CH 7 Equilibria

Saturday, 22 November 2025 1:34 PM

1 : 1

Reaction	$1CH_3COOC_2H_5$ +	$1H_2O$ $\rightleftharpoons$	$1CH_3COOH$ +	$1C_2H_5OH$
Initial Con	1 mole	1 mole	0 mol	0 mol
Change in Conc	1 − 0.3	1 − 0.3	X	X
Equilibrium Conc	$\frac{0.7\ mol}{1\ dm^3}$	$\frac{0.7\ mole}{1\ dm^3}$	$\frac{0.3\ mole}{1\ dm^3}$	? $\frac{0.3\ mol}{1\ dm^3}$

mole = CV

$C = \frac{mol}{V}$

mol/dm^3

Change in Con R = Equals Con P

$$K_c = \frac{[CH_3COOH][C_2H_5OH]}{[CH_3COOC_2H_5][H_2O]}$$

$$= \frac{(0.3)(0.3)}{(0.7)(0.7)}$$

$K_c = \frac{P}{R}$

Unit of K_c

$\boxed{K_c} = 0.18$ (no unit)

Example 3

1 : 2

R	A $\rightleftharpoons$	2B
I	4	0
C	4 − 1.5 2.50	
E	$\frac{1.5\ mole}{20}$	$2 \times 2.50 = \frac{5\ mole}{20}$
[ ]	0.075 mol/dm^3	0.25 mol/dm^3

$$A \rightleftharpoons ②B$$

$$K_c = \frac{\boxed{[B]^{②}}}{[A]} \quad 0{\cdot}83$$

$$\frac{\cancel{mol/dm^3} \cdot mol/dm^3}{\cancel{mol/dm}}$$

$$\frac{}{[A]^a[B]^b}$$

$$CO_2 + H_2 \rightleftharpoons CO + H_2O$$

$\boxed{I}$	$0{\cdot}50$	$0{\cdot}50$	$0{\cdot}20$	$0{\cdot}20$
$x.C$	x	x	~~x~~	~~x~~
E	$(0{\cdot}50 - x)$	$(0{\cdot}5 - x)$	$(0{\cdot}20 + x)$	$0{\cdot}20 + x$

$-x$ Because reactant decrease.

and P increasing $+x$

$$K_c = \frac{(0{\cdot}2 + x)(0{\cdot}2 + x)}{[0{\cdot}5 - x][0{\cdot}5 - x]}$$

$[\ ]$

$(\ )^x$

$$K_c = \frac{[0{\cdot}2 + x]^2}{[0{\cdot}5 - x]^2}$$

$$\sqrt{1{\cdot}44} = \sqrt{\frac{(0{\cdot}2 + x)^2}{(0{\cdot}5 - x)^2}}$$

$$1{\cdot}2 = \frac{0{\cdot}2 + x}{(0{\cdot}5 - x)}$$

$$0{\cdot}2 + x = 1{\cdot}2(0{\cdot}5 - x)$$

$$0{\cdot}2 + x = 0{\cdot}6 - 1{\cdot}2x$$

$$\begin{array}{r}1.2\\1.\\\hline 2.2\end{array}$$

$1x + 1.2x = 0.6 - 0.2$

$2.2x = 0.4$

$x = \frac{0.4}{2.2}$

$\boxed{x = 0.182}$

$CO_2 = 0.5 - x = 0.5 - 0.182$
$= \underline{0.318}$

$H_2 = 0.5 - x = 0.5 - 0.18$
$= 0.318$

$CO \quad 0.2 + x = 0.2 + 0.18$
$= 0.38$

$H_2O \quad 0.2 + x \quad 0.38$

R ① $1PCl_{5(g)} \rightleftharpoons 1PCl_{3(g)} + 1Cl_{2(g)}$

I $\quad 1 \quad 0 \quad 0$

C $\quad 1 - 0.816$

② $\boxed{\underline{Eq}}$ $\quad \frac{0.184\,mol}{1.81} \quad 0.816\,mol \quad 0.816\,mol$

③ $\boxed{n_T} = 0.184 + 0.816 + 0.816$

Total moles $= 1.81$

④ Partial Pressure for each gas

$\underline{P}_A = X_A P_t \qquad X_A \left(\text{Mole fraction}\right) = \frac{n_A}{n_T}$

$X_{pcl_5} = \frac{n_{pcl_5}}{n_T} \quad \underline{PCl_5}, \; PCl_3, \; Cl_2$

$P_{PCl_5} = X_{PCl_5} \times P_t$ $\quad P_{PCl_3} = X_{PCl_3} P_t$ $\quad P_{Cl_2} = X_{Cl_2} P_t$

$[\,] = 10.$

$$K_p = \frac{P_{PCl_3} \cdot P_{Cl_2}}{P_{PCl_5}}$$

$$K_p = \frac{\quad}{kPa}$$

No need to calculate Kp units because $P_t = 100\,kPa$

In finding Kp

① RICE table

② n_T

③ X (Mole fraction for each gas

④ Partial Pressure for each gas

$$P_A = X_A P_t$$

⑤ Kp equations

Le Chatelier's Principle

dynamic equilibrium $\quad R \rightleftharpoons P.$

if change is made to a system at dynamic equilibrium the position of the equilibrium moves to minimize this change.

