A-LEVEL
Chemistry

CHEM2 Chemistry in Action
Mark scheme

2420
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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**Cl^- ⟶ Cl_2 + **2**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)	MnO_4^- + $8H^+$ + 5**e**$^-$ ⟶ Mn^{2+} + $4H_2O$	1	Ignore state symbols Credit loss of electrons from RHS Credit multiples Do not penalise absence of charge on electron
1(b)(i)	Cl_2 + **2**Br^- ⟶ **2**Cl^- + Br_2 ***OR*** $\frac{1}{2}Cl_2$ + Br^- ⟶ Cl^- + $\frac{1}{2}Br_2$	1	One of these two equations only Ignore state symbols
1(b)(ii)	(Turns to) yellow / orange / brown (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) gains electron(s) / takes electron(s) / accepts electron(s) (from the bromide ions) *OR* (Chlorine) causes another species (Br^-) to lose electron(s)	1	Penalise "electron pair acceptor" Not simply "causes loss of electrons"

1(c)	**M1** $\mathbf{2}Cl_2 + \mathbf{2}H_2O \longrightarrow \mathbf{4}HCl + O_2$ ($\mathbf{4}H^+ + \mathbf{4}Cl^-$) **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 smaller 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 intermolecular force affects energy needed** The forces between chlorine / Cl_2 molecules are weaker (than the forces between bromine / Br_2 molecules) (or converse for bromine) ***OR*** chlorine / Cl_2 has weaker / fewer/ less (VdW) intermolecular forces / forces between molecules	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 of the force between molecules. Reference to Van der Waals forces alone is not enough.

	(or converse for bromine)		Penalise **M2** if (covalent) bonds are broken

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

2(b)	**M1** (Shake with) Br_2 ***OR*** bromine (water) ***OR*** bromine (in CCl_4 / organic solvent) **M2** (stays) orange / red / yellow / brown / the same ***OR*** no reaction ***OR*** no (observed) change **M3** decolourised / goes colourless / loses its colour / orange to colourless ***OR* as alternatives** **Use $KMnO_4/H_2SO_4$** **M1** acidified potassium manganate(VII) / potassium permanganate ***OR*** $KMnO_4/H_2SO_4$ ***OR*** $KMnO_4/H^+$ ***OR*** acidified $KMnO_4$ **M2** (stays) <u>purple</u> or no reaction or no (observed) change **M3** decolourised / goes colourless / loses its colour **Use iodine** **M1** **iodine** or I_2 / KI or iodine solution **M2** no change **M3** decolourised / goes colourless / loses its colour **Use concentrated sulfuric acid** **M1** <u>concentrated</u> H_2SO_4 **M2** no change	3	If no reagent or incorrect reagent in **M1**, **CE= 0** and no marks for **M1**, **M2** or **M3** If incomplete /inaccurate attempt at reagent (e.g. Br), **penalise M1 only and mark on** No credit for combustion observations; **CE=0** For **M2 in every case** Ignore “nothing (happens)” Ignore “no observation” Ignore “clear” **For M1**, it must be a whole reagent and/or correct formula **For M1** penalise incorrect attempt at correct formula, but mark **M2** and **M3** **With potassium manganate(VII)** If incomplete / inaccurate attempt at reagent e.g. “manganate” or “manganate(IV)” or incorrect formula or no acid, **penalise M1 only and mark on** Credit alkaline/neutral $KMnO_4$ for possible full marks but **M3** gives <u>brown precipitate</u> or solution goes <u>green</u> Apply similar guidance for errors in the formula of iodine or concentrated sulfuric acid reagent

	M3 brown		as those used for other reagents.

