OXFORD

INTERNATIONAL
AQA EXAMINATIONS

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____
I declare this is my own work.

INTERNATIONAL A-LEVEL
CHEMISTRY (9620)

Unit 5: Practical and synoptic

Monday 24 January 2022 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	

Do not write outside the box

Section A

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

0 1 This question is about acid-base titrations.

A student finds the concentration of a sample of sulfuric acid by titration using sodium hydrogencarbonate ($NaHCO_3$) solution.

The student makes the standard sodium hydrogencarbonate solution by dissolving a known mass of solid in water and making up to 250 cm^3

0 1 . 1 Calculate the mass, in g, of sodium hydrogencarbonate needed to make 250 cm^3 of 0.100 mol dm^{-3} sodium hydrogencarbonate solution.

[2 marks]

Mass_____ g

Method

- Weigh the sample of solid sodium hydrogencarbonate in a weighing bottle and record its mass.
- Transfer the solid to a beaker.
- Add approximately 100 cm^3 water and stir until the solid has dissolved.
- Pour the solution into a 250 cm^3 volumetric flask using a funnel.
- Add water to the flask up to the mark and shake the flask.
- Pipette 25.0 cm^3 of this solution into a conical flask.
- Add two drops of methyl orange indicator.
- Add the sulfuric acid from a burette until the indicator first changes colour.

Repeat the last three steps until sufficient results are obtained.

Do not write outside the box

0 1 . 2 State how the student should make sure that the mass of the sodium hydrogencarbonate transferred to the beaker is known accurately.

[1 mark]

0 1 . 3 State how the student should make sure that all the sodium hydrogencarbonate solution is transferred from the beaker to the volumetric flask.

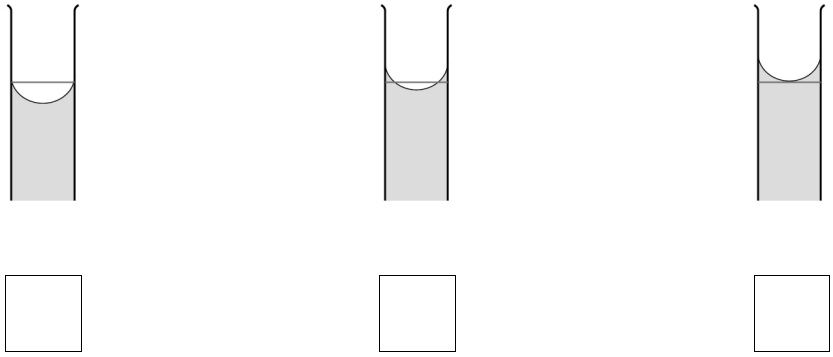
[1 mark]

0 1 . 4 The three diagrams show the neck of the 250 cm^3 volumetric flask containing the solution.

Which diagram shows that the volumetric flask contains exactly 250 cm^3 of solution?

Tick (✓) **one** box.

[1 mark]



Question 1 continues on the next page

Do not write outside the box

0 1 . 5 **Table 1** shows the titration results.

Table 1

Final reading / cm^3	23.75	47.25	36.95	36.15
Initial reading / cm^3	00.00	24.70	14.55	13.55
Volume used / cm^3	23.75	22.55		22.60

Complete **Table 1**.

Calculate the mean titre.

[2 marks]

Mean titre_____ cm^3

0 1 . 6 Another student uses 2.052 g of sodium hydrogencarbonate ($NaHCO_3$) to make a 250 cm^3 standard solution for a similar titration.

25.0 cm^3 portions of this sodium hydrogencarbonate solution are used.

This student's mean titre is 22.75 cm^3 of sulfuric acid.

Calculate the concentration, in mol dm^{-3}, of the sulfuric acid.

[3 marks]

Concentration_____ mol dm^{-3}

10

Do not write outside the box

Turn over for the next question

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Do not write outside the box

0 2 This question is about the reaction between iodide ions and acidified hydrogen peroxide.

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

A series of experiments is used to determine the order of reaction with respect to iodide ions.

The initial amounts of all the reagents except potassium iodide are the same in each experiment.

Table 2 shows the volumes of water and potassium iodide solution used in each experiment.

Table 2

Experiment	Water / cm^3	KI(aq) / cm^3
1	0	25.0
2	5.0	20.0
3	12.0	13.0
4	15.0	10.0
5	20.0	5.0

The time is measured for a fixed amount of iodine to be formed at different concentrations of iodide ions.

Table 3 shows the results of a series of experiments.

The initial concentration of iodide ions and the initial rate have been calculated for most of the experiments.

