CHEMISTRY | LEE

NAME ____

DATE _________________________ BLOCK __________

UNIT SEVEN

PROBLEM SET

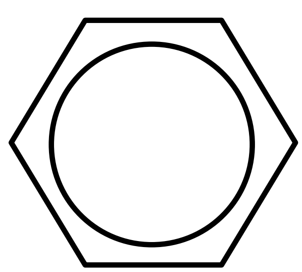
Score:

Do not cheat by copying the work of another person, or by allowing another person to copy your answers. Cheating results in a 0% grade for both parties involved.

Signature_________________________________ Date__________

In the event any or all of this Problem Set is assessed for a grade, it must be signed and dated in order to receive a grade. The work shall be your own.

Problem Sets are generally not accepted late. Late assignments are 50% off.



Ch 7 WS 8: Empirical Formulas

1. Determine the empirical formula from the compound formula. Circle the ionic compounds.

a) C_6H_6

b) C_2H_6

c) C_3H_8

d) $Fe_3(CO)_9$

e) $C_2H_4O_2$

f) N_2H_4

g) $CaBr_2$

h) C_2H_2

i) Na_2SO_4

j) C_6H_5N

k) P_4O_{10}

l) Re_2Cl_6

m) Se_3O_9

n) $LiCl$

Determine the empirical formula of the following compounds based on the percent compositions

1. 92.24 % C; 7.76 % H

2. 86.7% carbon, 14.3% hydrogen?

3. 49.99 % C; 5.61 % H; 44.40 % O

Answers:2= CH , 3= CH_2 , 4=$C_3H_4O_2$

Chapter 7 Worksheet 9: More Empirical Formulas

What is the empirical formula (lowest whole number ratio) of the below compounds

1. 52.7% potassium, 47.3% chlorine

2. 43.6% phosphorus, 56.4% oxygen

3. 71.0% potassium, 29% sulfur?

4. 37.0% iron, 20.5% phosphorus, 42.5% oxygen?

5. 32..4% sodium, 22.6% sulfur, 45.1% oxygen

Answers: 1: KCl, 2=P_2O_5, 3=K_2S, 4=$FePO_4$, 5=Na_2SO_4

Chapter 7 Worksheet 10: Determining Molecular Formulas

1. The empirical formula of a compound is NO. Its molar mass is 60. g/mol. What is the molecular formula?

2. The empirical formula of a compound is CH_2. Its molecular mass is 84 g/mol. What is the molecular formula?

3. An unknown compound is found to contain 49.2% phosphorus and 50.8% oxygen. The molar mass is determined to be 125.94 g/mole. What is the compound's molecular formula?

4. A molecular compound contains 40.0% carbon, 6.7% hydrogen, and 53.3% oxygen. Its molar mass is 180.18 g/mol. What is the compound's molecular formula?

5. A molecular compound contains 52.2% carbon, 13.1% hydrogen, and 34.7% oxygen. Its molar mass is 46.07 g/mol. What is the compound's molecular formula?

Answers: 1: N_2O_2, 2:C_6H_{12}, 3: P_2O_4, 4: $C_6H_{12}O_6$, 5: C_2H_6O

Ch 18 WS 1 Molarity Calculation Worksheet

$$\text{Molarity} = \frac{\text{moles of solute}}{\text{liters of solution}}$$

1. What is the molarity of a solution in which 58 grams of NaCl are dissolved in 2.1 liter of solution?

2. What is the molarity of a solution in which 10.0 g of $AgNO_3$ is dissolved in 500. mL of solution?

3. How many grams of KNO_3 should be used to prepare 2.00 L of a 0.750 M solution?

4. To what volume should 5.0 g of KCl be diluted in order to prepare a 0.25 M solution?

5. How many grams of $CuSO_4{\bullet}5H_2O$ are needed to prepare 100. mL of a 0.10 M solution?

Answers to molarity problems: 1=0.47M, 2=0.118M, 3=152 g, 4=0.27 L, 5=2.5 g

Ch 18 WS 2 Dilution Practice Problems

1. A stock solution of 1.00 M NaCl is available. How many milliliters are needed to make 100.0 mL of 0.750 M?

2. What volume of 0.250 M KCl is needed to make 100.0 mL of 0.100 M solution?

3. Concentrated H_2SO_4 is 18.0 M. What volume is needed to make 2.00 L of 1.00 M solution?

4. Concentrated HCl is 12.0 M. What volume is needed to make 2.00 L of 1.00 M solution?

5. A 0.500 M solution is to be diluted to 500.0 mL of a 0.150 M solution. How many mL of the 0.500 M solution are required?

