

Please write clearly in block capitals.

Centre number

--	--	--	--	--

Candidate number

--	--	--	--

Surname

---

Forename(s)

---

Candidate signature

---

I declare this is my own work.

# INTERNATIONAL A-LEVEL CHEMISTRY (9620)

## Unit 5: Practical and synoptic

Friday 21 June 2024

07:00 GMT

Time allowed: 1 hour 25 minutes

### Materials

For this paper you must have:

- the Periodic Table/Data Sheet, provided as an insert
- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate.

### Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do **not** write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

### Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 60.

For Examiner's Use

Question	Mark
1	
2	
3	
4-33	
<b>TOTAL</b>	



J U N 2 4 C H O 5 0 1

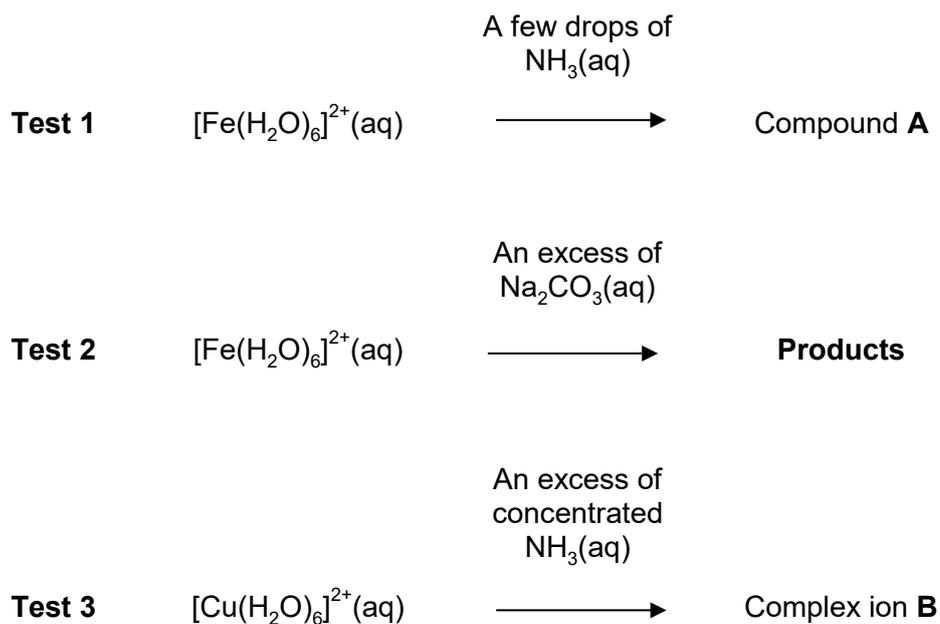
**Section A**

Answer **all** questions in the spaces provided.

**0 1**

This question is about reactions of some transition metal complexes.

**Figure 1** shows tests a student did with some transition metal complexes.

**Figure 1****0 1 . 1**

Give the colour and physical state of compound **A**.

**[1 mark]**


---

**0 1 . 2**

Compound **A** is oxidised when left in air.

Write a half-equation to show this oxidation.

**[1 mark]**


---



0 1 . 3 Write an equation for the reaction in **Test 2**.

[1 mark]

---

0 1 . 4 Give the formula of complex ion **B**.

[1 mark]

---

—  
4

Turn over for the next question

Turn over ►



**There are no questions printed on this page**

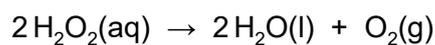
*Do not write  
outside the  
box*

**DO NOT WRITE ON THIS PAGE  
ANSWER IN THE SPACES PROVIDED**



0 2

Hydrogen peroxide solution slowly forms water and oxygen.



0 2 . 1

A student investigated the rate of reaction using a continuous monitoring method.

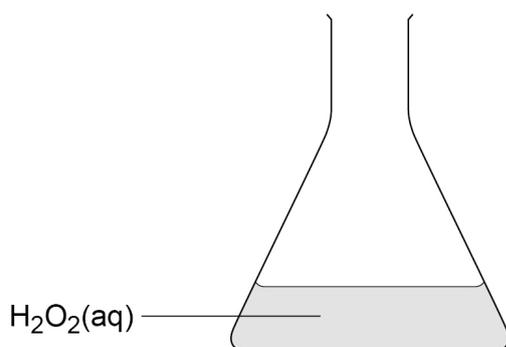
The student took readings at various times.

**Figure 2** shows some of the equipment the student used.

**Figure 2**



Clock



Complete **Figure 2** to show how the equipment the student should use is set up to measure the rate of reaction using a continuous monitoring method.

Label any equipment you draw.

[2 marks]

0 2 . 2

When the reaction stops and the clock is stopped there is an error due to human reaction time.

Suggest **one** other source of error in the experiment.

