OXFORD

INTERNATIONAL
AQA EXAMINATIONS

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

Thursday 22 June 2023 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 test-tube reactions of some transition metal ions in aqueous solution.

0 1 . 1 A student adds sodium carbonate solution to a solution of iron(II) sulfate to form iron(II) carbonate.

Give the colour of the precipitate.

Give the ionic equation for the reaction, including state symbols.

[2 marks]

Colour of precipitate Green (precipitate)

Equation

$Fe^{2+}(aq) + CO_3^{2-}(aq) \rightarrow FeCO_3(s)$

0 1 . 2 Calculate the maximum mass, in g, of iron(II) carbonate that can be formed from 10.0 cm^3 of 0.500 mol dm^{-3} iron(II) sulfate solution.

[2 marks]

Amount of $FeSO_4$ = 0.500 × 10.0 ÷ 1000 = 5.00×10^{-3} mol

$FeSO_4 : FeCO_3$ = 1 : 1, so 5.00×10^{-3} mol $FeCO_3$

M_r $FeCO_3$ = 55.8 + 12.0 + 3 × 16.0 = 115.8

Mass = $5.00 \times 10^{-3} \times 115.8$ = 0.579 g

Mass 0.579 g

0 1 . 3 A solution of iron(III) sulfate has pH < 7

Write an ionic equation to show why the solution is acidic.

[1 mark]

$[Fe(H_2O)_6]^{3+} + H_2O \rightleftharpoons [Fe(H_2O)_5(OH)]^{2+} + H_3O^+$

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0 1 . 4 Explain why iron(III) carbonate is **not** formed by adding sodium carbonate solution to a solution of iron(III) sulfate.

[1 mark]

The iron(III) sulfate solution is acidic, so the carbonate ions react with the H_3O^+ ions forming CO_2 gas; brown $Fe(OH)_3$ forms instead.

0 1 . 5 A student adds sodium hydroxide solution to a solution of copper(II) sulfate.

State what is observed after a few drops of sodium hydroxide solution are added.

State what is observed after an excess of sodium hydroxide solution is added.

[2 marks]

A few drops A pale blue precipitate forms.

An excess No further change: the blue precipitate does not dissolve.

0 1 . 6 A student adds concentrated ammonia solution to a solution of copper(II) sulfate.

State what is observed after a few drops of concentrated ammonia solution are added.

State what is observed after an excess of concentrated ammonia solution is added.

[2 marks]

A few drops A pale blue precipitate forms.

An excess The precipitate dissolves to give a deep blue solution.

0 1 . 7 Give the formula of the copper-containing species formed when an excess of concentrated ammonia solution is added to copper(II) sulfate solution.

[1 mark]

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

0 1 . 8 Give the formula of the copper-containing species formed when an excess of concentrated hydrochloric acid is added to copper(II) sulfate solution.

[1 mark]

$[CuCl_4]^{2-}$

12

Turn over ►

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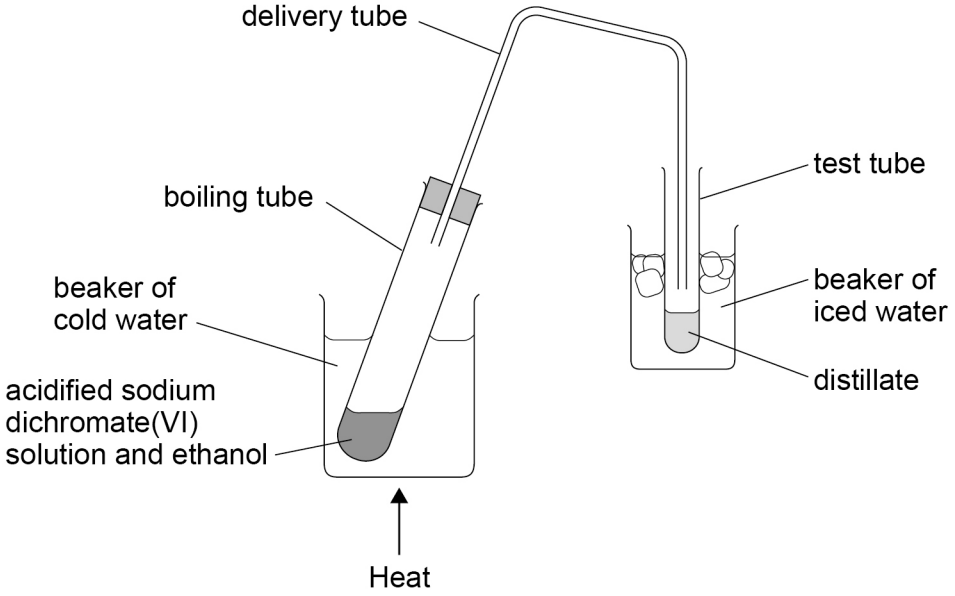
0 2 A student converts ethanol to ethanal.

