Set 15 Indicators and their use

1. (a) An organic acid or base
   (b) The acid must be distinctly different in colour to its conjugate base.
   For example : $H(Litmus)_{(aq)} \leftrightarrows H^+_{(aq)} + (Litmus)^-_{(aq)}$
   Red Blue

2. (a) $H(Indicator)_{(aq)} \leftrightarrows H^+_{(aq)} + (Indicator)^-_{(aq)}$
   Red Yellow

   (b) Addition of an acid results in an increase $[H^+]$. This causes the production of more H(Indicator) (red) and a reduction in the concentration of $(Indicator)^-$ (yellow). The colour of the solution changes from yellow to red.

   (c) Addition of a base results in a reduction in $[H^+]$ as H^+ reacts with OH^- to produce water. This causes the production of more $(Indicator)^-$ (yellow) and reduction in the concentration of H(Indicator) (red). The colour of the solution therefore changes from red to yellow.

   (d) Addition of Acid:
   The increase in $[H^+]$ causes an increase in the rate of the reaction producing with no immediate change to the reaction producing $(Indicator)^-$. This results in an increase in the concentration of H(Indicator) and a reduction in the concentration of $(Indicator)^-$ hence a colour change from yellow to red.

   Addition of Base:
   The increase in $[OH^-]$ causes a reduction in $[H^+]$ which causes a reduction in the rate of the reaction producing H(Indicator) with no immediate change in the rate of the reaction producing $(Indicator)^-$. This results in a reduction in the concentration of H(Indicator) and an increase in the concentration of $(Indicator)^-$ hence a colour change from red to yellow.

3.

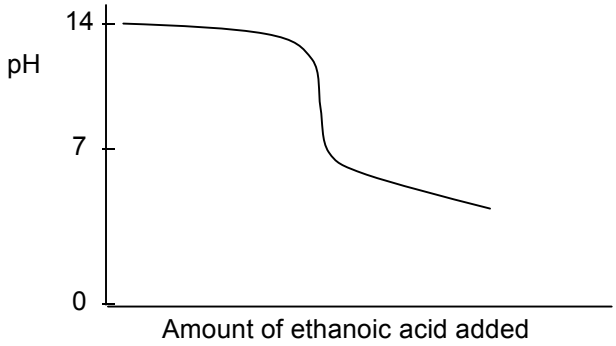
(a)	Phenolphthalein	Alizarin Yellow
(b)	<pH = 8.3 (Colourless) >pH = 10 (Pink)	<pH = 10.1 (Yellow) >pH = 12.0 (Red)
(c)	8.3 to 10	10.1 to 12.0

4.

(a)	Methyl red	Methyl orange	Bromophenol blue	Methyl violet
(b)	<pH = 4.4 (Red) >pH = 6.2 (Yellow)	<pH = 3.1 (Red) >pH = 4.4 (Yellow)	<pH = 3.0 (Yellow) >pH = 4.6 (blue)	<pH = 0 (Yellow) >pH = 1.6 (Violet)
(c)	4.4 to 6.2	3.1 to 4.4	3.0 to 4.6	0 to 1.6

5. (a) H_2O, Na^+, CH_3COO^-, OH^-, CH_3COOH, H^+

(b)



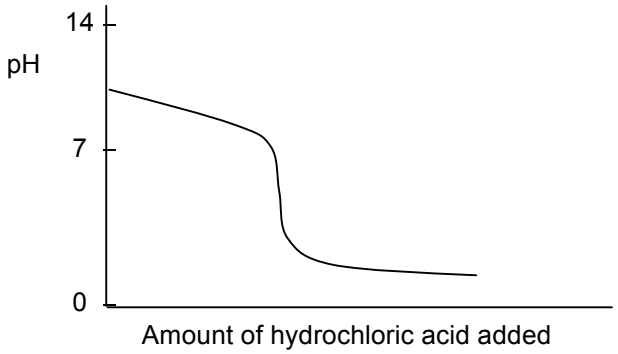
(c) The solution is basic.

$CH_3COO^-(aq) + H_2O(\ell) \leftrightarrows CH_3COOH(aq) + OH^-(aq)$

(d) Phenolphthalein.
The end point (the point where the colour changes) must occur at the equivalence point. As the equivalence point is basic an indicator that changes colour at a pH between about 7 and 11 is required. Phenolphthalein changes colour in the pH range 8.3 to 10.

6. (a) H_2O, $C\ell^-$, NH_4^+, H^+, NH_3, OH^-

(b)



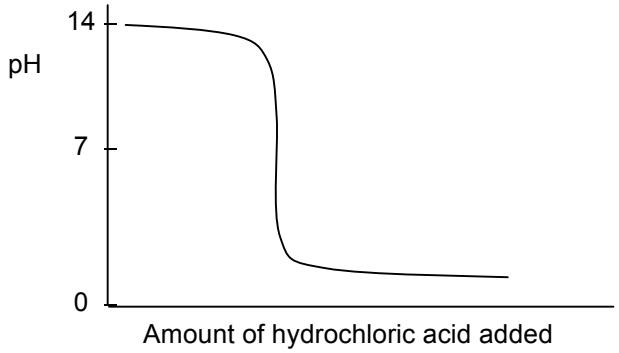
(c) The solution is acidic.

$NH_4^+(aq) + H_2O(\ell) \leftrightarrows NH_3(aq) + H_3O^+(aq)$

(d) methyl orange, methyl red or bromothymol blue.
The end point (the point where the colour changes) must occur at the equivalence point. As the equivalence point is acidic an indicator that changes colour at a pH between about 3 and 7 is required. Methyl orange, methyl red and bromothymol blue all change colour within this range. (see answer to Q4)

7. (a) H_2O, Ca^{2+} = $C\ell^-$, H^+, = OH^-=1.00×10^{-7} mol L^{-1}

(b)



(c) The solution is neutral. Neither the calcium ion nor the chloride ion will react with water to undergo hydrolysis.

(d) Most indicators will give the correct end point which is at pH = 7 as long as they change colour somewhere in the range of pH = about 3 to 11.

8. (a) Phenolphthalein.

(b) More acid will be used.

(c) The concentration will be measured lower than it actually is.