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

Monday 20 January 2025 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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ANSWER IN THE SPACES PROVIDED

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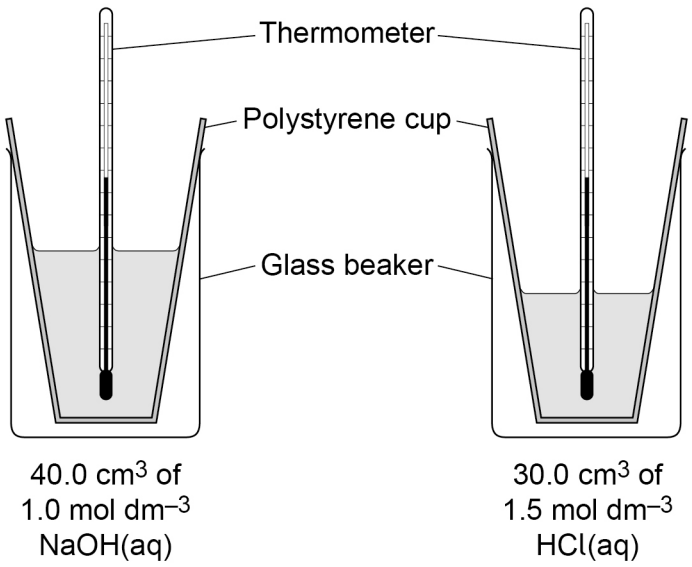
Section A

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

0 1 A student investigates the enthalpy change when an acid reacts with an alkali.

Figure 1 shows the equipment used.

Figure 1



Method

Step 1 The temperature of each solution is recorded every minute.

Step 2 At the fourth minute, the temperature is not recorded.
The hydrochloric acid is poured into the sodium hydroxide and the mixture is stirred.

Step 3 The temperature of the mixture is recorded at the fifth minute and every minute for five more minutes.

0 1 . 1 Suggest why the acid and alkali should be kept in the laboratory with a thermometer in each for at least an hour before the experiment is started.

[1 mark]

So that both solutions reach the same (room) temperature before they are mixed, giving a steady starting temperature.

Question 1 continues on the next page

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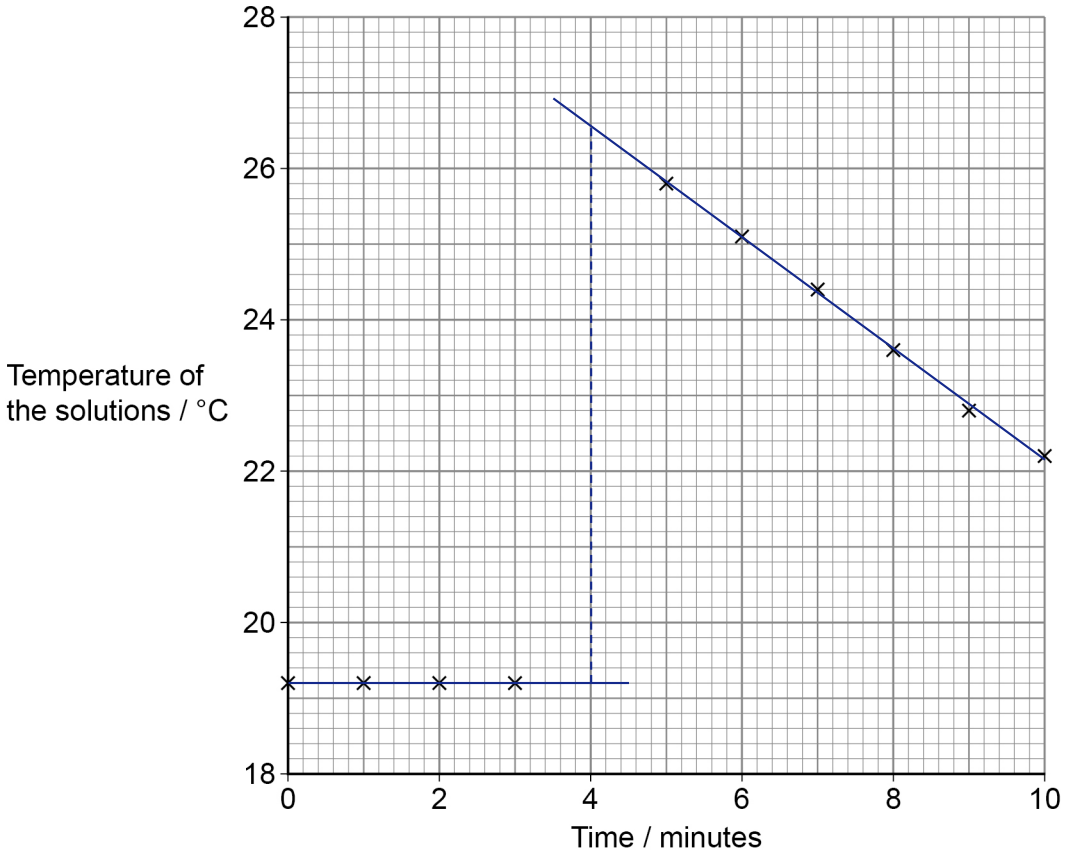
Figure 2 shows the student's results.