Method

1. Pour 10 cm^3 acidified sodium dichromate(VI) solution into a boiling tube.
2. Place the boiling tube in a beaker of cold water to cool the solution.
3. Slowly add 2 cm^3 of ethanol to the acidified sodium dichromate(VI) solution and swirl the boiling tube gently.
4. Attach a delivery tube to the boiling tube.
5. Heat the water in the beaker and collect the distillate in a test tube surrounded with iced water.

Figure 1 shows the apparatus used in step 5 of the method.

Figure 1



0 2 . 1 State the role of the acidified sodium dichromate(VI) solution in the reaction.

[1 mark]

Oxidising agent (it oxidises the ethanol to ethanal).

0 2 . 2 Suggest **one** reason why the acidified sodium dichromate(VI) solution is cooled before adding the ethanol.

[1 mark]

The reaction is very exothermic, so cooling stops it being too violent and stops the ethanol evaporating before the apparatus is assembled.

0 2 . 3 State what should be added to the boiling tube to prevent violent bubbling during heating.

[1 mark]

Anti-bumping granules

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0 2 . 4 A different student does not surround the test tube with iced water.

Suggest why this student obtains a much smaller volume of ethanal.

[1 mark]

Ethanal has a very low boiling point, so without iced water the ethanal vapour does not condense and it evaporates from the test tube.

0 2 . 5 State the colour of the mixture in the boiling tube after all the acidified sodium dichromate(VI) solution has reacted.

[1 mark]

Green

0 2 . 6 Tollens' reagent is used to test for an aldehyde.

Give the formula of the complex ion in Tollens' reagent.

State what is observed when Tollens' reagent reacts with an aldehyde.

[2 marks]

Formula of complex ion $[Ag(NH_3)_2]^+$

Observation A silver mirror forms.

0 2 . 7 Identify a reagent used to show that the final product does **not** contain any ethanoic acid.

Give the observation that shows that the final product does **not** contain any ethanoic acid.

[2 marks]

Reagent Sodium carbonate solution (Na_2CO_3)

Observation No effervescence (no bubbles of CO_2 gas).

9

Turn over for the next question

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0 3 **Table 1** shows some electrochemical data.

Table 1

	$E^{\ominus}$ / V
$Mg^{2+}(aq) + 2e^- \rightarrow Mg(s)$	–2.38
$Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$	–0.44
$O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$	+0.40

0 3 . 1 Iron reacts with water that contains dissolved oxygen.

