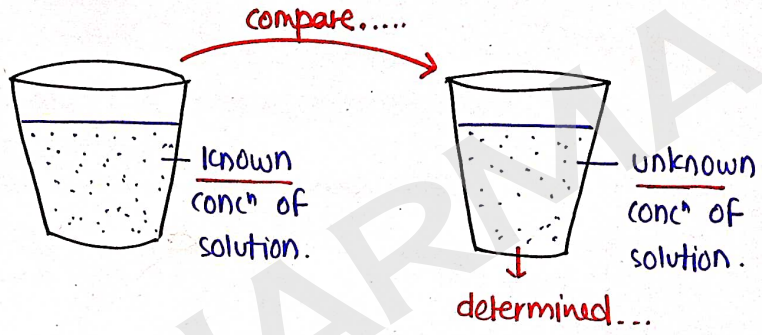
# ACID BASE TITRATION

**CHAPTER - 1** **UNIT - 2**




## • SYLLABUS:

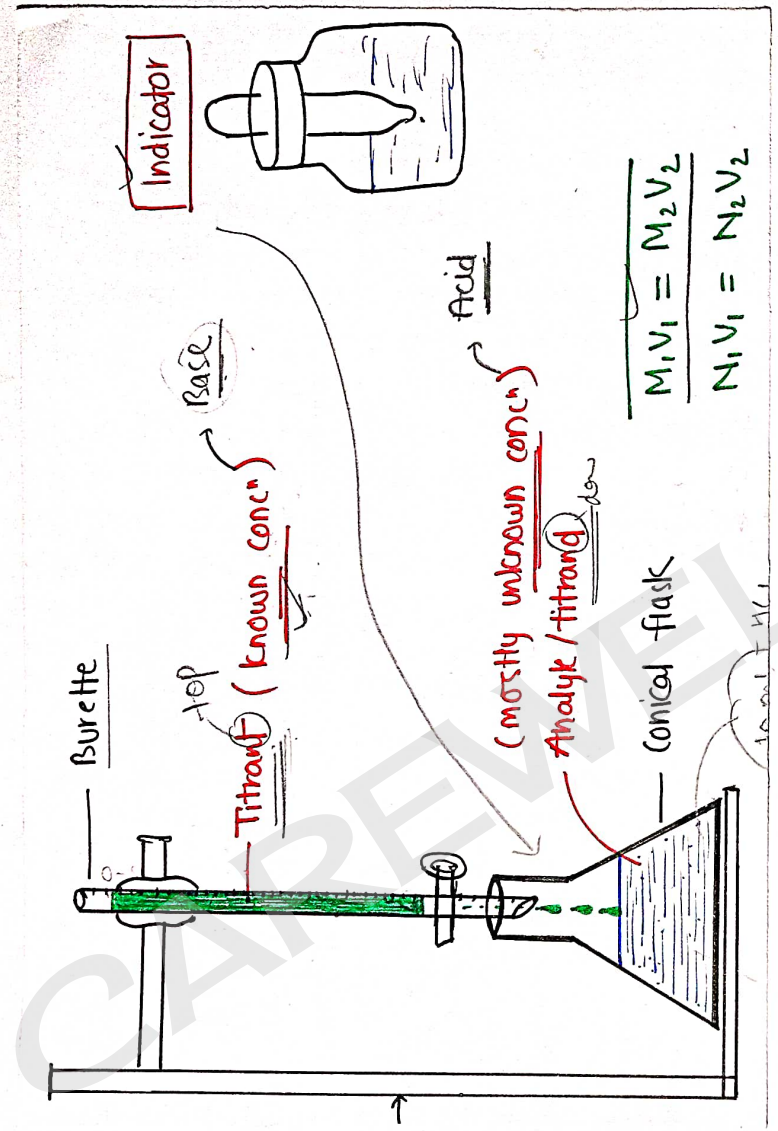
Acid Base Titration - Introduction

Theories of acid base indicators, classification of acid base titration and theory involved in titrations of strong, weak, and very weak acids and bases, Neutralization curves.

## • TITRATION:

It is a process / technique in which a solution of known concentration is used to determine the concentration of an unknown solution.

- During titration, the titrant (the know solution) is added from a burette to a titrand (the unknown solution) until the reaction is complete. i.e. till end point (occurs by indicator).
- Some common terms :-
- Titrant → A solution with known concentration, which is taken in burette
- Titrand → A solution with unknown concentration which is taken in conical flask.
- Indicator → A substance which is added in titrand for identifying end point.
- Equivalence point → When moles of titrand




or analyte is equal to the moles of titrant (i.e. known concentration).

- End point → The point which indicates that reaction is completed by changing the color of solution.

## ACID - BASE TITRATION

It is a quantitative analysis which is used for determination of unknown concentration of acid / base with the help of known concentration of base / acid.

