



Markscheme

November 2021

Chemistry

Higher level

Paper 2

24 pages

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Subject Details: Chemistry Higher Level Paper 2 Markscheme

Candidates are required to answer **ALL** questions. Maximum total = **[90 marks]**.

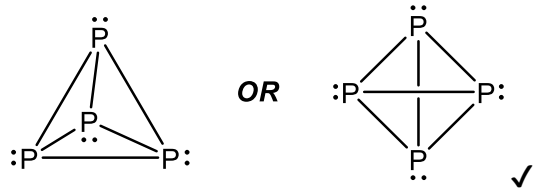
1. Each row in the “Question” column relates to the smallest subpart of the question.
2. The maximum mark for each question subpart is indicated in the “Total” column.
3. Each marking point in the “Answers” column is shown by means of a tick (✓) at the end of the marking point.
4. A question subpart may have more marking points than the total allows. This will be indicated by “**max**” written after the mark in the “Total” column. The related rubric, if necessary, will be outlined in the “Notes” column.
5. An alternative word is indicated in the “Answers” column by a slash (/). Either word can be accepted.
6. An alternative answer is indicated in the “Answers” column by “**OR**”. Either answer can be accepted.
7. An alternative markscheme is indicated in the “Answers” column under heading **ALTERNATIVE 1** *etc.* Either alternative can be accepted.
8. Words inside chevrons « » in the “Answers” column are not necessary to gain the mark.
9. Words that are underlined are essential for the mark.
10. The order of marking points does not have to be as in the “Answers” column, unless stated otherwise in the “Notes” column.
11. If the candidate’s answer has the same “meaning” or can be clearly interpreted as being of equivalent significance, detail and validity as that in the “Answers” column then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by **OWTTE** (or words to that effect) in the “Notes” column.
12. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.
13. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded. When marking, indicate this by adding **ECF** (error carried forward) on the script.
14. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the “Notes” column.
15. If a question specifically asks for the name of a substance, do not award a mark for a correct formula unless directed otherwise in the “Notes” column. Similarly, if the formula is specifically asked for, do not award a mark for a correct name unless directed otherwise in the “Notes” column.
16. If a question asks for an equation for a reaction, a balanced symbol equation is usually expected, do not award a mark for a word equation or an unbalanced equation unless directed otherwise in the “Notes” column.
17. Ignore missing or incorrect state symbols in an equation unless directed otherwise in the “Notes” column.

Question		Answers	Notes	Total
1.	a	$\left\langle \frac{8.802 \text{ g}}{44.01 \text{ g mol}^{-1}} \Rightarrow 0.2000 \text{ «mol of C/CO}_2\text{»} \right\rangle$ <p>AND $\left\langle \frac{3.604 \text{ g}}{18.02 \text{ g mol}^{-1}} \Rightarrow 0.2000 \text{ «mol of H}_2\text{O»} / 0.4000 \text{ «mol of H»} \right\rangle$</p> <p>OR</p> $\left\langle \frac{8.802 \text{ g}}{44.01 \text{ g mol}^{-1}} \times 12.01 \text{ g mol}^{-1} \Rightarrow 2.402 \text{ «g of C»} \right\rangle$ <p>OR</p> $\left\langle \frac{3.604 \text{ g}}{18.02 \text{ g mol}^{-1}} \times 2 \times 1.01 \text{ g mol}^{-1} \Rightarrow 0.404 \text{ «g of H»} \right\rangle \checkmark$ <p>$\left\langle 4.406 \text{ g} - 2.806 \text{ g} \right\rangle = 1.600 \text{ «g of O»} \checkmark$</p> $\left\langle \frac{2.402 \text{ g}}{12.01 \text{ g mol}^{-1}} = 0.2000 \text{ mol C}; \frac{0.404 \text{ g}}{1.01 \text{ g mol}^{-1}} = 0.400 \text{ mol H}; \right\rangle$ $\frac{1.600 \text{ g}}{16.00 \text{ g mol}^{-1}} = 0.1000 \text{ mol O} \left. \right\rangle$ <p>$\text{C}_2\text{H}_4\text{O} \checkmark$</p>	<p><i>Award [3] for correct final answer.</i></p>	<p>3</p>