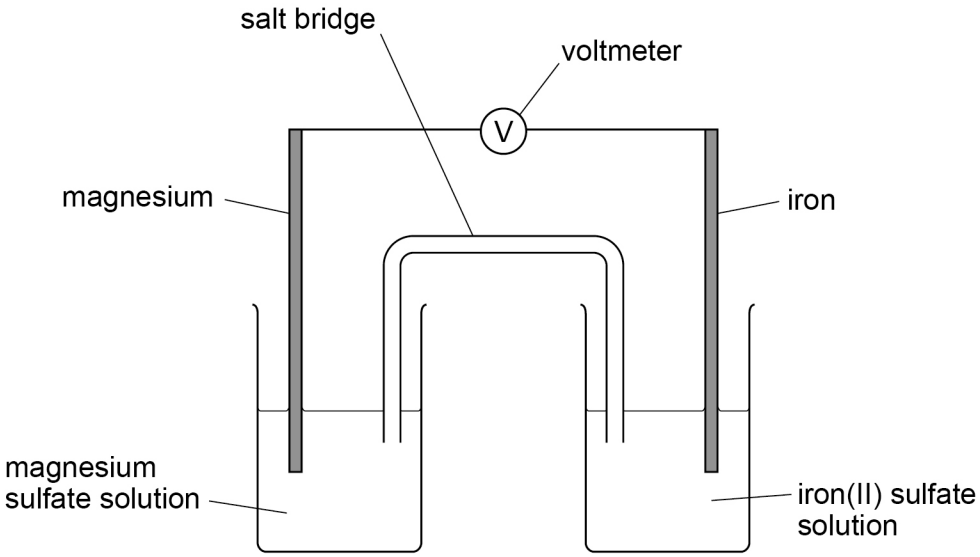
Use the data in **Table 1** to write an overall equation for this reaction.

[1 mark]

$2\ Fe(s) + O_2(g) + 2\ H_2O(l) \rightarrow 2\ Fe^{2+}(aq) + 4\ OH^-(aq)$

A student sets up the electrochemical cell shown in **Figure 2**.

Figure 2



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0 3 . 2 Before setting up the cell, the student cleaned the surfaces of the metals by

- gently rubbing the surfaces of the metals with sandpaper
- wiping the surfaces of the metals with propanone.

State what is removed from the surfaces of the metals by each process.

Explain why it is important to clean the surfaces of the metals.

[3 marks]

Rubbing with sandpaper The oxide layer (coating) on the surface of the metal.

Wiping with propanone Any grease (oil) on the surface of the metal.

Explanation To ensure good electrical contact between the metal and the solution, so the EMF measured is accurate.

0 3 . 3 State the purpose of the salt bridge in **Figure 2**.

[1 mark]

To allow ions to flow between the two solutions, which completes the circuit and balances the charges.

0 3 . 4 Calculate the EMF, under standard conditions, of the cell in **Figure 2**.

[1 mark]

$EMF = E_{right} - E_{left} = E_{Fe} - E_{Mg}$

$= -0.44 - (-2.38) = +1.94$ V

EMF 1.94 V

0 3 . 5 Write an equation for the process that occurs at the negative electrode when the cell is working.

[1 mark]

$Mg(s) \rightarrow Mg^{2+}(aq) + 2e^-$

Turn over ▶

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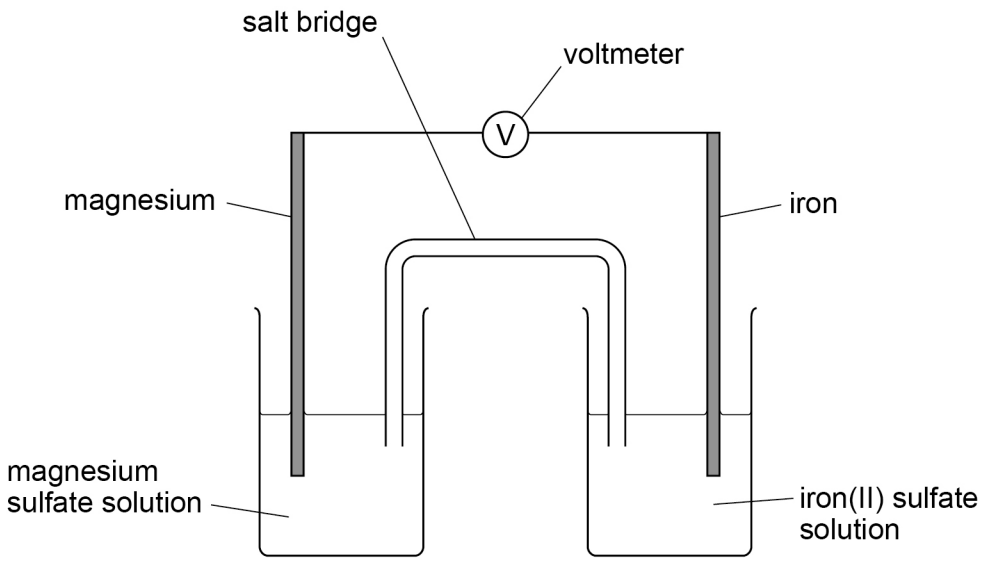
Table 1 and **Figure 2** are repeated here.

