42. Arrange the following compounds in their order of increasing boiling point

(a)pentanoic acid (b)pentanal (c)pentane (d)pentanone Ans = c < d < b < a

43. what product is formed by the acid-catalyzed addition of water to 2-methylpropene.

2-methylPropan-2-ol Ans = 2-methylPropan-2-ol.

44. An unknown compound decolorizes bromine water and on reaction with ozone it gave propanal and butan-2-one. What is the structure of the unknown compound? _____ Ans = $CH_3-C(CH_3)=C(CH_3)-CH_2-CH_3$

45. Name the compound in question 44. Ans = 2,3-dimethyl Pent-2-ene.

**FEDERAL UNIVERSITY OF TECHNOLOGY OWERRI**

**DEPARTMENT OF CHEMISTRY CHM 102 TEST 2015/2016 SESSION**

1. Draw the structure of 3-ethyl -3-methyl hexane.

Ans = $CH_3-CH_2-\underset{\underset{CH_3}{|}}{\overset{\overset{C_2H_5}{|}}{C}}-CH_2-CH_2-CH_3$

2. Give the structure of 3-bromo-2,5-dimethyl hex-3-ene.

Ans = $CH_3-\underset{CH_3}{CH}-\underset{Br}{C}=CH-\underset{CH_3}{CH}-CH_3$

3. The compound dioxane contains carbon hydrogen and oxygen only. 0.956g on analysis gave 1.91g of $CO_2$ and 0.782g of $H_2O$. In another analysis, $6.04 \times 10^{-3}$ mol of the compound weighed 0.532g, calculate its molecular formula.

$$Mole = \frac{mass}{Molar\ mass}$$

Ans = $C_4H_8O_2$ $\quad \therefore Molar\ mass = \frac{mass}{mole} = \frac{0.532}{6.04 \times 10^{-3}}$

4. Pent-1-ene and pent-2-ene are examples of Positional isomers.

5. Treatment of pentan-1-ol with pyridinium chlorochromate in $CH_2Cl_2$ is expected to give Pentanal

NB:- PCC is a mild oxidizing agent.

6. $POCl_3$ can be used in the presence of a base to convert alcohols to Ans = Alkene

7. How many isomers has this compound $C_5H_{10}$ Ans = 5 isomers.

8. Give the product of the reaction

$$(CH_3)_2C=CH_2 + Br_2 \xrightarrow{H_2O} ?$$

Ans = $(CH_3)_2\overset{OH}{\overset{|}{C}}-\overset{Br}{\overset{|}{C}}H_2$

9. In the addition reaction of propene with hcl, give the markownikows product formed.

$CH_3CH=CH_2 + HCl \longrightarrow ?$ Ans = $CH_3\overset{Cl}{\overset{|}{C}}H-CH_2$

10. Why is the boiling point of a branched chain alkanes lower than that of a straight chained alkanes. Ans = Branched Compounds have lower surface area and lower intermolecular force than the straight chain alkane.

FEDERAL UNIVERSITY OF TECHNOLOGY OWERRI, DEPARTMENT OF CHEMISTRY

RAIN SEMESTER EXAMINATION 2015/2016 SESSION

CHM 102 EXAM : GENERAL CHEMISTRY 2 TIME : 2HR

1. A sample of methane weighing 9.67mg produced 26.53mg of $CO_2$ and 21.56mg of $H_2O$. Calculate the % composition of carbon. Ans = %C = $\frac{\text{mass of C}}{\text{Total mass}} \times \frac{100}{1}$

$$\%C = \frac{7.243}{9.636} \times \frac{100}{1} = 75.17\%.$$

2. An organic compound contains 38.7% carbon and 9.75% hydrogen and the rest is oxygen, what is its molecular formula if its molecular weight is 62.07g. Empirical formular = $CH_4O$

Ans = $C_2H_6O_2$ (molecular formular).

3. 0.956g of an organic compound contains carbon, hydrogen, and oxygen gave on analysis 1.52g of $CO_2$ and 0.782 of $H_2O$. If $6.04 \times 10^{-3}$ mol of the substance weighs 0.532g, calculate its molecular formula. $[C_2H_4]n$ = Molar mass

Ans = $C_4H_8O_2$. Molar mass = mass/mole = $\frac{0.532}{6.04 \times 10^{-3}}$

Molar mass = 88.

COMPLETE THE FOLLOWING REACTION

4. $CH_3CH_2\overset{CH_3}{\underset{|}{C}}=CHCH_3 \xrightarrow[Zn/ACOH]{O_3}$ Ans = $CH_3\overset{CH_3}{\underset{|}{C}}=O + CH_3CHO$

5. $HC\equiv CCH_3 + NaNH_2 \xrightarrow{NH_3}$ Ans = $NaC\equiv CCH_3$

6. $CH_3CH_2Cl + CH_3CH_2ONa \longrightarrow$ Ans = $CH_3CH_2OCH_2CH_3$

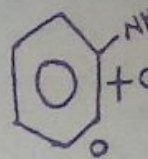
7. $CH_3CH_2Br + NaOH \longrightarrow$ Ans = $CH_3CH_2OH$

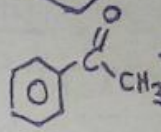
8. $CH_3CH_2CH_2OH + KCN \longrightarrow$ Ans = $CH_3CH_2CH_2CN$

9. $CH_3CH_2CH_2Br \xrightarrow[\text{dry ether}]{Mg}$ Ans = $CH_3CH_2CH_2MgBr$

10. $CH_3OH + CH_3CH_2COCl \longrightarrow$ Ans = $CH_3CH_2COOCH_3 + HCl$

11. $CH_3CH_2CH_2OH + HCl \longrightarrow$ Ans = $CH_3CH_2CH_2Cl$

12.  $+ CH_3COCl \longrightarrow$

13.  $\xrightarrow[\text{Conc.HCl}]{Zn/Hg}$

14. $CH_3CH_2CHO + Br_2 \xrightarrow{NaOH} ?$

15. $CH_3CH=CH_2 + HI \longrightarrow ?$

16. $(CH_3)_3COH + SOCl_2 \longrightarrow ?$

17. $CH_3CHOHCH_3 + Cr_2O_7^{2-} \longrightarrow ?$

18. $CH_3CH_2COOCH_3 + NaOH \xrightarrow{H_2O} ?$

19. $CH_3CH_2COCH_3 + \longrightarrow$

20. $(CH_3)_2C=CH_2 + BY_2 + H_2O \longrightarrow$

21. $(CH_3)_2CHCH=CH_2 + H_2O + Hg(OA$

22. $CH_3CH_2OH + SOCl_2 + Pyridine \longrightarrow$

23. $CH_3CH_2CH_2CH_2Cl + Mg \xrightarrow{\text{dry ethe}}$

24. $CH_3C\equiv CH + NaNH_2 + NH_3 \longrightarrow$

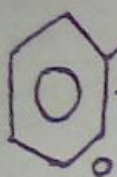
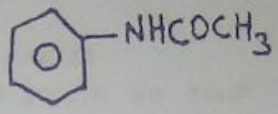
25. $3CH_3CH_2CH(CH_3)CH_2OH + PBr_3 +$

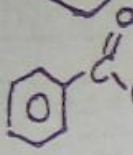
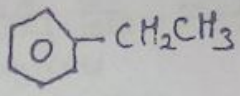
26. $(CH_3)_3CBr + CN^- + \text{Alcohol} \longrightarrow$

27. $(CH_3)_2CO + H_2NNH_2 \longrightarrow$

Give the structural diagram of these com

28. Non-3-yne Ans =

12.  $+CH_3COCl \longrightarrow ?$ Ans = 

13.  $\xrightarrow[\text{Conc.HCl}]{Zn/Hg} ?$ Ans = 

14. $CH_3CH_2CHO + Br_2 \xrightarrow{NaOH} ?$ Ans = $CH_3CHBrCHO$

15. $CH_3CH=CH_2 + HI \longrightarrow ?$ Ans = $CH_3CHICH_3$

16. $(CH_3)_3COH + SOCl_2 \longrightarrow ?$ Ans = $(CH_3)_3C-Cl$

17. $CH_3CHOHCH_3 + Cr_2O_7^{2-} \longrightarrow ?$ Ans = $CH_3COCH_3$

18. $CH_3CH_2COOCH_3 + NaOH \xrightarrow{H_2O} ?$ Ans = $CH_3CHCOONa + CH_3OH$

19. $CH_3CH_2COCH_3 + \longrightarrow ?$

20. $(CH_3)_2C=CH_2 + Br_2 + H_2O \longrightarrow ?$ Ans = $(CH_3)_2\overset{OH}{C}-\overset{Br}{C}H_2$

21. $(CH_3)_2CHCH=CH_2 + H_2O + Hg(OAc)_2 + NaBH_4 \longrightarrow$ Ans = $(CH_3)_2CH\overset{OH}{C}HCH_3$

22. $CH_3CH_2OH + SOCl_2 + Pyridine \longrightarrow ?$ Ans = $CH_3CH_2Cl$

23. $CH_3CH_2CH_2CH_2Cl + Mg \xrightarrow{dry\ ether} ?$ Ans = $CH_3CH_2CH_2CH_2MgCl$

24. $CH_3C\equiv CH + NaNH_2 + NH_3 \longrightarrow ?$ Ans = $CH_3C\equiv CNa$

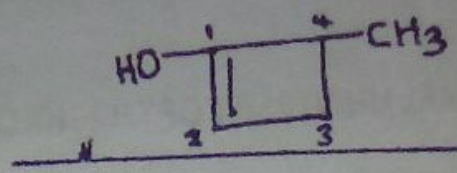
25. $3CH_3CH_2CH(CH_3)CH_2OH + PBr_3 + Heat \longrightarrow ?$ Ans = $3CH_3CH_2CH(CH_3)CH_2Br$