② Temp ③ Pressure

① Concentration ② temp

$$\longrightarrow$$

$$\downarrow \boxed{A} + B \rightleftharpoons C + D$$

$$\longleftarrow$$

$$A + B \rightleftharpoons C + \boxed{D} \downarrow$$

② Pressure $V \propto \frac{1}{P}$ $V \propto$ number of mole

↑P

$$2A + 1B \rightleftharpoons 3C$$

↑P $N_2 + 3H_2 \rightleftharpoons 2NH_3$

4V 2V

③ Temp

exothermic favoured by low temp

endothermic " " high temp

↑T

$$N_2 + 3H_2 \underset{\text{endo}}{\overset{\text{exo}}{\rightleftharpoons}} 2NH_3 \quad \Delta H = -ive$$

↓T

① $\boxed{NH_3}$ Haber Process

$$N_2 + 3H_2 \rightleftharpoons \boxed{2NH_3} \quad \Delta H = -92\,kJ/mol$$

① Concentration

removing NH_3

② Pressure $\boxed{200\ atm}$

③ Temperature

Decrease → rate of reaction

optimum temp 400-450°C

④ Catalyst Iron

② Contact Process H_2SO_4

$S + O_2 \rightarrow SO_2$

$2SO_2 + O_2 \underset{\substack{V_2O_5 \\ 400-450°C}}{\overset{1-2atm}{\rightleftharpoons}} \boxed{2SO_3}$ $\Delta H = -ive$

Misty fume $SO_3 + H_2O \longrightarrow H_2SO_4$ ✗

$SO_3 + H_2SO_4 \longrightarrow H_2S_2O_7$

oleum

fuming H_2SO_4

$H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$

① Concentration

② Pressure

③ Temp

④ Catalyst

pH Titration Curves

Titration

spectator ions

HCl + NaOH

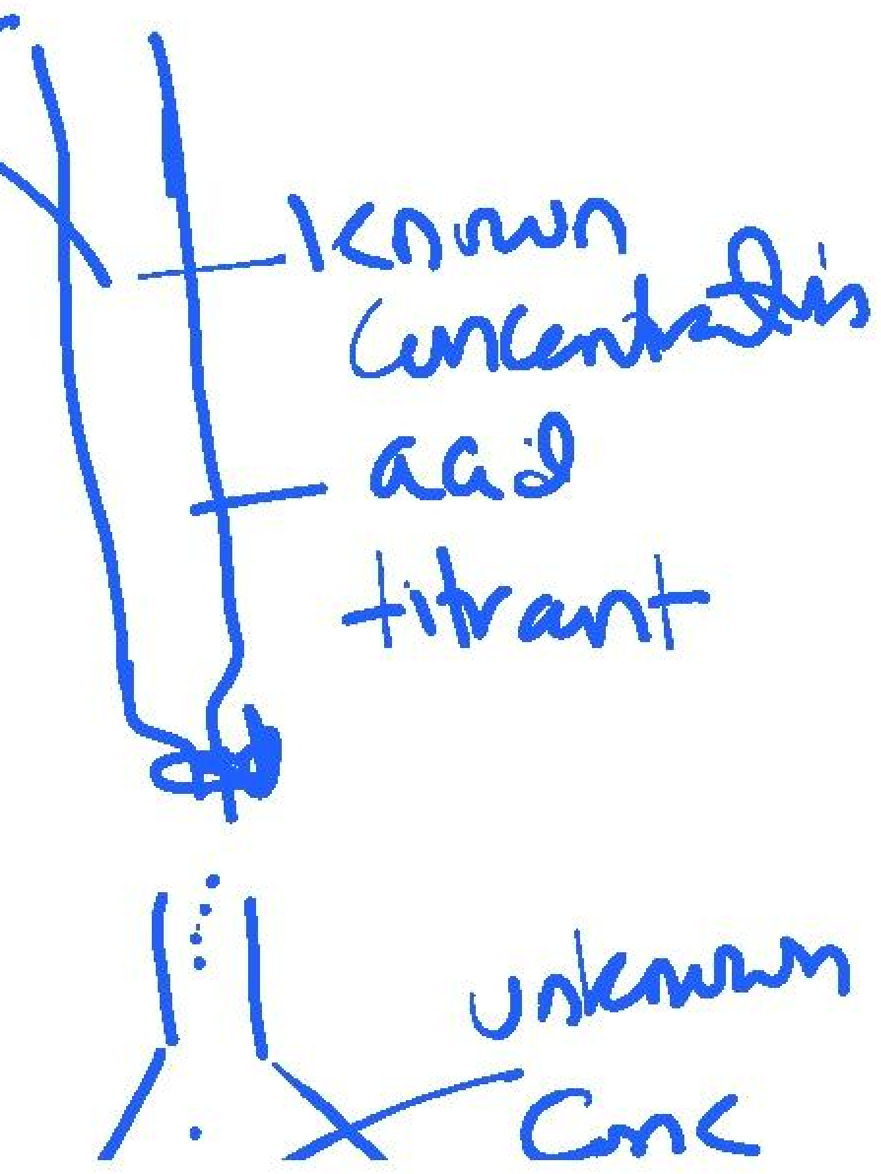
$\underset{known}{\underline{Acid}} + \underset{unknown}{\underline{Base}} \rightarrow salt + H_2O$

