Introduction to Acids and Bases

- Acids and bases are a special class of chemical compounds with certain properties in aqueous solution

Properties of Acids vs. Bases

Acids	Bases
• Taste sour	• Taste bitter
• Solutions don't feel slippery	• Solutions feel slippery
• pH<7	• pH>7
• Usually lots of H^+/H_3O^+ in solution	• Usually lots of OH^- in solution
• Turn blue litmus paper red	• Turn red litmus paper blue
• Corrodes metals; reacts with metal to make compound + H_2	• Does not corrode/react with metal usually
• Colorless with phenolphthalein	• Pink with phenolphthalein
• Conducts in solution (electrolyte)	• Conducts in solution (electrolyte)
• Undergo neutralization reaction with bases	• Undergo neutralization reaction with acids

List of Common Acids and Bases

Acids	Bases
H_2SO_4 Sulfuric acid (car batteries)	$NaOH$ Sodium hydroxide (lye)
HNO_3 Nitric Acid (fertilizer, explosives)	$Mg(OH)_2$ Magnesium hydroxide (milk of magnesia
H_3PO_4 Phosphoric acid (flavoring in food)	$Ca(OH)_2$ Calcium hydroxide (lime)
HCl Hydrochloric Acid (stomach acid)	NH_3 Ammonia (cleaning, fertilizer)
HCH_3COO or $HC_2H_3O_2$ acetic acid (vinegar)	$NaHCO_3$ Sodium bicarbonate (baking soda)
H_2CO_3 Carbonic acid (carbonated sodas)	

Review: Names and Formulas of Acids

• Rules for Naming Acids

- Binary acids: H + Nonmetal Element
  H + Polyatomic Ion not containing O

  Name the acid using the prefix hydro- and the suffix -ic

  ex. HF = hydrofluoric acid
  HCN = hydrocyanic acid

- Oxyacids: H + Polyatomic Ion Containing O

  Name the acid without using the prefix hydro-

  If the oxyacid contains a polyatomic ion which ends in -ate, change that ending to -ic

  ex. HNO_3 NO_3^- is nitrate, so the acid is called nitric acid
  $HClO_4$ ClO_4^- is perchlorate, so the acid is called perchloric acid

  If the oxyacid contains a polyatomic ion which ends in -ite, change that ending to -ous

  ex. HNO_2 NO_2^- is nitrite, so the acid is called nitrous acid
  HClO ClO^- is hypochlorite, so the acid is called hypochlorous acid

• Writing Formulas for Acids

- Acids fall into the category of ionic compounds (the H^+ acts as a metal). In order to write a neutral formula it is necessary to "swap and drop" the charges to get the subscripts in the acid's formula

ex. hydrosulfuric acid

$H^+_2 \quad S^{2-}_1$

H_2S

ex. phosphoric acid

$H^+_3 \quad PO_4^{3-}_1$

H_3PO_4

Acid Base Definitions

Arrhenius:

- Acids release H^+ ions in water
- Bases release OH^- ions in water

ex. $HCl + H_2O \rightarrow H_3O^+ + Cl^-$

$NH_3 + H_2O \rightarrow NH_4^+ + OH^-$

Bronsted-Lowery:

$HCO_3^- + H_2O \rightleftharpoons H_3O^+ + CO_3^{-2}$

acid base CA CB

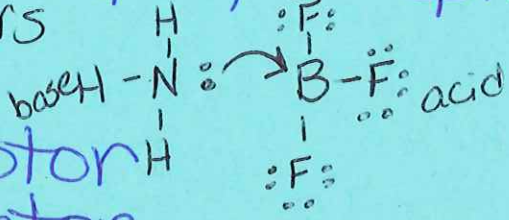
- Acid is a proton donor, donates H^+
- Base is a proton acceptor, accepts H^+

*Conjugate acid-base pairs

Lewis:

Acid - Electron pair acceptor

Base - Electron pair donator



Amphoteric: substances that can act as acids or bases depending on what substances are present

ex. HSO_4^- can be amphoteric

ex.

$$H_3O^+ + \underset{\text{(base)}}{HSO_4^-} \rightleftharpoons H_2SO_4 + H_2O$$

$$\underset{\text{(acid)}}{HSO_4^-} + OH^- \rightleftharpoons SO_4^{2-} + H_2O$$

Water can be amphoteric, can react with itself in a process of ionization

$$H_2O + H_2O \rightleftharpoons H_3O^+ + OH^-$$

base acid acid base

$$K_c = [H_3O^+][OH^-] = (1.0 \times 10^{-7})(1.0 \times 10^{-7}) = 1.0 \times 10^{-14}$$

