GENERAL CHEMISTRY 2
2nd Semester - Module 4
COLLIGATIVE PROPERTIES OF SOLUTIONS

Name of Learner: ____________________________________________
Grade & Section: ____________________________________________
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**Printed in the Philippines by**

**Department of Education – Region IX– Dipolog City Schools Division**

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What I Need to Know

This module was written to provide STEM students enough understanding of the fundamental concepts on the colligative properties of solutions.

The module covers lessons and activities aligned with the prescribed content standards and the Most Essential Learning Competencies (MELCS):

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<td>Describe the effect of concentration on the colligative properties of solutions</td>
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What's In

In the previous module, you have learned about the different ways of expressing the concentration of solutions. You also solved quantitative problems involving the stoichiometry of reactions in solution.

Activity 1: Concentrate on the Solution

Complete the concept map that represents the core solution concepts covered in Module 3.
This module deals with the colligative properties of a solution. These properties depend on how many solute particles are present in the solution and the amount of solvent. Colligative properties do not depend on the type of solute particles, although they do depend on the type of solvent. Thus, colligative properties can be linked to several quantities that express the concentration of a solution.

What’s New

Electrolyte and Nonelectrolyte

Solutions can be formed from the physical combination of different solutes and solvents. An aqueous solution is water that contains one or more dissolved substances. Water is generally the solvent in aqueous solutions as it has the ability to dissolve a lot of substances, both electrolytes, and nonelectrolytes.

An electrolyte is a substance that forms ions when dissolved in water, which is then able to conduct a current (conductivity). When ionic compounds dissolve in water, the ions in the solid separate and disperse uniformly throughout the solution because water molecules surround and solvate the ions, reducing the strong electrostatic forces between them. This process represents a physical change known as dissociation.

In an aqueous solution, a strong electrolyte is considered to be completely ionized or dissociated in water, meaning it is soluble. Strong acids and bases are usually strong electrolytes. In solutions containing strong electrolytes, only ions are present. Many ionic compounds are soluble in water. However, not all ionic compounds are soluble. Ionic compounds that are soluble in water exist in their ionic state within the solution. The dissociation equation for three ionic salts are shown below:

\[
\begin{align*}
\text{KCl (s)} & \rightarrow \text{K}^+ (aq) + \text{Cl}^- (aq) \\
\text{MgCl}_2 (s) & \rightarrow \text{Mg}^{2+} (aq) + 2\text{Cl}^- (aq) \\
\text{Al(NO}_3)_3 (s) & \rightarrow \text{Al}^{3+} (aq) + 3\text{NO}_3^- (aq)
\end{align*}
\]

The arrows used point only to the direction of the formation of ions (right side). The equation shows 100% ionization of the ionic compounds in water since, in the solid form, the compounds do not form ions and will not be able to conduct electricity.

Ionic compounds that are not completely dissociated or ionized in water are classified as weak electrolytes. Weak acids and bases are generally weak electrolytes. In a solution of weak electrolytes, both ions and molecules exist; thus, the dissociation equation would show arrows pointing to both the reactants and products. The double arrow represents a reversible reaction:

\[
\begin{align*}
\text{HCH}_3\text{COO} (aq) & \rightleftharpoons \text{H}^+ (aq) + \text{CH}_3\text{COO}^- (aq) \\
\text{NH}_4\text{OH} (aq) & \rightleftharpoons \text{NH}_4^+ (aq) + \text{OH}^- (aq)
\end{align*}
\]
A **nonelectrolyte** is a compound that does not ionize in solution at all. A solution that contains nonelectrolytes will not conduct electricity. Many molecular compounds, such as sugar or ethanol, which are primarily held together by covalent rather than ionic bonds, are nonelectrolytes. Glucose (sugar) or C₆H₁₂O₆ readily dissolves in water but does not dissociate into ions in solution. It is considered a nonelectrolyte.

- *Most soluble ionic compounds and few molecular compounds are strong electrolytes.*
- *Most molecular compounds are weak or nonelectrolytes.*

Strong electrolytes have a better tendency to supply ions to the aqueous solution than weak electrolytes or nonelectrolytes because of the degree or extent of their dissociation or ionization in water. Thus, strong electrolytes have a greater effect on the properties of a solution.