2(c)	**M1** Any soluble chloride including hydrochloric acid (ignore concentration) **M2** white precipitate or white solid / white suspension **M3** remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear ***OR* as an alternative** **M1** Any soluble iodide including HI **M2** yellow precipitate or yellow solid / yellow suspension **M3** remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear ***OR* as an alternative** **M1** Any soluble bromide including HBr **M2** cream precipitate or cream solid / cream suspension **M3** remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear ***OR* as an alternative** **M1** NaOH or KOH or any soluble carbonate **M2** brown precipitate or brown solid / brown suspension with NaOH / KOH (white precipitate/ solid/ suspension with carbonate) **M3** remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear	3	If no reagent or incorrect reagent or insoluble chloride in **M1**, **CE= 0** and no marks for **M1**, **M2** or **M3** Allow chlorine water If incomplete reagent (e.g. chloride ions) or inaccurate attempt at formula of chosen chloride, or chlorine, **penalise M1 only and mark on** For **M2** require the word “white” and some reference to a solid. Ignore “cloudy solution” OR “suspension” (similarly for the alternatives) For **M3** Ignore “nothing (happens)” Ignore “no observation” Ignore “clear” on its own Ignore “dissolves”

2(d)	**M1** Any <u>soluble</u> <u>sulfate</u> including (dilute or aqueous) sulfuric acid **M2** remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear **M3** <u>white precipitate</u> or <u>white solid / white suspension</u> ***OR* as an alternative** **M1** NaOH or KOH **M2** <u>white precipitate</u> or <u>white solid / white suspension</u> **M3** remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear	3	If no reagent or incorrect reagent or insoluble sulfate in **M1**, **CE= 0** and no marks for **M1**, **M2** or **M3** Accept $MgSO_4$ and $CaSO_4$ but not barium, lead or silver sulfates If concentrated sulfuric acid or incomplete reagent (eg sulfate ions) or inaccurate attempt at formula of chosen sulfate, **penalise M1 only and mark on** For **M3 (or M2 in the alternative)** require the word "white" and some reference to a solid. Ignore "cloudy solution" OR "suspension" For **M2 (or M3 in the alternative)** Ignore "nothing (happens)" Ignore "no observation" Ignore "clear" <u>on its own</u> Ignore "dissolves" If incomplete reagent (e.g. hydroxide ions) or inaccurate attempt at formula of chosen hydroxide, **penalise M1 only and mark on** If **M1** uses NH_3 (dilute or concentrated) **penalise M1 only and mark on**

Question	Marking Guidance	Mark	Comments
3(a)	**M1** Increases / gets bigger **M2 requires a correct M1** More shells or sub-shells or (main) levels or sub-levels or orbitals (of electrons)	2	If **M1** is incorrect **CE=0** for the clip If **M1** is blank, mark on and seek to **credit the correct information in the text** **M2** requires correct **M1** If "molecules" penalise **M2** Not simply "more electrons" Not "more outer shells" Ignore reference to nuclear charge and shielding
3(b)(i)	Increases / gets more reactive / reacts more <u>vigorously / violently</u> (down the Group)	1	
3(b)(ii)	$Sr + 2H_2O \longrightarrow Sr(OH)_2 + H_2$	1	Credit multiples and correct ionic equations Ignore state symbols
3(c)	$Ba(OH)_2$	1	This MUST be a formula so ignore the name Credit Ba^{2+} $2OH^-$ Ignore state symbols

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

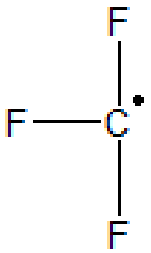
4(a)(ii)	**M1** The reaction <u>gets to equilibrium faster / in less time</u> ***OR*** Produces a small yield <u>faster / in less time</u> ***OR*** <u>Increases the rate</u> (of reaction / of attainment of equilibrium) **M2** High pressure leads to **one** of the following • <u>more particles / molecules in a given volume</u> • <u>particles / they are closer together</u> • <u>higher concentration of particles /molecules</u> ***<u>AND</u>*** • <u>more collisions in a given time</u> / <u>increased collision frequency</u>	2	Mark independently Penalise **M2** for reference to <u>increased</u> energy of the particles

4(a)(iii)	**M1** Increase in / more / large(r) / big(ger) surface area / surface sites **M2** increase in / more successful / productive / effective collisions (in a given time) (on the surface of the catalyst / with the nickel)	2	Mark independently For **M1** accept "an increase in surface" For **M2** not simply "more collisions" Ignore "the chance or likelihood" of collisions

