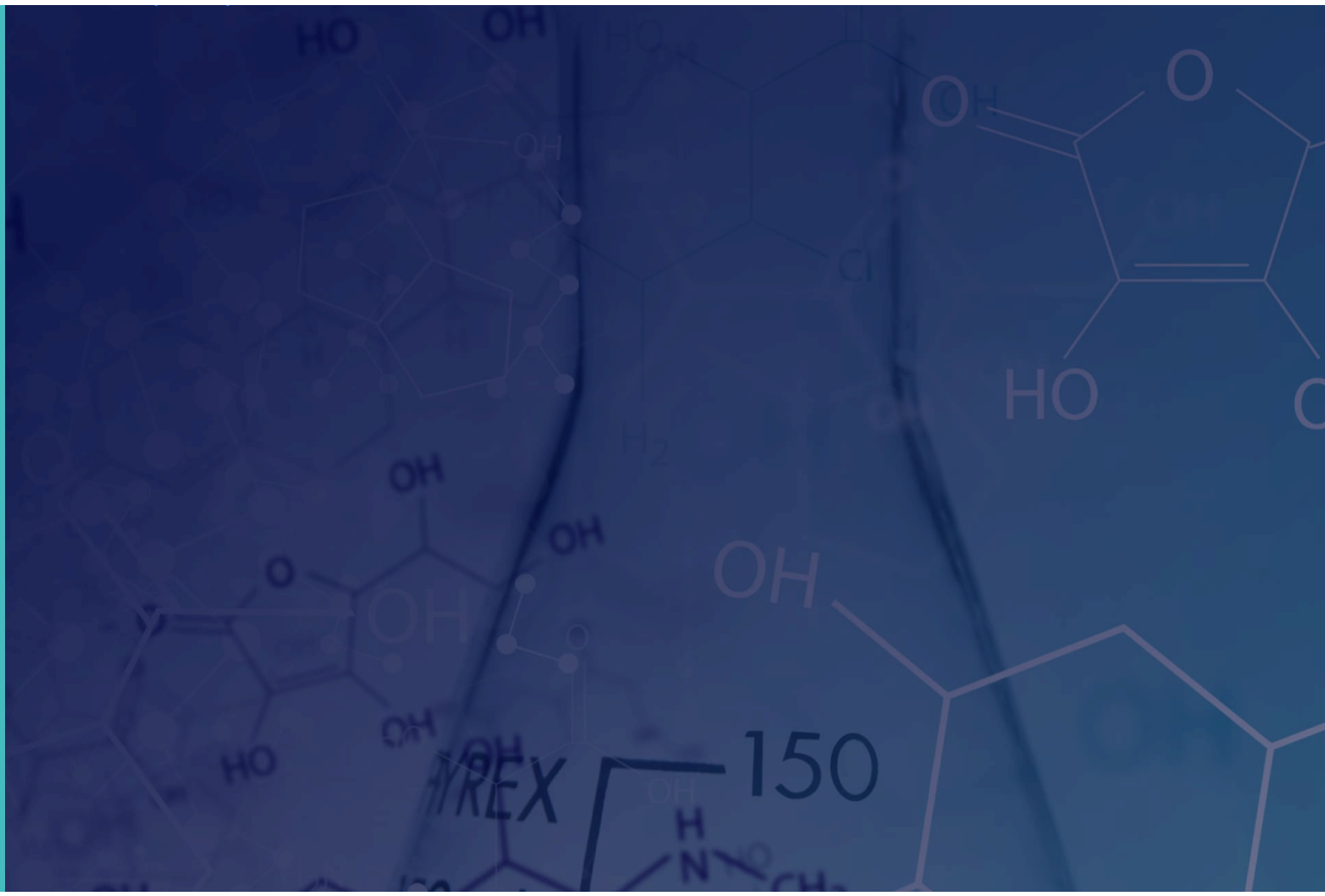

Ontario High School

Grade 11 Chemistry

Summer 2024, Chapter 8 Notes

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8. Acids and Bases

8.1 Acid Base Definitions

8.1.1

Acids and Bases Definitions

- **Arrhenius definition:** compounds identified as producing H^+ or OH^- ions in solution
  - Acids produce H^+ ions:

$$HNO_3(aq) \rightarrow H^+(aq) + NO_3^-(aq)$$

  - Bases produce OH^- ions:

$$LiOH(aq) \rightarrow Li^+(aq) + OH^-(aq)$$

- **Modified Arrhenius definition:** compounds identified as acids or bases based on their reaction with water
  - Acids react with water to produce H_3O^+ ions

