Discussed on Monday, February 15, 2021

1. Define the following terms:

solution

solute

solvent

dissolution

concentration

2. Describe your observations of the following experiments performed by the instructor.

a) Sodium chloride added to water
b) Sodium metal added to water

3. Complete the following table by providing physical examples of solute/solvent combinations.

Solute	Solvent	Example

Gas	Gas	
Gas Liquid Solid	Liquid	
Gas Liquid Solid	Solid	

4. Based on the lecture demonstrations describe what happens when the following pairs of liquids are mixed together.

   a) water and hexane

   b) hexane and carbon tetrachloride

   c) water and ethanol

5. List the set of rules which can be used to predict the polarity of a covalent molecule.

6. Briefly describe each of the following types of intermolecular attractive forces. Sketch the orientations of molecules and/or ions involved in the following intermolecular attractive forces. Include at least one specific example where each attractive force is important. For each one, tell what causes the force and describe its strength relative to the others.

dipole-dipole forces

London dispersion forces

hydrogen-bonding forces

7. The three attractive interactions which are important in solution formation are; solute-solute interactions, solvent-solvent interactions, and solute-solvent interactions. Define each of these interactions and describe their importance in determining whether a particular solute-solvent pair will form a homogeneous mixture or a heterogeneous mixture.

Shown below are two beakers. One contains liquid water and the other contains liquid carbon tetrachloride. For simplicity a circle is used to represent the molecule. Complete the beaker on the right to illustrate the result of mixing the two liquids.	
Shown below are two beakers. One contains liquid hexane and the other contains liquid carbon tetrachloride. For simplicity a circle is used to represent the molecule. Complete the beaker on the right to illustrate the result of mixing the two liquids.	

8a. In terms of the attractive interaction discussed in exercise #6 explain how it is the formation of a solution can be exothermic or endothermic.

b. Describe the underlying thermodynamic property which favors the formation of a solution. Explain why some combinations of chemicals do not form homogeneous mixtures.

9a. Define the following terms;

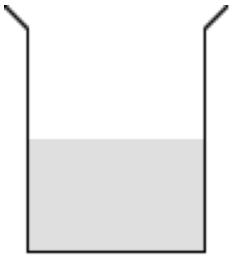
solubility

unsaturated solution

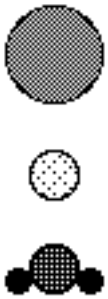
saturated solution

supersaturated solution

b. Given that the beaker to the right contains an aqueous solution of NaCl, describe a simple test to determine whether the solution is unsaturated, saturated or supersaturated. What would you expect to happen during the test if the solution were unsaturated? saturated? supersaturated?



10a. Given the representations below, sketch the orientations of a chloride ion and a several water molecules and a sodium ion and several water molecules to illustrate the ion-dipole interaction.



b) Briefly describe ion-dipole intermolecular attractive forces which occur when an ionic solid dissolves in water. Indicate what causes the attractive force and describe how the strength depends on the charge and the size of the ion.

11. Define the term *lattice energy* and explain its importance in the enthalpy of solution.

12. Explain how pressure, temperature and molar mass effect the solubility of a gas in a liquid.

Discussed in lecture on Wednesday, February 17, 2021

13a.Define the concentration terms;

weight percent

mole fraction

molarity

molality

b. Calculate the molality and mol fraction of HCl for a solution which is 37.1 % HCl by weight (mass).

Ans: 16.2 *m*

c. If the density of the solution described in b. is 1.18 g/mL, calculate the molarity of the solution.

Ans: 12.0 M

d. Calculate the weight percent NaCl in a solution which is 0.632 molal.

Ans: 3.57 %

e. A solution of ethylene glycol, $C_2H_4(OH)_2$, which is 6.77 molar has a density of 1.05 g/mL. Calculate the mole fraction of ethylene glycol in the solution.

Ans: 0.162

Discussed in lecture on Friday, February 19, 2021

14. Define the term *colligative property* and list those physical properties of a solution which can be classified as colligative properties.

15. Illustrate and explain how the presence of a nonvolatile solute affects the vapor pressure of a liquid.

16a. Draw the vapor pressure versus temperature curve for water and label the important features. On the same diagram draw the vapor-pressure versus temperature curve for an aqueous solution containing a nonvolatile solute.

b. Write Raoult's law and define each term.

c. Calculate the expected vapor pressure at 25 °C for a solution prepared by dissolving 97.4 g of common table sugar (sucrose, MM = 342 $\frac{g}{mol}$) in 453 mL of water.

Ans:

23.5 mmHg

d. A solution was prepared by adding 20.0 g of urea to 125 g of water at 25 °C, a temperature at which pure water has a vapor pressure of 23.76 mm of Hg. The observed vapor pressure of the solution was found to be 22.67 mm of Hg. Calculate the molecular weight of urea.

Ans: 59 $\frac{\mathbf{g}}{\mathbf{mol}}$

e. Show the derivation of a mathematical relationship for the vapor pressure lowering ($P^{\circ}_{solvent} - P_{solution}$) of a liquid following the addition of a nonvolatile solute.

17. Draw the vapor pressure versus temperature curve for water and label the important features. On the same diagram draw the vapor-pressure versus temperature curve for an aqueous solution containing a nonvolatile solute. Explain how the addition of a nonvolatile solute affects the freezing point and boiling point of water.

18a. Write the general mathematical relation which describes the dependence of the freezing point or boiling point on the concentration of solution.

b. Calculate the freezing point and boiling point of a solution prepared by mixing 6.00 g of $C_6H_{12}O_6$ with 35.0 g of H_2O.

Ans: T_{fp} = –1.77 ˚C : T_{bp} = 100.486 ˚C

c. A solution containing a nonelectrolyte dissolved in water has a boiling point of 100.305 ˚C. Calculate the freezing point of the same solution.

Ans: T_{fp} = -1.11 ˚C

d. What is the molecular mass of nicotine if 5.04 grams of this compound changes the freezing point of 90.0 g of water by 0.647 °C?

Ans: 161 $\frac{\mathbf{g}}{\mathbf{mol}}$

e. Calculate the freezing point and the boiling point of a saturated solution of Li_2CO_3. The solubility of lithium carbonate is 0.72 g per 100 g of water at 100 ˚C.

Ans: T_{fp} = –0.544 ˚C : T_{bp} = 100.149 ˚C

f. 2.57 g of an ionic compound with the formula KX are dissolved in 120 g of water. The freezing point of the solution was lowered by 1.37 ˚C. Determine the formula weight of X.

Ans: 19 $\frac{\mathbf{g}}{\mathbf{mol}}$