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

Tuesday 26 January 2021 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 pH

0 1 . 1 Calculate the pH of a 0.200 mol dm^{-3} aqueous solution of hydrochloric acid.
Give your answer to 2 decimal places.

[1 mark]

$pH = -\log_{10}[H^+] = -\log_{10}(0.200)$

$= 0.70$

pH 0.70

0 1 . 2 A pH meter is used to measure the pH of some hydrochloric acid.

Describe how a pH meter is calibrated before use.

[2 marks]

Measure the pH of a buffer of known pH (e.g. pH 7) and set the meter to that value (set pH).

Rinse, measure a second buffer of known pH (e.g. pH 4) and adjust the slope, or plot a calibration graph.

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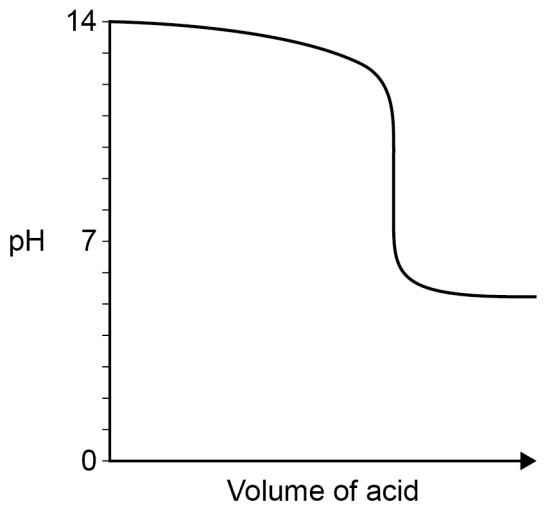
0 1 . 3 Some data about indicators are shown in **Table 1**.

Table 1

Indicator	pH range
Bromophenol blue	3.0–4.6
Methyl red	4.2–6.3
Bromothymol blue	6.0–7.6
Thymol blue	8.0–9.6

Figure 1 shows how the pH changes during a titration.

Figure 1



Identify the best indicator from **Table 1** for the titration shown in **Figure 1**.

Justify your choice.

[2 marks]

Indicator Thymol blue

Justification All of its pH range (8.0 to 9.6) lies within the vertical part of the curve; the other three ranges lie outside it.

Turn over ►

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0 1 . 4 Give a reason why universal indicator is not a good choice for any titration.

[1 mark]

It has no sharp colour change: the colour changes gradually over a wide pH range.

0 1 . 5 Explain why there is no suitable indicator for the titration of a weak base with a weak acid.

[1 mark]

The curve has no steep (vertical) section at equivalence, the pH changes gradually, so no indicator changes colour sharply.

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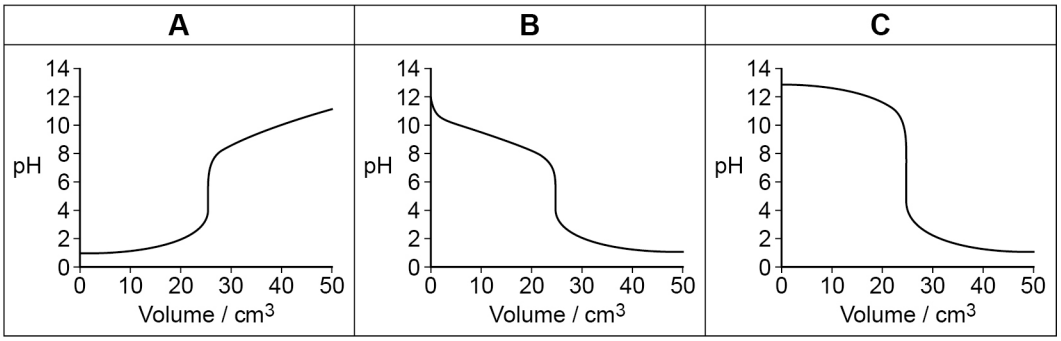
Hydrochloric acid is added to ammonia solution.

Three titration curves are shown.

0 1 . 6 Which curve is expected when 0.2 mol dm^{-3} hydrochloric acid is added to 0.2 mol dm^{-3} ammonia solution?

Tick (✓) **one** box.

[1 mark]



A ☐ B ☑ C ☐

0 1 . 7 During a titration, the inside of the conical flask is washed with deionised water.

Give a reason why this washing is done.