$$HNO_3(aq) + H_2O(\ell) \rightarrow H_3O^+(aq) + NO_3^-(aq)$$

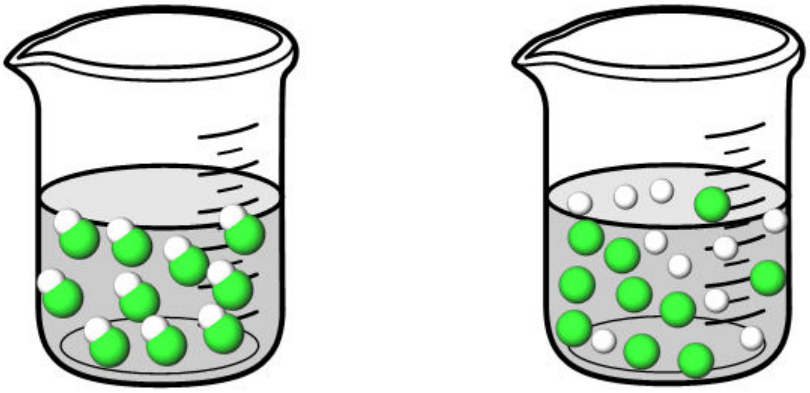
  - Bases react with water to produce OH^- ions

$$NH_3(aq) + H_2O(\ell) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$

Acid and Base Strength

- Strong acids ionize completely:

$$HNO_3(aq) \rightarrow H^+(aq) + NO_3^-(aq)$$



- Weak acids partially ionize to give H^+:

$$HF(aq) \rightleftharpoons F^-(aq) + H^+(aq)$$

- Strong bases dissociate completely in water:

$$LiOH(s) \rightarrow Li^+(aq) + OH^-(aq)$$

- Weak bases react with water to give OH^-, but the reaction is not complete

$$NH_3(aq) + H_2O(\ell) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$

8.1.2

Properties of Acids and Bases

Acids

- Taste Sour
- No particular texture
- Turns blue litmus paper red
- pH < 7

Bases

- Taste Bitter
- Feel slippery
- Turns red litmus paper blue
- pH >7

8.1.3

Naming Acids and Bases

Naming Acids without Oxygen

- A **binary acid** is an acid that consists of hydrogen and one other element.
- To name a binary acid, start with the **prefix *hydro-*,** followed by the **base name of the anion** and **the ending *-ic*** then the word **acid**

  Example: HCl is _____

Naming Acids with Oxygen

- Acids that are made out of hydrogen, oxygen and a third element are known as **oxyacids.** The third element is usually a nonmetal.
- If the anion has the ***-ite*** ending, the name of the acid is the root of the anion followed by the suffix ***-ous***.
  Example: HNO_2 is _____
- If the anion has the ***-ate*** ending, the name of the acid is the root of the anion followed by the suffix ***-ic***.
  Example: HNO_3 is _____

Naming Bases

- Most common bases are ionic hydroxides. Use the naming convention for ionic compounds with polyatomic ionds

  Example: NaOH is _____

8.1.4

Practice: Acids and Bases Definitions and Properties

Match the following terms and definitions

A. Feels slippery

B. Completely dissociates in solution

C. Partially ionize in solution

D. Taste sour

Weak acid

Strong base

Property of an acid

Property of a base

8.1.5

Practice: Identifying Arrhenius Acids and Bases

Part 1

Which of the following compounds is a base according to the Arrhenius theory? Select all that apply.

- [ ] KOH
- [ ] HClO
- [ ] $Ba(OH)_2$
- [ ] H_3PO_4

Practice: Identifying Arrhenius Acids and Bases

Part 2

Which of the following compounds is an acid according to the Arrhenius theory? Select all that apply.

- [ ] NaOH
- [ ] $Ca(OH)_2$
- [ ] H_3PO_3
- [ ] HF

8.1.6

Which one of the following statements about strong acids is true?

- All strong acids have H atoms bonded to electronegative oxygen atoms.
- Strong acids are 100% ionized in water.
- Strong acids are very concentrated acids.
- Strong acids produce solutions with a higher pH than weak acids.

8.1.7

Example: Identifying Strong Acids and Bases

Group the following molecules as strong acids, strong bases, or neither: HBr, NaCl, H_2SO_4, $Mg(OH)_2$, KOH, H_3PO_4

8.2 Titrations

8.2.1

Introduction to Titrations

- **Titrations** always involve an acid reacting with a base. We perform titrations to determine the unknown concentration of an acid or a base.
- Titrations are **neutralization reactions** between a **titrant** and **analyte**.

