

GCE















Chemistry B

H433/01: Fundamentals of chemistry

Advanced GCE

Mark Scheme for Autumn 2021

1. Annotations

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

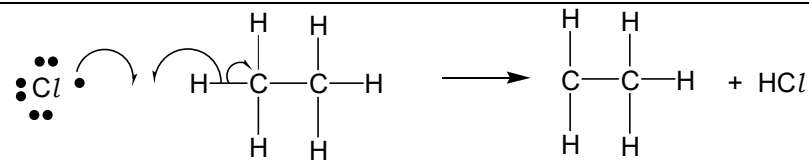
2. Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

Annotation	Meaning
/	alternative and acceptable answers for the same marking point
✓	Separates marking points
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

Section A

Q	Key	Mark	AO
1	D	1	1.1
2	B	1	1.2
3	A	1	1.2
4	B	1	1.2
5	A	1	1.2
6	D	1	1.2
7	A	1	1.2
8	B	1	1.1
9	A	1	2.2
10	C	1	1.1
11	B	1	1.1
12	D	1	1.1
13	C	1	1.1
14	C	1	2.8
15	D	1	2.7
16	A	1	1.2
17	A	1	2.4
18	D	1	2.5
19	D	1	2.1
20	C	1	2.8
21	A	1	2.6
22	B	1	1.2
23	C	1	2.2
24	C	1	2.3
25	C	1	2.8
26	B	1	1.2
27	A	1	1.2
28	C	1	1.1
29	B	1	1.1
30	D	1	1.1

Question		Answer	Mark	AO	Guidance	
31	a	$\left[\begin{array}{c} \text{H} \\ \text{H}:\text{N}:\text{H} \\ \text{H} \end{array} \right]^+$ ✓	1	1.1	IGNORE brackets	
31	b	i	(Warm with) sodium hydroxide AND gas/ammonia/fumes turns indicator paper/red litmus paper blue ✓	1	1.2	
31	b	ii	NH_4^+ -3 ✓ NO_3^- , +5 ✓	2	2.6 x 2	Must have the sign
31	b	iii	$\text{NH}_4^+ + 2\text{O}_2 \rightarrow \text{NO}_3^- + \text{H}_2\text{O} + 2\text{H}^+$ ✓	1	2.6	ALLOW multiples
31	b	iv	(colourless gas turns to) a brown gas ✓	1	1.2	
31	c	i	(Ba ions are) Ba^{2+} and (sulfate is) SO_4^{2-} OR both ions have same/2 charge ✓	1	1.2	
31	c	ii	CHECK ANSWER LINE If answer = 62.2% award 5 marks (Moles of Ba^{2+} = moles of SO_4^{2-} in $25 \text{ cm}^3 = 0.0155 \times 0.2$) $= 3.1 \times 10^{-3}$ ✓ Moles of Ba^{2+} = moles of SO_4^{2-} stated or implied AND moles of SO_4^{2-} in $0.250 \text{ dm}^3 = 0.031$ moles ✓ Mass ammonium sulfate = $0.031 \times 132.1 (= 4.0951)$ ✓ % ammonium sulfate is $4.0951/6.58 \times 100 = 62.2\%$ (to any sf) ✓ 62.2% (3sf) ✓	5	2.4 x 4 3.1	ECF throughout ALLOW any calculated answer to 3 sf for last MPt.
31	c	iii	CHECK ANSWER LINE If answer = $2.4(38) \times 10^{17}$ award 3 marks $[\text{SO}_4^{2-}] = \sqrt{(1 \times 10^{-10})} = (1 \times 10^{-5})$ in 1 dm^3 ✓ No of moles of in $40.5 \text{ cm}^3 = (0.0405 \times 1 \times 10^{-5})$ $= 4.05 \times 10^{-7}$ ✓ No of ions = $(4.05 \times 10^{-7} \times 6.02 \times 10^{23}) = 2.4(38) \times 10^{17}$ ✓	3	2.2 x 3	6.02×10^{18} scores 2 ALLOW a calculated value x 6.02×10^{23} correctly evaluated for last point.
			15			

