

Please write clearly in block capitals.

Centre number

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Candidate number

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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

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. Use pencil for drawing only.
- 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.
- All working must be shown.
- 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).
- 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	



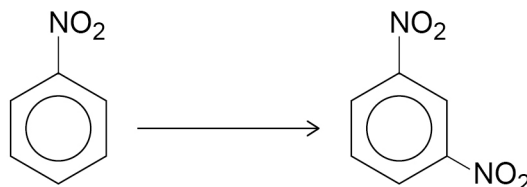
Section A

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

0 1

This question is about the preparation of 1,3-dinitrobenzene from nitrobenzene.

Nitrobenzene is heated with concentrated nitric acid and concentrated sulfuric acid.

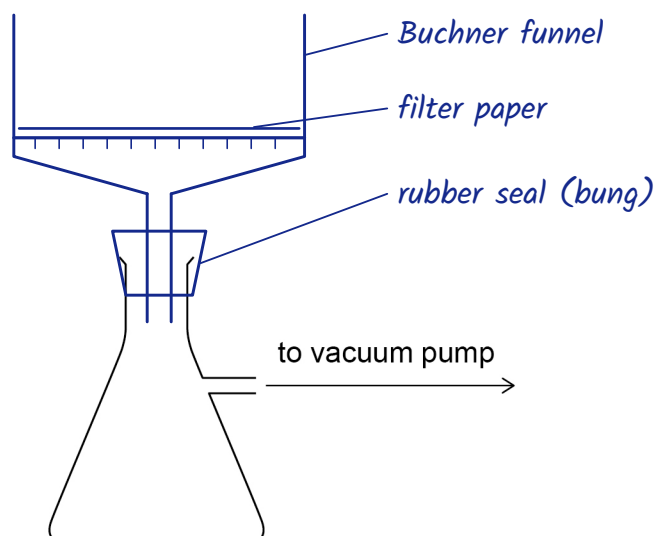


0 1 . 1

During the reaction, 1,3-dinitrobenzene forms as a solid.
This solid is collected by filtration under reduced pressure.

Complete the diagram to show the apparatus you would use to collect the solid under reduced pressure.

[2 marks]



0 1 . 2

Give a reason why the solid is washed with water after filtration.

[1 mark]

To remove any soluble impurities, such as remaining sulfuric acid and nitric acid.



0 1 . 3

Suggest **two** possible reasons why the yield in this preparation of 1,3-dinitrobenzene is less than 100%

[2 marks]

Reason 1 *Some product was left in the reaction flask or filter funnel.*

Reason 2 *Other isomers formed, such as 1,4-dinitrobenzene.*

0 1 . 4

The sample is dried.

Describe how to measure the melting point of the dry sample.

[2 marks]

Place a small sample in a sealed capillary tube inside a melting point apparatus (or oil bath).

Heat slowly near the melting point and record the melting temperature.

0 1 . 5

A data book value for the melting point of 1,3-dinitrobenzene is 90 °C

State **two** ways that the measured melting point will differ from the data book value if the 1,3-dinitrobenzene is impure.

[2 marks]

1 *It will be lower than 90 °C.*

2 *It will melt over a range of temperatures, not sharply.*

9

Turn over for the next question

Turn over ►



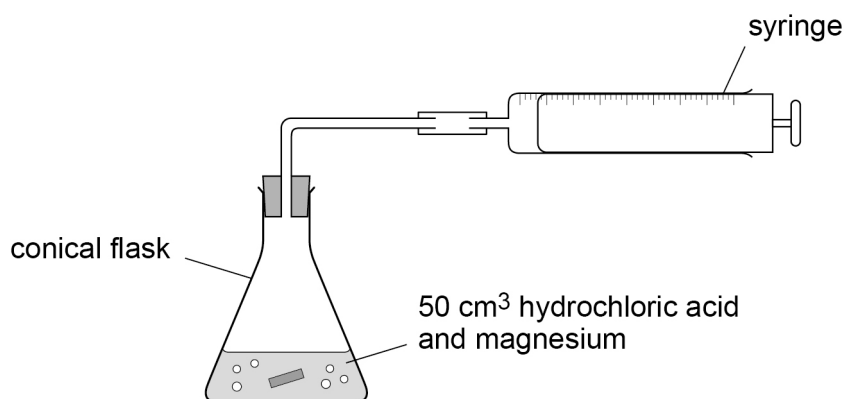
0 2

This question is about rates of reaction.

A student does an experiment to find the rate of reaction between magnesium ribbon and dilute hydrochloric acid using a continuous monitoring method.

