

**Model**

1.  $\text{NaOH(s)} + \text{H}_2\text{O(l)} \rightarrow \text{Na}^+(\text{aq}) + \text{OH}^-(\text{aq})$
2.  $\text{HCl(aq)} + \text{H}_2\text{O(l)} \rightarrow \text{H}_3\text{O}^+(\text{aq}) + \text{Cl}^-(\text{aq})$
3.  $\text{NH}_3(\text{g}) + \text{H}_2\text{O(l)} \rightarrow \text{NH}_4^+(\text{aq}) + \text{OH}^-(\text{aq})$
4.  $\text{H}_2\text{CO}_3(\text{g}) + \text{H}_2\text{O(l)} \rightarrow \text{H}_3\text{O}^+(\text{aq}) + \text{HCO}_3^-(\text{aq})$
5.  $\text{HCl(aq)} + \text{NH}_3(\text{aq}) \rightarrow \text{NH}_4^+(\text{aq}) + \text{Cl}^-(\text{aq})$

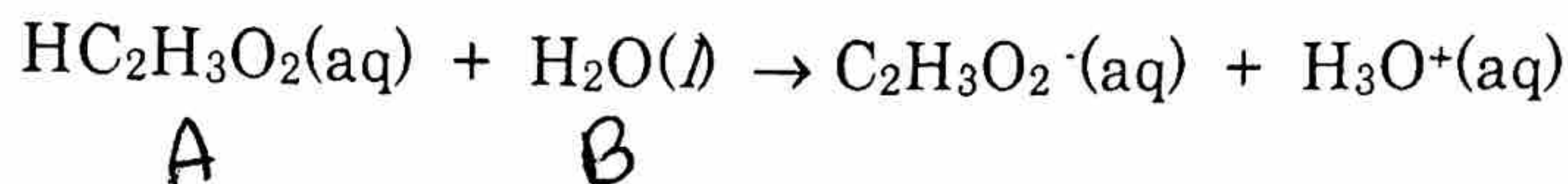
**Key Questions**

1. In equation 1, is  $\text{NaOH(s)}$  an acid or a base? Explain.  
base b/c it produces  $\text{OH}^-$  in water
2. In equation 2, is  $\text{HCl(aq)}$  an acid or a base? Explain.  
acid b/c it produces  $\text{H}_3\text{O}^+$  in water
3. In equation 3, is  $\text{NH}_3(\text{g})$  an acid or a base? Explain.  
base b/c it produce  $\text{OH}^-$  in water
4. In equation 3, is  $\text{H}_2\text{O(l)}$  an acid or a base? Explain.  
acid b/c it produces  ~~$\text{H}_3\text{O}^+$~~  in water  
donated as  $\text{H}^+$  ion
5. In equation 4, is  $\text{H}_2\text{O(l)}$  an acid or a base? Explain.  
base b/c it accepted a  $\text{H}^+$  ion
6. Is  $\text{H}_2\text{CO}_3(\text{g})$  in equation 4 an acid or a base? Explain.  
acid b/c it produced  $\text{H}_3\text{O}^+$  in water
7. Compare the behavior of  $\text{NH}_3$  in equations 3 and 5. Identify any similarities and differences. Explain.  
Both accept a proton ( $\text{H}^+$ ) making them a base in both
8. Identify the substances in the Model that behave as both an acid and a base? Explain how this duplicity in behavior can or cannot occur.  
 $\text{H}_2\text{O}$  acted like both an acid and a base because it can gain or lose a proton ( $\text{H}^+$ ) (amphoteric species)



**Exercises**

1. In the reaction below identify which of the reactants is an acid and which is a base:



2. Consider the atomic structure of the  $\text{H}^+$  ion. Complete the table below indicating the correct number of each subatomic particle.

Composition of the  
 $\text{H}^+$  ion ( ${}^1_1\text{H}^+$ )

Subatomic particle	Number of subatomic particles
Protons	1
Electrons	0
Neutrons	0

3. In some textbooks, when explaining the Brønsted – Lowry definition, acids and bases are described as proton donors and proton acceptors. Based on your response to Exercise 2, explain why these are correct terms.

$\text{H}^+$  is really only a proton, so it is transferred from one compound to the next, all you are really doing is changing the # of protons.

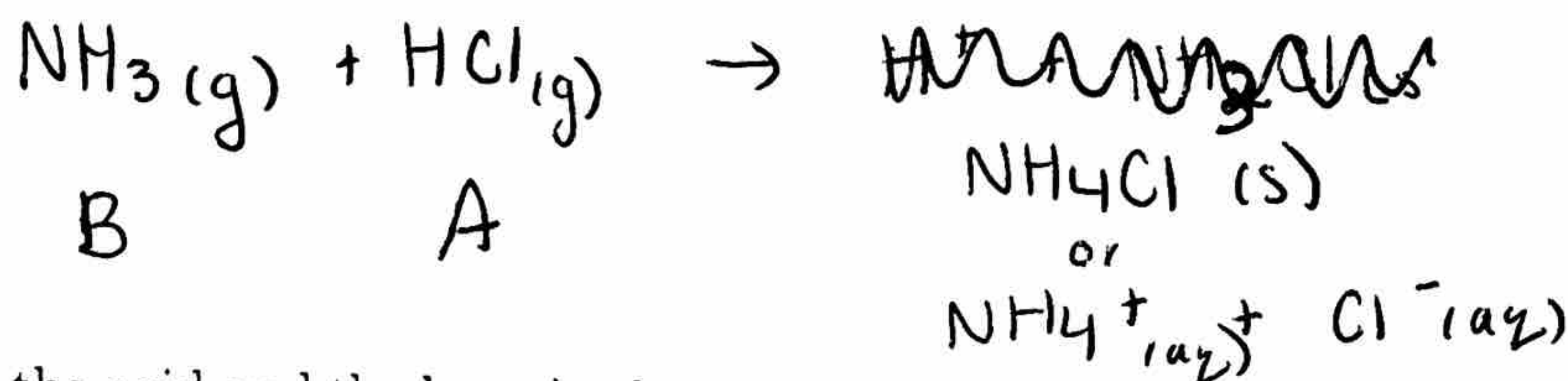
4. A definition of the prefix *amphi* is; "both or of both kinds." Define the term "amphiprotic" and based on the insight you gained from examining the model, explain why the term is used to describe water.

