CONCEPT MAP

ESSENTIALS OF INORGANIC CHEMISTRY (PART I)

General Principles and Processes of Isolation of Elements

Metallurgy

- **Minerals :** Naturally occurring chemical substances in the earth's crust obtainable by mining.
- **Ores :** The minerals from which metal can be extracted profitably and conveniently.
- **Metallurgy :** The entire scientific and technological process used for isolation of the metal from its ore.

Concentration of Ore

The whole process of obtaining a pure metal from its ore.

- **Crushing and Grinding (Pulverisation) :**

  Lumps of ore $\xrightarrow{\text{Crushers}}$ Small pieces $\xrightarrow[\text{mill}]{\text{Ball}}$ Fine powder

- **Concentration or Benefication of Ore :** It is the removal of gangue or matrix from the powdered ore. The impurities present in an ore are called gangue or matrix.
- **Gravity separation or levigation or hydraulic washing :** For oxide ores, based on difference in the densities of ore (heavier) and gangue particles, using wilfley tables.
- **Froth floatation :** For sulphide ores, based on perferential wetting of ore (by oil) and gangue (by water).
- **Magnetic separation :** Based on difference in magnetic properties. (Either ore or the impurities associated with magnetic nature.)
- **Leaching :** When ore is soluble in a suitable solvents while impurities are not.
  For Al → Baeyer's process : from bauxite ore
  For Au → Mac-Arthur Forest cyanide process : from argentite ore.

Thermodynamic Principles of Metallurgy

For a reaction to occur, ΔG should be negative. A reaction with ΔG positive can be made to occur if it is coupled with another reaction having a large negative ΔG, so that the net ΔG of both the reactions is positive.

Ellingham Diagram : Plots of $\Delta_r G^\circ$ *vs* T. These help in predicting the feasibility of thermal reduction of an ore to metal.

- Slope = Positive, because ΔG° increases with rise in T.
- Each curve is a straight line except when phase changes take place ($s \rightarrow l$, $l \rightarrow g$).
- Metal oxide placed higher in the diagram can be reduced by the metal placed lower.

Metals from Concentrated Ore

- **Concentrated Ore :** Conversion of concentrated ore into reducible form (oxidation).
  - **Calcination :** Converting concentrated ore into oxide by heating it strongly below its melting point in the absence of air
  - **Roasting :** The concentrated ore (usually sulphide) is heated strongly, in the presence of excess of air below its melting point.
- **Reduction or conversion of oxides to metals :** The ore obtained after calcination or roasting is reduced to metal and choice of reducing agent depends upon the nature of ore.
- Carbon or carbon monoxide is used for oxides of Fe, Cu, Zn, Mg, Co, etc. and the process is called smelting.
- Electropositive metals like Na, Al, Mg or hydrogen are used for reduction of ores of Mn, Cr, Ti, Mo, W, etc.
- Auto-reduction process is used for ores of Pb, Hg, Cu, etc.
- Electrolytic reduction is used for highly electropositive metals.
- Hydrometallurgy or displacement method is used for Ag, Au, etc.

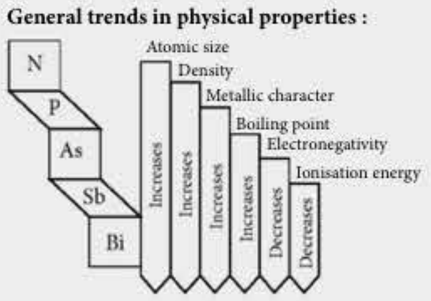
Refining

Methods	Metals Purified
Liquation	Used for low melting metals like Sn, Pb, Hg, Bi, etc.
Distillation	Used for volatile metals like Zn, Hg, Cd, etc., or metals containing non-volatile impurities.
Poling	Used for metals which contain impurities of their own oxides *e.g.*, Cu.
Cupellation	Used for metals containing easily oxidisable impurities *e.g.*, Ag containing Pb impurities.
Electrolytic refining	Used for metals like Cu, Ag, Au, Al which get deposited at cathode and impurities get deposited at anode. Solution of a soluble metal salt acts as an electrolyte.
Mond's process	Used for refining of Ni.
Zone refining	Used to produce extremely pure metals (semiconductors) like Si, Ge, Ga, B and In.
van Arkel method	Used for ultra-pure metals like Ti, Zr which are used in space technology.

