



AQA Qualifications

A-LEVEL

Chemistry

CHEM2 Chemistry in Action

Mark scheme

2420

June 2015

Version 0.3 – Post Standardisation

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this Mark Scheme are available from aqa.org.uk

Question	Marking Guidance	Mark	Comments
1(a)(i)	$2\text{Cl}^- \longrightarrow \text{Cl}_2 + 2\text{e}^-$	1	Ignore state symbols Credit loss of electrons from LHS Credit multiples Do not penalise absence of charge on electron
1(a)(ii)	+7 OR 7 OR VII OR +VII	1	Allow Mn^{+7} and 7+
1(a)(iii)	$\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^- \longrightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O}$	1	Ignore state symbols Credit loss of electrons from RHS Credit multiples Do not penalise absence of charge on electron
1(b)(i)	$\text{Cl}_2 + 2\text{Br}^- \longrightarrow 2\text{Cl}^- + \text{Br}_2$ OR $\frac{1}{2}\text{Cl}_2 + \text{Br}^- \longrightarrow \text{Cl}^- + \frac{1}{2}\text{Br}_2$	1	One of these two equations <u>only</u> Ignore state symbols
1(b)(ii)	(Turns to) <u>yellow / orange / brown</u> (solution)	1	Penalise “red / reddish” as the only colour Accept “red-brown” and “red-orange” Ignore “liquid” Penalise reference to a product that is a gas or

			a precipitate
1(b)(iii)	(Chlorine) <u>gains electron(s)</u> / <u>takes electron(s)</u> / <u>accepts electron(s)</u> (from the bromide ions) OR (Chlorine) <u>causes another species</u> (Br ⁻) <u>to lose electron(s)</u>	1	Penalise “electron pair acceptor” Not simply “causes loss of electrons”
1(c)	M1 $2\text{Cl}_2 + 2\text{H}_2\text{O} \longrightarrow 4\text{HCl} + \text{O}_2$ $(4\text{H}^+ + 4\text{Cl}^-)$ M2 Oxidation state -1	2	Ignore state symbols Credit multiples M2 consequential on HCl or Cl ⁻ which must be the only chlorine-containing product in the (un)balanced equation. For M2 allow Cl ⁻¹ or Cl ¹⁻ but not Cl ⁻
1(d)	M1 The relative size (of the molecules/atoms) Chlorine is <u>smaller</u> than bromine OR has fewer electrons/electron shells OR It is smaller / It has a smaller atomic radius / it is a smaller molecule / atom (or converse) M2 How size of the <u>intermolecular force</u> affects energy needed The <u>forces between</u> chlorine / Cl ₂ <u>molecules</u> are <u>weaker</u> (than the forces between bromine / Br ₂ <u>molecules</u>) (or converse for bromine) OR chlorine / Cl ₂ has <u>weaker / fewer/ less</u> (VdW) <u>intermolecular forces / forces between molecules</u>	2	For M1 ignore whether it refers to molecules or atoms. CE=0 for the clip for reference to (halide) ions or incorrect statements about relative size Ignore molecular mass and M _r Ignore shielding QoL in M2 for clear reference to the difference in size <u>of the force between molecules.</u> Reference to Van der Waals forces alone is not enough.

(or converse for bromine)	Penalise M2 if (covalent) bonds are broken
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Question	Marking Guidance	Mark	Comments
2(a)	<p>M1 acidified potassium dichromate or $K_2Cr_2O_7/H_2SO_4$ OR $K_2Cr_2O_7/H^+$ OR acidified $K_2Cr_2O_7$</p> <p>M2 (orange to) <u>green</u> solution OR goes <u>green</u></p> <p>M3 (solution) remains <u>orange</u> or no reaction or no (observed) change</p> <p>Alternative using $KMnO_4/H_2SO_4$</p> <p>M1 acidified potassium manganate(VII) / potassium permanganate or $KMnO_4/H_2SO_4$ OR $KMnO_4/H^+$ OR acidified $KMnO_4$</p> <p>M2 <u>colourless</u> solution OR goes <u>colourless</u></p> <p>M3 (solution) remains <u>purple</u> or no reaction or no (observed) change</p>	3	<p>If no reagent or incorrect reagent in M1, CE= 0 and no marks for M1, M2 or M3</p> <p>If incomplete / inaccurate attempt at reagent e.g. “dichromate” or “dichromate(IV)” or incorrect formula or no acid, penalise M1 only and mark on</p> <p>For M2 ignore dichromate described as “yellow” or “red”</p> <p>For M3 ignore “nothing (happens)” or “no observation”</p> <p>For M1</p> <p>If incomplete / inaccurate attempt at reagent e.g. “manganate” or “manganate(IV)” or incorrect formula or no acid, penalise M1 only and mark on</p> <p>Credit alkaline $KMnO_4$ for possible full marks but M2 gives <u>brown precipitate</u> or solution goes <u>green</u></p>