amphiprotic means that something can act like an acid or base. water can do this



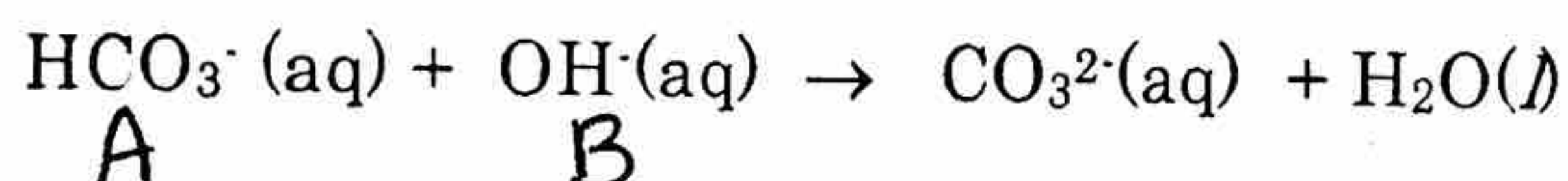
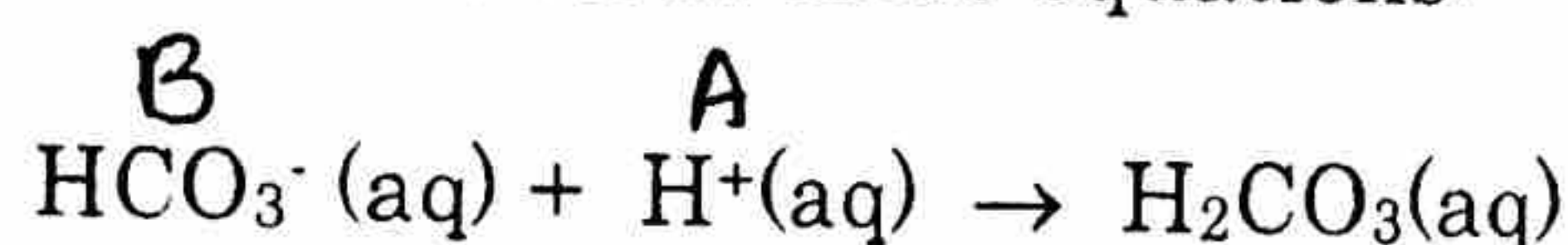
## Applications

1. Ammonium chloride is one component of ordinary dry cell batteries. Ammonia gas can react with hydrogen chloride gas to form the solid salt ammonium chloride. Write the balanced equation for this reaction including the phases of each substance.



2. Label the acid and the base in the reactants of your equation in Application 1.

3. Your blood contains an acid-base buffer system. A buffer system is a chemical system that resists changes in pH when small amounts of either acid or base are added to the system. It is important that our blood pH does not change suddenly. A pH balance ensures that chemical reactions in the body take place correctly. If the pH drops below 6.8 or rises above 7.8, death can occur. The buffer in blood is the bicarbonate ion,  $\text{HCO}_3^-(aq)$ . Two equations that illustrate bicarbonate's buffering action are shown in these equations:

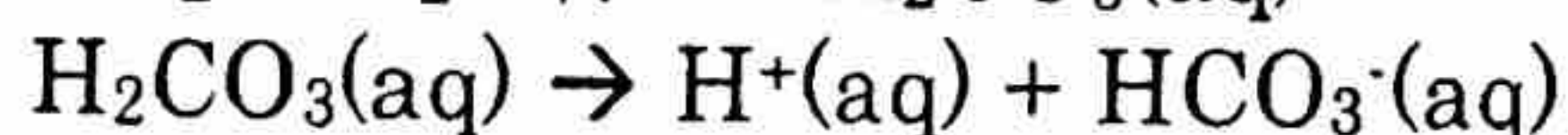
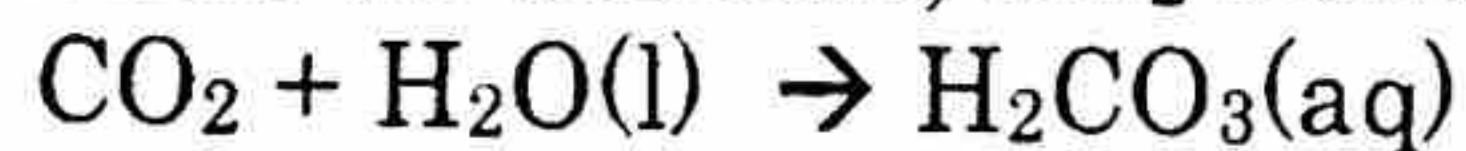


Label the acid and the base in each of these equations.

4. Explain why bicarbonate ions are said to be amphiprotic.

they can either give or accept  $\text{H}^+$  ions.