[1 mark]

---

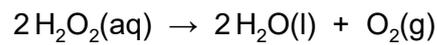


---

Turn over ►



**0 2 . 3** The experiment was repeated with the addition of a catalyst.



**Table 1** shows the amount of oxygen, in mol, recorded at various times.

**Table 1**

Time / s	Amount of oxygen / mol
0	0
20	$0.34 \times 10^{-3}$
40	$0.61 \times 10^{-3}$
60	$0.88 \times 10^{-3}$
100	$1.42 \times 10^{-3}$
120	$1.62 \times 10^{-3}$
140	$1.83 \times 10^{-3}$
160	$1.96 \times 10^{-3}$
180	$2.04 \times 10^{-3}$
200	$2.04 \times 10^{-3}$

Some of the results have been plotted on **Figure 3**.

Complete **Figure 3** using data from **Table 1**.

Draw a line of best fit.

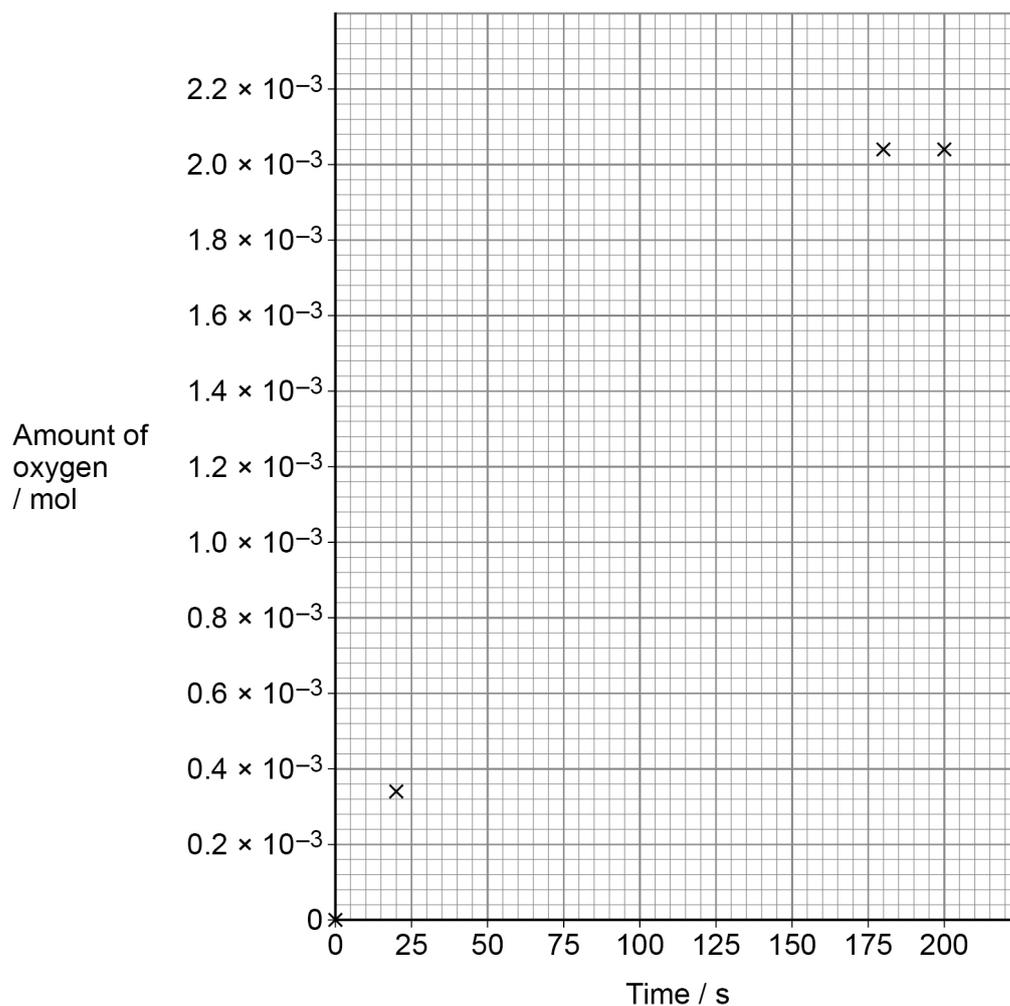
Calculate the rate of reaction, in  $\text{mol s}^{-1}$ , at 100 s

**[4 marks]**

Rate at 100 s \_\_\_\_\_  $\text{mol s}^{-1}$



Figure 3



**0 2 . 4** Use the graph in **Figure 3** to calculate the final volume, in  $\text{cm}^3$ , of oxygen gas produced at a temperature of  $25.0^\circ\text{C}$  and a pressure of  $101\text{ kPa}$

The gas constant,  $R = 8.31\text{ J K}^{-1}\text{ mol}^{-1}$

**[3 marks]**

Final volume of oxygen \_\_\_\_\_  $\text{cm}^3$

Turn over ►



**0 2 . 5** The catalysed reaction is repeated using a higher concentration of hydrogen peroxide.

Explain why increasing the concentration increases the rate of reaction.