2(b)	<p>M1 (Shake with) Br₂ OR bromine (water) OR bromine (in CCl₄ / organic solvent)</p> <p>M2 (stays) orange / red / yellow / brown / the same OR no reaction OR no (observed) change</p> <p>M3 decolourised / goes colourless / loses its colour / orange to colourless</p> <p>OR as alternatives</p> <p>Use KMnO₄/H₂SO₄</p> <p>M1 acidified potassium manganate(VII) / potassium permanganate OR KMnO₄/H₂SO₄</p> <p>OR KMnO₄/H⁺ OR acidified KMnO₄</p> <p>M2 (stays) <u>purple</u> or no reaction or no (observed) change</p> <p>M3 decolourised / goes colourless / loses its colour</p> <p>Use iodine</p> <p>M1 iodine or I₂ / KI or iodine solution</p> <p>M2 no change</p> <p>M3 decolourised / goes colourless / loses its colour</p> <p>Use concentrated sulfuric acid</p> <p>M1 <u>concentrated</u> H₂SO₄</p> <p>M2 no change</p>	3	<p>If no reagent or incorrect reagent in M1, CE= 0 and no marks for M1, M2 or M3</p> <p>If incomplete /inaccurate attempt at reagent (e.g. Br), penalise M1 only and mark on</p> <p>No credit for combustion observations; CE=0</p> <p>For M2 in every case</p> <p>Ignore “nothing (happens)”</p> <p>Ignore “no observation”</p> <p>Ignore “clear”</p> <p>For M1, it must be a whole reagent and/or correct formula</p> <p>For M1 penalise incorrect attempt at correct formula, but mark M2 and M3</p> <p>With potassium manganate(VII)</p> <p>If incomplete / inaccurate attempt at reagent e.g. “manganate” or “manganate(IV)” or incorrect formula or no acid, penalise M1 only and mark on</p> <p>Credit alkaline/neutral KMnO₄ for possible full marks but M3 gives <u>brown precipitate</u> or solution goes <u>green</u></p> <p>Apply similar guidance for errors in the formula of iodine or concentrated sulfuric acid reagent</p>
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	M3 brown		as those used for other reagents.
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<p>2(c)</p>	<p>M1 Any <u>soluble chloride</u> including hydrochloric acid (ignore concentration)</p> <p>M2 <u>white precipitate</u> or <u>white solid / white suspension</u></p> <p>M3 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear</p> <p>OR as an alternative</p> <p>M1 Any <u>soluble iodide</u> including HI</p> <p>M2 <u>yellow precipitate</u> or <u>yellow solid / yellow suspension</u></p> <p>M3 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear</p> <p>OR as an alternative</p> <p>M1 Any <u>soluble bromide</u> including HBr</p> <p>M2 <u>cream precipitate</u> or <u>cream solid / cream suspension</u></p> <p>M3 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear</p> <p>OR as an alternative</p> <p>M1 NaOH or KOH or any <u>soluble carbonate</u></p> <p>M2 <u>brown precipitate</u> or <u>brown solid / brown suspension</u> with NaOH / KOH (<u>white precipitate/ solid/ suspension</u> with carbonate)</p> <p>M3 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear</p>	<p>3</p>	<p>If no reagent or incorrect reagent or insoluble chloride in M1, CE= 0 and no marks for M1, M2 or M3</p> <p>Allow chlorine water</p> <p>If incomplete reagent (e.g. chloride ions) or inaccurate attempt at formula of chosen chloride, or chlorine, penalise M1 only and mark on</p> <p>For M2 require the word “white” and some reference to a solid. Ignore “cloudy solution” OR “suspension” (similarly for the alternatives)</p> <p>For M3</p> <p>Ignore “nothing (happens)”</p> <p>Ignore “no observation”</p> <p>Ignore “clear” <u>on its own</u></p> <p>Ignore “dissolves”</p>
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<p>2(d)</p>	<p>M1 Any <u>soluble sulfate</u> including (dilute or aqueous) sulfuric acid</p> <p>M2 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear</p> <p>M3 <u>white precipitate</u> or <u>white solid / white suspension</u></p> <p>OR as an alternative</p> <p>M1 NaOH or KOH</p> <p>M2 <u>white precipitate</u> or <u>white solid / white suspension</u></p> <p>M3 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear</p>	<p>3</p> <p>If no reagent or incorrect reagent or insoluble sulfate in M1, CE= 0 and no marks for M1, M2 or M3</p> <p>Accept MgSO_4 and CaSO_4 but not barium, lead or silver sulfates</p> <p>If concentrated sulfuric acid or incomplete reagent (eg sulfate ions) or inaccurate attempt at formula of chosen sulfate, penalise M1 only and mark on</p> <p>For M3 (or M2 in the alternative) require the word “white” and some reference to a solid.</p> <p>Ignore “cloudy solution” OR “suspension”</p> <p>For M2 (or M3 in the alternative)</p> <p>Ignore “nothing (happens)”</p> <p>Ignore “no observation”</p> <p>Ignore “clear” <u>on its own</u></p> <p>Ignore “dissolves”</p> <p>If incomplete reagent (e.g. hydroxide ions) or inaccurate attempt at formula of chosen hydroxide, penalise M1 only and mark on</p> <p>If M1 uses NH_3 (dilute or concentrated) penalise M1 only and mark on</p>
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Question	Marking Guidance	Mark	Comments
3(a)	<p>M1 Increases / gets bigger</p> <p>M2 requires a correct M1</p> <p>More shells or sub-shells or (main) levels or sub-levels or orbitals (of electrons)</p>	2	<p>If M1 is incorrect CE=0 for the clip</p> <p>If M1 is blank, mark on and seek to credit the correct information in the text</p> <p>M2 requires correct M1</p> <p>If “molecules” penalise M2</p> <p>Not simply “more electrons”</p> <p>Not “more outer shells”</p> <p>Ignore reference to nuclear charge and shielding</p>
3(b)(i)	Increases / gets more reactive / reacts more <u>vigorously / violently</u> (down the Group)	1	
3(b)(ii)	$\text{Sr} + 2\text{H}_2\text{O} \longrightarrow \text{Sr}(\text{OH})_2 + \text{H}_2$	1	<p>Credit multiples and correct ionic equations</p> <p>Ignore state symbols</p>
3(c)	$\text{Ba}(\text{OH})_2$	1	<p>This MUST be a formula so ignore the name</p> <p>Credit $\text{Ba}^{2+} 2\text{OH}^-$</p> <p>Ignore state symbols</p>

