Name of the Student:_____
Max. Marks :18 Marks **Time : 18 Minutes**

Q1.

Ethanoic acid is manufactured in industry from methanol and carbon monoxide in a multi-step process involving hydrogen iodide. Ethanoic acid is obtained from the reaction mixture by fractional distillation. Methanoic acid is a useful by-product of this process.

The K_a value of an organic acid can be determined by using the pH curve obtained when the acid is titrated against sodium hydroxide. The pH of the solution formed when exactly half of the acid has been neutralised is equal to the pK_a value of the acid. The K_a value of the acid can be used to confirm its identity.

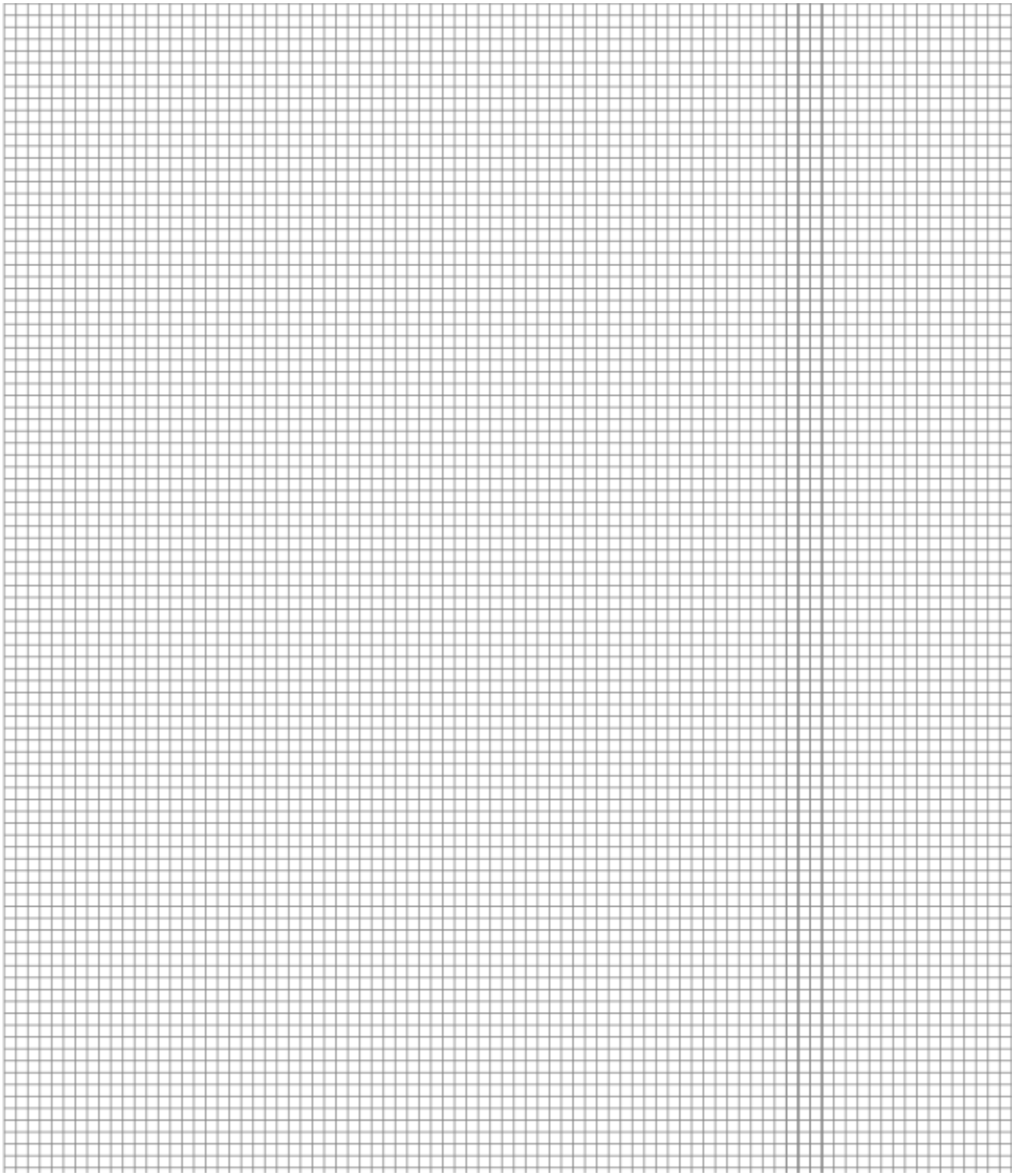
A chemist used a pH curve to determine the pK_a value of acid **Y**, formed during the manufacture of ethanoic acid. The chemist transferred 25.0 cm^3 of a solution of acid **Y** into a beaker using a pipette, and measured the pH of the acid solution using a pH meter which could be read to one decimal place. A solution of sodium hydroxide of concentration 0.100 mol dm^{-3} was added from a burette in small portions. The pH of the mixture was recorded after each addition of the sodium hydroxide solution. The chemist's results are given in the table below.

Volume of sodium hydroxide solution added / cm^3	pH
0.0	3.0
2.0	3.4
4.0	3.5
8.0	3.7
12.0	4.3
16.0	4.1
20.0	4.3
22.0	4.7

Volume of sodium hydroxide solution added / cm^3	pH
23.5	5.1
24.0	5.5
24.5	11.8
25.0	12.1
26.0	12.3
27.0	12.4
28.0	12.5
30.0	12.5

(a) Use the results given in the table above to plot a graph of pH (y-axis) against volume of sodium hydroxide solution added. Use the points to draw the pH curve, ignoring any anomalous results.

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(6)

(b) Use your graph from part (a) to determine the

(i) volume of sodium hydroxide solution at the end-point of the titration

_____ cm^3

(ii) volume of sodium hydroxide solution needed to neutralise half the acid

_____ cm^3

(iii) pH of the half-neutralised mixture. Give your answer to one decimal place.

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(3)

(c) Use the pH of the half-neutralised mixture from part (b) (iii) to calculate the value of the acid dissociation constant, K_a, of the acid **Y**. Show your working.

(2)

(d) The table below shows the K_a values for some organic acids.

Acid	K_a / mol dm^{-3}
Methanoic acid	1.6×10^{-4}
Ethanoic acid	1.7×10^{-5}
Iodoethanoic acid	6.8×10^{-4}
Propanoic acid	1.3×10^{-5}

Use your answer from part (c) to identify acid **Y** from this table.

(1)

(e) For the pipette and the burette, the maximum total errors are shown below. These errors take into account multiple measurements.

pipette ± 0.05 cm^3
burette ± 0.15 cm^3

Estimate the percentage error in using each of these pieces of apparatus. You should use your answer to part (b) (i) to estimate the percentage error in using the burette.

(1)

(f) Calculate the difference between the K_a value from part (c) and the K_a value of the acid you identified as the acid **Y** in the table in part (d).

Express this difference as a percentage of the value given in the table in part (d). (If you could not complete the calculation in part (c), you should assume that the K_a value determined from the graph is 1.9×10^{-4} mol dm^{-3}. This is not the correct value.)

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_____

(1)

(g) Other than by using a different pH meter, state **one** way in which the accuracy of the pH readings could be improved.

_____

_____

(1)

(h) State why there was little change in the pH value of the mixture when between 8 cm^3 and 20 cm^3 of alkali were added.

_____

(1)

(Total 16 marks)

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Q2.

Describe briefly how you would ensure that a reading from a pH meter is accurate.

_____

_____

_____

(Total 2 marks)

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