

GCE

Chemistry A

H432/01: Periodic table, elements and physical chemistry

Advanced GCE

Mark Scheme for November 2020

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All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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Annotations

Annotation	Meaning
	Correct response
	Incorrect response
	Omission mark
	Benefit of doubt given
	Contradiction
	Rounding error
	Error in number of significant figures
	Error carried forward
	Level 1
	Level 2
	Level 3
	Benefit of doubt not given
	Noted but no credit given
	Ignore
	Blank page

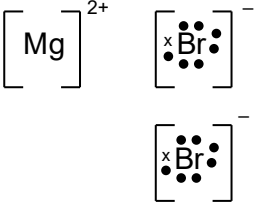
Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
()	Words which are not essential to gain credit
—	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

SECTION A

Question	Answer	Marks	AO element	Guidance
1	D	1	2.7	
2	B	1	1.2	
3	B	1	2.2	
4	C	1	2.2	
5	A	1	1.1	
6	A	1	2.2	
7	D	1	1.1	
8	D	1	2.6	
9	B	1	2.6	
10	C	1	1.2	ALLOW 2 in the answer box
11	D	1	2.2	
12	C	1	2.6	
13	B	1	1.1	
14	D	1	1.2	ALLOW 1 in the answer box
15	C	1	1.1	
	Total	15		

SECTION B

Question		Answer	Marks	AO element	Guidance
16	(a)	(The mean/average mass) taking into account the relative abundances of the isotopes ✓	1	1.1	ALLOW sum of (isotopic mass × %abundance) sum of (isotopic mass × abundance) / total abundance DO NOT ALLOW average mass of the isotopes
	(i)	 <p>Mg with no (or 8) outer electrons AND 2 × Br with 'dot-and-cross' outer octet ✓ Correct charges ✓</p>	2	1.2 2.5	ALLOW 8 electrons in Mg ²⁺ BUT 'extra' electron in Br ⁻ must match symbol for electrons in Mg ²⁺ IGNORE inner shells and circles ALLOW 1 mark if both electron arrangements and charges are correct but only one Br is drawn. ALLOW 2[Br ⁻], 2[Br] ⁻ (brackets not required)
	(ii)	<p>FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 1.71 × 10²² award 3 marks</p> <p>-----</p> $n(\text{MgBr}_2) = \frac{1.74}{184.1} = 0.00945\dots \text{ mol } \checkmark$ <p>Moles of ions = 0.00945... × 3 = 0.0283... mol ✓</p> <p>Number of ions = 0.0283... × 6.02 × 10²³ = 1.71 × 10²² ✓ 3SF required</p>	3	2.2×3	ALLOW ECF Calculator answer = 9.451385117 × 10 ⁻³ ALLOW ECF from incorrect moles of ions. e.g. 0.00945 Common error 5.69 × 10 ²¹ no × 3 2 marks

Question	Answer	Marks	AO element	Guidance
(c)*	<p><i>Refer to marking instructions on page 5 of mark scheme for guidance on marking this question.</i></p> <p>Level 3 (5–6 marks) Explains all three melting point values and conductivities in terms of structure, bonding, particles and relative strengths of the forces.</p> <p><i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i></p> <p>Level 2 (3–4 marks) Attempts to explain all three melting point values and conductivities in terms of the structure, bonding, particles of all three substances, but explanations may be incomplete or may contain only some correct statements or comparisons.</p> <p>OR Correctly explains two of the melting point values and conductivities in terms of the structure, bonding, particles.</p> <p><i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i></p> <p>Level 1 (1–2 marks) Identifies only some of the structures, forces and particles</p> <p>AND Attempts to explain the melting point values OR conductivities in terms of the structure, bonding, particles</p> <p><i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i></p> <p>0 marks <i>No response or no response worthy of credit.</i></p>	6	1.1×3 2.1×3	<p>Indicative scientific points may include:</p> <p><u>Structure and bonding</u></p> <p>Magnesium</p> <ul style="list-style-type: none"> • Structure: giant lattice • Metallic bonding • Delocalised electrons <p>Bromine</p> <ul style="list-style-type: none"> • Structure: simple molecular • induced dipole dipole forces (London forces) • (Between) molecules <p>DO NOT ALLOW (between) atoms</p> <p>Magnesium bromide</p> <ul style="list-style-type: none"> • Structure: giant lattice • Ionic bonding • (Between) oppositely charged ions <p><u>Comparison of bond strengths</u></p> <ul style="list-style-type: none"> • Metallic and ionic bonds are stronger than London forces <p>OR Metallic and Ionic bonds need more energy to break than London forces</p> <p><u>Conductivity</u></p> <ul style="list-style-type: none"> • Magnesium: conducts due to delocalised electrons can move/mobile. <p>IGNORE 'Carry' charge for movement • Magnesium bromide: In solid IONS cannot move; in solution IONS can move. <p>DO NOT ALLOW electrons.</p> <ul style="list-style-type: none"> • Bromine: Does not conduct as no mobile charge carriers. </p>