26. $(CH_3)_3CBr + CN^- + Alcohol \longrightarrow ?$ Ans = $(CH_3)_3C-CN$

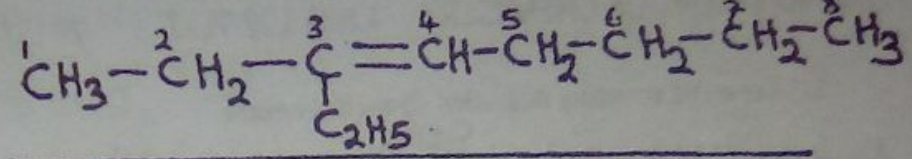
27. $(CH_3)_2CO + H_2NNH_2 \longrightarrow ?$ Ans = $(CH_3)_2C=N-NH_2 + H_2O$

Give the structural diagram of these compounds:

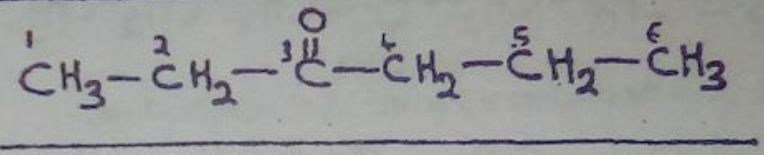
29. 4-methyl-cyclobut-1-enol



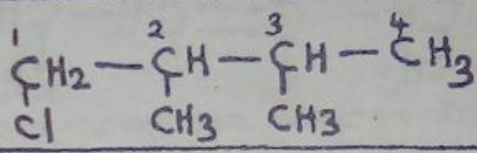
30. 3-ethyl-oct-3-ene



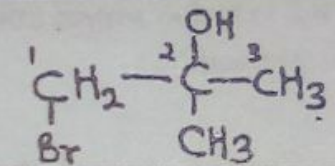
31. Hexan-3-one



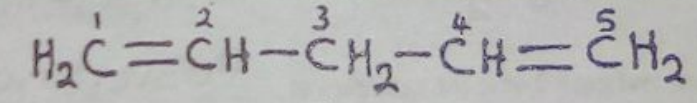
32. 1-chloro-2,3-dimethyl butane



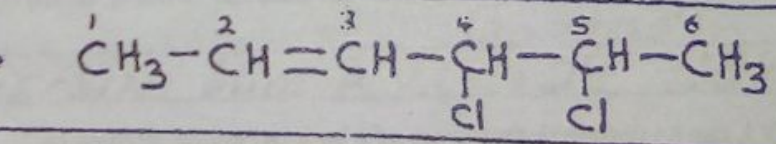
33. 1-bromo-2-methylpropan-2-ol



34. Penta-1,4-diene



35. 4,5-dichloro hex-2-ene



36. How many structural isomers are there in $C_4H_{10}O$ 5.

37. Arrange the following in the decreasing order of ease of dehydration, 2°, 1°, 3°, alcohols

3° > 2° > 1°

38. In the addition reaction of propene with HCl, name the markownikov product formed

Ans = 2-ChloroPropane. $CH_3CHClCH_3$

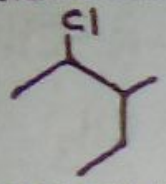
39. Arrange the following isomeric alkanes in order of decreasing boiling points : pentane, 2,2-dimethyl propane and 2-methyl butane

Ans = Pentane > 2-methylbutane > 2,2-dimethyl Propane.

NB:- The more the branches, the lower the boiling Point.

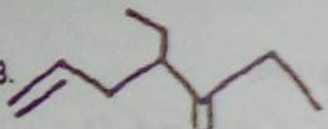
40. Predict the product of the reaction of pent-1-yne and excess HCl in the presence of hydrogen peroxide Ans = $H_2C=C(Cl)-CH_2-CH_2-CH_3$

GIVE THE IUPAC NAMES OF THE FOLLOWING ORGANIC STRUCTURES

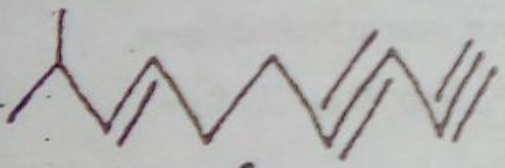
41. 

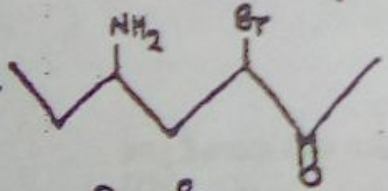
Ans = 2-chloro-3-methyl Pentane.

42. $CH_3CH_2CH(Br)CH_2CH_2CH(NH_2)CH_2CH_2CH_3$ Ans = 4-Amino-7-Bromononane

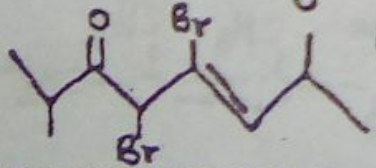
43. 
Ans = 4-Ethylhept-6-ene-3-one.

44. $CH_3CH_2CH=CHCH_2CH_2CH=CHCH_2CH_3$ Dec-3,7-diene

45. 
Ans = 9-methyldec-7-ene-1,3-diyne

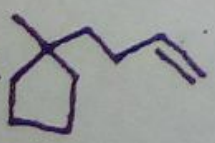
46. 

Ans = 5-Amino-3-Bromoheptan-2-one.

47. 

4,5-diBromo-2,7-trimethyl Oct-5-ene-3-one

48. $CH_2=CHCH_2CH=CHCH_2CH_2CH_3$ Oct-1,4-diene

49. 
Ans = 5-Cyclopentylhex-1-ene

50. $CH_3CH_2CH_2CH(Br)CH_2CH_2OH$ Ans = 3-Bromohexan-1-ol
OR
3-Bromohexanol

83|THE CATALYST CHM 102

FEDERAL UNIVERSITY OF TECHNOLOGY, OWERRI
SCHOOL OF SCIENCE
2008/2009 RAIN SEMESTER PRE-DEGREE EXAMINATIONS 2008/2009
CHM 002: BASIC CHEMISTRY II TIME: 1½ HOURS
INSTRUCTION: ANSWER ALL QUESTIONS

1) Find the molecular formular of a compound with molecular weight of 60 containing 40.0% carbon and 6.7% ydrogen, (a) $CH_2O$ (b) $CH_3CHO$ (c) $C_2H_4O_2$ (d) CHO (e)None

2) How many sigma bonds are contained in $CH_3OCH_3$? (a) 8 (b) 10 (c) 6 (d) 7 (e) 4

3) A gaseous compound of carbon and hydrogen contains 80% carbon by weight. If one $dm^3$ of the compound at s.t weighs 1.35g, calculate the molecular formular. [C = 12, H = 1, molar vol. at s.t.p = $22.4dm^3$]

a) $CH_4$ (b) $C_3H_8$ (c) $C_4H_{10}$ (d) $C_2H_6$ (e) None

4) The first hydrocarbon to exhibit structural isomerism is? (a) Methane (b) Ethane (c) Propane (d) Butane (e) Non

5) How many isomers are possible with the compound Hexane? (a) 5 (b) 6 (c) 4 (d) 8 (e) 3

6) Geometrically isomerism is common in compounds containing———bonds?

a) Single (b) Double (c) Triple (d) Covalent bonds (e) Ionic

7) Structures that are mirror images of one another are called...?

a) Asymmetric (b) Chiral (c) Enantiomers (d) Racemic (e) None

8) One method of separating racemic mixture is by...?

a) Reconciliation (b) racemification (c) resolution (d) resourcitation (e) None

9) The region in which an electron is most probably to be found and is clearly and closely elated to the well defined orbit of the Bohr theory is called?

a) Hybridization (b) orbital (c) dumb bell (d) quantum number (e) None

10) $SP^3$ hybridization is also called? (a) Diagonal hybridization (b) Trigonal hybridization (c) Octahedr ybridization (d) tetragonal hybridization (e) none

11) The bond angle in diagonal hybridization is? (a) 109.5° (b) 180° (c) 120° (d) 200° (e) none

12) How many sigma bonds are found in ethyne? (a) 1 (b) 2 (c) 3 (d) 4 (e) 5

13) Cyclohexane and the higher cycloalkanes can relieve bond strain by?

a) Isomerization (b) Puckering (c) Polarisation (d) thermal cracking (e) none

14) The main product obtained when ozone attacks points of unsaturation is called?

a) Ozonide (b) Ozonolysis (c) Hydrolysis (d) Oxidation (e) none

15) In the hydration of alkynes using water in the presence of mercury salt, movement of both electrons and atoms are involved. This is called? a) Warpping (b) Isotopy (c) Tautomerism (d) Isomerism

16) Ethanol with 40% concentration is called?

(a) Rectified alcohol (b) Spirit (c) Absolute alcohol (d) bad liquor (e) none

17) What type of nuclear reaction is given by the equation? $^{27}_{13}Al + ^{4}_{2}\alpha = ^{30}_{14}Si + ^{1}_{1}H$

(a) γ, n (b) p, γ (c) α, p (d) n, α (e) none

18) which one of the following reagents does propanone undergo a differe type of reaction to ethanol? (a) HCN (b) $NaHSO_3$ (c) $NH_3$ (d) $NH_2NH_2$ (e)$NH_2OH$

(19) Which one of the following compounds does not give triiodomethane (iodoform) test?

(a) $CH_3CHO$ (b) $CH_3CH_2OH$ (c) $CCl_3COCH_3$ (d) $CH_3CH_2CH_2OHCH_3$ (e) $C_6H_5CH_2CH_2OH$

20) A certain compound is a viscous high boiling point liquid, miscible with water. The compound is most likely to l (a) $CH_3CH_2OH$ (b) $CH_3CH_2CH_2OH$ (c) $CH_3CHOHCH_3$ (d) $CH_3CH_2CH_2CH_2OH$ (e) $CH_2OHCHOHCH_2OH$

21) Bromoethane is best hydrolysed to ethanol by refluxing it with? (a) Water (b) aqueous sulphuric acid (c) alcoholic potassium hydroxide (d) Aqueous potassium hydroxide (e) Silver (I) oxide in moist ethoxythane

Which one of the following reagents does not undergo a reaction with ethene? (a) Acidified potassium manganate v hydrogen cyanide (c) aqeous ammonia (d) Bromine in tetrachloromethane (e) hydrogen chloride (23) In which o the following properties will cis-hex-3-ene not differ from trans hex-3-ene? (a) Boiling point (b) melting point (c) dip moment (d) Product of hydrogenation (e) infra-red spectrum (24) Which one of the molecules of the following compounds possesses a dipole moment?

