ACID BASE CHEMISTRY

pH Titration Curves

Titration:
Titration is a laboratory technique used to determine the concentration of an unknown solution by gradually adding a solution of known concentration (the titrant) until the reaction reaches completion.

pH Titration Curve:
A pH titration curve is a graph that shows how the pH of a solution changes as a titrant is added during a titration.

Titrant:
The titrant is the solution of known concentration that is added from the burette during a titration.

Analyte:
The analyte is the solution of unknown concentration present in the conical flask that reacts with the titrant.

Endpoint:
The endpoint is the stage in a titration at which the indicator changes colour, showing that the reaction is nearly or completely complete.

Equivalence Point:
The equivalence point is the stage in the titration at which the exact number of moles of acid and alkali have reacted with each other. At this point:

$$\textbf{Moles of alkali} = \textbf{Moles of acid}$$

It is usually located at the **midpoint of the steep vertical section** on the titration curve and represents the point of complete neutralization.

Types of Titration Curves

1. Strong Acid–Strong Alkali pH Titration Curve

Beginning of Titration

- Hydrochloric acid (HCl) is in the conical flask; sodium hydroxide (NaOH) is added from the burette.
- Only H^+ ions are present, so the pH starts very low (around 1–2).

Adding Alkali

- OH^- ions from NaOH react with H^+ ions to form water:

$$H^+ + OH^- \rightarrow H_2O$$

- pH rises slowly until it gets close to the equivalence point.

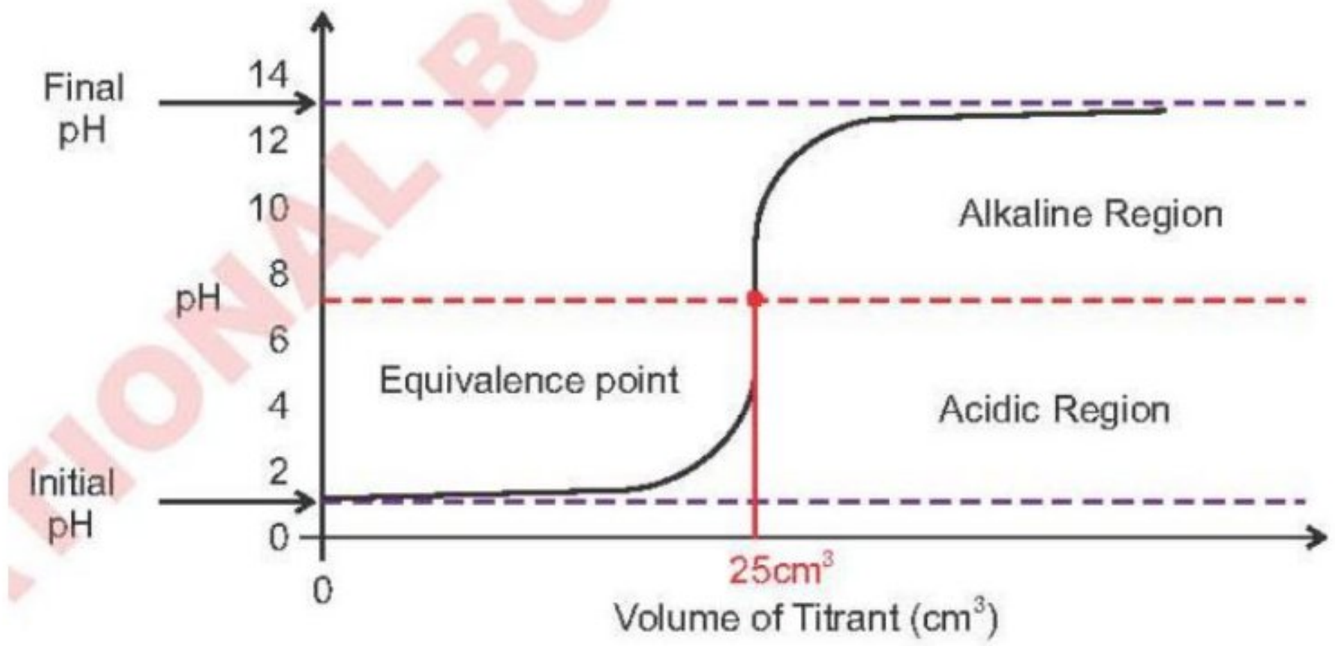

Figure 4.1: The diagram shows a pH titration curve of 1.0 mol dm³ HCL (25 cm³) with NaOH

Equivalence Point

- All H^+ ions are neutralized.
- pH at this point is **7**.

