AQA Qualifications

A-LEVEL
CHEMISTRY

CHEM2 Chemistry in Action
Mark scheme

2420
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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)	Award mark for **X on the time axis** at the point where the lines just become **horizontal**	1	Allow this mark If **X** is above the letters "sh" in the word "show' in Question 1(a)(ii) - in the range of lines 31 to 33
1(a)(ii)	They are equal / the same **OR** Forward (rate) = Reverse / backward (rate)	1	Allow the word 'speed' in this context. Ignore reference to concentration.
1(b)	Both **OR** forward and reverse reactions occur at the same time **OR** both are occurring at once **OR** both occur all of the time **OR** both are ongoing **OR** both never stop	1	Ignore 'at equal rates'. Ignore reference to concentration or equilibrium. The idea that both reactions occur simultaneously is essential. The simple idea of 'both reactions occurring' is insufficient for the mark.
1(c)(i)	**M1** No effect / no change / none / stays the same **M2** requires correct **M1** **M2** Equal (number of) moles / molecules on both sides	2	In **M2**, ignore reference to particles or atoms.

1(c)(ii)	**M1** Less time or it decreases or (equilibrium) <u>reached</u> faster (ie **M1** is a reference to time taken) **M2** <u>More</u> particles / molecules in a <u>given volume / space</u> **OR** the particles / molecules are close<u>r</u> together **M3** <u>More</u> <u>successful / productive</u> collisions <u>in a given time</u> **OR** <u>more</u> collisions with <u>$E>E_{Act}$ in a given time</u> **OR** <u>more frequent</u> <u>successful / productive</u> collisions **OR** <u>increased / greater</u> <u>successful / productive</u> collision <u>frequency / rate</u>	3	If **M1** is 'more time / it increases' or 'no effect', then **CE=0** for the clip. Reference to faster / increased rate / increased speed <u>alone</u> penalises **M1**, but mark on **M2** and **M3** If **M1** is blank, then look for all three marks in the text. Ignore reference to reactants / products. Penalise **M3** if an increase / decrease in the value of E_{Act} is stated.

Question	Marking Guidance	Mark	Comments
2(a)	Amount / number / proportion / percentage / fraction / moles of molecules / particles	1	Penalise an incorrect qualification of the number eg NOT number of molecules with E greater than Ea Not 'atoms'.
2(b)	There are no molecules / particles with zero energy **OR** All of the molecules / particles are moving / have some energy	1	Not 'atoms'. The answer should relate the energy to the molecules.
2(c)	**C** (The most probable energy)	1	

2(d)	**M1** The peak of the new curve is <u>displaced to the right</u> and <u>lower</u> than the original **M2** All of the following needed • The new curve starts at the origin and should begin to separate from the original almost immediately • <u>and</u> the new curve only crosses the original curve once • <u>and</u> the total area under the new curve is <u>approximately</u> the same as the original • <u>and</u> an attempt has been made to draw the new curve correctly towards the axis <u>above the original curve</u> but not to touch the original curve	2	

2(e)	None / no effect / stays the same	1	

Question	Marking Guidance	Mark	Comments
3(a)(i)	**3**Fe + Sb_2S_3 ⟶ **3**FeS + **2**Sb	1	Or multiples. Ignore state symbols.
3(a)(ii)	Fe ⟶ Fe^{2+} + $2e^-$	1	Ignore charge on the electron unless incorrect. Or multiples. Credit the electrons being subtracted on the LHS. Ignore state symbols.
3(b)(i)	Sb_2S_3 + **4.5**O_2 ⟶ Sb_2O_3 + **3**SO_2	1	Or multiples. Ignore state symbols.
3(b)(ii)	SO_3 or sulfur trioxide / sulfur (VI) oxide	1	Credit also the following ONLY H_2SO_4 or sulfuric acid ***OR*** gypsum / $CaSO_4$ or plaster of Paris

3(c)(i)	**M1 (could be scored by a correct mathematical expression)** **M1** $\underline{\Delta H_r = \sum \Delta H_f(\textbf{products}) - \sum \Delta H_f(\textbf{reactants})}$ **OR** a <u>correct cycle of balanced equations / correct numbers of moles</u> **M2** = 2(+20) + 3(– 394) – (– 705) – 3(–111) = 40 –1182 + 705 + 333 = –1142 – (–1038) (This also scores M1) **M3** = **<u>–104</u>** (kJ mol^{-1}) **(Award 1 mark ONLY for + 104)**	3	Correct answer gains full marks. Credit 1 mark for +104 (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. • If no AE, check for a correct method; this requires either a correct cycle with 3CO, 2Sb and $3CO_2$ OR a clear statement of **M1** which could be in words and scores **<u>only M1</u>**.
3(c)(ii)	It / Sb is <u>not in its standard state</u> **OR** <u>Standard state</u> (for Sb) <u>is solid / (s)</u> **OR** <u>(Sb) liquid is not its standard state</u>	1	Credit a correct definition of standard state as an alternative to the words 'standard state'. **QoL**
3(c)(iii)	Reduction **OR** reduced **OR** redox	1	

3(d)	Low-grade ore extraction / it • uses (cheap) <u>scrap / waste</u> <u>iron / steel</u> • is a single-step process • uses / requires <u>less / low(er) energy</u>	1	Ignore references to temperature / heat or labour or technology.

