OXFORD AQA
INTERNATIONAL QUALIFICATIONS

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 19 January 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 Hydrogen peroxide reacts with iodide ions to form iodine.

$$H_2O_2 + 2H^+ + 2I^- \longrightarrow I_2 + 2H_2O$$

A student does a set of experiments to investigate how the initial rate of this reaction varies with temperature.
The student keeps all other variables constant.
The student measures the time taken for a fixed amount of iodine to be produced.

0 1 . 1 The reactants were kept in a water bath before each experiment.

Suggest why.

[1 mark]

Table 1 shows the time taken (t) for a fixed amount of iodine to be produced at each temperature (T).

Table 1

Experiment	T / K	$\frac{1}{T}$ / K^{-1}	t / s	$\frac{1}{t}$ / s^{-1}	$\ln \frac{1}{t}$
1	345	2.90×10^{-3}	10	0.100	–2.30
2	340	2.94×10^{-3}	16	0.0625	–2.77
3	335	2.99×10^{-3}	27	0.0370	–3.30
4	330	3.03×10^{-3}	46	0.0217	–3.83
5	325	3.08×10^{-3}	78	0.0128	–4.36
6	320		135	0.00741	

0 1 . 2 Complete **Table 1**.

[2 marks]

Do not write outside the box

0 1 . 3 Suggest why the student did **not** use a temperature much higher than 345 K

[1 mark]

_____

_____

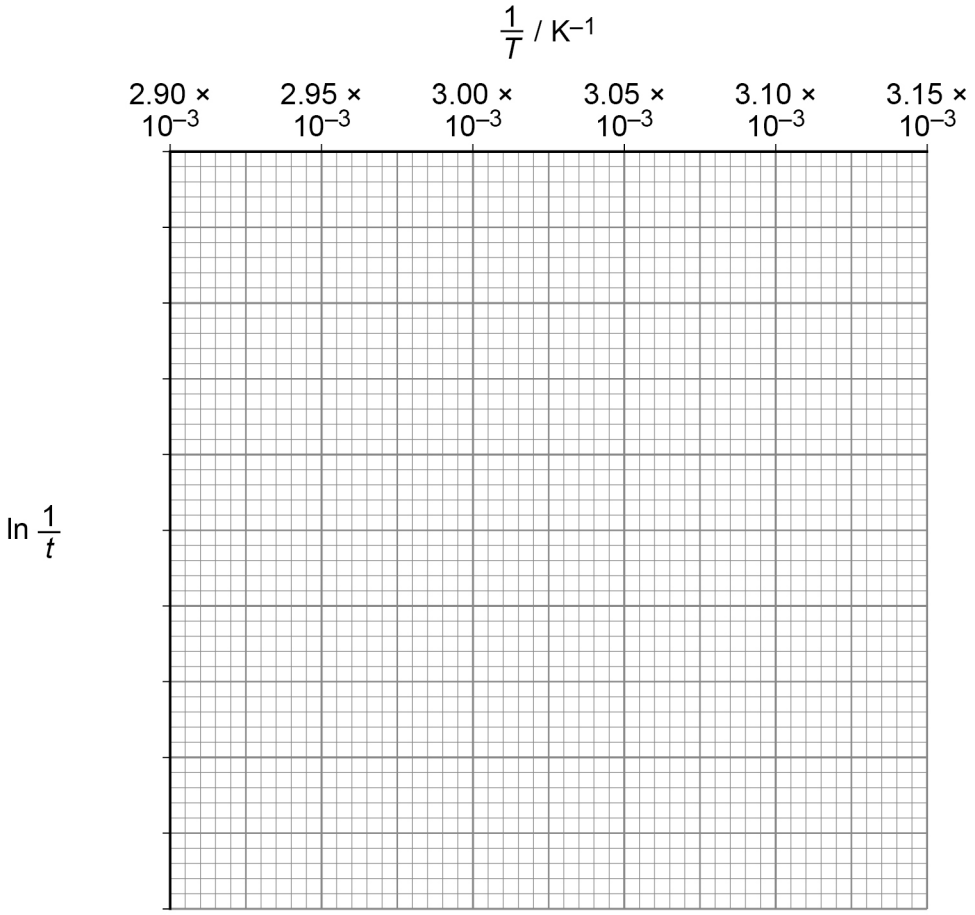
0 1 . 4 On **Figure 1**, plot a graph of $\ln \frac{1}{t}$ on the *y*-axis against $\frac{1}{T}$ on the *x*-axis for experiments **1** to **5** from **Table 1**.

Draw a straight line of best fit through your points.

Determine the gradient of the line.