In Module 3, you have discussed the different quantitative ways of expressing the concentration of solutions - % concentration, molarity (M), molality (m), and mole fraction.

**Molality** is an intensive property of a solution and is defined as the number of moles of solute per kilogram of solvent. Molal concentration is used when the temperature is a concern. Molarity depends on the volume, but volume can change when the temperature changes. Molality is based on the mass of solvent used to create the solution because mass does not change as the temperature changes. Since molality is a more accurate measure of solutes in solution when working with a range of temperature (or pressure), it is often used in comparing and determining colligative properties.

**A saltwater solution.** Table salt readily dissolves in water to form a solution. If the masses of the salt and of the water are known, the molality can be determined. Try this problem on molality calculation.

![Saltwater solution](https://www.emedicinehealth.com/13_uses_for_salt_healthy/article_em.htm)

**Problem No. 1.** Calculate the molality of a solution prepared from 29.22 grams of NaCl in 2.00 kg of water.

**Answer:** The molality of the NaCl solution is 0.25 molal.

Calculations for molality are straightforward. Just remember to find the number of moles of solute and the mass of the solvent. If the mass of the solvent is unknown, the volume is often given. In such a case, use the density of the solvent to find the mass of solvent that you need.
What Are Colligative Properties?

The physical properties of a solution differ from that of either the pure solute or solvent. Dilute solutions that contain nonvolatile solute exhibit some properties which depend only on the number of solute particles present and not on the type of solute present. These properties are called colligative properties. The word "colligative" comes from the Latin word "colligatus" which means "bound together," but the Greek translation is "related to the number," implying that these properties are related to the number of solute particles, not their identities.

Colligative properties include vapor pressure lowering, boiling point elevation, freezing point depression, and osmotic pressure.

A. VAPOR PRESSURE LOWERING

The vapor pressure of a liquid is determined by how easily its molecules overcome the attractive forces and are able to escape the surface of the liquid then enter the gaseous phase. In a closed container, a liquid will evaporate until an equal amount of molecules are returning to the liquid state as there are escaping into the gas phase. The pressure of the vapor phase above the liquid at this point is called the equilibrium vapor pressure.

Vapor pressure is dependent on a number of factors, including the temperature of the system (kinetic energy is required to help the molecules escape into the gas phase), the pressure of the system (high pressure can keep the gas contained in the liquid), and also the intermolecular forces of the liquid itself (stronger bonds will require more kinetic energy to break and slows down the evaporation process, lowering the overall vapor pressure of the system).

If the liquid is volatile, the tendency for solvent molecules to escape is high, and the vapor pressure is high. In contrast, a nonvolatile substance has a lower vapor pressure and a low tendency to escape.

What happens to the pure water system (a) in the figure if we add a nonvolatile solute to the solvent in question, as shown in the aqueous solution system (b) in the figure?

In a pure solvent, the entire surface is occupied by the molecules of the solvent. If a nonvolatile solute is added to the solvent, the surface now has both solute and solvent molecules. Some of the solute molecules will take up spaces at
the surface of the liquid and limit the number of solvent molecules at the surface. The addition of solute also increases the solute-solvent interactions than the solvent-solvent interactions making it more difficult for the solvent molecules to escape to the vapor phase. Since the vapor pressure of the solution is due to solvent alone, at the same temperature, the presence of the solute particles lowers the number of solvent molecules coming and going and therefore lowers the equilibrium vapor pressure of the solution than that of the pure solvent.

The greater the concentration of solute present in the solution, the greater the reduction in vapor pressure. Therefore, the vapor pressure of an electrolyte solution will be lower than that of a weak electrolyte and a nonelectrolyte.

If the vapor pressure of pure solvent ($P_0$) and the vapor pressure of the solution ($P_s$), then the difference $P_0 - P_s$ is termed as lowering in vapor pressure. The ratio $P_0 - P_s / P_0$ is known as the relative lowering of vapor pressure.

**Activity 2: On Vapor Pressure Lowering**

Consider two different solutions of equal concentration. One is made from the ionic compound sodium chloride, while the other is made from the molecular compound glucose. The following equations show what happens when these solutes dissolve.

$$\text{NaCl}(s) \rightarrow \text{Na}^+ (aq) + \text{Cl}^- (aq) \quad 2 \text{ dissolved particles}$$

$$\text{C}_6\text{H}_12\text{O}_6(s) \rightarrow \text{C}_6\text{H}_12\text{O}_6 (aq) \quad 1 \text{ dissolved particle}$$

The sodium chloride dissociates into two ions, while the glucose does not dissociate. Therefore, equal concentrations of each solution will result in twice as many dissolved particles in the case of the sodium chloride.

