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General Certificate of Education (A-level)
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Chemistry CHEM2

(Specification 2420)

Unit 2: Chemistry In Action

Final

Mark Scheme

Mark schemes are prepared by the Principal Examiner 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 examiners participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for standardisation each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised they are required to refer these to the Principal Examiner.

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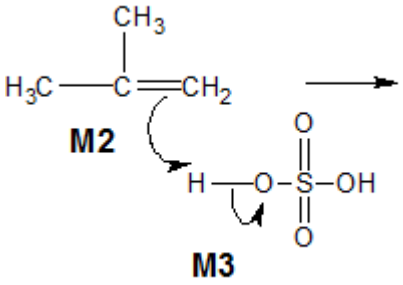
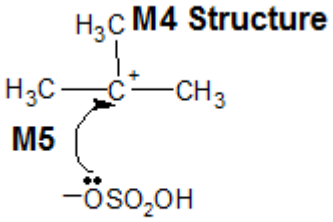
Question	Marking Guidance	Mark	Comments
1(a)(i)	**M1 (**Yield) increases / goes up / gets more **M2** The (forward) reaction / to the right is <u>exothermic</u> or <u>gives out / releases heat</u> ***OR*** The reverse reaction / to the left is <u>endothermic</u> or <u>takes in / absorbs heat</u> **M3 depends on correct M2 and must refer to temperature/heat** The (position of) <u>equilibrium shifts / moves</u> left to right to <u>oppose the decrease in temperature</u>	3	If **M1** is blank, mark on and seek to **credit the correct information in the explanation.** If **M1** is incorrect **CE=0** for the clip. **M3** depends on a correct statement for **M2** For **M3**, the <u>equilibrium shifts/moves</u> to <u>release heat</u> ***OR*** to <u>raise the temperature</u> ***OR*** to <u>heat up the reaction.</u>
1(a)(ii)	**M1** <u>Concentration(s)</u> (of reactants and products) remain or stay constant / the same **M2** <u>Forward rate</u> = <u>reverse / backward rate</u>	2	For **M1** credit [ ] for concentration. Not “equal concentrations”. Not “concentrations <u>is / are the same</u>”. Not “amount”. Ignore “dynamic” and ignore “speed”. Ignore “closed system”. It is possible to score both marks under the heading of a single feature.

1(b)	$KBr + H_2SO_4 \longrightarrow KHSO_4 + HBr$	1	Credit this equation in its ionic form. Ignore state symbols. Credit multiples.
1(c)	**M1** SO_2 identified **M2 correctly balanced equation (would also gain M1)** $\mathbf{2}HBr + H_2SO_4 \longrightarrow Br_2 + SO_2 + \mathbf{2}H_2O$ **Mark M3 independently** **M3** Oxidising agent ***OR*** electron acceptor ***OR*** oxidant ***OR*** to oxidise the bromide (ion) / HBr	3	Credit **M2** equation in its ionic form. Ignore state symbols. Credit multiples. Not H_2SO_3 on the right-hand side. **M3** Not “electron pair acceptor”.

1(d)(i)	**M1 Electrophilic addition**   **M2** must show an arrow from the double bond towards the H atom of the H – O bond / HO on a compound with molecular formula for H_2SO_4 **M2** could be to an H+ ion and **M3** an independent O – H bond break on a compound with molecular formula for H_2SO_4 **M3** must show the breaking of the O ─ H bond on H_2SO_4 **M4** is for the structure of the carbocation **M5** must show an arrow from the lone pair of electrons on the correct oxygen of the negatively charged ion towards the positively charged carbon atom on <u>their</u> carbocation **NB The arrows here are double-headed**	5	**M1** both words required. **For the mechanism** **M3** Penalise incorrect partial charges on O – H bond and penalise formal charges Ignore partial negative charge on the double bond. **M5** Not HSO_4^- For **M5**, credit <u>as shown</u> or <u>$^-OSO_3H$</u> ONLY with the negative charge anywhere on this ion ***OR*** <u>correctly</u> drawn out with the negative charge placed correctly on oxygen. <u>Max any 3 of 4 marks</u> **<u>for a correct mechanism</u>** using 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**
1(d)(ii)	Hydrolysis	1	Credit “(nucleophilic) substitution” but do not accept any other prefix. Credit phonetic spelling.
1(d)(iii)	Catalyst	1	

