INDEX

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# Inorganic chemistry Notes

"kishor. publications"

04-04-2020 : Saturday.

My own Notes.

- m.R. kuy

put me to the Bottom

And

I'll work in my way to

Reach Top

- Kicchakishor

[m.R. kuy]

# Coordination Compounds

These are the complex salts in which the metal ion accepts a pair of electron from which of molecule (or) ion ligand involved in the formation of co-ordinated co-valent bond.

**Ligands:** The molecule (or) ion containing lone pair of electron forming co-ordinate with the central metal atom.

Classification.

1) **monodentate Ligand:** It contains a pair of electron forming one co-ordinate bond.

Ex: $C_6H_5MgX$.

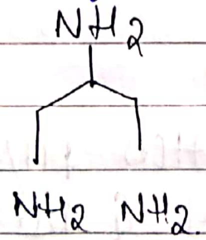
2) **Bidentate Ligand:-** It contains 2 pair of electron forming 2 co-ordinate bond

Ex: $H_2N-CH_2-COO^-$

Glycinate ion.

3) **Tridentate Ligand:** It contains 3 pair of electron forming of 3 co-ordinate bond.

Ex:



1,2,3-triamino propane.

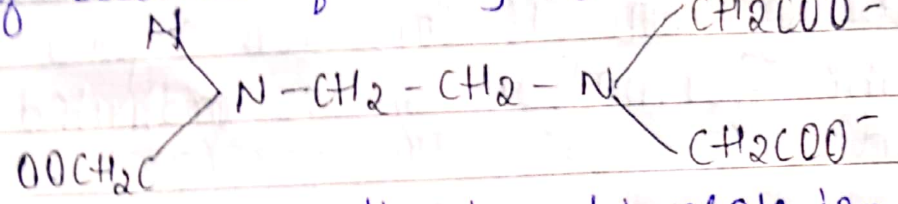
4) **Tetradentate Ligand:** It contains 4 pair of electron forming of 4-co-ordinate bond.

Ex:

$$N \begin{cases} CH_2COO^- \\ CH_2COO^- \\ CH_2COO^- \end{cases}$$

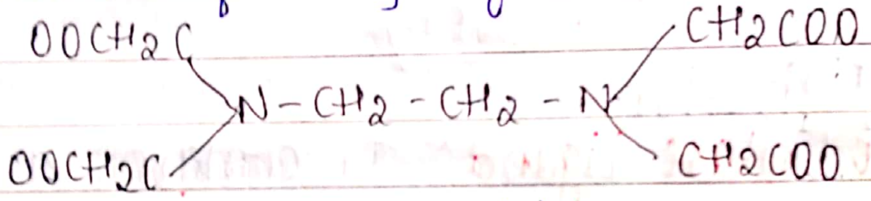
Nitriotriacetate ion

5) **pentadentate ligands:** It contains 5 pair of electron forming of 5-coordinate bond



Ethylenediamine triacetate ion.

6) **Hexadentate ligands:** It contains 6 pair of electron forming of 6-coordinate bond.



Ethylenediamine tetracetate ion (EDTA)

7) **Ambidentate ligands:** A ligand which can bond with a metal atom through more than one site

Ex: $:NO_2$ & $ONO:$

→ **Coordination no:-** The number of Ligands attached to central metal ion through co-ordinate bonds.

Nomenclature

* Name of cation is written first then name of anion is written first & then name of metal ion is written.
* In complex ion, name of ligand is written first & then name of metal is written.
* In dlf ligand are present, their names are written in alphabetic order.

* when complex is anionic, name of metal ion is ended with 'ate'
* Bridging ligand is represented by symbol 'μ' before the name.
* Geometrical isomers are indicated by writing cis or trans before the name.

Ex:- Dimethyglyoximato - DMG.

$[Ag(NH_3)_2]Cl$ = Diammine silver(I) chloride.
$[Co(NH_3)_6]Cl_3$ = Hexaamine (III) Chloride.
$K_3[Fe(CN)_6]$ = potassium chromium (III) chloride.
$[Ni(CO)_4]$ = Tetracarbonyl nickel (0)
$[Ni(NH_3)_6]Cl_2$ = hexaaminenickel (II) chloride.
$K[BF_4]$ = pottasium tetra floroborate (III).
$[Fe(H_2O)_6]SO_4$ = Hexaaquairon (II) Sulphate.
$Na[Au(CN)_2]$ = Sodiumdicyanoaurate (I)
$[Cr(H_2O)_6]Cl_3$ = Hexaaquachromium (III) chloride.

→ Werner's theory.

postulates:

* The metal consists of 2 type of valencies
  a> 1° valency (or) ionisable valency
  b> 2° valency (or) non-ionisable valency.

* In a complex both valencies of metal are satisfied.
* Each metal has fixed no of 2° valencies.
* Neutral molecules or anions satisfy 2° valency & are oriented in define direction of space.

Merits :

* It explain the formation of co-ordination compounds
* It explains the geometery of complex.

Demerits

* It doesn't give explaination for excistence of 2 type of valencies
* It couldn't be justified in light of electronic theory.

→ Sidgwick theory / Effective atomic number [EAN rule].

According to this rule the central atom of co-ordination compounds accepts lone pair of electron donating by ligands till the total number of electron is equal to the atomic number of that period.

Calculation of EAN of central metal atom

EAN = Z − X + Y

where, Z = Atomic no
X = oxdⁿ. state of metal ion
Y = Total number of electron donate by ligand.

1) $K_4[Fe(CN)_6]$

$Z - X + Y$

$= 26 - 2 + (6 \times 2)$

$= 24 + 12$

$= 36$

* Hence it obey EAN rule
* The molecule is diamagnetic

2) $K_3[Fe(CN)_6]$

$Z - X + Y$

$= 26 - 3 + (6 \times 2)$

$= 23 + 12$

$= 35$

* The complex doesn't obey EAN rule
* The molecule is paramagnetic.

3) $[Cu(NH_3)_4]SO_4$

$Z - X + Y$

$= 29 - 2 + (4 \times 2)$

$= 27 + 8$

$= 35$

* The complex doesn't obey EAN rule.
* The molecule is paramagnetic

4) $[Pt(NH_3)_6]Cl_4$

$Z - X + Y$

$= 78 - 4 + (6 \times 2)$

$= 74 + 12$

$= 86$

* Hence it obey EAN rule
* The molecule is diamagnetic.

## Valence bond theory

These theory was mainly due to pauling & slater (1935)
It deals with electronic configuration of CMI in its ground state, kind of bonding, geometery & magnetic properties of complexes

postulates of VBT:

- CMI must contain number of empty s, p & d-orbitals equal to its co-ordinator number
- These vacant orbitals undergo hybridisation to form hybrid orbitals.
- vacant hybrid orbitals are equivalent in energy & have definite geometery
- Each ligand has atleast one orbital containing lone pair of $\bar{e}$ to donate to empty hybrid orbital of CMI to form co-ordinate bond
- The geometery of the molecule is decided by the character of the hybrid orbitals.
- Metal cation are formed by loss of valence electron.

octahedral complexes.

1) Hexaflurocabaltate (III) ion $[CoF_6]^{3-}$.

The elements Co has the outer electronic configuration $3d^7 4s^2$ & $Co^{3+}$ ion has the outer electronic configuration $3d^6 4s^0$ which may be represented as.

| ↑↓ | ↑ | ↑ | ↑ | ↑ | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3d | | | | | 4s | 4p | | | 4d | | | | | | |

A ligand orbital containing a pair of $\bar{e}$ overlaps with an empty orbital of the metal ion to form a co-ordinate bond which is shown diagrammatically below & the $\bar{e}$ from ligands are shown as xx.

| ↑↓ | ↑ | ↑ | ↑ | ↑ | | xx | xx | xx | xx | xx | xx | | | | |

$sp^3d^2$ hybrid orbitals  unhybridised

These are unpaired electron in the complex. hence it is paramagnetic in nature

2) Hexaamine cobalt (III) $[Co(NH_3)_6]^{3+}$

The pairing of 3d orbital electrons take place at the approach of ligands as shown

| ↑↓ | ↑ | ↑ | ↑ | ↑ | $\xrightarrow{\text{on approach of ligands}}$ | ↑↓ | ↑↓ | ↑↓ | | |

3d  3d

for octahedral arrangement the 6 empty orbitals needed are made available by hybridisation of two 3d, 4s & three 4p orbitals. this is called $d^2sp^3$ hybridisation.

| ↑↓ | ↑↓ | ↑↓ |   | xx | xx | xx | xx | xx | xx |

unhybridised  $d^2sp^3$ hybrid orbitals

There are no unpaired electron in the ion & its diamagnetic nature.

- Square planar complexes.

$[Ni(CN)_4]^{2-}$

Ni(II) complex ions generally have CN 4. Nickel has atomic number 28 & $Ni^{2+}$ ion has outer electronic configuration $3d^8$ which may represented as

| ↑↓ | ↑↓ | ↑↓ | ↑↓ |

for $dsp^2$ hybridisation, an empty d orbital should be available. this possible if pairing of two of the d electron takes place.

| ↑↓ | ↑↓ | ↑↓ | ↑↓ | |   | | | | |   | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3d | | | | | | 4s | | | | | 4p | | | |

| ↑↓ | ↑↓ | ↑↓ | ↑↓ | xx | xx | xx | xx |

unhybridised      $dsp^2$ hybrid orbital.

No unpaired electron, the complex ion is Diamagnetic. & it is square planar

## Limitations of VBT:

* It can not be extended quantitavely.
* does not explain characteristic absorbtion spectra of coordination compounds
* does not explain the relative stabilities of diff structures
* fails to account for the thermodyanic properties of coordination compounds.
* It cannot interpret the colour of complexes
* It does not explain magnetic behaviour of complexes.

# Crystal field theory

The CFT is an electrostatic model which considered the metal-ligand bond to be ionic arising purely from electrostatic interactions b/w the metal ion & the ligand.

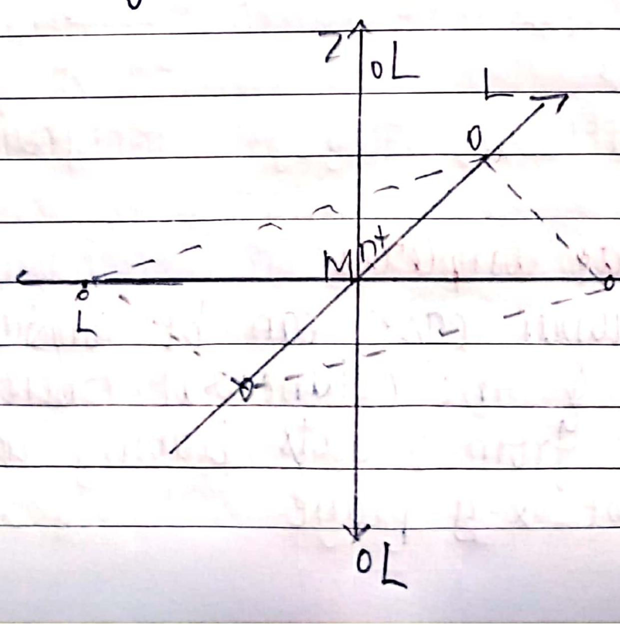
Ligands are treated as point charges in case of anion (or) dipoles in case of neutral molecules.

