Boiling Point Elevation Lab

Title of the Expt.: To determine the molar mass and nature of the unknown sample by boiling point elevation method.

Purpose: In this experiment, you will investigate the effect that adding a solute has on the boiling point of a solvent and use the colligative property relationship to determine the molar mass of the solute.

Background:

When a solute is dissolved in a solvent, the properties of the solvent are changed by the presence of the solute. The magnitude of the change generally is proportional to the number of moles of solute added per kilogram of solvent (molality). Colligative properties of a solution are those properties of a solvent that are changed only by the number of solute particles present, without regard to the particular nature of the solute. These properties include changes in vapor pressure, the boiling point, and the freezing point. When a solute is added to a solvent, the amount of solvent that can escape from the surface of the solution at a given temperature is lowered, relative to the amount of particles that can escape from the pure solvent. Therefore, the vapor pressure above such a solution will be lower than the vapor pressure above of the pure solvent under the same conditions. Molecules of the solute physically block the surface of the solvent, thereby preventing as many solvent molecules from evaporating at a given temperature. The presence of a solute lowers the temperature at which the solution freezes and raises the temperature at which the solution boils relative to the pure solvent.

When a non-volatile solute is added to a pure solvent, the resultant solution would have a higher boiling point than the pure solution. The boiling point of a solution is a colligative property and is dependent on the concentration of the solute in the solution but not on what the solute and solvent are.

$T_1 - T_2 = \Delta T = K_b m$ where ΔT is the magnitude of the boiling point elevation

K_b is the ebullioscopic constant of the solvent

m is the molality of the solution

Using the equation above, the molality of the solution can be determined. Consequently, the molar mass and nature of the unknown sample can be determined.

Materials: 100ml Graduated Cylinder, 150ml Beaker, 250ml Beaker, Thermometer, Clamp, Stirring Rod, Hot plate, Distilled Water, Unknown solute (Sodium Chloride, Calcium Chloride, Sucrose, Urea, oxalic acid, etc.)

Procedure:

- With your graduated cylinder, measure out exactly 100mL of distilled water and transfer to the 250 beaker.
- Place this beaker on Hot plate. Hang a thermometer into the water. Set up the thermometer so that the temperatures above 100 ˚ C can be easily read. Make sure the thermometer can be supported in the middle of the liquid being heated, and that it is not resting on the bottom of the beaker in contact with the burner flame.
- Switch on the hotplate and adjust the temperature.
- Begin heating the water and bring it to a gentle boil.

- When the water is gently boiling, determine its temperature. The boiling point of water varies with atmospheric pressure, but should be very near to 100 ˚C. Note if the temperature as read on your thermometer differs from 100˚C.

- Turn off the hotplate and then very slowly and carefully add the unknown solute sample to the hot water. Restart the hotplate and stir the solution with a stirring rod to dissolve the solute while bringing the solution to a gentle boil. Determine the temperature of the boiling water solution. Record the b.p. value.

- Calculate the molar mass of the solute (from its molality provided) and identify it.

Calculations: Molality = m = moles of solute particles / kg of solvent

$\Delta T_b = K_b\, m$ $K_b = 0.52^{\circ}\mathrm{C/molal}$ $BP = 100^{\circ}\mathrm{C} + \Delta T_b$