

GCE

Chemistry B

H033/02: Chemistry in depth

Advanced Subsidiary GCE

Mark Scheme for November 2020

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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.

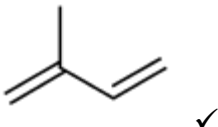
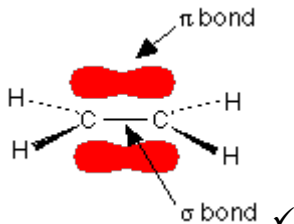
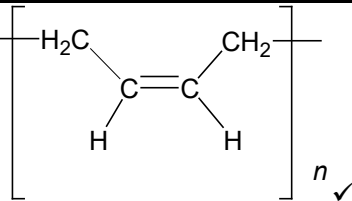
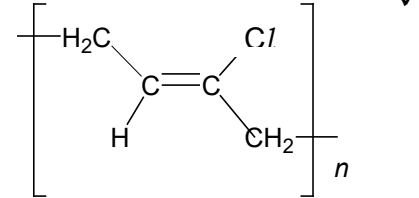
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Annotations

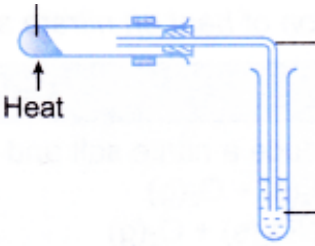
Annotation	Meaning
	Correct response
	Incorrect response
	Omission mark
	Benefit of doubt given
	Contradiction
	Rounding error
	Error in number of significant figures
	Error carried forward
	Level 1
	Level 2
	Level 3
	Benefit of doubt not given
	Noted but no credit given
	Ignore

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

Question			Answer	Mark	AO element	Guidance
1	(a)			1	2.1	ALLOW other correct representations.
1	(b)	(i)		1	1.1	Labelling of π -bond not essential for mark Precise shape of π -bond not essential, though must be both above and below labelled σ -bond ALLOW , for example, the following shape (filled or open) 
1	(b)	(ii)	(It represents) a bond (in a direction) in front of (the plane of) the paper ✓	1	1.1	ALLOW (coming) out of (the plane of) the paper
1	(c)	(i)		1	2.1	ALLOW CH instead of the displayed C-H bonds ALLOW CHCH for double bond ALLOW without bracket and/or n
1	(c)	(ii)		1	2.1	ALLOW other correct representations. ALLOW without bracket and/or n
	(c)	(iii)	Each carbon atom of the double bond has got two different groups attached ✓	2	1.1 x2	

Question			Answer	Mark	AO element	Guidance
			There is no (free) rotation about a carbon-carbon double bond ✓			
1	(d)	(i)	Electrophilic Addition ✓	1	1.1	
1	(d)	(ii)	$\text{CH}_2=\text{CHCH}=\text{CH}_2 + \text{H}-\text{Br} \rightarrow \text{CH}_2=\text{CHCH}^+\text{CH}_3 + \text{Br}^-$ $\delta+ \quad \delta-$ $\text{CH}_2=\text{CHCH}^+\text{CH}_3 + \text{Br}^- \rightarrow \text{CH}_2=\text{CHCHBrCH}_3$ both curly arrows in Step 1 ✓ partial and full positive/negative charges shown) ✓ curly arrow in Step 2 ✓	3	1.2 x3	Curly arrows must start (when projected backwards) on the bond concerned OR the minus sign (or a shown lone pair) on the bromide. They must finish (when projected) at the atom concerned or point towards the bond being formed. Product not essential