Question		Answers	Notes	Total									
1.	b	« $\frac{88.12 \text{ g mol}^{-1}}{44.06 \text{ g mol}^{-1}} = 2$ » C ₄ H ₈ O ₂ ✓	C ₂ S ₂ if CS used.	1									
1.	c	<table border="1"> <thead> <tr> <th>Spectrum</th> <th>Identity</th> <th>Reason</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>Propan-1-ol</td> <td>absence of carbonyl/C=O «absorption»/ no peak in 1700 - 1750 «cm⁻¹» range OR presence of hydroxyl/O-H in <u>alcohols</u> «absorption»/peak in 3200 – 3600 «cm⁻¹» range ✓</td> </tr> <tr> <td>B</td> <td>Propanoic acid</td> <td>ALTERNATIVE 1: carbonyl/C=O AND hydroxyl/O-H «in carboxylic acids absorptions» OR «strong» peaks in 2500 – 3000 «cm⁻¹» AND 1700 – 1750 «cm⁻¹» ranges ✓ ALTERNATIVE 2: O-H in carboxylic acids «absorption» AND 2500 – 3000 «cm⁻¹» range ✓ ALTERNATIVE 3: strong/broad «peak» AND 2500 – 3000 «cm⁻¹» range ✓</td> </tr> </tbody> </table>	Spectrum	Identity	Reason	A	Propan-1-ol	absence of carbonyl/C=O «absorption»/ no peak in 1700 - 1750 «cm ⁻¹ » range OR presence of hydroxyl/O-H in <u>alcohols</u> «absorption»/peak in 3200 – 3600 «cm ⁻¹ » range ✓	B	Propanoic acid	ALTERNATIVE 1: carbonyl/C=O AND hydroxyl/O-H «in carboxylic acids absorptions» OR «strong» peaks in 2500 – 3000 «cm ⁻¹ » AND 1700 – 1750 «cm ⁻¹ » ranges ✓ ALTERNATIVE 2: O-H in carboxylic acids «absorption» AND 2500 – 3000 «cm ⁻¹ » range ✓ ALTERNATIVE 3: strong/broad «peak» AND 2500 – 3000 «cm ⁻¹ » range ✓	<p>Award [1 max] for correctly identifying all 3 compounds without valid reasons given.</p> <p>Accept specific values of wavenumbers within each range.</p>	3
Spectrum	Identity	Reason											
A	Propan-1-ol	absence of carbonyl/C=O «absorption»/ no peak in 1700 - 1750 «cm ⁻¹ » range OR presence of hydroxyl/O-H in <u>alcohols</u> «absorption»/peak in 3200 – 3600 «cm ⁻¹ » range ✓											
B	Propanoic acid	ALTERNATIVE 1: carbonyl/C=O AND hydroxyl/O-H «in carboxylic acids absorptions» OR «strong» peaks in 2500 – 3000 «cm ⁻¹ » AND 1700 – 1750 «cm ⁻¹ » ranges ✓ ALTERNATIVE 2: O-H in carboxylic acids «absorption» AND 2500 – 3000 «cm ⁻¹ » range ✓ ALTERNATIVE 3: strong/broad «peak» AND 2500 – 3000 «cm ⁻¹ » range ✓											

			C	Propanal	presence of carbonyl/C=O «absorption»/ peak in 1700 – 1750 «cm ⁻¹ » range AND absence of hydroxyl/O-H «in carboxylic acids absorption»/ no «broad» peak in 2500 – 3000 «cm ⁻¹ » range ✓		
1.	d		Compound	Number of signals	Splitting pattern of –CH₃		2
			<i>propanone</i>	1	singlet		
			<i>propanal</i>	3	triplet		
1.	e		CH ₃ O ⁺			<i>Accept any structure i.e. "CH₂OH⁺".</i>	1

Question			Answers	Notes	Total
2.	a		increasing number of protons OR increasing nuclear charge ✓ «atomic» radius/size decreases OR same number of shells/electrons occupy same shell OR similar shielding «by inner electrons» ✓		2
2.	b		$\llcorner \Delta E = hv = 6.63 \times 10^{-34} \text{ J s} \times 5.09 \times 10^{14} \text{ s}^{-1} \Rightarrow 3.37 \times 10^{-19} \llcorner \text{J} \llcorner \checkmark$		1

