VII) Acid/Base Titration Curves

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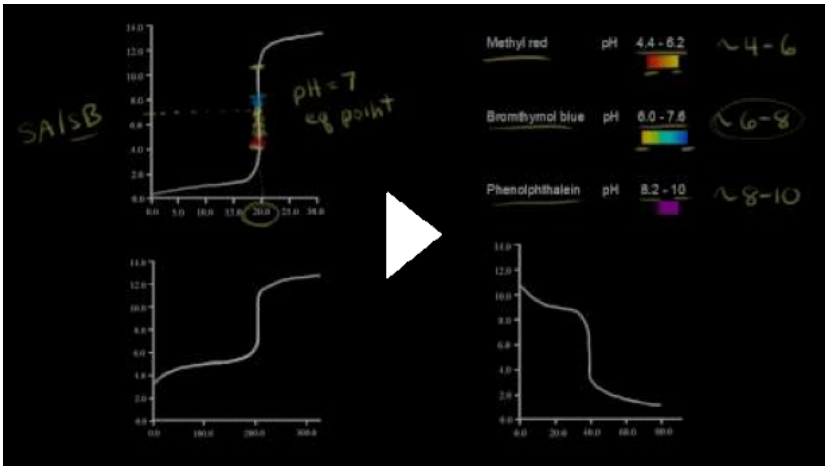
[Titration curves and acid-base indicators | Chemistry | Khan Academy]

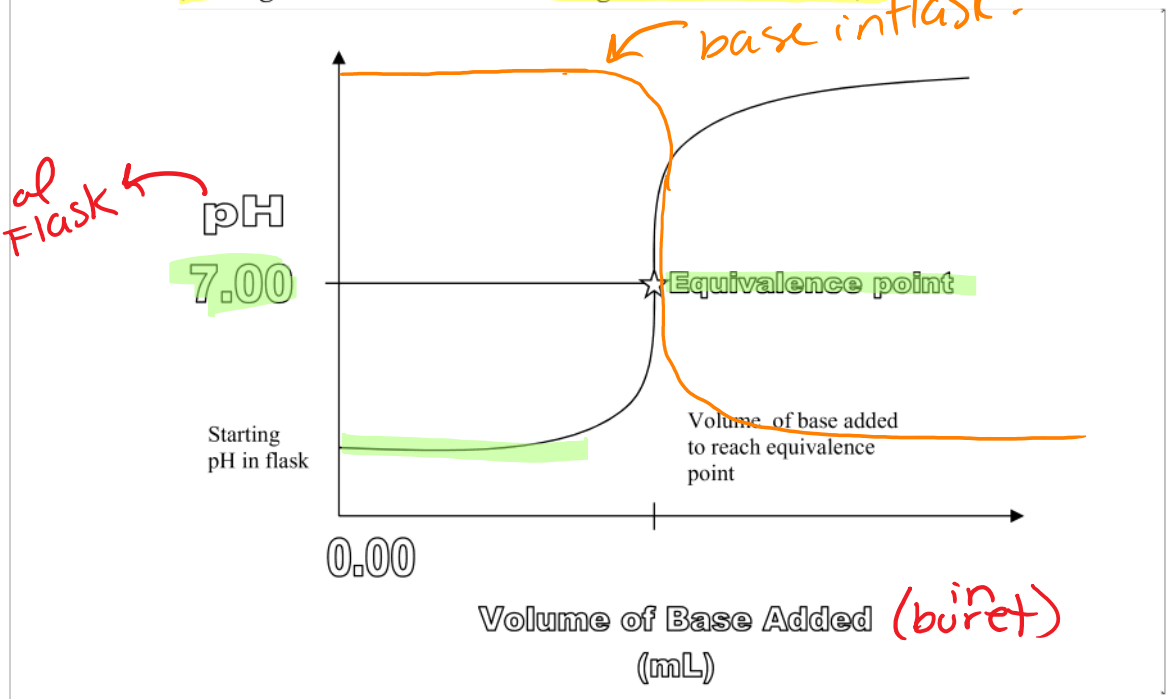


VII) Acid/Base Titration Curves

Titrations are commonly carried out to find the concentration of an acidic or basic solution.

A standard titration curve has an *x* axis that is the *Volume of Base (or Acid) Added* from the buret and the *y* axis is the *pH* in the flask.

Strong Acid/Strong Base Titration Curve
(strong acid in the flask, strong base in the buret)



Notice the general shape of the titration curve. The pH rises very slowly at the start of the titration, drastically in the middle region, and then very slowly again at the end. Why is this so?

At the start, in order to make the pH change 1 unit (from say 2 to 3) you have to add a large amount of OH^- from the buret. pH 2 is an $[H_3O^+]$ = 0.01 M and pH 3 is an $[H_3O^+]$ = 0.001 M.