$\boxed{H^+ + OH^-_{(aq)} \rightarrow H_2O_{(l)}}$

ionic equation for Neutralization

C = ✓

V = ?



reaction

titrant analyte

Base

$\boxed{V_1}$ C?

$10NaOH + HCl \rightarrow 10NaCl + H_2O$

$10OH^- = 10H^+$

end point $10OH^- = 12H^+$

equivalence point

moles of acid = moles of Base/Alkali

Examiner will check

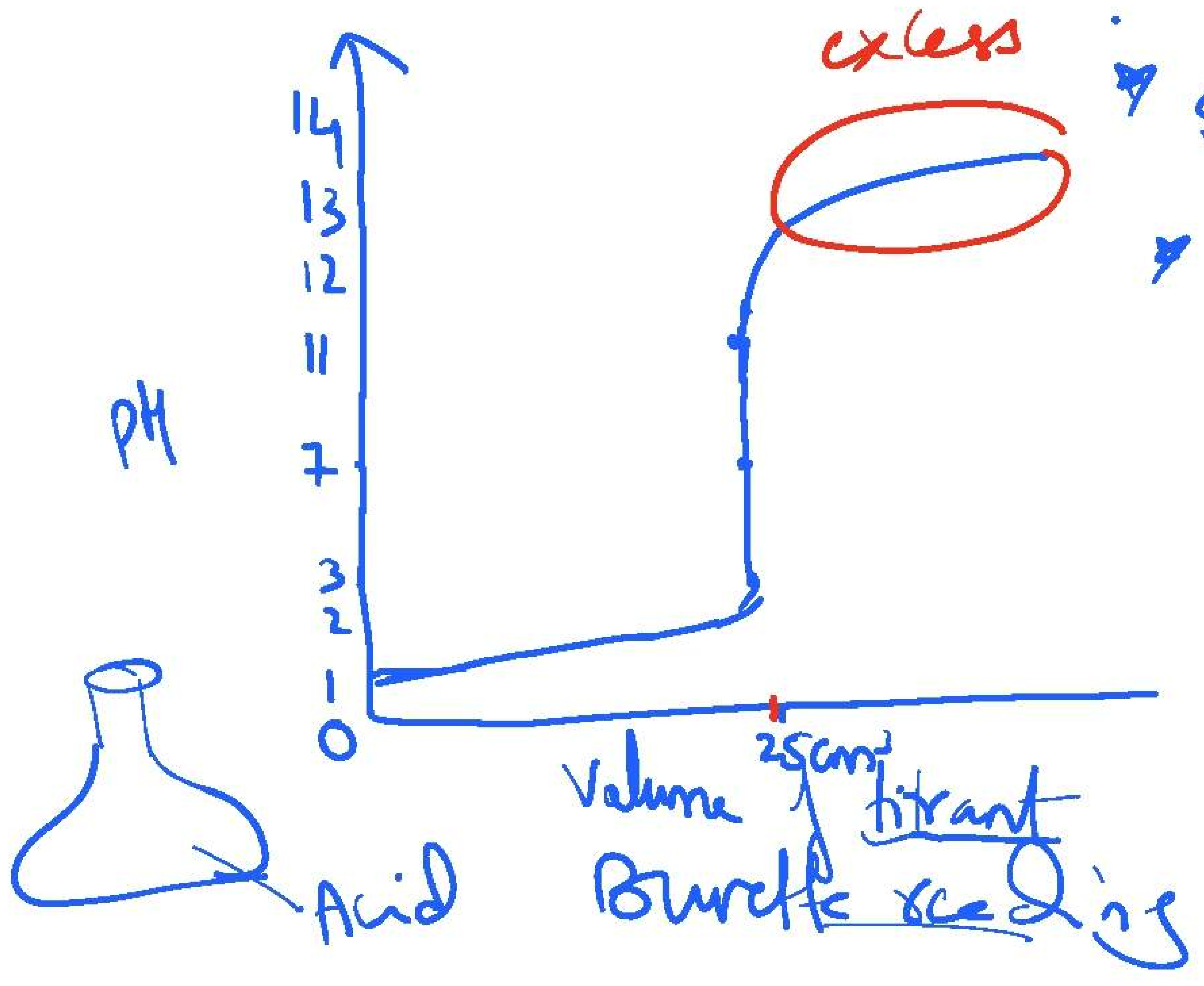
1. ✓ Starting Point
2. ✓ equivalence point (vertical line)
3. ~~end point~~
4. ✓ Volume of equivalence Point

4 different titration Curves

1. strong acid Vs Strong Alkali
2. " Vs week "
3. week acid vs strong "
4. week acid Vs week Alkali.

