Chapter 13: Chemical Kinetics

&

Chapter 14: Chemical Equilibrium

Practice Worksheet Naming Acids

Review:

- Binary Acids – (When the anion does NOT contain Oxygen):

Use the prefix *hydro* + **root of the anion's name** – *ic* + the word acid
Examples: HCl - *hydro***chlor***ic* acid; HBr- *hydro***brom***ic* acid

- Oxyacids – (When the anion contains Oxygen):

The name will depend on the name of the polyatomic anion. DO NOT use the prefix hydro. Examples: H_2SO_4 the anion is sulf**ate**, therefore the acid name will end in **ic – Sulfuric acid.** H_2SO_3 the anion is sulf**ite**, therefore the name of the acid will end in **ous – sulfurous acid.**

ATE → IC
ITE → OUS

Complete the Following:

POLYATOMIC ION	POLYATOMIC ION NAME	ACID NAME	ACID FORMULA
		Nitric acid	
	Acetate		
			H_2SO_3
ClO_3^-			
	Chlorite		
		Phosphoric acid	
	Nitrite		
ClO^-			
ClO_4^-			
		Carbonic acid	
			$HClO_4$
	Permanganate		
			H_2SO_4
		Thiocyanic acid	
	Borate		
$C_2O_4^{2-}$			
		Bromic acid	

Naming Acids and Writing formulas of acids

Directions: Use the naming rules from your notes to name these acids.

Formula	Name	Formula	Name
1) HF		10)HClO	
2) HI		11) $HClO_2$	
3) HCl		12) $HClO_3$	
4) HBr		13) $HClO_4$	
5) H_2S		14) H_2CO_3	
6) HNO_3		15) $H_2C_2O_4$	
7) HNO_2		16) H_3PO_4	
8) H_2SO_4		17) H_3PO_3	
9) H_2SO_3		18) H_2CrO_4	

Directions: Use the rules for writing formulas to write the proper formulas for these acids.

Name	Formula	Name	Formula
19) Hydrobromic acid		28) Carbonic acid	
20) Hydroiodic acid		29) Chloric acid	
21) Hydrofluoric acid		30) Chlorous acid	
22) Hydrochloric acid		31) Perchloric acid	
23) Hydrosulfuric acid		32) Hypochlorous acid	
24) Phosphoric acid		33) Permanganic acid	
25) Phosphorous acid		34) Acetic acid	
26) Sulfuric acid		35) Nitric acid	
27) Sulfurous acid		36) Nitrous acid	

Name each of the following bases - remember to use the rules for ionic naming.

1. KOH: _____
2. LiOH: _____
3. $Ca(OH)_2$: _____
4. $Ba(OH)_2$: _____
5. $Mg(OH)_2$: _____
6. $Be(OH)_2$: _____
7. $Sr(OH)_2$: _____
8. $Fe(OH)_3$: _____
9. $Fe(OH)_2$: _____
10. $Al(OH)_3$: _____

Write formulas for each of the following bases- remember to use the rules for writing ionic formulas.

11. potassium hydroxide_____
12. aluminum hydroxide_____
13. iron (III) hydroxide_____
14. copper (I) hydroxide_____
15. copper (II) hydroxide_____
16. strontium hydroxide_____
17. lithium hydroxide_____
18. sodium hydroxide_____
19. rubidium hydroxide_____
20. calcium hydroxide_____

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			$HClO_4$
	Permanganate		
			H_2SO_4
		Thiocyanic acid	
	Borate		
$C_2O_4^{2-}$			
		Bromic acid	

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			$HClO_4$
	Permanganate		
			H_2SO_4
		Thiocyanic acid	
	Borate		
$C_2O_4^{2-}$			
		Bromic acid	

Name: _____ pH, pOH, Weak Acids Wk

1) Determine the pH of a 0.0034 M HNO_3 solution.

2) Determine the pOH of a 0.0034 M HNO_3 solution.

3) Determine the pH of a 4.3×10^{-4} M NaOH solution.

4) If a solution is created by adding water to 2.3×10^{-4} moles of NaOH and 4.5×10^{-6} moles of HBr until the final volume is 1 L, what is the pH of this solution?

5) Determine the pH of a 4.5×10^{-11} M NaOH solution.

