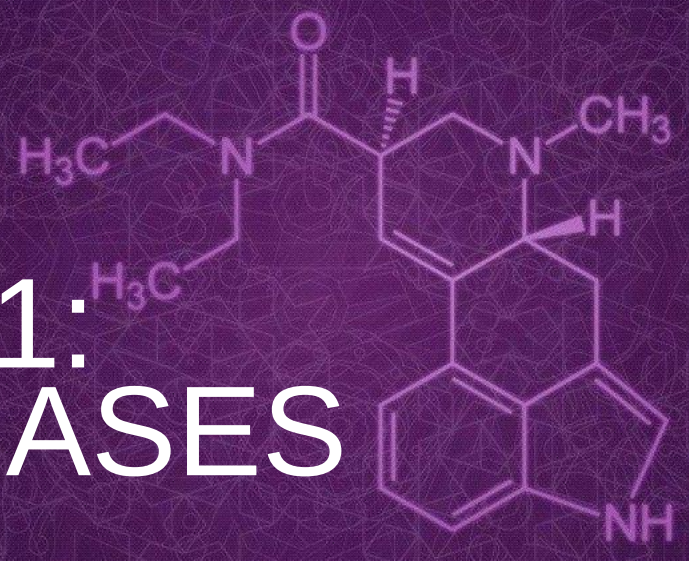


TOPIC 7.1: ACID & BASES

THE ABOUT

CHAPTER ANALYSIS

TIME

- Very important chapter that is needed for Salts & QA
- 4 **key** concepts: Acids, Bases, pH & indicators
- 2 **advanced** concepts: Strength/Concentration/Basicity & Base vs Alkaline

EXAM

- Commonly tested every year
  Need to know relevant chemical and ionic equations (not going through in detail here, will focus on equations for “Chemical Equations” chapter instead)

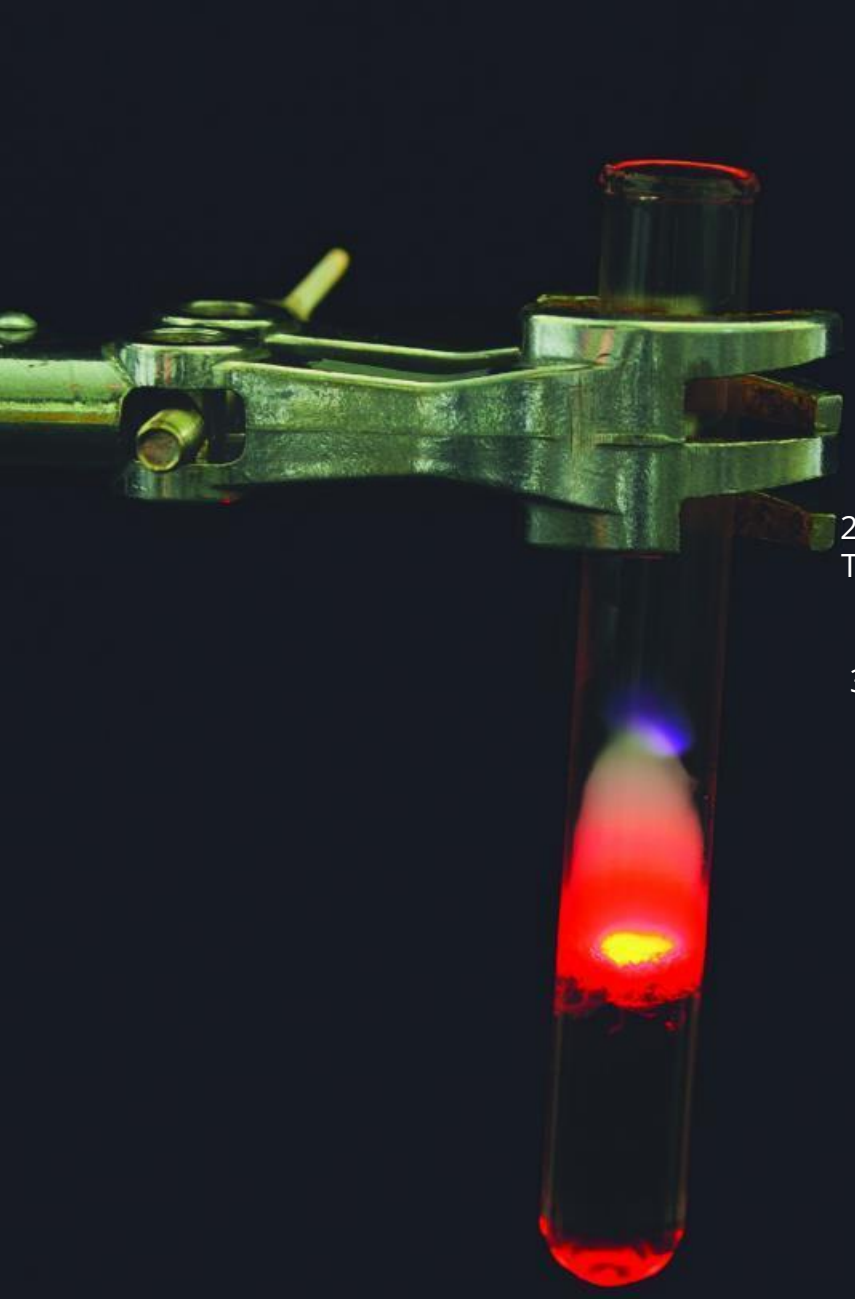
WEIGHTAGE

- Medium overall weightage
- Constitute to **6%** of marks for past 5 year papers

