Titration of a weak acid with strong base

- Objectives:

- To study titration curves.
- Determine the pKa value of a weak acid.
- Reinforce the understanding of buffers.

- Titration Curves:

- Titration Curves are produced by monitoring the pH of a given volume of a sample solution after successive addition of acid or alkali.
- The curves are usually plots of pH against the volume of titrant added.
- **The relation between the strength of acid / base and Ka/Kb respectively:**
- As an acid/base get weaker, its Ka/Kb gets smaller and Pka/PKb gets larger.

- Example:

- HCl is a strong acid , it has **1×10^7 Ka** value and **-7 pKa value.**

- CH3COOH is a weak acid , it has **1.76 x 10-5 Ka** value and **4.75 pKa** value.

- Type of weak acid and how did they dissociate:

- The weak acid will **dissociate** in solution (the group of weak acid), the weak acid may be contain **1 group or more than one**, and each group has own **Ka value**.

- Type of weak acid:

1- Monoprotenation (contain 1 group, hydrogen ions).

2- Diportonation (contain two group).

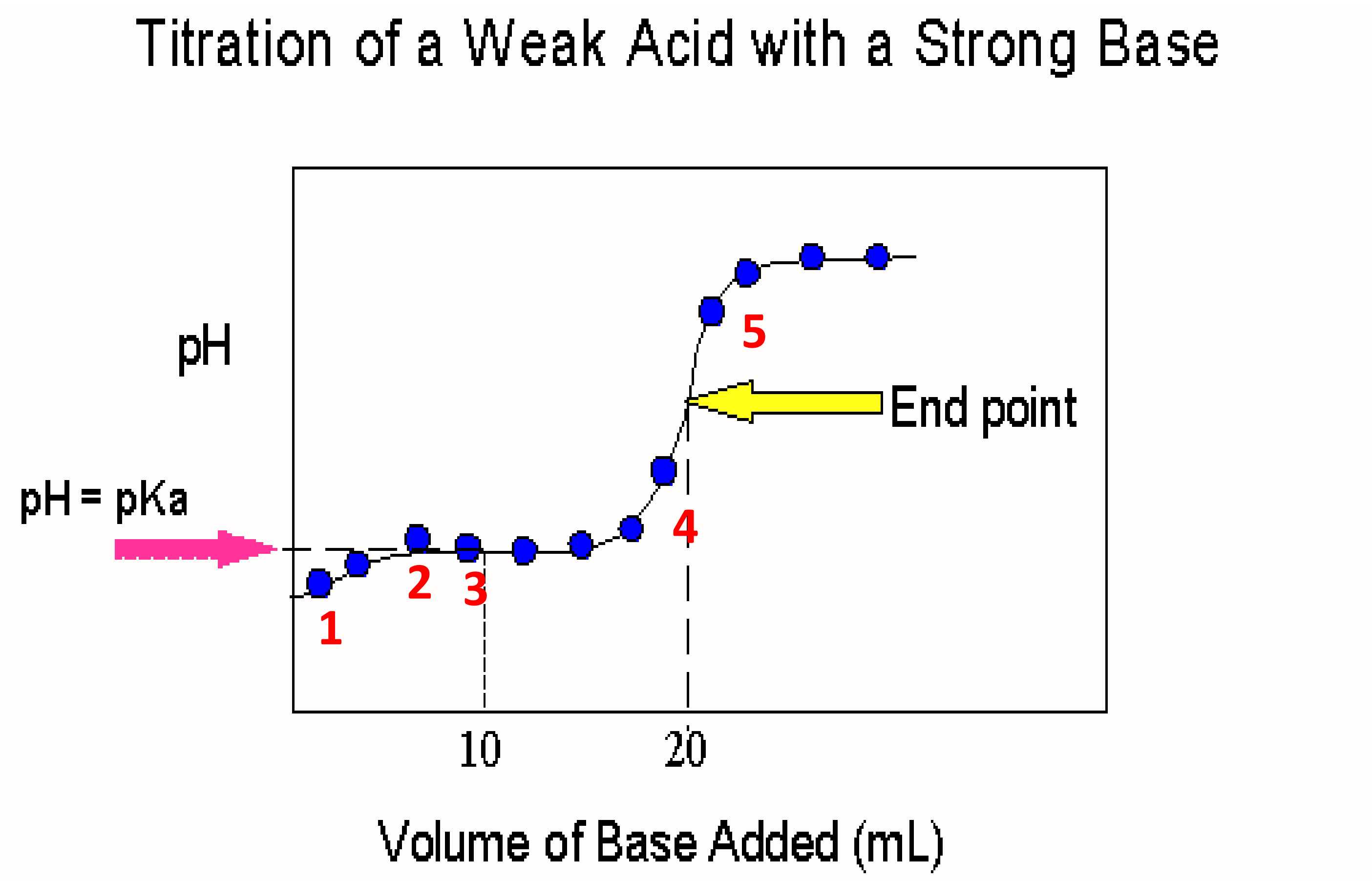
3- Polyprotonaion (contain more than two group).

