

Q/ The specific resistance (ρ) of metal is $2.8 \times 10^{-8} \Omega \cdot \text{cm}$. calculate the voltage across metal wire if length is 1m and diameter 2mm, the current pass its wire is 1.25A.

$$\rho = 2.8 \times 10^{-8} \Omega \cdot \text{cm}$$

$$l = 1 \text{ m}$$

$$I = 1.25 \text{ A}$$

$$\text{Diameter} = 2 \text{ mm}$$

Sol/

$$R = \rho \frac{l}{A}$$

$$1 \text{ m} = 100 \text{ cm}$$

$$A = \pi r^2$$

So

$$r = \frac{2 \text{ mm}}{2} = 1 \text{ mm}$$

$$1 \text{ cm} = 10 \text{ mm}$$

So

$$r = 1 \text{ mm} / 10 = 0.1 \text{ cm}$$

So

$$A = 3.14 \times (0.1 \text{ cm})^2 \\ = 0.0314 \text{ cm}^2$$

So

$$R = 2.8 \times 10^{-8} \Omega \cdot \text{cm} \times \frac{100 \text{ cm}}{0.0314 \text{ cm}^2} = 89.17 \times 10^{-6} \Omega$$

$$R = \frac{E}{I}$$

$$E = R \times I$$

$$= 89.17 \times 10^{-6} \Omega \times 1.25 \text{ A} = 111.46 \times 10^{-6} \text{ V}$$

Q2/ The resistance of a conductivity cell when filled with 0.02M KCl solution is 164 ohm at 298K. However, when filled with 0.05M AgNO₃ solution, its resistance is found it be 78.5 ohm. If the specific conductivity of 0.02M KCl is 2.768 x10⁻³ ohm⁻¹.cm⁻¹. Calculate:

A- The specific conductivity (L) of 0.05M AgNO₃

B- The molar conductivity of AgNO₃ Solution

Sol/ A-

$$L (\text{KCl}) = G \times K$$

$$G (\text{KCl}) = \frac{1}{R} = \frac{1}{164\Omega} = 0.00601 \Omega^{-1}$$

$$K = \frac{L}{G} = \frac{2.768 \times 10^{-3} \Omega^{-1} \text{cm}^{-1}}{0.00601 \Omega^{-1}} = 0.46 \text{ cm}^{-1}$$

$$L (\text{AgNO}_3) = G \times K$$

$$G (\text{AgNO}_3) = \frac{1}{R} = \frac{1}{78.5\Omega} = 0.0127 \Omega^{-1}$$

$$L = 0.0127 \Omega^{-1} \times 0.46 \text{ cm}^{-1} = 0.0058 \Omega^{-1} \text{ cm}^{-1}$$

Sol/ B-

$$\lambda = \frac{1000 L}{C} = \frac{1000 \times 0.0058 \Omega^{-1} \text{ cm}^{-1}}{0.05 \text{ mol cm}^{-3}} = 116 \Omega^{-1} \text{ mol}^{-1} \text{ cm}^2$$

Q3/ Calculate resistance for 0.01N KCl solution if that equivalent conductance (λ) is equal $141.3 \text{ cm}^2.\text{ohm}^{-1}.\text{eq}^{-1}$, the cell constant is 1.48cm^{-1} , conductivity of distilled water is $10^{-6} \text{ ohm}^{-1}.\text{cm}^{-1}$.

$$\lambda = \frac{1000 L}{C}$$

$$L = \frac{\lambda C}{1000} = \frac{141.3 \text{ cm}^2.\text{ohm}^{-1}.\text{eq}^{-1} \times 0.01 \text{ eq cm}^{-3}}{1000}$$

$$= 1.413 \times 10^{-3} \text{ ohm}^{-1}\text{cm}^{-1}$$

L Solution = L Solute + L Solvent

L Solute = L Solution - L Solvent

$$= 1.413 \times 10^{-3} \text{ ohm}^{-1}\text{cm}^{-1} - 10^{-6} \text{ ohm}^{-1}\text{cm}^{-1}$$

$$L = 1.412 \times 10^{-3} \text{ ohm}^{-1}\text{cm}^{-1}$$

$$L = G \times K$$

$$G = \frac{L}{K} = \frac{1.412 \times 10^{-3} \text{ ohm}^{-1}\text{cm}^{-1}}{1.48 \text{ cm}^{-1}} = 9.540 \times 10^{-4} \text{ ohm}^{-1}$$

$$R = \frac{1}{G} = \frac{1}{9.540 \times 10^{-4} \text{ ohm}^{-1}} = 1048 \Omega$$

