RAFFLES INSTITUTION
2025 YEAR 6 TERM 3 TIMED PRACTICE

Higher 2

CANDIDATE NAME

CLASS

INDEX NUMBER

CHEMISTRY 9729

3 Jul 2025

2 hours 45 minutes

Additional Materials: Multiple Choice Answer (OMR) Sheet
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name, 6-digit exam index number and civics tutorial group in the spaces provided on the OMR sheet and the cover sheets on **pages 1 and 7**. Shade your 6-digit exam index number on the OMR sheet.

This paper consists of three sections, **A**, **B** and **C**.

Section A (15 marks) consists of 15 multiple-choice questions.
Answer this section first. The OMR sheet will be collected after the **first 30 minutes**.
For each question there are four possible answers **A**, **B**, **C** and **D**. Choose the **one** you consider correct and record your choice in **soft pencil** on the OMR sheet. Each correct answer will score one mark. A mark will not be deducted for a wrong answer. Any rough working should be done in the question paper.

Section B (40 marks) consists of 3 structured questions.
Answer **all** questions in the spaces provided in the question paper.

Section C (40 marks) consists of 4 free-response questions.
Answer both **C1** and **C2**, and only **one** of **C3 EITHER** or **C3 OR**.
Answers to this section are to be written in the spaces provided in the question paper.

If additional space is required, you should use the page at the end of the booklet (page 34).
The question number must be clearly shown.

Write in dark blue or black pen. You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

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

Section A (15 marks)

For each question, there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

1 Copper has two stable isotopes, ^{63}Cu and ^{65}Cu.

Which statement is correct?

A $^{63}Cu^{+}$ ion has fewer unpaired electrons than $^{65}Cu^{3+}$ ion.

B The electronic configuration of $^{63}Cu^{+}$ is [Ar] $3d^9\ 4s^1$.

C $^{63}Cu^{+}$ ion has the same number of neutrons as $^{65}Cu^{3+}$ ion.

D $^{63}Cu^{2+}$ ion has fewer protons than $^{65}Cu^{+}$ ion.

2 *Use of the Data Booklet is relevant to this question.*

The volume strength of H_2O_2 is the volume of oxygen in dm^3 (measured at s.t.p.) that can be obtained by the decomposition of 1 dm^3 of H_2O_2.

H_2O_2 decomposes to form H_2O and O_2.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

A solution of H_2O_2 has a volume strength of 10.

10 cm^3 of this solution is used in a titration with 0.0200 mol dm^{-3} acidified $KMnO_4$.

Given that MnO_4^- reacts with H_2O_2 in a 2 : 5 ratio, what volume of $KMnO_4$ is required?

A 88 cm^3 **B** 167 cm^3 **C** 176 cm^3 **D** 551 cm^3

3 The boiling point of butan-1-ol is greater than 2-methylpropan-2-ol.

Which statements explain the relative boiling points of these two compounds?

1 The strength of the instantaneous dipole–induced dipole interactions is greater in butan-1-ol than in 2-methylpropan-2-ol.

2 The strength of the hydrogen bonds is greater in butan-1-ol than in 2-methylpropan-2-ol.

3 The extent of hydrogen bonding is greater in butan-1-ol than in 2-methylpropan-2-ol.

A 1, 2 and 3 **B** 1 and 3 only **C** 1 only **D** 2 only

4 In which row does **G** have a smaller overall dipole moment than **H**?

	G	H
A	COS	CS_2
B	PCl_3	PF_3
C	IF	BrCl
D	XeF_4	PCl_5

5 When 30 cm^3 of 1.0 mol dm^{-3} KOH(aq) is neutralised with an equal volume of 1.0 mol dm^{-3} HCl(aq), the temperature of the mixture rose by 6.8 °C.

What would be the temperature change if 15 cm^3 of 2.0 mol dm^{-3} KOH(aq) is reacted with an equal volume of 2.0 mol dm^{-3} HCl(aq)?

A 3.4 °C **B** 6.8 °C **C** 13.6 °C **D** 27.2 °C

6 Which row gives the correct signs of $\Delta H^{\ominus}$ and $\Delta S^{\ominus}$ for the following process?

$$C_6H_{12}(s) \rightarrow C_6H_{12}(l)$$

	$\Delta H^{\ominus}$	$\Delta S^{\ominus}$
A	+	+
B	+	–
C	–	–
D	–	+

7 Ozone decomposes naturally into oxygen according to the following equation.

$$2O_3 \longrightarrow 3O_2$$

The following mechanism has been proposed.

step 1 $O_3 \rightleftharpoons O^{\bullet} + O_2$ fast

step 2 $O^{\bullet} + O_3 \longrightarrow 2O_2$ slow

K_1 is the equilibrium constant of step 1 and k_2 is the rate constant of step 2.

