OXFORD AQA
INTERNATIONAL QUALIFICATIONS

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname StemUp Model Solution

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	
TOTAL	

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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

Test 1	$[Fe(H_2O)_6]^{2+}(aq)$	A few drops of $NH_3(aq)$ →	Compound **A**
Test 2	$[Fe(H_2O)_6]^{2+}(aq)$	An excess of $Na_2CO_3(aq)$ →	**Products**
Test 3	$[Cu(H_2O)_6]^{2+}(aq)$	An excess of concentrated $NH_3(aq)$ →	Complex ion **B**

0 1 . 1 Give the colour and physical state of compound **A**.

[1 mark]

Green precipitate (solid)

0 1 . 2 Compound **A** is oxidised when left in air.

Write a half-equation to show this oxidation.

[1 mark]

$[Fe(H_2O)_4(OH)_2] + OH^- \rightarrow [Fe(H_2O)_3(OH)_3] + H_2O + e^-$

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

[1 mark]

$[Fe(H_2O)_6]^{2+} + CO_3^{2-} \rightarrow FeCO_3 + 6\ H_2O$

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

[1 mark]

$[Cu(NH_3)_4(H_2O)_2]^{2+}$

4

Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

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0 2 Hydrogen peroxide solution slowly forms water and oxygen.

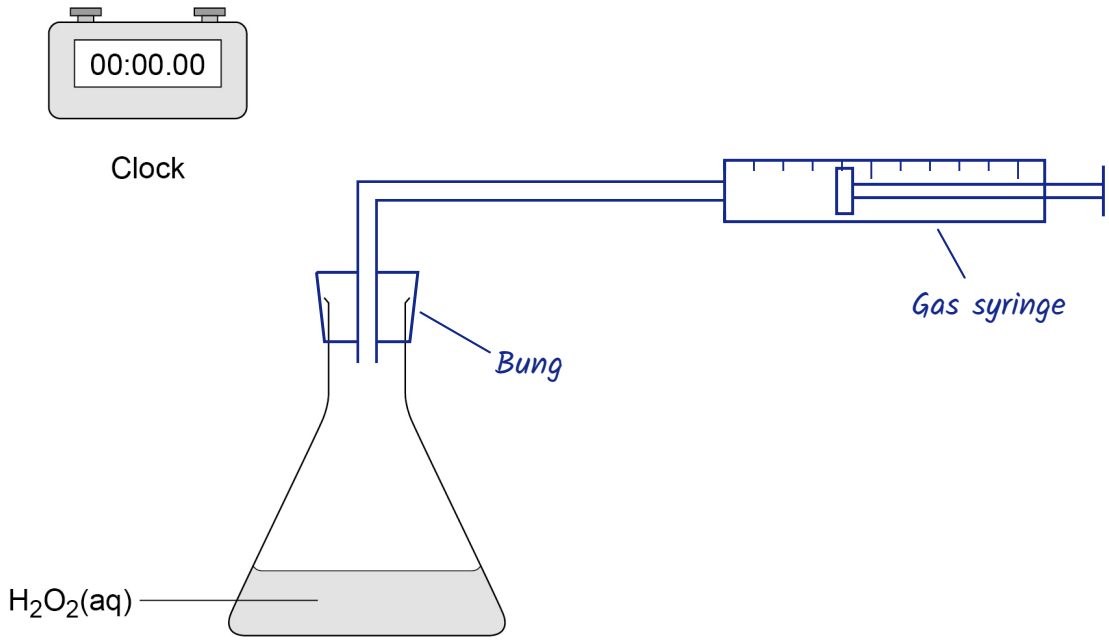
$$2\,H_2O_2(aq) \rightarrow 2\,H_2O(l) + O_2(g)$$

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



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]

Gas escapes from the flask before the bung is put in (gas loss while inserting the bung).

