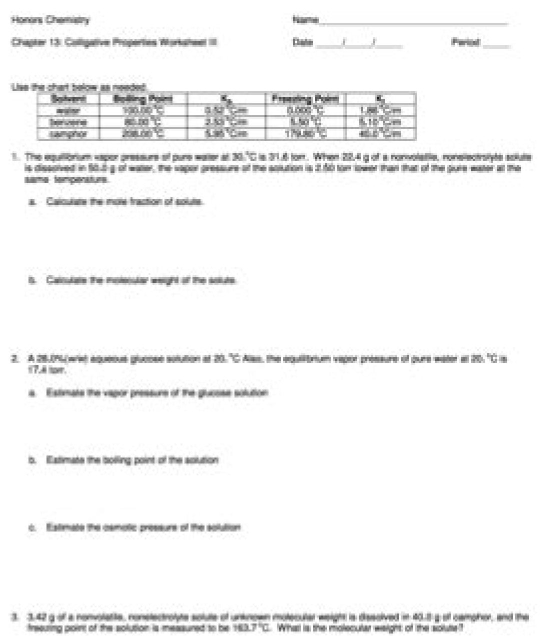
184 Calculations Involving Colligative Properties Answers



Honors Chemistry Name________________

Chapter 13: Colligative Properties Worksheet III Date ___/___/___ Period ___

Use the chart below as needed:

Solvent	Boiling Point	K_b	Freezing Point	K_f
water	100.00 °C	0.52 °C/m	0.000 °C	1.86 °C/m
benzene	80.00 °C	2.53 °C/m	5.50 °C	5.10 °C/m
camphor	208.00 °C	5.95 °C/m	179.80 °C	40.0 °C/m

1. The equilibrium vapor pressure of pure water at 30. °C is 31.6 torr. When 22.4 g of a nonvolatile, nonelectrolyte solute is dissolved in 50.0 g of water, the vapor pressure of the solution is 2.50 torr lower than that of the pure water at the same temperature.
   a. Calculate the mole fraction of solute.
   b. Calculate the molecular weight of the solute.
2. A 26.0%(w/w) aqueous glucose solution at 20. °C Also, the equilibrium vapor pressure of pure water at 20. °C is 17.4 torr.
   a. Estimate the vapor pressure of the glucose solution
   b. Estimate the boiling point of the solution
   c. Estimate the osmotic pressure of the solution
3. 3.42 g of a nonvolatile, nonelectrolyte solute of unknown molecular weight is dissolved in 40.0 g of camphor, and the freezing point of the solution is measured to be 163.7 °C. What is the molecular weight of the solute?

184 calculations involving colligative properties answers are essential for understanding how solutes affect the physical properties of solvents. Colligative properties are those properties that depend on the number of solute particles in a given amount of solvent, rather than the identity of the solute itself. This article will delve into the key concepts of colligative properties, outline the formulas used for calculations, and provide examples of 184 calculations, illustrating their application in real-world scenarios.

Understanding Colligative Properties

Colligative properties include four primary phenomena:

1. Vapor Pressure Lowering - This occurs when a non-volatile solute is added to a solvent, resulting in a decrease in the solvent's vapor pressure.

2. Boiling Point Elevation - The addition of a solute increases the boiling point of the solvent.

3. Freezing Point Depression - The presence of a solute lowers the freezing point of the solvent.

4. Osmotic Pressure - This is the pressure required to stop the flow of solvent into a solution through a semipermeable membrane.

Key Formulas for Colligative Properties

The calculations for colligative properties typically involve the following equations:

1. Vapor Pressure Lowering:

$$
\Delta P = P^0 - P = X_{solute} \cdot P^0
$$

Where:
- ΔP = decrease in vapor pressure
- P^0 = vapor pressure of the pure solvent
- P = vapor pressure of the solution
- X_{solute} = mole fraction of the solute

2. Boiling Point Elevation:

$$
\Delta T_b = i \cdot K_b \cdot m
$$

Where:
- ΔT_b = boiling point elevation
- i = van 't Hoff factor (number of particles the solute dissociates into)
- K_b = ebullioscopic constant of the solvent
- m = molality of the solution

3. Freezing Point Depression:

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

Where:
- ΔT_f = freezing point depression
- K_f = cryoscopic constant of the solvent

4. Osmotic Pressure:

$$
\Pi = i \cdot C \cdot R \cdot T
$$

Where:
- Π = osmotic pressure
- C = molar concentration of the solution
- R = universal gas constant (0.0821 L·atm/K·mol)
- T = temperature in Kelvin

Applications of Colligative Properties

Colligative properties have wide-ranging applications in several fields, including chemistry, biology, and engineering. They are crucial for understanding phenomena such as:

- The behavior of antifreeze in automotive fluids
- The preservation of food through freezing
- The functioning of biological cells in various osmotic environments

Example Calculations

To illustrate how colligative properties are calculated, we will go through several examples. These calculations demonstrate how to apply the formulas mentioned above.

