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Unit 2

Phase → A phase is a homogenous, physically distinct and Mechanically separable part of a system which is separated from other part of the system by definite boundaries.

Example

1) One phase system

A gaseous Mixture, being thoroughly Miscible in all proportion constitutes one phase only.

Example → A Mixture of N_2 & H_2 forms one phase only.

Two Miscible liquids (eg water & alcohol) constitute one phase only

A Solute completely dissolved in a solvent constitutes a single phase.

like salt in water. (Mohr's Salt)

2) Two phase System

If two liquid are immiscible eg (oil & water) they will constitute two separate phases.

ex) benzene & water.

3) Three phase System

At freezing point water consist of three phases

$$Ice\,(s) \rightleftharpoons Water\,(l) \rightleftharpoons Water\ vapour\,(g)$$

When $CaCO_3$ is heated in closed vessel, it decompose into CaO and CO_2 at equilibrium there are two solid and one gaseous phase so it is three phase system

$$\underset{(s)}{CaCO_3} \longrightarrow \underset{(s)}{CaO} + \underset{(g)}{CO_2}$$

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$Fe(s) + H_2O(g) \rightleftharpoons FeO(s) + H_2(g)$

There are two solid phases Fe and FeO and one gaseous phase consisting of $H_2O(g)$ and $H_2(g)$ Thus they are three phase exist in equilibrium

Q) Identify No. of phase

1) A bottle containing aqueous Solⁿ of ammonium hydroxide

Ans) 1

2) Ether and water contained in stoppered flask

Ans) 2

3) A Mixture containing powdered sulphur, sugar and urea

Ans) (Three) 3

4) Sulphur system $S_R = S_M = S_L = S_V$

Ans) 4

5) An aqueous solution of glucose

Ans) 1

6) Mixture of N_2 & O_2

Ans) 1

Component

It is defined as the smallest number of independently variable constituent at equilibrium by means of which the composition of each phase present can be expressed either directly or in the form of a chemical reaction

Ex→
One component System

a) Ice (s) = water (l) = water vapour (g)
It is a three phase
but the all has a same chemical component H_2O so they are one component System

b) $S(R) = S(M) = S(L) = S(V)$
phase 4
same sulphur composition so it is one component System

Two component System
$CaCO_3(s) = CaO(s) + CO_2(g)$
3 Phase (two solid + 1 gases)
but it is a two component system

$CaCO_3$	solid phase	$CaCO_3 = CaCO_3 + 0\ CaO$
CaO	solid phase	$CaO = 0\ CaCO_3 + CaO$
CO_2	gaseous phase	$CO_2 = CaCO_3 - CaO$

Here only two component are required to express the composition of each phase it is a two component System or **binary System**

$MgCO_3 = MgO(s) + CO_2(g)$

Calculation of No. of components

a) $\boxed{C = S - R}$ when No ions present

C → Component of System
S → Substances or No. of constituent
R → is the relation (No of equations relating to these constituent in an equilibrium state

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b) $\boxed{C = S - [R+1]}$

When ions are also present in the system then the condition of electroneutrality (No of +ve & -ve charges should be equal)

Q1) Predict the no. of component for dissociation of $KClO_3$ in a closed vessel (Same for $CaCO_3$, $MgCO_3$)

Sol) $2KClO_3(s) \rightleftharpoons 2KCl(s) + 3O_2(g)$

$R = 1$ (1 eqn only), $S = 3$

$C = S - R$

$= 3 - 1 = 2$

Q2) Predict No of component for dissociation of NH_4Cl on being heated alone in a closed system

Sol) $NH_4Cl \rightleftharpoons NH_3 + HCl$ — ①

$[NH_3] = [HCl]$ — ②

$R = 2$ $S = 3$

$C = S - R = 3 - 2 = 1$

$\boxed{\text{It is two Phase}}$

Q3) Predict the no of component when NH_3 and NH_4Cl is heated in a closed vessel along with HCl

Sol) $NH_4Cl \rightarrow NH_3 + HCl$ — ①

$[NH_3] \neq HCl$ — ②

$R = 1$, $S = 3$

$C = 3 - 1 = 2$

Q4) $CaCO_3(s)$, $CaO(s)$, $CO_2(g)$ when CaO and CO_2 in the system are formed exclusively by decomposition of $CaCO_3$

Sol) $CaCO_3 = CaO + CO_2$ $R = 1$, $S = 3$

$C = 3 - 1$

$C = 2$ Ans

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Q) Explain why $KCl - NaCl - H_2O$ should be regarded as a three component system whereas $KCl - NaBr - H_2O$ should be regarded as four component system.

