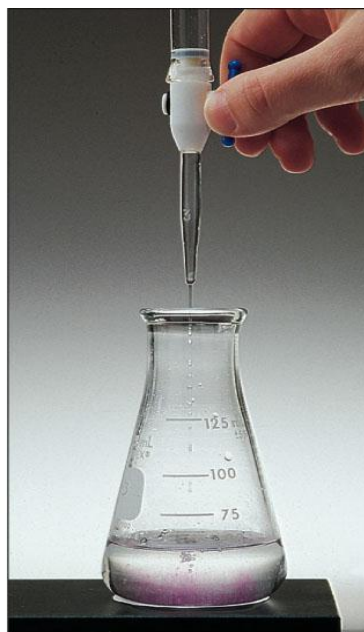


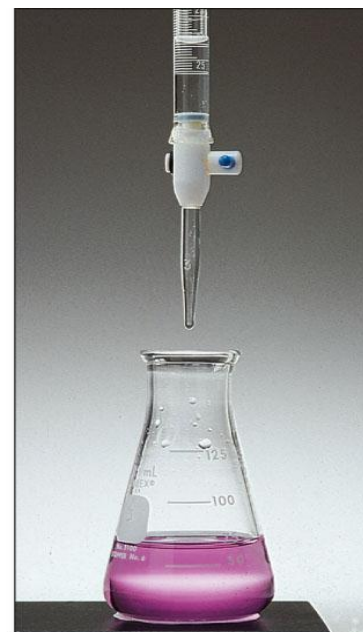
ACID-BASE TITRATION



(a)



(b)



(c)

OM PAL SINGH
ASSISTANT DIRECTOR
(PMRA), PMD, NIPHM

Titration: A **titration** is a technique where a solution of known concentration is used to determine the concentration of an unknown solution.

Volumetric titration: Volumetric titrations involve measuring the volume of a solution of known concentration that is needed to react completely with the analyte.

Titrimetric Analysis: Titration, also known as titrimetry, is a common laboratory method of quantitative chemical analysis that is used to determine the concentration of an identified analyte.

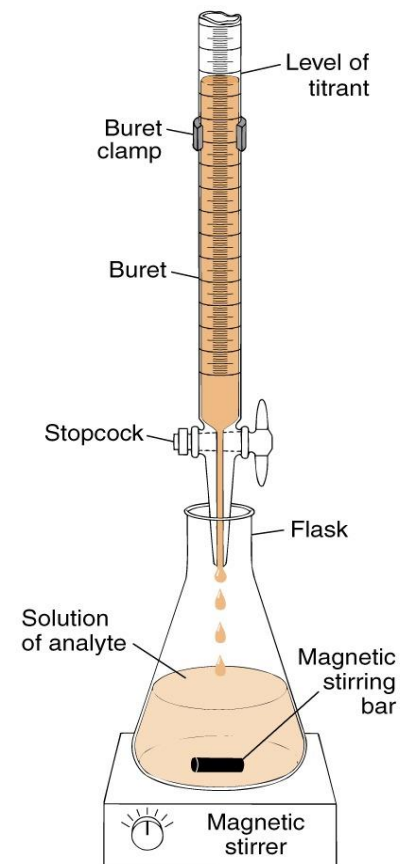
The volume of titrant reacted is called titration volume (tv).

Titrant : The **titrant** is usually a standard solution added carefully to the analyte until the reaction is complete.

The **titrant** is usually the solution of known concentration that is delivered by a burette into a known quantity of the solution of unknown concentration.

The **titrand** is the amount of analyte is calculated from the volume of **titrant** required for complete reaction.

Indicator : **Chemical indicator**, any substance that gives a visible sign (usually by a **colour change**) of the presence or absence of a threshold concentration of a **chemical species**, such as an acid or an alkali in a solution.

