

BORON FAMILY

Non-metal ← **5 B** Most abundant metal Third most element in earth crust (O > Si > Al > Fe)

← **13 Al**

← **31 Ga** exists as Ga₂ molecules & thus low M.P (29.67° C) - liquid up to 2000° C Used in high T thermometer

← **49 In**

← **81 Tl**

← **113 Nh** Radioactive

Metal ←

PHYSICAL PROPERTIES

Atomic radii B < Ga < Al < In < Tl

Ionisation enthalpy B > Tl > Ga > Al > In

Electronegativity B > Tl > In > Ga > Al

Ionic radii Decreases down the group

Density Increases Down the group

M.p decreases from B to Ga and then increases B > Al > Tl > In > Ga

B.p Decreases down the group

CHEMICAL PROPERTIES

Reducing power Al > Ga > In > Tl

Stability order of O.S: Tl¹⁺ > In¹⁺ > Ga¹⁺ > Al¹⁺ > B¹⁺ (Inert pair effect)

B³⁺ > Al³⁺ > Ga³⁺ > In³⁺ > Tl³⁺

Tl³⁺ = Strong oxidant, Ga⁻¹ = Strong reductant

Maximum covalency of B is 4 (absence of valence d orbitals)

Halides - Lewis acids (BF₃ < BCl₃ < BBr₃)

Oxides
 B₂O₃
Al₂O₃
Ga₂O₃
In₂O₃
Tl₂O₃
↓
Acidic Character Decreases
↓
Basic Character Increases

Hydroxides
 B(OH)₃
Al(OH)₃
Ga(OH)₃
In(OH)₃
Tl(OH)₃
↓
Acidic Character Decreases
↓
Basic Character Increases

COMPOUNDS OF Al

AlCl₃

- Al₂O₃ + 3C + 3Cl₂ → 2AlCl₃ + 3CO
- Aqueous solution is acidic due to the formation of HCl. AlCl₃ + 3H₂O → Al(OH)₃ + 3HCl
- Anhyd. AlCl₃ is covalent & dimeric.

Alum

M₂SO₄ M₁(SO₄), 24H₂O
M - Monovalent metal M¹⁺ - Trivalent metal

Examples:
Potash alum K₂SO₄·Al₂(SO₄)₃·24H₂O
Chrome alum K₂Cr₂(SO₄)₆·24H₂O
Ferric alum (NH₄)₂SO₄·Fe₂(SO₄)₃·24H₂O
Each cation is surrounded by 6 H₂O

BORIC ACID

- Weak monobasic acid (Lewis acid)
H₃BO₃ + H₂O → [B(OH)₄]⁻ + H⁺
- Heating effect:
H₃BO₃ $\xrightarrow{277K}$ HBO₂ $\xrightarrow{433K}$ H₂B₃O₇ \xrightarrow{red} B₂O₃

Metaboric acid Tetraboric acid Boron trioxide (Boric anhydride)

- Forms 6 H-bonds in aqueous solution.

DIBORANE

- Highly reactive: it catches fire
B₂H₆ + 3O₂ → B₂O₃ + 3H₂O, ΔH = -ve
- With water: B₂H₆(g) + 6H₂O(l) → 2B(OH)₃(aq) + 6H₂(g)
- Reaction with ammonia:
B₂H₆ + 2NH₃ → [BH₂(NH₂)₂]₂ (BH₂)₂ → 2B₂N₂H₆ + 12H₂

two 3c-2e banana bond
four 2c-2e Terminal bonds

BORAX / TINCAL

Na₂B₄O₇ · 10H₂O / Na₂[B₄O₇(OH)₄] · 8H₂O

- Aqueous solution of borax is alkaline in nature
- Na₂B₄O₇ + 7H₂O → 2NaOH + 4H₂BO₃
- Borax bead test (Detection of transition metal)

Na₂B₄O₇ · 10H₂O $\xrightarrow{\Delta}$ Na₂B₄O₇ $\xrightarrow{strong heat}$ 2NaBO₂ + B₂O₃

T.M Colour: Cu/Co Blue

Uses: As flux, Water softening agent, As antiseptic, In making enamel, Manufacture of glass

* There are 5 B-O-B bridge bonds

CARBON FAMILY

1) Oxidation State: +2, +4, -2
Stability of +4: C > Si > Ge > Sn > Pb
Stability of +2: Pb > Sn > Ge > Si > C