5. When we exercise,  $\text{CO}_2$  builds up in our blood and the following reactions occur.



How does the buffer system in our blood respond to this reaction in order to keep the pH within the acceptable range?

it will be reacted with  $\text{OH}^-$  after to re-neutralize a body

## Got It?

Is water an acid, a base, neither, or both? Explain.

both  $\rightarrow$  amphoteric



### Acid Base Worksheet

1. Identify whether each is an acid or base:

- |      |                             |
|------|-----------------------------|
| acid | Turns blue litmus paper red |
| base | Turns red litmus paper blue |
| acid | Tastes sour                 |
| base | Tastes bitter               |

2. A Bronsted-Lowry acid is an proton donor.

3. A Bronsted-Lowry base is an proton accepter.

4. A Lewis acid is an electron pair accepter.

5. A Lewis base is an electron pair donor.

6. True or False

True According to the Arrhenius system, water is neither an acid nor a base.

false A solution with a pH of 13 would be acidic.

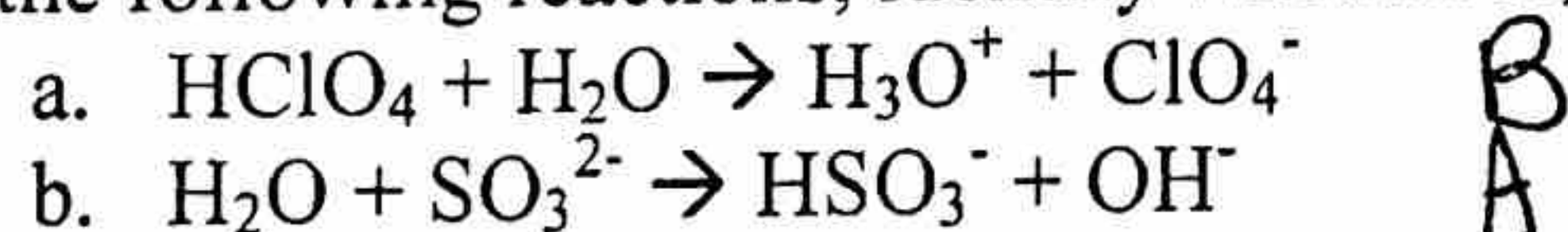
true A solution with a pH of 2 would be acidic.

false A solution with a pOH of 13 would be basic.

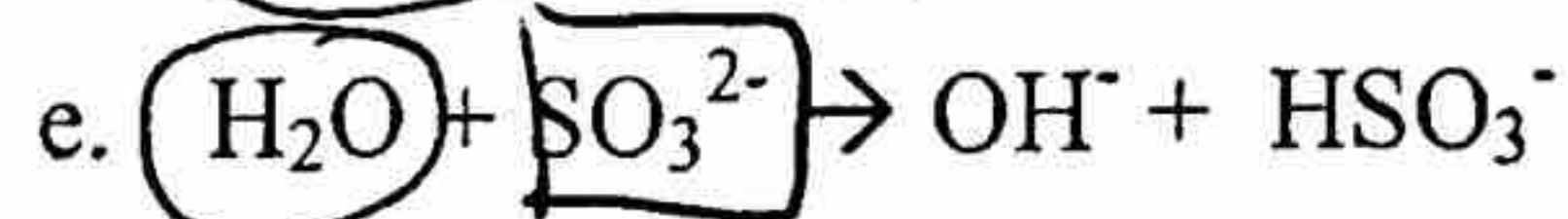
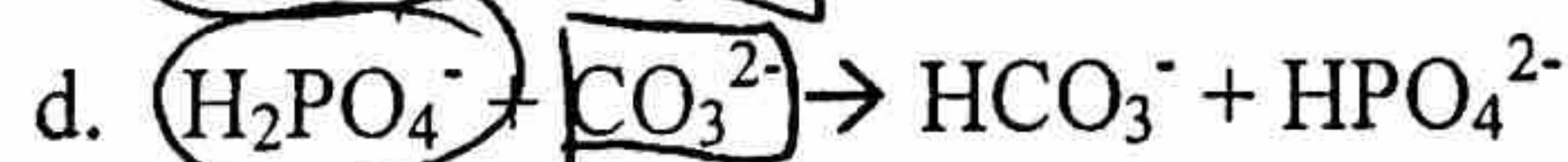
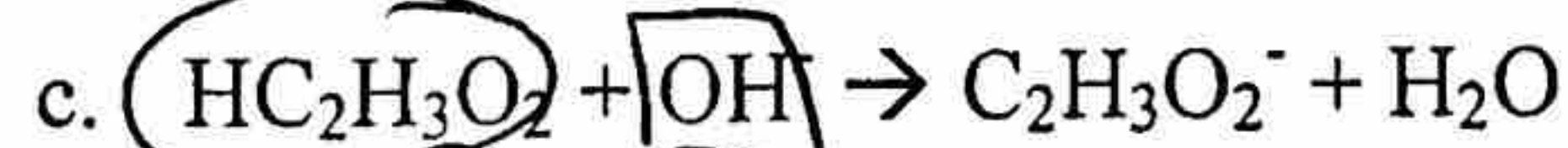
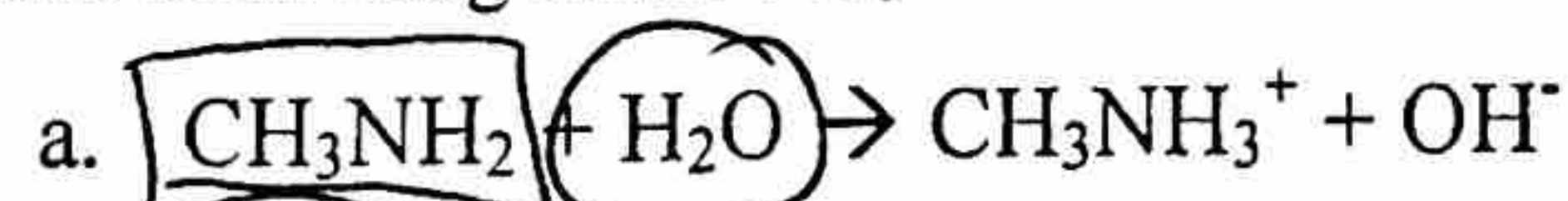
true A solution with a pOH of 2 would be basic.