Explain why the addition of water does not give an incorrect value for the titre.

[2 marks]

Reason for washing To wash solution splashed on the sides back down so that all of the chemicals react.

Explanation Water does not react with any of the reagents, so it does not change the number of moles of ammonia in the flask, only its volume.

Do not write outside the box

0 1 . 8 In a titration the titre is 27.55 cm^3

The total uncertainty in the titre is ±0.15 cm^3

Calculate the percentage uncertainty in the titre.

[1 mark]

% uncertainty = (0.15 ÷ 27.55) × 100

= 0.544%

Percentage uncertainty 0.544%

0 1 . 9 25.0 cm^3 of a different ammonia solution are neutralised by 27.55 cm^3 of 0.200 mol dm^{-3} hydrochloric acid.

Calculate the concentration, in mol dm^{-3}, of the ammonia solution.

[2 marks]

$n(HCl) = 27.55 \div 1000 \times 0.200 = 5.51 \times 10^{-3}$ mol

$NH_3 + HCl \rightarrow NH_4Cl$, so $n(NH_3) = 5.51 \times 10^{-3}$ mol

$[NH_3] = 5.51 \times 10^{-3} \times 1000 \div 25.0 = 0.220$ mol dm^{-3}

Concentration 0.220 mol dm^{-3}

13

Do not write outside the box

Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

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0 2 This question is about an experiment to determine the enthalpy of neutralisation.

Method

- 25.0 cm^3 of 1.00 mol dm^{-3} hydrochloric acid are added to a beaker.
- A thermometer is placed in the acid.
- The acid is stirred, a timer is started and the temperature measured every minute for 3 minutes.
- At 4 minutes, 25.0 cm^3 of 1.00 mol dm^{-3} sodium hydroxide solution are added to the acid. The temperature is not measured at this time.
- At 5 minutes, and then every minute until 10 minutes, the temperature is measured.

Table 2 shows the results of this experiment.

Table 2

Time / minutes	Temperature / °C
0	19.8
1	19.8
2	19.8
3	19.8
4	
5	26.2
6	26.0
7	25.8
8	25.5
9	25.4
10	25.2

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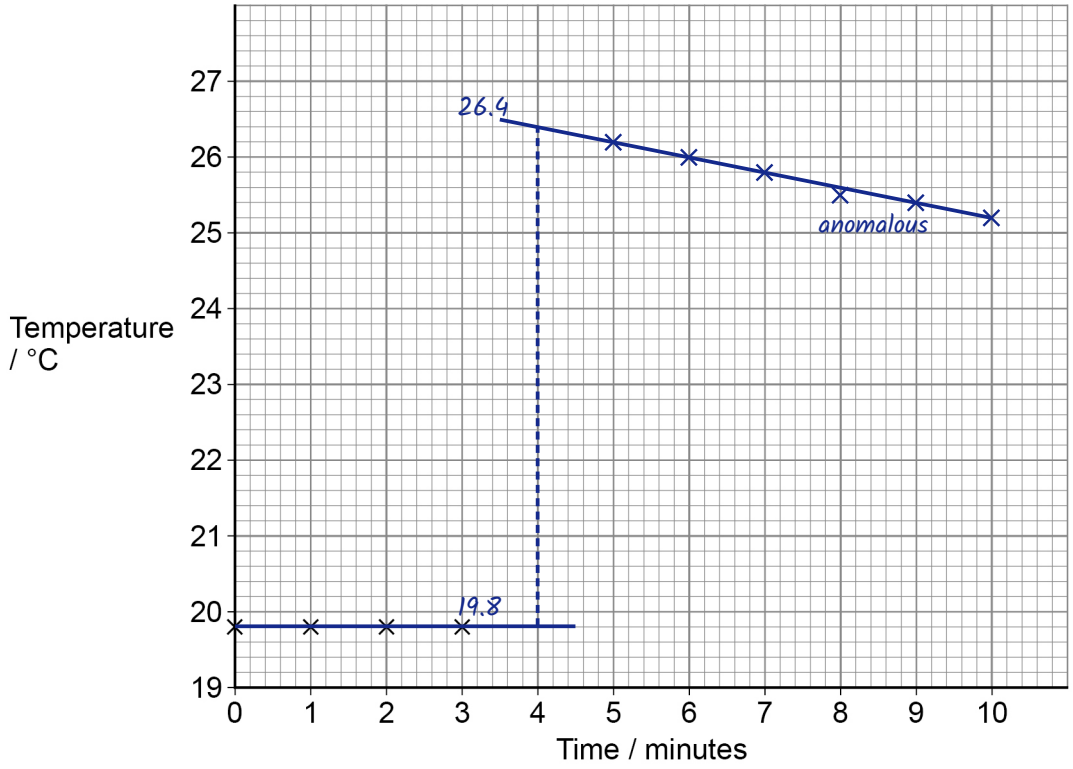
0 2 . 1 Use the data from **Table 2** to plot a graph of temperature against time on the grid below. Some of the points have already been plotted for you.