2) Oxides

CO	Neutral	CO ₂	Acidic
SiO	Neutral	SiO ₂	Acidic
GeO	Acidic	GeO ₂	Acidic
SnO	Amphoteric	SnO ₂	Amphoteric
PbO	Amphoteric	PbO ₂	Amphoteric

(Litharge)

Halide

- Thermal stability order:
CCl₄ < SiCl₄ < GeCl₄ < SnCl₄ < PbCl₄
CCl₂ < SiCl₂ < GeCl₂ < SnCl₂ < PbCl₂
- CCl₄ can't be hydrolysed due to absence of valence d orbitals
- PbI₂ & PbBr₂ does not exist due to strong oxidising nature of Pb⁴⁺

COMPOUNDS OF CARBON

CO

- HCOOH $\xrightarrow{conc. H_2SO_4}$ CO + H₂O (100% yield)
- Coal gasification
C + H₂O (steam) → CO + H₂ (Syn gas / Water gas)
- Producer gas (CO + N₂)
- With Hb it forms 300 Times stable Carboxy Hb (w.r. To oxyHb)

CO₂

- Solid CO₂ - Dry ice (Refrigerant)
- CO₂ in water gives carbonic acid (maintain pH 7.26-7.42)
- NaOH + CO₂ → NaHCO₃
- Used in soft drinks
- Used as fire extinguisher

P-BLOCK ELEMENTS

COMPOUNDS OF SILICON

SILICA

- SiO₂ - sand, quartz (piezoelectric)
- Insoluble in H₂O & inert at room temp.
- Reacts with HF (etching of glass)
HF + SiO₂ → SiF₄
SiF₄ + 2HF → H₆SiF₈
- 3D Network Covalent Solid

SILICONES

- general formula (R₂Si)_n
- R₂SiCl₂ + H₂O → R₂Si(OH)₂ (Linear Chain Silicones)
- RSiCl₃ $\xrightarrow{H_2O}$ RSi(OH)₃ (Cross linked silicones)
- R₃SiCl → stopping agent / Dimer

SILICATES

- Metal derivatives of silicic acid H₄SiO₄
- Basic unit is (SiO₄)⁴⁻ Tetrahedral

ZEOLITES

- Sodium Aluminium silicates (Na₂Al₂Si₂O₈ · XH₂O)
- (i) Used for Purification of H₂O to remove hardness of water
- (ii) ZSM 5 is a shape selective catalyst to convert alcohol to gasoline

ALLOTROPES OF CARBON

DIAMOND

- C-C bond length is 154 pm
- C is sp³ hybridised
- Good thermal conductor
- ΔH of formation is 1.9KJ/mol
- Used as abrasive for sharpening of tools

GRAPHITE

- C-C bond length is 141.5pm
- Thermodynamically most stable due to ΔH = 0
- C is sp² hybridised
- Good electric conductor
- Hexagonal ring layers which are 340pm apart
- Used as dry lubricant in machines

FULLERENES

- C₆₀-C₇₀ (Bucky balls)
- C is sp² hybridised
- C-C → 143.5pm
C=C → 138.3pm
- C₆₀ has 12 pentagons and 20 hexagons

NITROGEN FAMILY

PREPARATION OF N₂

NH_4NO_2
(NH_4), Cr_2O_7 Heating
 $\text{Ba}(\text{N}_3)_2$

PROPERTIES OF N₂

$\text{Mg} + \text{N}_2 \rightarrow \text{Mg}_3\text{N}_2$
 $\text{CaC}_2 + \text{N}_2 \rightarrow \text{CaCN}_2 + \text{C}$
NETRILIME

OXIDES OF NITROGEN

NO $\text{N}=\text{O}$ (DIATOMIC GAS)
N₂O $\text{N}=\text{N}-\text{O}$ (DIATOMIC GAS)
NO₂ $\text{O}=\text{N}-\text{O}$ (DIATOMIC BROWN GAS)
N₂O₄ $\text{O}=\text{N}-\text{O}-\text{N}=\text{O}$ (DIATOMIC BLUE SOLID)
N₂O₅ $\text{O}=\text{N}(\text{O})-\text{O}-\text{N}(\text{O})=\text{O}$ (DIATOMIC COLORLESS GAS)
N₂O₃ $\text{O}=\text{N}-\text{O}-\text{N}=\text{O}$ (DIATOMIC COLORLESS GAS)