Sol) $KCl - NaCl - H_2O$

$[KCl, NaCl, H_2O, K^+, Na^+, Cl^-]$ $S = 6$

$NaCl \rightarrow Na^+ + Cl^-$

$KCl \rightarrow K^+ + Cl^-$

$R = 2$

$C = S - [R+1]$

$= 6 - [2+1] = 3$

$KCl - NaBr - H_2O$

$[KCl, NaBr, H_2O, K^+, Na^+, Cl^-, Br^-, KBr, NaCl]$

$S = 9$

$NaCl \rightarrow Na^+ + Cl^-$

$KCl \rightarrow K^+ + Cl^-$

$K^+ + Br \rightarrow KBr$

$Na^+ + Cl^- \rightarrow NaCl$

$R = 4$

$C = 9 - (5) = 4$

Proved

Degree of freedom (Variance)

The minimum no. of independent variable (such as temperature, pressure and composition of the phase) which must be specified in order to define the system completely is called degree of freedom

Ex→ Ice $\rightleftharpoons$ water $\rightleftharpoons$ vapour $\boxed{F = 0}$

If $F = 0$ system is invariant or Non variant

If $F = 1$ system is univariant or Monovariant

If $F = 2$ system is bivariant, $F = 3$ System trivariant

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Phase Rule → Phase rule enables us to predict the condition that must be specified for a system to exhibit equilibrium

Gibbs Phase Rule

$\boxed{P + F = C + 2}$

$\boxed{F = C - P + 2}$

No of degree of freedom — No of component — No of phases

In Reduced Phase Rule If one variant fixed
$P + F = C + 2 - 1$
if two fixed
$P + F = C + 2 - 2$

Q) Calculate F

a) Solid Iodine in equilibrium with its vapour

Sol) $I_2(s) \rightleftharpoons I_2(v)$

$F = C - P + 2$
$= 1 - 2 + 2$
$= 1$

b) NH_3 at $42°C$

$F + P = C + 2 - 1$ (because on 42°C given)
$F + P = C + 1$
$F + 1 = 1 + 1$
$\boxed{F = 1}$

Phase diagram for water system (one component system)

$C = 1$
$P = 1$ (Minimum phase)
$F = C - P + 2$
$= 1 - 1 + 2$
$= 2$

Minimum $F = 0$
$F = C - P + 2$
$0 = C - P + 2$
$0 = 1 - P + 2$
$\boxed{P = 3}$

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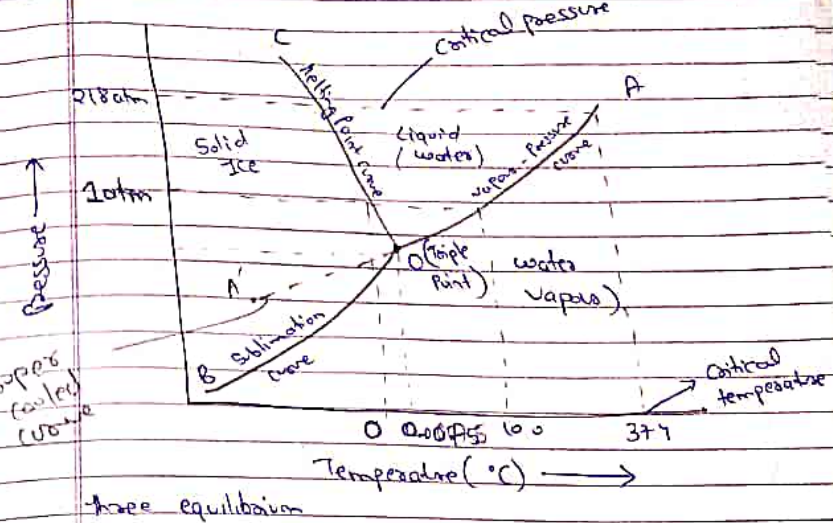

Three equilibrium
Solid ⇌ liquid
Solid ⇌ gas
Liquid ⇌ gas

Sublimation → Solid to gas directly

Critical temperature → इस temperature के बाद वह
Critical pressure — अपना state change कर देगा

Triple point → is a point जिस पर पानी की तीनों phases एक साथ exist कर सकती हैं।

OA curve $F = C - P + 2$
$F = 1 - 2 + 2 = 1$

OB curve $F = C - P + 2$
$= 1 - 2 + 2 = 1$

OC curve $F = 1 - 2 + 2 = 1$

Metastable equilibrium
at 0°C water change its state and become freezen
पानी को 0°C से नीचे temperature पर cool करना called super cooled water

at Triple point O = $F = C - P + 2$
$= 1 - 3 + 2 = 0$

अगर रखा Ice का Piece and तो वो अपना equilibrium change करेगा called meta

Phase Rule
water system
sulphur system

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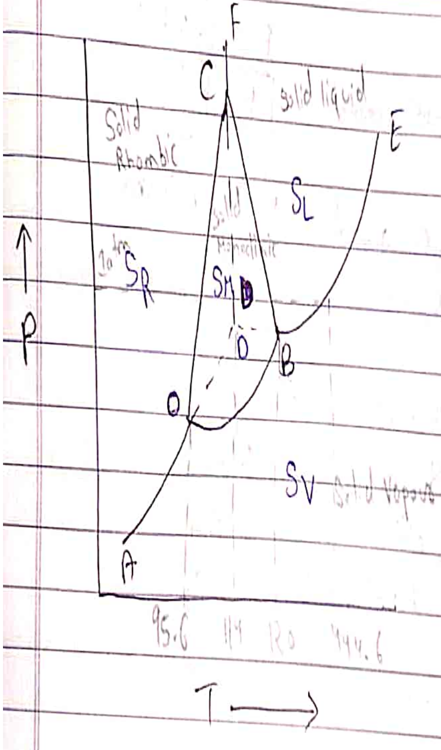
One component system
water system