Thus, you must add pH2 0.01 M - pH3 0.001 M = 0.009 M OH^-, quite a large amount.

In the middle region, to change the pH from 6 to 7, you must add pH6 0.000001 M - pH7 0.0000001 M = 0.0000009 OH^-, one ten-thousandth of the OH^- needed to change the pH from 2 to 3!

explain vertical region

This is why, from about pH 4 to pH 10, you add very little OH^- and the pH changes so quickly. After pH 10, the same effect takes place as early on.

An analogy using $: If you need to pay a $10 000 loan down to $1 000, it costs $9 000. This may take awhile to pay off! But suppose you had to pay a $1 000 loan down to $100, a $100 loan down to $10, a $10 loan down to $1, a $1 loan down to $0.10, and a $0.10 loan down to $0.01 (simulating the middle of the pH curve). This, in total, costs $999.99, a fraction of the first loan!

Here is an example of a strong acid/strong base titration reaction:

$$HCl_{(aq)} + NaOH_{(aq)} \Rightarrow H_2O_{(l)} + NaCl_{(aq)}$$

What products result? water + salt.

Water is, of course, neutral. Is the resulting salt neutral? Why or why not?

$NaCl \rightarrow Na^+ + Cl^-$ neither will hydrolyze (spectator ions) ∴ neutral.

Therefore, what is the pH at the **equivalence point** of a strong acid/strong base titration? pH ≅ 7 b/c both products are neutral.

Strong acid/strong base titrations result in a salt that does not hydrolyze, therefore the **equivalence point** is always 7.

endpoint of indicator

An ideal indicator for a titration is one in which the colour change encompasses the equivalence point. want endpoint ≅ equivalence point

- phenolphthalein ~9.1
- bromthymol blue ~7.2
- phenol red ~7.4
- neutral red
- methyl orange

List the ideal indicators for a strong acid/strong base titration.

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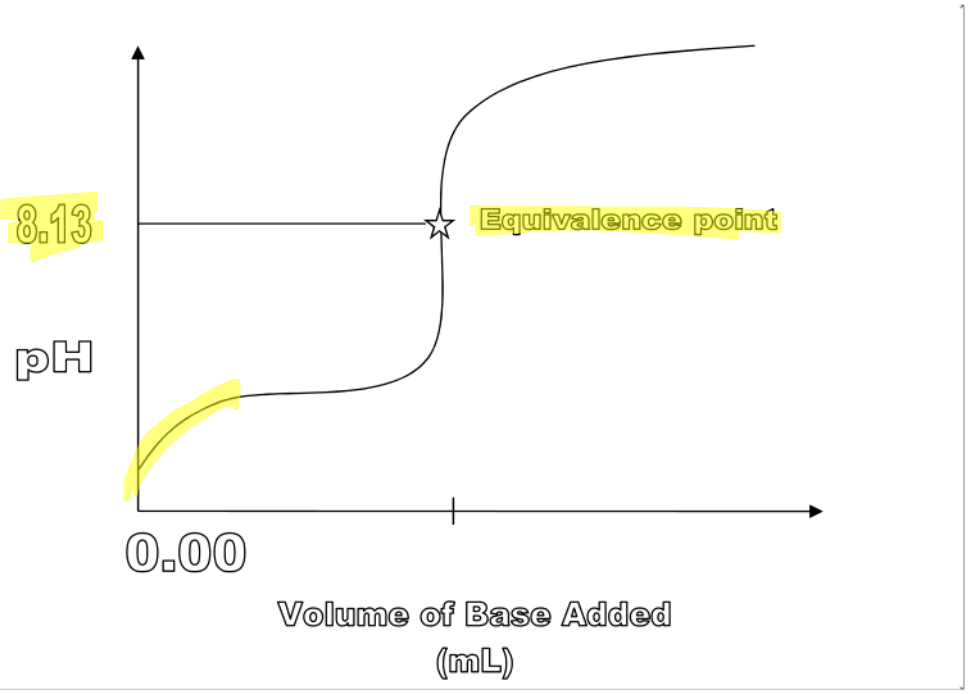
However, in our lab, we used phenolphthalein to indicate the equivalence point of a strong acid/strong base titration, even though the endpoint of phenolphthalein is 9.1. Why is this okay?

B/C of the sharp vertical rise on the graph, where the pH changes rapidly, but there is very small changes in the volume of base added (few drops)
Differences in indicator endpoints would be a very small volume (small source of error)

Weak Acid/Strong Base Titration (strong base is in the buret)



Though two parts of this curve are different than the strong acid/strong base curve, the vertical rise is still present.

What is different compared to a strong/strong titration?

↑ graph.

1. small jump at start of curve (point ②), OH^- added at start depletes any H_3O^+ and ↓ pH initially.