OXIDES OF NITROGEN

N_2O , $\text{NH}_4\text{NO}_2 \xrightarrow{\Delta}$
NO BROWN RING TEST
 N_2O , $\text{NO} + \text{N}_2\text{O}_4 \rightarrow$
 NO , $\text{Pb}(\text{NO}_3)_2 \xrightarrow{\Delta}$
 N_2O , $2\text{NO}_2(\text{g}) \xrightarrow[\text{high P}]{\text{low T}}$
 N_2O , $\text{P}_2\text{O}_{10} + \text{HNO}_3 \rightarrow$

COMMERICAL PREPARATIONS

HABER'S PROCESS
 $\text{N}_2 + 3\text{H}_2 \xrightarrow[\text{Iron catalyst, 400-450°C}]{\text{High P}}$ 2NH_3

REACTIONS

$\text{CuSO}_4 + \text{NH}_3 + \text{H}_2\text{O} \rightarrow [\text{Cu}(\text{NH}_3)_4]\text{SO}_4 \cdot (\text{NH}_4)_2\text{SO}_4$

OXOACIDS OF NITROGEN

COMMERCIAL PREPARATIONS
OSTWALD'S PROCESS
 $\text{NH}_3 + \text{O}_2 \rightarrow \text{NO}$
 $\text{NO} + \text{O}_2 \rightarrow \text{NO}_2$
 $\text{NO}_2 + \text{H}_2\text{O} \rightarrow \text{HNO}_3$

REACTION WITH NON METALS

$\text{I}_2 + \text{HNO}_3 \rightarrow \text{HI} + \text{NO}_2$
 $\text{P}_4 + \text{HNO}_3 \rightarrow \text{H}_3\text{PO}_4 + \text{NO}_2$
 $\text{S} + \text{HNO}_3 \rightarrow \text{H}_2\text{SO}_4 + \text{NO}_2$
 $\text{C} + \text{HNO}_3 \rightarrow \text{CO}_2 + \text{NO}_2$

REACTION WITH METALS

Zn-dil. $\text{HNO}_3 \rightarrow \text{Zn}(\text{NO}_3)_2 + \text{N}_2\text{O}$
Cu-dil. $\text{HNO}_3 \rightarrow \text{Cu}(\text{NO}_3)_2 + \text{NO}$
Zn-Conc. $\text{HNO}_3 \rightarrow \text{Zn}(\text{NO}_3)_2 + \text{NO}_2$

AMMONIA

COMMERCIAL PREPARATIONS

HABER'S PROCESS
 $\text{N}_2 + 3\text{H}_2 \xrightarrow[\text{Iron catalyst, 400-450°C}]{\text{High P}}$ 2NH_3

OXOACIDS OF PHOSPHORUS

PHOSPHORUS TYPE
- Hypophosphoric acid ($\text{H}_2\text{P}_2\text{O}_6$)
P-OH \rightarrow 2
Basicity-1
- Orthophosphoric acid (H_3PO_4)
P-OH \rightarrow 3
Basicity-3
- Pyrophosphoric acid ($\text{H}_4\text{P}_2\text{O}_7$)
P-OH \rightarrow 4
Basicity-4

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OXIDES OF PHOSPHORUS

P_4O_{10} (P-O-P) $\text{P}-\text{O}-\text{P}$ Bond-3
Basicity-3
 P_4O_6 (P-O-P) $\text{P}-\text{O}-\text{P}$ Bond-3
Basicity-3

HALIDES OF PHOSPHORUS

1) PCl_3 2) PCl_5
Preparation: $\text{P}_4 + 3\text{Cl}_2 \rightarrow \text{PCl}_3$ (white phosphorus)
 $\text{P}_4 + 5\text{Cl}_2 \rightarrow \text{PCl}_5$ (white phosphorus)

PROPERTIES

PCl_3 $\text{P}(\text{Cl})_3$ (trigonal bipyramidal)
 PCl_5 $\text{P}(\text{Cl})_5$ (trigonal bipyramidal)

- In PCl_3 gaseous & liquid phase exist as trigonal bipyramidal
- In solid phase, it exist as ionic crystal
 $\text{PCl}_5 \rightarrow [\text{PCl}_4]^+[\text{Cl}]^-$