### Bronsted-Lowry Worksheet

1. In the following reactions, identify whether H<sub>2</sub>O behaves as a Bronsted acid or base.



2. In the following reactions, circle the Bronsted acid and box the Bronsted base.



3. Fill in the following table with the appropriate conjugate acid or base:

ACID	CONJUGATE BASE	BASE	CONJUGATE ACID
H <sub>2</sub> O	OH <sup>-</sup>		
H <sub>2</sub> SO <sub>4</sub>	HSO <sub>4</sub> <sup>-</sup>		
		H <sub>2</sub> O	H <sub>3</sub> O <sup>+</sup>
		HPO <sub>4</sub> <sup>2-</sup>	H <sub>2</sub> PO <sub>4</sub> <sup>-</sup>



## CW: pH & pOH Calculations

**Directions:** Show work for all problems! Write what you put in the calculator!!

Let's Start with some basic powers of 10.

1. Calculate pH from the following  $[H^+]$ : Identify each solutions as acidic, basic, or neutral.  
a.  $1.00 \times 10^{-4} M$    b.  $1.00 \times 10^{-12} M$    c.  $1.00 \times 10^{-6} M$    d.  $1.00 \times 10^{-13} M$

a)  $pH = 4$    b)  $pH = 12$    c)  $pH = 6$    d)  $pH = 13$   
A                      B                      A                      B

2. Calculate  $[H^+]$  from the following pH: Identify each solution as acidic, basic, or neutral.  
a. 2.00   b. 5.00   c. 10.00   d. 12.00

a)  $1.00 \times 10^{-2}$    b)  $1.00 \times 10^{-5}$    c)  $1.00 \times 10^{-10}$    d)  $1.00 \times 10^{-12}$   
A                      A                      B                      B

3. Calculate pOH from the following  $[OH^-]$ : Identify each solutions as acidic, basic, or neutral.  
a.  $1.00 \times 10^{-2} M$    b.  $1.00 \times 10^{-13} M$    c.  $1.00 \times 10^{-5} M$    d.  $1.00 \times 10^{-11} M$

a)  $pOH = 2$    b)  $pOH = 13$    c)  $pOH = 5$    d)  $pOH = 11$   
B                      A                      B                      A

4. Calculate  $[OH^-]$  from the following pOH: Identify each solution as acidic, basic, or neutral.  
a. 3.00   b. 7.00   c. 11.00   d. 9.00

a)  $1.00 \times 10^{-3}$    b)  $1.00 \times 10^{-7}$    c)  $1.00 \times 10^{-11}$    d)  $1.00 \times 10^{-9}$   
B                      N                      A                      A

Now some that require a little more work:

Calculate the pH for the following:

1.  $[H^+] = 1.6 \times 10^{-4} M$

$$pH = -\log(1.6 \times 10^{-4}) = 3.8$$

2.  $[H^+] = 6.7 \times 10^{-8} M$

$$pH = -\log(6.7 \times 10^{-8}) = 7.2$$

3.  $[OH^-] = 5.6 \times 10^{-11} M$

$$pOH = -\log(5.6 \times 10^{-11}) = 10.3 \quad 14 - 10.3 = 3.7 \quad \text{or} \quad 14 - 10.3 = 3.7 \quad 4.0$$

Calculate the pOH for the following:

1.  $[OH^-] = 7.7 \times 10^{-7} M$

$$pOH = -\log(7.7 \times 10^{-7}) = 6.1$$

2.  $[OH^-] = 9.6 \times 10^{-5} M$

$$pOH = -\log(9.6 \times 10^{-5}) = 4.0$$

3.  $[H^+] = 1.7 \times 10^{-3} M$

$$pH = -\log(1.7 \times 10^{-3}) = 2.8 \quad 14 - 2.8 = 11.2$$



Calculate the  $[H^+]$  for the following:

1.  $pH=4.1$   $[H^+] = 10^{-4.1} = 7.9 \times 10^{-5} M$

2.  $pH=7.9$   
 $[H^+] = 10^{-7.9} = 1.3 \times 10^{-8} M$

3.  $pH=10.2$   
 $[H^+] = 10^{-10.2} = 6.30 \times 10^{-11} M$

4.  $pOH=7.1$   
 $14-7.1 = 6.9 = pH$   $[H^+] = 10^{-6.9} = 1.3 \times 10^{-7} M$

5.  $pOH=2.1$   
 $pH = 14-2.1 = 11.9$   $[H^+] = 10^{-11.9} = 1.3 \times 10^{-12} M$

Calculate the  $[OH^-]$  for the following:

1.  $pOH=12.1$   
 $[OH^-] = 10^{-12.1} = 7.90 \times 10^{-13} M$

2.  $pOH=1.6$   
 $[OH^-] = 10^{-1.6} = 0.025 M$

3.  $pOH=13.2$   
 $[OH^-] = 10^{-13.2} = 6.30 \times 10^{-14} M$

4.  $pH=10.9$   
 $pOH = 14-10.9 = 3.1 = 10^{-3.1} = 7.9 \times 10^{-4} M$

5.  $pH=2.5$   
 $pOH = 14-2.5 = 11.5 = 10^{-11.5} = 3.2 \times 10^{-12} M$

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Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class Pd. \_\_\_\_\_

### Titration Classwork

#### Part I. Fill in the Blank.

1. A titration is a controlled addition of a titrant used to determine the concentration of an unknown.
2. The titrant goes into the buret. \* analyte goes into erlenmeyer flask
3. The titrant is the solution of known concentration.
4. The analyte is the solution of unknown concentration.
5. The point when an indicator changes color is known as the endpoint.
6. A weak acid or base that changes color when the pH changes is called a(n) indicator.
7. The equivalence point is when there are equal amounts of hydrogen ions and hydroxide ions.  
acid  
base

#### Part II. Problems.

Directions: Show ALL work and CIRCLE your final answer.

