

GCE

Chemistry B

Unit **H433/01**: Fundamentals of chemistry

Advanced GCE

Mark Scheme for June 2018

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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.

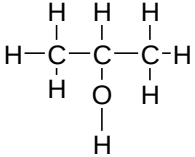
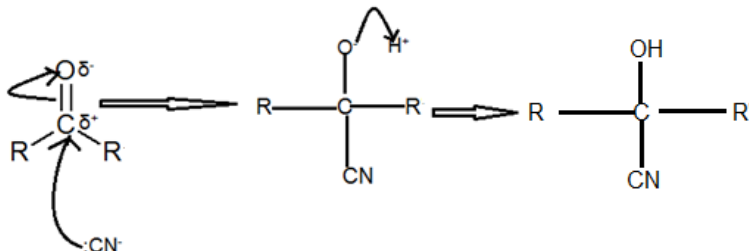
You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New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

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

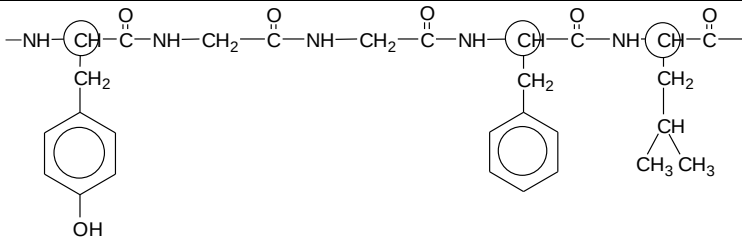
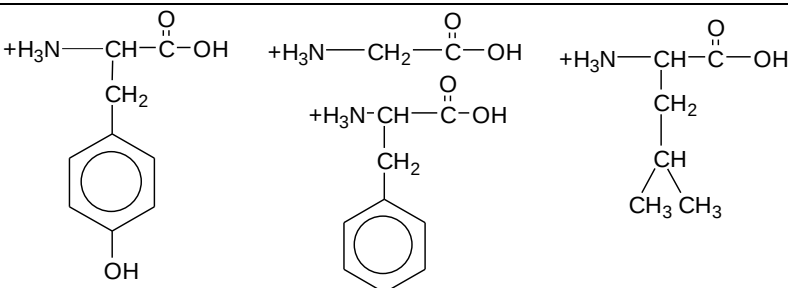
Section A

Q	Key	Mark	
1	C	1	
2	D	1	
3	C	1	
4	B	1	
5	B	1	
6	C	1	
7	C	1	
8	C	1	
9	D	1	
10	B	1	
11	C	1	
12	C	1	
13	A	1	
14	B	1	
15	B	1	
16	C	1	
17	B	1	
18	B	1	
19	A	1	
20	B	1	
21	D	1	
22	C	1	
23	B	1	
24	B	1	
25	A	1	
26	B	1	
27	A	1	
28	A	1	
29	D	1	
30	C	1	
		30	