Question			Answer	Mark	AO element	Guidance
2	(a)		$\text{BaCO}_3(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow \text{BaCl}_2(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$ equation + balancing ✓ states ✓	2	2.2 x2	
2	(b)	(i)	Experimental method (diagram with labels): Heat Group 2 carbonates AND pass gas through lime water. ✓ Valid test: Use same amount/moles of carbonate ✓ Idea of same heating intensity ✓ Observation: It takes longer to go cloudy for BaCO_3 (than CaCO_3) (ORA)/down the Group (AW) ✓	4	1.2 3.3 3.3 2.3	Group 2 carbonate  lime water Heated tube can be at an angle ALLOW white(precipitate)/milky/chalky for cloudy. ALLOW it goes less cloudy for BaCO_3 (than CaCO_3) (ora)/down the Group.
2	(b)	(ii)	(The student is incorrect in that) it is not because the (Group 2) metals become more reactive (going down the Group) ✓ It is because the (Group 2) cations have a <u>lower charge density</u> going down the Group (ORA) ✓ This causes less <u>polarisation/distortion</u> of the carbonate ion AND greater (thermal) stability (ORA) ✓	3	3.1 1.1 1.1	ALLOW it is not to do with the reactivity of the (Group 2) metals ALLOW <u>larger size to charge ratio</u>. going down the Group ALLOW correct reference to specific examples to illustrate these MPs.
2	(c)	(i)	calcium = (brick) red ✓	1	1.2	
2	(c)	(ii)	<u>Black lines</u> AND at the <u>same wavelengths/frequencies</u> as the lines in the atomic emission spectrum ✓	2	2.1 x2	ALLOW "lines in same places" for 'same wavelengths/frequencies'.

Question			Answer	Mark	AO element	Guidance
			on a background of the continuous spectrum/of visible light ✓			ALLOW on a coloured background
2	(c)	(iii)	FIRST CHECK THE ANSWER ON THE ANSWER LINE If answer = 3.21×10^{-22} (kJ) award 3 marks $(\nu = c/\lambda)$ $\nu = (3.00 \times 10^8 / 6.20 \times 10^{-7})$ $= 4.84 \times 10^{14} \text{ Hz} \checkmark$ $(\Delta E = h\nu)$ $\Delta E = (6.63 \times 10^{-34} \times 4.84 \times 10^{14})$ $= 3.21 \times 10^{-19} \text{ J} \checkmark$ $= 3.21 \times 10^{-22} \text{ (Kj)} \checkmark$	3	2.2 x3	ALLOW 2 or more sf
2	(d)	(i)	$(0.06 / 25.0) \times 100$ $= 0.24(\%) \checkmark$	1	2.4	
2	(d)	(ii)	FIRST CHECK THE ANSWER ON THE ANSWER LINE If answer = $1.73 \text{ (g dm}^{-3}\text{)}$ award 4 marks Amount of HCl (in mean titre) = $(11.70 / 1000 \times 0.100)$ $= 1.17 \times 10^{-3} \text{ mol} \checkmark$ Amount of Ca(OH)_2 (in 15.0 cm^3) = $1.17 \times 10^{-3} / 2$ $= 5.85 \times 10^{-4} \text{ mol} \checkmark$ Concentration $\text{Ca(OH)}_2 = (5.85 \times 10^{-4} \times 1000 / 25)$ $= 0.0134 \text{ mol dm}^{-3} \checkmark$ M_r of $\text{Ca(OH)}_2 = 74.1$ Concentration $\text{Ca(OH)}_1 = (0.0134 \times 74.1)$ $= 1.73 \text{ (g dm}^{-3}\text{)} \checkmark$	4	2.8 x4	ALLOW two or more sf

Question			Answer	Mark	AO element	Guidance
2	(e)		The mean titre/it would be greater/larger (than 11.70 cm³). AND Barium hydroxide is more soluble than calcium hydroxide/Solubility increases down Group 2/the Group. ✓	1	3.2	ALLOW (A) <u>saturated</u> (solution of) barium hydroxide has a higher concentration of hydroxide ions than that of calcium hydroxide.