Question	Marking Guidance	Mark	Comments
4(a)	**M1** Used in a barium meal / barium swallow / barium enema **OR** (used to absorb) X-rays **M2** $\underline{BaSO_4}$ / barium sulfate / it is insoluble	2	Credit a correct reference to **M1** written in the explanation in **M2** unless contradictory. For **M2** penalise obvious reference to barium or to barium ions being insoluble.
4(b)	$Mg(OH)_2 + \mathbf{2}HCl \longrightarrow MgCl_2 + 2H_2O$	1	Or multiples. Ignore state symbols.
4(c)	It / magnesium hydroxide is insoluble / insufficiently soluble / sparingly soluble / less soluble than barium hydroxide / forms low concentration solutions	1	Weak alkali alone is insufficient. Formation of a precipitate needs explanation.
4(d)	$TiCl_4 + \mathbf{2}Mg \longrightarrow \mathbf{2}MgCl_2 + Ti$	1	Or multiples. Ignore state symbols.

4(e)	**M1** Hydrogen / H_2 produced **OR** an equation to produce <u>hydrogen / H_2</u> (eg Mg + **2**H_2O ⟶ $Mg(OH)_2$ + H_2) (eg Mg + H_2O ⟶ MgO + H_2) **M2** requires correct **M1** risk of explosion **OR** forms explosive mixture (with air) **OR** (highly) flammable	2	For **M1** Do not penalise an incorrect equation; the mark is for H_2 or hydrogen. Award one mark only for '<u>exothermic reaction</u> with steam / H_2O' for a student who has not scored **M1** Ignore 'violent' reaction.

Question	Marking Guidance	Mark	Comments
5(a)(i)	**M1 Initiation** $Cl_2 \longrightarrow 2Cl\bullet$ **M2 First propagation** $Cl\bullet + CHF_3 \longrightarrow CF_3\bullet + HCl$ **M3 Second propagation** $Cl_2 + CF_3\bullet \longrightarrow CClF_3 + Cl\bullet$ **M4 Termination (must make C_2F_6)** $2\ CF_3\bullet \longrightarrow C_2F_6$ or CF_3CF_3	4	Penalise absence of dot once only. Penalise + or – charges <u>every time</u> Credit $CF_3\bullet$ with the radical dot above / below / to either side. Mark independently.
5(a)(ii)	ultra-violet / uv / sun light **OR** (very) high temperature **OR** 500 °C ≤ T ≤ 1000 °C **OR** 773 K ≤ T ≤ 1273 K	1	

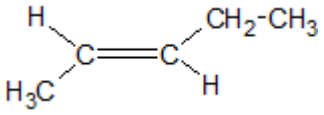
5(b)(i)	Cl• **OR** chlorine atom / chlorine (free-) radical / Cl (atom)	1	Not 'chlorine' alone. Credit 'Cl' alone on this occasion.

5(b)(ii)	**2**O_3 $\longrightarrow$ **3**O_2	1	Or multiples. Ignore state symbols. If the correct answer is on the line OR clearly identified below some working, then ignore any working.

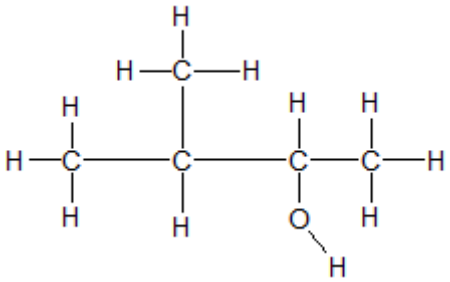
Question	Marking Guidance	Mark	Comments
6(a)(i)	**M1** (+) 4 **OR** IV **M2** (+) 6 **OR** VI	2	
6(a)(ii)	It / Chlorine has gained / accepted electron(s) **OR** Correctly balanced half-equation eg $Cl_2 + \mathbf{2}e^- \longrightarrow \mathbf{2}Cl^-$	1	Credit 1 or 2 electrons but not lone pair. The idea of 'reduction' alone is not enough.
6(b)(i)	$\mathbf{6}KI + \mathbf{7}H_2SO_4 \longrightarrow \mathbf{6}KHSO_4 + \mathbf{3}I_2 + S + \mathbf{4}H_2O$	1	
6(b)(ii)	$\mathbf{2}I^- \longrightarrow I_2 + \mathbf{2}e^-$ **OR** $8I^- \longrightarrow 4\mathbf{I_2} + 8e^-$	1	Ignore charge on the electron unless incorrect. Or multiples. Credit the electrons being subtracted on the LHS. Ignore state symbols.
6(b)(iii)	$H_2SO_4 + \mathbf{8}H^+ + \mathbf{8}e^- \longrightarrow H_2S + \mathbf{4}H_2O$ **OR** $SO_4^{2-} + \mathbf{10}H^+ + \mathbf{8}e^- \longrightarrow H_2S + \mathbf{4}H_2O$	1	Ignore charge on the electron unless incorrect. Or multiples. Credit the electrons being subtracted on the RHS. Ignore state symbols.

