

ESSENTIAL CONCEPTS OF PHYSICAL CHEMISTRY

Get well-prepared for exams with quick revision of important concepts of physical chemistry.

CONCEPT MAP

CLASS XII

Solid State

Packing efficiency

$$= \frac{\text{Volume occupied by two spheres in the unit cell}}{\text{Total volume of the unit cell}} \times 100$$

- Mass of the atoms of unit cell = Number of atoms in a unit cell (Z) \times Mass of atom (M_{atom})
- Mass of one atom = $\frac{\text{Molar mass } (M)}{\text{Avogadro's constant } (N_A)}$
- Density (ρ) of unit cell of a cubic crystal = $\frac{ZM}{V \times N_A} = \frac{ZM}{a^3 N_A}$
- Bragg's equation: $2d \sin\theta = n\lambda$
- Number of octahedral voids = No. of particles present in the close packing
- Number of tetrahedral voids = $2 \times$ No. of octahedral voids

Characteristics of Different Types of Unit Cells

Crystal	No. of atom(s)/ unit cell	Packing efficiency	C.No.	Relation in d, a and r
<i>scc</i>	1	52.4%	6	$r = d/2 = a/2$
<i>bcc</i>	2	68%	8	$r = d/2 = \sqrt{3}a/4$
<i>fcc</i>	4	74%	12	$r = d/2 = a/2\sqrt{2}$

Void	Radius Ratio
Triangular	$0.155 \leq r^+/r^- < 0.225$
Tetrahedral	$0.225 \leq r^+/r^- < 0.414$
Octahedral	$0.414 \leq r^+/r^- < 0.732$
Body-centred cubic	$0.732 \leq r^+/r^- < 1$

Solids on the Basis of Electrical Properties

- **Conductors:** Electrical conductivity, 10^4 to $10^7 \text{ ohm}^{-1} \text{ m}^{-1}$
- **Insulators:** Electrical conductivity, 10^{-20} to $10^{-10} \text{ ohm}^{-1} \text{ m}^{-1}$
- **Semiconductors:** Electrical conductivity, 10^{-6} to $10^4 \text{ ohm}^{-1} \text{ m}^{-1}$
 - ***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.

Solutions

$$\bullet \text{ Molality } (m) = \frac{M}{\rho - \frac{MM_2}{1000}} \quad \bullet \text{ Molarity } (M) = \frac{n_1}{(n_1M_1 + n_2M_2)/\rho}$$

- **Henry's law:** $p_A = K_H \cdot x_A$; K_H increases with increase of temperature implying that solubility decreases with increase of temperature at the same pressure.
- **Raoult's law:** $p_1 = p_1^\circ x_1$, this law is applicable only if the two components form a homogeneous mixture.
- **Dalton's law of partial pressure:** $p_{\text{total}} = p_1 + p_2 + \dots + p_n$ and for two components system, $p_{\text{total}} = p_1^\circ + (p_2^\circ - p_1^\circ)x_2$

Ideal and Non-ideal Solutions

Ideal Solutions	Non-ideal Solutions
$p_1 = x_1 p_1^\circ; p_2 = x_2 p_2^\circ$ $\Delta H_{\text{mix}} = 0, \Delta V_{\text{mix}} = 0$ $A - B$ interactions $\approx A - A$ and $B - B$ interactions.	$p_1 \neq x_1 p_1^\circ; p_2 \neq x_2 p_2^\circ$ $\Delta H_{\text{mix}} \neq 0, \Delta V_{\text{mix}} \neq 0$ $A - B$ interactions $\neq A - A$ and $B - B$ interactions.

Non-ideal Solutions Showing Positive and Negative Deviations from Raoult's Law

Solutions showing positive deviation	Solutions showing negative deviation
$A - B \ll A - A$ or $B - B$ interactions. $\Delta H_{\text{mix}} > 0, \Delta V_{\text{mix}} > 0$ $p_1 > p_1^\circ x_1$	$A - B \gg A - A$ or $B - B$ interactions. $\Delta H_{\text{mix}} < 0, \Delta V_{\text{mix}} < 0$ $p_1 < p_1^\circ x_1$

Colligative Properties

- **Relative lowering of vapour pressure:** $(p_A^\circ - p_A)/p_A^\circ = x_B$
- **Elevation in boiling point:** $\Delta T_b = T_b - T_b^\circ = K_b m$
- **Depression in freezing point:** $\Delta T_f = T_f^\circ - T_f = K_f m$
- **Osmotic pressure:** $\pi = CRT = (n/V)RT$

van't Hoff Factor and its Significance

$$i = \frac{\text{Observed value of colligative property}}{\text{Calculated value of colligative property}}$$

- **For association of solute:** $nA \rightarrow (A)_n$
Degree of association (α) = $(1 - i)n/n - 1; i < 1$
- **For dissociation of solute:** $(A)_n \rightarrow nA$
Degree of dissociation (α) = $i - 1/n - 1; i > 1$
- **Modified colligative properties:**
 $p_A^\circ - p_A/p_A^\circ = ix_B; \Delta T_b = iK_b m; \Delta T_f = iK_f m; \pi = iCRT$