GCE

Chemistry A

H432/03: Unified chemistry

Advanced GCE

Mark Scheme for June 2019

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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.

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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
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

Subject-specific Marking Instructions

INTRODUCTION

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

Question			Answer	Marks	AO element	Guidance
1	(a)		**Polar bonds** F (atom) is more electronegative (than C atom) **OR** F is very/the most electronegative ✓ **No overall dipole** (CF_4 is) symmetrical **OR** tetrahedral **OR dipoles** cancel **OR dipoles** act in opposite directions ✓	**2**	AO1.1 ×2	**Mark independently** **ALLOW** C and F have **different** electronegativities **OR** the atoms have different electronegativities **……BUT** **DO NOT ALLOW** C is more electronegative **ALLOW** C–F shown with correct dipole, i.e. $C^{\delta+}–F^{\delta–}$. **IGNORE** square planar **IGNORE** polar **bonds** cancel **BUT ALLOW** polarities cancel **IGNORE** charges cancel
	(b)		(Molecules) contain • ^{2}H **OR** deuterium/D • ^{3}H **OR** tritium/T **OR** O/H atoms have more neutrons (than ^{1}H) **OR** (different) O/H isotopes are present **OR** (Molecules are) D_2O ✓	**1**	AO1.2	**ALLOW** Molecules contain ^{18}O Idea of **isotopes** is critical **……..BUT** **DO NOT ALLOW** isotopes of elements different from H and O (e.g. C)
	(c)		$p(O_2) = 0.21 \times 1.00 \times 10^5$ = **21,000 / 2.1 × 10^4** (Pa) ✓	**1**	AO2.2	

Question	Answer	Marks	AO element	Guidance
(d)	**FIRST, CHECK ANSWER** **IF** answer = **231 000,** award **2 marks** --- ***n*(C$_3$H$_8$)** $n(C_3H_8) = \frac{42.0 \times 10^3}{24.0}$ **OR** $\frac{42.0 \times 10^6}{24\,000}$ **OR** 1750 (mol) ✓ **Mass of CO$_2$** mass CO$_2$ = 3 × 1750 × 44 = **231 000 / 2.31 × 10^5** (g) ✓ **ALLOW 2 SF**, e.g. 230 000	**2**	AO2.2 AO2.6	**ALLOW** use of ideal gas equation with a sensible temperature (20–25ºC) and pressure (100/101 kPa) At 20ºC and 100 kPa, $n(C_3H_8) = \frac{100 \times 10^3 \times 42.0}{8.314 \times 293}$ = 1724… (mol) → ~ 227586 (g) (dependent on roundings) At 25ºC and 100 kPa, $n(C_3H_8) = \frac{100 \times 10^3 \times 42.0}{8.314 \times 298}$ = 1695… (mol) → ~ 223767 (g) (dependent on roundings) **ALLOW** use of 8.31 for *R* **ALLOW ECF** from *n*(C$_3$H$_8$) --- **Common errors from 24.0 dm^3** 231 → 1 mark *No conversion of m^3 to dm^3* 0.231 → 1 mark *Confusion of cm^3 and dm^3* 77 000 → 1 mark *No 3 × for CO$_2$*
(e)	Initial rate = 10^{-2} × 2.4 × 10^{-3} s^{-1} = **2.4 × 10^{-5}** (mol dm^{-3} s^{-1}) ✓	**1**	AO2.2	
(f)	**FIRST, CHECK ANSWER** **IF** answer = **9.03 × 10^{22},** award **2 marks** --- $n(P_2O_5) = \frac{4.26}{142.0}$ **OR** 0.03(00) (mol) ✓ O atoms = 5 × 0.0300 × 6.02 × 10^{23} = **9.03 × 10^{22}** ✓ Minimum 3 SF required	**2**	AO2.2	**Alternative approach** $n(\text{O atoms}) = \frac{4.26}{142.0} \times 5 = 0.15$ ✓ O atoms = 0.15 × 6.02 × 10^{23} = 9.03 × 10^{22} ✓ **ALLOW ECF** from incorrect *n*(P$_2$O$_5$) **ALLOW** use of 6.022 × 10^{23} --- **Common error** 1.806 × 10^{22} **OR** 1.81 × 10^{22} → 1 mark No × 5
	Total	**9**		