Conj. Acid/Base Pairs:

Give conj. base:

HF	F^-
H_3PO_4	$H_2PO_4^-$
H_3O^+	H_2O

Give conj. acid:

Br^-	HBr
HSO_4^-	H_2SO_4
CO_3^{2-}	HCO_3^-

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

① Identify reactant acid & base

② Find species that differs from acid by a proton, that is the conj. base

③ Find species that differs from base by a proton, that is the conj. acid

HNO_3 acid - NO_3^- conj. base

H_2O base - H_3O^+ conj. acid

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

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

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:

$$\underset{\text{base}}{NH_3} + \underset{\text{acid}}{HCl} \leftrightarrows \underset{\text{c. acid}}{NH_4^+} + \underset{\text{c. base}}{Cl^-} \qquad (H^+ \text{ transferred})$$

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.

Conjugate Acid Base Pairs

Chem Worksheet 19-2

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Acids donate protons
Bases accept protons

A proton is a hydrogen ion

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

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.

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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:

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

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	H_3O^+	NO_2^-	$HNO_2 + H_2O \rightarrow NO_2^- + H_3O^+$
10	H_2O	F^-	HF	OH^-	$H_2O + F^- \rightarrow HF + OH^-$
11	HCN	NH_3	NH_4^+	CN^-	$NH_3 + HCN \rightarrow NH_4^+ + CN^-$
12	$HClO_3$	OH^-	H_2O	ClO_3^-	$HClO_3 + OH^- \rightarrow H_2O + ClO_3^-$
13	HSO_4^-	PO_4^{3-}	HPO_4^{2-}	SO_4^{2-}	$HSO_4^- + PO_4^{3-} \rightarrow HPO_4^{2-} + SO_4^{2-}$
14	H_2O	S^{2-}	HS^-	OH^-	$S^{2-} + H_2O \rightarrow OH^- + HS^-$
15	HCO_2H	OH^-	H_2O	CO_2H^-	$HCO_2H + OH^- \rightarrow H_2O + CO_2H^-$

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.
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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.

16) $\underset{B}{NH_3} + \underset{A}{HBr} \rightarrow \underset{CA}{NH_4^+} + \underset{CB}{Br^-}$

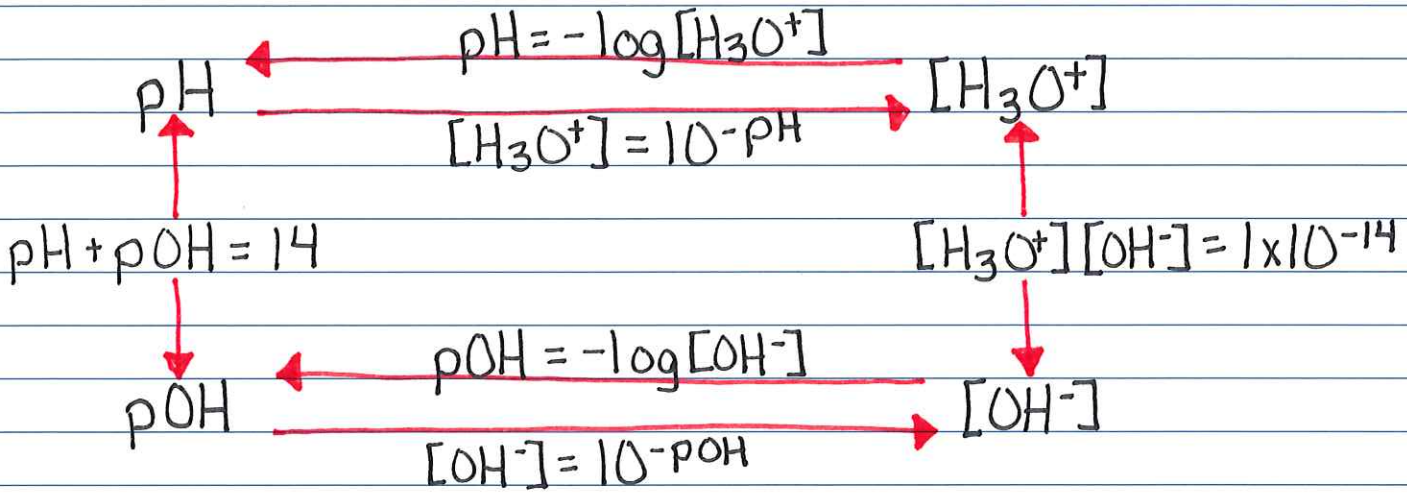
17) $\underset{B}{PO_4^{3-}} + \underset{A}{H_3O^+} \rightarrow \underset{CB}{H_2O} + \underset{CA}{HPO_4^{2-}}$