Question			Answer	Mark	AO element	Guidance
3	(a)		Sodium hydroxide reacts with both the phenol and carboxyl (functional) groups to give $\text{NaOC}_6\text{H}_4\text{COONa}$ ✓ sodium carbonate only reacts with the carboxyl (functional) group to give $\text{HOC}_6\text{H}_4\text{COONa}$ ✓ The carboxyl (functional) group is more acidic than the phenol (functional) group ✓	3	3.1 3.1 2.5	ALLOW structures with ionic charges shown. ALLOW structures with benzene rings drawn. ALLOW the (sodium) carbonate is not a strong enough base to remove the hydrogen from the phenol group.
3	(b)	(i)	To prevent loss of reactants/products/mixture (by vaporisation) ✓	1	1.2	
3	(b)	(ii)	FIRST CHECK THE ANSWER ON THE ANSWER LINE If answer = 61 (%) award 3 marks $2.8 / [(3.5 / 138) \times 180] \times 100 = 61(\%)$ $[(3.5 / 138) \times 180]$ ✓ calculation of % ✓ 2 s.f. ✓	3	2.8 x3	61.3(3) DOES NOT score s.f. mark
3	(c)		Ester ✓	1	2.1	
3	(d)		The oxygen atom is more electronegative than the carbon atom AND the carbon to oxygen double bond is polar covalent ✓ pd-pd attractions (between $\text{C}^{\delta+}$ and $\text{O}^{\delta-}$) are strong/ not the strongest imbs ✓ The high melting point is due to the (stronger) <u>hydrogen bonds</u> between the carboxyl groups (in neighbouring molecules) ✓	3	3.1 3.2 x2	

Question			Answer	Mark	AO element	Guidance
3	(e)		(Neutral) iron(III) chloride solution will give a purple colouration with (only) the 4-hydroxybenzoic acid ✓	1	2.7	ALLOW ferric for iron(III)
3	(f)		Dissolve the crude product in the <u>minimum</u> volume of <u>hot ethanol</u> ✓ (Filter to remove insoluble impurities). Allow the hot solution to <u>cool</u> . ✓ <u>Filter</u> to remove recrystallised product. ✓ <u>Wash</u> (the solid with cold solvent) AND <u>dry</u> . ✓	4	1.2 x4	ALLOW 'solvent' for 'ethanol'

Question		Answer	Mark	AO element	Guidance
3	(g)*	<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) Detailed description of how to produce a chromatogram (with some fine detail [italic]). AND Detailed explanation of what the results show. <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) Detailed description of how to produce a chromatogram (with some fine detail [italic]). OR Describe in partial detail how the chromatogram is produced. AND Provide a partial explanation of what the results show. OR Detailed explanation of what the results show. <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) Describe in partial detail how the chromatogram is produced. OR Provide a partial explanation of what the results show.	6	1.2 x3 3.2 x3	<i>Indicative Scientific points include:</i> Description of how the thin-layer chromatogram is produced <i>(fine detail in italic)</i> • Draw a pencil line on tlc plate # • <i>Line must come above solvent level #</i> • Spot mixture and pure samples onto pencil line # • Place plate in a beaker of solvent # • <i>Beaker covered #</i> • Remove plate when solvent front is near to top of plate • <i>Mark how far solvent has reached</i> • Allow plate to dry • Locate any spots • <i>with iodine or under a u.v. lamp</i> (# can be achieved in a labelled diagram) Analysis of results of the experiment • Alkaline results/Fig 3.1 show some breakdown of paraben/4-acetyloxybenzoic acid after 1 week and even more after 1 month * • The amounts/spots of P decreases and B increases between 1 week and 1 month • Acidic results/Fig 3.2 show no breakdown after 1 week and some after 1 month. * • No B was produced after 1 week but amounts/spots of P decreases and B increases slightly between 1 week and 1 month * faster hydrolysis in alkaline than acidic (conditions)

Question			Answer	Mark	AO element	Guidance
			OR Detailed explanation of what the results show. <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 <i>No response or no response worthy of credit.</i>			