Initial rate is given by $\frac{1}{\text{time}}$

Table 3

Experiment	Volume of water / cm^3	Volume of KI(aq) / cm^3	Initial $[I^-]$ / mol dm^{-3}	Time / s	Initial rate / s^{-1}
1	0	25.0	0.0050	20.9	0.0478
2	5	20.0	0.0040	27.0	0.0370
3	12	13.0		38.0	
4	15	10.0	0.0020	52.1	0.0192
5	20	5.0	0.0010	99.0	0.0101

Do not write outside the box

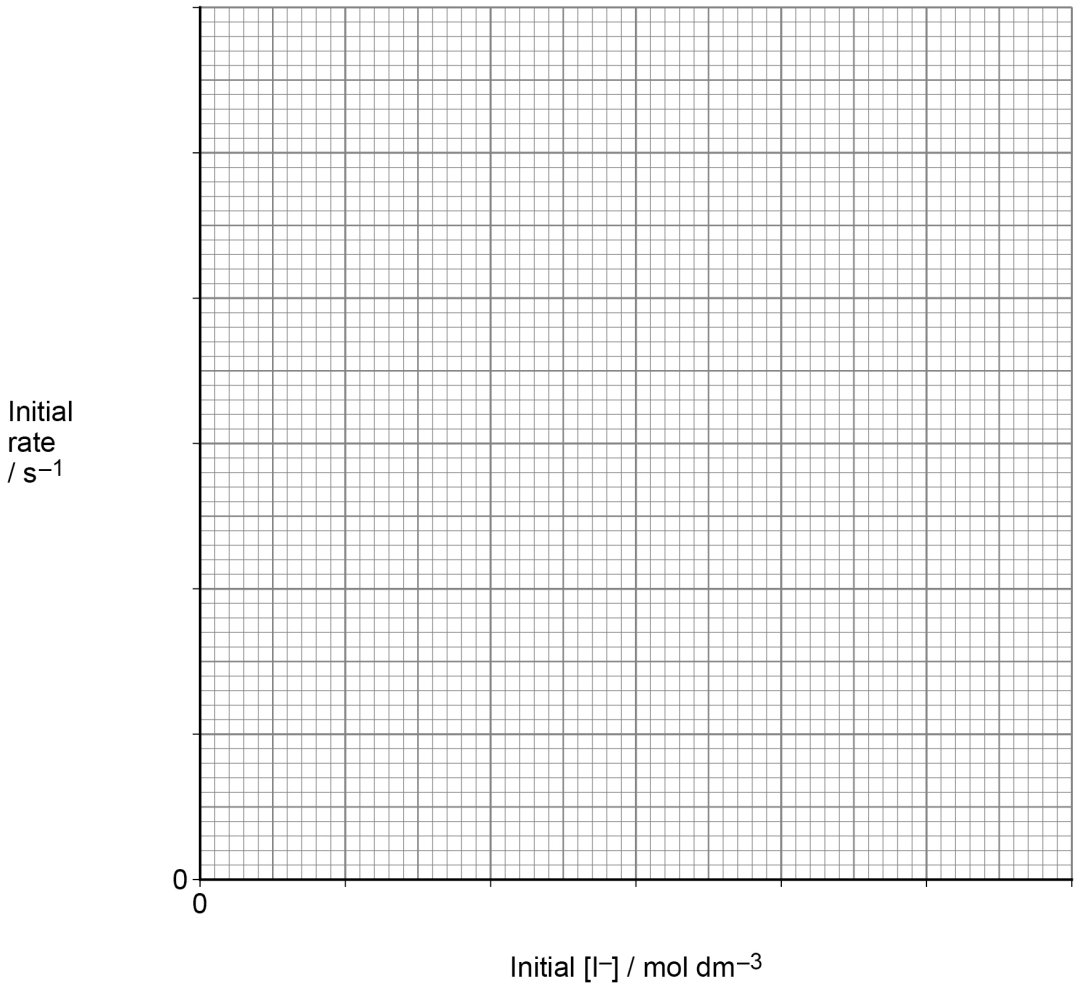
0 2 . 1 Complete **Table 3**.

[2 marks]

0 2 . 2 Draw a graph of initial rate (*y*-axis) against initial concentration of I^- on the grid in **Figure 1** using data from the completed **Table 3**.

[3 marks]

Figure 1



0 2 . 3 State how the graph in Question **02.2** shows that the reaction is first order with respect to $[I^-]$

[1 mark]

_____

_____

6

Turn over for the next question

Do not write outside the box

0 3 This question is about electrochemical cells.

Table 4 shows some electrode half-equations and their standard electrode potentials.

Table 4

Electrode half-equation	$E^{\ominus}$ / V
$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(l)$	+1.52
$VO_2^+(aq) + 2H^+(aq) + e^- \rightarrow VO^{2+}(aq) + H_2O(l)$	+1.00
$Ag^+(aq) + e^- \rightarrow Ag(s)$	+0.80
$VO^{2+}(aq) + 2H^+(aq) + e^- \rightarrow V^{3+}(aq) + H_2O(l)$	+0.34
$Pb^{2+}(aq) + 2e^- \rightarrow Pb(s)$	–0.13
$Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$	–0.25
$V^{3+}(aq) + e^- \rightarrow V^{2+}(aq)$	–0.26
$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$	–0.76
$V^{2+}(aq) + 2e^- \rightarrow V(s)$	–1.20

0 3 . 1 Identify the weakest oxidising agent in **Table 4**.

Explain your choice.

