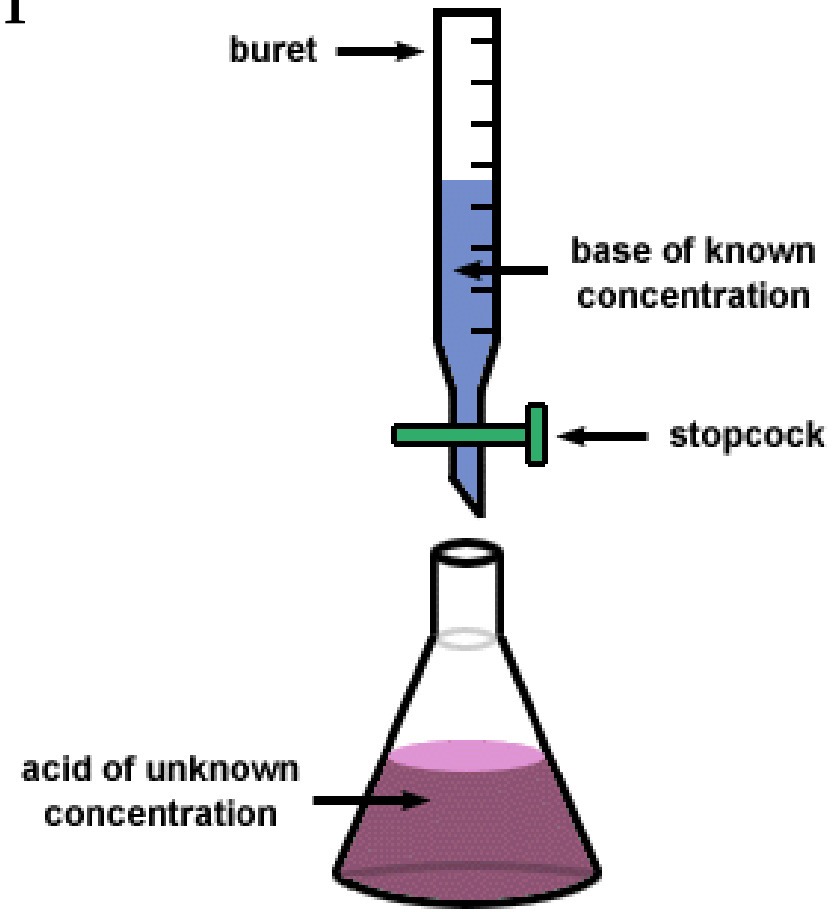
[7.6]
Molarity and Titrations

Hebden Textbook: pg. 129 - 131



What if we don't know the concentration of a solution?