- Which dissociation group will dissociate first?

- The group that has **higher Ka** value or that has **lower Pka value.**

- Acetic acid has **one dissociation** group (monoprotention) COOH “carboxyl”.

- So, the titration curve of acetic acid with strong base contain **one stage.**

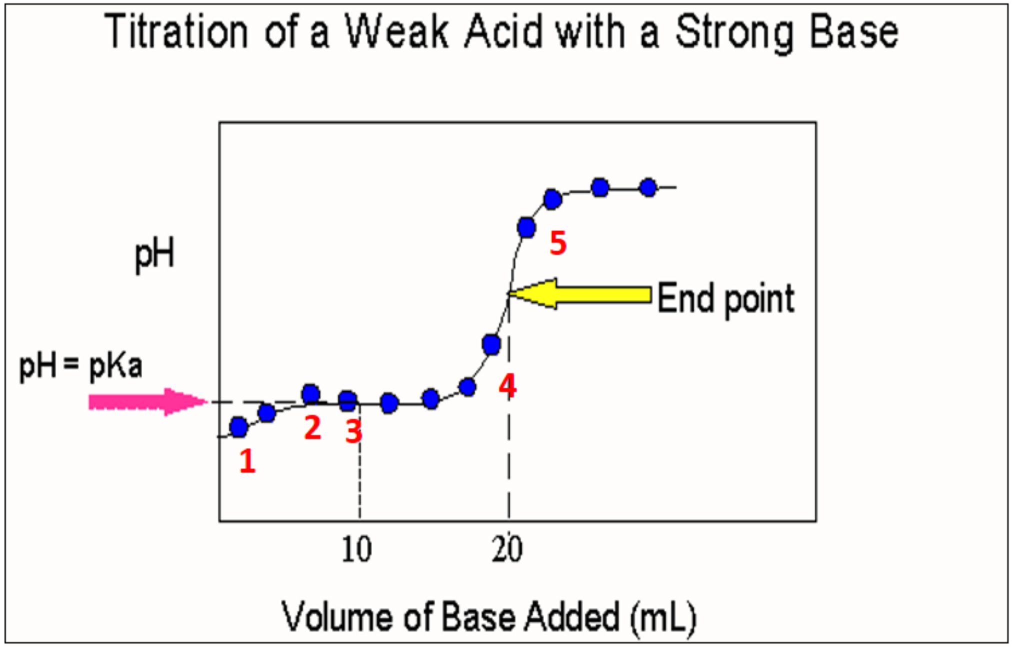


[1] Before any addition of strong base the (starting point) All weak acid is in the form of full protenation [CH3COOH] ; all weak acid as electron donor.

- In this point PH of weak acid < Pka.

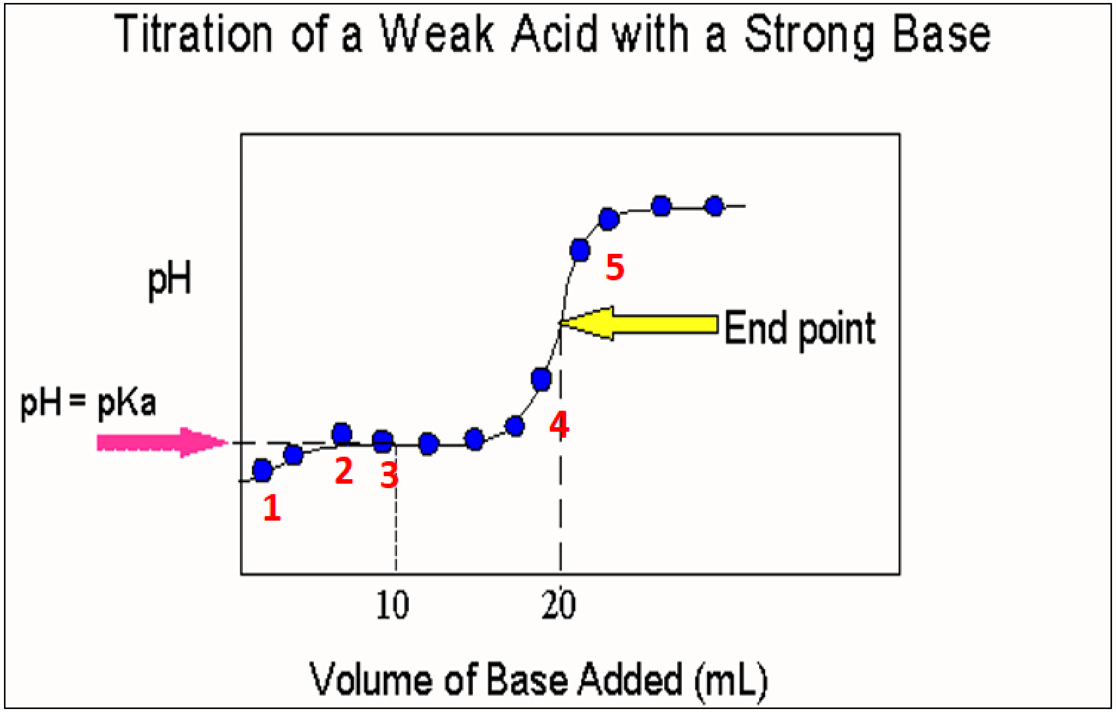
[2] When certain amount of strong base added (any point before the middle of titration), the weak acid starting dissociate [CH3COOH]>[CH3COO-] (Donor > Acceptor).

