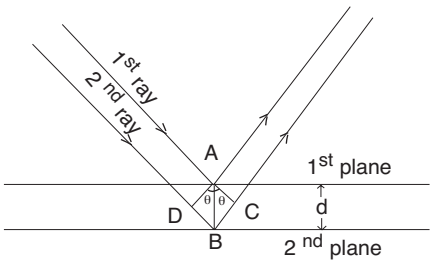
Senior INTERMEDIATE Chemistry

Solid State, Solutions

4 Marks Questions

Q: Derive Bragg's equation.

A: A crystal has many planes. Atoms or ions are arranged in systematic geometry in these planes.



When x-rays incident on these crystal planes, they undergo diffraction. When the waves are diffracted from these atoms or ions, they may have constructive interference or destructive interference. From the figure, it is very clear that 1st and 2nd x-rays travel the same distance till the wave front AD. Where as 2nd x-ray travels an extra distance DB + BC (path difference) than that of 1st x-ray. If the 2 waves are present in the same phase (constructive interference), the path difference must be equal to the wavelength λ or an integral multiple wavelength.

In Δ ADB, $\sin\theta = \frac{DB}{AB} = \frac{DB}{d}$ $\therefore$ DB = d sin θ

Δ ABC, $\sin\theta = \frac{BC}{AB} = \frac{BC}{d}$ $\therefore$ BC = d sin θ

$\therefore n\lambda = DB + BC = 2d \sin\theta$

This relation is Bragg's equation.

Where λ = Wavelength of x-ray,

θ = angle of incident x-ray

n = order of diffraction

d = interplanar distance

Q: What is ...

a) Ferromagnetism b) Paramagnetism

c) Ferrimagnetism d) Antiferromagnetism?

A: a) The substances which are strongly attracted by external magnetic field due to presence of more number of unpaired e^- are called ferromagnetic, the phenomenon is called ferromagnetism.

Eg: Iron, Cobalt

b) The substances which are weakly attracted by external magnetic field due to presence of less no. of unpaired e^- are called paramagnetic, the phenomenon is called paramagnetism. **Eg:** O_2, Cu^{+2}

c) The phenomenon of weak attraction of a substance by external magnetic field when the magnetic domains in a substance are aligned in a parallel and antiparalled direction in unequal numbers is called ferrimagnetism.

Eg: $MgFe_2O_4$, $NiFe_2O_4$

d) The phenomenon of cancellation of magnetic moment due to alignment of magnetic domains are equal in number and are oppositely oriented is called antiferromagnetism. **Eg:** MnO

Q: Define mole fraction. Calculate the molefraction of H_2SO_4 in a solution containing 98% H_2SO_4 by mass.

A: The ratio of number of moles of one component to the total number of moles of all the components present in the solution.

$n_{H_2O} = \frac{2}{18} = 0.11$ $\quad n_{H_2SO_4} = \frac{98}{98} = 1$

$$\therefore X_{H_2SO_4} = \frac{n_{H_2O}}{n_{H_2O} + n_{H_2SO_4}} = \frac{1}{1 + 0.11} = 0.9$$

Q: State Raoult's law. Calculate the mass of non-volatile solute (molar mass 40 g mol^{-1}) which should be dissolved in 114 g octane to reduce its vapour pressure to 80%.

A: The relative lowering of vapour pressure of a dilute solution is equal to the mole fraction of non volatile solute present in it.

$$\frac{p^\circ - p}{p^\circ} = \frac{w_2}{M_2} \times \frac{M_1}{w_1}$$

$$\frac{100 - 80}{100} = \frac{w_2}{40} \times \frac{114}{114} \quad \therefore w_2 = 8 \text{ grams.}$$

Q: What is relative lowering of vapour pressure? How is it useful to determine the molar mass of a solute?

A: The ratio of lowering of vapour pressure ($p^\circ - p$) to that vapour pressure of pure solvent (p°) is called R.L.V.P.

$$\text{R.L.V.P.} = \frac{p^\circ - p}{p^\circ}$$

According to Raoult's law, $\frac{p^\circ - p}{p^\circ} = X_2$

$$\frac{p^\circ - p}{p^\circ} = \frac{n_2}{n_1 + n_2} = \frac{\frac{w_2}{M_2}}{\frac{w_1}{M_1} + \frac{w_2}{M_2}}$$

for dilute solutions, $n_2 << n_1$, hence n_2 in the denominator may be neglected.

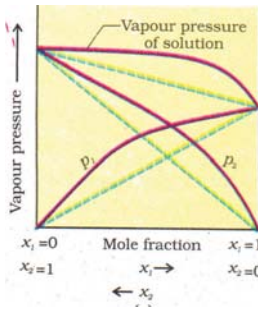
$$\frac{p^\circ - p}{p^\circ} = \frac{w_2}{M_2} \times \frac{M_1}{w_1}$$

$\therefore M_2$ = molar mass of solute =

$$\frac{p^\circ}{p^\circ - p} \cdot \frac{w_2 M_1}{M_1}$$

Q: What is meant by positive deviation from Raoult's law and how is the sign of Δ_{mix} H related to positive deviation from Raoult's law?

A: When A-B interactions are weaker than solvent - solvent (A – A) & solute - solute (B – B) interactions of a non-ideal solution, the vapour pressure of solution will increase due to easy escape of molecules of A or B.

