Titration Curves

- in order to perform a titration, you must start with a standardized solution

standard (or standardized) solution = solution with a precisely known concentration

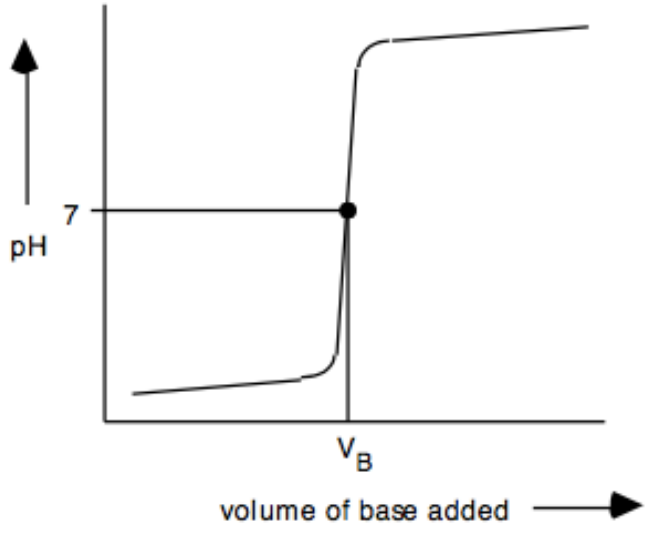
- standard solutions can be prepared by
  - > using a substance which can be obtained in a pure and stable form (does not absorb water or CO_2 from air) and which has a known molar mass so that it can be used to prepare a solution of known concentration (primary standard)

    ex. potassium hydrogen phthalate - $KHC_8H_4O_4$
    oxalic acid dihydrate - $H_2C_2O_4 \bullet 2H_2O$
  - > titrating a base with an acidic primary standard

- a titration curve is produced by plotting the pH change that occurs during a titration

a) Titration of a <u>strong acid</u> with a <u>strong base</u>

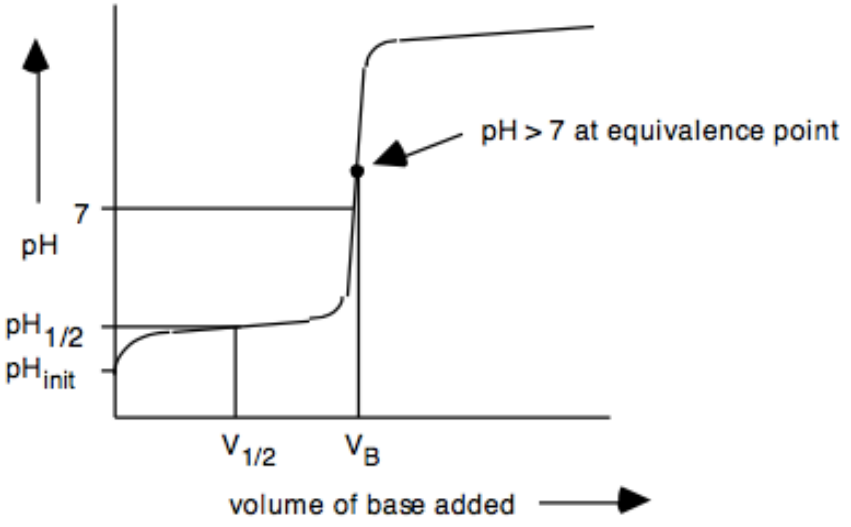
$$HCl(aq) + NaOH \rightarrow \mathbf{NaCl(aq)} + H_2O(l)$$



- the pH rises almost **vertically** around the value of V_B
- V_B is the volume of the base required to reach the equivalence point
- **strong acid - strong base** titration produce a **neutral** salt solution so **pH = 7** at the equivalence point
- choose indicator which changes colour around pH = 7 (pKin = 7) such as phenol red or neutral red

b) Titration of a <u>weak acid</u> with a <u>strong base</u>

$$NaOH + HNO_2 \rightarrow \mathbf{NaNO_2(aq)} + H_2O$$



- initial upswing in the pH at the start of the titration (**buffering zone**)
- **weak acid - strong base** titration produces a **basic** salt solution; as such, the **pH > 7** at the equivalence point

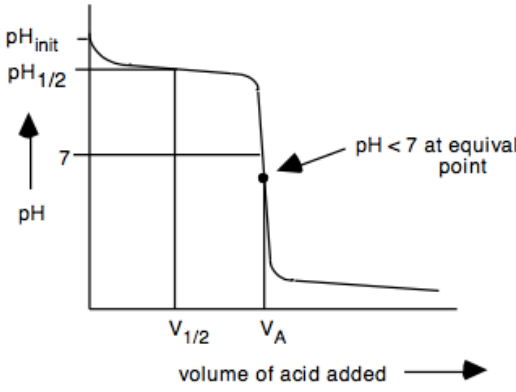
($NaNO_2$ hydrolyzes to give a base)

$$NO_2^-(aq) + H_2O(l) \rightarrow HNO_2(aq) + \mathbf{OH^-(aq)}$$

- requires an indicator than changes colour at pH > 7 (pKa > 7) such as phenolpthalein

c) Titration of a <u>weak base</u> with a <u>strong acid</u>

$$NH_4OH(aq) + HCl(aq) \rightarrow \mathbf{NH_4Cl(aq)} + H_2O(l)$$



- similar to weak acid and strong base, except curve is flipped upside down
- graph gives pH values not pOH, therefore pHs need to be converted to pOH
- **weak base - strong acid** titration produces **acidic** salt solution with **pH < 7** at equivalence point

(NH_4Cl hydrolyzes to give acid)

$$NH_4^+(aq) + H_2O(l) \rightarrow NH_3(aq) + H_3O^+(aq)$$

- titration requires an indicator which changes colour at pH < 7 (pKa < 7) such as methyl red

strong acid + strong base → neutral (pH = 7)
weak acid + strong base → basic (pH > 7)
strong acid + weak base → acidic (pH < 7)

Note: Phenolpthalein (pH 8.2 - 10.0) is used for weak acid - strong base titrations but it is also often used for strong acid - strong base titrations even though pH = 7 at the equivalence point. This is because there is a dramatic colourless to magenta colour change.