

OCR A-LEVEL CHEMISTRY A • H432

CHEMISTRY



EXAM QUESTION PACK

3.1.2-3.1.3 GROUP 2 AND THE HALOGENS

SCORE

/103

PERCENTAGE

%

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1 A chemist carries out reactions of barium and barium nitride, Ba_3N_2 .

Reaction 1 Barium is reacted with water.

Reaction 2 Barium nitride is reacted with water, forming an alkaline solution and an alkaline gas.

Reaction 3 Barium is reacted with an excess of oxygen at 500°C , forming barium peroxide, BaO_2 .

(i) Write equations for **Reaction 1** and **Reaction 2**.

Ignore state symbols.

Reaction 1: _____

Reaction 2: _____

[3]

(ii) Predict the structure and bonding of Ba_3N_2 .

_____ [1]

(iii) BaO_2 formed in **Reaction 3** contains barium and peroxide ions.

The peroxide ion has the structure $[\text{O}-\text{O}]^{2-}$.

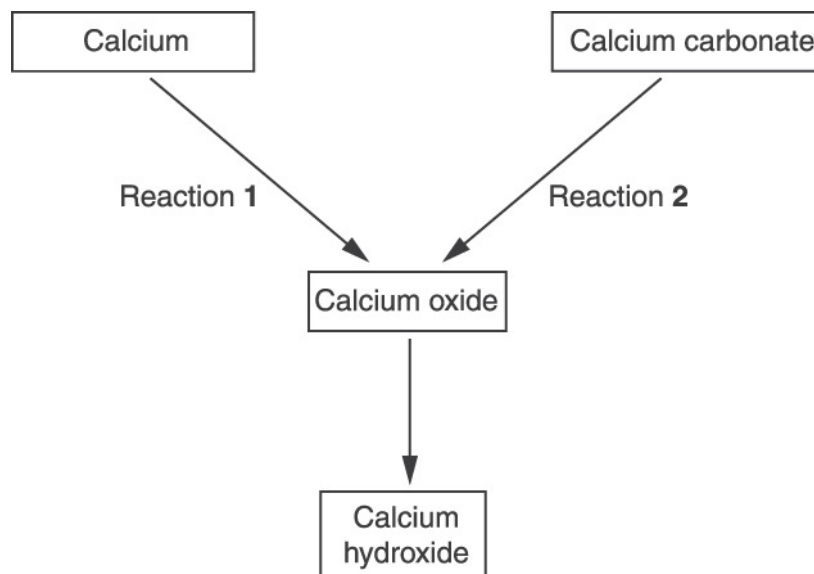
Suggest a '*dot-and-cross*' diagram for BaO_2 .

Show outer shell electrons only.

[1]

2(a) Calcium is in Group 2 of the Periodic Table.

The diagram shows some reactions of calcium and its compounds.



Reactions 1 and 2 both form calcium oxide.

(i) Write the equation for reaction 1.

----- [1]

(ii) What type of reaction is reaction 2?

----- [1]

(b) A student prepared some calcium hydroxide by adding a small piece of calcium to a large excess of water.

Describe what the student would observe and write the equation for the reaction.

Observation -----

Equation ----- [2]

3 Which row is correct?

	Highest pH when added to water	Most reactive halogen
A	MgO	F ₂
B	MgO	I ₂
C	BaO	F ₂
D	BaO	I ₂

Your answer

[1]

4 Which statement is **not** correct for Group 2 metals?

- A An unpaired electron is present in an s-orbital.
- B Chemical reactivity increases with increasing atomic number.
- C The first ionisation energy decreases with increasing atomic number.
- D Atomic radius increases with increasing atomic number.

Your answer

[1]

5 This question looks at groups in the periodic table.

Calcium and strontium are Group 2 metals. They both react with water.

A chemist reacts 0.200 g of strontium with 250 cm³ water, leaving a colourless solution containing strontium ions. The volume remains at 250 cm³.

(i) Write an equation for the reaction between strontium and water.

Include state symbols.

----- [1]

(ii) Calculate the concentration, in mol dm⁻³, of strontium ions in the resulting solution.

concentration of strontium ions = ----- mol dm⁻³ [2]

(iii) A student plans to carry out this experiment using 0.200 g of calcium instead of 0.200 g of strontium.

Predict the difference, if any, between the volume of gas produced by calcium and strontium.

Explain your reasoning and include a calculation in your answer.

----- [3]

- 6 The trend in the first and second ionisation energies of Group 2 elements can be linked to the increase in chemical reactivity down the group.

The first and second ionisation energies of calcium and strontium are given in the table.

Element	First ionisation energy / kJmol^{-1}	Second ionisation energy / kJmol^{-1}
Ca	590	1145
Sr	550	1064

- (i) Write an equation, including state symbols, to represent the **second** ionisation energy of strontium.

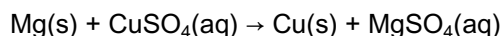
-----[1]

- (ii) Explain why the first ionisation energy of strontium is less than the first ionisation energy of calcium.

-----[3]

7(a) Magnesium will undergo redox reactions with aqueous salts of less reactive metals.

(i) A student reacts magnesium with aqueous copper(II) sulfate.



Explain, in terms of **numbers** of electron transferred, the redox processes taking place in this reaction.

----- [2]

(ii) The student also noticed that the magnesium started fizzing.

The student thought the fizzing was due to the magnesium reacting with water in the mixture.

Write the equation for the reaction of magnesium with water.

Include state symbols.

----- [2]

(b) Compounds of calcium have many uses.

(i) Identify a compound of calcium that could be used to convert a soil pH from 5.8 to 7.5.

-----[1]

(ii) Calcium phosphide, Ca_3P_2 , is an ionic compound used in rat poison.

Calcium phosphide can be prepared by reacting calcium metal with phosphorus, P_4 .

Write the equation for the reaction of calcium with phosphorus to form calcium phosphide.

-----[1]

(iii) Draw a 'dot-and-cross' diagram to show the bonding in calcium phosphide, Ca_3P_2 .

Show outer electrons only.

[2]

8

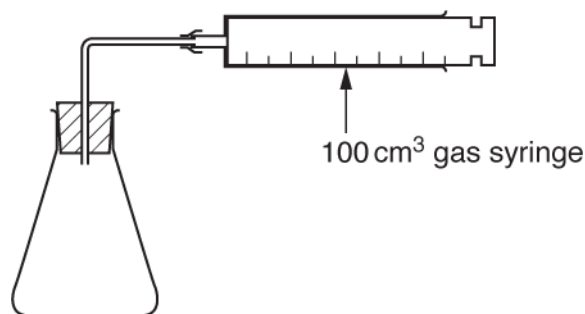


A student was asked to carry out an experiment to determine the initial rate of reaction of zinc and hydrochloric acid.

The student plans to collect a total of about 72 cm^3 of hydrogen at RTP and to use an excess of zinc.

The student selects the following apparatus:

- the apparatus shown in the diagram
- 100 cm^3 measuring cylinder
- stop clock
- 2 decimal place balance



Outline how the student could carry out the experiment and explain how the results could be processed

Show all working in your calculations.

[6]

[6]

9 Calcium reacts with nitrogen to form calcium nitride, Ca_3N_2 , which is an ionic compound.

(i) Construct a 'dot-and-cross' diagram for Ca_3N_2 .

Show outer electrons only and the charges on each ion.

[2]

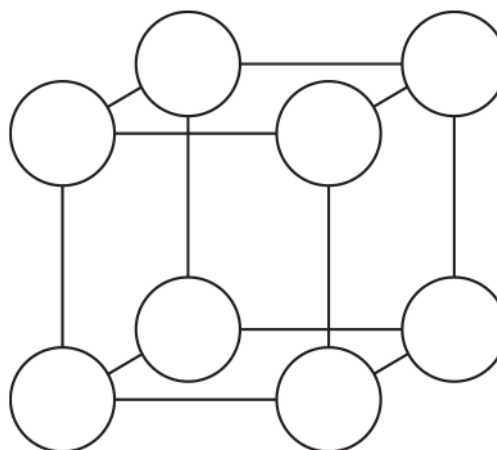
(ii) Calcium nitride reacts with water to form a solution containing two alkaline compounds.

Write an equation for this reaction.

[2]

(iii) Calcium reacts with oxygen to form a compound which has a giant ionic lattice structure.
The diagram shows ions as circles in part of the lattice.

