Q1. For this question **one or more** of the options given may be correct. Select your answer by means of the following code

A if **1**, **2** and **3** only are correct

B if **1** and **3** only are correct

C if **2** and **4** only are correct

C if **4** alone is correct

Directions summarised			
A	**B**	**C**	**D**
1, **2** and **3** only correct	**1** and **3** only correct	**2** and **4** only correct	**4** only correct

Solutions with a pH of 1.0 include

1 0.1 mol dm^{-3} hydrochloric acid

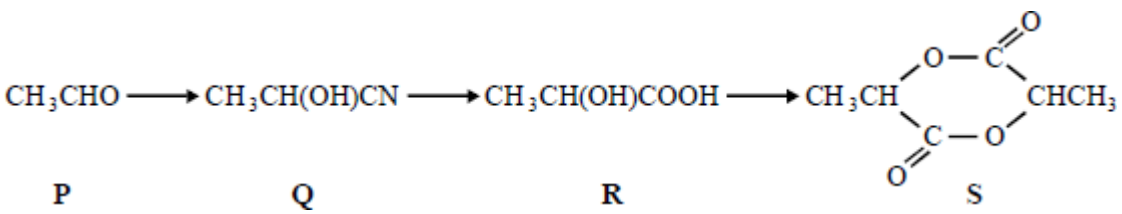
2 0.1 mol dm^{-3} ethanoic acid

3 0.05 mol dm^{-3} sulphuric acid

4 0.2 mol dm^{-3} nitric acid

(Total 1 mark)

Q2. This question refers to the reaction sequence below.



HCN is a weak acid with a pK_a value of 9.40. If a 0.010 mol dm^{-3} solution of HCN was used in the first step, the concentration of cyanide ions, in mol dm^{-3}, would be

A 2.0×10^{-6}

B 6.4×10^{-5}

C 2.0×10^{-5}

D 3.1×10^{-1}

(Total 1 mark)

Q3. In this question, give all values of pH to two decimal places.

Calculating the pH of aqueous solutions can involve the use of equilibrium constants such as K_w and K_a

K_w is the ionic product of water. The value of K_w is 5.48×10^{-14} mol^2 dm^{-6} at 50 °C.

(a) (i) Write an expression for pH.

.....

(1)

(ii) Write an expression for K_w

.....

(1)

(b) (i) Calculate the pH of pure water at 50 °C.

.....

.....

.....

(2)

(ii) Suggest why this pure water is **not** acidic.

.....

.....

(1)

(iii) Calculate the pH of 0.140 mol dm^{-3} aqueous sodium hydroxide at 50 °C.

.....

.....

.....

.....

.....

(3)

(c) Calculate the pH of the solution formed when 25.0 cm^3 of 0.150 mol dm^{-3} aqueous sulfuric acid are added to 30.0 cm^3 of 0.200 mol dm^{-3} aqueous potassium hydroxide at 25 °C. Assume that the sulfuric acid is fully dissociated.

.....

.....

.....

.....

.....

.....

.....

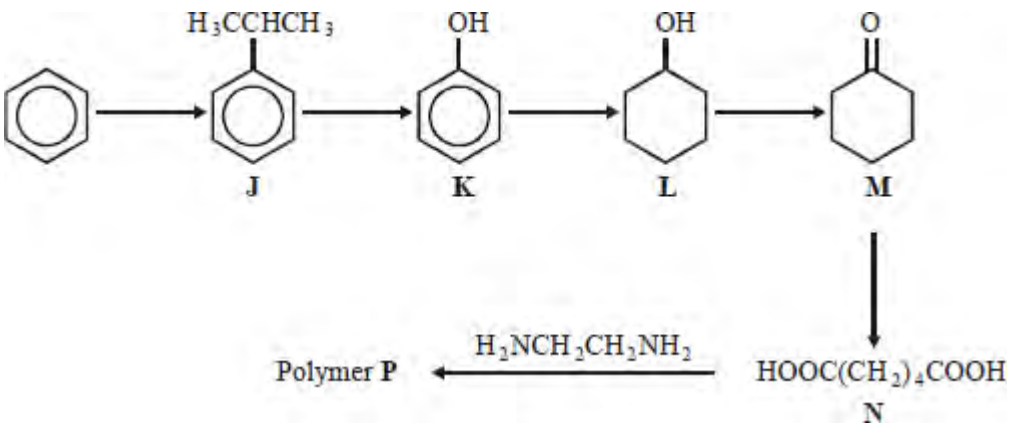
.....