18) $\underset{A}{HS^-} + \underset{B}{OH^-} \rightarrow \underset{CA}{H_2O} + \underset{CB}{S^{2-}}$

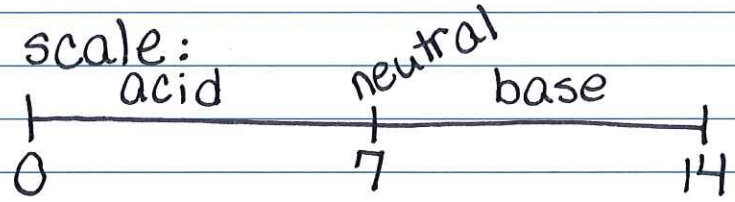
pH Calculations

- Units:
  - pH = measure of acidity
  - pOH = measure of basicity
  - $[H_3O^+]$ = concentration (molarity) of hydronium
  - $[OH^-]$ = concentration (molarity) of hydroxide

- Converting from One Unit to Another:



- pH scale:



pH is a logarithmic scale - ever unit on the scale represents a x10 change.
ex. pH 5 vs. pH 6 : pH 5 is 10x more acidic than pH 6

pH Calculation

ex. What is the pH of a soln. made by dissolving 2.5g NaOH in 400mL of water

$$2.5\text{g NaOH} \times \frac{1\text{mol}}{40\text{g}} = 0.0625\text{mol NaOH}$$

$$M = \frac{\text{mol}}{L} = \frac{.0625\text{ mol}}{.4\text{L}} = .15625M$$

$$pOH = -\log[OH]$$
$$= -\log[.15625] = 0.8$$

$$pH = 14 - .8 = 13.2$$

ex. One gram of concentrated H_2SO_4 is diluted to a volume of 1L with water. What is the molar concentration of the hydrogen ion in this solution? What is the pH?

$$1\text{g } H_2SO_4 \times \frac{1\text{mol}}{98\text{g}} = 0.010\text{mol } H_2SO_4$$

$H_2SO_4 \rightarrow H^+ + HSO_4^-$ and $HSO_4^- \rightarrow H^+ + SO_4^{2-}$

Overall: Assume

$$H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$$
$$0.010M \qquad .020M$$

$$pH = -\log[H^+]$$
$$= -\log[.020] = 1.7$$

pH calculations

ex. Find $[OH^-]$ of 3.0×10^{-2} M HCl

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

3.0×10^{-2} M 3.0×10^{-2} M

$$[H^+][OH^-] = 1 \times 10^{-14}$$
$$[3 \times 10^{-2}][OH^-] = 1 \times 10^{-14}$$
$$[OH^-] = 3.3 \times 10^{-13} M$$

ex. The pH of coke is 3.12. Find $[H^+]$

$$[H^+] = 10^{-pH} = 10^{-3.12} = 7.6 \times 10^{-4} M$$

ex. Given 0.050M HNO_3, find pH

$$pH = -\log[H^+]$$
$$= -\log(.050) = 1.3$$

ex. Find pH of 0.050M HNO_3

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

$= -\log[.050]$

$pH =$

ex. What is molarity of HBr in a solution with pOH = 9.6?

$pH + pOH = 14$

$pH = 4.4$

$[H_3O^+] = 10^{-pH}$

$= 10^{-4.4}$

$[H_3O^+] = 4.0 \times 10^{-5} M$

Acid Dissociation Examples

ex. $H_3PO_4 \rightarrow 3H^+ + PO_4^{3-}$

The pH of the soln. is 2.1. Find the molarity of $[H_3PO_4]$

$[H^+] = 10^{-2.1} = 7.94 \times 10^{-3} M$

$H_3PO_4 : H^+$

1 : 3 ratio

$$\frac{7.94 \times 10^{-3} M}{3} = 0.00265 M \; H_3PO_4$$

ex. How many grams of $Mg(OH)_2$ are needed to add to 500. mL H_2O to yield a pH of 10.0

