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.

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.

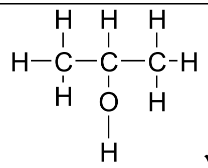
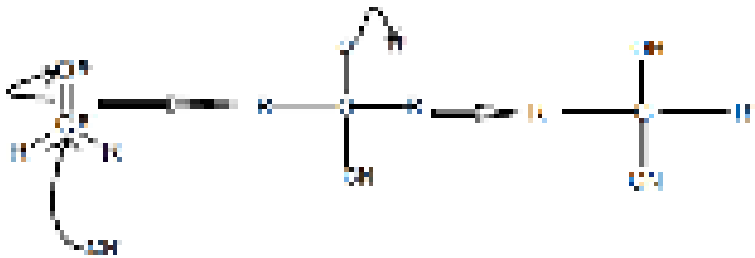
You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New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

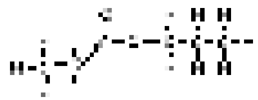
Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader

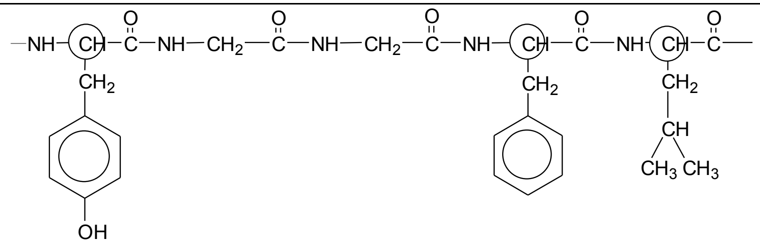
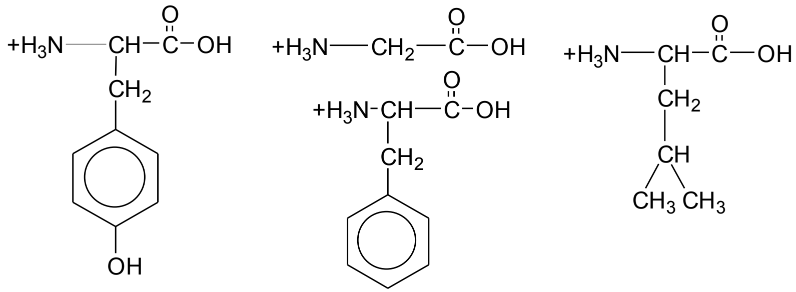
Section A

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 x 10^6/170 (=8.824 x 10^3)✓ Expected yield of C_6H_{12} =8.824 x 10^3 x 86 (=7.589 x10^5g or 758.9 kg)✓ % yield = 478 x100/758.9 = 63.0(%) (2 or more sf)✓	3	**ALLOW** alternative method: Moles of hexane =478000/86 = (5.558 x 10^3) ✓ % yield = 5.558 x 10^3x 100/8.824 x 10^3 = 63.0 ✓ 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 ✓	1	
		(ii)	Find energy transferred to water using Q= mcΔT. **AND** Find energy that would be transferred per mole of fuel. ✓	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 ✓ Use draught excluders **OR** insulate sides of calorimeter ✓ Allow enough air/oxygen to reach flame to minimise incomplete combustion **OR** Move burner closer to calorimeter ✓ Cover the wick of the burner when it is not in use to reduce evaporation of the fuel ✓ Use a bomb calorimeter ✓ Use copper calorimeter instead of beaker ✓ Make sure thermometer is not in contact with bottom of beaker ✓ Stir to improve heat distribution ✓	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
			$\Delta_cH^{\ominus}$ hexane = (6 x -393) + (7 x -286) – (-199) (expression must be correct) **OR** shown on an appropriate cycle ✓ – 4161 (kJ mol^{-1}) ✓		**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 $Cr_2O_7^{2-}$ 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. *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)** 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. *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 some evidence from two spectra. *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		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/ CH_3-CH_2 2.3 quartet so 3 protons attached to adjacent C/ CH_2-CH_3 1.6 multiplet, several protons attached to adjacent C, possibly $CH_3CH_2CH_2$ **Mass Spectrum:** Mol mass is 116 **Extra detail** Sensible discussion of at least 1 fragment e.g. peak at 87 loss of CH_3CH_2 or peak at 73 loss of $CH_3CH_2CH_2$ or peak at 57 due to $CH_3CH_2C{=}O^+$ **OR** 116 – 6C = 44 (2O) possibly ester Structure is 
			Total	**22**	

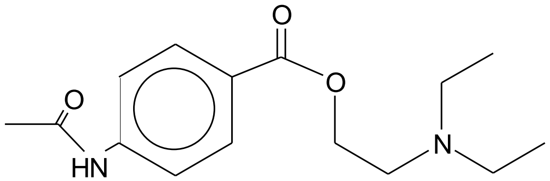
Question			Answer	Marks	Guidance
32	(a)		The 3D shape **OR** the shape produced by the folding of the protein molecule ✓	1	
	(b)		**Any two from:** ✓ Instantaneous dipole-induced dipole hydrogen bonds ionic bonds covalent bonds	1	**IGNORE** specific groups mentioned after bond types.
	(c)	(i)	 All required ✓	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

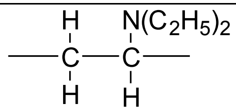
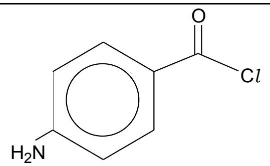
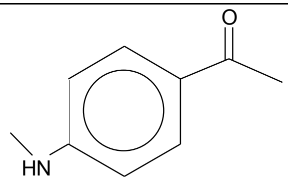
	(d)		*Please refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question.*
			
			Level 3 (5–6 marks)
			Gives a clear and detailed account of all three parts, including most of the points listed.
			
