

Worksheet 3

1. Indicate the principal types of solute-solvent interaction in each of the following solutions, and rank the solutions from weakest to strongest solute-solvent interaction: a) KCl in water, b) CH₂Cl₂ in benzene (C₆H₆), c) methanol (CH₃OH) in water.

KCl in water = Ionic interaction (polar) →

Methanol in water = Hydrogen bonding (polar) →

CH₂Cl₂ in benzene = London Dispersion forces →

Solute-solvent interaction:

Strongest

Weakest

2. A solution is made containing 25.5 g of phenol (C₆H₅OH) in 495 g of ethanol (CH₃CH₂OH).

Calculate a) the mole fraction of phenol, b) the mass percent of phenol, c) the molality of phenol.

$$\frac{\text{Mass}}{\text{Molar Mass}} = \text{Moles of Phenol} = \frac{25.5 \text{ g}}{94 \text{ g mol}^{-1}} = 0.27 \text{ mole} \quad \text{Moles of Ethanol} = \frac{495 \text{ g}}{10.76 \text{ g mol}^{-1}} = 10.8 \text{ mol}$$

a) Mole fraction of phenol = $\frac{0.27 \text{ mole}}{(0.27 + 10.8) \text{ mole}} = 0.024$

b) Mass percent of phenol = $\frac{25.5 \text{ g}}{(25.5 + 495) \text{ g}} \times 100 = 4.90\%$

c) Molality of phenol = $\frac{\text{No. of moles of phenol}}{\text{No. of Kg's of EtOH}} = \frac{0.27 \text{ moles}}{0.495 \text{ kg}} = 0.55 \text{ moles kg}^{-1}$

3. A dilute aqueous solution of an organic compound soluble in water is formed by dissolving 2.35 g of the compound in water to form a 0.250 L solution. The resulting solution has an osmotic pressure of 0.605 atm at 25 °C. Assuming that the organic compound is a nonelectrolyte, what is its molar mass?

$$\text{Osmotic pressure } \pi = MRT \Rightarrow \pi = \left(\frac{n}{V}\right) \cdot RT$$

So $\pi = 0.605 \text{ atm}; T = 25^\circ\text{C} = 298 \text{ K}; \text{Volume } V = 0.250 \text{ L}$

So number of moles of solute } $n = \frac{\pi \cdot V}{RT} = \frac{0.605 \text{ atm} \times 0.250 \text{ L}}{0.0821 \frac{\text{L-atm}}{\text{mol}\cdot\text{K}} \cdot 298 \text{ K}} = 0.00618 \text{ moles}$

Moles = $\frac{\text{Mass}}{\text{Molar Mass}} \Rightarrow \text{Molar Mass} = \frac{\text{Mass}}{\text{Moles}} = \frac{2.35 \text{ g}}{0.00618 \text{ moles}} = 380. \text{ g moles}^{-1}$

4. Using Table 11.4 in the book, calculate the boiling point of 20.0 g of decane (C₁₀H₂₂) in 45.5 g CHCl₃.

So, Solute: Decane

Solvent: CHCl₃

Boiling pt = 61.2 °C
K_b = 3.63 °C/m

Moles of solute = $\frac{20.0 \text{ g}}{142 \text{ g mol}^{-1}} = 0.141 \text{ mol}$

Kg of solvent = 45.5 g = 0.0455 kg

So, Increase in Boiling pt $\Delta T_b = K_b \cdot m$

$$\Delta T_b = 3.63 \frac{^\circ\text{C}}{\text{m}} \times 3.10 \text{ m} = 11.3 \text{ }^\circ\text{C}$$

molality (m) = $\frac{\text{Moles of solute}}{\text{kg of solvent}}$

$$m = \frac{0.141 \text{ mol}}{0.0455 \text{ kg}} = 3.10 \text{ mol kg}^{-1} (\text{or } \text{m}^{-1})$$

Final Boiling pt of solution = (61.2 + 11.3) = 72.5 °C