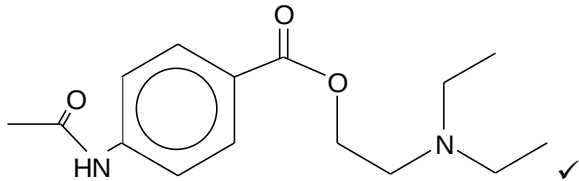
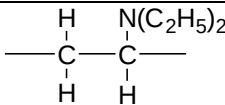
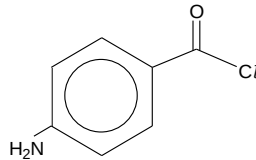
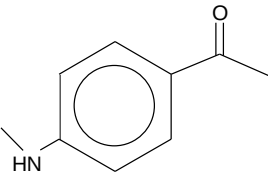
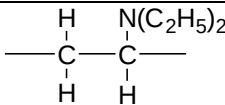
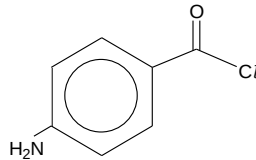
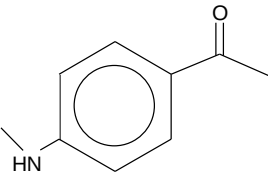
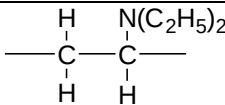
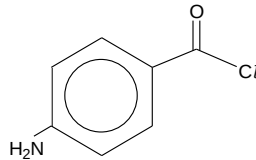
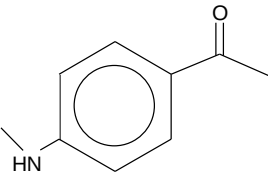
Question			Answer	Marks	Guidance
31	(a)		FIRST CHECK THE ANSWER ON THE ANSWER LINE If answer = 63(%) or rounds to 63.0(%) award 3 marks Moles of $C_{12}H_{26} = 1.5 \times 10^6 / 170 (=8.824 \times 10^3) \checkmark$ Expected yield of $C_6H_{12} = 8.824 \times 10^3 \times 86 (=7.589 \times 10^5 \text{g or } 758.9 \text{ kg}) \checkmark$ % yield = $478 \times 100 / 758.9 = 63.0(\%)$ (2 or more sf) $\checkmark$	3	ALLOW alternative method: Moles of hexane = $478000 / 86 = (5.558 \times 10^3) \checkmark$ % yield = $5.558 \times 10^3 \times 100 / 8.824 \times 10^3 = 63.0 \checkmark$ A correctly rounded answer to 1sf scores 1 If units incorrectly converted ALLOW ECF for second mark
	(b)	(i)	Set up: burning fuel under a container of water OR measure the temperature <u>increase</u> of water $\checkmark$	1	
		(ii)	Find energy transferred to water using $Q = mc\Delta T$. AND Find energy that would be transferred per mole of fuel. $\checkmark$	1	Must make a comment about how the moles are obtained (i.e. using the mass of fuel burnt)
		(iii)	Any two from: Have a lid on the container of water to reduce heat loss/stop water evaporating $\checkmark$ Use draught excluders OR insulate sides of calorimeter $\checkmark$ Allow enough air/oxygen to reach flame to minimise incomplete combustion OR Move burner closer to calorimeter $\checkmark$ Cover the wick of the burner when it is not in use to reduce evaporation of the fuel $\checkmark$ Use a bomb calorimeter $\checkmark$ Use copper calorimeter instead of beaker $\checkmark$ Make sure thermometer is not in contact with bottom of beaker $\checkmark$ Stir to improve heat distribution $\checkmark$	2	ALLOW well ventilated
	(c)		FIRST CHECK THE ANSWER ON THE ANSWER LINE If answer = -4161 (kJ mol⁻¹) award 2 marks	2	ALLOW ECF from incorrect cycle as long as some working is shown

Question	Answer	Marks	Guidance
	$\Delta_c H^\ominus$ hexane = $(6 \times -393) + (7 \times -286) - (-199)$ (expression must be correct) OR shown on an appropriate cycle ✓ $-4161 \text{ (kJ mol}^{-1}\text{)}$ ✓		ALLOW -4160 (3sf based on question data) $2358 + 2002 - -199 = -4161$ -480 and a cycle scores 1 (+) 4161 scores 1
(d)	 ✓ ^{13}C spectrum has only 2 peaks so only 2 carbon environments ✓	2	ALLOW OH
(e)	Acidified potassium/sodium dichromate AND heat/high temperature ✓	1	IGNORE reflux or distil IGNORE dichromate or $\text{Cr}_2\text{O}_7^{2-}$ alone
(f)	 Dipole ✓, both curly arrows ✓ intermediate and curly arrow and product ✓ Nucleophilic addition ✓	4	Curly arrow on carbonyl must start at double bond and end on oxygen atom. Other curly arrows must start either at lone pair or negative charge and point either to atom attacked or bond between atoms. ALLOW dipole and movement of electrons to O for 1 mark, then C^+ intermediate and attack by CN for the second mark Intermediate and final product must have correct bonds (i.e. not through the N atom)
(g)	Please refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question. Level 3 (5–6 marks) Deduces correct structure with detailed evidence referring to all	6	Indicative scientific points may include: Infrared spectrum: C=O as strong absorbance at approx 1750 cm^{-1} No O-H from carboxylic acid or alcohol

