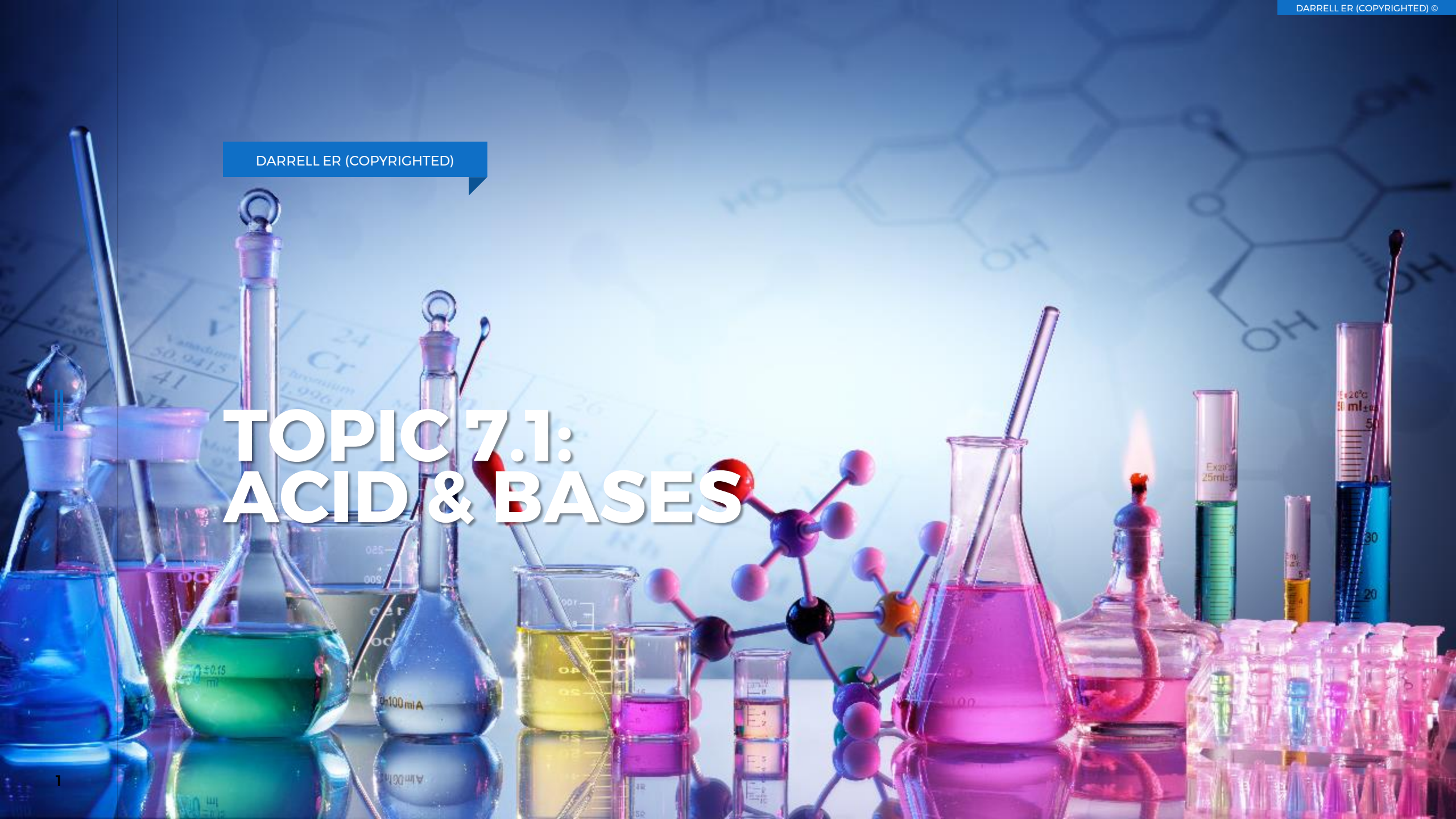
TOPIC 7.1: ACID & BASES



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)