Q4/ The resistance of conductivity cell, when filled with 0.1N KCl solution, is 24.36 ohm. However, when filled with 0.1M CH₃COOH solution, its resistance it's found 1.1658 ohm. If specific conductivity of 0.1N KCl is 0.01285 ohm⁻¹.cm⁻¹ and the conductivity of distilled water is 7.5x10⁻⁶ ohm⁻¹.cm⁻¹. How can you calculate the equivalent conductance for CH₃COOH.

$$L (\text{KCl}) = G \times K$$

$$L = \frac{1}{R} \times K$$

$$K = L \times R$$

$$= 0.01285 \text{ ohm}^{-1}\text{cm}^{-1} \times 24.36 \text{ ohm}$$

$$= 0.313 \text{ cm}^{-1}$$

$$L (\text{CH}_3\text{COOH}) = \frac{1}{R} \times K = \frac{0.313 \text{ cm}^{-1}}{1.1658 \text{ ohm}} = 0.268 \text{ ohm}^{-1}\text{cm}^{-1}$$

L Solute = L Solution - L Solvent

$$= 0.268 \text{ ohm}^{-1}\text{cm}^{-1} - 7.5 \times 10^{-6} \text{ ohm}^{-1}\text{cm}^{-1} = 0.2679 \text{ ohm}^{-1}\text{cm}^{-1}$$

$$\lambda (\text{molar}) = \frac{1000 L}{M} = \frac{1000 \times 0.2679 \text{ ohm}^{-1}\text{cm}^{-1}}{0.1 \text{ mol cm}^{-3}} = 2679 \text{ ohm}^{-1} \text{ mol}^{-1}\text{cm}^2$$