**Q1:** Which is true of the vapor pressure of sodium chloride solution?

A. Lowered twice the amount as the glucose solution  
B. Increased twice the amount as the glucose solution  
C. Equal to that of the glucose solution  
D. Does not change

**B. BOILING POINT ELEVATION**

The boiling point is the temperature at which the vapor pressure of a liquid is equal to the atmospheric pressure. If we change the external pressure from 1 atm lower or higher, the boiling point changes as well. A liquid (a) with higher vapor pressure means that the molecules evaporate faster, and it takes a shorter time to equalize the vapor pressure of the liquid and the atmospheric pressure.

Remember that the addition of a nonvolatile liquid to a pure solvent causes the vapor pressure of the solution to decrease (b). A solution has lower vapor pressure than its pure solvent. To make the vapor pressure of the solution equal to atmospheric pressure, we have to increase the temperature of the
solution. Therefore, it takes a higher temperature to attain the boiling point of a solution than that of its solvent.

The difference in the boiling point of the solution and the boiling point of the pure solvent is termed as elevation in boiling point ($\Delta T_b$). This is the amount by which the boiling point temperature of a solvent is raised (elevated).

\\[
\text{The boiling point } (\Delta T_b) = \text{ Boiling point} - \text{ Boiling point elevation of solution} - \text{ Boiling point of pure solvent}
\\]

The increase in boiling point ($\Delta T_b$) observed when a nonvolatile solute is dissolved in a solvent is directly proportional to the molal concentration of solute particles:

$$\Delta T_b = Kb \times m$$

Where:
- $\Delta T_b$ is the boiling point elevation
- $Kb$ is the molal boiling point constant
- $m$ is the molal concentration of solute particles

We add salt to boiling water when preparing spaghetti in order to add flavor to the food. However, some people believe that the addition of salt increases the boiling point of the water. Technically, they are correct, but the increase is rather small. You would need to add over 100 grams of NaCl to a liter of water to increase the boiling point a couple of degrees, which is just not healthy as it makes the food very salty.

The extent to which the vapor pressure of a solvent is lowered and the boiling point is elevated depends on the total number of solute particles present in a given amount of solvent, not on the mass or size or chemical identities of the particles.

**Activity 3: Boiling the Toil**

Which is correct about the boiling point of a 1 m aqueous solution of sucrose (342 g/mol) and a 1 m aqueous solution of ethylene glycol (62 g/mol)? [Hint: Both solutions are nonelectrolytes.]

- A. exhibit the same boiling point because each solution has one mole of solute particles (molecules) per kilogram of solvent.
- B. sucrose solution boils at higher temperature as it has more solute particles than ethylene glycol solution
- C. ethylene glycol solution boils at higher temperature as it has less solute particles than sucrose solution

The table of molal boiling point constants ($Kb$) for substances will help one determine the elevation in boiling point. In the case of water, its boiling point is increased by 0.512 °C for every 1 mole of nonelectrolyte solute dissolved in one kilogram of water or 1 molal solution. Thus, a 1 m aqueous nonelectrolyte solution has a boiling point of 100.512°C (100°C + 0.512 °C = 100.512°C) and a 2 m aqueous solution of the same solute will boil at 101.024°C (100°C + 2 x 0.512 °C = 101.024°C).
C. FREEZING POINT DEPRESSION

The normal freezing point of a liquid is the temperature at which a liquid becomes a solid at 1 atm. It is the temperature at which the solid and liquid phases coexist, and their vapor pressures are the same. In order to freeze water, the temperature is lowered, and its particles become more ordered towards the solid phase as the intermolecular forces between particles become more permanent. In the case of water, the hydrogen bonds make the hexagonally-shaped network of molecules that characterizes the structure of ice.