3.	a	i		Accept any diagram with each P joined to the other three. Accept any combination of dots, crosses and lines.	1
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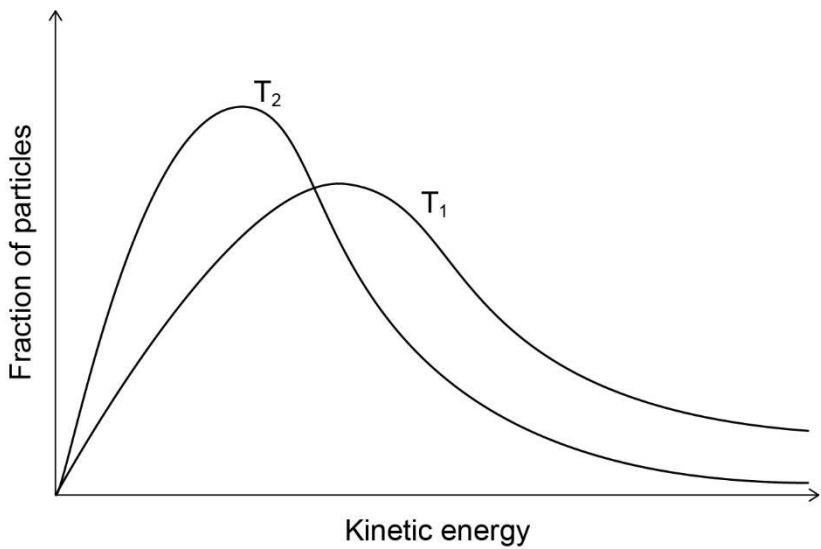
Question			Answers	Notes	Total
3.	a	ii	$P_4(s) + 6Cl_2(g) \rightarrow 4PCl_3(l)$ ✓		1
3.	b	i	<i>Electron domain geometry: tetrahedral</i> ✓ <i>Molecular geometry: trigonal pyramidal</i> ✓ <i>Bond angle: 100«°»</i> ✓	Accept any value or range within the range 91–108«°» for M3 .	3
3.	b	ii	<i>PCl₅ is non-polar:</i> symmetrical OR dipoles cancel ✓ <i>PCl₄F is polar:</i> P–Cl has a different bond polarity than P–F ✓ non-symmetrical «dipoles» OR dipoles do not cancel ✓	Accept F more electronegative than /different electronegativity to Cl for M2 .	3
3.	c	i	«-398.9 kJ mol ⁻¹ – (-306.4 kJ mol ⁻¹) =» -92.5 «kJ mol ⁻¹ » ✓		1
3.	c	ii	«ΔS = 364.5 J K ⁻¹ mol ⁻¹ – (311.7 J K ⁻¹ mol ⁻¹ + 223.0 J K ⁻¹ mol ⁻¹) =» -170.2 «J K ⁻¹ mol ⁻¹ » ✓		1

(continued...)

(Question 3c continued)

Question			Answers	Notes	Total
3.	c	iii	<p>«$\Delta S =$» $-0.1702 \text{ kJ mol}^{-1} \text{ K}^{-1}$» OR 298 «K» ✓ «$\Delta G = -92.5 \text{ kJ mol}^{-1} - (298 \text{ K} \times -0.1702 \text{ kJ mol}^{-1} \text{ K}^{-1}) =$» $-41.8 \text{ kJ mol}^{-1}$» ✓</p>	<p>Award [2] for correct final answer. If -87.6 and -150.5 are used then -42.8.</p>	2
3.	c	iv	<p>«$\Delta G = -41.8 \text{ kJ mol}^{-1} = -\frac{8.31 \text{ J mol}^{-1} \text{ K}^{-1}}{1000} \times 298 \text{ K} \times \ln K$» OR «$\Delta G = -41800 \text{ J mol}^{-1} = -8.31 \text{ J mol}^{-1} \text{ K}^{-1} \times 298 \text{ K} \times \ln K$» «$\ln K =$» 16.9 ✓ «$K = e^{16.9} =$» 2.19×10^7 ✓</p>	<p>Award [2] for correct final answer. Accept range of $1.80 \times 10^6 - 2.60 \times 10^7$. If -43.5 is used then 4.25×10^7.</p>	2
3.	c	v	<p>«$K_c =$» $\frac{[\text{PCl}_5]}{[\text{PCl}_3][\text{Cl}_2]}$ ✓</p>		1
3.	c	vi	<p>«shifts» left/towards reactants AND «forward reaction is» exothermic/ΔH is negative ✓</p>		1