Question	Answer	Marks	Guidance
	three spectra. <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Deduces correct structure using some evidence. OR Deduces compound A is an ester with evidence from at least two spectra. OR Gives detailed analysis of three spectra while failing to determine the structure of compound A. <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i> Level 1 (1–2 marks) Gives some evidence from two spectra. <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> 0 marks No response or no response worthy of credit		C-H at approx. 2950 cm⁻¹ possibly ester NMR: 5 proton environments as 5 peaks δ = 0.9, 1.1, 1.6 H-CR. δ = 2.3 HC-C=O δ = 4.0 HC-O Splitting: 0.9, 1.1 and 4.0 triplets so 2 protons attached to adjacent C/ CH₃-CH₂ 2.3 quartet so 3 protons attached to adjacent C/ CH₂-CH₃ 1.6 multiplet, several protons attached to adjacent C, possibly CH₃CH₂CH₂ Mass Spectrum: Mol mass is 116 Extra detail Sensible discussion of at least 1 fragment e.g. peak at 87 loss of CH₃CH₂ or peak at 73 loss of CH₃CH₂CH₂ or peak at 57 due to CH₃CH₂C=O⁺ OR 116 – 6C = 44 (2O) possibly ester Structure is $ \begin{array}{c} \text{H} & \text{H} & & \text{O} & & \text{H} & \text{H} & \text{H} \\ & & & & & & & \\ \text{H}-\text{C}-\text{C}-\text{C} & - & \text{O}- & \text{C}- & \text{C}- & \text{C}- & \text{H} \\ & & & & & & \\ \text{H} & \text{H} & & & \text{H} & \text{H} & \text{H} \end{array} $
	Total	22	

Question			Answer	Marks	Guidance
32	(a)		The 3D shape OR the shape produced by the folding of the protein molecule ✓	1	
	(b)		Any two from: ✓ Instantaneous dipole-induced dipole hydrogen bonds ionic bonds covalent bonds	1	IGNORE specific groups mentioned after bond types.
	(c)	(i)	 All required ✓	1	ALLOW C or CH ringed Extra carbons ringed are CON
		(ii)	 ✓✓✓✓ one for each	4	ALLOW ECF if all the NH_3^+ groups are not protonated IGNORE Cl^- ions. IGNORE number of moles of aminoethanoic acid. Structures with deprotonated carboxylate groups score 0 (no ECF) Extra incorrect structures CON a correct one

Question	Answer	Marks	Guidance
(d)	<i>Please refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question.</i> Level 3 (5–6 marks) Gives a clear and detailed account of all three parts, including most of the points listed. <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Gives an outline account of all three parts OR gives a detailed account of two parts. <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i> Level 1 (1–2 marks) Makes some relevant points <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> 0 marks No response or no response worthy of credit	6	Indicative scientific points may include: Developing • spray with ninhydrin ALLOW UV light • dry (in an oven/ fume cupboard) Chromatogram • Start line • Starting dot of hydrolysate OR Dots of suspected hydrolysis products for reference • (four spots above) • Spots level with suspected hydrolysis products • Mark position of solvent front • Lid • Stop when solvent gets near the top of the paper Analysis • Measure R_f values of spots • R_f = distance moved by spot/distance moved by solvent front • Look up R_f values for the three amino acids • Compare with measured values OR Compare R_f values with reference amino acids IGNORE use of tlc plate instead of paper
	Total	13	

Question			Answer	Marks	Guidance									
33	(a)	(i)	NaOH(aq) AND (Heat under) Reflux ✓	1	ALLOW warm for reflux									
		(ii)	Acidify (until neutral) ✓ Filter off C OR evaporate to give C ✓	2	ALLOW any dilute named acid .									
		(iii)		1	ALLOW any unambiguous representation ALLOW C ₁₅ H ₂₂ O ₃ N ₂ if both shown an incorrect formula CONs a correct structure or vice versa									
	(b)		<table><tr><th>Monomer</th><th>Repeat unit</th><th>Type of polymerisation</th></tr><tr><td>CH₂CHN(C₂H₅)₂</td><td></td><td>Addition</td></tr><tr><td></td><td></td><td>Condensation</td></tr></table> Completely correct – 2 marks; 1 mark for a correct row or column	Monomer	Repeat unit	Type of polymerisation	CH ₂ CHN(C ₂ H ₅) ₂		Addition			Condensation	2	ALLOW any unambiguous representation.
Monomer	Repeat unit	Type of polymerisation												
CH ₂ CHN(C ₂ H ₅) ₂		Addition												
		Condensation												
			Total	6										

