Chapter Review Worksheet

Topics:

- Definition of equilibrium
- K_{eq}: law of mass action
- Le Chatelier's Principle
- Properties of acids & bases
- Brønstead-Lowry Acids & Bases definition
- K_w & calculating $[H_3O^+]$, $[OH^-]$, pH

1. If the reaction below is initially at equilibrium, and then each of the following changes are made, predict which direction the reaction rate will be fastest until equilibrium is once again established: **forward, reverse, or no change.**

$$H_{2(g)} + Cl_{2(g)} \rightleftarrows 2\ HCl_{(g)}$$

   a. the amount of H_2 is increased
   b. the amount of HCl is decreased
   c. the amount of Cl_2 is decreased

2. If the reaction below is initially at equilibrium, and then more NH_4^+ is added, predict which direction the reaction rate will be fastest until equilibrium is once again established**: forward, reverse, or no change**.

$$NH_4^+ + H_2O \rightleftarrows NH_3 + H_3O^+$$

3. Define (a) **reversible reaction** and (b) **equilibrium**.

4. For the reaction below:

$$2NO_{2\ (g)} + O_{2\ (g)} \rightleftarrows 2NO_{3\ (g)}$$

   a. Write the law of mass action (the equilibrium expression for K_{eq})

   b. If gas concentrations are as follows, 2.10 M NO_2, 1.75 M O_2, and 1.00 M NO_3, calculate K_{eq}

   c. Using K_{eq} from part b, are the **reactants** <u>or</u> **products** *predominant* (predominant means that there is a greater amount present)?

   d. Using K_{eq} from part b, calculate **$[NO_3]$** if $[NO_2] = [O_2] = 4.3 \times 10^{-6}$ M

Acids and Bases

5. For each of the following, write whether it describes acids/acidic (**A**), bases/basic (**B**), or both (**A** & **B**):

a. pH = 9.7	f. $[H_3O^+] > [OH^-]$	k. sour
b. $[H_3O^+]= 1 \times 10^{-9}$ M	g. pH = 2.7	l. slippery
c. bitter	h. pH =13.0	
d. pH = 1.0	i. gains/accepts an H^+ in a reaction	
e. $[OH^-] = 6.8 \times 10^{-2}$ M	j. electrolytes	

6. For each of the following ***neutralization reactions***, predict the products AND balance the equation:

   a. $HCl + KOH \rightleftarrows$

   b. $HCN + Ca(OH)_2 \rightleftarrows$

7. Identify the acid and the base (for the forward direction) in each of the following reactions:

   a. $BH_3 + H_2O \rightarrow BH_4^+ + OH^-$

   b. $CH_3COOH + H_2O \rightarrow CH_3COO^- + H_3O^+$

   c. $HCO_3^- + H_2O \rightarrow CO_3^{-2} + H_3O^+$

   d. $HCN + H_2O \rightarrow CN^- + H_3O^+$

   e. $HNO_3 + H_2O \rightarrow NO_3^- + H_3O^+$

8. What is the conjugate acid of...
   a. NH_3
   b. HCO_3^-
   c. H_2O

9. What is the conjugate base of...
   a. H_2O
   b. HF
   c. HPO_4^{-2}

10. a. In a neutral solution, what is the concentration of H_3O^+?

    b. In a neutral solution, what is the concentration of OH^-?

11. Solutions in which the...

    a. $[H_3O^+]$ is greater than 1 x 10^{-7} M are _____ [**Choose one:** acidic, basic, or neutral]

    b. $[H_3O^+]$ is less than 1 x 10^{-7} M are _____ [**Choose one:** acidic, basic, or neutral]

    c. $[OH^-]$ is greater than 1 x 10^{-7} M are _____[**Choose one:** acidic, basic, or neutral]

    d. $[OH^-]$ is less than 1 x 10^{-7} M are _____[**Choose one:** acidic, basic, or neutral]

    e. $[H_3O^+]$ is equal to 1 x 10^{-7} M are _____[**Choose one:** acidic, basic, or neutral]

12. What is the concentration of H_3O^+ and OH^- for each of the following conditions?

    a. pH = 8.0

    b. pH = 6.50

    c. pH = 10.60

13. If the pH > pK_a in a buffer solution, which is larger, the concentration of the acid form or the concentration of base form.

KEY

1. If the reaction below is initially at equilibrium, and then each of the following changes are made, predict which direction the reaction rate will be fastest until equilibrium is once again established: forward, reverse, or no change.

$$H_{2(g)} + Cl_{2(g)} \rightleftarrows 2\ HCl_{(g)}$$

a. If the amount of H_2 is increased, then the **forward** reaction will be fastest until equilibrium is re-established.
b. If the amount of HCl is decreased, then the **forward** reaction will be fastest until equilibrium is re-established.
c. If the amount of Cl_2 is decreased, then the **reverse** reaction will be fastest until equilibrium is re-established.

