Acids & Bases

1. List the differences between an acid and a base. Your description should include such things as whether both are electrolytes, which contains a hydronium ion and which includes a hydroxide ion, and you should also include two examples of an acid and two examples of a base that are present in your household.

Acids	Bases
Sour corrosive Burns pH < 7 produce H^+	Bitter Burns corrosive pH > 7 produce OH^- Feels soapy

2. List 3 strong acids and explain why these acids are considered strong acids.

   HCl, H_2SO_4, HNO_3 completely dissociate in soln

3. List 3 weak acids and explain why these acids are considered weak acids.

   $HC_2H_3O_2$, HF, $HClO$ does not completely dissociate.

4. List 2 strong bases and explain why these bases are considered strong bases.

   $NaOH$, KOH 100% dissociation

5. List 1 weak base and explain why it is considered a weak base.

   NH_3 Does not completely dissociate.

6. Listed below are some of the properties of acids and bases. Fill in the blanks with the appropriate word, acids or bases:

   a) A produce hydrogen ions (H+) in solution
   b) B have a bitter taste
   c) B produce hydroxide ions (OH-) ions
   d) A react with bases to form salts
   e) A have a sour taste
   f) B have a slippery, soapy feel
   g) B react with acids to form salts
   h) A react with many metals

7. Write an equation for the dissociation (ionization) of the following acids in water: (follow example:)

   a) $HClO_4$ ---> $H^+ + ClO_4^-$
   b) $H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$
   c) $HC_2H_3O_2 \rightleftharpoons H^+ + C_2H_3O_2^-$
   d) $H_2S \rightleftharpoons 2H^+ + S^{2-}$
   e) $HCl \rightarrow H^+ + Cl^-$
   f) $HNO_3 \rightarrow H^+ + NO_3^-$

8. Write an equation for the dissociation (ionization) of the following bases in water: (follow example:)

   a) $Mg(OH)_2$ ---> $Mg^{+2} + 2OH^-$
   b) $NaOH \rightarrow Na^+ + OH^-$
   c) $Ba(OH)_2 \rightarrow Ba^{2+} + 2OH^-$
   d) $KOH \rightarrow K^+ + OH^-$
   e) $Mg(OH)_2 \rightleftharpoons Mg^{2+} + OH^-$
   f) $LiOH \rightarrow Li^+ + OH^-$

ACID AND BASE PRACTICE

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) $HNO_3 + OH^- \rightarrow NO_3^- + H_2O$

A B CB CA

b) $CH_3NH_2 + H_2O \rightarrow CH_3NH_3^+ + OH^-$

B A CA CB

c) $OH^- + HPO_4^{-2} \rightarrow$

B A H_2O CA + PO_4^{3-} CB

2) The compound NaOH is a base by all three of the theories we discussed in class. However, each of the three theories describes what a base is in different terms. Use your knowledge of these three theories to describe NaOH as an Arrhenius base, a Brønsted-Lowry base, and a Lewis base.

A: When dissolved in H_2O produces OH^- ions.

B:L: When in soln the OH^- can accept a H^+

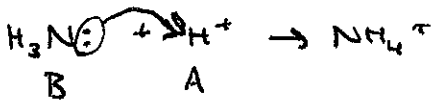
L: When in soln the OH^- has a L.P. that can be donated

3) When hydrogen chloride reacts with ammonia, ammonium chloride is formed. Write the equation for this process, and indicate which of the reagents is the Lewis acid and which is the Lewis base.

$HCl + NH_3 \rightarrow NH_4Cl$

A B

$H^+ + Cl^- + NH_3 \rightarrow NH_4^+ + Cl^-$



B A

4) Write an equation for the reaction of potassium metal with hydrochloric acid.

$2K(s) + 2HCl(aq) \rightarrow 2KCl + H_2$

$2K + 2H^+ \rightarrow K^+ + H_2$

6) Write the names for the following acids and bases:

a) KOH potassium hydroxide

b) HCL hydrochloric acid

c) HF hydrofluoric acid

d) $Fe(OH)_2$ Iron (II) hydroxide

e) H_2SO_4 Sulfuric acid.

7) What is the pH of a solution that contains 25 grams of hydrochloric acid (HCl) dissolved in 1.5 liters of water?