- The principle of acid - base titration is based on the neutralisation reaction, in which acid is react with base and formed salts.

$$\underset{\text{Acid}}{HCl} + \underset{\text{Base}}{NaOH} \longrightarrow \underset{\text{Salt}}{NaCl} + \underset{\text{water}}{H_2O}$$

- It is also known as Neutralisation titration.
- Phenolphthalein is the most commonly used indicator for acid-base titration.

**Theories:**

| THEORY | ACID | BASE |
|---|---|---|
| Arrhenius | $H^+$ producer | $OH^-$ producer |
| Bronsted-Lowry | $H^+$ donor | $H^+$ acceptor |
| Lewis | Electron pair acceptor | Electron pair donor |

- **Acidimetry** (basic by std. acid) :- It is determination of unknown concentration of basic/alkaline solution by standard acidic solution
- **Alkalimetry** (acid by std. basic) :- It is determination of unknown concentration of acidic solution by standard basic solution.

## THEORIES OF INDICATORS

- **Indicators:** These are those substances which are used in titration for determine end point by changing color of solution.
  (eg. Phenopthalein, Methyl Red etc..
- **Theories:** These are those theories which explain the working/mechanism of indicators i.e. how they change their color.
- **Acid-Base Indicators:**

These are those indicators which are used in acid-base titration.

- They are mainly weak organic acids / bases
- The principle of acid-base indicator is depends on that they show/produce different color in different solutions based upon the conc$^n$ of $H^+$ ions.
- They change the color of solution when the

nature of solution changes (i.e Acidic to basic or vice-versa). → End Point.

- They also known as Visual Indicators.

(eg. p-nitrophenol, Phenolphthalein, Methyl orange

⊙ They have mainly two types of theories:

(i) Ostwald's theory

(ii) Quinonoid theory

## (i) Ostwald's theory:

Acc. to this theory, Indicators are generally weak acids or weak bases and they change their color on the basis of their ionization state.

- Indicator produce different-2 colors in their ionized and unionized state.

Unionized (color-A) ⟶ Ionized (color-B)

### (a) When indicator is weak acids -

- Now, when indicator is weak acids, it present in unionized form in acidic solution because weak acids does not dissociates (very low) in acidic solution due to common ion effects.
- example - Phenophthalein (HPh) → weak acid

Acidic: HPh (unionized) colorless ⇌ $H^+$ + $Ph^-$ (ionized form) pink color (basic)

- But, these indicator dissociates in basic solution and convert into ionized form and change color.

### (b) When indicator is weak bases -

- Now, when indicator is weak bases, it present in unionized form in basic solution and ionized form in acidic solution.

- example - Methyl Orange (MeOH) → weak base

Basic

$$MeOH \rightleftharpoons Me^{+} + OH^{-}$$

(unionized) (ionized)

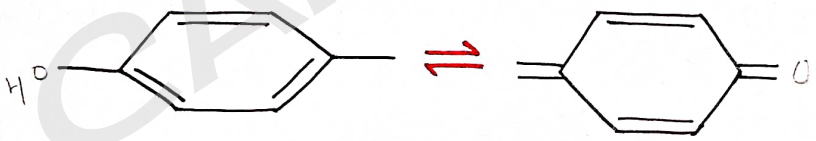
Yellow Red

Acidic

## (ii) Quinonoid theory :

According to this theory, Indicators are present in different tautomeric forms (diff. structure)

- Indicator produce different color in different forms, i.e. Benzenoid form and Quinonoid form.



Benzenoid form

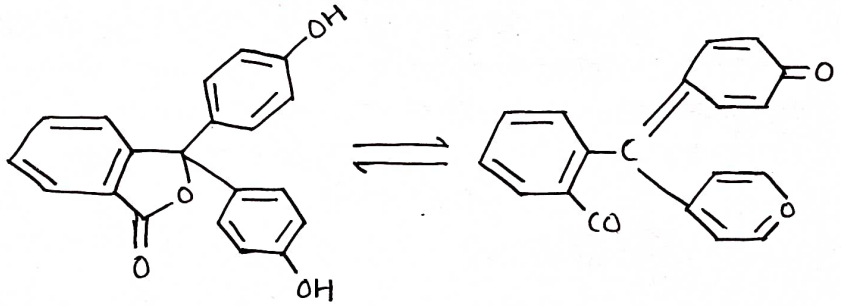


Quinonoid form

- Now, in this one form is exist in acidic solution and other one in alkaline / basic and produces color.
- example - Phenolphthalein

In acidic medium, phenolphthalein is in benzenoid form and colorless.

while in alkaline medium, it is (pink) and in quinonoid form.