Table 1

	$E^{\ominus}$ / V
$Mg^{2+}(aq) + 2e^- \rightarrow Mg(s)$	–2.38
$Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$	–0.44
$O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$	+0.40

Figure 2



0 3 . 6 Deduce the conventional cell representation for the cell in **Figure 2**. Include all state symbols.

[1 mark]

$Mg(s) \mid Mg^{2+}(aq) \parallel Fe^{2+}(aq) \mid Fe(s)$

0 3 . 7 The student adds some solid magnesium sulfate to the magnesium sulfate solution and stirs until the solid dissolves.

Suggest how the EMF of the cell changes, if at all.

[1 mark]

The EMF decreases: a higher $[Mg^{2+}]$ shifts the Mg^{2+}/Mg equilibrium to the left, so its electrode potential becomes less negative.

9

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Turn over for Section B

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Turn over ►

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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 answer completely fill in the circle alongside the appropriate answer.

CORRECT METHOD ⬬ WRONG METHODS

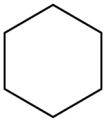
If you want to change your answer you must cross out your original answer as shown.

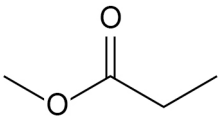
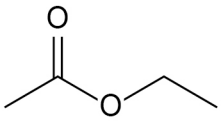
If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown.

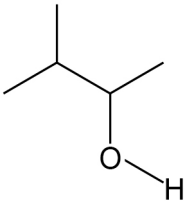
You may do your working in the blank space around each question but this will not be marked.

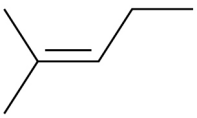
0 4 Which statement is correct?

[1 mark]

A and  are functional group isomers

B  and  are functional group isomers

C  exists as stereoisomers

D  exists as stereoisomers

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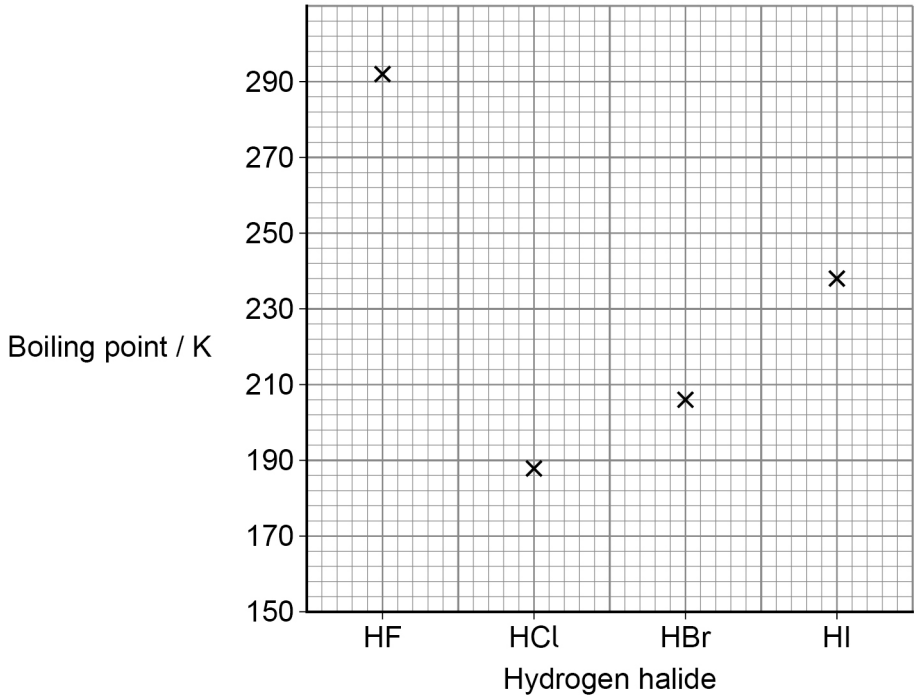
0 5 The graph shows the boiling points of the hydrogen halides.