The apparatus is shown in **Figure 1**.

Figure 1



Method

- 50 cm³ of hydrochloric acid are placed in a conical flask.
- A piece of magnesium ribbon is cleaned by rubbing with sandpaper.
- The magnesium is added to the acid, the bung is put into the flask and a timer is started.
- The total volume of gas collected in the gas syringe is recorded every 10 seconds.

0 2 . 1

Suggest a reason why the magnesium ribbon is cleaned by rubbing with sandpaper.

[1 mark]

To remove the magnesium oxide layer from the surface so that all the magnesium is exposed to the acid.

0 2 . 2

Give a reason why the bung is put into the flask as quickly as possible after the magnesium ribbon is added to the acid.

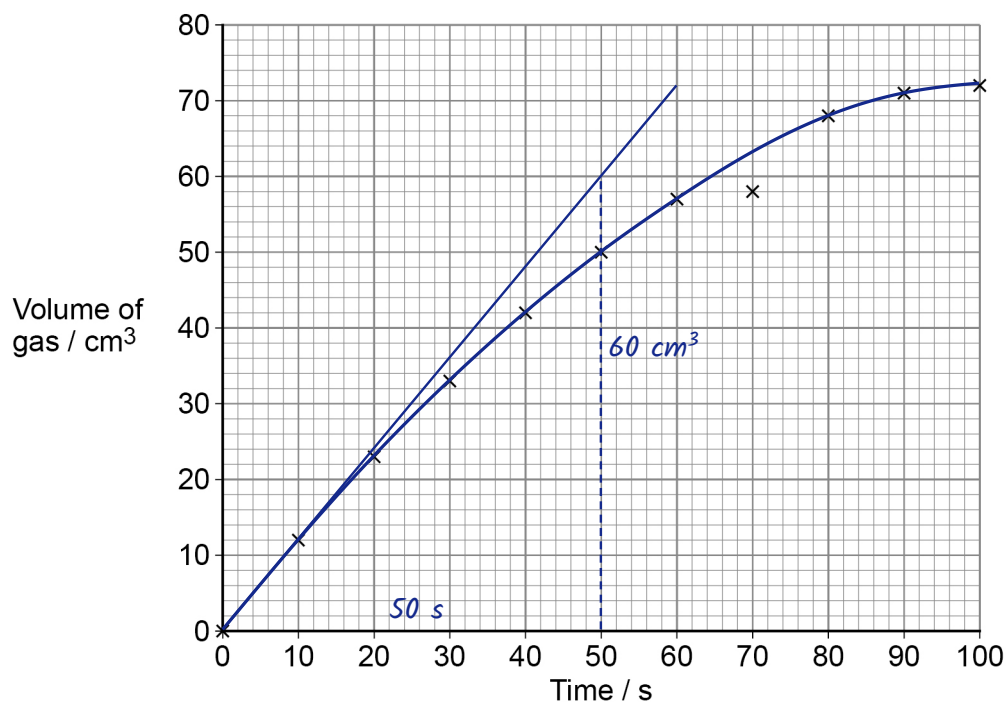
[1 mark]

So that hydrogen gas cannot escape, to minimise loss of gas before it is collected.



Figure 2 shows the results of the experiment.

Figure 2



0 2 . 3 Draw a suitable line to complete the graph in **Figure 2**.

[1 mark]

0 2 . 4 Draw a tangent on the graph at $t = 0$ on **Figure 2**.

Use the tangent to calculate the initial rate of reaction.

Give the units of the initial rate of reaction.

[3 marks]

Tangent drawn at $t = 0$ (see Figure 2)

$$\text{Gradient} = 60 \text{ cm}^3 \div 50 \text{ s}$$

$$= 1.2$$

Initial rate of reaction 1.2

Units $\text{cm}^3 \text{ s}^{-1}$

Turn over ►



0 2 . 5

During the experiment, the temperature of the mixture in the conical flask increased.

Predict how the increase in temperature affects the shape of the graph.

Suggest how the temperature increase can be minimised.

[2 marks]

Effect on shape of graph *The curve would be steeper at the start and would level off sooner (the reaction finishes faster).*

How temperature increase can be minimised *Stand the conical flask in a water bath (at room temperature) to keep the temperature constant.*

0 2 . 6

The acid concentration used in the experiment was 1.0 mol dm^{-3}

Suggest why an acid concentration of 3.0 mol dm^{-3} was **not** used.

Do **not** include safety in your answer.

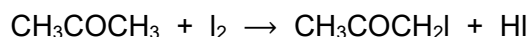
[1 mark]

The reaction would be too fast to measure accurately, so too much gas would be produced too quickly to record readings every 10 seconds.