Question			Answer	Marks	AO element	Guidance
2	(a)		$CO_3^{2-} + H_2O \rightarrow OH^- + HCO_3^-$ **OR** $CO_3^{2-} + H_2O \rightarrow 2OH^- + CO_2$ ✓	1	AO1.2	**ALLOW** $CO_3^{2-} + 2H_2O \rightarrow 2OH^- + H_2CO_3$ **IGNORE** state symbols **ALLOW** inclusion of Na^+ as spectator ion, e.g. $2Na^+ + CO_3^{2-} + H_2O \rightarrow 2OH^- + 2Na^+ + CO_2$ **IGNORE** $Na_2CO_3 + H_2O \rightarrow 2NaOH + CO_2$ *Ionic equation required* **IGNORE** equation with H^+ or H_3O^+ e.g. $CO_3^{2-} + H^+ \rightarrow OH^- + CO_2$ *Question asks for reaction with H_2O*
	(b)		Acid/H^+/HCl reacts with **OR** protonates • benzoate / $C_6H_5COO^-$ • carboxylate / salt (to form benzoic acid) ✓	1	AO2.3	**ALLOW** suitable equation, e.g. $C_6H_5COO^- + H^+ \rightarrow C_6H_5COOH$ **IGNORE** responses purely in terms of neutralisation of alkali, e.g. Acid/H^+/HCl **neutralises** / reacts with/removes alkali **/** OH^- / CO_3^{2-} / Na_2CO_3
	(c)		$C_6H_5CH_2OH + 2[O] \rightarrow C_6H_5COOH + H_2O$ ✓	1	AO2.6	**ALLOW** molecular, structural, displayed formulae, etc e.g. molecular: $C_7H_8O + 2[O] \rightarrow C_7H_6O_2 + H_2O$

Question	Answer	Marks	AO element	Guidance
(d)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 33.8 OR 33.9 (%) award 3 marks** --- **Theoretical moles** $n(C_6H_5COOH)$ **OR** $n(C_6H_5CH_2OH)$ $= \frac{4.00 \times 1.04}{108.0}$ **OR** 0.0385….. (mol) ✓ **Actual moles** $n(C_6H_5COOH) = \frac{1.59}{122.0}$ **OR** 0.013(0)…. (mol) ✓ % yield = $\frac{0.0130\ldots}{0.0385\ldots.} \times 100$ = 33.8% **OR** 33.9 (3 sig fig) ✓ *Answer depends on some intermediate roundings to 3SF*	3	AO2.8 ×1 AO2.8 ×1 AO1.2	**ALLOW ECF** for each step Calculator = 0.03851851852 Calculator = 0.01303278689 --- **Alternative method using mass** 1. Theoretical moles = 0.0385 mol 2. Mass = 0.0385 × 122.0 = 4.70 g 3. % yield = $\frac{1.59}{4.70} \times 100$ = 33.8% --- **Common errors** 35.2% → 2 marks • From $\frac{4.00}{108}$ = 0.0370 *(no use of density)* 36.5 **OR** 36.6% → 2 marks • $\frac{4.00/1.04}{108} = \frac{3.846}{108}$ = 0.0356 *(÷ density instead of × density)*

Question			Answer	Marks	AO element	Guidance
	(e)		Dissolve in the **minimum** quantity of **hot** water/solvent ✓ Cool **AND** Filter **AND** (leave to) dry ✓ *All three needed*	**2**	AO3.3 ×2	**ALLOW** any solvent **DO NOT ALLOW** use of drying agent (e.g. $MgSO_4$) **IGNORE** • Initial filtering • hot filtration to remove insoluble impurities
			Total	**8**		

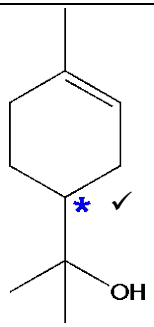
Question			Answer	Marks	AO element	Guidance
3	(a)	(i)	$4Pb_2O_3 + 3CH_4 \rightarrow 8Pb + 3CO_2 + 6H_2O$ **OR** $Pb_2O_3 + CH_4 \rightarrow 2Pb + CO + 2H_2O$ **OR** $2Pb_2O_3 + 3CH_4 \rightarrow 4Pb + 3C + 6H_2O$ ✓	1	AO2.6	**ALLOW** multiples **IGNORE** state symbols
		(ii)	**ONE Safety issue AND precaution** ✓ **From:** **Safety issue:** Compounds may be toxic/poisonous/flammable **AND** **Precaution**: Use a fume cupboard/good ventilation **----------** **Safety issue:** Lead (compounds) is/are toxic/poisonous **AND** **Precaution**: Wear gloves **----------** **Safety issue:** Methane is flammable **AND** **Precaution**: Keep away from flame **----------**	1	AO3.3	**IGNORE** use safety glasses, lab coat (*in question)* and tying hair back, safety screen Definite safety issue needed. Not just 'harmful' **OR** dangerous (Too vague). **FOR OTHER SAFETY ISSUES AND PRECAUTIONS, CONTACT TEAM LEADER**

