

Steps to drawing a titration curve

Question:

mL of mol L⁻¹
 is titrated with mol L⁻¹
 up to a total of mL
 pKa () =

Of acid (or
conj acid)

Acid In flask

Base in burette

In order to graph a titration curve there are a number of points that need to be calculated in their specific order

1. The pH before any base is added
2. The volume of the base at equivalence point
3. The volume of base when pH = pKa
4. The pH at equivalence point
5. The pH after all of the base has been added

Base in burette

Step One: Start pH

concentration

Find the pH of:

Weak acid or base

molL⁻¹ of pKa =

K_a =

$$\frac{[\text{ }][\text{ }]}{[\text{ }]} = 10^{-\text{pKa}}$$

= 10⁻

Dissociation equation
of weak acid or base

= 10⁻

K_a =

K_a expression

Conc of conj

Assume

1. =
2. = molL⁻¹

Calculate K_a from pK_a
given

Assumptions for pH
calculation

Starting concentration of weak
acid or base

Step One: Start pH

Equilibrium expression of acid dissociation in water

$K_a =$

$$K_a = \frac{[] []}{[]}$$

Rearrange expression

Calculate

$$[H_3O^+] = \sqrt{K_a \times c(HA)}$$

$[H_3O^+] =$

$$\times \text{ mol L}^{-1}$$

Could also use 10^{-pK_a} directly in formula

$$[H_3O^+] =$$

$$pH = -\log ()$$

Double check your answer by making sure the pH fits within the range of your starting acid or base (weak or strong)

pH =

Step Two: Volume of equivalence

Calculate the volume of at the endpoint.

Titration reaction is:

Added base

$$n() = cV$$

$$= \text{mol L}^{-1} \times \text{L}$$

$$= \text{mol}$$

Neutralisation equation at endpoint

From the equation 1:1. Every mole of $CH_3COOH = NaOH$

Starting acid

$$n() = n()$$

$$= \text{mol}$$

Volume of acid in flask at start

Added base

Added base

$$v()$$

$$= n / c$$

$$v()$$

$$= \text{mol}$$

$$\text{mol L}^{-1}$$

Convert to mL for titration curve

Rearrange $n=c/v$ to calculate v of Base needed to neutralise acid present

$$v() = \text{mL}$$

Step Three:

Mid-point of Buffer

Calculate the volume of when $\text{pH} = \text{pK}_a$

Added base

The volume of at equivalence point is

When exactly $\frac{1}{2}$ way to end point then $\frac{1}{2}$ acid has dissociated into conjugate
(CH_3COOH) = (CH_3COO^-)

mL $\div 2 =$ mL (x)
 $\text{pK}_a =$ (y)

These points intercept on the graph

Added base

The $\text{pH} = \text{pK}_a$ when mL of has been added

The buffer zone will be 1 pH point above and below pH
Once the curve is drawn this can be sketched as a circle around the area from on the line.

pK_a

+1 and -1 around pK_a

The buffer zone is where pH will change slowly (flatter line) due to equilibrium principles

Step Four:

pH of equivalence

Calculate the pH at equivalence point.
At the Equivalence point we will have:

$n(\text{conj.B})$ mol of in

(mL + mL = mL) of solution

Conj. base

acid vol.

base vol.

Conj. base

$c(\text{ }) =$ mol

Total volume from starting flask + added from burette

At neutralisation (from equation), for every mole of original acid there is now an equal amount of conjugate (CH_3COO^-) formed

$=$ L
 $=$ mol L^{-1}

$c = n/v$

We need to calculate the pH of a solution of
with this concentration: mol L^{-1}

As the pH of the equivalence point is determined by a conjugate that is base (paired with starting weak acid) then it will be above pH 7

The amount of conjugate of the weak acid present will determine the pH at end point. All acid at start has been now been neutralised