A different reaction is studied using continuous monitoring.

Iodine reacts slowly with propanone in the presence of an acid catalyst.



Method

- 20.0 cm³ of an acidified iodine solution are placed in a beaker.
- Some aqueous propanone is added and a timer is started.
- Every 20 seconds, 0.50 cm³ of the reaction mixture is removed, added to a large volume of cold sodium hydrogencarbonate solution, and the amount of iodine is determined.

The change in the amount of iodine over time is used to determine the rate of reaction.

0 2 . 7

Explain why each 0.50 cm³ sample is added to a large volume of cold sodium hydrogencarbonate solution.

[2 marks]

To stop (quench) the reaction, so the amount of iodine in the sample no longer changes.

The sodium hydrogencarbonate removes (neutralises) the acid catalyst, and the large volume of cold solution dilutes the sample massively.

The rate of reaction between iodine and propanone is measured in a series of experiments (**A**, **B**, **C** and **D**) to find the order of the reaction.

Table 1 shows the volumes used in each experiment.

Table 1

Experiment	A	B	C	D
Volume of acidified iodine solution / cm ³	20.0	20.0	20.0	20.0
Volume of 1.00 mol dm ⁻³ aqueous propanone / cm ³	50.0	40.0	30.0	20.0
Volume of distilled water / cm ³	0.0	10.0	20.0	30.0

Turn over ►



0 2 . 8

Explain why different volumes of water are added in experiments **A** to **D**.

[2 marks]

To keep the total volume of every mixture the same (70.0 cm³).

*So the initial concentration of iodine is the same in each experiment
and only the concentration of propanone changes.*

0 2 . 9

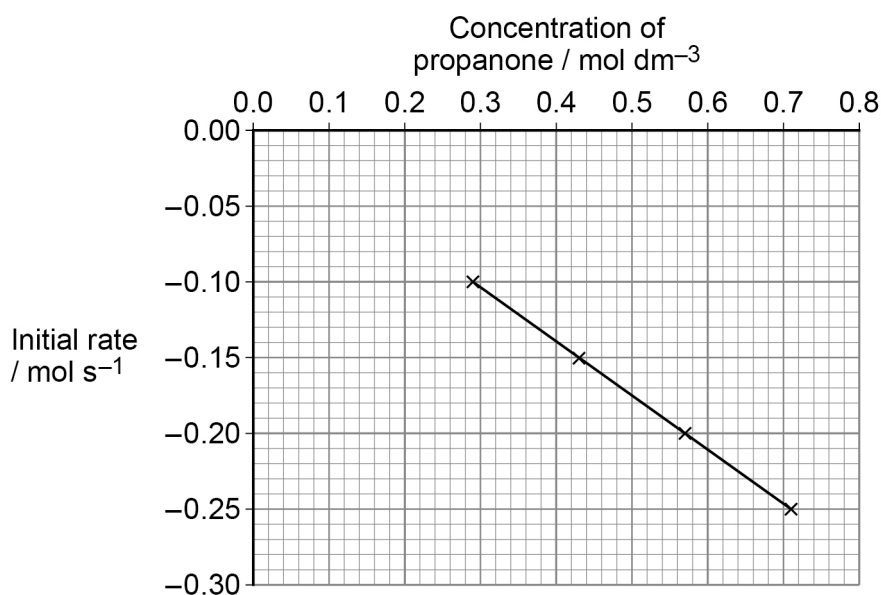
Figure 3 shows a graph of the results of experiments **A** to **D**.

Use **Figure 3** to deduce the order of reaction with respect to propanone.

Justify your answer.

[2 marks]

Figure 3



Order *First order*

Justification *The graph is a straight line through the origin, so the
(initial) rate is directly proportional to the concentration of propanone.*



0 3

This question is about halide ions.

In a test for a halide ion, a solution is acidified before silver nitrate solution is added.

0 3 . 1

Explain why the solution is acidified.

[1 mark]

To remove carbonate or hydroxide ions, which would form other silver precipitates and interfere with the test.

0 3 . 2

Identify an acid that can be used to acidify the solution.

[1 mark]

Nitric acid (dilute HNO_3)

0 3 . 3

State what is observed when silver nitrate solution is added to sodium chloride solution.

[1 mark]

A white precipitate forms.

0 3 . 4

Solid Y is a sodium halide. Concentrated sulfuric acid is added to a sample of solid Y. An orange-brown gas is given off.

Identify the halide ion in Y.

Write an equation for the reaction of concentrated sulfuric acid with Y to produce the orange-brown gas.

