EQUILIBRIUM & K_{eq} NOTES

REVERSIBLE REACTION: a reaction where the reactants form the products, then the products re-form the reactants

* can proceed in _____
* represented by _____

GENERALIZED EQUILIBRIUM RXN:

A + B ←→ C + D

- **A + B → C + D** _____ reaction
- **C + D → A + B** _____ reaction

CHEMICAL EQUILIBRIUM:

- occurs when _____
  _____
- concentration _____
  _____

EQUILIBRIUM CONSTANT EXPRESSION (K_{eq})

n A + m B ←→ e C + f D

lowercase letters (n, m, e, f) represent _____

CAPITAL LETTERS (A, B, C, D) represent _____

$K_{eq} = \frac{[\quad][\quad]}{[\quad][\quad]}$

* [ ] means "_____ of"

$K_{eq} = \frac{[\text{\_\_\_\_\_ side}]}{[\text{\_\_\_\_\_ side}]}$

EXTRA K_{eq} NOTE:

- Do NOT include (s) or (ℓ) in K_{eq} expressions – (aq) and (g) only!

EXAMPLE 1: $H_2\,(g) + I_2\,(g) \leftrightarrow 2\,HI\,(g)$

EXAMPLE 2: $H_2\,(g) + N_2\,(g) \leftrightarrow NH_3\,(g)$

EXAMPLE 3: $NaCl\,(s) \leftrightarrow Na^{+1}\,(aq) + Cl^{-1}\,(aq)$

EQUILIBRIUM CONSTANT WORKSHEET

Part 1 – Write the K_{eq} expressions for the reactions below. NOTE: Equations are not balanced.

1.) $N_2\,(g) + H_2\,(g) \leftrightarrow NH_3\,(g)$

2.) $KClO_3\,(s) \leftrightarrow KCl\,(s) + O_2\,(g)$

3.) $H_2O\,(\ell) \leftrightarrow H^{+1}\,(aq) + OH^{-1}\,(aq)$

4.) $CO\,(g) + O_2\,(g) \leftrightarrow CO_2\,(g)$

5.) $Li_2CO_3\,(s) \leftrightarrow Li^{+1}\,(aq) + CO_3^{-2}\,(aq)$

Use the K_{eq} expressions written above to determine the value of K in each of the following sets of conditions.

1.) $[N_2] = 0.0200$ M, $[H_2] = 0.0200$ M, $[NH_3] = 0.0100$ M
2.) $[O_2] = 0.0500$ M
3.) $[H^{+1}] = 1 \times 10^{-8}$ M, $[OH^{-1}] = 1 \times 10^{-6}$ M
4.) $[CO] = 2.0$ M, $[O_2] = 1.5$ M, $[CO_2] = 3.0$ M
5.) $[Li^{+1}] = 0.2$ M, $[CO_3^{-2}] = 0.1$ M

LE CHATELIER'S PRINCIPLE NOTES

~ When a system at equilibrium is stressed, the equilibrium will shift in the direction that will relieve the stress.

- "stress" on equilibrium = _____
  _____

~ Changes in PRESSURE

** only affect _____ **

- RULE: If the pressure goes up (increases), equilibrium will shift towards the side of the equation with the LOWER number of moles of gas.
  * How do you figure out the number of moles of gas?*
  _____

EXAMPLE 1: $N_2\ (g) + 3\ H_2\ (g) \leftrightarrow 2\ NH_3\ (g)$

If the pressure on this system increases, the shift in equilibrium will be towards the _____ side because _____

EXAMPLE 2: $H_2\ (g) + I_2\ (g) \leftrightarrow 2\ HI\ (g)$

If the pressure on this system decreases, the shift in equilibrium will be towards the _____ side because _____

~ Changes in CONCENTRATION

- RULE: If the concentration of a substance on one side of the equation goes up (increases), the equilibrium will shift towards the other side.

EXAMPLE 3: $N_2\ (g) + 3\ H_2\ (g) \leftrightarrow 2\ NH_3\ (g)$

If $[N_2]$ increases, equilibrium shift will be towards _____ side.
If $[NH_3]$ increases, equilibrium shift will be towards _____ side.

- RULE: If the concentration of a substance on one side of the equation goes down (decreases), the equilibrium will shift towards that side.

EXAMPLE 4: $N_2\ (g) + 3\ H_2\ (g) \leftrightarrow 2\ NH_3\ (g)$

If $[H_2]$ decreases, equilibrium shift will be towards _____ side.
If $[NH_3]$ is removed, equilibrium shift will be towards _____ side.

- RULE: If the concentration of a substance is increased, the other substances on that side of the equation will decrease. The substances on the other side of the equation will increase.

- EXAMPLE 5: $4\ HCl_{(g)} + O_{2(g)} \leftrightarrow 2\ H_2O_{(g)} + 2\ Cl_{2(g)}$

If $[O_2]$ decreases, equilibrium shift will be towards _____ side.

$[HCl]$ _____
$[H_2O]$ _____
$[Cl_2]$ _____

If $[H_2O]$ increases, equilibrium shift will be towards _____ side.

