Acids & Bases

Lesson 1: Definition of Acids and Bases; Identification of a Bronsted-Lowry Acid & Bases and Characteristics of Acids and Bases

Essential Questions: How do we describe acids and bases both qualitatively and quantitatively? Why is it important to know the difference between a strong and weak acid/base?

Questions/ Vocab, etc.	Notes:

Name the 5 Acids

HCl

HNO_3

H_2SO_4

H_2CO_3

$HC_2H_3O_2$

What is an acid? Arrhenius Acids

→ a substance that produces _____, H^+ ions when dissolved in water.

$$HA \rightarrow H^+_{(aq)} + A^-_{(aq)}$$

→ The Hydrogen ions (H^{1+}) immediately react (attach) to water to form the _____ ion, H_3O^+.

→ *To recognize and ACID, look for an aqueous covalent compound that has a hydrogen as the first element*

Examples:

$H_2SO_{4\,(aq)}$ $HCl_{(aq)}$ $H_2CO_{3\,(aq)}$ $HNO_{3\,(aq)}$

What is a base? Arrhenius Bases

→ a substance that produces _____, OH^{-1} when dissolved in water

$$MOH \rightarrow M^{+1} + OH^{1-}$$

How do you identify an Arrhenius Base

To recognize a base, look for an ionic compound that contains a **METAL connected to a hydroxide ion OR recognize the molecule, NH_3,** which is called ammonia

- Not all compounds ending in -OH are bases. The -OH ***must be*** connected to a metal.
- CH_3OH is an alcohol.

Another Definition of ACIDS & BASES:

Bronsted -Lowry Acids

- Is a substance that is a proton or _____donor

Bronsted -Lowry Bases

- Is a substance that is a proton or _____ acceptor

Conjugate Acid & Base Pairs: FOUND ONLY ON THE RIGHT SIDE OF AN EQUATION

- ***Conjugate Bases: substance formed when an acid loses a H^+ ion***
- ***Conjugate Acids: substance formed when a base gains a H^+ ion***

Example:
Label each side of the equation with Acid, Base, Conjugate Acid and Conjugate base

HNO_3 + H_2O → H_3O^{1+} + NO_3^{1-}

_____ _____ _____ _____

HCO_3^{-1} + H_2O ↔ H_2CO_3 + OH^-

_____ _____ _____ _____

Characteristics of Acids & Bases

Acids	Bases
Examples:	Examples:
Produce _____ ions when dissolved in water	Produce _____ ions when dissolved in water
Tastes _____	Tastes _____
Reacts with Metals to produce _____ gas	Feels _____
Neutralizes a base to form a _____ and _____	Neutralizes an acid to form a _____ and _____
Both form ions when dissolved in water. They are called _____	

Lesson 2 : Difference between Strength & Concentration of Acids & Bases and The pH Scale & The Use of Indicators to Identify an Acidic or Basic Solution

Essential Question: How do we use the chemical formulas, the pH scale and color changes of indicators to describe whether a solution is acidic or basic?

Questions/ Vocab, etc.	Notes
	Strength vs Concentration ***STRENGTH: determined by how many ions are present*** ✔ *Ionization/Dissociation: molecules separate into ions* **Strong acids** show ***ALL*** acid molecules separating (dissociating) into hydrogen ions (H^{1+}) and anions in water. ***ONLY ions are present.*** o Considered strong electrolytes o Examples would be: HCl, H_2SO_4, HNO_3 **Weak acids** show **mostly acid molecules intact** with only a few hydrogen ions (H^{1+}) and anions present in water. *(Less than 5% of molecules dissociate into ions; MOSTLY molecules are present)* o Considered weak electrolytes

- Examples would be: H_2CO_3, $HC_2H_3O_3$

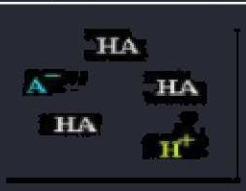
CONCENTRATION: determined by how much solute is dissolved in solvent

Look at whether there is a lot or little of the dissolved substance; DO NOT LOOK AT THE IONS vs MOLECULES; the solute is the acid or base molecule; the solvent is the water

Concentrated Acid: Lots of acid (solute) is dissolved into water (solvent)

Dilute Acid: A little amount of acid(solute) is dissolved into water(solvent)