State the role of sulfuric acid in this reaction.

[3 marks]

Halide ion in Y *Bromide ion, Br^-*

Equation *$\text{H}_2\text{SO}_4 + 2\text{H}^+ + 2\text{Br}^- \rightarrow \text{SO}_2 + \text{Br}_2 + 2\text{H}_2\text{O}$*

Role of sulfuric acid *Oxidising agent*

6

Turn over ►



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.
Do **not** use additional sheets for this working.

0 4

Which is the definition of mass number?

[1 mark]

A Average mass of an atom of an isotope compared to the mass of an atom of ^{12}C

☐

B Total number of protons and electrons in an atom

☐

C Average mass of an atom of an element compared to $\frac{1}{12}$ of the mass of an atom of ^{12}C

☐

D Total number of protons and neutrons in an atom

☒

0 5

Which of these elements has the highest first ionisation energy?

[1 mark]

A Helium

☒

B Hydrogen

☐

C Krypton

☐

D Potassium

☐


0 6 What is the formula of chromium(III) sulfate?

[1 mark]

A CrSO_4 ☐

B Cr_2SO_4 ☐

C $\text{Cr}_2(\text{SO}_4)_3$ ☒

D $\text{Cr}_3(\text{SO}_4)_2$ ☐

0 7 Which row is correct for solid magnesium chloride?

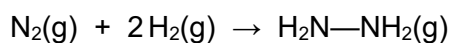
[1 mark]

	Crystal structure	Bonding	Electrical conductivity	
A	macromolecular	van der Waals	poor	☐
B	giant	ionic	good	☐
C	ionic	ionic	poor	☒
D	metallic	metallic	good	☐

0 8 Some mean bond enthalpies are given.

Bond	N–N	$\text{N}\equiv\text{N}$	H–H	N–H
Bond enthalpy / kJ mol^{-1}	163	943	436	391

These bond enthalpies are used to calculate the enthalpy change for this reaction.



What is the value of the enthalpy change, in kJ mol^{-1} , for this reaction?

[1 mark]

A +88 ☒

B –88 ☐

C –348 ☐

D –692 ☐

Turn over ►



0 9

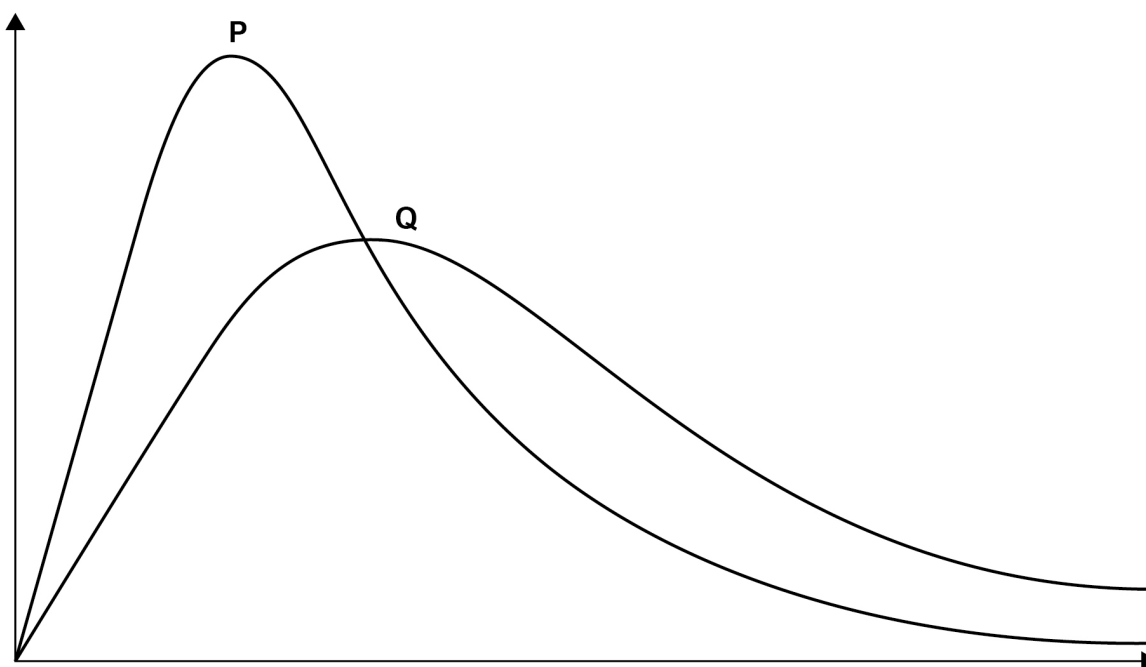
What is the electron configuration of a Co^{2+} ion?