Complete the diagram by showing the symbols of the ions, including charges.



[2]

- (iv) Nitrogen forms an oxide with the formula N_2O . A molecule of N_2O is linear and has a nitrogen atom in the centre.

Draw a 'dot-and-cross' diagram for an N_2O molecule.

Show outer electrons only.

[2]

- 10 A student adds a small amount of strontium to water.

When the reaction has finished, the student measures the pH of the final solution.

- (i) Write the equation for the reaction of strontium with water.

[1]

- (ii) Describe **two** observations which would be different if the student had used calcium in place of strontium.

1 _____

2 _____

[2]

END OF QUESTION PAPER

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
1		i	Reaction 1: $\text{Ba} + 2\text{H}_2\text{O} \rightarrow \text{Ba}(\text{OH})_2 + \text{H}_2$ ✓ Reaction 2: $\text{Ba}_3\text{N}_2 + 6\text{H}_2\text{O} \rightarrow 3\text{Ba}(\text{OH})_2 + 2\text{NH}_3$ Correct products ✓ Balancing ✓	3	Ignore state symbols Examiner's Comments Both equations were relatively challenging. Reaction 1 was a direct question about reactions of Group 2 elements. Reaction 2 demanded a higher level of application based upon information given. Many identified the alkaline gas as NH_3, but then incorrectly assumed that the alkaline solution was BaO instead of $\text{Ba}(\text{OH})_2$. Weaker candidates suggested equations with hypothetical species that could not have born any relation to formulae that they might have encountered before.
		ii	Giant ionic (lattice) ✓	1	ALLOW 'Giant lattice with ionic bonds' ALLOW 'Giant ionic bonds' DO NOT ALLOW 'atoms or molecules or dipoles' Examiner's Comments This question was relatively well answered, although some candidates did negate the mark by referring to molecules of Ba_3N_2 either directly or by indirect reference to intermolecular forces.
		iii		1	Ba must have a 2+ charge Ba can be with or without octet. IGNORE lack of charge on O_2^{2-} ion

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
	$\left[\begin{array}{c} \text{x x} \\ \text{x Ba x} \\ \text{x x} \end{array} \right]^{2+}$ $\left[\begin{array}{cc} \bullet\bullet & \bullet\bullet \\ \text{x O} & \bullet\text{O x} \\ \bullet\bullet & \bullet\bullet \end{array} \right]^{2-}$ OR $\left[\begin{array}{c} \text{x x} \\ \text{x Ba x} \\ \text{x x} \end{array} \right]^{2+}$ $\left[\begin{array}{cc} \bullet\bullet & \circ\circ \\ \text{x O} & \circ\text{O x} \\ \bullet\bullet & \circ\circ \end{array} \right]^{2-}$ OR $\left[\begin{array}{c} \text{x x} \\ \text{x Ba x} \\ \text{x x} \end{array} \right]^{2+}$ $\left[\begin{array}{cc} \bullet\bullet & \circ\circ \\ \text{x O} & \circ\text{O} \\ \bullet\bullet & \circ\circ \end{array} \right]^{2-}$ OR $\left[\begin{array}{c} \text{x x} \\ \text{x Ba x} \\ \text{x x} \end{array} \right]^{2+}$ $\left[\begin{array}{cc} \bullet\bullet & \bullet\bullet \\ \text{x O} & \bullet\text{O} \\ \bullet\bullet & \bullet\bullet \end{array} \right]^{2-}$		O_2^{2-} ion to have 12 electrons belonging to O atoms + 2 other electrons of another symbol. The 2 other electrons must match Ba if Ba has an octet. If O electrons are shown as 6 of one symbol and 6 of another, each O must have six electrons of the same symbol ALLOW $\left[\begin{array}{c} \text{x x} \\ \text{x Ba x} \\ \text{x x} \end{array} \right]^{2+}$ $\left[\begin{array}{cc} \bullet\bullet & \bullet\bullet \\ \bullet\text{O} & \text{x O} \\ \bullet\bullet & \bullet\bullet \end{array} \right]^{2-}$ OR $\left[\begin{array}{c} \text{x x} \\ \text{x Ba x} \\ \text{x x} \end{array} \right]^{2+}$ $\left[\begin{array}{cc} \bullet\bullet & \bullet\bullet \\ \bullet\text{O} & \text{x O} \\ \bullet\bullet & \bullet\bullet \end{array} \right]^{2-}$ Examiner's Comments This question was designed to be difficult, but many candidates rose to the challenge. Weaker candidates simply drew a 'dot-and-cross' diagram for BaO_2 in which they treated each oxygen species as an oxide ion each having a single negative charge. Many stronger candidates did realise from the structure given in the question that there was only a single bond between the two oxygen atoms, as was clear from their suggested diagram. Only the stronger candidates managed to incorporate correctly the electrons from barium, to arrive at a correct version of the bonding of BaO_2.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
			Total	5	
2	a	i	$2\text{Ca} + \text{O}_2 \rightarrow 2\text{CaO}$ ✓	1	ALLOW multiples e.g. $\text{Ca} + \frac{1}{2}\text{O}_2 \rightarrow \text{CaO}$ IGNORE state symbols Examiner's Comments This straightforward equation was well known.
		ii	Thermal decomposition ✓	1	Examiner's Comments Some candidates omitted 'thermal' and so did not secure the mark while others wrote out the equation rather than stating the type of reaction.
	b		Effervescence OR fizzing OR bubbling OR gas produced AND The solid OR calcium OR the metal would dissolve OR disappear OR a (colourless) solution forms ✓ $\text{Ca} + 2\text{H}_2\text{O} \rightarrow \text{Ca}(\text{OH})_2 + \text{H}_2$ ✓	2	IGNORE 'hydrogen produced' but ALLOW 'hydrogen gas produced' DO NOT ALLOW an incorrectly named gas (eg CO_2) produced ALLOW multiples IGNORE state symbols Examiner's Comments In the observation section most candidates noted effervescence but few then added the necessary observation of the calcium dissolving often despite $\text{Ca}(\text{OH})_2(\text{aq})$ appearing in the equation. The equation was well answered generally, although CaOH was not an uncommon species.
			Total	4	
3			C	1	
			Total	1	
4			A	1	
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
5		i	$\text{Sr(s)} + 2\text{H}_2\text{O(l)} \rightarrow \text{Sr(OH)}_2\text{(aq)} + \text{H}_2\text{(g)}$ Note: all state symbols required	1	allow multiples
		ii	$n(\text{Sr}) = n(\text{Sr}^{2+}) = 0.200 / 87.6 = 2.28 \times 10^{-3}$ (1) $[\text{Sr}^{2+}] = 2.28 \times 10^{-3} \times 1000 / 250 = 9.13 \times 10^{-3} \text{ (mol dm}^{-3}\text{)}$ (1)	2	allow ecf
		iii	Greater volume with Ca AND larger amount / more moles of Ca OR A_r Ca is smaller (1) $n(\text{Ca}) = 0.200/40.1 = 0.005(0) \text{ (mol)}$ (1) volume H_2 with Sr = 55 cm^3 AND volume with Ca = 120 cm^3 OR 65 cm^3 more H_2 with Ca (1)	3	ora allow values up to calculator values allow volumes $\pm 1 \text{ cm}^3$
			Total	6	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
6		i	$\text{Sr}^+(\text{g}) \rightarrow \text{Sr}^{2+}(\text{g}) + \text{e}^- \checkmark$	1	ALLOW $\text{Sr}^+(\text{g}) - \text{e}^- \rightarrow \text{Sr}^{2+}(\text{g})$ ALLOW e for electron (i.e. charge omitted) IGNORE states on the electron Examiner's Comments The equation for the second ionisation energy of strontium proved no difficulty for the most able candidates who provided both the correct state symbols and charges. It was surprising however that 40% of candidates failed to score what was meant to be a straightforward mark.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	<i>Atomic radius</i> larger atomic radius OR more shells ✓ <i>Effect of nuclear charge / shielding</i> Increased nuclear charge outweighed by increased distance / shielding OR more / increased shielding ✓ <i>Nuclear attraction</i> less nuclear attraction OR less attraction on electrons ✓	3	FULL ANNOTATIONS MUST BE USED ----- ALLOW ORA: comparison needed for each mark. ALLOW 'more / higher energy levels' ALLOW 'electrons further from nucleus' ALLOW 'extra / new shell' IGNORE more orbitals OR more sub-shells OR different shell ALLOW more electron repulsion from inner shells IGNORE responses with no comparison IGNORE nuclear charge / effective nuclear charge ALLOW 'less nuclear pull' OR 'electrons held less tightly' Examiner's Comments This descriptive question was well answered with the vast majority of candidates picking up two of the three available marks. Where a candidate scored two marks it was often due to the omission of any comment about the reduction in attraction between the nucleus and the electron as the group was descended. A common error was to discuss the reduction in nuclear charge rather than nuclear attraction.
			Total	4	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
7	a	i	Magnesium (atoms) has been oxidised AND Because it has lost two electrons ✓ Copper (ions) has been reduced AND Because it has gained two electrons ✓	2	IGNORE use of oxidation numbers if electron gain/loss is mentioned. Electrons gain/loss could be in half equations In the absence of text look for evidence on the equation ALLOW 'donated' for 'lost' Assume 'Cu' refers to copper in 'CuSO₄' ALLOW one mark two electrons gained and lost for each species but oxidation/reduction is incorrect or is omitted ALLOW one mark for correct oxidation and reduction if electron transfer is omitted and correct changes of oxidation state are shown (ie Mg 0 --> (+)2 AND Cu (+)2 to 0) ALLOW 'two' electrons transferred from magnesium to copper Examiner's Comments This type of question in the past has proved difficult but the current cohort found little difficulty. By far, the most common error was to use changes in oxidation numbers as the basis of the redox rather than using the number of electrons gained and lost for the explanation of the redox process.
		ii	$\text{Mg(s)} + 2\text{H}_2\text{O(l)} \rightarrow \text{Mg(OH)}_2\text{(aq)} + \text{H}_2\text{(g)}$ Correct reactants and products ✓ Balance and state symbols ✓	2	ALLOW multiples ALLOW $\text{Mg(OH)}_2\text{(s)}$ ALLOW $\text{Mg(s)} + \text{H}_2\text{O(g)}$ OR $\text{H}_2\text{O(l)}$ MgO(s) + $\text{H}_2\text{(g)}$ including state symbols for one mark Examiner's Comments The equation for the reaction between magnesium and water was well known – but many erroneously assumed MgO was formed.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	b	i	Ca(OH) ₂ OR Calcium hydroxide OR CaO OR Calcium oxide ✓ □	1	ALLOW Calcium carbonate OR CaCO ₃ Examiner's Comments The unusual equation involving P ₄ molecules was answered well. Weaker candidates assumed that phosphorus was monatomic and consequentially lost credit.
		ii	6Ca + P ₄ □ 2Ca ₃ P ₂ ✓	1	ALLOW multiples IGNORE state symbols Examiner's Comments This potentially difficult dot-and-cross diagram of the ions present was done well by candidates.
		iii	$3x \begin{bmatrix} & x & x \\ x & Ca & x \\ x & & x \end{bmatrix}^{2+} \quad 2x \begin{bmatrix} \bullet & \bullet & \bullet \\ x & P & x \\ \bullet & \bullet & x \end{bmatrix}^{3-}$ Ca with 8 (or no) electrons AND phosphide ion with dot-and-cross outermost octet ✓ Three Ca ions AND two phosphide ions with correct charges ✓	2	For first mark: If 8 electrons are shown on the cation then the extra electron in the anion must match the symbol chosen for the electrons in the cation. IGNORE inner shells IGNORE circles ALLOW one mark if both electron arrangements and charges are correct but only one of each ion is drawn. ALLOW (brackets not required) 3[Ca²⁺] 3[Ca]²⁺ [Ca²⁺]₃ 2[P³⁻] 2[P]³⁻ [P³⁻]₂ DO NOT ALLOW [Ca₃]²⁺ [3Ca]²⁺ [Ca]³²⁺ [P₂]³⁻ [2P]³⁻ [P]₂
			Total	8	