- In this point the PH of weak acid < Pka.



[3] point At middle of titration [CH3COOH]=[CH3COO-] (Donor=Acceptor) , PH=Pka , The component of weak acid work as Buffer that has maximum buffer capacity (Can resistant the change of PH) .

- Pka define as: The PH value at middle of titration at which they will be [donor]=[acceptor].



[4] Any point after mid of titration , [CH3COOH]<[CH3COO-] ,

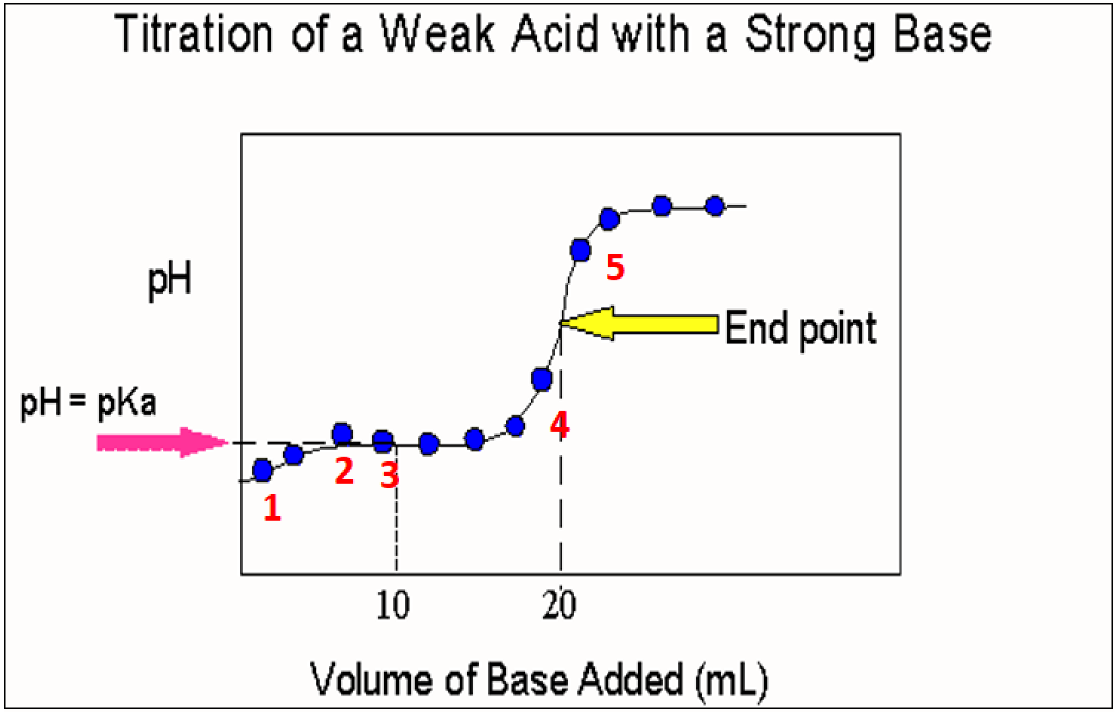
(donor<Acceptor).

- In this point the PH > Pka.

[5] Finally; At the end point the group of weak acid will full dissociate

(electron acceptor) , [CH3COO-].

