



GCE

Chemistry A

Unit **H032/01**: Breadth in chemistry

Advanced Subsidiary GCE

Mark Scheme for June 2016

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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 available in RM Assessor

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

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

Annotation	Meaning
/, OR	alternative and acceptable answers for the same marking point
✓	Separates marking points
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	B	1		
2	C	1		
3	D	1		
4	A	1		
5	C	1		ALLOW +5 OR 5+ in box
6	C	1		ALLOW 8 in box
7	B	1		
8	D	1		
9	C	1		
10	B	1		
11	D	1		
12	B	1		
13	B	1		
14	C	1		
15	B	1		
16	D	1		
17	D	1		
18	B	1		
19	B	1		
20	D	1		
	Total	20		

SECTION B

Question			Answer	Marks	AO element	Guidance
21	(a)	(i)	<p>Similarities: (Same) number of protons AND electrons ✓</p> <p>Differences: (Different) number of neutrons ✓</p>	2	AO1.1 x2	<p>ALLOW same electron configuration</p> <p>ALLOW 'amount' for 'number'</p> <p>IGNORE different masses/mass numbers (Question asks for atomic structures)</p>
	(b)	(i)	<p>FIRST CHECK ANSWER ON THE ANSWER LINE If answer = 63.62 award 2 marks</p> <p>-----</p> <p>$\frac{(63 \times 69.17) + (65 \times 30.83)}{100}$</p> <p>OR 63.6166 OR 63.617 ✓</p> <p>= 63.62 (to 2 DP) ✓</p> <p>IGNORE any units with A_r</p>	2	AO1.2 x2	<p>ALLOW ECF for a correct calculation to 2 DP if:</p> <ul style="list-style-type: none"> %s have been used with wrong isotopes i.e. $\frac{(63 \times 30.83) + (65 \times 69.17)}{100} \rightarrow \mathbf{64.38}$ <p>OR</p> <ul style="list-style-type: none"> decimal places for ONE % have been transposed, i.e. 69.71 \rightarrow 63.96; 30.38 \rightarrow 63.32

Question		Answer	Marks	AO element	Guidance
(b)	(ii)	<p>FIRST CHECK ANSWER ON THE ANSWER LINE If answer = 3.97×10^{22} (from 63.62) award 2 marks If answer = 3.98×10^{22} (from 63.5) award 2 marks</p> <p>-----</p> <p>Using 63.62: correct A_r of Cu from 21(b)(i) See bottom of answer zone</p> $n(\text{Cu}) = \frac{5.00 \times 0.840}{63.62} = \frac{4.2}{63.62} = 0.066(0) \text{ (mol)} \checkmark$ <p>Cu atoms = $0.0660 \times 6.02 \times 10^{23} = 3.97 \times 10^{22} \checkmark$ <i>Must be calculated in standard form AND to 3 SF</i></p> <p>OR-----</p> <p>Using 63.5: A_r of Cu from periodic table</p> $n(\text{Cu}) = \frac{5.00 \times 0.840}{63.5} = \frac{4.2}{63.5} = 0.0661 \text{ (mol)} \checkmark$ <p>Cu atoms = $0.0661 \times 6.02 \times 10^{23} = 3.98 \times 10^{22} \checkmark$ <i>Must be calculated in standard form AND to 3 SF</i></p>	2	AO2.2 x2	<p>If there is an alternative answer, check to see if there is any ECF credit possible SEE answer from 21b(i) at bottom of answer zone</p> <p>ALLOW correct answer from 3 SF up to calculator value of 0.06601697579</p> <p>ALLOW incorrect $n(\text{Cu}) \times 6.02 \times 10^{23}$ correctly calculated to 3 SF AND in standard form For ECF, A_r must have been used for $n(\text{Cu})$</p> <p>-----</p> <p>ALLOW correct answer from 3 SF up to calculator value of 0.06614173228</p> <p>ALLOW incorrect $n(\text{Cu}) \times 6.02 \times 10^{23}$ correctly calculated to 3 SF AND in standard form For ECF, A_r must have been used for $n(\text{Cu})$</p> <p>-----</p> <p>Common errors Using 63.62: 3.984×10^{22} 1 mark (SF) 4.73×10^{22} 1 mark (ECF: omitting 0.840) Using 63.5: 3.982×10^{22} 1 mark (SF) 4.74×10^{22} 1 mark (ECF: omitting 0.840)</p>
(c)	(i)	$\text{NiO} + 2\text{HNO}_3 \rightarrow \text{Ni}(\text{NO}_3)_2 + \text{H}_2\text{O} \checkmark$	1	AO1.2	<p>ALLOW multiples</p> <p>IGNORE state symbols (even if wrong)</p>