**[2 marks]**

---

---

---

---

**0 2 . 6** The student suggests that changing the temperature of the reaction mixture will affect the rate of reaction.

Describe **one** change needed to the equipment used that will allow the student to investigate the rate of reaction between 10 °C and 70 °C

Suggest why the student does **not** include an experiment at 0 °C

**[2 marks]**

Change to equipment \_\_\_\_\_

---

---

Reason for no experiment at 0 °C \_\_\_\_\_

---

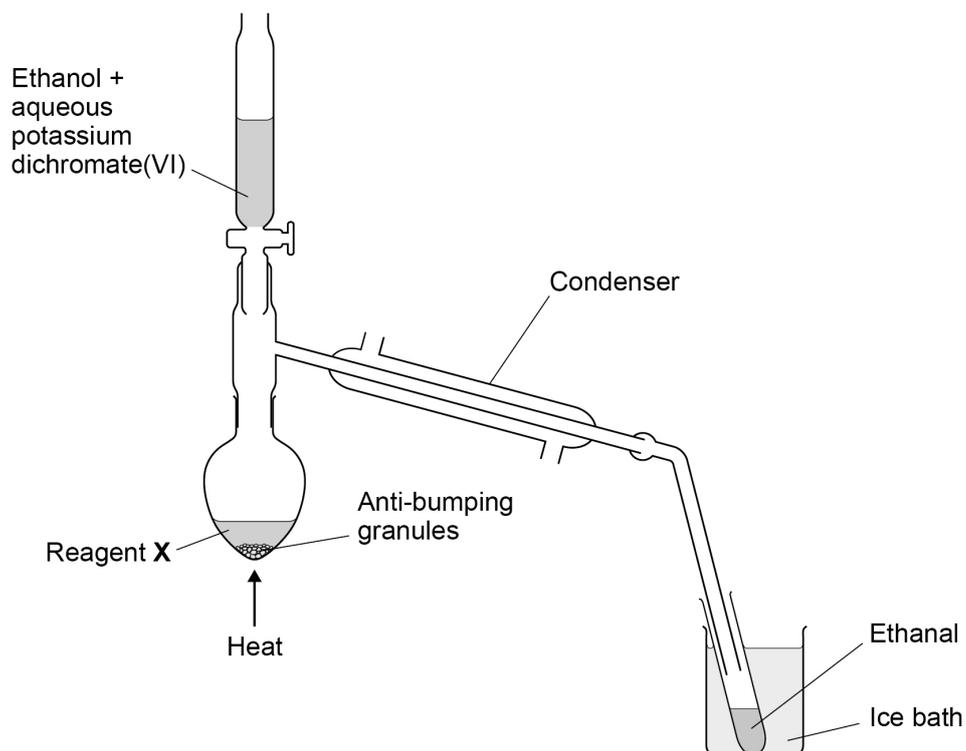
---



0 3

Figure 4 shows the equipment set up to make ethanal from 5.00 g of ethanol.

Figure 4



An ethanol and aqueous potassium dichromate(VI) mixture is added to reagent X in the flask.

Ethanal is formed and immediately distils from the reaction mixture.

The ethanal is collected in a test tube in an ice bath.

0 3 . 1

Identify reagent X.

[1 mark]

---

0 3 . 2

Complete Figure 4 to show the direction of the flow of water through the condenser.

[1 mark]

0 3 . 3

Describe why anti-bumping granules are needed in the flask.

[1 mark]

---



---



---

Turn over ►



**Table 2** shows some data about ethanol, ethanal and water.

**Table 2**

	<b>Ethanol</b>	<b>Ethanal</b>	<b>Water</b>
Boiling point / °C	78.5	20.8	100
Density / g cm <sup>-3</sup>	0.79	0.78	1.00

**0 3 . 4** The reaction mixture is heated to 70 °C

Justify this choice of temperature.

**[1 mark]**

---

---

---

**0 3 . 5** State why it is important that the ethanal distils immediately.

**[1 mark]**

---

---

---

**0 3 . 6** Explain, in terms of intermolecular forces, why ethanal has a much lower boiling point than both water and ethanol.

**[2 marks]**

---

---

---

---



0 3 . 7 5.00 g of ethanol produced 2.5 cm<sup>3</sup> of ethanal.

Use data from **Table 2** to calculate the percentage yield of ethanal.

[4 marks]

Percentage yield \_\_\_\_\_

0 3 . 8 In a different experiment, the student makes ethanoic acid from ethanol.

Suggest how the equipment in **Figure 4** needs to be modified to make ethanoic acid.

[1 mark]

---

---

12

Turn over for the next section

Turn over ►



**Section B**

Each question is followed by four responses, **A**, **B**, **C** and **D**.

For each question select the best response.

Only **one** answer per question is allowed.

For each question completely fill in the circle alongside the appropriate answer.

CORRECT METHOD



WRONG METHODS



If you want to change your answer you must cross out your original answer as shown.



If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown.



You may do your working in the blank space around each question but this will not be marked.

**0 4**

A sample of argon is analysed using time of flight (TOF) mass spectrometry using electron impact ionisation.

The mass spectrum has two peaks.

$\frac{m}{z}$	Relative intensity
39	68
42	37

Which is the relative atomic mass ( $A_r$ ) of the sample of argon?