① Strong Acid Vs strong Alkali

$$\frac{C_1V_1}{n_1} = \frac{C_2V_2}{n_2}$$



- Strong Acid PH 1-2
- " Alkali PH 12-14

Vertical line must be drawn b/w PH 3-11

Mid point $\boxed{PH\ 7}$ equivalence point

shape must be Sigmoid Curve

For finding the volume at equivalence point if mole ratio 1:1 then volume will be same

25cm³ acid → 25cm³ Alkali

Dilution formula

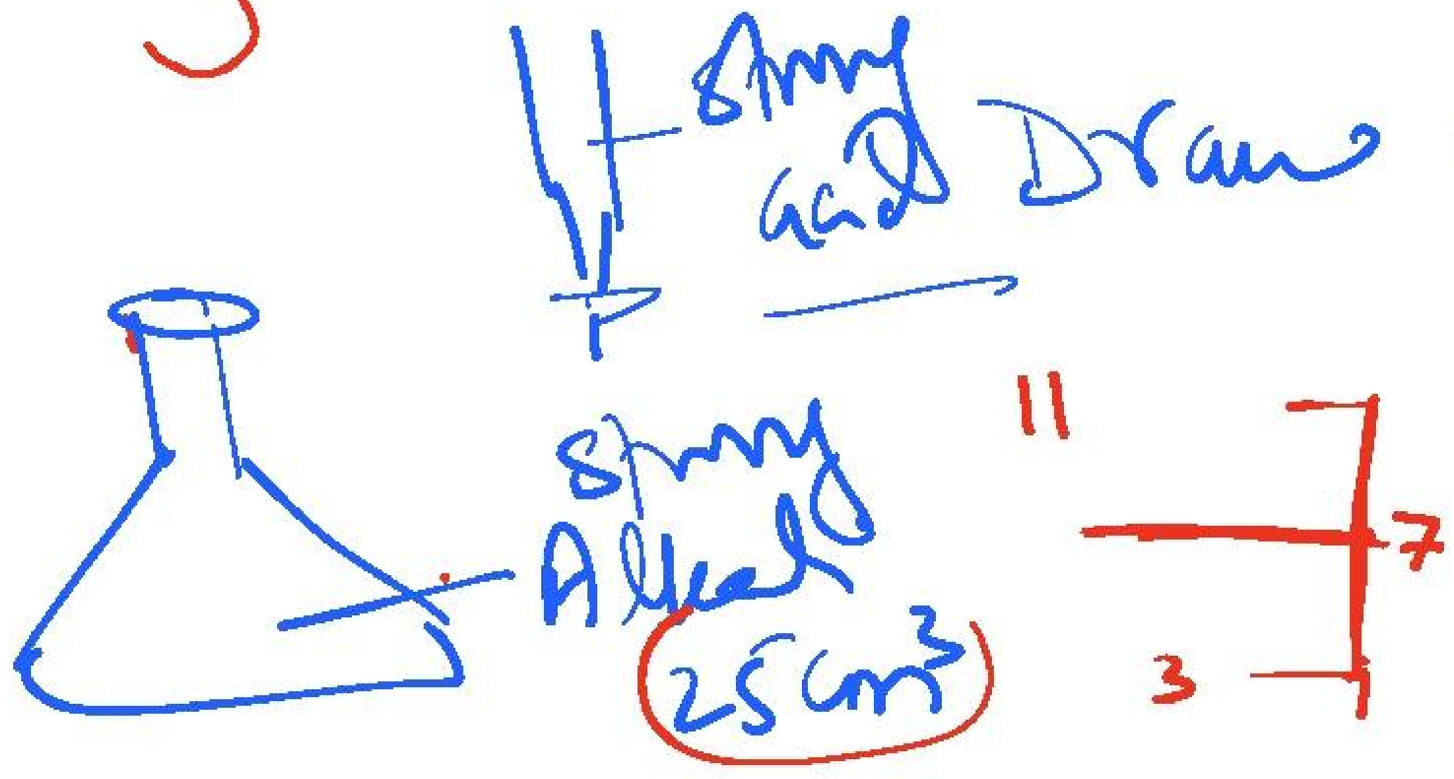
1 HCl + 1 NaOH

$$\frac{C_1V_1}{n_1} = \frac{C_2V_2}{n_2}$$

Acid Base

Mole ratio 1:1

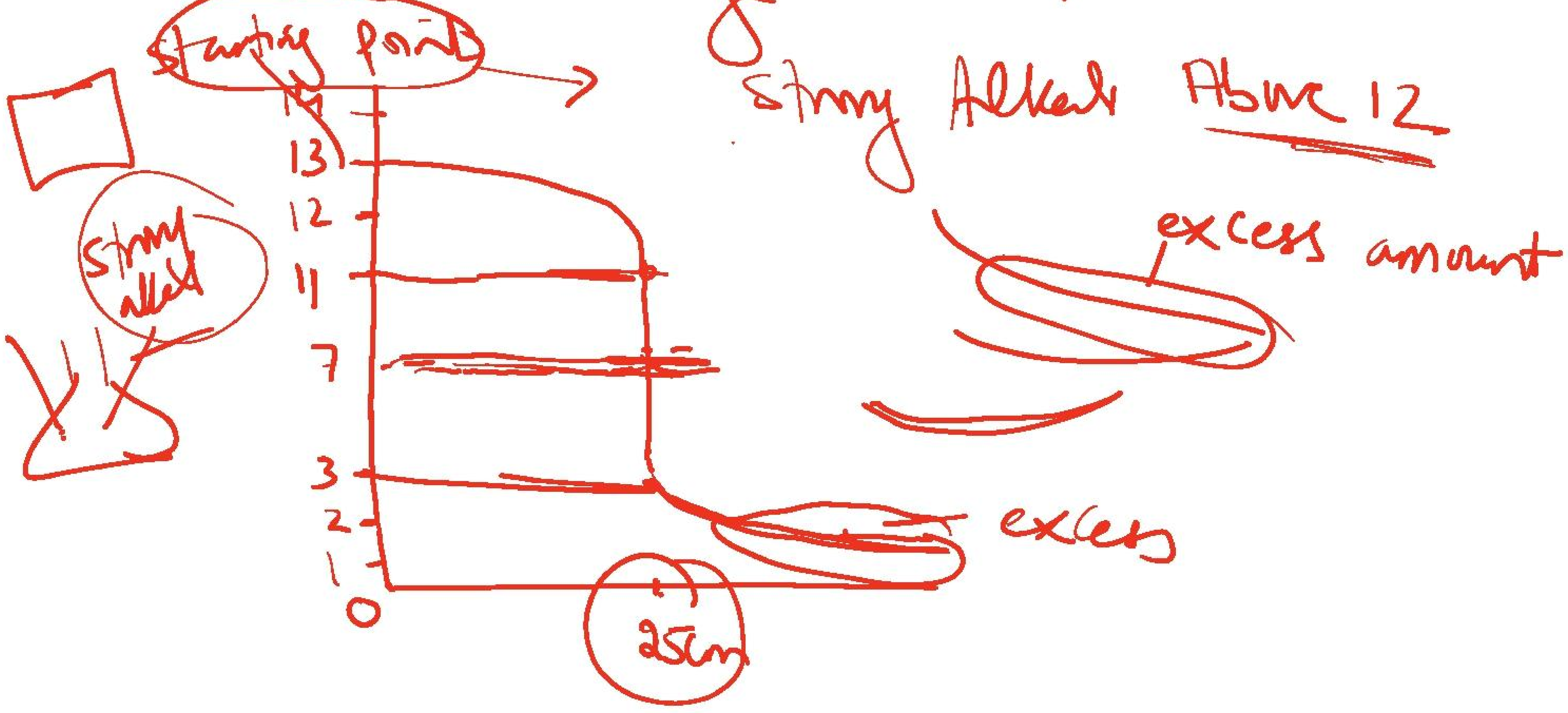
→ What is in Flask will decide the Starting point



