

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Friday 20 June 2025 – Morning

A Level Chemistry A

H432/03 Unified chemistry

**Time allowed: 1 hour 30 minutes
plus your additional time allowance**

YOU MUST HAVE:

the Data Sheet for Chemistry A

the Loose Sheet for question 3(b) (with this document)

YOU CAN USE:

**a scientific or graphical calculator
an HB pencil**

Please write clearly in black ink.

Centre number

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Candidate number

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First name(s) _____

Last name _____

READ INSTRUCTIONS OVERLEAF



INSTRUCTIONS

Use black ink. You can use an HB pencil, but only for graphs and diagrams.

Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.

Answer ALL the questions.

Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION

The total mark for this paper is 70.

The marks for each question are shown in brackets [].

Quality of extended response will be assessed in questions marked with an asterisk (*).

ADVICE

Read each question carefully before you start your answer.

1 This question is about spectra.

(a) The mass spectrum for Br_2 has peaks at m/z values of 79, 81, 158, 160 and 162.

The peaks at m/z 79 and 81 have virtually the same relative abundance.

(i) Complete the table to show the number of protons, neutrons and electrons in the particles that cause the peaks at m/z 79 and 81. [2]

m/z	Number of protons	Number of neutrons	Number of electrons
79			
81			

(ii) Explain why there are peaks with m/z values of 158, 160 and 162 and predict their relative abundances. [3]

Explanation _____

Relative abundances _____

(b) This question looks at proton NMR spectra of dibromoalkanes.

Predict the following. [3]

Compound	Number of peaks	CH ₂ splitting pattern(s)
BrCH ₂ CH ₂ Br		
BrCH ₂ CH ₂ CH ₂ Br		

- 2 This question is about different compounds that each contain O and H atoms covalently bonded together.**
- (a) The alcohol 2,3-dimethylhexan-1-ol has the molecular formula $C_8H_{18}O$.**
- (i) Draw the skeletal formula of 2,3-dimethylhexan-1-ol. Use the space below. [1]**
- (ii) What is the number of H atoms in 8.45 g of 2,3-dimethylhexan-1-ol?**

Give your answer to 3 significant figures and in standard form.

Number of H atoms = _____ [3]

(b) Nuromol tablets are used to relieve pain.

Nuromol tablets contain a mixture of ibuprofen and paracetamol.

The structures of ibuprofen and paracetamol are shown opposite.

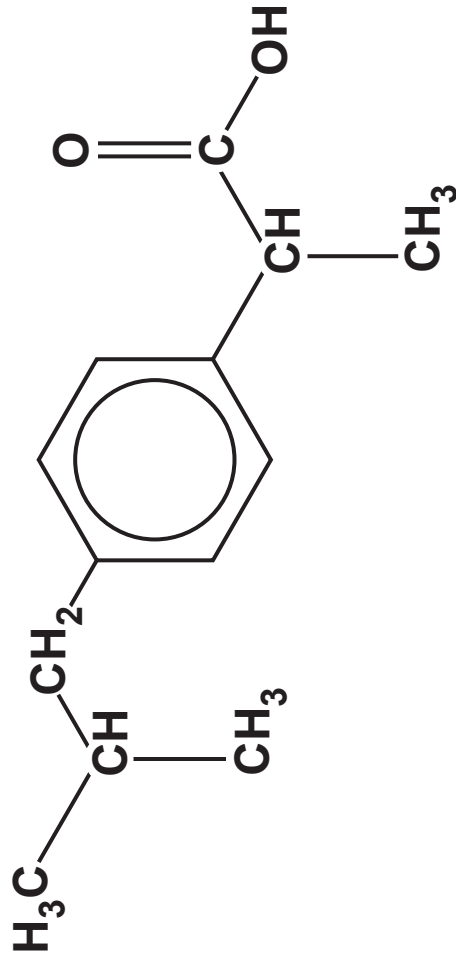
A student carries out an investigation to determine the mass of ibuprofen and the mass of paracetamol in one nuromol tablet.

