Cryoscopic Determination of Molecular Weight

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Introduction

This experiment shows one method of determining the molecular weight of a compound. The student will measure the depression of the freezing point of a solvent by addition of known weights of solute. The observed depression of the freezing point, combined with the accurately measured weight of the solute (and that of the solvent, obtained from its volume) can be used to determine the molecular weight of the solute. The solvent used will be cyclohexane. The students will measure a series of cooling curves for a known solute (naphthalene).

Procedure

Follow the procedure described in the laboratory text (1), with the following exceptions: you will determine the molecular weight of both naphthalene and the unknown compound, and you will continue adding 0.06 g pellets to the solution until the observed freezing point is off the thermometer scale. You will be using a Beckman thermometer, which is designed to read temperature differences, rather than actual temperatures. The cyclohexane should be close to its freezing point before the thermometer is placed in the solution, otherwise the mercury may leave the working column.

Calculations

Using Equations 12 and 21, calculate the molecular weight of the solute for each of the solutions:

$$M = 1000\frac{g}{G}\frac{K_f}{\Delta T_f}$$

$$M = 1000\frac{g}{G}\frac{K_f}{\Delta T_f}\left(1 - k_f\Delta T_f\right) ,$$

where g is the mass of solute added, G the mass of solvent used, K_f is 20.4 K molal^{-1}, and k_f is 0.003 K^{-1}. A plot of M versus ΔT_f can be used to extrapolate to infinite dilution. Report the calculated molecular weight of the solute.

(1). Garland, et al., *Experiments in Physical Chemistry, Eighth Edition 2009*, pp. 179-187.