Question	Answer	Marks	AO element	Guidance
(iii)	Any 2 modifications ✓ ✓ from **1.** Heat to constant mass (Ensures all lead oxide has reacted) **2.** Spread/stir/break up lead oxide **OR** increase surface area **OR** use powder rather than lumps (Ensures all lead oxide has reacted) **3.** Pass methane/inert gas/N_2 through tube as it cools **OR** don't pass cold air (Prevents O_2 reacting with Pb) **4.** Use excess methane **OR** more methane (Ensures all lead oxide has reacted) **5.** Bubble (escaping) gas through lime water (Ensures all lead oxide has reacted **OR** ensures all CO_2 has been produced)	**2**	AO3.4 ×2	**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* **IGNORE** 'weigh straight after heating' **IGNORE** idea of repeating the experiment/ taking an average/ getting concordant results / larger sample size, etc.
(iv)	Pb : O Masses(/g): 3.132 **AND** 0.322 **OR** Mole ratios: $\frac{\mathbf{3.132}}{207.2} : \frac{\mathbf{0.322}}{16.0}$ **OR** Mole ratios: 0.0151: 0.020125 ✓ Empirical formula Pb_3O_4 (must come from masses) ✓	**2**	AO2.8 ×2	**NO ECF** from incorrect masses

Question	Answer	Marks	AO element	Guidance
(b)	**Type of lattice 2 marks** • **SiO_2**: Giant (covalent lattice) ✓ • **CO_2**: Simple molecular/covalent (lattice) ✓ **----------** **Explanation 2 marks** **1. Forces in CO_2** • Induced dipole–dipole interactions / London forces ✓ **2. Comparison of forces with strength / melting point** • (Covalent) bonds in SiO_2 are stronger **THAN intermolecular** forces in CO_2 **OR** • More energy to break (covalent) bonds in SiO_2 **THAN intermolecular** forces in CO_2 ✓ **ORA**	**4**	AO1.1 ×2 AO1.1 ×1 AO2.1 ×1	**Throughout, IGNORE** 'ionic' for SiO_2 **FOR SiO_2, IGNORE** macromolecular **DO NOT ALLOW** giant **metallic** Mark explanation independently on type of lattice i.e. no **ECF** from incorrect lattice For CO_2 **IGNORE** • covalent bonds • van der Waals' forces • idid • LDF **DO NOT ALLOW** hydrogen bonds **OR** permanent dipole interactions For SiO_2, comparison needs just 'bonds' **OR** 'forces' For intermolecular, **ALLOW** 'between molecules' For comparison, **ALLOW** strong in SiO_2 **AND** weak in CO_2 **DO NOT ALLOW** responses containing intermolecular forces in SiO_2 **IGNORE** 'More bonds'
	Total	**10**		

Question			Answer	Marks	AO element	Guidance
4	(a)	(i)	4-chloro-3,5-dimethylphenol ✓ **CARE**: Look for **di**methyl	1	AO1.2	**ALLOW** 3,5-dimethyl-4-chlorophenol **ALLOW** absence of hyphens or extra hyphen or space, e.g. 4 chloro 3,5 dimethylphenol **ALLOW** full stops or spaces between numbers e.g. 4-chloro-3.5-dimethylphenol **ALLOW** name based on benzene, if unambiguous e.g.1-chloro-4-hydroxy-2,6-dimethylbenzene **DO NOT ALLOW** meth **OR** methy
		(ii)	5 ✓	1	AO2.5	
		(iii)	**Functional group** Phenol ✓ **Test** Indicator/pH paper turns red / orange **OR** pH < 7 **OR** pH meter < 7 **AND** No reaction with Na_2CO_3/CO_3^{2-}/carbonate ✓	2	AO1.2 AO2.3	**DO NOT ALLOW** alcohol **OR** hydroxide **IGNORE** hydroxyl **OR** hydroxy **IGNORE** OH (*name asked for*) **ALLOW** Add bromine **AND** white precipitate **ALLOW** $FeCl_3$ **AND** violet/blue colour

