Name ..... **Unit 10 Notes: Solutions and Acids/Bases** Period _____

SKILLS

1. **Identifying PARTS OF A SOLUTION**
2. **Factors that affect solubility**
3. **Expressing Concentration and using table G**
4. **Calculating Molarity**
5. **Using PPM**
6. **COLLIGATIVE PROPERTIES**
7. **PROPERTIES OF ACIDS AND BASES**
8. **Understand pH scale**
9. **Measuring pH using table M**
10. **Neutralization Reactions**
11. **Titrations**

Vocab **Due Test Day**

Word	Definition
Homogeneous Mixture	
Solution	
Miscible	
Solute	
Solvent	
Saturation	
Molarity	
Acid	
Base	
pH Scale	
Hydronium ion	
Types of Indicators	
Titration	
Neutralization	

Skill 1: Identify parts of a solution

Heterogeneous Mixture – substances in which particles are _____

Homogenous Mixture – substances in which particles are _____

- **Solute:** substances that is being _____
- **Solvent:** substances that _____

SKILL 2: FACTORS THAT EFFECT SOLUBILITY:

Review! Ionic compounds can or cannot be soluble (dissolve in water). If it is soluble the phase is _____, if it is insoluble the phase is _____

Use Table _____ to identify the phase! 1) $PbCO_3$_____ 2) KNO_3 _____

FACTORS AFFECTING Rate of SOLUBILITY (How much it dissolves)

Solubility: _____

Nature of Solute and Solvent: _____

Solution Type	Nonpolar Solvent	Polar Solvent
Nonpolar		
Polar		
Ionic		

1. **Temperature:**
   - Solids: _____ temperature, _____ solubility (more solid will dissolve)
   - Gases: _____ temperature, _____ solubility
2. **Pressure:**
   - Only effects gases in liquids
   - Gases: _____ pressure, _____ solubility

FACTORS AFFECTING RATE OF DISSOLUTION (How quickly it dissolves)

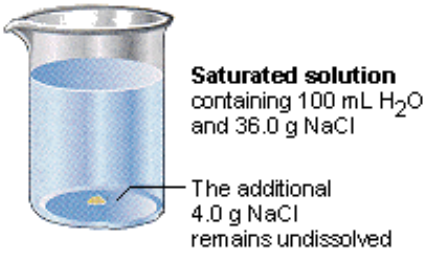
1. **Size of particles:** (_____ surface area, _____ rate of solution)
2. **Amount already dissolved**: (_____ dissolved, _____ rate)
3. **Temperature:**
   a. Solids and Liquids: _____ temperature, _____ rate
   b. Gases: _____ temperature, _____ rate

PRACTICE:

Solute Name	Solute Formula	Temperature		Pressure			Best Solvent	
		Low	High	Low	High	No Effect	H_2O	CCl_4
	KNO_3(s)							

SKILL 3: Expressing concentrations and using table G

1. **Saturated Solution**



- ☐ Solution that contains the _____ amount of _____ at a given temperature
- ☐ Saturated solutions are in _____ (rate of dissolving = rate of recrystallization)

Indicating Behavior: _____

2. **Unsaturated Solution**

- ☐ Solution is holding _____

Indicating Behavior: _____

3. **Supersaturated Solution**

- ☐ Solution is holding _____
- ☐ Unstable…

Indicating Behavior: _____

Using SOLUBILITY CURVES (FOUND ON TABLE _____)

Table G Shows: mass of solute that will dissolve in 100 g (or 100 mL) of water at different temperatures

How to Use Table G to determine saturation at 100g of H_2O:

1) Identify solute line on Table G
2) Find interception point between GRAMS given and Temperature
   Below Curve = _____
   On Curve = _____
   Above Curve = _____

Identify the following as being saturated, unsaturated, or supersaturated:

a. 20 °C and 20 g of KNO_3 _____

b. 40 °C and 20 g of $KClO_3$ _____

c. 90 °C and 10 g of NH_3 _____

d. 80 g $NaNO_3$ in 100 g H_2O at 10°C _____

e. 75 g $NaNO_3$ in 100 g H_2O at 10°C _____

How to Use Table G to determine saturation at 200g of H_2O:

3) Identify solute line on Table G
4) Determine the number of grams to saturate at 100g
5) Double the number of grams needed for saturation (b/c H_2O is doubled)
   Below Curve = _____
   On Curve = _____
   Above Curve = _____

Extension: Get to saturation… find difference between given and needed amount!