Question			Answers	Notes	Total
4.	a	i	«nucleophilic» substitution/S _N 2 ✓	<i>Do not accept if “electrophilic” or “free radical” substitution is stated.</i>	1
4.	a	ii	«acts as a» nucleophile/Lewis base OR donates/provides lone pair «of electrons» OR attacks the «partially» positive carbon ✓		1
4.	a	iii	bond enthalpy C–I lower than C–Cl OR C–I bond weaker than C–Cl ✓ «weaker bond» broken more easily/with less energy OR lower E_a «for weaker bonds» ✓	<i>Accept the bond enthalpy values for C–I and C–Cl for M1.</i>	2

Question		Answers	Notes	Total
4.	b	 <p>peak at T₁ to right of AND lower than T₂ ✓ lines begin at origin AND T₁ must finish above T₂ ✓</p>		2
5.	a	$\text{H}_3\text{PO}_4(\text{aq}) + \text{NaOH}(\text{aq}) \rightarrow \text{NaH}_2\text{PO}_4(\text{aq}) + \text{H}_2\text{O}(\text{l}) \checkmark$	Accept net ionic equation.	1

Question		Answers	Notes	Total
5.	b	$\text{H}_2\text{PO}_4^- (\text{aq}) + \text{H}^+ (\text{aq}) \rightarrow \text{H}_3\text{PO}_4 (\text{aq}) \checkmark$ $\text{H}_2\text{PO}_4^- (\text{aq}) + \text{OH}^- (\text{aq}) \rightarrow \text{HPO}_4^{2-} (\text{aq}) + \text{H}_2\text{O} (\text{l}) \checkmark$	<p>Accept reactions of H_2PO_4^- with any acidic, basic or amphoteric species, such as H_3O^+, NH_3 or H_2O.</p> <p>Accept $\text{H}_2\text{PO}_4^- (\text{aq}) \rightarrow \text{HPO}_4^{2-} (\text{aq}) + \text{H}^+ (\text{aq})$ for M2.</p>	2
5.	c	<p>«$\text{NaOH} \frac{28.40 \text{ cm}^3}{1000} \times 0.5000 \text{ mol dm}^{-3} = 0.01420 \text{ mol}$»</p> <p>«$\frac{0.01420 \text{ mol}}{3} \Rightarrow 0.004733 \text{ «mol»} \checkmark$»</p> <p>«$\frac{0.004733 \text{ mol}}{\frac{25.00 \text{ cm}^3}{1000}} \Rightarrow 0.1893 \text{ «mol dm}^{-3}\text{»} \checkmark$»</p>	Award [2] for correct final answer.	2
5.	d	<p><i>Brønsted–Lowry base:</i> proton acceptor</p> <p>AND</p> <p><i>Lewis Base:</i> e^- pair donor/nucleophile \checkmark</p>		1

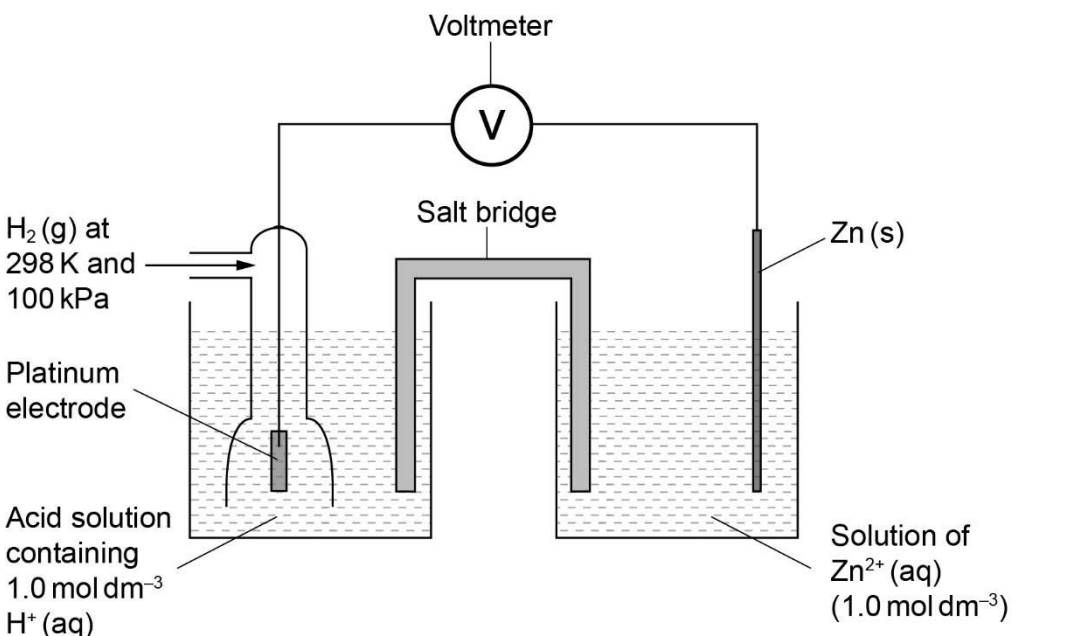
Question			Answers	Notes	Total
6	a		«amount of» oxygen used to decompose the organic matter in water ✓		1
6.	b		$\left\langle \frac{0.0001 \text{ g}}{0.1240 \text{ g}} \times 100 \% \Rightarrow 0.08 \text{ «\%»} \right\rangle$ <p>OR</p> $\left\langle \frac{0.4 \text{ cm}^3}{1000.0 \text{ cm}^3} \times 100 \% \Rightarrow 0.04 \text{ «\%»} \right\rangle \checkmark$ $\left\langle 0.08 \% + 0.04 \% \Rightarrow 0.12/0.1 \text{ «\%»} \right\rangle \checkmark$	<p><i>Award [2] for correct final answer.</i></p> <p><i>Accept fractional uncertainties for M1, i.e., 0.0008 OR 0.0004.</i></p>	2
6.	c	i	$\left\langle \frac{37.50 \text{ cm}^3}{1000} \times 5.000 \times 10^{-4} \text{ mol dm}^{-3} \Rightarrow 1.875 \times 10^{-5} \text{ «mol»} \right\rangle \checkmark$		1
6.	c	ii	1:4 ✓	<p><i>Accept "4 mol S₂O₃²⁻ :1 mol O₂", but not just 4:1.</i></p>	1