PH₃, phospheni

- Holmes signal ($\text{Ca}_3\text{P}_2 + \text{CaCl}_2$)
 $\text{CaC}_2 + \text{H}_2\text{O} \rightarrow \text{C}_2\text{H}_2$ (Flammable)

PHOSPHOROUS & ITS ALLOTROPES

1. White phosphorous

- Translucent white waxy solid
- Insoluble in water and CS₂, but soluble in H₂O
- Occurs in discrete units
- Highly reactive due to angle strain
- Burns in air due to formation of P₂O₅
- In basic medium, disproportionate to form PH₃ & NaH₂PO₂
 $\text{P}_4 + 3\text{NaOH} + 3\text{H}_2\text{O} \rightarrow \text{PH}_3 + 3\text{NaH}_2\text{PO}_2$

2. Red phosphorous

- Grey lustre
- Insoluble in water and CS₂, but soluble in H₂O
- Non poisonous
- No chemiluminescence
- Obtained by heating white P at 573 K
- Occurs as polymer.
- So it is less reactive

3. Black phosphorous

(α) - black phosphorous
- Prepared by heating Red P at 803 K
(β) - black phosphorous
- Prepared by heating white P at 473 K

CHEMICAL PROPERTIES

Hydrides

NH_3 , PH_3 , AsH_3 , SbH_3 , BiH_3
 NH_3 , PH_3 , AsH_3 , SbH_3 , BiH_3
(Reducing nature/ ability to act as RA)
Acidity
 BiH_3 , SbH_3 , AsH_3 , PH_3 , NH_3
(Due to large size of Bi, it can easily release H)

Thermal stability/ Bond dissociation energy

NH_3 , PH_3 , AsH_3 , SbH_3 , BiH_3
(Bi can easily release H and hence have low thermal stability)

BP

BiH_3 , SbH_3 , NH_3 , AsH_3 , PH_3
(As molecular mass \uparrow \rightarrow BP \uparrow)

MP

NH_3 , SbH_3 , AsH_3 , PH_3
(Due to similar size of N and H, NH₃ has high M.P)

Nature of Oxides

N_2O , P_2O_5 Acidic
 As_2O_3 , Sb_2O_3 Amphoteric
 Bi_2O_3 Basic

Oxides

- Generally it forms oxides of the type A₂O₃ and A₂O
- Acidic character increases with increase in oxidation number
 $\text{H}_2\text{O} < \text{NO} < \text{N}_2\text{O} < \text{NO}_2 < \text{N}_2\text{O}_4 < \text{N}_2\text{O}_5$
- In a group thermal stability of oxides decreases down the group
 $\text{N}_2\text{O} > \text{P}_2\text{O}_5 > \text{As}_2\text{O}_3 > \text{Sb}_2\text{O}_3 > \text{Bi}_2\text{O}_3$

OXYGEN FAMILY

PHYSICAL PROPERTIES

Electron affinity
 $-\text{S} > \text{Se} > \text{Te} > \text{Po} > \text{O}$

CHEMICAL PROPERTIES

Hydrides

Bond Angle
 $\text{H}_2\text{O} > \text{H}_2\text{S} > \text{H}_2\text{Se} > \text{H}_2\text{Te}$

Thermal Stability

$\text{H}_2\text{O} > \text{H}_2\text{S} > \text{H}_2\text{Se} > \text{H}_2\text{Te}$

Acidic Character

$\text{H}_2\text{Te} > \text{H}_2\text{Se} > \text{H}_2\text{S} > \text{H}_2\text{O}$

Reducing Power

$\text{H}_2\text{Te} > \text{H}_2\text{Se} > \text{H}_2\text{S} > \text{H}_2\text{O}$

B.P

$\text{H}_2\text{O} > \text{H}_2\text{Te} > \text{H}_2\text{Se} > \text{H}_2\text{S}$

OXOACIDS OF SULPHUR

1) Thionous type

i) Dithionous acid $\text{H}_2\text{S}_2\text{O}_4$ (S₂O₄²⁻) +3
ii) Dithionic acid $\text{H}_2\text{S}_2\text{O}_6$ (S₂O₆²⁻) +5
iii) Polythionic acid $\text{H}_2\text{S}_n\text{O}_{3n}$ (S_nO_{3n}²⁻) +5, 0
iv) Thiosulphuric acid $\text{H}_2\text{S}_2\text{O}_3$ (S₂O₃²⁻) +6, -2