-In this point PH of weak acid >Pka



- Now,

- How to calculate the pH value at these different points?

[1] At starting point: PH= (Pka+P[HA])/2.

[2] At any point within the curve (after , in or after middle titration):

PH=Pka+log[A-]/[HA].

[3] At end point: POH=(PKb+P[A-])/2

PH=PKw – POH

- Henderson-Hasselbalch equation is an equation that is often used to:

1- To calculate the PH of the Buffer

2-To preparation of Buffer.

3-To calculated the PH in any point within the **titration curve** (Except starting and ending point)

- Note:

- If you start titration using 20 ml of the weak acid, In titration curve….

a] In titration curve if the total volume of weak acid is **20 ml** , we need to add **20 ml** of strong base to full dissociate the group of weak acid.

b] We can reach to middle titration if we add 10 ml of strong base (half the amount of 20 ml).

*** How we can determine the Pka from the curve??**

Example: **Determine the PH value of 500 ml of weak acid (0.1M) , titrated with 0.1M KOH (Pka=5), after addition: 100 ml , 250 ml , 375 and 500 ml of KOH??**

[1] PH after addition of 100 ml of KOH?

PH= Pka + log[A-]/[HA]

HA + KOH → KA + H2O

-We should calculate the No. of moles of remaining [HA] first because it is reflect the pH value at this stage.

Mole of HA [original] **–** mole of KOH [added] = mole of HA remaining.

-No. of KOH mole = 0.1 X 0.1 L = **0.01 mole**

-No. of HA mole originally = 0.1 X 0.5 L =0.05 mole

-No. of HA mole remaining = 0.05 – 0.01 = **0.04 mole**

So,

PH = 5 + log [0.01]/[0.04]

PH = 4.4

- Note: pH<pKa

[2] After addition of 250 ml of KOH??

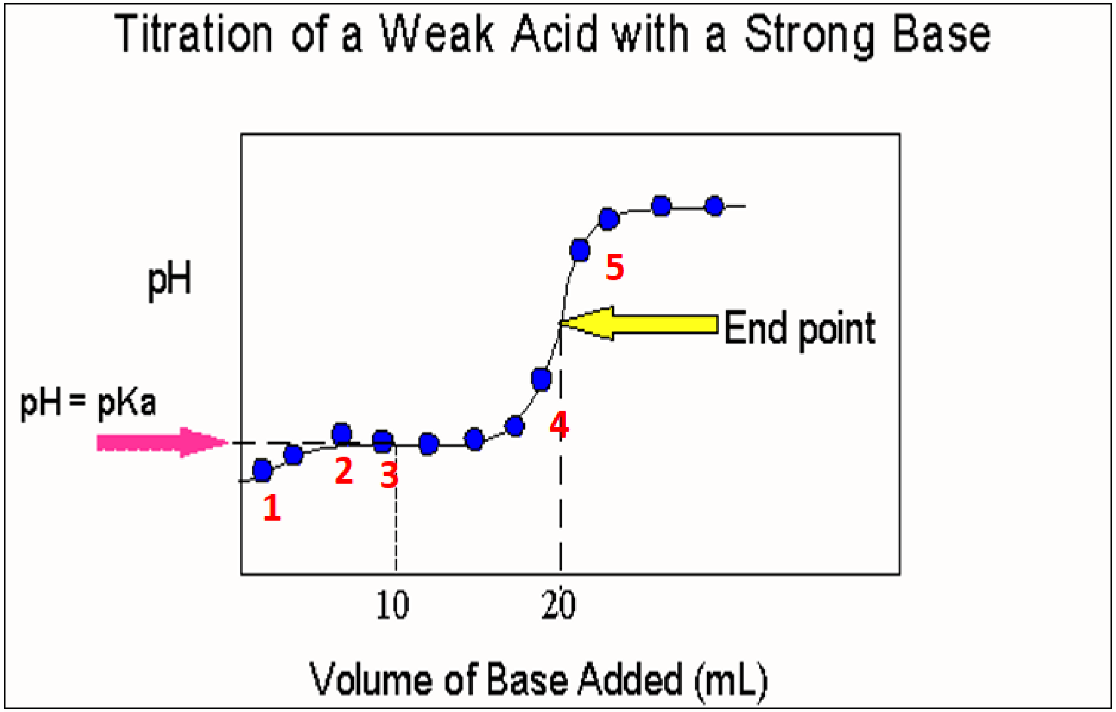
Mole of HA [originally] – mole of KOH [added] = mole of HA remaining.