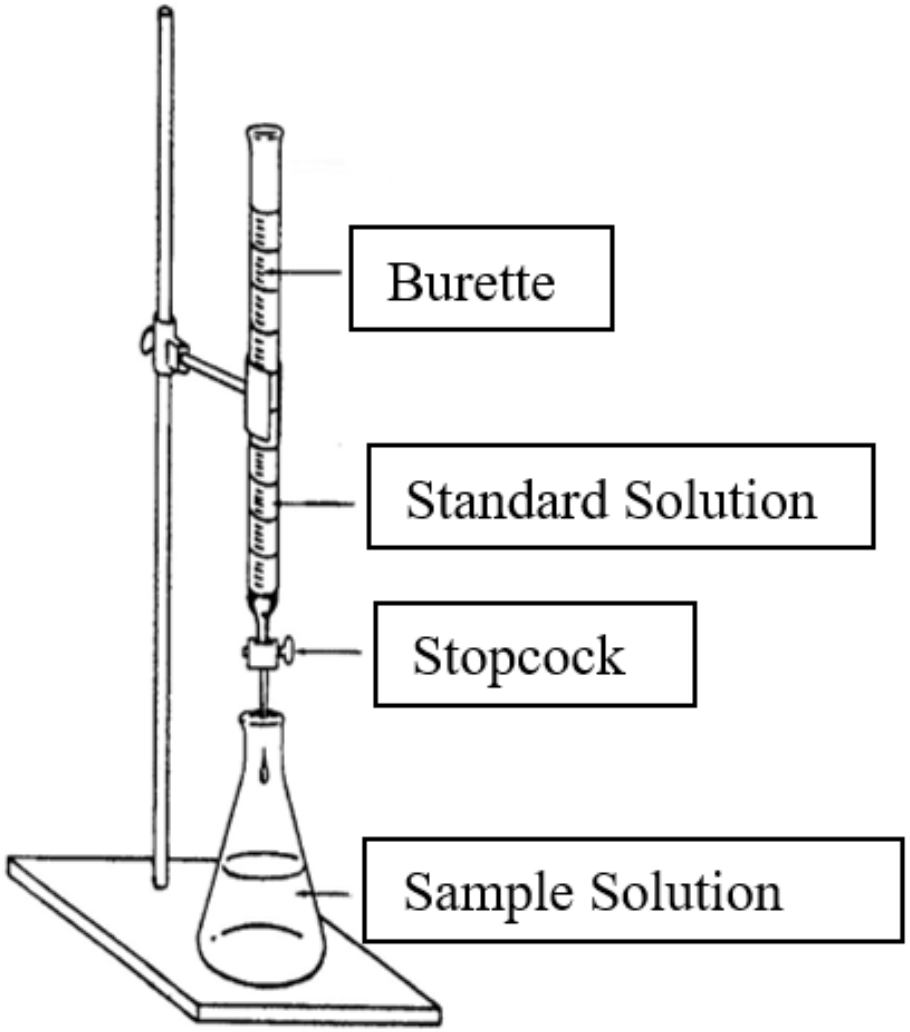
- To determine the **molarity** of a concentration **(浓度)** by stoichiometry, one common application is by the method called **titration**.

What if we don't know the concentration of a solution?

- **Note:** When we deal with **liquid volume**, we **cannot** use **22.4L/mol**. This conversion factor is used **only** for **gases at STP**.

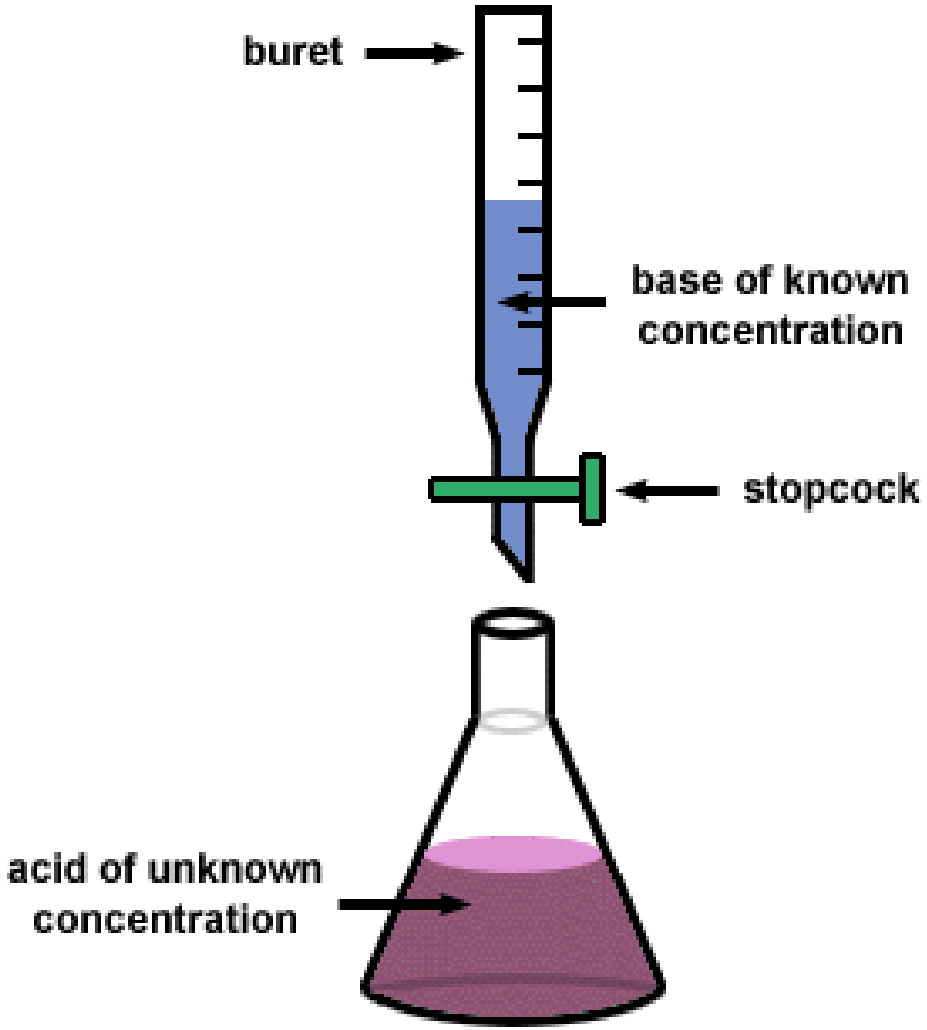
- **Remember:** When you see a chemical formula written in square brackets (example: **$[H_2SO_4]$**) This means that it is the molar concentration (units mol/L)