## Features

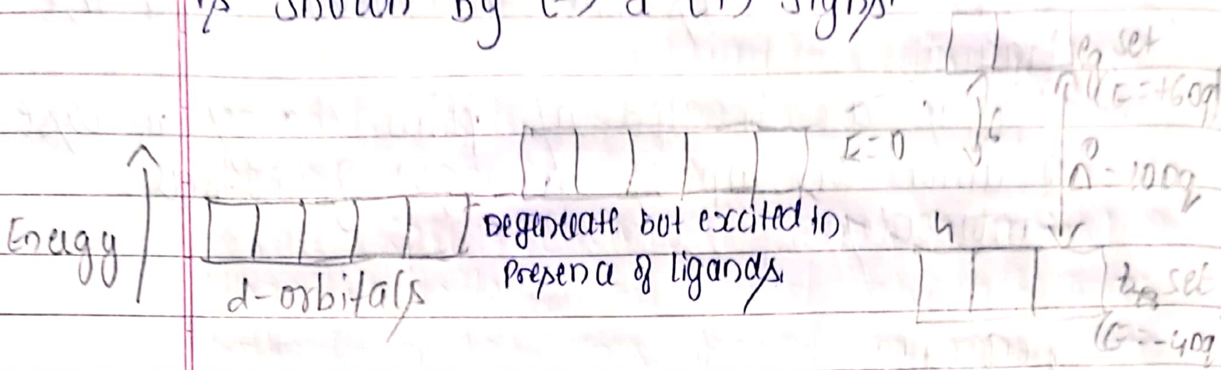
* CMI is sorrounded by ligands which contain one or more loan pair of $\bar{e}$.
* Ionic ligand are treated as point charges. Neutral ligands are treated at point dipoles.
* Bonding b/w CMI & ligands arises from purely electrostatic interactions.
* Metal ion & ligands do not mix their orbitals to share $\bar{e}$.

## Octahedral complex (CN = 6)

In this, metal ion is the centre of octahedron & 6 ligands occupy the 6 corners of octahedron

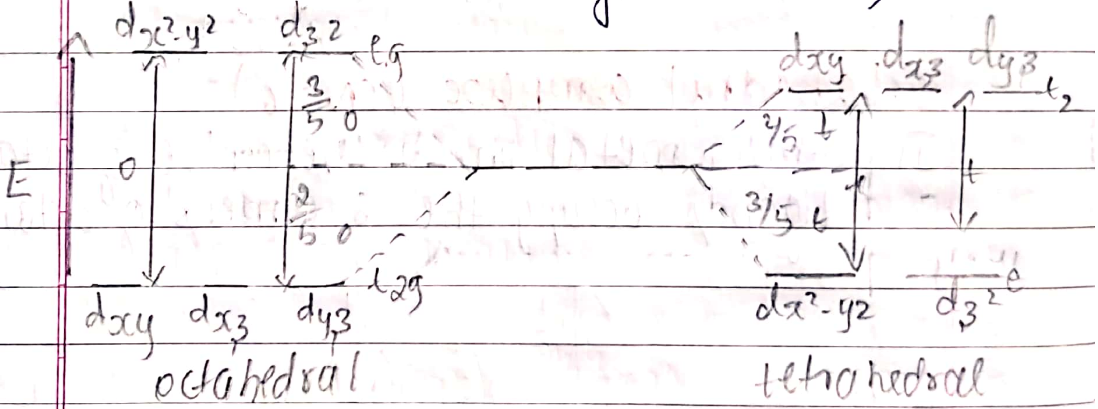


The energy is set 4 Dq less than that of hypothetical degenerate d orbitals the energy of eg set is 6 Dq greater than of hypothetical degenerate d-orbitals. loss & gain of energy is shown by (-) & (+) signs.




## Tetrahedral Complex

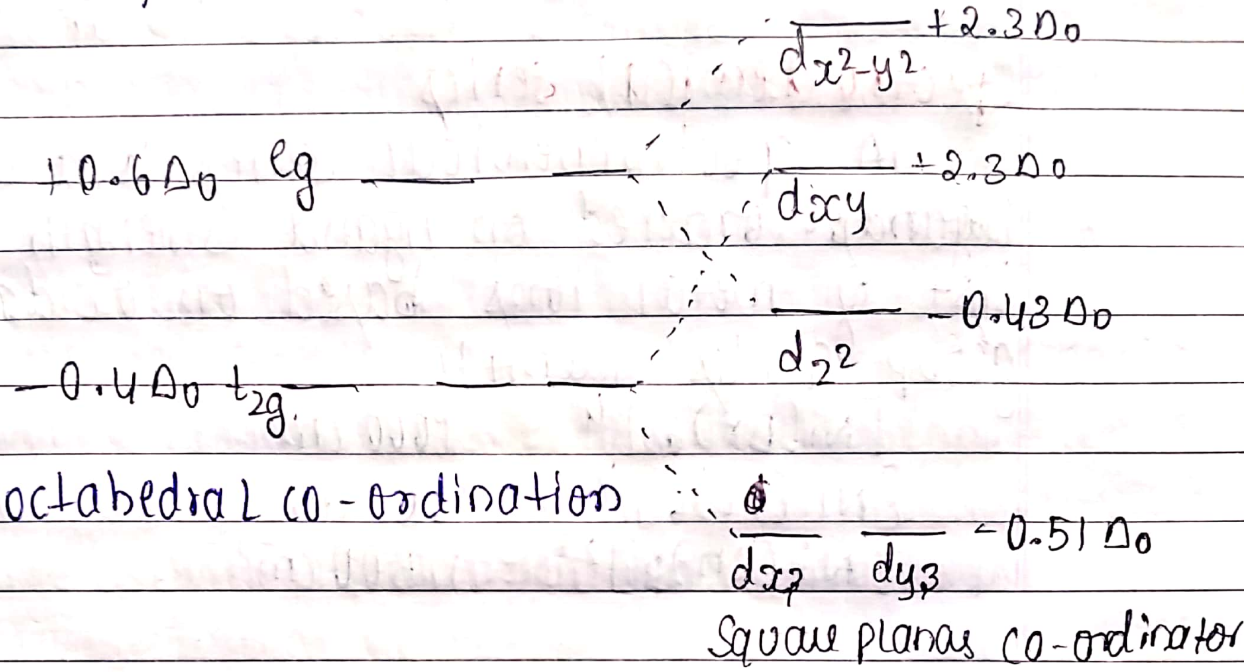
In this, there are 4 Ligands attached to the central metal. the d orbitals also split into different energy levels. the top 3 consist of $d_{xy}$, $d_{yz}$, $d_{xz}$ orbitals. the bottom 2 consist of $d_{x^2-y^2}$ & $d_{z^2}$ orbitals. The reason is poor orbital overlap b/w the metal & the ligand orbitals



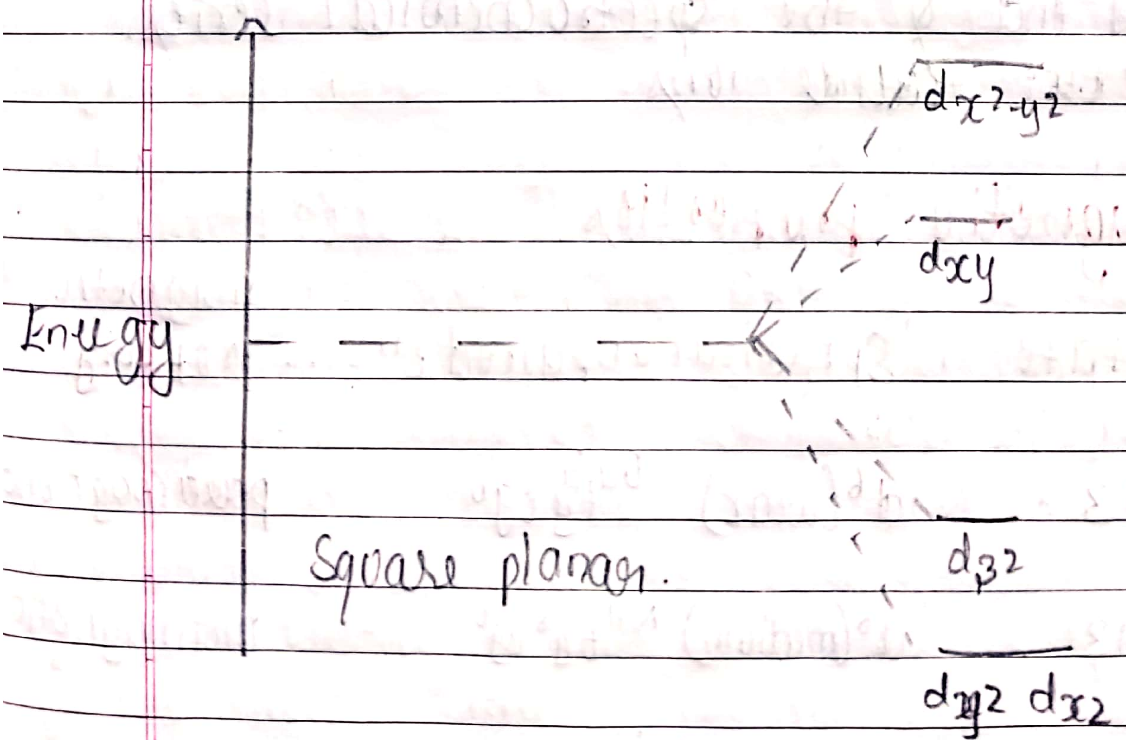

## Square planar complexes

The sq planar case can be considered as an extension of the octahedral, where 2 ligands are removed from z-axis leaving ligands only in the x-y plane.

* Consequently, repulsion of an $\bar{e}$ in the $d_{z^2}$ orbital will no longer be equivalent that experienced by an $\bar{e}$ in $d_{x^2-y^2}$ orbital its energy falls down.
* The $d_{xz}$ & $d_{yz}$ orbitals also drop in energy, but not as much. the energy of ($d_{x^2-y^2}$) & $d_{xy}$ orbitals increases.




Simply the splitting of d-orbitals in sq planar complexes is shown as below.



## Crystal field stabilization energy:

It defined as the energy of the electronic configuration in the ligand field minus the energy of the e configuration in the isotropic field.

CSFE = DE = E ligand field − E isotropic field

## Spectrochemical series

A spectrochemical series is a list of ligands ordered on ligand strength & a list of metal ions based on oxidation no group & its identity.

$[Ni(Br)_6]^{4-}$ = 7000 $cm^{-1}$

$[Ni(Cl)_6]^{4-}$ = 7200 $cm^{-1}$

$[Ni(en)_3]^{2+}$ = 11500 $cm^{-1}$

**Weak field ligands:** Ligands that produce a small Δ are called WFL & lie at the left end of the spectrochemical series.

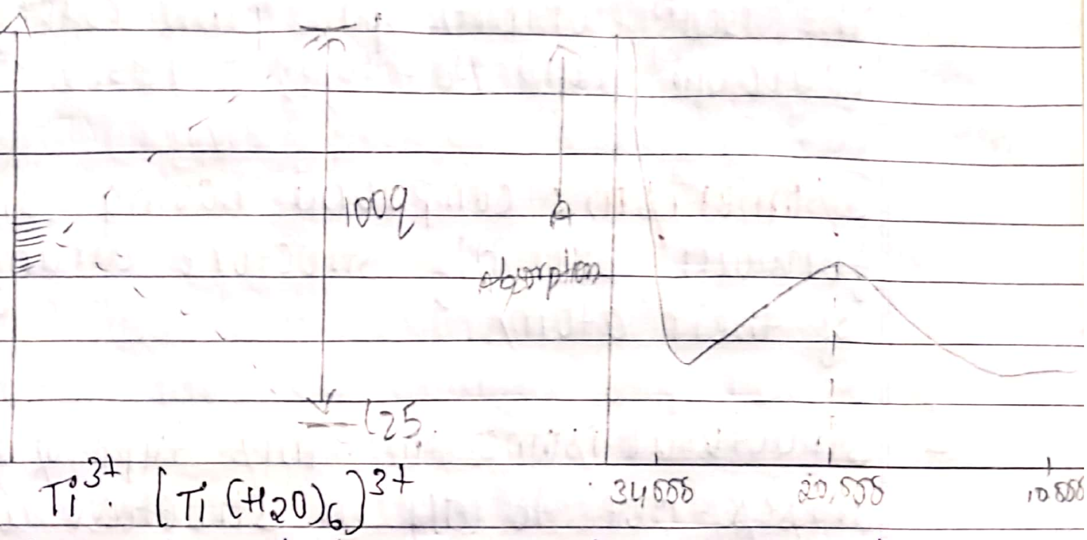
Ex:- Halide ions.