Grams Solute per 200 g H_2O	Saturation?		Grams Solute per 200 g H_2O	Solute Added to make Saturated	Grams Solute per 100 g H_2O	Solute Added to make Saturated
e. 70 g NaCl at 90ºC			i. 25 g NH_3 at 5ºC		a. 35 g KNO_3 at 40ºC	
f. 10 g NH_3 at 90ºC			j. 30 g $NaNO_3$ at 50ºC		b. 50 g NH_3 at 10ºC	

How much will crystallize out of solution?

1) Identify solute line on Table G
2) Determine the number of grams to saturate at 100g at initial temperature
3) Determine the number of grams to saturate at 100g at final temperature
4) Find the difference between these values. This is how much will solidify given the temperature decrease.

Tell how many grams of each solute will <u>crystallize/precipitate/settle.</u> Assume all solutions are saturated and in 100 grams of H_2O.

Amount cooled	Amount Precipitated		Amount cooled	Amount Precipitated
a. KNO_3 (aq) is cooled from 70ºC to 40ºC			e. NaCl (aq) is cooled from 100ºC to 40ºC	
b. NH_4Cl (aq) is cooled from 90ºC to 20ºC			f. KNO_3 (aq) is cooled from 65ºC to 25ºC	

Skill 4: Calculating Molarity

- **Concentration:**_____
- **Molarity**:_____

Equation (See Ref. Tabs.)

Examples:

1) What is molarity of a solution that contains 4.0 mol of NaOH in 0.50 L of solution?

2) Calculate the molarity of 2.0 moles of HCl dissolved in 500. mL solution.

3) Calculate the molarity of each of the following solutions:

(a) 2.5 mol of NaOH in 0.500 L of solution

(b) 1.8L of solution containing 3.3 mol KNO_3

4) Calculate the total moles of solute in each of the following solutions:

(a) 1.7 L of 0.35M NaOH

(b) 50 mL of 3.3-molar KNO_3

(c) 5.0 L of 1.25 M NaOH

(d) 116 mL of 1.5 M K_2SO_4

Molarity from Grams (If you are given grams instead of moles):

What is the molarity of a solution containing 82.0 g of $Ca(NO_3)_2$ in 2.0 L of solution?

Step 1: Convert grams to moles by finding the GFM

Step 2: Use the molarity equation

a) There is a 0.250 L solution with 53 g of Na_2CO_3 completely dissolved. What is the molarity of the solution?

b) What is the Molarity of 30. g of NaOH in 0.500 L of solution

How to Make a Solution:

What mass of sodium carbonate is required to prepare 2.00 L of 0.250 M Na_2CO_3 solution?

Step 1: Find out how many moles are needed

Step 2: Convert moles to grams

Calculate the total grams of solute in each of the following solutions:

(a) 1.0 L of 0.5 M $CaCl_2$

(b) 500 mL of 3.3-molar KNO_3

Skill 5: Using Parts Per Million to describe Molarity

Parts Per Million (ppm): _____

Equation (See Ref. Tabs.)

Example 1: Approximately 0.0043 g of oxygen can be dissolved in 100. mL of water at 20°C. Express this in terms of parts per million.

Example 2: 2.5 grams of a groundwater solution are found to contain 5.4×10^{-6} grams of the Cu^{+2} ion. What is the concentration of the copper ion in ppm?

