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
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**
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

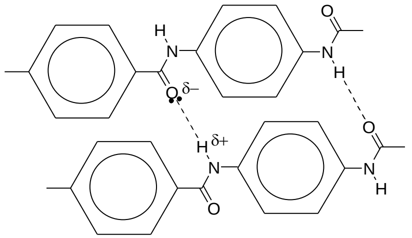
Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

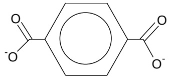
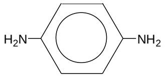
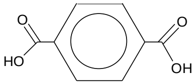
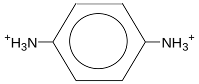
- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

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^{o} ✓ 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)**	 H N O N H O δ− O H δ+ N O N H O ✓	**1**	**1.1**	**BOTH** dotted lines required but not lone pairs or partial charges
1	**(f)**	**(i)**	Heat/ reflux with HCl / H_2SO_4 / NaOH / acid / alkali / names ✓	**1**	**1.2**	**DO NOT ALLOW** conc. H_2SO_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

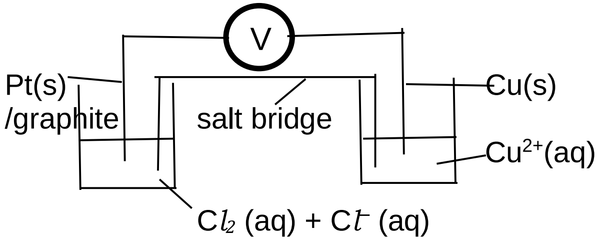
Question			Answer	Marks	AO element	Guidance
			 ✓and  ✓ acid hydrolysis:  ✓ and  ✓			**ALLOW** one mark for unionised diamine and dicarboxylic acid **IGNORE** ambiguous attachments eg OH attached through H

Question			Answer	Marks	AO element	Guidance
2	**(a)**		electrons raised/excited to higher energy levels (by heat) ✓ fall and release energy/visible light/photon ✓ frequency of energy/light/photon proportional to gap between energy levels / (∆)E = hv ✓	**3**	**1.2 x 3**	**DO NOT ALLOW** answers where energy source is e/m radiation
2	**(b)**	**(i)**	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 1260 (cm^3) award 4 marks** amount $SrCO_3$ (= 12.0/147.6) = 0.0813 (mol) ✓ V = nRT/P ✓ V = 0.0813 x 8.314 x 290 x 10^6/155000 = 1260 (cm^3) (3 or more sf) ✓ Answer to 3sf ✓	**4**	**2.8 x 4**	**ALLOW ECF** **ALLOW** answers rounding to 1260 for 3 marks If values inserted into equation that clearly demonstrates use of MP2 this scores MP2 **ALLOW** sf mark for any calculated volume to 3 sf.
2	**(b)**	**(ii)**	strontium ions are larger (and attraction less) ✓ strontium (ions) have lower charge density ✓ they distort/polarise the carbonate (ions) less ✓ thermal stability of strontium (carbonate) is higher ✓	**4**	**3.2 x 4**	**ALLOW** ora throughout **DO NOT ALLOW** atomic radius **ALLOW** thermal stability increases down the group.
2	**(c)**	**(i)**	46 ✓	**1**	**1.1**	
2	**(c)**	**(ii)**	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 87.71 award 2 marks** (84 x 0.56) + (86 x 9.86) + (87 x 7.00) + (88 x 82.58) ✓ evaluated as percentage and expressed to 2 dp ✓	**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)***		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)** Chooses an appropriate acid concentration.	**6**	**3.4 x 3** **3.3 x 3**	**Indicative scientific points include**: **Choice of acid concentration**

Question			Answer	Marks	AO element	Guidance
			AND Gives a detailed description, including some fine detail, of procedure. **AND** Describes how the result would be calculated. *There is a well-developed line of reasoning which is clear and logically structured.* **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. *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)** 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. *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.			• Calculates conc of $Sr(OH)_{2(aq)}$ = 0.08 mol dm^{-3}; • use of reaction stoichiometry 2:1 to determine appropriate concentration of acid to be used (approx. 0.15 – 0.2 mol dm^{-3}) **Practical details** • pipette 20/25 cm^3 $Sr(OH)_2/HC\ell$ 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 ***Relevant fine detail*** • Rinses pipette with solution to be delivered • Rinses burette with solution to be delivered • Performs a rough titration • Add dropwise near to end point **Final calculation** • 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)	$Sr(OH)_2(s) \rightleftharpoons Sr^{2+}(aq) + 2OH^{-}(aq)$ ✓ $K_{sp} = [Sr^{2+}]\,[OH^{-}]^2$ ✓	2	2.2 1.1	Equilibrium can be either way round. Penalise incorrect charge on Sr ions once only
2	(e)	(ii)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 1.6 x 10^{-4} mol^3 dm^{-9} award 3 marks**	3	2.6 x 3	**If final answer does not = 1.6 x 10^{-4} mol^3 dm^{-9}** **ALLOW ECF** from (i) provided only Sr and OH ions are involved