Which statements are correct for this reaction?

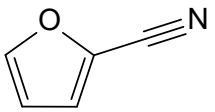
1 The order of reaction with respect to O_3 is 2.

2 The overall rate equation is $\text{rate} = k_2 K_1 \dfrac{[O_3]^2}{[O_2]}$.

3 Increasing $[O_2]$ slows down the reaction.

A 1, 2 and 3 **B** 1 and 3 only **C** 1 only **D** 2 only

8 2-Furonitrile has the following structure.



Which row correctly describes the bonding and hybridisation in 2-furonitrile?

	number of π bonds	number of sp C atoms	number of sp^2 C atoms
A	3	0	5
B	4	1	4
C	4	0	5
D	2	1	4

9 Which statement about a weak acid is **always** correct?

A The conjugate base is a strong base.

B Addition of a strong base results in a buffer solution.

C A weak acid dissociates to a greater extent with increasing dilution.

D The acid dissociation constant, K_a, decreases with increasing temperature.

10 Which solution is the most effective in resisting pH changes when a small amount of acid or base is added?

A A solution obtained by mixing 15 cm^3 of 1 mol dm^{-3} CH_3CO_2Na with 30 cm^3 of 1 mol dm^{-3} HC*l*.

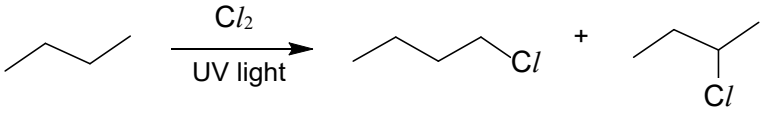
B A solution obtained by mixing 20 cm^3 of 1 mol dm^{-3} CH_3CO_2Na with 10 cm^3 of 1 mol dm^{-3} HC*l*.

C A solution obtained by mixing 10 cm^3 of 1 mol dm^{-3} CH_3CO_2H with 20 cm^3 of 1 mol dm^{-3} NaOH.

D A solution obtained by mixing 30 cm^3 of 1 mol dm^{-3} CH_3CO_2H with 15 cm^3 of 1 mol dm^{-3} NaOH.

11 *Use of the Data Booklet is relevant to this question.*

Butane reacts with chlorine to form two constitutional isomers.



Which statement is correct?

A The reaction is endothermic.

B Traces of 3-methylheptane are formed.

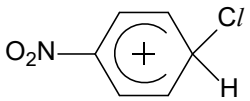
C The reaction takes place in the presence of aqueous chlorine.

D Monochlorination of butane gives a total of two isomers including stereoisomers.

12 When heated with concentrated nitric acid in the presence of a catalyst, chlorobenzene undergoes a reaction to form 4-chloronitrobenzene.

Which statement about the above reaction is correct?

A $FeCl_3$ is a suitable catalyst for the reaction.

B One of the intermediates is 

.

C The reaction requires a lower temperature compared to benzene.

D The reaction involves the electrophilic attack of NO_2^+ on the benzene ring.

[Turn Over

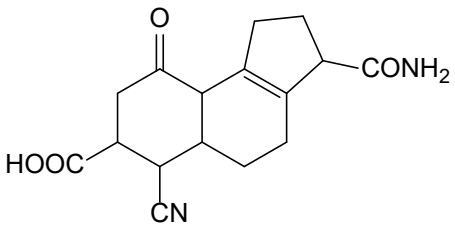
13 An equal amount of each of the following substances was dissolved separately in 1 dm^3 of water. The pH of the resultant solutions was measured.

$$CH_3COO^-Na^+,\ CH_3CH_2O^-Na^+,\ C_6H_5O^-Na^+$$

Which row is correct?

	lowest pH	⟶	highest pH
A	$CH_3COO^-Na^+$	$CH_3CH_2O^-Na^+$	$C_6H_5O^-Na^+$
B	$C_6H_5O^-Na^+$	$CH_3CH_2O^-Na^+$	$CH_3COO^-Na^+$
C	$CH_3COO^-Na^+$	$C_6H_5O^-Na^+$	$CH_3CH_2O^-Na^+$
D	$CH_3CH_2O^-Na^+$	$C_6H_5O^-Na^+$	$CH_3COO^-Na^+$

14 Which statements are correct about the compound below?



1 It reacts with H_2 in the presence of Pt catalyst to incorporate six hydrogen atoms into the compound.

2 It reacts with $LiAlH_4$ in dry ether to produce an organic compound containing one primary amine group.

3 It reacts with $NaBH_4$ to produce an organic compound containing one secondary alcohol group.

A 1 and 2 **B** 2 and 3 **C** 1 only **D** 3 only

15 In a rechargeable nickel-cadmium battery, the charging process takes place by passing an electric current through the cells.