KEY CONCEPTS

ACIDIC PROPERTIES
ACID'S CHEMICAL REACTIONS
STRENGTH, COCENTRATION, BASICITY

ACIDS



Physical properties of acids

1) Acids have a **sour taste.** Many fruits such as lemon and lime contain weak acids like citric acid.

2) Dilute acids are **irritants**. They can cause skin to have rashes and blisters.

3) Acids are able to **change the colour of indicators**, turns blue litmus paper to red.

Examples of acids:

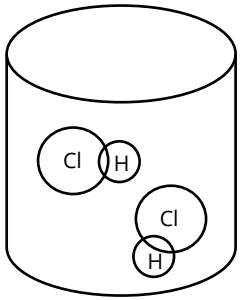
Hydrochloric acid, HCl
Sulfuric acid, H_2SO_4
Nitric acid, HNO_3
Phosphoric acid, H_3PO_4
Hydrofluoric acid, HF
Hydrobromic acid, HBr

What makes an acid contain its 'acidic properties'?

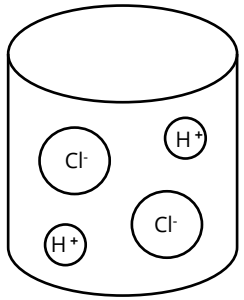
All acids have their acidic properties due to the dissociation of **H^+ ions** when the acids are dissolved in water.

For example,

$HCl_{(l)}$ in liquid state is called hydrogen chloride. (not acid yet)
$HCl_{(aq)}$ in aqueous state is called hydrochloric acid.



Hydrogen Chloride



Hydrochloric Acid

This is because when HCl dissolves in water, it dissociates to produce **H^+ ions** which gives it its acidic properties.

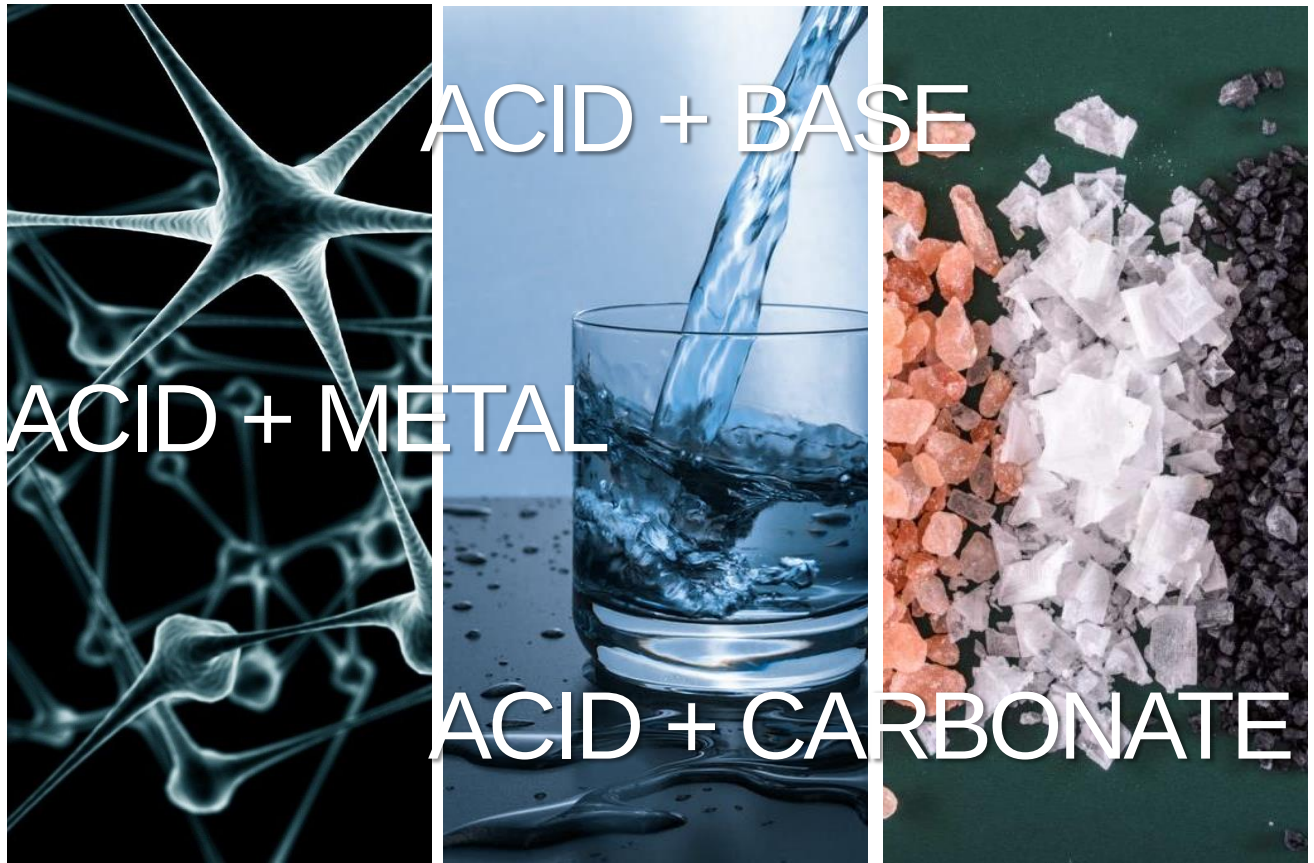
$$HCl_{(aq)} \rightarrow \mathbf{H^+}_{(aq)} + Cl^-_{(aq)}$$