6. A stock solution of 10.0 M NaOH is prepared. From this solution, you need to make 250.0 mL of 0.375 M solution. How many mL will be required?

7. 2.00 L of 0.800 M $NaNO_3$ must be prepared from a solution known to be 1.50 M in concentration. How many mL are required?

Answers to Dilutions: 1=75mL, 2=40.0mL, 3=0.111L, 4=0.167L, 5=150.mL, 6=9.38mL, 7=1070 mL

Name____________________________________

Chapter 18: Molarity and Dilutions WS 2—Mixed Problems TWO SIDES

Key equations: M = mol/L $\quad$ $M_1V_1 = M_2V_2$

1. What is the molarity of 4.5 grams of $CaCl_2$ in 400. mL of solution?(Ans = 0.10M)

2. What is the final concentration if 60.0 mL of a 6.0 M solution is diluted to 800 mL?(Ans = 0.45 M)

3. How many grams of NaOH are needed to prepare 4.0 Liters of a 1.2 M solution?(Ans = 190 g)

4. What is the concentration of 15 mL of 6.0 M HCl diluted to 2.0 Liters?(Ans = 0.045 M)

5. What volume, L, of solution is required to prepare a 3.0 M solution from 29 grams of lithium fluoride?(Ans = 0.37 L)

6. What is the molarity of a solution containing 8.9 grams of $NaNO_3$ in 250 mL of solution?(Ans = 0.42M)

7. How many milliliters of 0.80 Molar $KMnO_4$ are needed to provide 0.240 mol of $KMnO_4$?(Ans = 300 mL)

8. A solution contains 16 grams of Na_2SO_4 dissolved in enough water to make 4.0 liters of solution. What is the molarity of the solution?(Ans = 0.028M)

9. A 0.50 L solution of $MgSO_4$ contains 0.25 mole of the solute. What is the approximate molarity of the solution?(Ans = 0.50 M)

10. How many mL of 0.25 M $Cu(NO_3)_2$ are required to prepare 25 mL of 0.050 M $Cu(NO_3)_2$?(Ans = 5.0 mL)

Molarity Calculation Worksheet Name ___________________________ Block ____
Chemistry - Becke

$$Molarity = \frac{moles\ of\ solute}{liters\ of\ solution}$$

1. How many grams of $AgNO_3$ are required to make 25 mL of a 0.80M solution?

2. What volume of 0.15M $SrSO_4$ can be made from 23.1 grams?

3. Find the molarity of a 2.50 L solution containing 7 g of potassium fluoride.

4. How many grams of aluminum chloride are required to make 0.50 L of a 1.0M solution?

5. Find the molarity of an 85 mL solution containing 2.6 g of $ZnCl_2$.

6. Find the molarity of a 750 mL solution containing 20.0 g of lithium bromide.

Answers: 1) 3.4 g, 2) 0.84 L, 3) 0.048 M, 4) 67 g, 5) 0.22 M, 6) 0.31 M

Dilution Practice Problems
Chemistry – Becke

Name ____________________________ Block _____

$$M_1 V_1 = M_2 V_2$$

1. A solution of 1.00 M NaCl is available. How many milliliters are needed to make 100.0 mL of 0.750 M?

2. What volume of 0.250 M KCl is needed to make 100.0 mL of 0.100 M solution?

3. Concentrated H_2SO_4 is 18.0 M. What volume is needed to make 2.00 L of 1.00 M solution?

4. Concentrated HCl is 12.0 M. What volume is needed to make 2.00 L of 1.00 M solution?

5. A 0.500 M solution is to be diluted to 500.0 mL of a 0.150 M solution. How many mL of the 0.500 M solution are required?

6. A stock solution of 10.0 M NaOH is prepared. From this solution, you need to make 250.0 mL of 0.375 M solution. How many mL will be required?

7. 2.00 L of 0.800 M $NaNO_3$ must be prepared from a solution known to be 1.50 M in concentration. How many mL are required?