Benzenoid form

(Acidic medium)

Colorless

Quinonoid form

(Basic / alkalani medium)

Pink color

# CLASSIFICATION OF ACID-BASE T.

Acid Base titration is based on the neutralization reaction in which acid is react with base and formed salts.

ACIDS

- Strong acid → Those acids which dissociates completely. pH → 0-3
- Strong base → Those bases which dissociates completely. pH → 11-14

eg. $HCl \xrightarrow{aq.} H^+ + Cl^-$ (strong acid)

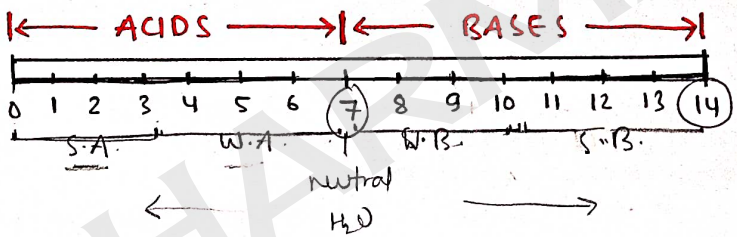
$NaOH \longrightarrow Na^+ + OH^-$ (strong base)

BASES

- Weak acid → Those acids which dissociates partially. pH → 3-7
- Weak base → Those bases which dissociates partially. pH → 07-10

eg. $CH_3COOH \rightleftharpoons CH_3COO^- + H^+$ (W.A.)

$NH_4OH \rightleftharpoons NH_4^+ + OH^-$ (W.B.)




- Based on the nature of an acid and base, these reaction can be classified into:-

① Strong Acid (neutralized) and Strong Base :- In this, strong acid is react with strong base which forms neutral salt.

$HCl + NaOH \longrightarrow NaCl + H_2O$

Hydrochloric acid + Sodium hydroxide → Sodium chloride + water

② Strong Acid (neutralized) and weak base :- In this, strong acid is react with weak base

which forms acidic salt. (due to strong acid).

$HCl + NH_4OH \longrightarrow NH_4Cl + H_2O$

Hydrochloric acid — Ammonium hydroxide — Ammonium chloride — Water

### ③ Weak Acid (neutralized) and Strong Base :-

In this, weak acid is react with strong base, which form alkali/basic salts.

$CH_3COOH + NaOH \longrightarrow CH_3COONa + H_2O$

Acetic acid — Sodium Hydroxide — Sodium acetate

### ④ Weak Acid (neutralized) and Weak Base :-

In this, weak acid is react with weak base forms neutral salt.

$CH_3COOH + NH_4OH \longrightarrow CH_3COONH_4 + H_2O$

Acetic acid — Ammonium Hydroxide — Ammonium acetate

## NEUTRALIZATION CURVE

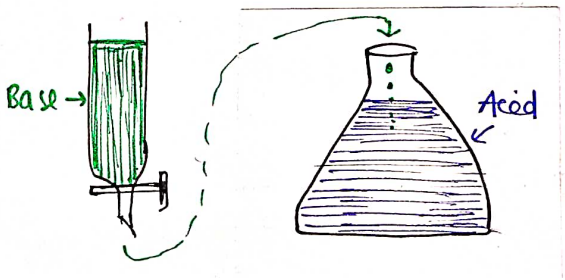
During Acid Base titration, acid is neutralized by base.

Now, that time during titration the pH of acid is changes when base is added in it.

So,

Neutralization curves are those graph/curve in which pH is plotted against the volume of alkali/base added during titration.

- In case, when base is neutralized, pOH is plotted against the volume of acid added.
- It is also known as titration curve

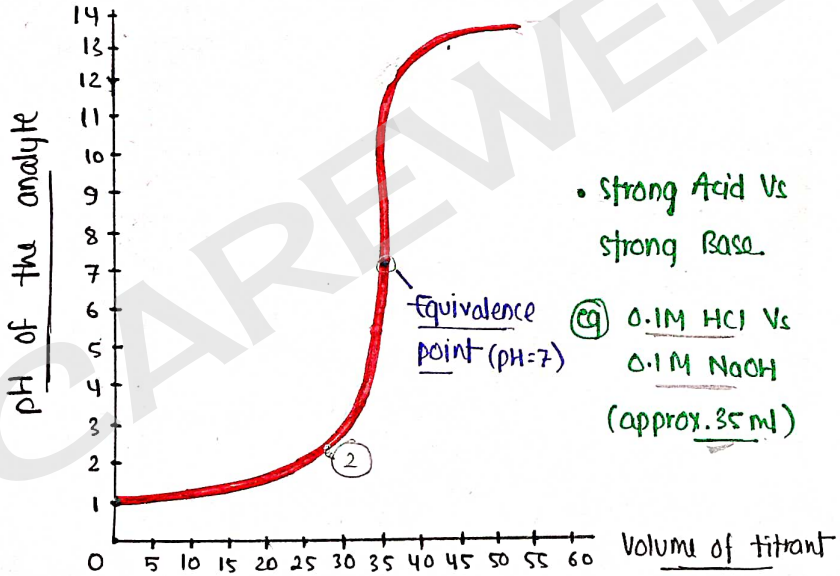



- pH of Acid ↓ Slightly increases ↓ Acid Neutralized

- It is of four types :-
  - (I) Strong Acid Vs Strong Base
  - (II) Strong Acid Vs Weak Base
  - (III) Weak Acid Vs Strong Base
  - (IV) Weak Acid Vs weak Base