1. **Calculate the concentration of chlorine in a swimming pool if there is 0.02 g of chlorine in 10,000 g of pool water.**

2. **Exposure to lead has been linked to delays in physical and mental development and attention deficit disorders in children as well as kidney problems in adults. One source of this toxic heavy metal is drinking water in older homes whose plumbing contains lead. Water with a lead concentration of below 0.015ppm is considered safe to drink. A 100 g water sample taken from a home contains 1.2×10^{-6} grams of lead. Is this water considered safe to drink?**

3. The health of fish depends on the amount of oxygen dissolved in the water. A dissolved oxygen (DO) concentration between 6 parts per million and 8 parts per million is best for fish health. A DO concentration greater than 1 part per million is necessary for fish survival. Fish health is also affected by water temperature and concentrations of dissolved ammonia, hydrogen sulfide, chloride compounds, and nitrate compounds.

   A student's fish tank contains fish, green plants, and 3800 grams of fish-tank water with 2.7×10^{-2} gram of dissolved oxygen.

   a.) State how an increase in the temperature of the fish-tank water affects the solubility of oxygen in the water.

   b.) Determine if the DO concentration in the fish tank is healthy for fish in terms of ppm.

   c.) Explain, in terms of molecular polarity, why oxygen gas has low solubility in water. Your response must include *both* oxygen and water.

   d.) Under what kind of conditions of temperature and pressure would oxygen gas be most soluble in water?

   e.) An aqueous solution has a concentration of 7 ppm of oxygen dissolved in 1000. grams of water. Calculate the amount of oxygen in the solution in grams. Your response must include *both* a correct numerical setup and the calculated result.

4. A safe level of fluoride ions is added to many public drinking water supplies. Fluoride ions have been found to help prevent tooth decay. Another common source of fluoride ions is toothpaste. One of the fluoride compounds used in toothpaste is tin(II) fluoride.

   A town located downstream from a chemical plant was concerned about fluoride ions from the plant leaking into its drinking water. According to the Environmental Protection Agency, the fluoride ion concentration in drinking water cannot exceed 4 ppm. The town hired a chemist to analyze its water. The chemist determined that a 175-gram sample of the town's water contains 0.000 250 gram of fluoride ions.

   a. What is the chemical formula for tin(II) fluoride?

   b. How many parts per million of fluoride ions are present in the analyzed sample?

Skill 6: COLLIGATIVE PROPERTIES FOR ELECTROLYTES

Electrolyte = A substance that produces _____ when dissolved in a solution. Because the ions are FREE TO MOVE AROUND (_____) in the solution, the solution is able to _____ electricity (salts).

When a solute is dissolved in a solvent, solvent molecules surround the particles of the solute. This causes the boiling point and freezing point of the solution to change in a very specific and predictable way.

Boiling Point Elevation = b.p. _____ when solute is added

Ex: Adding salt to water allows you to boil pasta at 102-103 ^{0} C (cooks it faster)

Freezing Point Depression = f.p. _____ when solute is added

Ex: Putting salt on roads causes ice to melt because it drops freezing point below 0^{o}C.

IONIC VS MOLECULAR SOLUTES: Why do we salt the roads in the winter rather than sugar them!

	MOLECULAR/ Covalent: $C_{12}H_{22}O_{11}$	**IONIC: Salt (NaCl)**
Reaction in water		
# of Moles Produced		
General Rule: The solute that dissolves to form a greater number of products (ions) will have a greater f.p. depression **(f.p. will decrease by more)** and a greater boiling point elevation **(b.p. will increase by more**)		

$CaCl_2$ i$ even better than NaCl, $o why don't we u$e it to $alt our road$? Becau$e _____

1) Which of the following solutions will boil at the highest temperature?

a) 100 g NaCl in 1000 g of water
b) 100 g NaCl in 500 g water
c) 100 g NaCl in 250 g of water
d) 100 g NaCl in 125 g of water

2) Which solution has the highest boiling point?

a) 1.0 M KNO3
b) 2.0 M KNO3
c) 3.0 M C6H12O6
d) 2.0 M Ca(NO3)2

3) Which of the following solutions will freeze at the lowest temperature?

a) 100 g NaCl in 150 g of water
b) 100 g NaCl in 600 g water
c) 100 g NaCl in 125 g of water
d) 100 g NaCl in 250 g of water

Time for some Ice Cream!!