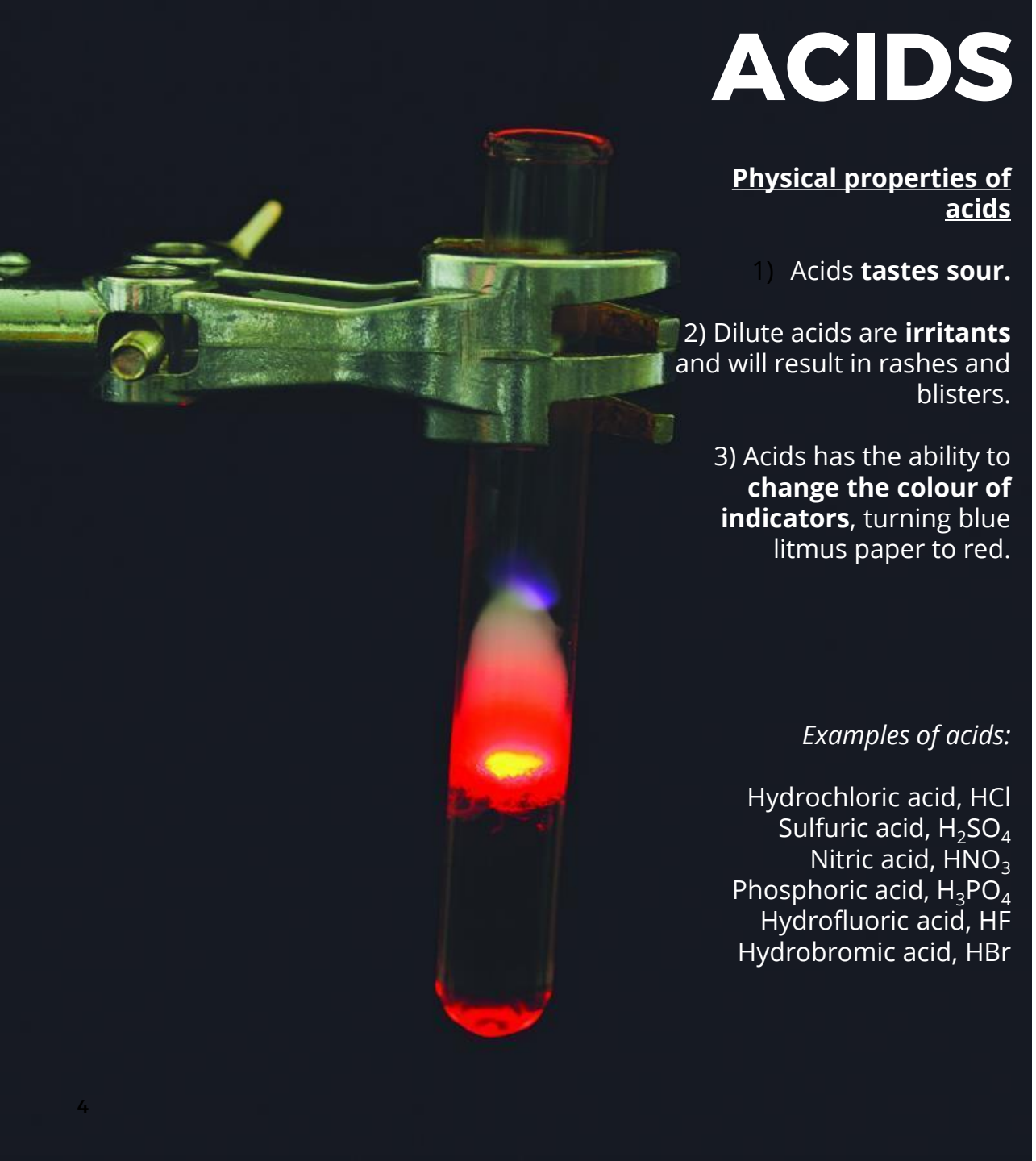
WEIGHTAGE

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

KEY CONCEPTS

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

ACIDS



Physical properties of acids

1) Acids **tastes sour.**

2) Dilute acids are **irritants** and will result in rashes and blisters.

3) Acids has the ability to **change the colour of indicators**, turning blue litmus paper to red.

Examples of acids:

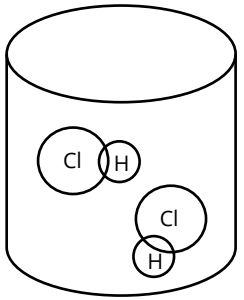
Hydrochloric acid, HCl
Sulfuric acid, H_2SO_4
Nitric acid, HNO_3
Phosphoric acid, H_3PO_4
Hydrofluoric acid, HF
Hydrobromic acid, HBr

What makes a compound/substance an 'acid'?

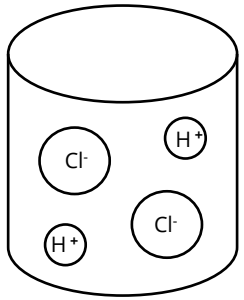
A compound is considered as an 'acid' due to the ability to dissociate **H^+ ions** when they are dissolved in water.