During discharge, the battery acts as a voltaic cell. The half-equations of the reactions at the electrodes and their reduction potentials are as follows.

$$Cd(OH)_2 + 2e^- \rightleftharpoons Cd + 2OH^- \qquad E^\ominus = -0.40\ V$$
$$NiOOH + 2H_2O + 2e^- \rightleftharpoons Ni(OH)_2 + 2OH^- \qquad E^\ominus = +1.32\ V$$

Which species is formed at the negative electrode of the battery during discharge?

A $Cd(OH)_2$ **B** Cd **C** NiOOH **D** $Ni(OH)_2$

RAFFLES INSTITUTION
2025 YEAR 6 TERM 3 TIMED PRACTICE

Higher 2 Chemistry

CANDIDATE NAME			
CLASS		INDEX NUMBER	

For Examiner's Use Only

Section		Marks
A		**/ 15**
B	**B1**	**/ 12**
	B2	**/ 17**
	B3	**/ 11**
C Answer **both C1** and **C2**. **Circle the question (C3 EITHER or C3 OR)** you have answered.	**C1**	**/ 10**
	C2	**/ 20**
	C3 EITHER	**/ 10**
	C3 OR	**/ 10**
Total		**/ 95**
Percentage		**/ 100**
Penalty		
Overall		**/ 100**
Grade		

Section B (40 marks)

This section consists of **3** questions.
Answer **all** the questions in this section in the spaces provided.

1 (a) There are strict regulations imposed on industries to limit the concentration of Pb^{2+} ions in wastewater discharge. A simple method to determine the concentration of Pb^{2+} ions in a solution is through precipitation gravimetry.

A sample collected from a sewage plant was found to contain an unknown concentration of Pb^{2+}. When 100 cm^3 of 0.2 mol dm^{-3} aqueous NaBr was added to an equal volume of the sample solution, a precipitate of $PbBr_2$ was formed. Thereafter, the precipitate was separated from the mixture and weighed.

(i) Write an expression for the K_{sp} of $PbBr_2$.

……[1]

(ii) Given that the mass of $PbBr_2$ precipitated was 2.57 g, calculate the concentration of $Br^-(aq)$ remaining in solution.
[M_r of $PbBr_2$ = 367]

[3]

(iii) Hence, determine the initial concentration of $Pb^{2+}(aq)$ in the original sample.
[K_{sp} of $PbBr_2 = 4.0 \times 10^{-5}$ mol^3 dm^{-9}]

[2]

[Turn Over

		(iv)	The maximum permissible limit of Pb^{2+} in industrial waste is 1 part per million (ppm) by mass. This means that there should be no more than 1 g of Pb^{2+} per 10^6 g of solution for the solution to meet safety regulations. Calculate the concentration, in ppm, of Pb^{2+} in the sample. Hence, state whether the sample meets safety regulations. [Assume the density of the solution is 1.0 g cm^{-3}.]
			[2]
		(v)	After further analysis of the original sample collected from the sewage plant, it was found to contain Ag^+. Even though the solubility of AgBr is lower than that of $PbBr_2$, the precipitate obtained in **(a)(ii)** does not contain AgBr. Explain why this is so.
			…… …… ……[1]
		(vi)	Suggest why precipitation gravimetry cannot be used to determine the concentration of $K^+(aq)$.
			…… ……[1]

(b) When a few drops of $AgNO_3(aq)$ is added to a solution of KC*l*, a precipitate is formed. When excess aqueous NH_3 is added into the resulting mixture, the precipitate dissolves.

With the aid of balanced equation(s), explain why the precipitate is soluble in excess aqueous NH_3.

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[Total: 12]

2 Phenylamine, $C_6H_5NH_2$, is widely used as a reactant for organic synthesis. The pK_b for phenylamine at 25 °C is 9.40.

(a) The conjugate acid of phenylamine is the phenylammonium ion.

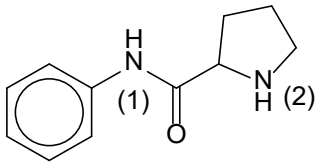
(i) Write an equation for the reaction of the phenylammonium ion with water.

……..…[1]

(ii) Calculate the pH of a 0.100 mol dm^{-3} phenylammonium chloride solution.

[2]

(b) Phenylamine can be used to synthesise compound **A**.



compound **A**

(i) Name the two nitrogen-containing functional groups in compound **A**.

……[1]

(ii) Explain why (1) is effectively neutral.

