Lecture 26
Solutions I
Tutorial

1) How many grams of $MgSO_4 \cdot 9H_2O$ are needed to prepare 125 mL of 0.200 M magnesium sulfate?

$$125\text{ mL} \times \frac{1\text{L}}{1000\text{ mL}} \times \frac{0.200\text{ mol } MgSO_4 \cdot 9H_2O}{1\text{L}} \times \frac{282.56\text{ g } MgSO_4 \cdot 9H_2O}{1\text{mol } MgSO_4 \cdot 9H_2O} = 7.06\text{ g } MgSO_4 \cdot 9H_2O$$

2) 251 mL of 0.45 M HCl is added to 455 mL of distilled water. What is the molarity of the final solution?
(Hint: find moles of HCl and total volume of the final solution)

$$251\text{mL Solution} \times \frac{1\text{L}}{1000\text{mL}} \times \frac{0.45\text{mol HCl}}{1\text{L Solution}} = 0.11\text{mol HCl}$$

$$251\text{ mL} + 455\text{ mL} = 706\text{ mL}$$

$$\text{Molarity} = \frac{0.11\text{mol HCl}}{0.706\text{L}} = 0.16\text{ M HCl}$$

3) A 5.75 g sample of KOH is dissolved in 425 mL of water. Find the molality of the solution.

$$5.75\text{g KOH} \times \frac{1\text{mol KOH}}{56.11\text{g KOH}} = 0.102\text{ mol KOH} \qquad \text{molality} = \frac{0.102\text{ mol KOH}}{0.425\text{ kg water}} = 0.240\text{ m}$$

4) Find the molality of a 5.25 M LiBr solution that has a density of 1.25 g/mL.

$$1\text{ L solution} \times \frac{5.25\text{ mol LiBr}}{1\text{ L solution}} \times \frac{86.84\text{ g LiBr}}{1\text{mol LiBr}} = 456\text{ g LiBr}$$

$$1\text{L solution} \times \frac{1000\text{ mL}}{1\text{L}} \times \frac{1.25\text{ g solution}}{1\text{ mL solution}} = 1250\text{ g solution}$$

mass solvent = mass solution - mass solute

mass solvent = 1250g solution - 456g LiBr = 794 g solvent

$$\text{molality} = \frac{\text{moles solute}}{\text{kg solvent}} = \frac{5.25\text{ mol LiBr}}{0.794\text{ kg solvent}} = 6.61\text{ m}$$

5) Find the mole fraction of glucose, $C_6H_{12}O_6$, in a 2.1 *m* solution of glucose and water.

$$molality = \frac{2.1 \text{ mol } C_6H_{12}O_6}{1 \text{ kg } H_2O}$$

$$1000 \text{ g } H_2O \times \frac{1 \text{ mol } H_2O}{18.02 \text{ g } H_2O} = 55.49 \text{ mol } H_2O$$

$$X_{C_6H_{12}O_6} = \frac{n_{C_6H_{12}O_6}}{n_{C_6H_{12}O_6} + n_{H_2O}} = \frac{2.1 \text{ mol}}{2.1 \text{ mol} + 55.49 \text{ mol}} = 0.036$$

6) A 0.452 g sample of an unknown compound is dissolved in 8.543 g of water. Find the molar mass of the unknown compound if the molality of the solution was found to be 0.524 *m*.

$$molality = \frac{\text{mol solute}}{\text{kg solvent}}$$

$$\text{mol solute} = (molality)(\text{kg solvent}) = 0.524m \times 0.008543 \text{ kg} = 0.00448 \text{ mol}$$

$$MM = \frac{mass}{moles} = \frac{0.452 \text{ g}}{0.00448 \text{ mol}} = 101 \text{ g/mol}$$

7) 200 mL of 2.0 M copper (I) nitrate is mixed with 150 mL of 2.5 M sodium chloride. The mixture produces a precipitate.

a. Identify the precipitate.

$CuCl_{(s)}$

b. What is the limiting reactant? Justify your answer.

$$Cu^+_{(aq)} + Cl^-_{(aq)} \rightarrow CuCl_{(s)}$$

$$200 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{2.0 \text{ mol } Cu^+}{1 \text{ L}} \times \frac{1 \text{ mol CuCl}}{1 \text{ mol } Cu^+} = 0.40 \text{ mol CuCl}$$

$$150 \text{ mL} \times \frac{1\text{L}}{1000 \text{ mL}} \times \frac{2.5 \text{ mol } Cl^-}{1\text{L}} \times \frac{1 \text{ mol CuCl}}{1 \text{ mol } Cl^-} = 0.38 \text{mol CuCl}$$

NaCl or Cl^- is the limiting reactant as it will produce less CuCl.

c. What is the maximum mass of precipitate that can be formed in this reaction?

$$0.38 \text{ mol CuCl} \times \frac{99.00 \text{ g CuCl}}{1 \text{ mol CuCl}} = 38 \text{ g CuCl}$$

d. What is the percent yield if 31 g of precipitate is formed in the reaction?

$$\%yield = \frac{actual \text{ yield}}{theory \text{ yield}} \times 100$$

$$\%yield = \frac{31 \text{ g}}{38 \text{ g}} \times 100 = 82\%$$

e. The percentage yield increases when the temperature of the solution is reduced. Explain why this is.

The solubility of CuCl decreases as temperature decreases. Thus, at lower temperatures, more precipitate will form.

8) Describe the process for making a saturated solution of sugar and water.

To do this, you must keep the solution at a constant temperature. Keep adding sugar and stirring until the sugar will no longer dissolve. When the solution has dissolved as much sugar as it can, and excess solid sugar remains on the bottom of the container, the solution is saturated.