pH Titration curves

pH/Titration curves

#Chemistry

General

Many indicators are weak acids and partially dissociate in aqueous solutions

$$\mathrm{HIn}_{(aq)} \rightleftharpoons {H^+}_{(aq)} + {In^-}_{(aq)}$$

The un-ionised form (HIn) is a different colour to the anionic form.

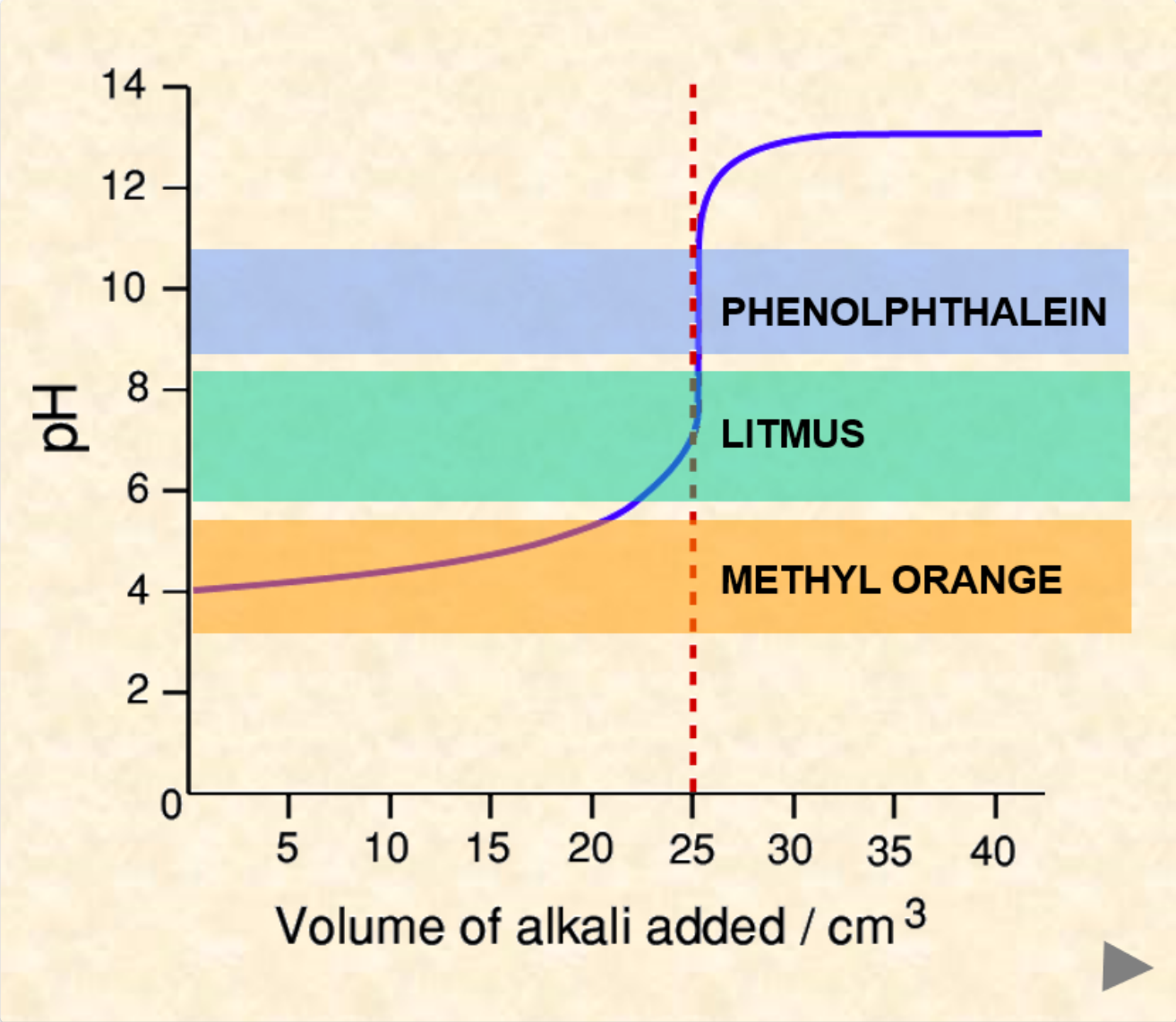
Apply Le Chatelier's Principle to predict any colour change

In Acid:

- Increase of $[H^+]$
- equilibrium moves to the left to give red undissociated form In Alkali:
- Increase of $[OH^-]$
- OH^-ions remove H^+ions to form water; ${H^+}_{(aq)} + {OH^-}_{(aq)} \rightleftharpoons {H_2O}_{(l)}$
- equilibrium moves to the right to produce a blue colour

Acid Base Indicators

- Must have an easily observable colour change.
- Must change immediately in the required pH range over the addition of 'half' a drop of reagent (the solution in your burette). To be useful, an indicator must change over the “vertical” section of the curve where there is a large change in pH for the addition of a very small volume of alkali. The indicator used depends on the pH changes around the end point - the indicator must change during the ‘vertical’ portion of the curve.



