Q1. (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 .....

.....

.....

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.

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.....

(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)

Q2. In this question, give all pH values to 2 decimal places.

(a) (i) Write expressions for the ionic product of water, K_w, and for pH.

K_w = ...

pH = ...

(ii) At 318 K, the value of K_w is 4.02×10^{-14} mol^2 dm^{-6} and hence the pH of pure water is 6.70
State why pure water is not acidic at 318 K.

.....

.....

(iii) Calculate the number of moles of sodium hydroxide in 2.00 cm^3 of 0.500 mol dm^{-3} aqueous sodium hydroxide.

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.....

(iv) Use the value of K_w given above and your answer to part (a)(iii) to calculate the pH of the solution formed when 2.00 cm^3 of 0.500 mol dm^{-3} aqueous sodium hydroxide are added to 998 cm^3 of pure water at 318 K.

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.....

(6)

(b) At 298 K, the acid dissociation constant, K_a, for propanoic acid, CH_3CH_2COOH, has the value 1.35×10^{-5}mol dm^{-3}.

(i) Write an expression for K_a for propanoic acid.

.....

.....

(ii) Calculate the pH of 0.125 mol dm^{-3} aqueous propanoic acid at 298 K.

.....

.....

.....

.....

.....

.....

(4)

(c) Sodium hydroxide reacts with propanoic acid as shown in the following equation.

$$NaOH + CH_3CH_2COOH \rightarrow CH_3CH_2COONa + H_2O$$

A buffer solution is formed when sodium hydroxide is added to an excess of aqueous propanoic acid.

(i) Calculate the number of moles of propanoic acid in 50.0 cm^3 of 0.125 mol dm^{-3} aqueous propanoic acid.

.....

.....

(ii) Use your answers to part (a)(iii) and part (c)(i) to calculate the number of moles of propanoic acid in the buffer solution formed when 2.00 cm^3 of 0.500 mol dm^{-3} aqueous sodium hydroxide are added to 50.0 cm^3 of 0.125 mol dm^{-3} aqueous propanoic acid.

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(iii) Hence calculate the pH of this buffer solution at 298 K.

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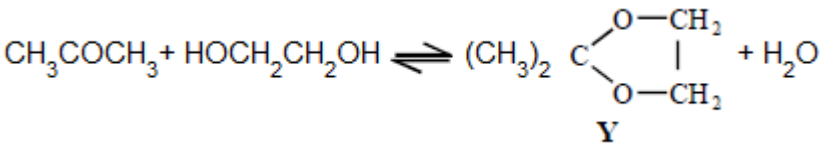
(6)
(Total 16 marks)

Q3. This question is about the reaction between propanone and an excess of ethane-1,2-diol, the equation for which is given below.



Y

In a typical procedure, a mixture of 1.00 g of propanone, 5.00 g of ethane-1,2-diol and 0.100 g of benzenesulphonic acid, $C_6H_5SO_3H$, is heated under reflux in an inert solvent. Benzenesulphonic acid is a strong acid.

If 0.100 g of the strong monoprotic acid, benzenesulphonic acid, was dissolved in 100 cm^3 of water, the pH of the solution would be

A 0.20

B 1.20

C 2.20

D 3.20

(Total 1 mark)

Q4. Iodine and propanone react in acid solution according to the equation

$$I_2 + CH_3COCH_3 \rightarrow CH_3COCH_2I + HI$$

The rate equation for the reaction is found to be

$$\text{rate} = k\,[CH_3COCH_3][H^+]$$

(a) Deduce the order of reaction with respect to iodine and the overall order of reaction.

Order with respect to iodine .....

Overall order .....

(2)

(b) At the start of the experiment, the rate of reaction was found to be 2.00×10^{-5} mol dm^{-3} s^{-1} when the concentrations of the reactants were as shown below.

Reactant	Concentration / mol dm^{-3}
CH_3COCH_3	1.50
I_2	2.00×10^{-2}
H^+	3.00×10^{-2}

Use these data to calculate a value for the rate constant and deduce its units.

Rate constant .....

.....

.....

Units .....

(3)

(c) How can you tell that H^+ acts as a catalyst in this reaction?

.....

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(2)

(d) Calculate the initial rate of reaction if the experiment were to be repeated at the same temperature and with the same concentrations of iodine and propanone as in part (b) but at a pH of 1.25

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(3)
(Total 10 marks)

Q5. 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

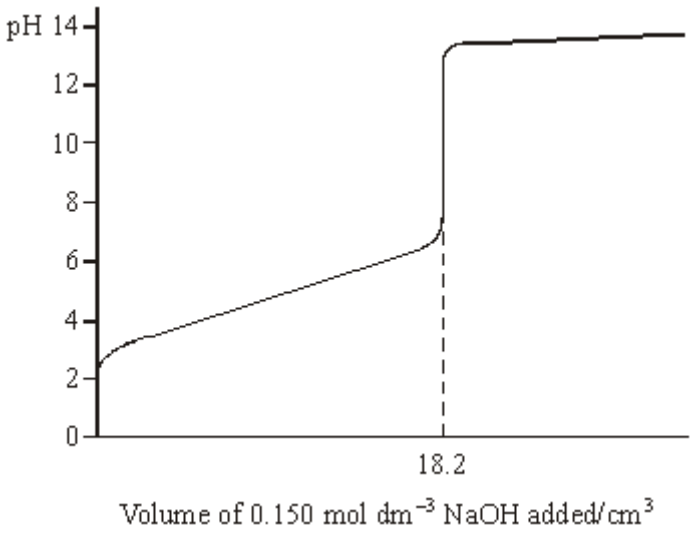
2 0.1 mol dm^{-3} ethanoic acid

3 0.05 mol dm^{-3} sulphuric acid

4 0.2 mol dm^{-3} nitric acid

(Total 1 mark)

Q6. 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.

.....

.....

.....

(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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(4)

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

.....

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(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)

Q7. Use the information about the following solutions to answer the question below.

Solution F: This is a mixture of 1 mol of propanoic acid, 1 mol of methanol and 2 mol of water.

Solution G: This was originally the same mixture as solution **F** but it has been left to reach equilibrium.

Compared to the pH of solution **F**, the pH of solution **G** will be

A considerably lower.

B slightly lower.

C slightly higher.

D exactly the same.

(Total 1 mark)