AQA

AS
Chemistry
(7404/1)

Paper 1: Inorganic and Physical Chemistry

Specimen 2015 v0.5 Session 1 hour 30 minutes

Materials

For this paper you must have:

- the Data Sheet, provided as an insert
- a ruler
- a calculator.

Instructions

- Answer **all** questions.
- Show **all** your working.

Information

- The maximum mark for this paper is 80.

Please write clearly, in block capitals.

Centre number ☐☐☐☐☐ Candidate number ☐☐☐☐

Surname

Forename(s)

Candidate signature _____

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Section A

Answer **all** questions in this section.

1 This question is about the elements in Group 2 and their compounds.

0 1 . 1 Use the Periodic Table to deduce the full electron configuration of calcium.

[1 mark]

0 1 . 2 Write an ionic equation, with state symbols, to show the reaction of calcium with an excess of water.

[1 mark]

0 1 . 3 State the role of water in the reaction with calcium.

[1 mark]

0 1 . 4 Write an equation to show the process that occurs when the first ionisation energy of calcium is measured.

[1 mark]

0 1 . 5 State and explain the trend in the first ionisation energies of the elements in Group 2 from magnesium to barium.

[3 marks]

Trend

Explanation

0 2 . 1 A sample of sulfur consisting of three isotopes has a relative atomic mass of 32.16
Table 1 gives the relative abundance of two of these isotopes.

Table 1

Mass number of isotope	32	33
Relative abundance / %	91.0	1.8

Use this information to determine the relative abundance and hence the mass number of the third isotope.
Give your answer to the appropriate number of significant figures.

[4 marks]

Mass number = _____

0 2 . 2 Describe how ions are formed in a time of flight (TOF) mass spectrometer.

[2 marks]

_____

_____

_____

_____

_____

0 2 . 3 A TOF mass spectrometer can be used to determine the relative molecular mass of molecular substances.

Explain why it is necessary to ionise molecules when measuring their mass in a TOF mass spectrometer.

[2 marks]

Turn over for the next question

0 3 . 1 Write an equation, including state symbols, for the reaction with enthalpy change equal to the standard enthalpy of formation for $CF_4(g)$.

[1 mark]

0 3 . 2 Explain why CF_4 has a bond angle of 109.5°.

[2 marks]

0 3 . 3 **Table 2** gives some values of standard enthalpies of formation ($\Delta_f H^{\ominus}$).

Table 2

Substance	$F_2(g)$	$CF_4(g)$	$HF(g)$
$\Delta_f H^{\ominus}$ / kJ mol^{-1}	0	–680	–269

The enthalpy change for the following reaction is –2889 kJ mol^{-1}.

$$C_2H_6(g) + 7F_2(g) \longrightarrow 2CF_4(g) + 6HF(g)$$

Use this value and the standard enthalpies of formation in **Table 2** to calculate the standard enthalpy of formation of $C_2H_6(g)$.

[3 marks]

Standard enthalpy of formation of $C_2H_6(g)$ = _____ kJ mol^{-1}

0 3 . 4 Methane reacts violently with fluorine according to the following equation.

$$CH_4(g) + 4F_2(g) \longrightarrow CF_4(g) + 4HF(g) \quad \Delta H = -1904 \text{ kJ mol}^{-1}$$

Some mean bond enthalpies are given in **Table 3.**

Table 3

Bond	C–H	C–F	H–F
Mean bond enthalpy / kJ mol^{-1}	412	484	562

A student suggested that one reason for the high reactivity of fluorine is a weak F–F bond .

Is the student correct? Justify your answer with a calculation using these data.

[4 marks]

Turn over for the next question

4 Colourless solutions of **X**(aq) and **Y**(aq) react to form an orange solution of **Z**(aq) according to the following equation.

$$\mathbf{X}(aq) + 2\mathbf{Y}(aq) \rightleftharpoons \mathbf{Z}(aq) \qquad \Delta H = -20 \text{ kJ mol}^{-1}$$

A student added a solution containing 0.50 mol of **X**(aq) to a solution containing 0.50 mol of **Y**(aq) and shook the mixture.
After 30 seconds, there was no further change in colour.
The amount of **Z**(aq) at equilibrium was 0.20 mol.