2) Sulphurous type

i) Sulphurous acid H_2SO_3
ii) Sulphuric acid H_2SO_4
iii) Pyrosulphuric acid $\text{H}_2\text{S}_2\text{O}_7$ (Oleum)

3) Peroxo type

i) Peroxomonosulphuric acid H_2SO_5 (Caro's acid)
ii) Peroxodisulphuric acid $\text{H}_2\text{S}_2\text{O}_8$ (Marshall's acid)

ALLOTTROPES OF SULPHUR

1) Rhombic Sulphur [S₈]
- Exist in room temperature
- Soluble in CS₂ but insoluble in H₂O
- Exist below 369 K
2) Monoclinic Sulphur [S₇]
- Soluble in CS₂
- Obtained by melting rhombic sulphur above 369 K

Transition Temperature:

369 K, at which both monoclinic & rhombic exist. Above this temperature monoclinic exist, below this temperature rhombic sulphur exist.

SO₂

Uses:
1. Act as a bleaching agent due to the formation of nascent oxygen
2. SO₂ \rightarrow SO<sub>2} \cdot 2\text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_3 (20%)
100% oleum/sulphur \rightarrow liquid SO₂</sub>

PROPERTIES

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PHYSICAL PROPERTIES

Electron affinity/EGE
 $-\text{Cl} > \text{F} > \text{Br} > \text{I}$

CHEMICAL PROPERTIES

1) Oxidising Power:
- F is the strongest oxidising agent
 $\text{F}_2 > \text{Cl}_2 > \text{Br}_2 > \text{I}_2$ (O.A)
- F₂ displaces Cl₂, Br₂ & I₂
- Cl₂ displaces Br₂ and I₂
- Br₂ & I₂ \rightarrow 2KBr & 2KI
- I₂ + KBr \rightarrow No reaction

2) With H₂O:
- $\text{F}_2 + \text{H}_2\text{O} \rightarrow \text{HF} + \text{O}_2$ (Releases O₂ from H₂O, good oxidising agent)
- $\text{Cl}_2/\text{Br}_2 + \text{H}_2\text{O} \rightarrow \text{HCl} + \text{HOCl}$
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COMPOUNDS OF CHLORINE

1) Cl_2 Preparation: Commercial
 $\text{HCl} + 1/2\text{O}_2 \rightarrow \text{H}_2\text{O} + 1/2\text{Cl}_2$

PROPERTIES

- Greenish yellow coloured gas
- $\text{Cl}_2 + \text{H}_2\text{O} \rightarrow \text{HOCl} + \text{HCl}$
- With NH₃ colourless
1) $\text{NH}_3 + \text{Cl}_2 \rightarrow \text{NH}_4\text{Cl} + \text{N}_2$ (excess)
2) $\text{NH}_3 + \text{Cl}_2 \rightarrow \text{NCl}_3 + \text{HCl}$ (excess)
3) $\text{NaOH} + \text{Cl}_2 \rightarrow \text{NaOCl} + \text{NaCl} + \text{H}_2\text{O}$ (Cold & dilute)
4) $\text{Ca(OH)}_2 + \text{Cl}_2 \rightarrow \text{CaOCl}_2 + \text{H}_2\text{O}$ (Calcium hypochlorite)
5) $\text{Ca(OH)}_2 + \text{Cl}_2 \rightarrow \text{CaCl}_2 + \text{H}_2\text{O}$ (Bleaching powder)

USES

- Powerful bleaching agent due to oxidising property
- Bleaching powder \rightarrow $\text{Ca}(\text{OCl})_2$, CaCl_2
- Preparation of poisonous gas
1) Tear gas \rightarrow CCl_4NO_2
2) Phosgene \rightarrow COCl_2
3) Mustard gas \rightarrow $\text{Cl}-\text{CH}_2-\text{S}-\text{CH}_2-\text{Cl}$

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NOBLE GASES

All these, except Radon & Oganesson occur in the atmosphere.