After Equivalence

- Extra OH^- ions remain in the solution, making the pH rise to **13–14**.
- 25 cm³ of 1.0 mol/dm³ NaOH neutralizes 25 cm³ of 1.0 mol/dm³ HCl.

Reverse Titration

- If HCl is added to NaOH instead, the curve shape is the same, but the starting and final pH are swapped, and the equivalence point is still at **pH 7**.

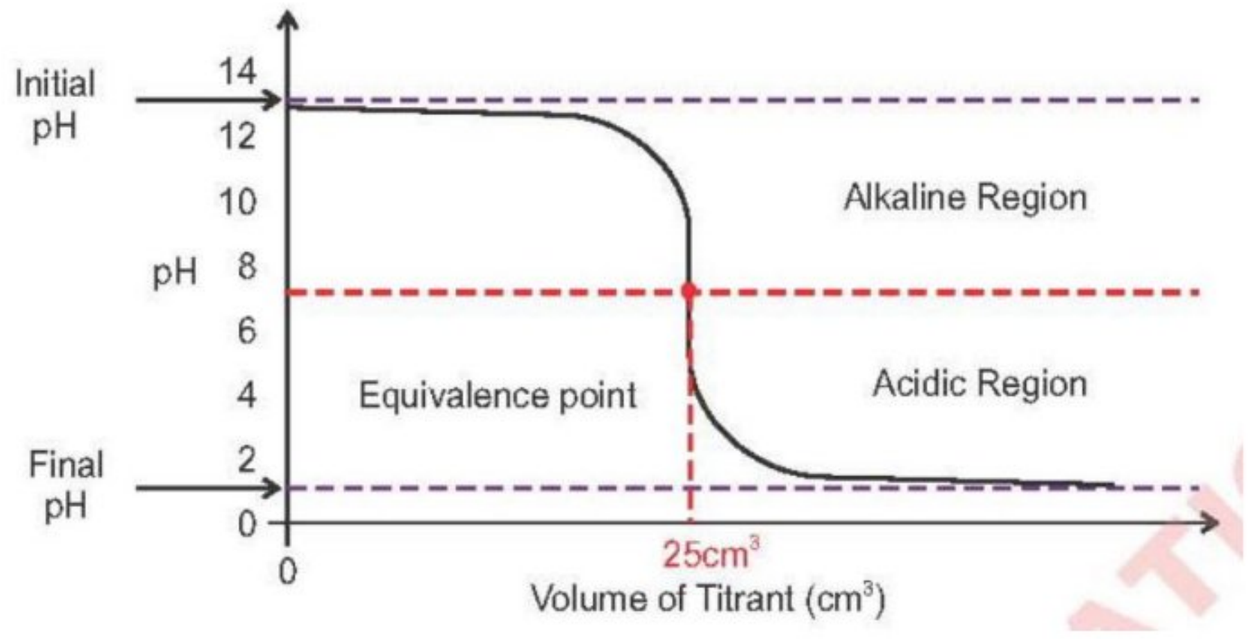

Figure 4.2: The diagram shows a pH titration curve of 1.0 mol dm³ NaOH (25 cm³) with HCI

2.Strong Acid–Weak Alkali pH Titration Curve

Beginning of Titration

- Only H^+ ions are present in the conical flask, so the pH starts very low (around 1–2).

Adding Weak Alkali (NH_3)

- Ammonia (NH_3) from the burette reacts with H^+ ions to form ammonium ions (NH_4^+).
- The pH rises slowly at first and doesn't change much until it nears the equivalence point.