Question	Marking Guidance	Mark	Comments
2(a)	**M1** concentrated sulfuric acid OR c(onc) H_2SO_4 **M2** (cream solid) turns orange ***OR*** orange / red / brown fumes / gas / vapour **M3** (yellow solid) turns black ***OR*** purple fumes / gas / vapour ***OR*** correct reference to H_2S observation (eg bad egg smell) ***OR* as an alternative** **M1** concentrated ammonia ***OR*** c(onc) NH_3 **M2** (cream solid) dissolves / solution formed **M3** precipitate remains / does not dissolve / insoluble ***OR*** no reaction / no change / (yellow solid) turns to white solid	3	If no reagent or incorrect reagent in **M1**, **CE= 0** and no marks for **M2** or **M3** If dilute sulfuric acid OR "aq" (alone) **CE=0** If H_2SO_4 / sulfuric acid given but not stated whether dilute or concentrated, penalise **M1** and mark on for **M2** and **M3** If incorrect formula for the acid, penalise **M1** but mark **M2** and **M3** If NH_3 / ammonia / aq ammonia given, but not stated as concentrated ***OR*** if dilute ammonia given, penalise **M1** but mark on for **M2** and **M3** Ignore "partially" and ignore "clear" in **M2** If incorrect formula for ammonia, penalise **M1** but mark **M2** and **M3** In **M3** for ammonia. Ignore "nothing (happens)". Ignore "no observation".

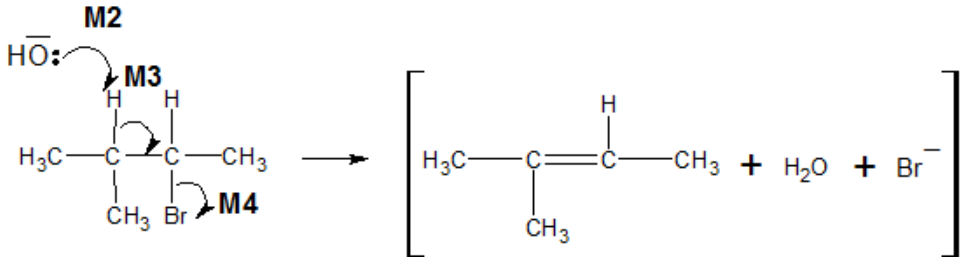
2(b)	**M1** $AgNO_3$ ***OR*** silver nitrate ***OR*** any <u>soluble</u> silver salt **M2** <u>white precipitate</u> or <u>white solid / white suspension</u> **M3** remains colourless ***OR*** no reaction ***OR*** no (observed) change ***OR*** no precipitate Credit alternative test for nitrate ions	3	If no reagent or incorrect reagent in **M1**, **CE= 0** and no marks for **M2** or **M3** An insoluble silver salt OR Tollens' ***OR*** Ag ***OR*** ammoniacal silver nitrate or HCl / $AgNO_3$ **CE= 0** for the clip. For **M1** Credit acidified (or HNO_3) silver nitrate for **M1** and mark on. If silver ions or incorrect formula for silver nitrate, penalise **M1** but mark **M2** and **M3** For **M2** Ignore "cloudy solution" ***OR*** "suspension". For **M3** Ignore "nothing (happens)". Ignore "no observation". Ignore "clear". Ignore "dissolves".