[4 marks]

Figure 1



Gradient _____ K

Question 1 continues on the next page

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0 1 . 5 The Arrhenius equation can be written in this form.

$$\ln k = \frac{-E_a}{RT} + \ln A$$

In this experiment, the rate constant, k, is proportional to $\frac{1}{t}$

Therefore

$$\ln \frac{1}{t} = \frac{-E_a}{RT} + \text{constant}$$

Use this equation and the gradient you determined in Question **01.4** to calculate the activation energy (E_a) of this reaction, in kJ mol^{-1}

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

(If you could not determine the gradient of the line in Question **01.4**,
you should use the value –13 400 K
This is **not** the correct value.)

[2 marks]

E_a _____ kJ mol^{-1}

Do not write outside the box

In a different series of experiments, the student measures the initial rate of reaction for different concentrations of each of the reactants.

The student keeps all other variables constant.

$$H_2O_2 + 2H^+ + 2I^- \longrightarrow I_2 + 2H_2O$$

Table 2 shows the results of the investigation.

Table 2

Experiment	Concentration at start of experiment / mol dm^{-3}			Initial rate of reaction / mol dm^{-3} s^{-1}
	$[H_2O_2]$	$[H^+]$	$[I^-]$	
7	0.010	0.010	0.010	1.50×10^{-3}
8	0.020	0.010	0.010	3.00×10^{-3}
9	0.030	0.010	0.010	4.50×10^{-3}
10	0.010	0.020	0.010	1.50×10^{-3}
11	0.040	0.005	0.020	12.0×10^{-3}

0 1 . 6 Use the data in **Table 2** to deduce the order of reaction with respect to each of H_2O_2, H^+ and I^-

Deduce the rate equation for the reaction.

Give the units for the rate constant, *k*

[5 marks]

Order with respect to H_2O_2 _____

Order with respect to H^+ _____

Order with respect to I^- _____

Overall rate equation _____

Units of *k* _____

15

Turn over ►

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0 2 This question is about Tollens' reagent and Fehling's solution.

0 2 . 1 Several compounds have the molecular formula C_4H_8O
Butanal gives a positive test with Tollens' reagent.
Butanone does **not** give a positive test with Tollens' reagent.

State what is observed when butanal reacts with Tollens' reagent.

Give the structural formula of a compound with molecular formula C_4H_8O, apart from butanal, that gives a positive test with Tollens' reagent.

Give the structural formula of a compound with molecular formula C_4H_8O, apart from butanone, that does **not** give a positive test with Tollens' reagent.

[3 marks]

Observation with Tollens' reagent _____

_____

Gives a positive test with Tollens' reagent	
Does **not** give a positive test with Tollens' reagent	

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0 2 . 2 The compound being tested with Fehling's solution is placed in a test tube.
The test tube is heated using a water bath instead of a Bunsen burner.

Suggest **two** reasons why a water bath is used.

[2 marks]

Reason 1 _____

_____

Reason 2 _____

_____

0 2 . 3 State the observation when ethanal is warmed with Fehling's solution.

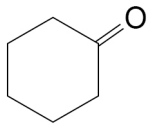
[1 mark]

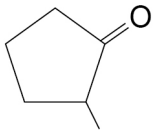
_____

0 2 . 4 These two isomers of $C_6H_{10}O$ both show the same result with Fehling's solution.
The isomers can be distinguished by the number of peaks in their ^{13}C NMR spectra.

State the number of peaks in the ^{13}C NMR spectrum for each isomer.

[1 mark]





Number of peaks

_____ _____

7

Turn over for the next question

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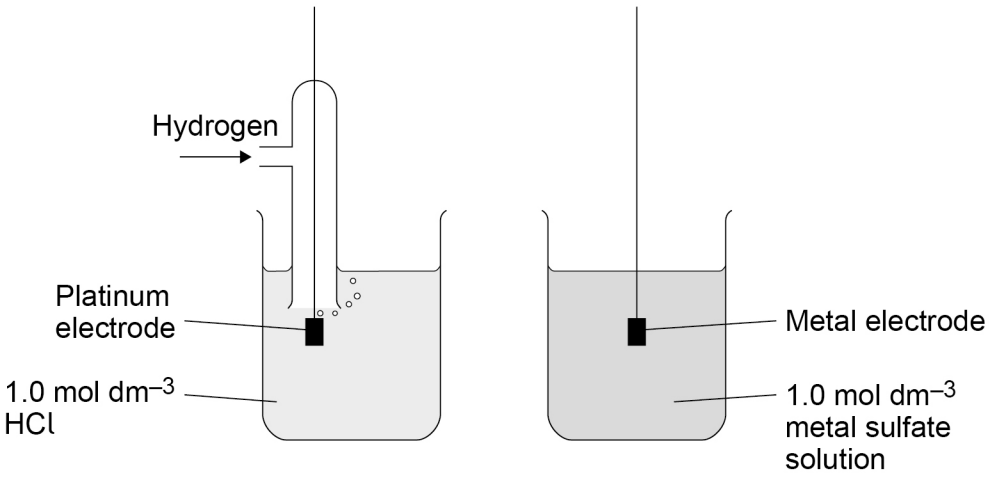
0 3 A student investigates the reactivity of five metals by measuring standard electrode potentials.

