Oxford Cambridge and RSA

GCE

Chemistry A

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

Advanced Subsidiary GCE

Mark Scheme for June 2016

This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

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.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

Annotations available in RM Assessor

Annotation	Meaning
✓	Correct response
✗	Incorrect response
^	Omission mark
BOD	Benefit of doubt given
CON	Contradiction
RE	Rounding error
SF	Error in number of significant figures
ECF	Error carried forward
L1	Level 1
L2	Level 2
L3	Level 3
NBOD	Benefit of doubt not given
SEEN	Noted but no credit given
I	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

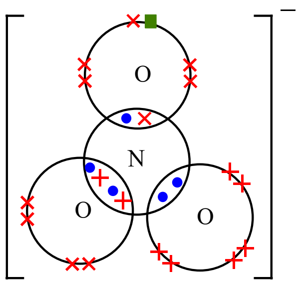
SECTION A

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)	**Similarities**: (Same) **number** of protons **AND** electrons ✓ **Differences**: (Different) **number** of neutrons ✓	**2**	AO1.1 ×2	**ALLOW** same electron configuration **ALLOW** 'amount' for 'number' **IGNORE** different masses/mass numbers (*Question asks for atomic structures*)
	(b)	(i)	**FIRST CHECK ANSWER ON THE ANSWER LINE** **If answer = 63.62 award 2 marks** **---** $\frac{(63 \times 69.17) + (65 \times 30.83)}{100}$ **OR** 63.6166 **OR** 63.617 ✓ = 63.62 (to 2 DP) ✓ ***IGNORE*** *any units with* A_r	**2**	AO1.2 ×2	**ALLOW ECF** for a correct calculation to 2 DP if: • %s have been used with wrong isotopes i.e. $\frac{(63 \times 30.83) + (65 \times 69.17)}{100}$ → **64.38** **OR** • decimal places for **ONE** % have been transposed, i.e. 69.71 → **63.96**; 30.38 → **63.32**

Question			Answer	Marks	AO element	Guidance
	(b)	(ii)	**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** --- **Using 63.62:** *correct A_r of Cu from 21(b)(i)* See bottom of answer zone $n(\text{Cu}) = \frac{5.00 \times 0.840}{63.62} = \frac{4.2}{63.62} = 0.066(0)$ (mol) ✓ Cu atoms = $0.0660 \times 6.02 \times 10^{23}$ = $\mathbf{3.97 \times 10^{22}}$ ✓ *Must be calculated in standard form **AND** to 3 SF* **OR**--- **Using 63.5:** *A_r of Cu from periodic table* $n(\text{Cu}) = \frac{5.00 \times 0.840}{63.5} = \frac{4.2}{63.5} = 0.0661$ (mol) ✓ Cu atoms = $0.0661 \times 6.02 \times 10^{23}$ = $\mathbf{3.98 \times 10^{22}}$ ✓ *Must be calculated in standard form **AND** to 3 SF*	2	AO2.2 ×2	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 **ALLOW** correct answer from 3 SF up to calculator value of 0.06601697579 **ALLOW** incorrect n(Cu) × 6.02×10^{23} correctly calculated to 3 SF **AND** in standard form *For **ECF**, A_r **must** have been used for n(Cu)* --- **ALLOW** correct answer from 3 SF up to calculator value of 0.06614173228 **ALLOW** incorrect n(Cu) × 6.02×10^{23} correctly calculated to 3 SF **AND** in standard form *For **ECF**, A_r **must** have been used for n(Cu)* **--** **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)
	(c)	(i)	$NiO + 2HNO_3 \rightarrow Ni(NO_3)_2 + H_2O$ ✓	1	AO1.2	**ALLOW** multiples **IGNORE** state symbols (even if wrong)

