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Chemistry 2, Lesson 1

Mixtures and Solutions

Types of Mixtures

1. Use the properties of seawater to describe the characteristics of mixtures.

   Sea water is a mixture. It consists of multiple substances, one or more of which dissolve into a main one, water. Understanding this, it is a homogeneous mixture, and in the form of a liquid.

2. What is the difference between a solute and a solvent?

   "The solute is the substance that dissolves. The solvent is the dissolving medium."

3. Distinguish between suspensions and colloids.

   A suspension is "a mixture containing particles that are large enough that, if left undisturbed, will settle out over time due to gravity". A colloid is "A heterogeneous mixture of intermediate-sized particles, between atomic scale solution particles and larger suspension particles".

4. What type of heterogeneous mixture is salad dressing? What characteristic is most useful in classifying the mixture?

   Salad dressing is a suspension. Left alone long enough, salad dressing tends to separate into layers, provoking a shaking before use.

5. What causes the Brownian motion observed in liquid colloids?

   "Brownian motion results from collisions of particles of the dispersion medium with the dispersed particles. These collisions prevent the colloid particles from settling out of the mixture and, over time, the particles will spread evenly throughout the medium."

6. How can the Tyndall effect be used to distinguish between a colloid and a solution? Why?

   "dispersed colloid particles scatter the light, unlike particles in the solution". This behavior is unique to heterogeneous colloid mixtures, and so its observation distinguishes a given mixture from mixtures that may be classified as solutions.

7. Use the Tyndall effect to explain why it is more difficult to drive through fog using high beams than using low beams.

   Fog is a heterogeneous colloid mixture. High beam lights provide more light to be scattered by fog than low beam lights. The increase in scattered light results in lessened visibility, resulting in a more di cult driving experience.

Factors Affecting Solvation

1. Sucrose dissolves in water because ___.

   c. both water and sucrose are polar molecules.
   "Sucrose molecules contain eight O—H bonds and are polar. Polar water molecules form hydrogen bonds with the O—H bonds, which pulls the sucrose into solution."

2. Describe the solvation of sodium chloride to form an aqueous solution.

   "Sodium Chloride dissolves in water as the water molecules surround the sodium and chloride ions." ... "When a crystal of an ionic compound, such as Sodium Chloride (NaCl), is placed in water, the water molecules collide with the surface of the crystal. The charged ends of the water molecules attract the positive sodium ions and negative chloride ions. This attraction between the dipoles and the ions is greater than the attraction among the ions in the crystal, so the ions break away from the surface."

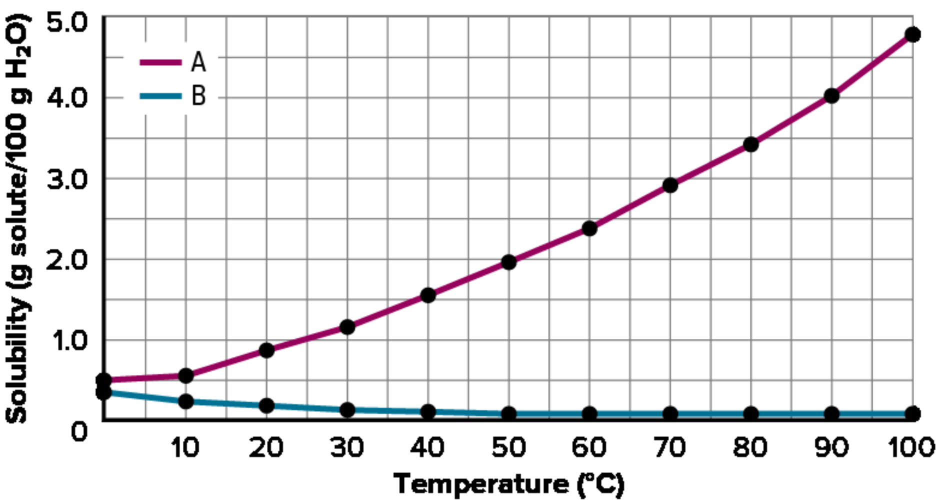
3. List several factors that affect the rate of solvation.