[1 mark]

A $1s^2 2s^2 2p^6 3s^2 3p^6 3d^7 4s^2$ ☐B $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^2$ ☐C $1s^2 2s^2 2p^6 3s^2 3p^6 3d^7$ ☒D $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$ ☐

1 0

The diagram shows the Maxwell–Boltzmann distribution of molecular energies for 1 mole of gas under different conditions.



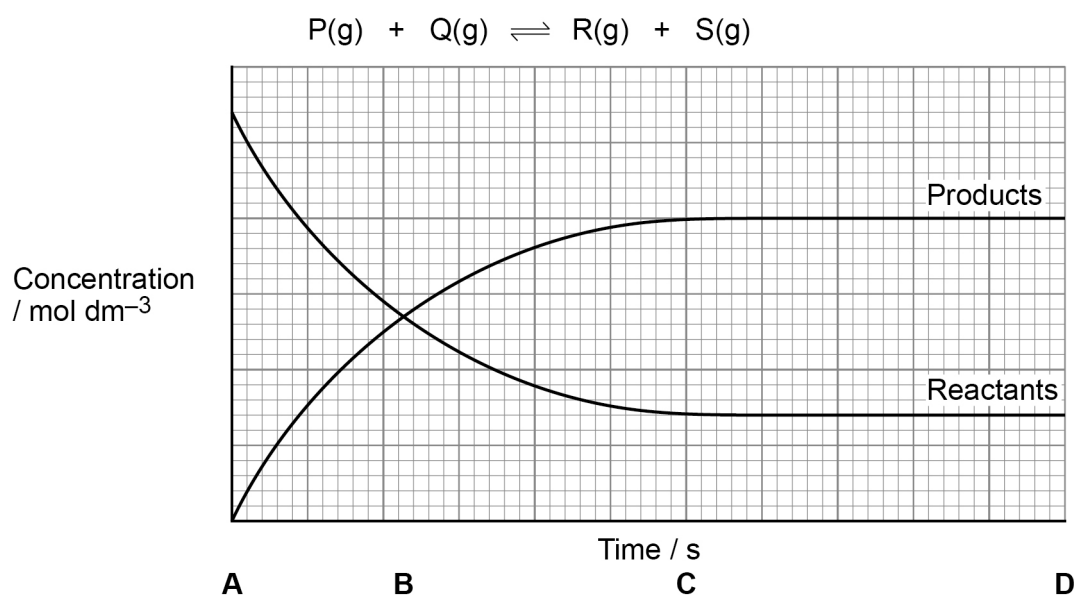
Which statement is correct?

[1 mark]

A The number of molecules is plotted on the x-axis. ☐B Curve P is at a higher temperature than curve Q. ☐C The area under each curve is the same. ☒D The most probable energy of the molecules represented by curve P is higher than that for curve Q. ☐

1 1

The graph shows changes in concentration during a reversible reaction.



At which time is equilibrium reached?

[1 mark]

- A ☐
- B ☐
- C ☒
- D ☐

1 2

The electron configurations of four atoms are shown.

Which is the strongest oxidising agent?

[1 mark]

- A $1s^2 2s^2 2p^5$ ☒
- B $1s^2 2s^2 2p^6 3s^1$ ☐
- C $1s^2 2s^2 2p^6 3s^2 3p^5$ ☐
- D $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$ ☐

Turn over ►



1 3 Which row shows the electrode equations for a lithium cell when it is being used?

[1 mark]

	Positive electrode	Negative electrode
A	$\text{Li} \rightarrow \text{Li}^+ + \text{e}^-$	$\text{Li}^+ + \text{CoO}_2 + \text{e}^- \rightarrow \text{Li}^+[\text{CoO}_2]^-$
B	$\text{Li}^+ + \text{e}^- \rightarrow \text{Li}$	$\text{Li}^+[\text{CoO}_2]^- \rightarrow \text{Li}^+ + \text{CoO}_2 + \text{e}^-$
C	$\text{Li}^+ + \text{CoO}_2 + \text{e}^- \rightarrow \text{Li}^+[\text{CoO}_2]^-$	$\text{Li} \rightarrow \text{Li}^+ + \text{e}^-$
D	$\text{Li}^+[\text{CoO}_2]^- \rightarrow \text{Li}^+ + \text{CoO}_2 + \text{e}^-$	$\text{Li}^+ + \text{e}^- \rightarrow \text{Li}$

A ☐

B ☐

C ☒

D ☐

1 4 In which equation is the first species acting as an acid?