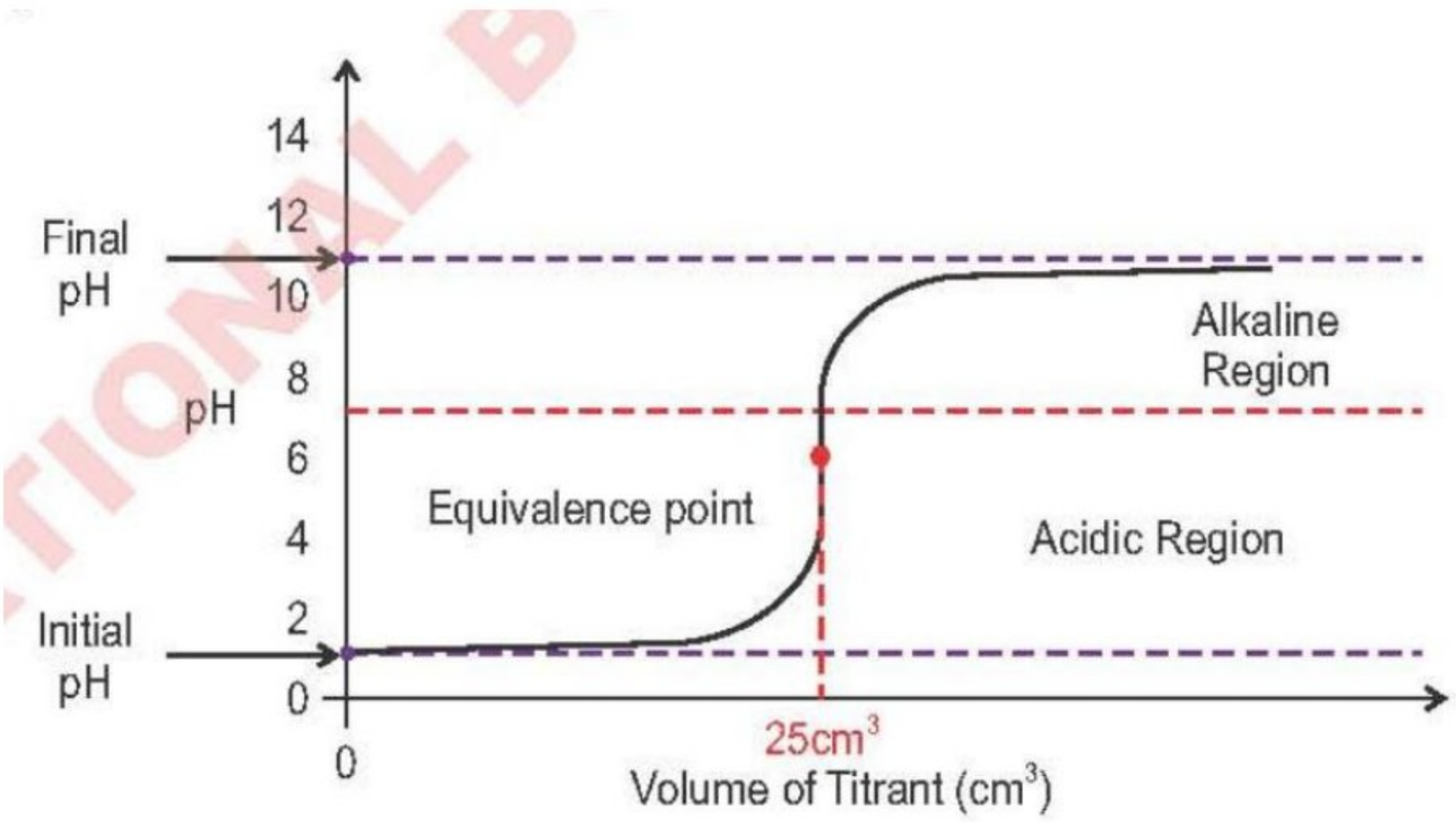

Figure 4.3: The diagram shows a pH titration curve of 1.0 mol dm^3 HCI (25 cm^3) with NH_3

Equivalence Point

- All H^+ ions have reacted with NH_3 to form NH_4^+.
- The pH here is acidic (about 5.5) because NH_4^+ is a weak acid.

After Equivalence

- Extra NH_3 makes the solution basic, but the pH only rises slightly above 7 (not up to 13–14 like a strong alkali).

Reverse Titration

- If strong acid (HCl) is added to a weak alkali (NH_3) instead, the curve has the same shape but the starting and final pH values are reversed.
- The equivalence point remains around **pH 5.5**.