Question		Answer	Marks	AO element	Guidance	
22	(a)	<p>Initial ratios Cr, $\frac{19.51}{52.0}$; Cl, $\frac{39.96}{35.5}$; H, $\frac{4.51}{1.0}$; O, $\frac{36.02}{16.0}$</p> <p>OR Cr, 0.375; Cl, 1.126; H, 4.51; O, 2.25 ✓</p> <p>Whole number ratios Cr, 1; Cl, 3; H, 12; O, 6 ✓</p> <p>Formula with water of crystallisation $\text{CrCl}_3 \cdot 6\text{H}_2\text{O}$ ✓</p>	3	AO1.2 AO1.2 AO2.2	<p>NOTE: If only the correct answer of $\text{CrCl}_3 \cdot 6\text{H}_2\text{O}$ is seen with no working, award 1 mark only</p> <p>IF there is no whole number ratio, ALLOW empirical formula: $\text{CrCl}_3\text{H}_{12}\text{O}_6$</p> <p>ALLOW ECF from incorrect whole number ratio, provided ONLY Cl incorrect AND $6\text{H}_2\text{O}$, e.g. $\text{CrCl}_2 \cdot 6\text{H}_2\text{O}$</p>	
	(b)	(i)	$\frac{2 \times 0.005}{0.58} \times 100 = 1.72\% \checkmark$	1	AO2.8	ALLOW 2% OR 1.7% up to calculator value of 1.724137931
	(b)	(ii)	<p>Use balance weighing to 3/more decimal places</p> <p>OR</p> <p>Use a larger mass/amount <input type="checkbox"/> ✓</p>	1	AO3.3	<p>ALLOW more precise/more accurate/ more sensitive/higher resolution/smaller division</p> <p>IGNORE 'less error/smaller interval balance'</p> <p>IGNORE any reference to lid on crucible (<i>water can't escape</i>)</p> <p>IGNORE 'weigh straight after heating'</p> <p>IGNORE idea of repeating the experiment/ taking an average/ getting concordant results /larger sample size, etc.</p>

Question		Answer	Marks	AO element	Guidance
(b)	(iii)	Heat to constant mass ✓	1	AO3.4	ALLOW response that implies heating to constant mass, e.g. Heat again until the mass does not change IGNORE 'heat for longer' <i>Needs link to constant mass</i>
(c)		<p>FIRST CHECK ANSWER ON THE ANSWER LINE If answer = 24.8 (cm³) award 3 marks</p> <p>-----</p> $n(\text{NaOH}) = 0.124 \times \frac{25.0}{1000} = 3.1(0) \times 10^{-3} \text{ (mol) } \checkmark$ $n(\text{H}_2\text{SO}_4) = \frac{3.10 \times 10^{-3}}{2} = 1.55 \times 10^{-3} \text{ (mol) } \checkmark$ $V(\text{H}_2\text{SO}_4) = 1.55 \times 10^{-3} \times \frac{1000}{6.25 \times 10^{-2}} = 24.8 \text{ (cm}^3\text{) } \checkmark$	3	AO2.8 x3	<p>ALLOW ECF from $\frac{n(\text{NaOH})}{2}$</p> <p>ALLOW ECF from $n(\text{H}_2\text{SO}_4) \times \frac{1000}{6.25 \times 10^{-2}}$</p>
(d)		<p>Element oxidised: aluminium/Al 0 to +3 ✓</p> <p>Element reduced: hydrogen/H/H⁺ +1 to 0 ✓</p>	2	AO1.1 AO1.2	<p>MAX 1 mark if no '+' sign for oxidation number</p> <p>ALLOW 3+</p> <p>ALLOW 1+</p> <p>ALLOW H₂ for hydrogen</p> <p>ALLOW 1 mark for all oxidation numbers correct, but oxidised and reduced the wrong way around</p> <p>IGNORE numbers around equation <i>i.e. treat as rough working</i></p>
		Total	14		

Question			Answer	Marks	AO element	Guidance
23	(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	AO1.1	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 $1s^2 2s^2 2p^6 3s^2 3p^6$
	(a)	(ii)	$Cl_2 + 2Br^- \rightarrow 2Cl^- + Br_2$ ✓ Chlorine/Cl/Cl ₂ is more reactive/stronger oxidising agent OR reactivity decreases down group ✓	2	AO1.1 AO1.1	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
	(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	AO1.1	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

Question		Answer	Marks	AO element	Guidance
	(c) (i)	Silver nitrate OR AgNO ₃ ✓	1	AO1.1	ALLOW Ag ⁺ IF name correct, IGNORE an incorrect formula IGNORE acidified/HNO ₃
	(c) (ii)	Chloride: white (precipitate) AND Bromide: cream (precipitate) AND iodide: yellow (precipitate) ✓	1	AO1.1	All three required for the mark
		Total	6		