Answers: 1)75 mL, 2) 40.0 mL, 3) 0.111 L, 4) 0.167 L, 5) 150 mL, 6) 9.38 L, 7) 1070 mL

The pH Scale
Chem Worksheet 19-3

Name ___________________

An **acid** is a substance that creates the **hydronium ion**, H_3O^+, in solution. The concentration of hydronium is represented by $[H_3O^+]$ and this value determines the pH of a solution. The pH is calculated by taking the logarithm of $[H_3O^+]$ and changing the sign: pH = -log $[H_3O^+]$. A neutral solution has a pH of 7, while acidic solutions have pH values less than 7. Basic or **alkaline** solutions have pH values greater than 7.

pH Scale

pH	$[H_3O^+]$	$[OH^-]$	pOH	
0	1×10^{0}	1×10^{-14}	14	More acidic
2	1×10^{-2}	1×10^{-12}	12	
4	1×10^{-4}	1×10^{-10}	10	
6	1×10^{-6}	1×10^{-8}	8	
7	1×10^{-7}	1×10^{-7}	7	**neutral**
8	1×10^{-8}	1×10^{-6}	6	More basic
10	1×10^{-10}	1×10^{-4}	4	
12	1×10^{-12}	1×10^{-2}	2	
14	1×10^{-14}	1×10^{0}	0	

USEFUL EQUATIONS

$$pH = -\log [H_3O^+]$$
$$pOH = -\log [OH^-]$$
$$pH + pOH = 14.00$$
$$[H_3O^+] \times [OH^-] = 1.0 \times 10^{-14}$$

Examples

Find the pH of a solution with $[H_3O^+] = 8.6 \times 10^{-9}$ *M*.

$pH = -\log [H_3O^+]$

$pH = -\log (8.6 \times 10^{-9})$

$pH = -(-8.07) = 8.07$

Find the pOH of a solution with $[OH^-] = 1.3 \times 10^{-2}$ *M*.

$pOH = -\log [OH^-]$

$pOH = -\log (1.3 \times 10^{-2})$

$pOH = -(-1.89) = 1.89$

Find the $[H_3O^+]$ of a solution with a pH = 9.27.

$pH = -\log [H_3O^+]$

$-pH = \log [H_3O^+]$

$\text{antilog} -(9.27) = \cancel{\text{antilog}}\ \cancel{\log} [H_3O^+]$

$5.4 \times 10^{-10}\ M = [H_3O^+]$

Find the pOH of a solution with pH = 3.21.

$pOH = 14.00 - pH$

$pOH = 14.00 - 3.21 = 10.79$

Solve the following problems. Show all work.

1. Find the pH of a solution with $[H_3O^+] = 2.3 \times 10^{-4}$ *M*. Is the solution acidic or basic?
2. Find the pH of a solution with $[H_3O^+] = 7.42 \times 10^{-11}$ *M*. Is the solution acidic or basic?
3. Vinegar (acetic acid) has a pH of about 2.4. Determine the $[H_3O^+]$ for vinegar. Is it acidic or basic?
4. Baking soda has a pH of about 8.15. Find the $[H_3O^+]$ for a baking soda solution. Is it acidic or basic?
5. Find the pOH for a solution with $[OH^-] = 5.5 \times 10^{-3}$ *M*. Is the solution acidic or basic?
6. Find the pOH for a solution with $[OH^-] = 3.71 \times 10^{-6}$ *M*. Is the solution acidic or basic?
7. A 0.05 *M* solution of NaOH contains 0.05 *M* OH^-. Find the pOH of this solution and convert to pH.
8. In a blood sample $[OH^-] = 3.2 \times 10^{-7}$ *M*. Find the pOH of blood and convert to pH.
9. The pOH of household ammonia is 2.5. Determine the $[OH^-]$ in ammonia. Is the solution acidic or basic?
10. Lemon juice has a pH of about 3.6. Determine the $[H_3O^+]$ in lemon juice. Is it acidic or basic?

Ch 20 WS 1--Recognizing Acids and Bases/pH and pOH

Acids generate H^+ (H_3O+) ions in water. They are molecular compounds that dissociate in water. Usually the formula begins with an H. A hydrogen bonded to carbon is never acidic. The hydrogen will not dissociate from the molecule in water. **Bases generate hydroxide ions in water.** They are ionic compounds with a hydroxide polyatomic. However, ammonia, NH_3, also produces hydroxide in water through the reaction $NH_3 + H_2O \rightarrow NH_4OH$. Many compounds are neither Bronsted acids nor bases. This includes most molecular compounds and ionic compounds that do not produce a hydroxide ion in water

Identify the following compounds as acids, bases, or neither by making a check mark in the appropriate column.