0 3 . 1 **Figure 2** represents the cell the student uses to measure a value for the standard electrode potential for each metal.

Figure 2



Complete **Figure 2**.

Label any equipment you draw.

[2 marks]

0 3 . 2 State the temperature and pressure used when the student measures the standard electrode potential.

[1 mark]

Temperature _____

Pressure _____

Do not write outside the box

The student measures the standard electrode potentials for other metals.
Table 3 shows the student's results.

Table 3

Electrode equation	Student's measured standard electrode potential / V
$Mg^{2+}(aq) + 2e^- \rightarrow Mg(s)$	–2.39
$Al^{3+}(aq) + 3e^- \rightarrow Al(s)$	–1.60
$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$	–0.77
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	+0.35

0 3 . 3 Identify the strongest oxidising agent in **Table 3**.

Justify your choice.

[2 marks]

Strongest oxidising agent _____

Justification _____

_____

0 3 . 4 The student checked the conditions and made sure that the metal sulfate solutions all had a concentration of 1.0 mol dm^{-3}

Identify **one** error in the student's method when measuring a value of the standard electrode potential for aluminium.

[1 mark]

_____

_____

0 3 . 5 Suggest **two** reasons why the student would **not** be able to measure a standard electrode potential for the metal barium using the method shown in **Figure 2**.

[2 marks]

Reason 1 _____

_____

Reason 2 _____

_____

8

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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 The concentration of sodium hydroxide solution is determined by titration against hydrochloric acid of known concentration.

The acid is in the burette.

What causes the percentage uncertainty in the burette reading to be lower?

[1 mark]

A Adding a smaller volume of indicator ⬭

B Adding water to the conical flask ⬭

C Using a smaller pipette ⬭

D Using hydrochloric acid of lower concentration ⬭

Do not write outside the box

0 5 The uncertainty in each reading of a burette is ±0.05 cm^3
There is a further uncertainty of ±0.05 cm^3 in judging the colour change at the end point.

What is the total percentage uncertainty, to 2 significant figures, if the titre is 26.05 cm^3 ?

[1 mark]

A 0.19% ⬭

B 0.38% ⬭

C 0.57% ⬭

D 0.58% ⬭

0 6 Which statement is correct?

[1 mark]

A Diamond has a very high melting point because there are very strong van der Waals forces between molecules. ⬭

B Magnesium has a high melting point because there are strong electrostatic attractions between atoms. ⬭

C Phosphorus (P_4) has a low melting point because there are weak van der Waals forces between molecules. ⬭

D Sodium chloride has a high melting point because there are strong dipole–dipole forces between the atoms. ⬭

0 7 Which equation and value represent an enthalpy of hydration?

'aq' means water added to infinite dilution.

[1 mark]