Combinations of Strength and Concentration

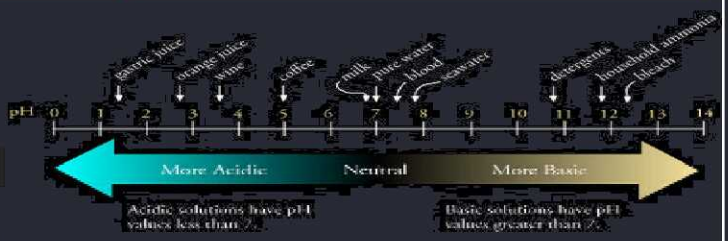
	Concentrated	Dilute
Strong	 ALL IONS LOTS OF SOLUTE PRESENT (8 acid molecules)	 ALL IONS PRESENT LITTLE SOLUTE PRESENT (2 acid molecules)
Weak	 MOSTLY MOLECULES; FEW IONS LOTS OF SOLUTE PRESENT (14 molecules)	 MOSTLY MOLECULES; FEW IONS LITTLE SOLUTE PRESENT (4 molecules)

✔ Base Strength & Concentration follow the same patterns as acids

The stronger an acid/base is, & the more concentrated it is, the more dangerous it is to you!

pH scale- measures the acidity of a sample

✔ Acids have a pH less than 7.0
✔ Bases have a pH more than 7.0
✔ Neutral solutions have a pH of exactly 7.0



Example:

[1] Circle the more acidic pH: 2 or 6

[2]Circle the more basic pH: 11 or 13

Measuring pH

Indicators are substances that are added to a solution and change color based on pH

- Liquid indicators: examples can be phenolphthalein and bromothymol blue)

Liquid Indicators	Acid	Base
phenolphthalein	it stays colorless	it turns pink
bromothymol blue	it turns yellow	it turns blue

- pH meters or probes: provide a digital reading of pH

	○ Paper indicators: examples are litmus and pH paper; pH paper is more precise; allows a color to match to a specific pH number ***LITMUS paper*:** **pH paper** Red-acid 1-6 - acid Blue- base 8-14 - base **Review: Try these questions and then check your answers!** 1. Which of the following is an Arrhenius Acid? a. CuOH b. NH_3 c. $HC_2H_3O_2$ d. CaS 2. Which of the following substances has a bitter taste and slippery feel? a. CH_3OH b. NH_3 c. $HC_2H_3O_2$ d. K_2S 3. Which of the following has a pH of 4? a. NaOH b. SO2 c. baking soda d. H_2SO_4 4. Which of the following substances will cause red litmus to turn blue? a. NaCl b. KOH c. H_3PO4 d. H_2CO_3 5. Which of the following will neutralize an acid? a. NaOH b. CH_4 c. CaF_2 d. HNO_2 6. Which of the following substances will increase the number of hydroxide ions in solution? a. Fe_2O_3 b. H_2SO_4 c. NH_3 d. H_2CO_3

Lesson 3: pH Calculations

Essential Question: How can the pH of a solution be calculated if one knows the hydronium or hydroxide concentration?

Questions/ Vocab, etc.	Notes
	Calculating pH **The pH Scale** ○ The formula for calculating pH is: **$pH= -log[H_3O^+]$** ○ The formula for calculating the concentration of H^{1+} (H_3O^+)is: **$[H_3O^+] = 10^{-pH}$** ○ The lowest pH represents the _____ concentration of hydronium ion. ○ Each time pH changes by 1, the concentration of hydronium changes 10x. **Practice Calculating pH:** [1] The pH of a solution changes from a pH of 5 to a pH of 3. Did it increase or decrease in hydrogen ion concentration? By what factor did it change? [2] Find the pH if the concentration of H_3O^+ is 1.0×10^{-8}M. [3] Find the H_3O^+ concentration if the pH is 5.0. [4] Find the pH if the concentration of H_3O^+ is 5.6×10^{-8}M. [5] Find the H_3O^+ concentration if the pH is 3.8.