Titration



- **Titration**: A process used to determine the **concentration** of a solution.
- Titrations are used to find the **unknown** concentration of a chemical in a solution.
- The **known solution** is called the **standard** solution. It is in the **burette** (the long tube). The solution in the flask has an unknown concentration, it is called the **sample**

Titration

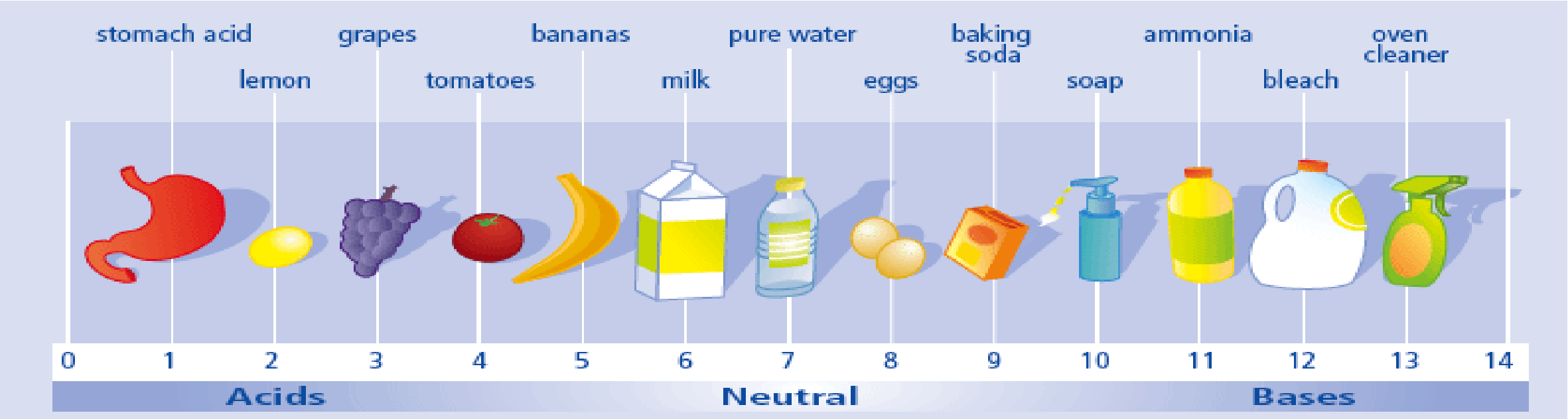


- The solutions react until the **equivalence point.** is reached. At this point, the moles of the **standard** solution **equals** the moles of the **unknown** solution, using a **ration in the given equation.**
- Eg. **$H_2SO_4 + 2\ NaOH \rightarrow Na_2SO_4 + H_2O$**
- The equivalence point is the point when exactly 1 mole of H_2SO_4 has reacted for every 2 moles of NaOH.
- The equivalence point is shown by a **color change**
- The color change is caused by an **indicator** that is in the sample solution.