[1 mark]

A $\text{CH}_3\text{COO}^- + \text{H}_2\text{O} \rightarrow \text{CH}_3\text{COOH} + \text{OH}^-$ ☐

B $\text{HNO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{H}_2\text{NO}_3^+ + \text{HSO}_4^-$ ☐

C $\text{H}_2\text{O} + \text{NH}_4^+ \rightarrow \text{H}_3\text{O}^+ + \text{NH}_3$ ☐

D $[\text{Fe}(\text{H}_2\text{O})_6]^{2+} + \text{H}_2\text{O} \rightarrow [\text{Fe}(\text{H}_2\text{O})_5(\text{OH})]^+ + \text{H}_3\text{O}^+$ ☒

1 5 What is the pH of a $2.0 \times 10^{-1} \text{ mol dm}^{-3}$ sodium hydroxide solution at 25°C ?

$K_w = 1.0 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6}$ at 25°C

[1 mark]

A 13.30 ☒

B 13.70 ☐

C 14.30 ☐

D 14.70 ☐



1 6 A weak acid has $K_a = 4.30 \times 10^{-6} \text{ mol dm}^{-3}$ at 25°C

What is the $\text{p}K_a$ of this acid at 25°C ?

[1 mark]

A -5.37 ☐

B -4.37 ☐

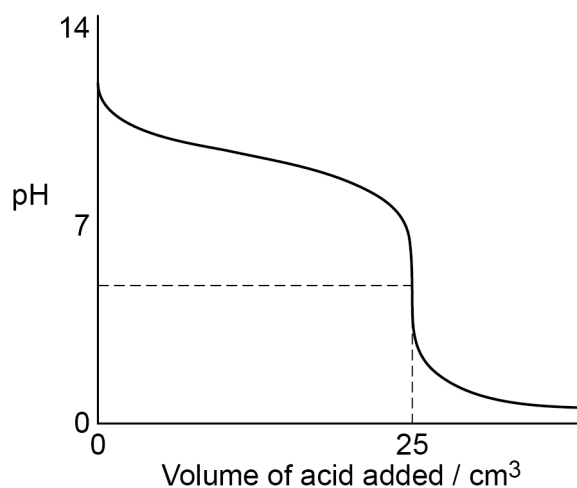
C 4.37 ☐

D 5.37 ☒

1 7 A titration was done with 1.0 mol dm^{-3} acid solution and 1.0 mol dm^{-3} alkali solution.

Which titration would produce the pH curve shown?

[1 mark]



A Adding hydrochloric acid to ammonia solution. ☒

B Adding hydrochloric acid to sodium hydroxide solution. ☐

C Adding ethanoic acid to ammonia solution. ☐

D Adding ethanoic acid to sodium hydroxide solution. ☐

Turn over ►



1 8 Which shows the oxides of Period 3 elements in order of increasing melting point?

[1 mark]

A $\text{SiO}_2 < \text{P}_4\text{O}_{10} < \text{SO}_2$ ☐

B $\text{SO}_2 < \text{SiO}_2 < \text{P}_4\text{O}_{10}$ ☐

C $\text{SO}_2 < \text{P}_4\text{O}_{10} < \text{SiO}_2$ ☒

D $\text{P}_4\text{O}_{10} < \text{SO}_2 < \text{SiO}_2$ ☐

1 9 An unknown oxide, **X**, is added to a test tube of water and the mixture is stirred. When some universal indicator is added, the mixture turns green.

Which of these could be oxide **X**?

[1 mark]

A Na_2O ☐

B MgO ☐

C Al_2O_3 ☒

D P_4O_{10} ☐

2 0 Which row is correct for these complexes?

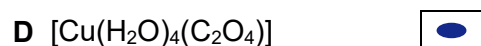
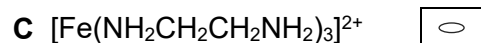
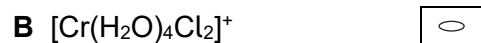
[1 mark]

	Complex	Co-ordination number	Shape	
A	$\text{Pt}(\text{NH}_3)_2\text{Cl}_2$	2	tetrahedral	☐
B	CuCl_4^{2-}	4	square planar	☐
C	$[\text{Co}(\text{C}_2\text{O}_4)_3]^{4-}$	3	octahedral	☐
D	$[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$	6	octahedral	☒



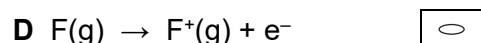
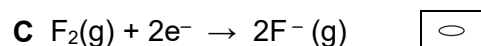
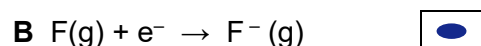
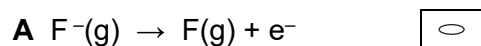
2 1 Which complex does **not** show stereoisomerism?