Auto-Ionization of water

→ Water will split into ions on its own every so often, called _____.

$$H_2O + H_2O \rightarrow H_3O^{1+} + OH^{1-}$$

→ The following expressions shows this relationship: **$[H_3O^+]\,[OH^-] = 1.0 \times 10^{-14}\ M^2$**

Is the solution Acidic, Basic, or Neutral- Look at it from the hydrogen ion(pH) perspective

Acid:

→ hydronium ion concentration is greater than the hydroxide ion

→ $[H^+] > 1.0 \times 10^{-7}\ M$ → pH<7

Base

→ hydronium ion concentration is less than the hydroxide ion

→ $[H^+] < 1.0 \times 10^{-7}\ M$ → pH >7

Neutral

→ hydronium ion concentration and hydroxide ions are equal

→ $[H^+] = 1.0 \times 10^{-7}\ M$ → pH = 7

Calculating pOH

→ To calculate the pOH from the hydroxide concentration: **$pOH = -\log[OH^-]$**

→ The formula for calculating OH^- concentration is: **$[OH^-] = 10^{-pOH}$**

→ To relate pH and pOH: **$pH + pOH = 14$.**

Let's Practice

1. Find the pOH if the $[OH^{-1}] = 1.0 \times 10^{-5}\ M$

2. Find the pOH if the pH is 4.

3. Calculate the concentration of $[OH^-]$ if the concentration of $[H_3O^+] = 1.0 \times 10^{-9}\ M$

4. What is the pH of a solution if the concentration of $[OH^-] = 1.0 \times 10^{-7}\ M$?

Mixed Practice- You Try

1. The $[H^+] = 1.0 \times 10^{-11}\ M$, what is the pH?

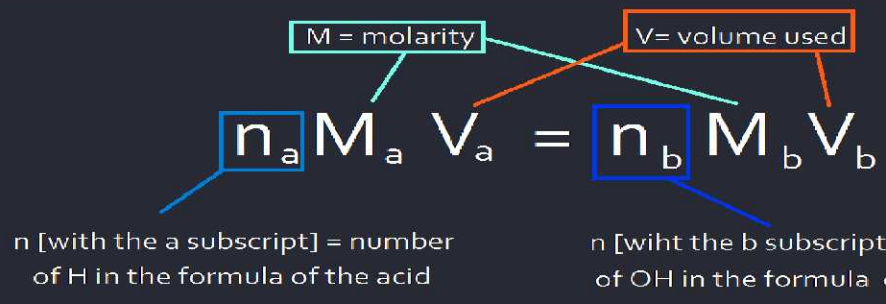
2. An aqueous solution has a pH of 2.7 What is the $[OH^-]$ of the solution?

3. Calculate the [H+] of a solution if the pOH is 4.50.

4. The $[OH^-] = 6.8 \times 10^{-5}\ M$, what is the pOH?

Lesson 4 : Neutralization Reactions & Titrations

Essential Question: How can you identify the concentration of an unknown acid or base using a technique called a titration.

Questions/ Vocab, etc.	Notes
	• Neutralization Reaction: when an acid and a base react to form a slat(ionic compound) and water • Titrations: A technique where the addition of a known volume of a known concentration solution (acid or base) is reacted with a known volume of unknown concentration solution to determine the concentration of the solution. • Use a ***buret*** to titrate the unknown concentration of solutions • The _____is the known concentration in the ***buret*** and the _____is the unknown concentration in the Erlenmeyer flask • Add indicator to the analyte in the flask • Add titrant to the analyte drop by drop until a permanent color change persists • _____ point is the point at which the indicator changes color. It signals the equivalence point and the stop of the titration. • EQUIVALENCE Point (or Stoichiometric Point) – When there are no reactants left over—they have all been reacted and completely used up. The solution contains only products at this point. When the ***: Moles of Acid = Moles of Base*** $HCl + NaOH \rightarrow H_2O + NaCl$ ~~1.0 mol 1.0 mol~~ 1.0 mol 1.0 mol **Indicators** Are liquids that change color based on pH level. They are used to show when the endpoint has been reached ✔ Examples are Phenolphthalein & Bromothymol Blue ✔ Select a liquid indicator that has a pH range close to that of the pH of the equivalence point of the titration. **Short Cut Formula:** 

Examples

1. How many liters of 0.10 M NaOH is needed to react with 0.125 L of 0.25 M HCl?

2. What is the molarity of a $Ca(OH)_2$ solution if 30.0 ml of the solution is neutralized by 20.0 ml of 0.50 M solution of HCl?