**[1 mark]**

**A** 39.9

**B** 40.0

**C** 40.1

**D** 42.1



**0 5** Which property is different for  $^{24}\text{Mg}$  and  $^{26}\text{Mg}$ ?

[1 mark]

- A Electron configuration of their atoms
- B First ionisation energy of their atoms
- C Reaction when solid samples are heated in steam
- D Time of flight of their 1+ ions in a TOF mass spectrometer

**0 6** Which equation represents the second ionisation energy of sodium?

[1 mark]

- A  $\text{Na(s)} \rightarrow \text{Na}^{2+}(\text{g}) + 2\text{e}^{-}$
- B  $\text{Na(g)} \rightarrow \text{Na}^{2+}(\text{g}) + 2\text{e}^{-}$
- C  $\text{Na}^{+}(\text{s}) \rightarrow \text{Na}^{2+}(\text{g}) + \text{e}^{-}$
- D  $\text{Na}^{+}(\text{g}) \rightarrow \text{Na}^{2+}(\text{g}) + \text{e}^{-}$

**0 7** Which does **not** describe the relative atomic mass ( $A_r$ ) of magnesium?

[1 mark]

- A  $\frac{\text{average mass of 1 atom of magnesium}}{\frac{1}{12} \text{ mass of one atom of } ^{12}\text{C}}$
- B  $\frac{\text{average mass of 1 mole of magnesium atoms} \times 12}{\text{mass of 1 mole of } ^{12}\text{C atoms}}$
- C  $\frac{\text{average mass of 1 atom of magnesium} \times 12}{\frac{1}{12} \text{ mass of one atom of } ^{12}\text{C}}$
- D  $\frac{\text{average mass of all of the magnesium isotopes}}{\frac{1}{12} \text{ mass of one atom of } ^{12}\text{C}}$

Turn over ►



**0 8**

During a titration, the inside of the conical flask should be washed with deionised water from a wash bottle.

Which is the main reason for doing this?

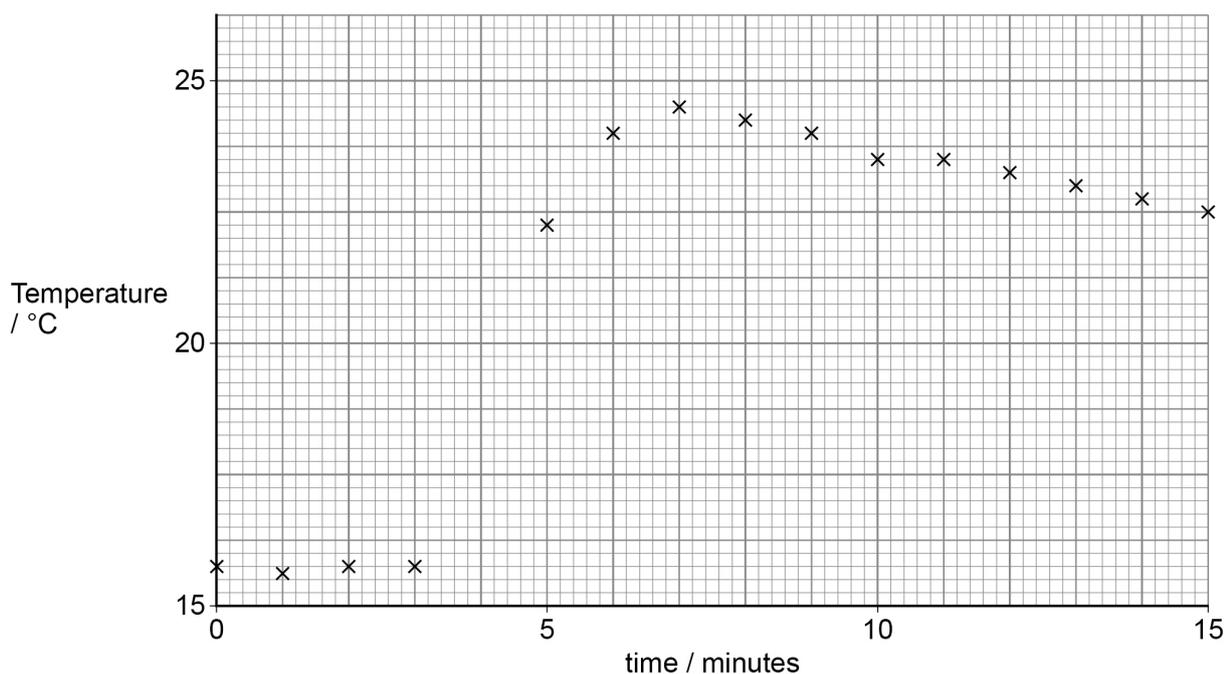
**[1 mark]**

- A** To clean the equipment
- B** To dilute the reactants, so they are less hazardous
- C** To see the colour change of the indicator more clearly
- D** To be sure all of the reagents are included in the titration

**0 9**

A student records the temperature at 1 minute intervals when investigating the heat energy change in a reaction. The reactants are mixed at time = 4 minutes.

Which temperature rise should the student use to calculate the heat energy released in this reaction?