The *p*-Block Elements (Group 15 to 18)

Group-15 Elements

- **General electronic configuration :** ns^2np^3
- **General trends in physical properties :**



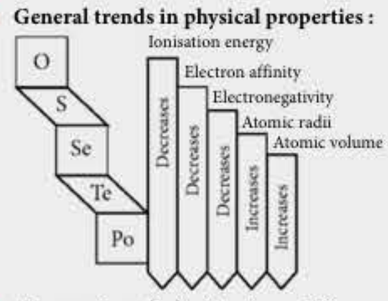
- **Moscovium (Mc) :** Atomic no. 115

Chemical Properties

- **Hydrides :** Form MH_3 type hydrides.
  - **Melting point :** $PH_3 < AsH_3 < SbH_3 < NH_3$
  - **Boiling point :** $BiH_3 > SbH_3 > NH_3 > AsH_3 > PH_3$
- **Halides :** Form MX_3 and MX_5 types of halides.
  - **Lewis acid strength :** $PCl_3 > AsCl_3 > SbCl_3$ and $PF_3 > PBr_3 > PI_3$
  - **Lewis base strength :** $NI_3 > NBr_3 > NCl_3 > NF_3$

Group-16 Elements

- **General electronic configuration :** ns^2np^4
- **General trends in physical properties :**



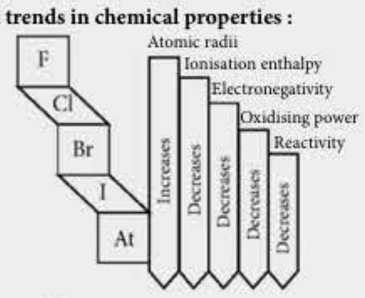
- **Livermorium (Lv) :** Atomic no. 116

Chemical Properties

- **Hydrides :** H_2M type, where M is sp^3 hybridised.
  - **M.Pt. and B.Pt. :** $H_2O > H_2Te > H_2Se > H_2S$
  - **Thermal stability :** $H_2O > H_2S > H_2Se > H_2Te$
  - **Volatility :** $H_2O < H_2Te < H_2Se < H_2S$
  - **Reducing power :** $H_2O < H_2S < H_2Se < H_2Te$
  - **Bond angle and dipole moment :** $H_2Te < H_2Se < H_2S < H_2O$
- **Halides :** Form MX_6, MX_4 and MX_2 types of halides.
  - **Dihalides :** All elements except selenium form dihalides.
  - **Tetrahalides :** SF_4(gas), SeF_4(liquid), TeF_4 (solid). SF_4 is readily hydrolysed than SF_6.
- **Oxyhalides :** Only S and Se form oxyhalides.
- **Oxides :** SO_2 and SeO_2 ; SO_3, SeO_3 and TeO_3 : Acidic
  - TeO_2 and PoO_2 : Amphoteric

Group-17 Elements

- **General electronic configuration :** ns^2np^5
- **General trends in chemical properties :**



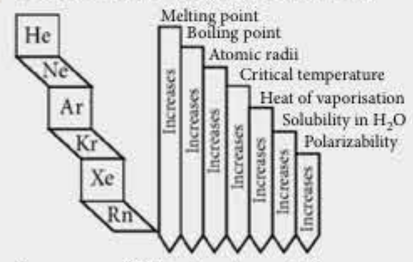
- **Tennessine (Ts) :** Atomic no. 117

Chemical Properties

- **Oxidizing power :** $F_2 > Cl_2 > Br_2 > I_2$
- **Hydrogen halides :**
  - **B.Pt. and M.Pt. :** HF > HI > HBr > HCl
  - **Dipole moment and Thermal stability :** HF > HCl > HBr > HI
  - **Bond length, acidic strength and reducing nature :** HF < HCl < HBr < HI
- **Oxoacids of halogens :**
  - **Acidic strength :** $HClO < HClO_2 < HClO_3 < HClO_4$

Group-18 Elements

- **General electronic configuration :** ns^2np^6
- **General trends in physical properties :**



- **Oganesson (Og) :** Atomic no. 118

Chemical Properties

- M.Pt. and B.Pt. are very low.
- **Ionisation enthalpy :** He > Ne > Ar > Kr > Xe > Rn