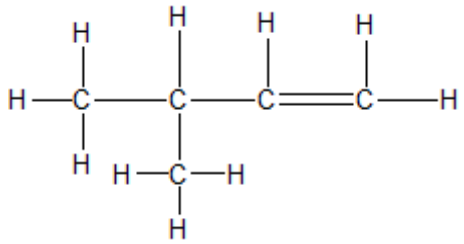
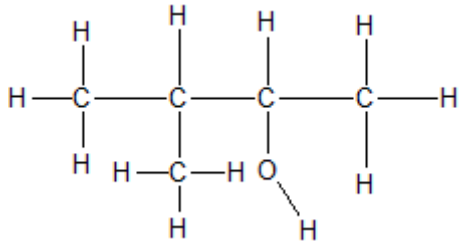
2(c)	**M1** Br_2 ***OR*** bromine (water) ***OR*** bromine (in CCl_4 / organic solvent) **Either order** **M2** (stays) orange / red / yellow / brown / the same ***OR*** no reaction ***OR*** no (observed) change ***OR*** reference to colour going to cyclohexane layer **M3** decolourised / goes colourless / loses its colour ***OR* as an alternative** **Use $KMnO_4/H_2SO_4$** **M1** acidified potassium manganate(VII) 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** <u>purple to colourless</u> solution ***OR*** goes <u>colourless</u> Credit alternative test using **iodine** (for **M1**) **M2** (brown) to purple or accept no change, **M3** colourless Credit alternative test using <u>concentrated</u> H_2SO_4 **M2** no change, **M3** brown	3	If no reagent or incorrect reagent in **M1**, **CE= 0** and no marks for **M2** or **M3** No credit for combustion observations; **CE=0** For **M2 in every case.** Ignore "nothing (happens)". Ignore "no observation". Ignore "clear". **With bromine (water)** **For M1**, it must be a whole reagent and/or correct formula. If oxidation state given in name, it must be correct. **For M1** penalise incorrect formula, but mark **M2** and **M3** **With potassium manganate(VII)** **For M1** If "manganate" or "manganate(IV)" or incorrect formula or no acid, penalise **M1** but mark **M2** and **M3** Credit alkaline/neutral $KMnO_4$ for possible full marks but **M3** gives <u>brown precipitate</u> or solution goes <u>green.</u>

2(d)	**M1** Tollens' (reagent) OR ammoniacal silver nitrate OR a description of making Tollens' (Ignore either $AgNO_3$ or $[Ag(NH_3)_2^+]$ or "the silver mirror test" on their own, but mark **M2** and **M3**) **M2** silver mirror ***OR*** black solid/precipitate (ignore silver precipitate) **M3 (**stays) colourless or no reaction or no (observed) change Alternative using Fehling's (solution) **M1** Fehling's (solution) or Benedict's solution (Ignore $Cu^{2+}(aq)$ or $CuSO_4$ on their own, but mark **M2** and **M3**) **M2** Red solid/precipitate (Credit orange or brown solid) **M3 (**stays) blue or no reaction or no (observed) change Alternative using $K_2Cr_2O_7/H_2SO_4$ **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** (stays) orange or no reaction or no (observed) change Alternative using $KMnO_4/H_2SO_4$ **M1** acidified potassium manganate(VII) or $KMnO_4/H_2SO_4$ ***OR*** $KMnO_4/H^+$ ***OR*** acidified $KMnO_4$ **M2** purple to colourless solution OR goes colourless **M3** (stays) purple or no reaction or no (observed) change	3	If no reagent or incorrect reagent in **M1**, **CE= 0** and no marks for **M2** or **M3** For **M3 in every case** Ignore "nothing (happens)". Ignore "no observation". **With potassium dichromate(VI)** **For M1** If "dichromate" or "(potassium) dichromate(IV)" or incorrect formula or no acid, penalise **M1** but mark **M2** and **M3** **For M3** Ignore dichromate described as "yellow" or "red". **With potassium manganate(VII)** **For M1** If "manganate" or "(potassium manganate(IV)" or incorrect formula or no acid, penalise **M1** but mark **M2** and **M3** Credit alkaline/neutral $KMnO_4$ for possible full marks but **M2** gives brown precipitate or solution goes green.

Question	Marking Guidance	Mark	Comments
3(a)	**M1** On the energy axis E_{mp} at the maximum of the original peak **M2** The peak of their new curve is displaced to the left and higher than the original **M3 All of the following** are required • The new curve starts at the origin and should begin to separate from the original almost immediately • and the new curve crosses the original curve once • and an attempt has been made to draw the new curve correctly towards the energy axis below the original curve but not to touch the original curve or the axis	3	**M1** The limits for the horizontal position of E_{mp} are defined as above the word "the" in the sentence below the graph.
3(b)	**The rate of reaction decreases as the temperature decreases because** **M1** A decrease in the number / proportion of molecules with $E \geq E_a$ ***OR*** fewer molecules have $E \geq E_a$ ***OR*** fewer molecules have sufficient / enough energy to react / decompose **M2** Fewer effective / productive / successful collisions in a given time / given period ***OR*** fewer frequent effective / productive / successful collisions ***OR*** lower rate of effective / productive / successful collisions	2	**In M1** Ignore "molecules have less energy". Ignore "less energetic collisions". Ignore "molecules do not gain activation energy". Ignore "fewer collisions". Credit "particles" for "molecules" but NOT "atoms". Ignore "chance of collision"; this alone does not gain **M2**