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 classifies it as an acid.

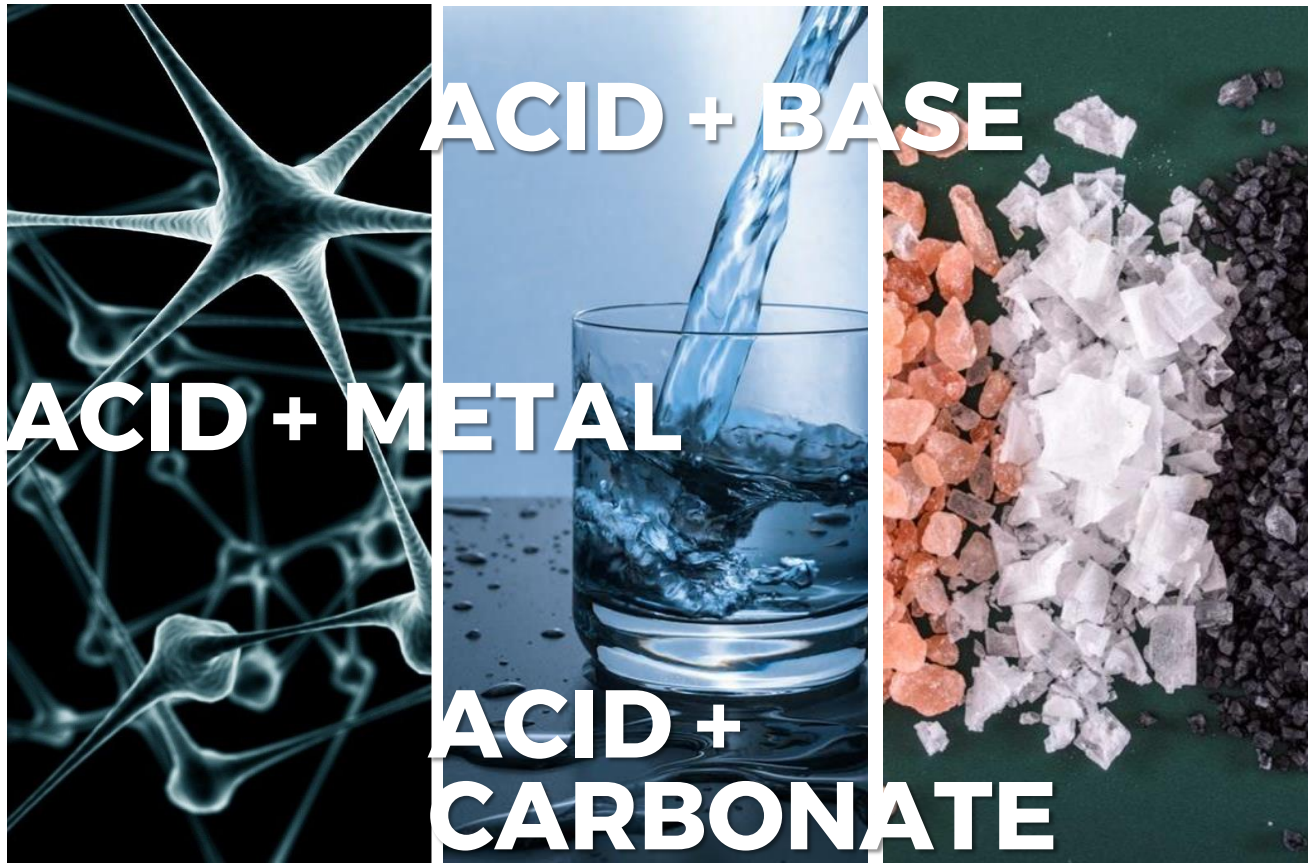
$$HCl_{(aq)} \rightarrow \mathbf{H^+}_{(aq)} + Cl^-_{(aq)}$$

In other words**, an acid is only considered as 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,

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

In order to test for hydrogen gas, use a 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.

