Name\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date\_\_\_\_\_\_\_\_

**Freezing Point Depression with Antifreeze**

**Introduction**

Have you ever wondered how antifreeze lowers the freezing point of water in the cooling systems of automobiles? In the later part of the nineteenth century French chemist Francois Raoult noted that the vapor pressure of a solvent was lowered by the addition of a solute (Raoult’s law), and that the freezing points of solutions also were lowered.

Eventually, the following mathematical expression that related the freezing point depression and molality (moles of solute per kilogram of solvent) was developed.

T = Kfm

In the equation, T is the freezing point depression; Kf is the molal freezing point constant for the solvent, and m is the molality of the solvent in the solution.

As you can see from the equation the lowering of the freezing point depends on the concentration of dissolved particles present not the identity of the particles. This is referred to as a colligative property. In the case of a non-electrolyte, the molality of the non-electrolyte and the molality of particles in solution is the same (a 1:1 ratio). For electrolytes, the molality of particles is equal to the molality of the electrolyte times the number of ions in the chemical formula of the compound.

Automobile manufacturers make use of the principle of freezing point depression to protect engines from freezing in cold weather. Antifreeze, a non-electrolyte, is added to the water filled radiator that cools the engine. Under most conditions the presence of the antifreeze molecules in the water is sufficient to keep the system from freezing.

In this investigation, you will determine the freezing point depression of antifreeze solutions by cooling them in an ice-salt bath. You will also use this information to find the molar mass of ethylene glycol.

**Pre-Lab Discussion**

1. What is the mathematical relationship between freezing point depression and molality? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. What is a colligative property? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Objective**

To determine the molar mass of ethylene glycol using freezing point depression.

**Problem**

Using freezing point depression, how can you determine the molar mass of ethylene glycol (antifreeze)?

**Materials**

Chemical splash goggles 3 large test tubes

Beaker 600 mLs distilled water

300 ml crushed ice 40 mLs of antifreeze

Sodium chloride Stirring rod

Thermometer

**Safety**

Wear your goggles at all times during this investigation. Commercial antifreeze is primarily ethylene glycol which is highly toxic. The ice used in this investigation could become contaminated with antifreeze by accident. Do not eat the ice.

**Procedure**

1. Put your goggles on and half fill a 600-ml beaker with ice and cover it with about 20 grams of sodium chloride (NaCl).Stir this ice-salt mixture with a stirring rod until it reaches a constant temperature at or below -100 C.

2. Half fill a test tube with distilled water and place it in the ice bath. Rinse the stirring rod and use it to stir the water gently until the ice crystals first appear. Use a thermometer to measure the freezing point and record it in the data table.

3. Half fill a second test tube with antifreeze solution A. (Solution A consists of 10 grams of antifreeze dissolved in 100 grams of water.)Place this test tube back in the ice-salt bath and wait till ice crystals first appear and record freezing point using a thermometer.

4. Repeat step three this time using solution B. (Solution B consists of 20 grams of antifreeze dissolved in 100 grams of water).Record freezing point in data table.

5. Dispose of antifreeze in container provided by your teacher. Clean up your work station and wash your hands before leaving the laboratory.

**Observations**

Data Table

Freezing point of distilled water TH2O\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Freezing point of Solution A (T1) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Freezing point of Solution B (T2) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Calculations**

1 Determine the freezing point depression of Solution A

2. Determine the freezing point depression of Solution B

3. Determine the molality (m) of Solution A. (Kf = -1.860 C-kg/ mol for water)

4. Determine the molality (m) of solution B.

5. Using the molality and mass of water in kg, determine the number of moles of antifreeze in each solution A and B.

Solution A:

Solution B:

6. Calculate Molar Mass of antifreeze by dividing grams of antifreeze by number of moles of antifreeze in each solution.

Solution A:

Solution B:

**Questions**

1. Permanent antifreeze is almost 100 % ethylene glycol C2H4(OH) 2. Calculate its molar mass.

2. Calculate percent error in both trials.

Solution A:

Solution B:

**Conclusions**