Aim: What is Entropy?

Entropy: ΔS- is the measure of disorder, randomness or lack of organization in a chemical reaction

- Solid (Low ΔS) most organized gas more disorganized
- higher temperature = more randomness = more disorder
- Reactions that produce more moles = more disorder
- $\Delta S = (+)$ = favorable $\Delta S = (-)$ = unfavorable

S → L → G = $\uparrow \Delta S$

LESS MOLES → MORE MOLES = $\uparrow \Delta S$

Spontaneous reactions require

① Low Energy - Exothermic $\Delta H = (-)$

② more disorder = $\uparrow \Delta S$

Nature is Lazy and disorganized
(Low Energy) (High entropy)
Enthalpy = ΔH

ENTROPY

Name _____

Entropy is the degree of randomness in a substance. The symbol for change in entropy is ΔS.

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.

1. $2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$ increase ΔS
2. $H_2O(l) \rightarrow H_2O(s)$ decrease ΔS
3. $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ decrease ΔS
4. $NaCl(s) \rightarrow Na^+(aq) + Cl^-(aq)$ increase ΔS
5. $KCl(s) \rightarrow KCl(l)$ increase ΔS
6. $CO_2(s) \rightarrow CO_2(g)$ increase ΔS
7. $H^+(aq) + C_2H_3O_2^-(aq) \rightarrow HC_2H_3O_3(l)$ decrease ΔS
8. $C(s) + O_2(g) \rightarrow CO_2(g)$ increase ΔS
9. $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$ decrease ΔS
10. $Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$ decrease ΔS
11. $2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$ increase ΔS
12. $2Al(s) + 3I_2(s) \rightarrow 2AlI_3(s)$ decrease ΔS
13. $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$ decrease ΔS
14. $2NO(g) \rightarrow N_2(g) + O_2(g)$ increase ΔS
15. $H_2O(g) \rightarrow H_2O(l)$ decrease ΔS

GIBBS FREE ENERGY

Name _____

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

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

where ΔH = change in enthalpy or heat of reaction
T = temperature in Kelvin
ΔS = change in entropy or randomness

Complete the table for the sign of ΔG; +, – or undetermined. When conditions allow for an undetermined sign of ΔG, temperature will decide spontaneity.

ΔH	ΔS	ΔG
–	+	(–) spontaneous
+	–	(+) Not spontaneous
–	–	UNDETERMINED
+	+	UNDETERMINED

Answer the questions below.

1. The conditions in which ΔG is always negative is when ΔH is (–) and ΔS is (+).
2. The conditions in which ΔG is always positive is when ΔH is (+) and ΔS 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: $Na(OH)_s \rightarrow Na^+(aq) + OH^-(aq)$ + energy will always be spontaneous.
5. The reaction: energy + $2H_2(g) + O_2(g) \rightarrow 2H_2O$ (l) will never be spontaneous.
6. The reaction: energy + $H_2O(s) \rightarrow H_2O(l)$ will sometimes be spontaneous.
7. What is the value of ΔG if ΔH = -32.0 kJ, ΔS = +25.0 kJ/K and T = 293 K? 7357 KJ/Mol
   $\Delta G = (-32) - (25)(293)$
8. Is the reaction in Problem 7 spontaneous? yes
9. What is the value of ΔG if ΔH = +12.0 kJ, ΔS = -5.00 kJ/K and T = 290. K? 1462 KJ/Mol
   $\Delta G = (12) - (-5)(290)$
10. Is the reaction in Problem 9 spontaneous? No