4(b)	**M1** No effect / None **M2 requires a correct M1** Equal / same number / amount of moles / molecules / particles on either side of the equation ***OR*** 2 moles / molecules / particles on the left and 2 moles / molecules / particles on the right	2	If **M1** is incorrect **CE=0** for the clip If **M1** is blank, mark on and seek to **credit the correct information in the text** **M2** depends on a correct statement for **M1** In **M2 not** "atoms"

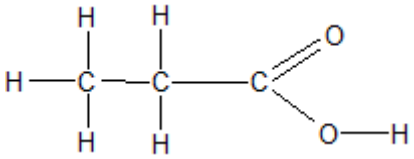
Question	Marking Guidance	Mark	Comments
5(a)(i)	**Initiation** $Br_2 \longrightarrow 2Br\bullet$ **First propagation** $Br\bullet + CHF_3 \longrightarrow \bullet CF_3 + HBr$ **Second propagation** $Br_2 + \bullet CF_3 \longrightarrow CBrF_3 + Br\bullet$ **Termination** $2\bullet CF_3 \longrightarrow C_2F_6$ ***OR*** CF_3CF_3 ***OR*** $2Br\bullet \longrightarrow Br_2$ ***OR*** $Br\bullet + \bullet CF_3 \longrightarrow CBrF_3$	4	Penalise absence of dot once only Credit the dot anywhere on the radical

5(a)(ii)	Ultra-violet / uv / sunlight ***OR*** T > 100°C OR high temperature	1	

5(b)(i)		1	Displayed formula required with the radical dot on carbon

5(b)(ii)	(The) C—Br (bond) breaks more readily / is weaker than (the) C—Cl (bond) (or converse) ***OR*** The C—Br bond enthalpy / bond strength is less than that for C—Cl (or converse)	1	Requires **a comparison** between the two bonds Give credit for an answer that suggests that the UV frequency / energy may favour C—Br bond breakage rather than C—Cl 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)	**M1** $Br\bullet + O_3 \longrightarrow BrO\bullet + O_2$ **M2** $BrO\bullet + O_3 \longrightarrow Br\bullet + 2O_2$ **M3 One of the following** They / it / the bromine (atom) • 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	**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

Question	Marking Guidance	Mark	Comments
6(a)(i)	C_4H_{10} M_r = 4(12.00000) + 10(1.00794) = 58.07940 or 58.0794 or 58.079 or 58.08 **and** **58.1**	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)	By definition ***OR*** The standard / reference (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)	Addition (polymerisation)	1	ONLY this answer

6(c)(iii)	**M1** **C=C** (in range) **1620 to 1680** (cm^{-1}) **M2** **O—H** (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_3COCH_3	1	Any correct representation including correct use of “sticks”

6(d)(ii)	C	1	

Question	Marking Guidance	Mark	Comments
7(a)(i)	**2**$C_6H_{12}O_6$ ⟶ **3**CH_3COCH_3 + **3**CO_2 + **3**H_2O	1	Or multiples
7(a)(ii)	to speed up the reaction ***OR*** (provide a) catalyst or catalyses the reaction or biological catalyst ***OR*** release / contain / provides an enzyme	1	Ignore “fermentation” Ignore “to break down the glucose” Not simply “enzyme” on its own
7(b)(i)	$CH_3CH(OH)CH_3$ + [O] ⟶ CH_3COCH_3 + H_2O	1	Any correct representation for the two organic structures. Brackets not essential. Not “sticks” for the structures in this case
7(b)(ii)	Secondary (alcohol) OR 2^o (alcohol)	1	

