# Solutions to:
## Solutions Homework Problem Set
## Chemistry 146, Chapter 14

1. 0.8687 g of Calcium Chloride is dissolved in water and diluted to a total volume of 500.0 mL.
   a.What is the concentration of calcium chloride (molarity)?
   b.What is the concentration of calcium (molarity)?
   c.What is the concentration of chloride (molarity)?

Calculate the MW of Calcium Chloride:

$MW_{Ca} := 40.078 \cdot gm \cdot mole^{-1}$

$MW_{Cl} := 35.4527 \cdot gm \cdot mole^{-1}$

$MW_{CaCl2} := MW_{Ca} + 2 \cdot MW_{Cl}$

$MW_{CaCl2} = 110.9834 \cdot gm \cdot mole^{-1}$

Calculate the moles of Calcium Chloride:

$Mass_{CaCl2} := 0.8687 \cdot gm$

$Mole_{CaCl2} := \frac{Mass_{CaCl2}}{MW_{CaCl2}}$

$Mole_{CaCl2} = 0.00783 \cdot mole$

Calculate the concentrations:

$V_{solution} := 500 \cdot mL$ $\quad V_{solution} = 0.5 \cdot liter$ $\quad M := \frac{mole}{liter}$

$Mole_{Ca} := Mole_{CaCl2}$ $\quad Mole_{Ca} = 0.00783 \cdot mole$

$Mole_{Cl} := 2 \cdot Mole_{CaCl2}$ $\quad Mole_{Cl} = 0.01565 \cdot mole$

$C_{CaCl2} := \frac{Mole_{CaCl2}}{V_{solution}}$ $\quad C_{CaCl2} = 0.01565 \cdot M$

$C_{Ca} := \frac{Mole_{Ca}}{V_{solution}}$ $\quad C_{Ca} = 0.01565 \cdot M$

$C_{Cl} := \frac{Mole_{Cl}}{V_{solution}}$ $\quad C_{Cl} = 0.03131 \cdot M$

2. 0.8687 g of Calcium Chloride is dissolved in 500.0 mL of water at 30ºC.
   a.What is the molality of the calcium chloride?
   b.What is the concentration of calcium chloride (weight %)?
   c.What is the concentration of calcium chloride (ppth)?
   d.What is the concentration of calcium (ppm)?

In this problem the same mass of calcium chloride is used so that:

$$\text{Mole}_{CaCl2} = 0.00783 \cdot \text{mole}$$

Molality is moles of solute per kg of solvent. So we need the moles of calcium chloride (already known) and the kg of solvent. We know the volume of water and the temperature. So from the density (0.99565 g $cm^3$ at 30 ºC, *CRC Handbook of Chemistry and Physics*, 73st ed, 1992) we can determine the mass.

$$V_{solvent} := 500.0 \cdot mL$$

$$\text{Density}_{H2O} := 0.99565 \cdot gm \cdot cm^{-3}$$

$$\text{Mass}_{solvent} := V_{solvent} \cdot \text{Density}_{H2O}$$

$$\text{Mass}_{solvent} = 0.49783 \cdot kg$$

$$C_{CaCl2} := \frac{\text{Mole}_{CaCl2}}{\text{Mass}_{solvent}} \qquad \text{molal} := \frac{\text{mole}}{\text{kg}}$$

$$C_{CaCl2} = 0.01572 \cdot \text{molal}$$

The Concentration in weight %:

$$C_{CaCl2} := \frac{\text{Mass}_{CaCl2}}{\text{Mass}_{solvent} + \text{Mass}_{CaCl2}}$$

$C_{CaCl2} = 0.00174$ The weight fraction

$C_{CaCl2} = 0.1742 \cdot \%$ Expressed as a percentage

The Concentration in ppth

$$\text{ppth} := 10^{-3}$$

$C_{CaCl2} = 1.74195 \cdot \text{ppth}$ Just multiply the weight fraction from above by 1000.

The Concentration of Ca in ppm by mass

$Mass_{Ca} := Mole_{Ca} \cdot 40.078 \cdot gm \cdot mole^{-1}$ $Mass_{Ca} = 0.3137 \cdot gm$

$$C_{Ca} := \frac{Mass_{Ca}}{Mass_{solvent} + Mass_{CaCl2}}$$

The mass of calcium divided by the total mass of the solution.

$C_{Ca} = 6.29048 \cdot 10^{-4}$

$ppm := 10^{-6}$

$C_{Ca} = 629.04825 \cdot ppm$

Just multiply the concentration (expressed as a mass ratio) times $10^6$ to find the concentration in ppm. More precisely this is parts per million by mass.