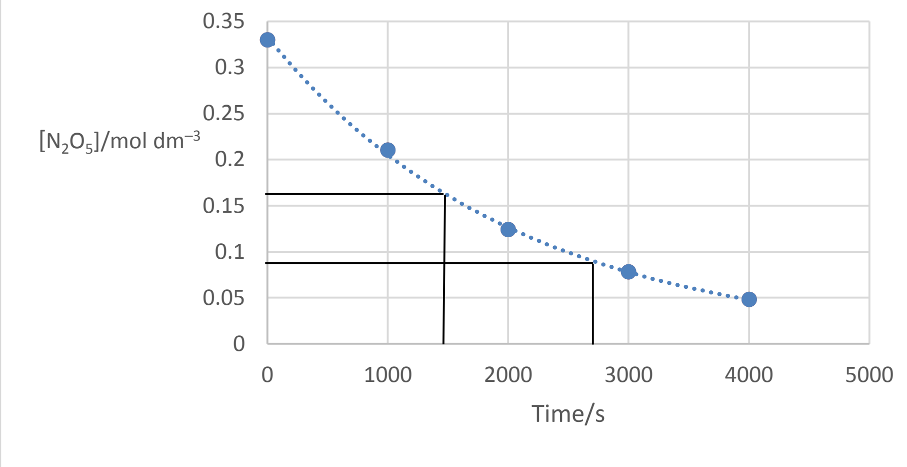
Question			Answer	Marks	AO element	Guidance
			$[Sr^{2+}] = 3.4 \times 10^{-2}$ **AND** $[OH^-] = 6.8 \times 10^{-2}$✓ $K_{sp} = 3.4 \times 10^{-2} \times (6.8 \times 10^{-2})^2 = 1.6 \times 10^{-4}$ ✓ units $mol^3\ dm^{-9}$ ✓			**ALLOW ECF** from incorrect concentrations of Sr or OH ions, including 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)**		$3Cl_2 + 6\ OH^- \rightarrow ClO_3^- + 5\ Cl^- + 3H_2O$ 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)**	ClO_3^-/ClO_2 is less positive/ more negative than Cl_2/Cl^-✓	**2**	**2.8 x 2**	**IGNORE** ‘larger’/’smaller’

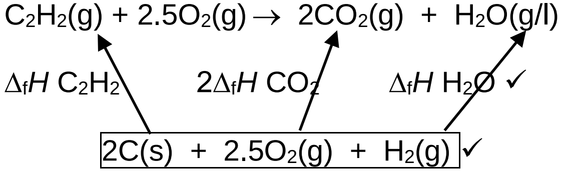
			so ClO_2 is oxidised AND Cl_2 is reduced / electrons flow from ClO_3^-/ ClO_2 (ora) / half equations are reversed✓			**ALLOW** by reference to one species in either half equation.
3	**(b)**	**(ii)**	Larger $[H^+]$ / $[Cl^-]$ ✓ Equilibrium / equation 3.1 moves to right ✓	**2**	**3.1 x 2**	**IGNORE** 'more' **ALLOW** E^{θ} for ClO_3^-/ ClO_2 more positive OR E^{θ} Cl_2/Cl^- becomes more negative
3	**(c)**	**(i)**	 V Pt(s) /graphite salt bridge Cu(s) Cu^{2+}(aq) Cl_2 (aq) + Cl^- (aq) voltmeter and salt bridge ✓ Cu^{2+}(aq) and Cu(s) ✓ Cl_2(aq)/ Cl^-(aq) and Pt / C electrode ✓ solutions 1 mol dm^{-3} and 298 K ✓	**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)**	$2H^+(aq) + 2e^- \leftrightharpoons H_2(g)$	**1**	**1.2**	**ALLOW** equation: •halved •with arrow •other way round

