Lab 13-1 COLLIGATIVE PROPERTIES
MOLAR MASS BY FREEZING POINT ANALYSIS

KeY
name

Background: The presence of solute lowers the freezing point and raises the boiling point of the solution. The amount of lowering or raising is determined by the molality of the solution. For water, the freezing point is lowered by 1.86°C/ molal and the boiling point is raised by .51°C/molal. Using these constants one can determine the molar mass of the solute.
The solution in this lab was made by dissolving 5.0 g. of solute and dissolving it in 50 g of water.

Procedure:

1. Obtain a 50 ml centrifuge tube and fill it with 50 ml of the solute.
2. Adjust the freezing bath so that it has the consistency of a "slurpee"
3. Insert a thermometer in the centrifuge tube and turn it on to degrees Celsius.
4. Place the tube/thermometer into the ice/salt water bath .
5. Move the tube around in the freezing bath until the temperature is 0°C.
6. Place a small piece of ice in the tube to prevent supercooling. (going colder than the freezing point without crystallization)
7. Continue to move and observe the tube until crystals of ice appear throughout the tube.
8. Record the temperature at this point.

Data:

1. Freezing temperature of the solution $-3.1\,^{\circ}C$

Calculations: $\Delta T_f = K_f \times m$; $m = \frac{\Delta T_f}{K_f} = \frac{-3.1\,^{\circ}C}{-1.86\,^{\circ}C/m} = 1.66\,m$

1. Calculate the molality of the solution 1.66 m
2. Use the fact that 5.0 g. in 50 g. of water was given to you.
3. Calculate the molar mass of the solute $1.66\,m = \frac{1.66\,mol}{Kg} \times .05\,Kg = .083\,mol$

Molar mass of solute 60 g/mol

$\frac{5\,g}{.083\,mol} = 60\,g/mol$

$\Delta T_f = K_f \times m$

LAB 13-1 NON ELECTROLYTES

1. A solution contains 25 grams of Methanol (CH_3OH) in 65 grams of water. What is the molality of this solution?

12 m

2. How many grams of water must be added to 100 grams of Sucrose ($C_{12}H_{22}O_{11}$) to make .63 m solution?

464 g H_2O

3. What is the freezing point of a solution containing 3.10 g of Ethylene Glycol ($C_2H_4(OH)_2$) per 125 g of water?

$\Delta T_f = K_f \times m = -1.86\,^\circ C/m\,(.3995\ molal) = -.743\,^\circ C$

$3.10\ g\ C_2H_4(OH)_2 \times \frac{1\ mol}{62.08\ g} = .0499\ mol$

$\frac{.0499\ mol}{.125\ Kg\ H_2O} = .3995\ molal$

4. What is the molecular weight of a substance if 16 g of it in 125 g of water makes a solution that freezes at -3.72°c?

$\Delta T_f = K_f \times m \;;\; m = \frac{\Delta T_f}{K_f} = \frac{-3.72\,^\circ C}{-1.86\,^\circ C/m} = 2\ molal = \frac{2\ mol}{1\ Kg\ solvent} \times .125\ Kg\ solvent$

$= .250\ mol \quad \frac{16\ g}{.250\ mol} = 64\ g/mol$

5. How many grams of the Glycerin (M.W. 92) should be dissolved in 300 g of Water to give a solution with a freezing point of -9°c?

$\Delta T_f = K_f \times m$

$m = \frac{\Delta T_f}{K_f} = \frac{-9\,^\circ C}{-1.86\,^\circ C/m} = 4.84\ molal = \frac{4.84\ mol\ glycerin}{1\ Kg\ H_2O} \times .3\ Kg\ H_2O = 1.45\ mol$

$1.45\ mol \times \frac{92\ g}{1\ mol} = 134\ g\ glycerin$

6. What is the molecular weight of a substance if 45 g of it in 250 g of water Boils at 100.78°c?

$\Delta T_b = K_b \times m$

$m = \frac{\Delta T_b}{K_b} = \frac{.78\,^\circ C}{.51\,^\circ C/m} = 1.53\ molal = \frac{1.53\ mol}{Kg\ H_2O} \times .250\ Kg = .3824\ mol$

$\frac{45\ g}{.3824\ mol} = 118\ g/mol$

LAB 13-1

ELECTROLYTE SOLUTION

1. What boiling point elevation will be caused by a .29 molal solution of NaBr $\Delta T_b = k_b \times m \times i$ $NaBr \rightarrow Na^+ + Br^-$ $i = 2$