Question	Marking Guidance	Mark	Comments
4(a)(i)	$3CuS(s) + \mathbf{8}HNO_3(aq) \longrightarrow \mathbf{3}CuSO_4(aq) + \mathbf{8}NO(g) + \mathbf{4}H_2O(l)$	1	
4(a)(ii)	**(+) 5** **(+) 2**	2	
4(a)(iii)	$\mathbf{4}H^+ + NO_3^- + \mathbf{3}e^- \longrightarrow \mathbf{2}H_2O + NO$	1	Ignore state symbols. Credit multiples of **this equation only.** Ignore absence of charge on the electron.
4(a)(iv)	$S^{2-} + \mathbf{4}H_2O \longrightarrow SO_4^{2-} + \mathbf{8}e^- + \mathbf{8}H^+$	1	Ignore state symbols. Credit multiples of **this equation only.** Ignore absence of charge on the electron.
4(b)	**M1** add <u>scrap / recycled / waste iron (or steel)</u> to the aqueous solution **M2** the iron is a <u>more reactive</u> metal ***OR*** <u>Fe is a better reducing agent</u> **M3** <u>Cu^{2+} /copper ions</u> are <u>reduced</u> / <u>gain electrons</u> ***OR*** $Cu^{2+} + 2e^- \longrightarrow Cu$ ***OR*** <u>copper / Cu is displaced by Fe</u> **M4** $Fe + Cu^{2+} \longrightarrow Fe^{2+} + Cu$ ONLY	4	If **M1** refers to iron / steel, but does not make it clear in the text that it is "scrap" / "waste" / "recycled", penalise **M1** but mark on. Credit zinc or magnesium as an alternative to iron for **M2**, **M3** and **M4** only, penalising **M1** Ignore absence of charge on the electron. For **M4**, ignore state symbols.

Question	Marking Guidance	Mark	Comments
5(a)(i)	**M1 Elimination**  **M2** must show an arrow from the lone pair on the oxygen of a negatively charged hydroxide ion to a correct H atom **M3** must show an arrow from a correct C–H bond adjacent to the C–Br bond to a correct C–C bond. Only award if an arrow is shown attacking the H atom of a correct adjacent C–H bond in **M2** **M4** is independent provided it is from their original molecule, **BUT CE=0 for the mechanism (penalise M2, M3 and M4 only) if nucleophilic substitution mechanism is shown** Award full marks for an E1 mechanism in which **M4** is on the correct carbocation **NB These are double-headed arrows**	4	**M1** Credit "base elimination" but no other prefix. Penalise **M2** if covalent KOH Penalise **M4** for formal charge on C or Br of C–Br or incorrect partial charges on C–Br Ignore other partial charges. Penalise **once only** in any part of the mechanism for a line and two dots to show a bond. **Maximum any 2 of 3 marks for the mechanism** for wrong organic reactant or wrong organic product (if shown). Credit the correct use of "sticks" for the molecule except for the C–H being attacked. Penalise **M4**, if an additional arrow is drawn from Br eg to K+

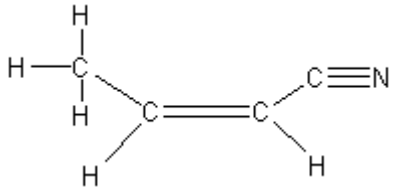
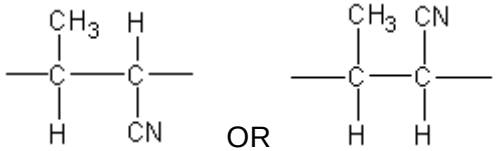
5(a)(ii)	Displayed formula for 3-methylbut-1-ene 	1	All bonds and atoms must be drawn out, but ignore bond angles.
5(a)(iii)	Position(al) (isomerism or isomer)	1	Penalise any other words that are written in addition to these.
5(b)(i)	Displayed formula for 3-methylbutan-2-ol 	1	All bonds and atoms must be drawn out, but ignore bond angles.
5(b)(ii)	Any **one** from • Lower / decreased temperature ***OR*** cold • Less concentrated (comparative) ***OR*** dilute KOH • Water (as a solvent) / (aqueous conditions)	1	Ignore “pressure”.
5(b)(iii)	Nucleophilic substitution	1	Both words needed – credit phonetic spelling.