Ibuprofen reacts with aqueous sodium carbonate, $\text{Na}_2\text{CO}_3(\text{aq})$, to produce a gas.

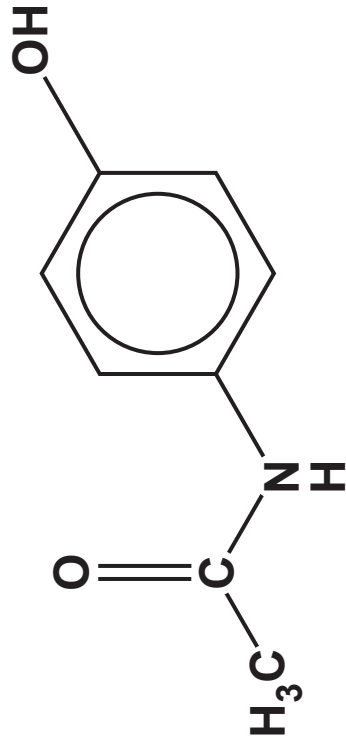


Paracetamol does NOT react with $\text{Na}_2\text{CO}_3(\text{aq})$.

Ibuprofen



Paracetamol



(i) Why does paracetamol NOT react with $\text{Na}_2\text{CO}_3(\text{aq})$?

[1]

(ii) The student uses the reaction of nuromol tablets with $\text{Na}_2\text{CO}_3(\text{aq})$ to determine the mass of ibuprofen and the mass of paracetamol in one nuromol tablet.

The student's method is outlined below.

Weigh FOUR nuromol tablets.

Add the tablets to an excess of aqueous sodium carbonate.

Collect the gas produced and measure its volume.

RESULTS

Mass of four nuromol tablets = 2.80 g

Volume of gas collected at RTP = 48.0 cm³

Assume that ibuprofen is the only compound in nuromol tablets that reacts with $\text{Na}_2\text{CO}_3(\text{aq})$.

Determine the mass of ibuprofen and the mass of paracetamol, in mg, in ONE nuromol tablet. [4]

Mass of ibuprofen = _____ mg

Mass of paracetamol = _____ mg

(c) Barium hydroxide, $\text{Ba}(\text{OH})_2$, is an alkali.
A student is supplied with a solution of $\text{Ba}(\text{OH})_2$ with a concentration of 46.80 g dm^{-3} at 25°C .

The student dilutes 20.0 cm^3 of this solution of $\text{Ba}(\text{OH})_2$ with water and the solution is made up to 100.0 cm^3 at 25°C .

Calculate the pH of the diluted solution of $\text{Ba}(\text{OH})_2$ at 25°C .

Give your answer to 2 decimal places.

pH = _____ [5]

3 This question is about equilibrium and rates.

- (a) Methanol, CH₃OH, can be made industrially by the reaction of carbon monoxide, CO, with hydrogen, H₂, in the presence of a catalyst. This is a reversible reaction.**

The equilibrium below is set up.



The concentrations of CO(g) and CH₃OH(g) in the equilibrium mixture are shown in the table below.

	CO(g)	CH ₃ OH(g)
equilibrium concentration / mol dm ⁻³	0.27	0.11

The value of the equilibrium constant, K_c , for this reaction is 1.8 dm⁶ mol⁻².

Explain the conditions of pressure and temperature that would give the maximum equilibrium yield of CH₃OH(g).

Calculate the concentration of H₂(g) in the equilibrium mixture to an APPROPRIATE number of significant figures. [5]

[illegible]

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(b)* A reaction takes place when aqueous solutions of propanone, $\text{CH}_3\text{COCH}_3(\text{aq})$, and bromine, $\text{Br}_2(\text{aq})$, are mixed in the presence of dilute acid, $\text{H}^+(\text{aq})$.

The overall equation for this reaction is shown below.

