



GCE A LEVEL

1410U30 – 1

TUESDAY, 10 JUNE 2025 – MORNING

CHEMISTRY – A2 UNIT 3

PHYSICAL AND INORGANIC CHEMISTRY

1 hour 45 minutes plus your additional time allowance

Surname: _____

First name(s): _____

Centre Number: _____

Candidate Number: 2 _____

FOR EXAMINER'S USE ONLY		
Question	Maximum Mark	Mark Awarded
1. to 6.	10	
7.	16	
8.	13	
9.	19	
10.	22	
Total	80	

Section A

Section B

ADDITIONAL MATERIALS

A calculator and ruler

DATA BOOKLET supplied by WJEC

ITEMS INCLUDED WITH QUESTION PAPER

A separate Diagram Booklet.

The Diagram Booklet **MUST** be handed in to the invigilators and sent for marking.

INSTRUCTIONS TO CANDIDATES

Use black ink, black ball – point pen, black felt tip or your usual method.

Write your name, centre number and candidate number in the spaces on the front cover.

SECTION A Answer ALL questions.

SECTION B Answer ALL questions.

Write your answers in the spaces provided. If you run out of space, use the additional pages at the back of this booklet, taking care to number the question(s) correctly.

(Turn over)

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part – question.

The maximum mark for this paper is 80.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

The assessment of the quality of extended response (QER) will take place in Question 9 (b) (iii).

(Turn over)

SECTION A

Answer ALL questions.

1. Complete the Arrhenius equation below.

$k =$ _____

[1 mark]

2. Give a reason why SiCl_4 reacts vigorously with water whilst CCl_4 does not.

[1 mark]

(Turn over)

3. Many reactions use heterogeneous catalysts.

(a) State what is meant by the term heterogeneous in this context.

[1 mark]

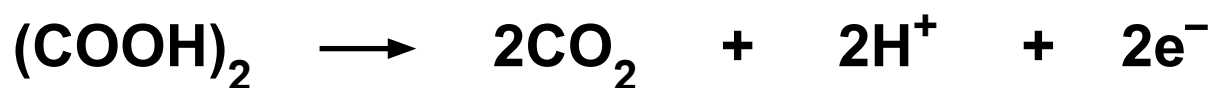
(b) Give an example of a heterogeneous catalyst and the reaction it catalyses.

[1 mark]

(Turn over)

4. Ethanedioic acid, $(\text{COOH})_2$ can be oxidised by acidified manganate(VII) ions.

Use the half-equations below to write the ionic equation for the reaction on the page for Question 4 in the separate Diagram Booklet.



[1 mark]

5. A metal halide gives a lilac flame test and the addition of concentrated sulfuric acid causes it to release coloured fumes and a smell of rotten eggs.

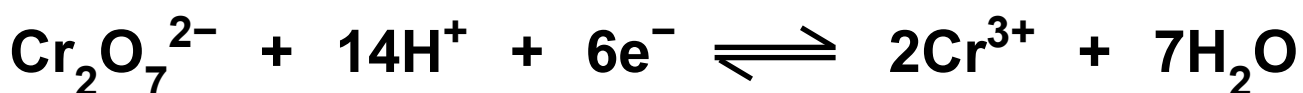
Identify the metal halide, giving reasons for your answer.

[2 marks]

6. (a) Give the observation(s) expected when aqueous sodium hydroxide is added gradually to aqueous chromium(III) chloride until the sodium hydroxide is in excess.

[1 mark]

- (b) Refer to the diagram for Question 6 (b) in the separate Diagram Booklet. The diagram shows the apparatus used to measure the standard electrode potential for the half – equation:



$$E^\theta = +1.33 \text{ V}$$

- (i) Name parts **A** and **B**.

A _____

B _____

[1 mark]

continued on the next page . . .

(Turn over)

Question 6 (b) continued

- 6. (b) (ii) LABEL THE DIAGRAM to show the direction of flow of electrons in the wire.**

[1 mark]

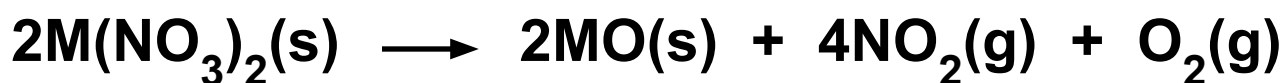
(Total for SECTION A = 10 marks)

(Turn over)

SECTION B

Answer ALL questions.

7. (a) Metal nitrates containing Group 2 metals decompose upon heating as shown by the equation below.