Draw the pH curve

Vertical line range 3 — 11

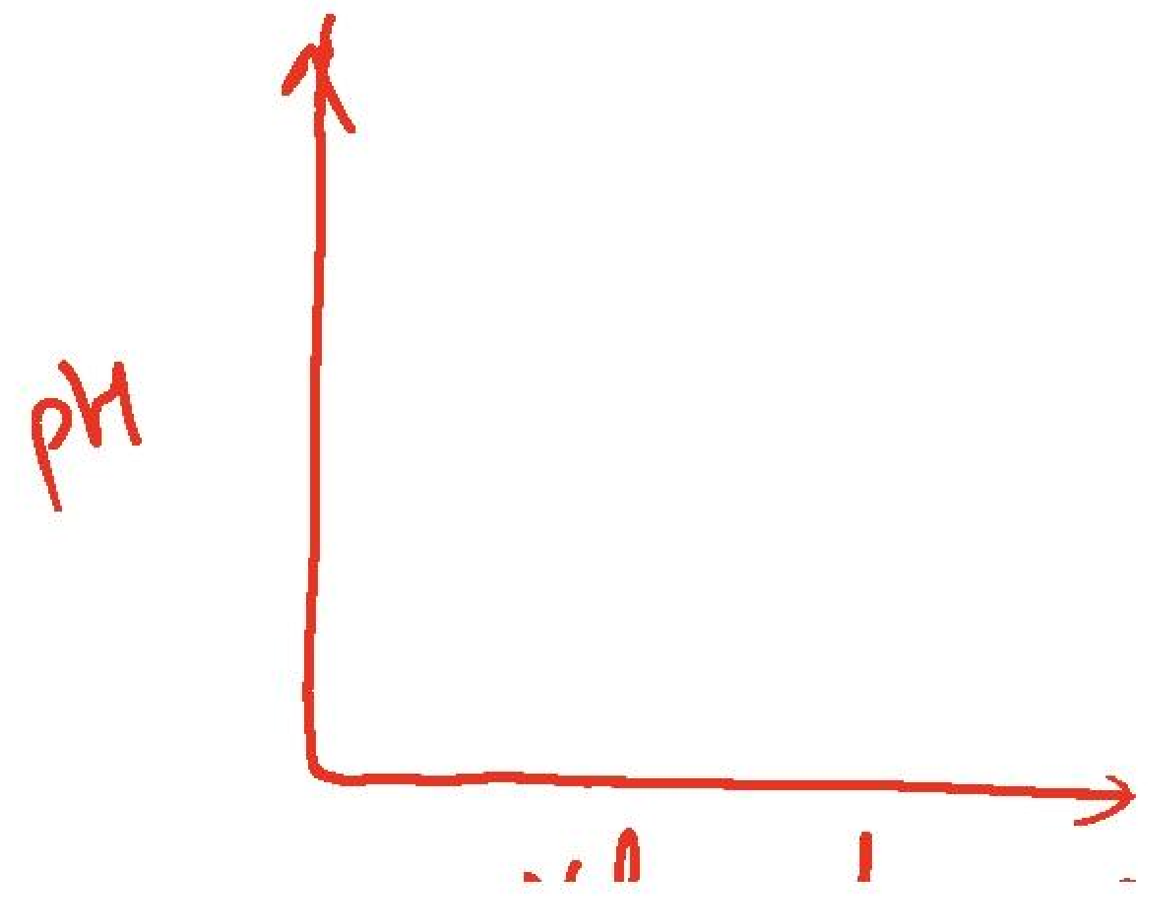
Starting point → Strong Alkali Above 12



sketch pH titration curve produced when 0.1 mol/dm³ $NaOH_{(aq)}$ is added to 25cm³ of 0.1 mol/dm³ $HBr_{(aq)}$ to excess.