Reaction 3.1



A student carries out three experiments to investigate the rate of this reaction.

In each experiment, the student investigates the effect of changing the concentration of one of the three chemicals whilst keeping the concentrations of the other chemicals constant.

The student's results are shown on the Loose Sheet.

Use the student's results to determine the order with respect to each of the three chemicals, the rate equation and rate constant for Reaction 3.1. Explain your reasoning.

Explain how the student's results can be used to show that the mechanism of Reaction 3.1 has more than one step. [6]

[illegible]

Extra answer space if required.

4 This question is about inorganic chemistry.

(a) The flowchart shows reactions involving $\text{SO}_3^{2-}(\text{aq})$ ions.

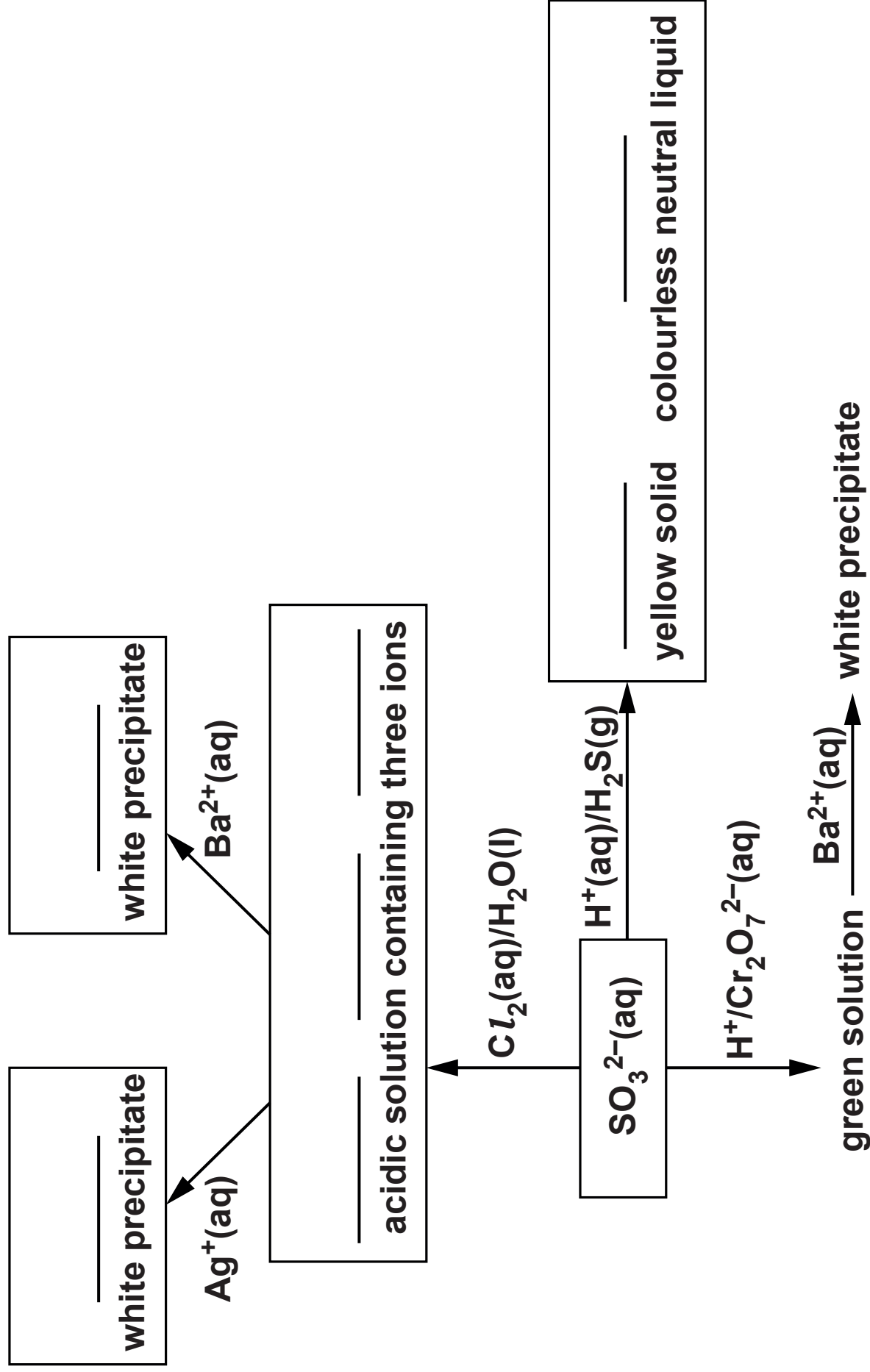
(i) What is the systematic name of a SO_3^{2-} ion?