Which statement is correct?

[1 mark]

A HCl has a lower boiling point than HF because HCl has weaker covalent bonds than HF

B HCl has a lower boiling point than HF because HCl has weaker hydrogen bonds between the molecules.

C HBr has a higher boiling point than HCl because H–Br bonds are more polar than H–Cl bonds.

D HI has a higher boiling point than HBr because HI molecules are larger and have more electrons than HBr molecules.

Turn over for the next question

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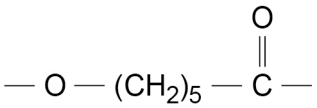
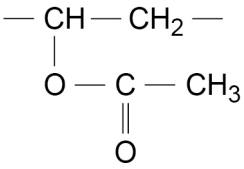
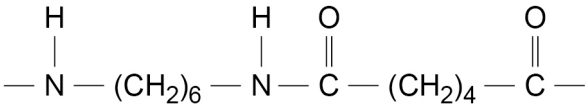
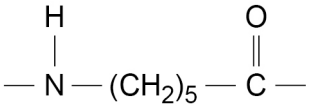
0 6 Which repeating unit represents a polymer that is **not** biodegradable?

[1 mark]

A 

B 

C 

D 

0 7 A solution with volume 100 cm^3 contains 1.34 g of rubidium sulfate (M_r = 267.1).

What is the concentration of rubidium ions in this solution?

[1 mark]

A 0.005 mol dm^{-3}

B 0.01 mol dm^{-3}

C 0.05 mol dm^{-3}

D 0.1 mol dm^{-3}

Do not write outside the box

0 8 What is the formula of strontium phosphate(V)?

[1 mark]

A $SrPO_4$ ○

B $Sr(PO_4)_2$ ○

C $Sr_2(PO_4)_3$ ○

D $Sr_3(PO_4)_2$ ●

0 9 What is the pH of a 0.15 mol dm^{-3} solution of nitric acid?

[1 mark]

A 0.71 ○

B 0.82 ●

C 1.00 ○

D 1.41 ○

1 0 What is the pH of a 0.50 mol dm^{-3} solution of sodium hydroxide at 25 °C?

The ionic product of water, $K_w = 1.00 \times 10^{-14}$ mol^2 dm^{-6} at 25 °C

[1 mark]

A 0.30 ○

B 13.70 ●

C 14.00 ○

D 14.30 ○

Turn over for the next question

Do not write outside the box

1 1 Which statement is correct?

[1 mark]

A The atomic radius of the elements in Period 2 increases from Mg to Si

B The first ionisation energies of the elements in Group 2 increase from Mg to Ba

C The electronegativities of the elements in Group 6 increase from O to Se

D The melting points of the elements in Period 3 increase from Mg to Si

1 2 What is the mechanism for the reaction between primary amines and acyl chlorides?

[1 mark]

A Electrophilic substitution

B Nucleophilic substitution

C Nucleophilic addition-elimination

D Electrophilic addition-elimination

1 3 Which statement explains the trend in melting point of Group 2 elements from Ca to Ba?