3.Weak Acid–Strong Alkali pH Titration Curve

Beginning of Titration

- Ethanoic acid (CH_3COOH) is in the conical flask with an initial pH of **about 2–3**.

Adding Strong Alkali (NaOH)

- OH^- ions from NaOH react with H^+ ions from CH_3COOH to form water.
- pH rises slowly at first and then sharply as it nears the equivalence point.

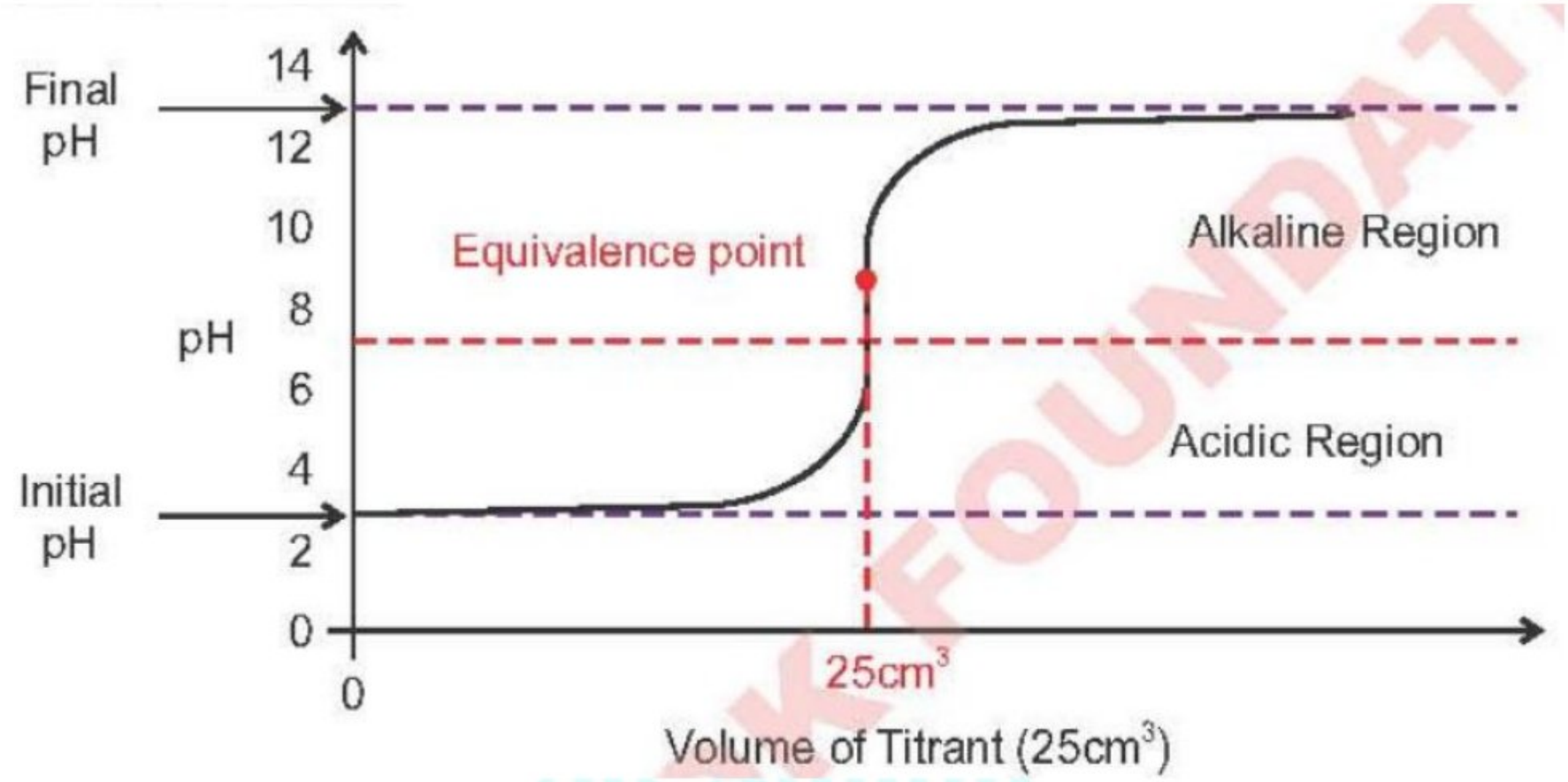

Figure 4.4: The diagram shows a pH titration curve of a weak acid with a strong base

Equivalence Point

- All H^+ ions from CH_3COOH are neutralized.
- pH is slightly **basic (around 9)** because CH_3COO^- (acetate ion) is a weak base.