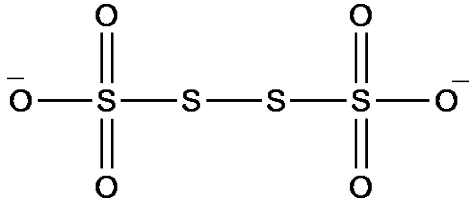
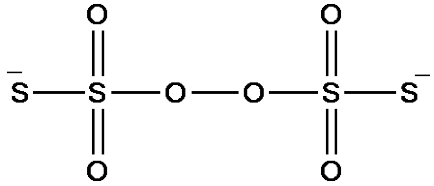
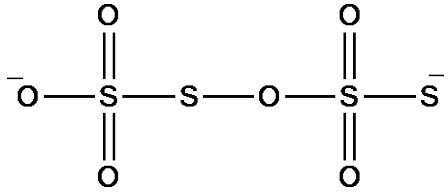
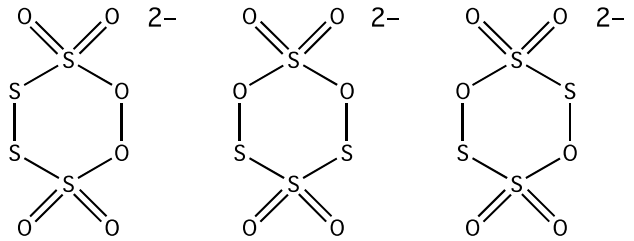
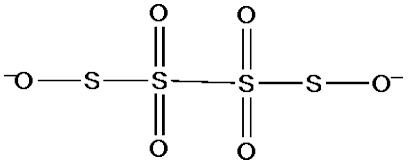
Question	Answer	Marks	AO element	Guidance
(iv)	**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF** answer = 1.71×10^{-10}, award **FOUR calculation marks** **CARE Separate mark for equation** --- **Equation (1 mark)** $C_8H_9ClO \rightleftharpoons H^+ + C_8H_8ClO^-$ ✓ *Molecular formulae required (atoms in any order)* **[C_8H_9ClO] calculation (2 marks)** Molar mass C_8H_9ClO = 156.5 (g mol^{-1}) ✓ **ONLY** correct answer $[C_8H_9ClO] = \frac{4.8 \times 10}{156.5}$ **OR** 0.3067….. (mol dm^{-3}) ✓ *Subsumes mark for molar mass = 156.5* **K_a calculation (2 marks)** $[H^+] = 10^{-5.14} = 7.244….. \times 10^{-6}$ (mol dm^{-3}) ✓ $K_a = \frac{(7.244…. \times 10^{-6})^2}{0.3067…..} = 1.71 \times 10^{-10}$ (mol dm^{-3}) ✓	5	AO1.2 ×1 AO2.8 ×4	**ALLOW** → for ⇌ **DO NOT ALLOW** C_8H_8ClOH in equation i.e. $C_8H_8ClOH \rightleftharpoons H^+ + C_8H_8ClO^-$ If equation is omitted, **ALLOW** equation mark for a correct K_a expression with molecular formula i.e. $\frac{[H^+]\,[C_8H_8ClO^-]}{[C_8H_9ClO]}$ **NO ECF** from an incorrect formula in equation **ALLOW ECF** from incorrect molar mass **ALLOW** 0.307 up to calculator value: 0.306709265 correctly rounded **ALLOW** 7.24×10^{-6} up to calculator value: $7.244359601 \times 10^{-6}$ correctly rounded **ALLOW 2 SF** ($1.7…. \times 10^{-10}$) up to calculator value, correctly rounded (but take care from acceptable intermediate rounding) **COMMON ERRORS** $2.36….. \times 10^{-5}$ 3/4 calculation marks *No squaring of 7.24×10^{-6}*