In other words**, an acid only becomes an acid after it has been dissolved in water!**

*Aqueous refers to a compound being in a solution. In other words, water is added.

3 CHEMICAL REACTIONS

1) **ACID + METAL → SALT + HYDROGEN GAS**
2) **ACID + BASE → SALT + WATER**
3) **ACID + CARBONATE → SALT + WATER + CARBON DIOXIDE GAS**



1) ACID + METAL → SALT + HYDROGEN GAS

For example,

$$H_2SO_4 + Mg \rightarrow MgSO_4 + H_2$$

Test for hydrogen gas using lighted splint, it should extinguish with 'pop sound.

2) ACID + BASE → SALT + WATER

For example,

$$H_2SO_4 + MgO \rightarrow MgSO_4 + H_2O$$

This is also known as a **neutralisation** reaction. It releases heat to the surroundings.

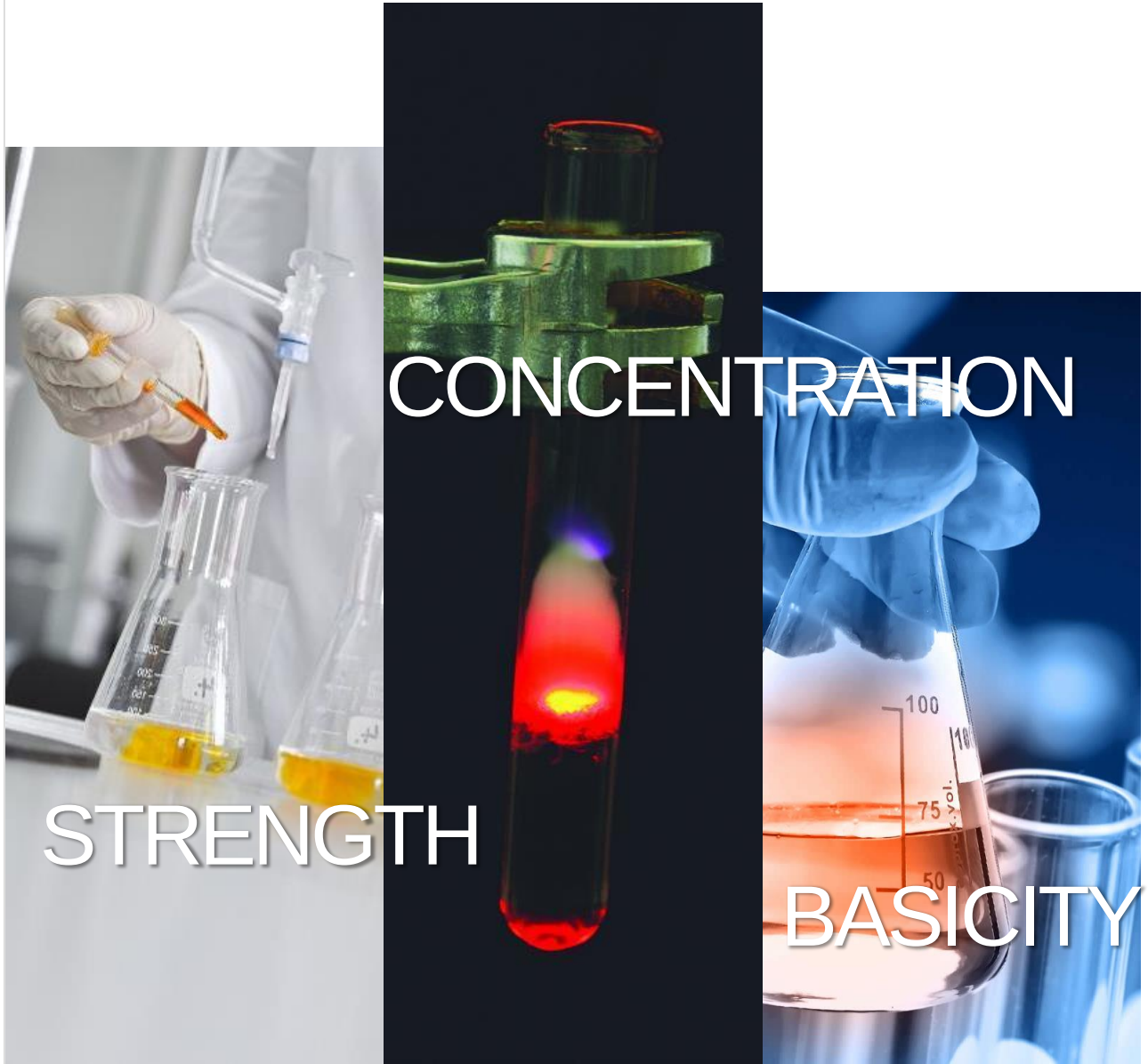
3) ACID + CARBONATE → SALT + WATER + CARBON DIOXIDE

