11. Molecular Mass Determination Using Boiling and Freezing Point

- Page 38
- Page 39
- Page 40
- Page 41

Page 38

Partners: Jeff Somvorachith

11. Molecular Mass Determination Using Boiling and Freezing Point

Purpose:

To practice calculating the molecular mass of solutes by comparing boiling and freezing point of two solutes with known concentrations.

Procedure:

A.

1. Measure 50g of distilled water into a 125ml flask. set up the flask on a hot plate and hang a thermometer in the flask using a clamp, not letting the thermometer touch the flask. Record the temperature to the nearest 0.5 ^{o}C after heated.
2. Prepare a solution of 10g potassium nitrate in 50g of distilled water. Determine the boiling point of the solution using the equation $m=\Delta T_{BP}/K_{BP}$ where $K_{BP}=0.512\ ^{o}C$, m=molality, and ΔT=change in temperature. Dispose of the solution by rinsing it down a sink.
3. Repeat step 2, but replace the KNO_3 with C6H12O_6, Dextrose.

B.

1. Dissolve 5g of KNO_3 in 50g of water in a 125ml flask. Place the flask in a beaker with rock salt, with the beaker wrapped in a paper towel. Wait until crystals form in the solution and becomes slushy. Record the temperature. Rinse the solution down a drain.
2. Dissolve 10g $C_6H_{12}O_6$ in 50g of distilled water. Place the flask with the solution in a beaker filled with ice an rock salt and wait until the solution crystalizes. Measure the temperature and rinse down a drain.

Page 39

Data:

Solution	BP(°C)	ΔBP(°C)	FP(°C)	ΔFP(°C)
H_2O	98.5	XXXXX	0	XXXXX
$C_6H_{12}O_6$	102.0	3.50	-2.00	2.00
KNO_3	100.5	2.00	-3.50	3.50

Analysis:

Solution	avg Molality(m)	avg experimental molar mass(g/mol)	actual molar mass(g/mol)	avg percent error(%)
H_2O	xxxxx	xxxxx	xxxxx	xxxxx
$C_6H_{12}O_6$	3.94	107	180.156	40.6
KNO_3	1.45	104	101.11	2.97

KNO_3:

Boiling:

m=2.00/(2*0.512)

m=1.94m *(50/1000)=0.097 mol

10/0.097= 103 g/mol

Freezing:

m=3.50/(2*1.85) =0.950m *(50/1000) =0.0475 mol

5/0.0475=105 g/mol

$C_6H_{12}O_6$:

Boiling:

m=3.50/0.515 =6.80m *(50/1000)=0.34 mol

10/0.34=29.4 g/mol

Freezing:

m=2.00/1.85 = 1.08m 8(50/1000)=0.054 mol

10/0.054=185 g/mol

% error:

KNO_3:

Boiling:

|103-101|/101 *100%=1.98% error

Freezing:

|105-101|/101 *100%=3.98% error

$C_6H_{12}O_6$:

Boiling:

|29.4-180|/180 *100%=83.7% error

Freezing:

|185-180|/180 *100%=2.78% error

Page 40

Values:

Solution	BP(°C)	ΔBP(°C)	FP(°C)	ΔFP(°C)	m_F(m)	m_B(m)
H_20	98.5	xxxxx	0	xxxxx	xxxxx	xxxxx
$C_6H_{12}O_6$	102	3.50	-2.00	2.00	1.08	6.80
KNO_3	100.5	2.00	-3.50	3.50	0.950	1.94

Solution	exp g/mol (F)	exp g/mol (B)	Actual g/mol	% error (F)	% error (B)
H_20	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
$C_6H_{12}O_6$	185	29.4	180.156	2.78	83.7
KNO_3	105	103	101.11	3.96	1.98

Conclusion:

The purpose of this lab was to practice calculating molecular mass of solutes by comparing the boiling and freezing point of two solutions with a known concentration, and using that to find the molar mass. We achieved this by finding the boiling and freezing points, finding the molality, and then calculating the molar mass. We only needed to measure the boiling point of water and not the freezing point because it is easier to accurately measure the boiling point, as well as more consistent across measurements. The major source of error in our experiment was inaccurate measurements of the temperature and solution. Other sources of error include delayed boiling and crystallization and heat gain/loss to the environment. Ice melts with $CaCl_2$ when the outside environment is below the freezing point of water because adding the salt lowers the freezing as it dissociates and

Page 41

bond with the water. $CaCl_2$ is more effective than NaCl because it produces more ions when dissolved per mole, leading to a larger decrease in the freezing point. If I were to do this lab again, I would measure out the solution more accurately and insulate the Ice better. The boiling trial for the potassium nitrate was the best of the two trials, giving a 1.98% error. The freezing point of the dextrose gave the best result of the two trials with a 2.78% error. These most likely resulted from inaccurate temperature and solution measurements. The molar mass of the boiling trial for dextrose was the only major outlier in % error.