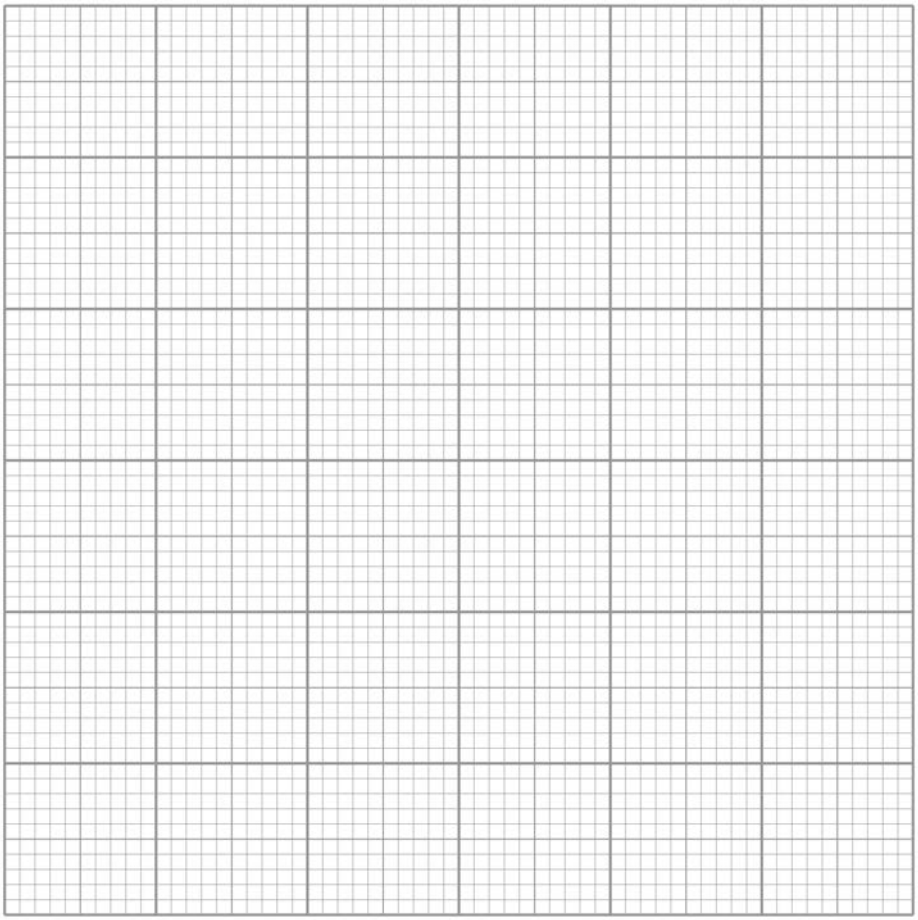
0 4 . 1 Deduce the amounts of **X**(aq) and **Y**(aq) at equilibrium.

[2 marks]

Amount of **X**(aq) =_____mol Amount of **Y**(aq) =_____mol

0 4 . 2 On the grid below, draw a graph to show how the amount of **Z**(aq) changed from the time of initial mixing until 60 seconds had elapsed.

[3 marks]



0 4 . 3 The student prepared another equilibrium mixture in which the equilibrium concentrations of **X** and **Z** were:
X(aq) = 0.40 mol dm^{-3} and **Z**(aq) = 0.35 mol dm^{-3}.

For this reaction, the equilibrium constant K_c = 2.9 mol^{-2} dm^6.
Calculate a value for the concentration of **Y** at equilibrium.
Give your answer to the appropriate number of significant figures.

[3 marks]

[**Y**] = _____ mol dm^{-3}

0 4 . 4 The student added a few drops of **Y**(aq) to the equilibrium mixture of **X**(aq), **Y**(aq) and **Z**(aq) in Question **4.3**.

Suggest how the colour of the mixture changed. Give a reason for your answer.

[3 marks]

Colour change _____

Reason _____

_____

_____

_____

0 4 . 5 The student warmed the equilibrium mixture from Question **4.3**.

Predict the colour change, if any, when the equilibrium mixture was warmed.

[1 mark]

_____

_____

5 This question is about the chemical properties of chlorine, sodium chloride and sodium bromide.

0 5 . 1 Sodium bromide reacts with concentrated sulfuric acid in a different way from sodium chloride.

Write an equation for this reaction of sodium bromide and explain why bromide ions react differently from chloride ions.