Refer to the table for Question 7 (a) provided separately in the Diagram Booklet.

- (i) Give a reason why all the entropy changes are positive.

[1 mark]

continued on the next page . . .

(Turn over)

Question 7 (a) continued

7. (a) (ii) The minimum temperature for decomposition of calcium nitrate is **1500 °C**.

Find the standard enthalpy change for this reaction.

Standard enthalpy change
= _____ kJ mol⁻¹

[3 marks]

continued on the next page . . .

(Turn over)

Question 7 (a) continued

7. (a) (iii) Treatment of aqueous barium nitrate with sulfuric acid produces a white precipitate of barium sulfate, whilst addition of the same acid to aqueous magnesium nitrate does not give a precipitate.

- I. Write the ionic equation for the formation of the precipitate, including state symbols.**

[1 mark]

continued on the next page . . .

(Turn over)

Question 7 (a) (iii) continued

- 7. (a) (iii) II. Refer to the table for Question 7 (a) (iii) II. provided separately in the Diagram Booklet. Use the data in the table to explain why barium sulfate is insoluble in water whilst magnesium sulfate is soluble.**

[3 marks]

continued on the next page . . .

(Turn over)

Question 7 continued

- 7. (b) Ammonium nitrate is a soluble salt. Suggest the pH of an aqueous solution of ammonium nitrate, giving a reason for your answer.**

[2 marks]

continued on the next page . . .

(Turn over)

Question 7 continued

- 7. (c) Aqueous lead(II) nitrate forms precipitates when a variety of aqueous solutions are added.**

Give the observations, if any, when the solutions named below are added to aqueous lead(II) nitrate.

Solution added: sulfuric acid

Observation: _____

Solution added: potassium iodide

Observation: _____

continued on the next page . . .

Question 7 continued

7. (d) Metal nitrates are often found in rocks mixed with materials such as limestone. A student is provided with a rock which contains a mixture of sodium nitrate and calcium carbonate. Heating the rock causes both substances to decompose according to the following equations.



The boiling temperatures of the gases produced are as follows.

oxygen gas, $\text{O}_2 = 90 \text{ K}$

carbon dioxide gas, $\text{CO}_2 = 195 \text{ K}$

continued on the next page . . .

(Turn over)

Question 7 (d) continued

Refer to the table for Question 7 (d) provided separately in the Diagram Booklet.

A sample of 81.3 g of the rock was heated until both substances decomposed completely.

The volume of gas produced was measured at 1 atm pressure at two different temperatures.

The table shows the results.

Find the percentage by mass of calcium carbonate in the rock.

Space for working continued on the next page.

Question 7 (d) continued

Percentage calcium carbonate = _____ %

[4 marks]

(Total for Question 7 = 16 marks)

(Turn over)

8. (a) When chlorine gas reacts with concentrated aqueous sodium hydroxide solution, it produces sodium chloride, sodium chlorate(V) and water.

(i) Write an equation for this reaction on the page for Question 8 (a) (i) in the separate Diagram Booklet.

[1 mark]

(ii) Use oxidation states to show why this reaction can be described as disproportionation.

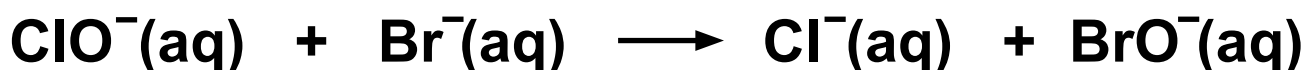
[2 marks]

continued on the next page . . .

(Turn over)

Question 8 continued

8. (b) Chlorate(I) ions can oxidise bromide ions according to the following equation.



- (i) One method of studying the rate of this reaction is by sampling and quenching.

State how you would quench the samples.

[1 mark]

continued on the next page . . .

(Turn over)

Question 8 (b) continued

8. (b) (ii) The reaction is first order with respect to each reactant therefore second order overall.

A student states that this means that successive half-life values for each reactant will be constant. Is the student correct?

Give a reason for your answer.

[1 mark]

continued on the next page . . .

(Turn over)

Question 8 (b) continued

8. (b) (iii) Refer to the graph for Question 8 (b) (iii) in the separate Diagram Booklet. A student follows the progress of the reaction at a temperature of **298 K**.

She obtains the results shown in the graph.

- I. Use the concentration of chloride ions to find the initial rate of the reaction.