8. What is the concentration of phosphoric acid if 10.0mL of acid is neutralized by 20.0mL of 0.20M sodium hydroxide?  $H_3PO_4 + NaOH$   
 $(3)(x)(10.0mL) = (1)(0.20)(20.0mL)$   
 $x = 0.13M$
9. What is the concentration of sulfuric acid if 30.0mL of acid is neutralized by 20.0mL of 0.5M aluminum hydroxide?  $H_2SO_4 + Al(OH)_3$   
 $(2)(x)(30.0mL) = (3)(0.5M)(20.0mL)$   
 $x = 0.5M$
10. What is the concentration of hydrochloric acid if 20.0mL of acid is neutralized by 40.0mL of 0.20M Aluminum hydroxide?  $HCl + Al(OH)_3$   
 $(1)(x)(20.0mL) = (3)(0.20M)(40.0mL)$   
 $x = 1.2M$
11. What is the concentration of sulfuric acid if 50.0mL of acid is neutralized by 30.0mL of 0.5M Sodium hydroxide?  $H_2SO_4 + NaOH$   
 $(2)(x)(50.0) = (1)(0.5M)(30.0mL)$   
 $x = 0.2M$



# Honors Chemistry: Interpreting a Titration Curve

Directions: Answer the questions below using the titration curves below.

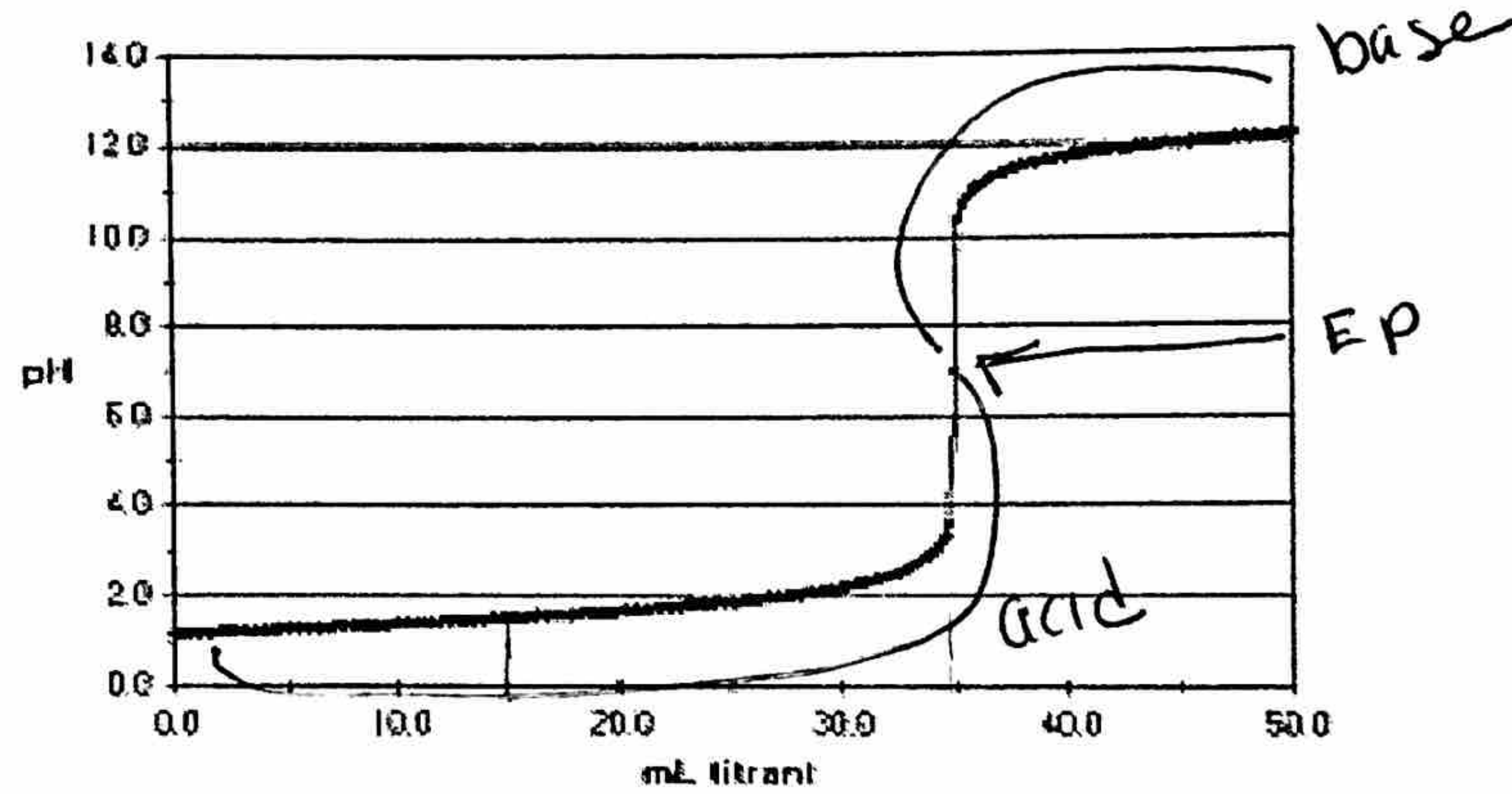
1. Write "Acid" where the solution has an acidic pH and "base" where it has a basic pH.