[3 marks]

Equation _____

Explanation _____

0 5 . 2 A colourless solution contains a mixture of sodium chloride and sodium bromide.

Using aqueous silver nitrate and any other reagents of your choice, develop a procedure to prepare a pure sample of silver bromide from this mixture.
Explain each step in the procedure and illustrate your explanations with equations, where appropriate.

[6 marks]

0 5 . 3 Write an ionic equation for the reaction between chlorine and cold dilute sodium hydroxide solution.
Give the oxidation state of chlorine in each of the chlorine-containing ions formed.
[2 marks]

Turn over for the next question

6 This question is about reactions of calcium compounds.

0 6 . 1 A pure solid is thought to be calcium hydroxide. The solid can be identified from its relative formula mass.

The relative formula mass can be determined experimentally by reacting a measured mass of the pure solid with an excess of hydrochloric acid. The equation for this reaction is

$$Ca(OH)_2 + 2HCl \longrightarrow CaCl_2 + 2H_2O$$

The unreacted acid can then be determined by titration with a standard sodium hydroxide solution.

You are provided with 50.0 cm^3 of 0.200 mol dm^{-3} hydrochloric acid.
Outline, giving brief practical details, how you would conduct an experiment to calculate accurately the relative formula mass of the solid using this method.

[8 marks]

0 6 . 2 A 3.56 g sample of calcium chloride was dissolved in water and reacted with an excess of sulfuric acid to form a precipitate of calcium sulfate.

The percentage yield of calcium sulfate was 83.4%.

Calculate the mass of calcium sulfate formed.
Give your answer to an appropriate number of significant figures.

[3 marks]

Mass of calcium sulfate formed = _____ g

Turn over for the next question

7 A sample of pure $Mg(NO_3)_2$ was decomposed by heating as shown in the equation below.

$$2Mg(NO_3)_2(s) \longrightarrow 2MgO(s) + 4NO_2(g) + O_2(g)$$

0 7 . 1 A 3.74×10^{-2} g sample of $Mg(NO_3)_2$ was completely decomposed by heating.

Calculate the total volume, in cm^3, of gas produced at 60.0 °C and 100 kPa.
Give your answer to the appropriate number of significant figures.
The gas constant $R = 8.31$ J K^{-1} mol^{-1}.

[5 marks]

Total volume of gas = _____ cm^3

0 7 . 2 The mass of MgO obtained in this experiment is slightly less than that expected from the mass of $Mg(NO_3)_2$ used.
Suggest **one** practical reason for this.

[1 mark]

_____

_____

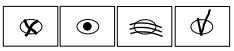
_____

Section B

Answer **all** questions in this section.

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. 

0 8 Which of these atoms has the largest atomic radius?

[1 mark]

A Ar ⬭

B Cl ⬭

C Mg ⬭

D Na ⬭

0 9 Which of these species is the best reducing agent?

[1 mark]

A Cl_2 ⬭

B Cl^- ⬭

C I_2 ⬭

D I^- ⬭

1 0 Which of these pieces of apparatus has the lowest percentage uncertainty in the measurement shown?

[1 mark]

A Volume of 25 cm^3 measured with a burette with an uncertainty of ±0.1 cm^3. ⬭

B Volume of 25 cm^3 measured with a measuring cylinder with an uncertainty of ±0.5 cm^3. ⬭

C Mass of 0.150 g measured with a balance with an uncertainty of ±0.001 g. ⬭

D Temperature change of 23.2 °C measured with a thermometer with an uncertainty of ±0.1 °C. ⬭

1 1 A student is provided with a 5.00 cm^3 sample of 1.00×10^{-2} mol dm^{-3} hydrochloric acid. The student is asked to devise a method to prepare a hydrochloric acid solution with a concentration of 5.00×10^{-4} mol dm^{-3} by diluting the sample with water.

Which of these is the correct volume of water that should be added?

[1 mark]

A 45.0 cm^3 ⬭

B 95.0 cm^3 ⬭

C 100 cm^3 ⬭

D 995 cm^3 ⬭

1 2 Which of these species has a trigonal planar structure?

[1 mark]

A PH_3 ⬭

B BCl_3 ⬭

C H_3O^+ ⬭

D CH_3^- ⬭

1 3 Use your understanding of intermolecular forces to predict which of these compounds has the highest boiling point.