			There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.
			
			Level 2 (3–4 marks)
			Gives an outline account of all three parts **OR** gives a detailed account of two parts.
			
			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)
			Makes some relevant points
			
			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	**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 Rf values of spots
					• Rf = distance moved by spot/distance moved by solvent front
					• Look up Rf 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	

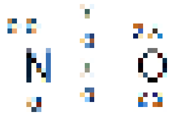
<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>33</td><td>(a)</td><td>(i)</td><td>NaOH(aq) AND (Heat under) Reflux ✓</td><td>1</td><td>ALLOW warm for reflux</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>Acidify (until neutral) ✓

Filter off C
OR
evaporate to give C ✓</td><td>2</td><td>ALLOW any dilute named acid
.</td></tr>
<tr><td></td><td></td><td>(iii)</td><td> ✓</td><td>1</td><td>ALLOW any unambiguous representation

ALLOW $C_{15}H_{22}O_3N_2$

if both shown an incorrect formula CONs a correct structure or vice versa</td></tr>
<tr><td></td><td>(b)</td><td></td><td>
<table>
<tr><th>Monomer</th><th>Repeat unit</th><th>Type of polymerisation</th></tr>
<tr><td>$CH_2CHN(C_2H_5)_2$</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</td><td>2</td><td>ALLOW any unambiguous representation.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>6</td><td></td></tr>
</table>

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)	$CO + 2O_2 \rightarrow O_3 + CO_2$ ✓	1	**IGNORE** h*v* Non reacting species shown on both sides are **CON**
	(c)		Frequency to break C—C*l* is 346000/ ($6.02 \times 10^{23} \times 6.63 \times 10^{-34}$) = 8.67×10^{14} Hz ✓ Frequency to break C—F is 467000/ ($6.02 \times 10^{23} \times 6.63 \times 10^{-34}$) =$11.7 \times 10^{14}$ 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 14.0×10^{14} = 559 $kJmol^{-1}$ and 10.1×10^{14} = 403 $kJmol^{-1}$ for marks 1 or 2 **ALLOW** a correct calculation of energy (h*v*) 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 (10.1×10^{14}) = 6.70×10^{-19}, E (14.0×10^{14}) = 9.28×10^{-19} E (C-Cl) = 5.75×10^{-19} E (C-F) = 7.76×10^{-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) x 0.2 (= 1.634 x 10^{-3}) ✓ Moles of Iron rusted in 10cm^3 solution =5 x 1.634 x 10^{-3} (=8.17 x10^{-3}) ✓ In 1dm^3 mass = 0.817 x 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)	$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$ ✓ $Fe \rightarrow Fe^{2+} + 2e^-$ **OR** $Fe - 2e^- \rightarrow Fe^{2+}$ ✓	2	**ALLOW** halved **ALLOW** reversible reactions shown either direction Extra half equations beyond 2 **CON**s 1 mark each
		(ii)	Green solid is $Fe(OH)_2$ **AND** orange solid is $Fe_2O_3(.xH_2O)$✓	1	**ALLOW** $Fe(OH)_3$,$[Fe(OH)_2(H_2O)_4]$,$[Fe(OH)_3(H_2O)_3]$
		(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+} $1s^22s^22p^63s^23p^63d^6$ ✓	1	**IGNORE** $4s^o$ **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 Ni^{2+} =0.025 x 0.25 = 6.25 x10^{-3} **AND** Moles EDTA = 0.0417 x 0.15 = 6.26 x 10^{-3} ✓ Ratio is 1:1 so formula is $[Ni(EDTA)]^{2-}$ ✓		
			Total	**15**	

Question			Answer	Marks	Guidance
36	(a)		<u>Triple</u> bond between N atoms requires a lot of energy to break (AW) /has a high bond enthalpy ✓	1	**IGNORE** very strong
	(b)	(i)	ΔS= (3 x 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 → 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 → 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 $dm^6\ mol^{-2}$ 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 ✓ ($[NH_3]^2/[N_2][H_2]^3$ $K_c = 0.2^2/0.9 \times 0.7^3$) 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)	$\mathbf{4}NH_3 + \mathbf{5}O_2 \rightarrow \mathbf{4}NO + \mathbf{6}H_2O$ ✓	1	**ALLOW** multiples, halves
		(ii)	**FIRST CHECK ANSWER ON ANSWER LINE** **If answer = 12 (tonnes) award 4 marks** Moles of NH_4NO_3 needed= $25 \times 10^6/80$ (=3.125×10^5) ✓ Moles of NH_3 needed to make nitric acid = ($100 \times 3.125 \times 10^5$)/77 ✓ Total moles of ammonia = 3.125×10^5+ ($100 \times 3.125 \times 10^5$)/77 = 7.18×10^5 moles ✓ Mass = $7.18 \times 10^5 \times 17 = 1.22 \times 10^7$ 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_2SO_4 solution followed by conc H_2SO_4) – a brown ring forms at the layer interface
			Total	**18**	

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