Use your graph to calculate the temperature rise at 4 minutes.

Show your working on the graph by drawing suitable lines of best fit.

[5 marks]



temperature rise at 4 min = 26.4 − 19.8 = 6.6 °C

Temperature rise 6.6 °C

Turn over ►

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0 2 . 2 Calculate the heat energy, in J, given out during the reaction.

The specific heat capacity of the solution is 4.18 J K^{-1} g^{-1}
The density of the solution is 1.00 g cm^{-3}

(If you were unable to answer Question **02.1**, you should use a value of 3.3 °C
This is **not** the correct answer.)

[2 marks]

mass of solution = 50.0 cm^3 × 1.00 g cm^{-3} = 50.0 g

$q = mc\Delta T$ = 50.0 × 4.18 × 6.6

= 1379 J

Heat energy 1379 J

0 2 . 3 Use your answer to Question **02.2** to calculate the enthalpy change, in kJ mol^{-1}, when 1 mol of hydrochloric acid is neutralised by 1 mol of sodium hydroxide.
Give your answer to 3 significant figures.

(If you were unable to answer Question **02.2**, you should use a value of 1279 J
This is **not** the correct answer.)

[2 marks]

n(HCl) = 25.0 ÷ 1000 × 1.00 = 0.0250 mol

ΔH = −1379 ÷ 0.0250 = −55 160 J mol^{-1}

= −55.2 kJ mol^{-1} (3 s.f.)

Enthalpy change −55.2 kJ mol^{-1}

0 2 . 4 Suggest **one** way to minimise heat loss to the surroundings.

[1 mark]

Put a lid on the beaker and insulate it (e.g. a polystyrene cup inside the beaker).

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0 2 . 5 Suggest **one** way, without changing the apparatus, that the experiment could be changed to reduce the percentage uncertainty in the volume of hydrochloric acid.

[1 mark]

Use a larger volume of the hydrochloric acid (and the same larger volume of sodium hydroxide).

0 2 . 6 Suggest **one** way, without changing the apparatus, that the experiment could be changed to reduce the percentage uncertainty in the temperature rise.

[1 mark]

Use more concentrated acid and alkali, so that the temperature rise is larger.

12

Turn over for the next question

Do not write outside the box

0 3 This question is about an experiment to determine the order of a reaction.

Hydrogen peroxide reacts with iodide ions in acidic solution

$$H_2O_2(aq) + 2I^-(aq) + 2H^+(aq) \rightarrow I_2(aq) + 2H_2O(l)$$

In a series of experiments the initial concentration of iodide ions is changed.
The initial concentrations of all other reagents are kept constant.

The reaction mixture becomes darker brown as more moles of iodine are formed.
The colour of the mixture is compared to a colour chart.