2. If the reaction below is initially at equilibrium, and then more NH_4^+ is added, predict which direction the reaction rate will be fastest until equilibrium is once again established: forward, reverse, or no change.

$$NH_4^+ + H_2O \rightleftarrows NH_3 + H_3O^+$$

Answer: If more NH_4^+ is added, then the **forward** reaction will be fastest until equilibrium is re-established.

3. Define (a) **reversible reaction** and (b) **equilibrium**:
SEE YOUR LECTURE NOTES

4. For the reaction below:

$$2NO_{2\ (g)} + O_{2\ (g)} \rightleftarrows 2NO_{3\ (g)}$$

a. Write the law of mass action (the equilibrium expression for K_{eq})

$$K_{eq} = \frac{[NO_3]^2}{[O_2\ ][NO_2]^2}$$

b. If gas concentrations are as follows, 2.10 M NO_2, 1.75 M O_2, and 1.00 M NO_3, calculate K_{eq}

$$K_{eq} = \frac{[1.00\ M]^2}{[1.75\ M\ ][2.10\ M]^2} = \mathbf{0.130\ M^{-1}}$$ **(NOTE: "M^{-1}" is another way to write "1/M")**

c. Using K_{eq} from part b, are the reactants or products *predominant*?
REACTANTS: K_{eq} is much less than 1

d. Using K_{eq} from part b, calculate **$[NO_3]$** if $[NO_2] = [O_2] = 4.3 \times 10^{-6}$

$$K_{eq} = \frac{[\ NO_3]^2}{(4.3 \times 10^{-6}M\ )(4.3 \times 10^{-6}M)^2} = \mathbf{0.130\ M^{-1}}$$

SOLVING THIS EQUATION FOR **$[NO_3]$** GIVES:

$$\mathbf{[\ NO_3]} = \sqrt{(\ 0.130\ M^{-1})\ (4.3 \times 10^{-6}\ M)(4.3 \times 10^{-6}M)^2} = \mathbf{3.2 \times 10^{-9}\ M}$$

5. For each of the following, write whether it describes acids/acidic (A), bases/basic (B), or both (A & B):

a. B	f. A	k. A
b. B	g. A	l. B
c. B	h. B	
d. A	i. B	
e. B	j. A & B	

6. For each of the following neutralization reactions, predict the products & balance the equation:

   a. $HCl + KOH \rightleftarrows \mathbf{KCl + H_2O}$

   b. $\mathbf{2}\ HCN + Ca(OH)_2 \rightleftarrows \mathbf{Ca(CN)_2 + 2\ H_2O}$

7. Identify the acid and the base (for the forward direction) in each of the following reactions:

   a. $BH_3 + H_2O \rightarrow BH_4^+ + OH^-$
   Base **Acid**

   b. $CH_3COOH + H_2O \rightarrow CH_3COO^- + H_3O^+$
   Acid **Base**

   c. $HCO_3^- + H_2O \rightarrow CO_3^{-2} + H_3O^+$
   Acid **Base**

   d. $HCN + H_2O \rightarrow CN^- + H_3O^+$
   Acid **Base**

   e. $HNO_3 + H_2O \rightarrow NO_3^- + H_3O^+$
   Acid **Base**

8. What is the conjugate acid of...
   a. NH_3 Conjugate acid = $\mathbf{NH_4^+}$
   b. HCO_3^- Conjugate acid = $\mathbf{H_2CO_3}$
   c. H_2O Conjugate acid = $\mathbf{H_3O^+}$

9. What is the conjugate base of...
   a. H_2O Conjugate base = $\mathbf{OH^-}$
   b. HF Conjugate base = $\mathbf{F^-}$
   c. HPO_4^{-2} Conjugate base = $\mathbf{PO_4^{-3}}$

10. a. In a neutral solution, what is the concentration of H_3O^+?
    1.0×10^{-7} M
    b. In a neutral solution, what is the concentration of OH^-?
    1.0×10^{-7} M

11. Solutions in which the...

    a. $[H_3O^+]$ is greater than 1×10^{-7} M are **acidic**

    b. $[H_3O^+]$ is less than 1×10^{-7} M are **basic**

    c. $[OH^-]$ is greater than 1×10^{-7} M are **basic**

    d. $[OH^-]$ is less than 1×10^{-7} M are **acidic**

    e. $[H_3O^+]$ is equal to 1×10^{-7} M are **neutral**

12. What is the concentration of H_3O^+ and OH^- for each of the following conditions?

    a. pH = 8.0 **$H_3O^+ = 1 \times 10^{-8}$ M OH= 1×10^{-6} M**

    b. pH = 6.50 **$H_3O^+ = 3.2 \times 10^{-7}$ M OH= 3.1×10^{-8} M**

    c. pH = 10.60 **$H_3O^+ = 2.5 \times 10^{-11}$ M OH= 4.0×10^{-4} M**

13. If the pH > pK_a, for a buffer, which is larger, the concentration of the acid [HA] or the concentration of the base $[A^-]$.
    Base form $[A^-]$