# CHEMISTRY 12 – PRACTICAL ASPECTS OF TITRATIONS WORKSHEET

1) Methyl red is orange in a 0.10 M solution of an acid. What is the possible identity of the acid? **(1 mark)**

If methyl red is orange, then the pH must be 5.4
If the acid was strong, the pH would be 1.0 → $pH = -\log[H_3O^+] = -\log(0.10) = 1.0$
∴ the acid is weak

HI HCl HCN $H_2SO_4$

2) Write formula, complete ionic and net ionic equations for the following titration pairs and estimate the approximate pH at the equivalence point. **(4 marks each)**

(a) HBr and $Ca(OH)_2$

$$2HBr + Ca(OH)_2 \rightarrow 2H_2O_{(l)} + CaBr_2$$

$$2H^+ + \cancel{2Br^-} + \cancel{Ca^{2+}} + 2OH^- \rightarrow 2H_2O_{(l)} + \cancel{Ca^{2+}} + \cancel{2Br^-}$$

$$H^+ + OH^- \rightarrow H_2O_{(l)}$$ write in lowest terms

$$pH = 7$$

(b) HCl and $NH_3$

$$HCl + NH_3 \rightleftharpoons NH_4Cl$$

$$H^+ + \cancel{Cl^-} + NH_3 \rightleftharpoons NH_4^+ + \cancel{Cl^-}$$

$$H^+ + NH_3 \rightleftharpoons NH_4^+$$

$$pH < 7$$

(c) KOH and $CH_3COOH$

$$KOH + CH_3COOH \rightleftharpoons H_2O_{(l)} + KCH_3COO$$

$$\cancel{K^+} + OH^- + CH_3COOH \rightleftharpoons H_2O_{(l)} + \cancel{K^+} + CH_3COO^-$$

$$OH^- + CH_3COOH \rightleftharpoons H_2O_{(l)} + CH_3COO^-$$

$$pH > 7$$

(d) $Sr(OH)_2$ and $H_2SO_4$

$$Sr(OH)_2 + H_2SO_4 \longrightarrow 2\,H_2O_{(l)} + SrSO_{4(s)}$$

$$Sr^{2+} + 2OH^- + 2H^+ + SO_4^{2-} \longrightarrow 2\,H_2O_{(l)} + SrSO_{4(s)}$$

same as complete ionic equation

$pH = 7$

(e) $H_2S$ and $Sr(OH)_2$

$$H_2S + Sr(OH)_2 \rightleftarrows 2H_2O_{(l)} + SrS$$

$$H_2S + \cancel{Sr^{2+}} + 2OH^- \rightleftarrows 2H_2O_{(l)} + \cancel{Sr^{2+}} + S^{2-}$$

$$H_2S + 2\,OH^- \rightleftarrows 2\,H_2O_{(l)} + S^{2-}$$

$pH > 7$

(f) HBr and $Pb(OH)_2$

$$2\,HBr + Pb(OH)_2 \longrightarrow 2\,H_2O_{(l)} + PbBr_{2(s)}$$

$$2H^+ + 2Br^- + Pb^{2+} + 2\,OH^- \longrightarrow 2\,H_2O_{(l)} + PbBr_{2(s)}$$

same as complete ionic equation

$pH = 7$

3) Define the term “standardized solution”. **(1 mark)**

A solution of known concentration. A solution that has had its concentration determined by carrying out a titration against another solution of known concentration.

4) What is the $[H_3O^+]$ at the equivalence point for the titration between HBr and KOH? **(1 mark)**

Since HBr is a strong acid and KOH is a strong base, the salt produced by the titration would be a neutral salt and therefore the **$[H_3O^+]$ = 1.0 x $10^{-7}$ M**. This value can be memorized as being the concentration of both $H_3O^+$ and $OH^-$ at a neutral pH or can be calculated when needed as follows:

$$[H_3O^+] = 10^{-pH} = 10^{-7.0} = 1.0 \times 10^{-7}\,M$$

5) Which of the following titrations would have a pH > 7 at the equivalence point? **(1 mark)**

a pH > 7 means the combination of a weak acid & strong base

HI with KOH　　HClO$_4$ with NH$_3$　　HCl with Sr(OH)$_2$　　HCOOH with NaOH

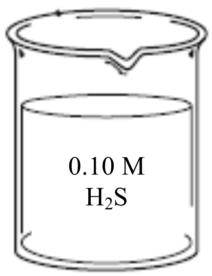
6) Which of the following indicators has a transition point closest to the equivalence point for the titration of a weak acid by a strong base? **(1 mark)**

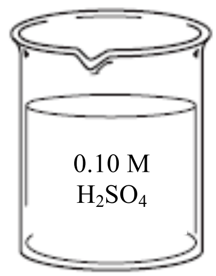
a weak acid & strong base titration would have a pH > 7 at the equivalence point

| | orange IV | thymol blue | methyl orange | bromcresol green |
|---|---|---|---|---|
| transition point | 2.1 | 8.8 | 3.8 | 4.6 |