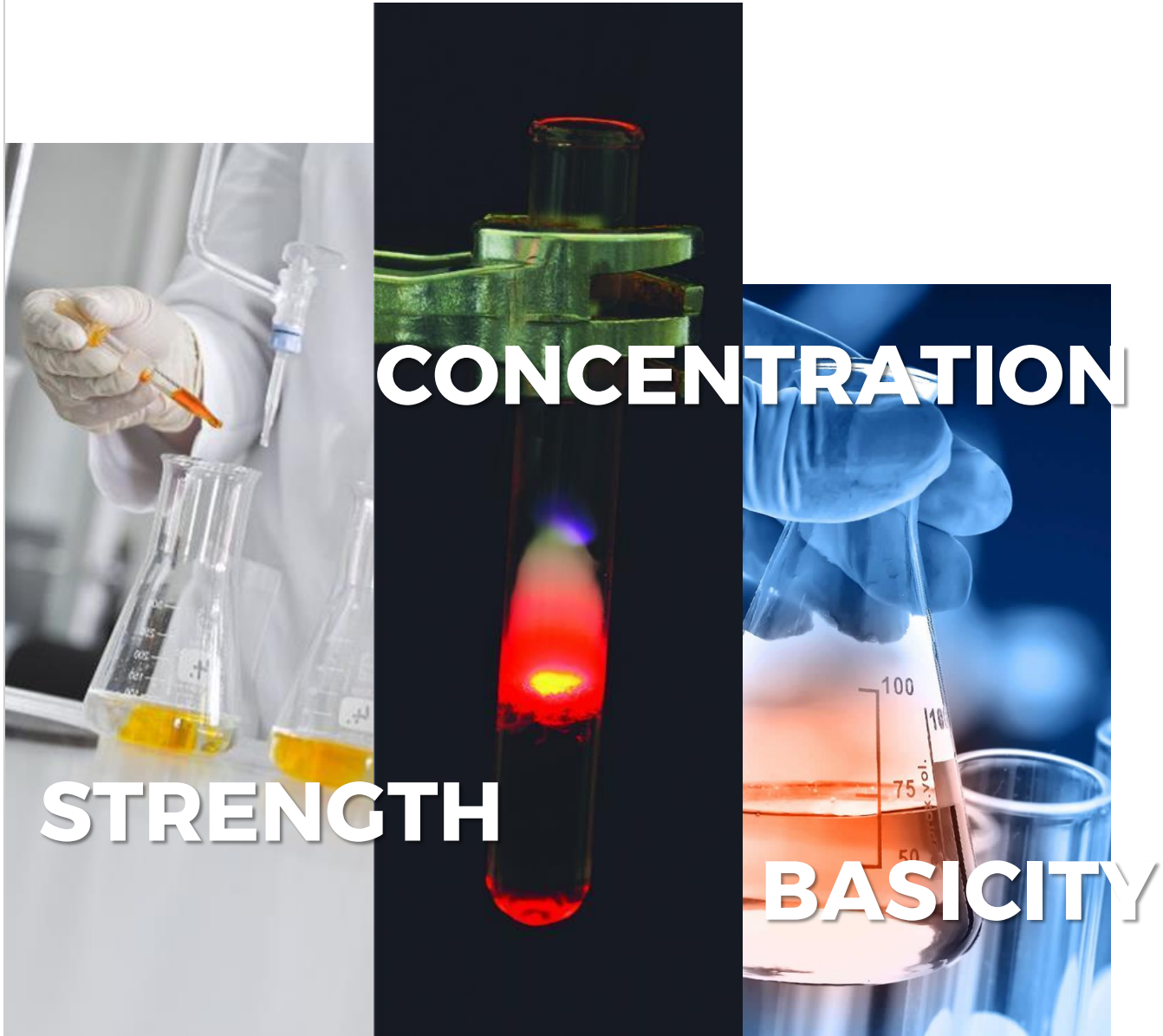
3) ACID + CARBONATE → SALT + WATER + CARBON DIOXIDE

For example,

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

In order to 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

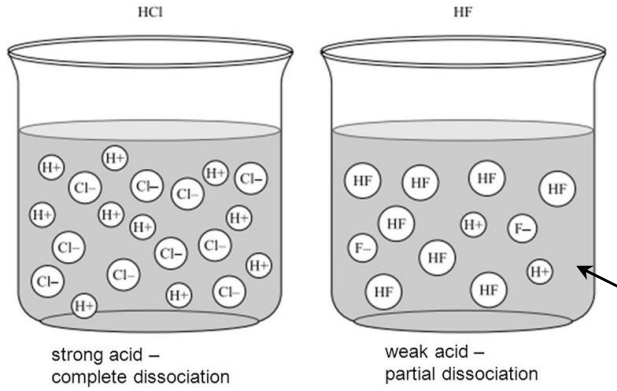
Strength of acid depends on the **nature** of the acid.

