SI Chemistry - Full Discipline Demo

Colligative Properties and Osmotic Pressure

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

Arrange the solutions in order from lowest to highest freezing point. Assume that each solution has a volume of 100 mL.

≡ pure water

1 **Correct answer:** water with 2 teaspoons of dissolved sugar

≡ water with 1 teaspoon of dissolved sugar

2 **Correct answer:** water with 1 teaspoon of dissolved sugar

≡ water with 1/2 teaspoon of dissolved sugar

3 **Correct answer:** water with 1/2 teaspoon of dissolved sugar

≡ water with 2 teaspoons of dissolved sugar

4 **Correct answer:** pure water

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.

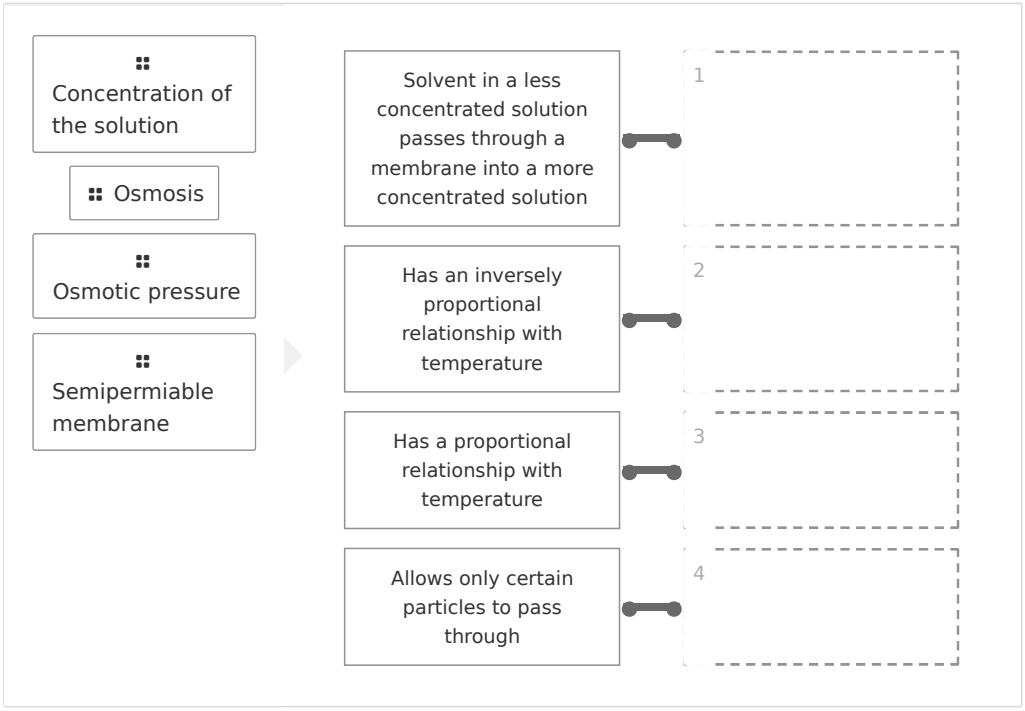
A 10% NaCl solution has a higher boiling point than a 5% NaCl solution.

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 the following terms with the best description.



Correct answers:

1 Osmosis 2 Concentration of the solution 3 Osmotic pressure

4 Semipermiable membrane

Exploration

Colligative properties are four properties that are dependent on the identity of the solute, but not dependent on the number (concentration) of solute particles that are present in the solution.

- True
- False ✔

When a cell is placed into a salt solution that has a salt concentration lower than the inside of the cell, the solution is said to be _____ .

- hypotonic ✔
- hypertonic
- colligative

_____ is/are needed to stop the movement of solvent through a membrane.

- Water molecules
- Solvent molecules
- Osmotic pressure ✔
- An increase in temperature
- An decrease in termperature

Colligative properties (freezing point depression, boiling point elevation, and osmotic pressure) have been used to determine the molar mass of a solute.

- True ✔
- False

When osmotic pressure is kept constant, the relationship of molarity (M) and temperature (T) is _____.

- directly proportional
- inversely proportional ✔
- not dependent on each other
- dependent on the gas

Exercise 1

In your experiment, is the light corn syrup in the dialysis tubing hypertonic or hypotonic to the water?

In the experiment, the corn syrup is hypertonic to the water resulting in the water moving into the dialysis tubing.