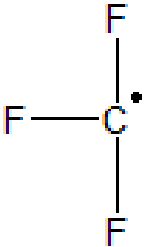
Question	Marking Guidance	Mark	Comments
4(a)(i)	<p>M1 High (temperature) OR Increase (the temperature)</p> <p>M2 The (forward) reaction / to the right is <u>endothermic</u> or <u>takes in / absorbs heat</u></p> <p>OR The reverse reaction / to the left is <u>exothermic</u> or <u>gives out / releases heat</u></p> <p>M3 depends on correct M2 and must refer to temperature/heat At high temperature, the (position of) <u>equilibrium shifts / moves</u> left to right to <u>oppose the increase in temperature</u></p>	3	<p>If M1 is incorrect CE=0 for the clip</p> <p>If M1 is blank, mark on and seek to credit the correct information in the text</p> <p>M3 depends on a correct statement for M2</p> <p>For M3, the position of <u>equilibrium shifts/moves</u> to <u>absorb heat</u> OR to <u>lower the temperature</u> OR to <u>cool down the reaction</u></p>

4(a)(ii)	<p>M1 The reaction <u>gets to equilibrium faster / in less time</u></p> <p>OR Produces a small yield <u>faster / in less time</u></p> <p>OR <u>Increases the rate</u> (of reaction / of attainment of equilibrium)</p> <p>M2 High pressure leads to one of the following</p> <ul style="list-style-type: none">• <u>more particles / molecules in a given volume</u>• <u>particles / they are closer together</u>• <u>higher concentration of particles / molecules</u> <p>AND</p> <ul style="list-style-type: none">• <u>more collisions in a given time / increased collision frequency</u>	2	Mark independently
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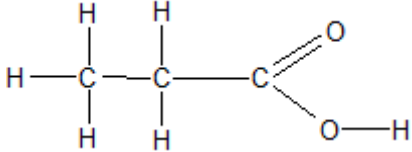
Penalise **M2** for reference to increased energy of the particles

4(a)(iii)	<p>M1 <u>Increase in / more / large(r) / big(ger) surface area / surface sites</u></p> <p>M2 <u>increase in / more successful / productive / effective collisions</u> (in a given time) (on the surface of the catalyst / with the nickel)</p>	2	<p>Mark independently</p> <p>For M1 accept “an increase in surface”</p> <p>For M2 not simply “more collisions”</p> <p>Ignore “the chance or likelihood” of collisions</p>
4(b)	<p>M1 No effect / None</p> <p>M2 requires a correct M1 <u>Equal / same number / amount of moles / molecules / particles</u> on either side of the equation OR 2 <u>moles / molecules / particles</u> on the left and 2 <u>moles / molecules / particles</u> on the right</p>	2	<p>If M1 is incorrect CE=0 for the clip</p> <p>If M1 is blank, mark on and seek to credit the correct information in the text</p> <p>M2 depends on a correct statement for M1</p> <p>In M2 not “atoms”</p>

Question	Marking Guidance	Mark	Comments
5(a)(i)	<p>Initiation $\text{Br}_2 \longrightarrow 2\text{Br}\cdot$</p> <p>First propagation $\text{Br}\cdot + \text{CHF}_3 \longrightarrow \cdot\text{CF}_3 + \text{HBr}$</p> <p>Second propagation $\text{Br}_2 + \cdot\text{CF}_3 \longrightarrow \text{CBrF}_3 + \text{Br}\cdot$</p> <p>Termination $2\cdot\text{CF}_3 \longrightarrow \text{C}_2\text{F}_6$ OR CF_3CF_3 OR $2\text{Br}\cdot \longrightarrow \text{Br}_2$ OR $\text{Br}\cdot + \cdot\text{CF}_3 \longrightarrow \text{CBrF}_3$</p>	4	<p>Penalise absence of dot once only</p> <p>Credit the dot anywhere on the radical</p>

5(a)(ii)	Ultra-violet / uv / sunlight OR T > 100°C OR <u>high</u> temperature	1	
5(b)(i)		1	Displayed formula required with the radical dot on carbon
5(b)(ii)	(The) <u>C—Br</u> (bond) breaks more readily / is weaker than (the) <u>C—Cl</u> (bond) (or converse) OR The <u>C—Br bond enthalpy / bond strength</u> is less than that for <u>C—Cl</u> (or converse)	1	Requires a comparison between the two bonds Give credit for an answer that suggests that the UV frequency / energy may favour <u>C—Br</u> bond breakage rather than <u>C—Cl</u> bond breakage Ignore correct references either to size, polarity or electronegativity Credit correct answers that refer to, for example “the bond between carbon and bromine requires less energy to break than the bond between carbon and chlorine”