Compound	Acid	Base	Neither
HCl			
KOH			
NaBr			
NH_3			
$Ba(OH)_2$			
$HC_2H_3O_2$			
CH_4			
H_2SO_4			
$Mg(OH)_2$			

pH and pOH

The pH of a solution indicates how acidic or basic that solution is

- **pH range of 0 – 7 acidic**
- **pH = exactly 7 neutral**
- **pH range of 7-14 basic**

Since **$[H+]x[OH-] = 1 \times 10^{-14}$** at 25°C, if [H+] is known, the [OH-] can be calculated and vice versa.

pH = -log[H+] So if $[H+] = 1 \times 10^{-6}$ M, pH = 6

pOH = -log[OH-] So if $[OH-] = 1 \times 10^{-8}$ M, pOH = 8

Together, **pH + pOH = 14**

Complete the following chart

	[H+]	pH	[OH-]	pOH	Acid or Basic
1.	1×10^{-5} M	5	1×10^{-9} M	9	Acid
2.		7			
3.			1×10^{-4} M		
4.	1×10^{-2} M				
5.				11	
6.		12			
7.			1×10^{-5} M		
8.	1×10^{-11}				
9.				13	
10.		6			

Naming Acids
Chem Worksheet 19-0

Name ________________

Acids are compounds that can donate the hydrogen ion, H^+. When the formula for an acid is written the symbol for this hydrogen generally appears at the beginning of the formula. For example the formula for hydrochloric acid is written HCl and the formula for phosphoric acid is H_3PO_4. Notice that both formulas begin with the letter H. In both cases the acid is made of a hydrogen ion (or hydrogen ions) and a negative ion, known as the **anion**.

The name for an acid is based on the name of the anion. If the anion ends with the letters –ide, the acid is named one way while acids containing anions that end with –ate use a different rule. Remember that monatomic anions typically end with –ide. The rules for naming acids are summarized below.

Naming Acids

Anion called (root) ide	Anion called (root) ate	Anion called (root) ite
Example: sulfide, S^{2-}	*Example: chlorate , ClO_3^-*	*Example: chlorite , ClO_2^-*
↓	↓	↓
Acid called hydro (root) ic acid	**Acid called (root) ic acid**	**Acid called (root) ous acid**
Example: hydrosulfuric acid, H_2S	*Example: chloric acid, $HClO_3$*	*Example: chlorous acid, $HClO_2$*

Examples

#1. Write the chemical formula for: sulfurous acid.

- this acid contains the hydrogen ion and the sulfite ion: H^+ SO_3^{2-}
- create a neutral compound from these ions: H^{1+} SO_3^{2-} H_2SO_3

#2. Name the following acid: H_2CO_3.

- this acid contains the hydrogen ion and the carbonate ion: H^+ CO_3^{2-}
- the name of the negative ion is **carbonate**, therefore the acid is called **carbonic acid.**

Fill in the following table with the missing information.

	Formula	Cation	Formula for anion	Name of anion	Name of Acid
1.	HCl	H^+	Cl^-	chloride	
2.	HNO_3	H^+		nitrate	
3.		H^+	F^-		hydrofluoric acid
4.	H_2SO_4	H^+	SO_4^{2-}		
5.		H^+		carbonate	
6.	H_2SO_3			sulfite	
7.			ClO_3^-		chloric acid
8.		H^+		phosphate	
9.	$H_2C_2O_4$			oxalate	
10.					hydrocyanic acid
11.					acetic acid
12.			I^-		
13.				sulfide	
14.	HClO				
15.			AsO_4^{3-}	arsenate	
16.					nitrous acid

Equations for Acids & Bases
Chem Worksheet 19-1

Name ________________

> Acids donate protons
> Bases accept protons
>
> A proton is a hydrogen ion

An **acid** is defined as a substance that donates a proton (written H^+) while a **base** is the substance that receives a proton. Typically the chemical formula can be used to determine the acid, because it will begin with the symbol H. For example in the following equation HCl is the acid and it donates a proton to water.

$$\underset{\textbf{acid}}{HCl} + \underset{\textbf{base}}{H_2O} \rightarrow H_3O^+ + Cl^-$$

In this reaction the HCl is the acid, while the H_2O acts as the base. This creates two new products: **hydronium**, H_3O^+, and the chloride ion, Cl^-.

Some acids have the ability to donate two or three protons and these are known as **diprotic** or **triprotic acids** respectively. For these acids each successive step of hydrogen donation is represented with its own equation. Consider the diprotic acid called carbonic acid, H_2CO_3.

First step: $\underset{\textbf{acid}}{H_2CO_3} + \underset{\textbf{base}}{H_2O} \rightarrow H_3O^+ + HCO_3^-$

Second step: $\underset{\textbf{acid}}{HCO_3^-} + \underset{\textbf{base}}{H_2O} \rightarrow H_3O^+ + CO_3^{2-}$

Example

Write the chemical equation that shows what happens when HF (acid) is added to water.