6) Why would we say that a solution with a H^+ concentration of 1.00×10^{-7} M is said to be neutral. If it contains acid, shouldn't it be acidic?

7) Find the pH of a 0.065 M solution of formic acid. The acid dissociation constant (K_a) for formic acid is 1.8×10^{-4}.

8) Find the pH of a 0.325 M acetic acid solution. $K_a = 1.8 \times 10^{-5}$.

9) Find the pH of a solution that contains 0.0034 M lactic acid ($K_a = 1.4 \times 10^{-4}$) and 0.056 M propionic acid ($K_a = 1.4 \times 10^{-5}$).

10) What is the pH of a 0.00056 M butyric acid solution. $pK_a = 4.82$.

Name:_____ Class:_____

Write the equilibrium expression for each reaction below.

1. $HF_{(g)} + H_2O_{(g)} \leftrightarrow H_3O^+_{(g)} + F^-_{(g)}$

2. $NO_{(g)} + O_{2(g)} \leftrightarrow NO_{2(g)}$

3. $CH_3COOH_{(g)} + C_2H_5OH_{(g)} \leftrightarrow CH_3COOC_2H_{5(g)} + H_2O_{(l)}$

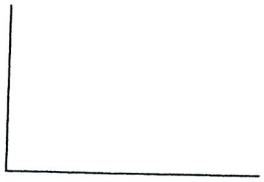
4. $(NH_4)_2Se_{(s)} \leftrightarrow NH_{3(g)} + H_2Se_{(g)}$

5. Write the equilibrium expression and then solve for the equilibrium constant, K for the following reaction if there are 0.249 moles of nitrogen gas, 3.21×10^{-2} moles of hydrogen gas and 6.42×10^{-4} moles of ammonia gas in a reaction volume of 3.0 L. Then report the value of K and Graph it. Circle which side of the reaction equilibrium will reside on.

$N_{2(g)}\ 3H_{2(g)} \leftrightarrow 2NH_{3(g)}$

Equilibrium Expression	K Value

Graph of K



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6) For the following reaction predict what direction the equilibrium will shift in response to the changes below.

$$H_{2\,(g)} + Cl_{2\,(g)} \leftrightarrow 2HCl_{(aq)} \qquad H = -495\ KJ$$

Equilibrium Expression

a) HCl is removed _____

b) Bromine gas is added _____

c) Hydrogen gas is added _____

d) NaCl is added _____

e) Chlorine is removed _____

f) The solution is boiled _____

Write a sentence on how letter F will effect K and the equilibrium of the reaction.

_____

_____

7

Conjugate Acids and Bases

Name:_____ **Class**_____

The **Brønsted-Lowry** definition of an acid is a substance capable of **donating** a **proton** (H^+), and **a base** is a substance capable of **accepting** a **proton**. For example, the weak acid, **HF**, can be dissolved in water, giving the reaction:

$$HF\,(aq) + H_2O\,(l) \leftrightarrows H_3O^+\,(aq) + F^-\,(aq)$$

_____ _____ _____ _____

The **acid** is the species losing the proton (H^+)

The **Base** is the species accepting the proton (H^+)

The **conjugate base** gains a proton in the reverse reaction

The **conjugate acid** lose a proton in the reverse reaction

Determine the conjugate acid for each:

H_2O		F^-	
HCO_3^-		SO_4^{2-}	
OH^-		PO_4^{3-}	
$H_2PO_4^-$		Cl^-	
ClO_4^-		CH_3COO^-	
SH^-		CN^-	
HSO_4^-		NH_3	

Determine the conjugate base for each:

H_2O		HF	
HCO_3^-		HSO_4^-	
OH^-		HPO_4^{2-}	
H_3PO_4		HCl	
$HBrO_2$		CH_3COOH	
H_2S		$HOCN$	
HSO_4^-		NH_3	

K_a Problems Worksheet

Name:_____ Class: _____

Attacking the Problem!!!!
Write ionization equation for the reaction
Write equilibrium expression
Use pH to solve for [H+] (If given pH)
ICE Box
Plug values into equilibrium expression and solve
NOTE: X = [ ] CONCENTRATION!!!!

Solve:

1) Find the pH of a 0.065 M solution of formic acid (HCOOH). The acid dissociation constant (K_a) for formic acid is 1.8×10^{-4}.