Turn over ►

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

$$2\,H_2O_2(aq) \rightarrow 2\,H_2O(l) + O_2(g)$$

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

Table 1

Time / s	Amount of oxygen / mol
0	0
20	0.34×10^{-3}
40	0.61×10^{-3}
60	0.88×10^{-3}
100	1.42×10^{-3}
120	1.62×10^{-3}
140	1.83×10^{-3}
160	1.96×10^{-3}
180	2.04×10^{-3}
200	2.04×10^{-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 mol s^{-1}, at 100 s

[4 marks]

Tangent drawn to the curve at t = 100 s (see Figure 3)

Gradient = $(2.21 - 0.63) \times 10^{-3} \div (170 - 30)$

$= 1.58 \times 10^{-3} \div 140$

$= 1.13 \times 10^{-5}$ mol s^{-1}

Rate at 100 s 1.13×10^{-5} mol s^{-1}

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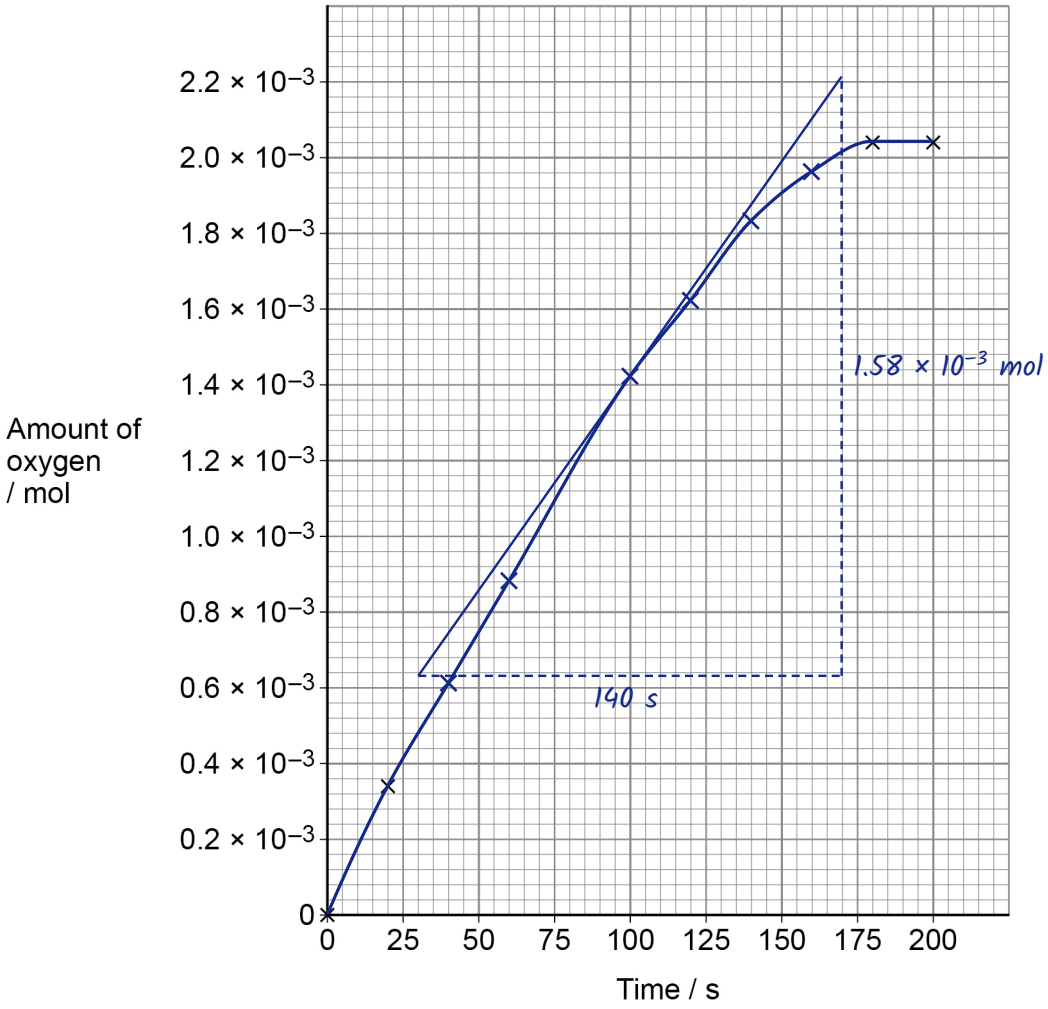
Figure 3