- write the equation $\underset{\textbf{acid}}{HF} + \underset{\textbf{base}}{H_2O} \rightarrow F^- + H_3O^+$

- check to make sure **the atoms** and the **charge** are balanced

Rewrite each equation and label the acid and the base in each reaction.

1. $NH_3 + H_2O \rightarrow NH_4^+ + OH^-$
2. $HI + OH^- \rightarrow I^- + H_2O$
3. $HCO_3^- + HNO_3 \rightarrow H_2CO_3 + NO_3^-$
4. $H_2O + CN^- \rightarrow HCN + OH^-$
5. $OH^- + NH_4^+ \rightarrow H_2O + NH_3$
6. $H_2SO_4 + PO_4^{3-} \rightarrow HPO_4^{2-} + HSO_4^-$

Fill in the following table.

	Acid	Base	Equation
7	HNO_3	OH^-	$HNO_3 + OH^- \rightarrow H_2O + NO_3^-$
8			$CH_3NH_2 + H_2O \rightarrow OH^- + CH_3NH_3^+$
9	HCN		$HCN + H_2O \rightarrow H_3O^+ + CN^-$
10	HBr	H_2O	
11	HPO_4^{2-}	NH_3	
12			$OH^- + H_2S \rightarrow H_2O + HS^-$
13	$H_2C_2O_4$	OH^-	
14	HClO	NH_3	
15	HSO_4^-	CO_3^{2-}	

Ch 20 WS 2 pH of Strong Acid or Strong Base Solutions

Calculate the pH of the solutions below. Assume all compounds dissociate completely in water.

1. 0.01 M HCl
2. 0.001 M HNO_3
3. 0.0001 M NaOH
4. 0.00010 M HBr
5. 0.1 M KOH
6. 0.0050 M $Ca(OH)_2$

And a little subatomic particle review:

How many protons are in Calcium-42?______

How many electrons are in Ca^{2+}?____

How many neutrons are in ^{32}P?______

How many neutrons are in $^{66}_{30}Zn$?______

How many valence electrons does silicon have?______

How many valence electrons do the halogens have?_____

When chlorine becomes an ion, it has the same number of total electrons as ____.

Ch 20 WS 3 pH calculations and polyatomic review

1. The pH of an aqueous solution that is 1 x 10^{-3} M HCl is _______.

2. The pH of an aqueous solution that contains 1 x 10^{-4} M HBr is ______.

3. The pH of an aqueous solution that contains 1 x 10^{-2} M NaOH is ______.

4. The pH of an aqueous solution with a pOH of 8 is _______

5. Indicate whether the solution is acidic or basic or neutral

Solution	Acidic	Basic	Neutral
pH = 2			
pH = 9			
pOH = 6			
pOH = 10			
1 x 10^{-4} M NaOH			
1 x 10^{-6} M HCl			
[OH-] = 1 x 10^{-9} M			
[H+] = 1 x 10^{-4} M			

6. Convert the following pH values to [H+] or [OH-] concentration

Example: pH = 7, [H+] = <u>1 x 10^{-7} M</u>

pH = 5, [H+] = __________

pOH = 6, [OH-] = __________

pOH = 11, [H+] = ________

pH = 2, [OH-] = ________

Polyatomic Review

What is the formula and charge of the following polyatomic ions:

__________ammonium

__________acetate

_________ carbonate

__________hydrogen carbonate

_________phosphate

__________nitrate

_________hydroxide

__________sulfate

Ch 20 WS 4 pH and neutralization reactions

1. What polyatomic ion is found in ionic compound bases? __________________
2. What does pH measure? ____
3. pH + pOH always = ____________ at 25°C in aqueous solutions.
4. [H+] x [OH-] always = _______________ at 25° C in aqueous solutions.
5. The hydrogen ion concentration is 1×10^{-6}. What is the pH of the solution? ____________
6. The hydroxide ion concentration is 1×10^{-3}. What is the pH of the solution? _________.
7. The pH of a 0.010 molar aqueous solution of hydrochloric acid, HCl, would equal__________.
8. Indicate whether the solution is acidic or basic.

   pH = 8_____________________ pH = 2_________________

   $[H^+] = 1 \times 10^{-4}$ Molar _____________ $[OH^-] = 1 \times 10^{-6}$ Molar _______________