Question			Answer	Mark	AO element	Guidance
4	(a)		Thermal decomposition requires heat ✓	1	3.4	ALLOW other reactions may occur
4	(b)		FIRST CHECK THE ANSWER ON THE ANSWER LINE If answer = (+)20.9 (kJ mol⁻¹) award 2 marks $(q = mc\Delta T)$ $q = 50.0 \times 4.18 \times 7.50$ $= 1.567.5 \text{ kJ} \checkmark$ $\Delta H = (+)(1 / 7.50 \times 10^{-2}) \times 1.567.5$ $\Delta H = (+)20.9 \text{ (kJ mol}^{-1}\text{)} \checkmark$	2	2.4 x2	ALLOW 20.9 without plus sign. ALLOW two or more sf Conversion of J to kJ can occur at any time.

Question		Answer	Mark	AO element	Guidance
4	(c)	<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) Detailed description of how to reduce measurement uncertainty AND reduce 'heat losses'. AND some detail for the graphical method. <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) Some description of how to reduce measurement uncertainty AND reduce 'heat losses'. OR Detailed description of how to reduce measurement uncertainty OR 'heat losses' with some reference to the graphical method. <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) Outline description of how to reduce measurement uncertainty. OR Outline description of how to reduce 'heat losses', OR Outline description for the graphical method. <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i>	6	3.3 x3 3.4 x3	<i>Indicative Scientific points include:</i> Making measurement uncertainty smaller • Use a 50.0 cm³ pipette/measuring cylinder • Use a thermometer of greater precision/to the nearest 0.5 or 0.1 °C • Use a balance weighing to 0.01g Making 'heat losses' smaller • Use a polystyrene beaker • lid on beaker (loose fitting – gas is evolved) • Stir throughout Graphical method (points can be achieved in words or by sketching graph) • Continue to record temperature every minute/half minute until temperature starts to fall again • Extrapolate cooling line • Read the theoretical maximum temperature change at the time when the reactants were mixed

Question			Answer	Mark	AO element	Guidance
			0 marks <i>No response or no response worthy of credit.</i>			
4	(d)		FIRST CHECK THE ANSWER ON THE ANSWER LINE If answer = (+)76 (kJ mol⁻¹) award 3 marks $ \begin{array}{ccc} 2\text{NaHCO}_3(\text{s}) & \xrightarrow{\Delta H_1} & \text{Na}_2\text{CO}_3(\text{s}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \\ & \swarrow \quad \searrow & \\ & \begin{array}{cc} + 2\text{HCl} & 2\Delta H_2 \quad \Delta H_3 \quad + 2\text{HCl} \end{array} & \\ & \searrow \quad \swarrow & \\ & 2\text{NaCl}(\text{aq}) + 2\text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) & \end{array} $ ✓ (for Hess' law enthalpy cycle) $\Delta H_1 = 2\Delta H_2 - \Delta H_3$ (for correct relationship between the three ΔH terms) ✓ $\Delta H_1 = 2(+23) - (-30)$ ✓ $\Delta H_1 = (+)76$ (kJ mol ⁻¹) ✓	4	2.4 x4	ALLOW 76 without sign Award the mark for the Hess' law enthalpy cycle separately to the three marks for the calculation. The ΔH values do not need to be included to achieve the mark for the Hess cycle as they occur in MP2. They are left in the cycle here to assist the marker.
4	(e)		FIRST CHECK THE ANSWER ON THE ANSWER LINE If answer = (+)463.5/464 (kJ mol⁻¹) award 2 marks $4\text{O-H} - 1370 = 484$ ✓ $\text{O-H} = + 463.5/464$ (kJ mol ⁻¹) ✓	2	2.2 x2	ALLOW number without sign
4	(f)		NaHCO_3 (and Na_2CO_3) ionic so not all bonds are covalent (AW) ✓	1	3.2	

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