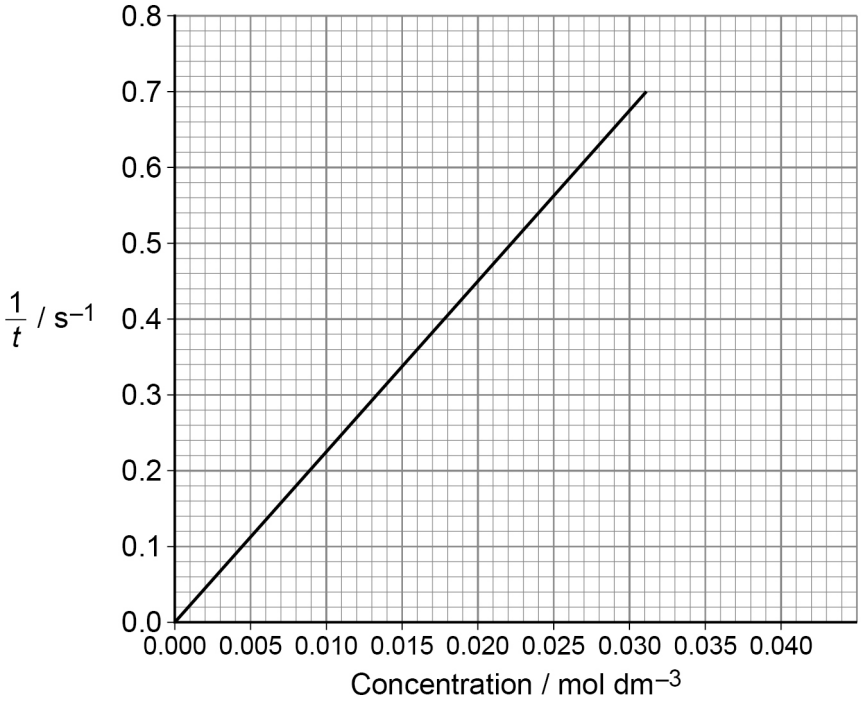
When a given number of moles of iodine are formed the time (t) is recorded.

0 3 . 1 The initial rate of the reaction can be represented as $\frac{1}{t}$

A graph is plotted of $\frac{1}{t}$ (on the y-axis) against initial concentration of iodide ions.
Use the graph to deduce the order of reaction with respect to iodide ions.

Explain your answer.

[2 marks]



Order First order (order = 1)

Explanation The graph of 1/t against [I⁻] is a straight line through the origin, so rate is directly proportional to [I⁻].

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0 3 . 2 The experiment is done using a flask on the laboratory bench.

Suggest how the experiment could be improved to maintain a constant temperature.

[1 mark]

Put the flask in a thermostatically controlled water bath.

0 3 . 3 The student used a colour chart to measure the number of moles of iodine.

Suggest how the measurement of the number of moles of iodine formed could be improved.

[1 mark]

Use a colorimeter to measure the absorbance (with a calibration curve), or add a fixed amount of thiosulfate with starch and time the blue-black colour.

0 3 . 4 Experiments were done to deduce the order of reaction with respect to each of the reagents. **Table 3** shows the results of these experiments.

Table 3

Reagent	Order with respect to the reagent
$H_2O_2(aq)$	a
$I^-(aq)$	b
$H^+(aq)$	c

Write the rate equation for the reaction

$$H_2O_2(aq) + 2I^-(aq) + 2H^+(aq) \rightarrow I_2(aq) + 2H_2O(l)$$

[1 mark]

5

rate $= k[H_2O_2]^a[I^-]^b[H^+]^c$

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 about the first ionisation energies of the elements in Group 2?

[1 mark]

A The decrease in first ionisation energy down the group provides evidence for electron shells.

B The decrease in first ionisation energy down the group provides evidence for electron sub-shells.

C The increase in first ionisation energy down the group provides evidence for electron shells.

D The increase in first ionisation energy down the group provides evidence for electron sub-shells.

Do not write outside the box

0 5 A 2.04 g sample of strontium hydroxide is completely dissolved in 10.0 dm^3 water. The strontium hydroxide completely ionises in water.

What is the concentration, in mol dm^{-3}, of strontium ions in the aqueous solution?

[1 mark]

A 1.68×10^{-3} ●

B 1.95×10^{-3} ○

C 1.68×10^{-2} ○

D 1.95×10^{-2} ○

0 6 What is the percentage atom economy for the formation of sodium chloride in this reaction?

$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$$

[1 mark]

A 32.7% ○

B 41.1% ○

C 55.2% ○

D 65.4% ●

Turn over for the next question

Do not write outside the box

0 7 Which reaction involves the formation of a dative covalent bond?

[1 mark]

A $^{\bullet}CH_3 + Cl^{\bullet} \longrightarrow CH_3Cl$ ⬭

B $BH_3 + H^- \longrightarrow BH_4^-$ ●

C $PCl_3 + Cl_2 \longrightarrow PCl_5$ ⬭

D $Na^+ + H^- \longrightarrow NaH$ ⬭

0 8 Which equation shows an equilibrium where the concentration of hydrogen decreases when the temperature is increased at constant pressure?