Sulphur System

$S_R \rightleftharpoons S_M \rightleftharpoons S_L \rightleftharpoons S_L$
S S S S

C=1 because one component system है



Area (A)	Curve	Point
AOCF, COBC	OA, OB, BE	O, B, C
FCBE, AOBE	OC, BC, CF	D

C=1, P=1 (ek area में रहे हैं)

$F = C - P + 2$

$F = 1 - 1 + 2 = 2$

$\boxed{F=2}$

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for curves

OA ⇒ $S_R \rightleftharpoons S_V$ — equilibrium represents

OC ⇒ $S_R \rightleftharpoons S_M$
OB ⇒ $S_M \rightleftharpoons S_V$
BE ⇒ $S_L \rightleftharpoons S_V$
BC ⇒ $S_M \rightleftharpoons S_L$
CF ⇒ $S_R \rightleftharpoons S_L$

these are represents the equilibrium b/w the two phases.

$C = 1 \quad P = 2$ (Two area intersect)

$F = C - P + 2$
$F = 1 - 2 + 2$
$\boxed{F = 1}$
it is univariant

here
OA = Sublimation curve of S_R
OC = Transition curve of S_R to S_M

OB = Sublimation curve of S_M
BE = Vapour pressure curve
BC = Melting curve of S_M
CF = Melting curve of S_R

for points

O, B, C, D $\quad C = 1$
$P = 3$
$F = 1 - 3 + 2 = 0$ — for O, B, C — triple point

O $\quad S_R \rightleftharpoons S_M \rightleftharpoons S_V \quad$ 95.6°C $\quad$ 0.06 mm
B $\quad S_M \rightleftharpoons S_L \rightleftharpoons S_V \quad$ 120°C $\quad$ 0.07 mm
C $\quad S_R \rightleftharpoons S_M \rightleftharpoons S_L \quad$ 151°C $\quad$ 1288 atm

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Point D

S_R | S_L
D
S_V

→ Metastable ~~point~~ Triple point
114°C & 0.03 mm of Hg

Two component System

$F = C - P + 2 \quad$ Put $C = 2$
$F = C - P + 2 = 2 - P + 2 = 4 - P$
if $P = 1$
$\boxed{F = 3} \quad P, T, C$

$\boxed{F = C - P + 2}$ for one ~~phase~~ component system

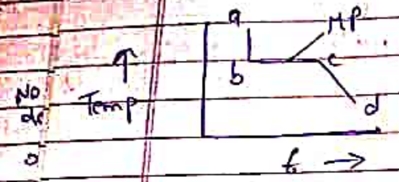
$\boxed{F = C - P + 1}$ for two component system

~~this is called Condensed phase rule~~
Reduced phase rule

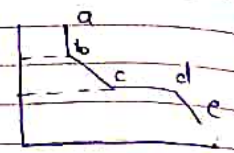
Solid $\rightleftharpoons$ liquid $\rightleftharpoons$ Reduce of system
Condensed system

Cooling curve

i) Pure Substance

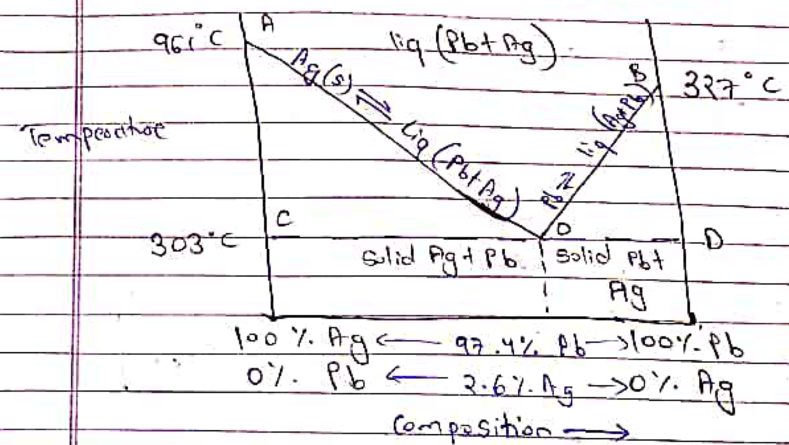


ii) Mixture of Substance



Two component System

Lead Silver System (Pb-Ag System)



Areas	Curves	Points
Above AOB	OA	A
Below line AO & OB	OB	B
Below line COD		O

A point is Melting point of silver (Ag) at 961°C

B point is Melting point of lead (Pb) at 327°C

O point is Eutectic point (below O all component solidify)

Area AOB $P=1$ $C=2$

$$F = C-P+1 = 2-1+1 = 2$$

Area below line AO & OB

AO $Ag(s) \rightleftharpoons liq(Pb+Ag)$

BO $Pb(S) \rightleftharpoons liq(Pb+Ag)$

$$F = C-P+1 = 2-2+1 = 1$$

Curve

OA $\quad Ag(s) \rightleftharpoons liq(Ag + Pb)$

OB $\quad Pb(s) \rightleftharpoons liq(Pb + Ag)$

$F = C - P + 1$
$= 2 - 2 + 1$

$\boxed{F = 1}$

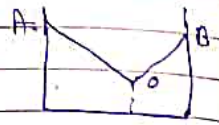
Area Below COD

$P = 2 \quad [Ag(s) + Pb(s)]$

$C = 2, \quad Ag, Pb$

$F = C - P + 1$

$F = 2 - 2 + 1 = 1$



Point O (has lowest Melting point)