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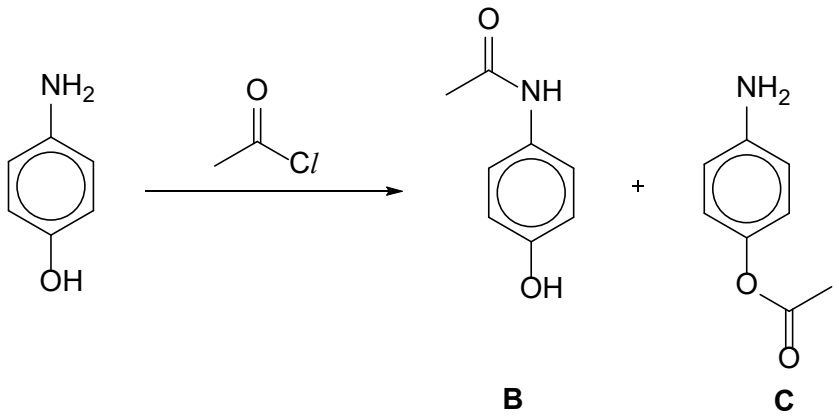
……[1]

(c) 4-Aminophenol reacts with ethanoyl chloride according to the following reaction.



B **C**

(i) Explain why **B** is the major product of this reaction.

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……[1]

(ii) Suggest a suitable reagent which can be added to 4-aminophenol to increase the yield of **C**.

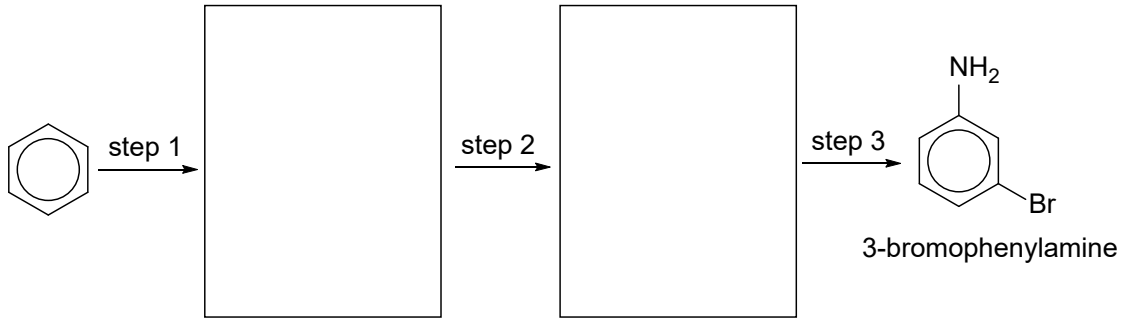
……[1]

(iii) Draw the structures of the products formed when **C** is heated with dilute HC*l*.

[2]

(d) Another substituted phenylamine, 3-bromophenylamine, can be prepared in a 3-step process.

Complete the reaction scheme to show how 3-bromophenylamine can be synthesised from benzene. Show the structures of the intermediate compounds and state the reagents and conditions for each step.



step 1 ……

step 2 ……

step 3 …… [3]

The hydrolysis reaction of amide bonds in proteins is an important process in living systems. The mechanism involves a nucleophile attacking the electron-deficient carbon in the amide group.

(e) A kinetics study on the basic hydrolysis of secondary amides was carried out and the results are given in Table 2.1.

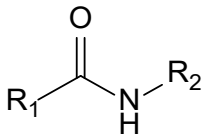


Table 2.1

experiment	R_1	R_2	relative rate of hydrolysis
1	CH_3-	CH_3-	1.5
2	$C\ell CH_2-$	CH_3-	5.0

(i) Using appropriate data, explain the relative rates of hydrolysis of experiments 1 and 2.

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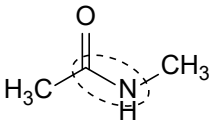
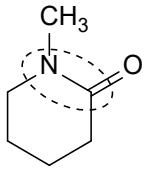
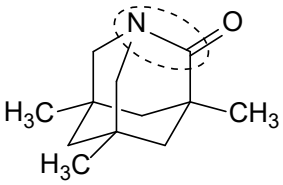
……[1]

(ii) Draw the structures of the products formed when the secondary amide from experiment 2 is heated with NaOH(aq).

[1]

The C–N bond lengths of some compounds are given in Table 2.2.

Table 2.2

compound	C–N bond length / x 10^{-10} m
$H_3C—NH_2$	1.469
	1.334
	1.325
 Kirby's twisted amide	1.475

(iii) With reference to the C–N bond lengths given, explain why Kirby's twisted amide undergoes a much faster hydrolysis reaction than other amides.