[1 mark]

A HF ⬭

B HCl ⬭

C HBr ⬭

D HI ⬭

1 4 Which type of bond is formed between N and B when a molecule of NH_3 reacts with a molecule of BF_3?

[1 mark]

A Ionic. ⬭

B Covalent. ⬭

C Co-ordinate. ⬭

D Van der Waals ⬭

1 5 Which of these atoms has the highest electronegativity?

[1 mark]

A Na ⬭

B Mg ⬭

C Cl ⬭

D Ar ⬭

1 6 Which of these atoms has the smallest number of neutrons?

[1 mark]

A ^{3}H ⬭

B ^{4}He ⬭

C ^{5}He ⬭

D ^{4}Li ⬭

1 7 Which of these substances does **not** show hydrogen bonding?

[1 mark]

A HF ⬭

B NH_3 ⬭

C CH_3COOH ⬭

D CHF_3 ⬭

1 8 What is the formula of calcium nitrate(V)?

[1 mark]

A $CaNO_3$ ⬭

B $Ca(NO_3)_2$ ⬭

C Ca_2NO_2 ⬭

D $Ca(NO_2)_2$ ⬭

1 9 Which of these elements has the highest second ionisation energy?

[1 mark]

A Na ⬭

B Mg ⬭

C Ne ⬭

D Ar ⬭

2 0 Which of the following shows chlorine in its correct oxidation states in the compounds shown?

[1 mark]

	HCl	$KClO_3$	HClO	
A	–1	+3	+1	⬭
B	+1	–5	–1	⬭
C	–1	+5	+1	⬭
D	+1	+5	–1	⬭

2 1 Which substance is **not** produced in a redox reaction when solid sodium iodide reacts with concentrated sulfuric acid?

[1 mark]

A H_2S ⬭

B HI ⬭

C SO_2 ⬭

D I_2 ⬭

2 2 Which of the following contains the most chloride ions?

[1 mark]

A 10 cm^3 of 3.30×10^{-2} mol dm^{-3} aluminium chloride solution ⬭

B 20 cm^3 of 5.00×10^{-2} mol dm^{-3} calcium chloride solution ⬭

C 30 cm^3 of 3.30×10^{-2} mol dm^{-3} hydrochloric acid ⬭

D 40 cm^3 of 2.50×10^{-2} mol dm^{-3} sodium chloride solution ⬭

END OF QUESTIONS

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

AQA Qualifications

AS

Chemistry

Paper 1 (7404/1): Inorganic and Physical Chemistry
Mark scheme

7404
Specimen paper

Version 0.6

Section A

Question	Marking guidance	Mark	AO	Comments
01.1	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$	1	AO1a	Allow correct numbers that are not superscripted
01.2	$Ca(s) + 2H_2O(l) \longrightarrow Ca^{2+}(aq) + 2OH^-(aq) + H_2(g)$	1	AO2d	State symbols essential
01.3	Oxidising agent	1	AO2c	
01.4	$Ca(g) \longrightarrow Ca^+(g) + e^-$	1	AO1a	State symbols essential Allow 'e' without the negative sign
01.5	Decrease	1	AO1a	If answer to 'trend' is not 'decrease', then chemical error = 0/3
	Ions get bigger / more (energy) shells	1	AO1a	Allow atoms instead of ions
	Weaker attraction of ion to lost electron	1	AO1a	

Question	Marking guidance	Mark	AO	Comments
02.1	Abundance of third isotope = 100 – 91.0 –1.8 = 7.2%	1	AO1b	
	$\frac{(32 \times 91) + (33 \times 1.8) + (y \times 7.2)}{100} = 32.16$	1	AO2f	
	$7.2y = 32.16 \times 100 – 32 \times 91 – 33 \times 1.8 = 244.6$	1	AO2f	
	$y = 244.6 / 7.2 = 33.97$			
	$y = 34$	1	AO1b	Answer must be rounded to the nearest integer
02.2	(for electrospray ionisation)			
	A high voltage is applied to a sample in a polar solvent	1	AO1b	
	the sample molecule, M, gains a proton forming MH^+	1	AO1b	
	OR			
	(for electron impact ionisation)			
	the sample is bombarded by high energy electrons	1	AO1b	
	the sample molecule loses an electron forming M^+	1	AO1b	

02.3	Ions, not molecules, will interact with and be accelerated by an electric field Only ions will create a current when hitting the detector	1 1	AO2e AO2e	