[1 mark]



2 2 Which equation represents the process that occurs when the first electron affinity of fluorine is measured?

[1 mark]

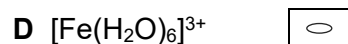
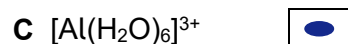
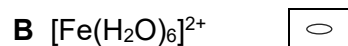
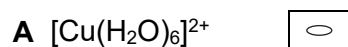


2 3 Dilute sodium hydroxide is added to a solution containing the complex ion **P**.

As the sodium hydroxide solution is added, a precipitate forms. This precipitate dissolves when excess sodium hydroxide solution is added.

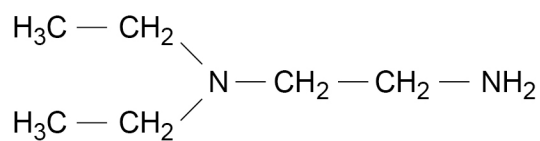
What is the formula of **P**?

[1 mark]



Turn over ►



2 4What is the integration ratio for peaks in the ^1H NMR spectrum of this amine?**[1 mark]****A** 3 : 3 : 2 : 2 : 2 : 2☐**B** 3 : 2 : 1 : 1 : 1☒**C** 3 : 2 : 1 : 1☐**D** 3 : 2 : 2 : 1☐**2 5**

What is the approximate C–O–C bond angle in epoxyethane?

[1 mark]**A** 60°☒**B** 105°☐**C** 109°☐**D** 120°☐**2 6**

Which compound is formed when epoxyethane reacts with methanol?

[1 mark]**A** $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$ ☐**B** $\text{CH}_3\text{OCH}_2\text{CH}_2\text{OH}$ ☒**C** $\text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_2\text{OH}$ ☐**D** $\text{CH}_3\text{OCH}_2\text{CH}_2\text{CH}_2\text{OH}$ ☐

2	7
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Why is ethanoic anhydride used instead of ethanoyl chloride in the manufacture of aspirin?

[1 mark]

- A** Ethanoic anhydride is more easily hydrolysed by water. ☐
- B** Ethanoyl chloride produces hydrogen chloride as a waste product. ☒
- C** Ethanoyl chloride reacts more slowly. ☐
- D** Ethanoic anhydride is a stronger acylating agent. ☐

2	8
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Benzene reacts with concentrated sulfuric acid to form benzenesulfonic acid.

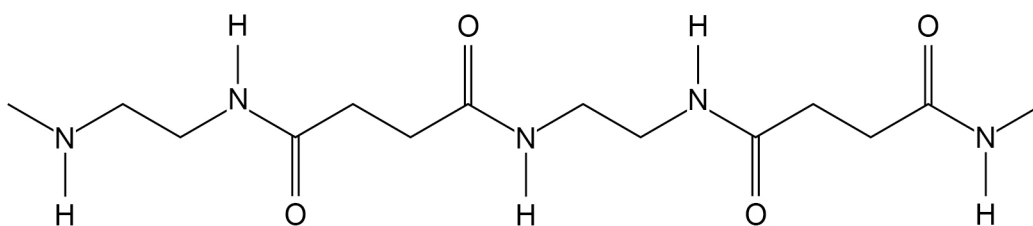
Which statement is correct?

[1 mark]

- A** Aluminium chloride is used as a catalyst. ☐
- B** Benzene is protonated by the sulfuric acid. ☐
- C** The electrophile has the molecular formula SO_3 ☒
- D** Benzenesulfonic acid has the molecular formula $\text{C}_6\text{H}_5\text{SO}_3$ ☐

2	9
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A section of a polymer is shown.



Which statement is correct?

[1 mark]

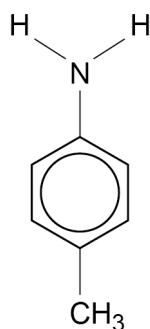
- A** The section shown has four repeating units. ☐
- B** The polymer is non-biodegradable. ☐
- C** The strongest forces between the polymer chains are hydrogen bonds. ☒
- D** The monomer ethanedioic acid could be used to make the polymer. ☐

Turn over ►

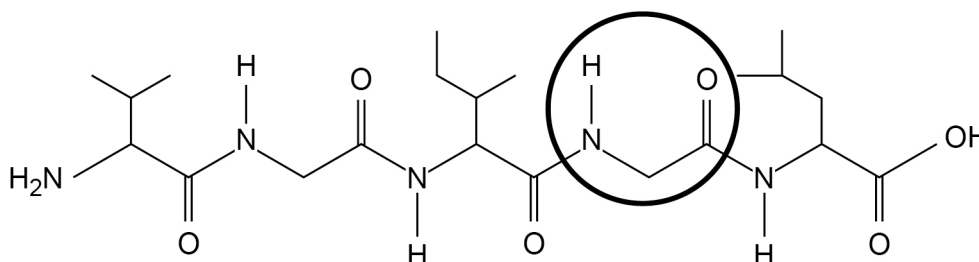


3 0

Which statement about 4-methylphenylamine is correct?

