



Unit 3

Acid-Base, Non-aqueous & Precipitation Titrations and Gravimetry, Complexometric & Redox Titrations



ANALYSIS



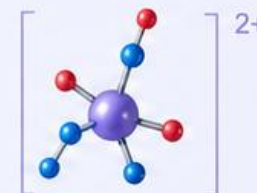
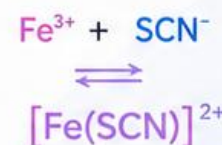
ACCURACY



QUALITY



RELIABILITY



TITRATION



PRECISION



ACCURACY



RELIABILITY



ACID-BASE INDICATORS: TWO MODELS

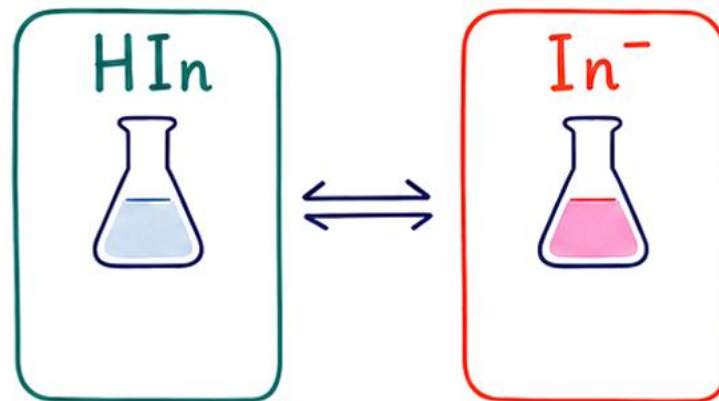
INDICATOR EQUILIBRIUM

An indicator is a weak acid or base whose conjugate forms have different colours.



$$\text{pH} = \text{pK}_a(\text{In}) + \log_{10}([\text{In}^-]/[\text{HIn}])$$

Visible transition is usually about $\text{pK}_a \pm 1$.



OSTWALD IONIZATION THEORY

pH shifts the HIn/In^- equilibrium; the predominant form controls colour.

PHENOLPHTHALEIN

pH 8.2-10.0: colourless $\rightarrow$ pink; several structural equilibria are involved.



STRUCTURAL / RESONANCE VIEW

Protonation can change electron delocalization and visible-light absorption.

This is a useful model, not one universal benzenoid/quinonoid rule.

METHYL ORANGE

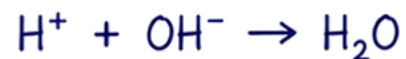
pH 3.1-4.4: red $\rightarrow$ yellow; protonation changes its azo-resonance system.



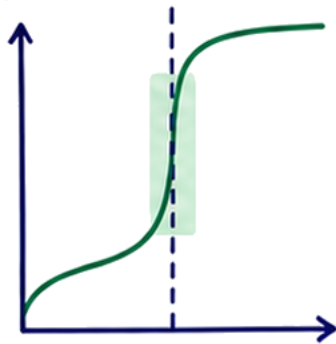
Endpoint colour approximates, but is not, the equivalence point.

ACID-BASE TITRATION TYPES

STRONG ACID + STRONG BASE



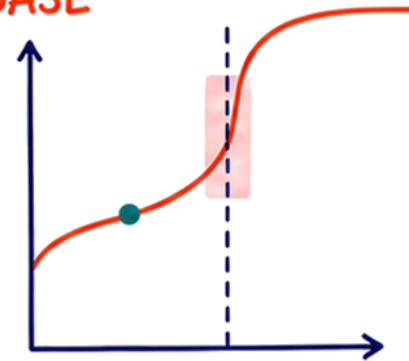
Large pH jump;
equivalence pH ≈ 7 near 25 °C.



WEAK ACID + STRONG BASE



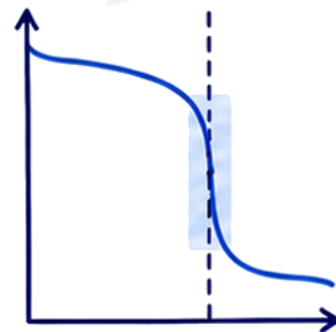
Buffer region; at half-equivalence,
pH = pK_a.
Equivalence pH > 7;
phenolphthalein is often suitable.