Example 1: Vapor Pressure Lowering

A solution consists of 1 mole of NaCl dissolved in 3 moles of water. The vapor pressure of pure water at a given temperature is 23.8 mmHg.

1. Calculate the mole fraction of the solvent (water):

$$
X_{H_2O} = \frac{3}{1 + 3} = \frac{3}{4} = 0.75
$$

2. Calculate the vapor pressure of the solution:

$$
P = X_{H_2O} \cdot P^0 = 0.75 \cdot 23.8 = 17.85 \text{ mmHg}
$$

3. Calculate the decrease in vapor pressure:

$$
\Delta P = P^0 - P = 23.8 - 17.85 = 5.95 \text{ mmHg}
$$

Example 2: Boiling Point Elevation

Determine the boiling point of a solution containing 2 moles of glucose (C6H12O6) in 1 kg of water. The ebullioscopic constant K_b for water is 0.512 °C kg/mol.

1. Calculate the molality:

$$
m = \frac{2 \text{ moles}}{1 \text{ kg}} = 2 \text{ mol/kg}
$$

2. Calculate the boiling point elevation:

$$
\Delta T_b = i \cdot K_b \cdot m = 1 \cdot 0.512 \cdot 2 = 1.024 \text{ °C}
$$

3. The boiling point of the solution is:

$$
T_b = 100 + \Delta T_b = 100 + 1.024 = 101.024 \text{ °C}
$$

Example 3: Freezing Point Depression

Calculate the freezing point of a solution with 3 moles of NaCl dissolved in 2 kg of water. The cryoscopic constant K_f for water is 1.86 °C kg/mol.

1. Calculate the molality:

$$
m = \frac{3 \text{ moles}}{2 \text{ kg}} = 1.5 \text{ mol/kg}
$$

2. Calculate the freezing point depression:

$$
\Delta T_f = i \cdot K_f \cdot m = 2 \cdot 1.86 \cdot 1.5 = 5.58 \text{ °C}
$$

3. The freezing point of the solution is:

$$
T_f = 0 - \Delta T_f = 0 - 5.58 = -5.58 \text{ °C}
$$

Example 4: Osmotic Pressure

Calculate the osmotic pressure of a solution containing 0.5 moles of KCl in 2 liters of solution at 25 °C.

1. Convert the temperature to Kelvin:

$$
T = 25 + 273.15 = 298.15 \text{ K}
$$

2. Find the molar concentration:

$$
C = \frac{0.5 \text{ moles}}{2 \text{ L}} = 0.25 \text{ mol/L}
$$

3. Calculate the osmotic pressure:

$$
\Pi = i \cdot C \cdot R \cdot T = 2 \cdot 0.25 \cdot 0.0821 \cdot 298.15 = 12.3 \text{ atm}
$$

Conclusion

In summary, the calculations involving colligative properties are vital for various scientific and practical applications. Understanding the principles behind vapor pressure lowering, boiling point elevation, freezing point depression, and osmotic pressure allows chemists and researchers to predict how solutions behave under different conditions. By mastering these calculations, one can apply this knowledge in fields ranging from pharmaceuticals to food science, enhancing our ability to manipulate and utilize chemical solutions effectively. The examples provided illustrate the utility of these calculations in real-world scenarios, paving the way for a deeper understanding of the interactions between solutes and solvents.

Frequently Asked Questions

What are colligative properties?

Colligative properties are properties of solutions that depend on the number of solute particles in a given amount of solvent, rather than the identity of the solute.

How do colligative properties affect boiling point and freezing point?

Colligative properties raise the boiling point and lower the freezing point of a solvent when a solute is added, due to the disruption of the solvent's molecular interactions.

What is the formula for calculating vapor pressure lowering?

The vapor pressure lowering can be calculated using Raoult's Law: $\Delta P = X_{solute} P°_{solvent}$, where ΔP is the vapor pressure lowering, X_{solute} is the mole fraction of the solute, and $P°_{solvent}$ is the vapor pressure of the pure solvent.

How can you determine the molality of a solution from colligative properties?

Molality can be determined by rearranging the formula for colligative properties: $\Delta T_f = K_f m$, where ΔT_f is the freezing point depression, K_f is the freezing point depression constant, and m is the molality.

What role do colligative properties play in real-

world applications?

Colligative properties are important in various applications, including antifreeze formulations, food preservation, and understanding biological processes in cells.

What is the significance of the van 't Hoff factor in colligative property calculations?

The van 't Hoff factor (i) accounts for the number of particles a solute dissociates into in solution; it is crucial for accurate calculations of colligative properties, as it affects the overall concentration of solute particles.

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