$\Delta T_b = .51^\circ C/m \times .29\ m \times 2 =$ .30 °C elevation

2. At what temperature will a solution of calcium chlorate freeze if 19g are dissolved in 1.3 Liters of water $\frac{19g}{207.9/mol} = .09178\ mol / 1.3\ kg = .0706\ molal$

$\Delta T_f = k_f \times m \times i$

$= -1.86^\circ C/m \times .0706\ m \times 3 =$ −.39 °C

$Ca(ClO_3)_2 \rightarrow Ca^{2+} + 2ClO_3^-$, $i = 3$

3. How many grams of sodium nitrate will be needed to cause a 2°C increase in boiling temperature of 750 g of water

$NaNO_3 \rightarrow Na^+ + NO_3^-$, $i = 2$

(molar mass of $NaNO_3$ = 85 g/mol)

$\Delta T_b = k_b \times m \times i$

$m = \frac{\Delta T_b}{k_b \times i} = \frac{2^\circ C}{.51^\circ C/m \times 2} = 1.9607\ molal = \frac{1.9607\ mol}{kg} \times .750\ kg = 1.47\ mol$

$1.47\ mol / \frac{85\ g}{1\ mol} =$ 125 g $NaNO_3$

4. What is the molality of a potassium carbonate solution if it boils at 105.2 °C $K_2CO_3 \rightarrow 2K^+ + CO_3^{2-}$, $i = 3$

$\Delta T_b = K_b \times m \times i$

$m = \frac{\Delta T_b}{K_b \times i} = \frac{5.2^\circ C}{.51^\circ C/m \times 3} = 3.398\ molal =$ 3.4 molal

5. Which would be most effective as a road salt amongst sodium chloride, sodium phosphate or sodium sulfide

$NaCl \rightarrow Na^+ + Cl^-$ $i = 2$

$Na_3PO_4 \rightarrow 3Na^+ + PO_4^{3-}$ $i = 4$

$Na_2S \rightarrow 2Na^+ + S^{2-}$ $i = 3$

$CaCl_2 \rightarrow Ca^{2+} + 2Cl^-$, $i = 3$

6. If the freezing point depression of a $CaCl_2$ solution is -0.056 ° C, what is the concentration of the solution? concentration = molality

$\Delta T_f = K_f \times m \times i$

$m = \frac{\Delta T_f}{K_f \times i} = \frac{-.056°C}{-1.86°C/m \times 3} = .01\ m$

7. What is the freezing point depression of a 0.05 m solution of $FeCl_3$?

$\Delta T_f = -1.86°C/m \times .05\ m \times 4 = -.372°C$

8. What is the freezing point of a 0.075 molal solution of Na_2SO_4?

$\Delta T_f = -1.86°C/m \times .075\ m \times 3 = -.42°C$

9. Solve for the formula weight of a molecular (non-electrolyte) solute if 12 grams dissolved in 98 grams of water causes a boiling point of 102.3 ° C

$\Delta T_b = K_b \times m$

$m = \frac{\Delta T_b}{K_b} = \frac{2.3°C}{.51°C/m} = 4.51\ molal = 4.51\ mol/kg \times .098\ kg$

$= .4419\ mol$

$\frac{12\ g}{.4419\ mol} = 27\ g/mol$

11. What is the molecular weight of a substance if 10 g. of it dissolved in 100 g. of naphthalene causes the solution to freeze at 75.3°C? The K_f for naphthalene is 6.9°C/molal, and the normal freezing point is 80.5°C.

$\Delta T_f = K_f \times m$, $m = \frac{\Delta T_f}{K_f} = \frac{5.2°C}{6.9°C/m} = .7536\ mol/kg \times .1\ kg = .075\ mol$

$\frac{10\ g}{.075\ mol} = 133\ g/mol$

12. Calculate the K_b from the following data:

Weight of solute used: 82 g.
Weight of solvent used: 350 g.
Boiling point of solution of solute in solvent 115.3°C
Molecular weight of solute 246g/mole
Boiling point of pure solvent 112°C

$\frac{82\ g\ solute / 1\ mol}{246\ g} = .333\ mol$

$\Delta T_b = K_b \times m$

$\frac{.333\ mol}{.350\ kg} = .952\ m$

$K_b = \frac{\Delta T_b}{m} = \frac{3.3°C}{.952\ m} = 3.5°C/m$