   - Agitation
     - Often stirring or shaking of a mixture constitutes agitation.
   - Surface area
   - Temperature
     - Warm solvents may allow quicker dissolution of a given solute.
   - Solubility
     - Once a solvent is saturated, conditions must change before dissolution may continue.

4. The decrease in solubility of a gas in a solution when the pressure is reduced is described by ___.

   c. Henry's law.
   "Henry's law states that at a given temperature, the solubility (S) of a gas in a liquid is directly proportional to the pressure (P) of the gas above the liquid."

5. The graph below shows the solubility versus temperature for two compounds, A and B.



One of the curves represent carbon dioxide, while the other represent tin (II) iodide. Identify compounds A and B. Explain your reasoning.

Compound B must represent carbon dioxide. In the given text, there is an included table of “Solubilities of Solutes in Water at Various Temperatures”. The following is an excerpt of that table.

Substance	Formula	0°C	20°C	60°C	100°C
Carbon dioxide	CO_2	1.713	0.878	0.359	-

Understanding that the solubility of carbon dioxide in water at 60°C is 0.359 grams of solute per 100 grams of H_2O, and that compound B is the only of the two compounds to match this value, Compound B must represent carbon dioxide. Through exclusionary means, it is made clear that Compound A must represent tin (II) iodide.

6. If a seed crystal is added to a supersaturated solution, how would you characterize the resulting solution?

   If a seed crystal is added to a supersaturated solution, I would characterize the resulting solution as apt to crystallization.

7. Explain the difference between saturated and unsaturated solutions.

   These terms are antonymous. “Saturated solutions occur when no more solute can be dissolved. The solution contains the maximum amount of dissolved solute for a given amount of solvent at a specific temperature and pressure.” ... “Unsaturated solutions contain less dissolved solute for a given temperature and pressure than a saturated solution. This means that more solute can be dissolved in an unsaturated solution.”

8. The solubility of a gas at 37.0 kPa is 1.80 g/L. At what pressure will the solubility reach 9.00 g/L?

   The solubility will reach 9.00 g/L at 185 kPa.

   Show Your Math Work Here:

   As pressure increases, solubility increases in direct proportion.

$$\frac{9 \text{ g/L}}{1.8 \text{ g/L}} \times 37 \text{ kPa} = 5 \times 37 \text{ kPa} = 185 \text{ kPa}$$

Colligative Properties of Solutions

1. Explain the nature of colligative properties.

   “Physical properties of solutions that are a ected by the number of particles but not by the identity of dissolved solute particles are called colligative properties. The word colligative means depending on the collection.”

2. Describe four colligative properties of solutions.

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

3. Explain why a solution has a higher boiling point than that of the pure solvent.

"Because a nonvolatile solute lowers a solvent's vapor pressure, it also a ects the boiling point of the solvent. Recall that liquid in a pot on a stove boils when its vapor pressure equals the atmospheric pressure. When the temperature of a solution containing a nonvolatile solute is raised to the boiling point of the pure solvent, the resulting vapor pressure is still less than the atmospheric pressure and the solution will not boil. Thus, the solution must be heated to a higher temperature to supply the additional kinetic energy needed to raise the vapor pressure to atmospheric pressure."

4. Calculate the boiling point elevation of a solution containing 50.0 g of glucose ($C_6H_{12}O_6$) dissolved in 500.0 g of water. Calculate the freezing point depression for the same solution.

$\Delta T_{\text{b}} = 0.1420800°C$
$\Delta T_{\text{f}} = 0.516150°C$

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It is written in the provided text: "Note that water's K_{b} value is 0.512°C/*m*. This means that a 1*m* aqueous solution containing a nonvolatile, nonelectrolyte solute boils at 100.512°C—a temperature just 0.512°C higher than pure water's boiling point of 100.0°C." It is later stated that water's freezing point depression constant, K_{f}, is 1.86°C/*m*. Understanding that *m* represents molality, the molality of $C_6H_{12}O_6$ must be calculated.