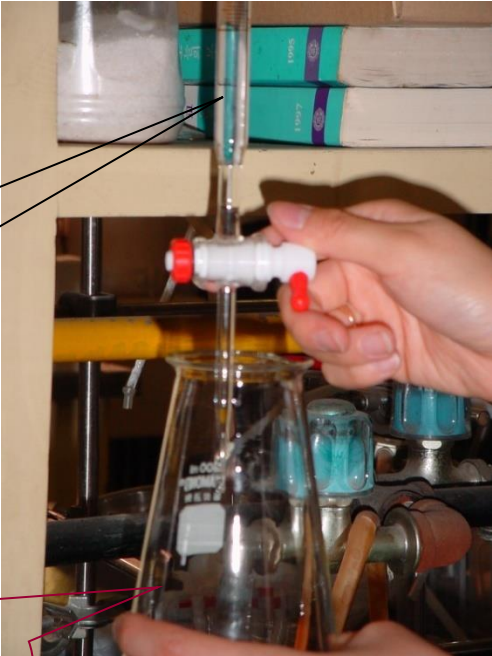


TITRIMETRIC ANALYSIS

1. **Acid base titration** *NaOH or HCl.* eg: 2,4-D,NAA, Carbofuran.
2. **Argentometric titration** *AgNO₃ & KSCN.* eg: Catan
3. **Iodometric titration** *Na₂ S₂ O₃ (Hypo) & Iodine.* eg: Mancozeb, Copper Oxychloride.
4. **Redox Titrations:** *Potassium permanganate and Oxalic acid.* eg: Zinc Phosphide/AlP.
5. **Non Aqueous Titrations:** *Perchloric acid.* eg: Carbendazim, Tridemorph

Equivalence point :

point in a titration at which equivalent amounts of titrant is the exact amount necessary for stoichiometric reaction with the analyte (titrand).



$N = \text{known}$
 $V = \text{measure}$

$N' = \text{unknown}$
 $V' = \text{known}$

End point : the point in a titration when **a physical change** occurs that is associated with the condition of chemical equivalence.

The experimental estimate of the equivalence point in a titration

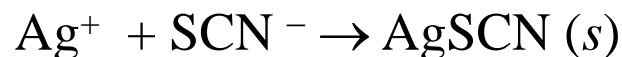
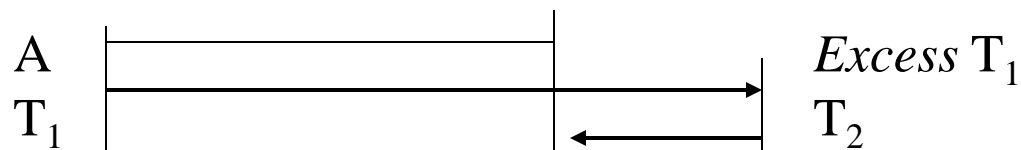
$$\text{titration error : } e_T = V_{ep} - V_{eq}$$

V_{ep} = actual volume at end point,

V_{eq} = theoretical volume of equivalence point

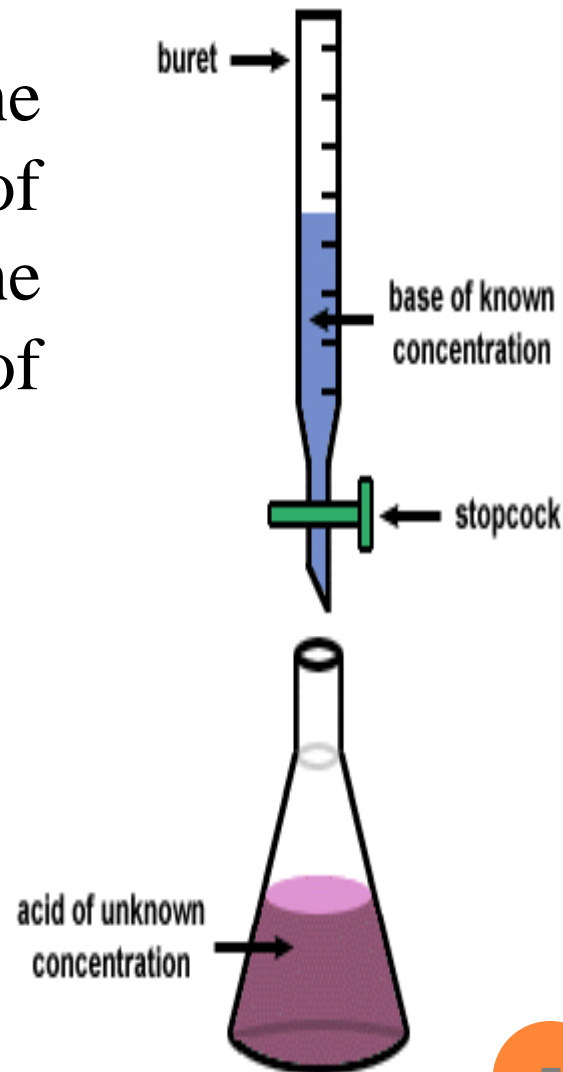
Direct titration : titrant is added to the analyte until the reaction is complete.