Strong acids have the ability to **dissociate fully** in water to produce a **high concentration of H^+ ions.**

Examples: nitric acid, hydrochloric acid, sulfuric acid

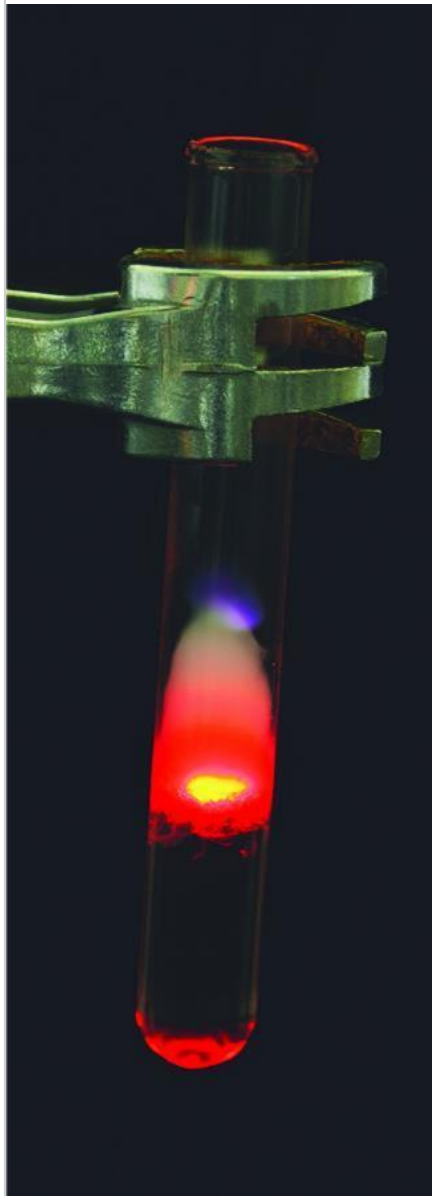
Weak acids only have the ability to **dissociate partially** in water to produce a **low concentration of H^+ ions.**

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 the strength of the acid**, hydrochloric acid is the stronger acid, since it produces more H^+ ions.**



Concentration of acid

Concentration of an acid is dependent on the **dilution factor of the solution,** or put in simple terms, 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 at high concentrations.
However, students use nitric acid on a regular basis in the school laboratories .

To make it safer, the lab staff adds a large amount of water to dilute the nitric acid.

Dilute nitric acid will then be able to be used in the chemical experiments, also being safe to use for the students as it is diluted.

Another example:

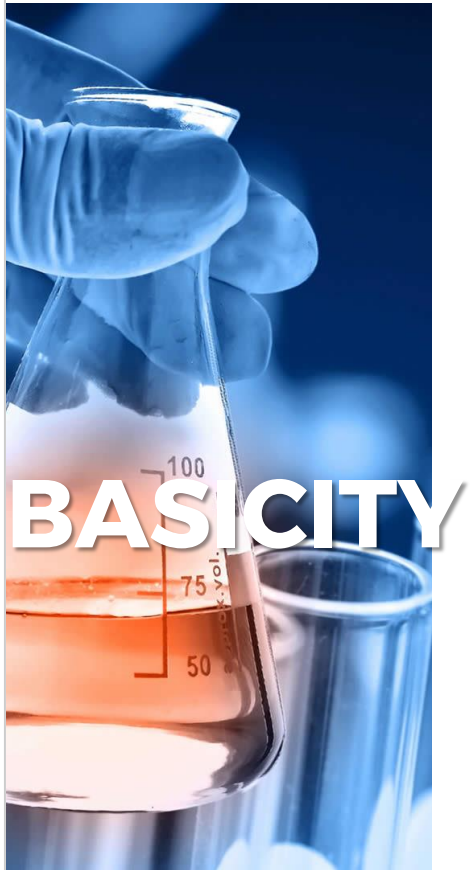
We buy ribena syrup from NTUC. Do we drink it straight? No, that will be too sweet because it is so concentrated.

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.