Question	Marking guidance	Mark	AO	Comments
03.1	$C(s) + 2F_2(g) \longrightarrow CF_4(g)$	1	AO1a	State symbols essential
03.2	Around carbon there are 4 bonding pairs of electrons (and no lone pairs) Therefore, these repel equally and spread as far apart as possible	1 1	AO1a AO1a	
03.3	ΔH = Σ $\Delta_f H$ products – Σ $\Delta_f H$ reactants or a correct cycle Hence = (2 × –680) + (6 × –269) – (x) = –2889 x = 2889 – 1360 – 1614 = –85 (kJ mol^{-1})	1 1 1	AO1b AO1b AO1b	 Score 1 mark only for +85 (kJ mol^{-1})
03.4	Bonds broken = 4(C–H) + 4(F–F) = 4 × 412 + 4 × F–F Bonds formed = 4(C–F) + 4(H–F) = 4 × 484 + 4 × 562 –1904 = [4 × 412 + 4(F–F)] – [4 × 484 + 4 × 562] 4(F–F) = –1904 – 4 × 412 + [4 × 484 + 4 × 562] = 632 F–F = 632 / 4 = 158 (kJ mol^{-1}) The student is correct because the F–F bond energy is much less than the C–H or other covalent bonds, therefore the F–F bond is weak / easily broken	 1 1 1 1	 AO3 1a AO3 1a AO3 1a AO3 1b	 Both required Relevant comment comparing to other bonds (Low activation energy needed to break the F–F bond)

Question	Marking guidance	Mark	AO	Comments
04.1	amount of X = 0.50 – 0.20 = 0.30 (mol) amount of Y = 0.50 – 2 × 0.20 = 0.10 (mol)	1 1	AO2h AO2h	
04.2	Axes labelled with values, units and scales that use over half of each axis Curve starts at origin Then flattens at 30 seconds at 0.20 mol	1 1 1	AO2h AO2h AO2h	All three of values, units and scales are required for the mark
04.3	Expression = $K_c = \frac{[Z]}{[X][Y]^2}$ $[Y]^2 = \frac{[Z]}{[X]\,K_c}$ $[Y] = (0.35 / 0.40 \times 2.9)^{0.5} = 0.5493 = 0.55$ (mol dm^{-3})	1 1 1	AO1a AO2b AO1b	Answer must be to 2 significant figures
04.4	Darkened / went more orange The equilibrium moved to the right To oppose the increased concentration of Y	1 1 1	AO2g AO2g AO2g	
04.5	The orange colour would fade	1	AO3 1a	

Question	Marking guidance	Mark	AO	Comments
05.1	$2NaBr + 2H_2SO_4 \longrightarrow Na_2SO_4 + Br_2 + SO_2 + 2H_2O$	1	AO1a	Allow ionic equation $2Br^- + 2H_2SO_4 \longrightarrow Br_2 + SO_4^{2-} + SO_2 + 2H_2O$
	Br^- ions are bigger than Cl^- ions	1	AO2c	
	Therefore Br^- ions more easily oxidised / lose an electron more easily (than Cl^- ions)	1	AO2c	

<table>
<tr>
<td>05.2</td>
<td colspan="2">This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.</td>
<td>6</td>
<td>2 AO1a

4 AO3 2b</td>
<td rowspan="5">Indicative chemistry content

Stage 1: formation of precipitates
• Add silver nitrate
• to form precipitates of AgCl and AgBr
• $AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$
• $AgNO_3 + NaBr \rightarrow AgBr + NaNO_3$

Stage 2: selective dissolving of AgCl
• Add excess of dilute ammonia to the mixture of precipitates
• the silver chloride precipitate dissolves
• $AgCl + 2NH_3 \rightarrow Ag(NH_3)_2^+ + Cl^-$

Stage 3: separation and purification of AgBr
• Filter off the remaining silver bromide precipitate
• Wash to remove soluble compounds
• Dry to remove water</td>
</tr>
<tr>
<td></td>
<td>Level 3
5–6 marks</td>
<td>All stages are covered and the explanation of each stage is generally correct and virtually complete. Stages 1 and 2 are supported by correct equations.

Answer communicates the whole process coherently and shows a logical progression from stage 1 to stage 2 and then stage 3. The steps in stage 3 are in a logical order.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Level 2
3–4 marks</td>
<td>All stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies OR two stages are covered and the explanations are generally correct and virtually complete.

