



GCE

Chemistry B

H433/02: Scientific literacy in 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

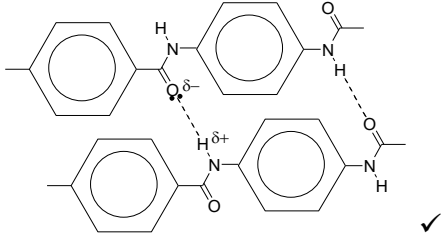
Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:


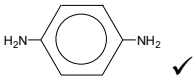
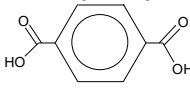
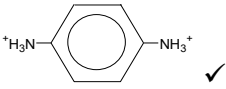
- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

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)		A: (di)acyl chloride ✓ B: (di)amine ✓	2	1.1 x 2	IGNORE arene/benzene/aromatic ring/secondary/ DO NOT ALLOW phenyl/amide/acyl on its own
1	(b)		Angle 120° ✓ three groups/sets of electrons/ 3 areas of electron density (around C) ✓ repel and get as far away as possible/minimise repulsion ✓	3	2.1 2.1 1.1	ALLOW 117 - 122 Mark separately (i.e. no ecf) IGNORE three (bonding) pairs
1	(c)		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 26 (g) award 2 marks Amount benzene-1,4-dicarboxylic acid = 32/166 = 0.19 mol ✓ Mass compound A = 0.19 x 0.67 x 203 = 26 (g) (nearest whole number) ✓	2	2.4 x 2	ALLOW ecf from incorrect number of moles
1	(d)		step 1: (conc) ammonia/NH ₃ ✓ step 2: Sn + <u>conc</u> HCl /names ✓	2	2.3 2.3	IGNORE heat/reflux/ethanolic but any other additional reagents is CON
1	(e)	(i)	hydrogen (bonds) ✓	1	1.1	
1	(e)	(ii)		1	1.1	BOTH dotted lines required but not lone pairs or partial charges
1	(f)	(i)	Heat/ reflux with HCl / H ₂ SO ₄ / NaOH / acid / alkali / names ✓	1	1.2	DO NOT ALLOW conc. H ₂ SO ₄
1	(f)	(ii)	Answer depends on catalysts chosen in (f)(i): alkaline hydrolysis:	2	1.2 x 2	ALLOW salts rather than cation/ anion ALLOW any unambiguous representation

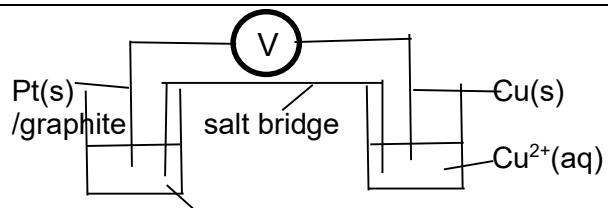
Question	Answer	Marks	AO element	Guidance
	<p data-bbox="360 240 813 320"> ✓ and  ✓</p> <p data-bbox="360 328 562 360">acid hydrolysis:</p> <p data-bbox="360 360 875 448"> ✓ and  ✓</p>			<p data-bbox="1447 240 2033 304">ALLOW one mark for unionised diamine and dicarboxylic acid</p> <p data-bbox="1447 304 2101 368">IGNORE ambiguous attachments eg OH attached through H</p>