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

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

[3 marks]

Final amount of O_2 from graph, $n = 2.04 \times 10^{-3}$ mol

$p = 101\ 000$ Pa, $T = 25.0 + 273 = 298$ K

$V = nRT \div p = (2.04 \times 10^{-3} \times 8.31 \times 298) \div 101\ 000$

$= 5.00 \times 10^{-5}\ m^3$

$= 5.00 \times 10^{-5} \times 10^6 = 50.0\ cm^3$

Final volume of oxygen 50.0 cm^3

Turn over ►

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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]

At a higher concentration there are more H_2O_2 molecules in the same volume (the particles are closer together).

So there are more frequent successful collisions (more successful collisions per unit time).

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 Stand the conical flask in a thermostatically controlled water bath set at each chosen temperature.

Reason for no experiment at 0 °C At 0 °C the reaction would be very slow, and the solution is close to its freezing point so the $H_2O_2(aq)$ may freeze.

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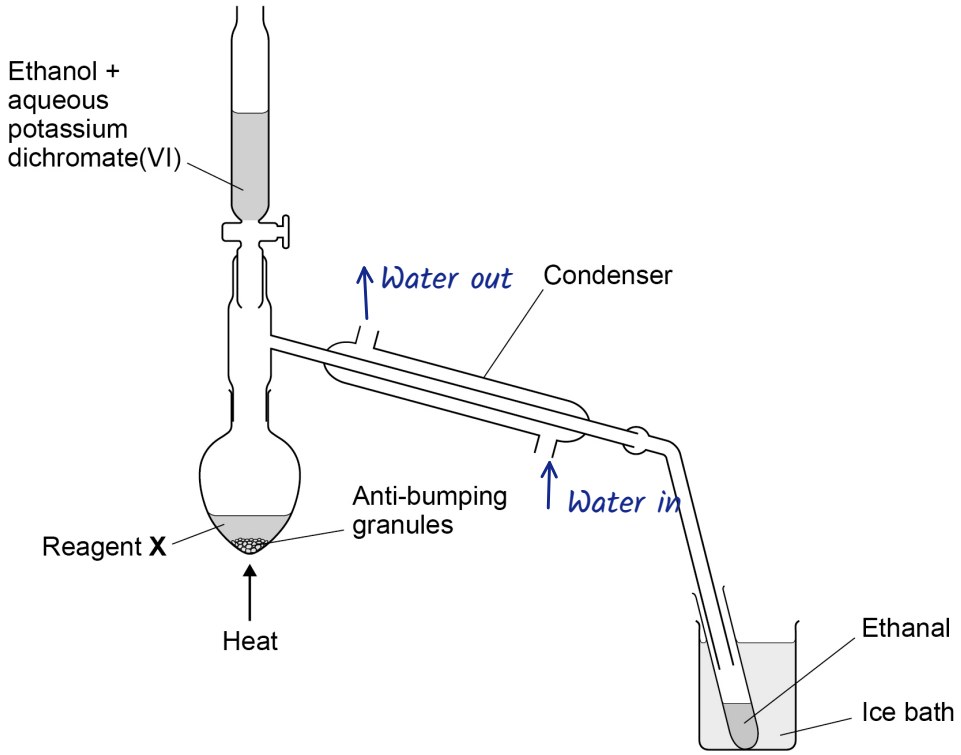
0 3 **Figure 4** shows the equipment set up to make ethanal from 5.00 g of ethanol.

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]

Sulfuric acid (dilute H_2SO_4)

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]

So that the mixture boils smoothly, forming lots of small bubbles instead of large ones, which stops the liquid splashing (bumping) into the condenser.

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

Table 2

	Ethanol	Ethanal	Water
Boiling point / °C	78.5	20.8	100
Density / g cm^{-3}	0.79	0.78	1.00

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

Justify this choice of temperature.

[1 mark]

70 °C is above the boiling point of ethanal (20.8 °C) but below that of ethanol (78.5 °C), so only the ethanal boils off and the ethanol stays in the flask.