.....

.....

(6)
(Total 14 marks)

Q4. This question is about the following reaction scheme which shows the preparation of polymer **P**.



K is a weak acid with a pK_a of 9.95. The pH of a 0.10 mol dm^{-3} solution of **K** is

A 4.48

B 4.98

C 5.48

D 5.98

(Total 1 mark)

Q5. 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.

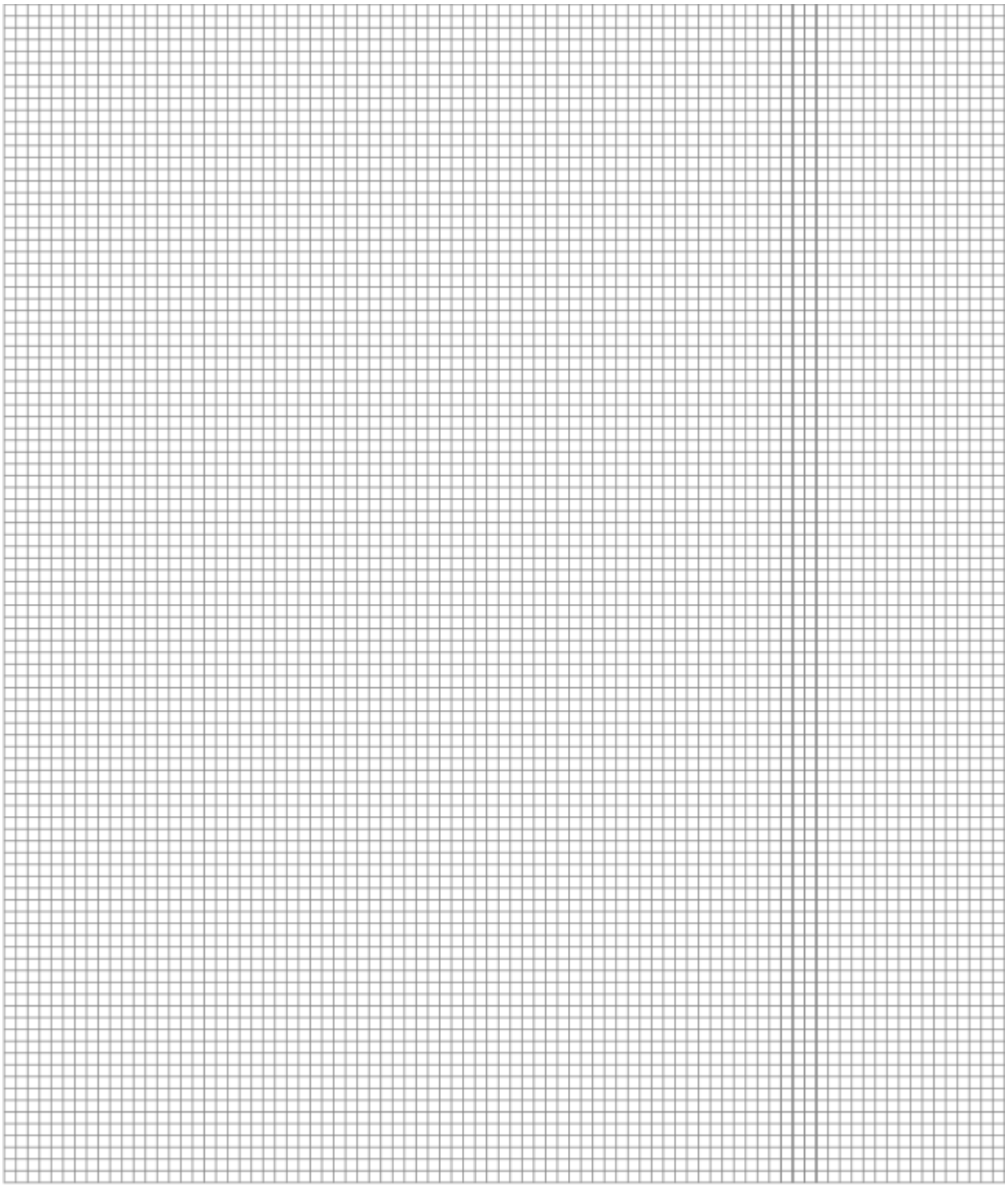
The K_a value of an organic acid can be determined by using the pH curve obtained when the acid is titrated against sodium hydroxide. The pH of the solution formed when exactly half of the acid has been neutralised is equal to the pK_a value of the acid. The K_a value of the acid can be used to confirm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