2) Find the pH of a 0.325 M acetic acid solution. $K_a = 1.8 \times 10^{-5}$.

3) Find the pH of a solution that contains 0.0034 M lactic acid ($K_a = 1.4 \times 10^{-4}$) and 0.056 M propionic acid ($K_a = 1.4 \times 10^{-5}$).

4) Find the K_a of a 0.065 M solution of formic acid. The pH of the solution is 4.56.

5) Find the K_a of a 0.325 M acetic acid solution if the pH of the solution is 3.24.

Name_____

Lewis Acid-Base Worksheet

Part 1

A. Classify each of the following as either a Brønsted Acid-Base reaction or as a Lewis Acid-Base Reaction. If it is better classified as a Brønsted reaction, write Brønsted. If it is better classified as a Lewis reaction, write Lewis.

B. Identify which reactant is the acid and which is the base. Circle the Acid and box the base.

a. $Zn(H_2O)_4^{2+} + H_2O \rightarrow Zn(H_2O)_3OH^+ + H_3O^+$

b. $SO_2 + OH^- \rightarrow HSO_3^-$

c. $HClO_4 + H_2O \rightarrow ClO_4^- + H_3O^+$

2. Circle any of the following compounds that are capable of acting as **Lewis acids.** (Draw the Lewis structure it may help)

F^- H_3O^+ PF_3^{2+} BF_3

S^{2-} NH_3 SO_2

Part 2

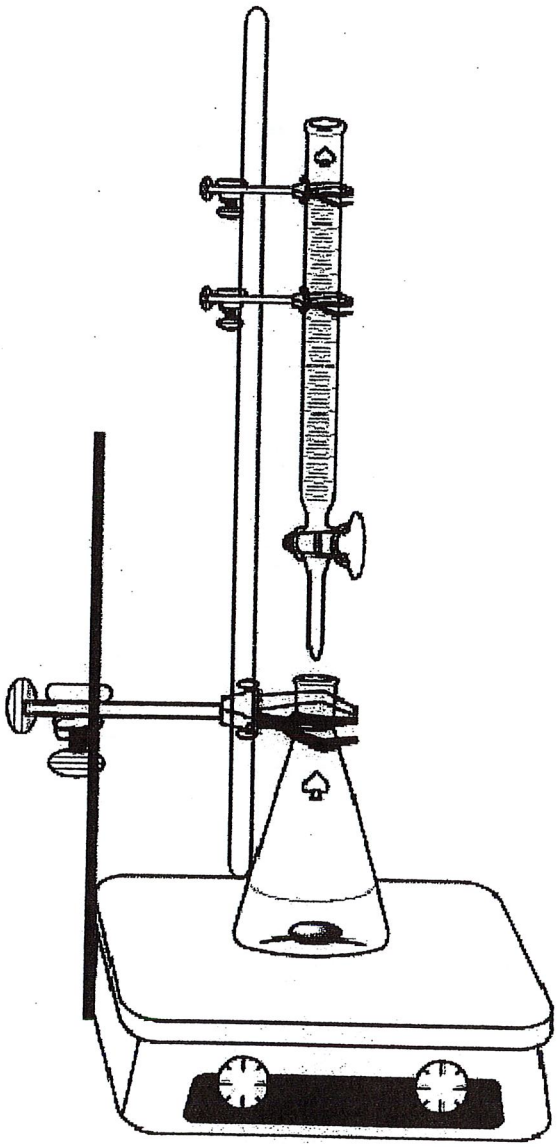
Circle the equations which represents Lewis acid-base reactions which are NOT Brønsted reactions. Box the equations which represent Brønsted acid-base reactions.