Back titration : Adding a *known excess* of reagent to the analyte, then, a second reagent is used to titrate the *excess* of the first reagent.



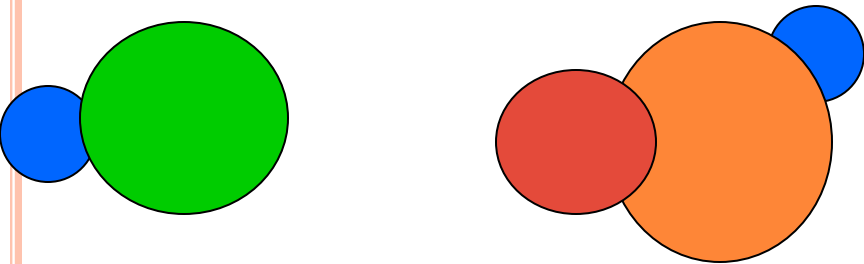
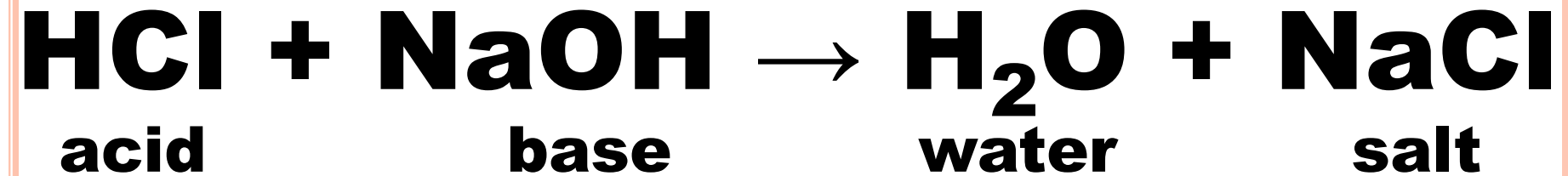
Acid-Base Titration

An acid-Base titration is the determination of the concentration of **acid/base** by neutralizing the **acid/base** with known concentration of **base/acid**.



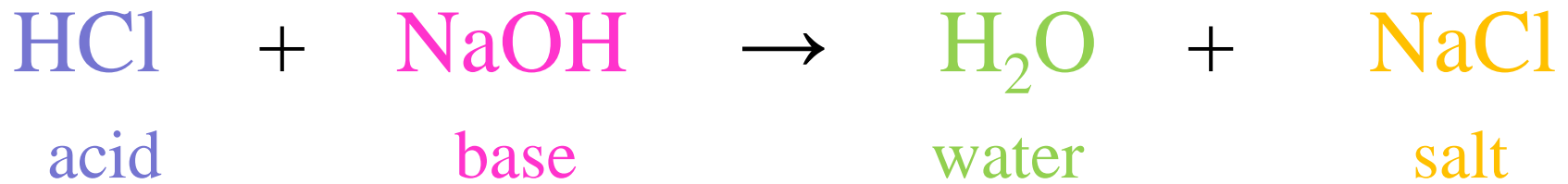
Reactions between acids and bases (Neutralization Reaction)

General acid base reaction



“Salt” means any ionic compound formed from an acid/base reaction

Volumetric analysis (Acid-Base titration)



IS : 13070 : 1991 - NAA – Technical
IS : 13138 : 1991 - NAA – SL

PROPERTIES OF ACIDS

1. **Acids release a hydrogen ion into water (aqueous) solution**
2. **Acids neutralize bases in a neutralization reaction.**
3. **Acids turn blue litmus to red.**
4. **Acids taste sour.**

Litmus Indicator

- Litmus paper exists in two colours, red and blue.



