1021SCG Chemistry 1A – Module 3: Physicochemical Concepts
Week 12

References and resources: Blackman, Bottle, Schmid, Mocerino and Wille, 3rd Edn., Chapter 10, Section 10.5

Learning Objectives
You should be able to:
- Define the terms:

    mass percentage (a mass ratio: $w = \dfrac{mass\,of\,component}{total\,mass\,of\,solution} \cdot 100\%$)

    parts per million (a mass ratio: $w = \dfrac{mass\,of\,component}{total\,mass\,of\,solution} \cdot 10^6$)

    mole fraction ($x = \dfrac{molar\,amount\,of\,component}{total\,molar\,amount\,of\,all\,components}$)

    molar concentration (also called molarity: $c = \dfrac{molar\,amount\,of\,solute}{volume\,of\,solution}$)

    molalilty ($b = \dfrac{molar\,amount\,of\,solute}{mass\,of\,solvent}$)

    and be able to calculate the concentration of a substance in any of these terms.
- Understand colligative properties and the effects of
    vapour pressure depression (Raoult's law)
    boiling point elevation
    freezing point depression
    osmotic pressure
    and calculate any of these properties given appropriate data.
- Explain the difference in the magnitude of changes in colligative properties caused by electrolytes and non-electrolytes.

Workshop and Study Questions

1. Mass concentration
(a) Calculate the mass percentage of Na_2SO_4 in a solution containing 11.7 g Na_2SO_4 in 443 g water.
(b) An ore contains 5.95 g of silver per 500kg of ore. What is the concentration of silver in ppm?

2. A solution is made containing 7.5 g CH_3OH in 495 g ethanol (CH_3CH_2OH). Calculate
(a) the mole fraction of CH_3OH;
(b) the mass ratio of CH_3OH as a percentage;
(c) the molality of CH_3OH.

3. Calculate the molar concentration of 10.5 g $Mg(NO_3)_2$ in 250 ml of solution.

4. Calculate the molality of the following solutions:
(a) 10.5 g benzene (C_6H_6) dissolved in 18.5 g carbon tetrachloride (CCl_4);
(b) 4.15 g NaCl dissolved in 0.250 l of water.

5. List four properties of a solution that depend on the concentration but not the type of particle or particles present as solute. Write the mathematical expression that describes how each of these properties depends on concentration.

6. Colligative properties
(a) Why does a 0.10 mol kg^{-1} aqueous solution of NaCl have a higher boiling point than a 0.10 mol kg^{-1} aqueous solution of $C_6H_{12}O_6$?
(b) Calculate the boiling point of each solution.

7. Lysozyme is an enzyme that breaks bacterial cell walls. A solution containing 0.150 g of this enzyme in 210 ml of solution has an osmotic pressure of 0.953 torr at 25°C. What is the molar mass of lysozyme?

8. The cooling system of a car is filled with a solution formed by mixing equal volumes of water (density = 1.00 g ml^{-1}) and ethylene glycol, $C_2H_6O_2$ (density = 1.12 g ml^{-1}). Estimate the freezing point and boiling point of the mixture.