Indicators

Indicators are based on the pH scale

pH: “power of Hydrogen”

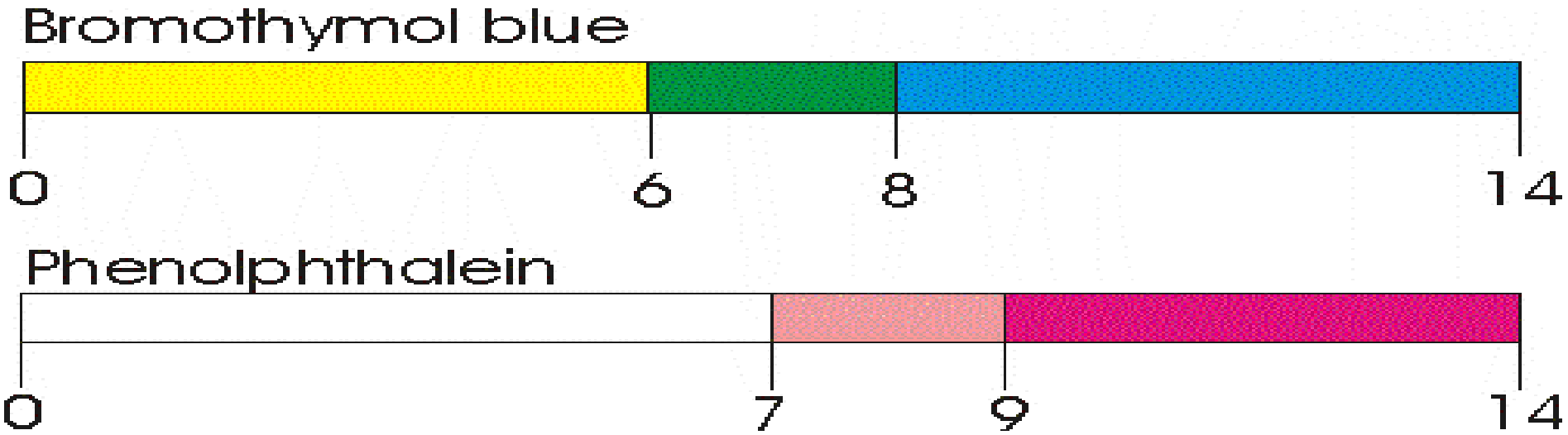


Acidic	Neutral	Basic
$[H^+] > [OH^-]$	$[H^+] = [OH^-]$	$[H^+] < [OH^-]$

Indicators

Phenolphthalein

Bromothymol Blue



Titration Calculations

- **Basically, this type of problem is a stoichiometry question in which you must use molarity at the beginning and the end of the question.**

- **<u>The 3-Steps To Solve the Problem:</u>**

<u>Step 1:</u> Units given in the question → Mole

<u>Step 2:</u> Mole Ratio (between the given and unknown)

<u>Step 3:</u> Mole of Unknown → molar concentration **(浓度)** of Unknown

Practice Problem #1

- A 10.00 mL sample of H_2SO_4 is titrated **(This means it is located in the flask)** with 15.55 mL of a 0.1000 M NaOH solution **(The standard is always located in the burette)**. What is the $[H_2SO_4]$? (Remember: Square brackets means you are asked to find the molar concentration, mol/L)

$$\mathbf{H_2SO_4 + 2\ NaOH \rightarrow Na_2SO_4 + 2\ H_2O}$$

	Concentration	**Volume**
Sample Solution		
Standard Solution		
Mole Ratio at the Equivalence Point		