Figure 2



0 1 . 2 Draw **two** lines of best fit on the graph in **Figure 2**.

Use your lines to calculate the temperature increase at the fourth minute.

[2 marks]

26.5 − 19.2 = 7.3

Temperature increase 7.3 °C

0 1 . 3 It is more accurate to measure the maximum temperature reached at the fourth minute using a graph rather than using the maximum temperature shown on the thermometer.

Suggest **two** reasons why.

[2 marks]

Reason 1 The reaction (mixing) is not complete immediately, and the thermometer takes time to respond to the temperature rise.

Reason 2 Extrapolating the cooling line back to the fourth minute allows for the heat lost to the surroundings.

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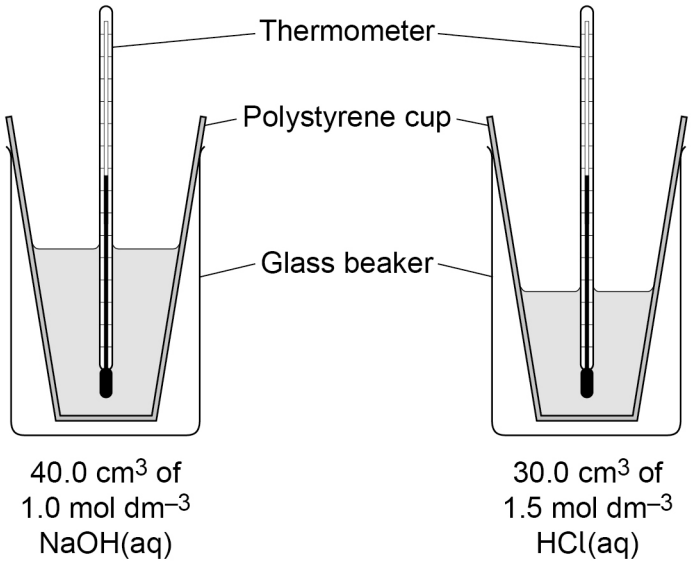
Figure 1 is repeated here.



The experiment provides data for the student to calculate the enthalpy change for the reaction

$$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$$

The student uses the equation to calculate the heat change, Q.

heat change, Q = mass × specific heat capacity × temperature change

Specific heat capacity of the solution = 4.18 J K^{-1} g^{-1}
Density of the solution after mixing = 1.00 g cm^{-3}

0 1 . 4 State the value, in g, the student should use for mass in the equation to calculate the heat change.

[1 mark]

70 g

0 1 . 5 One of the reagents is in excess.

Calculate the amount, in mol, of $H^+(aq)$ that reacts in this experiment.

[1 mark]

$n(H^+) = 30.0 \times 1.5 / 1000 = 0.045$ mol

$n(OH^-) = 40.0 \times 1.0 / 1000 = 0.040$ mol, so HCl is in excess

$n(H^+)$ that reacts $= n(OH^-) = 0.040$ mol

0.040 mol

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Turn over ▶

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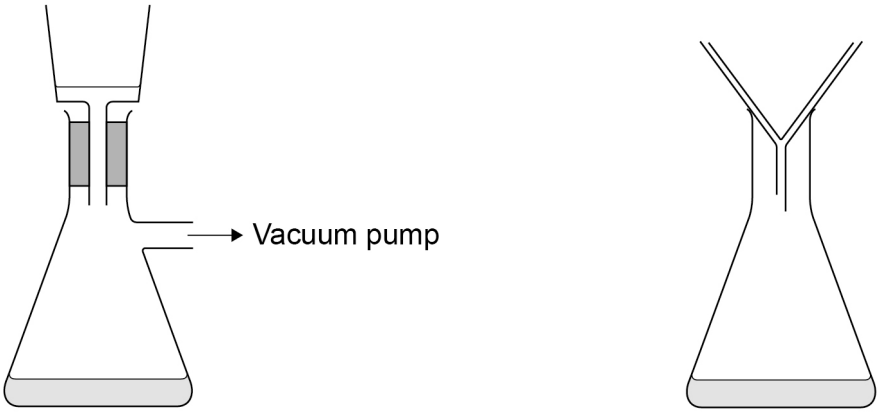
0 2 A precipitate of triiodomethane (CHI_3) is formed in a reaction and is purified by recrystallisation.

CHI_3 is almost insoluble in water but dissolves in hot ethanol.

Two methods of filtering are used.



Method **A** Method **B**

Procedure to purify the solid

Step 1 The impure solid is collected from the reaction mixture by filtering under reduced pressure (Method **A**) and washed with a small volume of cold water.

Step 2 The impure solid is dissolved in the minimum volume of hot ethanol.

Step 3 The hot mixture is filtered (Method **B**) through a hot funnel into a conical flask.

Step 4 The solution in the conical flask is then cooled in an ice bath.