A $Na(s) + aq \rightarrow Na(aq)$ –406 kJ mol^{-1} ⬭

B $Na^+(g) + aq \rightarrow Na^+(aq)$ –406 kJ mol^{-1} ⬭

C $Na(s) + aq \rightarrow Na(aq)$ 406 kJ mol^{-1} ⬭

D $Na^+(g) + aq \rightarrow Na^+(aq)$ 406 kJ mol^{-1} ⬭

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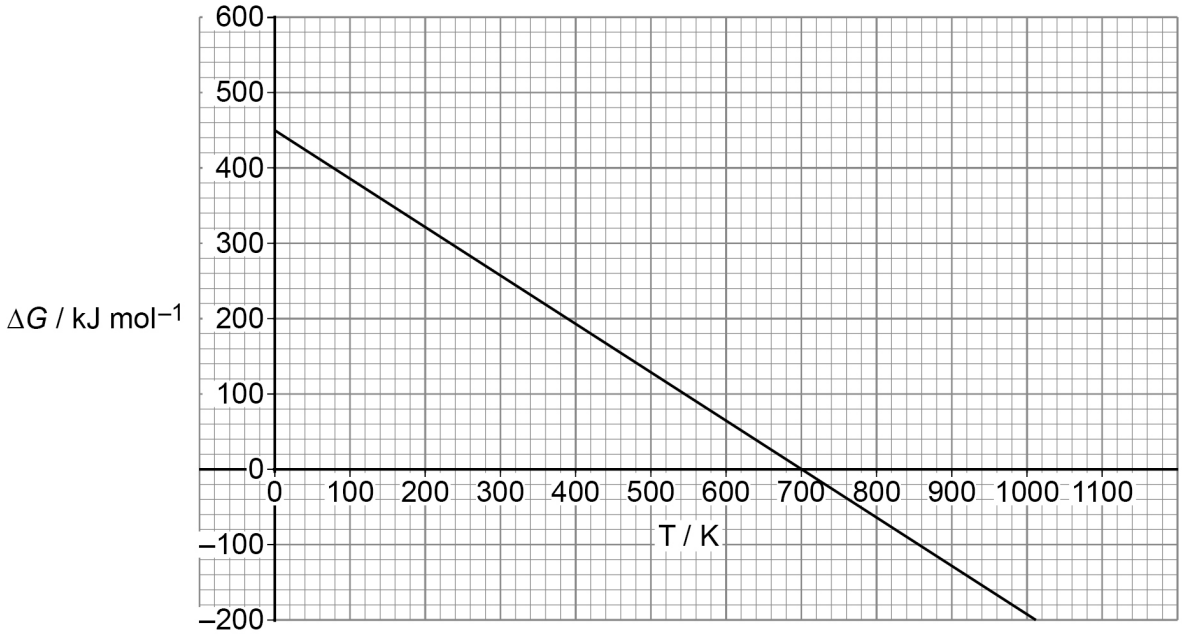
0 8 The graph shows how the Gibbs free-energy change, ΔG, for a reaction varies with temperature.



What is the entropy change, ΔS, for the reaction?

[1 mark]

A $-643\ J\ K^{-1}\ mol^{-1}$ ⬭

B $450\ J\ K^{-1}\ mol^{-1}$ ⬭

C $643\ J\ K^{-1}\ mol^{-1}$ ⬭

D $700\ J\ K^{-1}\ mol^{-1}$ ⬭

Do not write outside the box

0 9 Which silver species is able to oxidise V^{3+} to VO^{2+} but is not able to oxidise VO^{2+} any further?

	$E^{\ominus}$ / V
$VO_2^+ + 2H^+ + e^- \rightarrow VO^{2+} + H_2O$	1.00
$VO^{2+} + 2H^+ + e^- \rightarrow V^{3+} + H_2O$	0.34
$Ag^{2+} + e^- \rightarrow Ag^+$	1.98
$Ag(NH_3)_2^+ + e^- \rightarrow Ag + 2NH_3$	0.37
$AgBr + e^- \rightarrow Ag + Br^-$	0.07
$Ag(CN)_2^- + e^- \rightarrow Ag + 2CN^-$	–0.38

[1 mark]

A Ag^{2+} ⬭

B $Ag(NH_3)_2^+$ ⬭

C AgBr ⬭

D $Ag(CN)_2^-$ ⬭

1 0 The pK_a of propanoic acid is 4.87

What is the K_a for the equilibrium shown?

$$CH_3CH_2COOH \rightleftharpoons CH_3CH_2COO^- + H^+$$

[1 mark]