Litmus Indicator

Acids turn blue litmus paper red.



What about red litmus paper in acid?

Red litmus paper remains red.

Properties of bases

1. Bases release a hydroxide ion into water solution
2. Bases neutralize acids in a neutralization reaction.
3. Bases denature protein.
4. Bases turn red litmus to blue.
5. Bases taste bitter

Litmus Indicator

Alkalis turn red litmus paper blue.

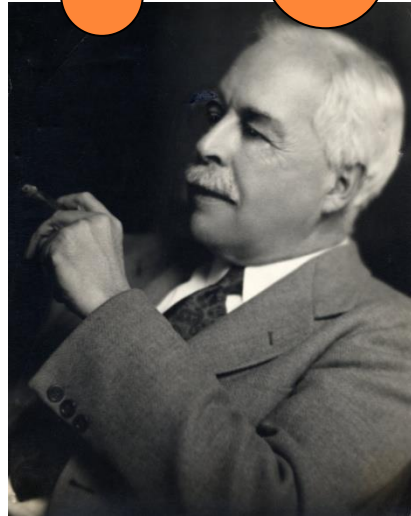
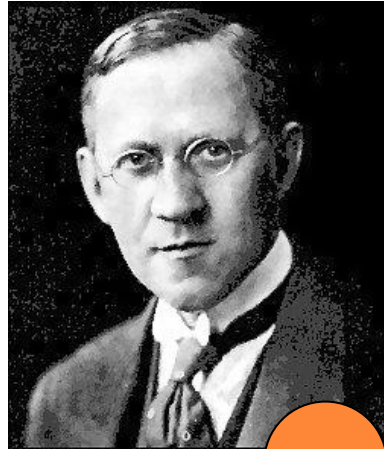


SCIENCEPHOTOLIBRARY

What about blue litmus paper in alkali?

Blue litmus paper remains blue.

LET'S START WITH THE THEORISTS!



How should we
define acids and
bases?

Arrhenius Theory



- **Acid** – a substance that produces H^+ ions (protons) when dissolved in water
 - Sour taste
 - Low pH
 - Turns blue litmus paper red
- **Base** – a substance that produces OH^- ions when dissolved in water
 - Bitter taste
 - Slippery feel
 - High pH
 - Turns red litmus paper blue

Red litmus paper with a drop of base here



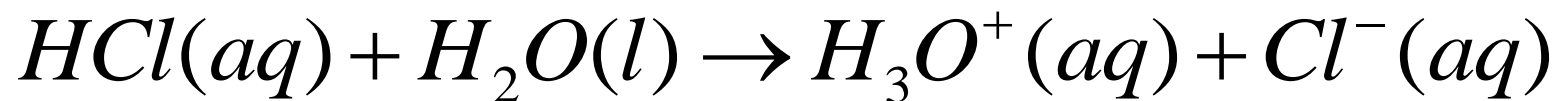
Blue litmus paper with a drop of acid here



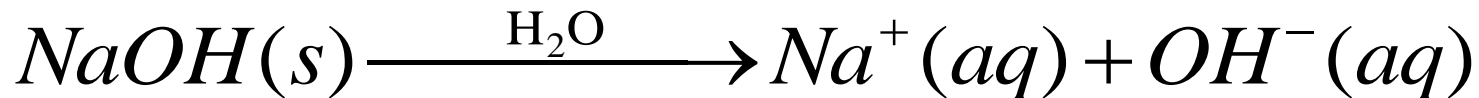


Arrhenius Theory

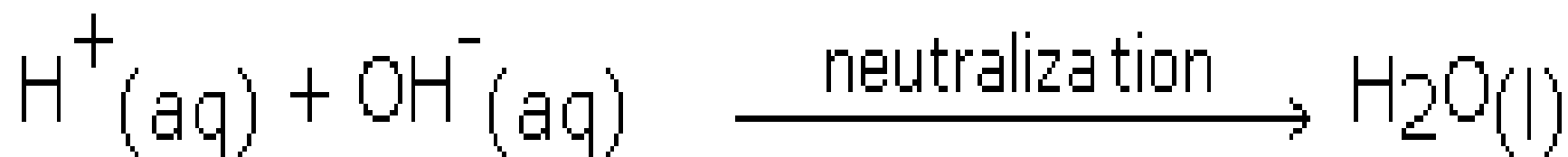
- ❖ **Acid:** any substance which delivers hydrogen ion (H^+) in **aqueous** solution.