Step 5 Crystals form and they are removed from the cold solution by filtering under reduced pressure (Method **A**).

0 2 . 1 State why, in **Step 1**, the impure solid product is washed after filtering.

[1 mark]

To remove soluble impurities (e.g. leftover reagents dissolved in the solution) from the surface of the solid.

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0 2 . 2 In **Step 2**, the ethanol used is heated using a water bath instead of a Bunsen burner.

Suggest why a water bath is used.

[1 mark]

Ethanol is flammable, so it could catch fire with the naked flame of a Bunsen burner.

0 2 . 3 State why, in **Step 3**, the hot mixture is filtered.

[1 mark]

To remove insoluble impurities, while the CHI_3 stays dissolved in the hot ethanol.

0 2 . 4 Explain why, in **Step 4**, the conical flask is cooled in an ice bath rather than in cold water.

[1 mark]

The lower temperature makes CHI_3 less soluble, so more crystals form and the yield is maximised.

0 2 . 5 In **Step 5**, suggest **two** advantages of using Method **A**.

[2 marks]

Advantage 1 It is faster.

Advantage 2 It helps to dry the solid (crystals).

0 2 . 6 The student measures the melting point of their sample of the solid CHI_3
The solid starts melting at 113 °C and finishes melting at 118 °C
A data book value for the melting point is 119 °C

Suggest why the student obtains a different result from the data book value.

[1 mark]

The solid is impure: impurities lower the melting point and widen the melting range.

7

Turn over ►

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0 3 A student investigates how pH changes when NaOH(aq) is added to a monoprotic weak acid (HA).

0 3 . 1 The student uses solid sodium hydroxide to prepare a solution of NaOH(aq) of known concentration.

Describe the method that the student should use to prepare 250 cm^3 of this solution.

[5 marks]

Weigh the solid NaOH in a weighing bottle, tip it into a beaker, then reweigh the empty weighing bottle so the mass of NaOH used is found by difference.

Dissolve the NaOH in about 100 cm^3 of distilled water in the beaker, stirring with a glass rod.

Transfer the solution into a 250 cm^3 volumetric flask using a funnel, and rinse the beaker, glass rod and funnel with distilled water, adding all the washings to the flask.

Add distilled water until the bottom of the meniscus is on the 250 cm^3 mark, adding the last few drops with a dropping pipette.

Stopper the flask and invert it several times so the solution is thoroughly mixed.

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The student uses the following method to investigate the pH change.

Step 1 Rinse a burette with water and then with a small volume of the NaOH(aq) made in Question **03.1**.

Step 2 Use a funnel to fill the burette with this NaOH(aq)

Step 3 Run a small volume of the NaOH(aq) through the burette tap.

Step 4 Fill the burette to the 0.00 cm^3 line with the NaOH(aq) and remove the funnel.

Step 5 Use a pipette to transfer 25.0 cm^3 of an aqueous solution of the weak acid to a beaker.

Step 6 Add small volumes of the NaOH(aq) to the beaker and swirl the mixture.

Step 7 Use a pH meter to measure the pH after each addition of NaOH(aq)

0 3 . 2 State why the student rinses the burette with NaOH(aq) in **Step 1**.

State why the student runs a small volume of the NaOH(aq) through the burette tap in **Step 3**.

State why the funnel is removed in **Step 4**.

[3 marks]

Step 1 So that the NaOH(aq) is not diluted by water left in the burette, so its concentration does not change.

Step 3 To fill the jet space below the tap with NaOH(aq), otherwise the titre recorded would be too large.

Step 4 So that drops of NaOH(aq) do not fall from the funnel into the burette, which would make the titre too small.