$PF_3^{2+} + F^- \rightarrow PF_4^-$ $BF_3 + NH_3 \rightarrow F_3B{-}NH_3$

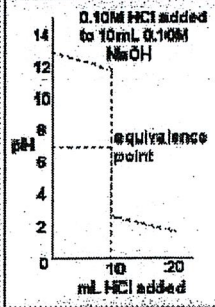
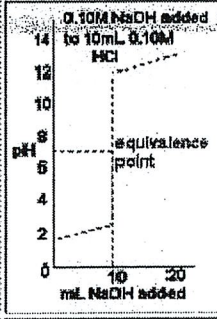
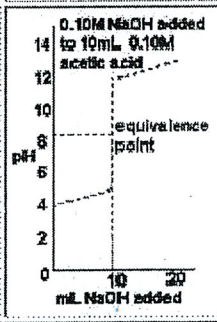
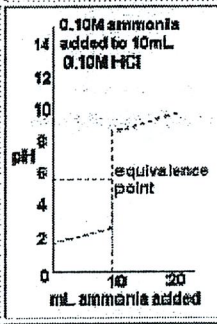
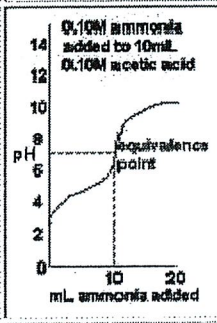
$H_3O^+ + F^- \rightarrow HF + H_2O$ $H_3O^+ + NH_3 \rightarrow NH_4^+ + H_2O$

Titration

Label the diagram below



Titration Curves

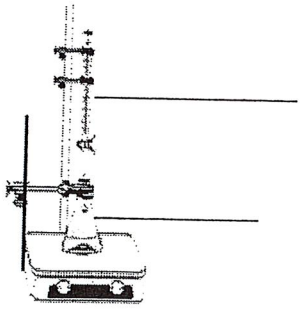
General Type	Example	Typical Titration Curve	Features of Curve
Strong Acid and Strong Base	HCl added to NaOH		Curve begins at high pH typical of strong base and ends at low pH typical of strong acid. There is a large rapid change in pH near the equivalence point (pH =7).
Strong Base and strong Acid	NaOH added to HCl		Curve begins at low pH typical of strong acid, and ends at high pH typical of strong base. There is a large rapid change in pH near the equivalence point (pH=7).
Weak Acid and Strong Base	NaOH added to acetic acid (CH_3COOH)		Curve begins at a higher acidic pH and ends at high basic pH. The pH change at the equivalence point (pH > 7)is not so great.
Strong Acid and Weak Base	Ammonia (NH_3) added to HCl		Curve begins at low pH and ends at a less high basic pH. The pH change at the equivalence point (pH < 7) is similar to that for Strong Base and Weak Acid.
Weak Acid and Weak Base	Ammonia (NH_3) added to Acetic acid (CH_3COOH)		Curve begins at higher acidic pH and ends at low basic pH. There is not a great pH change at the equivalence point (pH ~ 7) making this a very difficult titration to perform.

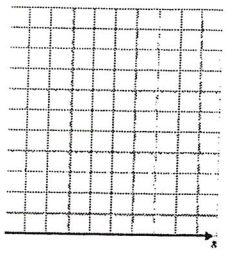
Name:_____ Class:_____

Titration Practice Worksheet

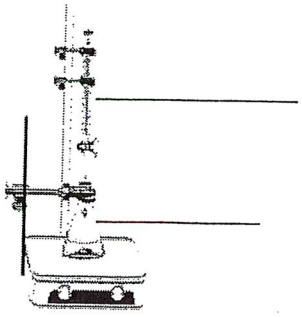
For each problem label the experimental set up and sketch an approximate graph. Then solve.

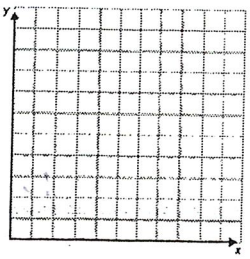
1. What is the M of NaOH if it takes 40 ml of NaOH to reach the equivalence point in a titration with 50 ml of 0.2 M HCl?



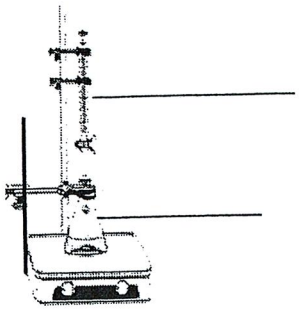


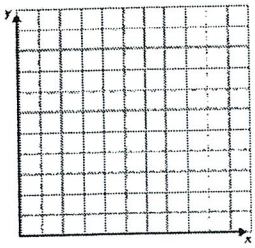
2. 50 ml of 0.3 M KOH are required to titrate 60 ml of H_2SO_4. What is the M of the H_2SO_4?