- ❖ **Base:** any substance which delivers hydroxide ion (OH^-) in **aqueous** solution.



Thus, according to **Arrhenius concept** of acids and bases, the neutralization of an acid with a base involves the reaction between $\text{H}^+(\text{aq})$ and $\text{OH}^-(\text{aq})$ i.e.,



from acid from base



Arrhenius concept

- ❖ Is applicable to the acid-base behavior only in the **aqueous** medium.
- ❖ This concept defines acids and bases as compounds-containing **hydrogen and hydroxyl** group respectively.

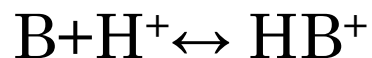
BRONSTED-LOWRY THEORY

- 1923
- **Acid** – a substance that produces H^+ ions (protons) when dissolved in the **any** medium
- **Bases** – proton acceptors

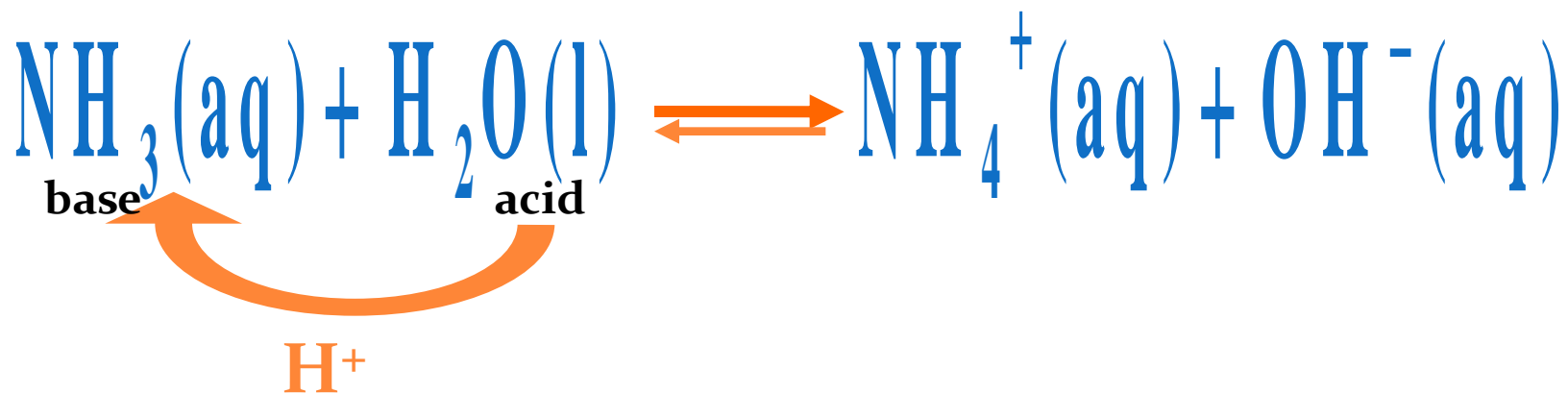


BRONSTED -LOWERY THEORY

- Any acid, (HB) is considered to dissociate in solution to give a proton (H^+) and a conjugate base (B^-) where as any base (B) will combine with a proton to produce a conjugate acid (HB^+)

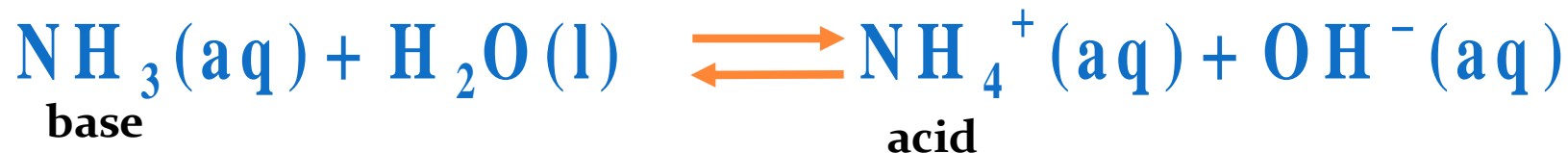


- Substances which are potentially acidic can function as acids only in the presence of a base to which they can donate a proton. Conversely basic properties do not become apparent unless an acid also is present.
- The ability of substances to act as acids or bases will very much depend on the choice of solvent system.