5(b)(iii)	<p>M1 $\text{Br}\cdot + \text{O}_3 \longrightarrow \text{BrO}\cdot + \text{O}_2$</p> <p>M2 $\text{BrO}\cdot + \text{O}_3 \longrightarrow \text{Br}\cdot + 2\text{O}_2$</p> <p>M3 One of the following They / it / the bromine (atom)</p> <ul style="list-style-type: none">• does not appear in the overall equation• is regenerated• is unchanged <u>at the end</u>• has <u>not been used up</u>• provides an alternative route / mechanism	3	<p>M1 and M2 could be in either order Credit the dot anywhere on the radical Penalise absence of dot once only Penalise the use of multiples once only</p>
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Question	Marking Guidance	Mark	Comments
6(a)(i)	C_4H_{10} $M_r = 4(12.00000) + 10(1.00794)$ $= \underline{58.07940}$ or $\underline{58.0794}$ or $\underline{58.079}$ or $\underline{58.08}$ and <u>58.1</u>	1	Working is essential, leading to the final value of 58.1 which must be stated in addition to one of the four numbers underlined
6(a)(ii)	<u>By definition</u> OR The <u>standard</u> / <u>reference</u> (value / isotope)	1	Reference to ^{12}C alone is not enough
6(b)		1	All bonds and atoms must be drawn Give credit for the displayed formula for the anion
6(c)(i)	$H_2C=CHCH_2OH$	1	Any correct representation including correct use of “sticks”. Require the double bond to be shown

6(c)(ii)	<u>Addition</u> (polymerisation)	1	ONLY this answer
6(c)(iii)	M1 <u>C=C</u> (in range) 1620 to 1680 (cm ⁻¹) M2 <u>O—H</u> (in range) 3230 to 3550 (cm ⁻¹)	2	Award one mark for two correct ranges but a failure to draw out the C=C or O—H bonds
6(d)(i)	CH ₃ COCH ₃	1	Any correct representation including correct use of “sticks”
6(d)(ii)	C	1	

Question	Marking Guidance	Mark	Comments
7(a)(i)	$2\text{C}_6\text{H}_{12}\text{O}_6 \longrightarrow 3\text{CH}_3\text{COCH}_3 + 3\text{CO}_2 + 3\text{H}_2\text{O}$	1	Or multiples
7(a)(ii)	to speed up the reaction OR (provide a) catalyst or catalyses the reaction or biological catalyst OR <u>release / contain / provides an enzyme</u>	1	Ignore “fermentation” Ignore “to break down the glucose” Not simply “enzyme” on its own
7(b)(i)	$\text{CH}_3\text{CH}(\text{OH})\text{CH}_3 + [\text{O}] \longrightarrow \text{CH}_3\text{COCH}_3 + \text{H}_2\text{O}$	1	Any <u>correct</u> representation for the two organic structures. Brackets not essential. Not “sticks” for the structures in this case
7(b)(ii)	Secondary (alcohol) OR 2° (alcohol)	1	