Question 3 continues on the next page

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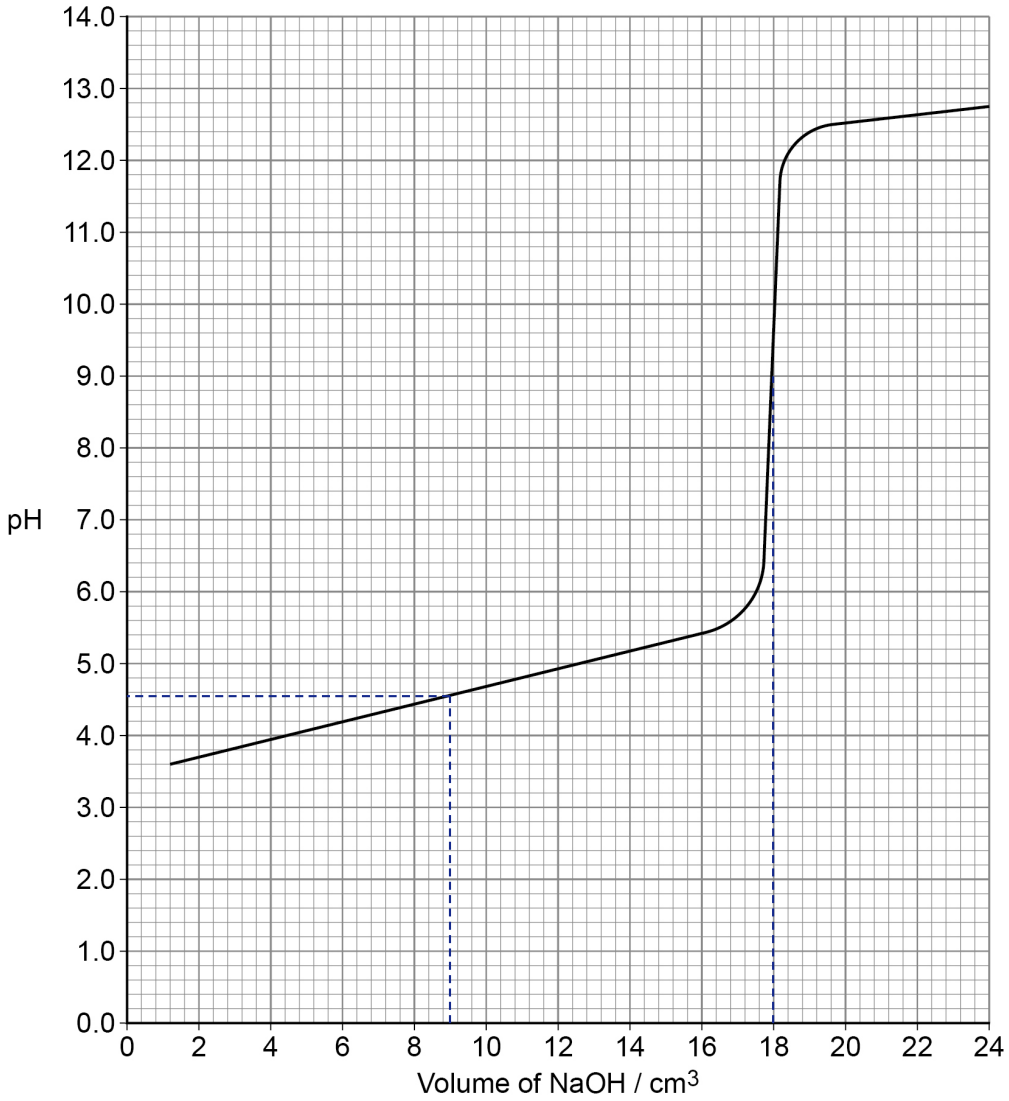
The student does not measure the initial pH of the weak acid solution.

Figure 3 shows a graph of the student's results.

Figure 3



0 3 . 3 The student uses the graph to identify the minimum volume of the NaOH(aq) that reacts with all of the weak acid.

The student could have used an indicator to determine this volume.

State the minimum volume of NaOH(aq) needed.

Suggest the pH range of the colour change of a suitable indicator.

[2 marks]

Minimum volume 18.0 cm^3

pH range 8.3 to 10 (phenolphthalein)

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0 3 . 4 The student's NaOH(aq) has a concentration of 0.194 mol dm^{-3}

Use your volume from Question **03.3** to calculate the initial concentration of 25.0 cm^3 of the weak acid solution.

[2 marks]

$n(NaOH) = 18.0 \times 0.194 / 1000 = 3.49 \times 10^{-3}$ mol

HA reacts 1 : 1 with NaOH, so $n(HA) = 3.49 \times 10^{-3}$ mol

$[HA] = 3.49 \times 10^{-3} \times 1000 / 25.0 = 0.140$ mol dm^{-3}

Initial concentration 0.140 mol dm^{-3}

0 3 . 5 Use the data from the graph in **Figure 3** to determine the value of the acid dissociation constant (K_a) for the weak acid.

[4 marks]

Half equivalence volume = 18.0 / 2 = 9.0 cm^3

At this point $[HA] = [A^-]$, so $K_a = [H^+]$ and $pH = pK_a$

From the graph, pH at 9.0 cm^3 = 4.55, so $pK_a = 4.55$

$pK_a = -\log_{10}K_a$, so $K_a = 10^{-4.55}$

$K_a = 2.82 \times 10^{-5}$ mol dm^{-3}

K_a 2.82×10^{-5} mol dm^{-3}

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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 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 Which is the relative atomic mass of boron?

[1 mark]

A The mean mass of one mole of atoms of boron compared with the mass of one atom of ^{12}C

B The mean mass of one mole of atoms of boron compared with $\frac{1}{12}$ of the mass of an atom of ^{12}C

C The mean mass of one atom of boron × 12 compared with the mean mass of one atom of carbon

D The mean mass of one atom of boron compared with $\frac{1}{12}$ of the mass of one atom of ^{12}C

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0 5 Which mass of hydrated ethanedioic acid crystals ($H_2C_2O_4.2H_2O$) is needed to make 50 cm^3 of solution with concentration 0.0456 mol dm^{-3}?