Question			Answer	Marks	AO element	Guidance
	(b)	(i)	 ✓	1	AO2.5	**DO NOT ALLOW** more than one * **ALLOW** a circle for *
		(ii)	**MAXIMUM OF 4 MARKS FROM 5 MARKING POINTS** **Requirement for *E*/*Z* isomerism** ***2 marks*** C=C/double bond ✓ Each C (in C=C) is attached to (two) different groups/atoms ✓ **Identification as *E*- or *Z*- isomer** ***2 marks*** *E/Z* isomerism linked to (high) **priority groups** ✓ ***Z*- isomer AND** groups are on **same side** **OR** the ring carbons ✓ **Reason why other *E*/*Z* isomer does not exist** ***1 mark*** **ring** would be strained **OR ring** would break/deform **OR** Cannot form **ring** if high priority groups are on opposite sides **OR** ring locks groups on one side of C=C bond ✓	4	AO1.2 ×2 AO2.5 ×2	**IGNORE** no H attached to C=C **IGNORE** functional', i.e. **ALLOW** different functional groups **ALLOW** in context of groups with largest atomic number ***ORA*** ***Award BOTH identification marks for:*** ***Z*-** isomer **AND** (high) **priority groups** on **same side** Mark independently of previous part Response **MUST** be linked to the **ring**/cyclic structure **IGNORE** just '*E* isomer is impossible' **IGNORE** C=C bond cannot rotate **IGNORE** Groups can't swap sides

Question			Answer	Marks	AO element	Guidance
		(iii)	**First group**: **Reagent** **AND** **Functional group**: Alkene **OR** cycloalkene ✓ ***Examples of reagents*** Br_2 or other halogen, HBr, H_2 **AND** Ni (catalyst), H_2O(**g**)/steam **AND** H^+ (catalyst) **Organic product** for reagent with **C=C** in α-terpineol ✓ ***ALLOW*** *product from H_2 or H_2O if H^+ catalyst has been omitted from reagent.* --- **Second group** **Reagent** **AND** **Functional group**: (Tertiary) alcohol ✓ ***Examples of reagents*** NaBr/KBr/Br^- **AND** acid/H^+ (substitution), **OR** HBr Acid/H^+ (catalyst) (elimination), CH_3COOH **AND** acid/H^+ (catalyst) (esterification) $CH_3COOCOCH_3$ (esterification) CH_3COCl (esterification) **Organic product** for reagent with **OH** in α-terpineol ✓ ***ALLOW*** *product if catalyst omitted from reagent*	**4**	AO3.2 ×4	**CONTACT TEAM LEADER FOR OTHER REACTIONS** --- **ALLOW GROUPS EITHER WAY ROUND IN BOXES** Functional group **MUST** be **named** **DO NOT ALLOW** UV with halogens **ALLOW** H_2SO_4/H_3PO_4/acid for H^+ **ALLOW** addition of HBr/ H_2O either way across C=C **ALLOW ANY HALIDE**, i.e. Cl^-, Br^-, I^- **ALLOW** H_2SO_4/H_3PO_4/acid for H^+ **ALLOW** HBr for H^+ and Br^- **ALLOW** name or formula of any carboxylic acid or acyl chloride for esterification **ALLOW** Na → product with –ONa **OR** $–O^-$ **DO NOT ALLOW** $Cr_2O_7^{2-}/H^+$ (tertiary alcohol)
			Total	**18**		