For example,

$$H_2SO_4 + MgCO_3 \rightarrow MgSO_4 + H_2O + CO_2$$

Test for carbon dioxide gas. Bubble the carbon dioxide gas into limewater, $Ca(OH)_2$, a white precipitate will be formed.

ADVANCED CONCEPT



What is the relationship between the 3?

Let's understand how all 3 are distinct yet related.

Let's run through each of them individually and keep it simple.

Strength of acid

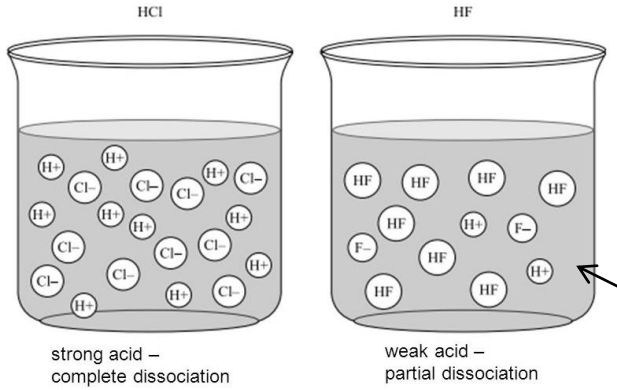
Strength of acid depends on the **nature** of the acid.

There are **strong acids**, which dissociates fully in water to produce a **high concentration of H^+ ions.**

Examples: nitric acid, hydrochloric acid, sulfuric acid

There are **weak acids**, which dissociates partially in water to produce a **low concentration of H^+ ions.**

Examples: citric acid, hydrofluoric acid, organic acid such as ethanoic acid



Hydrochloric acid fully dissociate in water to produce a high concentration of H^+ ions.
While for hydrofluoric acid, not all of them have dissociated, so there are <u>much lesser H^+ ions</u>**.**

So if you were to compare**, hydrochloric acid is the stronger acid, since it produces more H^+ ions.**

CONCENTRATION

Concentration of acid

Concentration of an acid depends on the **dilution factor,** or simply, the **amount of water added**.

Concentration refers to **the number of acid molecules present per water molecule**.

Concentration is usually expressed in **moldm^{-3}**. (Learn in detail in chapter "Mole Concept".)

Visualise this:

A strong acid like nitric acid can be very corrosive and dangerous.
In the school laboratory, however, students use nitric acid on a regular basis.

In order to make it safer, the lab staff added a large amount of water to dilute the nitric acid.

So dilute nitric acid will be able to produce chemical reactions, it is much safer for the students as it is diluted.

Another example:

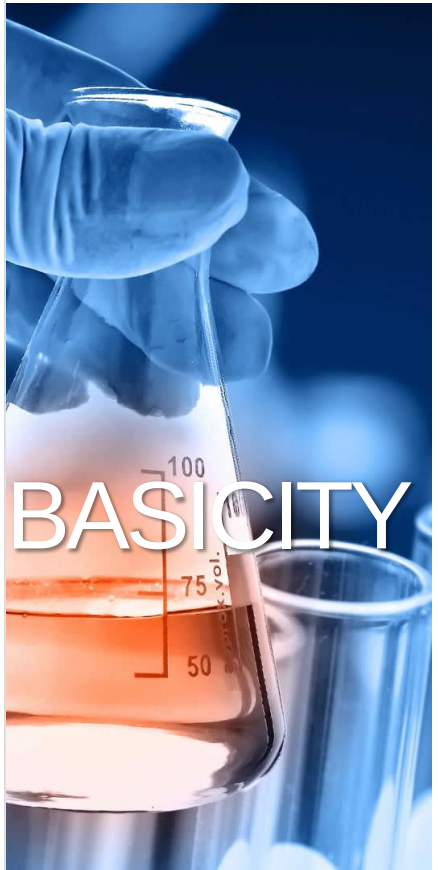
We buy ribena syrup from NTUC. Do we drink it straight? No, that will be too sweet because it is so concentrated.