(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.

.....

(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.)

.....

.....

(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)

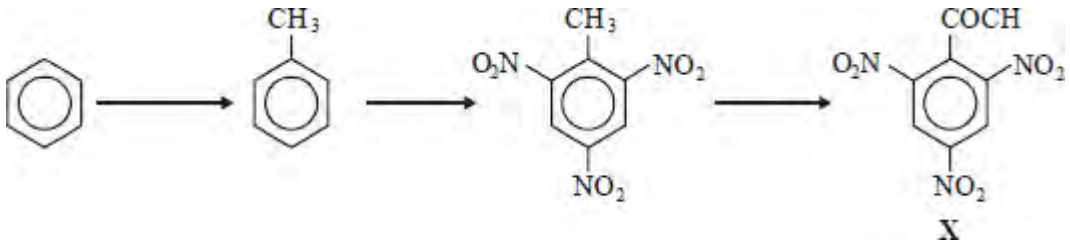
(h) State why there was little change in the pH value of the mixture when between 8 cm^3 and 20 cm^3 of alkali were added.

.....

(1)

(Total 16 marks)

Q6. This question is based on the reactions and compounds shown in the scheme below.



X

A 0.100 mol dm^{-3} solution of **X** is found to have a pH of 2.50. The value of K_a in mol dm^{-3} is

A 3.16×10^{-2}

B 3.16×10^{-3}

C 1.00×10^{-4}

D 1.00×10^{-5}

(Total 1 mark)

Q7. In this question, give all values of pH to 2 decimal places.

(a) (i) Write an expression for the term pH.

.....

(1)

(ii) Calculate the concentration, in mol dm^{-3}, of an aqueous solution of sulfuric acid that has a pH of 0.25

.....

.....

.....

.....

(2)

(b) A student carried out a titration by adding an aqueous solution of sodium hydroxide from a burette to an aqueous solution of ethanoic acid. The end-point was reached when 22.60 cm^3 of the sodium hydroxide solution had been added to 25.00 cm^3 of 0.410 mol dm^{-3} ethanoic acid.

(i) Write an equation for the reaction between sodium hydroxide and ethanoic acid.

.....

(1)

(ii) Calculate the concentration, in mol dm^{-3}, of the sodium hydroxide solution used.

.....

.....

.....

.....

(2)

(iii) A list of indicators is shown below.

Indicator	pH range
thymol blue	1.2–2.8
bromophenol blue	3.0–4.6
litmus	5.0–8.0
cresol purple	7.6–9.2

Select from the list the most suitable indicator for the end-point of this titration.

.....

(1)

(iv) Suggest why the concentration of sodium hydroxide in a solution slowly decreases when left open to air.

.....

.....

(1)

(c) At 298 K, the value of the acid dissociation constant, K_a, for ethanoic acid in aqueous solution is 1.74×10^{-5} mol dm^{-3}

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

.....

.....

(1)

(ii) Calculate the pH of 0.410 mol dm^{-3} ethanoic acid at this temperature.

.....

.....

.....

.....

(3)

(iii) Calculate the pH of the buffer solution formed when 10.00 cm^3 of 0.100 mol dm^{-3} potassium hydroxide are added to 25.00 cm^3 of 0.410 mol dm^{-3} ethanoic acid.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(6)
(Total 18 marks)