_____ **[1]**

(ii) Complete the flowchart opposite by adding formulae in the boxes. [7]

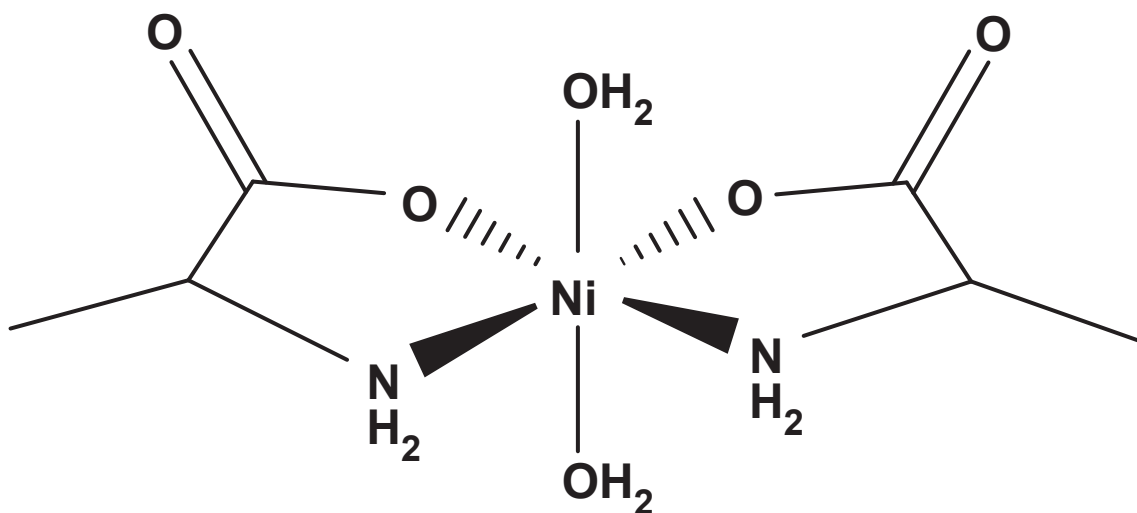
(iii) Construct an ionic equation for the reaction of SO_3^{2-} with $\text{H}^+/\text{Cr}_2\text{O}_7^{2-}$.

_____ **[2]**



- (b) The structure of a neutral nickel(II) complex, A, is shown below.

Complex A



- (i) What is the empirical formula of complex A?

_____ [1]

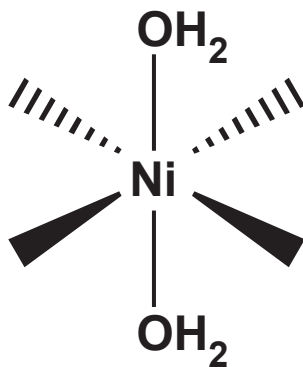
- (ii) Complex A can be prepared by reacting an aqueous solution of nickel(II) sulfate with amino acid B and potassium hydroxide.

Aqueous nickel(II) sulfate contains the octahedral hexaaquo complex ion C.

