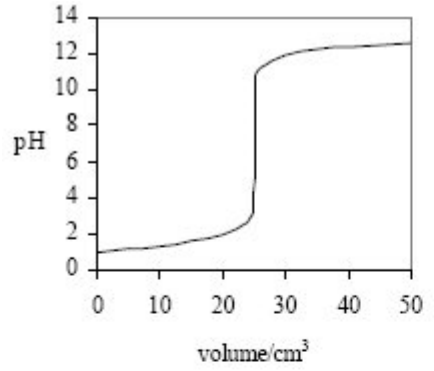
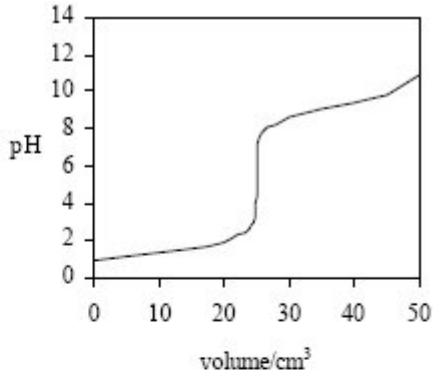
Q1. Indicators and pH curves can be used to determine the end point in a titration.

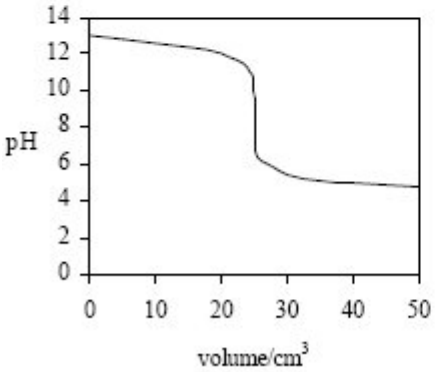
(a) The pH curves labelled **J, K, L** and **M** for combinations of different acids and bases are shown below. All solutions have a concentration of 0.1 mol dm^{-3}.



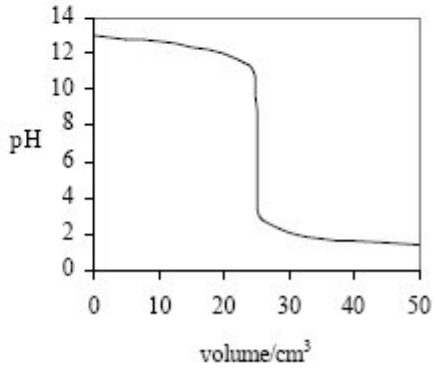
J



K



L



M

(i) Select from **J**, **K**, **L** and **M** the curve produced by the addition of

ammonia to 25 cm^3 of hydrochloric acid .....

ethanoic acid to 25 cm^3 of sodium hydroxide .....

sodium hydroxide to 25 cm^3 of hydrochloric acid .....

(ii) A table of acid–base indicators and the pH ranges over which they change colour is shown below.

Indicator	pH range
Thymol blue	1.2 – 2.8

Bromophenol blue	3.0 – 4.6
Methyl red	4.2 – 6.3
Cresolphthalein	8.2 – 9.8
Thymolphthalein	9.3 – 10.5

Select from the list above an indicator which could be used in the titration which produces curve **J** but not in the titration which produces curve **K**.

.....

(4)

(b) The acid dissociation constant, K_a, for the weak acid, ethanoic acid, has a value of 1.74×10^{-5} mol dm^{-3} at 25 °C.

$$K_a = \frac{[H^+][CH_3COO^-]}{[CH_3COOH]}$$

(i) Write an expression for the term pH.

.....

(ii) Calculate the pH of a 0.15 mol dm^{-3} solution of ethanoic acid. Give your answer to
2 decimal places.

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.....

(4)
(Total 8 marks)

Q2. (a) A sample of hydrochloric acid has a pH of 2.34
Write an expression for pH and calculate the concentration of this acid.

pH .....

Concentration .....

.....

(2)

(b) A 0.150 mol dm^{-3} solution of a weak acid, HX, also has a pH of 2.34

(i) Write an expression for the acid dissociation constant, K_a, for the acid HX.

.....

.....