Question			Answer	Mark	AO	Guidance
32	a		 <p>Half-headed arrows as shown ✓ HCl and ethyl radical product ✓</p>	2	2.1 x 2	ALLOW absence of right-hand arrow to match text-book page 207.
32	b	i	$\text{CH}_3\text{CH}_2\text{Cl} + \text{NH}_3 \rightarrow \text{CH}_3\text{CH}_2\text{NH}_2 + \text{HCl}$ ✓	1	1.1	ALLOW any unambiguous structures or molecular formulae.
32	b	ii	Nucleophilic ✓ Substitution ✓	2	1.1 x 2	
32	c	i	White AND (pale) yellow ✓	1	1.1	
32	c	ii	$\text{C}_2\text{H}_5\text{I} + \text{H}_2\text{O} \rightarrow \text{C}_2\text{H}_5\text{OH} + \text{HI}$ ✓ $\text{Ag}^+ + \text{I}^- \rightarrow \text{AgI}$ ✓	2	2.7 1.1	IGNORE state symbols ALLOW $\text{H}^+ + \text{I}^-$ for HI ALLOW other equations forming AgI such as: $\text{AgNO}_3 + \text{HI} \rightarrow \text{AgI} + \text{HNO}_3$
32	c	iii	C-Cl is more polar than C-I ✓ Bond strength more important and C-I bond is weaker than C-Cl AW ✓ (ppt forms) faster with iodoethane ✓	3	3.1 x 3	Mark independently ORA throughout
32	d	i	1,1,1-trichloroethane ✓	1	1.1	IGNORE commas and dashes

32	d	ii	<p><i>Refer to marking instructions on page 5 of mark scheme for guidance on marking this question.</i></p> <p>Level 3 (5-6 marks) Correctly identifies the imbs in all three compounds with some explanations AND Explains why fat is most soluble in A in terms of strength of imbs broken and made. <i>There is a well-developed line of reasoning which is clear and logically structured.</i></p> <p>Level 2 (3-4 marks) Makes a reasonable attempt to describe the points in all three sections or detailed description of 2 areas <i>There is a line of reasoning presented with some structure</i></p> <p>Level 1 (1-2 marks) Makes some relevant points but may contain errors. <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant and correct.</i></p> <p>Level 0 (0 marks) No response or nothing worthy of credit.</p>	6	1.1 x 2 2.5 x 2 3.2 x 2	<p>Indicative scientific points include:</p> <p>Strongest type of intermolecular bonds:</p> <ul style="list-style-type: none"> Fats have pd-pd imbs Substance A has pd-pd forces Hexane has only id-id forces. (Polar and non-polar must be correctly linked to imbs) <p>How intermolecular bonds arise:</p> <ul style="list-style-type: none"> Pd-pd form due to differences in atoms' electronegativity in a covalent bond $C^{\delta+}=O^{\delta-}$ and $C^{\delta+}-Cl^{\delta-}$ Causing electrostatic attractions Id-id forces due to uneven distributions of electrons creating temporary dipoles that induce dipoles in adjacent molecules OR Mention of instantaneous dipole-induced dipole forces at least once in full <p>Ability to dissolve fat molecules:</p> <ul style="list-style-type: none"> A substance will dissolve if the strength of intermol bonds broken < intermol bonds made OR energy required to break compared with energy released in making. Fat's pd-pd bonds stronger than id-id bonds with hexane so less soluble. Fat and A form pd-pd forces of comparable strength so soluble.
				18		

Question		Answer	Mark	AO	Guidance	
33	a	Blue/green(white flashes)✓ (Heat energy) excites e ⁻ so they emit light when they fall AW ✓	2	1.2 2.5		
33	b	i	Ammonia acts as a base ✓ NH ₃ + H ₂ O ⇌ NH ₄ ⁺ + OH ⁻ ✓ Pale blue ppt is Cu(OH) ₂ AND Cu ²⁺ + 2OH ⁻ → Cu(OH) ₂ OR Cu ²⁺ (aq) + 2OH ⁻ (aq) → Cu(OH) ₂ (s)✓	3	1.1 2.3 2.3	
33	b	ii	[Cu(NH ₃) ₄ (H ₂ O) ₂ ²⁺]/[NH ₃] ⁴ [Cu(H ₂ O) ₆ ²⁺] ✓ Units: dm ¹² mol ⁻⁴ ✓	2	2.1	ALLOW as shown without multiple square brackets. IGNORE state symbols, charges on ions must be present. ALLOW mol ⁻⁴ dm ¹² ALLOW units matching incorrect expression of K _c
33	b	iii	CHECK ANSWER ON ANSWER LINE If K_c = 1(.0) x 10¹³ award 3 marks Moles Cu ²⁺ at eqm (= 0.022 - 0.02) = 0.002.✓ Moles of ammonia at eqm (= 0.081 - (4 x 0.02))= 0.001✓ K _c = (0.02/(0.001 ⁴ x 0.002)) = 1.0 x 10 ¹³ ✓	3	3 x 2.8	ALLOW ecf from first two mpts and (b)(ii) . INGORE units