Draw the structure of amino acid B and the 3D structure, including the overall charge, of complex ion C in the space opposite. [3]

Amino acid B	Complex ion C

(iii) Complete the 3D diagram below to show a stereoisomer of complex A. [1]



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5 This question is about two metal hydrides, lithium aluminium hydride, LiAlH_4 , and sodium borohydride, NaBH_4 . Both hydrides are used as reducing agents in organic chemistry.

(a) LiAlH_4 is a stronger reducing agent than NaBH_4 , and can reduce esters to alcohols.

A student plans to use LiAlH_4 to reduce the liquid ester, ethyl phenylmethanoate, $\text{C}_6\text{H}_5\text{COOC}_2\text{H}_5$ (density = 1.05 g cm^{-3}) to the alcohol, $\text{C}_6\text{H}_5\text{CH}_2\text{OH}$ ($M_r = 108$).

The student uses $\text{C}_6\text{H}_5\text{COOC}_2\text{H}_5$ and LiAlH_4 (an excess) in a 1.0 : 2.5 molar ratio.

The student's method is outlined below.

STEP 1 7.50 cm^3 of $\text{C}_6\text{H}_5\text{COOC}_2\text{H}_5$ is dissolved in an organic solvent.

STEP 2 LiAlH_4 is added to the solution from STEP 1. The reduction takes place.

STEP 3 The mixture from STEP 2 is heated with dilute aqueous acid.

STEP 4 The impure $\text{C}_6\text{H}_5\text{CH}_2\text{OH}$ is purified.

The student carries out this preparation and obtains 4.40 g of pure $\text{C}_6\text{H}_5\text{CH}_2\text{OH}$.

- (i) What is the systematic name of the alcohol $\text{C}_6\text{H}_5\text{CH}_2\text{OH}$?

_____ [1]

- (ii) Calculate the mass of LiAlH_4 that the student should use in STEP 2 and the percentage yield of pure $\text{C}_6\text{H}_5\text{CH}_2\text{OH}$ obtained in STEP 4.

Give the mass of LiAlH_4 and the percentage yield of pure $\text{C}_6\text{H}_5\text{CH}_2\text{OH}$ to 3 significant figures. [4]

Mass of LiAlH_4 = _____ g

Percentage yield of
pure $\text{C}_6\text{H}_5\text{CH}_2\text{OH}$ = _____ %

(iii) In the preparation, LiAlH_4 behaves as a nucleophile.

What is meant by the term NUCLEOPHILE?