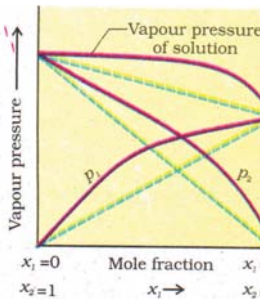


Eg: Mixture of Ethanol & Acetone

$p_A > p^\circ_A X_A$ $\qquad$ $p_B > p^\circ_B X_B$

Δ_{mix} H = +ve $\qquad$ Δ_{mix}V = +ve

Q: What is meant by negative deviation from Raoult's law and how is the sign of Δ_{mix} related to negative deviation from Raoult's law?



A: When A-B interactions are stronger than solvent - solvent (A-A) & Solute - Solute (B-B) interactions of non-ideal solution, the vapour pressure of solution will decrease due to difficult escape of molecules of A or B

Eg: Mixture of Phenol & Aniline

$p_A < p^\circ_A X_A$ $\qquad$ $P_B < p^\circ_B X_B$

Δ_{mix} H = –ve $\qquad$ Δ_{mix}V = –ve

Q: What is 'Schottky defect?

A: It is a stoichiometric defect, formed due to missing of equal number of +ve & – ve ions.

Eg: NaCl, KCl

Q: What is 'Frenkel defect'?

A: It is a stoichiometric defect, formed due to dislocation of cation from lattice site to interstitial site. **Eg:** AgCl, AgBr

Q: What are f-centres?

A: The anion vacancies are occupied by the electrons in metal excess defect. These electrons are responsible for colour and paramagnetic nature.

Q: What are n-type semi conductors?

A: A conductor in which conductivity is due to –vely charged electrons. n-type semi conductor is formed when IV group element is doped with V group element

Eg: Si is doped with Sb.

Q: What are p-type semi conductors? ***(2 Marks)***

A: The conductor in which conductivity is due to +ve charge (created hole). p-type semi conductor is formed when IV group element is doped with III group element.

Eg: Si is doped with B

What is Anti-ferromagnetism?

Two Marks Questions

Q: How do you distinguish between crystal lattice and unit cell?

A: Crystal lattice: It is a regular 3-D arrangement of identical points in space.

Unit Cell: It is a smallest basic 3-D repeating unit from which a crystal lattice is built.

Q: What are 'octahedral voids' and 'tetrahedral voids'?

A: Octahedral voids: The voids are formed when spheres are arranged octahedrally in two layers (3 + 3)

★ **Tetrahedral voids:** The voids are formed when spheres are arranged tetrahedrally in two layers (3 + 1).

Q: Silver Crystallizes in FCC lattice. If the edge of the cell is 4.07×10^{-8} cm and density is 10.5 g cm^{-3}. Calculate the atomic mass of silver.

A:

$$d = \frac{Z.M}{a^3.N_o}$$

$$M = \frac{d.a^3.N_o}{Z}$$

$$= \frac{10.5 \times (4.07 \times 10^{-8})^3 \times 6.023 \times 10^{23}}{4}$$

$$= 107.8$$

Q: What are "Colligative Properties"?

A: The properties which depends only on the number of solute particles but not on their nature.

Eg: osmotic pressure

Q: What are "Isotonic solutions"?

A: At a given temperature 2 different solutions possessing same osmotic pressure.

Eg: Saline solution (0.9% NaCl) is isotonic with blood.

Q: Calculate the molality of a solution prepared by dissolving 10 g. of glucose in 90 g. of water.

A:

$$m = \frac{\text{Wt.of solute}}{\text{g.m.Wt.of solute}} \times \frac{1000}{\text{Wt.of solvent}}$$

$$= \frac{10}{180} \times \frac{1000}{90} = 0.62$$

Q: What is "Ebullioscopic Constant"?

A: The elevation in boiling point, when 1 mole of solute is dissolved in 1 kg of solvent

$\Delta T_b = K_b.m$

Q: What is "Cryoscopic Constant"?

A: The depression in freezing point, when 1 mole of solute is dissolved in 1 kg of solvent.

$\Delta T_f = K_f.m$

Q: Calculate the molality of a solution containing 5 g. of NaOH in 450 ml solution

A:

$$m = \frac{\text{Wt.of Solute}}{\text{g.M.Wt. of Solute}} \times \frac{1000}{\text{Wt. of Solvent}}$$

$$= \frac{5}{40} \times = \frac{1000}{450} = 0.278$$

Q: What is an ideal solution?

A: The solution Which obeys Raoult's law at all concentrations and temperatures

$p_A = p^\circ_A X_A$

Q: Define osmotic pressure.

A: The pressure that prevents the passage of solvent into solution through semi permeable membrane.

Q: Calculate the mole fraction of Sucrose in 20% $\frac{W}{W}$ sucrose solution.

A:

$$n_{\text{Sucrose}} = \frac{20}{342} = 0.0585$$

$$n_{H_2O} = \frac{80}{18} = 4.44$$

$$X_{\text{Sucrose}} = \frac{n_{\text{Sucrose}}}{n_{\text{Sucrose}} + n_{H_2O}}$$

$$= \frac{0.0585}{0.0585 + 4.44} = 0.013$$

Q: Calculate the mass percentage of benzene if 2.2 g. of benzene is dissolved in 122 g. of CCl_4.

A: Mass % of benzene =

$$\frac{\text{Mass of } C_6H_6}{\text{Mass of } C_6H_6 + \text{Mass of } CCl_4} \times 100$$

$$= \frac{22}{22 + 122} \times 100 = 5.27\%$$