PHYSICAL PROPERTIES

- Atomic radii \rightarrow down the group
- IE \rightarrow down the group
- He is having maximum ionization energy of all known substances
- He is having lowest B.P among all known substance (4.2K)
- Xe is having highest positive value of electron gain enthalpy
- B.P \rightarrow down the group
- Xe is having lowest B.P among all known substance (4.2K)

ISOMERISM OF XENON FLUORIDE COMPOUNDS

[Preparation] XeF_2 (s) $\xrightarrow{\text{hv}}$ XeF_2 (s)
 XeF_2 (s) $\xrightarrow{\text{hv}}$ XeF_2 (s)
[Structure] XeF_2 (s) \rightarrow (2x2) \rightarrow linear
 XeF_2 (s) \rightarrow (2x2) \rightarrow square planar
 XeF_2 (s) \rightarrow (2x2) \rightarrow distorted Octahedral

INTERHALOGEN COMPOUNDS

Compounds formed b/w 2 different halogens
Types: XX' , XX'_2 , XX'_3 , XX'_4 , XX'_5 , XX'_6
Properties and uses
- ClF & BrF_3 \rightarrow Uranium enrichment for fissioning (U²³⁵)
- ClF_3 \rightarrow Spectroscopically detected
- ClF_3 \rightarrow Gas in 2 polymeric form (n & n+1)
- Inter halogens are very reactive than halogens (except F)
- XeF_2 \rightarrow XeF_2 (s) \rightarrow linear
 XeF_2 (s) \rightarrow (2x2) \rightarrow square planar
 XeF_2 (s) \rightarrow (2x2) \rightarrow distorted Octahedral

INTER-OXYGEN COMPOUNDS

[Preparation] XeO_3 (s) \rightarrow XeO_3 (s)
[Structure] XeO_3 (s) \rightarrow (2x2) \rightarrow Pyramidal
 XeO_3 (s) \rightarrow (2x2) \rightarrow Square planar
 XeO_3 (s) \rightarrow (2x2) \rightarrow Square planar

p-BLOCK ELEMENTS

HALOGENS & NOBLE GAS

d-Block transition elements (group 3-12)

Electronic configuration : $(n-1)d^{1-10} ns^{1-2}$

Exceptions $\left\{ \begin{array}{l} Cr=4s^1 3d^5 \\ Cu=4s^1 3d^{10}, Pd=5s^0 4d^{10} \end{array} \right.$ Non-typical transition elements
Zn, Cd & Hg

Physical properties:

- High melting and boiling point

Melting point: s-block metals < d-block metals

Sc < Ti < V < Cr > Mn < Fe > Co > Ni > Cu > Zn (3d Series)

Melting point $\left\{ \begin{array}{l} Zn > Cd > Hg \\ Cu > Ag < Au \end{array} \right.$

- High enthalpies of atomization (Highest for V in 3d, series)

Atomic Radius:

3d series: Sc > Ti > V > Cr > Mn > Fe > Co = Ni < Cu < Zn

In a group 3d < 4d < 5d (Lanthanide contraction)

eg: Ti < Zr < Hf $\left\{ \begin{array}{l} \text{Smallest radius - Ni} \\ \text{Largest radius - La} \end{array} \right.$

Density:

s-Block < d-Block

3d series: Sc < Ti < V < Cr = Mn < Fe < Co < Ni < Cu > Zn

In a group 3d < 4d < 5d

- Ionisation enthalpy: increases from left to right
- Oxidation states: Variable; higher O.S. stable down the group
- Trends in $E^{\circ}_{M^{n+}/M}$: E° for Mn, Ni and Zn are more negative than expected.
- Trends in $E^{\circ}_{M^{n+}/M}$: variable
- Chemical reactivity and E° values: Variable Ti^{2+} , V^{2+} and Cr^{2+} are strong reducing agents
- Magnetic properties: Diamagnetism and paramagnetism. $\mu = \sqrt{n(n+2)} \text{ BM}$
- Formation of coloured ions: due to d-d transitions
- Form a large number of complex compounds
- Forms interstitial compounds: Non-stoichiometric and are neither ionic nor covalent.
- Alloy formation: Due to similar atomic sizes (15% difference in metallic radius)

Lanthanoids

- Electronic configuration: $4f^{1-14} 5d^{0-1} 6s^2$ (Gd: $4f^7 5d^1 6s^2$)
- Atomic and ionic sizes: Decreases from La to Lu (Eu is the largest)
- Oxidation states: Most common is +3.
- Some elements: exhibit +2 and +4.
- General characteristics:
 - Silvery white soft metals and tarnish rapidly in air.
 - Hardness increases with increasing atomic number.
 - Metallic structure and good conductors of heat and electricity.
 - Variable density
 - Trivalent Lanthanoid ions are coloured.
 - Ionisation Enthalpies: Low third ionisation enthalpies.
 - Good reducing agents.

