1. *Litmus indicator is a weak acid. The undissociated acid, HIn, is red while $In^-$ is blue. The indicator dissociation constant for litmus takes the value $1 \times 10^{-7}$ mol $l^{-1}$.*

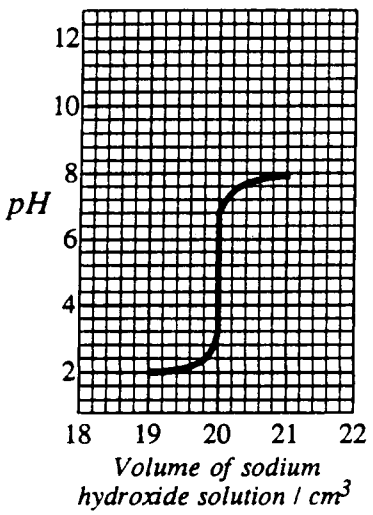
   *(a) At what pH will the concentration of $In^-$ and HIn be equal?*

   *(b) The pH range over which litmus changes colour is 5 (red) to 8 (blue). Calculate the ratio of the concentrations of HIn to $In^-$ when the indicator just appears blue.*

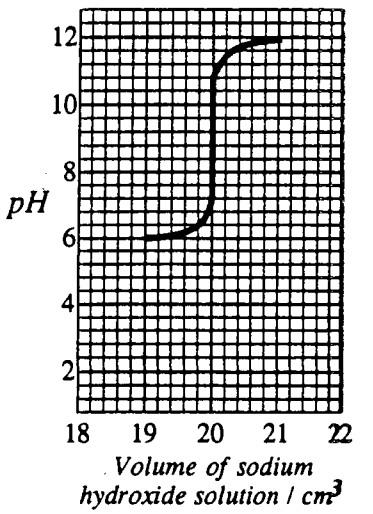
2. *Explain clearly and with the aid of equations why a solution of methylammonium chloride ($CH_3NH_3^+Cl^-$) has a pH value of less than 7.*

3. *(a) Which of the following titration curves would represent the addition of 0.1 mol $l^{-1}$ sodium hydroxide solution to 20cm$^3$ of 0.1 mol $l^{-1}$ butanoic acid? Justify your answer.*

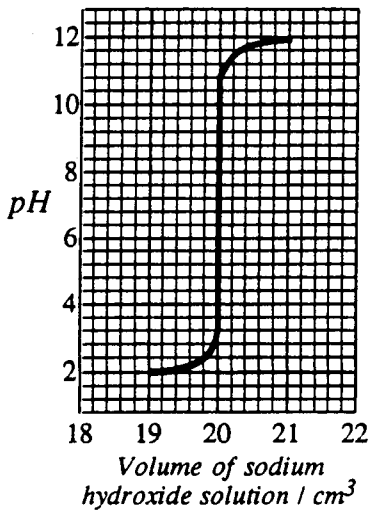
**Curve 1**




**Curve 2**




**Curve 3**



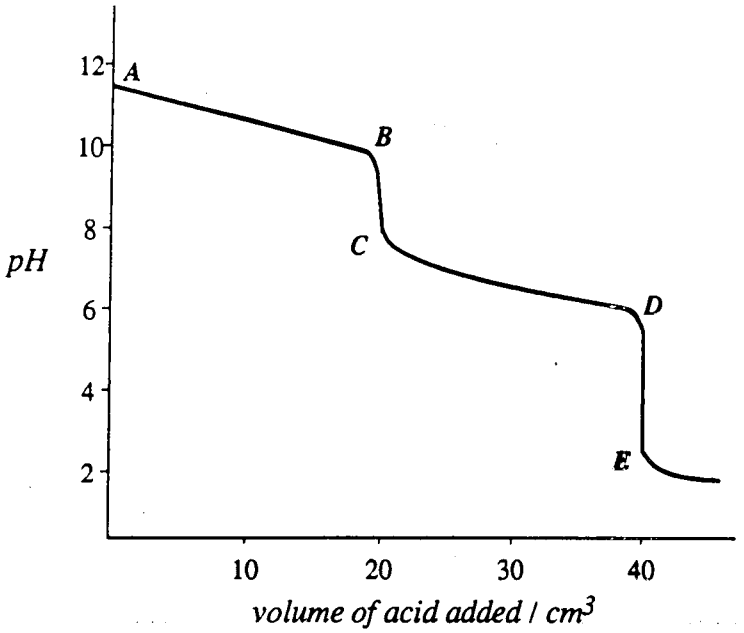

*(b) What criterion is applied in choosing a suitable indicator to detect the end-point of a reaction?*

