SI Chemistry - Full Discipline Demo

Digital Colligative Properties - Beyond Labz

Final Report - Answer Guide

Institution	Science Interactive University
Session	SI Chemistry - Full Discipline Demo
Course	SI Chemistry - Full Discipline Demo
Instructor	Sales SI Demo

Test Your Knowledge

Identify the following statements as true or false.

- A 2.0% NaCl solution has a higher freezing point than pure water.
- A 2.0% NaCl solution has a higher vapor pressure than pure water.
- A 5.0% NaCl solution has a lower freezing point than a 2.0% NaCl solution.
- A 5.0% sucrose solution has a higher boiling point than pure water.
- A 5.0% sucrose solution has a higher osmotic pressure than a 10% sucrose solution.
- A 10% NaCl solution has a higher boiling point than a 5% NaCl solution.

True	False
1	2

Correct answers:

1 A 5.0% sucrose solution has a higher boiling point than pure water.

A 5.0% NaCl solution has a lower freezing point than a 2.0% NaCl solution.

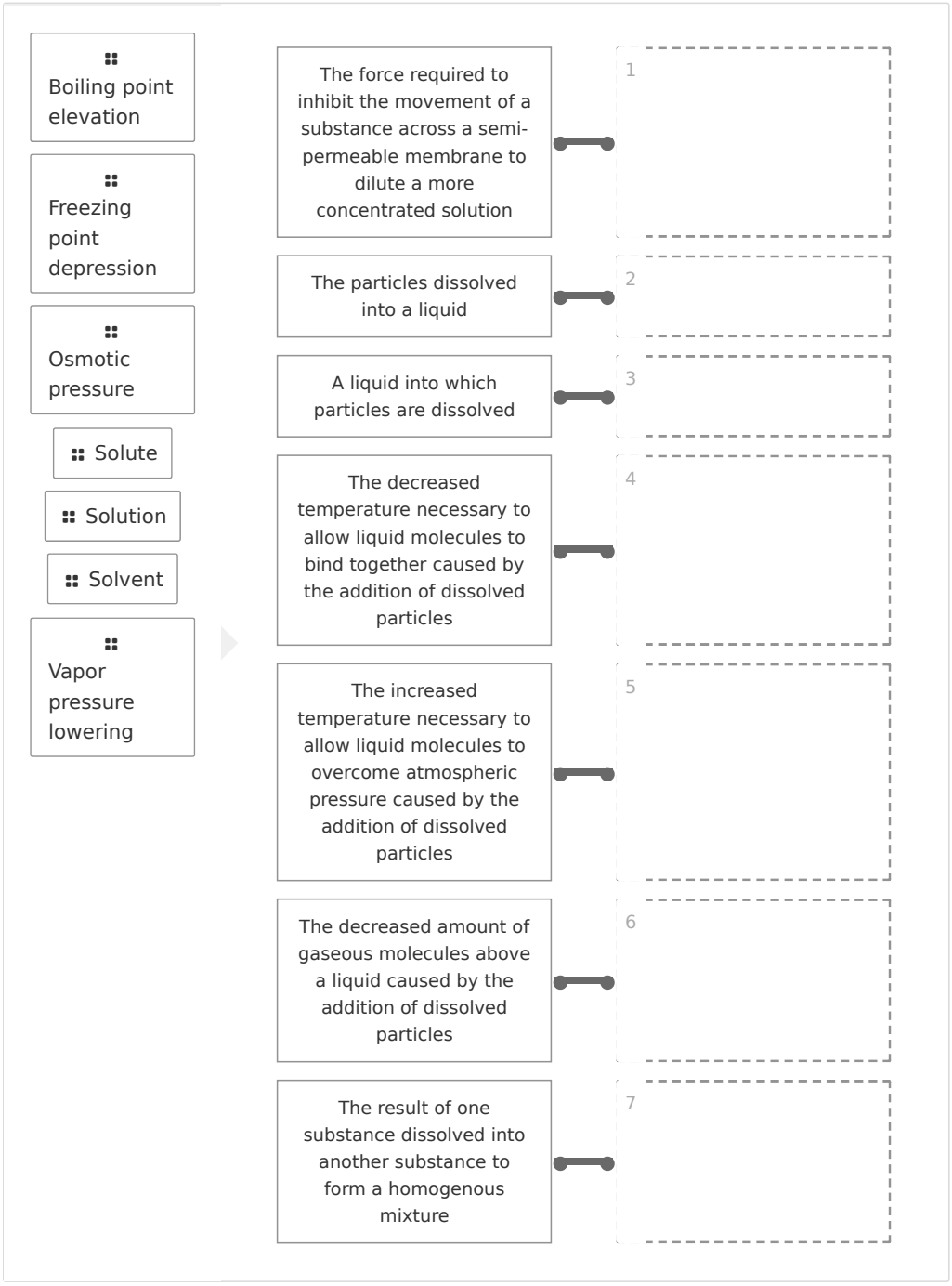
A 10% NaCl solution has a higher boiling point than a 5% NaCl solution.

2 A 2.0% NaCl solution has a higher freezing point than pure water.

A 5.0% sucrose solution has a higher osmotic pressure than a 10% sucrose solution.

A 2.0% NaCl solution has a higher vapor pressure than pure water.

Match each term with the best description.



Correct answers:

1 Osmotic pressure 2 Solute 3 Solvent 4 Freezing point depression

5 Boiling point elevation 6 Vapor pressure lowering 7 Solution

Typesetting math: 100%

Identify the term needed to validate each equation.