Question			Answer	Marks	AO element	Guidance
	(c)	(ii)	 **Global rules** • N and O electrons must be shown differently, e.g. • for N and × for O • 'Extra' electron shown with different symbol **MARKING** ***Bonding around central N atom*** ✓ • 5 electrons for N shown as • **OR** × • 3 electrons for O, different from N as • **OR** × • N=O bond with 2 N electrons **AND** 2 O electrons • N→O bond with 2 N electrons • N–O bond with 1 N electron **AND** 1 O electron ***Non-bonded (nb) electrons around 3 O atoms*** ✓ • N=O oxygen has 4 nb 'O' electrons • N→O oxygen has 6 nb 'O' electrons • N–O⁻ oxygen has 5 nb 'O' electrons **AND** 1 'extra' electron with different symbol	2	AO2.1 AO2.5	**NOT REQUIRED** • Charge ('–') • Brackets • Circles **IGNORE** inner shells **ALLOW** rotated diagram **ALLOW** diagram with missing N or O symbols. *Shown as diagram on QP anyway* In **N=O bond**, **ALLOW** sequence × × • • In **N–O bond**, **ALLOW** 'extra' electron with different symbol for O electron **ALLOW** non-bonding electrons unpaired If 'extra' electron has been used **in N–O⁻ bond**, N–O⁻ oxygen **MUST** have 6 nb 'O' electrons **ALLOW** 'extra' electron as • **OR** × if it has been **labelled** 'extra electron' or similar
			Total	9		

Question			Answer	Marks	AO element	Guidance
22	(a)		***Initial ratios*** Cr, $\frac{19.51}{52.0}$; Cl, $\frac{39.96}{35.5}$; H, $\frac{4.51}{1.0}$; O, $\frac{36.02}{16.0}$ **OR** Cr, 0.375; Cl,1.126; H,4.51; O, 2.25 ✓ ***Whole number ratios*** Cr, 1; Cl, 3; H, 12; O, 6 ✓ ***Formula with water of crystallisation*** $CrCl_3$•$6H_2O$ ✓	3	AO1.2 AO1.2 AO2.2	**NOTE**: If only the correct answer of $CrCl_3$•$6H_2O$ is seen with no working, award 1 mark only **IF** there is no whole number ratio, **ALLOW** empirical formula: $CrCl_3H_{12}O_6$ **ALLOW ECF** from incorrect whole number ratio, provided **ONLY Cl incorrect AND** $6H_2O$, e.g. $CrCl_2$•$6H_2O$
	(b)	(i)	$\frac{2 \times 0.005}{0.58} \times 100 = 1.72\%$ ✓	1	AO2.8	**ALLOW** 2% **OR** 1.7% up to calculator value of 1.724137931
	(b)	(ii)	Use balance weighing to 3/more decimal places **OR** Use a larger mass/amount □ ✓	1	AO3.3	**ALLOW** more precise/more accurate/ more sensitive/higher resolution/smaller division **IGNORE** 'less error/smaller interval balance' **IGNORE** any reference to lid on crucible (*water can't escape)* **IGNORE** 'weigh straight after heating' **IGNORE** idea of repeating the experiment/ taking an average/ getting concordant results /larger sample size, etc.

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' *Needs link to constant mass*
	(c)		**FIRST CHECK ANSWER ON THE ANSWER LINE** **If answer = 24.8 (cm^3) award 3 marks** --- $n(\text{NaOH}) = 0.124 \times \frac{25.0}{1000} = 3.1(0) \times 10^{-3}$ (mol) ✓ $n(H_2SO_4) = \frac{3.10 \times 10^{-3}}{2} = 1.55 \times 10^{-3}$ (mol) ✓ $V(H_2SO_4) = 1.55 \times 10^{-3} \times \frac{1000}{6.25 \times 10^{-2}} = 24.8$ (cm^3) ✓	3	AO2.8 ×3	**ALLOW ECF** from $\frac{n(\text{NaOH})}{2}$ **ALLOW ECF** from $n(H_2SO_4) \times \frac{1000}{6.25 \times 10^{-2}}$
	(d)		Element oxidised: aluminium/Al 0 to +3 ✓ Element reduced: hydrogen/H/H^+ +1 to 0 ✓	2	AO1.1 AO1.2	**MAX 1 mark** if no '+' sign for oxidation number **ALLOW** 3+ **ALLOW** 1+ **ALLOW** H_2 for hydrogen **ALLOW** 1 mark for all oxidation numbers correct, but oxidised and reduced the wrong way around **IGNORE** numbers around equation *i.e. treat as rough working*
			Total	**14**		

Question			Answer	Marks	AO element	Guidance
23	(a)	(i)	$1s^22s^22p^63s^23p^63d^{10}4s^24p^6$ ✓ Look carefully at $1s^22s^22p^63s^23p^6$ – there may be a mistake	1	AO1.1	**ALLOW** 3d after $4s^2$ or after $4p^6$, e.g. $1s^22s^22p^63s^23p^64s^23d^{10}4p^6$ **ALLOW** upper case D, etc and subscripts, e.g. ……$4S_23D_1$ **DO NOT ALLOW** [Ar] as shorthand for $1s^22s^22p^63s^23p^6$
	(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)		*Benefit **AND** risk required for mark* 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