Titrant

- Solution in the burette
- We know its concentration and it is usually a strong acid or base
- We control the amount of the titrant we add to the flask

Analyte

- Solution in the volumetric flask
- We don't know its concentration
- We do know its volume

Equivalence Point and End-Point

- Once the number of moles of titrant equals the number of moles of analyte, the reaction is complete and we have reached the **equivalence point**
- We follow the change in pH of the analyte as titrant is added to it:
    a. Using a pH meter
        - A sudden change in pH helps us determine when we have reached the equivalence point.
    a. Using an indicator
        - **Indicators** help to show a pH change by changing the color inside the flask
- We refer to the point at which the sudden change in pH occurs or when the color of the indicator changes, as the **end point** of the titration.

8.2.2

Indicators

- An **indicator** is a weak acid or base added in a very small quantity to the analyte of a titration before the experiment begins.
- We observe the colour changes in an indicator over a small pH range.
- To pick an indicator for your acid-base titration, select an indicator whose colour changes around the pH at the equivalence point

Name	Acid Colour	pH Range of Colour Change	Base Colour
Alizarin yellow	Yellow	$10.1 - 12.0$	Red
Phenolphthalein	Colorless	$8.2 - 10.0$	Pink
Bromothymol blue	Yellow	$6.0 - 7.6$	Blue
Methyl orange	Red	$3.2 - 4.4$	Yellow
Bromocresol green	Yellow	$3.8 - 5.4$	Blue

8.2.3

Example: Titrations

What volume of 0.030 mol/L HI (aq) is required to neutralize 15mL of 0.010 mol/L $Ba(OH)_2$ (aq)?

$$Ba(OH)_2(aq) + 2HI(aq) \rightarrow BaI_2(aq) + 2H_2O(\ell)$$

8.2.4

Practice: Titrations Terms and Definitions

Match the following terms and definitions.

A. the procedure used to determine the concentration of a solution

B. the standardized solution of known concentration

C. the point at which indicator colour changes permanently

D. the calibrated tube that is used measure titrant

E. the theoretical point at which neutralization is complete

F. solution whose concentration is unknown

titrant

end point

equivalence point

burette

titration

analyte

8.2.5

Practice: Indicators

Methyl orange indicator is added to a solution with a pH of 6.4. In this solution the colour of the indicator is predicted to be:

Name	Acid Colour	pH Range of Colour Change	Base Colour
Alizarin yellow	Yellow	10.1 – 12.0	Red
Phenolphthalein	Colorless	8.2 – 10.0	Pink
Bromothymol blue	Yellow	6.0 – 7.6	Blue
Methyl orange	Red	3.2 – 4.4	Yellow
Bromocresol green	Yellow	3.8 – 5.4	Blue

- colourless
- red
- orange
- yellow

8.2.6

25mL of a solution of 0.5mol/L KOH is required to neutralize 15mL of sulphuric acid. What is the concentration of the acid?

$$2KOH\,(aq) + H_2SO_4(aq) \rightarrow K_2SO_4(aq) + 2H_2O(\ell)$$

- 0.26mol/L
- 0.42mol/L
- 0.96mol/L
- 1.1mol/L

8.3 pH and pOH Calculations

8.3.1

pH and pOH Calculations

- In pure water, at 25°C the following chemical reaction takes place:

$$2H_2O \rightleftharpoons H_3O^+ + OH^-$$

- We can classify aqueous solutions based on the concentration of the hydronium ions:
  - neutral solutions: $[H_3O^+(aq)] = 1 \times 10^{-7} mol/L$
  - acidic solutions: $[H_3O^+(aq)] > 1 \times 10^{-7} mol/L$
  - basic solutions: $[H_3O^+(aq)] < 1 \times 10^{-7} mol/L$

- From here we can define pH, or the "power of hydrogen":

$$pH = -\log [H_3O^+ (aq)] \text{ and } [H_3O^+ (aq)] = 10^{-pH}$$

- We can also define pOH:

$$pOH = -\log [OH^- (aq)] \text{ and } [OH^- (aq)] = 10^{-pOH}$$

Example: Calculating pH

If 0.2mol of HCl are dissolved in 1.8L of water, what is the pH?

8.3.3

Practice: Calculating pH

Calculate the pH of a 2.75×10^{-3} mol/L aqueous HNO_3 solution. Give your answer to two decimal places.

Answer

8.3.4

Practice: Understanding pH

A solution with a pH of 1 has ____ the hydronium ion concentration compared to a solution with a pH of 4.

- 3 times
- 300 times
- 1000 times
- 3000 times

8.3.5

Practice: Solutions and pH

Calculate the pH of a solution prepared by adding 25.00mL of 0.100mol/L HCl with 75.00mL of $2.50x10^{-2}$mol/L HBr. Give your answer rounded to two decimal points.

Answer