(continued...)

(Question 6c continued)

Question			Answers	Notes	Total
6.	c	iii	$\llcorner 1.875 \times 10^{-5} \text{ mol} \times \frac{1}{4} \Rightarrow 4.688 \times 10^{-6} \llcorner \text{mol} \llcorner \checkmark$ $\llcorner \frac{4.688 \times 10^{-6} \text{ mol}}{\frac{25.00 \text{ cm}^3}{1000}} \Rightarrow 1.875 \times 10^{-4} \llcorner \text{mol dm}^{-3} \llcorner \checkmark$	Award [2] for correct final answer.	2
6.	c	iv	$\text{MnO}_2(\text{s}) + 2\text{e}^- + 4\text{H}^+(\text{aq}) \rightarrow \text{Mn}^{2+}(\text{aq}) + 2\text{H}_2\text{O}(\text{l}) \checkmark$		1
6.	c	v	rate of reaction of oxygen with impurities depends on temperature OR rate at which bacteria/organisms grow/respire depends on temperature \checkmark		1
7.	a		$\llcorner q = mc\Delta T = 20.0 \text{ g} \times 4.18 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1} \times 57.3 \text{ }^\circ\text{C} \Rightarrow 4790 \llcorner \text{J} \llcorner \checkmark$ $\llcorner \Delta H_c = -\frac{4790 \text{ J}}{8.75 \times 10^{-4} \text{ mol}} \Rightarrow -5470 \llcorner \text{kJ mol}^{-1} \llcorner \checkmark$	Award [2] for correct final answer. Accept answers in the range -5470 to -5480 $\llcorner \text{kJ mol}^{-1} \llcorner$. Accept correct answer in any units, e.g. -5.47 $\llcorner \text{MJ mol}^{-1} \llcorner$ or $5.47 \times 10^6 \llcorner \text{J mol}^{-1} \llcorner$.	2

Question		Answers	Notes	Total
7.	b	$\text{Cl}\cdot + \text{C}_2\text{H}_6 \rightarrow \cdot\text{C}_2\text{H}_5 + \text{HCl} \checkmark$ $\cdot\text{C}_2\text{H}_5 + \text{Cl}_2 \rightarrow \text{Cl}\cdot + \text{C}_2\text{H}_5\text{Cl} \checkmark$ $\cdot\text{C}_2\text{H}_5 + \text{Cl}\cdot \rightarrow \text{C}_2\text{H}_5\text{Cl}$ OR $\text{Cl}\cdot + \text{Cl}\cdot \rightarrow \text{Cl}_2$ OR $\cdot\text{C}_2\text{H}_5 + \cdot\text{C}_2\text{H}_5 \rightarrow \text{C}_4\text{H}_{10} \checkmark$	<p><i>Do not penalize incorrectly placed radical sign, eg $\text{C}_2\text{H}_5\cdot$.</i></p>	3