2. Write "EP" where the equivalence point is.

3. What is the pH at the equivalence point? 7

4. What volume of titrant would have to be added for the pH of the solution to be 5.00? about 35.0 mL

5. What is the pH of the solution when 15.00 mL of titrant has been added? about 1.8



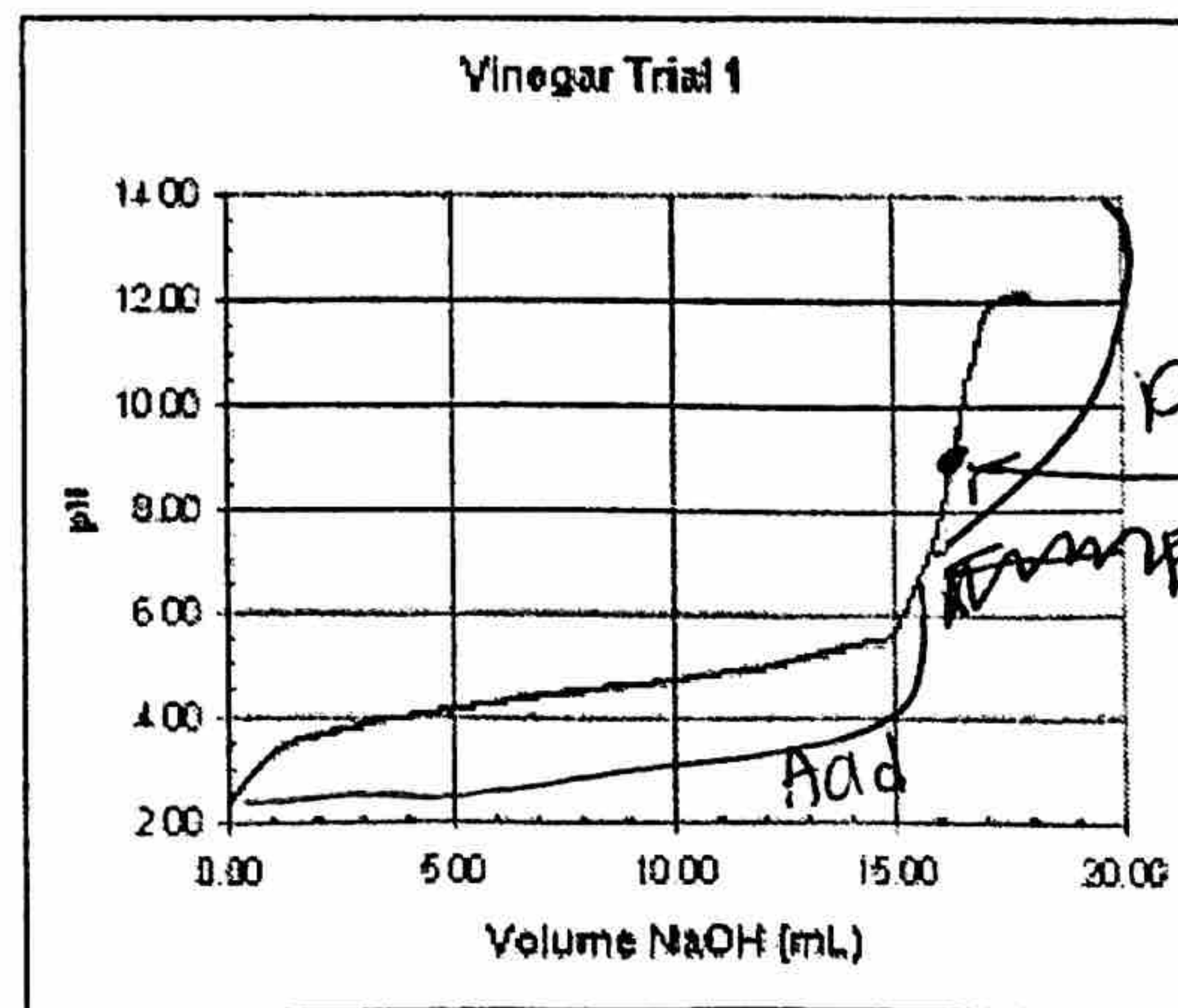
6. Write "Acid" where the solution has an acidic pH and "base" where it has a basic pH.

7. Write "EP" where the equivalence point is.

8. What is the pH at the equivalence point? 9

9. What volume of titrant would have to be added for the pH of the solution to be 8.00? 10.00 mL

10. What is the pH of the solution when 10.00 mL of titrant has been added? 4.5



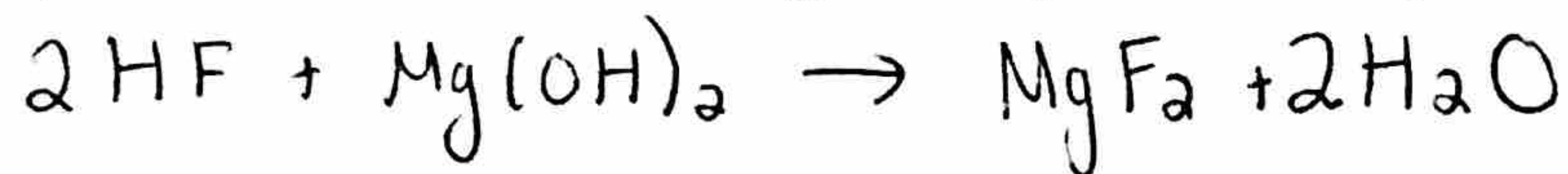


## Acid-Base Reactions

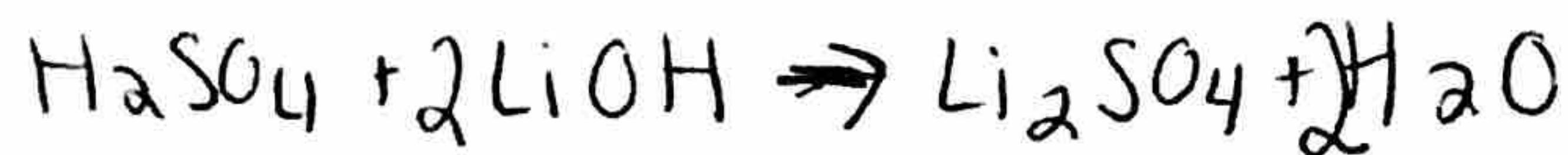
\* neutralization reactions \*

Directions: Write balanced acid-base reactions for the following.