Question			Answer	Marks	AO element	Guidance
2	(a)		<p>electrons raised/excited to higher energy levels (by heat) ✓</p> <p>fall and release energy/visible light/photon ✓</p> <p>frequency of energy/light/photon proportional to gap between energy levels / $(\Delta)E = hv$ ✓</p>	3	1.2 x 3	DO NOT ALLOW answers where energy source is e/m radiation
2	(b)	(i)	<p>FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 1260 (cm³) award 4 marks</p> <p>amount SrCO₃ (= 12.0/147.6) = 0.0813 (mol) ✓ $V = nRT/P$ ✓ $V = 0.0813 \times 8.314 \times 290 \times 10^6/155000 = 1260 \text{ (cm}^3\text{)}$ (3 or more sf) ✓</p> <p>Answer to 3sf ✓</p>	4	2.8 x 4	<p>ALLOW ECF ALLOW answers rounding to 1260 for 3 marks</p> <p>If values inserted into equation that clearly demonstrates use of MP2 this scores MP2</p> <p>ALLOW sf mark for any calculated volume to 3 sf.</p>
2	(b)	(ii)	<p>strontium ions are larger (and attraction less) ✓</p> <p>strontium (ions) have lower charge density ✓</p> <p>they distort/polarise the carbonate (ions) less ✓</p> <p>thermal stability of strontium (carbonate) is higher ✓</p>	4	3.2 x 4	<p>ALLOW ora throughout DO NOT ALLOW atomic radius</p> <p>ALLOW thermal stability increases down the group.</p>
2	(c)	(i)	46 ✓	1	1.1	
2	(c)	(ii)	<p>FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 87.71 award 2 marks</p> <p>$(84 \times 0.56) + (86 \times 9.86) + (87 \times 7.00) + (88 \times 82.58)$ ✓</p> <p>evaluated as percentage and expressed to 2 dp ✓</p>	2	1.2 x 2	If 2 marks not scored award max 1 mark for any calculated value between 86 and 88 to 2dp.
2	(d)*		<p>Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.</p> <p>Level 3 (5 – 6 marks) Chooses an appropriate acid concentration.</p>	6	3.4 x 3 3.3 x 3	<p>Indicative scientific points include:</p> <p>Choice of acid concentration</p>

Question			Answer	Marks	AO element	Guidance
			<p>AND Gives a detailed description, including some fine detail, of procedure. AND Describes how the result would be calculated.</p> <p><i>There is a well-developed line of reasoning which is clear and logically structured.</i></p> <p>Level 2 (3 – 4 marks) Gives most of the key steps in the procedure, may include some fine detail AND describes how the result would be calculated. OR Addresses all three areas but lacks depth in any of them.</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) A basic description of procedure. OR An attempt to describe the choice of acid concentration. OR An attempt to describe how the result would be calculated.</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 No response or no response worthy of credit.</p>			<ul style="list-style-type: none"> Calculates conc of $\text{Sr}(\text{OH})_{2(\text{aq})} = 0.08 \text{ mol dm}^{-3}$; use of reaction stoichiometry 2:1 to determine appropriate concentration of acid to be used (approx. $0.15 - 0.2 \text{ mol dm}^{-3}$) <p>Practical details</p> <ul style="list-style-type: none"> pipette $20/25 \text{ cm}^3$ $\text{Sr}(\text{OH})_2/\text{HCl}$ in a suitable flask; add indicator; (details not required) place acid/alkali in burette; titrate until colour change (details not required) repeat until concordant titres obtained <p>Relevant fine detail</p> <ul style="list-style-type: none"> Rinses pipette with solution to be delivered Rinses burette with solution to be delivered Performs a rough titration Add dropwise near to end point <p>Final calculation</p> <ul style="list-style-type: none"> Calculates average volume used Use of equation or mole ratio Gives example of suitable relationship to calculate actual concentration eg use of $c = n/v$
2	(e)	(i)	$\text{Sr}(\text{OH})_2(\text{s}) \rightleftharpoons \text{Sr}^{2+}(\text{aq}) + 2\text{OH}^{-}(\text{aq}) \checkmark$ $K_{\text{sp}} = [\text{Sr}^{2+}] [\text{OH}^{-}]^2 \checkmark$	2	2.2 1.1	Equilibrium can be either way round. Penalise incorrect charge on Sr ions once only
2	(e)	(ii)	<p>FIRST CHECK THE ANSWER ON ANSWER LINE If answer = $1.6 \times 10^{-4} \text{ mol}^3 \text{ dm}^{-9}$ award 3 marks</p>	3	2.6 x 3	If final answer does not = $1.6 \times 10^{-4} \text{ mol}^3 \text{ dm}^{-9}$ ALLOW ECF from (i) provided only Sr and OH ions are involved