Practice Problem #1

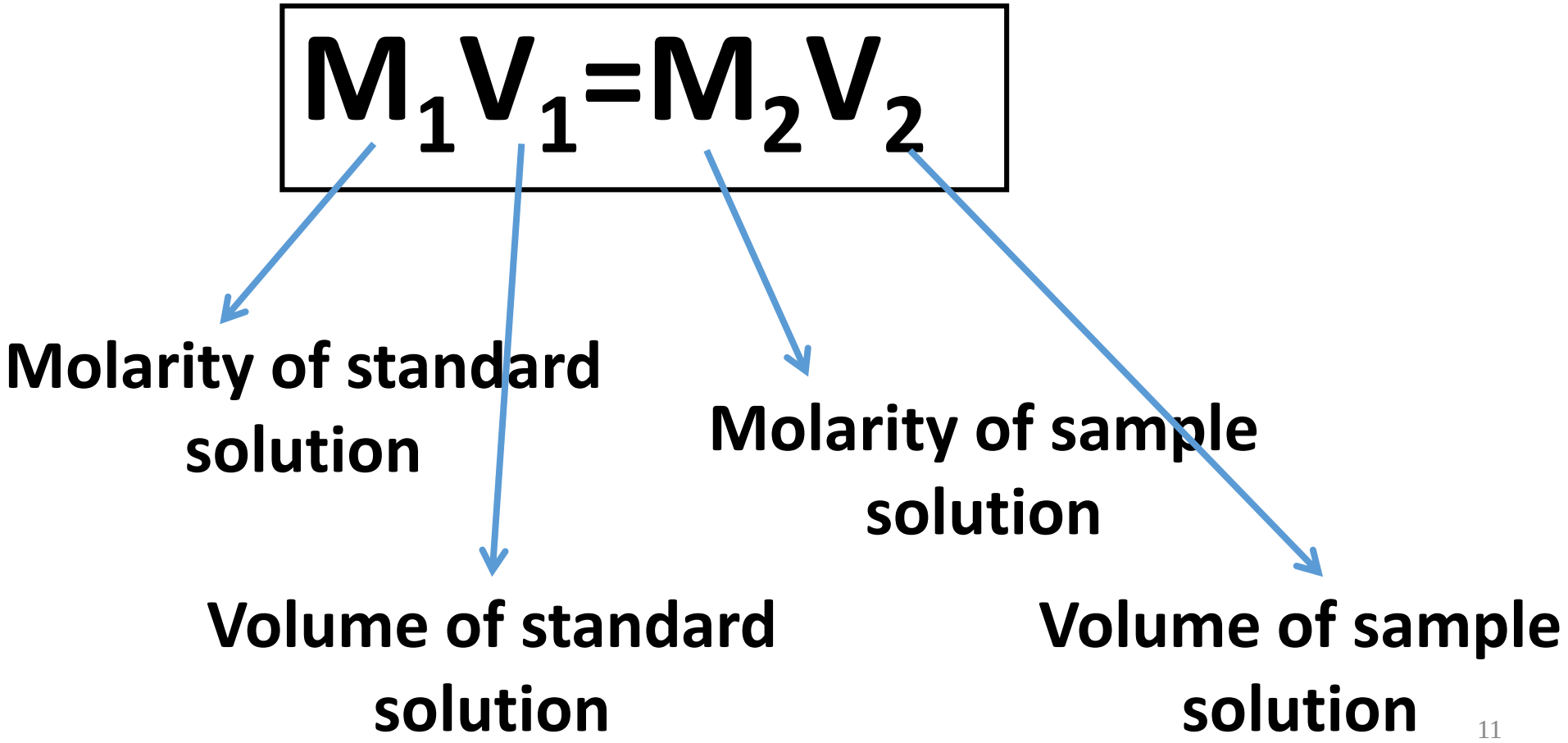
- A 10.00 mL sample of H_2SO_4 is titrated **(This means it is located in the flask)** with 15.55 mL of a 0.1000 M NaOH solution **(The standard is always located in the burette)**. What is the $[H_2SO_4]$? (Remember: Square brackets means you are asked to find the molar concentration, mol/L)

$$\mathbf{H_2SO_4 + 2\ NaOH \rightarrow Na_2SO_4 + 2\ H_2O}$$

	Concentration	**Volume**
Sample Solution		0.01000 L
Standard Solution	0.1000 M	0.01555 L
Mole Ratio at the Equivalence Point		

Practice Problem #1

Solve using this equation:



Practice Problem #1

1. $M_1V_1=M_2V_2$
2. $(0.1000 \text{ mol NaOH/L})(0.01555\text{L}) = M_2(0.01000\text{L})$

*We are solving for the molarity of H_2SO_4 so we need to convert the moles of NaOH to moles of H_2SO_4.