Question		Answer	Marks	AO element	Guidance
(d)	(i)	$\text{Mg}^{2+}(\text{g}) + 2\text{Br}(\text{g}) + 2\text{e}^{-} \checkmark$ $\text{Mg}(\text{s}) + \text{Br}_2(\text{l}) \checkmark$	2	1.2×2	State symbols required. CARE: Liquid state symbol for Br ₂
	(ii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = -346.5 award 2 marks ----- $2\Delta H_{\text{hyd}} =$ $-525 - 186 - (2 \times 112) - 148 - 736 - 1450 + (2 \times -325)$ $+ 1926$ OR $-525 - 186 - 224 - 148 - 736 - 1450 + 650 + 1926$ OR $= -693 \checkmark$ $\Delta H_{\text{hyd}} = -346.5 \text{ (kJ mol}^{-1}\text{)} \checkmark$	2	2.2×2	ALLOW -347 (kJ mol⁻¹) for 2 marks. ALLOW for 1 mark ONE error with sign OR use of 2: -693 (not divided by 2 at the end) 346.5 (wrong sign on answer) Common errors for 1 mark -2272.5 (-1926 instead of 1926) -1386 (2 x -693 instead of -693) -996.5 (-650 instead of 650) -509 (2 x 325 not used) -290.5 (2 x 112 not used) -198.5 (148 instead of -148) -160.5 (186 instead of -186) -122.5 (224 instead of -224) 178.5 (525 instead of -525) 389.5 (736 instead of -736) 1103.5 (1450 instead of -1450) For other answers, check for a single transcription error or calculation error which could merit 1 mark DO NOT ALLOW any answer which involves two errors e.g. -453 (2 x 325 not used AND 2 x 112 not used)

Question		Answer	Marks	AO element	Guidance
	(iii)	<p>Equation: $\text{Mg}^{2+}(\text{g}) + 2\text{Br}^{-}(\text{g}) \rightarrow \text{MgBr}_2(\text{s}) \checkmark$</p> <p>CHECK THE ANSWER ON ANSWER LINE If answer = -2433 award 2 marks</p> <p>-----</p> <p>Lattice enthalpy = $\Delta_{\text{hy}}H(\text{Mg}^{2+}) + 2 \times \Delta_{\text{hy}}H(\text{Br}^{-}) - \Delta_{\text{sol}}H(\text{MgBr}_2)$ OR $-1926 + (2 \times -346.5) - (-186)$ OR $\Delta_{\text{f}}H(\text{MgBr}_2) - 2\Delta_{\text{at}}H(\text{Br}) - \Delta_{\text{at}}H(\text{Mg})$ $- 1\text{st IE}(\text{Mg}) - 2\text{nd IE}(\text{Mg}) - 2\Delta_{\text{ea}}H(\text{Br})$ OR $-525 - (2 \times 112) - 148 - 736 - 1450 - (2 \times -325) \checkmark$</p> <p>Lattice enthalpy = -2433 kJ mol⁻¹ ✓</p>	3	1.2 2.2 x 2	<p>State symbols required</p> <p>For other answers, check for a single transcription error or calculation error which could merit 1 mark</p> <p>DO NOT ALLOW any answer which involves two errors</p> <p>ALLOW ECF from incorrect answer to d(ii)</p>
		Total	18		