[2 marks]

Weakest oxidising agent _____

Explanation _____

_____

_____

Do not write outside the box

0 3 . 2 A student measures the electrode potential of the Pb^{2+}/Pb electrode using a standard hydrogen electrode.

Give **three** conditions under which the EMF of this electrode is –0.13 V

[2 marks]

_____

_____

_____

_____

0 3 . 3 The total uncertainty when measuring the cell EMF of –0.13 V is ±0.01 V

Calculate the percentage uncertainty for this value.
Give your answer to 2 significant figures.

[1 mark]

_____

0 3 . 4 A Pb^{2+}/Pb electrode is connected to a Ni^{2+}/Ni electrode.

Write an equation for the cell reaction.

Calculate the cell EMF when the cell operates under standard conditions.

[2 marks]

Equation

_____

EMF_____V

Question 3 continues on the next page

Do not write outside the box

Table 4 is repeated here.

Table 4

Electrode half-equation	$E^{\ominus}$ / V
$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(l)$	+1.52
$VO_2^+(aq) + 2H^+(aq) + e^- \rightarrow VO^{2+}(aq) + H_2O(l)$	+1.00
$Ag^+(aq) + e^- \rightarrow Ag(s)$	+0.80
$VO^{2+}(aq) + 2H^+(aq) + e^- \rightarrow V^{3+}(aq) + H_2O(l)$	+0.34
$Pb^{2+}(aq) + 2e^- \rightarrow Pb(s)$	–0.13
$Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$	–0.25
$V^{3+}(aq) + e^- \rightarrow V^{2+}(aq)$	–0.26
$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$	–0.76
$V^{2+}(aq) + 2e^- \rightarrow V(s)$	–1.20

0 3 . 5 A VO_2^+/VO^{2+} electrode is connected to a MnO_4^-/Mn^{2+} electrode.

Write the conventional representation of this cell.

[2 marks]

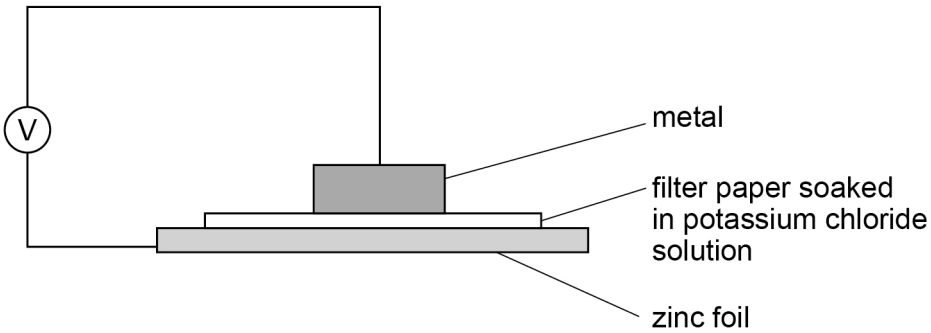
0 3 . 6 Use **Table 4** to explain why Ag will reduce VO_2^+ to VO^{2+} but no further.

[2 marks]

Do not write outside the box

0 3 . 7 The potential difference produced by a simple electrochemical cell can be measured in the experiment shown in **Figure 2**.

Figure 2



The zinc foil and the metal are cleaned with sandpaper before the potential difference is measured.
The sign and value of the potential difference are recorded.
The experiment is repeated with other pieces of the same metal.

State why the metals are cleaned with sandpaper.

State why the filter paper is soaked in potassium chloride solution.

Explain why the experiment is repeated using other pieces of the same metal.

[3 marks]

Clean with sandpaper _____

_____

Filter paper soaked in potassium chloride solution _____

_____

Repeat the experiment _____

_____

_____

14

Turn over for Section B

Do not write outside the box

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 shows the correct numbers of neutrons and electrons in $^{78}Se^{2-}$?

[1 mark]

	Number of neutrons	Number of electrons
A	44	32
B	78	32
C	44	36
D	78	36

0 5 A fluorocarbon has a relative molecular mass between 85 and 100
The fluorocarbon contains 51.1% of carbon and 8.5% of hydrogen by mass.

What is the molecular formula of the fluorocarbon?

[1 mark]

A C_2H_2F

B C_2H_4F

C $C_4H_4F_2$

D $C_4H_8F_2$

Do not write outside the box

0 6 What is the percentage atom economy for the production of zinc chloride in this reaction?

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

[1 mark]

A 47.3% ⬭

B 47.9% ⬭

C 72.9% ⬭

D 98.6% ⬭

0 7 During a titration, a student adds some solution from the burette then washes the inside of the flask with deionised water.

What is the reason for washing the inside of the conical flask?

[1 mark]

A So the reactants are more dilute and therefore less hazardous. ⬭

B So all the reagents are included in the titration. ⬭

C So the apparatus is clean. ⬭

D So it is easier to see the colour change of the indicator. ⬭

0 8 Consider the four compounds

BF_3 SiH_4 PH_3 SF_4

Which statement is correct?