(a) $CH_4$ (b) $CHCl_3$ (c) $CCl_4$ (d) $CH_3CH_3$ (e) $CH_3CH_2CH_3$

(25) Mesomeric effects are only operative in molecules which

(a) are saturated (b) are unsaturated (c) are highly polar (d) contain oxygen (e) contain electron donating group

(26) Which one of the following best describes the type of species formed as a result of heterolytic fission? (a) Atoms (b) free radicals (c) electrophiles and nucleophiles (d) acids (e) bases

(27) Ethoxyethane (b.p.35°C) is more volatile than ethanol (b.p.78°C) largely because of?

(a) The greater relative molecular mass of the ether (b) the strength of C—O bonds in the ether

(c) the highly polar —OH group in ethanol (d) the different shapes of the molecules

(e) Intramolecular hydrogen bonding between the ether molecules

(28) Which one of the following does not represent alkanes? (a) $C_6H_{14}$ (b) $C_{13}H_{28}$ (c) $C_{18}H_{36}$ (d) $C_{19}H_{40}$

(29) Which one of the following alkanes does not contain a secondary carbon atom? (a) $CH_3CH_2CH_3$

(b) $(CH_3)_2CHCH_2CH_3$ (c) $(CH_3)_2CHCH_2CH(CH_3)_2$ (d) $(CH)_3CCH_2CH_3$ (e) $(CH_3)_3CCH(CH_3)_2$

(30) Which of the following alcohols forms a ketone when oxidized?

(a) 1 - propanol (b) ethanol (c) 2 - methyl - 2 – propanol (d) 2 - propanol

(31) Which of the following substances is an ether?

(a) $CH_2CH_2$ (b) $CH_3CHO$ (c) $CH_3CH_2OCH_2CH_3$ (d) $CH_3COOCH_3$

(32) What is the expected product formed from the reaction between 2 - butene and $Cl_2$?

(a) 1 - Chlorobutane (b) 2 – Chlorobutane (c) 2,3 – dichlorobutane (d) 2,2 – dichlorobutane

(33) Given an organic compound with molecular formular $C_3H_8$. What is the percentage of C and H?

(a) 88.16%C; 13.23%H (b) 80.21%C; 11.86%H (c) 88.16%C; 11.84%H (d) 86.54%C; 13.2%H

(34) The order of boiling point values of the alkyl halides is?

(a) I > Br > F > Cl (b) F > Cl > Br > I (c) I > Br > Cl > F (d) I < Br < Cl < F

(35) What are the products of the following reaction $CH_3COCH_3 + PCl_5 \longrightarrow ?$

(a) $CH_3Cl_3CH_3$; $PCl_3$ (b) $CH_3CCICH_3$; $PCl_3$ (c) $CH_3CCl_2CH_3$; $POCl_3$ (d) $PCOCH_3$; $CH_3Cl_3$

(36) ( ? ) + KOH $\longrightarrow$ $RCO_2K$ + ( ? ) (a) RCOR; OH (b) ROH; KOH (c) RCOOR; ROH (d) $RCO_2R$; ROH

(37) $C_2H_4$ + ( ? ) $\longrightarrow$ $CH_3CH_2OH$ (a) $OH_2$ (b) $CH_3OH$ (c) COH (d) OH

(38) What is the catalyst used for this reaction: $C_6H_6 + CH_3COCl \dashrightarrow C_6H_5COCH_3 + HCl$

(a) Nickel (b) Aluminium Chloride (c) Copper (d) Silver

(39) Supply the missing organic substance in the reaction: $CH_3COOCH_3 \longrightarrow CH_3CH_2NHCOCH_3$

(a) $CH_3CH_2NH_2$ (b) $CH_3NH_2$ (c) $CH_3CH_2NHOH$ (d) $CH_3CH_2CONH_2$

(40) A compound contains 52.13%C; 13.15%H; 35.15%O. The empirical formula will be?

(a) $C_2H_6O$ (b) $C_2H_5O$ (c) $C_3H_7O$ (d) $C_4H_9O$

(41) What is the product of the reaction $2CH_3CH_2I + 2Na \xrightarrow{I} ?$

(a) $CH_3CH_2$ (b) $CH_3CH_3$ (c) $CH_3(CH_2)_2CH_3$ (d) $CH_3CH_2CH_3$

(42) $CH_3NH_2 + HNO_2 \longrightarrow ? + N_2 + H_2O$ (a) $CH_3NH_3$ (b) $CH_3OH$ (c) $CH_3NCH$ (d) $CH_3CH_2N_2$

(43) Given that the rate constant for a 2nd order reaction is $2.80 \times 10^{-3}$ L.mol$^{-1}$min$^{-1}$. if the initial concentration is 1.00m Calculate the half life (a) $6.8 \times 10^{-1}$ min (b) 68 min (c) 35.7 min (d) 24min

(44) For the reaction $N_2 + 3H_2 \longrightarrow 2NH_3$, if the concentration of $[N_2]$ = 1.0M, $[H_2]$ = 0.51M, and $[NH_3]$ = 0.095M, Calculate the equilibrium constant (a) $6.6 \times 10^{-1}$ (b) $6.8 \times 10^{-2}$ (c) $6.92 \times 10^{-1}$ (d) $6.77 \times 10^{-1}$

**Complete the following nuclear equations**

(45) $^{238}_{92}U \rightarrow ? + ^{4}_{2}He$ (a) $^{236}_{90}Th$ (b) $^{234}_{92}Th$ (c) $^{234}_{90}Th$ (d) $^{233}_{98}Th$ ANS = C

(46) $^{212}_{84}Po \rightarrow ^{208}_{82}Pb + ?$ (a) $^{1}_{2}\beta$ (b) $^{4}_{2}He$ (c) $^{1}_{1}H$ (d) $^{0}_{1}e$

(47) $^{0}_{-1}e + ^{0}_{1}e \rightarrow ?$ (a) $^{1}_{1}\beta$ (b) $^{1}_{1}N$ (c) $^{4}_{2}H$ (d) $2^{0}_{0}\gamma$

(48) $^{228}_{88}Ra \rightarrow ^{228}_{89}AC + Z$ (a) $^{0}_{1}e$ (b) $^{0}_{-1}e$ (d) $^{0}_{0}\gamma$

(49) Calculate the empirical formular of the compound represented with "Y" containing carbon, hydrogen, and oxygen which was subjected to combustion analysis; given that 0.1g of the compound on combustion gave 0.228g of carbondioxide and 0.0931g of water. (a) $C_3H_4O$ (b) $C_3H_6O$ (c) $C_4H_8O$ (d) $CH_4$

(50) Determine the reaction rate in a reaction between acidified hydrogen peroxide and potassium iodide to form iodine if the concentration of iodine rises from 0 to $10^{-3}$ mole dm$^{-3}$ in 10 seconds.

(a) $10^{-3}$moldm$^{-3}$sec$^{-3}$ (b) $10^{-4}$moldm$^{-3}$sec$^{-3}$ (c) $10^{-5}$moldm$^{-3}$sec$^{-3}$ (d) $10^{-6}$moldm$^{-3}$sec$^{-3}$ (e) none

PAPER OPTION 2

FEDERAL UNIVERSITY OF TECHNOLOGY, OWERRI
SCHOOL OF SCIENCE, PRE-DEGREE UNIT
2013/2014 RAIN SEMESTER EXAMINATION TIME ALLOLWED: 2HOURS
CHM 002: BASIC CHEMISTRY II DATE: 27/08/2014 2013/2014 EXAM