Rate = _____ $\text{mol dm}^{-3} \text{ min}^{-1}$
[2 marks]

continued on the next page . . .

(Turn over)

Question 8 (b) (iii) continued

8. (b) (iii) II. Find the value of the rate constant for the reaction, giving its unit.

k = _____

Unit _____

[4 marks]

continued on the next page . . .

(Turn over)

Question 8 (b) (iii) continued

8. (b) (iii) III. Another student chooses to plot the concentration of bromate(I) ions formed instead of the concentration of chloride ions formed.

State the differences in their graphs, if any, giving a reason for your answer.

[2 marks]

(Total for Question 8 = 13 marks)

(Turn over)

9. (a) Ethanoic acid can be produced in a reaction between iodomethane and carbon monoxide, followed by treatment with water.

Refer to the equations for Question 9 (a) in the separate Diagram Booklet.

Refer to the tables for Question 9 (a) in the separate Diagram Booklet. Use data from one of the tables to calculate the **MORE ACCURATE** value of the standard enthalpy change for reaction 1

Give a reason for your choice of data.

Space for working and answer continues on the next page.

Question 9 (a) continued**Enthalpy change for reaction 1****= _____ kJ mol⁻¹**

[3 marks]**continued on the next page . . .****(Turn over)**

Question 9 continued

9. (b) Reaction 2 produces a mixture of the weak acid CH_3COOH and the strong acid HI .

- (i) Suggest what effect the presence of HI will have on the dissociation of CH_3COOH in this mixture compared to an aqueous solution containing only CH_3COOH .
Give your reasoning.

[2 marks]

continued on the next page . . .

(Turn over)

Question 9 (b) continued

9. (b) (ii) Calculate the pH of an aqueous solution of the strong acid **HI** of concentration **$0.250 \text{ mol dm}^{-3}$** .

pH = _____

[2 marks]

continued on the next page . . .

(Turn over)

Question 9 (b) continued

9. (b) (iii) A student is given 100 cm^3 of a solution of ethanoic acid of concentration $0.100 \text{ mol dm}^{-3}$ and wishes to produce a buffer solution of pH 4.45. He has access to the full range of chemicals in a laboratory.

Describe how the buffer solution could be formed, calculating the amounts of any other substances required. Explain how the buffer solution works to keep the pH of the solution constant.

$$K_a \text{ for } \text{CH}_3\text{COOH} = 1.74 \times 10^{-5} \text{ mol dm}^{-3}$$

Space for working and answer continues on the next page.

Question 9 (b) (iii) continued

(Turn over)

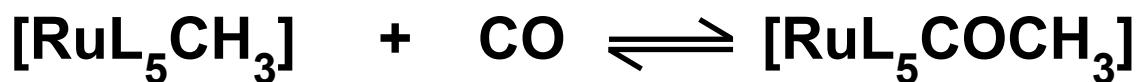
[6 QER marks]

continued on the next page . . .

(Turn over)

Question 9 continued

9. (c) The complex $[\text{Ru}(\text{CO})_2(\text{P}(\text{CH}_3)_3)_2\text{CH}_3\text{I}]$ catalyses the reaction of iodomethane with carbon monoxide. One stage in the process is the reversible reaction below, with five of the ligands shown as L.



The values of the equilibrium constant for this process at different temperatures in methylbenzene solvent are listed in the table for Question 9 (c) provided separately in the Diagram Booklet.

continued on the next page . . .

Question 9 (c) continued

- 9. (c) (i) Suggest what information this table allows us to deduce about the energy changes during this reversible reaction.**

[2 marks]

continued on the next page . . .

(Turn over)

Question 9 (c) continued

9. (c) (ii) A solution containing a mixture of complex $[\text{RuL}_5\text{CH}_3]$ of concentration $1.25 \times 10^{-3} \text{ mol dm}^{-3}$ and carbon monoxide of concentration $7.55 \times 10^{-4} \text{ mol dm}^{-3}$ is placed in a sealed tube, heated to a set temperature and the mixture allowed to reach equilibrium. The equilibrium mixture contains $1.37 \times 10^{-4} \text{ mol dm}^{-3}$ of $[\text{RuL}_5\text{COCH}_3]$.

Find the value of K_c and hence suggest the temperature used for the experiment.

Space for working and answer continues on the next page.