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
8	<i>Please refer to marking instructions on page 5 of mark scheme for guidance on how to mark this question.</i> Level 3 (5–6 marks) All three scientific points are covered in detail and explained thoroughly. <i>The method is logically structured and clear calculations are shown for an appropriate mass of metal and suitable volume of acid. The drawing of a tangent and determination of the gradient is communicated well.</i> Level 2 (3–4 marks) Candidates cover all three scientific points but explanations may be incomplete. OR Two of the scientific points are described thoroughly with no omissions. <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence. e.g. there are clear calculations to justify mass and acid volume supported by some working and units; a simple description for determining initial rate related to tangent but no detail of how to measure gradient..</i> Level 1 (1–2 marks) There is a description based on at least two of the main scientific points OR The candidate explains one scientific point thoroughly with few omissions. <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant. e.g. 'add zinc and acid and measure volume (no mass, volume or time intervals); calculations that have little structure, absent units and little working.</i>	6	Indicative scientific points 1. Method • measure mass of (excess) zinc (using 2 decimal place balance) • measure volume of hydrochloric acid (using measuring cylinder) • mix zinc and acid in flask • measure gas volume at time intervals 2. Calculations • moles of hydrogen $72/24000 = 0.00300 \text{ mol}$ • minimum mass of zinc $0.003 \times 65.4 = 0.20 \text{ g}$ • moles of hydrochloric acid $\text{Zn} + 2\text{HCl} \rightarrow \text{ZnCl}_2 + \text{H}_2$ $0.00300 \times 2 = 0.00600 \text{ mol}$ • volume / concentration of acid If $[\text{HCl}(\text{aq})] = 0.1 \text{ mol dm}^{-3}$ appropriate volume of acid = $0.006 \times 1000/0.1 = 60 \text{ cm}^3$ If $[\text{HCl}(\text{aq})] \geq 0.3 \text{ mol dm}^{-3}$, too low ($\leq 20 \text{ cm}^3$) If $[\text{HCl}(\text{aq})] \leq 0.03 \text{ mol dm}^{-3}$ too high ($\geq 200 \text{ cm}^3$) 3. Processing results • Plot a graph of volume against time • Draw a tangent at $t = 0$ • Gradient of tangent = initial rate • Gradient = volume / time

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
			0 marks <i>No response or no response worthy of credit.</i>		Examiner's Comment: This question was marked using a level of response mark scheme and relatively few candidates were able to achieve Level 3. Many vague and rambling responses failed to mention the basic requirement to measure the volume of gas at regular time intervals. Some preferred to record the change in mass and ignored the diagram with a labelled gas syringe, while some carried out the experiment in a measuring cylinder. The question advises candidates to show working in their calculations but many omitted calculations from their answer. The question asked for an explanation of how the results could be processed graphically but this section was often lacking detail. Level 1 responses usually included the measurement and mixing of reactants and an attempt at processing the results by plotting a graph but further detail was missing. Candidates achieving Level 2 usually included a calculation of the moles of reactants and a more detailed description of how to process the results. Some excellent Level 3 responses included a full calculation of the mass of zinc and volume of hydrochloric acid required for the experiment.
			Total	6	

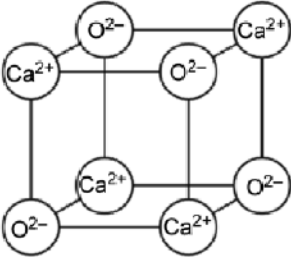
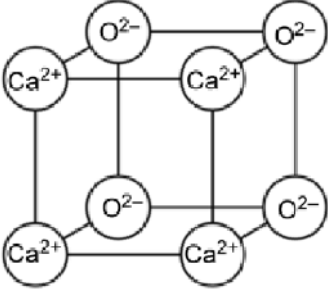
Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
9	i $3 \left[\text{Ca} \right]^{2+} 2 \left[\begin{array}{ccc} & \cdot & \times \\ \times & \text{N} & \times \\ & \cdot & \cdot \end{array} \right]^{3-}$ Ca shown with either 0 or 8 electrons AND N shown with 8 electrons with 5 dots and 3 crosses (or vice versa) ✓ 3 Ca AND 2 N AND correct charges on ions, i.e. $3\text{Ca}^{2+} 2\text{N}^{3-}$ ✓ Circles OR Brackets NOT required	2 (AO2.5) (AO1.2)	CARE: ALLOW any pairing if electrons correct, e.g. $3 \left[\text{Ca} \right]^{2+} 2 \left[\begin{array}{ccc} & \times \times & \\ \cdot & \text{N} & \times \\ & \cdot & \cdot \end{array} \right]^{3-}$ IF 8 electrons shown around Ca, 'extra' 3 electrons around N must match symbol for Ca electrons, e.g. $3 \left[\begin{array}{ccc} \times \times & & \\ \times & \text{Ca} & \times \\ \times \times & & \end{array} \right]^{2+} 2 \left[\begin{array}{ccc} & \cdot & \times \\ \times & \text{N} & \times \\ & \cdot & \cdot \end{array} \right]^{3-}$ IGNORE inner shells ALLOW drawing with 3Ca^{2+} and 2N^{3-} e.g. $\left[\text{Ca} \right]_3^{2+} \left[\begin{array}{ccc} & \times \times & \\ \cdot & \text{N} & \times \\ & \cdot & \cdot \end{array} \right]_2^{3-}$ <u>Examiner's Comments</u> Most candidates showed a correct, clear 'dot and cross' diagram. Lower attaining candidates sometimes used wrong charges, not enough ions or an incorrect number of electrons on N. Covalently-bonded molecules were seen, but rarely.

