EXPERIMENT - FREEZING POINT DEPRESSION

INTRODUCTION: When a solute dissolves in water, it lowers the freezing temperature of water. The change in freezing temperature is calculated from the formula:

\[ \Delta T_f = i (1.86 \, ^\circ C/molal) \, m \]

The \( i \)-factor indicates the number of particles the solute forms when dissolved. In the first part of this experiment you will determine the ionization factor for two acids, tartaric and sulfuric. Both acids are diprotic acids meaning that they have two H atoms that can react with bases. The structures of the two acids are shown below.

When the two acids are dissolved in water there are three possible reactions that could occur for each acid. Shown below are the reactions for tartaric acid. The \( i \)-factors of the resulting solution would be 1, 2 and 3 respectively. If either reaction 2 or 3 occurs, then the acid is a strong electrolyte and would be classified as a strong acid. If reaction 1 occurs the acid would be classified as a weak acid. By determining the actual \( i \)-factor of the solution you can determine which reaction is occurring and classify the acid as either strong or weak.

In the second part of the experiment you will use freezing point depression to determine the molar mass of a non-electrolyte solute.
PART 1: CALCULATION OF $i$ FACTORS

Open up Logger Pro. Right click on the graph and delete it from the screen. Change the digital display so that the temperature is recorded to 2 decimal places. This is done by double clicking on the temperature column heading and selecting 2 decimal places under “options”.

Prepare a salt/ice bath using a large styrofoam cup. To avoid making a mess and possible damage to the computer, put the entire assembly in a plastic bin. Place about 20 mL of distilled water in a 50 mL Erlenmeyer flask. Insert the digital thermometer into the flask and place the flask in the ice bath. Swirl the flask constantly until the water begins to freeze. It is very possible that the water will supercool but once it freezes the temperature will rise to the normal freezing temperature. The freezing temperature of a pure substance should remain constant as the liquid freezes. Once you are confident you have the freezing temperature of the water, record the value in your report.

Tare an empty 50 mL beaker. Add about 4 grams of tartaric acid to the beaker and determine the mass of the acid. Tare the beaker and chemical. Remove the beaker from the balance, add about 20 mL of distilled water, and determine the mass of the water. Stir to dissolve the solid and then transfer the solution to a dry Erlenmeyer flask. Dry off the thermometer and record the freezing temperature of the solution as you did the sample of water. Unlike a pure substance, the freezing point of a solution keeps decreasing as solvent solidifies out of the solution. Record the freezing temperature as the temperature when there is a just a loose “slush” of solid solvent. It may be necessary to remove the flask from the bath in order to achieve this state. Be sure you constantly swirl the flask to be sure that the temperature is uniform. If the solution supercools it may be necessary to seed the solution with a small crystal of ice in order make the solution freeze.

Place about 20 mL sample of sulfuric acid in another dry flask. Record the molality of the solution from the label of the bottle. Dry off the thermometer and determine the freezing point as before. When you have finished you may discard the solutions down the drain.
Use the data collected to determine the ionization factors for both acids. From the ionization factors decide which reaction best describes what happens when each acid is added to water.

PART 2: DETERMINATION OF MOLAR MASS

Mammals remove waste nitrogen by excreting urea in the urine. Due to its high nitrogen content, urea is produced commercially as a fertilizer. It is also used to melt ice on airport tarmacs. Prepare a solution of urea as you did with tartaric acid but use only about 2 grams of urea instead of 4 grams. Determine the freezing point and use it to calculate the molar mass of urea without looking up the chemical formula for urea. Urea is a non-electrolyte. Discard the urea solution down the drain.