3.What is the vapor pressure of a solution prepared when 0.8687 g of Calcium Chloride is dissolved in 5.00 mL of water at 30ºC. What is the vapor pressure of this solution at 100.0 ºC? What is the boiling point of this solution? What is the freezing point of this solution?

$V_{H2O} := 5.00 \cdot mL$

$Mass_{H2O} := V_{H2O} \cdot Density_{H2O}$ $Mass_{H2O} = 4.97825 \cdot gm$

$MW_{H2O} := (2 \cdot 1.00794 + 15.9994) \cdot gm \cdot mole^{-1}$

$$Mole_{H2O} := \frac{Mass_{H2O}}{MW_{H2O}}$$ $Mole_{H2O} = 0.27633$

$$X_{H2O} := \frac{Mole_{H2O}}{Mole_{H2O} + Mole_{Ca} + Mole_{Cl}}$$

Calculation of the mole fraction of water in the solution.

$X_{H2O} = 0.92168$

Vapor pressure of water from: *CRC Handbook of Chemistry and Physics, 73rd ed, 1992*.

at 30 C: $P_{30} := 4.2455 \cdot 10^3 \cdot Pa$ $P_{H2O} := P_{30} \cdot X_{H2O}$ $P_{H2O} = 3.91299 \cdot 10^3 \cdot Pa$

at 100 C: $P_{100} := 101.32 \cdot 10^3 \cdot Pa$ $P_{H2O} := P_{100} \cdot X_{H2O}$ $P_{H2O} = 9.33845 \cdot 10^4 \cdot Pa$

The Boiling Point of the solution:

$\text{Mass}_{\text{solvent}} := \text{Mass}_{\text{H2O}}$ $\text{Mass}_{\text{solvent}} = 0.00498 \cdot \text{kg}$

$C_{\text{CaCl2}} := \frac{\text{Mole}_{\text{CaCl2}}}{\text{Mass}_{\text{solvent}}}$ $C_{\text{CaCl2}} = 1.5723 \cdot \text{molal}$

$K_b := 0.5121 \cdot K \cdot \text{molal}^{-1}$ (*For water, from Textbook*)

$\Delta t_b := 3 \cdot C_{\text{CaCl2}} \cdot K_b$ $\Delta t_b = 2.41552 \cdot K$

$t_b := 373.15 \cdot K + \Delta t_b$ $t_b = 375.56552 \cdot K$

The Freezing Point of the solution:

$K_f := 1.86 \cdot K \cdot \text{molal}^{-1}$

$\Delta t_f := 3 \cdot C_{\text{CaCl2}} \cdot K_f$ $\Delta t_f = 8.77343 \cdot K$

$t_f := 273.15 \cdot K - \Delta t_f$ $t_f = 264.37657 \cdot K$

4.It is important to use an isotonic solution for an IV. IF, a solution of pure water was used instead of a 0.9% sodium chloride solution (as shown in figure 14.16 of your textbook), what is the osmotic pressure? Assume the density of the sodium chloride solution is 1.02 g per mL.

Need concentration in molarity (moles per liter of solution)

$C := 0.9 \cdot \%$

Since this is the percent NaCl by mass in the solution. One Liter of solution will contain:

$$\text{Mass}_{NaCl} := 1 \cdot \text{liter} \cdot \left( \frac{1000 \cdot \text{mL}}{1 \cdot \text{liter}} \right) \cdot \left( \frac{1.02 \cdot \text{gm}}{1 \cdot \text{mL}} \right) \cdot 0.9 \cdot \%$$

$$\text{Mass}_{NaCl} = 9.18 \cdot \text{gm}$$

$$\text{MW}_{NaCl} := (22.989768 + 35.4527) \cdot \text{gm} \cdot \text{mole}^{-1}$$

$$\text{Mole}_{NaCl} := \frac{\text{Mass}_{NaCl}}{\text{MW}_{NaCl}}$$

$$\text{Mole}_{NaCl} = 0.15708$$

$$C_{NaCl} := \frac{\text{Mole}_{NaCl}}{1 \cdot \text{liter}} \qquad C_{NaCl} = 0.15708 \cdot \text{M}$$

Now Calculate the osmotic pressure:

$R := 0.0821 \cdot \text{liter} \cdot \text{atm} \cdot \text{mole}^{-1} \cdot \text{K}^{-1}$

$T := (273 + 32) \cdot \text{K}$

$\Pi := C_{NaCl} \cdot R \cdot T \qquad \Pi = 3.9333 \cdot \text{atm}$

This is a rather large pressure difference and it would have significant consequences for any patient.