[1 mark]**A** It is a weaker base than ammonia.☒**B** It can be prepared by reduction of a nitrile.☐**C** There are four peaks in its ^{13}C NMR spectrum.☐**D** Its infrared spectrum has an absorption between 2220 and 2260 cm^{-1} ☐**3 1**

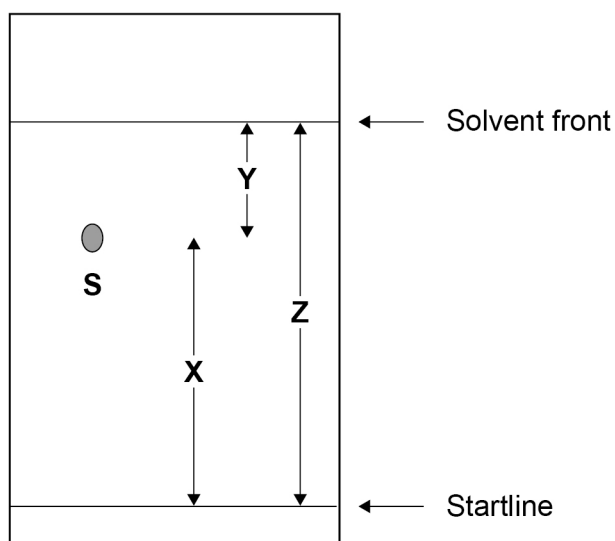
The diagram shows a peptide.



Which statement is correct?

[1 mark]**A** The peptide is made from five different amino acids.☐**B** The complete hydrolysis of the peptide produces four different amino acids.☒**C** The complete hydrolysis of the peptide allows the sequence of amino acids to be determined.☐**D** The circle on the diagram shows a peptide link.☐

3 2 A thin-layer chromatogram of substance **S** is shown.



Which calculation shows the R_f value of substance **S**?

[1 mark]

A $X \div Y$

B $X \div Z$

C $Y \div Z$

D $Z \div X$

☐☒☐☐

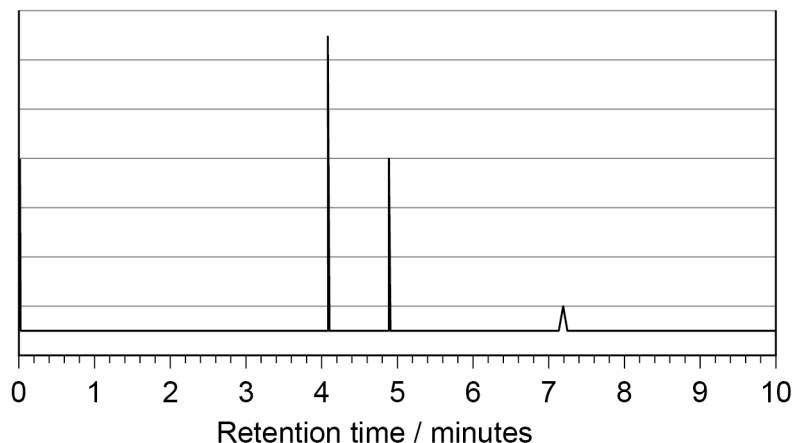
Turn over for the next question

Turn over ►



3 3

A mixture of organic compounds is analysed by gas chromatography (GC).
The GC trace is shown.



The retention times for some compounds using the same GC apparatus are given.

Compound	Retention time / min
2-methylnitrobenzene	4.1
3-methylnitrobenzene	4.4
4-methylnitrobenzene	4.9
1-methyl-2,4-dinitrobenzene	7.2

Which statement is correct?

[1 mark]

- A** 1-Methyl-2,4-dinitrobenzene travels through the column fastest.
- B** The length of the column does not affect the retention times.
- C** 3-Methylnitrobenzene is not detected in the mixture.
- D** The nature of the stationary phase does not affect the retention times.

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END OF QUESTIONS



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[illegible]

[illegible]

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