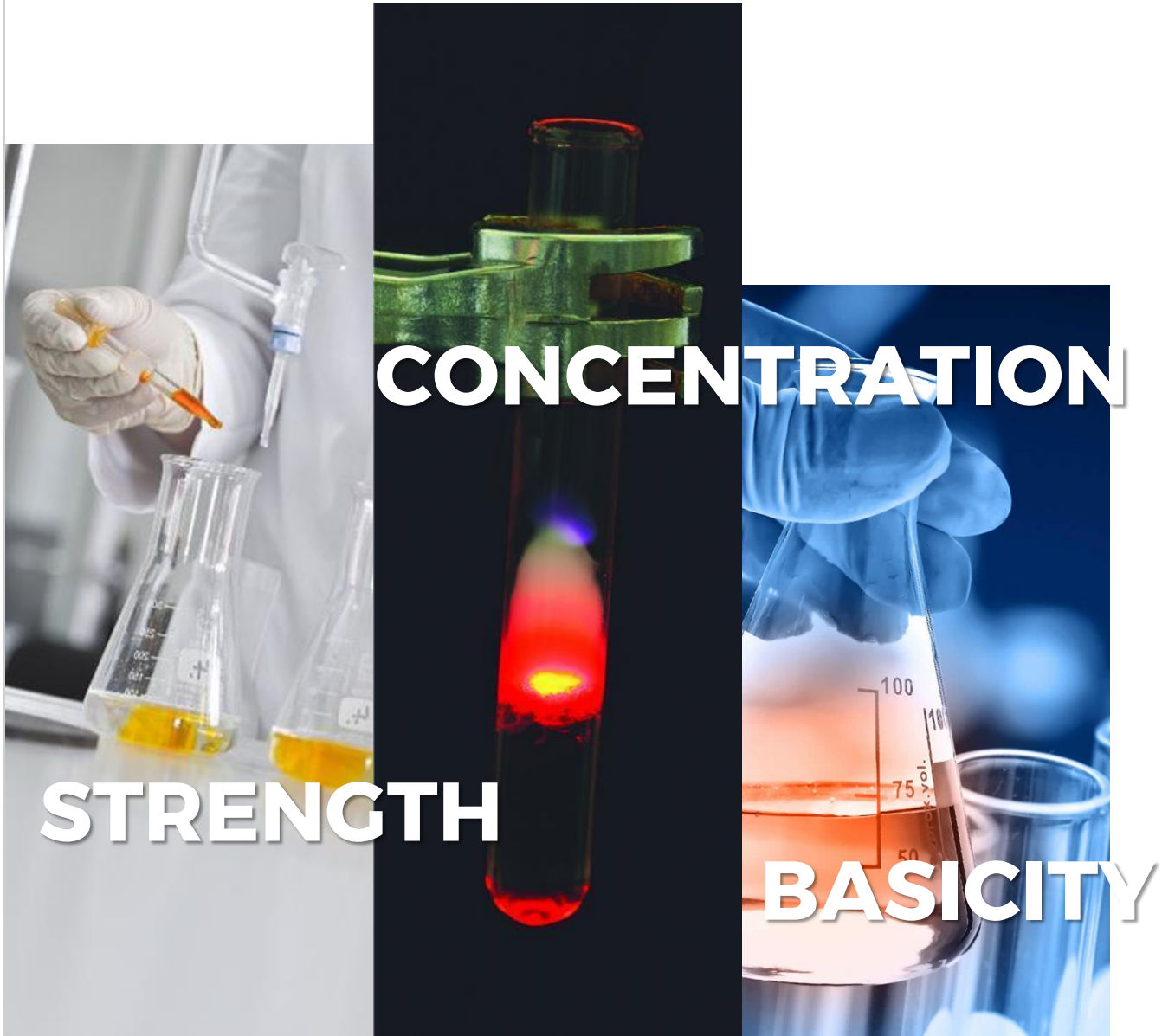


Acid	Chemical Formula	Basicity
Hydrochloric acid	HCl	monobasic
Nitric acid	HNO_3	monobasic
Sulfuric acid	H_2SO_4	dibasic
Phosphoric acid	H_3PO_4	tribasic

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 large amounts of water to it.

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 would produce a higher concentration of H^+ ions .

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

KEY CONCEPTS

DIFFERENTIATING BASE vs ALKALINE
ALKALINE PROPERTIES
ALKALINE'S CHEMICAL REACTIONS

BASE vs ALKALINE

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

ACID + BASE → SALT + WATER

$H_2SO_4 + MgO \rightarrow MgSO_4 + H_2O$

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

Alkaline are a special group of bases that are **soluble in water**.

Hence, alkaline have the ability to dissociate fully in water to produce **OH^- ions,** giving rise to its alkaline properties.