Question		Answer	Marks	AO element	Guidance
17	(a)	<p>High pressure AND low temperature ✓</p> <p>Right-hand side has fewer (gaseous) moles/molecules OR left-hand side has more (gaseous) moles/molecules ✓</p> <p>(Forward) reaction is exothermic/gives out heat OR reverse reaction is endothermic/takes in heat ✓</p>	3	1.2×1 1.1×2	<p>Marks are independent</p> <p>ORA throughout</p> <p>ALLOW RHS ALLOW suitable alternatives for RHS e.g. product side</p>
	(b)	<p>(Reaction can be carried out at) lower temperatures / lower energy demand ✓</p> <p>Less (fossil) fuels burnt / less CO₂ emissions ✓</p>	2	1.1×2	<p>ALLOW lower pressures as alternative to lower temperature</p> <p>ALLOW reduced carbon footprint as alternative to less fuels burnt</p> <p>ALLOW different reactions can be used with greater atom economy / less waste</p> <p>ALLOW can reduce use of toxic substances</p>

Question	Answer	Marks	AO element	Guidance
(c)	<p>FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 25.55 <u>kJ mol⁻¹</u> OR 25550 <u>J mol⁻¹</u> award first 4 marks -----</p> <p>$\Delta S = 238 - (198 + 2 \times 131) \checkmark$ $= -222 \text{ (J K}^{-1} \text{ mol}^{-1}\text{) OR } -0.222 \text{ (kJ K}^{-1} \text{ mol}^{-1}\text{) } \checkmark$</p> <p>$\Delta G = \Delta H - T\Delta S$ OR $\Delta G = -91 - (525 \times -0.222)$ OR $\Delta G = -91000 - (525 \times -222) \checkmark$ <math>= 25.55 \text{ <u>kJ mol}^{-1}\text{ OR } 25550 \text{ <u>J mol}^{-1}\text{ } \checkmark</u></u></math></p> <p>(Reaction is) not feasible AND $\Delta G > 0 \checkmark$</p>	5	2.2×4 3.2×1	<p>ALLOW ECF IGNORE units at this stage</p> <p>Units for ΔG required</p> <p>ALLOW 26 kJ mol⁻¹ OR 26000 J mol⁻¹ up to calculator value.</p>

Question		Answer	Marks	AO element	Guidance
	(d)	<p>FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 2.22×10^4 award first 2 marks</p> <p>-----</p> $\ln K_p = -\Delta G/RT = \frac{2.48 \times 10^4}{8.314 \times 298} = 10.01 \checkmark$ $K_p = 2.22 \times 10^4 \text{ (3SF required)} \checkmark$ <p>Units = atm⁻² ✓</p>	3	<p>3.1×2</p> <p>1.2×1</p>	<p>ALLOW ECF for transcription errors in first sum</p> <p>ALLOW 10 up to calculator value of 10.00979992</p> <p>ALLOW 22200</p> <p>ALLOW 2.20×10^4 OR 22000 (use of 10)</p> <p>ALLOW alternatives (k)Pa⁻² OR N⁻² m⁴ OR mmHg⁻² OR PSI⁻² OR bar⁻²</p> <p>Common errors for 1 mark: 22400 (use of 8.31) 4.50×10^{-5} (use of -10.01)</p>
		Total	14		