$HCl + NaOH \rightarrow \boxed{NaCl} + H_2O$

⑦ neutral Salt



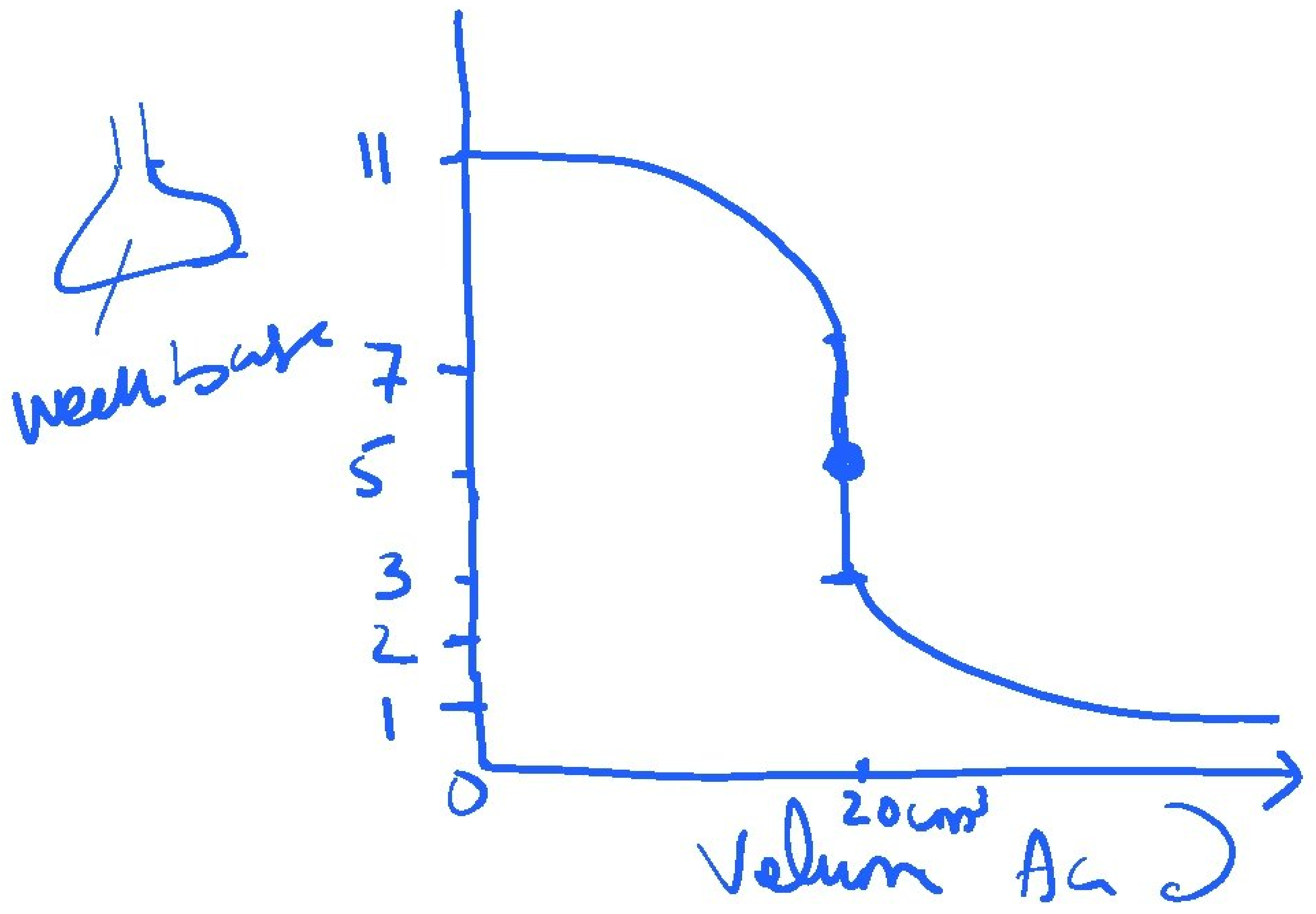
Volume of NaOH

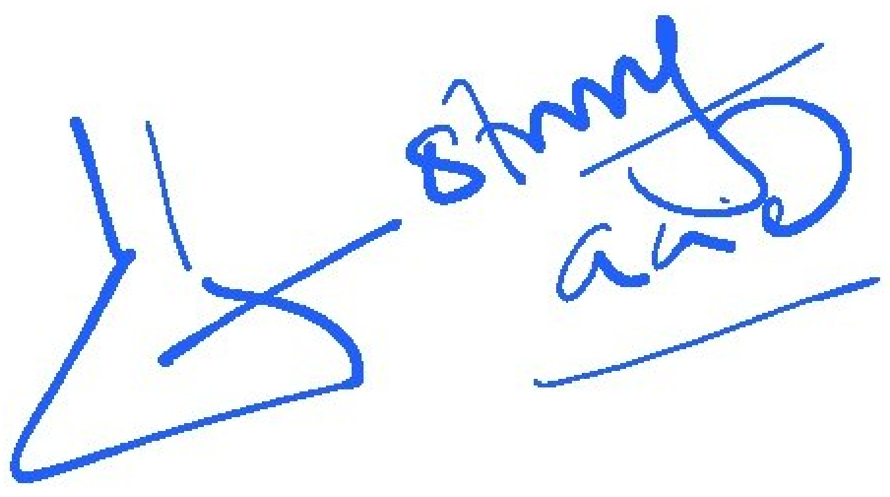
Strong Acid Vs weak Base

Vertical line range $3 \overset{5}{—} 7$ equivalence point

$$\underset{S.A}{HCl} + \underset{W.B}{NH_3} \rightarrow \overset{+}{N}H_4 + \overset{+}{H}$$

$$\boxed{\text{Weak base PH } 8 - 11.9}$$





Why eq point in acidic region

$$HCl + NH_4OH \rightarrow \boxed{NH_4Cl} + H_2O$$

acidic salt

salt + H_2O

$\boxed{NH_3 + HCl}$

(3) Weak Acid Vs Strong base

$7 \overset{9}{—} 11$

$$CH_3COOH + NaOH \rightarrow \underbrace{CH_3COONa}_{\text{Basic Salt}} + H_2O$$