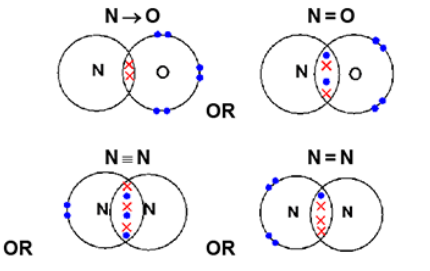
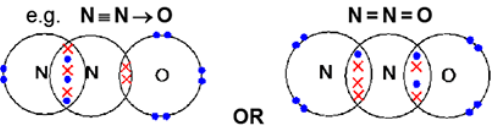
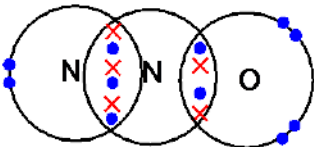
Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	$\text{Ca}_3\text{N}_2 + 6\text{H}_2\text{O} \rightarrow 3\text{Ca}(\text{OH})_2 + 2\text{NH}_3$ $\text{Ca}(\text{OH})_2$ OR NH_3 as product ✓ All species correct AND correct balancing ✓	2 (AO2.6×2))	ALLOW NH_4OH for NH_3 ALLOW $\text{Ca}_3\text{N}_2 + 8\text{H}_2\text{O} \rightarrow 3\text{Ca}(\text{OH})_2 + 2\text{NH}_4\text{OH}$ IGNORE other products <u>Examiner's Comments</u> Exemplar 1 (ii) Calcium nitride reacts with <u>water</u> to form a solution containing two alkaline compounds. Write an equation for this reaction. $\text{Ca}_3\text{N}_2 + 3\text{H}_2\text{O} \rightarrow 2\text{NH}_3 + 3\text{CaO}$ [2] Exemplar 2 (ii) Calcium nitride reacts with water to form a solution containing two alkaline compounds. Write an equation for this reaction. $\text{Ca}(\text{NO}_3)_2 + \text{H}_2\text{O} \rightarrow \text{Ca}(\text{OH})_2 + 2\text{HNO}_3$ [2] Most candidates were given 1 of the 2 available marks for showing the formula of one correct product, $\text{Ca}(\text{OH})_2$ or NH_3 . The best answers identified both products and were then able to balance the equation. Common errors included 'CaO' as a product and incorrect compounds of nitrogen (see the two responses above). This part discriminated very well.

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
iii	 Ca²⁺ shown alternately in FOUR circles ✓ O²⁻ shown alternately in FOUR circles ✓	2 AO1.1×2	ALLOW labels if seen outside circles provided it clear which circle the label applies to ALLOW 1 mark for Ca AND O shown alternately, each in FOUR circles <i>i.e. with no charges or incorrect charges</i> ALLOW 1 mark for 2+/-2 AND 2-/-2 shown alternately in FOUR circles (with no Ca and O) DO NOT ALLOW All circles with same ion, <i>i.e. all Ca²⁺ OR all O²⁻</i> ALLOW 1 mark for 4 Ca²⁺ AND 4O²⁻ but NOT shown alternately e.g.  ✓ Examiner's Comments Most candidates completed the diagram with correct Ca²⁺ and O²⁻ ions, shown alternately. Many different errors were seen for which 1 of the 2 marks could sometimes be given, e.g. 2+ and 2-, or Ca and O shown alternately. Some candidates used incorrect ions, with N³⁻ the most common as a carry-over from (i) and (ii). Some candidates completed each face of the structure with the same ion, rather than different ions alternately.

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
	iv 'Dot and cross' of central N to O OR N ✓  Rest of 'dot and cross' diagram correct ✓ 	2(AO2.5×2)	Electrons do NOT need to be shown paired. 'Dot and cross' of NO₂ ALLOW 1st mark for N → O OR N=O DO NOT ALLOW ions CARE For 2nd mark, watch for stray paired OR unpaired electrons on central N ALLOW 10 electrons around central N atom for 2 marks, i.e.  <u>Examiner's Comments</u> N₂O is a very unfamiliar molecule for candidates and they found this 'dot and cross' diagram far more difficult than diagram for Ca₃N₂ in (i). Information in the question clearly stated that a nitrogen atom is in the centre but many diagrams were drawn with the O atom at the centre. It was also fairly common to see NO₂ rather than N₂O. Candidates found the bonding of the O atom to the central N atom easier than the double or dative covalent bond between the two N atoms. Many candidates included lone pairs on the central N atom despite this resulting in a non-linear molecule. (The question states that the molecule is non-linear). It was common to see an expanded octet with 10 electrons being involved with the central N atom (a triple and double bond). If correct, this was given, reflecting a candidate's

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					knowledge at this stage of the course. Candidates are advised to take great care in showing clear symbols for electrons (dots and crosses or other symbols). Parts of the diagram where a dot and a cross cannot be distinguished cannot be credited. This part discriminated extremely well.
			Total	8	
10		i	$\text{Sr} + 2\text{H}_2\text{O} \rightarrow \text{Sr}(\text{OH})_2 + \text{H}_2$ ✓	1(AO2.6)	ALLOW correct multiples including fractions IGNORE state symbols <u>Examiner's Comments</u> Nearly half of the candidates did not answer this question correctly, mainly because of incorrect balancing or the formation of strontium oxide instead of strontium hydroxide.
		ii	Two points (✓✓) from With calcium: - less vigorous fizzing/bubbling/effervescence - dissolves more slowly/slower reaction - solution has a lower pH/less alkaline - precipitate forms/less soluble	2(AO2.3×2)	IGNORE gives out less/more heat, less reactive, less gas <u>Examiner's Comments</u> Most candidates were able to identify at least one difference, although a significant number of responses stated the opposite trend
			Total	3	

1(a)

- (i) Complete the electron configuration of a bromide ion.

1s² [1]

- (ii) A student adds a small volume of aqueous silver nitrate to an aqueous solution of bromide ions in a test-tube. The student then adds a similar volume of dilute aqueous ammonia to the same test-tube.

Describe what the student would see in the test-tube after the addition of aqueous ammonia.

..... [1]

- (iii) Write an ionic equation for any precipitation reaction which occurs in the student's tests.

Include state symbols.

..... [1]

(b) The Group 7 element chlorine reacts with sodium hydroxide, NaOH, under different conditions to give different products.

(i) Chlorine reacts with aqueous sodium hydroxide to form bleach.

Write the equation and state the conditions for this reaction.

equation _____

conditions _____

[2]

(ii) Under different conditions, chlorine reacts differently with aqueous sodium hydroxide.

A disproportionation reaction takes place as shown below.



State what is meant by disproportionation and show that disproportionation has taken place in this reaction.

Use oxidation numbers in your answer.

[3]

2(a) Chlorine gas can be added to a cold, dilute alkaline solution to form bleach.

Write the equation for this reaction.

-----[1]

(b) A student bubbles chlorine gas through aqueous potassium iodide. A reaction takes place.

(i) State what the student would observe.

-----[1]

(ii) Write the ionic equation for this reaction.

Include state symbols.

-----[1]

3 Which row is correct?

	Highest pH when added to water	Most reactive halogen
A	MgO	F ₂
B	MgO	I ₂
C	BaO	F ₂
D	BaO	I ₂

Your answer

[1]

- 4 A student carries out the following experiment to investigate the reaction between hexane and chlorine. The chlorine is made by reaction of aqueous sodium chlorate(I) with dilute hydrochloric acid.