STRONG ACID + WEAK BASE

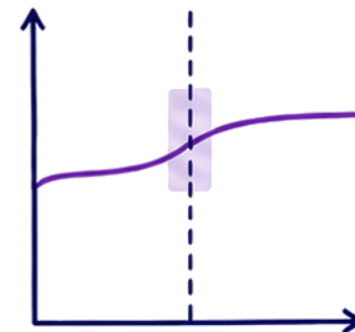


B/BH⁺ buffer forms;
equivalence pH < 7.
Choose an indicator whose range
lies within the steep fall.



WEAK ACID + WEAK BASE

Equivalence pH depends on K_a and K_b.
The pH break is small; use
potentiometric detection.



STOICHIOMETRIC EQUIVALENCE

For $a\text{A} + b\text{B} \rightarrow \text{products}$: $n(\text{A})/a = n(\text{B})/b$.

a and b are balanced-reaction coefficients.

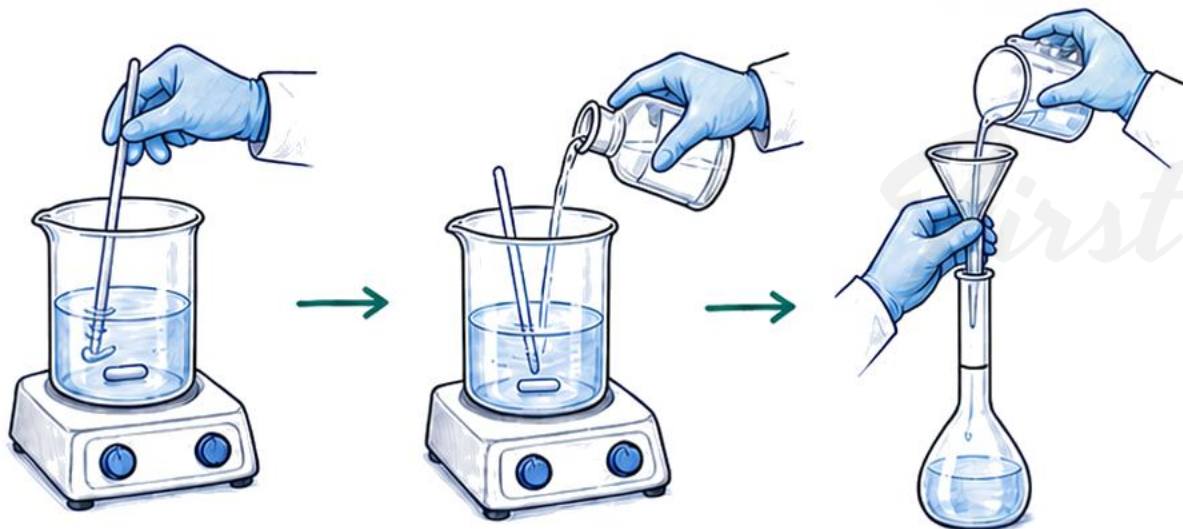
Endpoint = observed signal; equivalence point = stoichiometric condition.

HYDROCHLORIC ACID: PREPARE & STANDARDIZE

PREPARE AN APPROXIMATE SOLUTION

1. Place part of the water in a suitable vessel.
2. Add calculated concentrated HCl slowly to water with stirring.
3. Cool; transfer quantitatively; dilute to volume and mix.

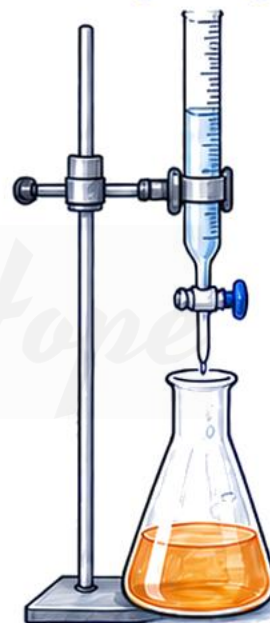
HCl is volatile, so preparation alone does not assign exact concentration.