ATTEMPT ALL QUESTIONS

01. What is the product of treatment of methane with excess molecules of chlorine: (a) $CH_3Cl$ (b) $CH_2Cl_2$ (c) $CCl_4$ (d) $CH_3Cl_2$
02. The product of the reaction between propyne and sodamins is one of the following: (a) $CH_3CH_2CH_3$ (b) $CH_3C\equiv CNa$ (c) $CH_3C\equiv CH$ (d) $CH_3CH_2OH$.
03. Heating n-heptane with platinum in the presence of alumina at 600°C and 10-12 atm pressure will give one of the following products
(a) Benzene (b) Toulene (c) Aniline (d) Propyne
04. What conditions are best for the dehalohydrogenation of vicinal dihal allkanes. (a) Zinc in acetic acid (b) Zinc in Acetone (c) Zinc in Alcohol (d) Zinc in Toulene
05. Give the product of peroxide catalyzed bromination of pent-1-ene. (a) $CH_3CH_2CH_2CH_2CH_3$ (b) $CH_3CH_2CH_2Br$ (c) $CH_3CH_2CH_2CH_2CH_2Br$ (d) $CH_3CH_2CH_2CH_2Cl$
06. Which of the following is not an electrophile? (a) $CH_2=CH_2$ (b) $H^+$ (c) $AlCl_3$ (d) $CH_3\overset{+}{C}HCH_3$ Ans=A
07. Which of the following contains an acid hydrogen? (a) $C_2H_5C\equiv CH$ (b) $C_2H_5CH=CH_2$ (c) $C_2H_5CH_2CH_3$ (d) $C_2H_5CH_3$
08. Give the product of the reaction between Ethanol and Acetic acid. (a) $CH_3CH_2OH$ (b) $CH_3COOH$ (c) $CH_3COOC_2H_5$ (d) $CH_3OC_2H_5$
09. Which of the following is a good nucleophile? (a) $NH_3$ (b) HBr (c) $Br_2$ (d) $BH_3$
10. Which of the following have the highest boiling point? (a) Formaldehyde (b) Ethanol (c) Ether (d) Propane
11. What is the product of the reaction between Ethanoic acid and phosphorus pentachloride (a) $CH_3COOH$ (b) $PCl_5$ (c) $CH_3COCl$ (d) $CH_3COOC_2H_5$
12. Which of the following will react most readily with water
(a) Ketone (b) Acetyl chloride (c) Acetic anhydride (d) Ethyl acetate ANS=C
Complete the following reaction
13. ..... $+ KOH \xrightarrow{KBr} C_4H_8 + H_2O$: (a) $C_4H_8$ (b) $C_4H_{10}$ (c) $C_3H_7$ (d) $C_4H_9$
14. $C_2H_5Cl + C_2H_5ONa \rightarrow$ ..... (a) Ether (b) Alcohol (c) Ester (d) Organic Acid
15. $RNH_2 + (RCO)_2O \rightarrow$ ..... (a) Amine (b) Amino (c) Amide (d) anunonia
16. $C_3H_6O + KCN \rightarrow$ ..... (a) $C_3H_7CN$ (b) $C_2H_5CN$ (c) $C_3H_8CN$ (d) $C_3H_5CN$
17. $C_4H_{10} \xrightarrow{KMnO_4} $ .....
(a) Monohydric alcohol (b) Dihydric alcohol (c) Trihydricalcohol (d) Poyhydric alcohol
18. $C_3H_7Br \xrightarrow{Mg(ether)}$ ..... (a) $C_3H_7$ (b) $C_3H_7Mg$ (c) $C_3H_7mgBr$ (d) $C_3H_5Mg$
19. $C_3H_6O + HCl \rightarrow$ .....
(a) Propane chloride (b) Propyl chloride (c) Propene chloride (d) Propyne chloride
20. $C_2H_6O + C_2H_4 \rightarrow$ .....
(a) Ether (b) Ester (Acid) (d) Alcohol
21. $R_3COH + SOCl_2$ ..... (Product is what term of carbon)
(a) Primary (b) Secondary (c) Tertiary (d) None of the above ANS = Tertiary = C
22. $C_2H_5 + HI \rightarrow$ ..... (a) $CH_2ICH_2CH_3$ (b) $CH_2CHICH_3$
(c) $CH_3CH_2CH_2I$ (d) $CH_3CICH$
23. How may σ– bonds are in $C_3H_7COOH$? (a) 2 (b) 5 (c) 7 (d) 9
24. How many π-bond are in $CH_3C\equiv C-CH=CH-C\equiv C$? (a) 4 (b) 5 (c) 8 (d) 10
25. What is the lenght of C = C bond in Ethene. (a) 1.66Å (b) 1.33Å (c) 1.77Å (d) 1.88Å
26. How many delocalized electrons are present in naphthalene? (a) 2 (b) 4 (c) 5 (d) 10
27. Estimate the number of asymmetric carbons that are found in the amino acid, serine
(a) zero (b) two (c) one (d) two
28. Geometric isomerism is common in compounds containing ---------- bond. (a) Single (b) double (c) triple (d) none

29. The technique used to separate racemic mixture is called (a) Resolution (b) revolution (c) evolution (d) restoration

30. Determine the molecular formula of a compound with molecular mass of 60 and whose carbon and hydrogen contents are 40.0% and 6.7% respectively.
(a) $CH_4O$ (b) $CH_3OH$ (c) $C_2H_4O_2$ (d) $CH_3OCH_3$

31. The storage problem of ethyne is solved by using ..... to store it.
(a) butanone (b) propanone (c) ethanol (d) methanol

32. How many minutes does the reaction below take to accomplish?
$CH_3CH_2(OH)CH_3 + Conc\ HCL \xrightarrow{ZNCL_2} CH_3CH_2CH(Cl)CH_3 + H_2O$
(a) 1minute (b) 3 minutes (c) 5 minutes (d) 10 minutes

33. In order to do silver mirror test, what reagent should be used ?
(a) Grignard reagent (b) Fehlings reagent (c) Jones reagent (d) Tollens reagent

34. How many $\pi$– bonds are in ethane? (a) 6 (b) 7 (c) 1 (d) none

35. Determine the stoichiometric coefficient of oxygen in the balanced combustion reaction: $C_4H_{10} + O_2 \rightarrow CO_2 + H_2O$. (a) 2 (b) 8 (c) 13 (d) 10

36. What type of geometry has ethane? (a) Tetragonal (b) Hexagonal (c) Trigonal (d) Octagonal

37. Which of the following compounds will not be able to rotate plane polarized light?
(a) Lactic acid (b) carboxylic acid (c) valine (d) alanine

38. In one of the methods of producing carboxylic acid, crushed dry ice is used at one stage. What is crushed dry ice? (a) ice block (b) particles of cold water ice block (c) solid carbon dioxide (d) None

39. Which of the following represents the arrangement of the $SP^3$ hybrid orbitals in methane?
(a) Planar (b) tetragonal planar (c) Tetrahechal (d) bipyramidal

40. How many electrons are actually involved in the carbon – carbon bond of acetylene?
(a) 2 (b) 3 (c) 4 (d) 6

41. Which of the following best represent the hydrogen - carbon - hydrogen bond angles in methane?
(a) $90^o$ (b) $109.5^o$ (c) $120^o$ (d) $180^o$

42. n-Butane and isobutane are best described as
(a) Stereoisomers (b) anomers (c) diicesteriomers (d) constitutional isomers

43. Which of the following choices represents the product of ozonolysis of 3 – Hexyne?
(a) Propanone (b) prepanal (c) Haxanoic acid (d) propanoic acid

44. The process by which an alkyne can be directly converted into an alkane is called:
(a) Dehydrohalogenation (b) dehydration (c) hydrolysis (d) hydrogenation

45. Which of the following is the most reactive by substitution mechanism
(a) $CH_3I$ (b) $CH_3F$ (c) $CH_3Cl$ (d) all are equally reaction

46. The conjugate base of alcohols are generally called?
(a) Alkyl ions (b) alcoholic ions (c) alkoxide ions (d) vinyl ions

47. Choose the correct product formed as a result of the reduction of a ketone
(a) primary alcohol (b) a secondary alcohol (c) tertiary alcohol (d) none of the above

48. Which of the following has the highest boiling point?
(a) Pentanoic acid (b) pentanol (c) pentane (d) pentanone

49. Formaldehyde can be converted to formic acid. What is the correct hybridization of the carbon in the formic acid? (a) SP (b) $SP^3$ (c) $SP^3d$ (d) $SP^2$

50. Which of the following compounds has the highest Pka value?
(a) $FCH_2CH_2COOH$ (b) $F_2CHCH_2COOH$ (c) $FCH_2CH_2(CH_3)CH_2COOH$ (d) $FCH_2COO$

FEDERAL UNIVERSITY OF TECHNOLOGY, OWERRI
SCHOOL OF PHYSICAL SCIENCES, PRE-DEGREE UNIT
2016/2017 RAIN SEMESTER EXAMINATION *DATE: 31/10/2017*
CHM 002- BASIC CHEMISTRY II TIME ALLOWED: 1HOUR

***Attempt all the questions and give the solutions on the provided computer sheet***

ALL WERE REPEATED FROM 2015/2016

1. The reaction $RCOCl + 2NH_3 \rightarrow RCONH_2 + NH_4Cl$, is an example of ? (a) acylation (b) acetylation (c) ammonolysis (d) acetyl-amidation
2. Decarboxylation of sodium ethanoate in the presence of an alkali gives (a) methanol (b) methane (c) ethanol (d) ethane
3. (X) + KOH → $RCO_2K$ + (Y); What is X and Y? (a) RCOR; OH (b) ROH; KOH (c) RCOOR; ROH (d) $RCO_2R$; ROH
4. The products of the following reaction; $CH_3CHO + NH_3 \rightarrow$ (?)
   (a) $CH_3NH_2 + NH_3$ (b) $CH_3NH_2 + CH_3O$ (c) $CH_3CHNH_2 + H_2O$ (d) $CH_3CH(OH)NH_2$
5. The loss of a halide atom to generate an alkene is known as? (a) A dehydrohalogenation (b) A dehydration (c) A reduction (d) An oxidation
6. Alkenes are prepared from alkanes and substituted alkanes by (a) Addition reactions (b) Substitution reactions (c) Elimination reactions (d) Free radical reactions
7. The geometry of the carbon atoms in an alkyne are: (a) Linear. (b) Bent. (c) trigonal plane. (d) Tetrahedral
8. Which pairing of alcohol and class is *incorrect*? (a) Butan-2-ol; secondary alcohol (b) Propan-1-ol; primary alcohol (c) 2-Methylpropan-2-ol; tertiary alcohol (d) Pentan-3-ol; tertiary alcohol
9. (?) + KOH → $CH_3CH{=}CH_2$ + KBr + $H_2O$. This reaction would be completed by using (a) $C_3H_9Br$ (b) $C_4H_7Br$ (c) $C_3H_7Br$ (d) $C_5H_{11}Br$
10. $C_2H_5OH + CH_2{=}CH_2 \rightarrow$ (?) (a) $C_4H_8O + H_2$ (b) $C_4H_8 + H_2O$ (c) $C_4H_{10}O$ (d) $C_2H_5 + C_2H_5O$
11. What is the IUPAC name for $HCOOCH_2CH_2CH_3$ ? (a) Butanal (b) Butanoic acid (c) Methylpropanoate (d) Propyl methanoate
12. How many molecules of water are required to hydrolysed $RCONH_2$ to an acid and amine? (a) one (b) two (c) three (d) four
13. The following reaction, $C_5H_8 + H_2 \rightarrow C_5H_{10}$, is called? (a) substitution (b) elimination (c) addition (d) polymerization
14. Which of the following will decolorize $KMnO_4$? (a) ethene (b) ethyne (c) ethanol (d) propene
15. Benzene is a polymer of which of the following? (a) ethane (b) ethyne (c) propene (d) propyne
16. .Only one benzene ring is present in compounds of (a) aryl (b) acryl (c) carboxylic (d) ketone
17. For complex molecules, a chemist usually represents a molecule by (a) molecular formula (b) skeletal formula (c) structural formula (d) b and c
18. . Aromatic compounds are known as (a) benzenes (b) arenes (c) cyclic alkenes (d) alkenes
19. $CH_3COOC_2H_5$ is structural formula for (a) ethyl ethanoate (b) propane (c) ethanoic acid (d) methylamine
20. Breakdown of any molecule with water ($H_2O$) is (a) addition reaction (b) elimination reaction (c) substitution reaction (d) hydrolysis
21. .Carbonyl group in aldehyde is (a) C=O (b) C-O (c) CO (d) CHO
22. $CH_3CH_2CH_2CH_2CHO$ is formula for (a) methanol (b) propanal (c) butanol (d) pentanal
23. .Ketones react with reducing agent to make (a) primary alcohols (b) secondary alcohol (c) tertiary alcohol (d) all of them
24. Reducing agent used for reduction of aldehydes and ketone is (a) tetrafluorate (b) tetrahydridoborate (c) tetrafluroborate (d) tetrachloride
25. A compound of empirical formula $CH_2$ has a molecular weight of 56g. What is the molecular formula?
   (a) $C_3H_6$ (b) $C_4H_8$ (c) $C_2H_4$ (d) $C_5H_{12}$
26. The reaction $CS_2 + 3Cl_2 \rightarrow CCl_4 + S_2Cl_2$ is catalysed by (a) Pd (b) Ni (c) CuO (d) $AlCl_3$
27. The order of boiling point values of the alkyl halides is? (a) I>Br>F>Cl (b) F>Cl>Br>I (c) I>Br>Cl>F (d) Br>Cl>I>F
28. The following are all monobasic except (a) ethanoic acid (b) ethanol (c) ethanedioc acid (d) trioxonitrate (V) acid
29. Which of the following compounds will form a white precipitate with aqueous solution of $AgNO_3$? (a) but-2-ene (b) but-1-yne (c) but-2-yne (d) butane