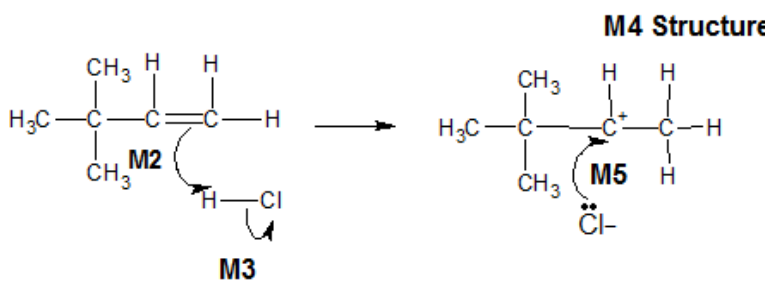
7(c)	<p>M1 $q = m c \Delta T$ OR $q = 150 \times 4.18 \times 8.0$</p> <p>M2 = ($\pm$) 5016 (J) OR 5.016 (kJ) OR 5.02 (kJ) (also scores M1)</p> <p>M3 This mark is for dividing correctly the number of kJ by the number of moles and arriving at a final answer in the range shown. Using 0.00450 mol therefore $\Delta H = \underline{-1115}$ (kJ mol⁻¹) OR $\underline{-1114.6}$ to $\underline{-1120}$ (kJ mol⁻¹)</p> <p>Range (+)1114.6 to (+)1120 gains 2 marks BUT - 1110 gains 3 marks and +1110 gains 2 marks AND - 1100 gains 3 marks and +1100 gains 2 marks</p>	3	<p>Award full marks for <u>correct answer</u></p> <p>In M1, do not penalise incorrect cases in the formula</p> <p>Penalise M3 ONLY if correct numerical answer but sign is incorrect; (+)1114.6 to (+)1120 gains 2 marks</p> <p>Penalise M2 for arithmetic error and mark on If $\Delta T = 281$; score $q = m c \Delta T$ only If $c = 4.81$ (leads to 5772) penalise M2 ONLY and mark on for M3 = - 1283</p> <p>Ignore incorrect units in M2</p> <p>If units are given in M3 they <u>must be either kJ or kJ mol⁻¹</u> in this case</p>
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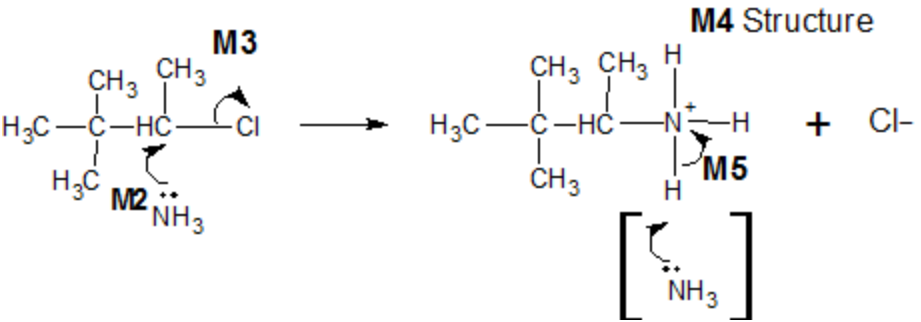
7(d)	<p>M1 The <u>enthalpy change / heat change at constant pressure</u> when <u>1 mol</u> of a compound / substance / element</p> <p>M2 is <u>burned / combusts / reacts completely in oxygen</u></p> <p>OR</p> <p><u>burned / combusted / reacted in excess oxygen</u></p> <p>M3 with (all) <u>reactants and products / (all) substances in standard / specified states</u></p> <p>OR</p> <p>(all) <u>reactants and products / (all) substances in normal states under standard conditions / 100 kPa / 1 bar and specified T / 298 K</u></p>	3	<p>If standard enthalpy of formation CE=0</p> <p>For M3</p> <p>Ignore reference to 1 atmosphere</p>
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7(e)	<p>M1 $\sum B(\text{reactants}) - \sum B(\text{products}) = \Delta H$ OR <u>Sum of bonds broken – Sum of bonds formed = ΔH</u> OR $2B(\text{C-C}) + B(\text{C=O}) + 6B(\text{C-H}) + 4B(\text{O=O})$ (LHS) $- 6B(\text{C=O}) - 6B(\text{O-H})$ (RHS) = <u>ΔH</u></p> <p>M2 (also scores M1) $2(348)+805+6(412)+4(496)$ [LHS = 5957] (696) (2472) (1984) $- 6(805) - 6(463)$ [RHS = (-)7608] = ΔH (4830) (2778) OR using only bonds broken and formed (5152 – 6803)</p> <p>M3 $\Delta H = \underline{-1651}$ (kJ mol⁻¹) Candidates may use a cycle and gain full marks.</p>	3	<p>Correct answer gains full marks</p> <p>Credit 1 mark for (+) 1651 (kJ mol⁻¹)</p> <p>For other incorrect or incomplete answers, proceed as follows</p> <ul style="list-style-type: none"> • check for an arithmetic error (AE), which is either a transposition error or an incorrect multiplication / addition error; this would score 2 marks (M1 and M2) • If no AE, check for a correct method; this requires either a correct cycle with 4O₂, 3CO₂ and 3H₂O OR a clear statement of M1 which could be in words and scores <u>only M1</u> <p>Allow a maximum of one mark if the <u>only</u> scoring point is LHS = 5957 (or 5152) OR RHS = 7608 (or 6803)</p> <p>Award 1 mark for +1651</p>
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7(f)	<p>For the two marks M1 and M2, <u>any two</u> from</p> <ul style="list-style-type: none">• <u>heat</u> loss or not all <u>heat</u> transferred to the apparatus or <u>heat</u> absorbed by the apparatus or (specific) heat capacity of the apparatus not considered• incomplete combustion / not completely burned / reaction is not complete• The idea that the water may end up in the gaseous state (rather than liquid)• reactants and/or products may not be in standard states.• MBE data refers to gaseous species but the enthalpy of combustion refers to liquids in their standard states / liquid propanone and liquid water in standard states• MBE do not refer to <u>specific compounds</u> OR MBE <u>values vary with different compounds / molecules</u> OR are average / mean values taken <u>from a range of compounds / molecules</u>	2	<p>Apply the list principle but ignore incomplete reasons that contain correct chemistry</p> <p>Ignore “evaporation”</p> <p>Ignore “faulty equipment”</p> <p>Ignore ”human error”</p> <p>Not enough simply to state that “MBE are mean / average values”</p>
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Question	Marking Guidance	Mark	Comments
8(a)	<p>P 3,3-dimethylbut-1-ene OR accept 3,3-dimethylbutene</p> <p>Q 3-chloro-2,2-dimethylbutane OR accept 2-chloro-3,3-dimethylbutane</p>	2	<p>Ignore absence of commas, hyphens and gaps Require correct spelling</p> <p>In Q, “chloro” must come before “dimethyl”</p>