5(b)(iv)	(Strong / broad) absorption / peak in the range **3230 to 3550** cm^{-1} or specified value in this range or marked correctly on spectrum	1	Allow the words "dip" ***OR*** "spike" ***OR*** "trough" ***OR*** "low transmittance" as alternatives for absorption.

Question	Marking Guidance	Mark	Comments
6(a)(i)	$\frac{1}{2}Cl_2 + I^- \longrightarrow \frac{1}{2} I_2 + Cl^-$ OR $Cl_2 + \mathbf{2}I^- \longrightarrow I_2 + \mathbf{2}Cl^-$	1	**Only** these two equations.
6(a)(ii)	(Solution turns from colourless to) <u>brown / red-brown solution</u>	1	Allow <u>grey / black solid.</u> Ignore "purple".
6(b)	$\mathbf{2}Cl_2 + \mathbf{2}H_2O \longrightarrow \mathbf{4}HCl + O_2$ $(\mathbf{4}H^+ + \mathbf{4}Cl^-)$	1	Credit multiples.
6(c)	**M1 The relative size (of the molecules/atoms)** Chlorine is small<u>er</u> than bromine OR has fewer electrons/electron shells ***OR*** It is smaller / It has a smaller atomic radius / it is a smaller molecule / or has smaller M_r (or converse for bromine) **M2 How size of the <u>intermolecular force</u> affects energy needed** The forces <u>between</u> chlorine / Cl_2 <u>molecules</u> are weak<u>er</u> (than the forces <u>between</u> bromine / Br_2 <u>molecules</u> leading to less energy needed to separate the <u>molecules</u>) (or converse for bromine) ***OR*** chlorine / Cl_2 has <u>weaker / less / fewer forces between molecules</u> ***OR*** chlorine / Cl_2 has <u>weaker / less / fewer intermolecular forces</u> (or converse for bromine)	2	Ignore general Group 7 statements. For **M1** ignore whether it refers to molecules or atoms. **CE=0** for reference to (halide) ions. QoL for clear reference to the difference in size <u>of the force between molecules.</u> Penalise **M2** if (covalent) <u>bonds</u> are broken.

Question	Marking Guidance	Mark	Comments
7(a)	**Initiation** $Cl_2 \longrightarrow 2Cl\bullet$ **First propagation** $Cl\bullet + CH_3Cl \longrightarrow \bullet CH_2Cl + HCl$ **Second propagation** $Cl_2 + \bullet CH_2Cl \longrightarrow CH_2Cl_2 + Cl\bullet$ **Termination (must make 1,2-dichloroethane)** $2 \bullet CH_2Cl \longrightarrow CH_2ClCH_2Cl$	4	Penalise absence of dot once only. Credit the dot anywhere on the radical. Penalise $C_2H_4Cl_2$
7(b)(i)	(chlorine free) <u>radical</u>	1	Ignore formula.
7(b)(ii)	**M1** $Cl\bullet + O_3 \longrightarrow ClO\bullet + O_2$ **M2** $ClO\bullet + O_3 \longrightarrow Cl\bullet + 2O_2$	2	**M1** and **M2** could be in either order. Credit the dot anywhere on the radical. Penalise absence of dot once only. Individual multiples acceptable but both need to be doubled if two marks are to be awarded.

Question	Marking Guidance	Mark	Comments
8(a)	Structure for 3-methylbut-1-ene $H_2C=CHCH(CH_3)_2$	1	Any correct structural representation. Credit "sticks" and require the double bond.
8(b)	Structure for 2-methylpropan-2-ol $(CH_3)_3COH$	1	Any correct structural representation. Credit "sticks".
8(c)	Structure for propene $H_2C=CHCH_3$	1	Any correct structural representation. Credit "sticks" and require the double bond.
8(d)	Structure for 2-aminobutane $CH_3CH_2CH(NH_2)CH_3$	1	Any correct structural representation. Credit "sticks".