PROPERTIES OF SOLUTIONS PRACTICE QUESTIONS

1. Which solution has the highest boiling point?
   (1) 0.5 M NaCl
   (2) 0.5 M $CaCl_2$
   (3) 1.0 M $(NH_4)_3PO_4$
   (4) 2.0 M CH_3OH

2. Compared to pure water, an aqueous solution of calcium chloride has a
   (1) higher boiling point and higher freezing point
   (2) higher boiling point and lower freezing point
   (3) lower boiling point and higher freezing point
   (4) lower boiling point and lower freezing point

3. Which solution has the highest boiling point?
   (1) 1.0 M KNO_3
   (2) 2.0 M KNO_3
   (3) 1.0 M $Ca(NO_3)_2$
   (4) 2.0 M $Ca(NO_3)_2$

4. Which solution has the *lowest* freezing point?
   (1) 10. g of KI dissolved in 100. g of water
   (2) 30. g of KI dissolved in 100. g of water
   (3) 20. g of KI dissolved in 200. g of water
   (4) 40. g of KI dissolved in 200. g of water

5. As water is added to a 0.10 M NaCl aqueous solution, the conductivity of the resulting solution
   (1) decreases because the concentration of ions decreases
   (2) decreases, but the concentration of ions remains the same
   (3) increases because the concentration of ions decreases
   (4) increases, but the concentration of ions remains the same

6. Which aqueous solution of KI freezes at the lowest temperature?
   (1) 1 mol of KI in 500. g of water
   (2) 2 mol of KI in 500. g of water
   (3) 1 mol of KI in 1000. g of water
   (4) 2 mol of KI in 1000. g of water

7. Compared to a 5.0 M aqueous solution of KCl at 1 atmosphere, a 2.0 M aqueous solution of KCl at 1 atmosphere has a
   (1) lower boiling point and a higher freezing point
   (2) lower boiling point and a lower freezing point
   (3) higher boiling point and a higher freezing point
   (4) higher boiling point and a lower freezing point

8. Based on Reference Table F, which of these saturated solutions has the lowest concentration of dissolved ions?
   (1) NaCl(aq)
   (2) $MgCl_2$(aq)
   (3) $NiCl_2$(aq)
   (4) AgCl(aq)

9. Compared to a 0.1 M aqueous solution of NaCl, a 0.8 M aqueous solution of NaCl has a
   (1) higher boiling point and a higher freezing point
   (2) higher boiling point and a lower freezing point
   (3) lower boiling point and a higher freezing point
   (4) lower boiling point and a lower freezing point

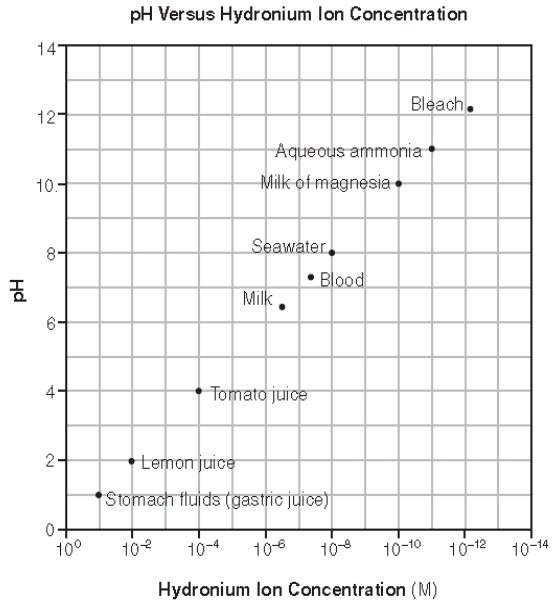
Skill 7: Properties of Acids & Bases

	Acids	Bases
Arrhenius Definition	**Substances that produce** **Ex:** **$HCl + H_2O \rightarrow H_3O^+ + Cl^-$**	**Substances that produce** **Ex:** **NaOH is a base**
Alternate Definition		
	Ex: **NH_3 + HOH → NH_4^+ + OH^-** **H+ ACCEPTOR** **H+ DONOR** E Dot Structures:	
General Formula	**C_xH_yCOOH**	***NH_3 is an exception**
Examples		
Electrolytes? (conduct electricity in solution?)		
pH	1 2 3 4 5 6 7	7 8 9 10 11 12 13 14 **WEAK BASE** **STRONG BASE**