So, what we do is to dilute the syrup by adding water. This is exactly the same for acid!

Basicity of acid

The basicity of an acid depends the **acid's chemical formula.**

Basicity refers to the number of H^+ ions produced per molecule.

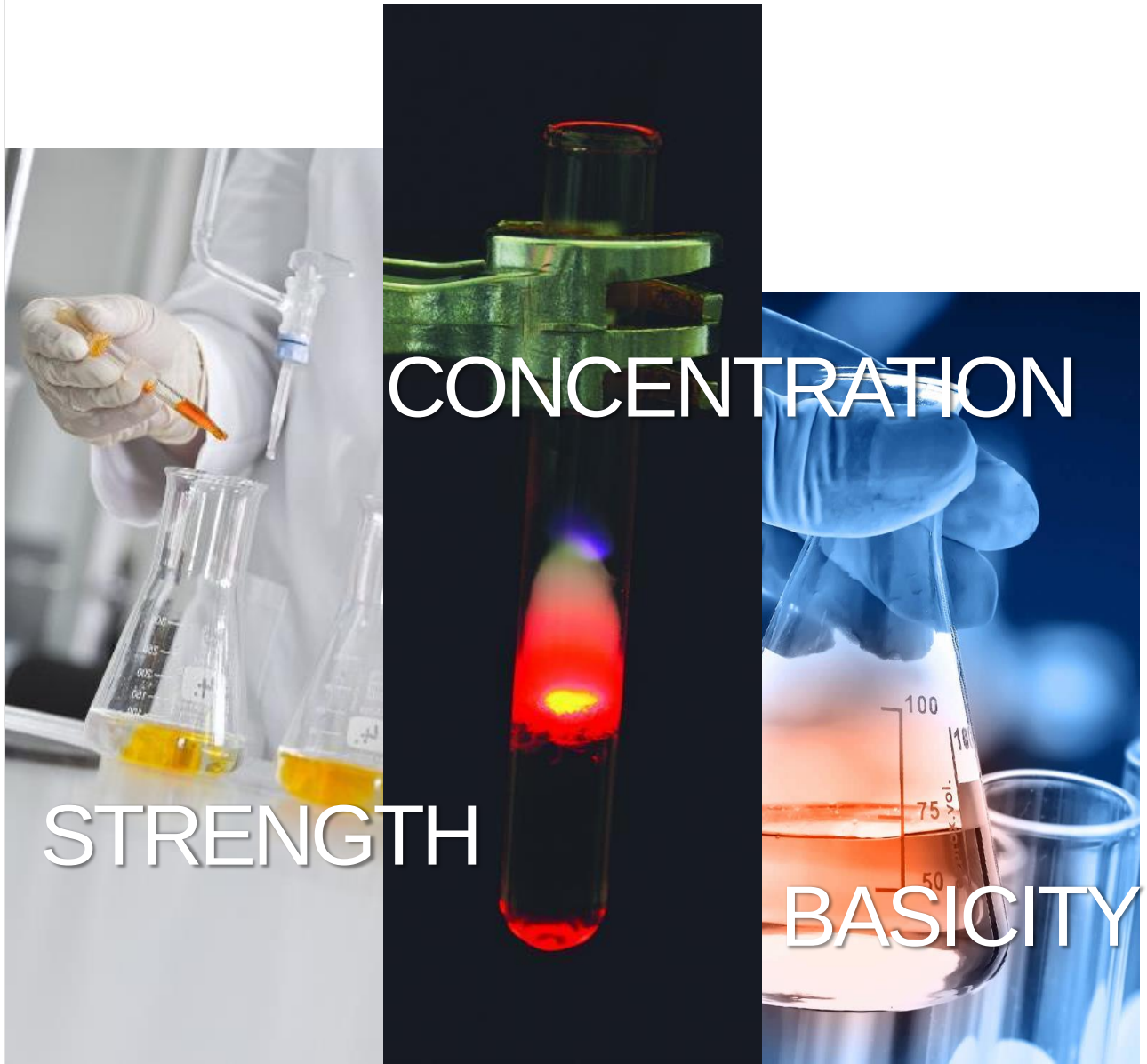


Acid	Chemical Formula	Basicity
Hydrochloric acid	HCl	monobasic
Nitric acid	HNO_3	monobasic
Sulfuric acid	H_2SO_4	dibasic
Phosphoric acid	H_3PO_4	tribasic

1 H^+ ion produced: monobasic

2 H^+ ions produced: dibasic

3 H^+ ions produced: tribasic



What is the relationship between the 3?