Question	Marking Guidance	Mark	Comments
9(a)(i)	Structure of (Z)-but-2-enenitrile with or without either or both of the CH_3 and the CN groups displayed 	1	Penalise C–NC Do <u>not</u> penalise C–H_3C Ignore bond angles.
9(a)(ii)	Restricted <u>rotation</u> / no (free) <u>rotation</u> about the double bond / about the C=C ***OR*** does not <u>rotate</u> (about the double bond)	1	Must use the word <u>rotate / rotation.</u>
9(b)	Repeating unit of polyalkene 	1	All the bonds relevant to the unit must be drawn out including those on either side of the unit. There is no need to expand either the CH_3 or the CN Penalise C–NC Penalise “sticks”. Ignore brackets. Penalise “n”

9(c)	**Feature 1** Absorption / peak in the range **2220 to 2260** cm^{-1} or specified value in this range or marked correctly on spectrum **and** (characteristic absorption / peak for) **C≡N / CN** group / **nitrile / cyanide** group **Feature 2** Absorption / peak in the range **1620 to 1680** cm^{-1} or specified value in this range or marked correctly on spectrum **and** (characteristic absorption / peak for) **C=C** group / **alkene** / **carbon-carbon double bond**	2	Allow the words "dip" ***OR*** "spike" ***OR*** "trough" ***OR*** "low transmittance" as alternatives for absorption. Allow a peak at 2200 cm^{-1} to 2220 cm^{-1} **in this case.** Ignore reference to other absorptions eg C-H Either order.

Question	Marking Guidance	Mark	Comments
10(a)(i)	**M1** c(oncentrated) phosphoric acid / c(onc.) H_3PO_4 ***OR*** c(oncentrated) sulfuric acid / c(onc.) H_2SO_4 **M2** Re-circulate / re-cycle the (unreacted) ethene (and steam) / the reactants ***OR*** pass the gases over the catalyst several / many times	2	In **M1**, the acid must be concentrated. Ignore an incorrect attempt at the correct formula that is written in addition to the correct name. In **M2**, ignore "remove the ethanol". Credit "re-use".
10(a)(ii)	**M1** (By Le Chatelier's principle) the equilibrium is driven / shifts / moves to the right / L to R / forwards / in the forward direction **M2 depends on a correct statement of M1** The equilibrium moves / shifts to • oppose the addition of / increased concentration of / increased moles/ increased amount of water / steam • to decrease the amount of steam / water **Mark M3 independently** **M3** Yield of product / conversion increase ***OR*** ethanol increases / goes up / gets more	3	

10(a)(iii)	**M1** Poly(ethene) / polyethene / polythene / HDPE / LDPE **M2 At higher pressures** More / higher cost of electrical energy to pump / pumping cost ***OR*** Cost of higher pressure equipment / valves / gaskets / piping etc. ***OR*** expensive equipment	2	Credit all converse arguments for **M2**

10(b)	**M1** for balanced equation **M2** for state symbols in a correctly balanced equation $2C(s / graphite) + 3H_2(g) + \frac{1}{2}O_2(g) \longrightarrow CH_3CH_2OH(l)$ (C_2H_5OH)	2	Not multiples but credit correct state symbols in a correctly balanced equation. Penalise C_2H_6O but credit correct state symbols in a correctly balanced equation.

10(c)(i)	**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.

10(c)(ii)	**M1** $\sum$ B(**reactants**) – $\sum$ B(**products**) = ΔH OR Sum of bonds broken – Sum of bonds formed = ΔH OR B(C-C) + B(C-O) + B(O-H) + 5B(C-H) + 3B(O=O) (LHS) – 4B(C=O) – 6B(O–H) (RHS) = ΔH **M2** (also scores **M1**) 348+360+463+5(412)+3(496) [LHS = **4719**] (2060) (1488) – 4(805) – 6(463) [RHS = – **5998**] = ΔH (3220) (2778) OR using only bonds broken and formed (**4256 – 5535**) **M3** ΔH = **– 1279** (kJ mol^{-1}) Award 1 mark for +1279 **Candidates may use a cycle and gain full marks**	3	Correct answer gains full marks Credit 1 mark for (+) 1279 (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 2C and 6H and 7O 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 = 4719 ***OR*** RHS = 5998

10(d)(i)	Reducing agent ***OR*** reductant ***OR*** electron donor ***OR*** to reduce the copper oxide	1	Not “reduction”. Not “oxidation”. Not “electron pair donor”.