Question		Answer	Marks	AO element	Guidance
18	(a)	<p>Equation: $\text{Mg} + 2\text{CH}_3\text{COOH} \rightarrow (\text{CH}_3\text{COO})_2\text{Mg} + \text{H}_2$ ✓</p> <p>Oxidation: Mg from 0 to +2 ✓</p> <p>Reduction: H from +1 to 0 ✓</p>	3	2.6 1.2 1.2	<p>ALLOW $\text{Mg}(\text{CH}_3\text{COO})_2$ ALLOW multiples IGNORE Oxidation numbers in formulae IGNORE state symbols</p> <p>Mark independently from equation</p> <p>ALLOW 1 mark for correct oxidation numbers but incorrectly linked to redox.</p>
	(b)	<p>$\text{HCOOH} + \text{CH}_3\text{COOH} \rightleftharpoons \text{HCOO}^- + \text{CH}_3\text{COOH}_2^+$ ✓</p> <p>A1 B2 B1 A2 OR A2 B1 B2 A1 ✓</p> <p>CARE: Both + and – charges required for products in equilibrium</p> <p>DO NOT AWARD the 2nd mark from an equilibrium expression that omits either charge</p>	2	1.2×2	<p>IGNORE state symbols (even if wrong)</p> <p>IF proton transfer is wrong way around ALLOW 2nd mark for idea of acid–base pairs, <i>i.e.</i> $\text{HCOOH} + \text{CH}_3\text{COOH} \rightleftharpoons \text{HCOOH}_2^+ + \text{CH}_3\text{COO}^-$ B2 A1 A2 B1</p> <p>NOTE For the 2nd marking point (acid–base pairs), this is the ONLY acceptable ECF <i>i.e.</i> NO ECF from impossible chemistry</p>
	(c)	(i)			
		<p>$[\text{H}^+] = 10^{-2.72}$ OR 1.905×10^{-3} (mol dm⁻³) ✓</p> <p>$[\text{CH}_3\text{COOH}] = \frac{(1.905 \times 10^{-3})^2}{1.78 \times 10^{-5}}$ ✓</p> <p>(= 0.204 mol dm⁻³)</p>	2	2.4×2	<p>ALLOW 2SF up to calculator value of $1.905460718 \times 10^{-3}$</p> <p>ALLOW use of [HA]</p> <p>Mark is for working.</p>

Question	Answer	Marks	AO element	Guidance
(ii)	<p>FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 2.4×10^{-2} (mol dm⁻³) award 4 marks</p> <hr/> <p>Calculation of H⁺ in buffer $[H^+]_{\text{buffer}} = 10^{-4.00}$ OR 1×10^{-4} (mol dm⁻³) ✓</p> <p>Calculation of CH₃COOH in buffer $n(\text{CH}_3\text{COOH})$ OR $[\text{CH}_3\text{COOH}]_{\text{buffer}}$ $= \frac{0.204}{1000} \times 400$ OR 8.16×10^{-2} ✓</p> <p>Calculation of [CH₃COO⁻] in buffer (in 1 dm³) $[\text{CH}_3\text{COO}^-]_{\text{buffer}} = 1.78 \times 10^{-5} \times \frac{8.16 \times 10^{-2}}{1 \times 10^{-4}}$ OR 1.5×10^{-2} (mol dm⁻³) ✓</p> <p>Calculation of original [CH₃COO⁻] (in 600 cm³) $[\text{CH}_3\text{COO}^-]_{\text{initial}} = \left(\frac{1.45248 \times 10^{-2} \times 1000}{600} \right)$ $= 2.4 \times 10^{-2}$ (mol dm⁻³) ✓</p>	4	3.3×3 3.4×1	<p>ALLOW ECF</p> <p>ALLOW [HA] and [A⁻] in working</p> <p>ALLOW 1.5×10^{-2} up to calculator value 1.45248×10^{-2} (mol dm⁻³)</p> <p>ALLOW 2.4×10^{-2} up to calculator value 2.4208×10^{-2} (mol dm⁻³)</p> <p>COMMON ERRORS BUT CHECK WORKING $[\text{CH}_3\text{COO}^-]_{\text{initial}} = 8.7 \times 10^{-3}$ 3 marks <i>600 and 1000 inverted</i> $[\text{CH}_3\text{COO}^-]_{\text{initial}} = 3.6 \times 10^{-6}$ 3 marks <i>[CH₃COOH] : [H⁺] inverted</i> $[\text{CH}_3\text{COO}^-]_{\text{initial}} = 1.3 \times 10^{-6}$ 2 marks <i>[CH₃COOH] : [H⁺] inverted</i> <i>AND 600 and 1000 inverted</i> No volumes used = 3.6×10^{-2} 2 marks</p>