**[1 mark]**

- A** 3.50 °C
- B** 8.75 °C
- C** 9.50 °C
- D** 10.75 °C



**1 0**These are the results from an experiment when compound **W** is dissolved in water.

Mass of <b>W</b>	2.14 g
Volume of solution	50.0 cm <sup>3</sup>
Temperature rise of water	2.45 °C
Specific heat capacity of the solution	4.18 J K <sup>-1</sup> g <sup>-1</sup>
Density of the solution	1.00 g cm <sup>-3</sup>

Which is the heat change, in J, for this process?

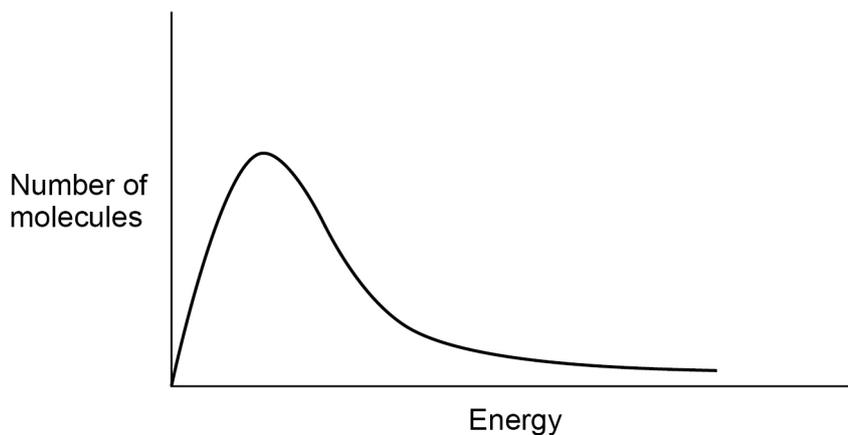
**[1 mark]**

- A**  $2.14 \times 4.18 \times 2.45$
- B**  $2.14 \times 4.18 \times (2.45 + 273)$
- C**  $50.0 \times 4.18 \times 2.45$
- D**  $50.0 \times 4.18 \times (2.45 + 273)$

**Turn over for the next question****Turn over ►**

1 1

This graph shows the Maxwell–Boltzmann distribution of energies of fluorine molecules at 350 K



Which row of the table describes the change to the distribution curve when the temperature is decreased to 298 K?

[1 mark]

	Number of molecules with mean energy	Number of molecules with energy greater than the activation energy	
<b>A</b>	Decrease	Increase	<input type="checkbox"/>
<b>B</b>	Decrease	Decrease	<input type="checkbox"/>
<b>C</b>	Increase	Increase	<input type="checkbox"/>
<b>D</b>	Increase	Decrease	<input type="checkbox"/>



**1 2** The electrode half-equations for a mercury oxide–zinc cell are shown.

Electrode half-equation	$E^\ominus / \text{V}$
$\text{HgO} + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Hg} + 2\text{OH}^-$	+0.10
$\text{ZnO} + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Zn} + 2\text{OH}^-$	To be calculated

The  $\text{HgO} | \text{Hg}$  electrode is the positive electrode.

The cell EMF is +1.35 V

Which is the electrode potential for the  $\text{ZnO} + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Zn} + 2\text{OH}^-$  half-equation?

[1 mark]

A -1.45 V

B -1.25 V

C +1.25 V

D +1.45 V

**1 3** In which reaction is the **first** species shown acting as a base?

[1 mark]

A  $\text{Br}^- + \text{H}_2\text{SO}_4 \rightarrow \text{HSO}_4^- + \text{HBr}$

B  $\text{NH}_4^+ + \text{H}_2\text{O} \rightarrow \text{NH}_3 + \text{H}_3\text{O}^+$

C  $\text{H}_2\text{SO}_4 + \text{HNO}_3 \rightarrow \text{H}_2\text{NO}_3^+ + \text{HSO}_4^-$

D  $\text{H}_2\text{O} + \text{CH}_3\text{COO}^- \rightarrow \text{CH}_3\text{COOH} + \text{OH}^-$

Turn over ►



1 4

Which indicator should be used in a titration when  $0.05 \text{ mol dm}^{-3}$  hydrochloric acid is added to aqueous ammonia?

Indicator	pH range
Thymol blue	1.2–2.8
Bromophenol blue	3.0–4.6
Phenolphthalein	8.3–10.0
Alizarin yellow	10.1–13.0

[1 mark]

- A Thymol blue
- B Bromophenol blue
- C Phenolphthalein
- D Alizarin yellow

1 5

Which solution would resist changes in pH when small quantities of acid or alkali are added?