Procedure	Observations
1 cm ³ of hexane is mixed with 1 cm ³ dilute aqueous sodium chlorate(I) in a test-tube.	The mixture forms two colourless layers.
1 cm ³ dilute hydrochloric acid is slowly added to the mixture.	The acid mixes with the lower layer, which turns a pale green colour.
The tube is then stoppered and shaken.	The pale green colour moves to the upper layer, leaving the lower layer colourless.
The tube is placed under a bright light and shaken at regular intervals for about 10 minutes. The stopper is loosened regularly to release any pressure.	The pale green colour slowly disappears leaving two colourless layers after about 10 minutes.

- (i) The reaction between aqueous sodium chlorate(I) and dilute hydrochloric acid produces aqueous sodium chloride as well as chlorine.

Suggest an equation for this reaction.

-----[2]

- (ii) Outline a simple practical test that would confirm the presence of chloride ions in the lower layer, and give the expected result.

test: -----

result: -----

-----[2]

- (iii) Name the apparatus that could be used to separate the two liquid layers present at the end of the experiment.

-----[1]

5 Which halogen most readily forms 1– ions?

- A bromine
- B chlorine
- C fluorine
- D iodine

Your answer

[1]

6 HBr(aq), forms two ions in solution.

Which observation is correct for reactions of HBr(aq)?

- A It effervesces addition of sodium carbonate solution.
- B It forms a white precipitate on addition of silver nitrate solution.
- C It turns orange on addition of silver nitrate solution.
- D It turns brown on addition of potassium chloride solution.

Your answer

[1]

7(a) Bromine reacts with iodine to form iodine monobromide, IBr.

The table below lists some average bond enthalpies which are required in different parts of this question.

Bond	Average bond enthalpy / kJ mol^{-1}
Br-Br	+193
I-I	+151
I-Br	+175

(i) Average bond enthalpy is the enthalpy change for the breaking of 1 mole of bonds in gaseous molecules.

Why do Br_2 and I_2 **not** exist in the gaseous state under standard conditions?

----- [1]

(ii) Calculate the enthalpy change of formation, $\Delta_f H$, for IBr.

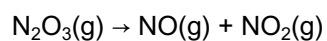
$\Delta_f H =$ ----- kJ mol^{-1} [2]

(b) Bromine disproportionates when it reacts with potassium hydroxide solution.

Suggest an equation for this reaction.

----- [1]

- 8 N_2O_3 is an unstable oxide of nitrogen that decomposes in a redox reaction.



- (i) State the oxidation number of nitrogen in each oxide in the table below.

Oxide	Oxidation number of nitrogen
N_2O_3	
NO	
NO_2	

[1]

- (ii) Name this type of redox reaction.

In your answer you should use appropriate technical terms spelled correctly.

-----[1]

9 A student carries out test-tube experiments to prove the trend in reactivity of halogens.

The student is provided with the following solutions:

- bromine water
- aqueous iodine
- aqueous barium chloride
- aqueous magnesium bromide
- aqueous calcium iodide.

Chlorine gas and chlorine water are **not** available.

The student carries out the **minimum** number of test-tube experiments using these solutions in the presence of cyclohexane (an organic solvent).

- State the solutions that need to be added together in order to prove the trend in reactivity of the halogens, using the **minimum** number of test-tube experiments.
- Describe the colour seen in the organic solvent at the end of each test-tube experiment.
- Write an ionic equation for **one** reaction that takes place.

10(a) This question is about properties of the halogens and halide ions.

Bromine can be extracted by bubbling chlorine gas through concentrated solutions containing bromide ions.

(i) Write the electron configuration of a bromide ion, in terms of sub-shells.

-----[1]

(ii) Write an ionic equation for this reaction and state why this reaction takes place in terms of reactivity of the halogens.

-----[2]

(b) Chlorine is used in water treatment.

State **one** benefit and **one** risk of chlorine in water treatment.

Benefit -----

Risk -----

-----[1]

(c) Precipitation reactions can be used to distinguish between halide ions.

(i) State the reagent needed for these precipitation reactions.

-----[1]

(ii) How would the appearance of the precipitates allow you to distinguish between chloride, bromide and iodide ions?

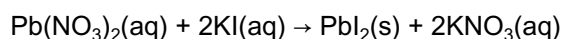
Chloride -----

Bromide -----

Iodide -----

[1]

11(a) Aqueous lead(II) nitrate, $\text{Pb}(\text{NO}_3)_2(\text{aq})$, and aqueous potassium iodide, $\text{KI}(\text{aq})$, react together.
The equation is shown below.



A student carries out an experiment to determine the enthalpy change of reaction, $\Delta_r H$, of this reaction.

The student follows the method outlined below.

- Add 50.0 cm^3 of 1.50 mol dm^{-3} $\text{Pb}(\text{NO}_3)_2(\text{aq})$ to a polystyrene cup.
- Measure out 50.0 cm^3 of a solution of $\text{KI}(\text{aq})$, which is in excess.
- Measure the temperature of both solutions.
- Add the $\text{KI}(\text{aq})$ to the polystyrene cup, stir the mixture and record the maximum temperature.

Temperature readings

Initial temperature of both solutions = 19.5°C

Maximum temperature of mixture = 30.0°C

Calculate $\Delta_r H$, in kJ mol^{-1} , for the reaction shown in the equation above.

Give your answer to an **appropriate** number of significant figures.

Assume that the density of all solutions and specific heat capacity, c , of the reaction mixture is the same as for water.

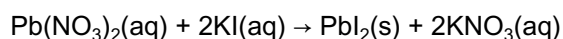
$\Delta_r H =$ _____ kJ mol^{-1} [4]

(b) Write an ionic equation for the reaction that the student carries out.

Include state symbols.

----- [1]

- (c) The 50.0 cm^3 of KI(aq) used in the experiment contains 10% more KI than is needed to react with 50.0 cm^3 of $1.50 \text{ mol dm}^{-3} \text{ Pb(NO}_3)_2\text{(aq)}$.



Calculate the concentration, in mol dm^{-3} , of KI that the student used.

concentration of KI = _____ mol dm^{-3} [2]

- 12 What is the best explanation for the trend in boiling points down the halogens group?

- A The covalent bonds become stronger.
- B The hydrogen bonds become stronger.
- C The permanent dipole–dipole interactions become stronger.
- D The induced dipole–dipole interactions (London forces) increase.

Your answer

[1]

- 13 Which silver compound is insoluble in concentrated $\text{NH}_3\text{(aq)}$?

- A AgNO_3
- B AgCl
- C AgBr
- D AgI

Your answer

[1]

14(a) This question is about halogens.

Bromine is used to extract iodine from a solution containing iodide ions.

(i) Write an ionic equation for the reaction.

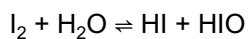
-----[1]

(ii) Explain why iodine is less reactive than bromine.

-----[3]

(b) Iodine can be used for the small-scale purification of drinking water.

(i) Iodine reacts with water as shown below.



Using oxidation numbers, explain why this reaction is a disproportionation.

[3]

(ii) Chlorine is used to purify water on a large scale.

State **one** disadvantage of using chlorine for the purification of drinking water.

[1]

15 This question is about halogens and halides.

The boiling points of the halogens are shown in the table.

Halogen	Boiling point / K
fluorine	85
chlorine	239
bromine	332
iodine	457
astatine	503

Explain the trend in boiling points of the halogens.