Question	Answers	Notes	Total
8.	 <p> $\text{H}_2(\text{g})$ at 298 K and 100 kPa Platinum electrode Acid solution containing $1.0 \text{ mol dm}^{-3} \text{H}^+(\text{aq})$ $\text{H}_2(\text{g})$ entering at «298 K and» 100 kPa ✓ platinum electrode on left ✓ voltmeter connecting electrodes AND salt bridge connecting electrolytes ✓ $1 \text{ mol dm}^{-3} \text{H}^+$ on the left AND $1 \text{ mol dm}^{-3} \text{Zn}^{2+}$ on the right ✓ </p>	<p> <i>Voltmeter and salt bridge need to be drawn but not necessarily annotated for M3.</i> </p> <p> <i>Concentrations, but not state symbols, required for M4.</i> </p>	4

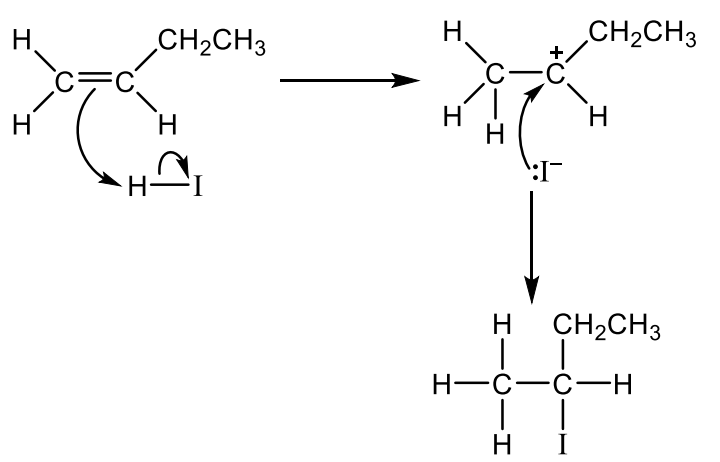
Question			Answers	Notes	Total						
9.	a		<p>Most ${}^4\text{He}^{2+}$ passing straight through: most of the atom is empty space OR the space between nuclei is much larger than ${}^4\text{He}^{2+}$ particles OR nucleus/centre is «very» small «compared to the size of the atom» ✓</p> <p>Very few ${}^4\text{He}^{2+}$ deviating largely from their path: nucleus/centre is positive «and repels ${}^4\text{He}^{2+}$ particles» OR nucleus/centre is «more» dense/heavy «than ${}^4\text{He}^{2+}$ particles and deflects them» OR nucleus/centre is «very» small «compared to the size of the atom» ✓</p>	<p>Do not accept the same reason for both M1 and M2. Accept “most of the atom is an electron cloud” for M1.</p> <p>Do not accept only “nucleus repels ${}^4\text{He}^{2+}$ particles” for M2.</p>	2						
9.	b	i	<table border="1" style="width: 100%; text-align: center;"> <tr> <td></td> <td></td> <td></td> </tr> <tr> <td>1s</td> <td>2s</td> <td>2p</td> </tr> </table> <p>1s AND 2s as spheres ✓ one or more 2p orbital(s) as figure(s) of 8 shape(s) of any orientation (p_x, p_y, p_z) ✓</p>				1s	2s	2p		2
											
1s	2s	2p									

(continued...)

(Question 9b continued)

Question			Answers	Notes	Total
9.	b	ii	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$ OR [Ar] $4s^1 3d^{10}$ ✓	Accept configuration with 3d before 4s.	1
9.	b	iii	chloride is lower in the spectrochemical series ✓ «ligand cause» decreased/lesser splitting «in d-orbitals compared to H ₂ O» ✓ frequency/energy of light absorbed is decreased OR wavelength of light absorbed is increased ✓	Accept ·chloride a weaker ligand than water/produces a smaller energy difference than water for M1 . Award [2 max] for mentioning splitting of orbitals is changed AND frequency/wavelength/energy of light absorbed are different/changed without mentioning correct decrease or increase.	3