Freezing point depression equation:

$\Delta T = K_f \bullet$ [1] $\bullet i$

Definition of molality:

[2] $= \frac{\text{moles solute}}{\text{molality}}$

Definition of molar mass:

molar mass • moles = [3]

grams | m (molality) | kg of solvent

Correct answers:

1 m (molality) 2 kg of solvent 3 grams

Exploration

Colligative properties are properties that are dependent only on the identity of the solute, but not dependent on the ratio of solute to solvent particles in the solution.

- True
- False ✔

Typesetting math: 100%

Colligative properties can be used to determine the molar mass of a solute.

- True ✔
- False

Boiling point elevation measurements can be used to determine the _____ of a solute.

- lustre
- molarity
- density
- molality ✔

Exercise 1

What species was the solute in the solution used in this experiment? What species was the solvent?

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How did the addition of the solute affect the boiling point of the solution? Reference your results in Data Table 1 in your answer.

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How is boiling point elevation used to compute the molar mass of the solute? Reference your procedures and the results in Data Table 1 in your answer.

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Typesetting math: 100%

Based on the calculations performed in this experiment, would the same mass of a solute with a significantly higher molar mass have a larger or smaller effect on the boiling point elevation? Reference the calculations you performed in your answer.

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Data Table 1: Boiling Point Elevation Data
(SAMPLE ANSWER BELOW)

Mass water (g)	100.0833
Max temp water (°C)	100.15
Mass NaCl (g)	4.9668
Max temp salt water (°C)	101.14
ΔT (°C)	0.99
Molality (m)	0.97
Number of moles of NaCl (mol)	0.097
Molar mass of NaCl (g/mol)	51
Percent error (%)	13%

Exercise 2

What species was the solute in the solution used in this experiment? What species was the solvent?

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How did the addition of the solute affect the freezing point of the solution? Reference your results in Data Table 2 in your answer.

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Typesetting math: 100%

Would adding more solute further decrease the freezing temperature? Use the calculations performed in this lesson to explain your prediction.

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Data Table 2: Freezing Point Depression Data
(SAMPLE ANSWER BELOW)

Mass NaCl (g)	5.0165
Mass water (g)	99.4405
Mass ice (g)	50.5600
Minimum temp water (°C)	0.00
Minimum temp salt water (°C)	-2.17
ΔT (°C)	2.17
Molality (m)	0.583
Number of moles of NaCl (mol)	0.0875
Molar mass of NaCl (g/mol)	57.3
Percent error (%)	1.90

Competency Review

A solution that contains a solvent and non-volatile solute particles has a lower vapor pressure than a pure solvent under the same conditions.

- True ✔
- False

The temperature at which the outward pressure of particles trying to escape into the gas phase is surpassing the atmospheric pressure holding them in the liquid phase is the _____.

- freezing point
- boiling point ✔
- melting point
- vapor pressure

Typesetting math: 100%

Adding sugar to water ____ the solution's boiling point.

- increases ✔
- decreases
- does not change
- inverts

If two solutions of different concentrations are separated by a semi-permeable membrane, solvent from the more concentrated solution will pass through the membrane into the less concentrated solution.

- True
- False ✔

Ten grams of a solute is dissolved in 500 mL of a solvent, and the solution has a freezing point depression of 4.3°C and a van 't Hoff factor of 1. The other information needed to determine the molar mass of the solute is the _____.

- molarity
- temperature
- freezing point depression constant ✔
- The molar mass can be determined by the factors already given.

When salt is added to ice, the freezing point is _____.

- lowered ✔
- elevated
- unable to be determined
- unchanged

Typesetting math: 100%

6.41 g of a solute was added to 0.255 kg of water and ice, and colligative properties experiments determined that the freezing point decreased by 3.67°C. Using the K_f of water (1.86°C/m) and these data points, the molar mass of the solute was determined to be _____. Note: the solute did not dissociate in water.

$$\Delta T_f = K_f \cdot \ m \cdot i$$

$$\text{molality} = \frac{\text{moles solute}}{\text{kg solvent}}$$

$$\text{molar mass} = \frac{\text{grams of compound}}{\text{moles of compound}}$$

- 3.23 g/mol
- 12.7 g/mol ✔
- 25.5 g/mol
- The molar mass could not be determined.

The amount of solute was doubled in a colligative properties freezing point depression experiment. The solution with the larger amount of solute had a(n) _____ freezing point compared to the freezing point with the smaller amount of solute.

- higher
- lower ✔
- unchanged
- indeterminate

Extension Questions

The molar mass of $CaCl_2$ is 110.98 g. By how many degrees would the freezing point decrease in a solution of 0.420 kg of water containing 12.98 g of $CaCl_2$? The K_f of water is 1.86°C/m, and the van 't Hoff factor of $CaCl_2$ is 3.

$$\Delta T_f = K_f \cdot \ m \cdot i$$

$$\text{molality} = \frac{\text{moles solute}}{\text{kg solvent}}$$

$$\text{molar mass} = \frac{\text{grams of compound}}{\text{moles of compound}}$$

(SAMPLE ANSWER BELOW)

1.55°C

Use molar mass definition to solve for the moles of $CaCl_2$:

moles compound = g compound/molar mass

Then determine the molality:

molality = moles solute/kg solvent

Then use the freezing point depression equation to solve for the change in freezing temperature.

While they are two distinct phenomena, boiling point elevation and vapor pressure lowering are related colligative properties. Explain how the vapor pressure of a solvent being lowered when solutes are dissolved in it contributes to the boiling point necessarily needing to be a higher temperature. (SAMPLE ANSWER BELOW)

Because the boiling point of a solvent is about the vapor pressure overcoming the atmospheric pressure, if the vapor pressure is decreased by adding a solute, the boiling point must necessarily be a higher temperature for solvent particles to begin overcoming the atmospheric pressure.