Why is the freezing point lowered when we add solutes to a solution? If a nonvolatile solute is added to a solvent, the ordering process is disrupted. As a result, more energy must be removed from the solution. The freezing point of the solution is lowered than that of the pure solvent. The magnitude of the freezing point depression is directly proportional to the molality of the solution. The equation is:

\[
\Delta T_f = K_f \times m
\]

Where:  
\(\Delta T_f\) is the freezing point depression (decrease)  
\(K_f\) is the molal freezing point constant  
\(m\) is the molal concentration of solute particles

\[
\Delta T_f = \text{Freezing point of pure solvent - Freezing point of solution}
\]

The \(K_f\) for water is 1.86°C/m. Thus, the freezing temperature of a 1 m aqueous solution of any nonvolatile molecular solute is -1.86°C (0°C – 1.86°C = -1.86°C). The freezing point of water is reduced (depressed) by 1.86°C. Every solvent has a unique molal freezing-point depression constant, as shown in Table 1.

### Table 1. Molal Freezing Point and Boiling Point Constants

<table>
<thead>
<tr>
<th>Solvent</th>
<th>Normal freezing point (°C)</th>
<th>Molal freezing-point depression constant, (K_f) (°C/m)</th>
<th>Normal boiling point (°C)</th>
<th>Molal boiling-point elevation constant, (K_b) (°C/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetic acid</td>
<td>16.6</td>
<td>3.90</td>
<td>117.9</td>
<td>3.07</td>
</tr>
<tr>
<td>Camphor</td>
<td>178.8</td>
<td>39.7</td>
<td>207.4</td>
<td>5.61</td>
</tr>
<tr>
<td>Benzene</td>
<td>5.5</td>
<td>5.12</td>
<td>80.1</td>
<td>2.53</td>
</tr>
<tr>
<td>Phenol</td>
<td>40.9</td>
<td>7.40</td>
<td>181.8</td>
<td>3.60</td>
</tr>
<tr>
<td>Water</td>
<td>0.00</td>
<td>1.86</td>
<td>100.00</td>
<td>0.512</td>
</tr>
</tbody>
</table>

The effect of an electrolyte as solute to the freezing point of the solution is greater as compared to nonelectrolyte because an electrolyte gives more moles of solute particles when ionized in water. The greater the number of moles of solute, the more reduced the freezing point of the solution is from the freezing point of its pure solvent.

**Activity 4: Depress My Ice**

Complete the paragraph by supplying the correct term or number.

If 2 moles of a nonelectrolyte solute is dissolved in 1 kilogram water, the solution has a molal concentration of (1)____moles/kilogram. This concentration of solute particles depresses the freezing point of water by (2)____°C since the freezing point depression constant of water which is equal to (3)____°C/m is doubled. Thus, the solution will now freeze at (4)____°C which is much lower than the boiling point of pure water at (5)____°C.
D. OSMOTIC PRESSURE

Imagine you have a cup that has 100 ml water, and you add 15 g of table sugar to the water. Imagine now that you have a second cup with 100 ml of water, and you add 45 grams of table sugar to the water. Just like the first cup, the sugar is the solute, and the water is the solvent. But now you have two mixtures of different solute concentrations.

In comparing two solutions of unequal solute concentration, the solution with the higher solute concentration is **hypertonic**, and the solution with the lower solute concentration is **hypotonic**. Solutions of equal solute concentration are **isotonic**. The first sugar solution is hypotonic to the second solution. The second sugar solution is hypertonic to the first.

You now add the two solutions to a beaker that has been divided by a selectively permeable membrane, with pores that are too small for the sugar molecules to pass through, but are big enough for the water molecules to pass through. The hypertonic solution is on one side of the membrane and the hypotonic solution on the other. The hypertonic solution has a lower water concentration than the hypotonic solution, so a concentration gradient of water now exists across the membrane. Water molecules will move from the side of higher water concentration to the side of lower concentration until both solutions are isotonic. At this point, **equilibrium** is reached.

**Osmosis** is the movement of solvent molecules through a semipermeable membrane from the side with pure solvent to the side with the solution. It could also be the movement of solvent molecules from a region (A) of low concentration (dilute) to a region (B) of high concentration (concentrated). A semipermeable membrane allows the passage of solvent molecules but not the solute molecules. The movement of solvent molecules continues until the concentration on both sides is the same, with an increase in the volume of the solution (or more concentrated solution).