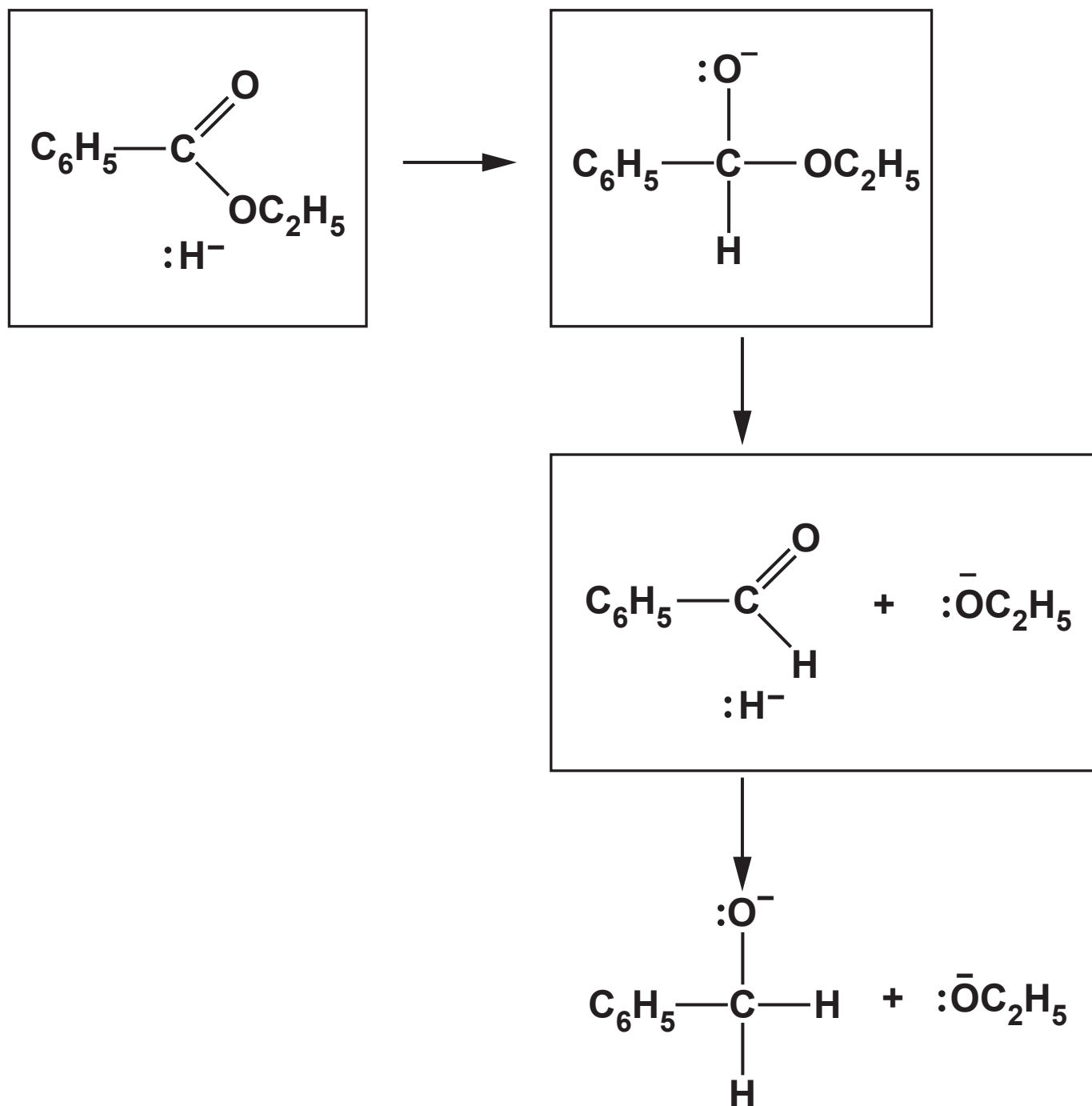
_____ [1]

(iv) The mechanism for STEP 2 in the reduction of $\text{C}_6\text{H}_5\text{COOC}_2\text{H}_5$ is shown opposite.
In the mechanism, LiAlH_4 can be represented as H^- .

Complete the mechanism by adding curly arrows to the three boxes opposite. [4]

(v) Suggest why the student heated the mixture from STEP 2 with dilute aqueous acid in STEP 3.

_____ [1]



(b) NaBH_4 contains Na^+ and BH_4^- ions.

Draw a 'dot-and-cross' diagram for NaBH_4 .

Use a different symbol for the electrons from each element.

Show outer electrons only. Use the space below. [2]

(c) NaBH_4/O_2 cells are being investigated as potential fuel cells.

The positive electrode contains O_2 .

The negative electrode contains NaBH_4 .

The reaction at the positive electrode and the overall cell reaction for a NaBH_4/O_2 fuel cell are shown below.

Reaction at positive electrode:



Overall cell reaction:



- (i) What is the standard electrode potential of the negative electrode in this cell?

Standard electrode potential = _____ V [1]

- (ii) Construct the equation for the reaction at the negative electrode of this cell.

_____ [2]

- 6* The enthalpy change of Reaction 6.1, ΔH_1 , shown below, is difficult to measure directly by experiment.