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

[1 mark]

To prevent further oxidation of the ethanal by the acidified potassium dichromate(VI), which would form ethanoic acid.

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

[2 marks]

Ethanal has only dipole-dipole and van der Waals' forces between molecules; water and ethanol both have hydrogen bonding. Hydrogen bonding is the strongest intermolecular force, so needs more energy to overcome.

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0 3 . 7 5.00 g of ethanol produced 2.5 cm^3 of ethanal.

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

[4 marks]

Mass of ethanal = 2.5 × 0.78 = 1.95 g

Amount of ethanal = 1.95 ÷ 44.0 = 0.0443 mol

Amount of ethanol = 5.00 ÷ 46.0 = 0.109 mol

$CH_3CH_2OH + [O] \rightarrow CH_3CHO + H_2O$ (1 : 1)

so maximum amount of ethanal = 0.109 mol

Percentage yield = 0.0443 ÷ 0.109 × 100 = 40.8 %

Percentage yield 40.8 %

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]

Set the condenser up vertically above the flask so the mixture is heated under reflux.

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Turn over for the next section

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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

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0 5 Which property is different for ^{24}Mg and ^{26}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 $Na(s) \rightarrow Na^{2+}(g) + 2e^-$ ○

B $Na(g) \rightarrow Na^{2+}(g) + 2e^-$ ○

C $Na^+(s) \rightarrow Na^{2+}(g) + e^-$ ○

D $Na^+(g) \rightarrow Na^{2+}(g) + e^-$ ●

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

[1 mark]

A $\dfrac{\text{average mass of 1 atom of magnesium}}{\frac{1}{12}\text{ mass of one atom of }^{12}C}$ ○

B $\dfrac{\text{average mass of 1 mole of magnesium atoms} \times 12}{\text{mass of 1 mole of }^{12}C\text{ atoms}}$ ○

C $\dfrac{\text{average mass of 1 atom of magnesium} \times 12}{\frac{1}{12}\text{ mass of one atom of }^{12}C}$ ●

D $\dfrac{\text{average mass of all of the magnesium isotopes}}{\frac{1}{12}\text{ mass of one atom of }^{12}C}$ ○

Turn over ►

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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

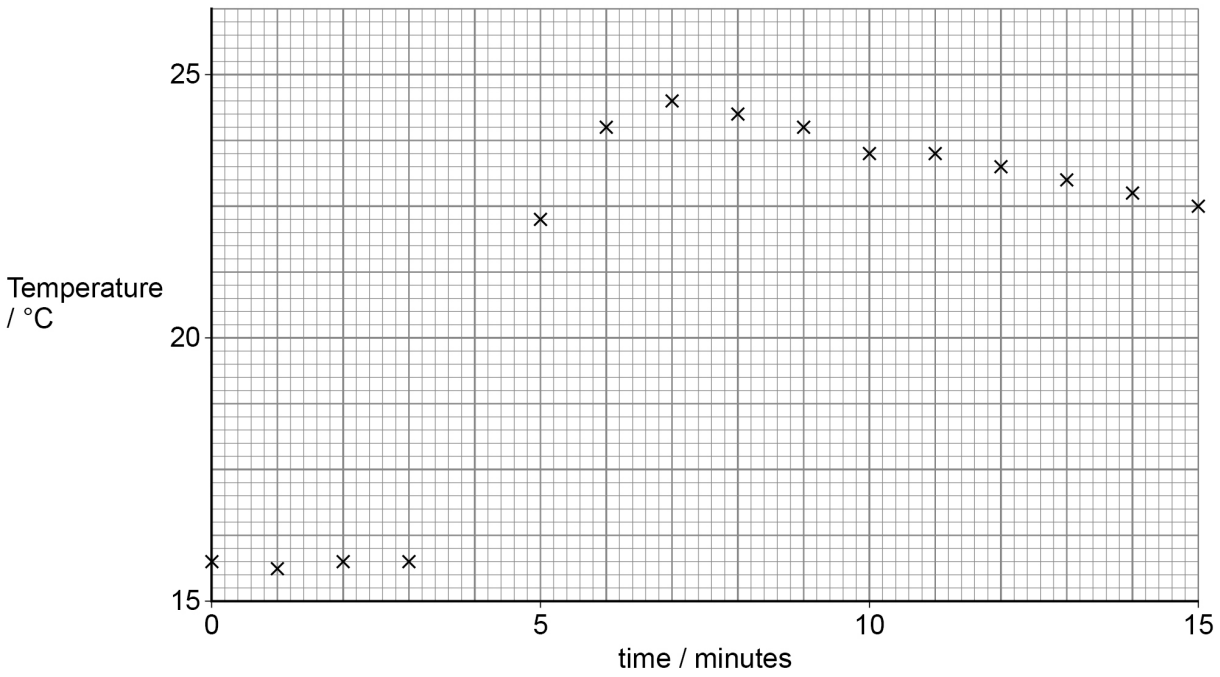
C To see the colour change of the indicator more clearly