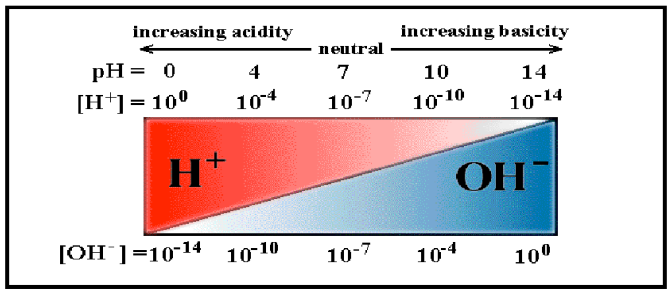
H+ and Hydronium	**Hydroxide**

Skill 8: Interpret the pH scale

- ☐ The pH scale is a measure of the _____in a solution, Write concentration _____
- ☐"pH" stands for _____
- ☐ **Acids have a _____pH** (a _____potential to attract H^+ ions (_____**)**
- ☐ **Bases have a _____ pH** (a _____ potential to attract H^+ ions **(bases are H^+ _____)**
- ☐ The pH scale is **logarithmic**, which means that a change of ***ONE*** pH unit will change the concentration of H^+ by a factor of _____
- ☐ The hydrogen ion concentration changes by a factor of _____ for EACH change of _____ pH unit



What is the relationship between pH value and hydrogen ion concentration?



More Acidic or More Basic?

	If an ACID is added…	If a BASE is added…
pH		
$[H^+]$ or $[H_3O^+]$		
$[OH^-]$		
Solution becomes…		

The pH is correlated to the concentration of H^+

pH	H^+ Concentration	Acidic or Basic
3		
7		
11		

Practice:

How much does the hydrogen/hydronium ion concentration change when the pH changes?

- ☐ increasing or decreasing the pH by 1 changes the $[H^+]$ by a factor of _____
- ☐ increasing or decreasing the pH by 2 changes the $[H^+]$ by a factor of _____
- ☐ increasing or decreasing the pH by 3 changes the $[H^+]$ by a factor of _____

Ex: Describe what happens to the concentration of hydrogen ions in a solution if the pH is changed from 7 to 5.

Ex: Describe what is happening to the concentration of hydrogen ions in a solution if the pH is changed from 5 to 8.

pH Change	$[H_3O^+]$ increase or decrease?	$[OH^-]$ increase or decrease?	Does the solution become more acidic or basic?	By a factor of…
6 to 8				
8 to 5				
3 to 7				
11 to 9				
14 to 13				
4 to 8				

1. Which change in pH represents a hundredfold increase in the concentration of hydronium ions in a solution?
   (1) pH 1 to pH 2 (3) pH 2 to pH 1
   (2) pH 3 to pH 5 (4) pH 5 to pH 3

2. The pH of an aqueous solution changes from 4 to 3 when the hydrogen ion concentration in the solution is
   (1) decreased by a factor of 100
   (2) decreased by a factor of 10
   (3) increased by a factor of 100
   (4) increased by a factor of 10

3. Solution A has a pH of 3 and solution Z has a pH of 6. How many times greater is the hydronium ion concentration in solution A than the hydronium ion concentration in solution Z?
   (1) 100 (3) 3
   (2) 2 (4) 1000

4. What is the pH of a solution that has a hydronium ion concentration 100 times greater than a solution with a pH of 4?
   (1) 5 (3) 3
   (2) 2 (4) 6

Skill 9: How to Measure pH—Using Table M

How to use Table M:

- ☐ If the pH is below the first number, the solution will be _____
- ☐ If the pH is above the second number, the solution will be _____
- ☐ If the pH is between the numbers, the solution will be a _____