A 1.35×10^{-5} mol dm^{-3} ⬭

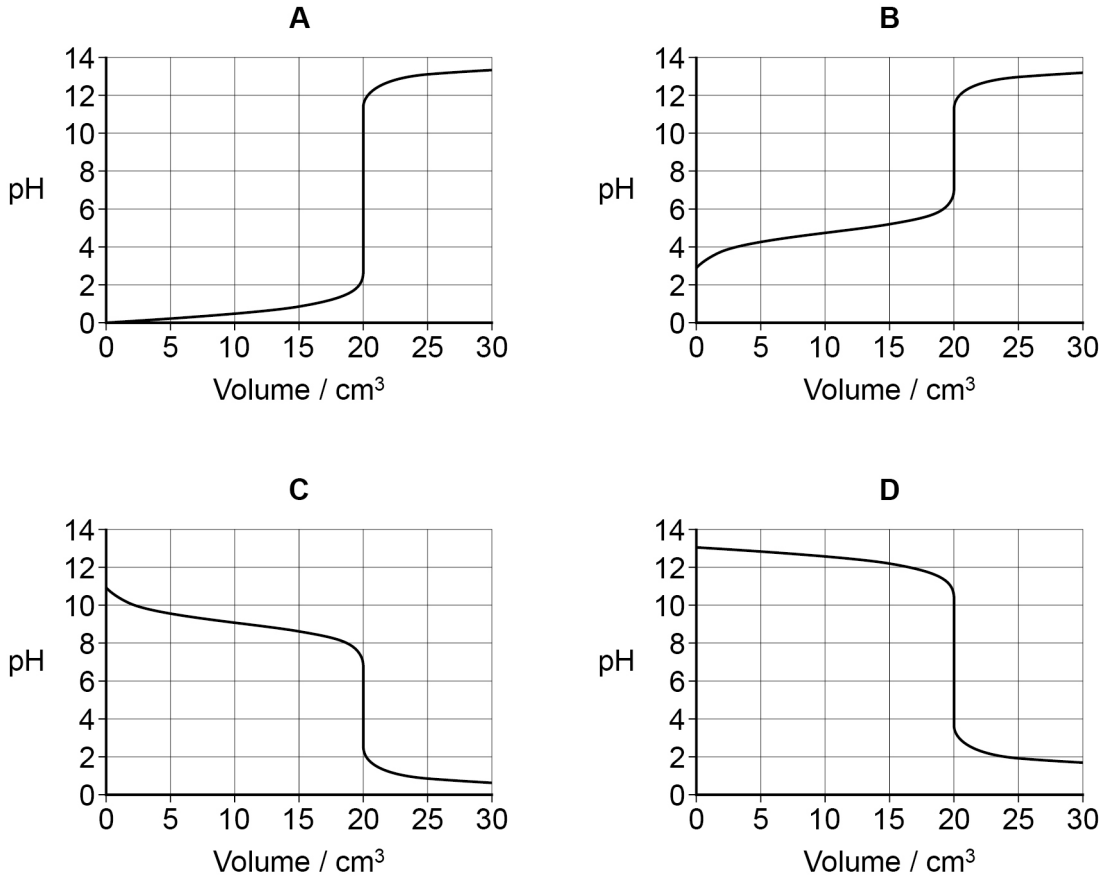
B 6.88×10^{-1} mol dm^{-3} ⬭

C 4.87 mol dm^{-3} ⬭

D 7.41×10^{4} mol dm^{-3} ⬭

Do not write outside the box

1 1 The graphs show the change in pH as one solution is added to another.



Which statement is correct?

[1 mark]

A Curve **A** is produced when dilute ammonia solution is added to hydrochloric acid. ⬭

B Curve **B** is produced when sodium hydroxide solution is added to hydrochloric acid. ⬭

C Curve **C** is produced when hydrochloric acid is added to dilute ammonia solution. ⬭

D Curve **D** is produced when ethanoic acid is added to dilute ammonia solution. ⬭

Do not write outside the box

1 2 25 cm^3 of aqueous **Solution 1** are added to 50 cm^3 of aqueous **Solution 2**.

The concentrations of both solutions are the same.

Which pair of solutions would produce an **acidic** buffer?

[1 mark]

	25 cm^3 of Solution 1	**50 cm^3 of Solution 2**	
A	NaOH	CH_3COOH	⬭
B	CH_3COOH	NH_3	⬭
C	CH_3COONa	HCl	⬭
D	HCl	NaOH	⬭

1 3 Which waste product from the burning of natural gas can be removed by calcium oxide?

[1 mark]

A carbon ⬭

B carbon monoxide ⬭

C sulfur dioxide ⬭

D unburned methane ⬭

1 4 Which statement explains the change in boiling point from fluorine to iodine?

[1 mark]

A The bonds between the atoms in the molecules get stronger. ⬭

B The nuclear charge increases. ⬭

C The shielding increases. ⬭

D The van der Waals forces between the molecules get stronger. ⬭

Do not write outside the box

1 5 Which statement is correct about reactions of chlorine?

[1 mark]

A When chlorine is added to water, in the dark, the only products are hydrochloric acid and chloric(I) acid. ⬭

B When chlorine is added to water, in sunlight, the only product is hydrochloric acid. ⬭

C When chlorine is added to cold sodium hydroxide solution the only products are sodium chlorate(I) and sodium chloride. ⬭

D When chlorine is added to sodium fluoride solution, the only products are sodium chloride and fluorine. ⬭

1 6 Which explains an increase in the rate constant, *k* ?

[1 mark]

A An increase in temperature increases the pressure in a gas. ⬭

B An increase in temperature increases the average kinetic energy of the molecules in a gas. ⬭

C An increase in temperature increases the activation energy of the molecules in a gas. ⬭

D An increase in temperature decreases the activation energy of the reaction. ⬭

1 7 Which statement is correct?

[1 mark]

A The ionisation energy of barium is higher than strontium because barium atoms are larger. ⬭

B When magnesium reacts with steam at 100 °C the products are magnesium hydroxide and hydrogen. ⬭

C When testing for sulfate ions, barium chloride is acidified with sulfuric acid to prevent other ions giving a false positive result. ⬭

D In the extraction of titanium, two moles of magnesium react with one mole of titanium(IV) chloride. ⬭

Do not write outside the box

1 8 Period 3 elements are reacted with an excess of chlorine.
The table shows some information about the products when they are cooled to room temperature.

Which row is correct?