Question	Answer	Marks	AO element	Guidance
	<p>ALLOW alternative approach based on Henderson–Hasselbalch equation (ALLOW $-\log K_a$ for pK_a) e.g.</p> $\text{pH} = \text{p}K_a + \log \frac{[\text{CH}_3\text{COOH}]}{[\text{CH}_3\text{COO}^-]} \quad \text{OR} \quad \text{p}K_a - \log \frac{[\text{CH}_3\text{COO}^-]}{[\text{CH}_3\text{COOH}]} \quad \text{OR}$ $4 = 4.75 + \log \frac{8.16 \times 10^{-2}}{[\text{CH}_3\text{COO}^-]} \quad \text{OR} \quad 4.75 - \log \frac{[\text{CH}_3\text{COO}^-]}{8.16 \times 10^{-2}} \quad \checkmark$ $\log[\text{CH}_3\text{COO}^-] = 4 - 4.75 - 1.09 = -1.84 \quad \checkmark$ $[\text{CH}_3\text{COO}^-]_{\text{buffer}} = 1.5 \times 10^{-2} \quad \checkmark$ $[\text{CH}_3\text{COO}^-]_{\text{initial}} = 2.4 \times 10^{-2} \quad \checkmark$			<p>ALLOW $-\log K_a$ for pK_a</p> <hr style="border-top: 1px dashed black;"/>
	Total	12		

Question		Answer	Marks	AO element	Guidance
19	(a)	<p>Circuit Complete circuit AND voltmeter AND salt bridge linking two half-cells ✓</p> <p>Half cells Ag AND Ag⁺ AND 1 mol dm⁻³ solution ✓</p> <p>Pt AND H⁺ AND MnO₄⁻ AND Mn²⁺ AND 1 mol dm⁻³ /equimolar solution ✓</p>	3	<p>3.4 × 1</p> <p>1.2 × 1</p> <p>1.2 × 1</p>	<p>Voltmeter must be shown AND salt bridge must be labelled ALLOW small gaps in circuit</p> <p>If species in BOTH half cells are correct but concentration of 1 mol dm⁻³ omitted, ALLOW 1 mark for BOTH half cells.</p> <p>ALLOW acidified as an alternative for H⁺</p> <p>IGNORE stated pressure <i>Not relevant here as no gas</i></p>
	(b)	<p>Comparison of E values <i>E</i> of redox system 4 (MnO₄⁻/Mn²⁺) is more positive/less negative than <i>E</i> of redox systems 2 (HCOOH/HCHO) OR 1 (CO₂/HCOOH) ✓</p> <p>Equilibrium shift related to E values More negative/less positive/system 2 (HCOOH/HCHO) OR system 1 (CO₂/HCOOH) shifts left OR Less negative/more positive/system 4 (MnO₄⁻/Mn²⁺) shifts right ✓</p> <p>• 2 and 4 2MnO₄⁻ + 5HCHO + 6H⁺ → 2Mn²⁺ + 5HCOOH + 3H₂O ✓</p> <p>• 1 and 4 2MnO₄⁻ + 5HCOOH + 6H⁺ → 2Mn²⁺ + 5CO₂ + 8H₂O ✓</p>	4	<p>3.1 × 2</p> <p>3.2 × 2</p>	<p>IGNORE higher/lower</p> <p>ALLOW Overall E_{reaction} = (+)1.54V OR (+)1.62V</p> <p>For 'shifts left', ALLOW 'is oxidised' OR 'electrons are lost' OR 'reducing agent'</p> <p>For 'shifts right', ALLOW 'is reduced' OR 'electrons are gained' OR 'oxidising agent'</p> <p>IGNORE state symbols ALLOW multiples DO NOT ALLOW un-cancelled species, e.g. H⁺, on both sides ALLOW for 1 mark two balanced equations with uncancelled species. ALLOW combined equation for 2 marks: 4MnO₄⁻ + 5HCHO + 12H⁺ → 4Mn²⁺ + 5CO₂ + 11H₂O</p>