33	b	iv	<p>Refer to marking instructions on page 5 of mark scheme for guidance on marking this question.</p> <p>Level 3 (5-6 marks) There is a clear outline of the experiment which includes detailed descriptions of most points in each section and which would produce valid results. <i>There is a well-developed line of reasoning which is clear and logically structured.</i></p> <p>Level 2 (3-4 marks) Most of the experimental details are described and there is reference to all three sections or two in detail. <i>There is a line of reasoning presented with some structure</i></p> <p>Level 1 (1-2 marks) Some details are described, but one of the sections may be omitted. <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant and correct.</i></p> <p>Level 0 (0 marks) No response or nothing worthy of credit.</p>	6	1.2 x4 3.3 3.4	<p>Indicative scientific points include:</p> <p>Setting up colorimeter:</p> <ul style="list-style-type: none"> Select a filter Orange filter/ complementary colour/ filter with greatest absorbance Zero with a cuvette of distilled water. <p>Calibration:</p> <ul style="list-style-type: none"> Make up set of solutions of the complex of known concentration. AO 3.3 calc of mass to produce conc $\geq 0.02M$ Use concentrations more and less concentrated than the unknown (details of dilution to get the concs). AO3.4 Measure absorbance of the solutions. AO1.2 Plot a graph of concentration against absorbance. AO1.2 Draw a line of best fit. <p>Measuring the concentration of the unknown sample: AO1.2</p> <ul style="list-style-type: none"> Place cuvette of sample in the machine Record absorbance Use the graph to read concentration of that absorbance <p>Calibration and measuring may be from a diagram. ALLOW % transmittance for absorbance.</p>
33	c	i	Bidentate ✓	1	1.1	ALLOW polydentate ✓.
	c	ii	6 ✓ octahedral ✓ 90° ✓	3	1.1 x 3	Mark independently
33	d		<p>Conc $H_2N CH_2CH_2NH_2 = 4.5/60 = 0.075 \text{ mol dm}^{-3}$ ✓</p> <p>Amt $H_2N CH_2CH_2NH_2$ in $20 \text{ cm}^3 = 1.5 \times 10^{-3} \text{ mol}$ ✓</p> <p>Amt $Cu^{2+} = 7.5 \times 10^{-4} \text{ mol}$ ✓</p> <p>Ratio 2:1 so formula is $[Cu(H_2N CH_2CH_2NH_2)_2]^{2+}$ ✓</p>	4	2.8	<p>ALLOW alternative method involving ratios for MP2 and 3</p> <p>$H_2N CH_2CH_2NH_2 : Cu^{2+} = 20 \times 0.075 : 15 \times 0.05$</p> <p>multiples or any correct ratio ✓</p> <p>1.5:0.75 ✓</p>
				24		

Question			Answer	Mark	AO	Guidance
34	a	i	Condensation ✓	1	1.1	ALLOW acylation
34	a	ii	(Secondary) amide/ peptide ✓	1	1.1	Primary or tertiary are CON
34	b		HCl ✓	1	1.1	
34	c		products are: $\text{NH}_3^+\text{CH}(\text{CH}_3)\text{COOH}$ ✓✓, (one mark if NH_2 not protonated) $\text{C}_2\text{H}_5\text{OH}$ ✓ $\text{CH}_3\text{CH}_2\text{COOH}$ ✓	4	3.1 x 4	NOT names NOT $-\text{NH}_3$ without a charge
34	d		ANY THREE FROM Select a solvent in which the product is much more soluble at high temperature ✓ Dissolve solid in minimum volume of hot solvent ✓ Filter when hot to remove insoluble impurities ✓ then cool and collect purer solid by filtration ✓	3	1.2 x 3	
34	e	i	SOCl_2 ✓	1	2.5	
	e	ii	The product molecules have functional groups on both ends so reactions can continue AW ✓	1	3.2	
				12		

Question			Answer	Mark	AO	Guidance
35	a	i	Rate is not proportional to concentration AW ✓	1	3.1	ALLOW numerical examples
35	a	ii	Scales and labels on axes, must take up half the graph paper ✓ Correct calculation of squares ✓ Plotting of points on a correct numerical scale and line of best fit ✓	3	2.6 x 3	look for values on the table for this marking point can be subsumed by correct numbers on x-axis ALLOW MP1 and 3 as ECF if conc not squared or rate squared.
35	a	iii	Rate = $k \times [\text{N}_2\text{O}]^2$ ✓	1	2.6	
35	a	iv	Evidence of use of graph to find gradient (lines on graph or working consistent with the graph) ✓ An answer that rounds to 4×10^4 ✓ Units $\text{dm}^3\text{mol}^{-1} \text{s}^{-1}$ ✓	3	2.2.x 3	ALLOW 2.5×10^{-5} as ECF if axes reversed in (a)(ii). No other ECF
35	b	i	Zero order ✓ Constant gradient so rate is constant AW ✓	2	3.2 x 2	
35	b	ii	The surface of the catalyst is completely covered so adding more gas doesn't increase the rate. AW ✓	1	3.1	
				11		

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