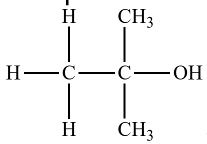
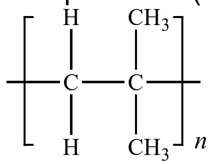
Question			Answer	Marks	AO element	Guidance
	(c)	(i)	Silver nitrate **OR** $AgNO_3$ ✓	1	AO1.1	**ALLOW** Ag^+ **IF** name correct, **IGNORE** an incorrect formula **IGNORE** acidified/HNO_3
	(c)	(ii)	Chloride: white (precipitate) **AND** Bromide: cream (precipitate) **AND** iodide: yellow (precipitate) ✓	1	AO1.1	All **three** required for the mark
			Total	**6**		

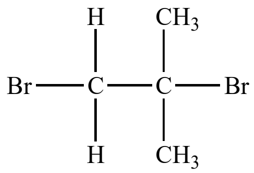
Question			Answer	Marks	AO element	Guidance
24	(a)		**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF $\Delta_r H$ = −58.5 (kJ mol^{-1}) award 4 marks** ----------------------------------- ***Energy released in J OR kJ*** = 100.0 × 4.18 × 10.5 = 4389 (J) **OR** 4.389 (kJ) ✓	4	AO2.4	***FULL ANNOTATIONS MUST BE USED*** ----------------------------------- **ALLOW** 4390 J; 4.39 kJ **DO NOT ALLOW** less than 3 SF **IGNORE** units *i.e.* ***ALLOW*** *correctly calculated number in J* ***OR*** *kJ*
			Correctly calculates n(Pb(NO$_3$)$_2$) $= 1.50 \times \frac{50}{1000}$ = 0.075(0) (mol) ✓		AO2.4	
			Δ*H* value in J OR kJ *Answer* ***MUST*** *divide energy by n(Pb(NO$_3$)$_2$)* $(–)\frac{4389}{0.0750}$ **OR** (–)58520 (J) **OR** $(–)\frac{4.389}{0.0750}$ **OR** (–)58.52 (kJ) ✓ *(Sign ignored and/or more than 3 SF)*		AO2.8	**ALLOW ECF** from *n*(Pb(NO$_3$)$_2$) **AND/OR** Energy **ALLOW** 58500 (from 4390) **IGNORE** absence of – sign and 3 SF requirement
			Correct $\Delta_r H$ in kJ **AND** – sign **AND** 3 SF = –58.5 (kJ mol^{-1}) ✓		AO2.8	Final mark requires – sign, kJ **AND** 3 SF **Note**: From 4390 J, $\Delta_r H$ = –58.5 (kJ mol^{-1}) (SAME) ----------------------------------- **Common error** –29.3 3 marks (50 g instead of 100 g in *mc*Δ*T*)

Question			Answer	Marks	AO element	Guidance
	(b)		$Pb^{2+}(aq) + 2I^{-}(aq) \rightarrow PbI_2(s)$ ✓ **State symbols required**	1	AO2.7	**ALLOW** $Pb^{+2}(aq)$ **IGNORE** spectator ions, $K^{+}(aq)$ and $2NO_3^{-}(aq)$ on both sides
	(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 $= 2 \times 0.0750 = 0.150 \text{ mol} \times \frac{1000}{50} = 3 \text{ (mol dm}^{-3}\text{)}$ ✓ 10% greater gives $3 \times 1.1 = 3.3(0)$ ✓ **OR**-- **Method 2** *n*(KI(aq)) required $= 2.2 \times 0.0750 = 0.165$ mol ✓ $[KI(aq)] = 0.165 \times \frac{1000}{50} = 3.3(0) \text{ (mol dm}^{-3}\text{)}$ ✓	2	AO2.8 ×2	**ALLOW ECF** from incorrect *n*($Pb(NO_3)_2$) 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 *Attempt at increasing concentration by 10%* $= 2 \times 0.0750 = 0.150 \text{ mol} \times \frac{1000}{45} = 3.33 \text{ (mol dm}^{-3}\text{)}$ **ALLOW ECF** from incorrect *n*(KI) -- **Common errors** 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 cm^3)
			Total	7		