The apparatus illustrated in the figures shows samples of pure solvent and a solution that are separated by a membrane that only solvent molecules may permeate. Solvent molecules will diffuse across the membrane in both directions. Since the concentration of solvent is greater in the pure solvent than the solution, these molecules will diffuse from the solvent side of the membrane to the solution side at a faster rate than they will in the reverse direction. The result is a net transfer of solvent molecules from the pure solvent to the solution.

The osmotic pressure of a solution is the difference in pressure between the solution and the pure liquid solvent when the two are in equilibrium across a semipermeable membrane.

Source: https://www.ck12.org/book/cbse_chemistry_book_class_xii/section/2.6/

Source: https://openstax.org/books/chemistry-2e/pages/11-4-colligative-properties
Osmosis can be prevented by applying pressure to the more concentrated solution equal to the osmotic pressure on the less concentrated side. This can be accomplished either physically, by applying force to one side of the system, or chemically, by modifying a solute concentration so that the two solute concentrations are equal. If the external pressure applied to the concentrated solution is greater than the osmotic pressure, the solvent molecules are forced to flow from the concentrated solution side to the pure solvent (or diluted solution) side. This process is known as reverse osmosis and is useful in the purification of water.

**Calculating Molar Mass Using Colligative Properties**
In the laboratory, freezing point or boiling point data can be used to determine the molar mass of an unknown solute. The $K_f$ or $K_b$ of the solvent must be known. We also need to know if the solute is an electrolyte or a nonelectrolyte. If the solvent is an electrolyte, you would need to know the number of ions is produced when it dissociates. Then we can calculate the molar mass of the solute.

**From the Boiling Point Elevation (or Freezing Point Depression)**
1. Determine the change in boiling point from the boiling point of the pure solvent.
   \[ \Delta T = T_{\text{solution}} - T_{\text{pure solvent}} \]
2. Determine the molal concentration ($m$) from the change in boiling point and the boiling point elevation constant.
   \[ \Delta T = K_b \times m \quad \text{or} \quad m = \frac{\Delta T}{K_b} \]
3. Determine the moles of unknown solute from the molality of the solution and the mass of the solvent (in kilograms) used to make the solution.
   \[ m = \frac{\text{moles of solute}}{\text{mass of solvent in kilogram}} \]
   \[ \text{moles of solute} = \text{molality} \times \text{mass of solvent} \]
4. Determine the molar mass from the mass of the unknown and the number of moles of unknown.
   \[ \text{moles of unknown solute} = \frac{\text{mass of unknown}}{\text{molar mass}} \]
   \[ \text{molar mass} = \frac{\text{mass of unknown}}{\text{moles of unknown}} \]

**Sample Problem:** To make a solution, 38.7 g of a nonelectrolyte is dissolved into 218 g of water. The freezing point of the solution is measured to be -5.53°C. Calculate the molar mass of the solute.

**Given:** mass of unknown = 38.7 g; mass of solvent = 218 g = 0.218 kg
\[ \Delta T_f = 5.53^\circ C; \text{freezing point of pure solvent} = 0^\circ C; K_f = -1.86^\circ C/m \]

**Unknown:** molar mass of solute

**Solution:**
\[ m = \frac{\Delta T_f}{K_f} = \frac{5.53^\circ C}{1.86^\circ C} = 2.97 \text{ m} \]
\[ \text{mole of solute} = m \times \text{mass of solvent} \]
\[ = 2.97 \times 0.218 \text{ kg} = 0.648 \text{ mole} \quad \text{(Hint: } m = \text{mole/kg}) \]
\[ \text{molar mass} = \text{mass of unknown} / \text{mole of unknown} \]
\[ = \frac{38.7 \text{ g}}{0.648 \text{ mole}} = 59.7 \text{ g/mole} \]

**What's More**

**Activity 5: Problem-Solving with Colligative Properties**
Read the problem and answer as directed. You may use a separate sheet of paper for your solution and answer.

1. The molal elevation constant for water is 0.513 °C kg mol⁻¹. When 0.2 mole of sugar is dissolved in 250 g of water, calculate the temperature at which the solution boils under atmospheric pressure. **Ans. 100.80 °C**
2. What is the freezing point of a 0.33 \( m \) solution of a nonvolatile nonelectrolyte solute in benzene? Ans. 3.8 °C

3. Five grams of an organic solid is dissolved in 100.0 g of benzene. The boiling temperature of this solution is 82.42 °C. The boiling temperature of pure benzene is 80.10 °C; \( K_b = 2.53 °C/m \). What is the molar mass of the unknown compound? Ans. 54.5 g/mole

### What I Have Learned

Activity 6: Quick Test on Colligative Properties

Complete the paragraph and find out how much you have learned about colligative properties. You may use a separate sheet of paper for your answers.