Molality calculation requires conversion of grams of glucose to moles of glucose. Research indicates that $C_6H_{12}O_6$ has a molar mass of 180.156 g/mol. 50 g ÷ 180.156 g/mol ≈ 0.2775 moles. The solution contains about 0.2775*m*. Boiling point elevation and freezing point depression may be calculated using this understanding.

$0.512°C/m \times 0.2775m = 0.1420800°C$
$1.86°C/m \times 0.2775m = 0.516150°C$

5. A lab technician determines the boiling point elevation of an aqueous solution of a nonvolatile, nonelectrolyte to be 1.12°C. What is the solution's molality?

Molality $= 2.1875m$

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The subject of study is "an aqueous solution," one that consists of water. The boiling point elevation constant of pure water is 0.512°C/*m*. Dividing the given solution's boiling point elevation by water's boiling point elevation constant provides the molality with which the boiling point elevation constant was multiplied.

$$\frac{1.12°C}{0.512°C/m}$$

$2.1875m$

6. A 4.305-g sample of a nonelectrolyte is dissolved in 105 g of water. The solution freezes at -1.23°C. Calculate the molar mass of the solute. Kf for water = 1.86°C/m

d. $62.0\ g/mol$

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The solution's molality must first be calculated.

$$-\frac{\Delta T_\mathrm{f}}{K_\mathrm{f}} = -\frac{-1.23°C}{1.86\,\frac{°C}{m}} = 0.6612m$$

Having calculated the solution's molality, the moles of solute may now be calculated.

$$\frac{0.6612m}{1kg} \times 0.105kg = 0.069426m$$

Knowing both the solute's mass and the moles of solute, the solute's molar mass may be calculated.

$$\frac{4.305g}{0.069426m} = \approx 62.0085g/m$$

7. The boiling point of ethanol (C_2H_5OH) changes from 78.5°C to 85.2°C when an amount of naphthalene ($C_{10}H_8$) is added to 1.00 kg of ethanol. How much naphthalene, in grams, is required to cause this change? Kb of ethanol = 1.22°C/m

$7 \times 10^2 g$

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Dividing the change in boiling point by the boiling point constant of ethanol provides the molality of the solution.

$$\frac{\Delta T_\mathrm{b}}{K_\mathrm{b}} = \frac{85.2°C - 78.5°C}{1.22\,\frac{°C}{m}} = \frac{6.7°C}{1.22\,\frac{°C}{m}} = \approx 5.4918m$$

Having calculated the solution's molality, the moles of solute may now be calculated.

$$\frac{5.4918m}{1kg} \times 1kg = 5.4918m$$

Research indicates that naphthalene has a molar mass of 128.17052 g/mol. Knowing the moles of solute and the molar mass of the solute, the mass of the solute may be found.

$$128.17052g/m \times 5.4918m = \approx 703.8869g$$

8. Which solute has the greatest effect on the boiling point of 1.00 kg of water: 50.0 g of strontium chloride ($SrCl_2$) or 150.0 g of glucose ($C_6H_{12}O_6$)? Justify your answer.

Glucose has the greatest e ect.
T_b of SrCl2 solution = 0.16148992°C → lesser value.
T_b of C6H12O6 solution = 0.42629632°C → greater value.

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The change in boiling point incurred by each solute must be calculated.

$\Delta T_\mathrm{b} = K_\mathrm{b} m$

Research indicates that strontium chloride has a molar mass of 158.526 g/mol. Research also indicates that glucose has a molar mass of 180.156 g/mol.

$$\frac{50g}{158.526g/m} = \approx 0.31541m$$

$$\frac{0.31541m}{1kg} \times 1kg = 0.31541m$$

$$\frac{150g}{180.156g/m} = \approx 0.83261m$$

$$\frac{0.83261m}{1kg} \times 1kg = 0.83261m$$

Understanding that $\approx 0.31541m < \approx 0.83261m$ is true, the glucose has a greater e ect on the boiling point of 1.00 kg of water. Knowing the molalities of each solute, the altered boiling point of each potential solution may be found.

$\Delta T_b = K_\mathrm{b} m = 0.512°C/m \times 0.31541m = 0.16148992°C$

$\Delta T_b = K_\mathrm{b} m = 0.512°C/m \times 0.83261m = 0.42629632°C$