[1 mark]

A	$MgCl_2$	Covalent solid	⬭
B	$AlCl_3$	Ionic solid	⬭
C	$SiCl_4$	Covalent liquid	⬭
D	PCl_5	Covalent gas	⬭

1 9 Which gives a change in the charge on the complex ion **and** a change in the co-ordination number on the transition metal ion?

[1 mark]

A Adding an excess of concentrated hydrochloric acid to aqueous cobalt(II) sulfate ⬭

B Adding an excess of sodium ethanedioate to aqueous copper(II) sulfate ⬭

C Adding an excess of ammonia to aqueous copper(II) sulfate ⬭

D Adding an excess of $EDTA^{4-}$ ions to aqueous iron(II) sulfate ⬭

2 0 Which would give no visible change after mixing?

[1 mark]

A $BaCl_2(aq)$ and $NaOH(aq)$ ⬭

B $BaCl_2(aq)$ and $Na_2SO_4(aq)$ ⬭

C $MgCl_2(aq)$ and $Ba(OH)_2(aq)$ ⬭

D $MgSO_4(aq)$ and $Ba(OH)_2(aq)$ ⬭

Do not write outside the box

2 1 What is observed when $AgNO_3(aq)$ followed by concentrated $NH_3(aq)$ are added to NaBr(aq)?

[1 mark]

A Cream precipitate, no visible change when concentrated $NH_3(aq)$ is added

B Cream precipitate, reacts to form a colourless solution when concentrated $NH_3(aq)$ is added

C Yellow precipitate, no visible change when concentrated $NH_3(aq)$ is added

D White precipitate, reacts to form a colourless solution when concentrated $NH_3(aq)$ is added

2 2 Which complex does **not** display *cis–trans* isomerism?

[1 mark]

A $Co(NH_3)_4Cl_2$

B $[Cr(H_2NCH_2CH_2NH_2)_3]^{3+}$

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

D $Pt(NH_3)_2Cl_2$

2 3 A solution absorbs visible light with wavelengths corresponding to red, yellow and green light.

Which ion is most likely to be in the solution?

[1 mark]

A $Cr^{3+}(aq)$

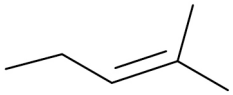
B $Cu^{2+}(aq)$

C $Fe^{2+}(aq)$

D $Zn^{2+}(aq)$

Do not write outside the box

2 4 Which is the correct name, using IUPAC rules, for the skeletal structure shown?



[1 mark]

A 1,1-dimethylbut-1-ene ⬭

B 2-methylpent-2-ene ⬭

C 4-methylpent-3-ene ⬭

D 4,4-dimethylbut-3-ene ⬭

2 5 A section of a polymer chain is shown

$$– CF_2 – CF_2 – CF_2 – CF_2 – CF_2 – CF_2 – CF_2 – CF_2 –$$

What is the name of the monomer used to form the polymer?

[1 mark]

A Difluoromethane ⬭

B Difluoroethene ⬭

C Tetrafluoromethane ⬭

D Tetrafluoroethene ⬭

2 6 Which forms a polymer with $ClOC(CH_2)_4COCl$?

[1 mark]

A $CH_3CH_2CH_2CH_2NH_2$ ⬭

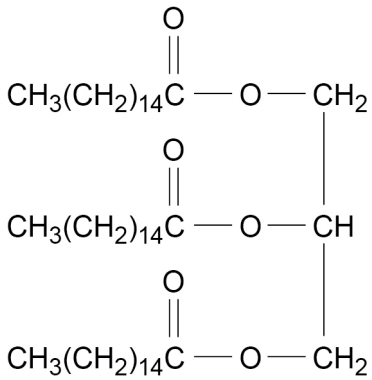
B $HOCH_2CH_2CH_2COOH$ ⬭

C $NH_2CH_2CH_2CH_2NH_2$ ⬭

D $HOOCCH_2CH_2COOH$ ⬭

Do not write outside the box

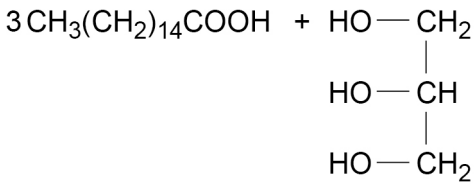
2 7 The structure of a vegetable oil is shown

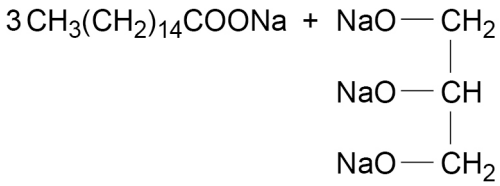


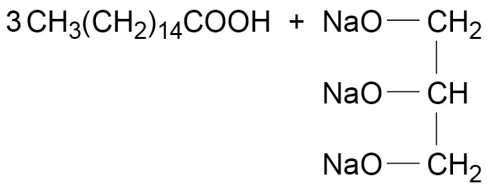
The vegetable oil is hydrolysed with an **excess** of sodium hydroxide solution.