Question		Answer	Marks	AO element	Guidance
	(c)	$2\text{H}^+ + \frac{1}{2}\text{O}_2 + 2\text{e}^- \rightarrow \text{H}_2\text{O} \checkmark$ $1.34 + (-0.11) = (+)1.23 \text{ (V)} \checkmark$	2	2.6 2.2×1	IGNORE state symbols ALLOW multiples
		Total	9		

Question			Answer	Marks	AO element	Guidance
20	(a)	(i)	To keep [CH ₃ OH] (effectively) constant OR Zero order with respect to CH ₃ OH OR To ensure equilibrium is far to the right ✓	1	3.3	ALLOW Change in [CH ₃ OH] is negligible ALLOW rate is independent of [CH ₃ OH] IGNORE Methanol doesn't run out/is not limiting reagent.
		(ii)	One half-life $t_{1/2}$ between 102 and 110 (mins) Two half-lives calculated OR evidence on the graph of two half-lives AND constant half-life/values (means first order) ✓	2	3.1 3.2	ALLOW any two combinations of positions, e.g. 5 and 2.5 AND 4 and 2 AND 3 and 1.5
		(iii)	Using gradients Evidence of tangent at $t = 0$ and intercept between 100 -140 (min) ✓ Correctly calculated gradient in the range of 2.9×10^{-5} to 4.0×10^{-5} (mol dm ⁻³ min ⁻¹) ✓ OR Using half-life $For t_{1/2} = 106 \text{ min}, k = \frac{\ln 2}{t_{1/2}} = 0.00654 \text{ (min}^{-1}\text{)} \checkmark$ rate = $0.00654 \times 5 \times 10^{-3}$ = 3.27×10^{-5} (mol dm ⁻³ min ⁻¹) ✓	2	3.1×1 3.2×1	ALLOW ECF from value of $t_{1/2}$ in (a)(ii)

Question	Answer	Marks	AO element	Guidance
(b)	<p>FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 7.4 award 4 marks</p> <p>-----</p> <p>Initial moles of reactants 1 mark</p> <p>$n(\text{CH}_3\text{OH})_{\text{initial}} = \frac{9.6}{32} = 0.3 \text{ (mol)}$</p> <p>AND</p> <p>$n(\text{CH}_3\text{COOH})_{\text{initial}} = \frac{12}{60} = 0.2 \text{ (mol)} \checkmark$</p> <p>Equilibrium moles 2 marks</p> <p>$n(\text{CH}_3\text{COOH})_{\text{reacted}} = 0.2 - 0.03 = 0.17 \text{ (mol)}$</p> <p>AND</p> <p>$n(\text{CH}_3\text{OH})_{\text{equil}} = 0.3 - 0.17 = 0.13 \text{ (mol)} \checkmark$</p> <p>$n(\text{CH}_3\text{COOCH}_3)_{\text{equil}} = 0.17 \text{ (mol)}$</p> <p>AND</p> <p>$n(\text{H}_2\text{O})_{\text{equil}} = 0.17 \text{ (mol)} \checkmark$</p> <p>K_c calculation 1 mark</p> <p>$K_c = \frac{0.17/V \times 0.17/V}{0.13/V \times 0.03/V} = 7.4 \checkmark$</p>	4	1.2×1 2.8×3	<p>ALLOW minimum of 2SF throughout</p> <p>ALLOW ECF from initial moles</p> <p>ALLOW ECF from equilibrium moles Use of V not required but K_c expression must be correct</p> <p>ALLOW up to calculator answer of 7.41025641</p>
	Total	9		