0.302 grams of an antibiotic was dissolved in enough water at 23.6°C to make 500.0 mL of solution. The solution has an osmotic pressure of 8.34 mm Hg. What is the molar mass of the antibiotic? Show your work.

8.34 mm Hg x 1 atm/760 mm Hg = 0.0110 atm
$T = T_{Celsius} + 273.15$
$T = 23.6 + 273.15$
$T = 296.75$ K
$0.0110 \text{ atm} = M \times (0.0821 \text{ (L) (atm)/(mol)(K)} \times (296.75 \text{ K})$
$0.0110 \text{ atm} = M \times 24.36 \text{ (L)(atm)/(mol)}$
$M = 4.50 \times 10^{-4}$ mol/L
Concentration = 0.302 g antibiotic/0.500 L = 0.610 g/L
$0.610 \text{ g} / 4.50 \times 10^{-4} \text{ mol} = x \text{ grams}/1.00 \text{ mol}$
$x = 1.34 \times 10^{3}$ g/mol

Data Table 1: Dialysis Tubing Results
(SAMPLE ANSWER BELOW)

Time	Mass of Dialysis Tubing and Contents
0 minutes	11.9 g
30 minutes	15.9 g
60 minutes	17.8 g

Exercise 2

Describe the three freezing points. Is there a relationship between the amount of solute in the solution and the freezing temperature?

The freezing point of the solution with 0.5 tsp of salt in it is lower than the control, and the solution with 1.0 tsp of salt in it is lower than the solution with 0.5 tsp of salt in it. Salt concentration is inversely related to freezing point: an increase in salt concentration results in a decrease in freezing point.

What are some practical applications of freezing point depression?

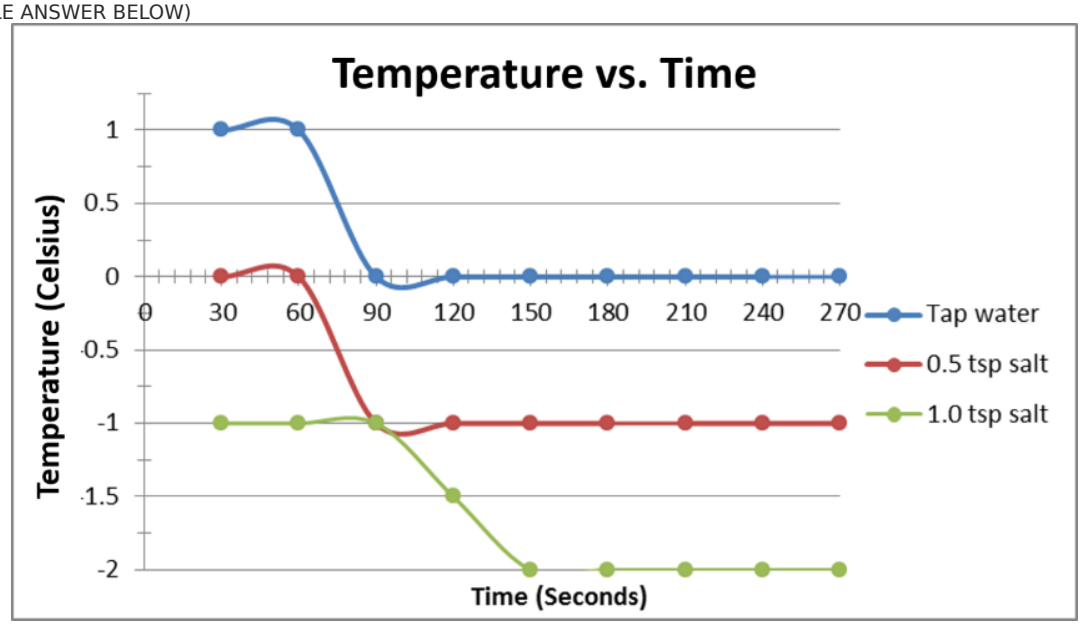
The student answers will vary as there are many options. A few possible student answers include: Making ice cream – salt is added to ice outside of the ice cream maker to let the temperature of the water go below the freezing point of the water so the cream freezes (which has a lower freezing point than water). Another example answer is putting salt on roads to lower the freezing point to the ice melts at a lower temperature.