## Magnetic properties

| Complex | State | Spherical unpaired $e^n$ | magnetic property. |
|---|---|---|---|
| $[CoF_6]^{3-}$ | +3 | $d^6$(weak) $t_{2g}^4 e_g^0$ | paramagnetic |
| $[Co(NH_3)_6]^{3+}$ | +3 | $d^6$(medium) $t_{2g}^6 e_g^0$ | Diamagnetic |
| $[Fe(CN)_6]^{4-}$ | +2 | $d^6$(strong) $t_{2g}^6 e_g^0$ | Diamagnetic |
| $[Fe(CN)_6]^{3-}$ | +3 | $d^5$(strong) $t_{2g}^5 e_g^0$ | para |

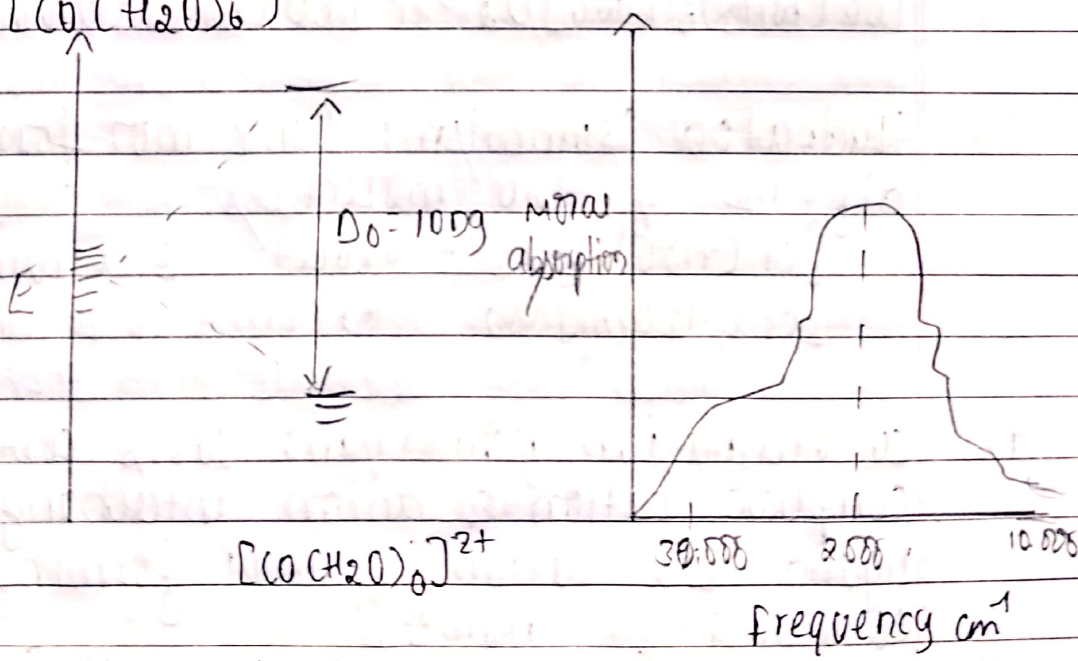
Special property of

1) $[Ti(H_2O)_6]^{3+}$




A single broad peak is frequency $cm^{-1}$ observed at 20,300 $cm^{-1}$ (or) at 493nm corresponding to the transition $t_{2g} \rightarrow e_g$.
The crystal field spilitting energy = 10Dq = $D_0$ = 20300 $cm^{-1}$. the solⁿ exhibits purple color because of absorption of yellow green & blue colour.

2) $[Co(H_2O)_6]^{2+}$




Based unpaired $\bar{e}$ in $t_{2g}$ set has the same Spin 2 paired $\bar{e}$ the $e_g$ level set. Hence to the

paired $\bar{e}$. In the opposite spins to eg level can only be promoted.
The soln exhibits pale pink colour at $19400 cm^{-1}$ (or) $\Delta_0 = 10Dq = 185.4$ KJ/mol

Isomerism: compound having same mol formula but dif structure arrangement of their atoms.

- Structural isomerism: This type of isomerism arises due to dif in structure complex

a) Ionisation isomerism: compounds have same mol formula but produce dif ion.
$[Co(NH_3)_5Br]SO_4$ & $[Co(NH_3)_5SO_4]Br$

b) Linkage isomerism: Same mol formula, same ligands but dif in linkage b/w donar atom of ligand.
$[Co(NH_3)_5ONO]Cl_2$ & $[Co(NH_3)_5ONO]Cl_2$.

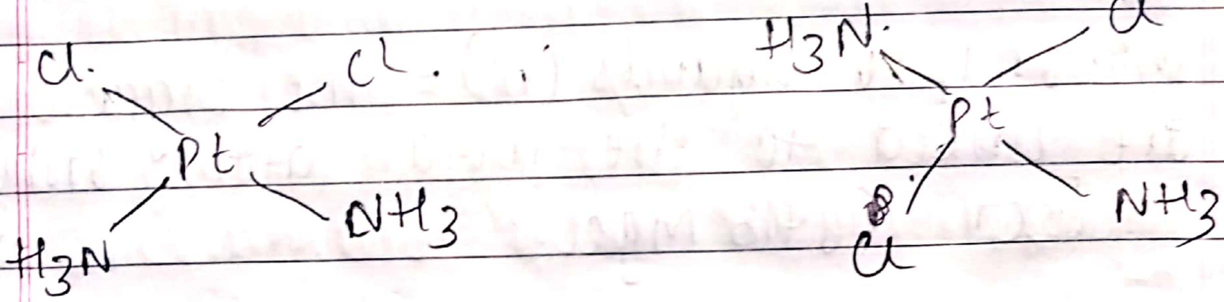
c) Hydrated isomerism: Same mol formula dif no of $H_2O$ molecules.
$[Cr(H_2O)_6]Cl_3$ – violet – 3 $Cl^-$ ions
$[Cr(H_2O)_5]Cl_2$ – Green – 2 $Cl^-$ ions

d) Co-ordination isomerism: salts containing complex cation & anion interchange ligand b/w cation & anion forming co-ordination isomers
$[Co(NH_3)_6][Cr(CN)_6]$ & $[Cr(CN)_6][Cr(NH_3)_6]$

stereo isomerism

a) Geometrical isomerism :- compounds have same mol formula but diff in their position of ligands about central metal atom.

Ex: Sq planar complex:

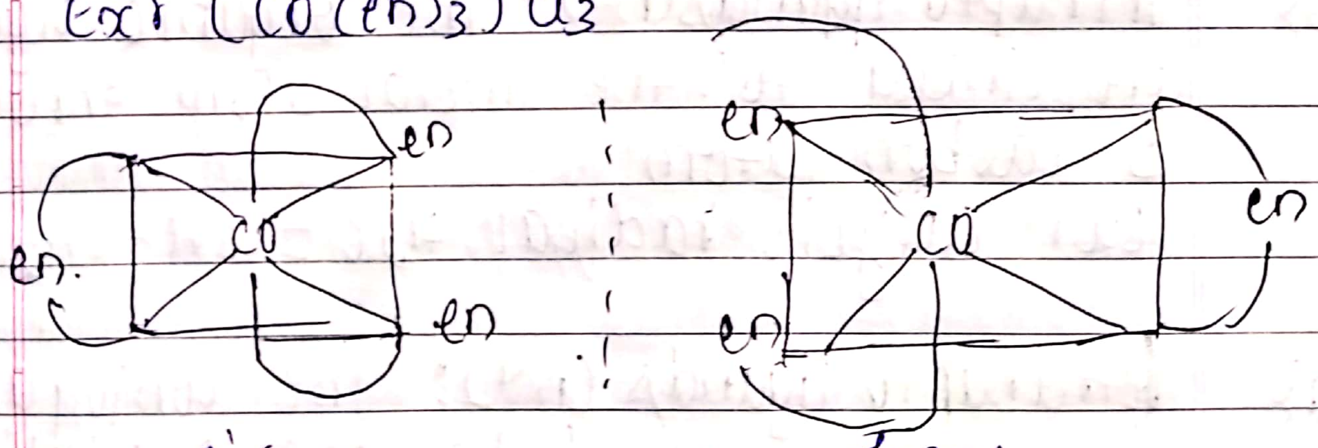


$\mu \neq 0$ cis $\qquad\qquad\qquad$ $\mu = 0$, trans

$[Pt(NH_3)_2Cl_2]$ = Diamine Dichloro platinum

b) optical isomerism: compounds have same mol formula, same chemical propeties but diffurent rotation of plane polarized light.

Ex: $[Co(en)_3]Cl_3$



cis $\qquad\qquad\qquad$ Trans.

## Organometallic compounds.

Compounds containing carbon metal bond & carbon atom of organic group is directly attached to metal atom

Ex: Grignard reagent ($RMgX$)

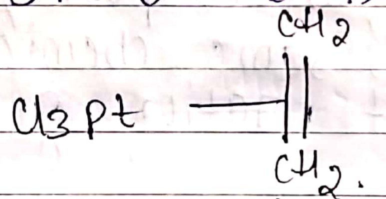
## Classifications:

1> Monohapto ligands ($\eta^1$) = The organic ligands are linked to the metal atom only

Ex: $C_6H_5MgCl$.

2> Dihapto ligands ($\eta^2$) The organic ligands are linked to the metal atom only 2 carbon atom.

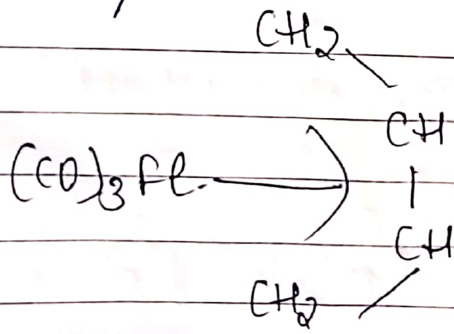
Ex: $Cl_3Pt(\eta^2 C_2H_4)$



3> Trihapto ligands ($\eta^3$): The organic ligands are linked to the metal atom through 3 carbon atom.

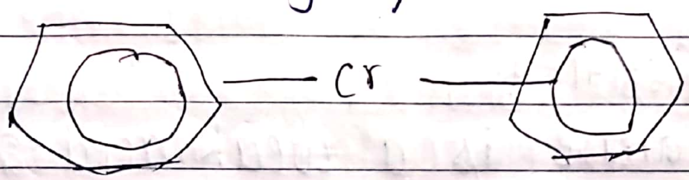
Ex: allylic radical $H_2C=CH-CH_2$

4> Tetrahapto ligands ($\eta^4$): The conjugated dienes such as butadiene & substituted butadienes.



5) pentahapto ligands ($\eta^5$): cyclopentadienyle radical links to iron atom in ferrocene through all its 5 carbon atom
Ex: $Fe(\eta^5(C_5H_5)_2]$ ferrocene.

6) Hexahapto Ligands ($\eta^6$): The benzene rings in Dibenzene chromium $Cr[\eta^6(C_6H_6)_2]$ is a Hexahapto ligands



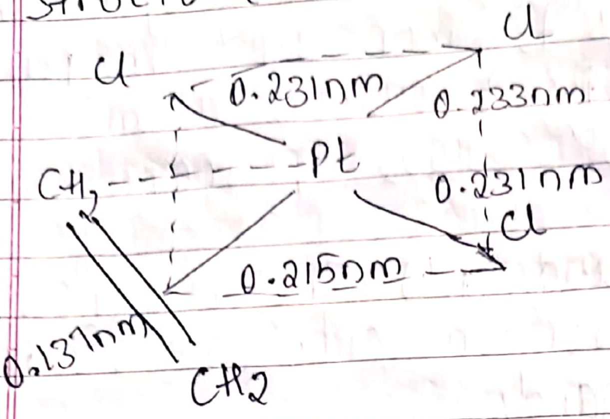
→ Hapticity of ligands:- The number of carbon atoms through which an organic Ligand is attached to the central atom.
It donated by smbol "$\eta$"

→ Synthesis & Structure

1) $K[PtCl_3(\eta^2 C_2H_4)]$
This was 1st organometallic compound of transition metal to be prepared. it is called Zeise's salt.
It is prepared as a yellow crystalline solid by displacing one of the chloride ions in the complex $K_2[PtCl_4]$ by ethylene molecule

$K_2[PtCl_4] + CH_2=CH_2 + HCl \longrightarrow K[PtCl_3(C_2H_4)]$
$+ KCl$.