(ii) Calculate the value of K_a for this acid and state its units.

Calculation .....

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Units .....

(iii) Calculate the value of pK_a for the acid HX. Give your answer to two decimal places.

.....

(5)

(c) A 30.0 cm^3 sample of a 0.480 mol dm^{-3} solution of potassium hydroxide was partially neutralised by the addition of 18.0 cm^3 of a 0.350 mol dm^{-3} solution of sulphuric acid.

(i) Calculate the initial number of moles of potassium hydroxide.

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.....

(ii) Calculate the number of moles of sulphuric acid added.

.....

.....

(iii) Calculate the number of moles of potassium hydroxide remaining in excess in the solution formed.

.....

.....

(iv) Calculate the concentration of hydroxide ions in the solution formed.

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(v) Hence calculate the pH of the solution formed. Give your answer to two decimal places.

.....

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(6)
(Total 13 marks)

Q3. The value of the acid dissociation constant, K_a, for the weak acid HA, at 298 K, is 1.45×10^{-4} mol dm^{-3}.

(a) Write an expression for the term K_a for the weak acid HA.

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(1)

(b) Calculate the pH of a 0.250 mol dm^{-3} solution of HA at 298 K.

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.....

.....

(4)

(c) A mixture of the acid HA and the sodium salt of this acid, NaA, can be used to prepare a buffer solution.

(i) State and explain the effect on the pH of this buffer solution when a small amount of hydrochloric acid is added.

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(ii) The concentration of HA in a buffer solution is 0.250 mol dm^{-3}. Calculate the concentration of A^- in this buffer solution when the pH is 3.59

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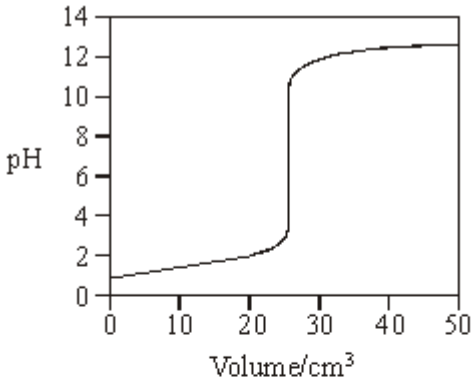
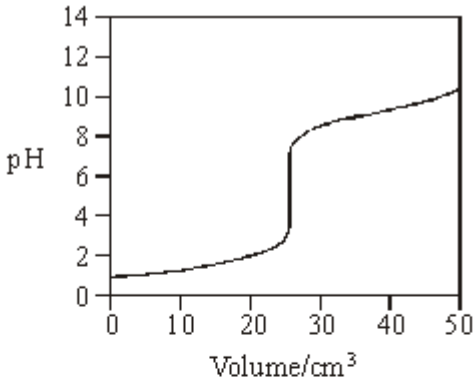
(6)
(Total 11 marks)

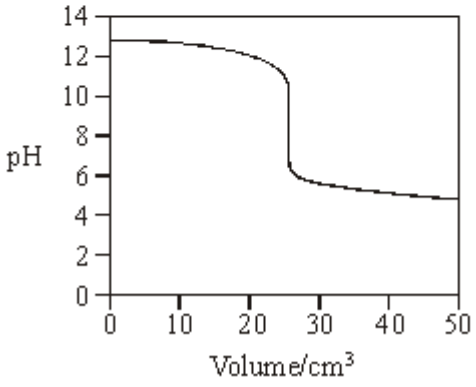
Q4. (a) Titration curves labelled **A**, **B**, **C** and **D** for combinations of different acids and bases are shown below. All solutions have a concentration of 0.1 mol dm^{-3}.



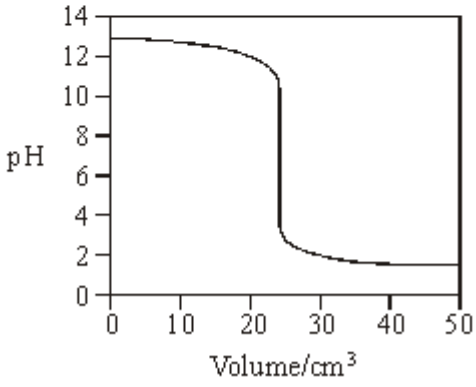
A



B



C



D

(i) Select from **A**, **B**, **C** and **D** the curve produced by the addition of

ammonia to 25 cm^3 of hydrochloric acid .....

ethanoic acid to 25 cm^3 of sodium hydroxide .....

sodium hydroxide to 25 cm^3 of hydrochloric acid .....

