

SOLUTION

2.11 Why do gases always tend to be less soluble in liquids as the temperature is raised?

Sol. When gases are dissolved in water, it is accompanied by a release of heat energy, i.e., process is exothermic. When the temperature is increased, according to Lechatlier's Principle, the equilibrium shifts in backward direction, and thus gases becomes less soluble in liquids.

2.12 State Henry's law and mention some important applications.

Sol. The effect of pressure on the solubility of a gas in a liquid is governed by Henry's Law. It states that the solubility of a gas in a liquid at a given temperature is directly proportional to the partial pressure of the gas Mathematically, $P = K_H X$ where P is the partial pressure of the gas; and X is the mole fraction of the gas in the solution and K_H is Henry's Law constant.

Applications of Henry's law

- (i) In the production of carbonated beverages (as solubility of CO_2 increases at high pressure).
- (ii) In the deep sea diving.
- (iii) For climbers or people living at high altitudes, where low blood O_2 causes climbers to become weak and make them unable to think clearly

2.13 The partial pressure of ethane over a solution containing 6.56×10^{-3} g of ethane is 1 bar. If the solution contains 5.00×10^{-2} g of ethane, then what shall be the partial pressure of the gas?

Sol.

We know that, $m = K_H \times P$

$$\therefore 6.56 \times 10^{-2} \text{ g} = K_H \times 1 \text{ bar} \quad \dots(i)$$

$$\therefore 5.00 \times 10^{-2} \text{ g} = K_H \times P \quad \dots(ii)$$

$$K_H = 6.56 \times 10^{-2} / 1 \text{ bar (from i)}$$

$$K_H = 5.00 \times 10^{-2} / p \text{ bar (from ii),}$$

$$\therefore \frac{6.56 \times 10^{-2}}{1} = \frac{5.00 \times 10^{-2}}{p}$$

$$\therefore P = \frac{5.00}{6.56} = 0.762 \text{ bar.}$$

2.14 According to Raoult's law, what is meant by positive and negative deviations and how is the sign of $\Delta_{\text{sol}}H$ related to positive and negative deviations from Raoult's law?

Sol. Solutions having vapour pressures more than that expected from Raoult's law are said to exhibit positive deviation. In these solutions solvent – solute interactions are weaker and $\Delta_{\text{sol}}H$ is positive because stronger A – A or B – B interactions are

replaced by weaker A – B interactions. Breaking of the stronger interactions requires more energy & less energy is released on formation of weaker interactions. So overall $\Delta_{\text{sol}}H$ is positive. Similarly $\Delta_{\text{sol}}V$ is positive i.e. the volume of solution is somewhat more than sum of volumes of solvent and solute.

So there is expansion in volume on solution formation.

Similarly in case of solutions exhibiting negative deviations, A – B interactions are stronger than A-A&B-B. So weaker interactions are replaced by stronger interactions so, there is release of energy i.e. $\Delta_{\text{sol}}H$ is negative.

2.15 An aqueous solution of 2% non-volatile solute exerts a pressure of 1.004 bar at the normal boiling point of the solvent. What is the molar mass of the solute?

Sol.

Vapour pressure of pure water at the boiling point

$$(P^\circ) = 1.013 \text{ bar}$$

Vapour pressure of solution (P_s) = 1.004 bar

Mass of solute (w_2) = 2g

Molar mass of solvent, water (M_1) = 18g

Mass of solvent (w_1) = 98g

Mass of solution = 100g

Applying Raoult's Law for dilute solutions,

$$\frac{P^\circ - P_s}{P^\circ} = \frac{n_2}{n_1 + n_2} \approx \frac{n_2}{n_1}$$

[Dilute solution being 2%]

$$\frac{P^\circ - P_s}{P^\circ} = \frac{n_2}{n_1} = \frac{W_2/M_2}{W_1/M_1}$$

$$\frac{(1.013 - 1.004)}{(1.013)} = \frac{2 \times 18}{M_2 \times 98}$$

$$\therefore M_2 = \frac{2 \times 18}{98 \times 0.009} \times 1.013 = 41.35 \text{ g mol}^{-1}$$