[3]

16 Which reaction shows chlorine only being oxidised?

- A $\text{Cl}_2 + \text{H}_2\text{O} \rightarrow \text{HCl} + \text{HClO}$
- B $2\text{ClO}_2 + 2\text{NaOH} \rightarrow \text{NaClO}_2 + \text{NaClO}_3 + \text{H}_2\text{O}$
- C $4\text{KClO}_3 \rightarrow 3\text{KClO}_4 + \text{KCl}$
- D $\text{MnO}_2 + 4\text{HCl} \rightarrow \text{MnCl}_2 + \text{Cl}_2 + 2\text{H}_2\text{O}$

Your answer

[1]

END OF QUESTION PAPER

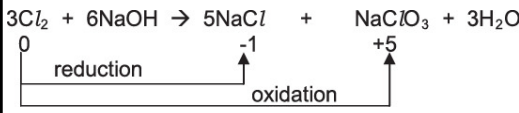
Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
1	a	i	$(1s^2) 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$ ✓	1	ALLOW ... $4s^2 3d^{10} 4p^6$ ALLOW subscripts AND 3D IGNORE $1s^2$ seen twice Examiner's Comments Most candidates were awarded the mark available for the electron configuration of the bromide ion, but weaker responses included the electronic configuration of a bromine atom or of the ion, Br^+.
		ii	Cream AND precipitate ✓	1	ALLOW solid OR ppt for precipitate IGNORE 'does not dissolve' OR 'partially dissolves' Examiner's Comments Many candidates focused exclusively in their answers on the solubility of silver bromide in aqueous ammonia, writing as a result that the precipitate would remain, or that it would not dissolve and so not gaining the mark by omitting the colour of the precipitate.
		iii	$Ag^+(aq) + Br^-(aq) \rightarrow AgBr(s)$ ✓	1	Equation AND state symbols required Examiner's Comments The majority of candidates answered this question successfully with the only recurring error made being to omit some or all of the state symbols.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	b	i	Equation $2\text{NaOH} + \text{Cl}_2 \rightarrow \text{NaCl} + \text{NaClO} + \text{H}_2\text{O}$ ✓ Conditions cold AND dilute (sodium hydroxide) ✓	2	ALLOW correct multiples IGNORE state symbols ALLOW room temperature OR $\leq 20^\circ\text{C}$ for cold Examiner's Comments This question was perhaps not as well answered as it might have been and although some candidates had memorised the equation that was needed here, many clearly had not and more alarmingly such candidates were then content to suggest equations which were chemical nonsense. It was very uncommon indeed to see candidates pick up the second mark for giving the correct conditions required to form bleach from chlorine, with few realising that as well as being cold, the NaOH(aq) needs to be dilute.
		ii	Definition of disproportionation mark M1 (Disproportionation) is the (simultaneous) oxidation and reduction of the same element (in the same redox reaction) ✓ M2 Assigning of oxidation numbers Cl in Cl_2 is 0 AND Cl in NaCl is -1 AND Cl in NaClO_3 is +5 ✓ M3 Chlorine has been oxidised from 0 to +5 AND Chlorine has been reduced from 0 to -1 ✓ 'Chlorine has been oxidised from 0 in Cl_2 to +5 in NaClO_3 and chlorine has been reduced from 0 in Cl_2 to -1 in NaCl' would secure M2 and M3	3	ALLOW 'an element' OR 'a species' for 'the same element' Assume 'it' means disproportionation M1 can be awarded for 'chlorine is oxidised and reduced and this is disproportionation' ALLOW oxidation numbers written above the equation if not seen in the text but IGNORE oxidation numbers written above the equation if seen in the text ALLOW 1- AND 5 AND 5+ DO NOT ALLOW chloride in place of chlorine except for NaCl DO NOT ALLOW Cl^- in NaCl AND Cl^{5+} in NaClO_3 (ie do not allow ionic charges for oxidation numbers) ALLOW Cl OR Cl_2 for chlorine DO NOT ALLOW M2 if incorrect oxidation numbers of other elements are seen in the text eg H = +2 ALLOW ECF for third marks if ONE incorrect oxidation number is assigned but directional changes are correct eg Cl = 0 and -1 and +3 instead 0 and -1 and +5 DO NOT ALLOW ECF if two oxidation numbers are incorrectly assigned

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
	$3\text{Cl}_2 + 6\text{NaOH} \rightarrow 5\text{NaCl} + \text{NaClO}_3 + 3\text{H}_2\text{O}$  This diagram, along with a correct definition, would secure all three marks.		IGNORE references to electron loss / gain If oxidation numbers are correct ALLOW third mark for: chlorine is oxidised to form NaClO_3 AND chlorine is reduced to form NaCl Examiner's Comments The concept of disproportionation has been tested before and candidates were able to address this part of the question successfully. Weaker candidates met problems in assigning the oxidation numbers and in particular the Cl in NaClO_3 was frequently misassigned as +1. Another frequent mistake was to identify that both oxidation and reduction had taken place, but not to say which changes in the oxidation numbers of which species corresponded to each of these processes. A large number of candidates relied for one of their marks on the examiner marking their working shown above the equation. It should be stressed that a complete answer should aim to restate these key assignments of oxidation numbers within the text.
	Total	8	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
2	a		$\text{Cl}_2 + 2\text{NaOH} \rightarrow \text{NaClO} + \text{NaCl} + \text{H}_2\text{O}$ ✓	1	ALLOW multiples IGNORE state symbols ALLOW OH^- and ClO^-, i.e. $\text{Cl}_2 + 2\text{OH}^- \rightarrow \text{ClO}^- + \text{Cl}^- + \text{H}_2\text{O}$ ALLOW NaOCl Examiner's Comments This equation was directly from the specification and candidates were familiar with it. Errors in balancing were rare.
	b	i	(The solution would turn) yellow OR orange OR brown ✓	1	ALLOW shades and colours (eg dark yellow, yellow-orange) DO NOT ALLOW 'purple' Examiner's Comments The lack of correct responses suggested that candidates may not have met this simple experiment. Centres are advised to use a practical approach in their teaching wherever possible. The most common error here was to suggest that the solution would turn purple.
		ii	$\text{Cl}_2 (\text{g}) + 2\text{I}^- (\text{aq}) \rightarrow \text{I}_2 (\text{aq}) + 2\text{Cl}^- (\text{aq})$ ✓	1	ALLOW multiples State symbols required ALLOW $\text{Cl}_2(\text{aq})$ Examiner's Comments The equation was correct in the majority of responses but the mark was lost by candidates due the state symbols not being included in their answer. Where state symbols were present it was very common to see I_2 given as a (g) rather than (aq). The reason for this is not clear but perhaps it stems from Cl_2 being (g) in the reactants.
			Total	3	
3			C	1	
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
4		i	$\text{NaClO} + 2\text{HCl} \rightarrow \text{NaCl} + \text{Cl}_2 + \text{H}_2\text{O}$ correct formulae of reactants, NaCl and chlorine (1) water and balancing (1)	2	allow $\text{NaClO}_3 + 6\text{HCl} \rightarrow \text{NaCl} + 3\text{Cl}_2 + 3\text{H}_2\text{O}$ for 1 mark
		ii	Test: add (a few drops of aqueous) silver nitrate (1) Result: white ppt (1)	2	ignore addition of dilute nitric acid before the AgNO_3 ignore redissolving in excess NH_3 or darkening of the ppt
		iii	separating funnel (1)	1	allow dropping pipette
			Total	5	
5			C	1	
			Total	1	
6			A	1	
			Total	1	
7	a	i	(because energy is needed to break) induced dipole–dipole interactions / London forces between molecules (1)	1	allow forces of attraction between molecules OR van der Waals' forces ignore reference to strong or weak
		ii	Bond breaking $(+193) + (+151) = (+)344$ AND Bond making $2(-175) = (-)350$ (1) $\Delta_f H = \frac{(+344) + (-350)}{2} = -3 \text{ (kJ mol}^{-1}\text{)}$ (1)	2	Correct answer scores 2 marks
	b		$\text{Br}_2 + 2\text{KOH} \rightarrow \text{KBr} + \text{KBrO} + \text{H}_2\text{O}$ (1)	1	allow $3\text{Br}_2 + 6\text{KOH} \rightarrow 5\text{KBr} + \text{KBrO}_3 + 3\text{H}_2\text{O}$ allow ionic equation
			Total	4	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
8		i	$\text{N}_2\text{O}_3 = +3$ $\text{NO} = +2$ $\text{NO}_2 = +4 \checkmark$	1	ALLOW '3' OR '3+' etc ALLOW oxidation numbers written over the equation but IGNORE if oxidation numbers are given on the answer lines Examiner's Comments The correct answer was almost universally known.
		ii	Disproportionation $\checkmark$	1	QWC 'disproportionation' spelled correctly. Examiner's Comments The correct answer was almost universally known with just the rare misspelling of disproportionation seen.
			Total	2	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
9			<i>M1 Mixing of first pair of solutions</i> Adding (aqueous) barium chloride to bromine (water) OR $\text{BaCl}_2 + \text{Br}_2$ <i>M2 Mixing of second pair of solutions</i> Adding (aqueous) calcium iodide to bromine (water) OR $\text{CaI}_2 + \text{Br}_2$ OR Adding aqueous magnesium bromide to aqueous iodine OR $\text{MgBr}_2 + \text{I}_2$ <i>M3 Colours in cyclohexane</i> Colour for M1 is orange OR yellow AND Colour for M2 is purple OR violet OR mauve OR pink OR lilac <i>M4 Ionic equation mark</i> $\text{Br}_2 + 2\text{I}_- \rightarrow \text{I}_2 + 2\text{Br}_-$ <i>M5 Use of M1 and one of M2 as only two experiments</i>	5	For M1 and M2 ALLOW any halide for the named halides in the question eg 'potassium chloride' for barium chloride 'potassium bromide' for barium chloride 'potassium iodide' for calcium iodide DO NOT ALLOW 'barium chloride/BaCl' 'calcium iodide/CaI' 'magnesium bromide/MgBr' as the halide DO NOT ALLOW 'bromide' for 'bromine' OR 'iodide' for 'iodine' M1 can be seen anywhere M2 could be awarded from a correct ionic equation in M4 M2 can be seen anywhere If both M2 tests and M1 are given, this will nullify M5 M3 is given for the correct resultant colour of pairs of solution given in M1 and M2. If both possible pairs of solutions in M2 are given, both colours must be correct. IGNORE colours of other combinations of solutions IGNORE colours in the aqueous layer if stated DO NOT ALLOW other colours for M1 and M2 (eg iodine is brown) M4 can be awarded anywhere M4 also scores M2 if not already awarded ALLOW multiples IGNORE state symbols IGNORE $\text{I}_2 + 2\text{Br}_- \rightarrow \text{I}_2 + 2\text{Br}_-$ IGNORE $\text{Br}_2 + 2\text{Cl}_- \rightarrow \text{Br}_2 + 2\text{Cl}_-$ DO NOT ALLOW other ionic equations DO NOT ALLOW if more than two experiment are attempted even if pointless eg 'barium chloride + calcium iodide' Place the 'tick' for M5 against the sub-total mark, [5], at the bottom right hand side of the answer space Examiner's Comments Able candidates were able to provide full answers involving only two reactions, one ionic equation and correct colours of