Structure




2) $[Fe[\eta^5(C_5H_5)_2]]$

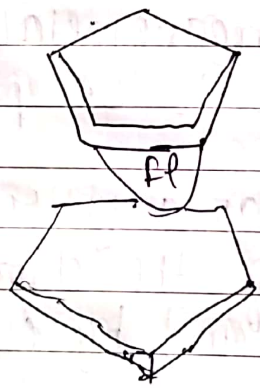
cyclopentadiene is a weak acid & form salts with strong base containing the symmetrical cyclopentadienide ion.

- cyclopentadiene reacts with Na/NaH in THF to form sodium salt. this solⁿ is treated with metal halides. etc

$2C_5H_5 + 2Na \xrightarrow{THF} 2C_5H_5 + 2Na^+ + H_2$

$FeCl_2 + 2C_5H_5Na \longrightarrow [Fe\ \eta^5(C_5H_5)_2] + 2NaCl$

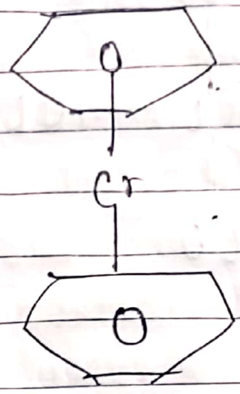
Structure




3) $Cr[\eta^6(C_6H_6)_2]$. [Fischner-Hafries method].

$3CrCl_3 + 2Al + AlCl_3 + 6C_6H_6 \longrightarrow 3[Cr(\eta^6 (C_6H_6)_2] [AlCl_4]$

Structure:




Dibenzene chromium.

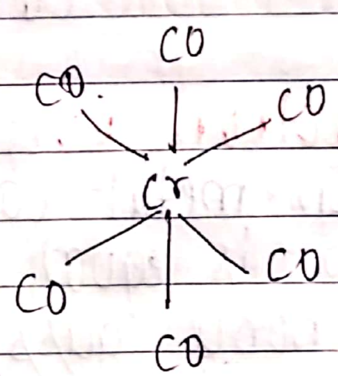
**Metalcarbonyls:-** A compound in which metal is linked to a CO molecule is called metal carbonyls.

Ex: $Ni(CO_4)$, $Fe(CO)_5$, $Cr(CO)_6$

1) $Cr(CO)_6$:- when $CrCl_3$ & Mg mixture is heated in a current of CO, hexacarbonyl is formed.

$$2CrCl_3 + 3Mg + 12CO \longrightarrow 2Cr(CO)_6 + 3MgCl$$

Structure:-

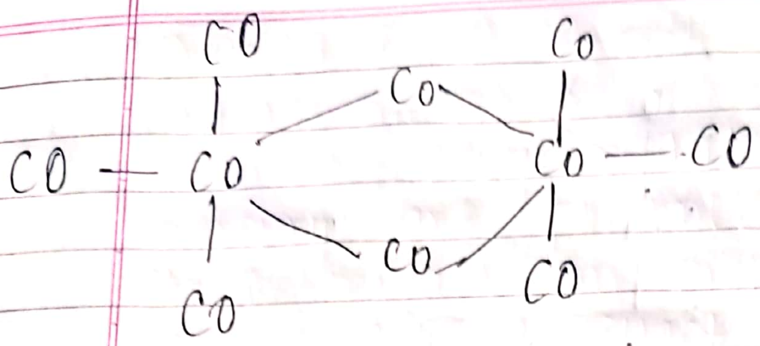



2) $CO_2(CO)_8$: when CoI & sodium is heated in a current of CO, octacarbonyl dicobalt is formed.

$$2CoI_2 + 8CO + 4Na \longrightarrow CO_2(CO)_8 + 4NaI$$

Structure:

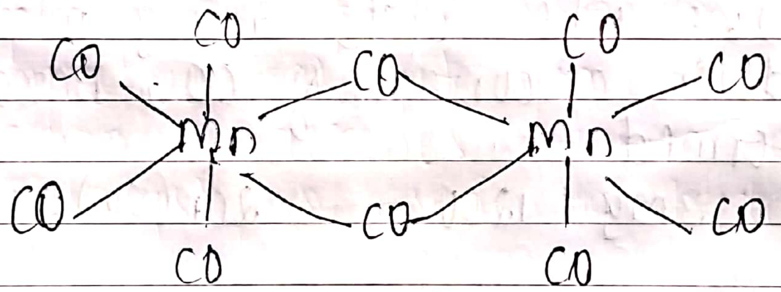
P.T.O.



3) $Mn_2(CO)_{10}$ : when a mixture of $MnI_2$ + mg is heated in a current of CO, Deca carbonyl Diamagnese is formed.

$$2MnI_2 + 2Mg + 10CO \longrightarrow Mn(CO_2)_{10} + 2MgI_2.$$

Structure:



→ Eighteen Electron Rule.

In metal carbonyl EAN of metal atom is equal to the atomic no of nearest noble gass element which contains 18 electrons in outermost shell.

In mononuclear metal carbonyls

EAN = At. no of metal + No of $\bar{e}$ donated by CO (ligands)

1) $Ni(CO)_4$ = EAN
= $28 + 4 \times 2$ = 36.

2) $Cr(CO)_6$ = $24 + 6 \times 2$ = 36

3) $Fe(CO)_5$ = $26 + 5 \times 2$ = 36

4) $V(CO)_6$ = $23 + 6 \times 2$ = 35

In polynuclear metal carbonyls

EAN = At. No of metal + No of $\bar{e}$ donated by CO (ligand) + No of $\bar{e}$ contributed to M-M bond.

5) $Co_2(CO)_8$ = $27 + 8 \times 2 + 2$ = 45

6) $Mn_2(CO)_{10}$ = $50 + 10 \times 2 + 2$ = 72.

## Applications of complex compounds & organo metallic compounds.

Cis - platin in cancer therapy.

cis platin is $[Pt(NH_3)_2Cl]$. cis platin can be used as anticancer drug for various type of tumours. when it is introduced to blood stream, the chlorine atom is lossed. the platinum bonds to nitrogen bonds of two guanine units of DNA

cis platin decreases the production of WBC & RBC. Hence calculated amt of cis-platinum to be introduced.

$Na_2$ Ca EDTA in the treatment of Heavy metal.

Heavy metals like lead, mercury are poisonous & presence of these metals in Biological system caused adverse effect.

Heavy metal poisony can be treated by oral consumption of $Na_2$ EDTA which forms complexes with heavy metals are soluble in water, which enables excretion through urine.

Wilkinson's catalyst in alkene hydrogenation

It is a monochlorotri phenyl phosphine Rhodium (I). It is an effective catalyst for selective hydrogenation of alkenes. When Wilkinson's catalyst is used in hydrogenation.

$$CH_2 \equiv CH - CH = CH - CH = CH_2 + 2H_2 \xrightarrow[\text{catalyst}]{\text{Wilkinson's}} CH_3 - CH_2 - CH = CH - CH_2 - CH_3$$

$[Rh\,Cl(PPh_3)_3]$

Monsanto acetic acid process.

Monsanto developed a process for large scale production of acetic acid from methyl alcohol.

When methyl alcohol reacts with CO in a presence of catalyst

$Rh(CO)_2I_2$ ion gives acetic acid.

$$CH_3OH + CO \xrightarrow{[Rh(CO)_2I_2]^-} CH_3COOH$$

# Industrial materials - I.

Refractories. A material which withstands extremely high tempⁿ without undergoing fusion.

uses :

* construction of furnaces, ovens, metal melting
* Atomic powerplant, Rockets & Jet
* Generally refractors used in form of bricks like Blast furnace.

properties

1) Refractoriness:- It is ability of material withstand high tempⁿ without melting.
* It is expressed in terms of pyrometric value [PCE].

2) spalling: cracking of refractory due to uneven expression of sudden variation of tempⁿ

3) Thermal conductivity: usually refractory have low thermal conductivity bcos of prevent loss of heat
Ex :- Alumina, dolomite.

4) chemical resistance: It is imp to select appropriate refractories to withstand the chemical action of slags, fuel ashes.

Date
Page

furnace glasses.

classification:

1) Acidic refractories: These are acidic in nature & thus resistant to acidic material but attacked by basic materials.
Ex: $SiO_2$, $Al_2O_3$, $SiO_3$

2) Basic refractories: These are Basic in nature & thus resistant to Basic material but attacked by acidic materials.
Ex: CaO, MgO, $Al_2O_3$, $ZrO_2$

3) Neutral refractories: Slightly acid or Base it acts as Both acidic (or) Basic slags.
Ex: $Cr_2O_3$, FeO, $ZrO_2$, SiC.

→ char. of Refractory

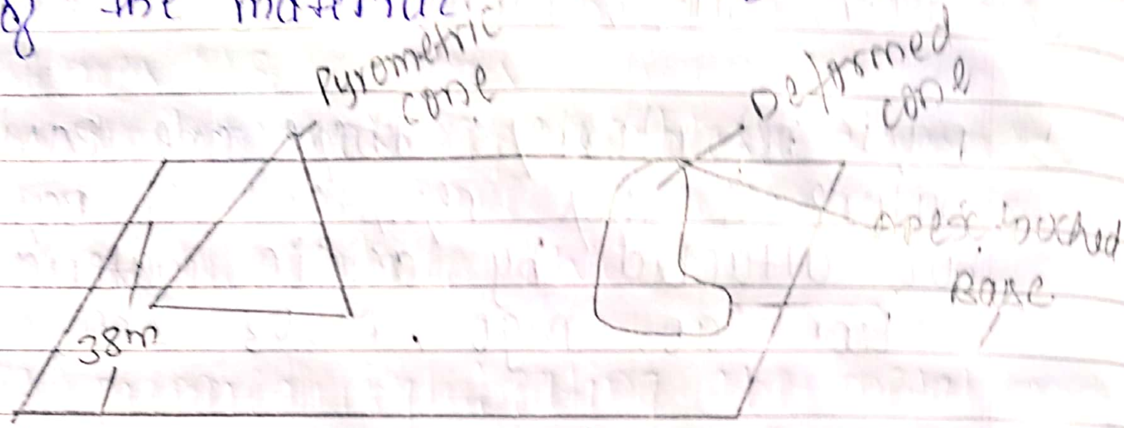
* Be able to withstand very high temp.
* Have resistance to withstand temp. fluctuations.
* Have low porosity
* Be able to withstand sudden changes in pressure, spalling ; cracking.
* preferably have Low electrical conductivity.

Determination of PCE value

It is determined by comparing the

Effect of temp? on standard cone (or) pyrometric cone.

In this method a test cone is prepared from the refractory material, then it deformation end point is compared to standard PCE cone. The resultant PCE value is a measure of refractories of the material.




Significance:

* The end point of deformation of a cone correspond to certain heat work cond?
* The PCE value are utilizes for sepeeration purposes.

→ Abrasives.