[1 mark]

A $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ $\Delta H = -92\ kJ\ mol^{-1}$ ⬭

B $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$ $\Delta H = +52\ kJ\ mol^{-1}$ ●

C $H_2(g) + Cl_2(g) \rightleftharpoons 2HCl(g)$ $\Delta H = -185\ kJ\ mol^{-1}$ ⬭

D $2H_2O(g) \rightleftharpoons 2H_2(g) + O_2(g)$ $\Delta H = +484\ kJ\ mol^{-1}$ ⬭

Do not write outside the box

0 9 Which change shows an oxidation of vanadium?

[1 mark]

A $V_2O_5 \longrightarrow 2VO_2$ ○

B $VO_2 \longrightarrow V^{2+}$ ○

C $VO_2 \longrightarrow V_2O_5$ ●

D $VO_2^+ \longrightarrow 2VO_2$ ○

1 0 Which is **not** a redox equation?

[1 mark]

A $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$ ○

B $2HNO_3 + 3H_3PO_3 \longrightarrow 2NO + 3H_3PO_4 + H_2O$ ○

C $KOH + HCl \longrightarrow H_2O + KCl$ ●

D $SnCl_2 + HgCl_2 \longrightarrow Hg + SnCl_4$ ○

Turn over for the next question

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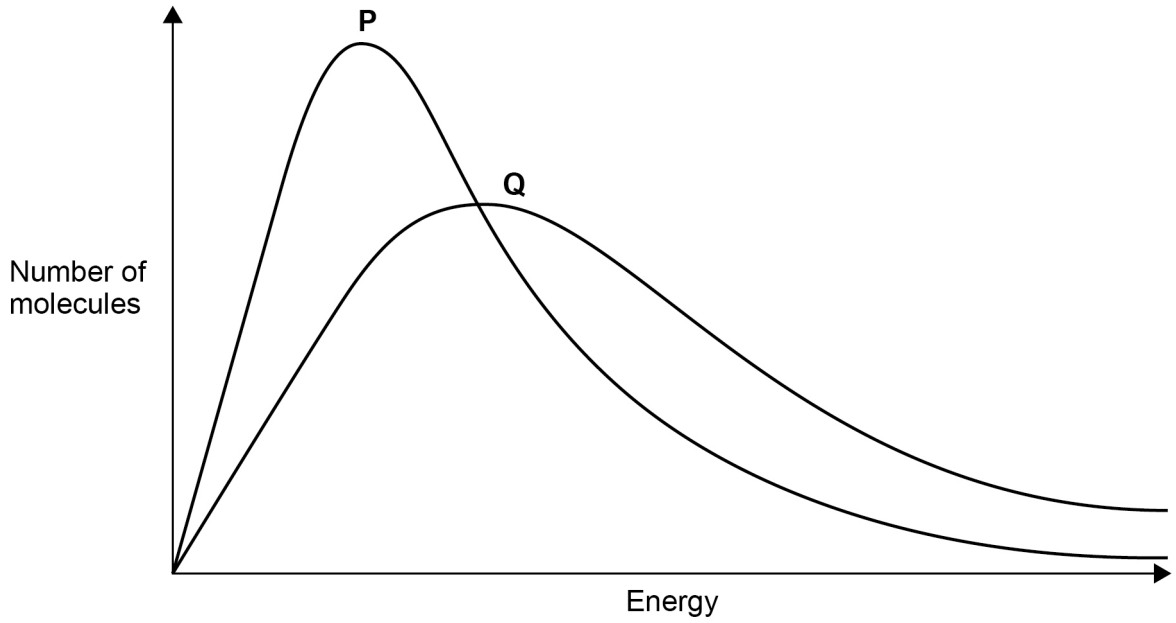
1 1



The diagram shows two Maxwell–Boltzmann distribution curves.
Curve **P** is for two moles of oxygen gas at 298 K

Which would give curve **Q**?

[1 mark]

A Two moles of oxygen at 258 K ○

B Four moles of oxygen at 298 K ○

C Four moles of oxygen at 298 K with a catalyst ○

D Two moles of oxygen at 338 K ●

Do not write outside the box

1 2 When an aqueous solution containing chloride ions is added to an aqueous solution containing cobalt ions, the following equilibrium occurs

$$[Co(H_2O)_6]^{2+}(aq) + 4\ Cl^-(aq) \rightleftharpoons [CoCl_4]^{2-}(aq) + 6\ H_2O(l)$$

pink blue

Which is the correct statement about the equilibrium?