[1 mark]

A The bond angles in both SiH_4 and SF_4 are 109.5° ⬭

B The molecules SF_4 and PH_3 both contain a lone pair of electrons. ⬭

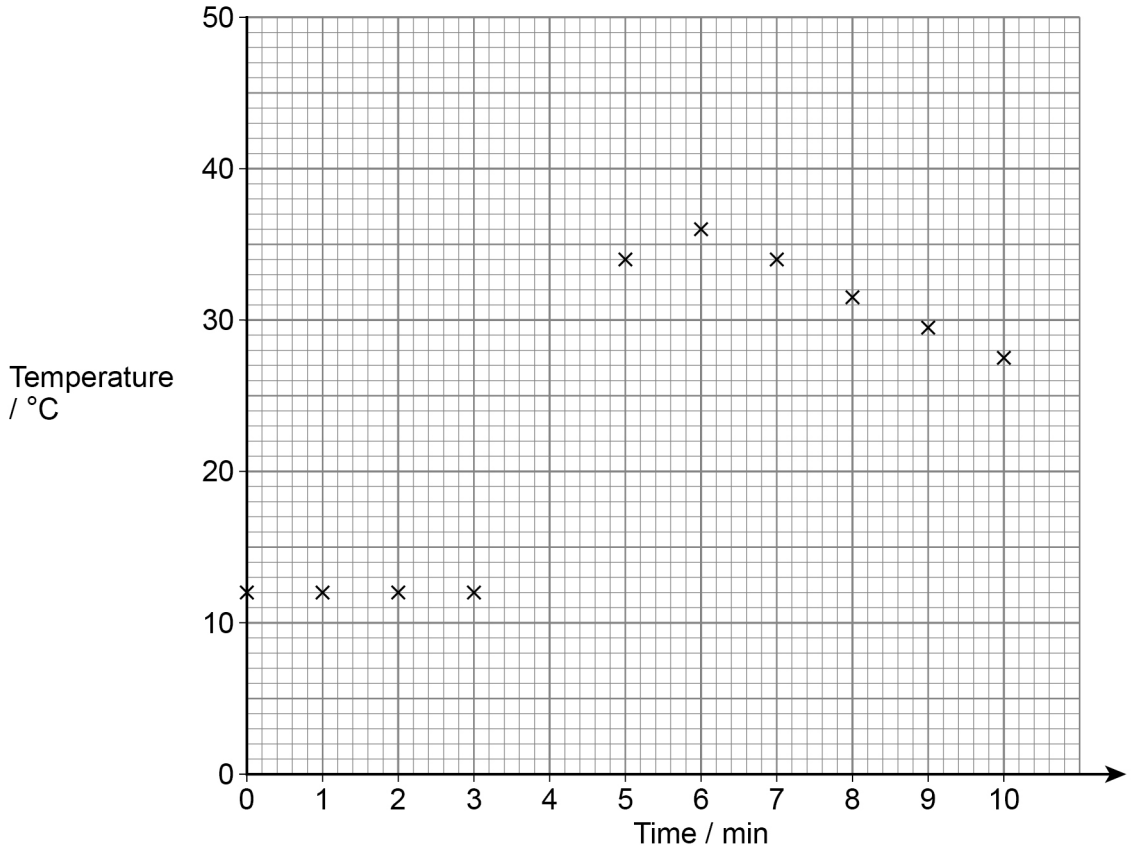
C The difference in electronegativity of the elements causes both SF_4 and BF_3 to be polar molecules. ⬭

D The shapes of PH_3 and BF_3 are both trigonal planar. ⬭

Do not write outside the box

0 9 A student plots results from a calorimetry experiment.

What is the value for the temperature rise at time = 4 minutes?



[1 mark]

A 40 °C

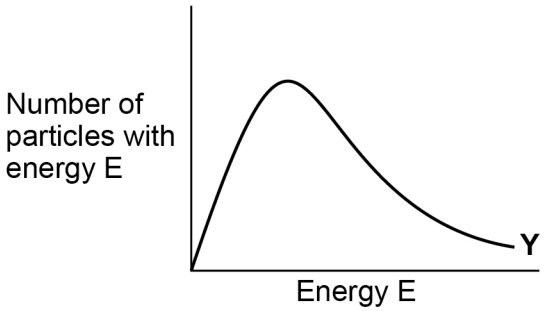
B 36 °C

C 28 °C

D 24 °C

Do not write outside the box

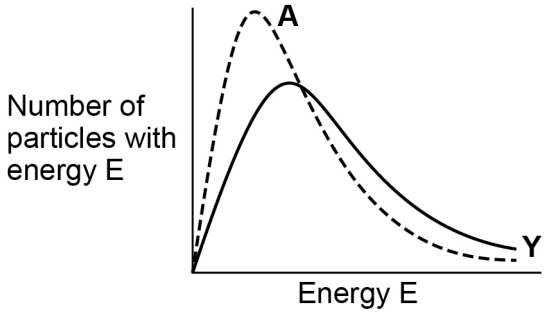
1 0 The Maxwell–Boltzmann distribution curve for gas **Y** at a given temperature is shown.