Question			Answers	Notes	Total								
10.	a	i	<p><i>Sigma (σ) bond:</i> overlap «of atomic orbitals» along the axial / intermolecular axis / electron density is between nuclei OR head-on/end-to-end overlap «of atomic orbitals» ✓</p> <p><i>Pi (π) bond:</i> overlap «of p-orbitals» above and below the internuclear axis/electron density above and below internuclear axis OR sideways overlap «of p-orbitals» ✓</p>	Accept a suitable diagram.	2								
10.	a	ii	<table border="1"> <tr> <td></td> <td>Ethane</td> <td>Ethene</td> <td>Ethyne</td> </tr> <tr> <td>Hybridization of carbon</td> <td>sp^3</td> <td>sp^2</td> <td>sp</td> </tr> </table> ✓		Ethane	Ethene	Ethyne	Hybridization of carbon	sp^3	sp^2	sp	All 3 required for mark.	1
	Ethane	Ethene	Ethyne										
Hybridization of carbon	sp^3	sp^2	sp										

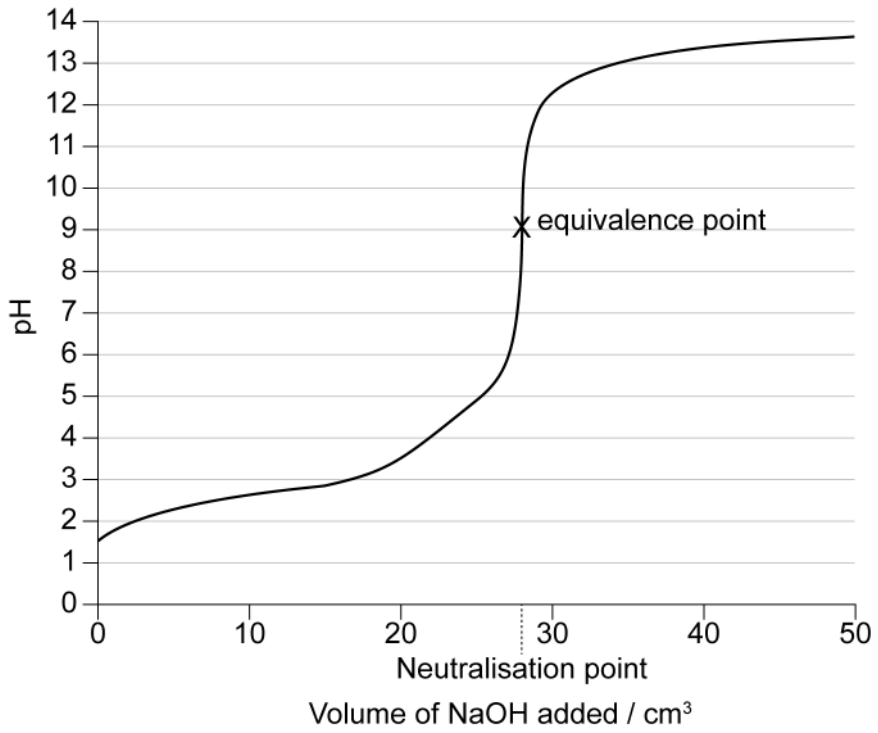
Question			Answers	Notes	Total
10.	b	i	no AND 2 groups on a carbon «in the double bond» are the same/hydrogen «atoms» OR no AND molecule produced by rearranging atoms bonded on a carbon «in the double bond» is the same as the original ✓		1
10.	b	ii	«electrophilic» addition ✓	<i>Do not allow nucleophilic addition.</i>	1
10.	b	iii	 <p>curly arrow going from C=C to H of HI AND curly arrow showing I leaving ✓ representation of carbocation ✓ curly arrow going from lone pair/negative charge on I⁻ to C⁺ ✓ 2-iodobutane formed ✓</p>	<i>Penalize incorrect bond, e.g. -CH-H₃C or -CH₃C once only.</i>	4