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

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

Mass of **W**	2.14 g
Volume of solution	50.0 cm^3
Temperature rise of water	2.45 °C
Specific heat capacity of the solution	4.18 J K^{-1} g^{-1}
Density of the solution	1.00 g cm^{-3}

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

[1 mark]

A 2.14 × 4.18 × 2.45 ⬭

B 2.14 × 4.18 × (2.45 + 273) ⬭

C 50.0 × 4.18 × 2.45 ●

D 50.0 × 4.18 × (2.45 + 273) ⬭

Turn over for the next question

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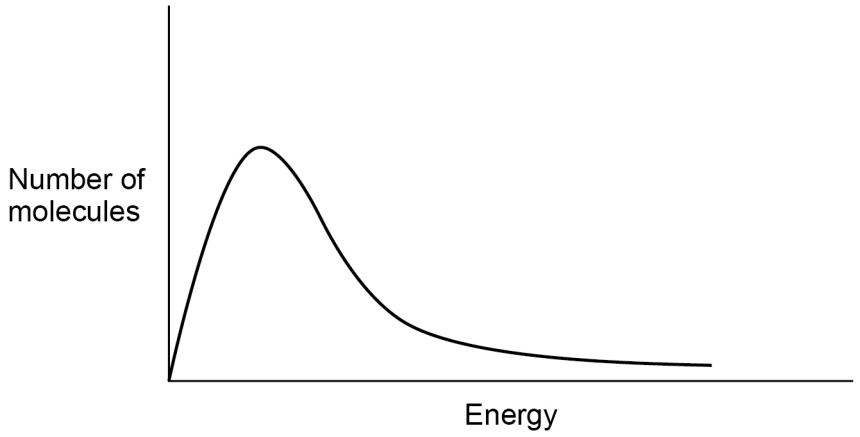
1 1 This graph shows the Maxwell–Boltzmann distribution of energies of fluorine molecules at 350 K



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	
A	Decrease	Increase	○
B	Decrease	Decrease	○
C	Increase	Increase	○
D	Increase	Decrease	●

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

Electrode half-equation	$E^{\ominus}$ / V
$HgO + H_2O + 2e^- \rightarrow Hg + 2OH^-$	+0.10
$ZnO + H_2O + 2e^- \rightarrow Zn + 2OH^-$	**To be calculated**

The HgO | Hg electrode is the positive electrode.

The cell EMF is +1.35 V

Which is the electrode potential for the $ZnO + H_2O + 2e^- \rightarrow Zn + 2OH^-$ 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 $Br^- + H_2SO_4 \rightarrow HSO_4^- + HBr$ ●

B $NH_4^+ + H_2O \rightarrow NH_3 + H_3O^+$ ○

C $H_2SO_4 + HNO_3 \rightarrow H_2NO_3^+ + HSO_4^-$ ○

D $H_2O + CH_3COO^- \rightarrow CH_3COOH + OH^-$ ○

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1 4 Which indicator should be used in a titration when 0.05 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 cm^3 of 0.100 mol dm^{-3} propanoic acid are added to 25.0 cm^3 of 0.150 mol dm^{-3} sodium hydroxide ○