M_r ($H_2C_2O_4.2H_2O$) = 126.0

[1 mark]

A 0.115 g ○

B 0.287 g ●

C 0.912 g ○

D 5.746 g ○

0 6 The M_r of a compound is 88.0

A sample of this compound contains 2.42 g of carbon, 0.401 g of hydrogen and 1.62 g of oxygen.

Which could be the molecular formula of this compound?

[1 mark]

A C_2H_4O ○

B $C_3H_4O_3$ ○

C $C_4H_8O_2$ ●

D $C_5H_{12}O$ ○

Turn over for the next question

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0 7 Ammonia reacts with 5.00 g of CH_3Br (M_r = 94.9)

1.01 g of $N(CH_3)_4Br$ is produced.

An equation for the reaction to form $N(CH_3)_4Br$ is

$$4\,CH_3Br + 4\,NH_3 \rightarrow N(CH_3)_4Br + 3\,NH_4Br$$

Which is the percentage yield of the $N(CH_3)_4Br$?

[1 mark]

A 54% ○

B 50% ●

C 20% ○

D 12% ○

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

[1 mark]

A $Sr_3(PO_4)_2$ ●

B $Sr_2(PO_4)_3$ ○

C $Sr(PO_4)_2$ ○

D $SrPO_4$ ○

0 9 The boiling point of hydrogen fluoride (HF) is 293 K
The boiling point of hydrogen iodide (HI) is 238 K

Which statement explains the difference in the boiling points?

[1 mark]

A The H–F bond is stronger than the H–I bond. ○

B M_r of HF is less than M_r of HI ○

C The induced dipole-dipole forces in HF are stronger than the induced dipole-dipole forces in HI ○

D HF has hydrogen bonding between its molecules but HI does not. ●

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1 0 Hydrogen-oxygen fuel cells can be acidic or alkaline.

Which is the reaction at the positive electrode in an alkaline hydrogen-oxygen fuel cell?

[1 mark]

A $2H_2O(l) + O_2(g) + 4e^- \rightarrow 4OH^-(aq)$ ●

B $4OH^-(aq) \rightarrow O_2(g) + 2H_2O(l) + 4e^-$ ○

C $2H_2O(l) + 2e^- \rightarrow 2OH^-(aq) + H_2(g)$ ○

D $2OH^-(aq) + H_2(g) \rightarrow 2H_2O(l) + 2e^-$ ○

1 1 Which equation has the nitrogen-containing reactant acting as a Brønsted–Lowry base?

[1 mark]

A $NH_4Cl + OH^- \rightarrow NH_3 + Cl^- + H_2O$ ○

B $HNO_3 + H_2SO_4 \rightarrow H_2NO_3^+ + HSO_4^-$ ●

C $2NO + O_2 \rightarrow 2NO_2$ ○

D $2HNO_2 + Mg(OH)_2 \rightarrow Mg(NO_2)_2 + 2H_2O$ ○

Turn over for the next question

Do not write outside the box

1 2 The acid-catalysed reaction

$$A + 2B \rightarrow C$$

has the rate equation

$$\text{rate} = k[A][B][H^+]$$

Which is a possible mechanism for this reaction?

[1 mark]

A

Step 1 $A + H^+ \xrightarrow{\text{fast}} X$

Step 2 $X + 2B \xrightarrow{\text{slow}} C + H^+$

B

Step 1 $B + H^+ \xrightarrow{\text{fast}} X$

Step 2 $X + A + B \xrightarrow{\text{slow}} C + H^+$

C

Step 1 $A + B \xrightarrow{\text{slow}} X$

Step 2 $X + H^+ \xrightarrow{\text{fast}} Y$

Step 3 $Y + B \xrightarrow{\text{fast}} C + H^+$

D

Step 1 $A + H^+ \xrightarrow{\text{fast}} X$

Step 2 $X + B \xrightarrow{\text{slow}} Y$

Step 3 $Y + B \xrightarrow{\text{fast}} C + H^+$

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1 3 The decomposition of nitrosyl chloride (NOCl) is endothermic.

$$2\,NOCl(g) \rightleftharpoons 2\,NO(g) + Cl_2(g)$$

Which **decreases** when the temperature of the equilibrium mixture is increased at a constant pressure?

[1 mark]

A The mole fraction of NOCl

B The partial pressure of NO

C The total number of moles of gas present in the mixture

D The value of the equilibrium constant, K_p

1 4 Which statement is correct about the elements magnesium, silicon, sulfur and chlorine?

[1 mark]

A Magnesium has the lowest first ionisation energy because the electron is lost more easily from the 2s orbital.

B Silicon has a high melting point because it is a giant structure that has strong ionic bonds.

C Sulfur has a low melting point because it only has van der Waals' forces between the molecules.

D Chlorine has the largest first ionisation energy because it is the largest atom.

1 5 Which is correct about the silver halides, from silver fluoride to silver iodide?

[1 mark]

A Silver chloride is soluble in concentrated ammonia.

B Silver bromide is soluble in dilute ammonia.

C Silver iodide is soluble in concentrated ammonia.

D The solubility of the silver halides in water increases down the group.