Question			Answer	Marks	Guidance
34	(a)		Diagram AND unpaired electron✓	1	Incorrect structure scores 0
	(b)	(i)	A radical is used and produced (to continue the reaction)✓	1	ALLOW there is a radical on both sides of the equation (AW)
		(ii)	$\text{CO} + 2\text{O}_2 \rightarrow \text{O}_3 + \text{CO}_2$ ✓	1	IGNORE $h\nu$ Non reacting species shown on both sides are CON
	(c)		Frequency to break C—Cl is $346000 / (6.02 \times 10^{23} \times 6.63 \times 10^{-34}) = 8.67 \times 10^{14} \text{ Hz}$ ✓ Frequency to break C—F is $467000 / (6.02 \times 10^{23} \times 6.63 \times 10^{-34}) = 11.7 \times 10^{14} \text{ Hz}$ ✓ C—Cl is broken, but UV absorbed is not of a harmful frequency AND C-F is broken and harmful UV absorbed. (AW) ✓ OR CFC-12 absorbs at both ends of the harmful range of radiation but not in the middle (AW) ✓	3	ALLOW ECF if kJ not turned into J or if Avogadro's constant is omitted. ALLOW a correct calculation of the bond energy needed to absorb $14.0 \times 10^{14} = 559 \text{ kJ mol}^{-1}$ and $10.1 \times 10^{14} = 403 \text{ kJ mol}^{-1}$ for marks 1 or 2 ALLOW a correct calculation of energy ($h\nu$) of UV light and then comparison with energy per bond (J/N_A) for C-Cl and C-F for marks 1 and 2. $E (10.1 \times 10^{14}) = 6.70 \times 10^{-19}$, $E (14.0 \times 10^{14}) = 9.28 \times 10^{-19}$ $E (\text{C-Cl}) = 5.75 \times 10^{-19}$ $E (\text{C-F}) = 7.76 \times 10^{-19}$ ALLOW 1 mark for a correctly calculated frequency based on the sum of the bond enthalpies ALLOW correct comment based on incorrectly calculated frequencies ALLOW CFC-12 breaks down (AW) or both bonds break if incorrect calculation supports the statement.
			Total	6	

Question			Answer	Marks	Guidance
35	(a)		Dissolve bolt in warm sulfuric acid ✓ Transfer to 1 dm ³ <u>volumetric</u> flask, (transfer washings) and make up to the mark (AW) ✓	2	Conc sulfuric acid is CON
	(b)		FIRST CHECK THE ANSWER ON THE ANSWER LINE If answer = 45.6 or rounds to 46 (g) award 3 marks Moles of MnO ₄ ⁻ not needed by the rusty nail = (0.01792 - 0.00975) × 0.2 (= 1.634 × 10 ⁻³) ✓ Moles of Iron rusted in 10cm ³ solution = 5 × 1.634 × 10 ⁻³ (= 8.17 × 10 ⁻³) ✓ In 1dm ³ mass = 0.817 × 55.8 = 45.6(g) ✓	3	ALLOW 2 or more sf ALLOW ECF between steps An answer rounding to 0.46 scores 2 (omission of the factor of 100 from 10 cm ³ to 1000cm ³)
	(c)	(i)	O ₂ + 2H ₂ O + 4e ⁻ → 4OH ⁻ ✓ Fe → Fe ²⁺ + 2 e ⁻ OR Fe - 2e ⁻ → Fe ²⁺ ✓	2	ALLOW halved ALLOW reversible reactions shown either direction Extra half equations beyond 2 CONs 1 mark each
		(ii)	Green solid is Fe(OH) ₂ AND orange solid is Fe ₂ O ₃ .(xH ₂ O) ✓	1	ALLOW Fe(OH) ₃ , [Fe(OH) ₂ (H ₂ O) ₄], [Fe(OH) ₃ (H ₂ O) ₃]
		(iii)	(Faster in salt water as) more (dissolved) ions (make it a better conductor) ✓ More OH ⁻ ions is CON	1	ALLOW '(water acts as a) 'salt bridge' and sea water contains a higher concentration of ions' ALLOW (the salt) acts as an electrolyte
	(d)		Fe ²⁺ 1s ² 2s ² 2p ⁶ 3s ² 3p ⁶ 3d ⁶ ✓	1	IGNORE 4s ⁰ IGNORE working elsewhere. No of electrons in orbitals must be superscripts NOT [Ar]...
	(e)		Ni(/Ni ²⁺) electrode potential is more negative than H ₂ (H ⁺) AND thus H ⁺ can oxidise Ni to Ni ²⁺ (ORA) ✓ Cu(/Cu ²⁺) electrode potential is more positive than H ₂ (H ⁺) so H ⁺ cannot oxidise Cu to Cu ²⁺ (ORA) ✓	2	ALLOW answers in terms of electron flow instead of oxidation We need a comment about each metal in relation to hydrog
	(f)	(i)	Reaction is ligand substitution/exchange AND new ligand splits the d-orbitals differently ✓	1	ALLOW new complex ion has a different colour ALLOW nucleophilic substitution
		(ii)	FIRST CHECK THE ANSWER ON THE ANSWER LINE If answer = [Ni(EDTA)]²⁻ award 2 marks	2	DO NOT ALLOW charges inside brackets