Step Four: pH of equivalence

Conj. Base dissociation equation

$$[\text{H}_3\text{O}^+] = \sqrt{K_a \times K_w \div [\text{Conj base}]}$$

$$[\text{H}_3\text{O}^+] = \sqrt{(\text{molL}^{-1}) \times (\text{molL}^{-1}) \div (\text{molL}^{-1})}$$

$$[\text{H}_3\text{O}^+] = (\text{molL}^{-1})$$

$$\text{pH} = -\log (\text{molL}^{-1})$$

Intercept this pH point with v calculated for the endpoint

pH =

Each mol of conjugate formed will produce 1 mol of OH⁻ ions, which determines the pH

Assume

1

$$[\text{molL}^{-1}] = [\text{OH}^-]$$

Conj. base

2

$$[\text{molL}^{-1}] = (\text{molL}^{-1})$$

Concentration calculated from previous step $c=n/v$

Step Five: Final pH

In question

Calculate the pH after has been added.

mL

base

Since the equivalence point is at mL this results in an excess of mL of base

Volume of after equivalence point

Calculate concentration of added base or acid. Although the conjugate does react we assume all [OH⁻] or [H₃O⁺] comes from excess added

$$\text{Total volume of solution} = (\text{mL}) + (\text{mL}) = (\text{mL})$$

$$c(\text{base}) = \frac{(\text{mL})}{(\text{mL})} \times (\text{molL}^{-1})$$

base

Total v

=

$$(\text{molL}^{-1})$$

New concentration after dilution

Original concentration

Dilution calculation

Step Five: Final pH

is a strong base

Assume $[\text{OH}^-] = c(\text{ })$

Strong bases or
acids fully
dissociate

$[\text{OH}^-] = \text{ } \text{molL}^{-1}$

$[\text{H}_3\text{O}^+] = K_w / [\text{OH}^-]$

$[\text{H}_3\text{O}^+] = K_w / \text{ } \text{molL}^{-1}$

$[\text{H}_3\text{O}^+] = 1 \times 10^{-14} / \text{ } \text{molL}^{-1}$

$[\text{H}_3\text{O}^+] = \text{ } \text{molL}^{-1}$

$\text{pH} = -\log(\text{ } \text{molL}^{-1})$

Plot this point on
your graph

$\text{pH} = \text{ }$

Drawing Curve

Now we have the key data points:

☐ The pH before any Base added =

☐ The volume of NaOH at equivalence point: mL

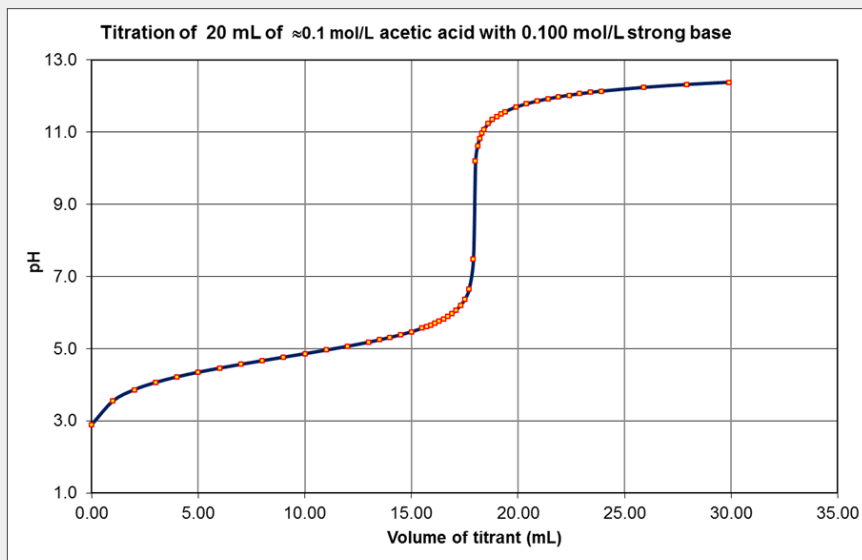
☐ The volume of NaOH when $\text{pH} = \text{pKa}$: mL

☐ The pH at equivalence point:

☐ The pH after mL of is added:

Drawing Curve

Plot these points on a graph



http://www.iq.usp.br/gutz/Curtipot_.html#Download