[1 mark]

A Van der Waals' forces become stronger as the number of electrons in each ion increases.

B The attraction between the nucleus and the delocalised electrons becomes weaker as the size of the ion increases.

C The attraction between the metal ions becomes greater as the size of the ion increases.

D The attraction between the nucleus and the bonding electrons becomes stronger as the nuclear charge increases.

Do not write outside the box

1 4 The temperature of a sample of gas is increased at a constant pressure.
This causes a large increase in the rate of decomposition of the gas.

What is the best explanation for this large increase in the rate of decomposition?

[1 mark]

A The gas particles are closer together. ○

B The average energy of the gas particles increases. ○

C The most probable energy of the gas particles increases. ○

D There are more gas particles with $E \geq E_a$ ●

1 5 An endothermic reaction has $\Delta H = \boldsymbol{x}$

For the uncatalysed forward reaction, activation energy = $\boldsymbol{y}$

For the catalysed forward reaction, activation energy = $\boldsymbol{z}$

What is the activation energy for the catalysed reverse reaction?

[1 mark]

A $\boldsymbol{y}$ ○

B $\boldsymbol{z}$ ○

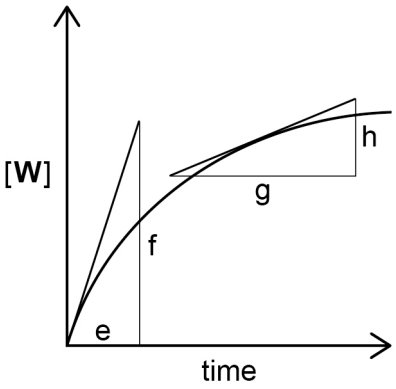
C $\boldsymbol{y - z}$ ○

D $\boldsymbol{z - x}$ ●

Turn over for the next question

Do not write outside the box

1 6 The graph shows how the concentration of a compound **W** changes during its formation in a reaction.
Two tangents are drawn to the curve.



What is the initial rate of this reaction?

[1 mark]

A $\frac{e}{f}$

B $\frac{f}{e}$

C $\frac{g}{h}$

D $\frac{h}{g}$

Do not write outside the box

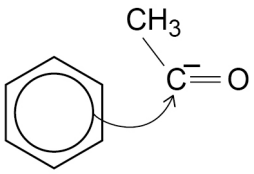
1 7 An equation for the reaction between benzene and ethanoyl chloride is shown.

$$C_6H_6 + CH_3COCl \rightarrow C_6H_5COCH_3 + HCl$$

Which is a correct step in the mechanism for this reaction?

[1 mark]

A



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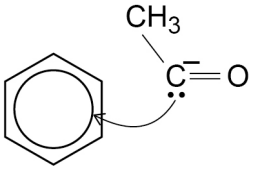

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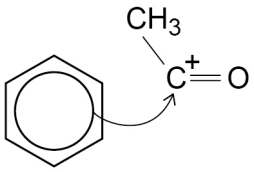

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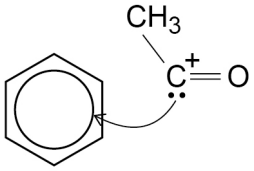

Turn over for the next question

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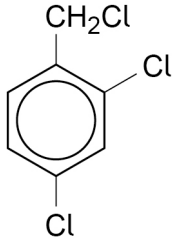
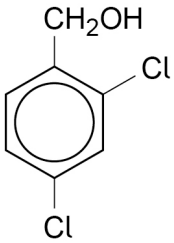
1 8 A compound has the structure



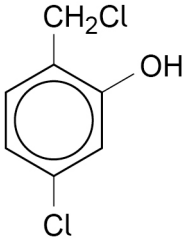
What is the structure of the major organic product when this compound is warmed with sodium hydroxide solution?