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

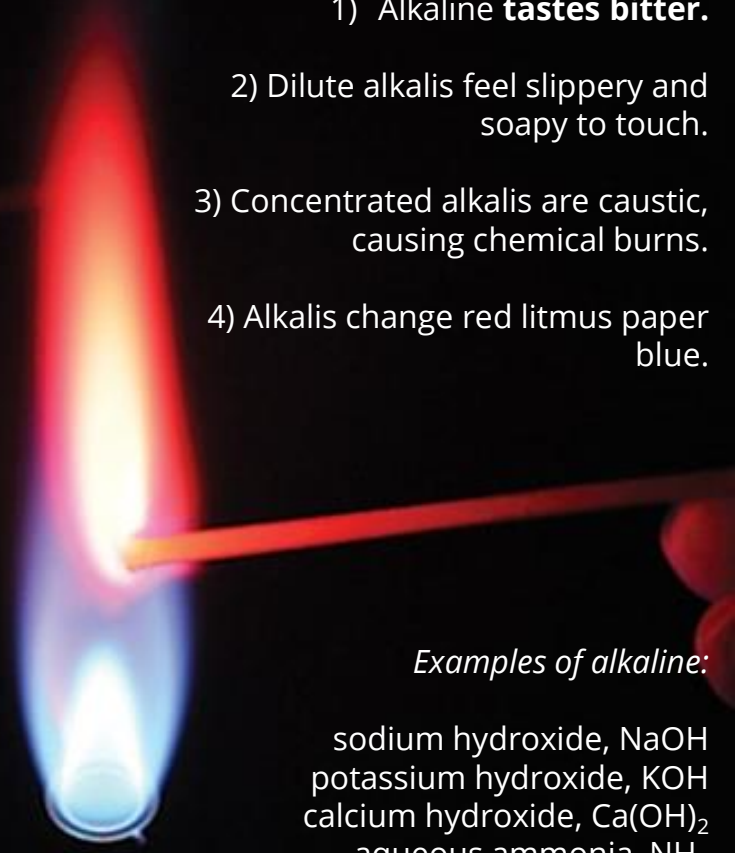
WHY?

All metal oxides and hydroxides are bases, but not all of them are soluble in water. Only 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 **tastes bitter.**

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

1) Calcium hydroxide used to neutralise acidity in soil

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

2) Sodium hydroxide in floor & cleaners

Examples of alkaline:

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

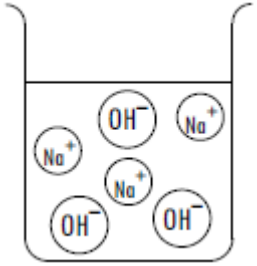
What makes a compound/substance an 'alkali'?

(Exactly the same as acid)

A compound is considered as an 'alkali' due to the ability to dissociate **OH^- ions** when the bases dissolve in water.

For example,

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



Sodium Hydroxide

Weak Alkaline

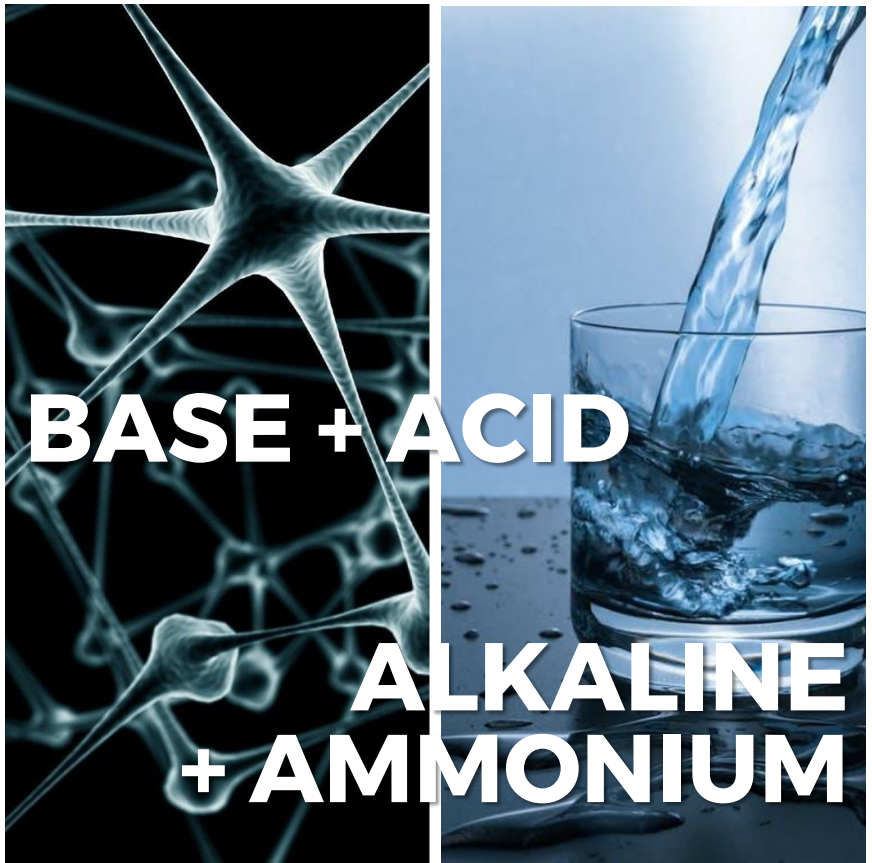
$$NH_3\ (g) + H_2O\ (l) \overset{\text{reversible}}{\rightleftharpoons} NH_4^+\ (aq) + OH^-\ (aq)$$