Eutectic Point

Temp = 303°C

$C = 2 \quad P = 3$

$Ag(S) \rightleftharpoons Pb(S) \rightleftharpoons liq(Pb + Ag)$

$F = C - P + 1$

$F = 2 - 3 + 1 = 0$

Composition (97.4% ~~Ao~~ Pb, 2.6% Ag)

Eutectic point → Two curve AO & BO intersect at point O at Temp 303°C. This point is known as eutectic point.

Desilverization of anti ferrous Lead
(Pattinson's Process)

~~Euth~~

Eutectic System A binary system consisting of two substances which are miscible in all proportion in the liquid phase & do not react chemically.

Eutectic Mixture → The two substance involved have the property of lowering each other freezing point. Solid sol^n of two or more substance having the lowest freezing point of all the possible mixture of the component is known as Eutectic Mixture.

The process of heating argentiferous lead containing a very small quantity of Ag (0.1%) and cooling it to get pure lead and liquid rich in silver is called Pattinson's Process

Two Component chemical reaction

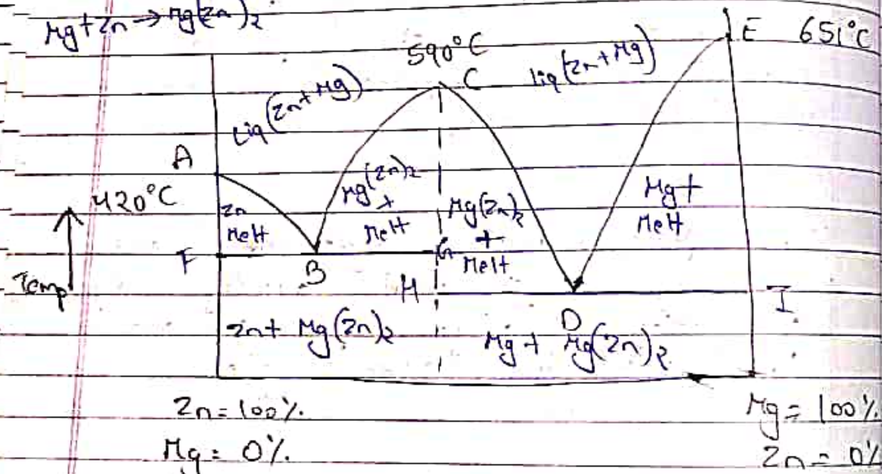
No → ~~Eut~~ Eutectic system (Miscible in all proportion) Pb - Ag

Yes →

- ~~Compound~~ Congruent compound (Same Composition) (Zn - Mg)
- Incongruent compound (Different Composition in both pha[ses]) (Na - K)

<u>Zn - Mg system</u>

$Mg + Zn \rightarrow Mg(Zn)_2$



<u>Points</u>

A → MP of Zn 420°C
C MP of $Mg(Zn)_2$ ~~420~~ 590°C
E MP of Mg → 651°C

$C = 2,\ P =$
$F = 2 - 2 + 1 = 1$

B Eutectic point 347°C

$Zn(s) \rightleftharpoons Mg(Zn)_2(s) \rightleftharpoons liq(Zn + Mg)$

$C = 2 \quad P = 3 \quad F = 2 - 3 + 1 = 0$

D → Eutectic point 347°C

$Mg(s) \rightleftharpoons Mg(Zn)_2 \rightleftharpoons Melt(Mg + Zn)$

Curve (Univariant)

AB $Zn(s) \rightleftharpoons liq(Zn + Mg)$
BC $Mg(Zn)_2 \rightleftharpoons liq(Zn + Mg)$
CD $Mg(Zn)_2 \rightleftharpoons liq(Zn + Mg)$
DE $Mg(s) \rightleftharpoons liq(Zn + Mg)$

$C = 2 \quad P = 2$
$F = C - P + 1 = 2 - 2 + 1 = 1$

<u>Area</u>

ABFA
BGCB
CHDC
EDIE

$P = 2 \quad C = 2 \quad F = 2 - 2 + 1 = 1$

Area above ABCDE $P = 1 \quad C = 2 \quad F = 2 - 1 + 1 = 2$

Area below FBG & HDI

$C = 2 \quad P = 2$
$F = 2 - 2 + 1 = 1$

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freedom

Polymer

Polymer — Many Parts/unit   Mono mer — Single Part/unit

It is composed a large no. of repeating unit of identical structure called Monomer (Combination or large ~~chain~~ chain of Monomer forms polymer)

Q/-)

$$n\,CH_2 = CH_2 \longrightarrow -\!\!\left(CH_2 - CH_2\right)\!\!-$$

ethene — Monomer   Polyethene — Polymer

Polymer

- Natural — Cellulose, Protein, Silk
- Synthetic — Nylon, plastics

Degree of Polymerization The no. of repeating units in a chain formed in a polymer is called degree of Polymerization.