It is a material having the ability to cut / Grind a surface (or) finish other materials

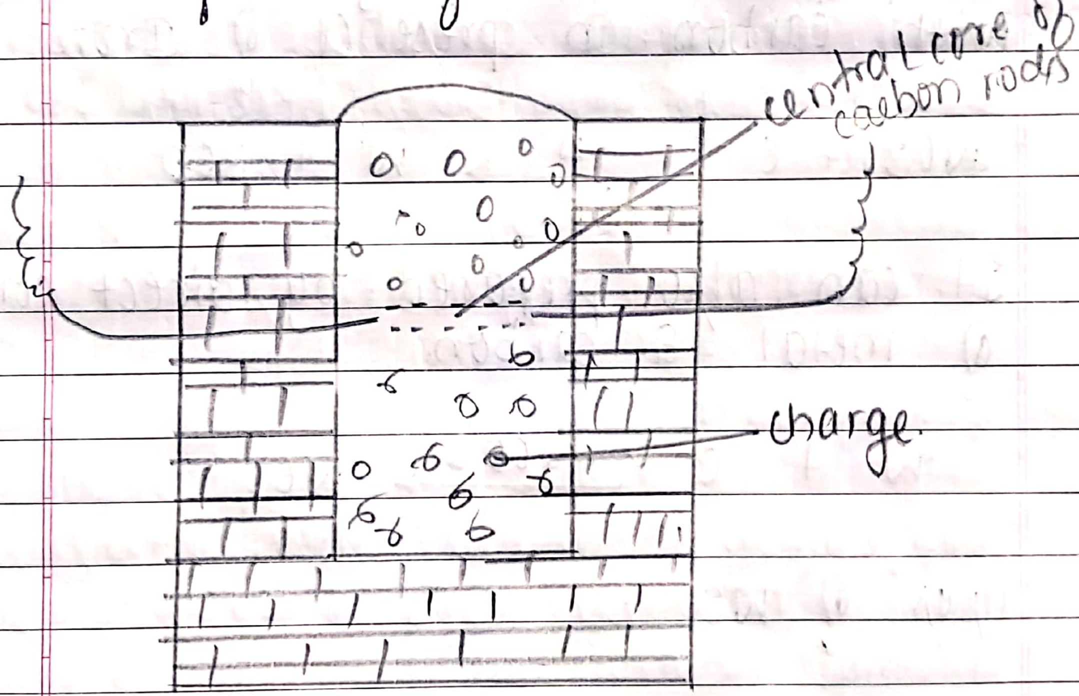
Classifications:

Natural Abrasives.
Artifical Abrasives.

1) Natural Abrasives:
   a) Hard abrasives.
      Ex: Diamond corundum emery
   b) Siliceous Abrasives
      Ex: Quartz, flint, pumice, standstone
   c) soft abrasives
      Ex:- Iron oxide, Tin & chromium oxide

2) Artificial Abrasives
   Ex: carborundum, Boron carbide, Tungsten carbide.

→ Manufacture of carborundum / SiC:




It the mfg of heating sand with carbon along with a small quantity of saw dust in an electric furnace at about 2500K.

$$SiO_2 + 3C \longrightarrow SiC + 2CO.$$

- furnace made up of fire bricks & provide carbon electrons
- saw dust make the charge porous & escape CO.

uses of SiC.

* used for making grinding machines, stones & crushes
* used for making crucibles

→ Tungsten carbide [WC].

It prepared by heating the metal oxide with carbon in presence of Iron

$$WO_3 + C \xrightarrow[(Fe)]{\Delta} W + 3CO$$

It can also prepared by direct comb^n of metal & carbon.

$$W + C \xrightarrow{2200^\circ C} WC.$$

uses of WC.

They are used as coating on paper, Grinding wheels or as loose stones

Page

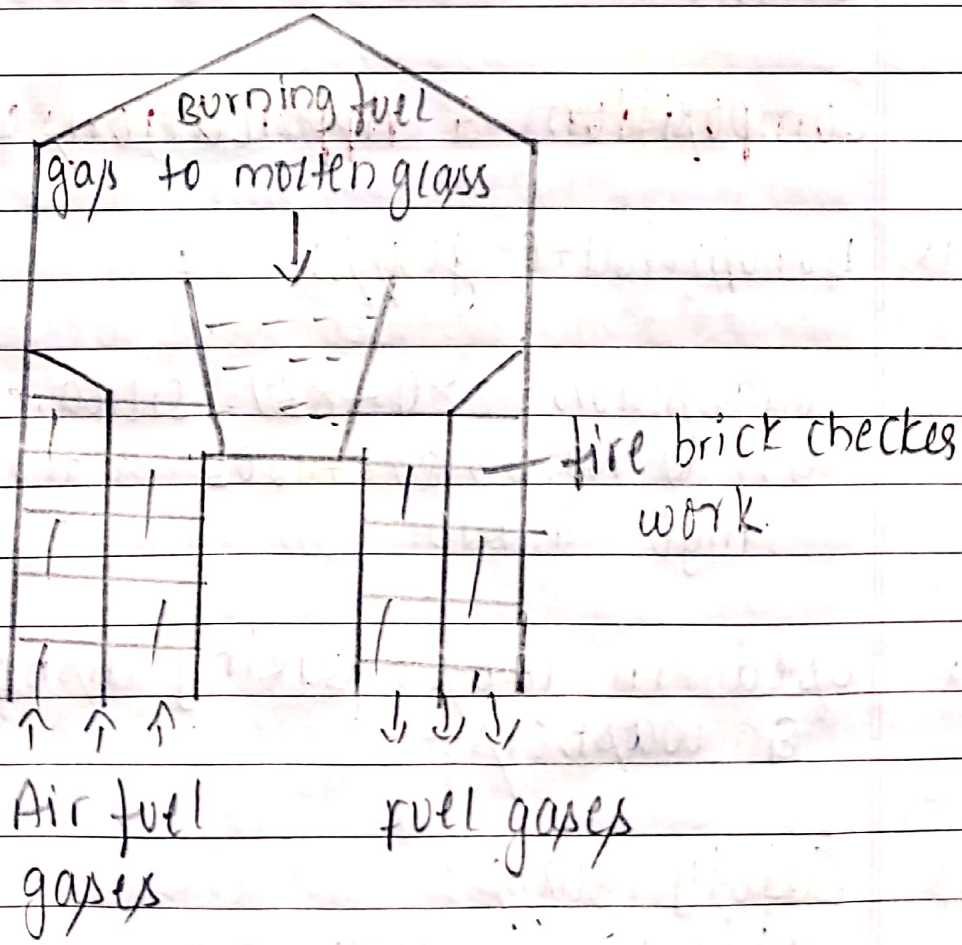
# Glass.

It is a rigid supercooled liquid having no definite m.p & a hight viscosity that prevent crystallisation

## properties.

* It is a non-crystalline, transparent solid & it is insoluble in water.
* It is very hard. it comes next to Diamond.
* It has no definite m.p.
* It can contain vaccum.
* It is Bad conductor of electricity.

## Manufacture of soda glass.



Stage I: Fusion of Raw materials
Raw materials are ground & through repeated grinding then it heated to 1400°c by burning fuel gas. it becomes transparent & cooled. undecomposed impurities all removed. then glass is ready to make article

Stage II: Shaping.
Molten glass is poured into diff mould to get desired shape. if colored glass is required.

Stage III: Annealing
finishing article should be cooled very slowly. Other wise glass becomes very brittle.

## Composition & Applications:

1) Borosilicate glass:

Composition: 80-83% silica, 10-12% $B_2O_3$. 4% of $Na_2O$, 2% $Al_2O_3$ & traces of CaO, MgO & $K_2O$.

* Used in labs, Baking dishes, pipelines & washers.

2) Safety glass:
Laminated safety glass made by bonding two sheets of ordinary glass with a

thin layer of vinyl plastic b/w them

Tempered safety glass: it obtained by heating a single sheet of glass to just below its fusion point & then quenching in oil, air (or) molten salt.

* used in mfg for doors & windowsheilds of automobiles, ships, aeroplanes & furnaces.

3) fibre glass: It used in textiles. this makes the cloth as fire proof.

4) silica glass: obtained from pure silica.
* used in mfg of Lab wares such as condensers, crucibles etc.

5) Soft glass:
composition: $SiO_2 = 70-74\%$.
$Na_2O = 13-16\%$.
$CaO = 10-13\%$
* used for window glass, bottles, tabewares.

6) potash glass:-
Composition: $SiO_2 = 71\%$.
$K_2O = 18\%$
$CaO = 11\%$,
* used for making hard glass apparatus

7) lead potash glass:-
composition: $SiO_2 = 53\%$.
$K_2O = 14\%$, $PbO = 33\%$.

* used for making prisms, lens & other optical glasses

## Ceramics.

Raw materials & their roles
clay, fledspar, sand.

1) clay: It defined as finely grinded rock which is highly plastic when wet, hard when dried & rock-like permenant when fired & unaffected by water. The composition of clay varies widely, clay are generally impure, hydrated aluminium silicate.
Some of the common clays are.
i) kaolmite = $Al_2O_3\ 2SiO_2\ 2H_2O$.
ii) Illite = $K_2O\ mgO,\ Al_2O_3,\ SiO_2\ H_2O$
iii) montmorillonite = $CaO\ mgO,\ Al_2O_3\ 5SiO_2.H_2O$

2) feldspar: It serve as a flux & blinder in ceramic article & also provide glassy appearance to article. Sand particles provides necessary skeletal struture to ceramic ware.

## production of ceramic ware.

1) preparation of SLIP.
The raw materials are ground to a fine powder seperately. they are mixed together with water in the material tank

A cream like paste is obtained which is called the slip.

2) Filtering: The paste is then passed through a filter press to remove excess of $H_2O$.

3) Casting: The soft mass obtained above is kneaded well to get off air bubbles. this is then cast into desired shape. Diff method of casting are known plaster of paris mould (or) handing some method of casting.
The articles are dried slowly & fired in an oven to get a porous called Bisque.

4) Glazing: ceramic ware obtained above is hard translucent & porous.
The ingredients required for glazing & quartz, feldspar, a little boric ā & metallic oxide of Zn, Pb & tin. these are finely powdered & mixed in required portion.
A Homogenous paste is made with water called slurry. it applied on ceramic ware by dipping, spraying or using a brush. the ceramic ware is dried & then fired.
Glaze provides a non-porous, hard, glossy surface.
purpose of glazing.

* To produce a decorative effect
* To make the surface impervious to $H_2O$.
* To increase the durability of ceramic ware.
* To provide a smooth glassy surface.

During firing, after applying glaze, it not allowed to come indirect contact with fire as dust & soot may discolour them.

5> Firing. It done at high tempr. & under controlled condn. Depending upon the tempr. of firing the pores get covered up.

Ceramic insulators

Insulators are materials, the transfer of heat as well as prevent conduction of electricity.

properties:

* ceramics are hard & rigid hence proved mechanical strength
* They are thermally stable.
* chemically inert & restorted transfer of heat to electricity.

Applications of ceramic ware.

* used to make lab items like crucibles, furnaces etc
* used in making kitchen wares
* used in making sanitary pipes & toilet articles
* used for making electrical insulators etc.

Cement

Raw materials & grades

Lime:- It provides strength to the cement
Silica: Imparts strength to cement
Alumina: Reduces the setting time of cement
Gypsum: Helps to retard the setting of action of cement
Iron oxide: provide strength, hardness & colour to the cement

Manufacture of cement.

The cheif raw material used for mfg of portland cement are lymstone & clay.

There are 2 methods of mfg:

a) Wet process: It used in India & Europe
The crushed limestone mixed with slurry of clay about 60% of $H_2O$ in proportion & pulverised in Ball mill & further ground in tube mills & thorolly homogenised by making of compressed air & then stored in tank. where after analysis, addition are made to adjust the proportion.
* It is superior quality.

b) Dry process: Here raw materials are sepeately crushed & ground in sutiable machine & dried then mixed in proper proportion pulverised in Ball mills & homogenised. then it dried, powdered & stored.
* It is low quantity & slow process.

Setting of cement.
It defined as stiffening of original plastic mass due to initial gel formation.

Initial setting of cement is due to hydration.

$3CaO Al_2O_3 + 6H_2O \longrightarrow 3CaO Al_2O_3 6H_2O$.