Question		Answer	Marks	AO element	Guidance
24	(a)	<p>FIRST, CHECK THE ANSWER ON ANSWER LINE IF $\Delta_r H = -58.5$ (kJ mol⁻¹) award 4 marks</p> <p>-----</p> <p>Energy released in J OR kJ</p> <p>$= 100.0 \times 4.18 \times 10.5 = 4389$ (J) OR 4.389 (kJ) ✓</p> <p>Correctly calculates $n(\text{Pb}(\text{NO}_3)_2)$ $= 1.50 \times \frac{50}{1000} = 0.075(0)$ (mol) ✓</p> <p>ΔH value in J OR kJ Answer <i>MUST</i> divide energy by $n(\text{Pb}(\text{NO}_3)_2)$ $(-)\frac{4389}{0.0750}$ OR $(-)$58520 (J)</p> <p>OR $(-)\frac{4.389}{0.0750}$ OR $(-)$58.52 (kJ) ✓ <i>(Sign ignored and/or more than 3 SF)</i></p> <p>Correct $\Delta_r H$ in kJ AND – sign AND 3 SF $= -58.5$ (kJ mol⁻¹) ✓</p>	4		<p>FULL ANNOTATIONS MUST BE USED</p> <p>-----</p> <p>AO2.4 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></p> <p>AO2.4</p> <p>ALLOW ECF from $n(\text{Pb}(\text{NO}_3)_2)$ AND/OR Energy ALLOW 58500 (from 4390)</p> <p>AO2.8 IGNORE absence of – sign and 3 SF requirement</p> <p>AO2.8 Final mark requires – sign, kJ AND 3 SF Note: From 4390 J, $\Delta_r H = -58.5$ (kJ mol⁻¹) (SAME)</p> <p>-----</p> <p>Common error –29.3 3 marks (50 g instead of 100 g in $mc\Delta T$)</p>

Question		Answer	Marks	AO element	Guidance
	(b)	$\text{Pb}^{2+}(\text{aq}) + 2\text{I}^{-}(\text{aq}) \rightarrow \text{PbI}_2(\text{s}) \checkmark$ <p>State symbols required</p>	1	AO2.7	<p>ALLOW $\text{Pb}^{+2}(\text{aq})$</p> <p>IGNORE spectator ions, $\text{K}^{+}(\text{aq})$ and $2\text{NO}_3^{-}(\text{aq})$ on both sides</p>
	(c)	<p>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</p> <p>-----</p> <p>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 $3 \times 1.1 = 3.3(0) \checkmark$</p> <p>OR-----</p> <p>Method 2 $n(\text{KI}(\text{aq}))$ required = $2.2 \times 0.0750 = 0.165 \text{ mol} \checkmark$ $[\text{KI}(\text{aq})] = 0.165 \times \frac{1000}{50} = 3.3(0) \text{ (mol dm}^{-3}\text{)} \checkmark$</p>	2	AO2.8 x2	<p>ALLOW ECF from incorrect $n(\text{Pb}(\text{NO}_3)_2)$ from 24(a) BUT if (a) is incorrect but 0.0750 used here, treat as a fresh start and IGNORE response from 24(a)</p> <p>ALLOW 2 marks for 3.3/3.3 recurring <i>Attempt at increasing concentration by 10%</i> $= 2 \times 0.0750 = 0.150 \text{ mol} \times \frac{1000}{45} = 3.33 \text{ (mol dm}^{-3}\text{)}$</p> <p>ALLOW ECF from incorrect $n(\text{KI})$</p> <p>-----</p> <p>Common errors</p> <p>3 1 mark (Correct for KI with no extra 10%) 1.65 1 mark (no factor of 2 used for KI) 2.7 1 mark (10% less rather than 10% more) 2.73/2.72 1 mark (10% increase in volume: 55 cm³)</p>
		Total	7		