[1 mark]

A The forward reaction is a reduction. ○

B The entropy change for the forward reaction has a negative value. ○

C The units for the equilibrium constant, K_c, are $mol^{-2}\ dm^6$ ○

D The colour changes from blue to pink when water is added. ●

1 3 Which is **not** a correct condition for measuring the standard electrode potential for the reduction shown?

$$Fe^{3+}(aq) + e^- \longrightarrow Fe^{2+}(aq)$$

[1 mark]

A A standard hydrogen electrode as the left–hand half cell ○

B A temperature of 25 °C for both half cells ○

C A mixture of equal volumes of 1.00 $mol\ dm^{-3}$ solutions of iron(II) sulfate and iron(III) sulfate ●

D A salt bridge made from some filter paper soaked in saturated sodium nitrate solution ○

Turn over for the next question

Do not write outside the box

1 4 Which shows the correct electrode reactions at each electrode in a lithium cell during use?

[1 mark]

	Positive Electrode	Negative Electrode	
A	$Li \longrightarrow Li^+ + e^-$	$Li^+ + CoO_2 + e^- \longrightarrow Li[CoO_2]$	○
B	$Li^+ + e^- \longrightarrow Li$	$Li[CoO_2] \longrightarrow Li^+ + CoO_2 + e^-$	○
C	$Li[CoO_2] \longrightarrow Li^+ + CoO_2 + e^-$	$Li^+ + e^- \longrightarrow Li$	○
D	$Li^+ + CoO_2 + e^- \longrightarrow Li[CoO_2]$	$Li \longrightarrow Li^+ + e^-$	●

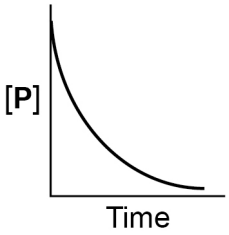
1 5 The equation for a reaction is

$$\mathbf{P} + \mathbf{Q} \longrightarrow \mathbf{R} + \mathbf{S}$$

Which is a possible concentration–time graph for this reaction?

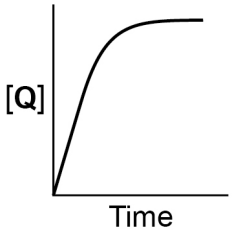
[1 mark]

A



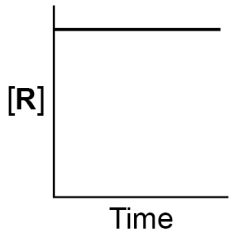
●

B



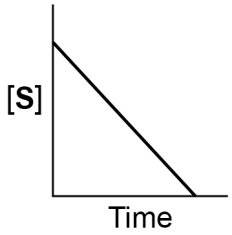
○

C



○

D



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1 6 The rate equation for the reaction between nitrogen monoxide and oxygen is

$$\text{rate} = k[NO]^2[O_2]$$

The results of an investigation into this reaction are shown in the table.

Experiment	[NO] / mol dm^{-3}	[O_2] / mol dm^{-3}	Rate / mol dm^{-3} min^{-1}
1	1.0×10^{-4}	2.0×10^{-4}	2.0×10^{-3}
2	2.0×10^{-4}	4.0×10^{-4}	to be calculated

What is the rate of reaction in Experiment **2**?

[1 mark]

A 4.0×10^{-3} mol dm^{-3} min^{-1} ○

B 8.0×10^{-3} mol dm^{-3} min^{-1} ○

C 1.6×10^{-2} mol dm^{-3} min^{-1} ●

D 3.2×10^{-2} mol dm^{-3} min^{-1} ○

1 7 Which substance is the most soluble in water?

[1 mark]

A AgCl ○

B $Ba(OH)_2$ ●

C $BaSO_4$ ○

D $Mg(OH)_2$ ○

1 8 Which of these solid compounds reacts with concentrated sulfuric acid to produce hydrogen sulfide?

[1 mark]

A KF ○

B KI ●

C NaBr ○

D NaCl ○

Turn over ►

Do not write outside the box

1 9 Which of these oxides reacts with water to form an acidic solution?

[1 mark]

A Al_2O_3 ○

B Na_2O ○

C P_4O_{10} ●

D SiO_2 ○

2 0 This question is about the chlorides of Period 3 elements from Na to P

What is the correct trend in the bonding of these chlorides and the pH of the solutions formed when these chlorides react with water?