Turn over ►

Do not write outside the box

1 6 Which can **not** be produced when chlorine gas is added to water?

[1 mark]

A Cl^- ○

B HClO ○

C OH^- ●

D O_2 ○

1 7 0.1 moles of some Period 3 oxides are reacted with 50 cm^3 of water.

Which reaction produces a solution with the lowest pH?

[1 mark]

A Na_2O ○

B Al_2O_3 ○

C P_4O_{10} ●

D SO_2 ○

1 8 Which of these complex ions shows *cis-trans* isomerism?

[1 mark]

A $[Co(NH_2CH_2CH_2NH_2)_3]^{2+}$ ○

B $[Co(NH_3)_4Cl_2]^+$ ●

C $[Fe(H_2O)_5Cl]^{2+}$ ○

D $[Fe(H_2O)_4(C_2O_4)]^+$ ○

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1 9 Which statement about catalysis is correct?

[1 mark]

A When catalysts and reactants are in the same phase, the reaction proceeds through an intermediate species. ●

B Homogeneous catalysts can be poisoned at active sites on their surface. ○

C Heterogeneous catalysts are in the same phase as the reactants. ○

D Vanadium(V) oxide is a heterogeneous catalyst in the Haber process. ○

2 0 $Al(H_2O)_3(OH)_3$ shows amphoteric character.

Which row correctly describes a reaction of $Al(H_2O)_3(OH)_3$?

[1 mark]

	Reagent	Observation	Equation	
A	NaOH(aq)	colourless solution forms white solid	$Al(H_2O)_3(OH)_3 + OH^- \rightarrow Al(OH)_4^- + 3H_2O$	○
B	NaOH(aq)	white solid forms colourless solution	$Al(H_2O)_3(OH)_3 + 3OH^- \rightarrow Al(OH)_4^{3-} + 3H_2O$	○
C	HCl(aq)	colourless solution forms white solid	$Al(H_2O)_3(OH)_3 + 3H^+ \rightarrow Al(H_2O)_3(OH)_3^{3+}$	○
D	HCl(aq)	white solid forms colourless solution	$Al(H_2O)_3(OH)_3 + 3H^+ \rightarrow Al(H_2O)_6^{3+}$	●

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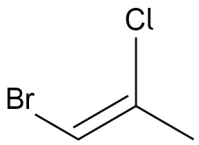
2 1 Which is the full IUPAC name of this molecule?



[1 mark]

A *E*-1-bromo-2-chloro-2-methylethene ○

B *E*-1-bromo-2-chloropropene ○

C *Z*-1-bromo-2-chloro-2-methylethene ○

D *Z*-1-bromo-2-chloropropene ●

2 2 HBr reacts with $CH_3CH{=}C(CH_3)_2$ to form $CH_3CH_2C(CH_3)_2Br$ as the major product.

Which statement explains this?

[1 mark]

A $CH_3CH_2C(CH_3)_2Br$ is a secondary bromoalkane. ○

B $CH_3CH_2C(CH_3)_2Br$ is a tertiary bromoalkane. ○

C $CH_3CH_2C(CH_3)_2Br$ is formed via a secondary carbocation. ○

D $CH_3CH_2C(CH_3)_2Br$ is formed via a tertiary carbocation. ●

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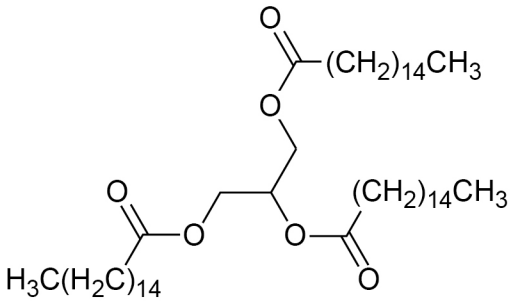
2 3 The vegetable oil shown is hydrolysed with aqueous sodium hydroxide.



Which is a correct product?

[1 mark]

A $H_3C(CH_2)_{14}COOH$ ○

B $H_3C(CH_2)_{14}COONa$ ●

C HOOCC(COOH)COOH ○

D NaOOCC(COONa)COONa ○

Turn over for the next question

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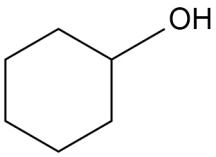
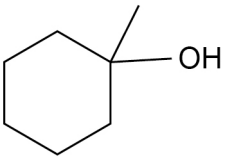
2 4 Which alcohol is **not** oxidised by acidified potassium dichromate(VI)?