The colligative properties of a 1._____ depend upon the 2._____ of solute molecules or ions, but not upon the identity of the solute. Colligative properties include 3._____, 4._____, 5.______ and 6.______. The effect of electrolytes would be greater on these properties than nonelectrolytes because electrolytes tend to 7.______ in the solution.

The vapor pressure of a solution is 8._____ than its pure solvent because the addition of solute to the solvent makes it difficult for the 9._____ molecules to escape from the solution into the vapor phase.

Since the vapor pressure of the solution is lower, more heat must be supplied to the solution to bring its vapor pressure up to the pressure of the external atmosphere. The 10.______ is the difference in temperature between the boiling point of the pure solvent and that of the solution.

The proportionality constant, \( K_f \), is called the 11.______. It is a constant that is equal to the change in the freezing point for a 12.______ solution of a nonvolatile molecular solute. The addition of any type of solute to a solvent will lower its 13.______.

Osmosis is the spontaneous net movement of 14.______ molecules through a selectively permeable membrane into a region of 15.______ solute concentration, in the direction that tends to equalize the solute concentrations on the two sides.

### What I Can Do

Activity 7: Colligative Properties in the Real World

Read and analyze the given situation. Identify the colligative property and explain the concepts behind it to support your answer. You may write your answer on a separate sheet of paper.

1. You are stranded on an island in the middle of the Pacific Ocean. You are extremely thirsty, and the water supply ran out. Why should you never drink the salty seawater?

2. Imagine that you live in an area with a cold and icy winter. On one winter day, you notice trucks dumping salt onto the roads as a preventive measure to avoid road accidents. Is the strategy effective?
**Assessment**

**Direction:** Circle the letter of the best answer.

1. Which observation(s) reflect(s) colligative properties?
   I. A 0.5 m NaBr solution has a higher vapor pressure than a 0.5 m BaCl₂ solution
   II. A 0.5 m NaOH solution freezes at a lower temperature than pure water.
   III. Pure water freezes at a higher temperature than pure methanol.
   A. only I  
   B. only II  
   C. only III  
   D. I and II

2. What is the freezing point of an aqueous 1.00 m NaCl solution? (Kf=1.86 °C/m and assume complete dissociation of the salt.)
   A. -1.86 °C  
   B. +1.86 °C  
   C. -3.72 °C  
   D. -0.93 °C

3. An aqueous solution of a nonelectrolyte has a vapor pressure
   A. Equal to that of water  
   B. Equal to that of methanol  
   C. Lower than that of water  
   D. More than that of methanol

4. When acetic acid is added to the aqueous solution of benzene, the
   A. Freezing point is raised  
   B. Freezing point is lowered  
   C. Freezing point does not change  
   D. Boiling point does not change

5. A 97.30 g sample of a mystery compound is added to 500.0 g of water, raising its boiling point to 100.78 degrees C. What is the molecular mass of the mystery compound? (Kb=0.512 °C/m).
   A. 130 g/mole  
   B. 260 g/mole  
   C. 100 g/mole  
   D. 230 g/mole

6. Colligative properties depend upon the
   A. Type of solution  
   B. Number of solute particles  
   C. Type of solvent  
   D. Number of solvent particles

7. Which of the following solutes will cause the highest elevation in the boiling point?
   A. NaCl  
   B. table sugar  
   C. CaCl₂  
   D. KNO₃

8. A semipermeable membrane allows
   A. Only solute particles through  
   B. Only solvent particles through  
   C. Both solute and solvent particles through  
   D. Neither solute nor solvent particles

9. Which of the following aqueous solutions will have the lowest freezing point?
   A. 0.1 m sodium chloride  
   B. 0.1 m aluminum nitrate  
   C. 0.2 m sucrose  
   D. all three have the same freezing point

10. Which is **not** a colligative property?
    A. Vapor pressure  
    B. Boiling point elevation  
    C. Freezing point depression  
    D. Osmotic Pressure
Additional Activities

Activity 8: The Life of a Food Scientist
This is an optional performance task you can do if you have Internet at home.