[1 mark]

	Trend in bonding	Trend in pH of solution	
A	covalent to ionic	acidic to neutral	○
B	covalent to ionic	neutral to acidic	○
C	ionic to covalent	acidic to neutral	○
D	ionic to covalent	neutral to acidic	●

2 1 Which row shows the correct properties of solid magnesium chloride?

[1 mark]

	Crystal structure	Bonding	Conducts electricity	
A	ionic	ionic	no	●
B	macromolecular	ionic	no	○
C	metallic	metallic	yes	○
D	molecular	covalent	yes	○

Do not write outside the box

2 2 Ammonium vanadate(V) can be reduced in acidic conditions using excess zinc metal.

Which ion is present at the end of the reaction?

[1 mark]

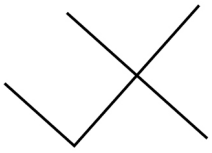
A V^{2+}

B V^{3+}

C VO_2^+

D VO^{2+}

2 3 What is the name of the molecule represented by this skeletal formula?



[1 mark]

A 2,2-dimethylbutane

B 3,3-dimethylbutane

C 1,1,1-trimethylpropane

D 1,2,2-trimethylpropane

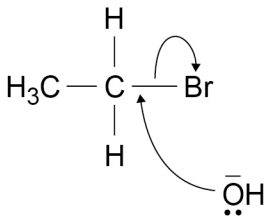
Turn over for the next question

Do not write outside the box

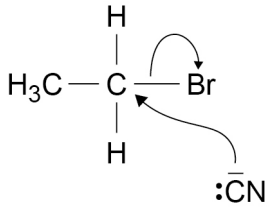
2 4 Which mechanism shows the correct use of curly arrows?

[1 mark]

A



B



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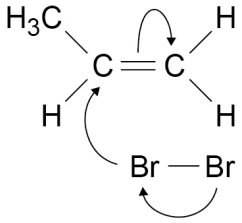

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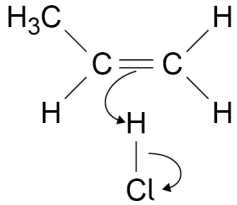


2 5 Which statement about the two stereoisomers of 1,2-dibromoethene is **not** correct?

[1 mark]

A All the atoms are in the same plane.

B The isomers have different effects on plane-polarised light.

C The isomers have different boiling points.

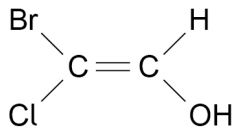
D Only one of the isomers has a permanent dipole.

Do not write outside the box

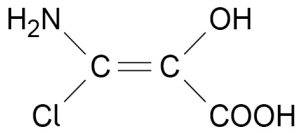
2 6 Which is a *Z* isomer?

[1 mark]

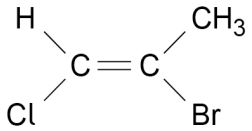
A



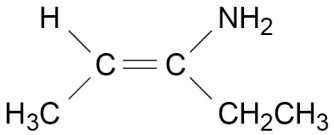
B



C



D



2 7 Which statement about the reaction of chlorine with methane in the presence of ultraviolet light is correct?

[1 mark]

A A chlorine free radical has the same electron configuration as a chlorine atom.

B The covalent bond in the chlorine molecule breaks to form chloride ions.

C The initiation step in this reaction is $CH_4 \longrightarrow {}^{\bullet}CH_3 + H^{\bullet}$

D When a mixture of chlorine and methane is exposed to ultraviolet light there are only two products.

Turn over ►

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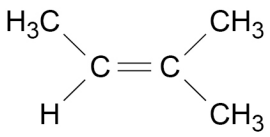
2 8 What is the IUPAC name of the major product when hydrogen bromide is added to the following molecule?



[1 mark]

A 1-bromo-1,1-dimethylpropane ○

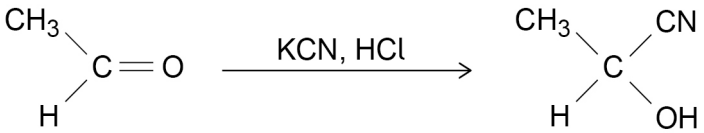
B 2-bromo-2-ethylpropane ○

C 2-bromo-3-methylbutane ○

D 2-bromo-2-methylbutane ●

2 9 Ethanal reacts with potassium cyanide followed by dilute hydrochloric acid to form 2-hydroxypropanenitrile.