Question 9 (c) continued

$K_c =$ _____ $\text{mol}^{-1} \text{dm}^3$
Temperature = _____ $^{\circ}\text{C}$

[4 marks]

(Total for Question 9 = 19 marks)

(Turn over)

- 10. Refer to the table for Question 10 provided separately in the Diagram Booklet. Copper is present in a range of alloys, including those listed in the table.**

One method of finding the copper content of an alloy is by treating the alloy with concentrated hydrochloric acid in the presence of air to form a solution containing metal ions and diluting this to a known volume. This solution can then be analysed by titration.

- (a) The class teacher notes that this method would not be suitable for analysing electrum or leaded tin bronze.**

Suggest how the method could be changed to allow for the analysis of electrum and leaded tin bronze. Give your reasoning.

[2 marks]

continued on the next page . . .

(Turn over)

Question 10 continued

- 10. (b) Several of the metals added to copper to form these alloys are amphoteric.**

Identify ONE amphoteric metal from the table and state what is meant by the term amphoteric.

[2 marks]

continued on the next page . . .

(Turn over)

Question 10 continued

10. (c) A 1.72 g sample of an alloy was used to make 250 cm^3 of an aqueous solution containing copper and other metal ions. Samples of 25.0 cm^3 of the solution were measured out and the copper ions reacted with excess iodide ions to form iodine.

The iodine was titrated using sodium thiosulfate solution of concentration $0.0500 \text{ mol dm}^{-3}$. The mean volume of sodium thiosulfate needed for complete reaction was 33.05 cm^3 .

continued on the next page . . .

Question 10 (c) continued

10. (c) (i) Write the equations for the following reactions:

- **$\text{Cu}^{2+}(\text{aq})$ with $\text{I}^{-}(\text{aq})$**
- **$\text{I}_2(\text{aq})$ with $\text{S}_2\text{O}_3^{2-}(\text{aq})$**

Hence show that 1 mol of $\text{S}_2\text{O}_3^{2-}(\text{aq})$ is equivalent to 1 mol of $\text{Cu}^{2+}(\text{aq})$ in the titration.

[3 marks]

continued on the next page . . .

(Turn over)

Question 10 (c) continued

- 10. (c) (ii) Find the percentage by mass of copper in the alloy and hence identify which alloy(s) could be present in the sample.**

Percentage copper = _____ %

[4 marks]

continued on the next page . . .

(Turn over)

Question 10 continued

- 10. (d) (i) Aqueous solutions formed from copper(II) compounds contain $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ ions.**

Explain why these solutions are pale blue.

[3 marks]

continued on the next page . . .

(Turn over)

Question 10 (d) continued

- 10. (d) (ii) Copper(I) compounds are often white solids.
Give a reason why these compounds are not
coloured.**

[1 mark]

continued on the next page . . .

(Turn over)

Question 10 (d) continued

- 10. (d) (iii) Refer to the diagram for Question 10 (d) (iii) in the separate Diagram Booklet. Many metal complexes change colour when a new ligand is added. The absorption spectra of two cobalt(II) complexes are given in the diagram.**

Suggest which wavenumber, in cm^{-1} , should be used to study the conversion of $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ into $[\text{CoCl}_4]^{2-}$

Give a reason for your selection.

[2 marks]

continued on the next page . . .

(Turn over)

Question 10 continued

10. (e) Refer to the table for Question 10 (e) provided separately in the Diagram Booklet. The standard electrode potentials for some reactions of copper and thallium ions are given in the table.

- (i) When copper(I) ions are formed in solution, the reaction below occurs.**



Use the standard electrode potential values to explain why this reaction occurs.

[2 marks]

continued on the next page . . .

(Turn over)

Question 10 (e) continued

- 10. (e) (ii) I. Copper(I) ions can act as a reducing agent. Identify the final thallium containing species formed when copper(I) ions reduce thallium(III) ions.**

Use the standard electrode potential values to explain your answer.

[2 marks]

continued on the next page . . .

(Turn over)

Question 10 (e) (ii) continued

- 10. (e) (ii) II. A student suggests that the more stable oxidation state of thallium can be predicted from its position in the Periodic Table.**

Suggest, giving a reason, which oxidation state of thallium will be more stable.