[1 mark]

A



B



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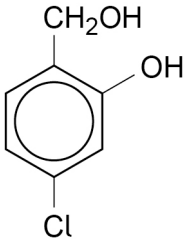
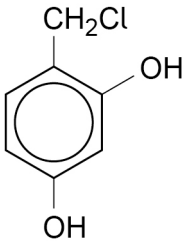


D



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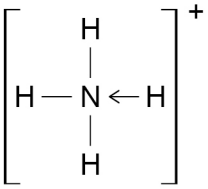
1 9 Some chemical reactions involve the formation of co-ordinate (dative covalent) bonds.

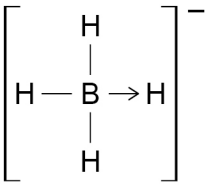
Which shows the correct bonding in the product of the reaction?

[1 mark]

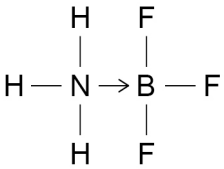
A $NH_3 + H^+ \rightarrow$



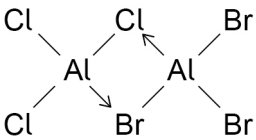
B $BH_3 + H^- \rightarrow$



C $NH_3 + BF_3 \rightarrow$



D $AlCl_3 + AlBr_3 \rightarrow$



2 0 Which row shows the number of each fundamental particle in a $^{15}N^{3-}$ ion?

[1 mark]

	protons	neutrons	electrons
A	7	7	10
B	7	8	7
C	7	8	10
D	8	7	10

Turn over ▶

Do not write outside the box

2 1 The equation for a ligand substitution reaction is

$$[Cu(H_2O)_6]^{2+} + EDTA^{4-} \rightarrow [Cu(EDTA)]^{2-} + 6\,H_2O$$

Which statement helps to explain why this reaction happens?

[1 mark]

A The entropy change is positive because there is an increase in the number of particles from 2 to 7

B The entropy change is negative because there is an increase in the number of particles from 2 to 7

C The bonds in $[Cu(EDTA)]^{2-}$ are much stronger than the bonds in $[Cu(H_2O)_6]^{2+}$ so the reaction is very exothermic.

D The bonds in $[Cu(EDTA)]^{2-}$ are much stronger than the bonds in $[Cu(H_2O)_6]^{2+}$ so the reaction is very endothermic.

2 2 Excess zinc is added to an acidic solution of ammonium vanadate(V) in a boiling tube.

What is the formula of the vanadium-containing species at the end of the reaction?

[1 mark]

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

B $[V(H_2O)_6]^{3+}$

C VO^{2+}

D VO_2^{+}

2 3 Which of the following does **not** change the redox potential for the reduction of $Co^{3+}(aq)$ to $Co^{2+}(aq)$?

[1 mark]

A Adding a strong alkali

B Adding a strong acid

C Adding a solution containing $EDTA^{4-}$ ions

D Adding an oxidising agent

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2 4 What is the mass, in kg, of one molecule of CH_4 ?

The Avogadro constant, $L = 6.02 \times 10^{23}$ mol^{-1}

[1 mark]

A 1.66×10^{-26} ⬭

B 2.66×10^{-26} ●

C 1.66×10^{-23} ⬭

D 2.66×10^{-23} ⬭

2 5 The table shows some enthalpy of hydrogenation data.

Substance	ΔH / kJ mol^{-1}
cyclohexene	–120
benzene	–208

Which calculation shows the extra stability of benzene compared with the theoretical molecule cyclohexa-1,3,5-triene?

[1 mark]

A –120 – (–208) ⬭

B (–120 × 3) – (–208) ●

C –120 – 208 ⬭

D (–120 × 3) + (–208) ⬭

Turn over for the next question

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2 6 Bauxite is an ore of aluminium.
A sample of bauxite contains 40% by mass of Al_2O_3 (M_r = 102.0).

What is the mass, in g, of aluminium in 500 g of this sample?