$20\ cm^3$

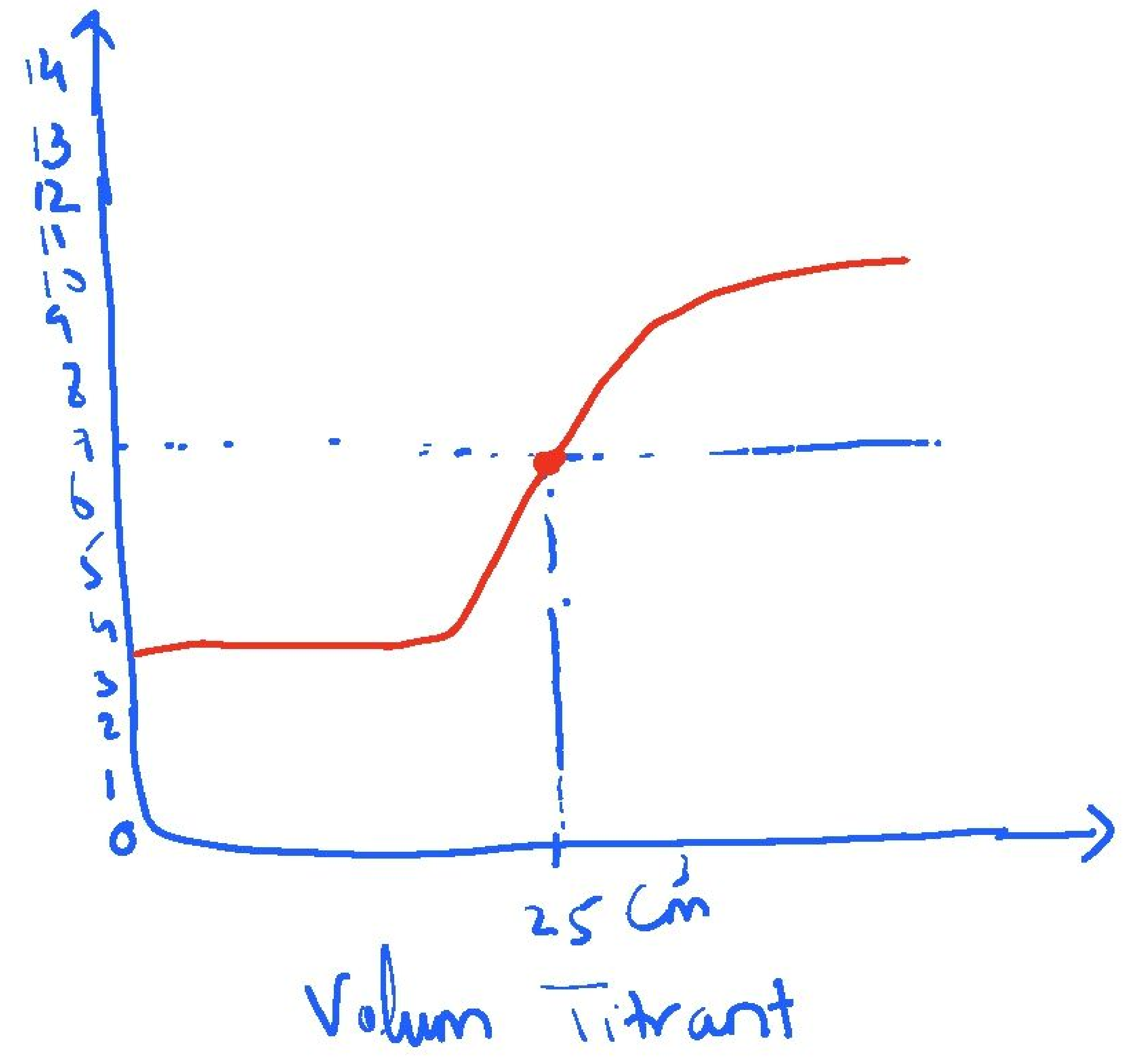
Dilution formula

Volum Titrant
Base

Acid Base
$C_1 V_1 = C_2 \boxed{V_2}$

Week Acid Vs Week Base

- → No vertical regions
- → Curves are not providing much info
- → Point of Infexion at equivalence point



Indicator

	Acid	Base	PH Range
Methyl orange	red	Yellow	3.1–4.4
Phenolphthalein	Colourless	Pink	8.3–10

① Strong Acid Vs Strong Base

Vertical line range 3 —7— 11

You can use both

② **Strong Acid** and weak Alkali ? Indicator

Vertical line range 3 —5— 7

Methyl orange ✓

③ Weak Acid Vs strong Alkali

Vertical line range 7 —9— 11

Phenolphthalein Indicator

PH Scale

Ionic product of H_2O

$K_w = [H^+][OH^-] = 1 \times 10^{-14}$

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

$$K_c = \frac{[H^+][OH^-]}{[H_2O]}$$

$$\underline{K_c \cdot [H_2O]} = [H^+][OH^-]$$

$[H^+] = 1 \times 10^{-7}$

$[OH^-] = 1 \times 10^{-7}$

At 25°C $\boxed{K_w = [H^+][OH^-]}$

→ $K_w = 1 \times 10^{-14}$

<u>Acid</u> <u>Base</u>

Conjugate Pair

In equilibrium acid/Base NH_3 reactions there are 2 Acids 2 Bases

A pair differ from each other by presence of or absence of transferable H^+ ion

$$\underbrace{H_2SO_4}_{\text{Acid}} + \underbrace{NH_3}_{\text{Base}} \rightleftharpoons \underbrace{HSO_4^-}_{\text{C.Base}} + \underbrace{NH_4^+}_{\text{C.Acid}}$$

H^+ H^+

↳ Strong Acids have weak C. Bases Vice Versa