CHEM 142 Review Sheet Handout

Topic 1: PROPERTIES of SOLUTIONS (Chapter 13)
Read Sections 1-5

Self-Study Textbook Problems (12^{th}Ed):
15,22,23,27,28,33-36,41,43,46,47,53,62,65,69,71,72,75-78,80,81,83,92,93,98,100,103,106,107,110

BACKGROUND REVIEW:

- The properties of **gases, liquids and solids**
- The nature of the attractive **inter-particle forces** between particles (atoms, molecules or ions) and how these affect the physical properties of solids and liquids
- The strengths of inter-particle forces affect the **physical properties** of liquids such as boiling point, viscosity, surface tension and vapour pressure
- The molecular nature of **phase changes** and role of intermolecular forces in changes of state
- The information summarized in a **phase diagram** such as sublimation curve, melting curve, boiling curve, normal melting point, normal boiling point, triple point and critical point

LEARNING OBJECTIVES:

- S**olutions** are composed of two or more substances mixed on the *molecular level*
- **Molecular level changes** take place when a *solution is formed*
- The tendency of solution formation depends on changes in **enthalpy** and **entropy** (the role of **inter-molecular forces**)
- **Solubility** is influenced by *intrinsic* factors (e.g., nature of the solute and solvent) and *extrinsic* factors (e.g., temperature and pressure)
- **Henry's Law** to calculate solubility of gases

$$[X_{(aq)}] = K_H\, P_{X(g)}$$

- **Solution composition** can be expressed in a variety of ways (e.g., mass %, ppm, mole fraction, molarity and molality)
- To **convert between concentration units**
- How the **properties of a solution** differ from those of a pure substance (e.g., *melting* versus *dissolution*)
- What is meant by a **colligative property**
- The factors affecting the **vapour pressure** of solutions ('ideal' solutions and **Raoult's Law**)

$$P_{soln} = \chi_{solvent} \times P^{o}_{solvent}$$

- calculate **boiling point elevations and freezing point depressions**

$$\Delta T = K_b \times m_{solute} \qquad\qquad \Delta T = K_f \times m_{solute}$$

- calculate **osmotic pressure** (Π)

$$\Pi = (n_{solute}/V_{soln})RT$$

- colligative properties to determine the **number of particles** present in a solution and hence molar mass for a non-electrolyte solute or degree of dissociation for an electrolyte solute (van't Hoff factors)

Summary of Five Fundamental Types of Inter-Molecular Forces

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1. London Dispersion Forces (aka induced dipole) — atom and molecules
2. Dipole – Dipole Forces — polar molecules
   (‘hydrogen bonding’ is a special case of a dipole-dipole force)
3. Metallic Forces — metal atoms
4. Ion-Ion Forces — oppositely charged ions
5. Network Covalent Bonding — atoms in a ‘giant’ molecule

In addition to these, solutes can interact with solvents via dipole-dispersion (induced dipole) and ion – dipole forces.

Summary of Concentration Units

Molarity (M)

$$\text{Molarity} = \frac{\text{moles of solute (mol)}}{\text{volume of solution (L)}}$$ mol/L

Mole Fraction (χ)

$$\text{Mole Fraction of Solute} = \frac{\text{moles of solute (mol)}}{\text{total moles of solution (mol)}}$$ dimensionless

Volume Percent (v/v %)

$$\text{Volume \%} = \frac{\text{volume of solute (L)}}{\text{total volume of solution (L)}} \times 10^2$$ dimensionless

Mass Percent (wt/wt %)

$$\text{Mass \%} = \frac{\text{mass of solute (g)}}{\text{total mass of solution (g)}} \times 10^2$$ dimensionless

Parts per million (ppm)

$$\text{ppm} = \frac{\text{mass of solute (g)}}{\text{total mass of solution (g)}} \times 10^6$$ dimensionless

(→ if density of solution is 1.0 kg/L, then 1 mg/kg = 1 mg/L = 1 ppm)

Molality (*m*)

$$\text{Molality} = \frac{\text{moles of solute (mol)}}{\text{mass of solvent (kg)}}$$ mol/kg