Strength of acid depends on the **nature** of the acid.
Concentration of an acid depends on the **dilution factor.**
Basicity of an acid depends the **acid's chemical formula.**

Can a strong acid have a low concentration of H^+ ions?

Yes, use a strong acid like nitric acid and add a ton of water.

If we were to compare nitric acid & sulfuric acid, both strong acids, which one will produce a higher concentration of H^+ ions?

Even though both strong acids will dissociate fully in water, sulfuric acid will produce a higher concentration of H^+ ions .

Sulfuric acid has a formula of H_2SO_4, it is dibasic, producing 2 H^+ ions per molecule.
Nitric acid has a formula of HNO_3, it is monobasic, producing 1 H^+ ions per molecule.

KEY CONCEPTS

DIFFERENTIATING BASE vs ALKALINE
ALKALINE PROPERTIES
ALKALINE'S CHEMICAL REACTIONS

BASE vs ALKALINE

<u>A base is defined as a substance which reacts with an acid to form a salt and water only.</u>

ACID + BASE → SALT + WATER

$H_2SO_4 + MgO \rightarrow MgSO_4 + H_2O$

Bases are usually the **oxides and hydroxides of metals**.

<u>Alkaline</u> <u>are a special group of bases that are</u> **<u>soluble in water</u>**<u>.</u>

Hence, alkaline are able to dissociate in water to produce **OH^- ions,** giving rise to its alkaline properties.

In other words, **alkaline is a subset of base**.

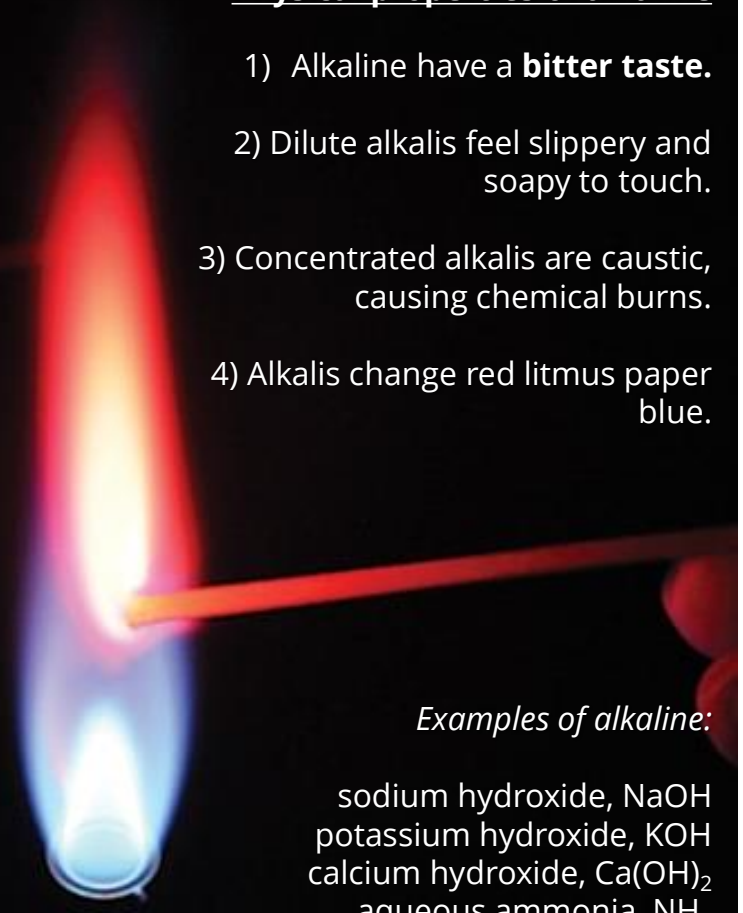
<u>WHY?</u>

All metal oxides and hydroxides are bases, but not all of them are soluble in water. Those that are soluble are known as alkaline.

Group I metals, such as potassium and sodium, always form alkaline as their oxides and hydroxides are highly soluble.

Group II metals, such as calcium, are slightly soluble, and can be an alkaline as well.

ALKALINE



Physical properties of alkaline

1) Alkaline have a **bitter taste.**

2) Dilute alkalis feel slippery and soapy to touch.

3) Concentrated alkalis are caustic, causing chemical burns.

4) Alkalis change red litmus paper blue.

Uses of alkaline

1) Found in toothpaste to neutralise acid on teeth

2) Calcium hydroxide used to neutralise acidity in soil

3) Magnesium hydroxide in indigestion tablets, also known as antacid pills

4) Sodium hydroxide in floor & oven cleaners

Examples of alkaline:

sodium hydroxide, NaOH
potassium hydroxide, KOH
calcium hydroxide, $Ca(OH)_2$
aqueous ammonia, NH_3

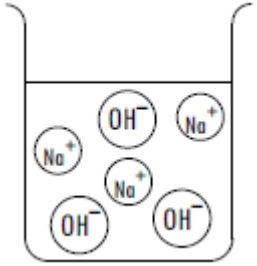
What makes an alkaline contain its 'alkaline properties'?