30. Substances which are basis of human life on earth are (a) atom (b) molecules (c) matter (d) organic compounds

31. Due to presence of double bonds, alkenes are (a) saturated (b) polar (c) unsaturated (d) non-polar

32. . Alkane molecules are not attacked by electrophiles or nucleophiles because they are
(a) polar (b) unstable (c) volatile (d) non-polar

33. Carbon atom which is further attached to four different atoms is called (a) nucleus centre (b) neutral centre (c) chiral centre (d) all of them

34. Wide range of different hydrocarbons are separated by (a) fractional decomposition (b) fractional distillation (c) fractional filteration (d) fractional polarization

35. Oxidation of primary alcohols give (a) aldehydes (b) ketones (c) both A and B (b) alcohols

36. Reduction reactions of carbonyl compounds is known to be (a) Nucleophilic addition (b) Nucleophilic substitution (c) addition reaction (d) elimination reaction

37. Almond essence in cakes and pudding is made from (a) ester (b) alcohol (c) benzaldehyde (d) ketone

38. Which compound can exist as stereoisomers ? (a) $CH_3CH_2CHO$ (b) $CH_3CH_2COCH_3$ (c) $CH_3CH(CH_3)_2$ (d) $CH_3CH_2CHOHCH_3$

39. When a molecule of water is removed from two molecules of organic acids, the compound formed is? (a) Primary alcohol (b) Secondary alcohol (c) Tertiary alcohol (d) acid anhydride

40. The compound $CH_3CH_2COOH$ was produced by oxidation. State the starting substance.
(a) 2-methylpropanol (b) butan-2-ol (c) propan-1-ol (d) propan-2-ol

41. The chlorination of an alkene is? (a) an SN1 reaction (b) an SN2 reaction (c) Free radical reaction (d) reduction reaction

42. When phosphorus pentachloride reacts with simple carbonyls, the compounds formed?
(a) $R_2CCl + PCl_3$ (b) $RCCl_2 + PCl_2 + Cl$ (c) $R_2CCl_2 + POCl_3$ (d) $R_2CCl_2 + PCl_3 + O^{2-}$

43. Monocarboxylic acids act upon phosphorus trichloride to form?
(a) RCOCl and $POCl_3$ (b) 3RCOCl and $H_3PO_3$ (c) RCOOH and $POCl_3$ (d) RCOOH, $H_3PO_3$ and $2Cl_2$

44. Which of the following reactions is not an example of addition reaction? (a) Combustion of propene. (b) Reaction of $Cl_2$ with propene (c) Polymerization of ethene. (d) Reaction of HBr with but-2-ene.

45. The carbon atoms in an alkyne are? (a) $sp^1$ hybridized. (b) $sp^3$ hybridized. (c) $sp^2$ hybridized. (d) sp hybridized.

46. Which of the following is a tertiary alkyl halide, halogenoalkane? (a) 2-Chloro-2-methylpropane. (b) 2-Chloropropane (c) 1-Chloropropane. (d) 1-Chloro-2-methylpropane.

47. What is the expected product of the reaction of butanal with $NaBH_4$? (a) Butanoic acid (b) Butan-2-ol (c) Butan-1-ol (d) Butanone

48. Complete the following reaction : $CH_3COCH_3 + 3Cl_2 \rightarrow$ (?);
(a) $CHClCOCH_3 + HCl$ (b) $CCl_3COCH_3 + 3HCl$ (c) $CCl_2COCH_3 + 3HCl$ (d) $3CCl_3COCH_3 + HCl$

49. The reaction of a Grignard reagent RMgX with a ketone, $R'_2CO$, followed by treatment with $H_3O^+$, would give which of the following products? (a) A secondary alcohol. (b) A mixture of secondary and tertiary alcohols. (c) A primary alcohol (d) A tertiary alcohol:

50. What is the IUPAC name for $CH_3C(CH_3)_2CH_2CH(CH_3)_2$ ? (a) 1,3- dimethyl pentane (b) 1.,1,3,3- tetramethyl butane (c) 2,4,4-trimetylpentane (d) 2,2,4-trimethylpentane

**Federal University of Technology Owerri, Department of Chemistry**
**Rain Semester test 201 7/2018 Session**

CHM 102: General Chemistry 22 Time: 1 Hr
Instruction: Answer all question in the spaces provided. Do your calculation at the back of the sheet
Name ..... Reg, No. ..... Dept. .....

1. Identity the product of this reaction
   $CH_3CH=CH_2 \xrightarrow{R_2O_2}$
2. 0.203g of a gave on organic compound gave on combustion 0.361g of $CO_2$ and 0.147 of $H_2O$. Calculate the molecular formula. If the relative molecular mass is 148
3. 0.956g of an organic compound contains carbon, hydrogen and oxygen gave on analysis 1.92g of $CO_2$ and 0.782g of $H_20$. If 6.04x10-3 mol of the substance weighs 0.532g, calculate its molecular formula
4. Give the structure of 4-ethyl-3-methylcyclohexene
5. Why does propanol boil at higher temperature than the corresponding hydrocarbons.....
   .....
6. Markownikoff's rule states that .....
   .....
   .....
7. Terminal alkynes are alkynes.....
   .....
8. Tautomerism is defined as .....
   .....
9. Ozonolysis is defined as.....
   .....
10. Catenation is defined as.....

# SOLUTION TO 2017/2018 CHM102 TEST

1. This will follow the "Anti-Markovnikoff's rule since peroxide ($R_2O_2$) is present

**Answer = $CH_3CHB_rCH_3$**

2. Mass of compound given = 0.203g

Mass of C = $\frac{12 \times 0.361}{44}$ = 0.0985g of C

Mass of H = $\frac{2 \times 0.147}{18}$ = 0.0163g of C

Mass of C + mass of H = 0.0985 + 0.0163 = 0.1148g

Since C+H is not up to the mass of the compound given, it means that will come in.

Mass of Oxygen = Mass of compound – (C + H)

= 0.203 – (0.0985 + 0.0163)

= 0. 0882g of Oxygen.

| C | H | O |
|---|---|---|
| $\frac{0.0985}{12}$ | $\frac{0.0163}{1}$ | $\frac{0.0882}{16}$ |
| $\frac{0.0082}{0.0055}$ | $\frac{0.0163}{0.0055}$ | $\frac{0.0055}{0.0055}$ |
| 1.49 | 2.96 | 1 |

Multiply through by 2.

| (1.49 x 2) | (2.96 x 2) | (1 x 2) |
|---|---|---|
| 2.98 | 5.9 | 2 |
| 3 | 6 | 2 |

**Empirical formula = $C_3H_6O_2$**

$[C_3H_6O_2]$ n = 148

$n = \frac{148}{C_3H_6O_2} = \frac{148}{12(3)+1(6)+16(2)}$

$n = \frac{148}{74} = 2$

**Molecular formula** = $[C_3H_6O_2]$ 2

= **$C_6H_{12}O_4$**

3. Mass of compound given = (

Mass of C = $\frac{12 \times 1.92}{44}$ =

Mass of H = $\frac{2 \times 0.782}{18}$ =

Then C + H = 0.524

= 0.611

Since 0.611 is less than the m compound given, oxygen will

Mass of Oxygen present = 0.

= 0.345g of oxyge

| C | H |
|---|---|
| $\frac{0.524}{12}$ | $\frac{0.087}{1}$ |
| $\frac{0.044}{0.022}$ | $\frac{0.087}{0.022}$ |
| 2 | 3.95 |
| 2 | 4 |

**Empirical formula** =

[Empirical formula] n = Mo

Here molar mass is not giv

Mole is given and mass is

From mole =

❖ Molar mass =

$= \frac{0.532}{6.04 \times 10^{-3}}$ = 88g

$[C_2H_4O]$ n = 88

e "Anti-Markovnikoff's
is present
$CH_3$
iven = 0.203g
0.0985g of C

.0163g of C

.0985 +

mass of the
that will come in.
compound – (C + H)
0163)
ygen.

| O |
|---|
| 0.0882 |
| 16 |
| 0.0055 |
| 0.0055 |
| 1 |

x 2)

$C_3H_6O_2$

5)+16(2)

2

$O_2$] 2

$_{12}O_4$

3. Mass of compound given = 0.956g

Mass of C = $\frac{12 \times 1.92}{44} = 0.524g$

Mass of H = $\frac{2 \times 0.782}{18} = 0.085g$

Then C + H = 0.524 + 0.087

= 0.611g

Since 0.611 is less than the mass of the compound given, oxygen will come in.