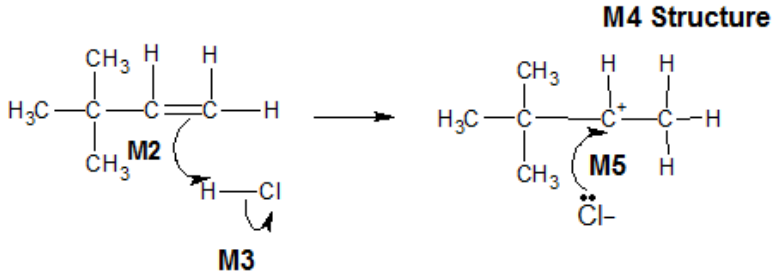
7(c)	**M1** q = m c ΔT ***OR*** q =150 × 4.18 × 8.0 **M2** = (±) 5016 (J) ***OR*** 5.016 (kJ) ***OR*** 5.02 (kJ) (also scores M1) **M3** This mark is for dividing correctly the number of kJ by the number of moles and arriving at a final answer in the range shown. Using 0.00450 mol therefore ΔH = **– 1115** (kJ mol^{-1}) ***OR*** **– 1114.6 to – 1120** (kJ mol^{-1}) **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**	3	Award full marks for correct answer In **M1**, do not penalise incorrect cases in the formula Penalise **M3** ONLY if correct numerical answer but sign is incorrect; **(+)1114.6 to (+)1120 gains 2 marks** Penalise **M2** for arithmetic error and mark on If ΔT = 281; score q = m c ΔT only If c = 4.81 (leads to 5772) penalise **M2** ONLY and mark on for **M3** = – 1283 Ignore incorrect units in **M2** If units are given in **M3** they must be either kJ or kJ mol^{-1} in this case

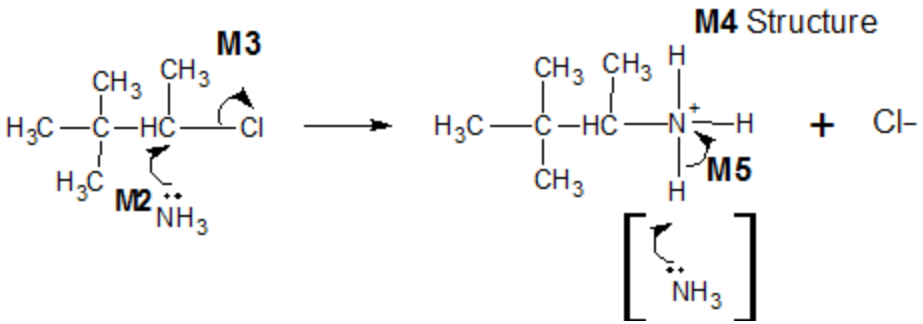
7(d)	**M1** The enthalpy change / heat change at constant pressure when 1 mol of a compound / substance / element **M2** is burned / combusts / reacts completely in oxygen ***OR*** burned / combusted / reacted in excess oxygen **M3** with (all) reactants and products / (all) substances in standard / specified states ***OR*** (all) reactants and products / (all) substances in normal states under standard conditions / 100 kPa / 1 bar and specified T / 298 K	3	If standard enthalpy of formation **CE=0** For **M3** Ignore reference to 1 atmosphere

7(e)	**M1** $\sum$ B(**reactants**) – $\sum$ B(**products**) = ΔH ***OR*** Sum of bonds broken – Sum of bonds formed = ΔH ***OR*** 2B(C-C) + B(C=O) + 6B(C-H) + 4B(O=O) (LHS) – 6B(C=O) – 6B(O–H) (RHS) = ΔH **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**) **M3** ΔH = **– 1651** (kJ mol^{-1}) **Candidates may use a cycle and gain full marks.**	3	Correct answer gains full marks Credit 1 mark for (+) 1651 (kJ mol^{-1}) For other incorrect or incomplete answers, proceed as follows • 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 $4O_2$, $3CO_2$ and $3H_2O$ OR a clear statement of **M1** which could be in words and scores **only M1** Allow a maximum of one mark if the only scoring point is LHS = 5957 (or 5152) OR RHS = 7608 (or 6803) Award 1 mark for +1651

7(f)	**For the two marks M1 and M2, <u>any two</u> from** • <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 <u>do not refer to 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	Apply the list principle but ignore incomplete reasons that contain correct chemistry Ignore “evaporation” Ignore “faulty equipment” Ignore ”human error” Not enough simply to state that “MBE are mean / average values”