$[HCl]$ _____
$[O_2]$ _____
$[Cl_2]$ _____

~ Changes in TEMPERATURE

- RULE: The word "heat" or a number of J, kJ, or cal should be treated as another product or reactant. Follow same rules as with concentration.
- EXAMPLE 6: $2\ H_2O_{(g)} \leftrightarrow 2\ H_{2(g)} + O_{2(g)} + \underline{16\ kcal}$ (heat)

If the temperature is increased, equilibrium shift will be towards _____ side.

~ Changes in K_{eq} VALUE

- RULE: Only changes in temperature affect the K_{eq} value. Changes in pressure and/or concentration do NOT affect the K_{eq} value for a reaction.
- If heat is added to start a reaction...
  - it is located on the _____ side of the equation.
  - it is an _____ reaction.
  - If the temperature increases, the value of K_{eq} will _____
- If heat is given off by a reaction...
  - it is located on the _____ side of the equation.
  - it is an _____ reaction.
  - If the temperature increases, the value of K_{eq} will _____

LE CHATELIER'S PRINCIPLE WORKSHEET

Complete the following chart by writing "left", "right", or "none" for equilibrium shift. Write "increases", "decreases", or "remains the same" for the concentration of reactants and products, and for the value of K.

N_2 (g) + 3 H_2 (g) ←→ 2 NH_3 (g) + 22.0 kcal

	Stress	Equilibrium Shift	[N_2]	[H_2]	[NH_3]	K
1	add N_2	right	---	decreases	increases	same
2	add H_2			---		
3	add NH_3				---	
4	remove N_2		---			
5	remove H_2			---		
6	remove NH_3				---	
7	increase temp.					
8	decrease temp.					
9	increase pressure					
10	decrease pressure					

12.6 kcal + H_2 (g) + I_2 (g) ←→ 2 HI (g)

	Stress	Equilibrium Shift	[H_2]	[I_2]	[HI]	K
1	add H_2	right	---	decreases	increases	same
2	add I_2			---		
3	add HI				---	
4	remove H_2		---			
5	remove I_2			---		
6	remove HI				---	
7	increase temp.					
8	decrease temp.					
9	increase pressure					
10	decrease pressure					

$NaOH_{(s)} \leftrightarrow Na^{+1}_{(aq)} + OH^{-1}_{(aq)} + 10.6\ kcal$

	Stress	Equilibrium Shift	Amount of NaOH (s)	$[Na^{+1}]$	$[OH^{-1}]$	K
1	add NaOH		---			
2	add NaCl (adds Na^{+1})			---		
3	add KOH (adds OH^{-1})				---	
4	add H^{+1} (removes OH^{-1})				---	
5	increase temp.					
6	decrease temp.					
7	increase pressure					
8	decrease pressure					

UNIT 13 REVIEW WORKSHEET

1. Given the equilibrium equation at 25°C: $A_2\ (g) + B_2\ (g) \leftrightarrow 2\ AB\ (g)$
   If, *at equilibrium*, the concentrations are as follows: $[A_2] = 3.45$ M, $[B_2] = 5.67$ M, and $[AB] = 0.67$ M
   (A) Write the K_{eq} expression for the reaction.

   (B) Find the value of the equilibrium constant at 25°C.

2. Given the equilibrium equation: $X_2\ (g) + 3\ Y_2\ (g) \leftrightarrow 2\ XY_3\ (g)$ at a temperature of 50°C, it is found that when equilibrium is reached that:
   $[X_2] = 0.37$ M, $[Y_2] = 0.53$ M and $[XY_3] = 0.090$ M
   (A) Write the equilibrium constant expression (K_{eq}).

   (B) Calculate the value of K_{eq} at 50°C.

3. Predict which way these equilibrium systems will shift when the total pressure is increased.
   (A) $N_2\ (g) + O_2\ (g) \leftrightarrow 2\ NO\ (g)$
   (B) $2\ SO_2\ (g) + O_2\ (g) \leftrightarrow 2\ SO_3\ (g)$
   (C) $4\ NH_3\ (g) + 5\ O_2\ (g) \leftrightarrow 4\ NO\ (g) + 6\ H_2O\ (g)$

4. Hydrogen peroxide decomposes according to the following equation:

   $187\ kJ + H_2O_2\ (\ell) \leftrightarrow H_2\ (g) + O_2\ (g)$

   Predict the direction of equilibrium shift by each of these changes:
   (A) Increase the $[H_2]$ (B) Decrease the $[O_2]$
   (C) Decrease the total pressure (D) Increase the temperature

5. Consider the following equilibrium and answer the questions when these changes are made.

Heat + CH_4 (g) + 2 H_2S (g) ↔ CS_2 (g) + 4 H_2 (g)

~ CH_4 gas is added
(A) direction of equilibrium shift?
(B) [H_2S]?
(C) [CS_2]?
(D) [H_2]?

~ CS_2 gas is removed
(A) direction of equilibrium shift?
(B) [CH_4]?
(C) [H_2S]?
(D) [H_2]?

~ H_2 gas is added
(A) direction of equilibrium shift?
(B) [CH_4]?
(C) [H_2S]?
(D) [CS_2]?

~ The temperature is increased
(A) direction of equilibrium shift?
(B) [CH_4]?
(C) [H_2S]?
(D) [CS_2]?
(E) [H_2]?