Name:

Volumetric Analysis	Objectives
2. Acids and Bases	-relate the properties of acids and bases to their household applications -recall that neutralisation is the formation of a salt from an acid and a base -relate their knowledge of neutralisation to everyday examples e.g. use of lime in agriculture , use of stomach powders -state the Arrhenius and **Brønsted-Lowry** theories of acids and bases **-define what is meant by a conjugate acid/base pair** -apply the Arrhenius and **Brønsted-Lowry** theories of acids and bases for aqueous solutions only

ARRHENIUS THEORY

Defⁿ: An **Arrhenius acid** is a substance that dissociates in water to produce H^+ ions.

e.g. $HCl \rightarrow H^+ + Cl^-$ (monobasic as one H^+ produced)

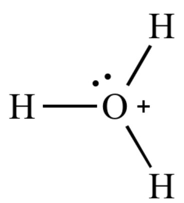
$H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$ (dibasic as two H^+ produced)

$H_3PO_4 \rightarrow 3H^+ + PO_4^{3-}$ (tribasic as three H^+ produced)

Strong Arrhenius acids dissociate *fully* in water. e.g. HCl

Weak Arrhenius acids dissociate *partially* in water. e.g. Ethanoic acid, CH_3COOH

Note: H^+ ions (which are just protons) cannot exist on their own in water. They bond with a water molecule to form a **hydronium ion, H_3O^+**, as seen in the picture to the right.



Defⁿ: An **Arrhenius base** is a substance that dissociates in water to produce OH^- ions.

e.g. $NaOH \rightarrow Na^+ + OH^-$

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

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

Strong Arrhenius bases dissociate *fully* in water. e.g. NaOH

Weak Arrhenius bases dissociate *partially* in water. e.g. Na_2CO_3

Note: Arrhenius's theory of acids and bases is limited to solutions dissolved in water. In reality, not all acid-base reactions need water, or even involve OH^- ions. Today, we have a more modern theory for how acids and bases work.

BRØNSTED-LOWRY THEORY

Defⁿ: A **Brønsted-Lowry acid** is a proton (H^+) *donor*

e.g. $HCl + NH_3 \rightarrow NH_4^+ + Cl^-$

HCl *donated* a proton to the NH_3 and became Cl^-. HCl is a Brønsted-Lowry acid

Strong Brønsted-Lowry acids are *good* proton donors. e.g. HCl, H_2SO_4, HNO_3

Weak Brønsted-Lowry acids are *poor* proton donors. e.g. CH_3COOH

Def^n*:* A **Brønsted-Lowry base** is a proton (H^+) *acceptor*

e.g. $HCl + NH_3 \rightarrow NH_4^+ + Cl^-$

NH_3 *accepted* a proton from the HCl and became NH_4^+. NH_3 is a Brønsted-Lowry base

Strong Brønsted-Lowry bases are *good* proton acceptors. e.g. $NaOH$, KOH, $Ca(OH)_2$

Weak Brønsted-Lowry bases are *poor* proton acceptors. e.g. NH_3

Some substances can act as both an acid and a base in Brønsted-Lowry theory, depending on what they react with.

e.g. $HCl + H_2O \rightarrow H_3O^+ + Cl^-$ $NH_3 + H_2O \rightarrow NH_4^+ + OH^-$

H_2O accepts proton $\rightarrow$ base H_2O donated proton $\rightarrow$ acid

Substances which can act like this are called **amphoteric**.

DIFFERENCES BETWEEN ARRHENIUS AND BRØNSTED-LOWRY THEORY

ARRHENIUS THEORY	***BRØNSTED-LOWRY THEORY***
Limited to reactions in water	Not limited to reactions in water
Limited to bases that produce OH^- ions	Not limited to bases that produce OH^- ions
Does not take the existence of hydronium ions into account	Takes the existence of hydronium ions into account
Cannot explain substances that act as both an acid and a base	Can explain substances that act as both an acid and a base

CONJUGATE ACID-BASE PAIRS

Def^n*:* An acid changes into its **conjugate base** when it donates a proton.

e.g. $\underset{\text{acid}}{CH_3COOH} \rightarrow \underset{\text{conj. base}}{CH_3COO^-} + H^+$

Def^n*:* A base changes into its **conjugate acid** when it accepts a proton.

e.g. $\underset{\text{base}}{CH_3COO^-} + H^+ \rightarrow \underset{\text{conj. acid}}{CH_3COOH}$

Every acid has a conjugate base.

Every base has a conjugate acid

We call these pairs **conjugate acid-base pairs.**

Def^n*:* A **conjugate acid-base pair** is any pair of substances that differ by a proton

e.g. $CH_3COOH + H_2O \rightarrow CH_3COO^- + H_3O^+$

acid base base acid

Conjugate acid-base pair

Conjugate acid-base pair

NEUTRALISATION

A **salt** is the substance formed when the H^+ from an acid is replaced with a metal or ammonium (NH_4^+) ion.

e.g. when the H^+ in HCl is replaced with sodium, we form the salt NaCl, sodium chloride.

when the H^+ in HCl is replaced with ammonium, we form the salt NH_4Cl, ammonium chloride.

Def^n: **Neutralisation** is the reaction between an acid and a base to form a salt and water.

Types of neutralisation reactions:

1. Acid + Metal → Salt + Hydrogen

   e.g. $2HCl + Zn \rightarrow ZnCl_2 + H_2$

2. Acid + Base → Salt + Water

   e.g. $HCl + NaOH \rightarrow NaCl + H_2O$

3. Acid + Carbonate → Salt + Water + Carbon Dioxide

   e.g. $2HCl + Na_2CO_3 \rightarrow 2NaCl + H_2O + CO_2$

Examples of neutralisation in everyday life:

1. **Medicine:**
   Excess HCl in the stomach causes heartburn.
   Gaviscon contains sodium hydrogencarbonate (a base) to neutralise the acid.

   $$HCl + NaHCO_3 \rightarrow NaCl + H_2O + CO_2$$

2. **Agriculture:**
   If soil is too acidic, lime (CaO, calcium oxide) is added to neutralise the acidity.

   $$CaO + H_2O \rightarrow Ca(OH)_2$$

   Lime and water make calcium hydroxide, a base. This base reacts with the acid in the soil.

   $$H_2SO_4 + Ca(OH)_2 \rightarrow CaSO_4 + 2H_2O$$

3. **Environmental Protection:**
   Some areas receive high amounts of acid rain, making lakes very acidic. Limestone is added to to these lakes to neutralise the acid.

   $$H_2SO_4 + CaCO_3 \rightarrow CaSO_4 + CO_2 + H_2O$$