Degradation of Polymer (Breakdown of Polymer)
Breakdown of Polymer by heat called Thermal degradation if by water it is called Hydrolytic degradation
if by Microorganism it is called Biodegradation
if by light it is called photo degradation
if by oxygen is called Oxidative degradation

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Environmentally Biodegradable Polymer
A polymer based on the C-C backbone tends to be Non biodegradable whereas hetero atom containing polymer backbones confer biodegradability.

Biodegradable Polymers Degradation Caused by Biological activity (Microorganisms)

Example a) (PHB) poly hydroxy butyrate
b) (PVOH) poly vinyl alcohol
c) PLA Poly Lactic acid

Classification of Polymer
1) On the Basis of origin

Natural
Starch
Protein
Cellulose

Semisynthetic
ex-) Rayon

Synthetic
PVC, Nylon
Polyethylene
etc

2) On the basis of chemical structure

Homopolymer
Consist same Monomer
ex-) Vinylchloride → PVC
ethylene → Polyethylene

Copolymer
or
Hetero polymer
Consist More than one type of Monomer

3) On the Basis of polymeric structure Nylon 6,6

Linear polymer
High density
- A - A - A - A -

Branched Polymer
low density
A - A - A - A
A' A'

Cross linked polymer
~~Natural~~ Network
A - A - A - A - A - A
A - A B' A - A - B' A' - A

4) On the Basis of Thermal Behavior

Thermoplastic — Thermosetting

Mechanism of Polymerization

① Additive Polymerization — ② Condensation Polymerization

1) Free radical addition polymerization

Step 1 chain initiation

$$I_2 \longrightarrow 2\dot{I}$$

$$\dot{I} + CH_2 = \underset{X}{\underset{|}{CH_2}} \longrightarrow I-CH_2-\underset{X}{\underset{|}{\dot{C}H_2}}$$

Step 2 chain propagation

$$I-CH_2-\underset{X}{\underset{|}{\dot{C}H_2}} + CH_2 = \underset{X}{\underset{|}{CH_2}} \longrightarrow ICH_2-\underset{X}{\underset{|}{CH_2}}-CH_2-\underset{X}{\underset{|}{\dot{C}H_2}} + CH_2 = \underset{X}{\underset{|}{CH_2}}$$

(PE)

Step 3 chain termination

$$ICH_2-CH_2-CH_2\underset{X}{\underset{|}{\dot{C}H_2}} + \underset{X}{\underset{|}{\dot{C}H_2}}CH_2CH_2CH_2I \longrightarrow ICH_2CH_2CH_2\underset{X}{\underset{|}{CH_2}}\underset{X}{\underset{|}{CH_2}}CH_2CH_2CH_2I$$

2) Ionic Mechanism (cationic or anionic)
3) Coordination Mechanism
(In the presence of organometalic compound)
(as Ziegler Natta catalyst)

Polymer Functionaility

The No of reactive sites in a Molecule is termed as functionality
for Molecule to act as Monomer it must have at least two reactive sites then its functionaility should be two

example

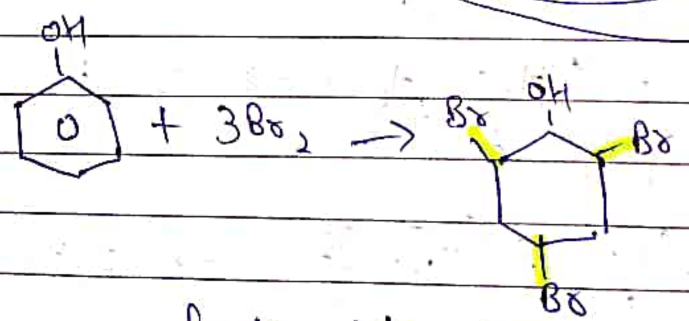
a) $CH_2=CH_2 + H_2 \longrightarrow H-CH_2-CH_2-H$

Here $-CH_2-CH_2-$

functionality = 2

b) $CH \equiv CH + 2Cl_2 \longrightarrow Cl-\underset{Cl}{\underset{|}{CH}}-\underset{Cl}{\underset{|}{CH}}-Cl$

functionality = 4 $\quad -\underset{|}{CH}-\underset{|}{CH}-$

c) 

functionality = ~~4~~ 3

Note Monomer has functionality = 2 it is linear polymer

Monomer has functionality = 3 it is cross linked polymer

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Molecular weight of polymer

Two ways

① Number average Molecular weight (M_n)

$n_1 n_2 n_3$ --- are No of Molecules & Molecular Mass $M_1 M_2 M_3$ ---

$$\overline{M_n} = \frac{n_1M_1 + n_2M_2 + n_3M_3 ---}{n_1 + n_2 + n_3}$$

$$= \frac{\text{Total Mass of Polymer}}{\text{Total No. of Molecules}}$$

② weight average Molecular weight

If $m_1 m_2 m_3$ --- are weight of ~~its~~ species $M_1 M_2 M_3$ --- ~~weig~~ Molecular Mass

$$M_w = \frac{m_1M_1 + m_2M_2 + m_3M_3}{m_1 + m_2 + m_3}$$

Polyethylene (Addition Polymers)

Polyethylene also known as polyethene, it is important thermoplastic resin ~~propa~~ prepared by the addition polymerization of ethylene.