[1 mark]

A 27 ○

B 53 ○

C 106 ●

D 265 ○

2 7 Four alcohols are each warmed with acidified potassium dichromate(VI) solution.

Which alcohol does **not** give a colour change?

[1 mark]

A 2-methylbutan-1-ol ○

B 2-methylbutan-2-ol ●

C 3-methylbutan-1-ol ○

D 3-methylbutan-2-ol ○

2 8 Which solution does **not** form a white precipitate when added to barium chloride solution?

[1 mark]

A nitric acid ●

B silver nitrate ○

C sodium sulfate ○

D sulfuric acid ○

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2 9 A solution of ammonium iodide is tested.

Test 1 Add sodium hydroxide solution and warm the mixture.
Test the gas produced with damp litmus paper.

Test 2 Add a few drops of silver nitrate solution.

Which row shows the results for ammonium iodide?

[1 mark]

	Test 1	Test 2	
A	blue litmus turns red	cream precipitate	○
B	blue litmus turns red	yellow precipitate	○
C	red litmus turns blue	cream precipitate	○
D	red litmus turns blue	yellow precipitate	●

3 0 What is the volume, in m^3, of 23.2 g of butane gas at 25 °C and 100 kPa?

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

[1 mark]

A 8.31×10^{-4} ○

B 9.91×10^{-3} ●

C 0.575 ○

D 9.91 ○

Turn over for the next question

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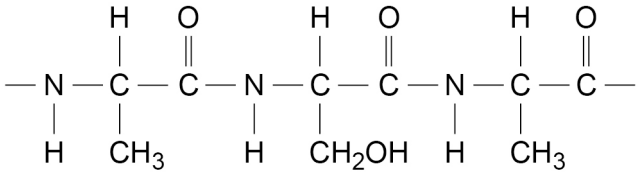
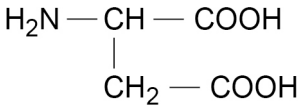
3 1 A section of the structure of a protein is shown.

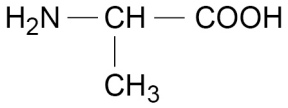


Which pair of amino acids react together to make this section of protein?

[1 mark]

A





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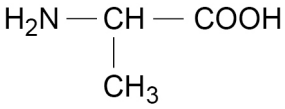

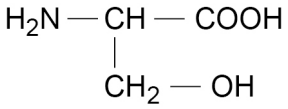

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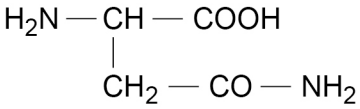

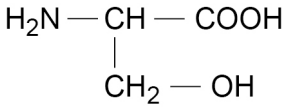

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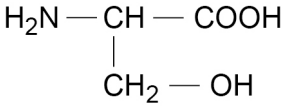

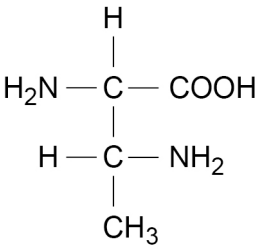

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3 2 Which compound has the highest boiling point?

[1 mark]

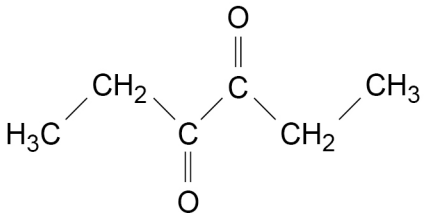
A $CH_3CH_2CH_2CH_2CH_2CH_2CH_3$ ○

B $(CH_3)_3CCH_2CH_2CH_3$ ○

C $CH_3CH_2CH_2CH_2COOH$ ●

D $CH_3CH_2CH_2COOCH_3$ ○

3 3 What is the splitting pattern in the ^1H NMR spectrum of this compound?



[1 mark]

A One doublet and one triplet ○

B Two doublets and two triplets ○

C One triplet and one quartet ●

D Two triplets and two quartets ○

30

END OF QUESTIONS

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