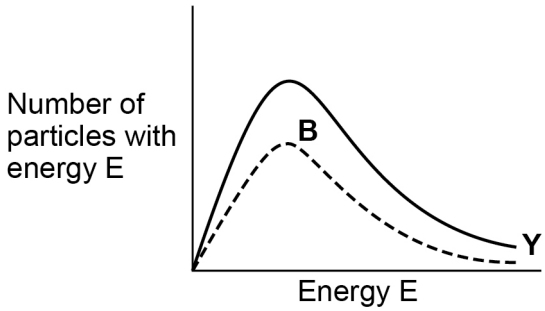
Which shows the distribution curve when the concentration is increased at this temperature?

[1 mark]

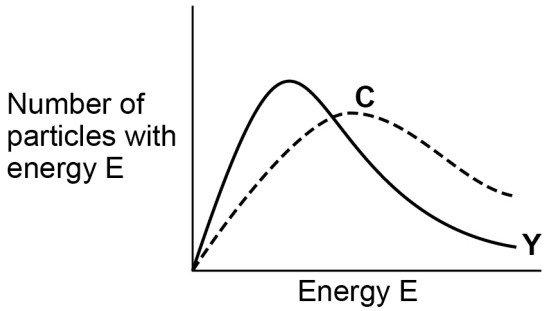
A



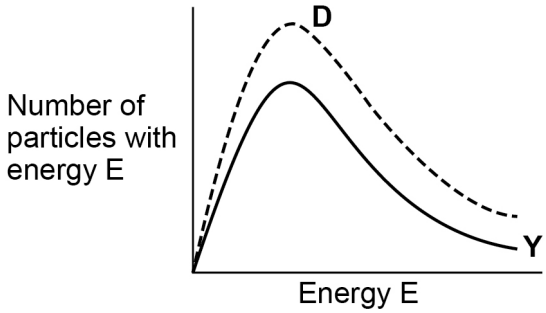
B



C



D



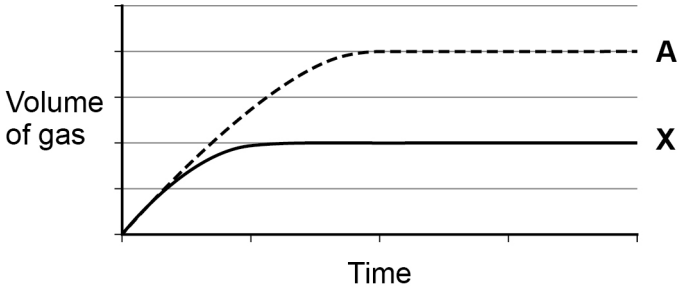
Do not write outside the box

1 1 **X** shows the volume of gas formed in a reaction between hydrochloric acid and an excess of calcium carbonate.

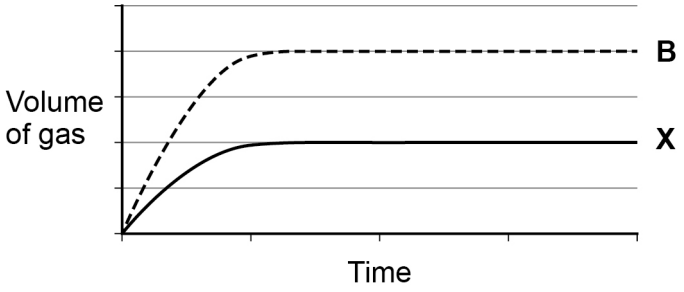
Which curve shows the volume of gas formed when the concentration of hydrochloric acid is doubled and there is still an excess of calcium carbonate?
All other conditions are the same.

[1 mark]

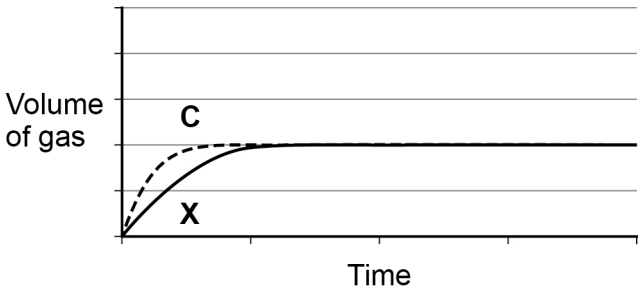
A



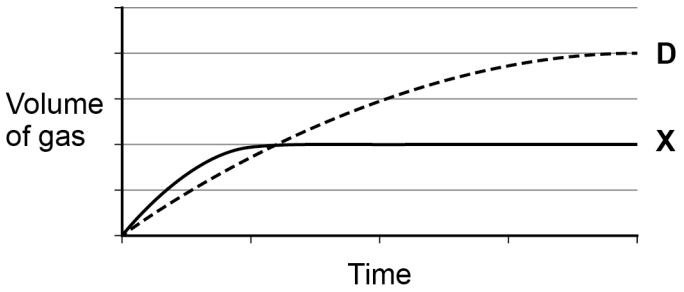
B



C



D



Do not write outside the box

1 2 An increase in temperature results in an increase in the value of K_c for a reaction at equilibrium.