(Exactly the same as acid)

All alkaline have their alkaline properties due to the dissociation of **OH^- ions** when the alkaline are dissolved in water.

For example,

$$NaOH_{(s)} \xrightarrow{\text{water}} Na^+_{(aq)} + \mathbf{OH^-}_{(aq)}$$



Sodium Hydroxide

Weak Alkaline

$$NH_3\ (g) + H_2O\ (l) \overset{\text{reversible}}{\rightleftharpoons} NH_4^+\ (aq) + OH^-\ (aq)$$

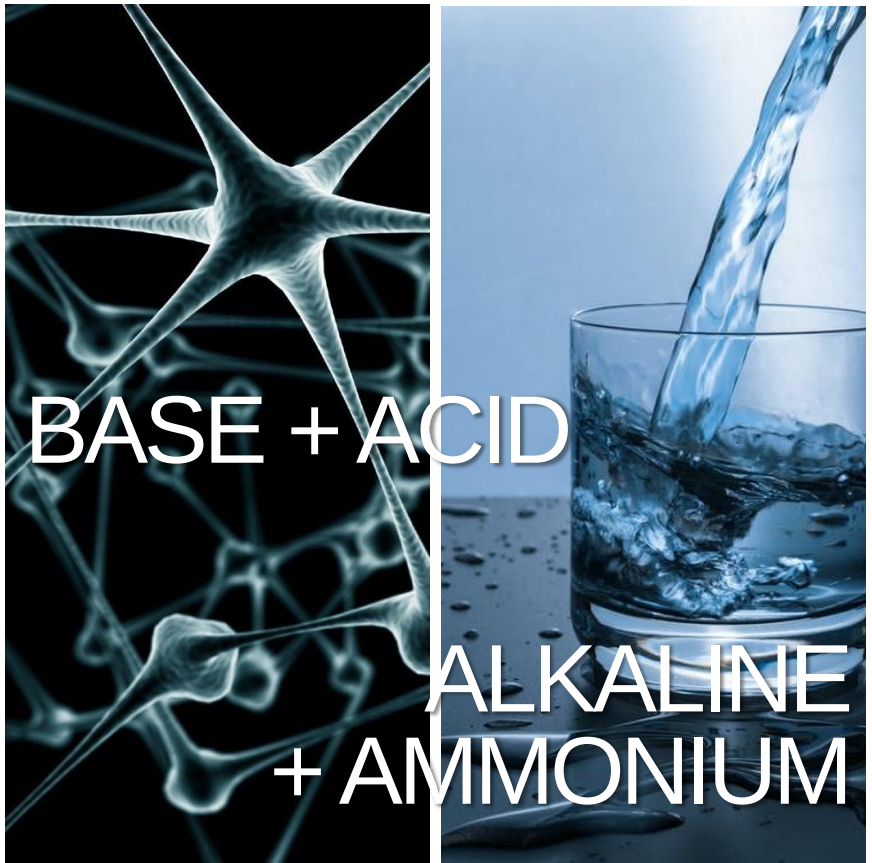
Aqueous ammonia is a commonly used weak alkaline that dissociates partially in water to produce a **low concentration of OH^- ions.**

As you can see in the equation, ⇌ is used instead of →.

⇌ means the reaction is **reversible**. So some of the NH_4^+ turns back to NH_3, resulting in **a low concentration of OH^- ions** produced.

2 CHEMICAL REACTIONS

1) BASE + ACID → SALT + WATER
2) ALKALINE + AMMONIUM SALT → SALT + WATER + AMMONIA GAS



1) BASE + ACID → SALT + WATER

For example,

$$Fe_2O_3\ (s) + 6HCl\ (aq) \rightarrow 2FeCl_3\ (aq) + 3H_2O\ (l)$$

This is also known as a **neutralisation** reaction.

In this example, hydrochloric acid is used to remove rust, Fe_2O_3.

2) ALKALINE + AMMONIUM SALT → SALT + WATER + AMMONIA GAS

*Ammonium = NH_4^+

For example,

$$2KOH\ (aq) + (NH_4)_2SO_4\ (s) \rightarrow K_2SO_4\ (aq) + 2NH_3\ (g) + 2H_2O\ (l)$$

To test for ammonia gas, place a strip of moist red litmus paper at the mouth of the test tube where the reaction is taking place.

The moist **red litmus paper will turn blue.**

Ammonia is a gas that has a characteristic pungent odour.

TAKE NOTE

Moist litmus paper must be used so that the ammonia gas can dissolve in water and undergo dissociate to form **OH^-** ions.

Remember that an alkaline only gets its alkaline properties **after** it has dissociated in water!