   1×10^{-6} Molar HCl ________________ 1×10^{-6} Molar NaOH ________________

9. Convert the following pH values to [H+] or [OH-] concentration:

   Example: pH = 7, $[H^+]$ concentration = $\underline{1 \times 10^{-7} M}$

   pH = 10, $[H^+]$ concentration = ________________

   pOH = 4, $[OH^-]$ concentration = ________________

   pOH = 3, $[H^+]$ concentration = __________________

   pH = 6, $[OH^-]$ concentration = ____________________

10. Circle the base in the following neutralization reactions. Box the salt if applicable.

    $HBr + LiOH \rightarrow LiBr + H_2O$

    $Mg(OH)_2 + 2HNO_3 \leftrightarrows Mg(NO_3)_2 + 2H_2O$

    $H_2SO_4 + 2 KOH \leftrightarrows 2H_2O + K_2SO_4$

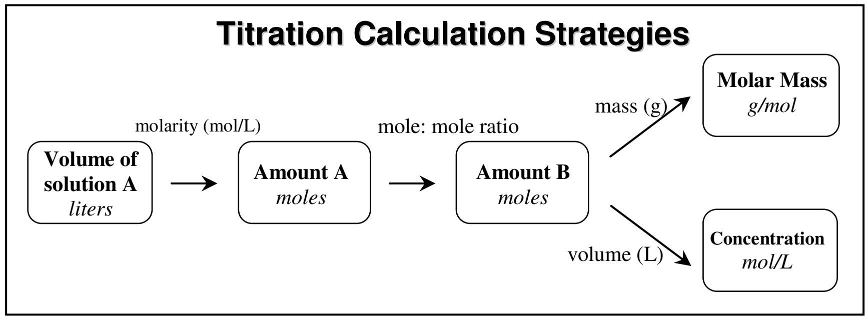
    $NH_3 + HCl \leftrightarrows NH_4^+ + Cl^-$

11. What is the name of the salt formed by the neutralization of hydrochloric acid and sodium hydroxide?

Acid-Base Titrations
Chem Worksheet 19-5

Name ________________

An acid is neutralized by a base. If the concentration and volume of the base are accurately known, the concentration or the molar mass of an acid can be determined. The **concentration** of an unknown acid is equal to the moles of acid per liter of acid. The **molar mass** of an acid is the grams of acid per mole of acid.



Examples

When 1.04 g of a monoprotic unknown acid (HA) is titrated with 0.300 *M* NaOH it takes 75.21 mL of base to neutralize the acid. Determine the **molar mass** of the unknown acid.

$$HA + NaOH \rightarrow NaA + H_2O$$

- begin with units of L on the bottom: (liters will be converted to moles, which are on the bottom of molar mass)

$$\frac{1}{0.07521\text{ L }\cancel{\text{NaOH}}} \times \frac{1\text{ L }\cancel{\text{NaOH}}}{0.300\text{ mol }\cancel{\text{NaOH}}} \times \frac{1\text{ mol }\cancel{\text{NaOH}}}{1\text{ mol HA}} \times \frac{1.04\text{ g HA}}{1} = 46.1\ \frac{\text{grams HA}}{\text{mol HA}}$$

An unknown diprotic acid (H_2A) with a volume of 10.0 mL is titrated with 165 mL of 0.15 *M* KOH. Find the **concentration** of the acid in mol/L.

$$H_2A + KOH \rightarrow K_2A + 2H_2O$$

- begin with units of L on the top: (liters will be converted to moles, which are on the top of the molarity units)

$$\frac{0.165\ \cancel{\text{L KOH}}}{1} \times \frac{0.15\ \cancel{\text{mol KOH}}}{1\ \cancel{\text{L KOH}}} \times \frac{1\text{ mol }H_2A}{2\ \cancel{\text{mol KOH}}} \times \frac{1}{0.0100\text{ L }H_2A} = 1.2\ \frac{\text{mol }H_2A}{\text{L }H_2A}$$

Answer the following questions. Show all work and report answers with units.

1. Lactic acid, a chemical responsible for muscle fatigue, is a monoprotic acid. When 0.578 g of lactic acid is titrated with 0.206 *M* NaOH, a volume of 31.11 mL of NaOH is used. What is the **molar mass** of lactic acid?
$$HA + NaOH \rightarrow NaA + H_2O$$

2. A volume of 25.0 mL of nitric acid, HNO_3 is titrated with 0.12 *M* NaOH. To completely neutralize the acid 10 mL of NaOH must be added. Find the **concentration** (mol/L) of the nitric acid.
$$HNO_3 + NaOH \rightarrow NaNO_3 + H_2O$$

3. Malonic acid is a diprotic acid used in the production of pharmaceuticals. A 0.965 g sample of malonic acid requires 45.91 mL of 0.404 *M* LiOH to be neutralized. Determine the **molar mass** (g/mol) for malonic acid.
$$H_2A + 2\ LiOH \rightarrow Li_2A + 2\ H_2O$$