Mass of Oxygen present = 0.956 – 0.611

= 0.345g of oxygen

| C | H | O |
|---|---|---|
| $\frac{0.524}{12}$ | $\frac{0.087}{1}$ | $\frac{0.345}{16}$ |
| $\frac{0.044}{0.022}$ | $\frac{0.087}{0.022}$ | $\frac{0.022}{0.022}$ |
| 2 | 3.95 | 1 |
| 2 | 4 | 1 |

**Empirical formula** = $C_2H_4O$.

[Empirical formula] n = Molecular mass

Here molar mass is not given.

Mole is given and mass is given

From mole = $\frac{\text{mass}}{\text{Molar mass}}$

❖ Molar mass = $\frac{\text{mass}}{\text{Mole}}$

= $\frac{0.532}{6.04 \times 10^{-3}}$ = 88g/mol

$[C_2H_4O]$ n = 88

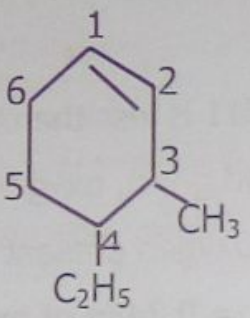
$$n = \frac{88}{C_2H_4O} = \frac{88}{12(2)+1(4)+16} = \frac{88}{44}$$

$n = 2$

**Molecular formula = $[C_2H_4O]\,2$**

**= $C_4H_8O_2$**

**4. 4 – Ethy-3- methyl cyclohexene**




5. Propanol boils at higher temperature than the corresponding hydrocarbons due to it's ability to undergo **hydrogen bonding** (presence hydroxy group in it)

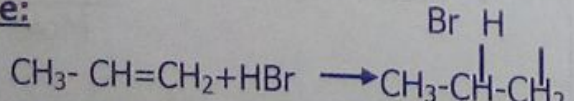
6. **Markovnikoff's rule** states that "in the addition of HX to an unsymmetric alkene, the hydrogen atom (H) bonds to the less substituted carbon atom while the halogen (X) bonds to the more substituted carbon atom".

Or

In the addition HX to an unsymmetric alkene, it goes to the carbon that has more it atoms while X goes to the carbon that has les it atoms.

Where **X** is a halogen.

**Example:**




7. **Terminal alkynes** are alkynes whose triple bond is located at position one along the carbon chain.

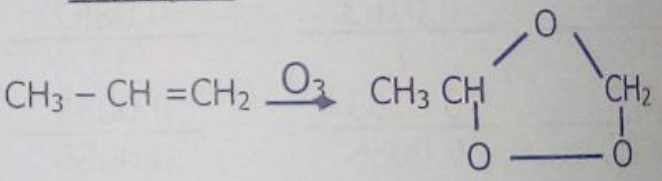
8. **Tautomerism** is defined as the type of isomerism in which the isomers are in dynamic equilibrium with each other as a result of the movement of the pi electrons within the molecule.

**Example:**


**Ethanal** **Ethenol**

9. **Ozonolysis** is an oxidation reaction in which ozone reacts with an alkene or alkyne to produce an ozonide as the intermediate product.

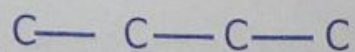
**Example:**




**Alkene** **Ozonide**

10. **Catenation** is defined as the ability of carbon atom to bond covalently with other carbon atoms to form a long carbon chain

**Example:**



**FEDERAL UNIVERSITY OF TECHNOLOGY OWERRI, DEPARTMENT OF CHEMISTRY**
**CHM102 GENERAL CHEMISTRY 11 2017/2018 SESSION TIME ALLOWED 1HR 30MINUTES TYPE 5**
**INSTRUCTION ANSWERS ALL QUESTIONS. DO NOT DETACH THE QUESTION PAPER FROM THE OMR SHEET**

1. How many pi and sigma orbitals are in the compound $H_2O{=}C{=}CH_2$ (A) 6 sigma and 2 pi (B) 4 sigma and 4 pi (c) 8 sigma and 4 pi (d) 5 sigma and 4 pi

2. Which of the following has the shortest carbon -carbon bond length (A) $CH_2{=}CH_2$ (B) $CH_3CH_3$ (c) $CH \equiv CH$ D) $C_4H_{10}$

3. Which of the following decolorize bromine water in carbon tetra chloride (A) 1, 2-dimethyl cyclopropane (B) cyclopropane (C) 1,2-dimet'yl cyclobutane (D)cycohexane

4. Which of the following compounds do not have cis-trans isomerism (A) $(CH_3)_2C{=}CHCH_3$ (B)$CH_3CH{=}CHCH_2CH_3$ (C) $CH_3CH_2CH{=}CHCH_2CH_3$ (D) $CH_3CH{=}CHCH_3$

5. Which of the following is not an electrophile (A) $H_2O{=}CH_2$ (B) H+(C) $CH_3CH{+}CH_3$ (D) $AlCl_3$

6. What product are obtained from oxidation of 2-hexene with warm $KMnO_4$ (A) acetate and butanone (B) aoetaldehyde and butanone (C) acelaldeliyde and butanal (D)Acetate and butanoate

7. What orbitals is used for the formation of C-H bond in ethane (A) C (sp) H(s) (B) $C(sp^2)$ H(s) (C) $C(sp^3)$ H(s) (D) $C(sp^2)H(p)$

8. What is the product of peroxide catalyseo hydroboration of 1methyl cyclohexene
(A) 4-bromo-1-methylcyciohexane ( B) 2-bromo-1-methylcyclohexane ( c) 1-bromo-1-cyclohexane
(d) 5-bromo~1-methylcyclohexarie
9. Which atomic orbital overlaps to form carbon -carbon triple bond (A) s+s;sp+sp;p+p (B) $sp^2{+}sp^2$, sp+sp; p+p (C) Sp+Sp;p+p:p+p (D) Sp+Sp;Sp+SP;P+P

10. Which of the following is most acidic (A) 1-butyne (B) 2-butyne (C) 1-butene (d) 2-butene

11. Which of the following will react with sodamine (A) cyclodecyne (b) 2-pentyne ( C) 2-butyne (D) 1-hexyne

12. Predict the product of the of 1-pentyne With excess $Br_2$ (A) 1,1-clibromo-1-pentno (B) 1,2-dibromo 1-pentene (C) 1,1,2,2-tetrabromopentane (D) 2,2-dibromo -1-pentene

13. A compound has a molecular formula $C_4H_6$ .When treated with excess hydrogen and a catalyst gave a compound $C_4H_{10}$ when treated with ammonical sliver nitrate a precipnate was formed. the compound is (A)1,3-butadiene( b) 2-butyne c) 1-bulyne (d) but-2-ene

14. Which reagent is a good nucleophile A) $NH_3$ B) HBr C) $Br_2$ D) $BH_3$

15. Compound A $C_4H_8Cl_2$ undergoes hydrolysis with aqueous KOH to give compound B. Compound B undergoes iodoform reaction to an oxime but does not react with tollens reagent. What is compound B (A ) 2-2-dichlorobutane (B) hexanone(C) 2-butanone (D) 3 pentanone

16. Which of these has the highest boiling point (A) $CH_3CH_2COOH$ (B) $CH_3CH_2OCH_2CH_3$ (C) $CH_3(CH_2)_3COOH$ (D)$CH_3CH_2CH_2CH_2OH$

17. All of the following will react with acid chloride to yield substituted amides EXCEPT ( A) $CH_3NH_2$ (B)$CH_3(CH_2)_5NH_2$ (C)$CH_3N(CH_3)CH_3$ (D)$CH_3CH_2$ $NHCH_3$

18. The following will release nitrogen on reaction with nitrous oxide except (A) Ethylamine (B) Diethylamine (C) methylamine (D)propylamine

19. Many amines in the liquid state have odours resembling that of (A) onion (B)garlic (C) rotten fish (D)fruits

20. The boiling points of amines are lower than those of alcohols of similar molecular mass because (A)amines do not contain oxygen atoms (B) amines cannot hydrogen bond to each other's (C)N-H hydrogen bonds are weaker than O-H hydrogen bonds (D) amines do not contain hydrogen

21. The process of converting one ester to another is called (A) Esterification (B)Transesterificatcn (C) Saponification (D)hydrolys

22. Give the name of the alcohol that will react with methyl propanoate to yield butyl propanoate in the presence of HCl (A) n-butanol (B) n-propanol (C) methanol (D) n-pentanol

23. A reversible process has the forward reaction as esterification, the backward reaction is (A) saponification (B)transesterification (C) decomposition (D) hydrolysis

24. These emit pale fumes of HCl when exposed to air due to reacting with moisture (A) carboxylic acid (B) acid chlorides (C) acid anhydrides (D) amides

25. Acid anhydrides have higher boiling points than the acids clue to (A) their large sizes (B) covalent bonds (C) hydrogen bonds (D)their small sizes

26. Which of these is a secondary amine? (A) $CH_3CH_2N(CH_3CH_2)CH_3CH_2$ (B) $CH_3CH_3NHCH_3CH_2$ (C) $CH_3CH_2NH_2$ (D) $CH_2CH_2N(CH_3)_2$

27. These homologues are identified by reaction with sodium bicarbonate, $NaHCO_3$ (A) amides (B) amines (C) carboxylic acid (D) nitriles

28. What type of orbital's are involved I C-O bonds in alcohols (A) $C(SP_2)$,o $(SP_2)$ (B)$C(SP)$,$O(SP_2)$ (C)$C(SP_2)$, O(SP) (D)$C(SP_3)$, O $(SP_3)$

29. Which of the following oxidation does one need to use pyridinum chlorochromate

A) Methanol to formic acid (A)Ethanol to acetic acid (B) ethanol to acetaldehyde (D) acetaldehyde to acetic acid

30. Which of the following constitutes lucas reagent (A)NaCl, HCl, $CuCl_2$ (B) HCl, $ZnCl_2$ (C) HCl, $SnCl_2$ (D) HCl,

31. Which of the following highest boiling point (A)$CH_3OCH_3$ (B) $CH_3CH_2OH$ (C) $CH_3CHCH_3$ (D) $CH_2{=}CHCH_3$

32. Which of the lowest solubility in water (A) pentanol (B) methanol (C) butanol (D) ethanol

33. Suppose you 3-phenyl -3-pentanol from an acid derivative, which acid derivative would you use(A) phenyl acetic acid anhydride(B) henzoic acid (C) phenyl acetic acid chloride (D) methyl benzoate