[1 mark]

(Total for Question 10 = 22 marks)

TOTAL FOR SECTION B = 70 MARKS

END OF PAPER

TOTAL = 80 MARKS

(Turn over)

[illegible]

(Turn over)

[illegible]

(Turn over)

[illegible]



GCE A LEVEL

1410U30 – 1

TUESDAY, 10 JUNE 2025 – MORNING

CHEMISTRY – A2 UNIT 3

PHYSICAL AND INORGANIC CHEMISTRY

Diagram Booklet

**This Diagram Booklet MUST be handed in
to the invigilators and sent for marking.**

Surname: _____

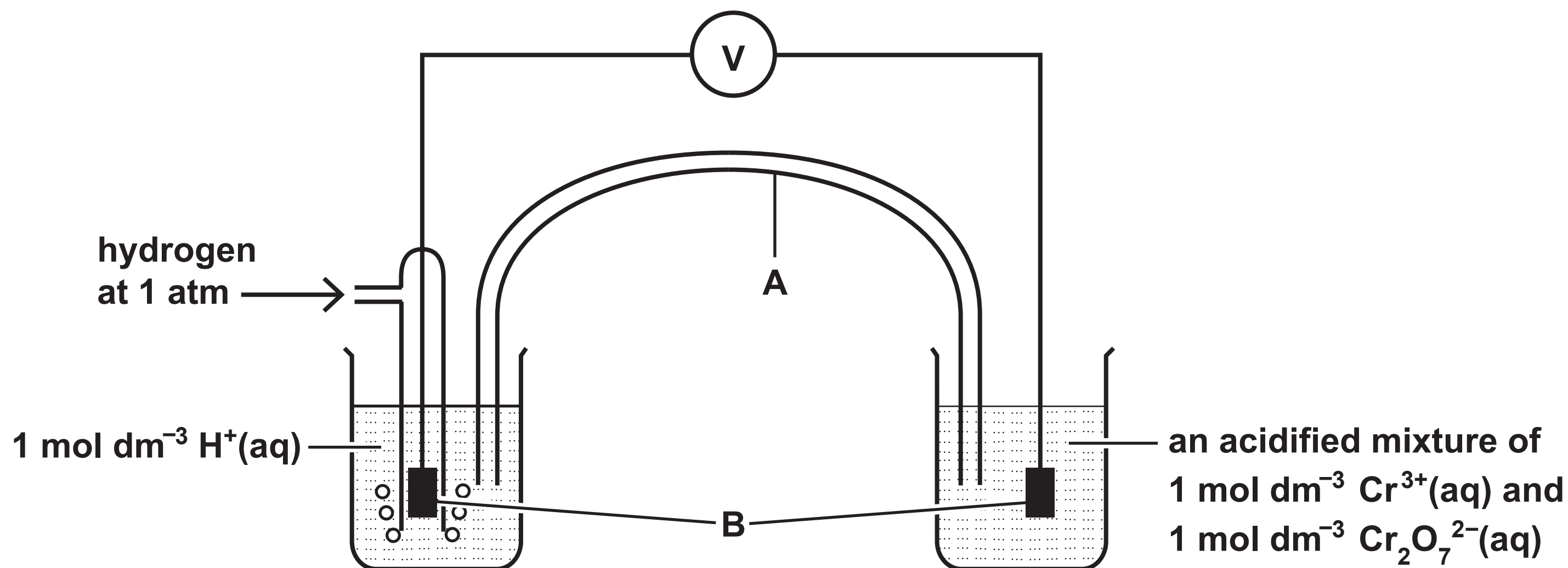
First name(s): _____

Centre Number: _____

Candidate Number: 2 _____

Question 4

Question 6 (b)



Question 7 (a)

Table

Metal nitrate	Standard enthalpy change of reaction (kJ mol ⁻¹)	Standard entropy change of reaction (J K ⁻¹ mol ⁻¹)
Mg(NO ₃) ₂	444	411
Ca(NO ₃) ₂		379
Ba(NO ₃) ₂	936	397

Question 7 (a) (iii) II.

Table

	Standard enthalpy change (kJ mol⁻¹)
Lattice breaking enthalpy of MgSO₄	2833
Lattice breaking enthalpy of BaSO₄	2474
Hydration enthalpy of Mg²⁺ ion	-1920
Hydration enthalpy of Ba²⁺ ion	-1360
Hydration enthalpy of SO₄²⁻ ion	-1059

Question 7 (d)