$25\ g\ HCl \left| \frac{}{36.5} = \frac{0.6860\ mol}{1.5\ L} = 0.457\ M \right.$

$[H^+] = 0.457\ M$ $\quad pH = -\log[H^+] = \boxed{0.34}$

8) What is the pH of a solution that contains 1.32 grams of nitric acid (HNO_3) dissolved in 750 mL of water?

$1.32\ g \left| \frac{}{63.015} = \frac{0.0209\ mol}{0.750\ L} = 0.0279\ M\ H^+ \right.$

$pH = -\log(0.0279)$

$\boxed{1.55}$

9) What is the pH of a solution that contains 1.2 moles of nitric acid (HNO_3) and 1.7 moles of hydrochloric acid (HCl) dissolved in 1000 liters of water?

mol $H^+ = 1.2 + 1.7 = 2.9$ mol

$M = \frac{2.9}{1000\ L} = .0029\ M$

$pH = -\log(.0029)$

$\boxed{= 2.537}$

10) If a solution has a $[H^+]$ concentration of 4.5×10^{-7} M, is this an acidic or basic solution? Explain.

$K_w = [H^+][OH^-]$

$[OH^-] = \frac{1 \times 10^{-14}}{4.5 \times 10^{-7}} = 2.22 \times 10^{-8}$

$[H^+] > [OH^-]$

$\therefore$ Acid

$pH = -\log 4.5 \times 10^{-7} = 6.35$

11) An acidic solution has a pH of 4. If I dilute 10 mL of this solution to a final volume of 1000 mL, what is the pH of the resulting solution?

$pH = 4$

$[H^+] = 10^{-4}$

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

$1 \times 10^{-4}(10) = x(1000)$

$[H^+] = 1 \times 10^{-6}$

$pH = -\log(1 \times 10^{-6})$

$\boxed{pH = 6}$

Ionization of Acids/Bases

$H_2O \rightleftharpoons H^+ + OH^-$ produces $H^+ + OH^-$ in equal quantities

1. Describe what occurs when water ionizes ("self-ionization of water"). Include an equation and an explanation.
2. What are the molar concentrations of [H+] and [OH-] in pure water at 25°C? 1×10^{-7}
3. What is the ion-product constant, K_w? $K_w = [H^+][OH^-] = 1 \times 10^{-14}$ @ 25°C

4. Find [H+] for solutions having the following [OH-] value:
   a) $[OH^-] = 1 \times 10^{-13}$
   b) $[OH^-] = 2.7 \times 10^{-4}$ SEE ATTACHED SHEET
   c) $[OH^-] = 1 \times 10^{-3}$
   d) $[OH^-] = 6.3 \times 10^{-10}$

5. Calculate $[OH^-]$ of a solutions when its $[H^+]$ has the following values:
   a) $[H^+] = 1 \times 10^{-3}$
   b) $[H^+] = 3.6 \times 10^{-5}$ SEE ATTACHED SHEET
   c) $[H^+] = 1 \times 10^{-2}$
   d) $[H^+] = 7.8 \times 10^{-8}$

6. A solution contains 0.635 g NaOH in 236 mL solution.

a) Write the eqn for the dissociation of NaOH:

$NaOH \rightarrow Na^+ + OH^-$

b) What is the $[OH^-]$?

$0.635\ g \left| \frac{1\ mol}{40} \right. = 0.0159\ mol$; $\frac{0.0159\ mol}{.236} = 0.0673\ M$

c) What is the $[H^+]$?

$[H^+] = \frac{K_w}{[OH^-]} = 1.48 \times 10^{-13}\ M$

7. A solution contains 0.737 g HNO_3 in 934 mL solution.

a) Write the eqn for the dissociation of HNO3:

$HNO_3 \rightarrow H^+ + NO_3^-$

b) What is the [H+]?

$0.737\ g \left| \frac{1}{63.02} \right. = 0.0117\ mol$; $\frac{0.0117\ mol}{0.934\ L} = 0.0125\ M$

c) What is the [OH-]?

$[OH^-] = \frac{K_w}{.0125} = 7.99 \times 10^{-13}\ M$

8. A solution contains 0.0441 g HCl in 560. mL.

a) Write the equation for the dissociation of HCl:

$HCl \rightarrow H^+ + Cl^-$

b) What is the [H+]?

