

ERUVIO MENTORING · EXTERNAL-STYLE EXAMINATION

Chemistry

Units 3 and 4 · Equilibrium, acids and redox reactions; structure, synthesis and design

Paper 2

SHORT RESPONSE · 50 MARKS

STUDENT DETAILS

GIVEN NAME(S)

FAMILY NAME

SCHOOL

DATE

BOOK OF

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Structure of this examination

PAPER	SECTION	QUESTION TYPE	TIME	MARKS
Paper 1	Section 1	Multiple choice, 20 questions	10 min perusal 90 min working	20
	Section 2	Short response, 5 questions		30
Paper 2	Section 1	Short response, 9 questions	10 min perusal 90 min working	50
Total		34 questions	200 minutes	100

Instructions

- **Perusal time: 10 minutes. Working time: 90 minutes.**
- You may use a QCAA-approved scientific or graphics calculator. The QCAA Chemistry formula and data book is provided.
- Write using black or blue pen. Planning paper will not be marked.
- All questions are drawn from Unit 3 (equilibrium, acids and redox reactions) and Unit 4 (structure, synthesis and design).
- **Paper 2 contains 9 short response questions.** Answer all questions in the spaces provided. Show all working.

Show all working. Marks are awarded for method as well as for the final answer, so a response with no working cannot receive full marks.

Section 1

Short response · 9 questions · 50 marks

1 This question is about equilibrium and acids.

[3 marks]

(a) Explain what is meant by the term *dynamic equilibrium*.

[1]

(b) State Le Châtelier's principle.

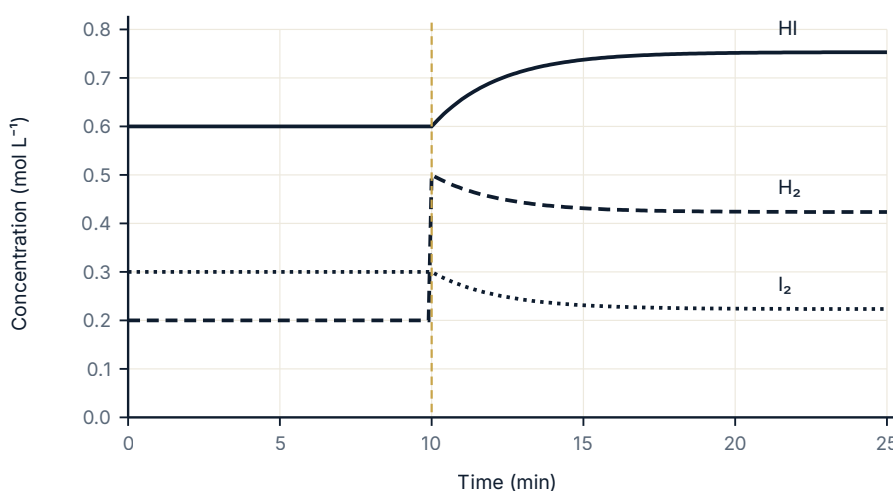
[1]

(c) State what is meant by a Brønsted-Lowry base.

[1]

2 The graph shows how the concentrations of the three species in the equilibrium below change with time. A change was made to the system at one point during the experiment.

[6 marks]



(a) Identify the time at which the change was made, and state what change was made to the system.

[2]

(b) Explain, using Le Châtelier's principle, the shape of each curve after the change was made.

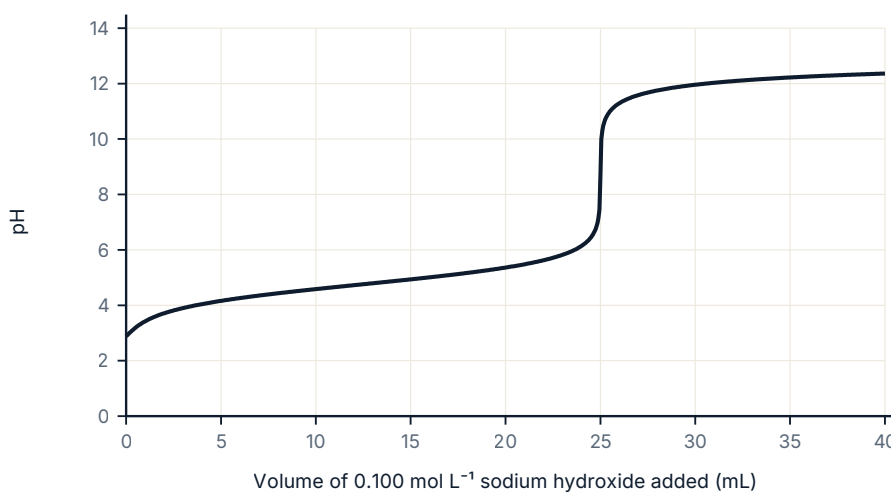
[3]

(c) State the effect of this change on the value of K_c .

[1]

3 25.0 mL of 0.100 mol L^{-1} ethanoic acid is titrated with 0.100 mol L^{-1} sodium hydroxide. The titration curve is shown below.

[5 marks]



(a) Determine the volume of sodium hydroxide added at the equivalence point and the pH at that point.

[2]

$V = \underline{\hspace{2cm}} \text{ mL}$ $\text{pH} = \underline{\hspace{2cm}}$

(b) Explain why the pH at the equivalence point is greater than 7.