Question	Marking Guidance	Mark	Comments
8(a)	**P** 3,3-dimethylbut-1-ene ***OR*** accept 3,3-dimethylbutene **Q** 3-chloro-2,2-dimethylbutane ***OR*** accept 2-chloro-3,3-dimethylbutane	2	Ignore absence of commas, hyphens and gaps Require correct spelling In Q, “chloro” must come before “dimethyl”

8(b)	**M1** **Electrophilic addition**  **M2** must show an arrow from the double bond towards the H atom of HCl **M3** must show the breaking of the H–Cl bond **M4** is for the structure of the carbocation **M5** must show an arrow from the lone pair of electrons on the negatively charged chloride ion towards the positively charged carbon atom on their carbocation. **NB The arrows here are double-headed**	5	**M1** both words required **For the mechanism** **M3** Penalise incorrect partial charge on H–Cl bond and penalise formal charges Ignore partial negative charge on the double bond. **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 Penalise once only in any part of the mechanism for a line and two dots to show a bond Credit the correct use of “sticks” For **M5**, credit attack on a partially positively charged carbocation structure, but penalise **M4**

8(c)	**M1** **Nucleophilic substitution**  **M2** must show an arrow from the lone pair of electrons **on the nitrogen atom** of an ammonia molecule to the correct C atom **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 their original molecule **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. **M5** is for an arrow from the N–H bond to the N atom Award full marks for an S_N1 mechanism in which **M2** is the attack of the ammonia on the intermediate carbocation **NB These are double-headed arrows**	5	For **M1**, both words required. Accept phonetic spelling **For the mechanism** Penalise **M2** if NH_3 is negatively charged. Penalise **M3** for formal charge on C of the C–Cl or incorrect partial charges on C–Cl Penalise **M3** for an additional arrow from the Cl to something else The second mole of ammonia is not essential for **M5**; therefore ignore any species here Penalise once only for a line and two dots to show a bond **Maximum 3 of 4 marks for the mechanism** for wrong organic reactant ***OR*** wrong organic product if shown Accept the correct use of “sticks”

8(d)	**M1** (base) elimination **M2** KOH ***OR*** NaOH **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** Any **one** from • high temperature OR hot OR heat / boil under reflux • concentrated • alcohol / ethanol (as a solvent) / (ethanolic conditions)	3	**M1** Dehydrohalogenation **M3** not "reflux" alone **M3** if a temperature is stated it must be in the range 78°C to 200 °C Ignore "pressure"

8(e)	**M1** $3NaBr + H_3PO_4 \longrightarrow 3HBr + Na_3PO_4$ **M2 and M3** SO_2 **and** Br_2 identified **M4** Concentrated sulfuric acid • is an oxidising agent • oxidises the bromide (ion) or Br^- or NaBr or HBr • is an electron acceptor	4	**M1** Credit correct ionic species in the equation 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 SO_2 and Br_2 • 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

Question	Marking Guidance	Mark	Comments
9(a)	**M1 (could be scored by a correct mathematical expression)** **M1** $\Delta H = \sum\Delta H_f$(**products**) - $\sum\Delta H_f$(**reactants**) ***OR*** a correct cycle of balanced equations **M2** = 5(–635) – (– 1560) = – 3175 + 1560 (This also scores M1) **M3** = **– 1615** (kJ mol^{-1}) **Award 1 mark ONLY for (+) 1615** **M4 Type of reaction is** • reduction • redox • (or accept) V_2O_5 / it / V(V) has been reduced	5	Correct answer to the calculation gains all of **M1**, **M2** and **M3** Credit 1 mark for(+) 1615 (kJ mol^{-1}) For other incorrect or incomplete answers, proceed as follows • 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 V_2O_5 and 5CaO OR a clear statement of **M1** which could be in words and scores **only M1** In **M4** not “vanadium / V is reduced”