[1 mark]

The solution formed when

- A  $15.0 \text{ cm}^3$  of  $0.100 \text{ mol dm}^{-3}$  propanoic acid are added to  $25.0 \text{ cm}^3$  of  $0.150 \text{ mol dm}^{-3}$  sodium hydroxide
- B  $25.0 \text{ cm}^3$  of  $0.150 \text{ mol dm}^{-3}$  propanoic acid are added to  $15.0 \text{ cm}^3$  of  $0.250 \text{ mol dm}^{-3}$  sodium hydroxide
- C  $25.0 \text{ cm}^3$  of  $0.150 \text{ mol dm}^{-3}$  propanoic acid are added to  $20.0 \text{ cm}^3$  of  $0.100 \text{ mol dm}^{-3}$  sodium hydroxide
- D  $25.0 \text{ cm}^3$  of  $0.150 \text{ mol dm}^{-3}$  sodium propanoate are added to  $15.0 \text{ cm}^3$  of  $0.150 \text{ mol dm}^{-3}$  sodium hydroxide



1 6

The reaction in aqueous solution between compounds **P** and **Q** in the presence of catalyst **X** produces compound **R**.

The equation for this reaction and rate equation are shown.



$$\text{Rate} = k[\text{P}][\text{Q}][\text{X}]$$

The temperature of the reacting solutions is decreased.

Which statement is correct about the effect of a **decrease** in temperature on the rate constant,  $k$ ?

[1 mark]

- A**  $k$  decreases because fewer of the reacting species have  $E \geq E_a$
- B**  $k$  stays the same because only the concentrations of **P**, **Q** and **X** affect the rate.
- C**  $k$  stays the same because the catalyst, **X**, is in the rate equation.
- D**  $k$  increases to oppose the effect of the temperature decrease.

1 7

Over the range of concentrations in this question, the rate equation for an acid-catalysed reaction is

$$\text{Rate} = k[\text{W}]^2[\text{H}^+]$$

Which conditions, at the same temperature, would give the **slowest** initial rate of reaction?

[1 mark]

- A**  $[\text{W}] = 0.3 \text{ mol dm}^{-3}$  pH = 0
- B**  $[\text{W}] = 1 \text{ mol dm}^{-3}$  pH = 2
- C**  $[\text{W}] = 3 \text{ mol dm}^{-3}$  pH = 3
- D**  $[\text{W}] = 10 \text{ mol dm}^{-3}$  pH = 4

Turn over ►



**1 8** Which Period 3 element has these successive ionisation energies?

	1st	2nd	3rd	4th	5th	6th	7th	8th
Ionisation energy / $\text{kJ mol}^{-1}$	1060	1900	2920	4960	6280	21 200	25 900	30 500

[1 mark]

A Al

B P

C S

D Ar

**1 9** Which aqueous reagents will produce a white precipitate when mixed?

[1 mark]

A  $\text{MgCl}_2$  and  $\text{H}_2\text{SO}_4$

B  $\text{AgNO}_3$  and KF

C  $\text{BaCl}_2$  and KOH

D  $\text{MgCl}_2$  and KOH

**2 0** Acidified barium chloride solution is used to test for sulfate ions.  
Acidified silver nitrate solution is used to test for chloride ions.

Which acid can be used to acidify the reagent in **both** tests?

[1 mark]

A HBr

B HCl

C  $\text{HNO}_3$

D  $\text{H}_2\text{SO}_4$



**2 1** Which is correct?

[1 mark]

- A** Chlorine reacts with sodium fluoride to form fluorine.
- B** Chlorine reacts with water, in sunlight, to form hydrochloric acid and oxygen.
- C** Chlorine is formed when concentrated sulfuric acid reacts with solid sodium chloride.
- D** Chlorine reacts with an excess of sodium hydroxide solution to form sodium chloride, chloric(I) acid (HOCl) and water.

**2 2** An excess of concentrated hydrochloric acid is added to a solution of  $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$

Which type of reaction happens?

[1 mark]

- A** Elimination
- B** Ligand substitution
- C** Precipitation
- D** Redox

**2 3** Which compound forms an acidic solution when added to water?

[1 mark]

- A** Aluminium chloride
- B** Aluminium oxide
- C** Sodium chloride
- D** Sodium oxide

Turn over ►



**2 4** A solution absorbs light with wavelengths corresponding to red, yellow and green light.

Which ion is most likely to be in the solution?

[1 mark]

A  $\text{Al}^{3+}(\text{aq})$

B  $\text{Fe}^{2+}(\text{aq})$

C  $\text{Fe}^{3+}(\text{aq})$

D  $\text{Cu}^{2+}(\text{aq})$

**2 5** Which alkene forms the most stable carbocation intermediate when reacted with hydrogen bromide?

[1 mark]

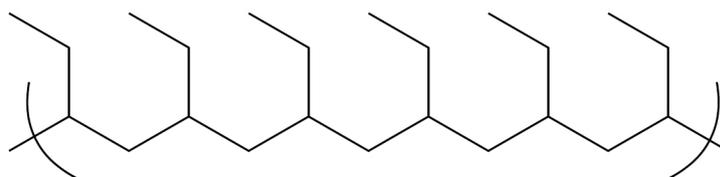
A  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}=\text{CH}_2$

B  $(\text{CH}_3)_2\text{C}=\text{CHCH}_3$

C  $(\text{CH}_3)_3\text{CCH}=\text{CH}_2$

D  $\text{CH}_3\text{CH}_2\text{CH}=\text{CHCH}_3$

**2 6** The skeletal formula of a section of a polymer is shown.



Which is the correct statement?