<p>8(b)</p>	<p>M1 <u>Electrophilic addition</u></p>  <p>M2 must show an arrow from the double bond towards the H atom of HCl</p> <p>M3 must show the breaking of the H–Cl bond</p> <p>M4 is for the structure of the carbocation</p> <p>M5 must show an arrow from the lone pair of electrons on the negatively charged chloride ion towards the positively charged carbon atom on <u>their</u> carbocation.</p> <p>NB The arrows here are double-headed</p>	<p>5</p> <p>M1 both words required</p> <p>For the mechanism</p> <p>M3 Penalise incorrect partial charge on H–Cl bond and penalise formal charges</p> <p>Ignore partial negative charge on the double bond.</p> <p>Maximum 3 of 4 marks for a correct mechanism using HBr or the wrong organic reactant or wrong organic product (if shown) or a primary carbocation</p> <p>Penalise once only in any part of the mechanism for a line and two dots to show a bond</p> <p>Credit the correct use of “sticks”</p> <p>For M5, credit attack on a partially positively charged carbocation structure, but penalise M4</p>
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<p>8(c)</p>	<p>M1 Nucleophilic substitution</p>  <p>M2 must show an arrow from the lone pair of electrons on the nitrogen atom of an ammonia molecule to the correct C atom</p> <p>M3 must show the movement of a pair of electrons from the C–Cl bond to the Cl atom. Mark M3 independently provided it is from <u>their original molecule</u></p> <p>M4 is for the structure of the alkylammonium ion, which could be a condensed formula. A positive charge must be shown on, or close to, the N atom.</p> <p>M5 is for an arrow from the N–H bond to the N atom</p> <p>Award full marks for an S_N1 mechanism in which M2 is the attack of the ammonia on the intermediate carbocation</p> <p>NB These are double-headed arrows</p>	<p>5</p>	<p>For M1, both words required. Accept phonetic spelling</p> <p>For the mechanism Penalise M2 if NH₃ is negatively charged.</p> <p>Penalise M3 for formal charge on C of the C–Cl or incorrect partial charges on C–Cl</p> <p>Penalise M3 for an additional arrow from the Cl to something else</p> <p>The second mole of ammonia is not essential for M5; therefore ignore any species here</p> <p>Penalise once only for a line and two dots to show a bond</p> <p>Maximum 3 of 4 marks for the mechanism for wrong organic reactant OR wrong organic product if shown</p> <p>Accept the correct use of “sticks”</p>
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8(d)	<p>M1 (base) elimination</p> <p>M2 KOH <i>OR</i> NaOH</p> <p>M3 Must be consequential on a correct reagent in M2, but if incomplete or inaccurate attempt at reagent (e.g. hydroxide ion), penalise M2 only and mark on</p> <p>Any one from</p> <ul style="list-style-type: none"> • <u>high temperature OR hot OR heat / boil under reflux</u> • <u>concentrated</u> • <u>alcohol / ethanol (as a solvent) / (ethanolic conditions)</u> 	3	<p>M1 Dehydrohalogenation</p> <p>M3 not “reflux” alone</p> <p>M3 if a temperature is stated it must be in the range 78°C to 200 °C</p> <p>Ignore “pressure”</p>
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8(e)	<p>M1</p> $3\text{NaBr} + \text{H}_3\text{PO}_4 \longrightarrow 3\text{HBr} + \text{Na}_3\text{PO}_4$ <p>M2 and M3</p> <p>SO₂ and Br₂ identified</p> <p>M4</p> <p>Concentrated sulfuric acid</p> <ul style="list-style-type: none"> • is an oxidising agent • oxidises the <u>bromide (ion) or Br⁻ or NaBr or HBr</u> • is an electron acceptor 	4	<p>M1 Credit correct ionic species in the equation</p> <p>In M2 and M3 the two gases need to be identified. If equations are used using sulfuric acid and the toxic gases are not identified clearly, allow one mark for the formulas of SO₂ and Br₂</p> <ul style="list-style-type: none"> • apply the list principle as appropriate but ignore any reference to HBr • the marks are for identifying the two gases either by name or formula
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Question	Marking Guidance	Mark	Comments
9(a)	<p>M1 (could be scored by a correct mathematical expression)</p> <p>M1 $\Delta H = \sum \Delta H_f(\text{products}) - \sum \Delta H_f(\text{reactants})$</p> <p>OR a <u>correct cycle of balanced equations</u></p> <p>M2 = 5(–635) – (– 1560)</p> <p> = – 3175 + 1560</p> <p> (This also scores M1)</p> <p>M3 = <u>– 1615</u> (kJ mol^{–1})</p> <p>Award 1 mark ONLY for (+) 1615</p> <p>M4 Type of reaction is</p> <ul style="list-style-type: none"> • reduction • redox • (or accept) <u>V₂O₅ / it / V(V)</u> has been <u>reduced</u> 	5	<p>Correct answer to the calculation gains all of M1, M2 and M3</p> <p>Credit 1 mark for(+) 1615 (kJ mol^{–1})</p> <p>For other incorrect or incomplete answers, proceed as follows</p> <ul style="list-style-type: none"> • check for an arithmetic error (AE), which is either a transposition error or an incorrect multiplication; this would score 2 marks (M1 and M2) • If no AE, check for a correct method; this requires either a correct cycle with V₂O₅ <u>and</u> 5CaO OR a clear statement of M1 which could be in words and scores <u>only</u> M1 <p>In M4 not “vanadium / V is reduced”</p>