B 25.0 cm^3 of 0.150 mol dm^{-3} propanoic acid are added to 15.0 cm^3 of 0.250 mol dm^{-3} sodium hydroxide ○

C 25.0 cm^3 of 0.150 mol dm^{-3} propanoic acid are added to 20.0 cm^3 of 0.100 mol dm^{-3} sodium hydroxide ●

D 25.0 cm^3 of 0.150 mol dm^{-3} sodium propanoate are added to 15.0 cm^3 of 0.150 mol dm^{-3} sodium hydroxide ○

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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.

$$\mathbf{P} + 2\mathbf{Q} \rightarrow \mathbf{R}$$

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

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

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

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

[1 mark]

A [**W**] = 0.3 mol dm^{-3} pH = 0 ○

B [**W**] = 1 mol dm^{-3} pH = 2 ○

C [**W**] = 3 mol dm^{-3} pH = 3 ●

D [**W**] = 10 mol dm^{-3} pH = 4 ○

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

	1st	2nd	3rd	4th	5th	6th	7th	8th
Ionisation energy / 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 $MgCl_2$ and H_2SO_4 ●

B $AgNO_3$ and KF ○

C $BaCl_2$ and KOH ○

D $MgCl_2$ 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 HNO_3 ○

D H_2SO_4 ●

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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 $[Cu(H_2O)_6]^{2+}$

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 ○

Do not write outside the box

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 $Al^{3+}(aq)$ ●

B $Fe^{2+}(aq)$ ○

C $Fe^{3+}(aq)$ ○

D $Cu^{2+}(aq)$ ○

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

[1 mark]

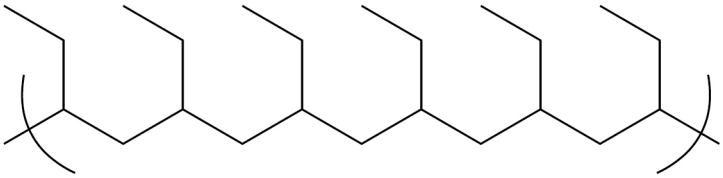
A $CH_3CH_2CH_2CH{=}CH_2$ ○

B $(CH_3)_2C{=}CHCH_3$ ●

C $(CH_3)_3CCH{=}CH_2$ ○

D $CH_3CH_2CH{=}CHCH_3$ ○

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 CH_2 ○

B The monomer is but-2-ene. ○

C The polymer is biodegradable. ○

D The polymer is poly(butane). ●

Do not write outside the box

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 ○

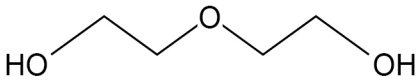
C 1.38 ○

D 0.688 ○

2 8 Which is a possible product when water reacts with an excess of epoxyethane?

[1 mark]

A



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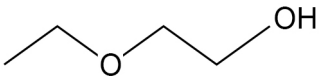
B



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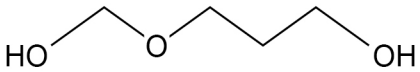
C



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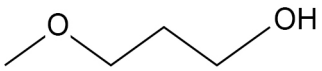
D



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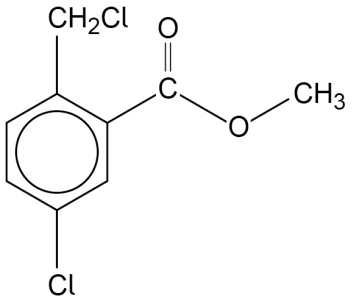
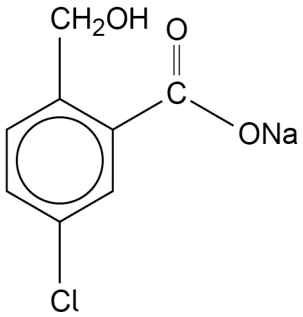
2 9 The compound shown is heated with an **excess** of aqueous sodium hydroxide.



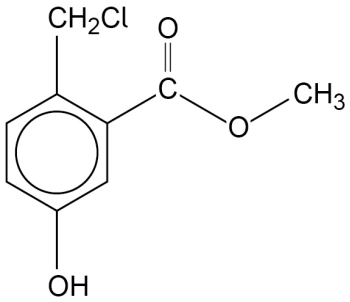
Which aromatic product would be formed?