Which is correct for the reaction?

[1 mark]

	Enthalpy change of forward reaction	% yield of products when temperature is increased	
A	exothermic	decrease	⬭
B	endothermic	decrease	⬭
C	exothermic	increase	⬭
D	endothermic	increase	⬭

1 3 Which equation shows the process occurring at the positive electrode when a lithium ion cell is discharging?

[1 mark]

A $Li^+ + e^- \rightarrow Li$ ⬭

B $Li \rightarrow Li^+ + e^-$ ⬭

C $Li^+ + CoO_2 + e^- \rightarrow LiCoO_2$ ⬭

D $LiCoO_2 \rightarrow Li^+ + CoO_2 + e^-$ ⬭

1 4 An acid (H_2X) is fully dissociated in aqueous solution.

$$H_2X(aq) \rightarrow 2H^+(aq) + X^{2-}(aq)$$

What is the concentration, in mol dm^{-3}, of a solution of H_2X with pH = −0.14?

[1 mark]

A 0.36 mol dm^{-3} ⬭

B 0.69 mol dm^{-3} ⬭

C 0.72 mol dm^{-3} ⬭

D 1.38 mol dm^{-3} ⬭

Do not write outside the box

1 5 A student adds x mol of sodium hydroxide to $2x$ mol of ethanoic acid in aqueous solution.

The student then measures the pH of the solution formed and uses this to calculate a value for the acid dissociation constant (K_a) of ethanoic acid.

The student misreads the burette and adds too much sodium hydroxide.

How does the calculated value of K_a compare with the actual value?

[1 mark]

The calculated value of K_a would be

A unchanged ⬭

B higher ⬭

C inverse ⬭

D lower ⬭

1 6 25.00 cm^3 of a 0.100 mol dm^{-3} solution of a base are added to a conical flask. Acid of concentration 0.100 mol dm^{-3} is added from the burette.

These data are recorded.

Volume of acid added / cm^3	pH
0.00	11.30
10.00	9.43
20.00	8.66
23.00	8.20
24.00	7.88
26.00	2.70
27.00	2.24
30.00	2.04
40.00	1.64
50.00	1.48

Which pair of solutions would produce these data?

[1 mark]

A ammonia and hydrochloric acid ⬭

B ammonia and ethanoic acid ⬭

C sodium hydroxide and hydrochloric acid ⬭

D sodium hydroxide and ethanoic acid ⬭

Do not write outside the box

1 7 Which pair of compounds in aqueous solution could be mixed to make a solution that will maintain a pH of 9.60 when small amounts of acid or base are added?

[1 mark]

A ammonia and ammonium chloride

B ammonia and potassium chloride

C propanoic acid and ammonium chloride

D propanoic acid and potassium propanoate

1 8 In a series of experiments, values of the rate constant (k) of a reaction are determined for a range of temperatures.

The Arrhenius equation can be written in the form

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

A graph of $\ln k$ against $\frac{1}{T}$ has a gradient = –7600 K

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

What is the value of the activation energy (E_a), in kJ mol^{-1}, from these experiments?

[1 mark]

A 63

B 7.6

C –7.6

D –63

Turn over for the next question

Do not write outside the box

1 9 Substances A and B react by the following mechanism.

Step 1 A + B → X

Step 2 A + X → Y

Step 3 Y → C + D

Step 2 is the rate determining step for the reaction.

What is the rate equation for the reaction?

[1 mark]

A *Rate* = k[A][B]

B *Rate* = $k[A]^2[B]$

C *Rate* = $k[A]^2[B][X]$

D *Rate* = $k[A]^2[B][X][Y]$

2 0 Which statement is correct?

[1 mark]

A Magnesium has a higher electronegativity than calcium.

B Magnesium hydroxide and hydrogen are formed when magnesium reacts with steam.

C Magnesium has a lower first ionisation energy than calcium.

D Magnesium hydroxide is more soluble in water than calcium hydroxide is in water.

2 1 Which compound produces a solution with an alkaline pH when added to water?

[1 mark]

A sodium chloride

B magnesium oxide

C phosphorus(V) chloride

D sulfur dioxide

Do not write outside the box

2 2 Which reaction, in aqueous solution, would have the most positive entropy change?

[1 mark]

A $[Cu(H_2O)_6]^{2+} + 4\,Cl^- \rightarrow [CuCl_4]^{2-} + 6\,H_2O$

B $[Cu(H_2O)_6]^{2+} + 3\,NH_2CH_2CH_2NH_2 \rightarrow [Cu(NH_2CH_2CH_2NH_2)_3]^{2+} + 6\,H_2O$

C $[CoCl_4]^{2-} + 6\,H_2O \rightarrow [Co(H_2O)_6]^{2+} + 4\,Cl^-$

D $[Co(H_2O)_6]^{2+} + 6\,NH_3 \rightarrow [Co(NH_3)_6]^{2+} + 6\,H_2O$

2 3 Which complex shows both *cis-trans* and optical isomerism?