9(a) cont.	**M5 Major reason for expense of extraction – the answer must be about calcium** Calcium is produced / extracted by electrolysis ***OR*** calcium is expensive to extract ***OR*** calcium extraction uses electricity ***OR*** calcium extraction uses large amount of energy ***OR*** calcium is a (very) reactive metal / reacts with water or air ***OR*** calcium needs to be extracted / does not occur native		**QoL** Accept calcium is expensive "to produce" but not "to source, to get, to obtain, to buy" etc. In **M5** it is neither enough to say that calcium is "expensive" nor that calcium "must be purified"
9(b)	**M1** $2Al + Fe_2O_3 \longrightarrow 2Fe + Al_2O_3$ **M2** (Change in oxidation state) **0** to (+)**3** ***OR*** (changed by) **+3**	2	Ignore state symbols Credit multiples of the equation In **M2** if an explanation is given it must be correct and unambiguous

9(c)	**M1** $VCl_2 + H_2 \longrightarrow V + 2HCl$ **M2** and **M3** Two hazards in either order • HCl / hydrogen chloride / hydrochloric acid is acidic / corrosive / toxic / poisonous • Explosion risk with hydrogen (gas) OR H_2 is flammable **M4** The only other product / the HCl is easily / readily removed / lost / separated because it is a gas *OR* will escape (or this idea strongly implied) as a gas ***OR*** vanadium / it is the only solid product (and is easily separated) ***OR*** vanadium / it is a solid and the other product / HCl is a gas	4	In **M1** credit multiples of the equation For **M2/M3** there must be reference to hydrogen; it is not enough to refer simply to an explosion risk For **M2/M3** with HCl hazard, require reference to acid(ic) / corrosive / toxic only In **M4** it is not enough to state simply that HCl is a gas, since this is in the question.

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 <u>required information</u> 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. <u>The "List principle" and the use of "ignore" in the mark scheme</u>

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. <u>Incorrect case for element symbol</u>

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. <u>Spelling</u>

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 $Ag(NH_3)_2^+$ 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

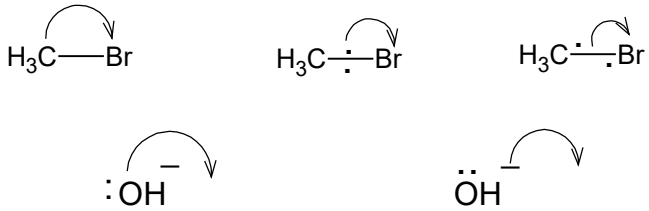
- The sign for an enthalpy change will be assumed to be positive unless specifically shown to be negative.
- A correct answer alone will score **full marks** unless the necessity to show working is specifically required in the question.
- A correct numerical value with the **wrong sign** will usually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

All other values **gain no credit** except

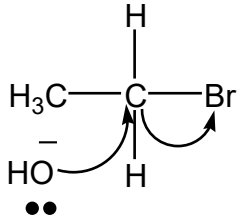
- Two marks can be awarded for correct chemistry with an arithmetic error.
- One mark can be awarded for a correct mathematical statement (or cycle) for the method.

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.

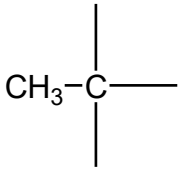
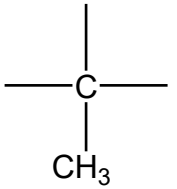
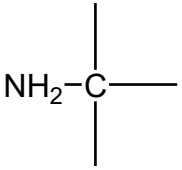
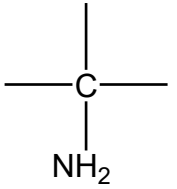
- The use of double-headed arrows or the incorrect use of half-headed arrows in free-radical mechanisms should be penalised **once only** within a clip

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 CH_3─ is considered to be interchangeable with H_3C─ even though the latter would be preferred.
- Poor presentation of vertical C ─ CH_3 bonds or C ─ NH_2 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)  allowed	(b)  allowed
(c)  allowed	(d)  allowed

- 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_3COH	for	ethanal
CH_3CH_2HO	for	ethanol
$OHCH_2CH_3$	for	ethanol
C_2H_6O	for	ethanol
CH_2CH_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, $H_2C=CH_2$
$CH_3CHOHCH_3$	for	propan-2-ol, $CH_3CH(OH)CH_3$

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. <u>Additional sheets and blank clips</u>

- 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**.