$2[2CaO \cdot SiO_2] + 8H_2O \longrightarrow 2[CaSiO_2 \cdot 2H_2O] + 2Ca(OH)_2$.

Final setting involves formation of collodial gel & crystalline. there is interlacing of crystals as well as with sandgrains to imprevious hard mass.

$2[3CaOSiO_2] + 6H_2O \longrightarrow 3CaO 2SiO_2 3H_2O + 3Ca(OH)_2$.
(Gel)
(crystalline)

As hydrolysed & crystalization proceed, the strength & hardness of the set mass increases. the entire process requires about 28 days.

# Industrial Materials - (II)

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## paints & varnishes

paint defined as a homogenous fluid containing suspension of finely divided solids that dries up when applied on a Surface.

Constituents of oil.

1> pigment:
* It provide color & to impart an aesthetic appeal to the film.
* To reduce gloss & weathering property.

2> Blinders: Non-valatile Liquid portion of the paint is Blinders.
* Give Adhension to the surface
* provide moisture - proofness.

3> Thinner: It are volatile liquid part of the paint
* Used in Benzene, xylene, ether, alcohol etc

4> Driers: These are the substance added to accelerate the drying of the film
* Suppress the action of antioxidants
* catalyse the drying of the film through oxidation.

5> Other Compounds:- water based also require dispersing agen (casein) antifoam agent (pine oil) & preservative (chlorophenol)

Constituents of Emulsion paints.

1) pigments & extendees.
These are water dispeesible such as
$TiO_2$, $ZnS$ etc.

2) Blinders:
The oils & resins used as blindees
are water dispersible, linseed oil polystueene
esteegum are commonly used.

3) Emulsifying agents:
It help to form an emulsion
depending on type of pigments & vehides
used.

4) Stabilizers: It added to increase the
stability of the paints. They serves as
thickneing agent for the $H_2O$ phase

5) preseuvatives: It added to prevent decompos-
ition of any protein & eliminate the growth
of fungus on paints.

6) Anti-foaming agent: Added to check form$^n$
of foam during the agitation of Emulsion
paints

Varnishes: It are transparent viscous
liquids & contain no pigment. It is a
homogenous colloidal dispersion of resins
in drying oil.

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# Constituents of varnishes.

1) Resins: It used may be synthetic like phenolic alkyl, urea formaldehyde, vinyl (or) silicone
* It provide glossy, adhesive, durable film

2) Drying oils: It used in linseed, tung oil, dehydrated castor oil, soyabeen oil.

3) Thinners: Turpentine, kerosene, xylol, acetone, ethanol, amylacetate etc., are used as thinners

4) Driers: It help in accelerating the drying rate.

5) Anti-skinning agents: It used in tert-amyl phenol, guiacol, etc.

## Fuels.

A fuel is any substance which on combustion produces heat (or) power.

Characterstics:

* It should be easily available
* It should be economical
* It contain low % of non combustible matter
* It should have proper irrigation temp.
* It should leave less ash

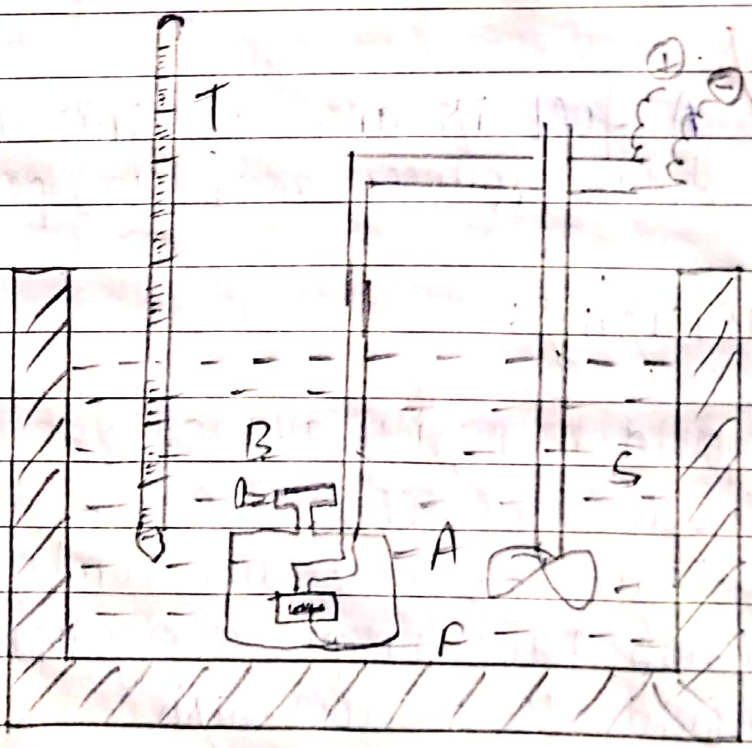
Calorific value of fuel: Amount of heat produced on complete combustion of a unit

quantity of the fuel
S.I unit is J/kg.

calorific value also be expressed in terms of British thermal unit (BTU).

Determination of calorific value of fuel by using Bomb calorimeter.

* The Bomb is made of a strong cylindrical steel container 'A' in which known amt of fuel is Burnt
* It is provided within air tight lid 'B' & an inlet value for passing oxygen.
* The Bomb is placed inside a cu calorimeter filled with definite mass of $H_2O$ this provided with a precision thermometer T & a stirrer S




A known mass of fuel is taken in a silica crucible F & kept inside the Bomb. A thin mg wire is projecting from crucible connected to terminal rods. $O_2$ filled into bomb the initial tempr of $H_2O$ in meter is down. The fuel in Bomb is ignited by connecting the terminal rods to source of electric current. The water is kept stirred & the maximum tempr attained by $H_2O$ is noted.

Calorific value of the fuel is calculated by the equation : $Q = WS\Delta T/M$.

Coal: It is a combustible black (or) browinsh black sedimentary rock usually occuring in rock strata in layers of veins.

Varities of coal.

1) peat: This is initial semi carbonized stage in the formation of coal. It content 30-40% of C & its calorific value about 16.2 MJ/kg.

2) Lignite: Brown coal & it is woody. 46-60% of C & calorific value about 12.8-19.3 MJ/kg.

3) sub-bituminous coal: Black & denser, harder than lignite. it content 46-60% of C & calorific value 19.2-30.2 MJ/kg.

4) Bituminous coal: Black coals which burn with a smoky yellow flame.

a) High volatile: carbon contains 46-69% & calorific value of 25.5-34.8 MJ/kg.

b) Low volatile: carbon contains 69-86% & calorific value of 33.6 - 36.2 MJ/kg.

5) Anthracite: Black, Hard & lustrous. carbon contains 86% to 98% & calorific value about 31.2 - 36.2 MJ/kg.

→ Gaseous fuels: It include the 1° fuel natural gas & secondary fuels like $H_2O$, gas, producer gas, coal gas, Biogas, LPG etc.

| fuel | composition | calorific value in: KJ/$m^3$ |
|---|---|---|
| Natural gas | $CH_4$ (80%), $C_2H_6$ (12.5%) $N_2$ (4%) & CO, $CO_2$, He, etc. | 30000 - 35000 |
| coal gas | $CH_4$ (32%), $H_2$ (40%) CO (7%), $C_2H_6$ (4%) $N_2$ etc. | 20000 |
| producer gas | $H_2$ (10%), CO (30%) $N_2$ (55%) | 5500 |
| water gas | $H_2$ (50%), CO (40-50%) $N_2$ (5%) | 12000 |
| liquid petroleum gas | n-butane (27%) isobutane (30%) Butane (40%) Ethane, propane | 120000 |

Biogas $CH_4$ (55%), $H_2$ (8%), 18000 - 20000.
$CO_2$ (35%)

## Advantages of gaseous fuel.

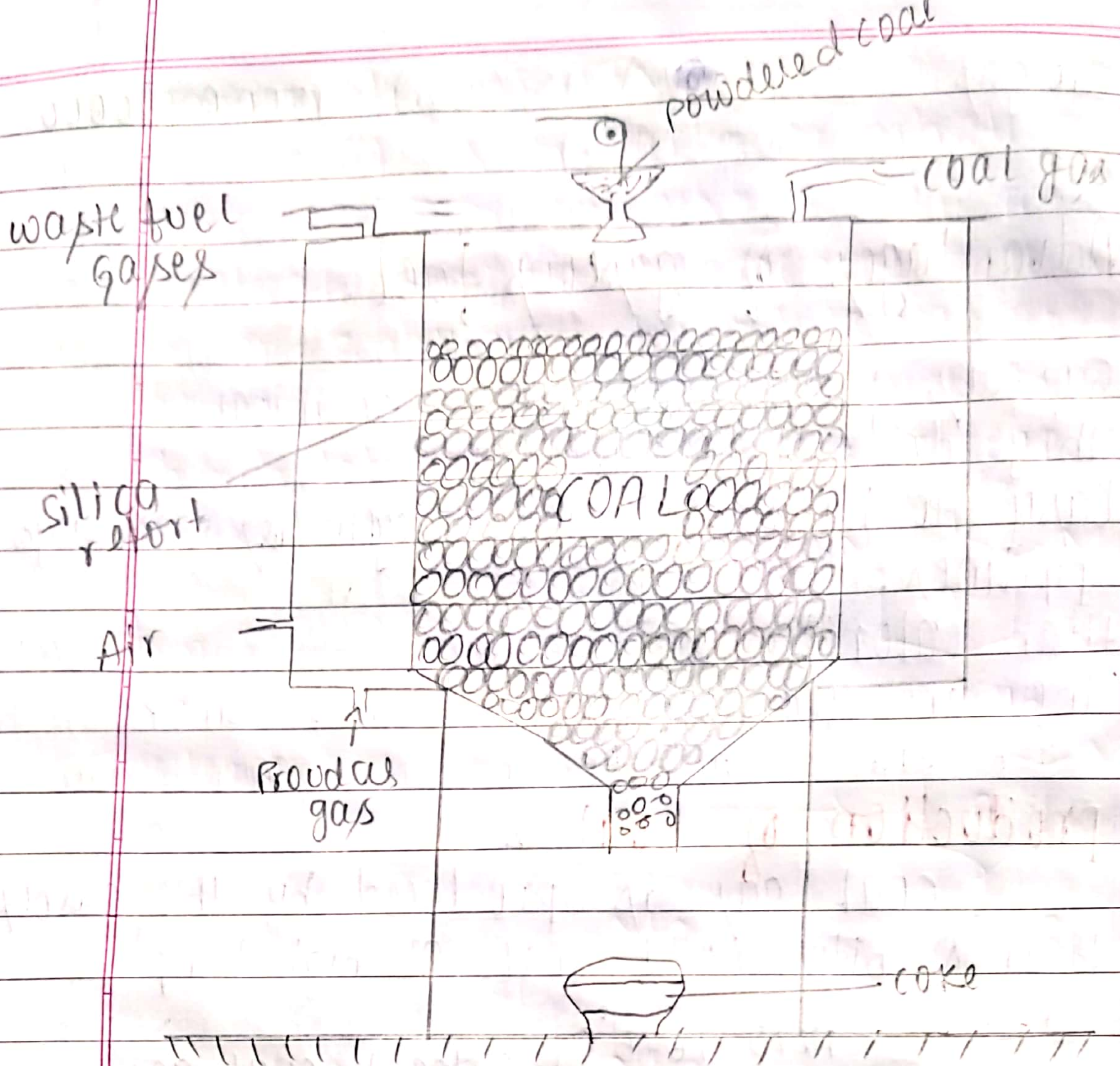
* Gaseous fuels are more economical.
* They do not produce ash
* Easy to handle, carried in cylinders & through pipelines.
* High calorific value.
* They are clean i.e. burn without smoke

## production of coal

coal gas is produced by the carbonization of bituminous coal at high tempr.

$$\text{coal} \xrightarrow[\text{In absence of air}]{1275-1675^\circ C} \text{coke} + \text{coal gas}.$$

In vertical process as shown in above diagram the bituminous coal is feed into closed silica retorts. it is heated by burning mixture of produce gas & air heating jackets. Sorrounding the retorts. An outlet is produced at the top of the retort through coal gas is collected. the resulting out coming gas contains $HCN$, $CO_2$, $H_2S$ & $CS_2$. this impurities are removed by passing through a scrubber containing $H_2O$. when $H_2O$ vapour, coal tar & little ammonia condenses.