[1 mark]

A $Pt(NH_3)_2Cl_2$

B $[Co(NH_2CH_2CH_2NH_2)_3]^{2+}$

C $[Cu(NH_2CH_2CH_2NH_2)_2(H_2O)_2]^{2+}$

D $[Fe(NH_3)_6]^{2+}$

2 4 An aqueous solution containing $[Cu(H_2O)_6]^{2+}$ is blue.
An aqueous solution containing $[CuCl_4]^{2-}$ is yellow-green.

Which does **not** help explain the difference in colour?

[1 mark]

A The ligands of the complex ions are different.

B The energy gap between the d-orbitals is different.

C The charges on the complex ions are different.

D The shapes of the complex ions are different.

Turn over for the next question

Do not write outside the box

2 5 The reaction between I^- ions and $S_2O_8^{2-}$ ions is catalysed by Fe^{2+} ions.

$$2\,I^- + S_2O_8^{2-} \rightarrow I_2 + 2\,SO_4^{2-}$$

Which is correct?

[1 mark]

A Fe^{2+} oxidises I^-

B Fe^{3+} reduces I^-

C Fe^{2+} reduces $S_2O_8^{2-}$

D Fe^{3+} oxidises $S_2O_8^{2-}$

2 6 Acidified barium chloride solution is used to test for sulfate ions.
Acidified silver nitrate solution is used to test for halide ions.

Which acid could be used in both of these tests?

[1 mark]

A hydrochloric acid

B nitric acid

C sulfuric acid

D ethanoic acid

2 7 Which equation shows a propagation step in the conversion of chloromethane into dichloromethane?

[1 mark]

A $\bullet CH_2Cl + \bullet Cl \rightarrow CH_2Cl_2$

B $\bullet CH_2Cl + Cl_2 \rightarrow CH_2Cl_2 + \bullet Cl$

C $CH_3Cl + \bullet Cl \rightarrow CH_2Cl_2 + \bullet H$

D $\bullet CH_3 + Cl_2 \rightarrow CH_3Cl + \bullet Cl$

Do not write outside the box

2 8 Which alkene reacts to produce a major product via a mechanism that does **not** involve a secondary carbocation?

[1 mark]

A $CH_2{=}CHC(CH_3)_3$

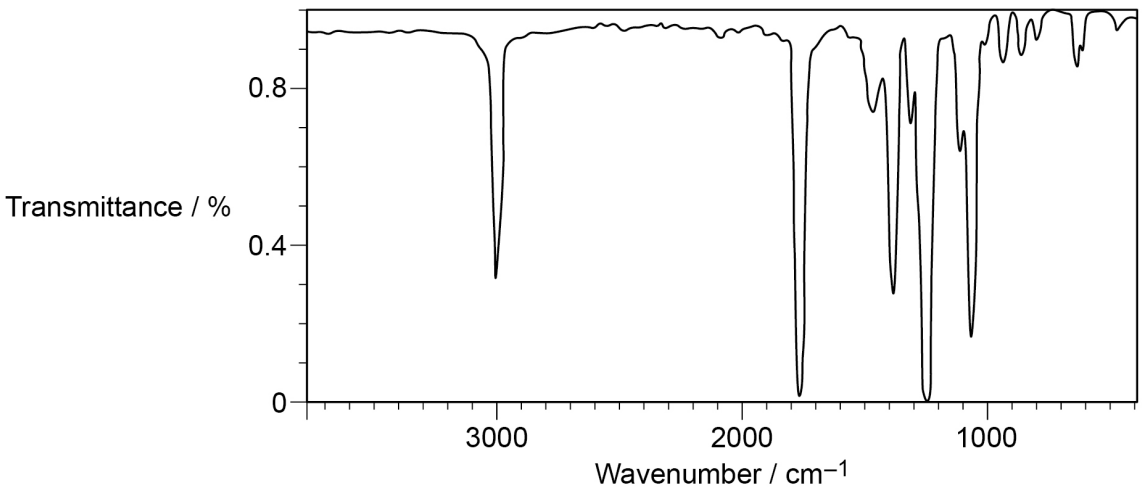
B $CH_2{=}CHCH(CH_3)_2$

C $CH_2{=}C(CH_3)CH_2CH_3$

D $CH_3CH{=}CHCH_2CH_3$

2 9 Which type of compound would give this infrared spectrum?

Use **Table A** on the Chemistry Data Sheet.



[1 mark]

A alcohol

B amine

C carboxylic acid

D ester

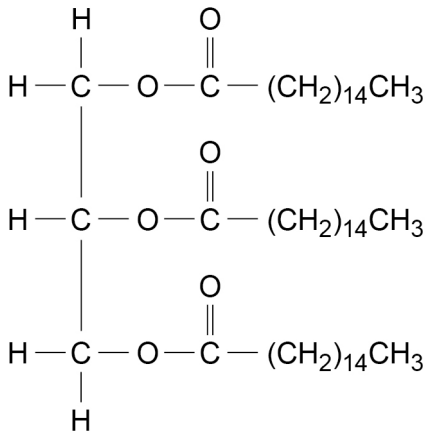
Turn over for the next question

Do not write outside the box

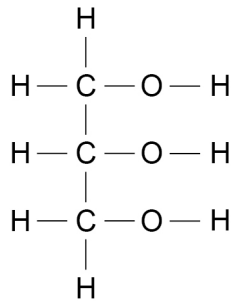
3 0 Which molecule is a component of biodiesel?

