

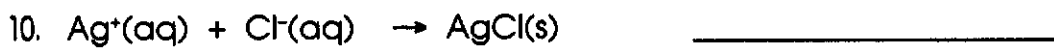
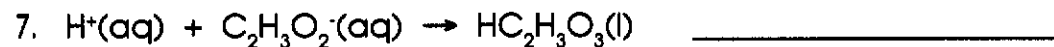
# ENTROPY

Name \_\_\_\_\_

Entropy is the degree of randomness in a substance. The symbol for change in entropy is  $\Delta S$ .

Solids are very ordered and have low entropy. Liquids and aqueous ions have more entropy because they move about more freely, and gases have an even larger amount of entropy. According to the Second Law of Thermodynamics, nature is always proceeding to a state of higher entropy.

Determine whether the following reactions show an increase or decrease in entropy.



# GIBBS FREE ENERGY

Name \_\_\_\_\_

For a reaction to be spontaneous, the sign of  $\Delta G$  (Gibbs Free Energy) must be negative. The mathematical formula for this value is:

$$\Delta G = \Delta H - T\Delta S$$

where  $\Delta H$  = change in enthalpy or heat of reaction  
 $T$  = temperature in Kelvin  
 $\Delta S$  = change in entropy or randomness

Complete the table for the sign of  $\Delta G$ ; +, - or undetermined. When conditions allow for an undetermined sign of  $\Delta G$ , temperature will decide spontaneity.

$\Delta H$	$\Delta S$	$\Delta G$
-	+	
+	-	
-	-	
+	+	

Answer the questions below.

1. The conditions in which  $\Delta G$  is always negative is when  $\Delta H$  is \_\_\_\_\_ and  $\Delta S$  is \_\_\_\_\_.
2. The conditions in which  $\Delta G$  is always positive is when  $\Delta H$  is \_\_\_\_\_ and  $\Delta S$  is \_\_\_\_\_.
3. When the situation is indeterminate, a low temperature favors the ( entropy / enthalpy ) factor, and a high temperature favors the ( entropy / enthalpy ) factor.

Answer Problems 4-6 with always, sometimes or never.

4. The reaction:  $\text{Na}(\text{OH})_s \rightarrow \text{Na}^+(\text{aq}) + \text{OH}^-(\text{aq}) + \text{energy}$  will \_\_\_\_\_ be spontaneous.
5. The reaction:  $\text{energy} + 2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{l})$  will \_\_\_\_\_ be spontaneous.
6. The reaction:  $\text{energy} + \text{H}_2\text{O}(\text{s}) \rightarrow \text{H}_2\text{O}(\text{l})$  will \_\_\_\_\_ be spontaneous.
7. What is the value of  $\Delta G$  if  $\Delta H = -32.0 \text{ kJ}$ ,  $\Delta S = +25.0 \text{ kJ/K}$  and  $T = 293 \text{ K}$ ? \_\_\_\_\_
8. Is the reaction in Problem 7 spontaneous? \_\_\_\_\_
9. What is the value of  $\Delta G$  if  $\Delta H = +12.0 \text{ kJ}$ ,  $\Delta S = -5.00 \text{ kJ/K}$  and  $T = 290. \text{ K}$ ? \_\_\_\_\_
10. Is the reaction in Problem 9 spontaneous? \_\_\_\_\_