Equivalent conductance = (Molar conductance)/n

M.Wt (CH₃COOH) = eq. Wt. = 60

$$\text{So } n = \frac{\text{M.Wt}}{\text{eq. Wt}} = 1$$

Equivalent conductance = (Molar conductance) = 2679 ohm⁻¹ mol⁻¹cm²

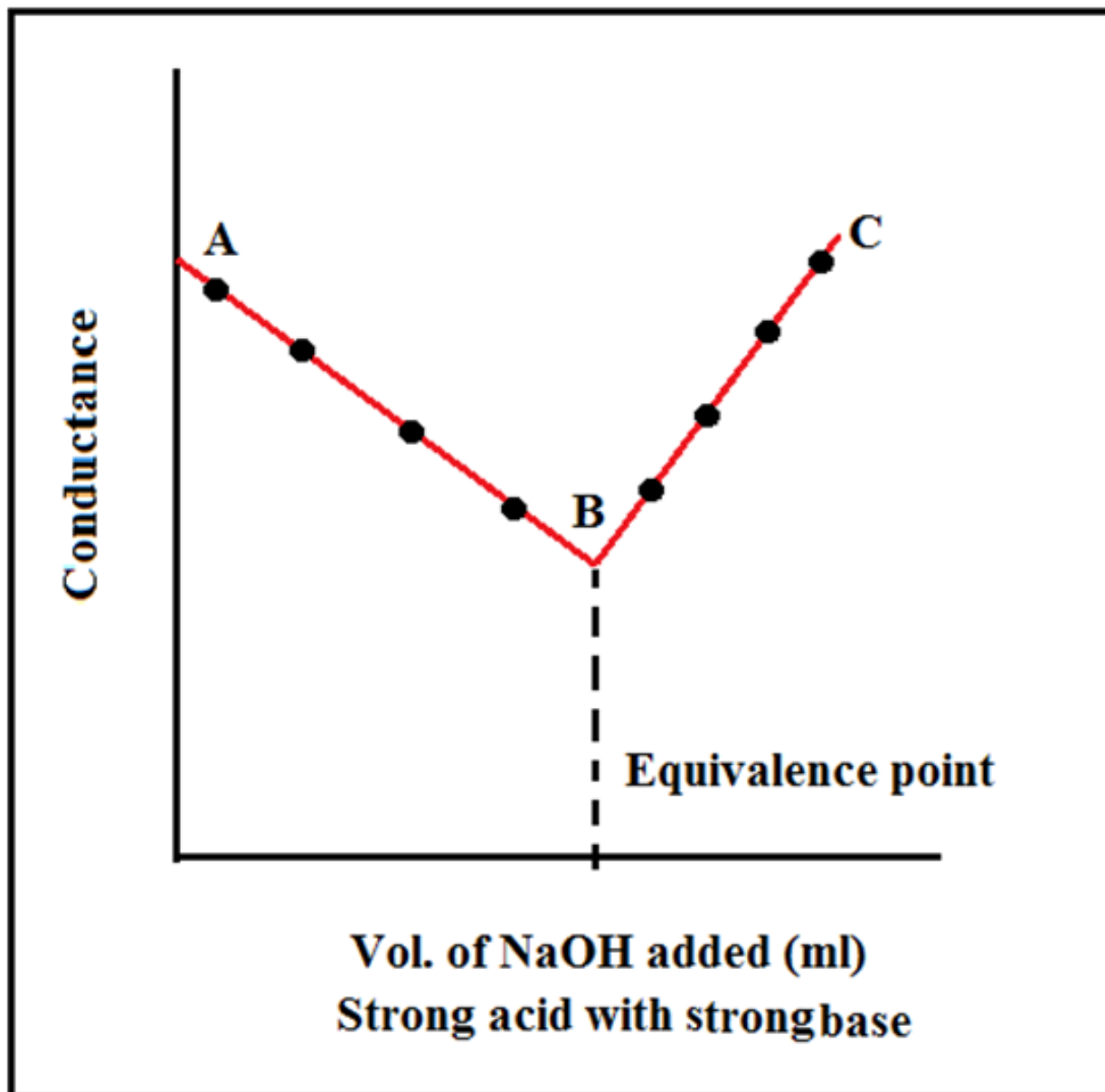
Conductometric titration

A. Conductometric titration of strong acid with strong base

Suppose a solution of HCl is to be titrated against NaOH solution. For this purpose, the acid solution is taken in a beaker and the NaOH solution in the burette. The conductance of the acid solution is noted initially as well as after successive additions of small amount of NaOH solution. Evidently, **the conductance of the acid solution in the beginning is very high because it contains highly mobile H⁺ ions (HCl → H⁺ + Cl⁻)**. As NaOH solution is added to the HCl solution, the H⁺ ions are replaced by the slow moving Na⁺ ions and hence the conductance of the solution after all the H⁺ ions are replaced by Na⁺ ions decreases.