## (I) Strong Acid Vs Strong Base :-

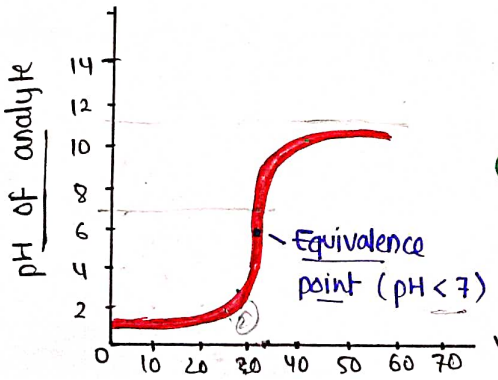
In this, strong acid (HCl) is neutralized by strong base (NaOH).




- Strong Acid Vs strong Base.
- eg. 0.1M HCl Vs 0.1 M NaOH (approx. 35 ml)
- In this, the curve begins acidic the rises gradually.
- Near equivalence point, pH increases at greater speed and then turns into basic.
- Equivalence point at pH = 7
- Phenolphthalein, bromo thymol blue and methyl red are used as Indicators.
- for neutralization of strong base, the curve is obtained identical.

## (II) Strong Acid Vs Weak Base :-

In this, strong acid is neutralize by weak base and formed acidic salt whoose equivalence point is slightly less than 7

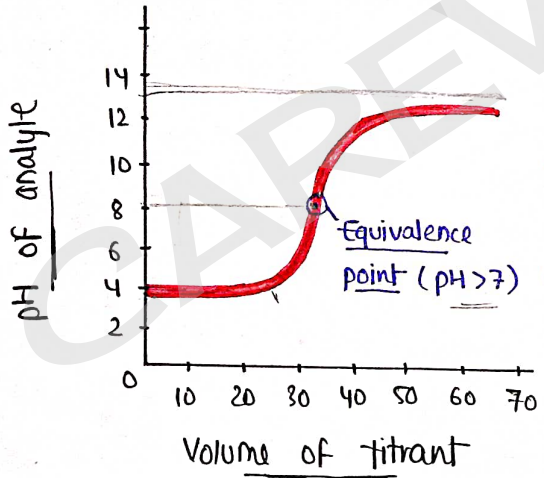



- Strong Acid Vs weak bas
- eg. 0.1 M HCl Vs 0.1 M $NH_4OH$. (approx. 3c ml)

- In this, the curve begins acidic and turns basic.
- Due to strong acid, its equivalence point is pH < 7.

## (III) Weak Acid Vs Strong Base :-

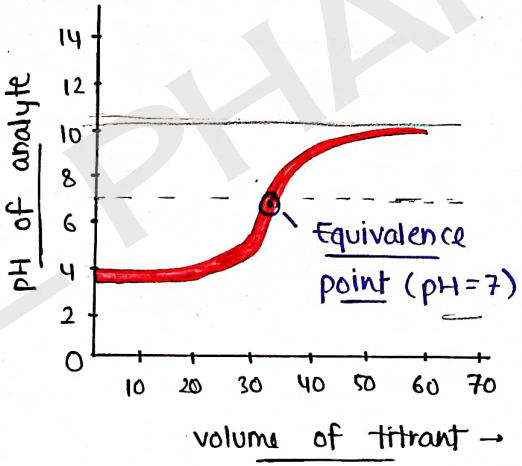
In this, weak acid is neutralized by strong base which formed basic salt, whoose equivalence point is slightly more than 7 i.e. (pH > 7) due to presence of strong base.




- Weak acid Vs strong base.
- eg. 0.1 M $CH_3COOH$ Vs 0.1M NaOH (approx. 30 ml)

## (IV) Weak Acid Vs Weak Base :-

In this, weak acid is neutralized by weak base which formed neutral salts, whoose equivalence point is about 7 (pH = 7).




- Weak acid Vs weak base.
- eg. 0.1M $CH_3COOH$ Vs 0.1M $NH_4OH$ (approx. 30ml)
- In this, the curve begins acidic (above 3) and turns basic.