34. Which product is catalytic hydrogenation of 2,2-dimethyl -4-pentenal (A)2,2-dimethyl pentonal (B)2,2-dimethyl -3- pentanol (C) 2,2-dimethyl-4- pentanol (D) none of the above

35. Which compound can be reduced easily with sodium borohydride (A) amides (B) esters (C) aldehydes and ketones (D) alkenes

36. Which of the following is a good method for preparing aldehydes (A) Jones reagent and 1° alcohols( B) Jones reagent and 2° alcohols (C) PCC and 1° alcohols (D) $H_2SO_4$ and 1° alcohols

37. Which of the following aldehydes used alone will undergo aldol condensation (A) formaldehyde (B) butanal (C) benzaldehyde (D)2-propanal

38. An unknown compound on ozonolysis gave acetaldehyde and benzophenone. What is the unkown (A) 1,2 diphenyl propane (B)1,1-dipnenyl propene (c) 2-phenyl-2-hexene (D) 1,2-diphenyl hexane

39. What is the function of acid catalyat in the esterification of carboxylic acid (A) protonation of the carbonyl oxygen (B) protonation of the OH group (C) protonation of the caebonyl carbon (D) protonation of the OH oxygen of the carbonyl group

40. Which of the following reagent will not reduce the carboxylic acid to primary alcohol under mild condition (A) BH in ether (B)$NaBH_4$ in ethanol (C) $H_2O_2$ in water (D) $LiALH_4$ in ether

41. Which of the following will react with tollens reagent (A) formic acid (B) acetic acid (C) propanoic acid (D) butanoic acid

42. Which of the following has banana flavor (A) ethyl format (B) pentyl ethanoate (C) 3-ethyl ethanoate (D) octyl ethanoate

43. The ester with pineapple flavor is (A) ethyl format (B) pentyl ethanoate (C)3-methyl ethanoate (D) ethyl butanoate

44. Basic hydrolysis of esters is known as (A) saponification (B) acidification( C) esterification (D) acetylation

45. Which of the following acid derivatives is most stable (A) acid chlorides (B) esters (C) anhydrides (D) amides

46. Which of these is not affected by the lone pair of electron on an amine nitrogen (A) basicity (B) melting point (C) solubility (D)hydrogen bond formation

47. What is the product of the reaction between primary amines and acid chloride (A) an amine(B) an ester (C) an amide (D) secondary amine

48. Which of the following is least soluble in water (A) ethylamine (B) methylamine (C) propylamine (D) cyclohexylamine

49. Which of the following is a reagent in Gabriele amine synthesis (A) acyl or aryl halide (B) hydroxylamine (C)phthalimide D sodium azide

50. Which converts methyl bromide to ethylamine (A) NaCN, $LiAlH_3$,$H_2O$ (B) $NaNO_3$, HCl (C) large excess $NH_3$ (D) $NaN_3$ then catalytic hydrogenation

51. The molecular formula of a compound with molecular weight 62.07 and which contains 9 75% H. 38 7%C and 51 55% O is (A) $C_2H_6O_2$ (B) $C_4H_{12}O_4$ (C) $C_6H_{18}O_5$ (D) $C_5H_{14}O_{2s}$

52. When 0.9559 of an organic compound was burned, 1.919 of $CO_2$ and 0.7829 of water was produced The empirical formula is (A)$C_3H_7O_2$ (B)$C_4H_8O_2$ (C) $C_3H_6O$ (D)$C_2H_4O$

53. How many carbon atoms are contained in undecane (A) 10 (B) 11 (C) 12 (D) 13

54. A sample of methane weighing 9.67mg produced 26 53mg of CO; and 21 .56mg of $H_20$ what is the % composition of carbon (A) 68% (B) 74.9% (C) 78% (D) 47.93°

55. Give the schematic name for the compound $CH3(CH_2)_7CH_3$ (A) iso nonane (B) n- nonane (C) bis nonane (D) t-nonane

56. The structural formula of trichloroacetic acid is (A) $CH_3Cl_3$,COOH (B)$CCl_3COOH$ (C) $CHCl_3COOH$ (D)$CCl_2COOH$

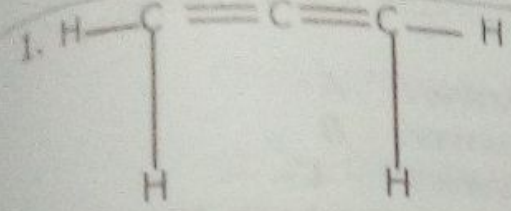
57. How many structural isomers are in this compound C4HmO (A) 6 (B) 7 (C) 8 (D) 9

58. The molecular formula CHOCl is called (A) formyl chloride (B) methyl chloride (C) ethanoyl chloride (D) butanoyl chloride

59. The following are various ways of drawing structural formula of an organic molecule except (A) displayed formula (B) 3D-structural formula (C) skeletal formula (D) semi-structural formula.

60. A reaction in which a carboxylic acid reacts with a base to form a salt and water is called (A ) saponification (B) neutralization (C)estenfication (D) hydrolysis

# SOLUTION TO 2017/2018 CHM102 EXAMINATION

1. 

There are 2 pi and 6 sigma orbitals present.

**Answer:** **A**

2. Alkane C C — ➡ 1.54A°

   Alkene C C = ➡ 1.34A°

   Alkyne C C ≡ ➡ 1.20A°

   Shortest carbon to carbon bond length is Alkyne.

   **Answer:** **C**

3. Alkenes decolorized bromine water in the presence of $CCl_4$.

   Also **cyclopropane** and **cyclobutane** reacts with bromine in the presence of $CCl_4$.

   **Answer: B**

4. For a compound to have a geometric isomer, the compound must

   i. Be an alkene or a cycloalkane

   ii. Not have the same two groups attached to the same carbon carrying the double bond.

   Like $CH_2 = CHB_r$

   This means that the two carbon atoms carrying the double bond must have different atoms or groups bonded to it.

   **Example:** $CHB_r = CHB_r$

   **Answer: A**

Compound "A" is incorrect.

**NB:** Another name for geo isomerism is Cis- trans isomerism.

5. **Answer: A**

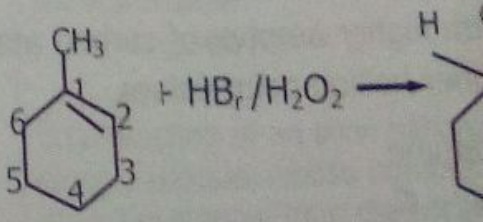
6. **Answer: D**

7. In C—H, the bond is a bond. Carbon uses hybridization in single bon hydrogen remains S.

   [NB:- H = $1S^1$]

   **Answer:C**

8. **Answer: B**




Anti- Mar

9. **Answer: C**

   SP + SP, P + P, P + P

10. Terminal alkynes are ac

    **Answer: A**

11. Terminal alkynes sodamine

    **Answer: D**

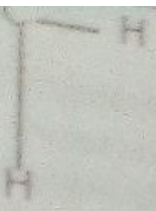
12. **Answer: C**

$CH_3\text{-}CH_2\text{-}CH_2\text{-}C \equiv C\text{—}H +$

$CH_3CH_2CH_2CBr_2CHBr_2$

13. Terminal alkynes ammonical silver nitra precipitate (Silver Mirro

    ***Answer:*** ***C***



2 pi and 6 sigma orbitals present.

**A**

C — → 1.54A°

C ≡ → 1.34A°

C ≡ → 1.20A°

arbon to carbon bond length is

**C**

colorized bromine water in the
$CCl_4$.

**opropane** and **cyclobutane**
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npound to have a geometric
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ne double bond must have
oms or groups bonded to it.

$CHB_r = CHB_r$
**: A**
is incorrect.

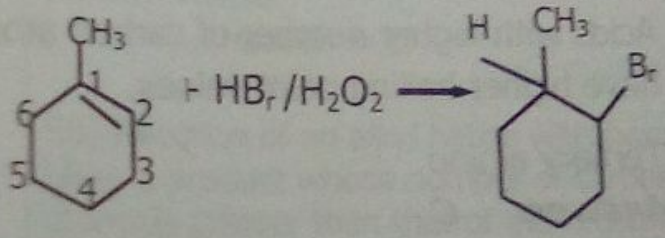
**NB:** Another name for geometric isomerism is Cis- trans isomerism.

5. **Answer: A**

6. **Answer: D**

7. In C—H, the bond is a single bond. Carbon uses SP3 hybridization in single bonds while hydrogen remains S.
[NB:- H = $1S^1$]
**Answer:C**

8. **Answer: B**




Anti- Markovnikoff's

9. **Answer: C**

SP + SP, P + P, P + P

10. Terminal alkynes are acidic

**Answer: A**

11. Terminal alkynes react with sodamine
**Answer: D**

12. **Answer: C**

$CH_3\text{-}CH_2\text{-}CH_2\text{-}C{\equiv}C\text{—}H + 2Br_2 \rightarrow$

$CH_3CH_2CH_2CBr_2CHBr_2$

13. Terminal alkynes react with ammonical silver nitrate to from a precipitate (Silver Mirror).
***Answer:*** ***C***

$H\text{-}C\equiv C\text{-}CH_2\text{-}CH_3 + 2H_2 \longrightarrow CH_3CH_2CH_2CH_3$

$(C_4H_6)$ $(C_4H_{10})$

The compound is **1- Butyne** $(C_4H_6)$

14. Ammonia is a good nucleophile

**Answer: A**

15. **Answer: C** (2-Butanone)

$CH_3CH_2\text{-}CCl_2\text{-}CH_3 + KOH_{(aq)} \longrightarrow CH_3CH_2C(OH)_2CH_3$

$(C_4H_8Cl_2)$

$CH_3CH_3C(OH)_2CH_3 \longrightarrow CH_3CH_2COCH_3 + H_2O$

(2-Butanone)

2- Butanone does not react with tollen's reagent.

16. ***Answer:*** ***C***

Acids with higher number of carbon atoms have higher boiling point values.