2. equivalence point is higher, @ pH ≅ 8-9 (due to the salt hydrolyzing basically)

Why, for a weak acid/strong base titration, is the equivalence point between pH 8 & 9?

eg. $HF + NaOH \rightarrow H_2O + NaF$

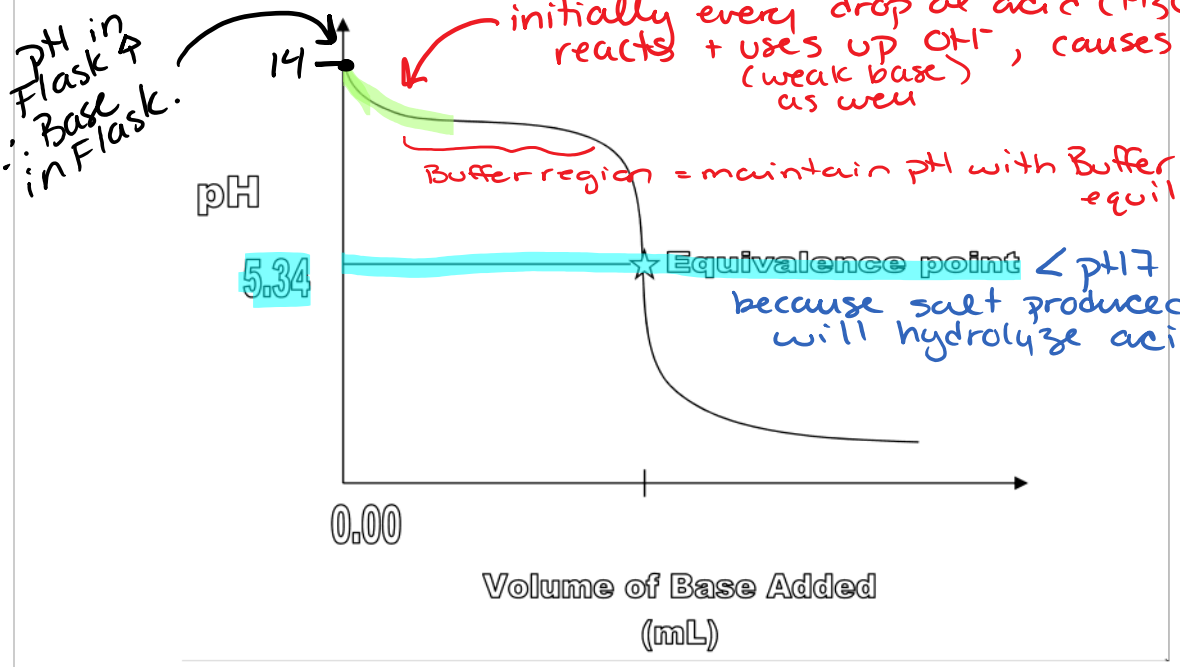
$NaF \rightarrow Na^+ + F^-$ (weak base)

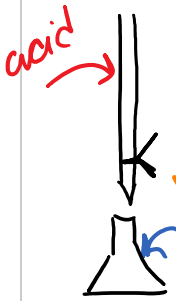
$F^- + H_2O \rightleftharpoons HF + OH^-$ (HF: weak acid; OH^-: strong base ↑ pH)

Which indicators would be **ideal** for a weak acid/strong base titration?

equivalence point ≅ 8-9 } indicator endpoint within this region
phenolphthalein ~9.1
Thymol Blue ~ 8.8

Weak Base/Strong Acid Titration (strong acid is in the buret)





Why does this curve start at a high pH and end at a low pH?

As you add acid ... ↑[H_3O^+] ∴ ↓pH

Characteristics include an initial dip in pH and an equivalence point pH of 5-6. This is because the salt produced will hydrolyze acidically:

ex. HCl + NH_3 ⇒ NH_4Cl (SA, WB) only product is a salt, dissoc. 100%.

NH_4Cl ⇒ NH_4^+ + Cl^-

NH_4^+ + H_2O ⇔ NH_3 + H_3O^+ Hydrolyze acidically.

(NH_4^+: weak acid.)

The extra H_3O^+ produced due to the hydrolysis of the salt lowers the equivalence point to pH 5-6. ↑[H_3O^+] = ↓pH

equivalence point.

List the ideal indicators for a weak base/strong acid titration:

want endpoint within pH 5-6 range.

- chlorophenol red
- methyl red.

Assignment 8: Titration Curve Exercises

1. Hebden p.176 #125
2. A student titrated a 25.00mL sample of 0.20M HX acid with 0.20M NaOH. The following data was collected.

Volume of NaOH added (mL)	pH
0.00	2.72
10.00	4.57
24.90	7.14
24.99	8.14
25.00	8.88
25.01	9.60
26.00	11.59
35.00	12.52

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