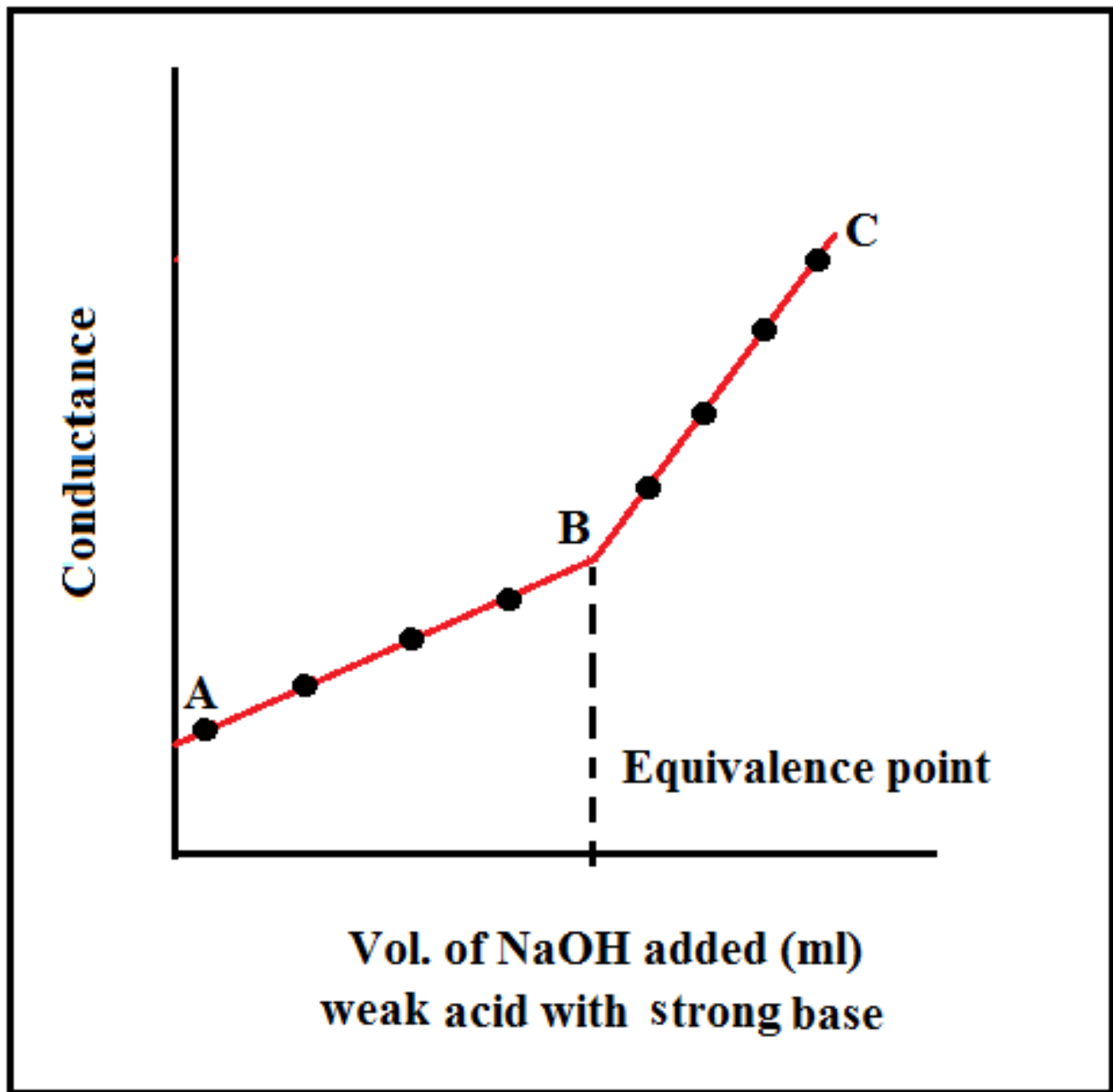


After the end point, further addition of NaOH solution brings in fast moving OH^- ions and hence the conductance of the solution again starts increasing. If conductance values are plotted against the volume of the alkali added, a curve of type ABC is obtained as shown fig below. Point of intersection (point B) corresponds to the end point.



B. Conductometric titration weak acid with strong base

Suppose a weak acid like acetic acid is titrated against a strong base like NaOH. **The conductance of the acid initially is very low because of low ionization of the acid.** However as NaOH solution is added more and more to the acid solution, the salt produced (CH_3COONa). CH_3COONa is highly ionized and hence the conductance keeps on increasing along the line AB as shown in figure below. **When the whole of acetic acid has been neutralized, further addition of NaOH solution causes the conductance to increase sharply along the line BC because the NaOH added introduces the fast moving OH^- ions.** Intersection of the two lines AB and BC, at the point B gives the equivalent point.