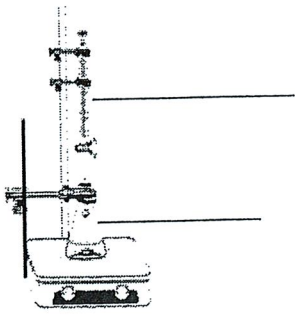


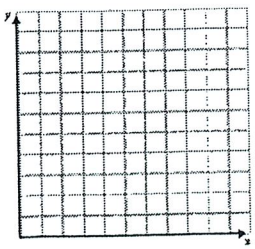
3. 60 ml of 1.2 M NaOH are required to titrate 40 ml of HF. What is the M of the HF?





6. 55 ml of 1.2 M H $C_2H_3CO_2$ are used to titrate a sample of 0.67 M $Ba(OH)_2$. What is volume of the $Ba(OH)_2$ used?





DO NOT PROCEED TO NEXT SECTION UNTIL YOU HAVE THOROUGHLY MASTERED PREVIOUS SECTION

IV. **BINARY ACIDS** - the water solutions of compounds composed of hydrogen and a nonmetal

RULE: Acids composed of hydrogen and a nonmetal are named by putting the prefix HYDRO before the root of the name of the nonmetal and adding the suffix -IC followed by the word ACID.

For example: When hydrogen chloride (HCl) is dissolved in water, we get hydrochloric acid.

HF(aq)	HYDROfluorIC acid
HCl(aq)	HYDROchlorIC acid
HBr(aq)	HYDRObromIC acid
HI(aq)	HYDROiodIC acid
H_2S(aq)	HYDROsulfurIC acid

NOTE: The formulas of binary acids must be followed by (aq). The (aq) means aqueous or dissolved in water. Without the (aq) it would represent a gas. For instance, HBr is hydrogen bromide gas.

V. ACIDS CONTAINING OXYGEN - compounds of H, O, and ...

RULES:

1. If there is only one oxygen acid, the name is that of the characteristic element followed by the suffix -IC.

2. If there are two oxygen acids, the name of the one with the larger number of oxygen atoms ends in -IC, and the name of the one with the smaller number of oxygen atoms ends in - OUS.

3. If there are four oxygen acids, like the oxyacids of the halogen family, the acid with the greatest number of oxygens is desiginated by the prefix PER- and suffix -IC, the one with the next fewer oxygens has the suffix -IC, the one with the next fewer has the suffix -OUS and the fewest oxygen acid is designated with the prefix HYPO- and the suffix -OUS.

For example: HNO_3 is nitrIC acid

HNO_2 is nitrOUS acid

H_2SO_4 is sulfurIC acid

H_2SO_3 is sulfurOUS acid

HBrO is HYPObromOUS acid

$HBrO_2$ is bromOUS acid

$HBrO_3$ is bromIC acid

$HBrO_4$ is PERbromIC acid

NOTE: Ternary acid formulas are not usually followed by (aq). It is assumed that they are dissolved in water.

VI. ACID SALTS

When one or more hydrogens of an acid is replaced by a metal, the result is an acid salt. We have already encountered salts which result from the replacement of all of the available hydrogens in the acid. However, if the metal replaces only one or two of the available number of hydrogen ions from an acid, provision must be made to distinguish between the different salts that may be formed.

For example: H_3PO_4 is phosphorIC acid

The salts are named as: KH_2PO_4 is potassium DIhydrogen phosphATE

K_2HPO_4 is potassium MONOhydrogen phosphATE

K_3PO_4 is potassium phosphATE

If the acid contains only two hydrogens, then only two different salts are possible. The salts derived from these acids can be named by the method just described, but a common method, using the prefix bi, will probably continue in use for many years.