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……[1]

(iv) By considering the structure of the compound, account for the C–N bond length of the Kirby's twisted amide compared to the other compounds in the table.

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……[2]

[Total: 17]

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3 (a) The kinetics for the oxidation of iodide ions by hydrogen peroxide in aqueous solutions can be studied using a clock reaction.

$$2I^-(aq) + H_2O_2(aq) + 2H^+(aq) \longrightarrow I_2(s) + 2H_2O(l)$$

Iodine reacts with ascorbic acid (Vitamin C) as shown.

$$\underset{\text{ascorbic acid}}{C_6H_8O_6} + I_2 \longrightarrow C_6H_6O_6 + 2H^+ + 2I^-$$

By using the solutions given below, the order of reaction with respect to H_2O_2 may be determined by performing a series of experiments and then graphically analysing the results.

FA 1 is 0.88 mol dm^{-3} hydrogen peroxide, H_2O_2.
FA 2 is 0.20 mol dm^{-3} potassium iodide, KI.
FA 3 is ascorbic acid solution, prepared by using two 500 mg Vitamin C tablets in 50 cm^3 of water.
Starch solution.

It is known that the Vitamin C tablets take a long time to dissolve when placed directly into water and stirred, and the final mixture is a cloudy suspension (due to other less soluble components making up the tablets).

For the first set of the series of experiments, a teacher uses 10 cm^3 of **FA 1**, 50 cm^3 of **FA 2**, 2.5 cm^3 of **FA 3** and 2.5 cm^3 of starch solution. Upon mixing, the faint-yellow mixture suddenly turns dark blue after some time.

Write a plan for such a series of experiments.

You may assume that you are provided with:
- **FA 1** and **FA 2**,
- starch solution,
- two 500 mg Vitamin C tablets,
- deionised water,
- pestle and mortar,
- a box of filter paper,
- 3.0 cm^3 syringes,
- a stopwatch,
- the apparatus normally found in a school or college laboratory.

In your plan you should include brief details of:
- how you would prepare a clear solution of **FA 3** quickly,
- the apparatus you would use,
- the procedure you would follow to carry out the series of experiments,
- an outline of how the results would be used to confirm that the order of reaction with respect to hydrogen peroxide is one.

You may find it useful to use $\frac{1}{\text{time}}$ to represent the reaction rate.

[Turn Over

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……[8]

(b) Explain, with the aid of a labelled Boltzmann distribution diagram, the effect of a catalyst on a rate constant.

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……[3]

[Total: 11]

Section C (40 marks)

Answer both C1 and C2, and only one of C3 EITHER or C3 OR in this section.
Answers to this section are to be written in the spaces provided in the question paper.

1 (a) (i) Sketch, on the same axes, the general trends for the atomic radius and ionic radius of the elements (Na to C*l*) across the third period of the Periodic Table. [2]

(ii) Explain why the ionic radius of P^{3-} is larger than the atomic radius of P. [2]

(iii) Explain why the ionic radius of Mg^{2+} is less than that of Na^{+}. [2]

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(b) Table 1.1 shows the ionisation energies, I.E. (in kJ mol^{-1}), of 4 unknown elements denoted by **P, Q, R** and **S**.

Table 1.1

element	1st I.E.	2nd I.E.	3rd I.E.	4th I.E.	5th I.E.
P	740	1450	7730	10500	13700
Q	500	4600	6910	9540	13400
R	420	3050	4420	5900	8000
S	580	1820	2750	11600	14900

(i) With reference to element **P**, explain why the difference between the 2nd and 3rd ionisation energies is much greater than that between the 1st and 2nd ionisation energies. [2]

(ii) Deduce whether element **Q** is a Period 2 element. [1]

(iii) Calculate the energy required to remove 0.06 moles of electrons from 0.02 moles of gaseous **R** atoms. [1]

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[Total: 10]

2 (a) $Mg^{2+}(aq)$ and $Al^{3+}(aq)$ exist as the aqua complexes, $[Mg(H_2O)_6]^{2+}$ and $[Al(H_2O)_6]^{3+}$, respectively. They hydrolyse in water to form H^+ ions as shown by the equation below.

$$[M(H_2O)_6]^{a+}(aq) \rightleftharpoons [M(H_2O)_5(OH)]^{(a-1)+}(aq) + H^+(aq)$$

The acidity of metal aqua complexes can be compared using their pK_a values. The pK_a values of the aqua complexes of Mg^{2+} and Al^{3+} are shown in Table 2.1.