1. Hydrofluoric acid reacts with magnesium hydroxide. HOH

→ Salt + H<sub>2</sub>O

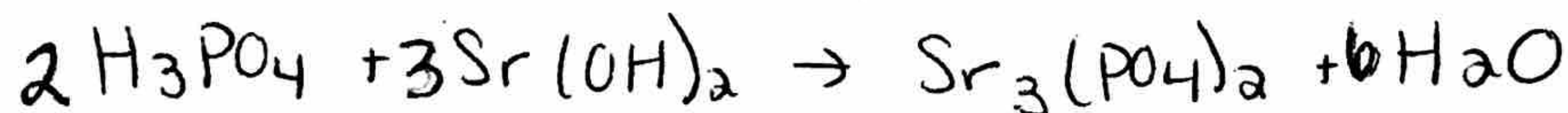
2. Sulfuric acid reacts with lithium hydroxide.



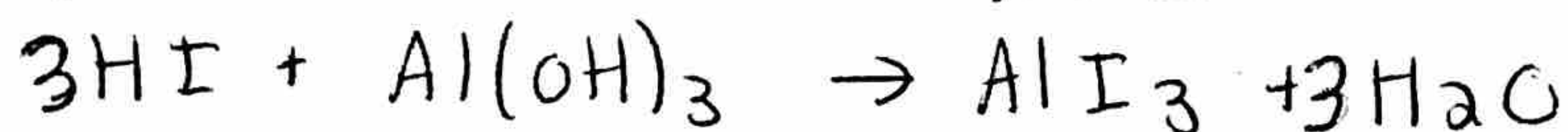
3. Hydrobromic acid reacts with copper (I) hydroxide.



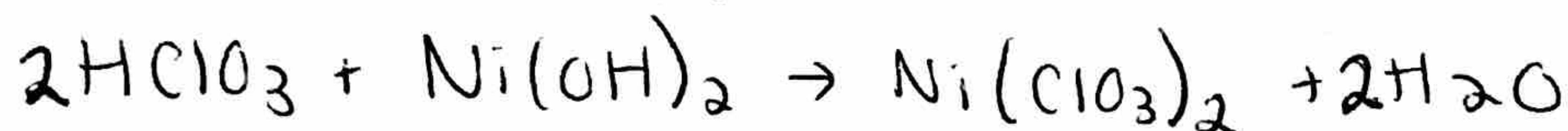
4. Phosphoric acid reacts with strontium hydroxide.



5. Hydroiodic acid reacts with aluminum hydroxide.



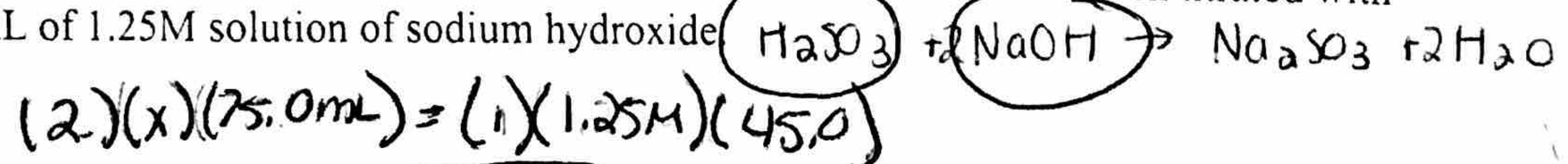
6. Chloric acid reacts with nickel (II) hydroxide.



## Titration Problems

M<sub>1</sub>V<sub>1</sub> = M<sub>2</sub>V<sub>2</sub>

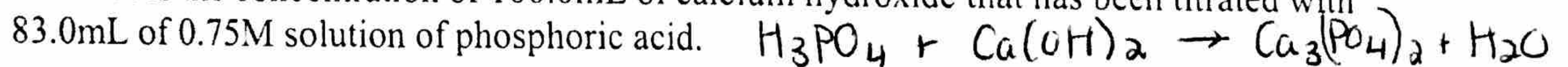
1. Determine the concentration of 75.0mL of sulfurous acid that has been titrated with 45.0mL of 1.25M solution of sodium hydroxide.



$$(2)(x)(75.0\text{mL}) = (1)(1.25\text{M})(45.0)$$

$$x = 0.375\text{M}$$

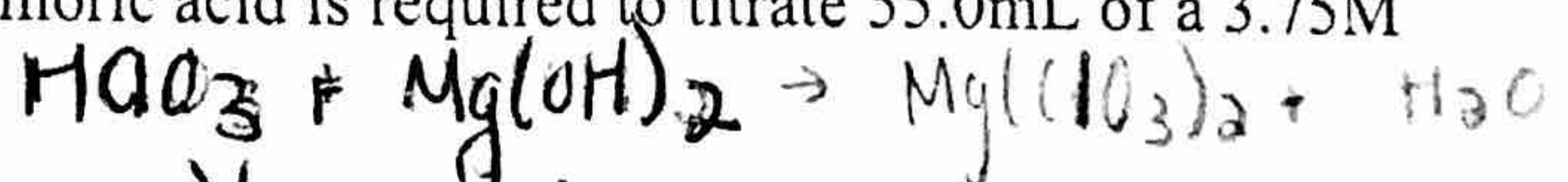
2. What is the concentration of 100.0mL of calcium hydroxide that has been titrated with 83.0mL of 0.75M solution of phosphoric acid.