$0.0441\ g \left| \frac{1\ mol}{36.5} \right. = 0.00121$; $\frac{0.00121}{.560} = 2.16 \times 10^{-3}\ M$

c) What is the [OH-] ?

$\frac{K_w}{2.16 \times 10^{-3}} = 4.63 \times 10^{-12}\ M$

9. A solution contains 8.93 g KOH in 636 mL.

a) Write the equation for the dissociation of KOH:

$KOH \rightarrow K^+ + OH^-$

b) What is the [OH-]?

$8.93\ g \left| \frac{1}{56.01} \right. = 0.159$; $\frac{0.159}{0.636} = 0.25\ M$

c) What is the $[H^+]$?

$[H^+] = \frac{K_w}{0.25} = 4.00 \times 10^{-14}\ M$

Ans (IRO+1): 1x10-14 4.0x10-14 1.49x10-13 7.98x10-13 1x10-12 4.63x10-12 3.7x10-11 1x10-11 2.8x10-10 2.3x10-8 1.3x10-7 1x10-7 1.6x10-5 2.16x10-3 1x10-1 1x10-1 0.250 0.0125 0.0673 Units: M (for all)

④ $K_w = [H^+][OH^-]$ $[H^+] = \frac{K_w}{[OH^-]}$ $K_w = 1 \times 10^{-14}$

ⓐ $[H^+] = \frac{K_w}{1 \times 10^{-13}}$

$[H^+] = 0.1\ M$

ⓑ $[H^+] = \frac{K_w}{2.7 \times 10^{-4}}$

$= 3.70 \times 10^{-11}\ M$

ⓒ $[H^+] = \frac{K_w}{1 \times 10^{-3}}$

$[H^+] = 1 \times 10^{-11}\ M$

ⓓ $[H^+] = \frac{K_w}{6.3 \times 10^{-10}}$

$= 1.59 \times 10^{-5}\ M$

⑤ $[OH^-] = \frac{K_w}{[H^+]}$

ⓐ $= \frac{K_w}{1 \times 10^{-3}}$

$[OH^-] = 1 \times 10^{-11}$

ⓑ $= \frac{K_w}{3.6 \times 10^{-5}}$

$= 2.78 \times 10^{-10}\ M$

ⓒ $= \frac{K_w}{1 \times 10^{-2}}$

$[OH^-] = 1 \times 10^{-12}\ M$

ⓓ $\frac{K_w}{7.8 \times 10^{-8}}$

$= 1.28 \times 10^{-7}\ M$

Unit 6 Review:
pH and pOH Review

1. What is the pH scale? STATES HOW ACIDIC A SUBSTANCE IS. Measure of hydrogen ion concentration
   0 - 14 * can be less than 0 & greater than 14.
2. What exactly do the initials "pH" stand for? POWER OF HYDROGEN
3. Why is pure water considered neutral on the pH scale?
   $H_2O \rightleftharpoons H^+ + OH^-$ 1 mol H^+ : 1 mol OH^- ∴ $[H^+] = [OH^-]$ & pH = 7
4. What is pH a measure of? HYDROGEN ION CONCENTRATION
5. 2. What is the equation used for finding pH? $pH = -\log[H^+]$
6. 3. What is the equation that relates to pH and pOH? $pH + pOH = 14$ $pOH = -\log[OH^-]$

7. Complete the following table

	$[H^+]$	$[OH^-]$	pH	pOH	acid, basic, neutral
a	3.2×10^{-3}	3.1×10^{-12}	2.5	11.5	ACID
b	0.555	1.8×10^{-14}	0.25	13.74	ACID
c	5.89×10^{-11}	1.70×10^{-4}	10.23	3.77	BASE
d	6.03×10^{-8}	1.66×10^{-7}	7.22	6.78	BASE
e	0.0050	2.0×10^{-12}	2.30	11.69	ACID
f	9.09×10^{-10}	0.000011	9.04	4.96	BASE
g	1.07×10^{-11}	9.33×10^{-4}	10.97	3.03	BASE
h	1.02×10^{-7}	9.77×10^{-8}	6.99	7.01	ACID