Table 2.1

metal aqua complex	$[Mg(H_2O)_6]^{2+}$	$[Al(H_2O)_6]^{3+}$
pK_a	11.4	5.0

(i) Explain why the pK_a of $[Mg(H_2O)_6]^{2+}$ is higher than that of $[Al(H_2O)_6]^{3+}$. [2]

When reacted separately with aqueous Na_2CO_3, $Mg^{2+}(aq)$ and $Al^{3+}(aq)$ each forms a white precipitate. However, effervescence is observed only for $Al^{3+}(aq)$.

(ii) By using the data given in Table 2.1 and the information shown below, explain why effervescence is observed for $Al^{3+}(aq)$ and identify the gas produced.

$H_2CO_3(aq) \rightleftharpoons HCO_3^-(aq) + H^+(aq)$ pK_{a1} = 6.4

$HCO_3^-(aq) \rightleftharpoons CO_3^{2-}(aq) + H^+(aq)$ pK_{a2} = 10.3 [2]

(iii) Identify the precipitates formed when $Mg^{2+}(aq)$ and $Al^{3+}(aq)$ are reacted separately with aqueous Na_2CO_3. [2]

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(b) Halogens form many interhalogen compounds. Iodine forms three diatomic interhalogen compounds: IF, IC*l* and IBr. Table 2.2 shows their bond energies.

Table 2.2

species	bond energy / kJ mol^{-1}
I–F	277
I–C*l*	208
I–Br	175

On heating, iodine monobromide decomposes to give iodine and bromine.

$$IBr(g) \longrightarrow \frac{1}{2}I_2(g) + \frac{1}{2}Br_2(g)$$

Using bond energies found in the *Data Booklet* and Table 2.2, calculate the enthalpy change, ΔH_r, of the above reaction. [1]

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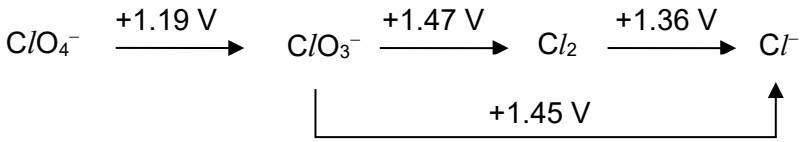
(c) The standard electrode potentials, $E^{\ominus}$, and standard Gibbs free energy changes, $\Delta G^{\ominus}$, of different chlorine-containing species are tabulated in Table 2.3.

Table 2.3

	half-equation	$E^{\ominus}$ / V	$\Delta G^{\ominus}$ / kJ mol^{-1}
1	$ClO_3^- + 6H^+ + 5e^- \rightleftharpoons \frac{1}{2}Cl_2 + 3H_2O$	+1.47	–710
2	$\frac{1}{2}Cl_2 + e^- \rightleftharpoons Cl^-$	+1.36	–131

These electrode potentials can be summarised using the Latimer diagram shown below. In a Latimer diagram, the most highly oxidised form of the element is on the left, with successively lower oxidation states to the right. The electrode potentials are shown on the arrows.



(i) State the oxidation number of C*l* in ClO_4^-. [1]

(ii) The standard electrode potential of converting ClO_3^- to Cl^- is **not** the summation of +1.47 V and +1.36 V. This is because the number of electrons transferred in each step must be taken into account.

1. Write a half-equation for the conversion of ClO_3^- to Cl^-.

2. Using your knowledge of Hess' Law, and with the aid of an energy cycle, calculate $\Delta G^{\ominus}$ for the conversion of ClO_3^- to Cl^-.

3. Hence, show that the $E^{\ominus}$ for the conversion of ClO_3^- to Cl^- is +1.45 V. [4]

(iii) Using the data in the Latimer diagram provided, calculate $E^{\ominus}_{cell}$ of the reaction below and hence determine its $\Delta G^{\ominus}$.

$$4ClO_3^-(aq) \longrightarrow 3ClO_4^-(aq) + Cl^-(aq)$$

[2]

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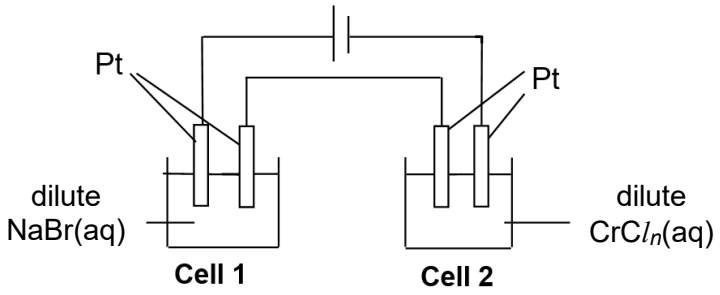
(d) *Use of the Data Booklet is relevant to this question.*

The figure below shows two cells connected in series. **Cell 1** and **Cell 2** involve the electrolysis of a dilute solution of NaBr and $CrCl_n$ respectively.