Indicator	Approximate pH Range for Color Change	Color Change
methyl orange	3.1–4.4	red to yellow
bromthymol blue	6.0–7.6	yellow to blue
phenolphthalein	8–9	colorless to pink
litmus	4.5–8.3	red to blue
bromcresol green	3.8–5.4	yellow to blue
thymol blue	8.0–9.6	yellow to blue

Source: *The Merck Index*, 14th ed., 2006, Merck Publishing Group

Ex: If you add bromthymol blue…

- ☐ **to a solution with a pH of 8, it will be** _____
- ☐ **to a solution with a pH of 6, it will be** _____
- ☐ **a solution with a pH of 4, it will be** _____

1. Which indicator, when added to a solution, changes color from yellow to blue as the pH of the solution is changed from 5.5 to 8.0?
   (1) bromcresol green
   (2) bromthymol blue
   (3) litmus
   (4) methyl orange

2. Which indicator would best distinguish between a solution with a pH of 3.5 and a solution with a PH of 5.5?

   (1) bromthymol blue (3) litmus
   (2) bromcresol green (4) thymol blue

3. In which solution will bromcresol green appear blue?
   (1) 1 M NaCl (3) 1 M NH_3
   (2) 1 M H_2CO_3 (4) 1 M CH_3COOH

4. In which solution will thymol blue indicator appear blue?
   (1) 0.1 M CH_3COOH (3) 0.1 M KOH
   (2) 0.1 M HCl (4) 0.1 M H_2SO_4

5. what is the color of the indicator methyl orange in a solution that has a pH of 2?
   (1) blue (3) yellow
   (2) orange (4) red

6. In a solution with a pH of 3, what color is bromcresol green?
   (1) yellow (3) green
   (2) blue (4) red

7. The results of the student's work are recorded in the table below.

Testing Results

Liquid Tested	Color of Blue Litmus Paper	Color of Phenolphthalein Paper	Measured pH Value Using a pH Meter
2% milk	blue	colorless	6.4
distilled water	blue	colorless	7.0
household ammonia	blue	pink	11.5
lemon juice	red	colorless	2.3
tomato juice	red	colorless	4.3
vinegar	red	colorless	3.3

a) Identify the liquid tested that has the lowest hydronium ion concentration.

b) Why is litmus not a good choice to differentiate the acidity levels of tomato juice and vinegar

Skill 10: Neutralization Reactions

- If _____ of acid and base are added together, the resulting solution is _____ (pH) (very important to know!)
- The products of an acid and a base are: A Salt and WATER!!

Ex: $HCl\ (aq) + NaOH\ (aq) \rightarrow NaCl\ (aq) + H_2O\ (l)$

Predict the products of and balance the following reactions:

___ H_2SO_4 (aq) + __ NaOH (aq) → __ _____

___ H_2CO_3 (aq) + ___ $Ca(OH)_2$ (aq) → ____ _____

*Neutralization reactions are a type of _____ reaction

1. What are the products of a reaction between KOH(aq) and HCl(aq)?
   (1) H_2 and KClO
   (2) H_2O and KCl
   (3) KH and HClO
   (4) KOH and HCl

2. Which word equation represents a neutralization reaction?
   (1) base + acid →salt + water
   (2) base + salt →water + acid
   (3) salt + acid →base + water
   (4) salt + water →acid + base

3. Which compound could serve as a reactant in a neutralization reaction?

   (1) NaCl (3) CH_3OH
   (2) KOH (4) CH_3CHO

4. Which substance is always a product when an Arrhenius acid in an aqueous solution reacts with an Arrhenius base in an aqueous solution?
   (1) HBr (3) KBr
   (2) H_2O (4) KOH