$$(3)(0.75\text{M})(83.0\text{mL}) = (2)(x)(100.0\text{mL})$$

$$x = 0.93\text{M}$$

3. What volume of 5.0M solution of chloric acid is required to titrate 55.0mL of a 3.75M solution of magnesium hydroxide?



$$(1)(5.0\text{M})(x) = (2)(3.75\text{M})(55.0\text{mL})$$

$$x = 83\text{mL}$$

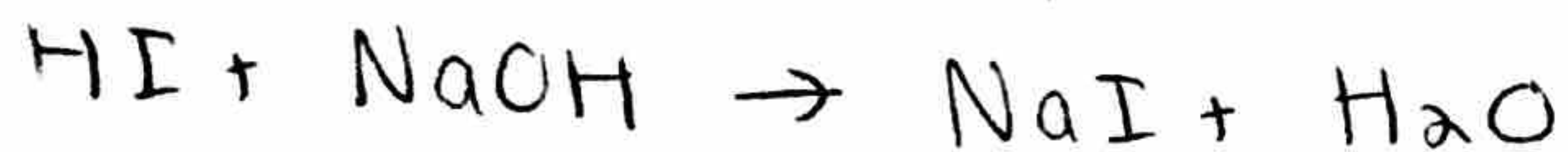




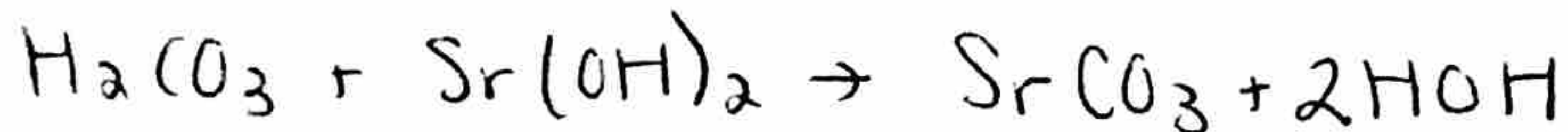
## Neutralization Reactions Worksheet

1. Write the balanced chemical equations for the neutralization reactions between:

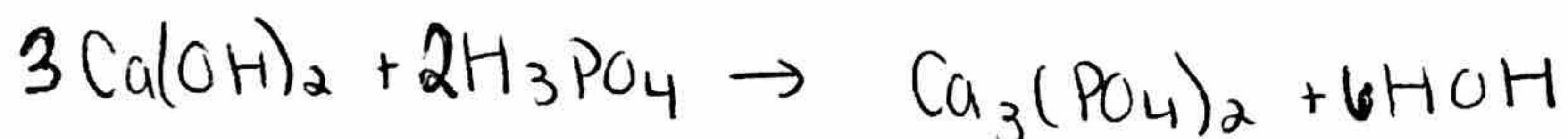
a) HI and NaOH



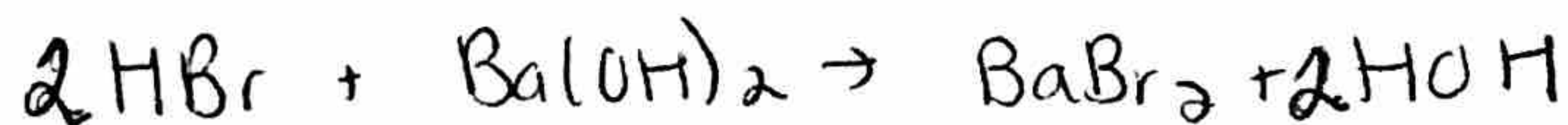
b)  $\text{H}_2\text{CO}_3$  and  $\text{Sr}(\text{OH})_2$



c)  $\text{Ca}(\text{OH})_2$  and  $\text{H}_3\text{PO}_4$



d) hydrobromic acid and barium hydroxide



e) zinc hydroxide and nitric acid



f) aluminum hydroxide and hydrochloric acid



2. Give the name and the formula of the ionic compound produced by neutralization reactions between the following acids and bases:

*will always be the anion from the acid and cation from base*

Acid and Base reactants	Name of ionic compound	Formula
a) nitric acid $\text{HNO}_3$ and sodium hydroxide $\text{NaOH}$	Sodium nitrate	$\text{NaNO}_3$
b) hydroiodic acid and calcium hydroxide	calcium iodide	$\text{CaI}_2$
c) magnesium hydroxide and hydrosulfuric acid	Magnesium sulfide	$\text{MgS}$
d) ammonium hydroxide and hydrofluoric acid	ammonium fluoride	$\text{NH}_4\text{F}$
e) barium hydroxide and sulfuric acid	Barium sulfate	$\text{BaSO}_4$
f) chloric acid and rubidium hydroxide	Rubidium chlorate	$\text{RbClO}_3$
g) calcium hydroxide and carbonic acid	Calcium carbonate	$\text{CaCO}_3$



3. For each of the following ionic compounds, identify the acid and base that reacted to form them.

	Salt	Acid	Base
a)	NaCl	hydrochloric acid	sodium hydroxide
b)	Ca <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub>	phosphoric acid	calcium hydroxide
c)	Zn(NO <sub>3</sub> ) <sub>2</sub>	nitric acid	zinc hydroxide
d)	Al(ClO) <sub>3</sub>	hypochlorous acid	aluminum hydroxide
e)	NH <sub>4</sub> I	hydroiodic acid	ammonium hydroxide

anion for acid, always starts with "H"

cation for base, then hydroxide