MISCH METAL - Alloy of Ln (95%), Fe (5%) & S, C, Ca, Al etc..

Uses

- In production of iron and steels.
- TiO in pigment industry
- MnO₂ in dry battery cells.
- As catalysts in industry.
- Ni complexes: polymerization of alkynes and other organic compounds
- AgBr in photographic industry.

Catalysts

Contact process = V₂O₅

Haber process = Fe₃O₄, Al₂O₃ + K₂O

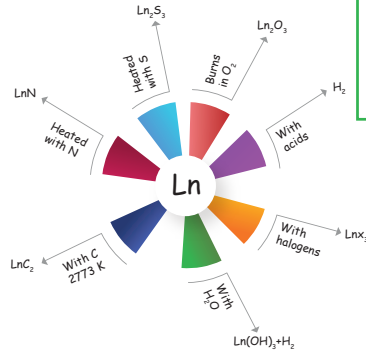
Decomposition of KClO₃ = MnO₂

Ostwald process = Pt/Rh

Zeigler Natta catalyst = TiCl₄ + (C₂H₅)₃Al

Hydrogenation of Alkene = Ni/Pd

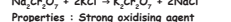
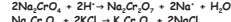
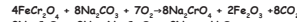
Wilkinson's catalyst = RhCl(PPh₃)₃



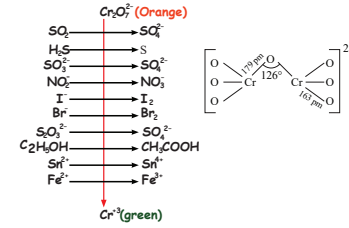
Compounds of d-block elements

Potassium dichromate K₂Cr₂O₇

Preparation:

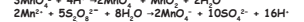


Properties: Strong oxidising agent



Potassium permanganate KMnO₄

Preparation: $2MnO_2 + 4KOH + O_2 \rightarrow 2KMnO_4 + 2H_2O$



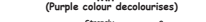
- Intense colour

- Paramagnetism

- Strong oxidising agent



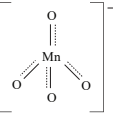
MnO₄⁻ (Purple)



Mn²⁺ (Purple colour decolourises)

MnO₄⁻ (purple) $\xrightarrow{\text{basic solution}}$ MnO₄²⁻ (green)

MnO₄⁻ (neutral medium) \rightarrow MnO₂ (Brown ppt)



Actinoids

- Electronic configuration: $[Rn]5f^{1-14} 6d^{0-1} 7s^2$
 - Ionic sizes: Gradual decrease along the series
 - Oxidation states: Most common is +3. They show O.S. of +4, +5, +6 and +7.
 - General characteristics:
 - Highly reactive metals
 - Irregularities in metallic radii, greater than in Lanthanoids.
 - Magnetic properties more complex than lanthanoids
- Actinoid Contraction > Lanthanoid Contraction



The element that usually does not show variable oxidation state is ?

- a) Cu b) Ti
c) Sc d) V

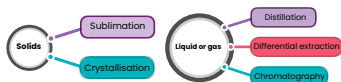
Which of the following is not formed when H₂S reacts with acidic K₂Cr₂O₇ solution ?

- a) CrSO₄ b) Cr₂(SO₄)₃
c) K₂SO₄ d) S

d&f BLOCK ELEMENTS

Purification of Organic Compounds

Methods of purification



Sublimation

Solid is converted directly into vapour without undergoing liquid state.
eg: Purification of Iodine, Camphor, Naphthalene, ammonium chloride etc.

Crystallisation:

- It is based on the difference in the solubilities of the compound & the impurities in a suitable solvent.
- The impure compound is dissolved in a solvent in which it is sparingly soluble at room temperature but appreciably soluble at higher temperature.
- If the compound is highly soluble in one solvent and very little soluble in another solvent, crystallisation can be satisfactorily carried out in a mixture of these solvents.
eg: Purification of sugar, purification of potash alum etc.

Distillation:

Principle: Based on difference in b.p. of components of mixture.
Also used to separate: Volatile liquids from nonvolatile impurities

Types of distillation:

Simple distillation:

It is based on difference in b.p.
eg: chloroform (34°C) & aniline (157°C)

Fractional distillation:

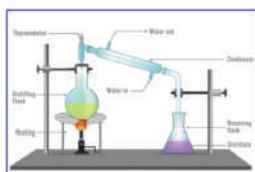
It is used to separate different fractions of crude oil in petroleum industry.

