Experiment 15 23-3-99

Aim:

- To obtain curves which show how the pH changes during an acid-base titration and;
- To use these curves to choose suitable indicators for different combinations of acid and alkali.

Procedure:

1. 25.0cm^3 of 0.100 M ethanoic acid was pipetted into a 100cm^3 beaker, a small stirring paddle was added, and the beaker was stood on a magnetic stirrer.
2. The electrode of a pH meter was carefully clamped so that the bulb is completely immersed in the acid and is clear of the stirring paddle. If a magnetic stirrer (or mechanical stirrer) is not available, it is better to swirl the beaker by hand. If a pH meter is not available, it is better to use a conical flask rather than a beaker.
3. A burette with 0.100M ammonia solution was filled and was clamped over the beaker (or flask) containing the acid.
4. A value of the pH of the acid was obtained, either by reading the pH meter (which must, of course, have been calibrated) or by removing 1 small drop on a thin glass rod and testing with narrow range indicator paper. If which range to use was not known, it is first tested with full range universal indicator paper. However, it is important not to remove more than the minimum acid from the flask.
5. The alkali form the burette were added in steps as shown in result table and the pH at each addition was recorded after thorough mixing.
6. Steps 1~5 were repeated with at least one other combination of acid and alkali, and a copy of result table was completed. As time was not enough, the second result table and the third result table were recorded while the others were from other students.

Result:

0.100M NH_3 added to 25.0cm^3 of 0.100M CH_3CO_2H									
Volume /cm^3	0.0	5.0	10.0	15.0	20.0	24.0	24.2	24.4	24.6
pH	5.15	5.7	5.9	6	6.15	6.3	6.3	6.3	6.3
Volume /cm^3	24.7	24.8	25	25.2	25.4	25.6	28	30	35
pH	6.3	6.3	6.3	6.35	6.35	6.35	6.50	7.40	8.05

0.100M NaOH added to 25.0cm^3 of 0.100M CH_3CO_2H												
Volume /cm^3	0.0	5.0	10.0	15.0	21.0	24.6	24.8	25	25.2	25.4	25.5	25.55

pH	4.5	5.4	5.8	6.2	6.7	7.3	7.5	7.6	7.7	7.8	8.0	8.1
Volume /cm^3	25.6	25.65	25.7	25.8	26.0	26.2	26.4	26.6	28	30	35.3	
pH	8.2	8.4	8.6	8.9	10.9	11.5	11.9	12.1	12.7	13.1	13.3	

0.100M NH_3 added to 25.0cm^3 of 0.100M HCl									
Volume /cm^3	0.0	5.0	10.0	15.0	20.0	24.7	24.9	25.1	25.3
pH	1.6	1.7	1.7	1.8	2.05	2.4	2.5	2.5	2.5
Volume /cm^3	25.5	25.6	25.65	25.7	25.8	25.9	26.1	26.3	27.0
pH	2.6	2.7	2.7	2.7	2.7	2.7	2.7	2.8	3.0
Volume /cm^3	27.2	27.35	27.5	27.7	27.8	27.9	27.95	28	28.1
pH	3.1	3.2	3.3	3.5	3.8	4.2	4.7	6	6.8
Volume /cm^3	28.15	28.2	28.3	28.5	28.7	28.9	30.0	35.0	40.0
pH	7	7.2	7.5	7.7	7.9	8.0	8.3	8.8	9.0

0.100M NaOH added to 25.0cm^3 of 0.100M HCl										
Volume /cm^3	0.0	5.0	10.0	15.0	20.0	24.0	24.2	24.4	24.6	24.8
pH	2.15	2.15	2.15	2.25	2.45	2.75	2.80	2.85	2.85	2.90
Volume /cm^3	24.9	24.95	25.0	25.05	25.1	25.2	25.4	25.6	25.8	26.0
pH	2.95	2.95	2.95	2.95	3.00	3.00	3.05	3.15	3.25	3.40
Volume /cm^3	26.2	26.5	26.8	27.0	27.1	27.5	28.0	30.0	35.0	
pH	3.60	4.1	7.3	9.5	9.90	10.30	10.55	10.85	11.15	

Calculation

- A graph of four curves are plotted. The pH is shown on the vertical scale, while the volume of added alkali is shown on the horizontal scale.
- The range of pH during sharp increase is noted below:

Acid and base	Range of pH in sharp change
A. 0.100M NH_3 added to 25.0cm^3 of 0.100M CH_3CO_2H	pH 6.5 to pH 7.4
B. 0.100M NaOH added to 25.0cm^3 of 0.100M CH_3CO_2H	pH 8.0 to pH 11.5
C. 0.100M NH_3 added to 25.0cm^3 of 0.100M HCl	pH 3.6 to pH 7.6
D. 0.100M NaOH added to 25.0cm^3 of 0.100M HCl	pH 4.0 to pH 9.9

- The range of color change of indicator is noted below:

Indicator	pH range of color change
Malachite green	0.2 ~ 1.8
Thymol blue	1.2 ~ 2.8 8.0 ~ 9.6
Methyl orange	3.2 ~ 4.4
Bromocresol green	3.8 ~ 5.4
Methyl red	4.8 ~ 6.0
Bromothymol blue	6.0 ~ 7.6
Cresol red	7.0 ~ 8.8
Phenolphthalein	8.2 ~ 10.0
Thymolphthalein	9.4 ~ 10.6
Alizarin yellow	10.1 ~ 12.0

- The suitable indicator is:

Acid and base	Indicator
A. 0.100M NH_3 added to 25.0cm^3 of 0.100M CH_3CO_2H	Bromothymol blue

B. 0.100M NaOH added to 25.0cm^3 of 0.100M CH_3CO_2H	Thymolphthalein
C. 0.100M NH_3 added to 25.0cm^3 of 0.100M HCl	Methyl red
D. 0.100M NaOH added to 25.0cm^3 of 0.100M HCl	Bromothymol blue

Conclusion:

1. The curves showing how the pH changes during an acid-base titration is obtained (in the graph paper).
2. The suitable indicators for different combinations of acid and alkali is found:

Acid and base	Indicator
A. 0.100M NH_3 added to 25.0cm^3 of 0.100M CH_3CO_2H	Bromothymol blue
B. 0.100M NaOH added to 25.0cm^3 of 0.100M CH_3CO_2H	Thymolphthalein
C. 0.100M NH_3 added to 25.0cm^3 of 0.100M HCl	Methyl red
D. 0.100M NaOH added to 25.0cm^3 of 0.100M HCl	Bromothymol blue

Discussion:

1. The reaction equation for the reaction occurring in the curves is noted:

Curve	Equation
A	$NH_3 + CH_3COOH \rightarrow CH_3COONH_4^+$
B	$NaOH + CH_3COOH \rightarrow CH_3COONa+ + H_2O$
C	$NH_3 + HCl \rightarrow NH_4Cl$
D	$NaOH + HCl \rightarrow NaCl + H_2O$

2. It is better to initialize the reading of the burette to zero by adding more alkali so that the volume of alkali added can be directly read from the burette and calculation is not needed.
3. The end point of the titration is not, in fact, 25cm^3. The end point is a little bit higher than or lower than 25cm^3 depend on which combination of acid and base is used. This is the strong conjugate acid or base from weak base or acid can react with H_2O and from base or acid, which make the pH value of the solution much higher or lower.
4. It is better to rinse the bulb of the pH meter before next titration, rather than dry the bulb with tissue paper.