[1 mark]

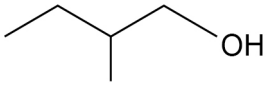
A



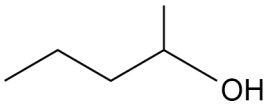
B



C



D



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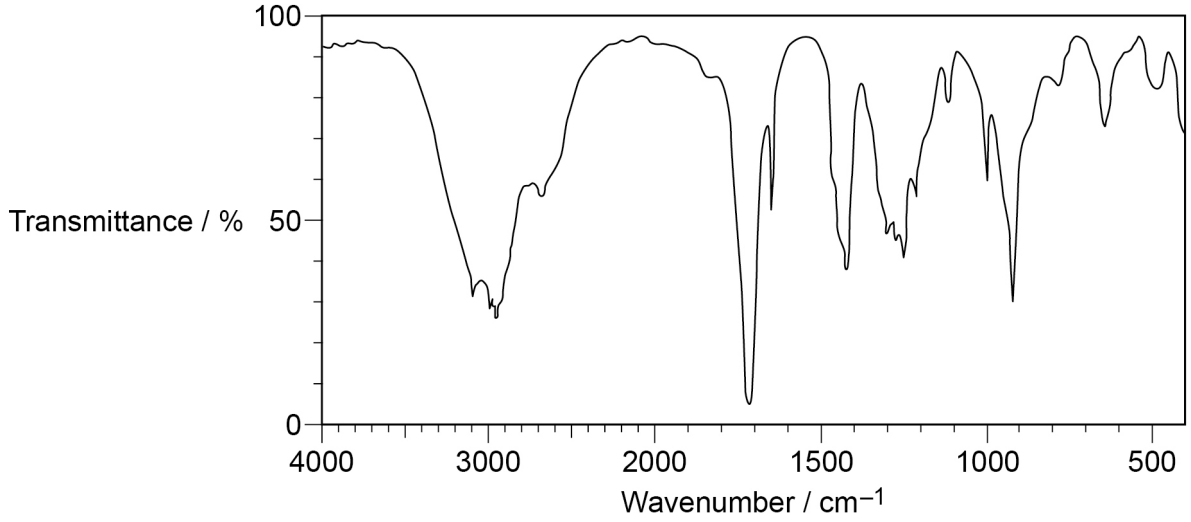
2 5 The infrared spectrum of an unknown compound $C_6H_{10}O_2$ is shown.



Use the Chemistry Data Sheet to determine which of the following is the most likely structure for $C_6H_{10}O_2$

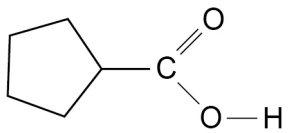
[1 mark]

A $CH_3CH{=}CHCH_2CH_2COOH$

B $CH_3CH{=}CHCH_2COOCH_3$

C $CH_3CH{=}CHCH{=}CHCOOH$

D



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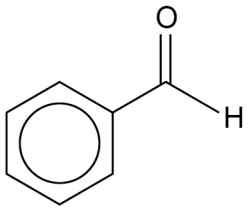
Do not write outside the box

2 6 Which forms a racemic mixture of alcohols when reduced?

[1 mark]

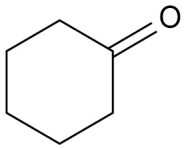
A $CH_3CH_2CH_2CHO$

B



C $CH_3CH_2COCH_3$

D



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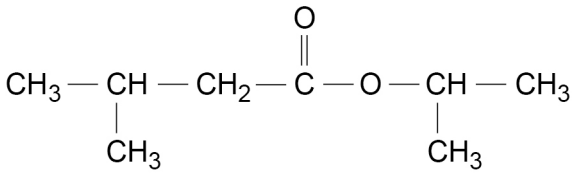
2 7 Which is formed by reaction of 2-methylbutanoic acid with propan-2-ol?

[1 mark]

A



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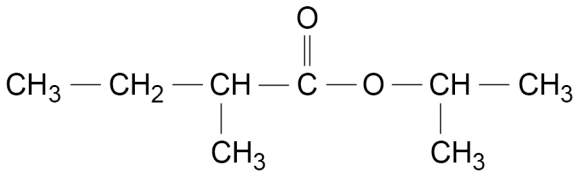

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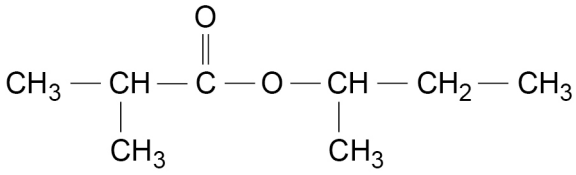

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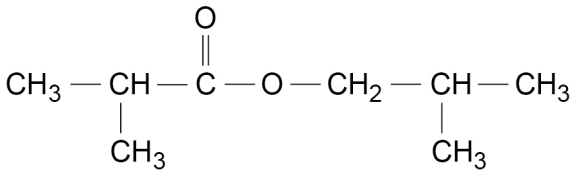

Turn over for the next question

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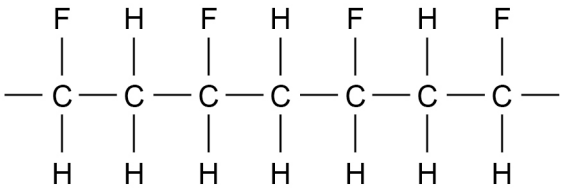
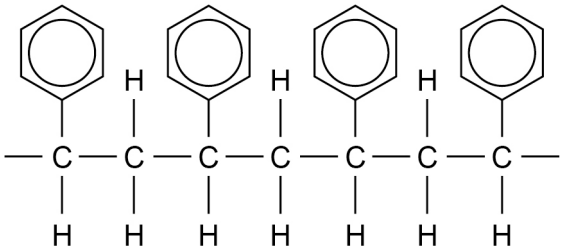
2 8 Sections from three polymers are shown.