- In the **forward reaction**, NH_3 accepts a proton from H_2O . Thus, **NH_3 is a base** and **H_2O is an acid**.

Consider the reaction of NH_3 and H_2O .



- The species NH_4^+ and NH_3 are a conjugate acid-base pair.
- Here **NH_4^+ is the conjugate acid** of NH_3 and **NH_3 is the conjugate base** of NH_4^+ .
- The Brønsted-Lowry concept defines a species as an acid or a base according to its function in the proton-transfer reaction.

❖ A Brønsted–Lowry acid...

...must have a removable (acidic) proton.



❖ A Brønsted–Lowry base...

...must accept a proton.



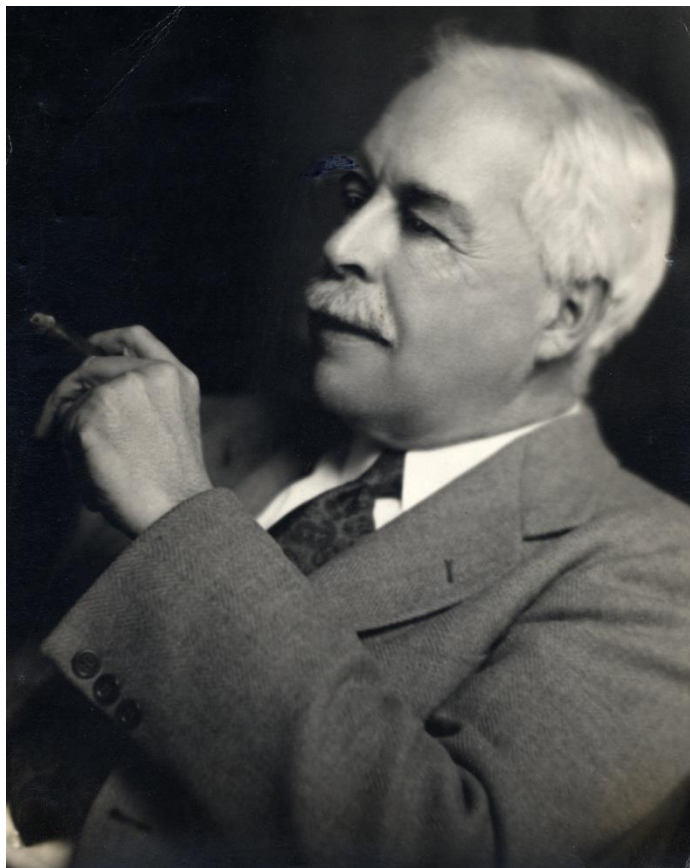
❖ IF IT CAN BE EITHER, IT IS AMPHIPROTIC



•In the Brønsted-Lowry concept:

1. A base is a species that accepts protons; OH^- is only one example of a base.
2. Acids and bases can be ions as well as molecular substances.
3. Acid-base reactions are not restricted to aqueous solution.
4. Some species can act as either acids or bases depending on what the other reactant is.

