Colligative properties – freezing-point depression and molar mass essay sample

Science, Chemistry

Introduction

There are two types of mixtures; homogenous and heterogeneous. Homogenous mixtures have components that are uniformly mixed, while heterogeneous mixtures do not. A solution is a homogenous mixture that has two or more substances. A solution is mainly made of a solvent, while the solute is the smaller part of the solution. A solution’s freezing point depression is a type of colligative property. There are four types of colligative properties: vapor pressure, freezing point depression, melting-point elevation, and osmotic pressure. When a non-volatile (does not vaporize) solute mixes with the solvent, it lowers the vapor pressure of the solvent. This also raises the boiling point and lowers the freezing point. To find the molar mass of the unknown substance, the colligative law has to be used. The law states that the freezing point and boiling point of a solution differ from those of the pure solvent by amounts that are directly proportional to the molar concentration of the solute.

Methods

To find the freezing point of cyclohexane we needed a test tube holder, 400 mL beaker, 600 mL beaker, large test tube, salt, water, ice, rubber stopper, stirrer, and thermometer. We took exactly 10 mL of cyclohexane using a buret and put it into the test tube. We then weighed out 50g of salt, mixed it in 400 mL of water, then added ice. Then the thermometer was inserted through the rubber stopper with the stirrer around the base of the thermometer to about halfway into the cyclohexane. The test tube is then placed in the test tube holder and the test tube containing the cyclohexane is placed into the ice bath solution. After the cyclohexane freezes to a solid, approximately 0 to -2˚C, the test tube is removed from the ice bath and the temperature is recorded every 30 seconds for 14 minutes. This process was done twice. After the freezing point was determined by the aforementioned process, 0. 500g of unknown salt #12 was added to the cyclohexane and dissolved completely. We then followed the same process as noted above to find the freezing point of the new solution. This experiment consisted of only one timed trial.

Based on the above graph, the freezing point of cyclohexane plus the unknown solute is 3. 0 ˚C.

Calculations

1. Plot the warming curves of pure cyclohexane.

See figure 2.

2. Find the freezing point of pure cyclohexane from the warming curve.

Based on the graph depicted in figure 2, the freezing point of cyclohexane is 6. 0 ˚C. 3. Calculate the average of the freezing point of cyclohexane from the two trials. The average freezing point of cyclohexane is 6. 0 ˚C.

4. Plot the warming curves of the solution (cyclohexane/unknown solute) and find the freezing point. See figure 4.

5. Calculate the average of the freezing point of the solution from the two trials. Based on the graph depicted in figure 4, the freezing point of cyclohexane plus the unknown solute is 3. 0 ˚C. 6. Determine the freezing point depression (ΔT).

ΔT= 6˚C – 3˚C so ΔT= 3

7. Calculate the molality of the unknown.

-m= ΔTf/kf

[3. 0˚C]/[20. 4˚C/mol]= 0. 1471 molal.

8. Find the molar mass of the unknown.

[0. 500g]/[(0. 1471)(0. 00773)]= 439. 722g/mol (unknown #12)

Questions:

1. What are the major sources of error in this experiment?

Major sources of error would be inaccurate recordkeeping, inaccurate thermometer, impurities in the pure cyclohexane, and inaccurate measurements of either cyclohexane or unknown salt. 2. Suppose your thermometer consistently read a temperature of 1. 2˚ lower than the correct temperature throughout the experiment. How would this have affected the molar mass you found? An inaccurate thermometer would result in an inaccurate freezing point. This would most likely give you a higher molar mass. 3. If the freezing point of the solution had been incorrectly read 0. 3̊ lower than the true freezing point, would the calculated molar mass of the solute be too high or too low? Explain. The solute's molar mass would be too high. The lesser the freezing point, the smaller the calculated molality. A higher mass would result from the molar mass equation. 4. Arrange the following aqueous solutions in order of increasing freezing points: 0. 10 m glucose, 0. 10 m BaCl2, 0. 20 m NaCl, and 0. 20 m Na2SO4. In order: 0. 10 m glucose, 0. 10 m BaCl2, 0. 20 m NaCl, and 0. 20 m Na2SO4.

Discussion

Based on the experiment, our determination was that the sample of cyclohexane we observed had a freezing point of approximately 6˚C. The reason it is approximate is because the thermometer used was not digital and can really only be used to the nearest . 5˚C. After adding the unknown salt #12, The freezing point appeard to be 3˚C. Using this calculation we were able to determine that the freezing point depression was 3˚C. This allowed us to calculate the unknown's molality as 0. 1471 molal. Using this number we were able to gain the molar mass of the unknown which was 439. 722g/mol. Conclusion

The prerecorded temperature of cyclohexane is 6. 6, our result of 6. 0 is reasonably accurate for the instruments and conditions that the experiment was conducted in. If the thermometer had been digital, we believe that the temperature might have been more true to 6. 6. The results for the freezing point of the unknown were based on the sudden sharp increase in temperature. This experiment should have conducted two trials of the cyclohexane/unknown but due to time constraints, we were unable to accomplish this. If two trials had been conducted, we would have been more confident in our results.