(i) Write ionic equations for the reactions occurring at the cathode and anode in **Cell 1** during electrolysis. [2]

(ii) A current was passed through the dilute solution of NaBr in **Cell 1** for 10 minutes. The product formed at the anode required 35.60 cm^3 of 0.500 mol dm^{-3} of thiosulfate ions, $S_2O_3^{2-}$, for complete reaction, giving SO_4^{2-} as the sulfur-containing product.

Write a balanced ionic equation for the reaction between the anode product and sodium thiosulfate. Hence, calculate the number of moles of electrons that passed through the circuit. [3]

(iii) In the same 10 minutes, 3.68 g of chromium was deposited at one of the electrodes in **Cell 2**. Calculate the value of n in $CrCl_n$. [1]

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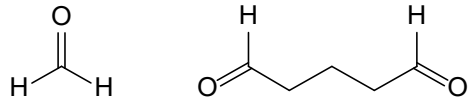
[Total: 20]

3 EITHER

Embalming fluid is used to preserve bodies of deceased persons for both funeral purposes and medical research in anatomical laboratories. Typically, embalming fluid contains a mixture of methanal, glutaraldehyde, methanol and other solvents.



methanal

glutaraldehyde

CH_3OH

methanol

(a) Suggest a simple chemical test to distinguish between methanal and methanol. [2]

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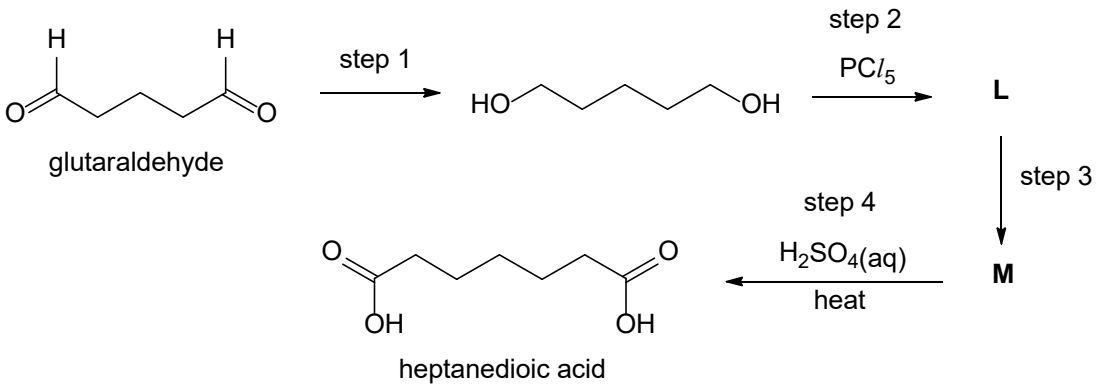
(b) Heptanedioic acid can be synthesised from glutaraldehyde by the following route.



glutaraldehyde

heptanedioic acid

(i) Suggest reagents and conditions for steps 1 and 3. [2]

(ii) Suggest the structures of **L** and **M**. [2]

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(c) Carbonyl compounds can undergo the Aldol reaction under basic conditions. The mechanism is shown in Fig. 3.1.

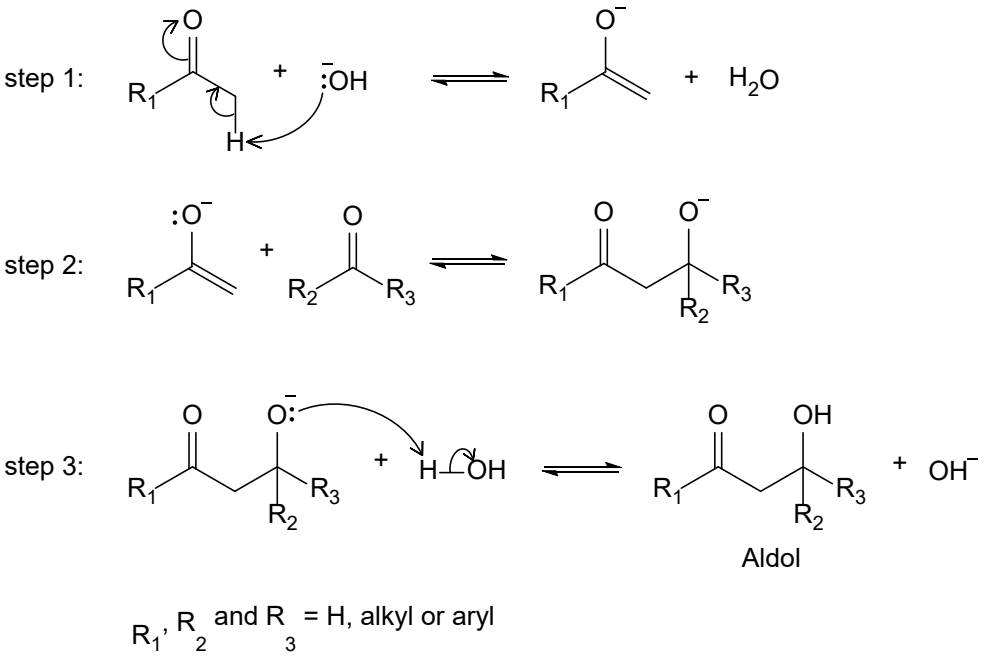
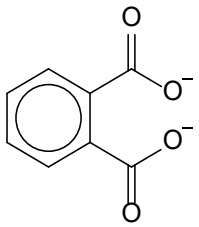