After removing the final traces of $NH_3$, the mixture is passed through ferric oxide followed by an alkaline solⁿ of ferrous sulphate to remove hydrogen sulphate & HCN. finally dehydrated by passing through anhydrous $CaCl_2$. the purified gas is stored in cylinders

Octane number: The standard measurment of an engine of fuel is called octane number

Significance: It is used to determine the quality of fuel (or) Engine.

Explosives: Those materials which under the influence of thermal decomposes rapidly chemical rxns with large volume of gases liberating a lot of heat energy.

Classification:

1) High explosive:- produce high amt of heat with rapid chemical rxns

a) primary explosive: These are highly sensitive explosive which explode by a slight shock.
Ex:- DDNP, $Hg(CNO)_2$, Lead azide.

b) 2° explosive: These are quite sensitive to fire & mechanical shock but they have high energy content.
Ex: TNT, Picric a, dynamite.

2) Low explosives: These are simply burns but do not explode suddenly.
Ex:- Dinitrotoluene, Gunpowder, nitrocellulose

preparation of Dynamite.

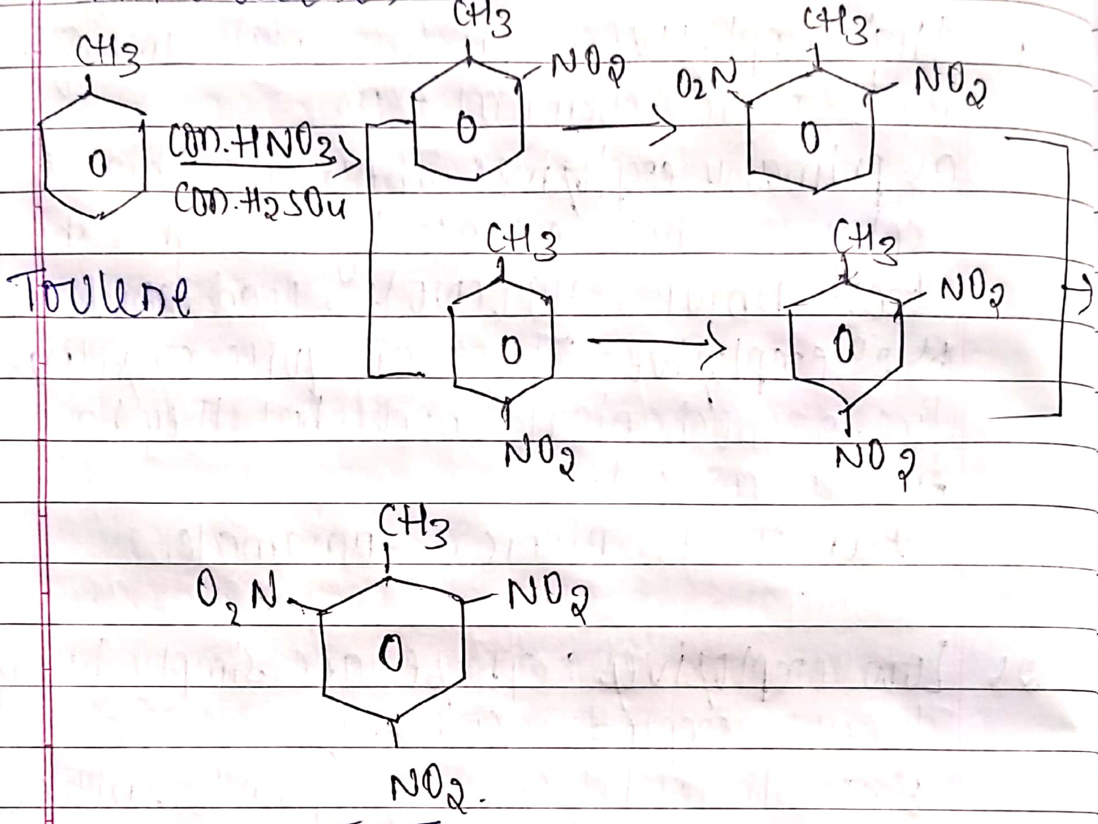
The major component of Dynamite is glycerol trinitrate which known as nitroglycerine.

Dynamite is prepared by subjecting glycerol to the nitration using nitrating mixture at 10°C temp$^r$

$$\begin{array}{l} H_2C-OH \\ \quad | \\ HC-OH \\ \quad | \\ H_2C-OH \\ \text{Glycerol} \end{array} + \begin{array}{c} 3HNO_3 \\ \text{con} \\ \text{Nitric a} \end{array} \longrightarrow \begin{array}{l} H_2C-ONO_2 \\ \quad | \\ HC-NO_2 \\ \quad | \\ H_2C-NO_2 \\ \text{Dynamite.} \end{array} + 3H_2O$$

preparation of TNT

It is prepared by nitration of toulene using con $HNO_3$ & $H_2SO_4$ mixture at moderate tempⁿ. the product is washed with water & followed by dilute $Na_2SO_3$ to remove unsymmetrical TNT such as 2,3,4-trinitrotoluene, 2,3,6-trinitrotoluene.




TNT

Propellants: A material containing a fuel & an oxidizer, which on combustion produces large volume of gases & high tempⁿ of about 3273K.

characterstics:

* It should be low explosive
* It should have low iginition time order of milli seconds

* It should have high calorific value
* It should have higher impulse.
* The product of combustion should have low mol wt.
* It should not leave behind any solid residue after combustion.

classification of propellants.

1) Solid propellants: propellants are solid in state.

a) Homogenous S.P:- It contain both fuel & oxidizer in the same compound
Ex:- Nitroglycerine, Ballistae.

b) Heterogenous S.P:- It contain solid fuel, solid oxidizer & a binder mixed together.
Ex: A mixture of sodium nitrate ammonium picrate & polybutadiene

2) Liquid propellants: propellants are liquid in state.

a) Monopropellants: It contain both fuel & oxidizers in the same molecule
Ex: Hydrazine, Ethyl oxide

b) Bipropellants. It consits of a liquid fuel & liquid oxidizer which are stored seperately & pumped into the cumbstion chamber at required rates.
Ex: common liquid fuel are keerose, liquid $H_2$, Dimethyl hydrazine etc,
common liquid oxidizer are liquid $H_2O_2$, fumic nitric oxide, nitrogen pentaxide etc.

App^n of propellants

* used as rocket fuel
* used as propulsion unit for missiles, target drones & supersonic sheilds.

# Bio Inorganic Chemistry

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**Essential (or) major elements:** These are elements which involve in major Biological process to maintain the existence & survival of the living organism.
Ex: Na, K, Ca, mg, P, ~~#~~S, Cl.

les,
ts.

**Trace elements:** These are elements which contributes quantity is very much loss i.e, interns of micrograms. they play an imp role in Biological process.
Ex: Fe, Cu, $I_2$, mn, Co, Zn, F, Cr, Ni.

**Functions.** Sodium.

* provide 92% of ECF osmolarity & maintains internal environment
* Maintance of electrolyte & fluid balance
* Exocrine secretion
* maintenance of Blood volume & B.P

2) potassium.

* It maintains intercellular osmotic pressure, acid base balance.
* It helps in contraction of heart
* Involved in proper transmission of nerve impulses.
* Involves in Biosynthesis of proteins

3) Calcium

* It helps in Blood coagulation
* It present in bones & teeth as salt along with mg & p.
* It required for normal function of heart,

muscles & nerves.

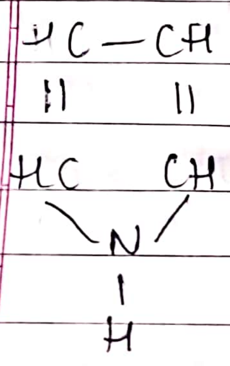
* It helps in oocyte, activation & building strong bones & teeth

4) Iron.
* It helps in formation of hemoglobin
* Regulation of Body tempr.
* Brain development
* Binding $O_2$ to RBC & transport
* Immune system.

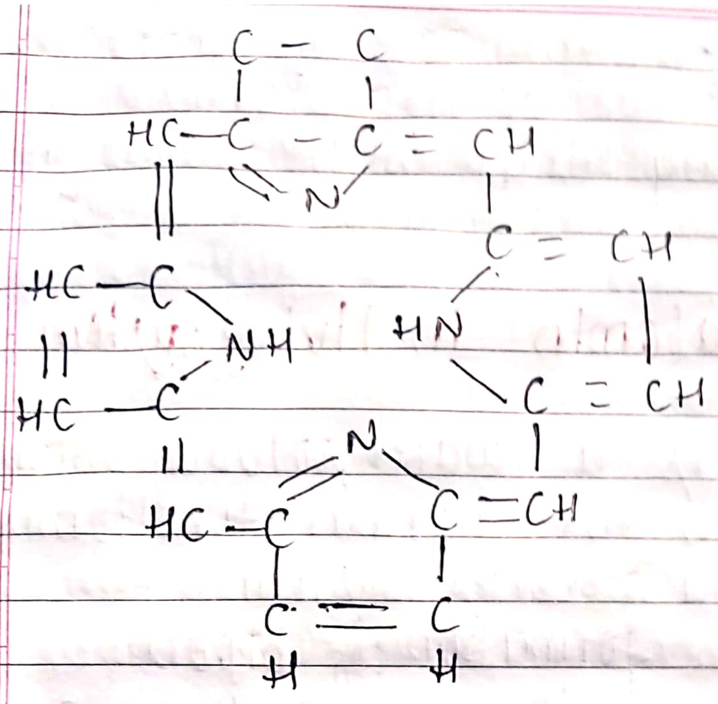
5) phosphorous.
* It gives structural support to the Body
* It has active in enzyme system
* It takes part in energy generation & storage of ATP
* It takes part in cell growth

Metallo - porphyrins.

These are cyclic compounds formed by the linkage of 4 pyrrole rings through methylene bridges.
It acts as cheating ligands 4 $N_2$ atoms of 4 pyrolle ring form coordinate bond with metal cation to form metal porphrins.



Pyrole.



porphyn ring

1. Haemoglobins: Iron porphyrins are attached to protein globin. they posses the ability to combine reversibly with oxygen. Haemoglobins serve as $O_2$ transportess in Blood.
* It also help in transport $CO_2$ from the tissues to the lungs.

2) Myoglobins: These occur in muscle cells of vertebrates & invertebrates.
* They serves as oxygen transporters within the muscle tissue.
* It present in flight muscles of birds.

3) Chlorophyll: It makes the entire molecule rigid so that energy is not easily lost thermally.

It increases the rate of short lived singlet excited is transformed into corresponding triple state, hence it transfe its excitation energy into the redox chain.

## Role of cobalamin in living system

cobalamin is a water soluble vitamin with a key role in the normal functioning of the brain & nervous system.
It helps in formation of blood.
It especially affecting DNA synthesis & regulation but also fatty acid synthesis & energy production.
It can be produced industrially only through bacterial fermentation synthesis.
This is used in the treatment of pernicious anemia, it is isolated from lever.
cobalamin is changed human cells to 2 principal cobamide coenzyme viz methyl cobalamin in cytosol in mitochondria.