LEWIS THEORY



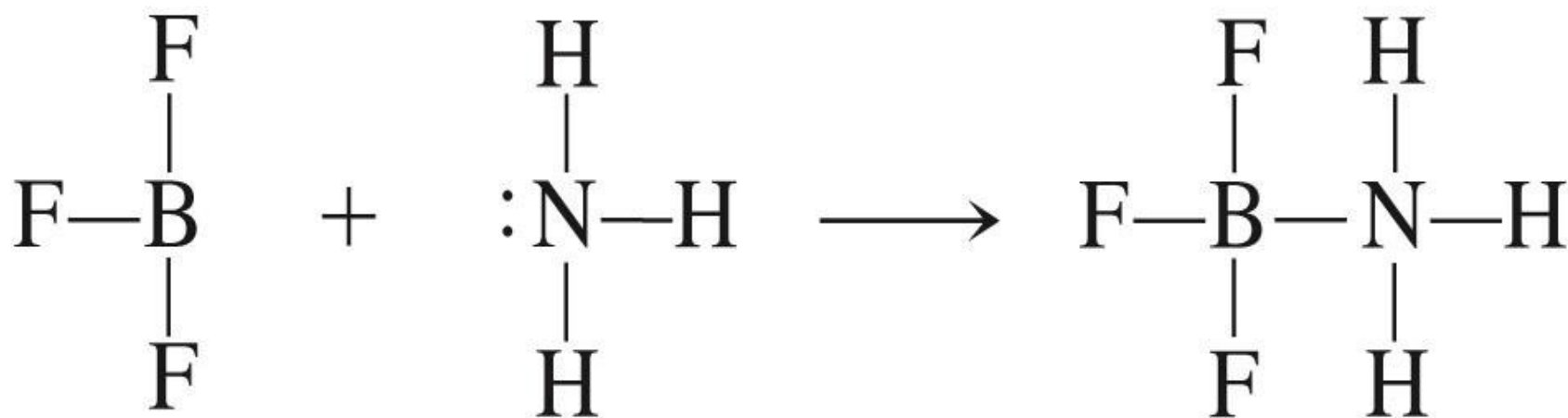
- Early 1920s
- Acid – electron-pair acceptor
- Base – electron-pair donor

Lewis concept of acids and bases

According to Lewis concept:

- **An acid is a substance which can accept a pair of electrons.**
- **A base is a substance which can donate a pair of electron**
- **Acid-base reactions according to this concept involve donation of electron pair by a base to an acid to form a co-ordinate bond.**

Lewis Theory of Acids & Bases



+



→



Lewis
Acid

Lewis
Base

(electron-pair
acceptor)

(electron-pair
donor)

DEFINITIONS

Arrhenius
only in water

- ❖ Acids – produce H^+ (HCl)
- ❖ Bases - produce OH^- (NaOH)

Bronsted-Lowry
any solvent

- ❖ Acids – produce H^+ (HCl)
- ❖ Bases - Accepts H^+ (NH_3)

Lewis

- ❖ Acids – accept e^- pair (BF_3)
- ❖ Bases – donate e^- pair ($:\text{NH}_3$)

Common Acids:

Strong Acids

The Formula

Sulphuric acid	H_2SO_4
Hydrochloric acid	HCl
Hydrobromic acid	HBr
Hydroiodic acid	HI
Nitric acid	HNO_3
Perchloric acid	HClO_4

All others considered Weak (examples)

Weak Acid	The Formula
Acetic acid (vinegar)	$\text{HC}_2\text{H}_3\text{O}_2$
Carbonic acid	H_2CO_3

Common Bases:

Strong Bases

The Formulae

Lithium hydroxide	LiOH
Sodium hydroxide	NaOH
Potassium hydroxide	KOH
Rubidium hydroxide	RbOH
Caesium hydroxide	CsOH
Barium hydroxide	Ba(OH) ₂
Calcium hydroxide	Ca(OH) ₂
Strontium hydroxide	Sr(OH) ₂

(Hydroxides of Group 1 and Group 2 Metals are STRONG)

All others are WEAK bases example

Weak Bases

The Formula

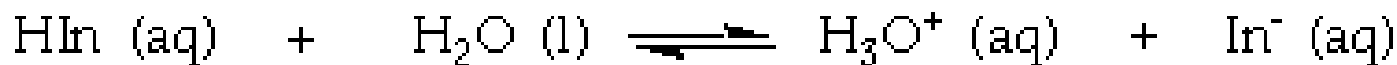
<u>Ammonia</u>	NH ₃
<u>Methylamine,</u>	CH ₃ NH ₂
<u>Ammoniumhydroxide</u>	NH ₄ OH

Acid–Base Titrations

1. Strong Acid – Strong Base Titrations ----- pH =7
2. Strong Acid – Weak Base Titrations ----- pH < 7
3. Weak Acid – Strong Base Titrations -----pH >7

Acid–Base Indicators

- An acid–base *indicator* is a weak acid or base.
- The acid form (HA) of the indicator has one color, the conjugate base (A⁻) has a different color. One of the “colors” may be colorless.
- In an acidic solution, [H₃O⁺] is high. Because H₃O⁺ is a common ion, it suppresses the ionization of the indicator acid, and we see the color of HA.
- In a basic solution, [OH⁻] is high, and it reacts with HA, forming the color of A⁻.