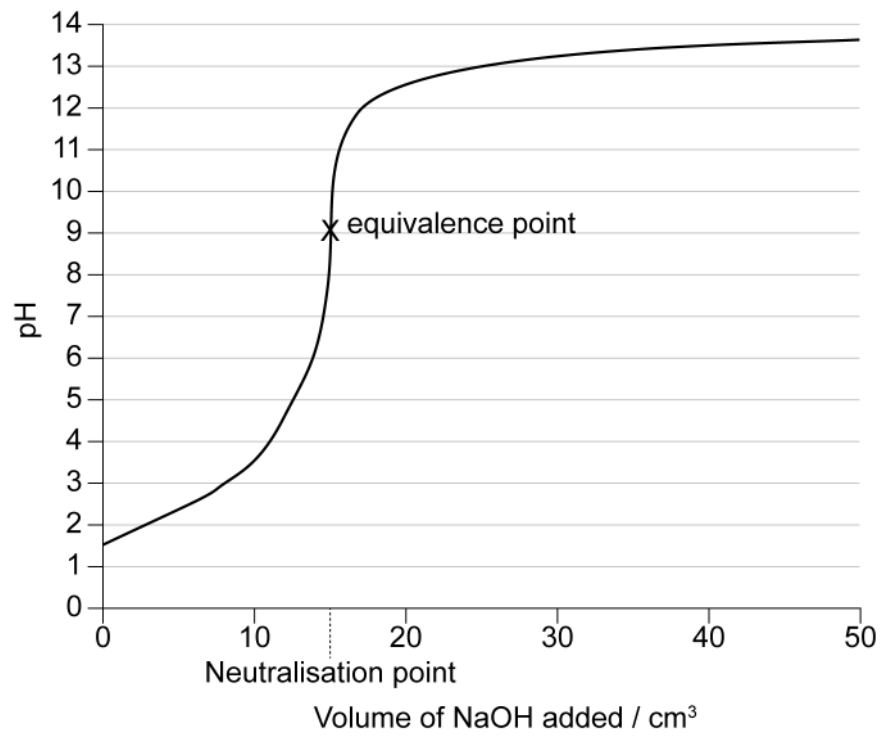
(continued...)

(Question 10b continued)

Question			Answers	Notes	Total
10.	b	iv	yes AND has a carbon attached to four different groups OR yes AND it contains a chiral carbon ✓	Accept yes AND mirror image of molecule different to original/non-superimposable on original.	1
10.	c	i	«rate => k[NaOH][C ₅ H ₁₁ Cl] ✓		1
10.	c	ii	mol ⁻¹ dm ³ s ⁻¹ ✓		1
10.	c	iii	ALTERNATIVE 1: «k = » 1.25 «mol ⁻¹ dm ³ s ⁻¹ » ✓ «rate = 1.25 mol ⁻¹ dm ³ s ⁻¹ × 0.60 mol dm ⁻³ × 0.25 mol dm ⁻³ » 1.9 × 10 ⁻¹ «mol dm ⁻³ s ⁻¹ » ✓ ALTERNATIVE 2: «[NaOH] exp. 4 is 3 × exp. 1» «[C ₅ H ₁₁ Cl] exp. 4 is 2.5 × exp. 1» «exp. 4 will be » 7.5× faster ✓ 1.9 × 10 ⁻¹ «mol dm ⁻³ s ⁻¹ » ✓	Award [2] for correct final answer.	2

Question		Answers	Notes	Total
10.	d	S_N2 AND rate depends on both OH^- and 2-chloropentane ✓	Accept E2 AND rate depends on both OH^- and 2-chloropentane.	1
10.	e	delocalized electrons/pi bonds «around the ring» OR molecule has a region of high electron density/negative charge ✓ electrophiles are attracted/positively charged AND nucleophiles repelled/negatively charged ✓	Do not accept just “nucleophiles less attracted” for M2 . Accept “benzene AND nucleophiles are both electron rich” for “repels nucleophiles”.	2
11.	a	« $K_a = 10^{-2.87} = 1.35 \times 10^{-3}$ » « $1.35 \times 10^{-3} = \frac{[\text{chloroethanoate}] \times [\text{H}^+]}{0.50 \text{ mol dm}^{-3}} = \frac{x^2}{0.50 \text{ mol dm}^{-3}}$ » « $x = [\text{H}^+] = \sqrt{1.4 \times 10^{-3} \times 0.50} \Rightarrow 2.6 \times 10^{-2}$ «mol dm ⁻³ » ✓ « $\text{pH} = -\log[\text{H}^+] = -\log(2.6 \times 10^{-2}) \Rightarrow 1.59$ ✓	Accept final answer in range 1.58-1.60. Award [2] for correct final answer.	2

Question		Answers	Notes	Total
11.	b	<p>«pOH = -log(0.362) = 0.441»</p> <p>«pH = 14.000 - 0.441 => 13.559 ✓</p>		1
11.	c	 <p>OR</p>	<p>Accept any range from 1.1-1.9 AND 13.1-13.9 for M1 or ECF from 11c(i) and 11c(ii).</p> <p>Award M2 for vertical climb at 28cm³ OR 15 cm³.</p> <p>Equivalence point must be labelled for M3.</p>	3



starts at 1.6 **AND** finishes at 13.6 ✓

approximately vertical at the correct volume of alkali added ✓

equivalence point labelled **AND** above pH 7 ✓