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					products in succinct form. Some candidates answered the question correctly then ignored the instruction to keep the number of reactions to a minimum and gave an unnecessary third confirmatory reaction. This question distinguished well for many weaker candidates were unable to produce chemically coherent responses. Suggestions for 'impossible' reactions such as adding magnesium bromide to calcium iodide were frequently seen from such candidates.
			Total	5	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
10	a	i	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$ ✓ Look carefully at $1s^2 2s^2 2p^6 3s^2 3p^6$ – there may be a mistake	1	ALLOW 3d after $4s^2$ or after $4p^6$, e.g. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6$ ALLOW upper case D, etc and subscripts, e.g. 4S ₂ 3D ₁ DO NOT ALLOW [Ar] as shorthand for $1s^2 2s^2 2p^6 3s^2 3p^6$ <u>Examiner's Comments</u> This part was generally answered well showing a good understanding of electron configuration. When incorrect, it was usually for giving the configuration of a bromine atom rather than a bromide ion, or the subtraction of an electron rather than addition giving $4p^4$.
		ii	$Cl^2 + 2Br^- \rightarrow 2Cl^- + Br_2$ ✓ Chlorine/Cl/Cl ₂ is more reactive/stronger oxidising agent OR reactivity decreases down group ✓	2	ALLOW multiples, e.g. $\frac{1}{2}Cl_2 + Br^- \rightarrow Cl^- + \frac{1}{2}Br_2$ IGNORE state symbols ALLOW bromine is less reactive IGNORE explanation in terms of electronegativity <u>Examiner's Comments</u> Most candidates identified that chlorine was the more reactive element, although a significant number responded in terms of electronegativity. More commonly, it was the equation that was incorrect, usually unbalanced or with bromine reacting instead of chlorine.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	b		<i>Benefit AND risk required for mark</i> Benefits: kills OR removes bacteria AND Risk: toxic/poisonous OR forms chlorinated hydrocarbons OR forms carcinogens/toxic compounds ✓	1	ALLOW kills germs OR kills micro-organisms OR kills pathogens OR sterilises/disinfects OR makes water potable/ safe to drink OR purifies water IGNORE antiseptic, reduces risk of disease, cleans water ALLOW reduces risk of water-born diseases, e.g. cholera/typhoid/dysentery IGNORE 'harmful'/'dangerous' IGNORE chlorine is carcinogenic/ dangerous for health/causes breathing problems <u>Examiner's Comments</u> Most candidates scored this mark by stating a benefit (usually 'kills bacteria') and a risk (usually 'toxic' or 'forms carcinogenic compounds'). Vaguer terms such as 'harmful', 'can make you ill', etc, were not credited.
	c	i	Silver nitrate OR AgNO_3 ✓	1	ALLOW Ag^+ IF name correct, IGNORE an incorrect formula IGNORE acidified/HNO_3 <u>Examiner's Comments</u> Most candidates responded correctly with either the name of the reagent: silver nitrate, or its formula: AgNO_3.
		ii	Chloride: white (precipitate) AND Bromide: cream (precipitate) AND iodide: yellow (precipitate) ✓	1	All three required for the mark <u>Examiner's Comments</u> The colours of the silver halide precipitates were well known and very few candidates failed to score here. Where mistakes were made, it was to put the three colours in the wrong order or to show the colours of halogens in solution.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
			Total	6	

Mark Scheme

Question		Answer/Indicative content	Marks	Guidance
11	a	FIRST, CHECK THE ANSWER ON ANSWER LINE IF $\Delta_r H = -58.5 \text{ (kJ mol}^{-1}\text{)}$ award 4 marks <i>Energy released in J OR kJ</i> $= 100.0 \times 4.18 \times 10.5 = 4389 \text{ (J) OR } 4.389 \text{ (kJ) } \checkmark$ <i>Correctly calculates $n(\text{Pb}(\text{NO}_3)_2)$</i> $= 1.50 \times \frac{50}{1000} = 0.075(0) \text{ (mol) } \checkmark$ ΔH value in J OR kJ Answer MUST divide energy by $n(\text{Pb}(\text{NO}_3)_2)$ $(-) \frac{4389}{0.0750} \text{ OR } (-)58520 \text{ (J)}$ OR $(-) \frac{4.389}{0.0750} \text{ OR } (-)58.52 \text{ (kJ) } \checkmark$ <i>(Sign ignored and/or more than 3 SF)</i> Correct $\Delta_r H$ in kJ AND – sign AND 3 SF $= -58.5 \text{ (kJ mol}^{-1}\text{)} \checkmark$	4	FULL ANNOTATIONS MUST BE USED ----- ALLOW 4390 J; 4.39 kJ DO NOT ALLOW less than 3 SF IGNORE units <i>i.e. ALLOW correctly calculated number in J OR kJ</i> ALLOW ECF from $n(\text{Pb}(\text{NO}_3)_2)$ AND/OR Energy ALLOW 58500 (from 4390) IGNORE absence of – sign and 3 SF requirement Final mark requires – sign, kJ AND 3 SF Note: From 4390 J, $\Delta_r H = -58.5 \text{ (kJ mol}^{-1}\text{)}$ (SAME) ----- Common error –29.3 3 marks (50 g instead of 100 g in $mc\Delta T$) <u>Examiner's Comments</u> Although similar in style to unstructured direct enthalpy calculations on the legacy specification, this question was harder for two reasons. Firstly, two volumes of 50 cm³ had to be added together to generate m as 100 g for $mc\Delta T$. Secondly, candidates were asked to quote their final answer to an ‘appropriate’ number of significant figures. This will be the least accurate measurement (to 3 significant figures in this example). Many incorrect answers used <i>m</i> as 50 g or

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					quoted a final numerical value to more than 3 significant figures. Even after obtaining a correct final value for ΔH, this was often not given a negative sign to indicate the exothermic change. It is important for candidates to show clear working so that markers can see what is intended and able to apply credit using error carried forward. Answer: $\Delta H = -58.5 \text{ kJ mol}^{-1}$
	b		$\text{Pb}^{2+}(\text{aq}) + 2\text{I}^{-}(\text{aq}) \rightarrow \text{PbI}_2(\text{s}) \checkmark$ State symbols required	1	ALLOW $\text{Pb}^{+2}(\text{aq})$ IGNORE spectator ions, $\text{K}^{+}(\text{aq})$ and $2\text{NO}_3^{-}(\text{aq})$ on both sides <u>Examiner's Comments</u> Only the best candidates were able to construct the required equation. Even when written correctly, state symbols (asked for in the question) were often omitted or shown incorrectly. Although very similar to the ionic equation for formation of silver halides, this equation was beyond most candidates at this stage of their chemistry studies.