Question		Answer	Marks	AO element	Guidance
21	(a)	<p>Interpretation of Results Orange contains bromine AND no reaction AND violet contains iodine ✓</p> <p>Ionic equation $\text{Br}_2 + 2\text{I}^- \rightarrow 2\text{Br}^- + \text{I}_2$ ✓</p> <p>Reactivity (down the group) Reactivity decreases AND oxidising power decreases OR gains electrons less easily OR forms negative ion/1- ion less easily OR less energy released when electron gained ✓ OR more negative electron affinity</p> <p>Size/shells/shielding (down the group) Greater atomic radius OR more shells OR more shielding ✓</p> <p>Attraction (down the group) Less nuclear attraction down the group ✓</p>	5	<p>2.3×1</p> <p>2.6×1</p> <p>1.1×3</p>	<p>Results can be interpreted anywhere in answer.</p> <p>ALLOW multiples, e.g. $\frac{1}{2}\text{Br}_2 + \text{I}^- \rightarrow \text{Br}^- + \frac{1}{2}\text{I}_2$ IGNORE other halogen/halide equations</p> <p>IGNORE state symbols</p> <p>ALLOW ORA</p> <p>DO NOT ALLOW idea of losing electrons/ionisation energy</p> <p>IGNORE chlorine is the most electronegative</p> <p>IGNORE explanations in terms of displacement</p>

Question		Answer	Marks	AO element	Guidance
	(b)	<p><i>Benefit AND risk required for ONE mark</i></p> <p>Benefit: kills bacteria ✓ AND Risk: toxic/poisonous OR forms chlorinated hydrocarbons OR forms carcinogens/toxic compounds ✓</p>	1	1.1	<p>ALLOW kills micro-organisms OR kills pathogens OR kills viruses OR sterilises/disinfects water</p> <p>IGNORE antiseptic, reduces risk of disease, cleans water</p> <p>IGNORE 'harmful'/'dangerous'</p> <p>IGNORE chlorine is carcinogenic/ dangerous for health/causes breathing problems</p>
	(c)	$n(\mathbf{A}) = \frac{0.209}{29} = 0.00721 \text{ (mol) } \checkmark$ $M_r = \frac{1.26}{0.00721} = 174.8 \checkmark$ <p>Molecular formula = BrF₅ ✓ Formula is dependent on M_r</p>	3	<p>2.2×2</p> <p>3.2</p>	<p>ALLOW ECF</p> <p>ALLOW 2SF 0.0072 up to calculator value 0.0072068965517</p> <p>ALLOW 175 up to calculator value 174.8325359</p> <p>ALLOW F₅Br</p> <p>ALLOW ECF that matches calculated M_r</p>
Total			9		

Question		Answer	Marks	AO element	Guidance
22	(a)* (i)	<p><i>Refer to marking instructions on page 5 of mark scheme for guidance on marking this question.</i></p> <p>Level 3 (5–6 marks) All three tests are covered in detail, with at least six of B to H identified correctly and equations mostly correct.</p> <p><i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i></p> <p>Level 2 (3–4 marks) All three tests are covered with at least four of B to H identified correctly. Some attempt at writing equations, but with several omissions or incorrect formulae.</p> <p><i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i></p> <p>Level 1 (1–2 marks) Only two tests covered with at least two of B to H identified correctly, and little attempt at writing equations.</p> <p><i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i></p> <p>0 marks <i>No response or no response worthy of credit.</i></p>	6	3.3×3 3.4×3	<p>Indicative scientific points may include:</p> <p>Identification of unknowns Can be identified within labelled equation. B is FeSO₄ OR Iron(II) sulfate</p> <ul style="list-style-type: none"> • Test 1: Fe²⁺ present • Test 2: SO₄²⁻ present <p>D is Fe(OH)₂ OR [Fe(H₂O)₄(OH)₂] OR iron(II) hydroxide G is BaSO₄ OR barium sulfate</p> <p>C is CrCl₃ OR chromium(III) chloride</p> <ul style="list-style-type: none"> • Test 1: Cr³⁺ present • Test 3: Cl⁻ present <p>E is Cr(OH)₃ OR [Cr(H₂O)₃(OH)₃] OR chromium(III) hydroxide F is [Cr(NH₃)₆]³⁺ H is silver chloride OR AgCl</p> <p>Equations</p> <p>D: [Fe(H₂O)₆]²⁺ + 2OH⁻ → Fe(OH)₂ + 6H₂O OR Fe²⁺ + 2OH⁻ → Fe(OH)₂ OR [Fe(H₂O)₆]²⁺ + 2OH⁻ → [Fe(H₂O)₄(OH)₂] + 2H₂O OR [Fe(H₂O)₆]²⁺ + 2NH₃ → [Fe(H₂O)₄(OH)₂] + 2NH₄⁺ OR [Fe(H₂O)₆]²⁺ + 2NH₃ → Fe(OH)₂ + 4H₂O + 2NH₄⁺</p> <p>E: [Cr(H₂O)₆]³⁺ + 3OH⁻ → Cr(OH)₃ + 6H₂O OR Cr³⁺ + 3OH⁻ → Cr(OH)₃ OR [Cr(H₂O)₆]³⁺ + 3OH⁻ → [Cr(H₂O)₃(OH)₃] + 3H₂O OR [Cr(H₂O)₆]³⁺ + 3NH₃ → [Cr(H₂O)₃(OH)₃] + 3NH₄⁺ OR</p>