Question			Answer	Marks	AO element	Guidance
5	(a)	(i)*	*Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** Calculates **CORRECT** enthalpy change with correct – signs for $\Delta_{sol}H$ ($CuSO_4$(s)) for **reaction 5.2** **AND** Δ_rH, for **reaction 5.1**. *There is a well-developed line of reasoning which is clear and logically structured.* *The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Calculates a value of $\Delta_{sol}H$ ($CuSO_4$(s)) for **reaction 5.2** from the: Energy change **AND** Amount in mol of $CuSO_4$. *There is a line of reasoning presented with some structure.* *The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** Processes experimental data to obtain the: Energy change from $mc\Delta T$ **OR** Amount in mol of $CuSO_4$. *There is an attempt at a logical structure with a line of reasoning.* *The information is in the most part relevant.*	**6**	AO3.1 ×4 AO3.2 ×2	*Indicative scientific points may include:* **1. Processing experimental data** **Energy change from $mc\Delta T$** • Energy in J **OR** kJ *Using 50.70 g, 50.0 g* = **50.70** × 4.18 × 13.5 = **2861** (J) **OR** 2.861 (kJ) *3SF or more (2.861001 unrounded)* **OR** **50.0** × 4.18 × 13.5 = **2821.5** (J) **OR** 2.8215 (kJ) **Amount in mol of $CuSO_4$** • $n(CuSO_4) = \frac{7.98}{159.6}$ = 0.0500 (mol) --- **2. ± value of $\Delta_{sol}H$($CuSO_4$(s)) for reaction 5.2** From m = 50.70 g = $\pm\frac{2.861}{0.0500}$ = **±57.22** (kJ mol^{-1}) *(–57.22002 unrounded)* From m = 50.0 g = $\pm\frac{2.8215}{0.0500}$ = **±56.43** (kJ mol^{-1}) --- **3. CORRECT enthalpy changes for reactions 5.2 and 5.1 with signs (using 50.70 g ONLY)** **Reaction 5.2** = **–57.22** (kJ mol^{-1}) *3SF or more with correct – sign* **Reaction 5.1** $\Delta_rH = \Delta_{sol}H(CuSO_4(s)) - \Delta_{sol}H(CuSO_4 \cdot 5H_2O(s))$ = –57.22 – 8.43 = **–65.65** (kJ mol^{-1}) *3SF or more with correct – sign* **NOTE:** *A clear and logically structured response would include an energy cycle* **ALLOW** omission of trailing zeroes **ALLOW** minor slips

Question			Answer	Marks	AO element	Guidance
			0 marks – No response or no response worthy of credit.			
	(a)	**(ii)**	Temperature change = $0.2 \times \frac{100}{20}$ **= 1(.0)°C** ✓	**1**	AO2.8	**IGNORE** direction of temperature change Working **NOT** required
	(b)		**FIRST CHECK THE ANSWER IN ON ANSWER LINE** **If answer = (+)156 (J K^{-1} mol^{-1}) award 4 marks** --- **Part 1: Calc of $\Delta_r S$** **Use of 298 K** (seen anywhere) **1 mark** ✓ • e.g. –16.1 = –55.8 – 298 × ΔS --- **CORRECT** use of Gibbs' equation **1 mark** • using candidate's temperature (e.g. 298) • with –16.1 **AND** –55.8 • to calculate ΔS *in kJ* ***OR*** *J* ✓ --- **Part 2: Calc of $S(Na_2S_2O_3)$** **1 mark** **CORRECT** use of standard *S* data in question ✓ Seen anywhere (could be within an expression) e.g. • 372.4 – [$S(Na_2S_2O_3)$ + (5 × 69.9)] • **OR** 372.4 – (5 × 69.9) • **OR** 372.4 – 349.5 • **OR** 22.9 **IGNORE** sign, i.e. **ALLOW** –22.9, etc --- **CORRECT** calculation of $S(Na_2S_2O_3)$ using candidate's calculated ΔS in Part 1 **to 3 SF** **1 mark** ✓	**4**	AO2.4 ×4	Using 298 K, $\Delta S = \frac{-55.8 - (-16.1)}{298} = \frac{-39.7}{298}$ = –0.133…(kJ $K^{-1}mol^{-1}$) **OR –133**… (J $K^{-1}mol^{-1}$) ***Sign required*** ***IGNORE*** *units* Calculator: –0.133221 (kJ K^{-1} mol^{-1}) –133.221 (J K^{-1} mol^{-1}) **ALLOW ECF** from incorrect temperature. Using –133: $S(Na_2S_2O_3)$ = 372.4– 349.5 – (–133) = 22.9 + 133 = (+)**156** (J K^{-1} mol^{-1}) **3 SF** required **ALLOW ECF** from incorrect $\Delta_r S$ (Part 1)

Question			Answer	Marks	AO element	Guidance
	(c)	(i)	109.5(°) **AND** tetrahedral ✓	1	AO1.2	**ALLOW** 109–110(°)
		(ii)	 **OR**  **OR**  ✓ **IGNORE** absence of charges **OR** incorrect charges	1	AO3.1	**IGNORE** charges **ALLOW** cyclic structures. Three 6-ring structures possible, e.g.  **NOTE**: There **MUST** be 2 atoms in centre between 6-bonded S atoms. e.g. **DO NOT ALLOW**  **For other structures, contact TL**
			Total	13		