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	c	FIRST, CHECK ANSWER ON ANSWER LINE IF [KI(aq)] rounds to 3.3 mol dm⁻³ e.g. 3.30, 3.33, 3.3 recurring ----- Method 1 [KI(aq)] for complete reaction $= 2 \times 0.0750 = 0.150 \text{ mol} \times \frac{1000}{50} = 3 \text{ (mol dm}^{-3}\text{)} \checkmark$ 10% greater gives $3 \times 1.1 = 3.3(0) \checkmark$ OR----- Method 2 $n(\text{KI(aq)})$ required = $2.2 \times 0.0750 = 0.165 \text{ mol} \checkmark$ $[\text{KI(aq)}] = 0.165 \times \frac{1000}{50} = 3.3(0) \text{ (mol dm}^{-3}\text{)} \checkmark$	2	ALLOW ECF from incorrect $n(\text{Pb(NO}_3)_2)$ from 24(a) BUT if (a) is incorrect but 0.0750 used here, treat as a fresh start and IGNORE response from 24(a) ALLOW 2 marks for 3.3/3.3 recurring <i>Attempt at increasing concentration by 10%</i> $= 2 \times 0.0750 = 0.150 \text{ mol} \times \frac{1000}{45} = 3.33 \text{ (mol dm}^{-3}\text{)}$ ALLOW ECF from incorrect $n(\text{KI})$ <u>Common errors</u> 3 1 mark (Correct for KI with no extra 10%) 1.6 1 mark (no factor of 2 used for KI) 5 2.7 1 mark (10% less rather than 10% more) 2.7 1 mark (10% increase in volume: 55 3/2. cm³) 72 <u>Examiner's Comments</u> This part was well attempted with many candidates able to score at least one of the two marks. Errors related to use of an incorrect mole ratio, applying 10% incorrectly, or ignoring 10% altogether. Answer: 3.30 mol dm⁻³
		Total	7	

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12			D	1	Examiner's Comments This part was generally well answered. The common incorrect answer was answer option A.
			Total	1	
13			D	1	Examiner's Comments Most candidates correctly identified answer option D as the correct insoluble compound. However, answer option A was a common incorrect answer, likely due to it being the only non-halide.
			Total	1	

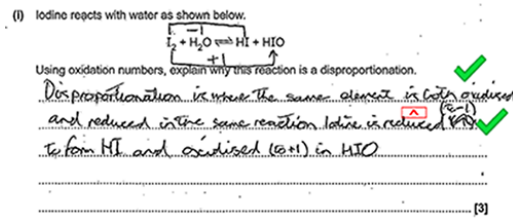
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14	a	i	$\text{Br}_2 + 2\text{I}^- \rightarrow \text{I}_2 + 2\text{Br}^-$ ✓	1	ALLOW multiples IGNORE state symbols <u>Examiner's Comments</u> Around 50% of candidates answered this correctly. The most common error was not balancing the equation, and many did not know what an ionic equation was.
		ii	Iodine has a larger atomic radius ✓ Iodine has greater shielding / more shells ✓ Iodine has weaker / less nuclear attraction (on electron gained than bromine) ✓	3	ORA ALLOW iodine is larger / bromine is smaller ALLOW electron added to a shell further from the nucleus ALLOW bromine has greater nuclear attraction IGNORE 'gained less easily' for 'weaker attraction' IGNORE references to ionisation energy DO NOT ALLOW mention of losing electrons for M3 ALLOW 'pull' for 'attraction' IGNORE just 'greater attraction' OR greater force <u>Examiner's Comments</u> This question was answered well by most candidates, although some omitted the word 'nucleus' when explaining attracting electrons, or answered in terms of losing electrons, and did not have the final marking point credited.

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					Exemplar 1 <i>Tadine is less reactive than Bromine because it does not accept electrons as easily. This is because it has a larger atomic radius so the attraction from the nucleus on electrons is weaker. It is also subject to more electron shielding as it has more shells so energy levels. This also decreases the attraction so it doesn't gain electrons as easily.</i> [3] This candidate was credited all three marks. Some candidates managed to be credited for all 3 marks in one short sentence that covered all 3 marking points.

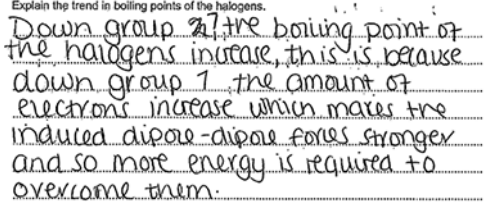
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	b	i	Disproportionation Oxidation AND reduction of same element/iodine OR Iodine has been oxidised and Iodine has been reduced ✓ Oxidation from 0 to +1 in HIO ✓ Reduction from 0 to -1 in HI ✓	3	ALLOW I or I₂ for iodine IGNORE numbers around equation for oxidation states ALLOW 1- for -1 AND 1+ for +1 NOTE (for iodine/I₂) from 0 only needs to be seen once, does not need to be stated twice ALLOW 1 mark for 3 ox nos correct but no mention of words oxidation/reduction: 0 in I₂ AND -1 in HI AND +1 in HIO ALLOW 1 mark for species missing: Iodine oxidised (from 0) to +1 AND iodine reduced (from 0) to -1 <u>Examiner's Comments</u> Most candidates were aware of disproportionation but lost marks by not stating the species or whether the process was oxidation or reduction. Exemplar 2  Here the candidate has lost a mark for not stating the initial oxidation number of elemental iodine as 0.

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		ii	Chlorine is toxic/poisonous OR forms halogenated hydrocarbons OR forms carcinogens/toxic compounds ✓	1	ALLOW (reacts with hydrocarbons to) form carcinogens/toxic compounds IGNORE • chlorine causes cancer • harmful/dangerous • chlorine causes breathing problems <u>Examiner's Comments</u> The majority of candidates stated that chlorine is toxic or forms carcinogens, although some stated that chlorine is a carcinogen which was not credited. 12
			Total	8	

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15	Electrons (down group) number of electrons increases ✓ Type of intermolecular force (ANYWHERE) induced dipole(–dipole) interactions OR London forces ✓ Link of energy with intermolecular forces (ANYWHERE) (Down group,) more energy to break/overcome intermolecular forces OR more/stronger intermolecular forces ✓	3 (AO1.1×3)	FULL ANNOTATIONS MUST BE USED ALLOW more electron shells IGNORE 'more shells' OR more (electron) shielding IGNORE comments about nuclear attraction, ionisation energy, etc. IGNORE van der Waals' forces, vdw IGNORE abbreviations e.g. LDF, IDID IGNORE less energy needed to break 'bonds' OR less energy needed to break 'London forces' <i>Too vague – needs idea of 'between molecules'</i> IGNORE 'covalent bonds' between atoms BUT response linking to breaking of covalent bonds is a CON for last marking point ONLY. Examiner's Comments Exemplar 4 Explain the trend in boiling points of the halogens.  [3] This question discriminated well. Candidates were expected to link increasing boiling point down the group with the increasing number of electrons and stronger induced dipole–dipole forces or London forces between molecules that

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					must be broken. To be given all 3 marks, candidates needed to show that intermolecular forces (or forces between molecules) are broken during boiling. This mark proved to be the most difficult. The response shows a typical response that did not include intermolecular forces. Lower attaining candidates often let themselves down by being unable to construct a well-reasoned, relevant response. Many discussed nuclear charge, shielding, atomic radius and the ease of losing or gaining an electron to produce a valid explanation for ionisation energy or electron gain trend but not for different boiling points. The contrast in the clarity of low- and high-attaining candidate responses was particularly pronounced for this question.
			Total	3	
16			D	1 (AO2.2)	<u>Examiner's Comments</u> Despite most scripts being covered with annotations of oxidation numbers, only about half of all candidates obtained the correct answer of D.. Option B was the most common incorrect response, followed by option C. The annotations on these scripts often showed incorrect assignments of oxidation numbers.
			Total	1	