5. Which reactants form the salt $CaSO_4(s)$ in a neutralization reaction?

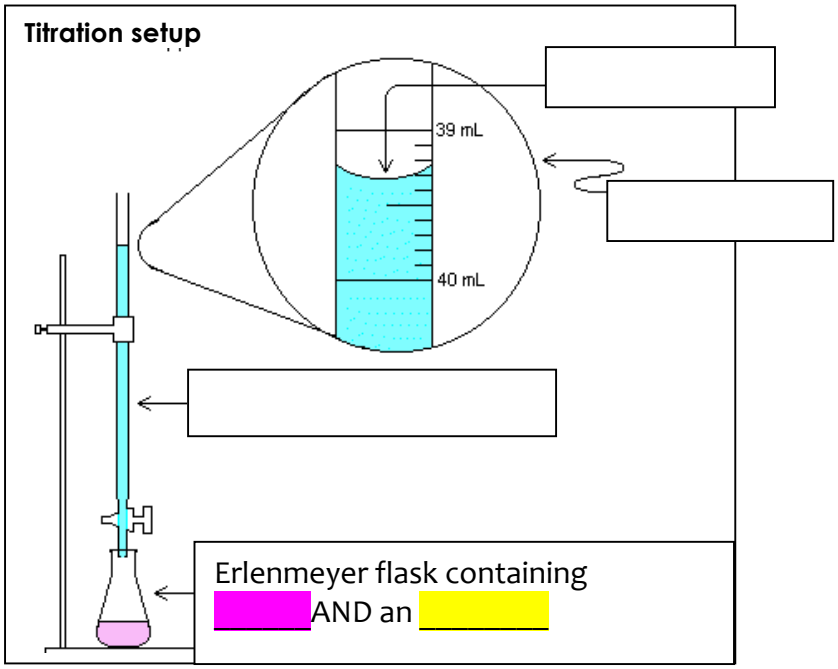
   (1) $H_2S(g)$ and $Ca(ClO_4)_2(s)$
   (2) $H_2SO_3(aq)$ and $Ca(NO_3)_2(aq)$
   (3) $H_2SO_4(aq)$ and $Ca(OH)_2(aq)$
   (4) $SO_2(g)$ and CaO(s

Skill 11: Titrations

☐ _____

☐ _____

_____



☐ Using the equation on **Reference Table T**, you can solve for either the _____

(M) OR the volume (V) of base needed to neutralize an acid

M_A = molarity of H^+ V_A = volume of acid

M_B = molarity of OH^- V_B = volume of base

Ex 1: A 25.0-milliliter sample of HNO_3 (aq) is neutralized by 32.1 milliliters of 0.150 M KOH (aq). What is the concentration of the acid?

$$M_A V_A = M_B V_B$$

Ex 2: How many milliliters of 0.200 M NaOH are needed to neutralize 100. mL of 0.10 M HCl?

$$M_A V_A = M_B V_B$$

Practice:

1. In a titration, 20.0 milliliters of 0.15 M HCl(aq) is exactly neutralized by 18.0 milliliters of KOH(aq).

   (a) Complete the equation below for the neutralization reaction by writing the formula of *each* product.

   $$KOH(aq) + HCl(aq) \rightarrow \_\_\_\_\_ + \_\_\_\_\_$$

   (b) Compare the number of moles of $H^+(aq)$ ions to the number of moles of $OH^-(aq)$ ions in the titration mixture when the HCl(aq) is exactly neutralized by the KOH(aq).

   (c) Determine the concentration of the KOH(aq).

2. In a laboratory activity, 0.500 mole of NaOH(s) is completely dissolved in distilled water to form 400. milliliters of NaOH(aq). This solution is then used to titrate a solution of $HNO_3(aq)$.

   (a) Identify the negative ion produced when the NaOH(s) is dissolved in distilled water.

   _____

   (b) Calculate the molarity of the NaOH(aq). Your response must include *both* a correct numerical setup and the calculated result.

   (c) If 26.4 milliliters of the NaOH solution is needed to exactly neutralize 44.0 milliliters of the HNO_3 solution, what is the molarity of the HNO_3 solution?

   (d) Complete the equation below representing this titration reaction by writing the formulas of the products.

   $$NaOH(aq) + HNO_3(aq) \rightarrow \_\_\_\_\_ + \_\_\_\_\_$$