After Equivalence

- Extra NaOH raises the pH further to about **13–14**.

Reverse Titration

- If weak acid is added to strong alkali instead, the curve has the same shape but starting and final pH values are swapped.
- The equivalence point remains at **pH ~9**.

4.Weak Acid–Weak Alkali pH Titration Curve

Beginning of Titration

- Only H^+ ions from the dissociation of ethanoic acid (CH_3COOH) are present.
- The initial pH is around **2–3**.

Shape of Curve

- As the weak alkali is added, pH rises gradually with **no steep vertical section**.

Equivalence Point

- There is only a **point of inflexion** at the equivalence point instead of a sharp jump.
- The curve doesn't give a clear pH reading for the equivalence point.

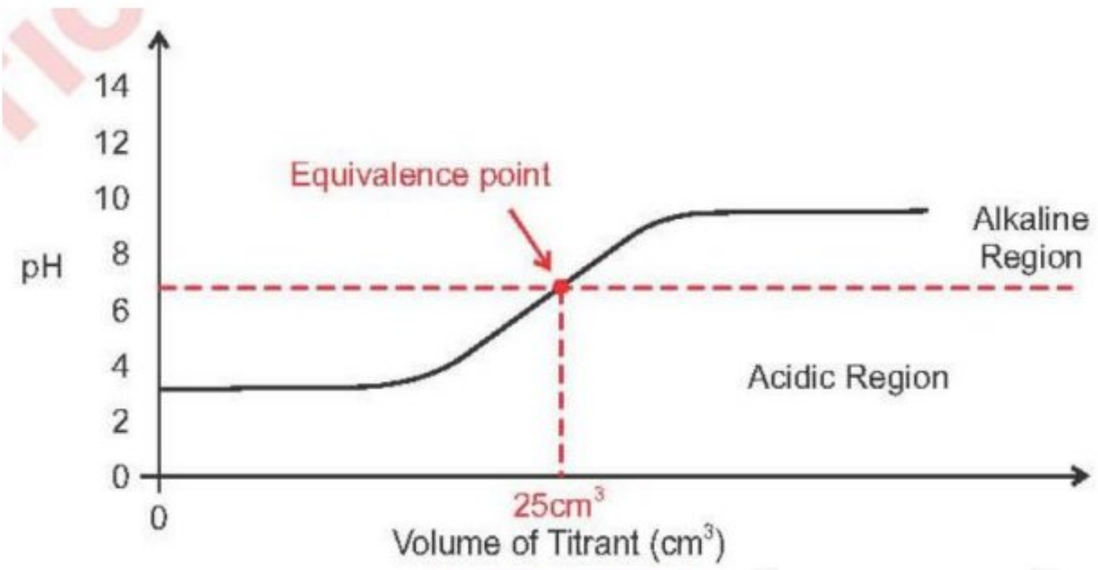

Figure 4.5: The diagram shows a pH titration curve of 1.0 mol dm³ weak acid (25 cm³) with weak alkali

Key Note

- The titration curve for weak acid–weak alkali provides **very little useful information** for determining the endpoint accurately.

For More Information:

WhatsApp: 0306-7395469

Join my WhatsApp Channel: Follow the Sir Amjad (Chemistry Info) channel on WhatsApp: https://whatsapp.com/channel/0029Vb6Hu0wEKyZO9OSkPz13

For chemistry preparation, join the following groups:

SSC-I: https://chat.whatsapp.com/ClKJMYFmE5vFbgg7oRMoSU

SSC-II: https://chat.whatsapp.com/DMYmTNYItL98P7IC5cwSoj

HSSC-I: https://chat.whatsapp.com/DMYmTNYItL98P7IC5cwSoj

HSSC-II: https://chat.whatsapp.com/DMYmTNYItL98P7IC5cwSoj

To subscribe my YouTube channel:

https://youtube.com/@siramjadchemist?si=O56Zh-WhQIQM7mnJ