9(a) cont.	<p>M5 Major reason for expense of extraction – the answer must be about calcium</p> <p><u>Calcium is produced / extracted by electrolysis</u></p> <p>OR <u>calcium is expensive to extract</u></p> <p>OR <u>calcium extraction uses electricity</u></p> <p>OR <u>calcium extraction uses large amount of energy</u></p> <p>OR <u>calcium is a (very) reactive metal / reacts with water or air</u></p> <p>OR <u>calcium needs to be extracted / does not occur native</u></p>		<p>QoL</p> <p>Accept calcium is expensive “to produce” but not “to source, to get, to obtain, to buy” etc.</p> <p>In M5 it is neither enough to say that calcium is “expensive” nor that calcium “must be purified”</p>
9(b)	<p>M1 $2\text{Al} + \text{Fe}_2\text{O}_3 \longrightarrow 2\text{Fe} + \text{Al}_2\text{O}_3$</p> <p>M2 (Change in oxidation state) 0 to (+)3</p> <p>OR (changed by) +3</p>	2	<p>Ignore state symbols</p> <p>Credit multiples of the equation</p> <p>In M2 if an explanation is given it must be correct and unambiguous</p>

9(c)	<p>M1 $\text{VCl}_2 + \text{H}_2 \longrightarrow \text{V} + 2\text{HCl}$</p> <p>M2 and M3 Two hazards in either order</p> <ul style="list-style-type: none"> • <u>HCl / hydrogen chloride / hydrochloric acid is acidic / corrosive / toxic / poisonous</u> • <u>Explosion risk with hydrogen (gas) OR H₂ is flammable</u> <p>M4 The only other product / the HCl is easily / readily <u>removed / lost / separated because it is a gas OR will escape</u> (or this idea strongly implied) <u>as a gas</u> OR vanadium / it is the <u>only solid product</u> (and is easily separated) OR vanadium / it is a <u>solid and the other product / HCl is a gas</u></p>	4	<p>In M1 credit multiples of the equation</p> <p>For M2/M3 there must be reference to hydrogen; it is not enough to refer simply to an explosion risk</p> <p>For M2/M3 with HCl hazard, require reference to acid(ic) / corrosive / toxic <u>only</u></p> <p>In M4 it is not enough to state simply that HCl is a gas, since this is in the question.</p>
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General principles applied to marking CHEM2 papers by CMI+ (June 2015)

It is important to note that the guidance given here is generic and specific variations may be made at individual standardising meetings in the context of particular questions and papers.

Basic principles

- **Examiners should note that throughout the mark scheme, items that are underlined are required information to gain credit.**
- **Occasionally an answer involves incorrect chemistry and the mark scheme records CE = 0, which means a chemical error has occurred and no credit is given for that section of the clip or for the whole clip.**

A. The “List principle” and the use of “ignore” in the mark scheme

If a question requires **one** answer and a candidate gives two answers, no mark is scored if one answer is correct and one answer is incorrect. There is no penalty if both answers are correct.

N.B. Certain answers are designated in the mark scheme as those which the examiner should “Ignore”. These answers are not counted as part of the list and should be ignored and will not be penalised.

B. Incorrect case for element symbol

The use of an incorrect case for the symbol of an element should be penalised **once only** within a clip. For example, penalise the use of “h” for hydrogen, “CL” for chlorine or “br” for bromine.

C. Spelling

In general

- The names of chemical compounds and functional groups **must be spelled correctly** to gain credit.
- Phonetic spelling may be acceptable for some chemical terminology.

N.B. Some terms may be required to be spelled correctly or an idea needs to be articulated with clarity, as part of the “Quality of Language” (QoL) marking. These will be identified in the mark scheme and marks are awarded only if the QoL criterion is satisfied.

D. Equations

In general

- Equations **must** be balanced.
- When an equation is worth two marks, one of the marks in the mark scheme will be allocated to one or more of the reactants or products. This is independent of the equation balancing.
- State symbols are generally ignored, unless specifically required in the mark scheme.

E. Reagents

The command word “Identify”, allows the candidate to choose to use **either** the name or the formula of a reagent in their answer. In some circumstances, the list principle may apply when both the name and the formula are used. Specific details will be given in mark schemes.

The guiding principle is that a reagent is a chemical which can be taken out of a bottle or container. Failure to identify complete reagents **will be penalised**, but follow-on marks (e.g. for a subsequent equation or observation) can be scored from an incorrect attempt (possibly an incomplete reagent) at the correct reagent. Specific details will be given in mark schemes.

For example, **no credit** would be given for

- the cyanide ion or CN^- when the reagent should be potassium cyanide or KCN;
- the hydroxide ion or OH^- when the reagent should be sodium hydroxide or NaOH;
- the $\text{Ag}(\text{NH}_3)_2^+$ ion when the reagent should be Tollens' reagent (or ammoniacal silver nitrate). In this example, no credit is given for the ion, but credit could be given for a correct observation following on from the use of the ion. Specific details will be given in mark schemes.

In the event that a candidate provides, for example, **both** KCN and cyanide ion, it would be usual to ignore the reference to the cyanide ion (because this is not contradictory) and credit the KCN. Specific details will be given in mark schemes.

F. Oxidation states

In general, the sign for an oxidation state will be assumed to be positive unless specifically shown to be negative.

G. Marking calculations, such as those involving enthalpy changes

In general

- The sign for an enthalpy change will be assumed to be positive unless specifically shown to be negative.
- A correct answer alone will score **full marks** unless the necessity to show working is specifically required in the question.
- A correct numerical value with the **wrong sign** will usually score **only one mark**.