- **No. of KOH mole =** 0.1 X 0.25 L = **0.025 mole**

- No. of HA mole remaining = 0.05 – 0.025 = **0.025 mole**

PH = 5 + log [0.025] / [0.025]

PH=5 =PKa



[3] After addition of 375 ml of KOH??

Mole of HA [originally] **–** mole of KOH [added] = mole of HA remaining.

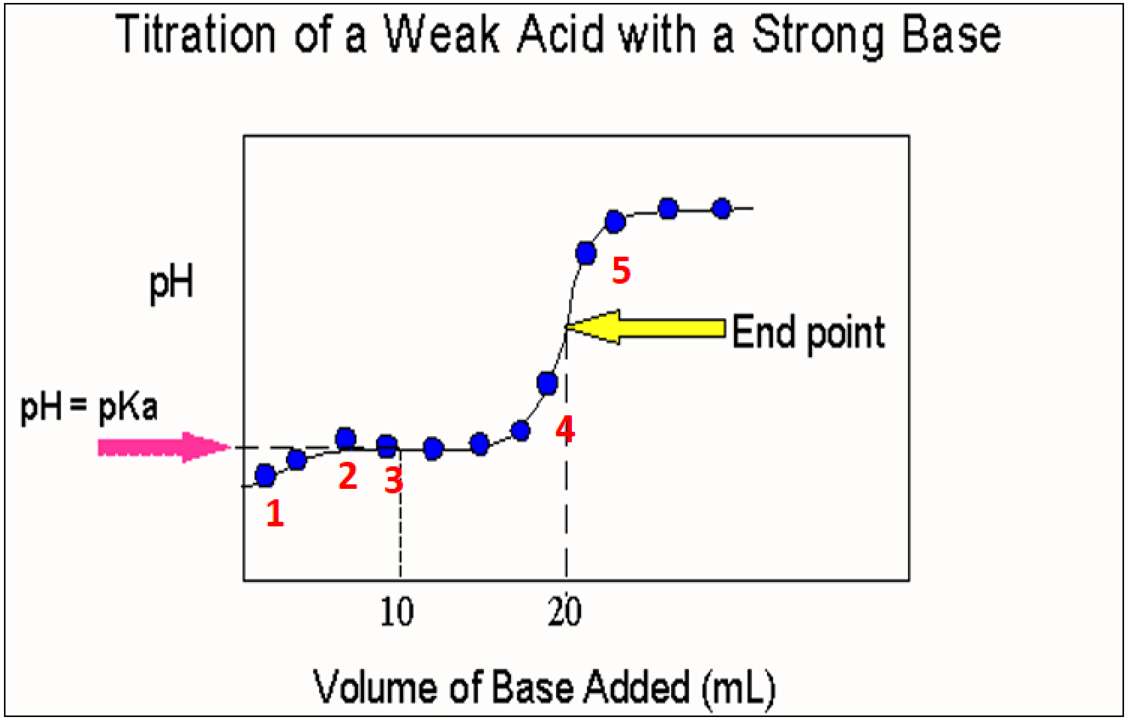
- No. of KOH mole = 0.1 X 0.375 L = **0.0375 mole**

- No. of HA mole remaining = 0.05 – 0.0375 = **0.0125 mole**

PH = 5 + log 0.0375/0.0125

PH= 5.48

- Note: The pH>pKa “slightly”



[4] After addition of 500 ml of KOH??

- **Note:** 500 ml the same volume of weak acid that mean the all weak acid are as [CH3COO].

POH = (PKb + P[A-])/2

PKb= PKw-Pka

P[A-]= - log [A-]

PKb=14-5=9

[A-]=??

- **No of a mole KOH=** 0.1 X 0.5 = 0.05 mole

(**Total volume =** 500+500=1000= 1L)

[A-] = 0.05/1 =0.05 M

P[A-]= - log 0.05 = 1.3

-POH=(9+1.3)/2 = 5.15

-PH= PKw-POH

Note: pH>pKa

PH = 14 – 5.15 = **8.85**

- Method:

- You are provided with **10 ml of a 0.1M CH_3COOH** weak acid solution, titrate it with **0.1m NaOH** adding the base drop wise mixing, and recording the pH after each 0.5 ml NaOH added until you reach a **pH=9**.

ml of 0.1 NaOH	PH
0	
0.5	
1	
1.5	
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- Result:

[1] Record the values in titration table and Plot a curve of pH versus ml of NaOH added.

[2]Calculate the pH of the weak acid HA solution after the addition of 3ml, 5ml, and 10ml of NaOH.

[3] Determine the Pka value of weak acid.

[4]Compare your calculated pH values with those obtained from curve.