[1 mark]

A The empirical formula of the repeating unit is  $\text{CH}_2$

B The monomer is but-2-ene.

C The polymer is biodegradable.

D The polymer is poly(butane).



**2 7**

Which is the maximum mass, in kg, of epoxyethane ( $M_r = 44.0$ ) that can be made from 1 kg of ethene and 1 kg of oxygen?

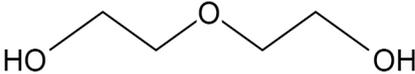
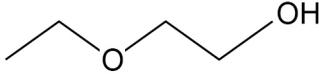
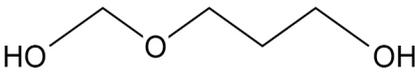
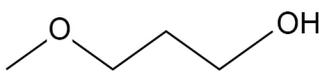
**[1 mark]**

- A 2.75
- B 1.57
- C 1.38
- D 0.688

**2 8**

Which is a possible product when water reacts with an excess of epoxyethane?

**[1 mark]**

- A 
- B 
- C 
- D 

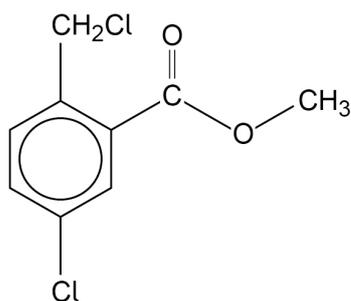
Turn over for the next question

Turn over ►



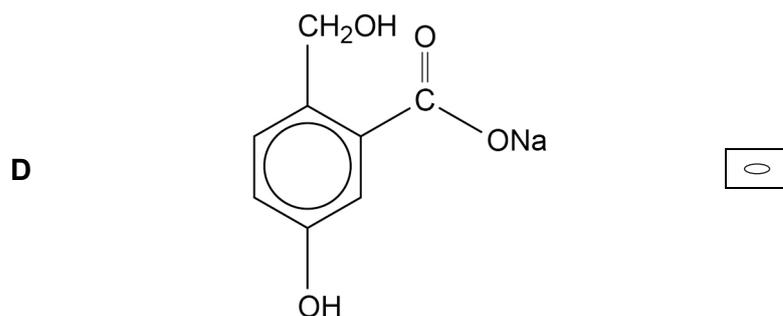
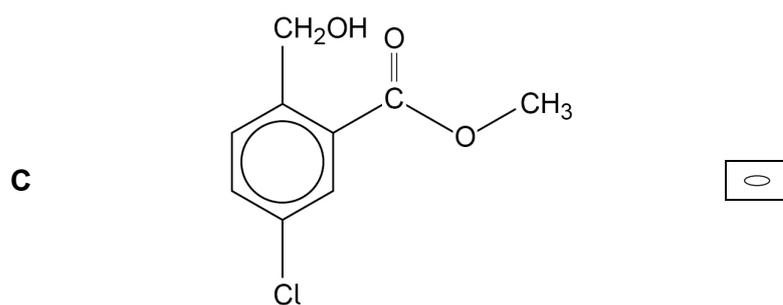
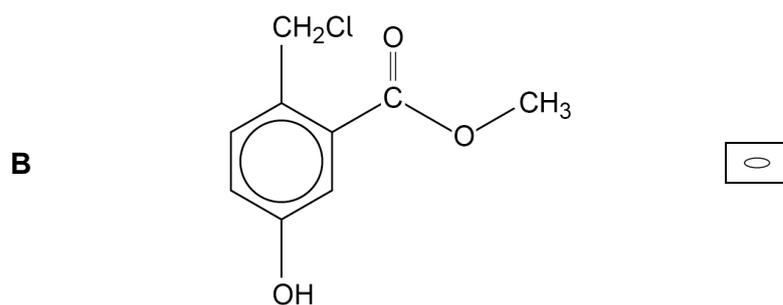
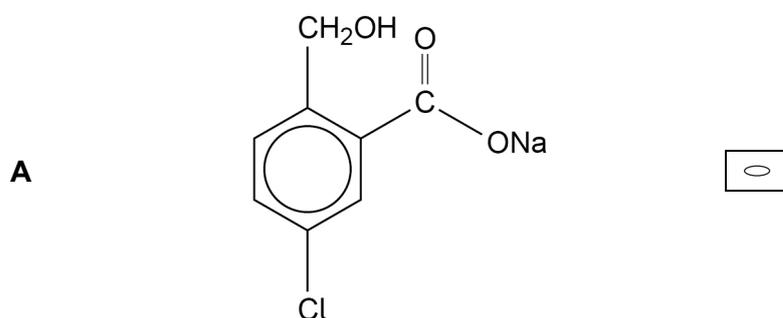
2 9

The compound shown is heated with an **excess** of aqueous sodium hydroxide.



Which aromatic product would be formed?