Question			Answer	Marks	AO element	Guidance
			$[\text{Sr}^{2+}] = 3.4 \times 10^{-2}$ AND $[\text{OH}^-] = 6.8 \times 10^{-2}$ ✓ $K_{\text{sp}} = 3.4 \times 10^{-2} \times (6.8 \times 10^{-2})^2 = 1.6 \times 10^{-4}$ ✓ units $\text{mol}^3 \text{dm}^{-9}$ ✓			ALLOW ECF from incorrect concentrations of Sr or OH ions, including units as appropriate ALLOW 2 or more sf ALLOW units derived from an attempt at a worked calculation
2	(e)	(iii)	larger/increased concentration of OH^- ✓ concentration of Sr^{2+} reduces in order for K_{sp} to remain constant AND solubility is lower ✓	2	3.2 x 2	ALLOW more hydroxide ions ALLOW moves equilibrium to left AND solubility is lower Any reference to K_{sp} changing is CON
2	(f)	(i)	s(-block) ✓	1	1.1	
2	(f)	(ii)	Any two from: Sr^{2+} and Rb^+ / Sr loses 2 electrons and Rb loses 1 electron ✓ more (delocalised) electrons in Sr ✓ Sr^{2+} attracts (more) electrons (in metallic structure) more strongly ✓	2	1.1 x 2	DO NOT ALLOW more outer shell electrons DO NOT ALLOW references to Sr nuclei

Question			Answer	Marks	AO element	Guidance
3	(a)		$3\text{Cl}_2 + 6 \text{OH}^- \rightarrow \text{ClO}_3^- + 5 \text{Cl}^- + 3\text{H}_2\text{O}$ Numbers in front of chlorine species ✓ Numbers in front of OH^- and H_2O correct ✓	2	2.5 x 2	ALLOW '1' in front of ClO_3^- / correct multiples
3	(b)	(i)	$\text{ClO}_3^-/\text{ClO}_2$ is less positive/ more negative than Cl_2/Cl^- ✓	2	2.8 x 2	IGNORE 'larger'/'smaller'

			so ClO_2 is oxidised AND Cl_2 is reduced / electrons flow from $\text{ClO}_3^- / \text{ClO}_2$ (ora) / half equations are reversed ✓			ALLOW by reference to one species in either half equation.
3	(b)	(ii)	Larger $[\text{H}^+] / [\text{Cl}^-]$ ✓ Equilibrium / equation 3.1 moves to right ✓	2	3.1 x 2	IGNORE 'more' ALLOW E^\ominus for $\text{ClO}_3^- / \text{ClO}_2$ more positive OR $E^\ominus \text{Cl}_2 / \text{Cl}^-$ becomes more negative
3	(c)	(i)	 <p> $\text{Cl}_2(\text{aq}) + \text{Cl}^-(\text{aq})$ voltmeter and salt bridge ✓ $\text{Cu}^{2+}(\text{aq})$ and $\text{Cu}(\text{s})$ ✓ $\text{Cl}_2(\text{aq}) / \text{Cl}^-(\text{aq})$ and Pt / C electrode ✓ solutions 1 mol dm^{-3} and 298 K ✓ </p>	4	3.4 x 4	IGNORE description of makeup of salt bridge IGNORE '2' in front of ' Cl^- ' ALLOW Cu and Pt/C without state symbols. ALLOW one mark for points 2 and 3 if all state symbols omitted ALLOW electrodes around the other way If no solution shown in either half cell MP2 OR MP3 cannot score If no solution shown in both half cells only penalise once.
3	(c)	(ii)	1.02 (V) ✓	1	2.8	IGNORE sign
3	(c)	(iii)	<u>in the wire</u> from Cu (ora) ✓	1	2.8	ALLOW movement of electrons correctly labelled on the diagram.
3	(c)	(iv)	$2\text{H}^+(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{H}_2(\text{g})$	1	1.2	ALLOW equation: •halved •with arrow •other way round