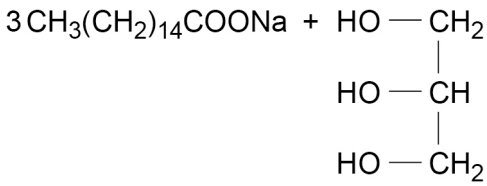
Which shows the correct products formed?

[1 mark]

A 

B 

C 

D 

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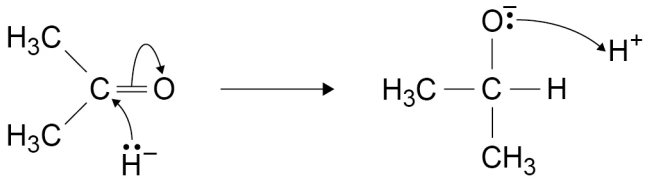
2 8 Which shows the correct mechanism for the reduction of propanone with $NaBH_4$ in aqueous solution?

[1 mark]

A



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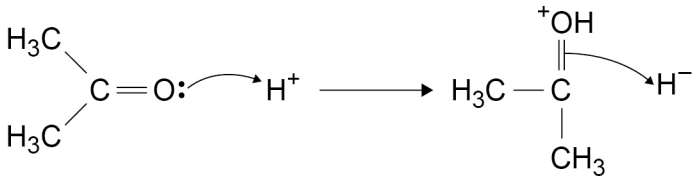

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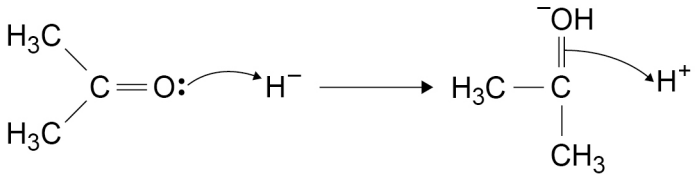

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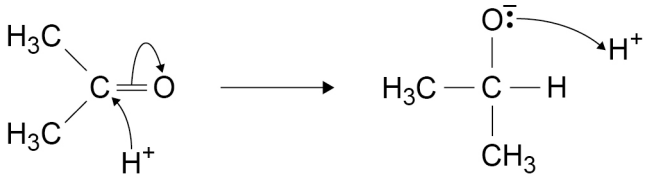

Turn over for the next question

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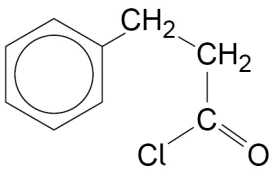
2 9 Compound **X** undergoes an electrophilic substitution reaction when it is mixed with $AlCl_3$ The $AlCl_3$ is used as a catalyst.

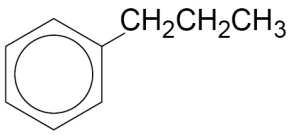


Compound **X**

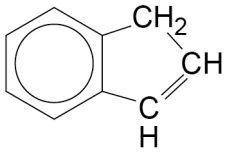
What is the structure of the organic product?

[1 mark]

A



B



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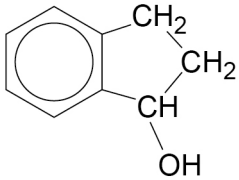

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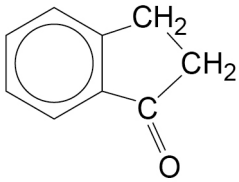

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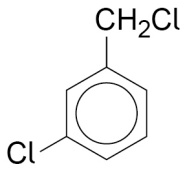
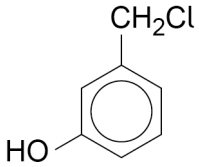
3 0 Which product is formed when Compound **Y** is reacted with warm aqueous sodium hydroxide?



Compound **Y**

[1 mark]

A



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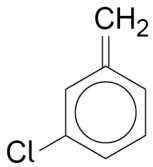

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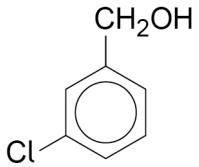

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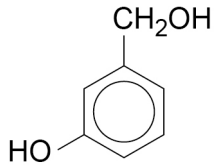