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

$\rightleftharpoons$ 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,

$$MgO\ (s) + 2HCl\ (aq) \rightarrow MgCl_2\ (aq) + H_2O\ (l)$$

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

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

*Ammonium = NH_4^+

For example,

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

In order 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.**

TAKE NOTE

Moist litmus paper must be used in order for the ammonia gas to dissolve in water and dissociate to form **OH^-** ions.

Remember that a base **is only considered as an 'alkali' after** it has dissociated in water!

KEY CONCEPT

pH SCALE INDICATORS

KEY CONCEPT

pH scale

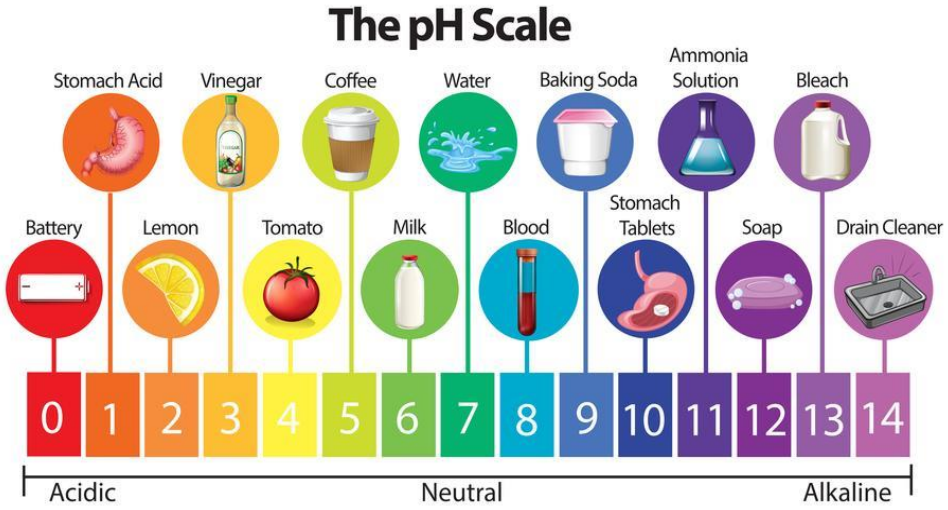
The pH of a solution is a quantitative measure of the extent of acidity or alkalinity. The pH scale ranges from 0 to 14.

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 decompose when it is attacked by bacteria.

Edible acids added and are used as preservatives as bacteria cannot grow well in acidic solutions.

For example,
ethanoic acid (vinegar): to preserve vegetables like kimchi

pH levels in soil

If the soil is too acidic, limestone, also known as calcium carbonate $CaCO_3$, can be added to neutralise the acidity.

Quick lime (CaO) or slaked lime, $Ca(OH)_2$, can be used too.

pH in human body

Gastric juices in the stomach are acidic due to hydrochloric acid, with a pH of 1.5-2.0.
Fluids in the small intestine are alkaline with a pH of 8+.
Blood is slightly alkaline with a pH in the range of above 7.

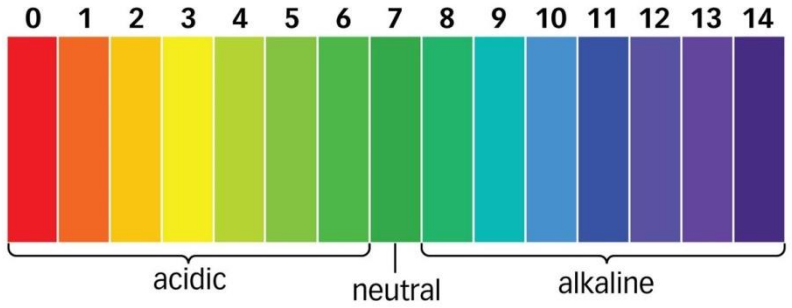
(Easy to understand if you take Biology, 'Digestive System'.)

KEY CONCEPT

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.



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