Types

a) Low density polyethene (LDPE)
b) High density polyethene (HDPE)
c) Linear low density polyethene (LLDPE)
d) Ultra high Molecular weight polyethene (UHMWPE)

1) Low density polythene (LDPE)

Preparation

High Temperature & ~~Low~~ pressure

$$\cancel{(CH_2 = CH_2) \longrightarrow (CH_2 - CH_2)_n}$$

$$\underset{\text{ethene Monomer}}{n\,H_2C = CH_2} \xrightarrow[\text{free Radical Mechanism}]{350-570\,K,\ 1000-2000\,atm} \underset{\text{Polythene}}{-(H_2C - CH_2)_n-}$$

Property
a) Low density
b) weak intermolecular force
c) chemically inert
d) Branched
e) Soft

Uses
a) soft Toys
b) squeeze bottles

2) High density polythene (HDPE)

Preparation

It can be obtained from ethene monomers by using zeigler Natta catalyst ($TiCl_4 + AlR_3$) low temperature & pressure

$$\underset{\text{ethene Monomers}}{n\,H_2C = CH_2} \xrightarrow[\text{Zeigler Natta Catalyst}]{333-343\,K,\ 5-7\,atm} \underset{\text{Polythene}}{-(H_2C - CH_2)_n-}$$

Property
a) Hard
b) High density
c) Unbranched

Uses
1. Bucket
2. Dustbins
3. Bottles, pipes

c) LLDPE (Linear low density polyethylene)

It is actually a copolymer of ethylene and 1 butene manufactured with Ziegler type catalyst
• LLDPE is attractive because it requires less energy to produce than LDPE.

Uses
a) Golf ball cover Making
b) Bottles

d) UHMWPE (ultra high Molecular - weight polyethylene)

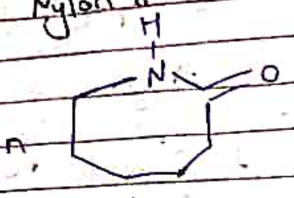
UHMWPE sheet is cut into small block to be used as a brake
UHMWPE is a successful bio material for use in hip knee
UHMWPE is used for Manufacturing of Hydraulic seals
It is used in Making ~~surgical~~, Machine parts.

Polymer Synthesis
1. Condensation polymerization
2. Addition Polymerization

1. condensation polymerization
→ for condensation polymerization Monomers should have at least two functional groups
Both functional group may be same or not
→ Monomers having two functional groups always give linear polymer
→ Monomer having three functional group always give cross linked Polymer

✱ All resins are cross linked polymer & all cross linked polymer are condensation polymers.

1) Nylon 6



$$\xrightarrow{-H_2O} \left(-\overset{O}{\overset{\|}{C}}-NH(CH_2)_5 - \right)_n$$

Caprolactum (Nylon 6) polyamide

Same type of Monomers combined together called Homo polymerization (Self polymerization)
→ Removal of water Molecule
→ Six Carbon atom present in the Monomer So this polymer is called Nylon-6
→ It is used for Manufacture of tyre cords and ropes

2) Nylon 66

$$n\ H_2N-(CH_2)_6-NH_2 + n\ HOOC-(CH_2)_4-COOH$$

Hexa Methylene diamine

$$\downarrow$$

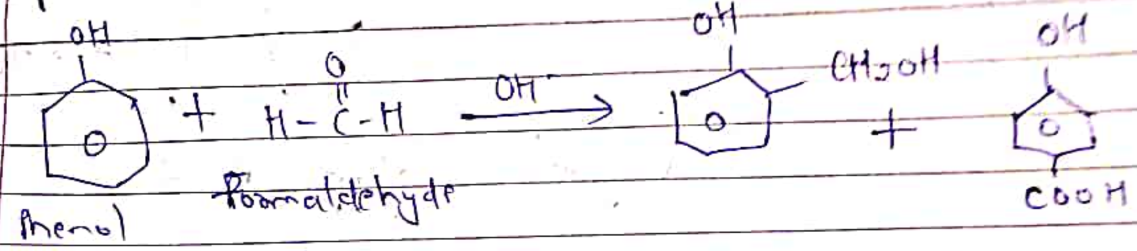
$$nH_2O + \left(-\overset{H}{\overset{|}{N}}-(CH_2)_6-\overset{H}{\overset{|}{N}}-\overset{O}{\overset{\|}{C}}-(CH_2)_4-\overset{O}{\overset{\|}{C}}- \right)_n$$

Polyamide (Nylon 66)

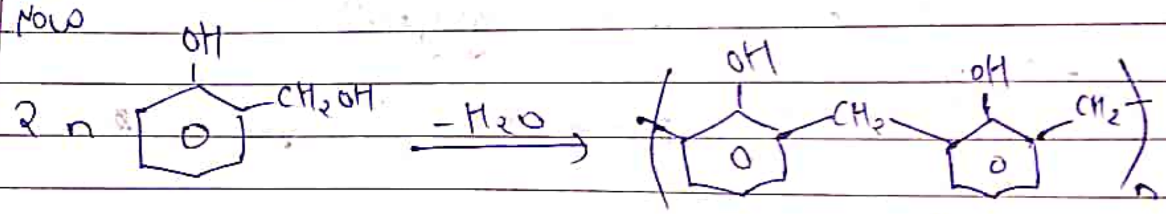
If different types of Monomers combined together called copolymerization with the elemination of H_2O
Both Monomers have 6 carbon atom so it is Nylon 66