*(c) From the list in the table below, choose all the indicators which would be suitable in accurately determining the end-point of **each** of the reactions represented by the curves in part (a).*

| *Indicator* | *pH range* |
|---|---|
| *bromocresol green* | *3.8 - 5.4* |
| *thymolblue* | *8.0 - 9.6* |
| *thymolthalein* | *9.3 - 10.5* |
| *phenol red* | *6.8 - 8.4* |
| *bromothymol blue* | *6.0 - 7.6* |
| *methyl red* | *4.2 - 6.3* |
| *phenolphthalein* | *8.3 - 10.0* |

*(c) If the titration referred to in part (a) was carried out using 0.1mol $l^{-1}$ ammonia solution the use of an indicator would not be a suitable method of determining the end-point. Why not?*

4. *Dilute hydrochloric acid was added slowly to 40cm$^3$ of 0.5 mol l$^{-1}$ sodium carbonate solution and the pH was measured continuously. The following graph was obtained.*




(a) *From the above data, calculate the concentration of the acid.*

(b) *Write an equation for the change that the carbonate ions undergo between **A** and **B**?*

(c) *Write an equation for the change taking place between **C** and **D**?*

(d) *Consider the following data concerning some indicators:*

| *Indicator* | *pH range* | *Colour change* |
|---|---|---|
| *thymol blue* | *1.2 - 2.8* | *red to yellow* |
| *methyl orange* | *3.1 - 4.4* | *red to yellow* |
| *bromocresol purple* | *5.2 - 6.8* | *yellow to purple* |
| *bromothymol blue* | *6.0 - 7.6* | *yellow to blue* |
| *phenol red* | *6.8 - 8.4* | *yellow to red* |
| *phenolphthalein* | *8.3 - 10.0* | *colourless to red* |
| *alizarin yellow* | *10.2 - 12.0* | *yellow to orange* |

*With the help of the data in the table, select two indicators which could be used to indicate the end-points represented by **BC** and **DE**.*
*List the colour changes which would take place during the titration.*

# Answers to extra indicator questions

1. (a) pH 7

(b) since Ka = [H+][In-]/[HIn] so Ka/[H+] = [In-]/[HIn] then = [HIn]/[In-] =[H+] /Ka

= 1x 10-8 (pH8)/1x10-7= 0.1 so [HIn] : [In-] = 1 : 10

2. CH3NH3+ ion dissociates to form CH3NH2 molecules and H+ ions because CH3NH2 is a weak base and its ionisation is reversible.

CH3NH3+ --------> CH3NH2 + H+

some of H+ ions produced will join with OH- ion to form water molecules

H+ + OH- ----------> H2O

net effect is that there will be an excess of H+ over OH- so salt will be acidic.

3. (a) curve 2 since end point of reaction (middle of steep section of curve) is above 7 which is to expected since salt of a strong alkali and weak acid will be alkaline.

(b) pH range for colour change of indicator lies within steep section of pH curve.

(c) Curve 1 bromocresol green and methyl red

Curve 2 thymolblue, thymolthalein and phenylphthalein

Curve 3 all of the indicators are suitable

(d) pH curve of weak base with weak acid has no pronounced steep section (inflection) at the end point so no indicator would rapidly change colour at end point of the reaction.

4. (a) alkali is fully neutralised after the addition of 40 ml of HCl (middle of steep section D to E)

mole of alkali = conc x volume = 0.5 x 0.04 = 0.02

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

moles acid = 2 x mole alkali = 2 x 0.02 = 0.04

conc acid = mol/vol = 0.04/0.04 = 1 mole/l

(b) $CO_3^{2-} + H^+ \longrightarrow HCO_3^-$

(c) $HCO_3^{3-} + H^+ \longrightarrow H_2CO_3$

(d) B to C phenylphthalein red to colourless

D to E methyl orange yellow to red