Answer is mainly coherent and shows a progression through the stages. Some steps in each stage may be out of order and incomplete.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Level 1
1–2 marks</td>
<td>Two stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies, OR only one stage is covered but the explanation is generally correct and virtually complete.

Answer includes some isolated statements, but these are not presented in a logical order or show confused reasoning.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Level 0
0 marks</td>
<td>Insufficient correct chemistry to warrant a mark.</td>
<td></td>
<td></td>
</tr>
</table>

05.3	$Cl_2 + 2HO^- \longrightarrow OCl^- + Cl^- + H_2O$	1	AO1a	
	OCl^- is +1 Cl^- is –1	1	AO2b	Both required for the mark

Question	Marking guidance	Mark	AO	Comments
06.1				Extended response Maximum of 7 marks for answers which do not show a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.
	Stage 1: appreciation that the acid must be in excess and calculation of amount of solid that permits this.			
	Statement that there must be an excess of acid	1	AO2d	
	Moles of acid = 50.0 × 0.200/1000 = 1.00 × 10^{-2} mol	1	AO3 2a	
	2 mol of acid react with 1 mol of calcium hydroxide therefore moles of solid weighed out must be less than half the moles of acid = 0.5 × 1.00 × 10^{-2} = 5.00 × 10^{-3} mol	1	AO3 2b	
	Mass of solid must be < 5.00 × 10^{-3} × 74.1 = < 0.371 g	1	AO3 2a	
	Stage 2: Experimental method.			
	Measure out 50 cm^3 of acid using a pipette and add the weighed amount of solid in a conical flask	1	AO3 2b	
	Titrate against 0.100 (or 0.200) mol dm^{-3} NaOH added from a burette and record the volume (v) when an added indicator changes colour	1	AO3 2b	
	Stage 3: How to calculate M_r from the experimental data.			
	Moles of calcium hydroxide = 5.00 × 10^{-3} – (v/2 × conc NaOH)/1000 = z mol	1	AO3 2a	
	M_r = mass of solid / z	1	AO3 2a	

06.2	Moles of calcium chloride = 3.56 / 111.1 = 3.204×10^{-2}	1	AO2h	
	Moles of calcium sulfate = $3.204 \times 10^{-2} \times 83.4/100 = 2.672 \times 10^{-2}$	1	AO2h	
	Mass of calcium sulfate = $2.672 \times 10^{-2} \times 136.2 = 3.6398 = 3.64$ (g)	1	AO2h	Answer must be to 3 significant figures

Question	Marking guidance	Mark	AO	Comments
07.1				Extended response calculation
	Stage 1			
	M_r for $Mg(NO_3)_2$ = 148.3			
	Moles of $Mg(NO_3)_2$ = $\frac{3.74 \times 10^{-2}}{148.3}$ = 2.522×10^{-4} mol	1	AO2h	
	Stage 2			
	Total moles of gas produced = 5/2 × moles of $Mg(NO_3)_2$			
	= $5/2 \times 2.522 \times 10^{-4}$ = 6.305×10^{-4}	1	AO2h	
	Stage 3			If ratio in stage 2 is incorrect, maximum marks for stage 3 is 2
	PV=nRT so volume of gas $V = nRT/P$	1	AO2h	
	$V = \frac{nRT}{P} = \frac{6.305 \times 10^{-4} \times 8.31 \times 333}{1.00 \times 10^{5}} = 1.745 \times 10^{-5}$ m^3	1	AO2h	
	$V = 1.745 \times 10^{-5} \times 1 \times 10^{6} = 17.45$ cm^3 = 17.5 (cm^3)	1	AO1b	Answer must be to 3 significant figures (answer could be 17.4 cm^3 dependent on intermediate values)
07.2	Some of the solid is lost in weighing product / solid is blown away with the gas	1	AO3 1b	

Section B

In this section, each correct answer is awarded 1 mark.

Question	Key	AO
8	D	AO1a
9	D	AO1b
10	A	AO3 1b
11	B	AO3 2a
12	B	AO2a
13	A	AO2a
14	C	AO1a
15	C	AO1a
16	D	AO2b
17	D	AO2a
18	B	AO1a
19	A	AO2a
20	C	AO2b
21	B	AO1b
22	B	AO2b