Data Table 2: Temperature Readings for Freezing Point
(SAMPLE ANSWER BELOW)

Time (seconds)	Temp (°C) of Control (tap water)	Temp (°C) of Solution +0.5 tsp (~2.5 mL) salt	Temp (°C) of Solution +1.0 tsp (~5 mL) salt
30	1.0	0.0	-1.0
60	1.0	0.0	-1.0
90	0.0	-1.0	-1.0
120	0.0	-1.0	-1.5
150	0.0	-1.0	-2.0
180	0.0	-1.0	-2.0
210	0.0	-1.0	-2.0
240			-2.0
270			-2.0
300	No sample answer	No sample answer	No sample answer
330	No sample answer	No sample answer	No sample answer
360	No sample answer	No sample answer	No sample answer
390	No sample answer	No sample answer	No sample answer
420	No sample answer	No sample answer	No sample answer
450	No sample answer	No sample answer	No sample answer
480	No sample answer	No sample answer	No sample answer
510	No sample answer	No sample answer	No sample answer
540	No sample answer	No sample answer	No sample answer
570	No sample answer	No sample answer	No sample answer

600	No sample answer	No sample answer	No sample answer

Graph 1: Freezing Point Depression of Salt Solutions
(SAMPLE ANSWER BELOW)



Exercise 3

Compare the three boiling points. Is there a relationship between the amount of solute in the solution and the boiling temperature?

The boiling point of the solution with 0.5 tsp of salt in it is higher than the control, and the solution with 1.0 tsp of salt in it is higher than the solution with 0.5 tsp of salt in it. Salt concentration is directly related to boiling temperature: as concentration increases, boiling temperature increases.

What are some practical applications of boiling point elevation?

Student answers will vary. The most common example is adding salt to water to increase the boiling temperature, shortening the amount of time needed to prepare pasta or create hard boiled eggs.

Incorrect examples often found on the internet include mixing antifreeze with water in windshield washing fluid (this is an example of freezing point depression), salt on sidewalks to prevent ice (also an example of freezing point depression), or pressure cookers (this is an example of how atmospheric pressure affects boiling point).

Data Table 3: Temperature Readings for Boiling Point
(SAMPLE ANSWER BELOW)

	Temp (°C) of Control (tap water)	Temp (°C) of Solution +0.5 tsp (~2.5 mL) salt	Temp (°C) of Solution +1.0 tsp (~5 mL) salt
Temperature at Rolling Boil	98.0	99.0	100.0

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 vapor pressure of a liquid is equal to the atmospheric pressure on the liquid is the _____.

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

Adding salt to water _____ the boiling point.

- increases ✔
- decreases
- does not change

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 ✔

The amount of pressure needed to stop the movement of solvent through a semi-permeable membrane is directly related to the concentration of solute particles in two solutions on either side of the semi-permeable membrane.

- True ✔
- False

Osmotic pressure is dependent on temperature and solution concentration.

- True ✔
- False

What happens when dialysis tube filled with corn syrup is submerged in distilled water?

- [x] Water enters the dialysis tubing where the corn syrup is located.
- [ ] Water exits the dialysis tubing from the corn syrup.
- [ ] Nothing happens, as water cannot cross the membrane of the dialysis tubing.
- [ ] Water evaporates more quickly outside of the dialysis tubing.

Ten grams of a solute is dissolved in 500 mL, and the solution has an osmotic pressure of 10 mm Hg. What other information is needed before determining the molar mass of the solute?

- [ ] The molarity
- [x] The temperature
- [ ] The rate of osmosis
- [ ] The molar mass can be determined by the factors already given.

When salt is added to ice, what happens to the freezing point?

- [x] The freezing point lowers.
- [ ] The the freezing point increases.
- [ ] No change occurs.

What happens to the boiling point of water when sugar is added?

- [ ] The the boiling point lowers.
- [x] The boiling point increases.
- [ ] No change occurs.

Extension Questions

Sally lives in Maine, where there was recently an ice storm. Her sidewalks are now very slippery. The temperature in the next few days is going to rise, but not quite enough to melt the ice on her sidewalks. What could Sally do to the ice on the sidewalk that would allow it to melt? Explain your answer.

(SAMPLE ANSWER BELOW)

Sally would add a non-volatile substance, such as salt, to her sidewalk, which will alter the freezing point of the ice on her sidewalk, allowing it to melt at a lower temperature.