$Mg(OH)_2 \rightarrow Mg^{2+} + 2OH^-$

pOH = 4.0

$[OH] = 10^{-4.0} = 1 \times 10^{-4} M$

$Mg(OH)_2 : OH$

1 : 2

$$[Mg(OH)_2] = \frac{1 \times 10^{-4} M}{2} = 5 \times 10^{-5} M$$

$$M = \frac{mol}{L} \qquad 5 \times 10^{-5} M = \frac{x}{.5L}$$

$$x = 2.5 \times 10^{-5} \text{ mol } Mg(OH)_2 \times \frac{58 g}{1 mol} = .00145 g \; Mg(OH)_2$$

Acid Base Equilibria

S16 Exp 7D #1-2 Report

~~F15~~ Week 11 Assessment

Name: _____KEY_____ Table No. _____

Strong acid example

1. Determine the pH of a 0.25 M solution of HCl.
   a) Put the Equation for the reaction of HCl with water in this box then fill in the ICE table below it:

	$HCl\ (aq) + H_2O\ (l) \rightleftharpoons H_3O^+\ (aq) + Cl^-\ (aq)$			
M (conc)				
Initial	0.25 M	---	0	0
Change	-X	---	+X	+X
Equilibrium	0.25 M – 0.25M = ~0 (negligible)	---	0.25 M	0.25 M

   b) Is HCl a strong acid? Yes, so X = 0.25 M
   c) What will be the $[H_3O^+]$ at equilibrium? 0.25 M
   d) What is the pH of the 0.25 M solution? (show work) $pH = -\log[H_3O^+] = -\log(0.25) = 0.60_2$

Weak acid example- use ICE table

2. Determine the pH of a 0.25 M solution of HOCl. $K_a = 2.5 \times 10^{-8}$
   a) Put the Equation for the reaction of HOCl with water in this box then fill in the ICE table below it:

	$HOCl\ (aq) + H_2O\ (l) \rightleftharpoons H_3O^+\ (aq) + OCl^-\ (aq)$			
M (conc)				
Initial	0.25 M	---	0	0
Change	-X	---	+X	+X
Equilibrium	0.25 M – X	---	X	X

   b) Is HOCl a strong acid? No, it is weak $K_a = 2.5 \times 10^{-8}$
   c) What is equilibrium expression for this reaction?

$$K_a = \frac{[H_3O^+][OCl^-]}{[HOCl]}$$

   d) Use the data table to substitute concentrations into the equilibrium expression and solve for X (Show work and assume that x is very small compared to 0.25 M)

$$K_a = 2.5 \times 10^{-8} = \frac{[H_3O^+][OCl^-]}{[HOCl]} = \frac{X^2}{(0.25 - X)} \cong \frac{X^2}{0.25} \qquad X = \sqrt{(0.25)(2.5 \times 10^{-8})} = 7.9_1 \times 10^{-5}$$

   e) What is 5% of 0.25 M? $(0.05 * 0.25M) = 0.0125\ M = 1.25 \times 10^{-2}\ M$
   f) Is your X in part D smaller than 5% of 0.25M? Yes. Was your assumption in part d valid? Yes, $7.9 \times 10^{-5} < 1.25 \times 10^{-2}\ M$
   g) What is the pH of the 0.25 M solution of HOCl? (show work)
   $pH = -\log[H_3O^+] = -\log(7.9 \times 10^{-5}) = 4.10_2$

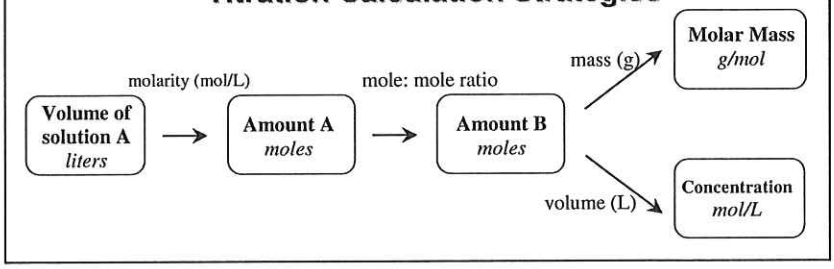
Acid-Base Titrations

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.