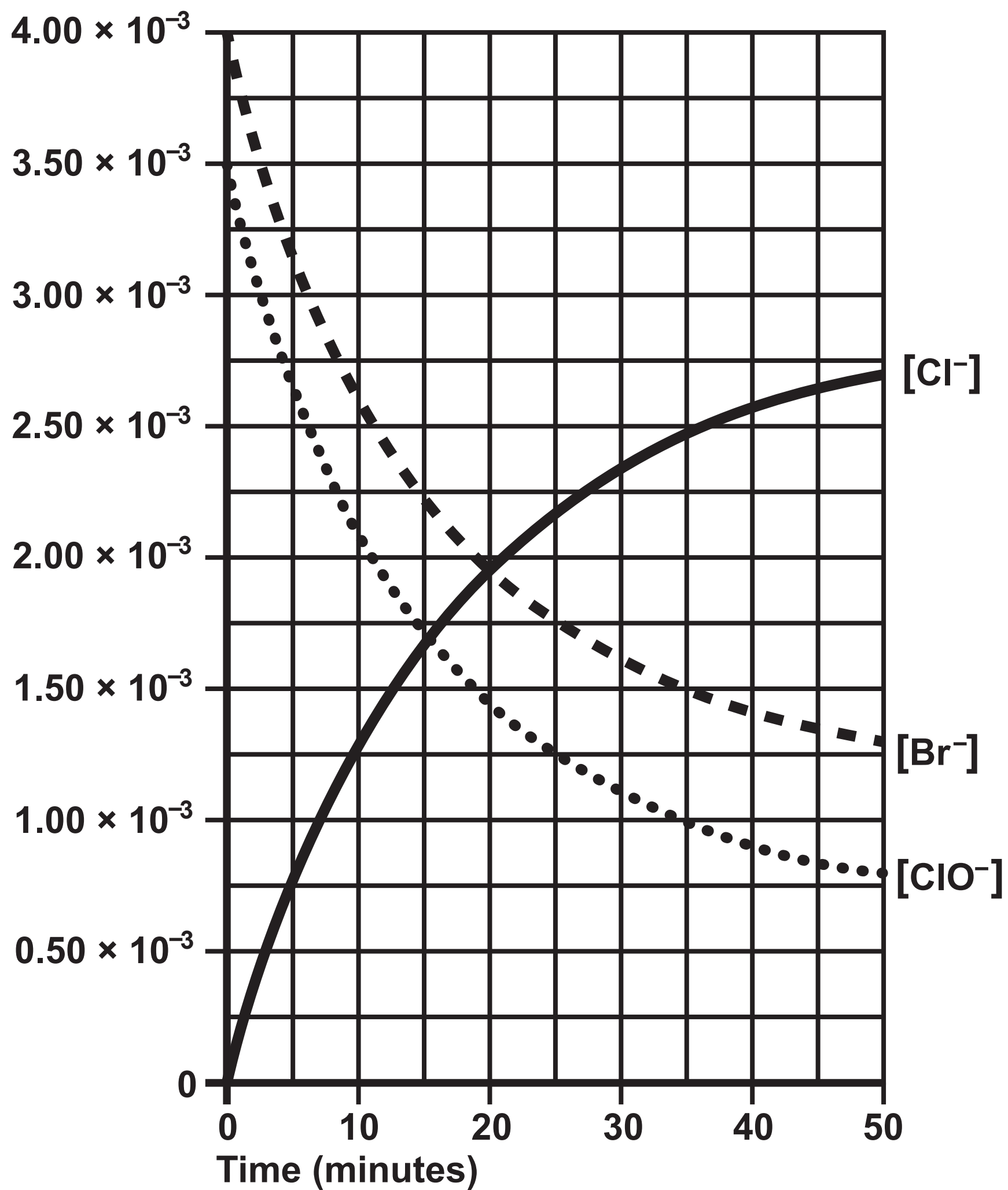
Table

Temperature (K)	Volume of gas produced (cm ³)
200	1.193×10^4
100	1.028×10^3

Question 8 (a) (i)

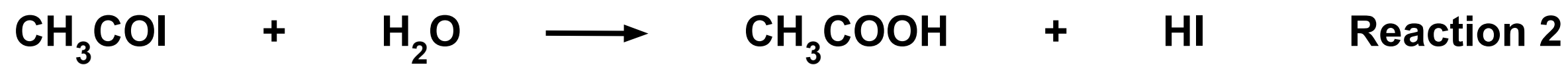
Question 8 (b) (iii)

Concentration (mol dm^{-3})



Question 9 (a)

Equations



Question 9 (a)

Tables

Bond	Bond energy (kJ mol ⁻¹)
C — H	413
C — C	346
C — I	240
C = O	745
C ≡ O in carbon monoxide	1072

Substance	Standard enthalpy change of formation (kJ mol ⁻¹)
CH ₃ I	-14
CO	-111
CH ₃ COI	-162