STANDARDIZE WITH DRIED Na_2CO_3



Add methyl orange; titrate to the prescribed orange/red endpoint.



$$n(\text{HCl}) = 2n(\text{Na}_2\text{CO}_3)$$

$$C(\text{HCl}) = 2m(\text{Na}_2\text{CO}_3)/[M(\text{Na}_2\text{CO}_3)V(\text{HCl})]$$

Use mass in g and titre volume in L.

SAFETY



Always add acid to water, never water to concentrated acid.



Use goggles, gloves, compatible ventilation, cooling, and a labelled closed bottle.



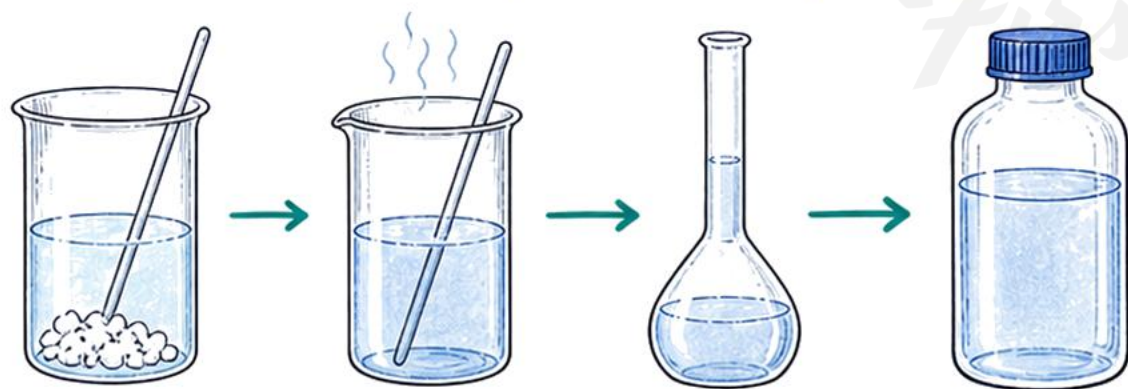
SODIUM HYDROXIDE: PREPARE & STANDARDIZE

WHY STANDARDIZE?

NaOH absorbs H₂O and CO₂; pellets are not a primary standard.

PREPARE AN APPROXIMATE SOLUTION

1. Dissolve pellets in freshly boiled, cooled water.
2. Allow the exothermic solution to cool.
3. Dilute to volume; mix and protect from atmospheric CO₂.



CONTROL

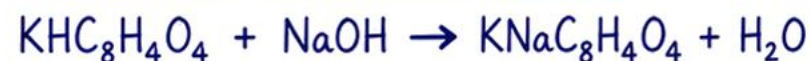
Weigh rapidly; use clean CO₂-free water and a tightly closed compatible bottle.



NaOH is corrosive:
goggles and gloves are essential.



STANDARDIZE WITH KHP



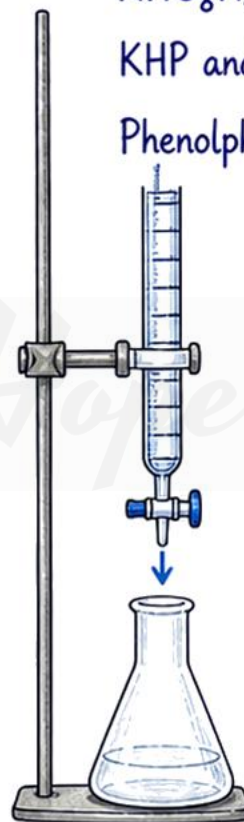
KHP and NaOH react 1:1.

Phenolphthalein: colourless → faint pink persisting as prescribed.

$$C(\text{NaOH}) = m(\text{KHP}) / [M(\text{KHP})V(\text{NaOH})]$$

$$M(\text{KHP}) = 204.22 \text{ g mol}^{-1};$$

use mass in g and volume in L.





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