Uses → Sheets, brushes, textiles

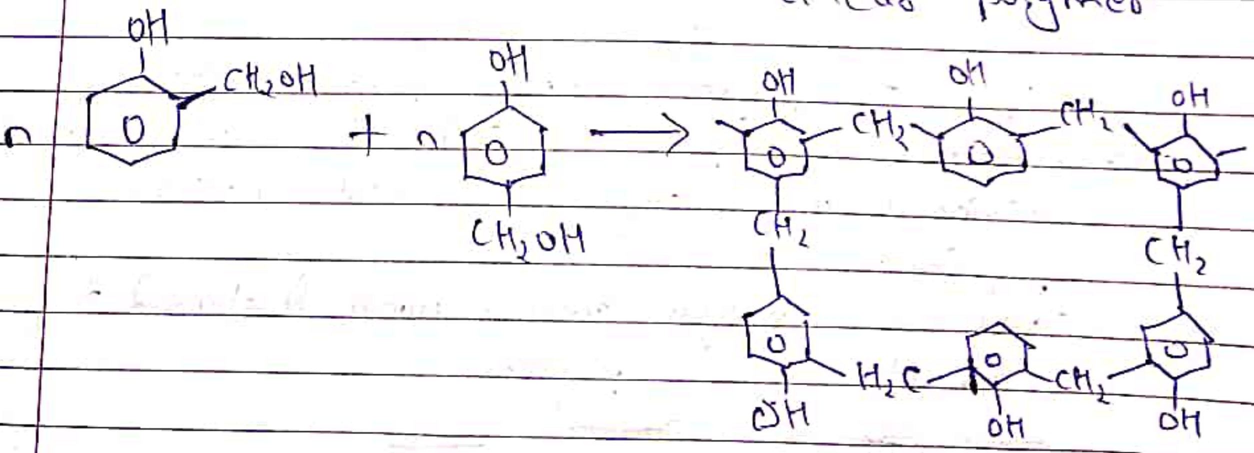
c) Phenol - formaldehyde resin (Bakelite)
→ Starting material is phenol and formaldehyde in the presence of basic catalyst these two combine & give either ortho & para hydroxy methyl phenol.
→ This ortho para hydroxy methyl phenol go condensation to produce cross linked polymer bakelite involving methylene bridges in ortho para or both ortho & para position.



Now



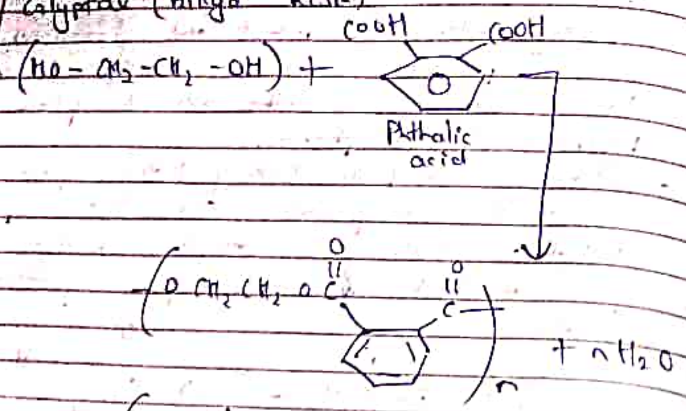
Linear polymer



Phenol formaldehyde resin (Bakelite)

Cross linked polymer

4) Glyptal (Alkyd Resin)



(Polyester) glyptal Resin

→ Copolymerization condensation with elemination of H_2O form glyptal

→ uses

① Manufacture of paints

Speciality Polymers

Specialty polymer are polymer having ~~Engineering~~ properties and characteristics specially designed for engineering and Medical purposes.

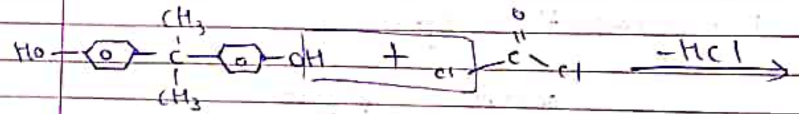
They are ranged from Mono functional to Multifunctional polymers.

~~Main classes~~ ~~and~~ Uses

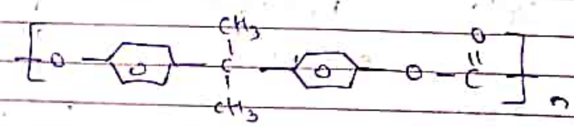
1) It is used in automobile idustry for Making Motorcycle, Safety helmets etc.
2) It is used for Making furniture, camera etc
3) Due to its temperature resistance, stability and chemical inertness it finds use in Manufacturing of Baby bottles etc
4) It is used for Molding for computers, CDs, DVD, hair driers etc

1) Polycarbonate (or Engineering thermoplastics)

commonly known as Lexon or Merlon obtained by reacting Bisphenol A with diphenyl Carbonate or Carbonyl chloride



Bisphenol A Carbonyl chloride



Poly carbonates

Properties

a) High impact Strength
b) Highly transparent (about 88%)
c) Good heat resistant
d) Low combustibility
e) High Melting point
f) Good thermal Stability

Application

1) Data storage
2) Electrical and electronic components.
3) Construction Material

3) Conducting polymers

Some polymers have been synthesised which have high planarity and conjugation of π e⊖ so these polymers are known as conducting polymers.