[2]

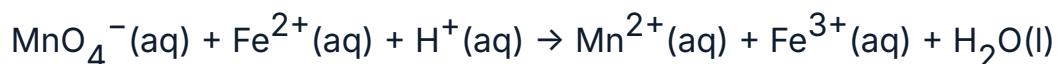
(c) Using the table below, identify the most suitable indicator for this titration and justify your choice.

[1]

Indicator	Methyl orange	Methyl red	Phenolphthalein
pH range	3.1 to 4.4	4.2 to 6.3	8.3 to 10.0

4 Acidified potassium permanganate reacts with iron(II) ions according to the unbalanced equation below.

[6 marks]



(a) Determine the oxidation number of manganese in MnO_4^- and identify the species that is oxidised.

[2]

WORKING

Oxidation number _____ Species oxidised _____

(b) Write the two half-equations and use them to write the balanced overall ionic equation.

[3]

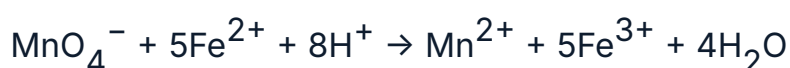
WORKING

(c) State one difference between a galvanic cell and an electrolytic cell.

[1]

5 25.00 mL of a solution of iron(II) sulfate requires 22.45 mL of $0.0200 \text{ mol L}^{-1}$ acidified potassium permanganate to reach the end point. The reaction is shown below.

[5 marks]



(a) Calculate the amount, in mol, of permanganate ions used.

[1]

WORKING

n = _____ mol _____

(b) Calculate the concentration of the iron(II) sulfate solution.

[2]

WORKING

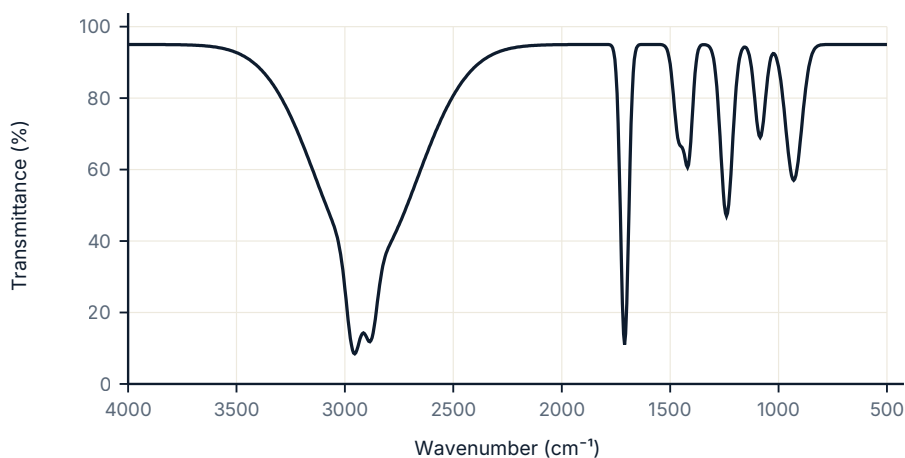
c = _____ mol L⁻¹ _____

(c) Explain why no indicator is required for this titration.

[2]

6 An unknown organic compound has the molecular formula C₃H₆O₂. Its infrared spectrum is shown below.

[7 marks]



(a) Identify the functional group present, and state the two absorptions in the spectrum that support your answer.

[2]

(b) The ^1H NMR spectrum of the compound shows three peaks with relative areas 3 : 2 : 1. Deduce the structure of the compound, explaining how the NMR data supports it.

[3]

DIAGRAM

(c) Give the IUPAC name of the compound.

[1]

Name _____

(d) State the mass-to-charge ratio of the molecular ion peak in its mass spectrum.

[1]

WORKING

m/z = _____

7 The diagram shows a three-step synthesis pathway.

[6 marks]



(a) Identify the reagents and conditions required for each step.

[3]

Step 1 _____

Step 2 _____

Step 3 _____

(b) Name the type of reaction occurring in each step.

[3]

Step 1 _____

Step 2 _____

Step 3 _____

8 This question is about polymers.

[6 marks]

(a) Draw the repeating unit of the addition polymer formed from propene, $\text{CH}_2=\text{CHCH}_3$.

[2]

DIAGRAM

(b) Distinguish between addition polymerisation and condensation polymerisation.

[2]

(c) High density polyethene has a higher melting point and greater rigidity than low density polyethene. Explain this difference in terms of chain structure and intermolecular forces.

[2]

9 Ethanol can be manufactured either by the fermentation of glucose or by the direct hydration of ethene. The two equations are shown below.

[6 marks]



- (a) Calculate the atom economy of the fermentation route for producing ethanol. $M(\text{C}_6\text{H}_{12}\text{O}_6) = 180.16 \text{ g mol}^{-1}$, $M(\text{C}_2\text{H}_5\text{OH}) = 46.07 \text{ g mol}^{-1}$. [2]

WORKING

Atom economy = _____ % _____

- (b) Explain why the direct hydration of ethene has an atom economy of 100%. [1]

- (c) Discuss two factors other than atom economy that should be considered when choosing between these two routes. [2]

- (d) A fermentation plant produces 4.60 tonnes of ethanol from 18.0 tonnes of glucose. Calculate the percentage yield. [1]

WORKING

Yield = _____ % _____

END OF PAPER