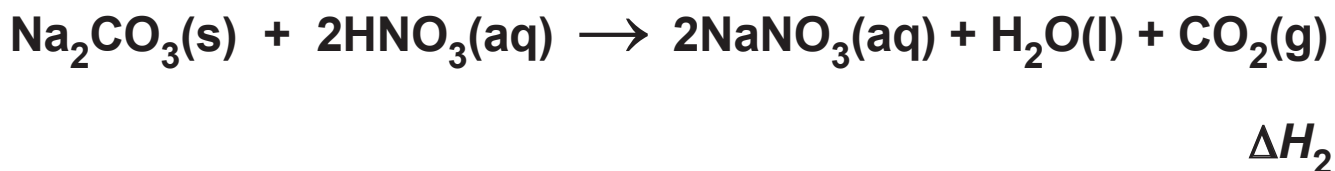
Reaction 6.1



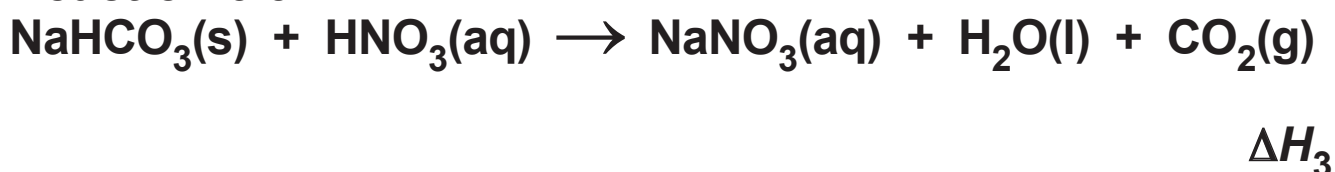
The enthalpy changes of reaction for the reactions of Na_2CO_3 and NaHCO_3 with excess $\text{HNO}_3(\text{aq})$ can be measured by experiment.

The reactions are shown below as Reaction 6.2 and Reaction 6.3.

Reaction 6.2



Reaction 6.3



A student reacts $\text{Na}_2\text{CO}_3(\text{s})$ with $\text{HNO}_3(\text{aq})$ to find ΔH_2 for Reaction 6.2.

STUDENT'S METHOD

Weigh a bottle containing $\text{Na}_2\text{CO}_3(\text{s})$ and weigh a polystyrene cup.

Add about 30 cm^3 of $1.00 \text{ mol dm}^{-3} \text{ HNO}_3(\text{aq})$ to the polystyrene cup and measure its temperature.

Add the $\text{Na}_2\text{CO}_3(\text{s})$, stir the mixture, and measure the maximum temperature reached.

Weigh the empty bottle and weigh the polystyrene cup with the final solution.

MASS READINGS

Mass of bottle + $\text{Na}_2\text{CO}_3(\text{s})/\text{g}$	3.26
Mass of empty bottle/g	1.29
Mass of polystyrene cup/g	21.08
Mass of polystyrene cup + final solution/g	54.58

TEMPERATURE READINGS

Initial temperature of $\text{HNO}_3(\text{aq})/^{\circ}\text{C}$	20.0
Maximum temperature of final solution/ $^{\circ}\text{C}$	24.0

The student follows a similar method and reacts $\text{NaHCO}_3(\text{s})$ with $\text{HNO}_3(\text{aq})$ to find ΔH_3 for Reaction 6.3.

The student calculates ΔH_3 for Reaction 6.3 as $+19.8 \text{ kJ mol}^{-1}$.

Calculate ΔH_2 for Reaction 6.2 and determine the enthalpy change of Reaction 6.1, ΔH_1 .

Assume that the density and specific heat capacity, c , of the final solution are the same as for water.

Show your working, including an energy cycle linking the enthalpy changes. [6]

[illegible]

Extra answer space if required.

END OF QUESTION PAPER

EXTRA ANSWER SPACE

If you need extra space use these lined pages. You must write the question numbers clearly in the margin.

[illegible]

[illegible]

[illegible]

[illegible]