Goal: Your task is to explain the chemistry behind ice cream sundaes using the concepts on colligative properties.
Role: You are a Food Scientist who is currently working for a fast-food chain that is popular with its ice cream sundaes.
Audience: The target audience is a group of Senior High School STEM students.
Situation: You need to convince them that making the perfect sundaes comes with knowing the chemistry behind its ingredients specifically ice cream and the caramel sauce.
Product: You will design an infographic material that explains how colligative properties are at work in the making of ice cream and caramel sauce.
Standards: See the rubrics below.

Infographic Rubric

<table>
<thead>
<tr>
<th></th>
<th>3 Points: Exceeds Expectations</th>
<th>2 Points: Meets Expectations</th>
<th>1 Point: Needs More Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topic/Purpose</td>
<td>The topic/purpose of the infographic was clear and concise.</td>
<td>The topic/purpose was somewhat broad and did not allow the viewer to understand the purpose.</td>
<td>The topic/purpose of the infographic was not clear and concise.</td>
</tr>
<tr>
<td>Data</td>
<td>Data of the infographic was accurate and relevant to the topic.</td>
<td>Data of the infographic was somewhat accurate and relevant to the topic.</td>
<td>Data of the infographic was not accurate and was not relevant to the topic.</td>
</tr>
<tr>
<td>Layout</td>
<td>The infographic had a great layout, with applicable graphics.</td>
<td>The graphics were somewhat applicable to the infographic, creating an average layout.</td>
<td>The graphics had nothing to do with the topic and had a poor layout. There was an overload of text.</td>
</tr>
<tr>
<td>Color/Font</td>
<td>The font was legible, and the color scheme enhanced the infographic.</td>
<td>The font was somewhat legible, and the color scheme didn't affect the infographic.</td>
<td>The font was not legible, and the color scheme detracted from the infographic.</td>
</tr>
<tr>
<td>Sourcing</td>
<td>Citations for the infographic’s sources were included.</td>
<td>Citations for some of the sources used were included.</td>
<td>No citations of the infographics sources were included.</td>
</tr>
</tbody>
</table>
Answer Key General Chemistry 2 Module 4

Activity 1.
1. Quantitative
2. Concentrated
3. Molarity/Normality
4. Molality
5. % m/v

Activity 2.
Q1: A. lowered twice the amount as the glucose solution

Activity 3. A

Activity 4.
1. 2
2. 3.72°C
3. 1.86°C/m
4. -3.72°C
5. 0°C

Activity 6.
1. solution
2. number/concentration/amount
3. vapor pressure lowering
4. boiling point elevation
5. freezing point depression
6. osmotic pressure
7. dissociate/ionize/break apart
8. lower
9. solvent
10. ΔTb
11. molal freezing point point depression constant
12. 1 molal or 1 mole/kilogram or
13. freezing point
14. solvent
15. higher/greater

Activity 7.
1. When a highly concentrated solution and a less concentrated solution is separated by a semipermeable membrane, water flow from the low concentration to the high concentration solution. This is called osmosis.

   The sea water is far more concentrated than our body cells. So if one drinks sea water, his cells will rapidly lose water as our body cell is also a semipermeable membrane and as a result it allow water to go out of the cells. This will cause dehydration and the cells will shrink.

   2. Yes. It is an effective strategy. The salts prevents snow or ice from accumulating and freezing. Salt melts ice and snow by lowering its freezing point. Salt is best put on the roads before they freeze or before snow arrives. Then, as snow falls, the salt mixes with it, lowering its freezing point.

Assessment
1. D 6. B
2. C 7. C
3. C 8. B
5. A 10. A

References


Borja, Marissa F. Ayson and Rebecca S. De. 2016. General Chemistry 2. Quezon City: Vibal Group Inc.

Colligative Properties - Definition, Types, Examples .... https://byjus.com/jee/colligative-properties/


7.5: Aqueous Solutions and Solubility - Compounds ...https://chem.libretexts.org/Bookshelves/Introductory_Chemistry/Map%3A_Introductory_Chemistry_(Tro)/07%3A_Chemical_Reactions/7.05%3A_Aqueous_Solutions_and_Solubility_-_Compounds_Dissolved_in_Water

You are stranded on an island in the middle of Pacific Ocean ...