(ii) A table of acid–base indicators and the pH ranges over which they change colour is shown below.

Indicator	pH range

Thymol blue	1.2 – 2.8
Bromophenol blue	3.0 – 4.6
Methyl red	4.2 – 6.3
Cresolphthalein	8.2 – 9.8
Thymolphthalein	9.3 – 10.5

Select from the table an indicator which could be used in the titration which produces curve **A** but not in the titration which produces curve **B**.

.....

(4)

(b) (i) Write an expression for the term *pH*.

.....

(ii) A solution of potassium hydroxide has a pH of 11.90 at 25°C. Calculate the concentration of potassium hydroxide in the solution.

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(4)

(c) The acid dissociation constant, K_a, for propanoic acid has the value of 1.35×10^{-5} mol dm^{-3} at 25 °C.

$$K_a = \frac{[H^+][CH_3CH_2COO^-]}{[CH_3CH_2COOH]}$$

In each of the calculations below, give your answer to 2 decimal places.

(i) Calculate the pH of a 0.117 mol dm^{-3} aqueous solution of propanoic acid.

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(ii) Calculate the pH of a mixture formed by adding 25 cm^3 of a 0.117 mol dm^{-3} aqueous solution of sodium propanoate to 25 cm^3 of a 0.117 mol dm^{-3} aqueous solution of propanoic acid.

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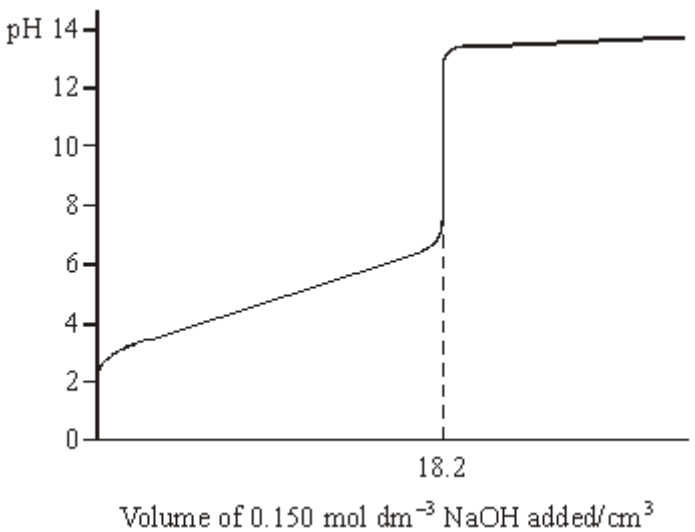
(5)
(Total 13 marks)

Q5. The pH curve shown below was obtained when a 0.150 mol dm^{-3} solution of sodium hydroxide was added to 25.0 cm^3 of an aqueous solution of a weak monoprotic acid, HA.



(a) Use the information given to calculate the concentration of the acid.

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.....

.....

(2)

(b) (i) Write an expression for the acid dissociation constant, K_a, for HA.

.....

(ii) Write an expression for pK_a

.....

(iii) Using your answers to parts (b)(i) and (b)(ii), show that when sufficient sodium hydroxide has been added to neutralise half of the acid,

pH of the solution = pK_a for the acid HA

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.....

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(4)

(c) Explain why dilution with a small volume of water does not affect the pH of a buffer solution.

.....

.....

(2)

(d) (i) Calculate the change in pH when 0.250 mol dm^{-3} hydrochloric acid is diluted with water to produce 0.150 mol dm^{-3} hydrochloric acid.

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(ii) Calculate the volume of water which must be added to 30.0 cm^3 of 0.250 mol dm^{-3} hydrochloric acid in order to reduce its concentration to 0.150 mol dm^{-3}.

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(4)
(Total 12 marks)