For example: H_2SO_4 is sulfuric acid

The salts are: $KHSO_4$ is potassium MONOhydrogen sulfATE

or

potassium BIsulfATE

K_2SO_4 is potassium sulfATE

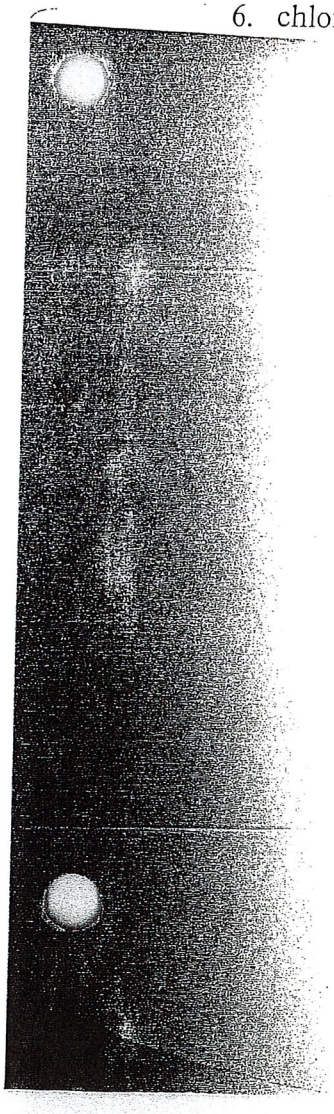
DRILL IV

I. Name each of the following:

1. H_2S (aq)
2. K_2HPO_4
3. $HC_2H_3O_2$
4. HBrO
5. H_3PO_4
6. $NaHCO_3$
7. HIO_3
8. $HBrO_2$

II. Give the chemical formula of each of the following:

1. magnesium monohydrogen phosphate
2. potassium monohydrogen sulfite
3. perbromic acid
4. sodium monohydrogen sulfate
5. iodous acid
6. chloric acid



Name:_____Class:_____Date:_____

Acid Base Practice Problems

Show all of your work and circle your final answer.

1. Complete the chart

Model	Definition of Acid	Definition of Base
Arrehnius		
Bronsted- Lowery		
Lewis		

2. Write the equation for percent ionization :

3. In a 0.5 M solution, uric acid ($HC_5H_3N_4O_4$) is 1.6% dissociated. Calculate the value of K_a value for uric acid.

4. Find the pH of a 0.065 M solution of formic acid. The acid dissociation constant (K_a) for formic acid is 1.8×10^{-4}.

5. Find the pH of a 0.325 M acetic acid solution. $K_a = 1.8 \times 10^{-5}$.

6. Determine the pH of a 0.0034 M HNO_3 solution.

7. Determine the pOH of a 0.0034 M HNO_3 solution.

8. Determine the pH of the following solutions:

   a. A 4.5×10^{-3} M HBr solution.

   b. A 3.67×10^{-5} M KOH solution.

15. The dissociation of acetic acid, CH_3COOH, has an equilibrium constant at 25°C of 1.8×10^{-5}. The reaction is

$$CH_3COOH\ (aq) \leftrightarrow CH_3COO^-\ (aq) + H^+\ (aq)$$

If the equilibrium concentration of CH_3COOH = 0.46 moles in 0.500 L of water and the concentration of CH_3COO^- is 8.1×10^{-3} moles in the same 0.500L calculate the concentration of H^+ for the reaction.

16. The reaction of carbon disulfide with chloride is as follows

$$CS_2(g) + 3Cl_2(g) \leftrightarrow CCl_4(g) + S_2Cl_2\ (g) \qquad \Delta H = -238\ kJ$$

Predict the effect of the following change to the system on the direction of the equilibrium.

a. The pressure on the system is doubled by halving the volume

b. CCl_4 is removed as it is generated

c. Heat is added to the system

17. Using your knowledge of the Brønsted-Lowry theory of acids and bases, write equations for the following acid-base reactions and indicate each conjugate acid-base pair:

a) $HNO_3 + OH^- \leftrightarrow$

b) $H_2CO_3 + H_2O \leftrightarrow$

18. Identify the following as a Lewis Acid or Lewis Base (draw the structure to support your answer:

a.) PH_3 b.) BCl_3 .) H_2S

9. Explain why even a basic solution contains some H^+ ions.

10. Explain why even an acidic solution contains some OH^- ions.

11. Kind K_a for a solution of 0.52 M phosphoric acid with a pH of 3.50

13. Write the equilibrium expression for each of the following

a. $2NO\ (g) + O_2(g) \leftrightarrow 2NO_2\ (g)$

b. $Ag^+(aq) + I^-(aq) \leftrightarrow AgI\ (s)$

c. $Fe^{3+}(aq) + 3OH^-(aq) \leftrightarrow Fe(OH)_3\ (S)$

14. For each value of K predict the effect on the reaction (equilibrium)

$K = 1$ _____

$K = 10^{10}$ _____

$K = 10^{-10}$ _____