[1 mark]



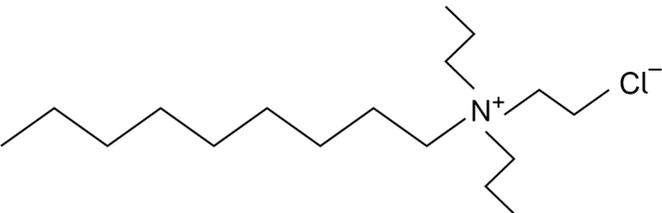
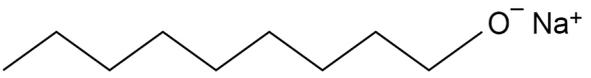
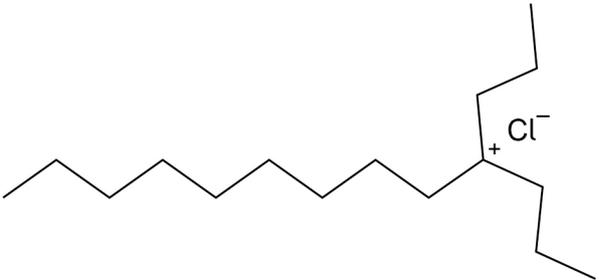
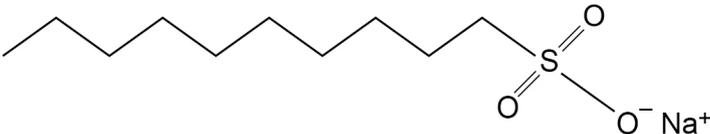
**3 0** Which amide is formed from the reaction between  $\text{CH}_3\text{CH}_2\text{NH}_2$  and  $\text{CH}_3\text{CH}_2\text{CH}_2\text{COCl}$ ?

[1 mark]

- A**  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CONHCH}_2\text{CH}_3$
- B**  $\text{CH}_3\text{CH}_2\text{CONHCH}_2\text{CH}_2\text{CH}_3$
- C**  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CONHCH}_2\text{CH}_2\text{CH}_3$
- D**  $\text{CH}_3\text{CH}_2\text{CONHCH}_2\text{CH}_3$

**3 1** Which could act as a cationic surfactant?

[1 mark]

- A** 
- B** 
- C** 
- D** 

Turn over for the next question

Turn over ►



**3 2**

A student recrystallised and dried some chloroethanoic acid.

The student measured the melting point of the chloroethanoic acid and compared this to a data book value.

Student value / °C	Data book value / °C
66	63

Which could explain the difference between the student's value and the data book value?

**[1 mark]**

- A** The chloroethanoic acid reacted with oxygen when heated.
- B** The chloroethanoic acid was impure.
- C** The melting point tube was heated too quickly.
- D** The melting point tube contained too little chloroethanoic acid.



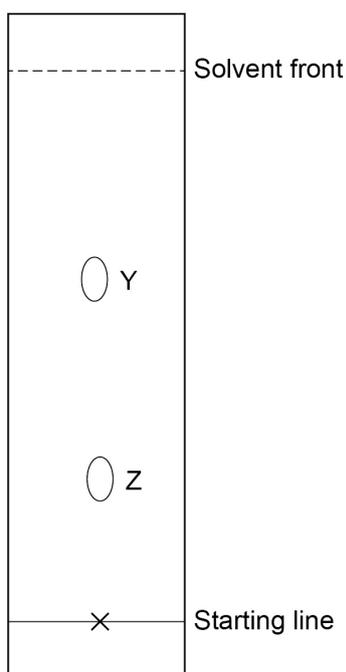
3 3

$R_f$  values of common amino acids are shown.

Amino acid	$R_f$ value
Lysine	0.14
Glycine	0.26
Serine	0.27
Alanine	0.38
Phenylalanine	0.62

A mixture of some of the amino acids in the table is analysed by thin-layer chromatography.

The chromatogram is shown.



Which statement is correct?

[1 mark]

- A** Spot **Y** **must** contain **both** alanine and phenylalanine.
- B** Spot **Y** shows a weaker affinity for the stationary phase than spot **Z**.
- C** Spot **Z** **must** contain **both** glycine and serine.
- D** Using a different solvent mixture would give spots with the same  $R_f$  values.

30

**END OF QUESTIONS**



**There are no questions printed on this page**

*Do not write  
outside the  
box*

**DO NOT WRITE ON THIS PAGE  
ANSWER IN THE SPACES PROVIDED**









**There are no questions printed on this page**

*Do not write  
outside the  
box*

**DO NOT WRITE ON THIS PAGE  
ANSWER IN THE SPACES PROVIDED**

**Copyright information**

For confidentiality purposes, all acknowledgements of third-party copyright material are published in a separate booklet. This booklet is published after each live examination series and is available for free download from [www.oxfordaqa.com](http://www.oxfordaqa.com)

Permission to reproduce all copyright material has been applied for. In some cases, efforts to contact copyright-holders may have been unsuccessful and OxfordAQA will be happy to rectify any omissions of acknowledgements. If you have any queries please contact the Copyright Team.

Copyright © 2024 OxfordAQA International Examinations and its licensors. All rights reserved.



3 2



2 4 6 X C H O 5

IB/G/Jun24/CH05