[1 mark]

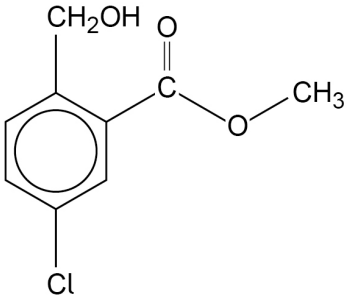
A



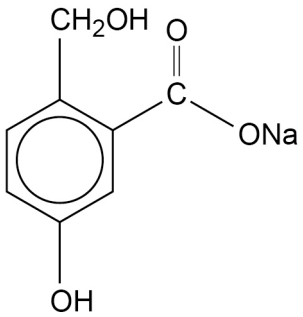
B



C



D



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3 0 Which amide is formed from the reaction between $CH_3CH_2NH_2$ and $CH_3CH_2CH_2COCl$?

[1 mark]

A $CH_3CH_2CH_2CONHCH_2CH_3$ ●

B $CH_3CH_2CONHCH_2CH_2CH_3$ ○

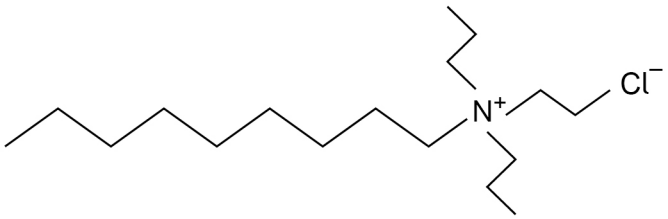
C $CH_3CH_2CH_2CONHCH_2CH_2CH_3$ ○

D $CH_3CH_2CONHCH_2CH_3$ ○

3 1 Which could act as a cationic surfactant?

[1 mark]

A



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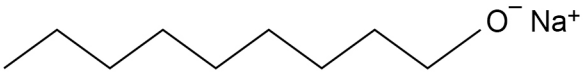
B



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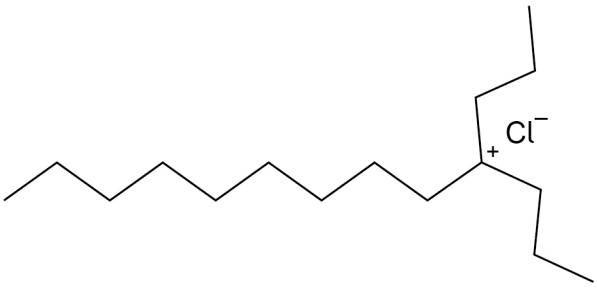
C



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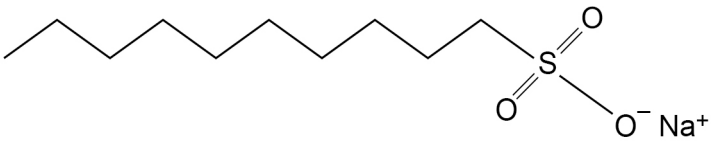
D



○

Turn over for the next question

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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. ⬭

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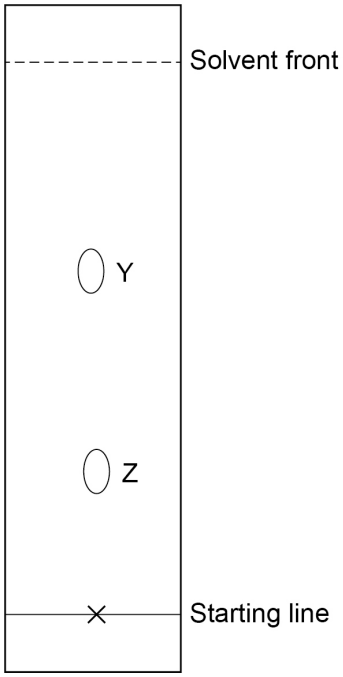
3 3 R_f values of common amino acids are shown.

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. ○

END OF QUESTIONS

30

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