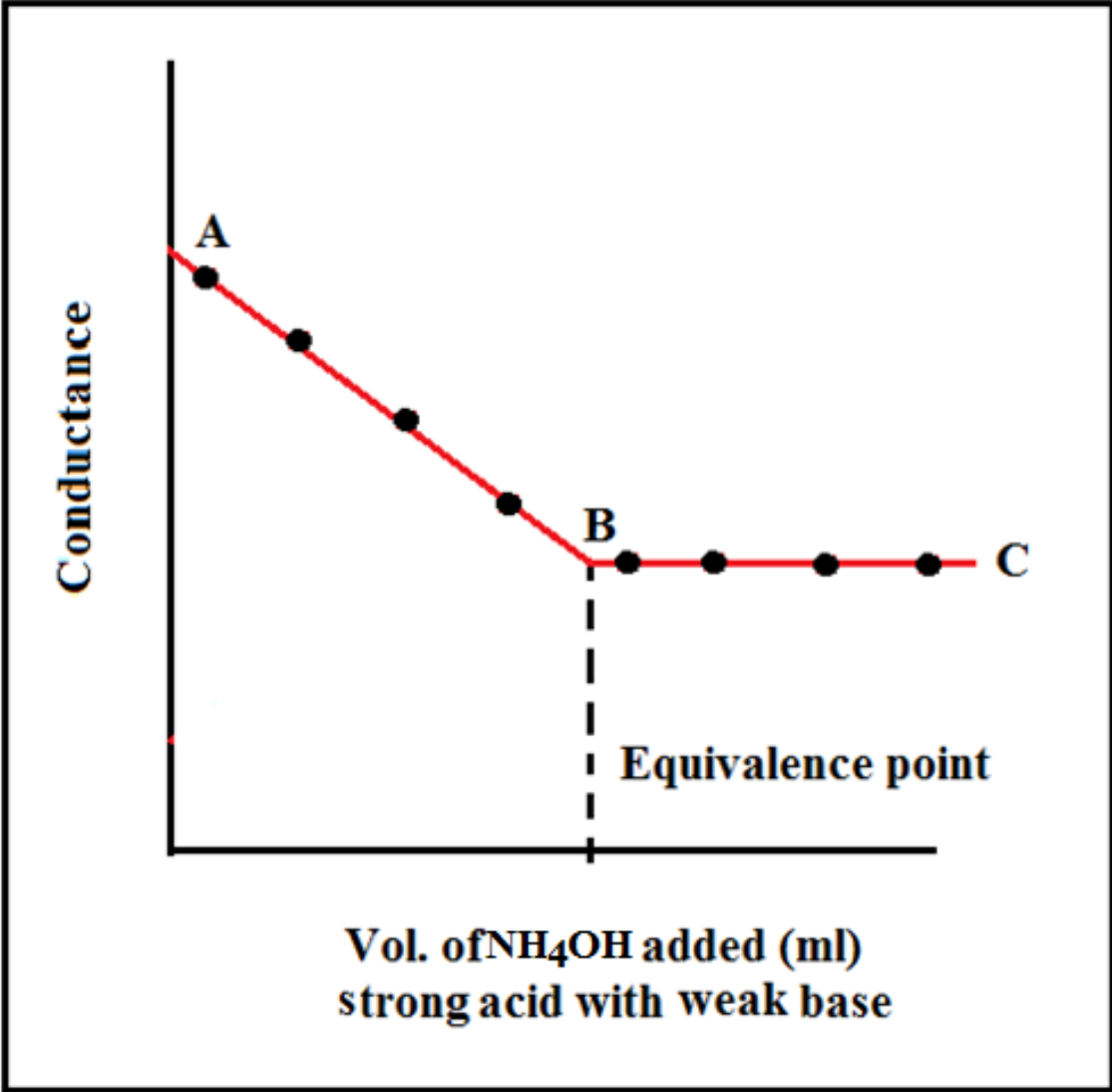


C. Conductometric titration strong acid with weak base

Titration strong acid with a weak base let us consider the titration of HCl against NH_4OH solution. **The conductance of HCl solution is initially high because of the presence of the fast moving H^+ ions.** As NH_4OH solution is added, the fast moving H^+ ions are replaced by the slower NH_4^+ ions and hence the conductance falls along the line AB.



When the end point is passed, further addition of NH_4OH does not cause much change in the conductance **because NH_4OH is a weakly ionized substance.** The line BC is thus almost horizontal (figure below).