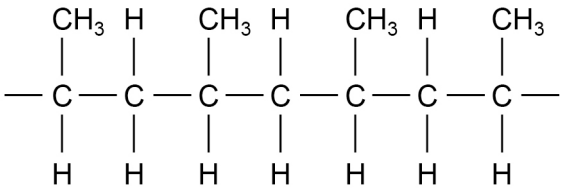
X



Y



Z



Which statement about the polymers is correct?

[1 mark]

A The strongest attractive forces between polymer chains in polymer **X** are hydrogen bonds. ○

B **X** is biodegradable because it has polar bonds. ○

C The strongest attractive forces between polymer chains in polymer **Y** are induced dipole-dipole forces. ●

D **X**, **Y** and **Z** are all are made from monomers with *E*–*Z* isomerism. ○

Do not write outside the box

2 9 Which statement is correct?

[1 mark]

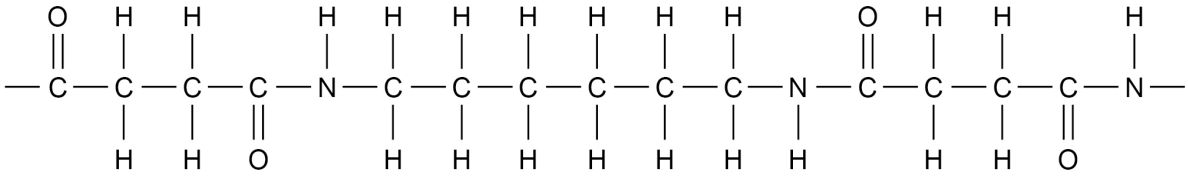
A Methylamine is a stronger base than dimethylamine. ○

B Methylamine is a weaker base than ammonia. ○

C Phenylamine is a stronger base than dimethylamine. ○

D Phenylamine is a weaker base than ammonia. ●

3 0 A section of a polymer is shown.



Which statement is correct?

[1 mark]

A The polymer can be made using 6-aminohexanoic acid. ○

B The polymer can be made using hexane-1,6-dioic acid as one of the starting materials. ○

C The polymer can be made using hexane-1,6-diamine as one of the starting materials. ●

D The polymer is not biodegradable. ○

Turn over for the next question

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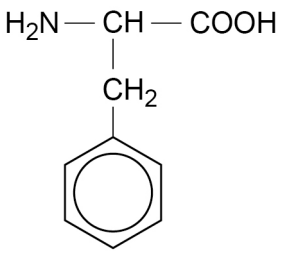
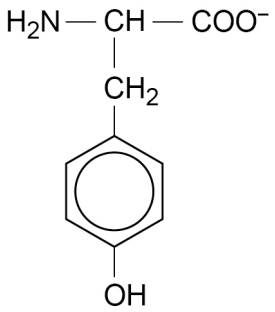
3 1 The table shows four amino acids and the species formed by each amino acid in strong alkali.

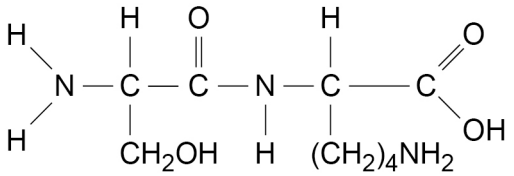
Which row shows the correct species?

[1 mark]

	amino acid	species formed in strong alkali	
A			○
B	$H_2N-CH(CH_2-CH_2-CH_2-NH_2)-COOH$	$H_3\overset{+}{N}-CH(CH_2-CH_2-CH_2-\overset{+}{N}H_3)-COOH$	○
C	$H_2N-CH(CH_2-COOH)-COOH$	$H_2N-CH(CH_2-COOH)-COO^-$	○
D	$H_2N-CH(CH_3)-COOH$	$H_2N-CH(CH_3)-COO^-$	●

Do not write outside the box

3 2 Which shows the products of hydrolysis of this dipeptide by an excess of acid?



[1 mark]

A ○

B ○

C ●

D ○

Turn over for the next question

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3 3 The ^{1}H NMR spectrum of an ester has only three peaks.
The chemical shifts and the splitting patterns of the peaks are shown in the table.

Chemical shift δ / ppm	1.0	1.2	4.1
Splitting pattern	singlet	triplet	quartet

Which ester gives these peaks?

[1 mark]

A $CH_3COOCH(CH_3)_2$ ⬭

B $CH_3CH_2COOC(CH_3)_3$ ⬭

C $(CH_3)_3CCOOCH_2CH_3$ ●

D $(CH_3)_2CHCOOCH_3$ ⬭

30

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