8. What would be the pH of each of the following: (DANGER! beware of tricks... use the ANS BANK!)

a) 0.0010 M HCl 3
b) 0.0010 M HNO3 3
c) 0.010 M NaOH 12
d) 0.0035 M HCl 2.46
e) 1.0 M HBr 0
f) 1.0 M KOH 14
g) 0.024 M HCl 1.62
h) 0.075 M KOH 12.87
i) 0.000034 M HCl 4.46
j) 0.000000000001M HCl 7
k) 12 M KOH 15.08
l) 12 M HCl -1.08

Unit 6 Acid/Base Neutralization & Titration Review:

1. What type of reaction is a neutralization reaction? ACID/BASE DR.
2. Write the generic equation for a neutralization:

Acid + Base → Salt + H_2O

$HA + BOH \rightarrow BA + H_2O$

3. Write the **balanced** equation for these neutralization reactions: (remember to balance charges for ionic compounds!)

a) $HCl + NaOH \rightarrow$ $NaCl + H_2O$

b) $HNO_3 + KOH \rightarrow$ $KNO_3 + H_2O$

c) $Ca(OH)_2 + H_2SO_4 \rightarrow$ $CaSO_4 + 2H_2O$

d) $3Mg(OH)_2 + 2H_3PO_4 \rightarrow$ $Mg_3(PO_4)_2 + 6H_2O$

e) $H_2CO_3 + Ca(OH)_2 \rightarrow$ $CaCO_3 + 2H_2O$

f) $2NH_4OH + H_2S \rightarrow$ $(NH_4)_2S + 2H_2O$

g) $H_2C_2O_4 + Ca(OH)_2 \rightarrow$ $CaC_2O_4 + 2H_2O$

h) $Al(OH)_3 + 3HClO_4 \rightarrow$ $Al(ClO_4)_3 + 3H_2O$

$M_A V_A n_B = M_B V_B n_A$

4. What volume of 2.00 M H_2SO_4 would be required to neutralize 54.1 mL of 1.40 M $Ca(OH)_2$?

1 mol H^+ : 1 mol OH^-

$2.00(V)(1) = (1)(54.1)(1.40)$ **37.87 mL H_2SO_4**

5. What volume of 2.00 M HCl would be required to neutralize 54.1 mL of 1.40 M $Ca(OH)_2$? $2HCl + Ca(OH)_2 \rightarrow CaCl_2 + H_2O$

2 mol H^+ : 1 mol OH^-

$2.00(V)(1) = (2)(54.1)(1.40)$ **75.74 mL HCl**

6. It was found that 33.8 mL of a triprotic acid was required to neutralize 43.1 mL of 1.10 M NaOH. What is the molarity of the acid?

1 mol H^+ ; 3 mol OH^-

$(33.8)(M_A)(3) = (1)(43.1)(1.10)$ **$M_A = 0.468$ M**

7. 30.0 mL of 0.250 M H_2CO_3 is titrated to the endpoint with 10.4 mL of $Al(OH)_3$. How many grams of aluminum hydroxide was in the solution?

3 mol H^+ : 2 mol OH^-

$0.250(0.300)(2) = (3)(10.4)(X)$

$X = 0.481$ M

$0.481 = \frac{X}{0.0104}$

$X = 0.005$ mol | 78.00

= 0.390 g

Ans #4-7 (IRO)+2: 0.390 0.468 0.955 29.8 37.9 75.7 units: mL, mL, M, g

Unit 6 Definitions of Acids and Bases Review:

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A B CB CA

b) $CH_3NH_2 + H_2O \rightarrow CH_3NH_3^+ + OH^-$
B A CA CB

c) $OH^- + HPO_4^{-2} \rightarrow PO_4^{3-} + H_2O$
B A CB CA

2) The compound NaOH is a base by all three of the theories we discussed in class. However, each of the three theories describes what a base is in different terms. Use your knowledge of these three theories to describe NaOH as an Arrhenius base, a Brønsted-Lowry base, and a Lewis base.

A: $NaOH_{(aq)} \rightarrow Na^+ + OH^-$ produces OH^- ions in soln

BL: $OH^- + H_3O^+ \rightarrow H_2O + H_2O$

OH^- capable of accepting a H^+

Lewis: $H\text{-}\ddot{O}: + H^+ \rightarrow H_2O$

L.P. on O in OH^- is donated to the H^+