Question			Answer	Marks	AO element	Guidance
6	(a)	(i)	**A**: $Fe(OH)_3(s)$ ✓ **B**: $Ag_2S(s)$ ✓	**2**	AO3.1 ×2	**ALLOW** $Fe(OH)_3(H_2O)_3$ **IGNORE** state symbols
		(ii)	Student is incorrect **AND** No oxidation numbers change **OR** example, e,g, Fe stays as +2 ✓	**1**	AO3.2	**ALLOW** no electron transfer
		(iii)	$2[Fe(H_2O)_6]^{2+} + Cl_2 \rightarrow 2[Fe(H_2O)_6]^{3+} + 2Cl^-$ ✓	**1**	AO3.1	**ALLOW multiples** **e.g.** $[Fe(H_2O)_6]^{2+} + ½Cl_2 \rightarrow [Fe(H_2O)_6]^{3+} + Cl^-$ **ALLOW** $2[Fe(H_2O)_6]^{2+} + Cl_2 \rightarrow 2[Fe(H_2O)_5OH]^{2+} + 2HCl$ **OR** $2[Fe(H_2O)_6]^{2+} + Cl_2 \rightarrow 2[Fe(H_2O)_5Cl]^{2+} + 2H_2O$ **NOTE:** equation **MUST** be balanced by charge and oxidation number **IGNORE** state symbols
		(iv)	$5H_2S + 2MnO_4^- + 6H^+ \rightarrow 2Mn^{2+} + 5S + 8H_2O$ ✓✓ **1st mark** **ALL** Correct species (**SIX**) **OR** Equation containing Mn and S species correctly balanced i.e. $5\ H_2S + 2\ MnO_4^-$ ……. $\rightarrow 2\ Mn^{2+} + 5\ S$ …….. **2nd mark** Complete correct balanced equation	**2**	AO3.1 ×2	**ALLOW** multiples, e.g. $2½\ H_2S + MnO_4^- + 3H^+ \rightarrow Mn^{2+} + 2½\ S + 4H_2O$ **ALLOW** equation with S^{2-}, e.g. $5S^{2-} + 2MnO_4^- + 16H^+ \rightarrow 2Mn^{2+} + 5S + 8H_2O$ **IGNORE** extra electrons for 1st mark

Question	Answer	Marks	AO element	Guidance
(b)*	*Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** Reaches a comprehensive conclusion to determine the correct formulae of **almost all** of **C**, **D**, **E**, **F**, **G AND 9H_2O** *There is a well-developed line of reasoning which is clear and logically structured.* *The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Reaches a sound conclusion to determine the correct formulae of **at least half** of **C**, **D**, **E**, **F, G AND 9H_2O**. *There is a line of reasoning presented with some structure.* *The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** Reaches a simple conclusion to determine the correct formulae of **some** of **C**, **D**, **E**, **F**, **G AND 9H_2O**. *There is an attempt at a logical structure with a line of reasoning.* *The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*	**6**	AO1.2 ×2 AO3.1 ×2 AO3.2 ×2	**Indicative scientific points may include:** **Formula of C, D, E, F and G** • **C**: $Fe(NO_3)_3•9H_2O$ **OR** $FeN_3O_9•9H_2O$ • **D**: FeN_3O_9 **OR** $Fe(NO_3)_3$ • **E**: Fe_2O_3 • **F**: NO_2 • **G**: O_2 • **9**H_2O *Examples of evidence* $n(H_2O) = \frac{0.486}{18.0} = 0.027$ (mol) 0.027 : 0.003 = 1 : 9 → **9H_2O** n(**F**) $= \frac{270-54}{24000} = \frac{216}{24000} = 0.009(00)$ (mol) M(**E**) = 55.8 × 2 + 16.0 × 3 = 159.6 $M(\mathbf{F}) = \frac{0.414}{0.009(00)} = 46$ (g mol^{-1}) **G**: oxygen linked to relighting glowing split ***NOTE**: Equations could include evidence* e.g $Fe(NO_3)_3•9H_2O \rightarrow Fe(NO_3)_3 + 9H_2O$ $FeN_3O_9•9H_2O \rightarrow FeN_3O_9 + 9H_2O$ $2Fe(NO_3)_3 \rightarrow Fe_2O_3 + 6NO_2 + 1½O_2$
	Total	**12**		

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