KEY CONCEPT

pH SCALE INDICATORS

KEY CONCEPT

pH scale

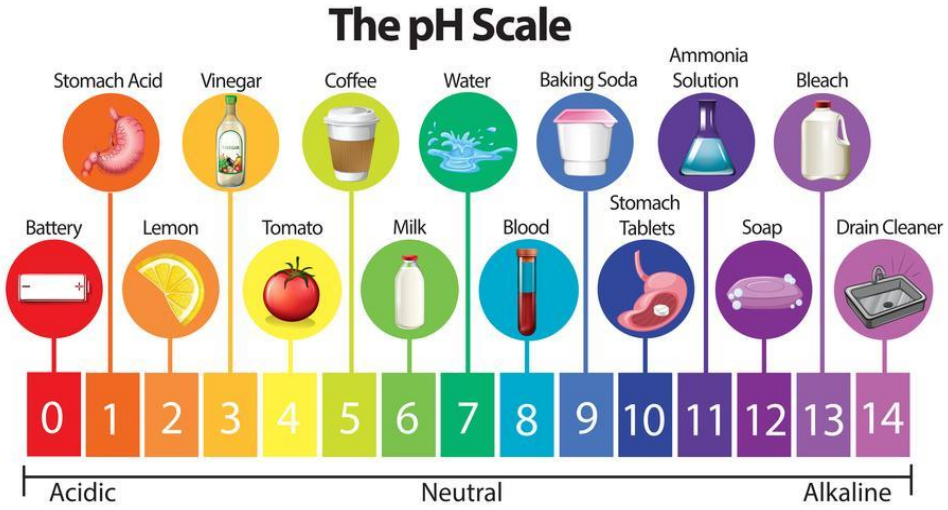
The pH of a solution is a quantitative measure of the extent of acidity or alkalinity. The pH scale ranges from 0 to 14.

pH actually stands for,

$$pH = -\log [H+]$$

To simplify, means that if pH values change by a factor of 1, the concentration is changed by a factor of 10.

pH 1 is 10 times more acidic than pH 2.



KEY CONCEPT

Importance of pH

Food preservatives

Food goes bad when it is attacked by microorganisms like bacteria.
Acids are used as preservatives as microorganisms cannot grow well in acidic solutions.

For example,
ethanoic acid (vinegar): to preserve vegetables like cabbage & kimchi
benzoic acid: to preserve jams, fruit juices and oyster sauces

pH in soil

Many plants grow best in weak acidic soil of pH 5.6.
If the soil is too acidic, limestone $CaCO_3$, in the form of agricultural lime can be added to raise the pH. Quick lime (CaO) or slaked lime, $Ca(OH)_2$, can be added too.

pH in human body

Different sections of the human body have different pH values.

Gastric juices in the stomach are acidic due to hydrochloric acid, with a pH of 1.5.
Fluids in the small intestine are alkaline with a pH of 8.4.
Blood is slightly alkaline with a pH in the range of 7.35 to 7.45.

(Easy to understand if you take Biology, 'Digestive System'.)

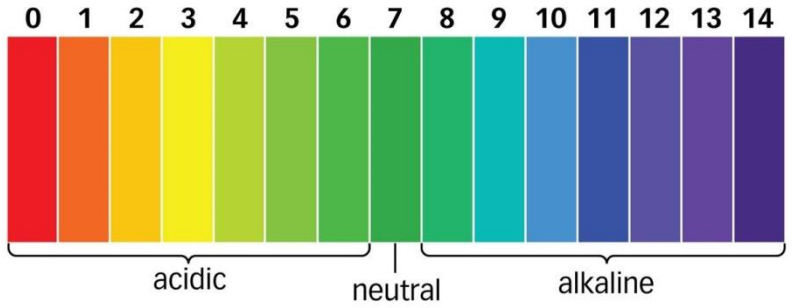
KEY CONCEPT

*Slowly familiarise but eventually must know them!

Indicators

Indicator	Acidic	Equivalence Point	Alkaline
Litmus	Red	Purple	Blue
Methyl orange	Red	Orange	Yellow
Screened methyl orange	Purple	Grey	Green
Phenolphthalein	Colourless	Pale pink	Pink
Bromothymol blue	Yellow	Green	Blue

Also, universal indicator.



OVERMUGGED
By Tutors, For Students

For more notes & learning materials, visit: www.overmugged.com

'O' levels crash course program

Professionally designed crash course to help you get a **condensed revision** before your 'O' Levels!

The **4 hour session** focuses on going through **key concepts** and **identifying commonly tested questions!**

Our **specialist tutors** will also impart valuable **exam pointers and tips** to help you maximise your preparation and ace your upcoming national exam!

The crash courses will begin in **June 2021 and last till Oct 2021**.

Pre-register now on our website and secure your slots!

IG handle:
@overmugged

Join our telegram channel:
@overmugged

Need help?

Darrell Er
(Private tutor with **8 years** of experience)

8777 0921
(Whatsapp)

@DarrellEr
(telegram username)