Conductance

A

B

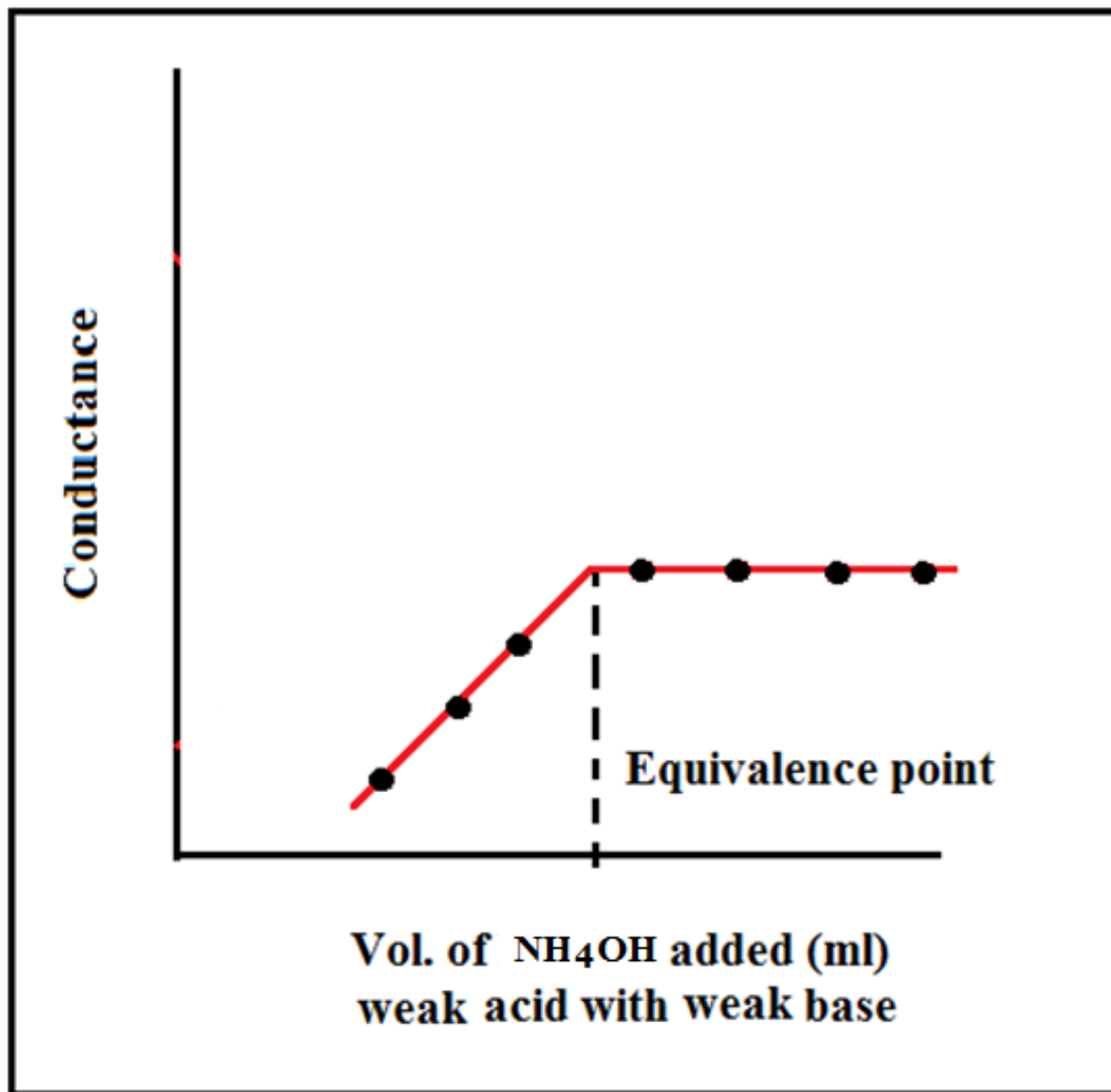
C

Equivalence point

Vol. of NH_4OH added (ml)
strong acid with weak base

D. Conductometric titration weak acid with weak base

Conductometric titration are particularly valuable as we do not get sharp end points with indicators. Consider the titration of acetic acid with ammonium hydroxide. Initially, the conductance of the solution is low due to poor dissociation of acetic acid. As the base is added to it, the conductance starts picking up due to the formation of ionizable ammonium acetate. After the neutralization point, conductance remains almost constant, because the free base NH_4OH is a weak electrolyte. This is illustrated in the figure below.



Advantages of conductometric titration

- 1. These titrations can be used for colored solution where ordinary indicators fail.**
- 2. As the end point in these titrations is the intersection of two lines, no extra care is needed near the end point.**
- 3. These can be used for the titration of mixture of weak and strong acids. These can be used for the titration of even very dilute solutions.**



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