Question			Answer	Marks	AO element	Guidance
						$[\text{Cr}(\text{H}_2\text{O})_6]^{3+} + 3\text{NH}_3 \rightarrow \text{Cr}(\text{OH})_3 + 3\text{H}_2\text{O} + 3\text{NH}_4^+$ F: $[\text{Cr}(\text{H}_2\text{O})_6]^{3+} + 6\text{NH}_3 \rightarrow [\text{Cr}(\text{NH}_3)_6]^{3+} + 6\text{H}_2\text{O}$ OR $\text{Cr}(\text{OH})_3 + 6\text{NH}_3 \rightarrow [\text{Cr}(\text{NH}_3)_6]^{3+} + 3\text{OH}^-$ OR $[\text{Cr}(\text{H}_2\text{O})_3(\text{OH})_3] + 6\text{NH}_3 \rightarrow [\text{Cr}(\text{NH}_3)_6]^{3+} + 3\text{H}_2\text{O} + 3\text{OH}^-$ G: $\text{Ba}^{2+} + \text{SO}_4^{2-} \rightarrow \text{BaSO}_4$ H: $\text{Ag}^+ + \text{Cl}^- \rightarrow \text{AgCl}$

Question		Answer	Marks	AO element	Guidance
	(b) (i)	$\text{Ni} : \text{S} : \text{N} = \frac{16.26}{58.7} : \frac{35.36}{32.1} : \frac{31.0}{14}$ OR 0.277 : 1.10 : 2.21 OR 1 : 4 : 8 ✓ x = 4 ✓ 2 + x + y = 8 y = 2 ✓	3	3.1×1 3.2×2	ALLOW any correct method ALLOW NiS ₄ N ₈ for ratio ALLOW ECF for y from incorrect x
	(ii)	+2 ✓	1	2.1	+ required ALLOW 2+
	(c)	$n(\text{MnO}_4^-) \text{ in titration}$ $= 0.01 \times \frac{12.6}{1000} = 1.26 \times 10^{-4} \checkmark$ $n(\text{SO}_3^{2-}) \text{ in } 25.0 \text{ cm}^3$ $= 1.26 \times 10^{-4} \times 2.5 = 3.15 \times 10^{-4} \text{ (mol)} \checkmark$ $n(\text{SO}_3^{2-}) \text{ in } 250 \text{ cm}^3$ $= 10 \times 3.15 \times 10^{-4} = 3.15 \times 10^{-3} \text{ (mol)} \checkmark$ mass Na ₂ SO ₃ in 525 g meat $= 3.15 \times 10^{-3} \times 126.1 = 0.397 \text{ (g)} \checkmark$ mass Na ₂ SO ₃ in 1 kg of meat $= 0.397215 \times \frac{1000}{525} = 0.7566 \text{ g OR } 756.6 \text{ mg}$ AND less than the maximum permitted level OR AW ✓	5	1.2×1 2.8×3 3.2×1	ALLOW 3 SF or more throughout ALLOW ECF throughout Calculator = 0.397215 g ALLOW within range: 756 to 757 mg ALLOW 0.397 g < 0.446 g per 525 g meat.
		Total	15		

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