AP Chemistry

Exercise 11.2
Solution Formation

Name: _____

Date: _____ Per: _____

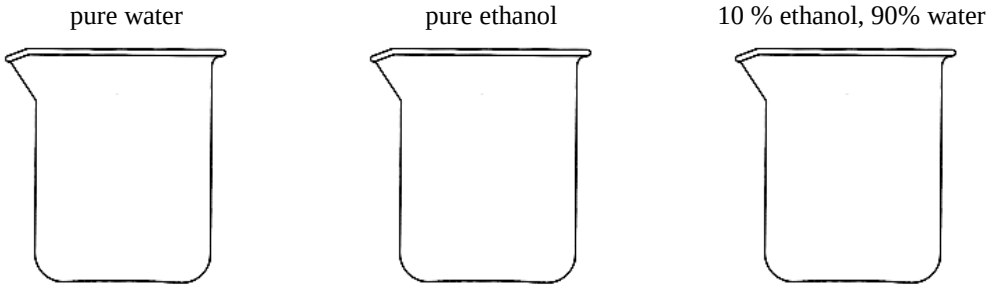
DIRECTIONS: Answer the following in the space provided:

1. Define:
   a. solution: _____
   b. solvent: _____
   c. solute: _____
2. Give an example of a common solution found in everyday life in each of the following phases.
   a. gas: _____
   b. liquid: _____
   c. solid: _____

Although solutions can occur for any solvent, and in any phase of matter, the most commonly encountered solutions are aqueous. Therefore, we will consider the solution process more closely for aqueous solutions.

3. In the beakers shown, use symbols to represent the appropriate compounds.

● = H_2O
Δ = Ethanol C_2H_5OH



4. During this process, significant changes in the intermolecular forces of attraction occur. List the IMF's present in each of the pure compounds.
   a. pure water _____ b. ethanol _____
5. In the solution, what IMF's are present? List what compounds are interacting and how. _____
6. One way to view the changes in energy associated with formation of solutions is to break the solution process down into a series of steps. The various steps are listed below. For our example of ethanol in water, circle the appropriate enthalpy change. Base your answer on the IMF's present and how these will be affected.

Step	Process	ΔH	Why?
Step 1 (ΔH_1)	Separating solvent molecules to make space available for the solute	exothermic endothermic	
Step 2 (ΔH_2)	Separating all solute molecules from each other.	exothermic endothermic	
Step 3 (ΔH_3)	Placing solute molecules in the available spaces in the solvent after step 1.	exothermic endothermic	

The overall enthalpy change is the sum of the enthalpy changes for these three steps,

$$\Delta H_{soln} = \Delta H_1 + \Delta H_2 + \Delta H_3$$

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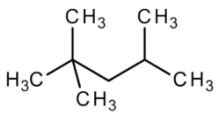
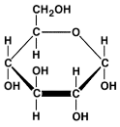
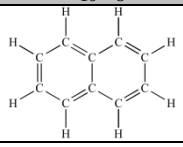
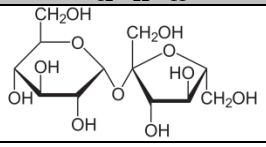
While each combination of solute and solvent will have a different value for ΔH_{soln}, as a general trend, a solution will form if ΔH_{soln} is exothermic and will not form is ΔH_{soln} is highly endothermic. Since ΔH_1 and ΔH_2 are ALWAYS endothermic, the magnitude of ΔH_3 is critical in determining solubility. If the IMF's formed between solute and solvent are of comparable magnitude to those broken, the solute will usually be soluble in that solvent. Exactly how much solute will dissolve before the solution becomes saturated is also determined by these relative strengths of IMF's. This type of analysis is often summarized in the common statement: "Like dissolves like."

7. Based upon the ideas illustrated above, complete the following table of solubilities.

Solvent		Solute		Soluble / Insoluble
Compound	polar/nonpolar?	Compound	Ionic? Molecular? (polar /nonpolar?)	
water	*polar*	KCl	*ionic*	*soluble*
water		NH_4NO_3		
water		glucose		
water		$C_{10}H_8$		
hexane, C_6H_{14}		water		
hexane		$C_{10}H_8$		
gasoline, C_8H_{18}		sucrose (a sugar)		

Gasoline (Isooctane) C_8H_{18}	Glucose $C_6H_{12}O_6$	Naphthalene $C_{10}H_8$	Sucrose $C_{12}H_{22}O_{11}$
			

8. Is the dissolving of $CaCl_2(s)$ into water endothermic or exothermic? (i.e., is ΔH_{soln} positive or negative?)

$E^o_{Lattice}$ $CaCl_2$	2258 kJ/mol
$H^o_{hydration}$ Ca^{2+}	1577 kJ/mol
$H^o_{hydration}$ Cl^-	381 kJ/mol

9. Is the dissolving of $NH_4Cl(s)$ into water endothermic or exothermic? (i.e., is ΔH_{soln} positive or negative?)

$E^o_{Lattice}$ NH_4Cl	708 kJ/mol
$H^o_{hydration}$ NH_4^+	307 kJ/mol
$H^o_{hydration}$ Cl^-	381 kJ/mol

Having a negative ΔH_{soln} is one factor that favors formation of solutions. However, many solutions are known to form spontaneously when ΔH_{soln} is zero or even positive. Another factor must also be involved in determining whether a solution will form. That factor is disorder or *entropy*.

10. Examine your three pictures on page 1 of this handout. Is disorder INCREASING OR DECREASING as the ethanol dissolves in the water? Explain your answer.

11. Does entropy increase or decrease when a solid lattice breaks apart into ions? _____

12. Does entropy increase or decrease when solutes are mixed into solvents? _____

13. Ions with high charges (+2, +3) strongly attract a shell of hydrated water molecules. Would locking a large number of water molecules in place this way increase or decrease the entropy of the system? _____