In the example, the only suitable indicator is Phenolphthalein.

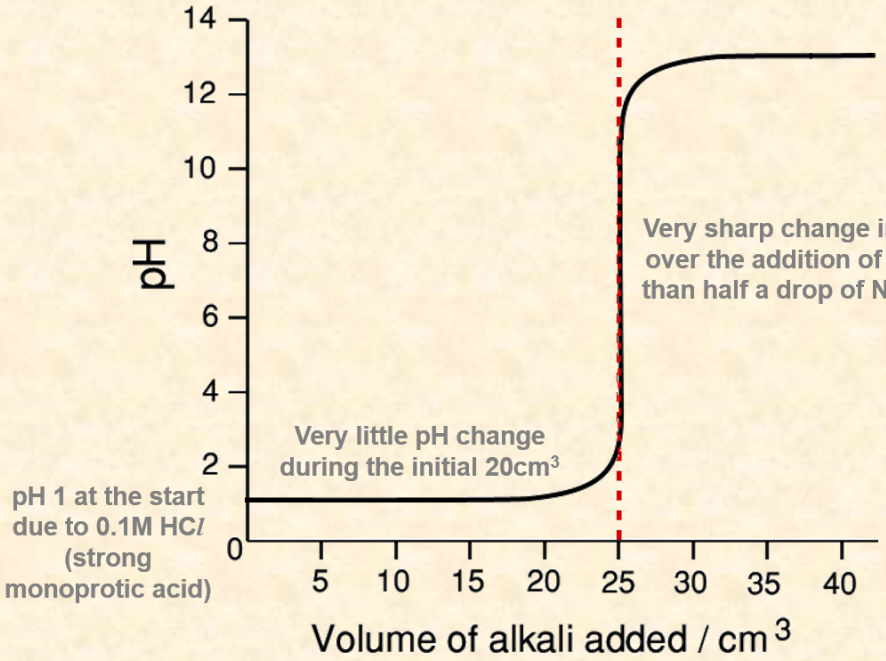
There are four types of acid-base titration; each has a characteristic curve.

1. Strong Acid HCl vs. Strong Base NaOH
2. Weak Acid $\mathrm{CH_3COOH}$ vs weak base NH_3
3. Strong Acid HCL vs weak base NH_3
4. Weak acid CH_3COOH vs weak base NH_3

In the following examples, alkali(0.1M) is added to 25cm ^3 of acid (0.1M).

End points need not be "neutral" due to salt hydrolysis (you don't have to know about this)

strong acid (HC*l*) v. strong base (NaOH)



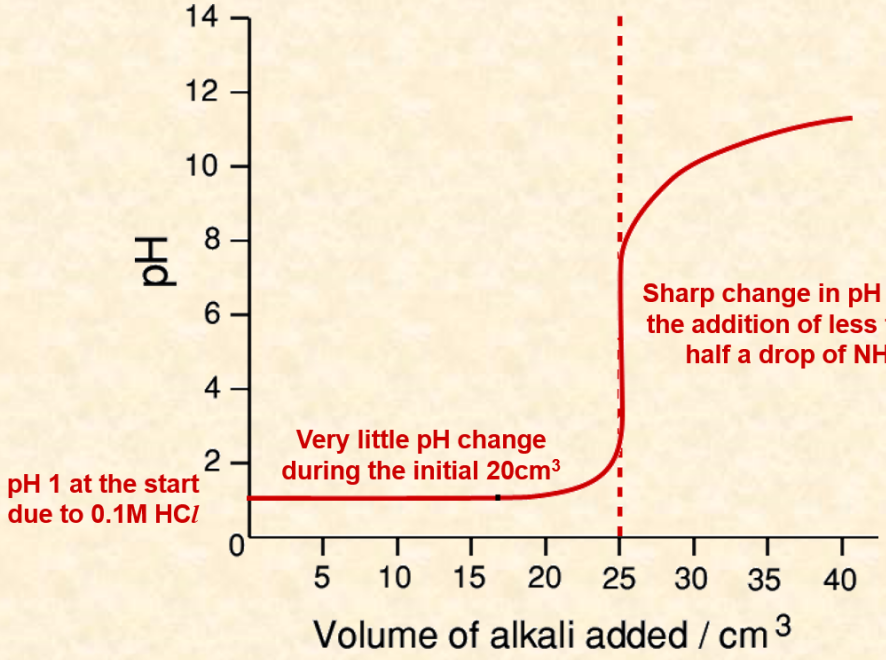
Curve levels off at pH 13 due to excess 0.1M NaOH (a strong alkali)