Titration Calculation Strategies



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)

$$\frac{0.165\ \text{L}\ \cancel{\text{KOH}}}{1} \times \frac{0.15\ \text{mol}\ \cancel{\text{KOH}}}{1\ \text{L}\ \cancel{\text{KOH}}} \times \frac{1\ \text{mol}\ \text{H}_2\text{A}}{2\ \text{mol}\ \cancel{\text{KOH}}} \times \frac{1}{0.0100\ \text{L}\ \text{H}_2\text{A}} = 1.2\ \frac{\text{mol}\ \text{H}_2\text{A}}{\text{L}\ \text{H}_2\text{A}}$$

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?

   $$H_2C_4H_4O_6 + 2\ NaOH \rightarrow Na_2C_4H_4O_6 + 2\ H_2O$$

Post Lab

Acid - Base Titrations

(1) $HA + NaOH \rightarrow NaA + H_2O$

0.578g HA, 31.11mL of 0.206M NaOH $MM_{HA} = ?$

$$\frac{1}{0.03111\,\cancel{L\,NaOH}} \times \frac{1\,\cancel{L\,NaOH}}{0.206\,\cancel{mol\,NaOH}} \times \frac{1\,\cancel{mol\,NaOH}}{1\,mol\,HA} \times \frac{0.578g\,HA}{1} = 90.19\,\frac{g}{mol}$$

(2) $HNO_3 + NaOH \rightarrow NaNO_3 + H_2O$

25.0mL acid, 10mL of 0.12 M NaOH

$$0.01\,\cancel{L\,NaOH} \times \frac{0.12\,\cancel{mol\,NaOH}}{1\,\cancel{L\,NaOH}} \times \frac{1\,mol\,HNO_3}{1\,\cancel{mol\,NaOH}} \times \frac{1}{0.025\,\cancel{L}\,HNO_3}$$

$$= 0.048\,\frac{mol\,HNO_3}{L} = 0.048\,M$$

(3) $H_2A + 2LiOH \rightarrow Li_2A + 2H_2O$

0.965g Acid, 45.91mL of 0.404 M LiOH $MM_{Acid} = ?$

$$\frac{1}{0.04591\,\cancel{L\,LiOH}} \times \frac{1\,\cancel{L\,LiOH}}{0.404\,mol\,\cancel{LiOH}} \times \frac{2\,mol\,\cancel{LiOH}}{1\,mol\,Acid} \times \frac{0.965g\,acid}{1\,\cancel{mol}} = 104.06\,g/mol$$

(4) $H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$

40.00 mL acid, 328.4mL of 0.75 M KOH Con. mol/L = ?

$$0.3284\,\cancel{L} \times \frac{0.75\,\cancel{mol\,KOH}}{\cancel{L}} \times \frac{1\,mol\,H_2SO_4}{2\,\cancel{mol\,KOH}} \times \frac{1}{0.04000\,L\,Acid} = 3.078\,M$$

(5) $H_3A + 3NaOH \longrightarrow Na_3A + 3H_2O$

1.42g Acid, 157mL of 0.4388M NaOH $\quad MM_{acid} = ?$

$$\frac{1}{0.157\,\cancel{L\ NaOH}} \times \frac{1\,\cancel{L\ NaOH}}{0.4388\,\cancel{mol\ NaOH}} \times \frac{3\,\cancel{mol\ NaOH}}{1\ mol\ H_3A} \times \frac{1.42g\ H_3A}{1}$$

$$= 61.84\ g/mol$$

(6) $H_2C_4H_4O_6 + 2NaOH \longrightarrow Na_2C_4H_4O_6 + 2H_2O$

3.0g acid, 45mL base $\quad [NaOH] = ?$

H_6 : 6.06
C_4 : 48.01
O_6 : 96.00
150.01

$$3.0g\ acid \times \frac{\cancel{2}\ mol\ base}{1\ mol\ acid}$$

$$\frac{1}{0.045\,\cancel{L\ base}} \times \frac{1\,\cancel{L\ base}}{x\ mol\ base} \times \frac{2\,\cancel{mol\ base}}{1\ mol\ acid} \times \frac{3.0g\ \cancel{acid}}{} \times \frac{\ mol}{150.01g}$$

$\Rightarrow \quad x = 0.888\ M$

$$3.0g\ acid \times \frac{1\ mol\ acid}{150.01g\ acid} \times \frac{2\ mol\ NaOH}{1\ mol\ acid} = 0.04\ mol\ NaOH$$

$$\frac{0.04\ mol\ NaOH}{0.045\ mL\ NaOH} = 0.889\ M\ NaOH$$