4. To find the molarity of sulfuric acid, H_2SO_4 it is titrated with 0.75 *M* KOH. It requires 328.4 mL of KOH to neutralize a 40.00 mL sample of sulfuric acid. Calculate the **concentration** (mol/L) of the sulfuric acid.
$$H_2SO_4 + 2\ KOH \rightarrow K_2SO_4 + 2\ H_2O$$

5. Boric acid is a triprotic acid that is used as an ant and roach killer. A 1.42-g sample of boric acid is neutralized by 157 mL of 0.4388 *M* NaOH. Determine the **molar mass** (g/mol) for boric acid.
$$H_3A + 3\ NaOH \rightarrow Na_3A + 3\ H_2O$$

6. Tartaric acid, $H_2C_4H_4O_6$ is neutralized with 0.100 *M* NaOH. A sample of 3.0 g of tartaric acid reacts with 45 mL of base. How **concentrated** is the base?
$$H_2C_4H_4O_6 + 2\ NaOH \rightarrow Na_2C_4H_4O_6 + 2\ H_2O$$

Ch 20 WS 5 Practice Acid-Base Titration Problems

1. Predict the products of the following neutralization reactions. Do not worry about balancing

   $HF + KOH \rightarrow$ ________ + _________

   $H_2SO_4 + NaOH \rightarrow$ _________ + _________

   $H_3PO_4 + KOH \rightarrow$ _________ + ___________

   $HCl + Ca(OH)_2 \rightarrow$ _________ + ___________

2. A 15 mL sample of acetic acid, HCH_3COO, is titrated with 5.0 mL of 0.25 M NaOH to its phenolphthalein endpoint. What is the concentration of the acetic acid? (Ans = 0.083 M)

$$H_3CH_3COO + NaOH \rightarrow H_2O + NaCH_3COO$$

3. 20. mL of 0.080 M KOH is required to titrate 34 mL of nitric acid, to its phenolphthalein endpoint. What is the molarity of the nitric acid? (Ans = 0.047 M)

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

4. How many mLs of 3.0 M NaOH is needed to completely neutralize 1200 mLs of 0.200 M HCl?(Ans = 80. mL)

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

5. How many moles of HCl are required to completely neutralize 0.55 moles of $Ba(OH)_2$?(Ans = 1.1 mol)

$$Ba(OH)_2 + 2HCl \rightarrow 2H_2O + BaCl_2$$

Practice Acid-Base Titration Problems

1. A 15 ml sample of Acetic Acid, HCH_3COO, is titrated with 5.0 mL of 0.25 M NaOH to its phenolphthalein endpoint. What is the concentration of the acetic acid?(Ans=0.083 M)

$$HCH_3COO + NaOH \rightarrow H_2O + NaCH_3COO$$

2. 20. mL of 0.080 M KOH is required to titrate 34 mL of hydrobromic acid, HBr, to its phenolphthalein endpoint. What is the molarity of the sulfuric acid?()

$$KOH(aq) + HBr(aq) \rightarrow KBr(aq) + H_2O(l)$$

3. A 94 mL sample of citric acid, $H_3C_6H_5O_7$, solution (example=orange juice) is titrated to the phenolphthalein endpoint using 7.0 mL of 0.010 M NaOH. What is the concentration of the citric acid in the orange juice?(Ans = 0.00025 M)

$$H_3C_6H_5O_7 + 3NaOH \rightarrow Na_3C_6H_5O_7 + 3H_2O$$

4. A 25 mL sample of 0.040 molar aqueous barium hydroxide, $Ba(OH)_2$, was titrated to its phenolphthalein endpoint using 0.080 M HCl. How many mLs of the HCl solution were required?(Ans = 25 mL)

$$Ba(OH)_2 + 2HCl \rightarrow 2H_2O + BaCl_2$$

Ch 20 pH worksheet 3

1. What polyatomic ion is found in ionic compound bases? ___________________
2. What does pH measure? ____
3. pH + pOH always = ____________ at 25°C in aqueous solutions.
4. [H+] x [OH-] always = _______________ at 25° C in aqueous solutions.
5. The hydrogen ion concentration is 1×10^{-6}. What is the pH of the solution? ____________
6. The hydroxide ion concentration is 1×10^{-3}. What is the pH of the solution? _________.
7. The pH of a 0.010 molar aqueous solution of hydrochloric acid, HCl, would equal__________.
8. Indicate whether the solution is acidic or basic.