Fig. 3.1

Draw three curly arrows on **step 2** of Fig. 3.1 to complete the mechanism for step 2. [2]

(d) Compound **H** has a molecular formula of $C_{10}H_{12}O_2$ and contains the carbonyl functional group. **H** exhibits optical activity and does not react with Tollens' reagent. **H** turns hot acidified potassium dichromate(VI) from orange to green to form **J** ($C_{10}H_{10}O_2$). **H** and **J** reacts with alkaline aqueous iodine to give a yellow precipitate and the following product.



Suggest the structures of **H** and **J**. [2]

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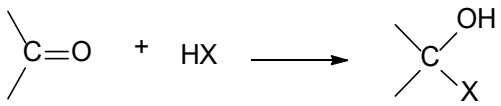
[Total: 10]

3 OR

Carbonyl compounds undergo addition reactions as shown.



An example is the formation of a cyanohydrin (where X = CN).

(a) Give two reasons why aldehydes are generally more reactive than ketones towards nucleophilic addition reaction. [2]

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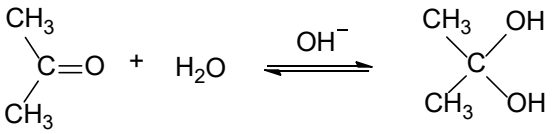
(b) Propanone undergoes a similar nucleophilic addition reaction with water, in the presence of sodium hydroxide, to form a geminal diol.



geminal diol

In this reaction, the hydroxide ion acts as a catalyst and a nucleophile.

Suggest a mechanism for this reaction, showing all charges and relevant lone pairs and show the movement of electron pairs by using curly arrows. [2]

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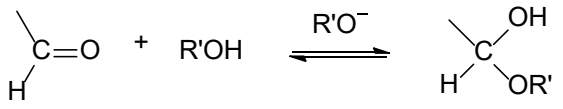
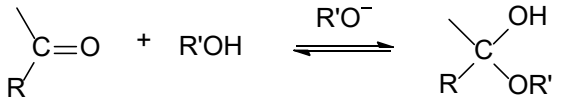
(c) Hemiacetal and hemiketal are formed, via a similar mechanism described in **(b)**, when an alcohol adds reversibly to an aldehyde and ketone respectively.



hemiacetal



hemiketal

(i) Draw the product formed from the reaction of propanal with methanol in the presence of trace amount of methoxide ions. [1]

(ii) Although the product in **(c)(i)** has a chiral centre, the sample obtained from the reaction does not rotate plane-polarised light.

Explain why this is so. [2]

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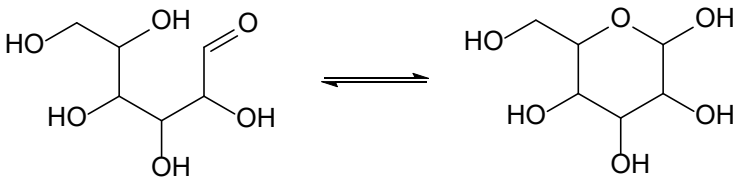
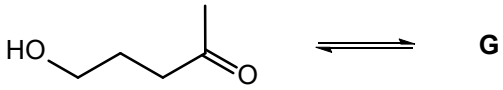
(d) Sugars containing five or six carbon atoms are important cyclic hemiacetals/hemiketals that can be formed spontaneously from hydroxy carbonyl compounds. An example is shown in Fig. 3.2.



E

Fig. 3.2

(i) **F** undergoes a similar cyclisation reaction to form **G**.



F **G**

Draw the structure of **G**. [1]

(ii) Suggest a simple chemical test to distinguish between **E** and **F**. [2]

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[Total: 10]

Additional answer space

If you use the following page to complete the answer to any question, the question number must be clearly shown.