7) Two acids of the same volume and concentration are titrated separately with 0.1 M NaOH. However, one acid is a weak acid ($H_2S$) and the other is a strong acid ($H_2SO_4$). Compare the titration volumes of 0.1 M NaOH required and give examples of the pH's that will result at the equivalence points. **(3 marks)**

$1\,H_2S + 2NaOH \rightarrow 2H_2O_{(l)} + Na_2S$   $1\,H_2SO_4 + 2\,NaOH \rightarrow 2H_2O_{(l)} + Na_2SO_4$




Since both reactions have the same ratio of 1 $H^+$:2 $OH^-$, the **volume of 0.1 M NaOH required to reach the equivalence point would be the same** for both the strong acid and the weak acid. The volume required to neutralize an acid or base is determined by the ratio of $H^+$:$OH^-$ and not the relative strength of the acid and base. The pH at the equivalence point however, is determined by the relative strength. The **pH at the equivalence point for the weak acid ($H_2S$) and the strong base (NaOH) would be greater than 7** since a basic salt would be produced, and the **pH at the equivalence point for the strong acid ($H_2SO_4$) and the strong base (NaOH) would be equal to 7** since a neutral salt would be produced.

8) The following two experiments were conducted:

Titration A: A strong acid was titrated with a strong base

Titration B: A weak acid was titrated with a strong base

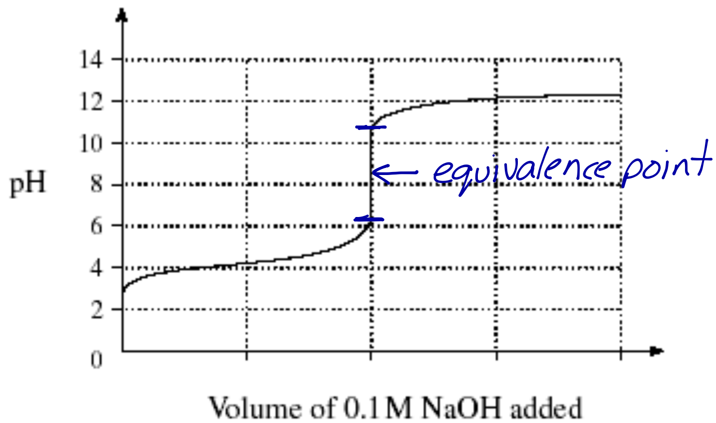
(a) How does the pH at the equivalence point of Titration B compare with the pH at the equivalence point of Titration A? **(1 mark)**

The pH at equivalence point for Titration A is 7, while Titration B has an equivalence point greater than 7.

(b) Explain your answer to (a). **(2 marks)**

Titration A produced a neutral salt that did not undergo hydrolysis, while Titration B produced a basic salt that underwent anionic hydrolysis.

9) A 0.1 M unknown acid is titrated with 0.10 M NaOH and the following titration curve results:



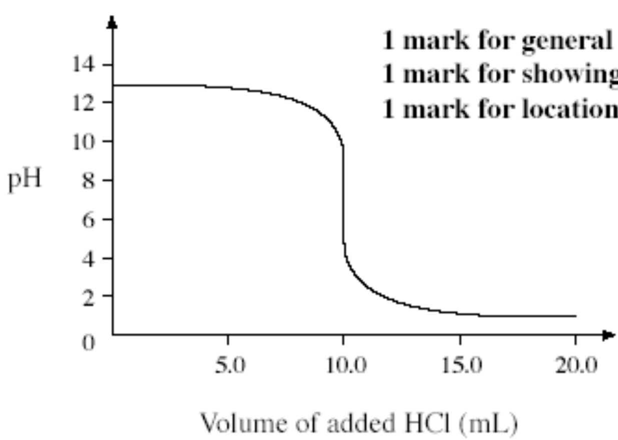

(a) Choose a suitable indicator (other than phenolphthalein) and give a reason for your choice. **(2 marks)**

The pH at the equivalence point on the graph (midpoint of the most vertical section) is approximately 8.3 therefore the indicator that has a transition point closest to 8.3 is the best indicator. Although neutral red or phenolphthalein could work, the best indicator to choose would be **thymol blue since its transition point (8.8) is closest to the equivalence point (8.3)**.

(b) Is the unknown acid weak or strong? Explain. **(2 marks)**

The unknown acid is **weak** since the **initial pH is greater than 1.0** (if the acid was strong, the starting pH would be 1.0 given that the concentration is 0.1 M), the **pH at the equivalence point is greater than 7.0** and a **buffer region is shown** which is characteristic of a weak acid/strong base titration.

10) a) In the space below, sketch the titration curve for the reaction when 0.10 M HCl is added to 10.0 mL of 0.10 M NaOH. **(3 marks)**




**1 mark for general shape**
**1 mark for showing curve drop**
**1 mark for location of equivalence point**

b) Describe two changes in the titration curve that would result from using 0.10 M $CH_3COOH$ in place of the HCl. **(2 marks)**

If a weak acid were used rather than a strong acid, the **equivalence point would be greater than 7**, **the vertical part of the curve would be shorter, a buffer region would be visible** and the **ending pH would be greater than 1.0**.