EXERCISE 14

Determination of Molecular Weight

OBJECTIVE:

To determine the molecular weight of an unknown compound by its effect on the freezing point of acetic acid.

It is observed that the freezing point of a solution is always lower than the freezing point of a pure solvent. This lowering of the freezing point is one of several properties that are referred to as colligative properties.

The mathematical relationship of interest to us is:

$$\Delta t_f = k_f m \quad \text{.....14-1}$$

where Δt_f = The difference in freezing points between the pure solvent and the solution.

k_f = The molal freezing point constant. This constant is characteristic of the solvent.

m = The molal concentration of the solution.

The expression can be rearranged to the form:

$$\text{molecular weight} = \frac{(\text{g solute})(1000)}{(\text{m})(\text{g solvent}} \quad \text{.....14-2}$$

where k_f = 3.9 for acetic acid

t_n = freezing point of acetic acid

t_s = freezing point of solution

weight of solute = grams of unknown sample

weight of solvent = grams of acetic acid

In this laboratory exercise the last four of the five quantities above are measured. Equation 14.2 is used to determine the molecular weight of an unknown.

Equipment

1. 25 x 200 mm test tube
2. 600 ml beaker
3. clamp
4. ring stand
5. thermometer

Procedure

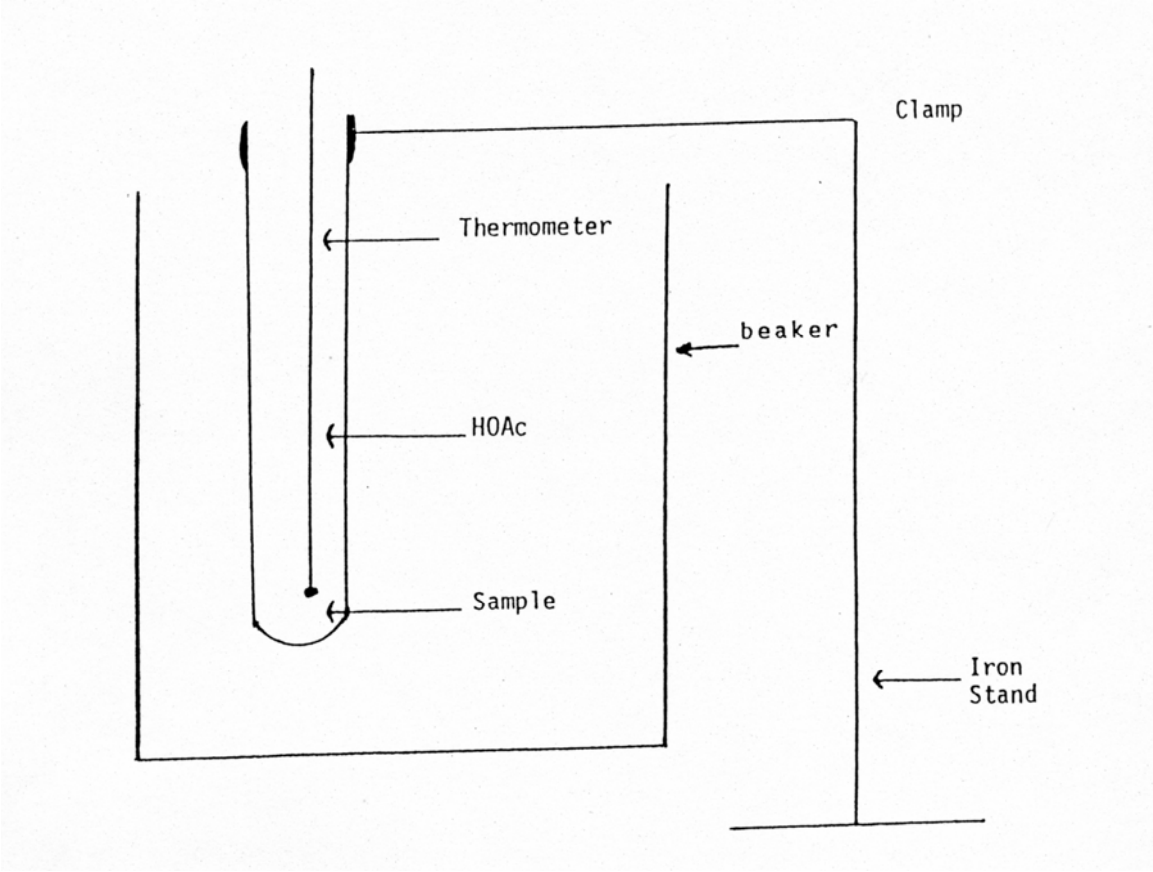

Figure 14-1

1. Weigh out a dry clean test tube.

2. Weigh out approximately 10 g of acetic acid, place it in the test tube, assemble apparatus as shown in Fig. 14-1, and determine its freezing point to nearest 1°C. To determine the freezing point, add a few ice cubes to the beaker. Use the thermometer as a stirrer. When the temperature has dropped to 18 C, begin recording temperature versus time and record the temperature every 30 seconds. Plot the data on a graph paper as shown in Fig. 14-2 and determine freezing point.

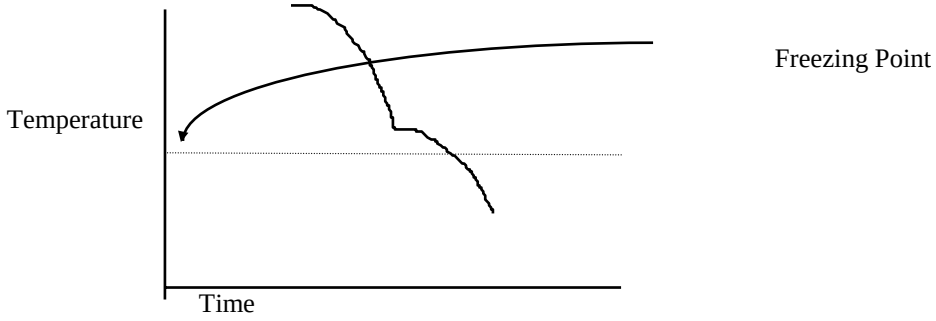

Figure 14-2

3. Remove the thermometer and wipe all the acetic acid off. Weigh the test tube and acetic acid to the nearest .01g and record the weight.

4. Determine the weight of acetic aid.

5. Weigh approximately 1/2 g of unknown measured to nearest .01 g, and carefully transfer all of its into the test tube containing HOAc.

6. Using the same thermometer as in part 2, stir the solution. Be careful that all of the unknown is completely dissolved. Determine the freezing point of the solution as in part 2.

7. Calculate the molecular weight for the unknown using expression 14-2.

8. Obtain the correct molecular weight of your unknown from your instructor.

9. Calculate the percent error.

10. Show all your calculations.

Clean-up:

To dispose of the acetic acid, pour it into the disposal jar in the hood.

ANSWER SHEET

EXERCISE 14

NAME_____ SECTION_____

DATE _____ SAMPLE NO._____

1. Weight of test tube ..... _____
2. Freezing point of pure acetic acid ..... _____
3. Weight of test tube and acetic acid..... _____
4. Weight of acetic acid..... _____
5. Weight of unknown ..... _____
6. Freezing point of solution ..... _____
7. Calculated molecular weight..... _____

8. Accepted molecular weight..... _____

9. Percent error ..... _____