Question			Answer	Marks	Guidance
			Moles of $\text{Ni}^{2+} = 0.025 \times 0.25 = 6.25 \times 10^{-3}$ AND Moles EDTA = $0.0417 \times 0.15 = 6.26 \times 10^{-3}$ ✓ Ratio is 1:1 so formula is $[\text{Ni}(\text{EDTA})]^{2-}$ ✓		
			Total	15	

Question			Answer	Marks	Guidance
36	(a)		Triple bond between N atoms requires a lot of energy to break (AW) /has a high bond enthalpy ✓	1	IGNORE very strong
	(b)	(i)	$\Delta S = (3 \times 130.6) + 197.6 - (186.2 + 189.0)$ Correct Expression evaluated with sign = +214.2 ✓	1	Sign must be included
		(ii)	Increase in entropy/positive as there are more molecules of products/gas ✓	1	NOT comments inconsistent with sign of ΔS calculated
	(c)		FIRST CHECK THE ANSWER ON THE ANSWER LINE If answer = 962 (K) award 2 marks $T = 206000/214.2$ ✓ Evaluated to 3sf =962 (K) ✓	2	ALLOW ECF from (b)(i) ALLOW 963 (early rounding of 214.2) for 1 mark
	(d)		CO_2 is used in 36.2 so it removes a greenhouse gas from the atmosphere, (this is greener) ✓ Plus 2 from: ✓ ✓ - Both reactions need high T as both are endothermic but become more feasible at higher T as both have + ΔS, so no difference - Both reactions give a higher yield at lower T - Both need low pressure as 2 moles $\rightarrow$ 4, so no difference 36.2 produces less hydrogen per mole of methane, so less green/ Atom economy is lower in 36.2. (ORA)	3	ALLOW 36.2 requires more energy than 36.1, so less green Comments about 36.2 producing more toxic CO must be qualified (burn off $\rightarrow$ CO_2 or use as fuel) to score. Toxicity alone does not score.

Question			Answer	Marks	Guidance
	(e)		FIRST CHECK ANSWER ON ANSWER LINE If answer= 0.13 units dm⁶ mol⁻² award 3 marks (0.1 moles of N ₂ react so 0.3 moles of H ₂ used and) 0.2 moles NH ₃ form, 0.7 moles H ₂ left ✓ ([NH ₃] ² /[N ₂][H ₂] ³ K _c = 0.2 ² /0.9 x 0.7 ³) evaluated = (0.13) ✓ units dm ⁶ mol ⁻² ✓	3	ALLOW ECF from incorrect concentrations but not from incorrect K _c expression ALLOW 2 or more sf ALLOW mol ⁻² dm ⁶
	(f)	(i)	4NH ₃ + 5O ₂ → 4NO + 6H ₂ O ✓	1	ALLOW multiples, halves
		(ii)	FIRST CHECK ANSWER ON ANSWER LINE If answer = 12 (tonnes) award 4 marks Moles of NH ₄ NO ₃ needed= 25 x 10 ⁶ /80 (=3.125 x 10 ⁵) ✓ Moles of NH ₃ needed to make nitric acid = (100 x 3.125 x 10 ⁵)/77 ✓ Total moles of ammonia = 3.125 x 10 ⁵ + (100 x 3.125 x 10 ⁵)/77 = 7.18 x 10 ⁵ moles ✓ Mass = 7.18 x 10 ⁵ x 17 =1.22 x10 ⁷ g, 12 (tonnes) ✓	4	ALLOW 2 or more sf ALLOW ECF between stages MP1 convert to tonnes and then divide by 80 MP2 x100/77 MP3 Total moles ammonia (to make nitric acid + ammonia needed for salt) MP4 X 17 and evaluation and conversion to tonnes
		(iii)	Add NaOH and Devarda's alloy or Al powder and warm ✓ Test gas with indicator paper/ red litmus/ rod dipped in HCl turns blue/ dense white fumes (due to ammonia) ✓	2	Reagents and heat needed Test and positive result for ammonia needed ALLOW Brown Ring Test (add Fe ₂ SO ₄ solution followed by conc H ₂ SO ₄) – a brown ring forms at the layer interface
			Total	18	

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

OCR Customer Contact Centre

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Telephone: 01223 553998

Facsimile: 01223 552627

Email: general.qualifications@ocr.org.uk

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