CONCEPT MAP

STATES OF MATTER

States of matter are distinguished by the strength of the bonds holding the molecules of the matter together. Gases, liquids and solids are all made up of microscopic particles, but the behaviour of these particles differs in the three phases.

SOLID STATE

Classification

- **Amorphous solids :** Constituent particles are not arranged in regular pattern.
  - short range order and isotropic in nature.
  - supercooled liquids or pseudo solids.
- **Crystalline solids :** Constituent particles are arranged in definite geometric pattern.
  - long range order and anisotropic in nature.
  - true solids.
- Crystalline solids can be *molecular solids, ionic solids, metallic solids* or *covalent solids* depending upon the nature of intermolecular forces.

Crystal Lattice and Unit Cell

- **Crystal lattice :** The regular arrangement of constituent particles in a three dimensional space.
- **Unit cell :** The smallest repeating unit of space lattice.
- **Types of unit cells :**

Simple cubic : Particles at the corners only, $r = \frac{a}{2}$, $\frac{a}{2}$, $Z = 1$, efficiency = 52%, C.No. = 6.

Body centred : Particles at the corners as well as body centre.

$Z = 2$, $r = \frac{d}{2} = \frac{\sqrt{3}a}{4}$, efficiency = 68%, C.No. = 8

Face centred : Particles at the corners as well as face centres, $Z = 4$, $r = \frac{d}{2} = \frac{a}{2\sqrt{2}}$, efficiency = 74%, C.No. = 12.

- If N is no. of spheres in cep then tetrahedral voids = $2N$, having radius = 0.225 R and octahedral voids = N, having radius = 0.414 R.

Imperfections in Solids

- **Defects in stoichiometric crystals :**
  - **Schottky defect :** Arises when equal number of cations and anions are missing from the lattice sites and results in *decrease in density* of the crystal.
  - **Frenkel defect :** Arises due to dislocation of smaller ion from its normal site in interstitial site and *does not affect the density.*
- **Defects in non-stoichiometric crystals :**
  - **Metal excess defect :**
    - ➡ Arises when a negative ion is missing from its lattice site, leaving a hole which is occupied by an electron (*F centre*).
    - ➡ When an extra cation is at interstitial site and electrical neutrality is maintained by electron present in another interstitial site.
  - **Metal deficiency defect :**
    - ➡ Arises when metal shows variable valency and is characterised by missing of a cation from its lattice site and the presence of a cation having higher charge in the adjacent site.
    - ➡ When extra anion is at interstitial site and electrical neutrality is maintained by extra charge on adjacent metal ion.

Magnetic Properties

- **Diamagnetic substances :** Weakly repelled by external magnetic field. e.g., N_2, NaCl, Zn, TiO_2, etc.
- **Paramagnetic substances :** Weakly attracted by external magnetic field. e.g., O_2, Cu^{2+}, Fe^{3+}, Cr^{3+}, etc.
- **Ferromagnetic substances :** Show permanent magnetism even in the absence of external magnetic field. e.g., Ni, Fe, Co, etc.
- **Antiferromagnetic substances :** Have zero net dipole moment due to presence of equal number of domains in the opposite directions, e.g., MnO.
- **Ferrimagnetic substances :** Possess very small net magnetic moment due to unequal number of domains in the opposite directions. *e.g.*, Fe_3O_4.

Electrical Properties

- **Conductors :** Conductivity range, 10^4 to 10^7 ohm^{-1} m^{-1}
- **Insulators :** Conductivity range, 10^{-20} to 10^{-10} ohm^{-1} m^{-1}
- **Semiconductors :** Conductivity range, 10^{-6} to 10^4 ohm^{-1} m^{-1}
  - ***n*-type semiconductors :** Group 14 elements doped with group 15 elements, free electrons increase conductivity.
  - ***p*-type semiconductors :** Group 14 elements doped with group 13 elements, holes increase conductivity.

GASEOUS STATE

- A substance exists in *gaseous state* if the thermal energy of molecules predominates over the intermolecular forces.
- **Gas laws :**
  - **Boyle's law :** $P \propto \frac{1}{V}$ (at constant T and n)
  - **Charles' law :** $V \propto T$ (at constant P and n)
  - **Gay Lussac's law :** $P \propto T$ (at constant V and n)
  - **Avogadro's law :** $V \propto n$ (at constant P and T)
  - **Dalton's law of partial pressures :** $P_{total} = p_1 + p_2 + \ldots + p_n$ (at constant V and T)

$P_{dry\ gas} = P_{moist\ gas} - $ aq. tension

  - **Graham's law of diffusion :** $\frac{r_1}{r_2} = \sqrt{\frac{d_2}{d_1}} = \sqrt{\frac{M_2}{M_1}}$
- **Ideal gases :** Follow gas laws in all conditions of temperature and pressure.
  - Follow ideal gas equation; $PV = nRT$
- **Real gases :** Follow gas laws only at high temperature and low pressure.

Follow van der Waals equation;

$$\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT$$

- **Critical constants and van der Waals constants :**

$$V_c = 3b,\ P_c = \frac{a}{27b^2},\ T_c = \frac{8a}{27Rb}$$

LIQUID STATE

- A substance exists in *liquid state* if the intermolecular forces lie between gaseous and solid states.
- **Properties of liquids :**
  - **Vapour pressure :** Pressure exerted by vapours in equilibrium with the liquid at a particular temperature.

Boiling point : Temperature at which the vapour pressure of a liquid becomes equal to the atmospheric pressure.

- **Surface tension :** Tangential force acting along the surface of a liquid at right angle to a line of one unit length drawn on the surface of the liquid.

Viscosity : Measure of resistance to flow.

- **Eotvos equation :** Relates surface tension (γ), temperature (T) and critical temperature (T_c) of liquid to its density (ρ) and molar mass (M).

$$\gamma = k(T_c - T)\left(\frac{\rho}{M}\right)^{2/3}$$