acid
(colour A)

conjugate base
(colour B)

Acid–Base Indicators

Indicator	Colour		pK _{ln}	pH range
	Acid	Base		
Methyl Orange	red	yellow	3.7	3.2 - 4.4
Bromocresol Green	yellow	blue	4.7	3.8 - 5.4
Methyl Red	yellow	red	5.1	4.8 - 6.0
Bromothymol Blue	yellow	blue	7.0	6.0 - 7.6
Phenol Red	yellow	red	7.9	6.8 - 8.4
Phenolphthalein	colourless	pink	9.4	8.2 - 10.0

TITRATION OF ACID AND BASE

Procedure for preparation of 0.1 N Sodium hydroxide (NaOH):

Weigh about 4 g of sodium hydroxide
(Equivalent wt = Molecular wt=40) in 100 ml beaker.
Add distilled water and dissolve using glass rod.
Transfer quantitatively in 1000 ml volumetric flask
and make up with distilled water.

Procedure for preparation of 0.1 N Hydrochloric Acid (HCl):

To prepare 1 L of 0.1 N HCl, the equation will be:

(note: Normality of concentrated HCl is about 12 N)

$$N_1 \times V_1 = N_2 \times V_2$$

$$(12 \text{ N}) \times V_1 = (0.1 \text{ N}) \times (1 \text{ L})$$

solving for the volume V_1 , we get:

$$V_1 = 8.33 \text{ ml}$$

So to prepare 1L, 0.1 N HCl from a stock solution of concentrated HCl (12 N), we will need to obtain 8.33ml of concentrated HCl and transfer it to a 1 L volumetric flask, then dilute to volume (1 L) with water.

$$\text{Normality} = \frac{\text{Specific Gravity (g/l)} \times \text{Percentage (\%)} \times 10}{\text{Equivalent Weight (g/ eq)}}$$

$$\text{Molarity} = \frac{\text{Specific Gravity (g/l)} \times \text{Percentage (\%)} \times 10}{\text{Molecular Weight (g/ mol)}}$$

Procedure for preparation of Phenolphthalein (0.1%):

Weigh about 0.1 g phenolphthalein and transfer into a 250 ml beaker.

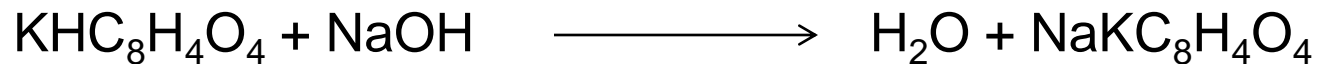
Dissolve it in 60 ml ethanol. Add 40 ml distilled water, shake well.

Transfer it into an indicator bottle

Procedure for standardization of Sodium hydroxide

(NaOH) solution:

1. Weigh about 0.4 - 0.5 g of potassium hydrogen phthalate (KHP) previously powdered and dried at 105°C for 1 hrs in a conical flask.
2. Dissolve it in 40 - 50 ml distilled water and add 3 to 4 drops of phenolphthalein indicator.
3. Titrate with 0.1 N sodium hydroxide solution.
4. End point will be **light pink**.



Note down the volume of sodium hydroxide consumed.

Calculation:

$$\text{Normality} = \frac{\text{Weight of primary standard (KHP)} \times 1000}{\text{Titre value (0.1N NaOH)} \times \text{Equivalent wt. of KHP}}$$

Equivalent wt. of KHP = 204.22

Procedure for standardization of Hydrochloric acid

(HCl) solution:

Weigh out accurately 0.2 g. of pure sodium carbonate into a 250 ml conical flask.

Dissolve it in 50-75 ml water and add 2 drops of methyl orange indicator.

Titrate against hydrochloric acid from the burette until the colour of the methyl orange becomes orange or a faint pink/ pinkish orange.

$$\text{Normality of HCl} = \frac{\text{Weight of Na}_2\text{CO}_3 \times 1000}{\text{Volume of HCl} \times 53}$$

Pesticides analysed by Acid base titration

- NAA
- Carbofuran

THANK YOU