3. What volume of 2.0 M solution of NH_4OH is needed to neutralize 50.0 ml of a 0.50 M H_2SO_4 solution?

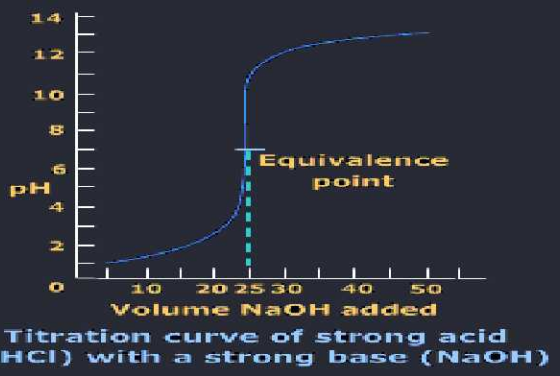
Titration Curve Graphs

- ✔ Show the changes of pH during a titration
- ✔ Identifies the pH of the equivalence point. → Take the vertical region and cut the length in half and then look to what pH value aligns to that point.

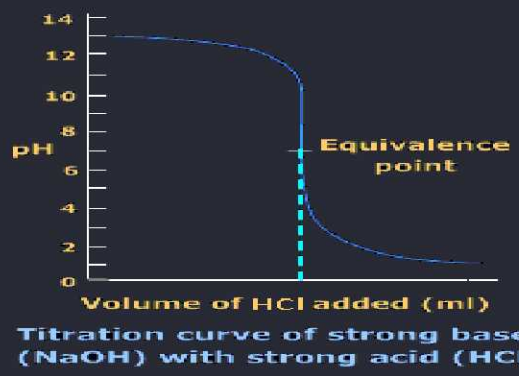
Titrating a STRONG ACID with a STRONG BASE

or

STRONG BASE with a STRONG ACID



Titration curve of strong acid (HCl) with a strong base (NaOH)



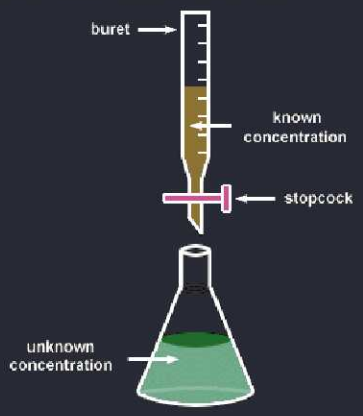
Titration curve of strong base (NaOH) with strong acid (HCl)

Titration Lab Based Example

Directions: Using the formula $n_A M_A V_A = n_B M_B V_B$ (n = number of H^- of an acid or number of OH^- of a base), calculate the following problems. Show all WORK.

Using the experimental set-up below, a student titrated 35.00 mLof HCl solution of unknown concentration with a solution of **4.75 M NaOH**. The data he recorded is also shown.

Solution	NaOH (aq)
Initial Buret Reading (mL)	12.65
Final Buret Reading (mL)	22.40

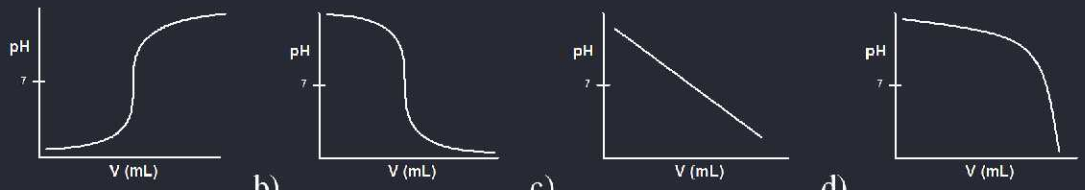


1. Determine the total volume of NaOH(aq) used.

V = _____

2. Based on the data, calculate the molarity of the hydrochloric acid solution.

3. In this experiment, the student placed a pH meter in the flask and monitored the pH in the flask as the solution in the buret was added. Choose the graph that would BEST represent this titration.



a) b) c) d)

The chart below shows common indicators used in titrations.

Indicator	Approximate pH Range for Color Change	Color Change
methyl orange	3.2–4.4	red to yellow
bromthymol blue	6.0–7.6	yellow to blue
phenolphthalein	8.2–10	colorless to pink
litmus	5.5–8.2	red to blue

4. If the student added 5 drops of *phenolphthalein* to the flask at the beginning of the titration, which color change would be observed during the titration?

A) red to blue B) pink to colorless C) colorless to pink D) yellow to red