Question		Answer	Marks	AO element	Guidance
25	(a)	<p>EQUILIBRIUM CONDITIONS 3 MAX 4 marking points → 3 max ✓✓✓ <i>Mark first three CORRECT responses seen</i></p> <p>Temperature: (Forward) reaction is exothermic/ΔH is negative OR (Forward) reaction gives out heat ✓</p> <p>Pressure: Right-hand side has fewer (gaseous) moles OR 3 (gaseous) moles form 2 (gaseous) moles ✓</p> <p>Equilibrium shift Correct equilibrium shift in terms of temperature ✓ Correct equilibrium shift in terms of pressure ✓</p> <p>-----</p> <p>INDUSTRIAL CONDITIONS Low temperature gives a slow rate/slower reaction OR high temperatures needed to increase rate ✓□</p> <p>(High) pressure provides a safety risk OR (High) pressure is expensive (to generate) /uses a lot of energy ✓□</p>	5	<p>AO3.1 x2</p> <p>AO3.2 x1</p> <p>-----</p> <p>AO1.2 x2</p>	<p>FULL ANNOTATIONS MUST BE USED -----</p> <p>ALLOW suitable alternatives for 'towards right', e.g.: towards SO_3/products OR in forward direction OR 'favours the right'</p> <p>ALLOW reverse reaction is endothermic /ΔH is positive/takes in heat</p> <p>For moles, ALLOW molecules/particles</p> <p>ORA for reverse reaction</p> <p>IGNORE responses in terms of activation energy</p> <p>ALLOW high pressure is dangerous/explosive</p> <p>ALLOW 'These conditions are expensive' Statement subsumes pressure as 'these' will apply to pressure (required for this mark) and temperature</p> <p>ALLOW ORA e.g. Lower pressure → less danger/uses less energy</p> <p>IGNORE 'It's expensive' Link with pressure required</p>

Question		Answer	Marks	AO element	Guidance
	(b)	<p>Value of K_c 1 mark K_c is small OR $K_c < 1$ AND equilibrium (position) is towards left ✓</p>	4		<p>FULL ANNOTATIONS MUST BE USED ----- ALLOW suitable alternatives for ‘towards left, e.g.: towards SO_2/O_2 OR towards reactants OR in reverse direction OR ‘favours the left</p>
		<p>Calculation: FIRST CHECK ANSWER IF $[\text{SO}_3] = 0.876$ OR 0.88 (mol dm^{-3}) award all 3 marks available for calculation -----</p> <p>K_c expression 1 mark $\frac{[\text{SO}_3]^2}{[\text{SO}_2]^2[\text{O}_2]}$ OR $\frac{[\text{SO}_3]^2}{2.00^2 \times 1.20}$ ✓</p> <p>Evaluation of K_c $[\text{SO}_2]^2[\text{O}_2]$ 1 mark $K_c [\text{SO}_2]^2[\text{O}_2] = 0.160 \times 2.00^2 \times 1.20$ $= 0.768$ ✓</p> <p>Calculation of $[\text{SO}_3]$ ONLY available from correct evaluation for 2nd mark $[\text{SO}_3] = \sqrt{0.160 \times 2.00^2 \times 1.20}$ $= 0.876$ (mol dm^{-3}) ✓</p>		<p>AO1.2 Square brackets required in K_c expression ALLOW ECF from $\frac{[\text{SO}_3]}{[\text{SO}_2]^2[\text{O}_2]}$, i.e. no $[\text{SO}_3]^2$</p> <p>AO2.6 ALLOW 0.77 (2 SF)</p> <p>AO2.6 ALLOW 0.88 (2 SF) up to calculator value of 0.876356092 correctly rounded</p> <p>AO2.6 IF K_c expression is inverted 2nd and 3rd marks are available by ECF: $[\text{SO}_3]^2 = \frac{2.00^2 \times 1.20}{0.160}$ OR 30 ✓ $[\text{SO}_3] = \sqrt{30} = 5.48$ OR 5.5 ✓</p> <p>Any other K_c expression → NO MARKS, e.g. $\frac{[\text{SO}_3]^2}{[\text{SO}_2]^2 + [\text{O}_2]}$ → $\sqrt{0.832}$ → 0.912 NO marks</p>	
		Total	9		

Question		Answer	Marks	AO element	Guidance
(c)	(ii)	Compound E: $\begin{array}{c} \text{H} \quad \text{CH}_3 \\ \quad \\ \text{Br}-\text{C}-\text{C}-\text{Br} \\ \quad \\ \text{H} \quad \text{CH}_3 \end{array} \quad \checkmark$ Stage 1: Compound E: Bromine/Br ₂ ✓ Stage 2: NaOH/KOH OR OH ⁻ ✓ <i>Only award if intermediate contains at least one halogen atom</i>	3		For structures: ALLOW correct structural OR skeletal OR displayed formula OR mixture of the above ALLOW dichloro/diiodo compound IGNORE connectivity of bonds to CH ₃ AO3.2 AO3.1 ALLOW chlorine/Cl ₂ OR iodine/I ₂ IGNORE conditions, e.g. u.v. AO3.1 DO NOT ALLOW H ₂ O IGNORE conditions NOTE: Max of 2 marks available for monobrominated intermediate 1 mark Reagent: HBr AND Intermediate: CH ₃ C(CH ₃) ₂ Br OR BrCH ₂ CH(CH ₃) ₂ 1 mark Intermediate: CH ₃ C(CH ₃) ₂ Br OR BrCH ₂ CH(CH ₃) ₂ AND Reagent: NaOH
Total			8		

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