Question			Answer	Marks	AO element	Guidance
3	(c)	(v)	<p>FIRST CHECK THE ANSWER ON ANSWER LINE If answer = +0.28 (V) award 2 marks</p> <p>$\ln 0.01 = -4.6 \checkmark$ $E = +0.34 - (0.0128 \times 4.6) = +0.28 (V) \checkmark$</p>	2	2.8 x 2	<p>ALLOW 2 or more sf + sign essential. (0.28 with no sign = 1)</p> <p>lg 0.01 answer is +0.31V for 1 mark only ALLOW If MP1 not clearly stated then by implication it can be credited from a subsequent calculation eg; $E_{\text{cell}} = 1.02$ answer is +0.96V for 1 mark only</p>
3	(d)	(i)	$Cl_2 + 2I^- \rightarrow 2Cl^- + I_2$	1	1.2	IGNORE state symbols
3	(d)	(ii)	iodide(ion)	1	1.2	IGNORE formulae
3	(d)	(iii)	brown/orange/yellow (solution)	1	1.2	ALLOW these colours or any combination but no others. IGNORE reference to starting colour. PPT or (s) is CON
3	(d)	(iv)	Chlorine has a greater attraction for (AW) electrons (than iodine) (ora)	1	2.5	Reference to molecules is CON IGNORE references to electronegativity / attraction to valence electrons
3	(e)		<p>Test tube or flask containing Sodium Chloride and concentrated sulphuric acid \checkmark</p> <p>Delivery tube for downward delivery into a test tube or boiling tube \checkmark</p>	2	3.3 x 2	<p>ALLOW formulae</p> <p>Collection over water, or into a sealed vessel CONs MP2</p>

Question			Answer	Marks	AO element	Guidance
4	(a)		<p>Oxides of nitrogen/NO_2 is recycled/regenerated/reformed \checkmark reactions are $NO_2 + O \rightarrow NO + O_2$ and $NO + O_3 \rightarrow NO_2 + O_2 \checkmark$</p>	2	3.1 x 2	
4	(b)	(i)		4	2.8 x 4	

Question			Answer	Marks	AO element	Guidance
			<p>axes round right way and labelled correctly ✓ scale to fill 2/3 of area ✓ plot with line of best fit ✓</p> <p>measurement of one half-life = 1400 s ± 100 ✓</p>			Should be a curve that touches at least 4 points. Mark half-life by answer given, no construction lines needed for <i>this</i> part.
4	(b)	(ii)	'Half lives constant' AND At least two half-lives constructed ✓	1	2.7	
	(c)		($k = 9.8 \times 10^{-5} / 0.210 =$) 4.7×10^{-4} ✓ units s^{-1} ✓	2	2.4 x 2	ALLOW 2 or more sf Mark units separately
	(d)		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = (+)100±10 (any sf) (kJ mol⁻¹) award 3 marks	3	2.6 x 3	ALLOW one or more sf ALLOW ECF
			slope = -12000 ± 500 ✓ $E_a = 12000 \times 8.314 = (+)99768$ (J) ✓ $= (+)99.8$ (kJ mol ⁻¹) ✓			MP1 is for calculating the gradient MP2 is for multiplying by R and evaluating MP3 is for converting from J to kJ
	(e)		(this is a possible mechanism because) reactions add to overall equation / $2N_2O_5 \rightarrow 4NO_2 + O_2$ ✓	3	3.1 x 3	

Question	Answer	Marks	AO element	Guidance
	<p>step 1 could be rate determining because it uses N_2O_5 as a reactant / N_2O_5 decomposes ✓</p> <p>step 3 could be rate determining because it uses N_2O_5 as a reactant / could be slow compared to steps 1 and 2 ✓</p>			<p>ALLOW cannot be step 2 as N_2O_5 does not appear in the equation for 1 mark if no reference made to either step 1 or step 3.</p> <p>ALLOW BOTH step 1 and step 3 could be RDS with a reason scores 2 marks BOTH step 1 and step 3 with no reason scores 1 mark.</p>