Application

i) In rechargable light weight batteries
ii) In transistor, photodiodes & LEDS
iii) Used in photovoltaic devices
iv) use in solar cells
v) telecommunication systems

Conducting polymer ↓

- Aromatic Cycle
  - Presence Heteroatom
    - Nitrogen containing — ex→ PPY
    - Sulfur containing — ex→ PT, PEDOT
  - absence Heteroatom — ex→ poly fluorenes
- Double bond — ex→ PAC
- Aromatic cycle and double bonds — ex→ PPV

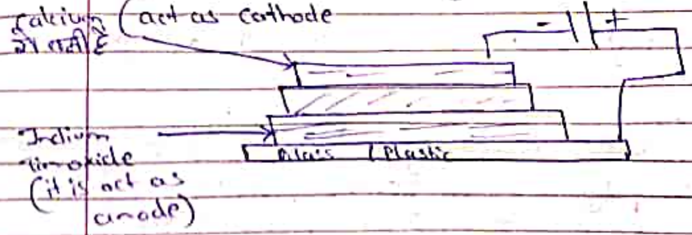
PAC Polyacetylene ⋀⋀⋀⋀ Conductivity 10^5

3) Electroluminescent Polymers

Electroluminescence is a phenomena in which a material emit light in response to the passage of an electric current or strong electric field

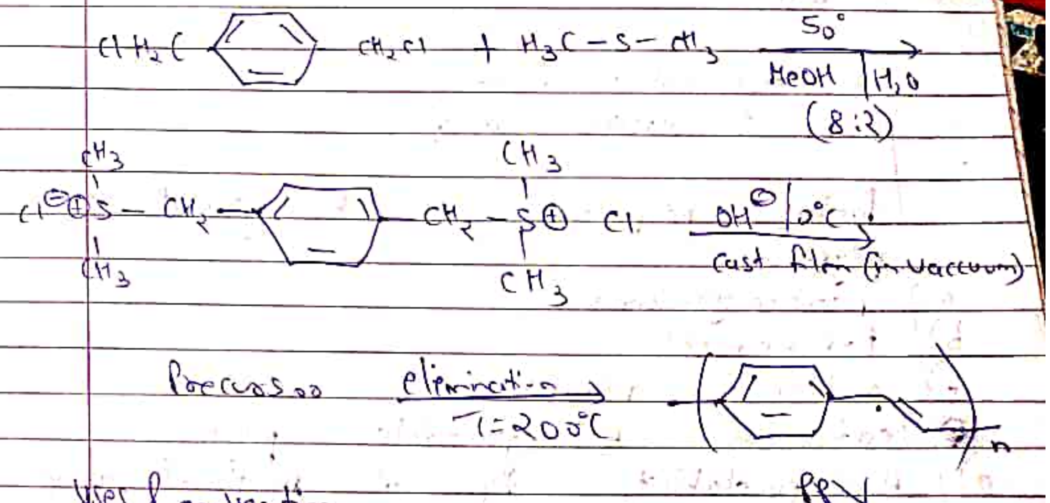
ex→ PPV (Poly phenylene vinylene)
These polymer are used in LED

Polymer Light Emitting diode (PLED)



b/w cathode & anode a electroluminescent polymer layer has been putted when current pass it emit light. The energy gap b/w these and conduction band of आने से e⊖ transfer होते & electricity flow and conductivity occurs and light emits

PPV Preparation



Uses & application

① PLED

4) Liquid crystalline polymers
Liquid crystalline polymer are those polymers that are capable of forming regions of highly ordered structure while in liquid phase.
It has high Mechanical Strength at high temperature.
High heat stability & flexibility
A very commonly known liquid crystalline polymer is Kevlar. It is an aromatic polyamide. It is prepared by the polycondensation of aromatic dichloride and aromatic diamines.

Uses
1) It is used in aerospace and aircraft industries
2) It is used in the fabrication of protective wear including bullet proof vests.

Biodegradable Polymer
(Same as starting wala)

factors Responsible for biodegradation of polymer:
a) Microorganisms
b) Environment
c) Nature of Polymer

Features of Biodegradable polymers
a) Biodegradability depend on functional group
eg→ ester > ether > amide

3) Hydrophilic has more degradable than hydrophobic
3) Amorphous are more degradable than crystalline

Classification

Natural Biopolymers	Biosynthesis Biopolymer	Synthetic Biopolymer
obtain from plant & animal	obtained from microorganisms	Produced synthetically
ex→ Cellulose	eg→ PHB, PHV	

Application
1) Used as food Packaging
2) Used in agriculture

Example
1) PHB (Polyhydroxy butyrate)
produced by fermentation of glucose by bacteria
2) PHV
3) PHBV