17. Tertiary amine

***Answer:*** ***C***

18. Only primary amines react with nitrous acid to release nitrogen.

***Answer:*** ***B***

Diethylamine is not a primary amine

19. Amines smell like a rotten fish

***Answer:*** ***C***

20. Both alcohols and amines can undergo hydrogen bonding but alcohols undergo hydrogen bonding more than amines.

***Answer:*** ***C***

21. ***Answer:*** ***B***

22. ***Answer:*** ***A***

Methylpropanoate + Butanol ⟶ butyl propamoate + methanol

23. ***Answer:*** ***D***

Acid + Alcohol ⟶ Ester + $H_2O$ **(Esterification)**

Ester + $H_2O$ ⟶ Acid + Alcohol **(Hydrolysis)**

24. ***Answer:*** ***B***

$CH_3COCl + H_2O \rightarrow CH_3COOH$

Here, moisture refers to water.

25. ***Answer:*** ***A***

26. ***Answer:*** ***B***

27. ***Answer:*** ***C***

Carboxylic acids react with NaH(

(Sodium bicarbonate) to give ou

28. C – O

The bond is a single bond in sir

$C = SP^3$, $O = SP^3$ ***Answer =***

(29) **Pyridinum chlorochron**

is used as a mild oxidizing age

an alcohol to an aldehyde.

***Answer = C***

(30) ***Answer = B***

$ZnCl_2$ in HCl

**Lucas reagent**

(31) ***Answer = B***

(32) The higher the number

atoms, the lower the solubil

compound. ***Answer = A***

(33). $CH_3CH_2 - \overset{\overset{O}{\|}}{C} - CH_2CH_3$

$\downarrow H+$

$CH_3CH_2 - \overset{\overset{OH}{|}}{C} -$

3 – Phenyl – 3 – pe

24. ***Answer:*** ***B***

$CH_3COCl + H_2O \rightarrow CH_3COOH + HCl$

Here, moisture refers to water.

25. ***Answer:*** ***A***

26. ***Answer:*** ***B***

27. ***Answer:*** ***C***

Carboxylic acids react with $NaHCO_3$ (Sodium bicarbonate) to give out $CO_2$ gas.

28. C – O

The bond is a single bond in single bonds,

$C = SP^3$, $O = SP^3$ ***Answer = D***

(29) **Pyridinum chlorochromate** (PCC) is used as a mild oxidizing agent to convert an alcohol to an aldehyde.

***Answer = C***

(30) ***Answer = B***

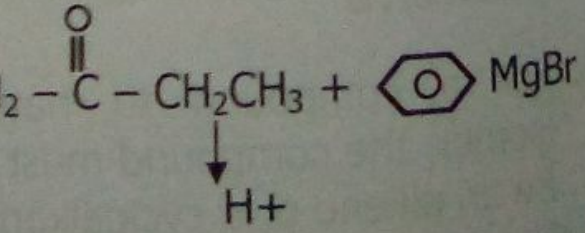
$ZnCl_2$ in HCl

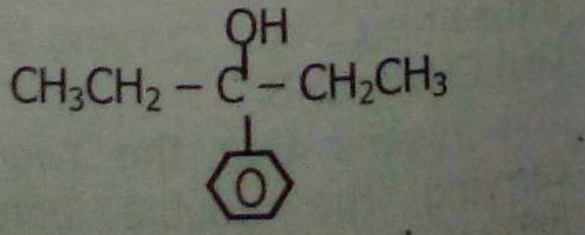
**Lucas reagent**

(31) ***Answer = B***

(32) The higher the number of carbon atoms, the lower the solubility of a compound. ***Answer = A***

(33).





3 – Phenyl – 3 – pentanol

(34). $H_2C = CHCH_2C($

$CH_3C$

(2, 2

(35) ***Answer = C***

(36) PCC + 1° Alcohol

***Answer = C***

(37) ***Answer = B***

$2CH_3CH_2CH_2CHO \rightarrow$

(39) ***Answer = A***

(40) **$NaBH_4$** can redu

reduce carboxylic acid

***Answer = B***

(41) Tollen's reagent

Tollen's reagent is **Ag**

(42) ***Pentylethanc***

both have banana fla

***Answer = B***

(43) ***Ethylbutan***

***Answer = D***

(44) Basic hydro

**saponification**

***Answer = A***

(34). $H_2C = CHCH_2C(CH_3)_2CHO$ + Reduction

$\downarrow$

$CH_3CH_2CH_2C(CH_3)_2CHO$

(2, 2 – Dimethylpentanal)

(35) ***Answer = C*** Aldehydes and ketones

(36) PCC + 1° Alcohol ⟶ Aldehyde
***Answer = C***

(37) ***Answer = B***
$2CH_3CH_2CH_2CHO \rightarrow CH_3CH_2CH(OH)CH(C_2H_5)$

(39) ***Answer = A***

(40) **$NaBH_4$** can reduce aldehydes and ketones but cannot reduce carboxylic acids.
***Answer = B***

(41) Tollen's reagent is used to detect aldehydes.
Tollen's reagent is **$Ag(NH_3)_2OH$**

(42) ***Pentylethanoate*** and ***3-methylbutylethanoate*** both have banana flavór
***Answer = B***

(43) ***Ethylbutanoate*** has pineapple flavour.
***Answer = D***

(44) Basic hydrolysis of an ester is called **saponification.**
***Answer = A***

(45) Amides are the most stat
carboxylic acids.
***Answer = D***

(46) Melting point
***Answer = D***

(47) 1° amines react with ac
amides
**Answer = C**

(48) The more the carb
the solubility.
***Answer = D***

(49) Gabriel's amine sy
***phthalimide***
***Answer = C***

50) Reaction of an alkyl
gives a product whose r
atoms is greater than th
one.
***Answer = A***

(51)

| | C | H |
|---|---|---|
| | 38.7 / 12 | 9.7 / 1 |
| | 3.225 / 3.222 | 9. / 3. |
| | 1 | 3 |

→ **Empirical = CH**
$[CH_3O]n = 62.07$

$n = \frac{62.07}{CH_3O} = \frac{62.0}{12+1x}$

Molecular formula =
**$= C_2H_6O_2$. Answe**

$)_2CHO$ + Reduction

↓

$H_2C(CH_3)_2CHO$

imethylpentanal)

ldehydes and ketones

Aldehyde

$(OH)CH(C_2H_5)$

des and ketones but cannot

detect aldehydes.

***ethylbutylethanoate***

neapple flavour.

ter is called

(45) Amides are the most stable derivatives of carboxylic acids.
***Answer = D***

(46) Melting point
***Answer = D***

(47) $1^{o}$ amines react with acid chlorides to form amides
**Answer = C**

(48) The more the carbon atoms, the lower the solubility.
***Answer = D***

(49) Gabriel's amine synthesis uses ***phthalimide***
***Answer = C***

50) Reaction of an alkyl halide with cyanide gives a product whose number of carbon atoms is greater than that of the reactant by one.
***Answer = A***

(51)

| | C | H | O |
|---|---|---|---|
| | 38.7 | 9.75 | 51.55 |
| | 12 | 1 | 16 |
| | 3.225 | 9.750 | 3.222 |
| | 3.222 | 3.222 | 3.222 |
| | 1 | 3 | 1 |

→ **Empirical = $CH_3O$**

$[CH_3O]n = 62.07$

$n = \frac{62.07}{CH_3O} = \frac{62.07}{12+1x3+16} = \frac{62.07}{31} = 2$

Molecular formula = $[CH_3O]n$

**= $C_2H_6O_2$. Answer = A**

(52) **Answer = D**

(53) ***Undecane*** is the hydrocarbon that has eleven (11) carbon atoms

C-C-C-C-C-C-C-C-C-C-C

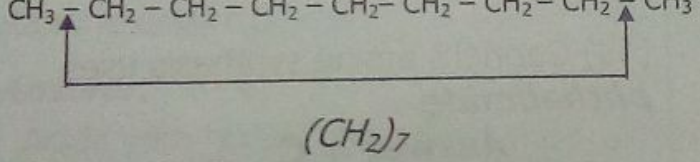
***Answer = B***

(54) Here, all we need to do is to find the mass of carbon present and then convert the mass to percentage.

Mass of carbon = $\frac{12}{144} \times 26.53 = 7.235$

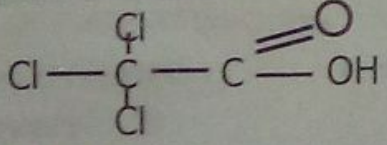
% of C = $\frac{7.235}{7.69} \times \frac{100}{} = 74.9\%$. ***Answer = B***

(55) $CH_3(CH_2)_7CH_3$



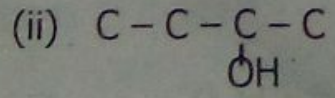
***Answer = B***

(56) Trichloroacetic acid



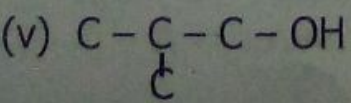
***Answer = B***

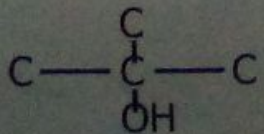
(57) (i) C – C – C – C – OH

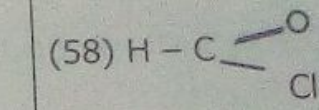
(ii) 

(iii) C – C – O – C – C

(iv) C – O – C – C – C

(v) 

(vi) 

(58) 

This is methanoyl chloride, a
formyl chloride

***Answer = A***

(59) ***types of formulae in***

*--structural formula*

*--condensed or semi-s*

*formula*

*--skeletal or line form*

*--three dimensional*

(60) Acid + Base ⟶ N

***Answer = B***

that has eleven (11)

he mass of carbon
rcentage.
235

**nswer = B**

$-CH_2-CH_3$

(58) H – C(=O)Cl

This is methanoyl chloride, also called formyl chloride

***Answer = A***

(59) ***types of formulae includes***

*--structural formula*

*--condensed or semi-structural formula*

*--skeletal or line formula*

*--three dimensional*

(60) Acid + Base ⟶ Neutralization

***Answer = B***