10(d)(ii)	CH_3COOH	1	

Question	Marking Guidance	Mark	Comments
11(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** = – 1669 – 3(– 590) = –1669 + 1770 (This also scores M1) **M3** = **+ 101** (kJ mol^{-1}) **Award 1 mark ONLY for – 101** **M4 – Using powders** Any **one** from • To increase collision frequency / collisions in a given time / rate of collisions • To increase the surface contact / contact between the solids / contact between (exposed) particles **M5 Major reason for expense of extraction** Any **one** from • Aluminium is extracted by electrolysis OR aluminium extraction uses(large amounts of) electricity • Reaction / process / It /the mixture requires heat • It is endothermic	5	Correct answer to the calculation gains all of **M1**, **M2** and **M3** Credit 1 mark for – 101 (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 3Sr and 2Al OR a clear statement of **M1** which could be in words and scores **only M1** Ignore dividing final answer by 3 Penalise **M4** for reference to molecules.

11(b)	Calcium has a higher melting point than strontium, because **Correct reference to size of cations/proximity of electrons** **M1** (For Ca) delocalised <u>electrons closer to cations / positive ions / atoms / nucleus</u> ***OR*** <u>cations / positive ions / atoms are smaller</u> ***OR*** <u>cation / positive ion / atom or it has fewer (electron) shells / levels</u> **Relative strength of metallic bonding** **M2** (Ca) has <u>stronger</u> attraction between the <u>cations / positive ions / atoms / nucleus</u> and the <u>delocalised electrons</u> ***OR*** <u>stronger metallic</u> bonding (assume argument refers to Ca but credit converse argument for Sr)	2	Ignore general Group 2 statements. Penalise **M1** if either of Ca or Sr is said to have <u>more or less</u> delocalised electrons OR the same nuclear charge. Ignore reference to shielding. **CE= 0** for reference to molecules or Van der Waals forces or intermolecular forces or covalent bonds.

11(c)	**M1** $\mathbf{2}Mg + O_2 \longrightarrow \mathbf{2}MgO$ **M2** $Mg + \mathbf{2}H_2O \longrightarrow Mg(OH)_2 + H_2$ **M3** Magnesium hydroxide is used as an antacid / relieve indigestion (heartburn) / neutralise (stomach) acidity / laxative	3	Credit multiples of the equations. Not simply “milk of magnesia” in **M3**

General principles applied to marking CHEM2 papers by CMI+ June 2013

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 $Ag(NH_3)_2^+$ 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

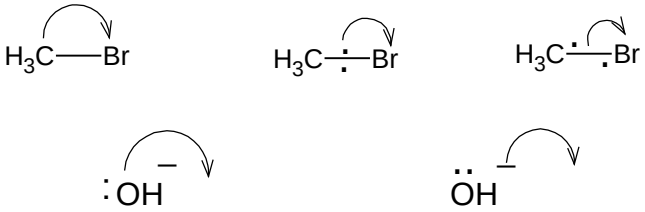
- The sign for an enthalpy change will be assumed to be positive unless specifically shown to be negative.
- A correct answer alone will score **full marks** unless the necessity to show working is specifically required in the question.
- A correct numerical value with the **wrong sign** will usually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

All other values **gain no credit** except

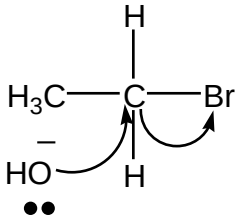
- Two marks can be awarded for correct chemistry with an arithmetic error.
- One mark can be awarded for a correct mathematical statement (or cycle) for the method.

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

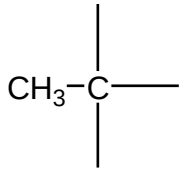
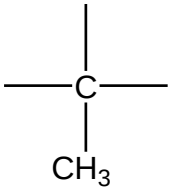
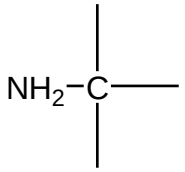
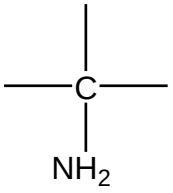
- The absence of a radical dot should be penalised **once only** within a clip.
- The use of double-headed arrows or the incorrect use of half-headed arrows in free-radical mechanisms should be penalised **once only** within a clip

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 <u>may</u> 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. <u>Organic names</u>

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**