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

Question			Answer	Marks	AO element	Guidance
	(b)		***Value of K_c*** ***1 mark*** K_c is small **OR** K_c < 1 **AND** equilibrium (position) is towards left ✓	4	AO3.2	***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
			Calculation: **FIRST CHECK ANSWER** **IF $[SO_3]$ = 0.876 *OR* 0.88 (mol dm^{-3})** **award all 3 marks available for calculation** --- **K_c expression** **1 mark** $\frac{[SO_3]^2}{[SO_2]^2[O_2]}$ **OR** $\frac{[SO_3]^2}{2.00^2 \times 1.20}$ ✓ **Evaluation of K_c $[SO_2]^2[O_2]$** **1 mark** K_c $[SO_2]^2[O_2]$ = 0.160 × 2.00^2 × 1.20 = 0.768 ✓ **Calculation of $[SO_3]$** ***ONLY*** *available from* ***correct*** *evaluation for 2nd mark* $[SO_3] = \sqrt{(0.160 \times 2.00^2 \times 1.20)}$ = 0.876 (mol dm^{-3}) ✓		AO1.2 AO2.6 AO2.6	Square brackets required in K_c expression **ALLOW ECF** from $\frac{\mathbf{[SO_3]}}{[SO_2]^2[O_2]}$, i.e. no $[SO_3]^2$ **ALLOW 0.77 (2 SF)** **ALLOW 0.88** (**2 SF**) up to calculator value of 0.876356092 correctly rounded **IF** K_c expression is inverted 2nd and 3rd marks are available by **ECF**: $[SO_3]^2 = \frac{2.00^2 \times 1.20}{0.160}$ **OR** 30 ✓ $[SO_3] = \sqrt{30}$ = 5.48 **OR** 5.5 ✓ Any other K_c expression → **NO MARKS,** e.g. $\frac{[SO_3]^2}{[SO_2]^2 + [O_2]} \rightarrow \sqrt{0.832} \rightarrow 0.912$ **NO** marks
			Total	**9**		

Question			Answer	Marks	AO element	Guidance
26	(a)	(i)	Alkene **AND** C_nH_{2n} ✓	1	AO1.1	**IGNORE** branched before alkene
	(a)	(ii)	Hydrogen/H_2 **AND** Ni (catalyst) ✓	1	AO1.2	**ALLOW** Pt **OR** Pd **OR** Rh **ALLOW** hydrogenation for hydrogen **IGNORE** any temperature and pressure stated
	(b)		Compound **C**:  ✓ **CARE**: Tertiary alcohol Compound **D**: (repeat unit)  ✓	2	AO2.5 AO2.5	**For structures:** **ALLOW** correct structural **OR** skeletal **OR** displayed formula **OR** mixture of the above -- ***Connectivity*** **IGNORE** connectivity of bonds to CH_3 e.g. **ALLOW** CH_3– **ALLOW any** vertical bond to OH, e.g. **ALLOW** OH | **OR** OH | **DO NOT ALLOW** OH– -- **DO NOT ALLOW** more than one repeat unit **REQUIRED:** Side links (dotted lines fine) **NOT REQUIRED:** Brackets and '*n*'
	(c)	(i)	C_2H_5O ✓	1	AO1.2	**ALLOW** elements in any order **DO NOT ALLOW** any other answer

Question			Answer	Marks	AO element	Guidance
	(c)	(ii)	Compound **E**:  ✓	3	AO3.2	**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
			Stage 1: Compound **E**: Bromine/Br_2 ✓		AO3.1	**ALLOW** chlorine/Cl_2 **OR** iodine/I_2 **IGNORE** conditions, e.g. u.v.
			Stage 2: NaOH/KOH **OR** OH^- ✓ *Only award if intermediate contains at least **one** halogen atom*		AO3.1	**DO NOT ALLOW** H_2O **IGNORE** conditions **NOTE:** Max of **2 marks** available for **monobrominated** intermediate **1 mark** Reagent: HBr **AND** Intermediate: $CH_3C(CH_3)_2Br$ **OR** $BrCH_2CH(CH_3)_2$ **1 mark** Intermediate: $CH_3C(CH_3)_2Br$ **OR** $BrCH_2CH(CH_3)_2$ **AND** Reagent: NaOH
			Total	8		

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