# Chemistry of Newer Materials.

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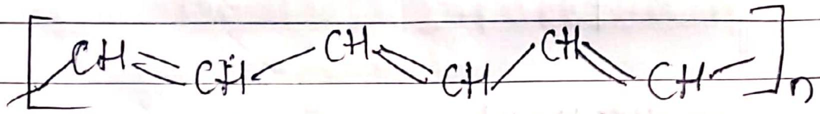
## Conducting polymers

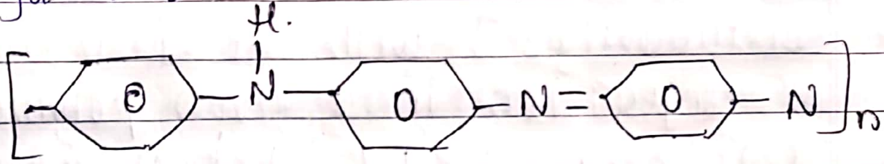
A polymer with highly delocalized π-ē system having electrical conductance.

Ex:

polyacetylene



polyaniline



## mechanism of conduction

conducting polymers have back bone of conjugated $sp^2$ hybridised carbon centres. one valence ē on each carbon centre residues in a $P_3$ orbital which is orthogonal to the other 3 sigma bond. All the $P_3$ orbitals Combine with each other in a molecule to form set of delocalised orbitals when it is polarity emptied this leads to conducting property to the polymer. Similarly polymer can be doped to reduction which adds can be dopped by reduction which adds ē to an unfilled electron bands. In most of the organic polymers are doped by either oxidation or reduction

Quantitative treatment of doping

In principle, objective of doping of polymer is to enhance their electrical conductivity. In most cases phenomenal increase in conductivity of the order $10^8 - 10^{12}$ results. The dopents used, the process of doping & doping level of the dopent in the polymer & temp.

properties:

* conductivity ↑s with the ↑ in the extent of conjugation in a given polymer
* Increase in doping level of the polymer conductivity is found to increase but after sometime it can be saturated
* Some of the properties can be varied by the change in the doping material they are:

Note 1) conductivity
of u 2) Ability to store a charge
3) Ability to ion exchange
4) coloured products
* o Elasticity with high electrical conductivity

rob

## Applications:

- Engineering field:

* m/g of organic solar cells
* printing electronic circuits
* chemical sensors
* electro magnetic sheilding
* flexible transparent displays

2} Biological applications:

* Bio actuators
* used in tissue
* Neural applications
* phy & che modifications of bio molecules can be done
* used as Biosensors

## Super conductors:

The phenomenon of electrical resistance becoming zero at low temp$^{r}$ is called super conductivity. the material with zero electrical resistance is called super conductors

Type-I :- super conductors are those super conductors which loose their super conductivity very easily or abruptly when placed in the external magnetic field.

Type-II :- Superconductors are those super conductors which lose their superconductivity gradually but not easily (or) abruptly when placed in external magnetic field

preparation of High temp$^{r}$ super conductor.

The $YBa_2Cu_3O_{7-x}$ compound is prepared by calcination & sintering of homogenous mixture of $Y_2O_3$, $BaCO_3$ & CuO in the

appropiate atomic ratio.
At the time sinetuing, the semiconductor tetragonal $YBa_2Cu_3O_6$ compound is formed, which on slow cooling in $O_2$ atmosphere turns into superconducting $YBa_2Cu_3O_{7-x}$.

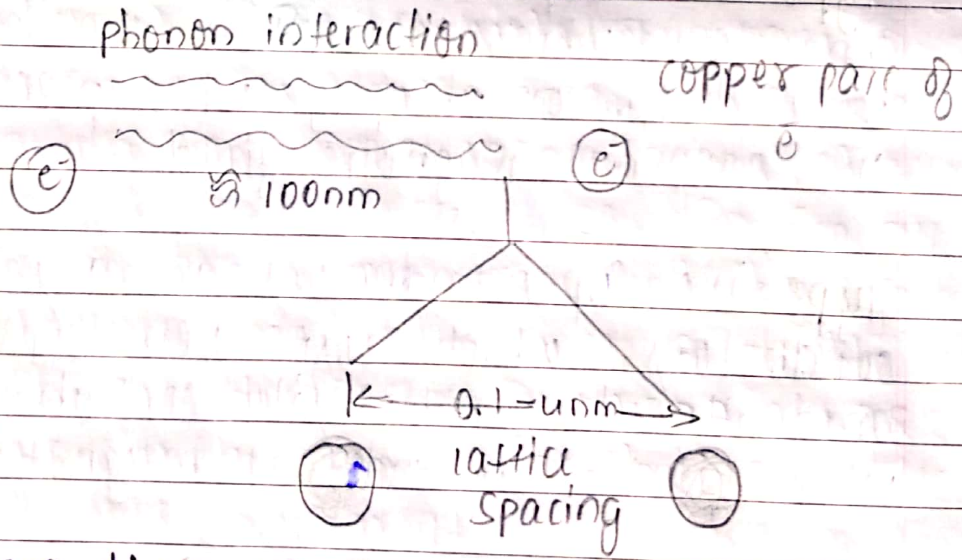
$$2Y^{+3} + 3HCO_3 \xrightarrow{-3H^+} Y_2(CO_3)$$

$$Ba^{2+} + HCO_3 \xrightarrow{-H^+} BaCO_3$$

$$Cu^{+2} + HCO_3 \xrightarrow{-H^+} CuCO_3$$

$$Y_2(CO_3) + 4BaCO_3 + 6CuCO_3 + (1/2 - x)O_2 \xrightarrow{950^\circ C} 2YBa_2Cu_3O_{7-x} + 13CO_2$$

## BCS Theory.




According to BCS theory,
* A metal in which the conduction e lie inside the fumi sphere. the electrons are repelled to each other. But these electrons attractive +ve ions towards it. Hence

these $\bar{e}$ are screened by +ve ions & the screening effect. reduces the repulsion b/w these electrons.

* In equilibrium condition, A balance ~~attra~~ b/w attraction & repulsion is established & two $\bar{e}$ combine to form pair called copper pair.
* At low temp$^{r}$ $T < T_C$ the $\bar{e}$ lattice interaction are stronger than $\bar{e}$-$\bar{e}$ repulsion & cu pair will move in lattice without any exchange of energy.
* In electric field the $\bar{e}$ gain additional K.E & gives rise to current. But they do not transfer this energy to lattice. hence they do not get slow down. so the substance doesnot posses any electrical restitivity & behave like super conductor.

General applications of High temp$^{r}$ super conductors.

* To make high strength super magnets which are used in MRI & NMR spectro-scopy
* Used in the energy releated areas such as production of magnetic fusion.
* In the transport field, high speed trains based on magnetic limitations
* used in chemical industries
* used in large synchronial generations & motors.

## Fullerenes:

fullerenes is an allotrope of carbon.

Ex: Bucky ball ($C_{60}$).

preparation & Isolation $C_{60}$.

A Graphite disc was heated by a high intensity laser beam that produces a hot vapour of carbon. A burst of Helium gas than the vapour of carbon out through an opening where the beam expands, the expansion, cooled the atoms & they condense into clusters (or) $C_{60}$ molecules i.e fullerene. pure $C_{60}$ & $C_{70}$ can be isolated by coloumn chromatography using aluminia column

## Structure & chemical reaction of $C_{60}$

$C_{60}$ consists of arrays of 60 carbon atoms with geometry of icosahedron having 20 hexa & 12 pentagons, A geometry typical of a soccer ball. In $C_{60}$ all the carbon atoms are equivalent by symmetry but there are both single & double bonds with C-C distances of 1.453 Å & 1.383 Å respectively. $C_{60}$ is a strained molecule but it shows great K.E. However they are thermodynamically less stable than Diamond & Graphite.

uses:

* It used as superconductors at low tempⁿ &

10 - 40 K

* It used as doped with metal like Na & K occupy the interstices b/w adjacent $C_{60}$
* It also used as lubricants due to their spherical st$^{re}$
* It also used in high energy fuels & medical materials.

## Carbon nanotubes.

A form of carbon in which atom are linked by a cylindrical frame with diameter of only a few nanometers is called carbon nanotubes.

Ex:- Single called CNT, cylindrical CNT & multiwalled CNT.

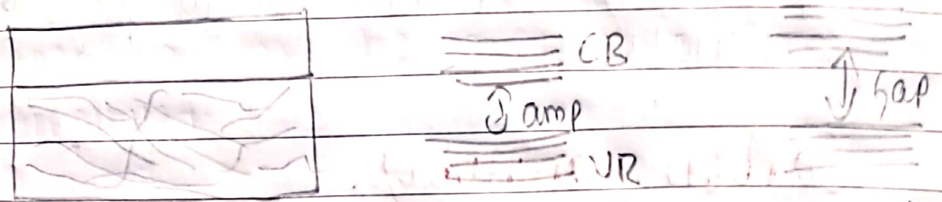
Structure :- CNT st$^{re}$ consist of a single sheet of graphite, rolled into a tube both ends of which are capped with $C_{60}$ fullerene hemisphere. The tubes can be either open at their ends or capped at one (or) both ends with half a spherical fullerence.

## Nanomaterials :

A natural as a set of substances where at least one dimensions is less than approximately 100 nm.

Electronic structure.

In terms of bulk material & their electronic structure. In case of nano materials energy gap b/w conduction band & valence band is different from bulk material. material having few hundred atoms. the continous density of states in the conduction band is replaced by a set of discrete energy levels




Bulk material — large metal cluster — nano material having 4 atoms.

for zero dimension, nano materials the $\bar{e}$ are fully continued. on other hand, for 3D materials. the $\bar{e}$ are fully delocalised In 1-D & 2-D nanomaterials $\bar{e}$ confinment & delocalization co-exist.

Different methods of production.
They are having widely 5 methods.

1. Sol-gel synthesis
2. Inert gas condensation
3. mechanical alloying
4. plasma synthesis.
5. Electro - deposition

## Sol-gel synthesis:

The method involves the formation of a conc suspension of a metallic oxide (or) Hydroxide (sol) which is dehydrated by solvent extraction resulting in a semi-rigid mass. this process gives a good control over composition & partical size. Almost nano size metal nano crystal can be produced in water but this method is limited in applicability.

## Intergas condensation

In this technique, A Inorganic material is vapourized using thermal evaportion (or) ē beam evaporation. In the method an atm of 1-50 m bar of inert gas due to high pressure of inergas molecules & their collision with the ultra fire particles having 10-100nm.

Ex:- Fe is evaporated into an inergas atm through collision with the atoms the evaporated Fe atoms K.E & condense In the form of small crystallite crystals.

## Mechanical alloying (Ball milling)

In this method, the milling is carried out at room temp for up to 150 hrs. following the milling, the powdered is annelead under inert gas at flow at temp at 1400°c for 6 hrs. mechanism of process is not known.

But in the process forms nanotube nuclei & the annealing process activates nanotube growth. In this method more multi walled nanotubes & few single walled nanotubes. Mechanical alloying leads to the formation of alloys which cannot produce in conventional process.

## plasma synthesis:

This method has been sucessfully used in the synthesis of advanced materials such as new ceramics, Nano metric metallic powders, Biomaterials & Superconductors. The typical size of the nanoparticles produced by this method ranges from 20 to 100nm depending on the quenching conditions Employed.

Solid precursor ⟩ plasma reactor → Nanopowder
Liquid precursor ⟩

Ex:- Size of nano powder: Al powder (60nm)
Silicon Carbide (50nm)

## Electro deposition:

In this method consists of an electrochemical cell & accessories for applying controlled current at a certain voltage. the cell contain cathode & anode. the cathode is made from non-metallic & metallic material.
using this surface of the cathode as a templeate, various desired nano str (or) morphologies synthesized for a specific applications. the electro deposition process involves the formation of either instaneously (or) progressive nucleation. Templete - assisted electron deposition is an important techniques

for synthetic metallic nano-materials with controlled shaped & size.

General application

* It used in medicines.
* used in making of high energies density batteries
* used to mfg of next generation computer technologies
* used in high sensitivity sensor.
* used in $H_2O$ purification process
* In food science.
* used in autospace
* used in automobiles.
* used in vetarnary application.
* used in High power magnets