Very sharp change in pH over the addition of less than half a drop of NaOH

Very little pH change during the initial 20cm^3

pH 1 at the start due to 0.1M HC*l* (strong monoprotic acid)

strong acid (HC*l*) v. weak base (NH_3)



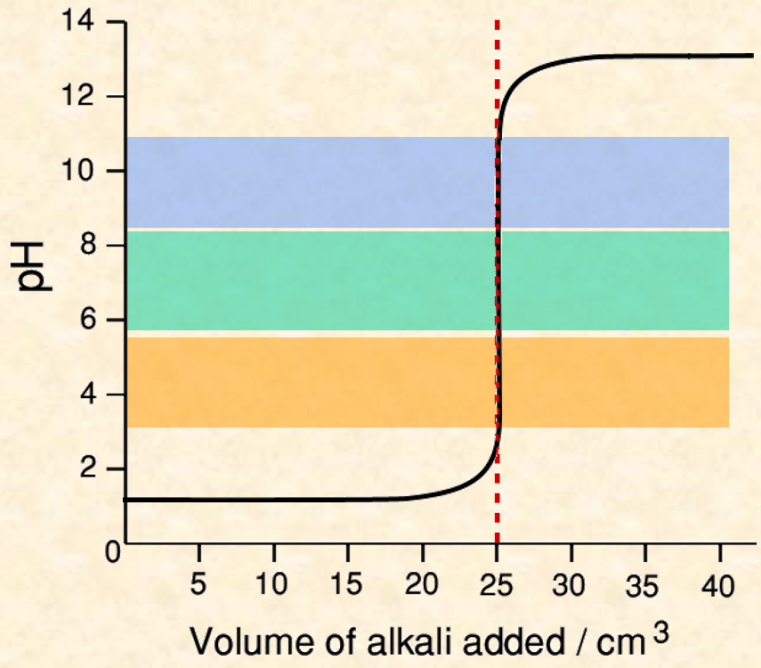
Curve levels off at pH 10 due to excess 0.1M NH_3 (a weak alkali)

Sharp change in pH over the addition of less than half a drop of NH_3

Very little pH change during the initial 20cm^3

pH 1 at the start due to 0.1M HC*l*

strong acid (HCl) v. strong base (NaOH)



Any of the indicators listed will be suitable - they all change in the 'vertical' portion

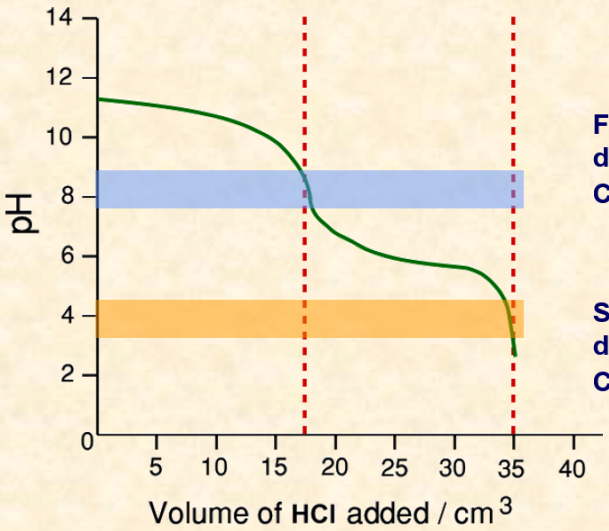
Other pH curves - acid v. carbonate

Sodium carbonate reacts with hydrochloric acid in two steps...

Step 1 $Na_2CO_3 + HCl \longrightarrow NaHCO_3 + NaCl$

Step 2 $NaHCO_3 + HCl \longrightarrow NaCl + H_2O + CO_2$

Overall $Na_2CO_3 + 2HCl \longrightarrow 2NaCl + H_2O + CO_2$



There are two sharp pH changes

First rapid pH change around pH = 8.5
due to the formation of $NaHCO_3$.
Can be detected using phenolphthalein

Second rapid pH change around pH = 4
due to the formation of acidic CO_2 .
Can be detected using methyl orange.