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.

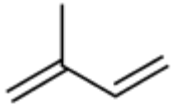
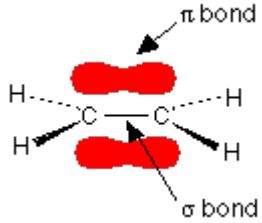
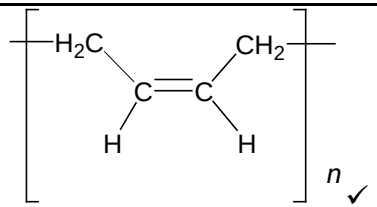
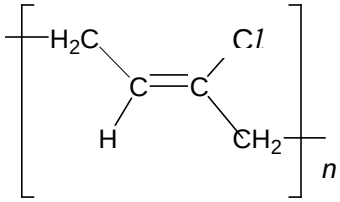
Mark schemes should be read in conjunction with the published question papers and the report on the examination.

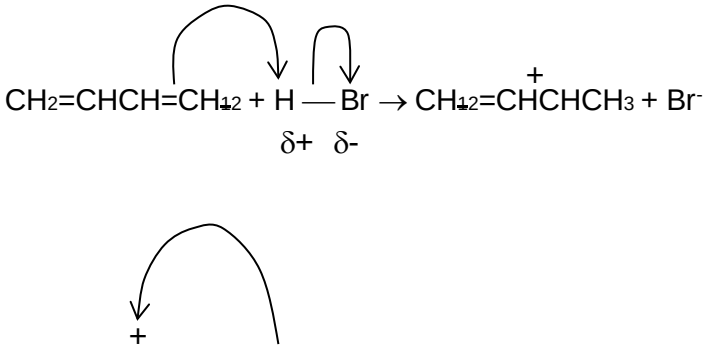
Annotations

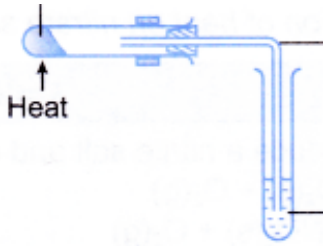
Annotation	Meaning
	Correct response
	Incorrect response
	Omission mark
	Benefit of doubt given
	Contradiction
	Rounding error
	Error in number of significant figures
	Error carried forward
	Level 1
	Level 2
	Level 3
	Benefit of doubt not given
	Noted but no credit given
	Ignore

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)	 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)		$BaCO_3(s) + 2HCl(aq) \rightarrow BaCl_2(aq) + CO_2(g) + H_2O(l)$ 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  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 x 10^{-22} (kJ) award 3 marks** ($\nu = c/\lambda$) $\nu = (3.00 \times 10^{8} / 6.20 \times 10^{-7})$ $= 4.84 \times 10^{14}$ Hz ✓ ($\Delta E = h\nu$) $\Delta E = (6.63 \times 10^{-34} \times 4.84 \times 10^{14})$ $= 3.21 \times 10^{-19}$ J ✓ $= 3.21 \times 10^{-22}$ (Kj) ✓	**3**	**2.2 x3**	**ALLOW** 2 or more sf
2	**(d)**	**(i)**	(0.06 / 25.0) x 100 = 0.24(%) ✓	**1**	**2.4**	
2	**(d)**	**(ii)**	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = 1.73 (g dm^{-3}) award 4 marks** Amount of HCl (in mean titre) = (11.70 / 1000 x 0.100) $= 1.17 \times 10^{-3}$ mol ✓ Amount of $Ca(OH)_2$ (in 15.0 cm^3) = $1.17 \times 10^{-3} / 2$ $= 5.85 \times 10^{-4}$ mol ✓ Concentration $Ca(OH)_2 = (5.85 \times 10^{-4} \times 1000 / 25)$ = 0.0134 mol dm^{-3} ✓ M_r of $Ca(OH)_2$ = 74.1 Concentration $Ca(OH)_1 = (0.0134 \times 74.1)$ = 1.73 (g dm^{-3}) ✓	**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 cm^3). **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 $NaOC_6H_4COONa$ ✓ sodium carbonate only reacts with the carboxyl (functional) group to give HOC_6H_4COONa✓ 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) x 180] x 100 = 61(%) [(3.5 / 138) x 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 $C^{\delta+}$ and $O^{\delta-}$) are strong/ not the strongest imbs ✓ The high melting point is due to the (stronger) hydrogen bonds 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 minimum volume of hot ethanol ✓ (Filter to remove insoluble impurities). Allow the hot solution to cool. ✓ Filter to remove recrystallised product. ✓ Wash (the solid with cold solvent) **AND** dry. ✓	4	1.2 x4	**ALLOW** 'solvent' for 'ethanol'

Question			Answer	Mark	AO element	Guidance
3	(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)** Detailed description of how to produce a chromatogram (with some fine detail [italic]). **AND** Detailed explanation of what the results show. *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)** 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. *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)** 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**	*Indicative Scientific points include:* **Description of how the thin-layer chromatogram is produced** *(fine detail in italic)* • Draw a pencil line on tlc plate # • *Line must come above solvent level* # • Spot mixture and pure samples onto pencil line # • Place plate in a beaker of solvent # • *Beaker covered* # • Remove plate when solvent front is near to top of plate • *Mark how far solvent has reached* • Allow plate to dry • Locate any spots • *with iodine or under a u.v. lamp* (# 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. *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.*			

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** ($q = mc\Delta T$) $q = 50.0 \times 4.18 \times 7.50$ $= 1.567.5$ kJ ✓ $\Delta H = (+)(1 / 7.50 \times 10^{-2}) \times 1.567.5$ $\Delta H = (+)20.9$ (kJ mol^{-1}) ✓	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)		*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)** Detailed description of how to reduce measurement uncertainty **AND** reduce 'heat losses'. **AND** some detail for the graphical method. *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)** 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. *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)** Outline description of how to reduce measurement uncertainty. **OR** Outline description of how to reduce 'heat losses', **OR** Outline description for the graphical method. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.*	6	**3.3 x3** **3.4 x3**	*Indicative Scientific points include:* **Making measurement uncertainty smaller** • Use a 50.0 cm^3 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 *No response or no response worthy of credit.*			
4	**(d)**		**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = (+)76 (kJ mol^{-1}) award 3 marks** $2NaHCO_3(s) \xrightarrow{\Delta H_1} Na_2CO_3(s) + CO_2(g) + H_2O(l)$ $+ 2HCl$ $2\Delta H_2$ ΔH_3 $+ 2HCl$ $2NaCl(aq) + 2CO_2(g) + 2H_2O(l)$ ✓ (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** 4O-H – 1370 = 484 ✓ 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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