4. $\left(\frac{1 \text{ mol } H_2SO_4}{2 \text{ mol NaOH}}\right) (0.1000 \text{ mol NaOH/L})(0.01555\text{L}) = M_2(0.01000\text{L})$

5. 7.775×10^{-1} M $H_2SO_4 = M_2$

Practice Problem #1

- A 10.00 mL sample of H_2SO_4 is titrated **(This means it is located in the flask)** with 15.55 mL of a 0.1000 M NaOH solution **(The standard is always located in the burette)**. What is the $[H_2SO_4]$? (Remember: Square brackets means you are asked to find the molar concentration, mol/L)

$$\mathbf{H_2SO_4 + 2\ NaOH \rightarrow Na_2SO_4 + 2\ H_2O}$$

	Concentration	**Volume**
Sample Solution	7.775×10^{-1} M H_2SO_4	0.01000 L
Standard Solution	0.1000 M	0.01555 L
Mole Ratio at the Equivalence Point	1:2	

Practice Problem #2

- A solution of HCl of unknown concentration was titrated with 0.150 M $Ba(OH)_2$. The equivalence point is reached when 14.83 mL of $Ba(OH)_2$ is added to 50.00 mL of the HCl solution. Find the [HCl] in the original sample.

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

Practice Problem #2

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

Practice Problem #2

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

1. $M_1V_1=M_2V_2$
2. $(0.150 \text{ mol } Ba(OH)_2/L)(0.01483L) = M_2(0.05000L)$

*We are solving for the molarity of HCl so we need to convert the moles of $Ba(OH)_2$ to moles of HCl.

4. $\left(\frac{2 \text{ mol HCl}}{1 \text{ mol } Ba(OH)_2}\right)(0.150 \text{ mol } Ba(OH)_2/L)(0.01483L) = M_2(0.05000L)$

5. 8.90×10^{-2} M HCl = M_2

Classwork 1:

- A student titrates a 20.00 mL sample of a solution of HBr with unknown molarity according to the following reaction:

$$\mathbf{HBr + NaOH \rightarrow NaBr + H_2O}$$

- The titration requires 20.05 mL of a 0.1819 M solution of NaOH. What is the molarity of the HBr solution?

Classwork 1:

$$HBr + NaOH \rightarrow NaBr + H_2O$$

1. $M_1V_1=M_2V_2$
2. $(0.1819\ mol\ NaOH/L)(0.02005L) = M_2(0.02000L\ HBr)$
4. $\frac{1\ mol\ HBr}{1\ mol\ NaOH}(0.1819\ mol\ NaOH/L)(0.02005L) = M_2(0.02000L\ HBr)$
5. $1.82 \times 10^{-1}\ M\ HBr = M_2$

Classwork 2:

$$H_3PO_4\,(aq) + 3KOH\,(aq) \rightarrow K_3PO_4(aq) + 3H_2O\,(l)$$

- a) If 19.8 ml of H_3PO_4 with an unknown molarity reacts with 25.0 ml of 0.500M KOH, what is the molarity of the H_3PO_4?

- b) What volume of 0.200M KOH is required to react with 125 ml of 0.250 M H_3PO_4 in order to reach the equivalence point?

Classwork 2:

H_3PO_4 (aq) +3KOH (aq) → K_3PO_4(aq) + 3H_2O (l)

- a) If 19.8 ml of H_3PO_4 with an unknown molarity reacts with 25.0 ml of 0.500M KOH, what is the molarity of the H_3PO_4?

HBr + NaOH → NaBr + H_2O

1. **M_1V_1=M_2V_2**
2. **(0.500 mol KOH/L)(0.0250L) = M_2(0.0198 H_3PO_4)**
3. **(1 mol H_3PO_4/ 3 mol KOH)(0.500 mol KOH/L)(0.0250L) = M_2(0.0198 H_3PO_4)**
4. **0.210 M H_3PO_4 = M_2**

HOMEWORK

<u>Textbook</u>: Hebden

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