An intermediate is formed during the reaction.



Which statement helps to explain why the organic product is a mixture of enantiomers?

[1 mark]

A The organic starting material is an aldehyde and not a ketone. ○

B The ^{-}CN ion is a nucleophile. ○

C The $>C=O$ group has a planar structure. ●

D The intermediate is attacked by ^{-}OH ions. ○

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3 0 Which pair of compounds reacts to form a condensation polymer?

[1 mark]

A CH_3CH_2OH + $HOOCCH_2COOH$ ○

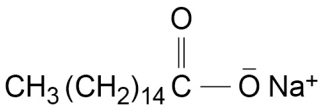
B $HOCH_2OH$ + CH_3COOH ○

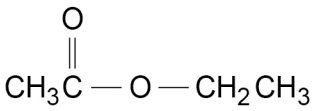
C $CH_3CH_2NH_2$ + CH_3COOH ○

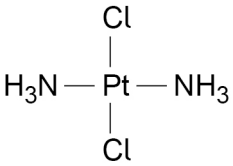
D $H_2NCH_2NH_2$ + $HOOCCH_2COOH$ ●

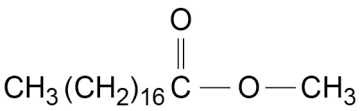
3 1 Which statement is correct?

[1 mark]

A  could be a component of biodiesel. ○

B  could be used as a solvent. ●

C  is used as an anti-cancer drug. ○

D  could be a component of soap. ○

Turn over ►

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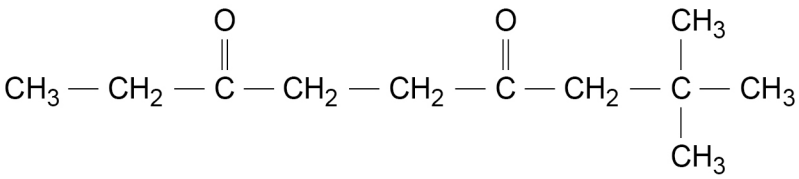
3 2 A molecule has the structure



Which row shows how many singlets, doublets, triplets and quartets there are in its ^{1}H NMR spectrum?

[1 mark]

	singlets	doublets	triplets	quartets
A	2	0	3	1
B	2	3	1	0
C	4	0	3	1
D	4	3	1	0

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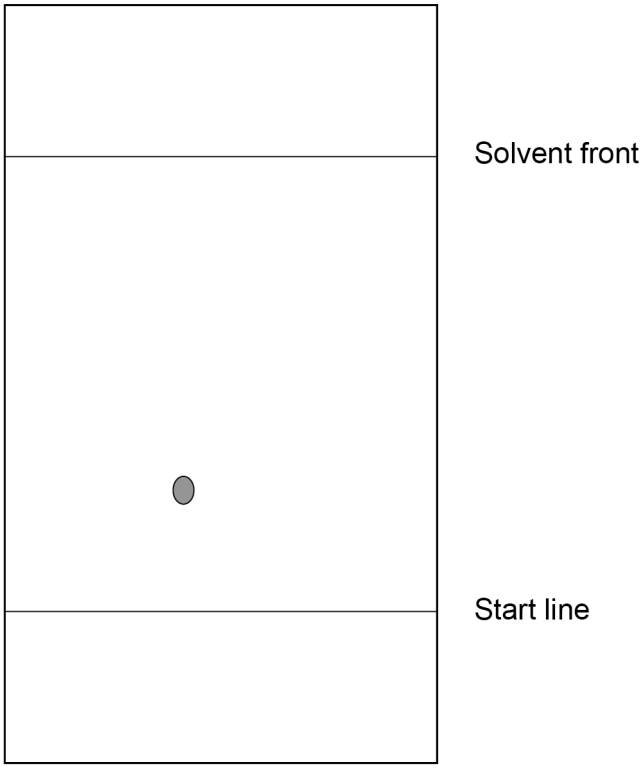
3 3 What is the R_f value of the spot in this chromatogram?



[1 mark]

A 0.16 ○

B 0.20 ○

C 0.27 ●

D 0.36 ○

30

END OF QUESTIONS

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ANSWER IN THE SPACES PROVIDED

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Question number	**Additional page, if required.** **Write the question numbers in the left-hand margin.**

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