Question			Answer	Marks	AO element	Guidance
3	**(c)**	**(v)**	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = +0.28 (V) award 2 marks** ln 0.01 = –4.6 ✓ E = +0.34 – (0.0128 x 4.6) = +0.28 (V) ✓	**2**	**2.8 x 2**	**ALLOW** 2 or more sf **+ sign essential. (0.28 with no sign = 1)** 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_{cell} = 1.02 answer is +0.96V for 1 mark only
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)**		Test tube or flask containing Sodium Chloride and concentrated sulphuric acid ✓ Delivery tube for downward delivery into a test tube or boiling tube ✓	**2**	**3.3 x 2**	**ALLOW** formulae Collection over water, or into a sealed vessel CONs MP2

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

Question			Answer	Marks	AO element	Guidance
			 axes round right way and labelled correctly ✓ scale to fill 2/3 of area ✓ plot with line of best fit ✓ measurement of one half-life = 1400 s ± 100 ✓			Should be a curve that touches at least 4 points. Mark half-life by answer given, no construction lines needed for *this* part.
4	(b)	(ii)	'Half lives constant' **AND** At least two half-lives constructed ✓	1	2.7	
	(c)		(k = 9.8 x 10^{-5}/ 0.210 =) 4.7 x 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** slope = –12000±500 ✓ Ea = 12000 x 8.314 = (+)99768 (J) ✓ = (+)99.8 (kJ mol $^{-1}$) ✓	3	2.6 x 3	**ALLOW** one or more sf **ALLOW ECF** 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
			step 1 could be rate determining because it uses N_2O_5 as a reactant / N_2O_5 decomposes ✓ step 3 could be rate determining because it uses N_2O_5 as a reactant / could be slow compared to steps 1 and 2 ✓			**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. **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.

Question			Answer	Marks	AO element	Guidance
5	(a)		 $C_2H_2(g) + 2.5O_2(g) \rightarrow 2CO_2(g) + H_2O(g/l)$ $\Delta_fH\ C_2H_2$ $2\Delta_fH\ CO_2$ $\Delta_fH\ H_2O$ ✓ $\boxed{2C(s) + 2.5O_2(g) + H_2(g)}$ ✓ $\Delta_cH = 2\Delta_fH\ CO_2 + \Delta_fH\ H_2O - \Delta_fH\ C_2H_2$ ✓	3	2.1 2.1 2.1	First mark for correct elements Second mark for correct Δ_fH descriptions and top equation **ALLOW** $\Delta_fH\ 2CO_2$ **IGNORE** $\Delta_fH\ O_2$ Third mark for correct expression for Δ_cH *Allow use of definitions/symbols from enthalpy cycle*
5	(b)		**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 1.9 (times greater) award 4 marks** Equation: $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$✓ 5/0.2 = 25 (moles 'air') ✓ 12.5 moles 'air' for acetylene ✓ 26/13.5 = 1.9 (times greater) ✓	4	2.5 2.5 2.6 2.6	**ALLOW** 3 marks if mole fraction route not used ie; Correct equation for propane ✓ 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 O_2✓ Ratio of acetylene to propane = 2 identified ✓ **ALLOW** ECF from an incorrect equation
5	(c)	(i)	Carbon atoms contain 4 outer (shell) electrons ✓ sp^2 (orbitals) uses 3 electrons ✓	2	2.1 x 2	
		(ii)	ethene: form a π bond ✓ naphthalene: delocalised/conjugated ✓	2	1.1 x 2	
5	(d)		Abstraction/removal of hydrogen from naphthalene ✓	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) ✓	1	2.1	
		(ii)	Provide energy/break bonds by colliding ✓	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
			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. *There is a well-developed line of reasoning which is clear and logically structured.* **Level 2** (3 – 4 marks) Gives an outline account of controlling flame temperature, small molecule reactions and competing reactions. **OR** Gives a detailed account of two of the following areas, controlling flame temperature, small molecule reactions, or competing reactions *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) Gives an outline account of two of the following areas, controlling flame temperature, small molecule reactions or competing reactions **OR** Gives a detailed account of one area *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.*			• 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) ***Small molecule reactions**:* • oxygen atoms/ molecules produce hydrogen atoms • use of appropriate equation(s), eg $CH + O \rightarrow CO + H$ or $CH_2 + O_2 \rightarrow CO_2 + 2H$ • more hydrogen atoms abstracted from growing PAH • balance entropy AW ***Competing reactions**:* • 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

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