Question		Answer	Marks	AO element	Guidance	
5	(a)	$\text{C}_2\text{H}_2(\text{g}) + 2.5\text{O}_2(\text{g}) \rightarrow 2\text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{g/l})$ $\Delta_c H = 2\Delta_f H \text{CO}_2 + \Delta_f H \text{H}_2\text{O} - \Delta_f H \text{C}_2\text{H}_2 \checkmark$	3	2.1 2.1 2.1	<p>First mark for correct elements Second mark for correct $\Delta_f H$ descriptions and top equation ALLOW $\Delta_f H \text{2CO}_2$ IGNORE $\Delta_f H \text{O}_2$</p> <p>Third mark for correct expression for $\Delta_c H$ <i>Allow use of definitions/symbols from enthalpy cycle</i></p>	
5	(b)	<p>FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 1.9 (times greater) award 4 marks</p> <p>Equation: $\text{C}_3\text{H}_8 + 5\text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O} \checkmark$ $5/0.2 = 25$ (moles 'air') \checkmark 12.5 moles 'air' for acetylene \checkmark $26/13.5 = 1.9$ (times greater) \checkmark</p>	4	2.5 2.5 2.6 2.6	<p>ALLOW 3 marks if mole fraction route not used ie; Correct equation for propane \checkmark Scaled equation for acetylene so that moles of O_2 are identical in both equations / acetylene needs 2.5 moles O_2 and propane needs 5 moles $\text{O}_2 \checkmark$ Ratio of acetylene to propane = 2 identified \checkmark</p> <p>ALLOW ECF from an incorrect equation</p>	
5	(c)	(i)	Carbon atoms contain 4 outer (shell) electrons \checkmark sp^2 (orbitals) uses 3 electrons \checkmark	2	2.1 x 2	
		(ii)	ethene: form a π bond \checkmark naphthalene: delocalised/conjugated \checkmark	2	1.1 x 2	
5	(d)		Abstraction/removal of hydrogen from naphthalene \checkmark	1	2.5	DO NOT ALLOW steps before abstraction IGNORE any further steps that grow PAH
5	(e)	(i)	initiation AND radicals formed (from molecules) \checkmark	1	2.1	
		(ii)	Provide energy/break bonds by colliding \checkmark	1	3.2	IGNORE reference to catalyst
5	(f)		Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.	6	3.1 x 6	Indicative scientific points include: Flame temp:

Question	Answer	Marks	AO element	Guidance
	<p>Level 3 (5 – 6 marks) Gives a detailed account of controlling flame temperature, small molecule reactions and competing reactions, exemplified by the use of at least one appropriate equation.</p> <p><i>There is a well-developed line of reasoning which is clear and logically structured.</i></p> <p>Level 2 (3 – 4 marks) Gives an outline account of controlling flame temperature, small molecule reactions and competing reactions.</p> <p>OR Gives a detailed account of two of the following areas, controlling flame temperature, small molecule reactions, or competing reactions</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) Gives an outline account of two of the following areas, controlling flame temperature, small molecule reactions or competing reactions</p> <p>OR Gives a detailed account of one area</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>			<ul style="list-style-type: none"> • saturated hydrocarbons need more oxygen per mole • fewer saturated hydrocarbon molecules in the same volume; • hence lower flame temp; • pure oxygen produces higher flame temperatures; • example comparison equations (Allow ORA for arguments in favour of unsaturated hydrocarbons) <p>Small molecule reactions:</p> <ul style="list-style-type: none"> • oxygen atoms/ molecules produce hydrogen atoms • use of appropriate equation(s), eg $\text{CH} + \text{O} \rightarrow \text{CO} + \text{H}$ or $\text{CH}_2 + \text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}$ • more hydrogen atoms abstracted from growing PAH • balance entropy AW <p>Competing reactions:</p> <ul style="list-style-type: none"> • production of acetylene vs CO_2; • saturated hydrocarbons produce more CO_2; • unsaturated hydrocarbons produce acetylene; • acetylene leads to soot formation • soot formation vs CO_2 production

OCR (Oxford Cambridge and RSA Examinations)
The Triangle Building
Shaftesbury Road
Cambridge
CB2 8EA

OCR Customer Contact Centre

Education and Learning

Telephone: 01223 553998

Facsimile: 01223 552627

Email: general.qualifications@ocr.org.uk

www.ocr.org.uk

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Head office
Telephone: 01223 552552
Facsimile: 01223 552553

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