Vacuum distillation

(distillation under reduced pressure)
eg: oily waste is separated from sugar - 1st in soap industry.

Steam Distillation

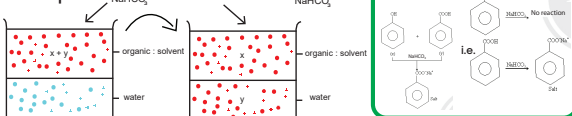
It is used to separate substances which are steam volatile and are immiscible with water.
eg: aniline, nitrobenzene, or oil of eucalyptus.



Differential Extraction Principle:-

- Based on difference in solubility of organic compounds in different solvents.
- When an organic compound is present in an aqueous medium, it is separated by shaking it with an organic solvent in which it is more soluble than in water.
- The organic solvent & aq. solvent should be immiscible with each other so that they form 2 distinct layers which can be separated by separating funnel.
- The aq. solvent is later removed by distillation or evaporation to get back org. comp.

Example:



Q. A mixture of camphor and benzoic acid can be separated by:

- Sublimation
- Extraction with a solvent
- Chemical method
- Fractional distillation

Q. The best method for the separation of naphthalene and benzoic acid from their mixture is:

- Chromatography
- Crystallisation
- Distillation
- Solvent extraction

Q. In steam distillation, the sum of the vapour pressure of the volatile compound and that of water is:

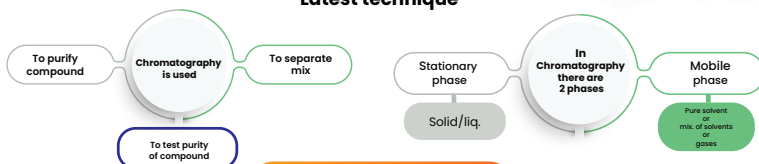
- Equal to atmospheric pressure
- Less than atmospheric pressure
- More than atmospheric pressure
- Exactly half of the atmospheric pressure

Q. A liquid compound can be purified by steam distillation only if it is:

- Steam volatile, miscible with water
- Not steam volatile, immiscible with water
- Steam volatile, immiscible with water
- Not steam volatile, miscible with water

Chromatography

Latest technique



Types of chromatography

1) Adsorption Chromatography:

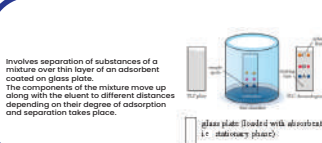
Based on the fact that different components of a mixture have different degrees of adsorption on adsorbent (silica gel or alumina)
Stationary phase - solid
Mobile phase - liquid/gas



a) Column Chromatography

- Involves separation of a mixture over a column of adsorbent (stationary phase) packed in a glass tube.
- Component of the mixture which is more soluble in stationary phase is adsorbed first than the component which is less soluble in stationary phase.
- The most readily adsorbed substances are retained near the top and others come down to various distances in the column.

b) Thin layer chromatography (TLC)



Retardation factor:-

express degree of adsorption of each component of mixture.

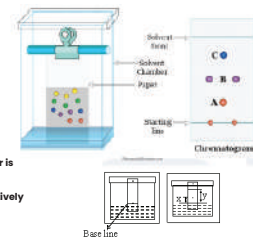
$$R_f = \frac{\text{distance moved by component of mixture from base line}}{\text{distance moved by solvent (mobile phase) from base line.}}$$

2) Partition chromatography:

Based on continuous differential partitioning of components of a mixture between stationary & mobile phase. Also known as **liquid paper chromatography**

Stationary phase - liquid
Mobile phase - liquid

- A special quality paper known as chromatography paper is used.
eg: cellulose paper
- Chromatography paper contains water trapped in it, which works as Stationary phase.
- Moving phase is a solvent or a mixture of solvents in which spotted chromatography paper is suspended.
- The solvent rises up the paper by capillary action and flows over the spot. The paper selectively retains different components according to their differing partition in the two phases. The paper strip so developed is called Chromatogram



Q. Paper chromatography is an example of:

- Partition chromatography
- Thin layer chromatography
- Column chromatography
- Adsorption chromatography

Q. The most suitable method of separation of 1:1 mixture of ortho & para-nitrophenols is

- Steam distillation
- Sublimation
- Chromatography
- Crystallisation