[1 mark]

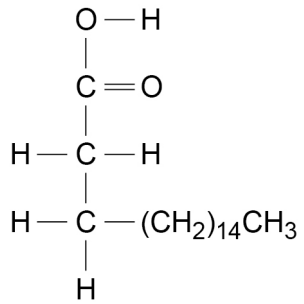
A



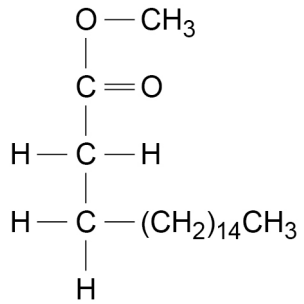
B



C



D



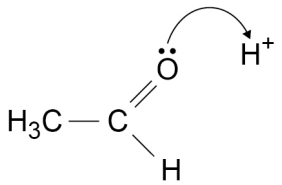
Do not write outside the box

3 1 Ethanal is reduced using $NaBH_4$

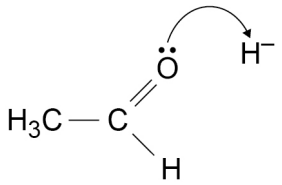
Which is the first step in the mechanism?

[1 mark]

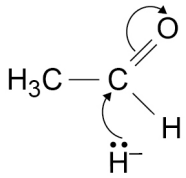
A



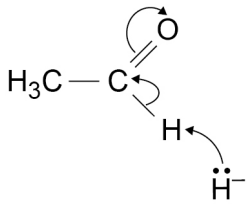
B



C



D



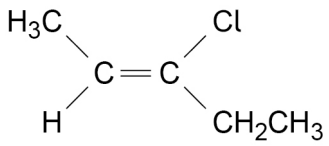
Turn over for the next question

Do not write outside the box

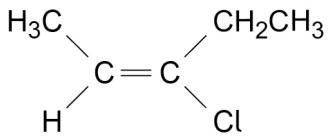
3 2 Which is an *E*-isomer?

[1 mark]

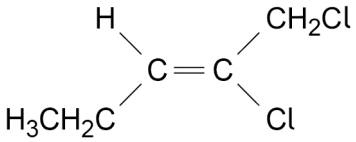
A



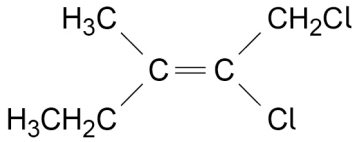
B



C

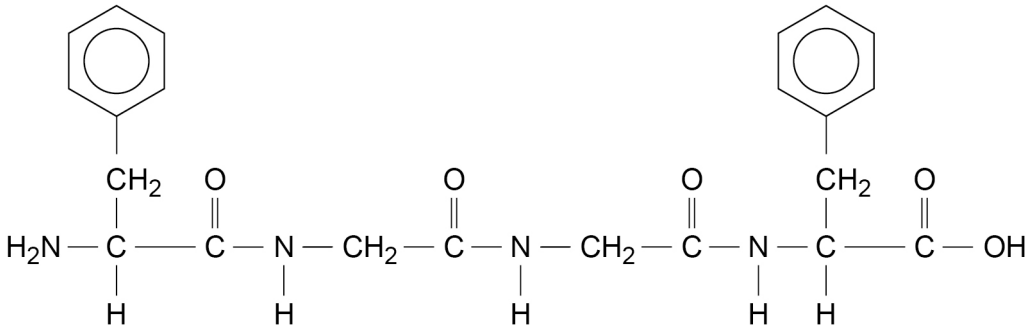


D



Do not write outside the box

3 3 This compound is formed from two molecules of glycine and two molecules of phenylalanine.



It can also be represented as Phe-Gly-Gly-Phe

This is hydrolysed to give a mixture containing partially hydrolysed and fully hydrolysed compounds.

How many organic products are in the mixture?

[1 mark]

A 4 ⬭

B 5 ⬭

C 7 ⬭

D 9 ⬭

30

END OF QUESTIONS

Do not write outside the box

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Do not write outside the box

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

Do not write outside the box

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

Do not write outside the box

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

Do not write outside the box

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Copyright information

For confidentiality purposes, all acknowledgements of third-party copyright material are published in a separate booklet. This booklet is published after each live examination series and is available for free download from www.oxfordaqaexams.org.uk.

Permission to reproduce all copyright material has been applied for. In some cases, efforts to contact copyright-holders may have been unsuccessful and Oxford International AQA Examinations will be happy to rectify any omissions of acknowledgements. If you have any queries please contact the Copyright Team.

Copyright © 2022 Oxford International AQA Examinations and its licensors. All rights reserved.