Question 9 (c)

Table

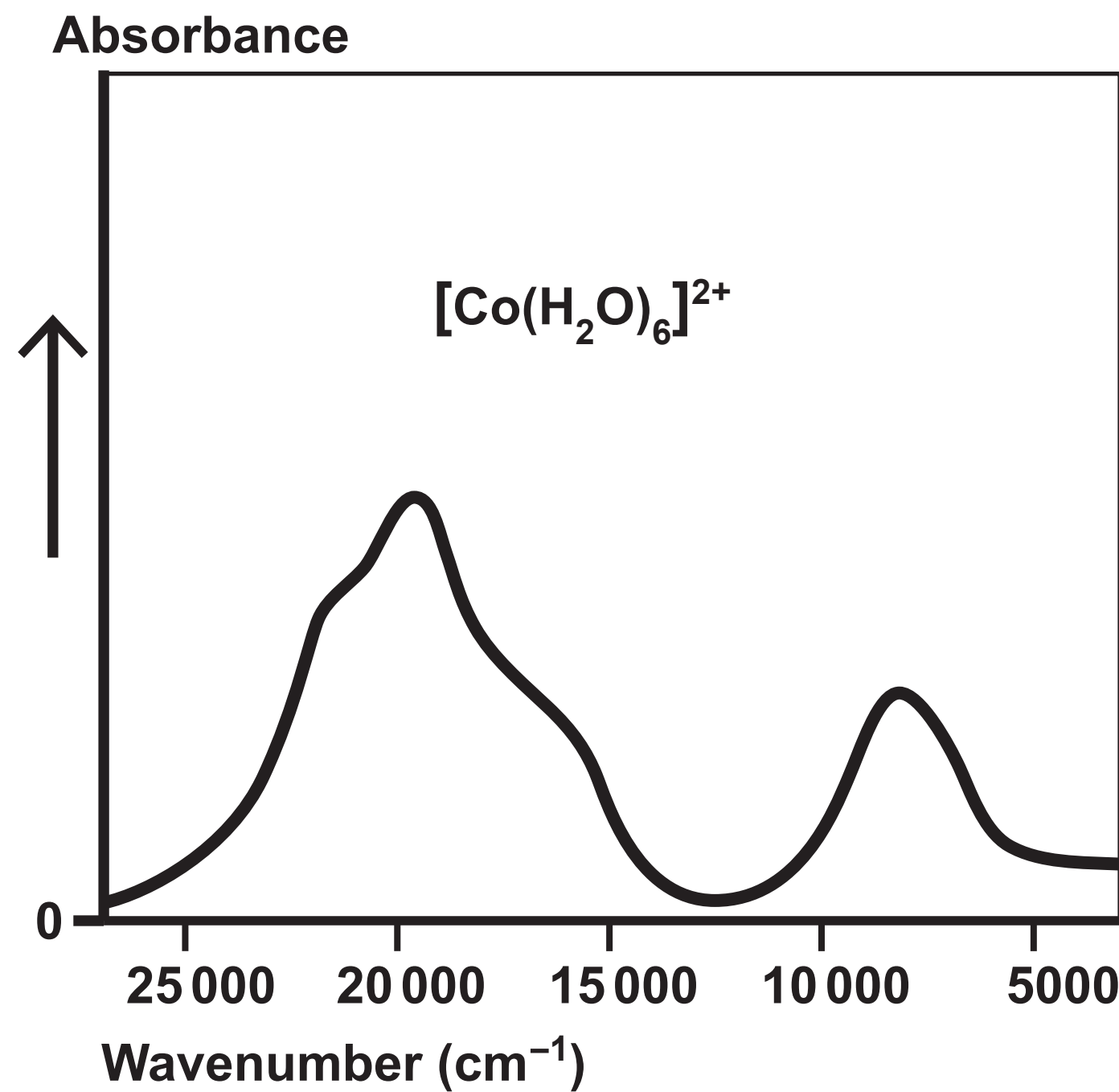
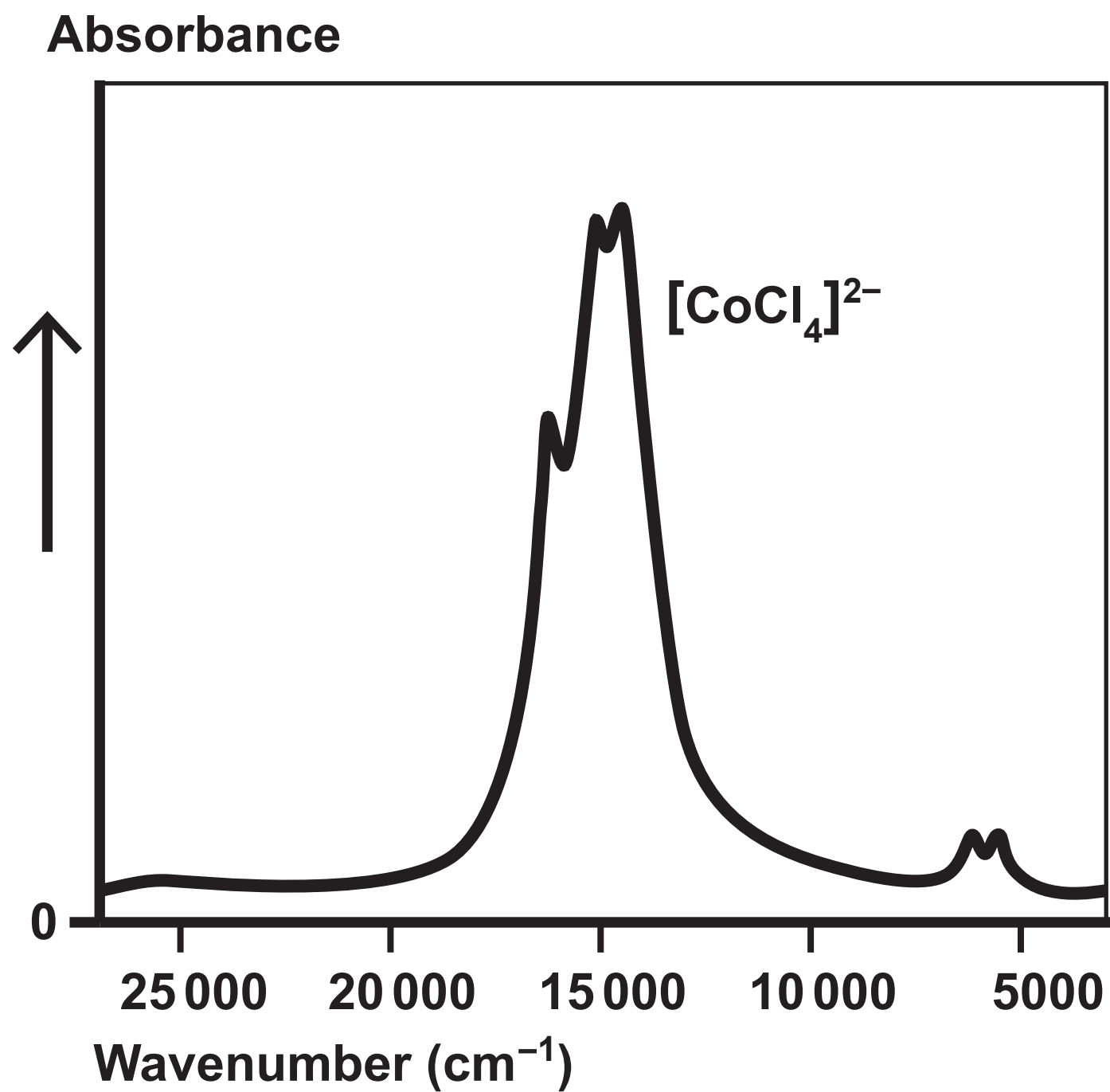
Temperature (°C)	K_c (mol ⁻¹ dm ³)
34	1220
42	694
49	406
56	290
64	196
74	120

Question 10

Table

Alloy	Typical copper content (% by mass)	Other element(s) present
brass	65 – 95	zinc
cupronickel	60 – 90	nickel
bronze	85 – 90	tin
electrum	6 – 25	gold silver
leaded tin bronze	70 – 85	tin lead

Question 10 (d) (iii)



Question 10 (e)

Table

Half – equation	Standard electrode potential, E^{θ} (V)
$\text{Ti}^{3+} + 2\text{e}^{-} \rightleftharpoons \text{Ti}^{+}$	+1•25
$\text{Cu}^{+} + \text{e}^{-} \rightleftharpoons \text{Cu}$	+0•52
$\text{Cu}^{2+} + \text{e}^{-} \rightleftharpoons \text{Cu}^{+}$	+0•16
$\text{Ti}^{+} + \text{e}^{-} \rightleftharpoons \text{Ti}$	–0•34