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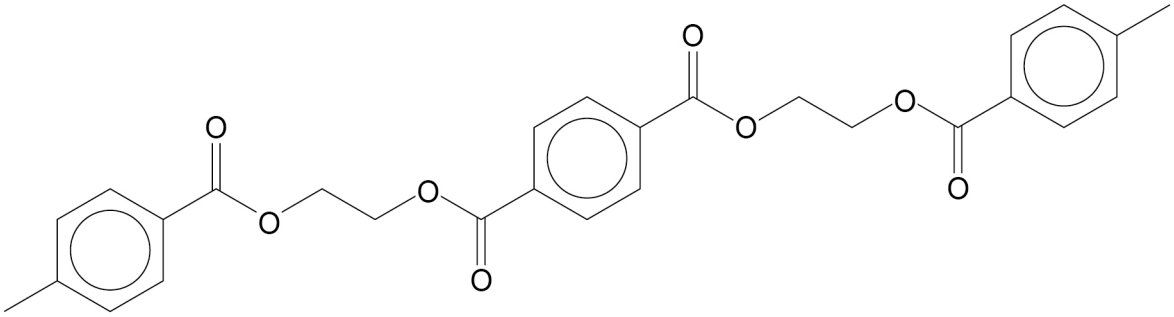
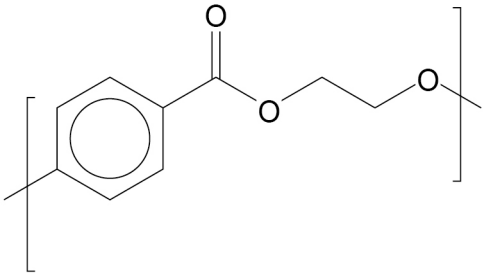
3 1 This is part of a polymer chain.



Which is the repeating unit of the polymer?

[1 mark]

A



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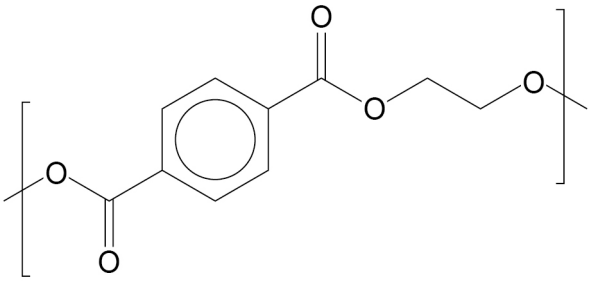

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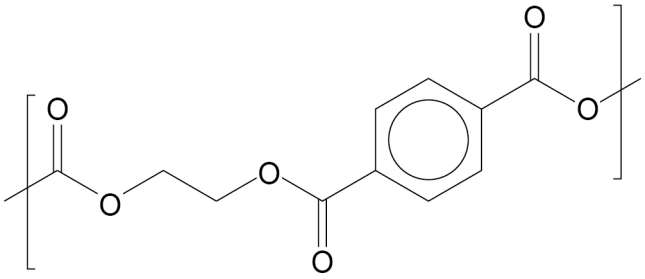

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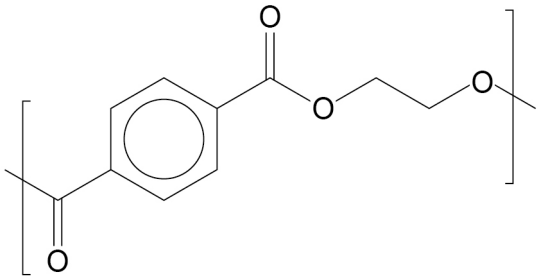

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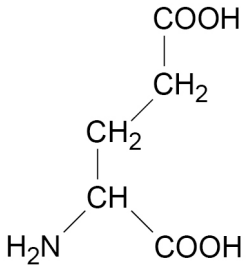
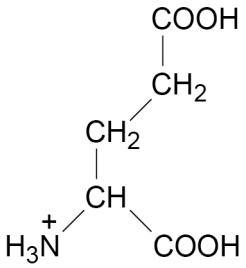
3 2 Which ion is formed by this amino acid in a solution at pH 12?



[1 mark]

A



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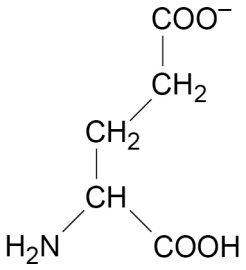

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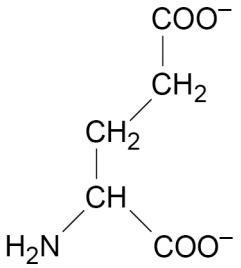

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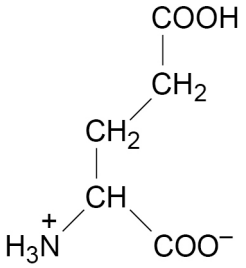

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3 3 Which solvent should be used when obtaining the ^{1}H NMR spectrum of an amino acid?

[1 mark]

A H_2O ⬭

B D_2O ⬭

C CD_4 ⬭

D CCl_4 ⬭

30

END OF QUESTIONS

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