   pH = 8______________________ pH = 2_________________

   $[H^+] = 1 \times 10^{-4}$ Molar ______________ $[OH^-] = 1\times10^{-6}$ Molar ________________

   1×10^{-6} Molar HCl _________________ 1×10^{-6} Molar NaOH _________________

9. Convert the following pH values to [H+] or [OH-] concentration:

   Example: pH = 7, $[H^+]$ concentration = $\underline{1 \times 10^{-7} M}$

   pH = 10, $[H^+]$ concentration = _________________

   pOH = 4, $[OH^-]$ concentration = _________________

   pOH = 3, $[H^+]$ concentration = ___________________

   pH = 6, $[OH^-]$ concentration = _____________________

10. Circle the base in the following neutralization reactions. Box the salt if applicable.

    $HBr + LiOH \rightarrow LiBr + H_2O$

    $Mg(OH)_2 + 2HNO_3 \leftrightarrows Mg(NO_3)_2 + 2H_2O$

    $H_2SO_4 + 2\,KOH \leftrightarrows 2H_2O + K_2SO_4$

    $NH_3 + HCl \leftrightarrows NH_4^+ + Cl^-$

11. What is the name of the salt formed by the neutralization of hydrochloric acid and sodium hydroxide?

Conjugate Acid Base Pairs

Chem Worksheet 19-2

Name ________________

An **acid** is defined as a proton (H^+) donor while a **base** is a proton acceptor. The substance that is produced after an acid has donated its proton is called the **conjugate base** while the substance formed when a base accepts a proton is called the **conjugate acid**. The conjugate acid can donate a proton to the conjugate base, to reform the original reactants in the reverse reaction.

> Acids donate protons
> Bases accept protons
>
> A proton is a hydrogen ion

$$\underset{\textbf{acid}}{HF} + \underset{\textbf{base}}{H_2O} \leftrightarrows \underset{\textbf{c. acid}}{H_3O^+} + \underset{\textbf{c. base}}{F^-}$$

In the reaction above HF is the acid and H_2O is the base. The HF has given a proton to the H_2O, forming H_3O^+ and F^-. Since the product H_3O^+ can donate a proton back to F^- it is labeled the conjugate acid, while the F^- is the conjugate base.

Example

Write an equation that shows NH_3 reacting with HCl. Label the acid, base, and conjugate acid and conjugate base.

- Write reactants and transfer a proton from the acid to the base:

$$\underset{\textbf{base}}{NH_3} + \underset{\textbf{acid}}{HCl} \leftrightarrows \underset{\textbf{c. acid}}{NH_4^+} + \underset{\textbf{c. base}}{Cl^-}$$

H^+

Rewrite each equation. Identify the acid, the base, the conjugate acid, and the conjugate base in each of the equations.

1. $HCl + NH_3 \rightarrow NH_4^+ + Cl^-$
2. $OH^- + HCN \rightarrow H_2O + CN^-$
3. $PO_4^{3-} + HNO_3 \rightarrow NO_3^- + HPO_4^{2-}$
4. $HCO_3^- + HCl \rightarrow H_2CO_3 + Cl^-$
5. $HCO_3^- + OH^- \rightarrow H_2O + CO_3^{2-}$
6. $NH_4^+ + H_2O \rightarrow NH_3 + H_3O^+$
7. $C_2O_4^{2-} + HC_2H_3O_2 \rightarrow HC_2O_4^- + C_2H_3O_2^-$
8. $HPO_4^{2-} + H_2O \rightarrow OH^- + H_2PO_4^-$

Fill in the following table.

	Acid	Base	Conjugate Acid	Conjugate Base	Equation
9	HNO_2	H_2O			$HNO_2 + H_2O \rightarrow NO_2^- + H_3O^+$
10	H_2O	F^-	HF	OH^-	
11					$NH_3 + HCN \rightarrow NH_4^+ + CN^-$
12			H_2O	ClO_3^-	
13	HSO_4^-	PO_4^{3-}			
14					$S^{2-} + H_2O \rightarrow OH^- + HS^-$
15	HCO_2H	OH^-			

16. Write an equation that shows the reaction of ammonia, NH_3 with hydrobromic acid, HBr. Label the acid, the base, the conjugate acid, and the conjugate base.
17. Write an equation that shows the reaction of phosphate ion, PO_4^{3-}, reacting with hydronium ion, H_3O^+. Label the acid, the base, the conjugate acid, and the conjugate base.
18. Write an equation that shows the reaction of hydrogen sulfide, HS^- with hydroxide ion, OH^-. Label the acid, the base, the conjugate acid, and the conjugate base.