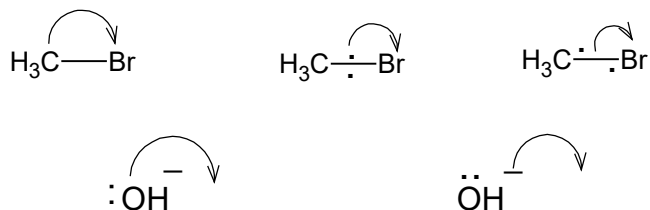
All other values **gain no credit** except

- Two marks can be awarded for correct chemistry with an arithmetic error.
- One mark can be awarded for a correct mathematical statement (or cycle) for the method.

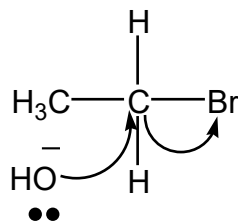
H. Organic reaction mechanisms

Curly arrows should originate either from a lone pair of electrons or from a bond.

The following representations should not gain credit **and will be penalised each time** within a clip.



For example, the following would score zero marks



When the curly arrow is showing the formation of a bond to an atom, the arrow can go directly to the relevant atom, alongside the relevant atom or **more than half-way** towards the relevant atom.

In free-radical substitution

- The absence of a radical dot should be penalised **once only** within a clip.

- The use of double-headed arrows or the incorrect use of half-headed arrows in free-radical mechanisms should be penalised **once only** within a clip

In mass spectrometry fragmentation equations, the absence of a radical dot on the molecular ion and on the free-radical fragment would be considered to be two independent errors and both would be penalised if they occurred within the same clip.

I. Organic structures

In general

- Displayed formulae must show all of the bonds and all of the atoms in the molecule, but need not show correct bond angles.
- Bonds should be drawn correctly between the relevant atoms.
For example, if candidates show the alcohol functional group as C – HO, they should be penalised **on every occasion**.
- Latitude should be given to the representation of C – C bonds in structures, given that CH₃– is considered to be interchangeable with H₃C– even though the latter would be preferred.
- Poor presentation of vertical C – CH₃ bonds or C – NH₂ bonds should **not** be penalised. For the other functional groups, such as – OH and – CN, the limit of tolerance is the half-way position between the vertical bond and the relevant atoms in the attached group.
By way of illustration, the following would apply

(a)	$\begin{array}{c} \\ \text{CH}_3\text{-C-} \\ \end{array}$ <p>allowed</p>	(b)	$\begin{array}{c} \\ \text{---C---} \\ \\ \text{CH}_3 \end{array}$ <p>allowed</p>
(c)	$\begin{array}{c} \\ \text{NH}_2\text{-C-} \\ \end{array}$ <p>allowed</p>	(d)	$\begin{array}{c} \\ \text{---C---} \\ \\ \text{NH}_2 \end{array}$ <p>allowed</p>

- In most cases, the use of “sticks” to represent C – H bonds in a structure should **not** be penalised. The exceptions will include structures in mechanisms when the C – H bond is essential (e.g. elimination reactions in haloalkanes) and when a displayed formula is required.
- Some examples are given here of **structures** for specific compounds that should **not** gain credit

CH ₃ COH	for	ethanal
CH ₃ CH ₂ HO	for	ethanol
OHCH ₂ CH ₃	for	ethanol
C ₂ H ₆ O	for	ethanol
CH ₂ CH ₂	for	ethene
CH ₂ .CH ₂	for	ethene
CH ₂ :CH ₂	for	ethene

N.B. Exceptions may be made in the context of balancing equations

- Each of the following **should gain credit** as alternatives to correct representations of the structures.

CH ₂ = CH ₂	for	ethene, H ₂ C=CH ₂
CH ₃ CHOHCH ₃	for	propan-2-ol, CH ₃ CH(OH)CH ₃

J. Organic names

As a general principle, non-IUPAC names or incorrect spelling or incomplete names should **not** gain credit. Some illustrations are given here.

but-2-ol	should be butan-2-ol
2-hydroxybutane	should be butan-2-ol
butane-2-ol	should be butan-2-ol
2-butanol	should be butan-2-ol

ethan-1,2-diol	should be ethane-1,2-diol
2-methpropan-2-ol	should be 2-methylpropan-2-ol
2-methylbutan-3-ol	should be 3-methylbutan-2-ol
3-methylpentan	should be 3-methylpentane
3-mythylpentane	should be 3-methylpentane
3-methypentane	should be 3-methylpentane
propanitrile	should be propanenitrile
aminethane	should be ethylamine (although aminoethane can gain credit)
2-methyl-3-bromobutane	should be 2-bromo-3-methylbutane
3-bromo-2-methylbutane	should be 2-bromo-3-methylbutane
3-methyl-2-bromobutane	should be 2-bromo-3-methylbutane
2-methylbut-3-ene	should be 3-methylbut-1-ene
difluorodichloromethane	should be dichlorodifluoromethane

K. Additional sheets and blank clips

- Markers should **mark all that is seen** and carry on marking as normal. Clips which refer to the use of additional sheets should **not** be referred to the senior team. Clips which refer to other parts of the script must be referred to the senior team.
- When considering crossed out work, **mark it** as if it were not crossed out **unless** it has been replaced by a later version; this later version then takes priority.
- Mark a blank section with a dash (—) and **not with a score of zero**.