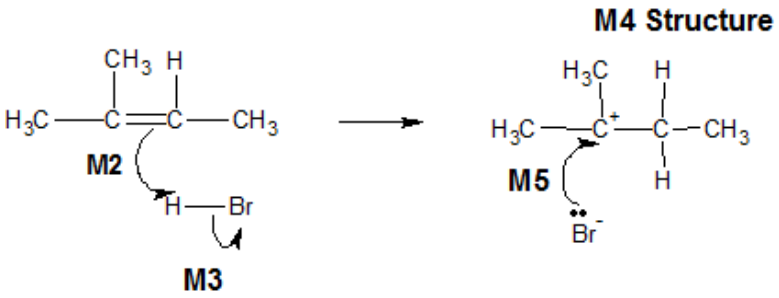
6(c)(i)	$Ag^+ + I^- \longrightarrow AgI$ ONLY	1	Ignore state symbols. Not multiples.
6(c)(ii)	The precipitate / solid / it does not dissolve / is insoluble / remains **OR** a <u>white / cream / yellow</u> <u>solid / precipitate</u> **OR** stays the same **OR** no (visible / observable) change **OR** no effect / no reaction	1	Ignore 'nothing (happens)'. Ignore 'no observation'.
6(c)(iii)	The silver nitrate is acidified to • react with / remove <u>(an)ions that would interfere</u> with the test • prevent the formation of other <u>silver precipitates</u> / <u>insoluble silver compounds</u> that would interfere with the test • remove (other) <u>ions that react</u> <u>with the silver nitrate</u> • react with / remove carbonate / hydroxide / sulfite (ions)	1	Credit a correct reference to <u>ions</u> that give a 'false positive'. Do not penalise an incorrect formula for an ion that is written in addition to the name. If only the formula of the ion is given, it must be correct. Ignore 'sulfate'.
6(c)(iv)	HCl would <u>form a</u> (white) <u>precipitate /</u> (white) <u>solid</u> (with silver nitrate and this would interfere with the test)	1	It is not sufficient simply to state either that it will interfere **or** simply that the ions / compounds react to form AgCl

6(d)(i)	Any **one** from • to sterilise / disinfect water • to destroy / kill microorganisms / bacteria / microbes / pathogens	1	Ignore 'to clean water'. Ignore 'water purification' and 'germs'. Credit 'remove bacteria etc' / prevent algae.
6(d)(ii)	The (health) benefit outweighs the risk **OR** a clear statement that once it has done its job, little of it remains **OR** used in (very) dilute concentrations / small amounts / low doses	1	
6(d)(iii)	$Cl_2 + H_2O \longrightarrow HClO + HCl$ **OR** $Cl_2 + H_2O \longrightarrow \mathbf{2}H^+ + ClO^- + Cl^-$ **OR** $\mathbf{2}Cl_2 + \mathbf{2}H_2O \longrightarrow \mathbf{4}HCl + O_2$	1	Credit HOCl or ClOH Or multiples. Credit other ionic or mixed representations. Ignore state symbols.
6(e)	**In either order - Both required for one mark only** NaClO (OR NaOCl) **and** NaCl	1	Credit correct ionic formulae. Give credit for answers in equations unless contradicted.

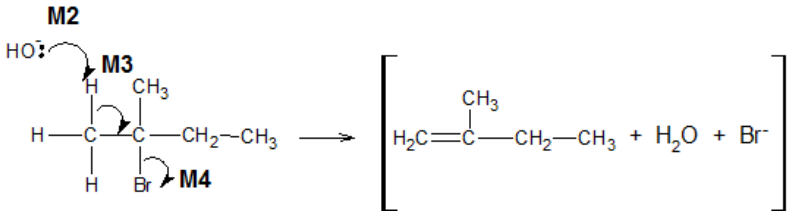
Question	Marking Guidance	Mark	Comments
7(a)(i)	**M1** (Compounds / molecules with) the <u>same structural formula</u> **M2** with <u>atoms / bonds / groups</u> arranged <u>differently in space</u> **OR** <u>atoms / bonds / groups</u> with <u>different spatial arrangements / different orientation</u>	2	Penalise **M1** if 'same structure' or 'different structural / displayed formula'. Ignore references to 'same molecular formula' or 'same empirical formula'. Mark independently.
7(a)(ii)		1	Credit C–H_3C Credit C_2H_5 Penalise C–CH_3CH_2

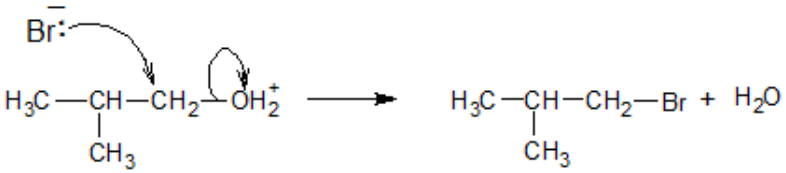
7(b)	**M1** Br_2 OR bromine (water) OR bromine (in CCl_4 / organic solvent) **M2** Isomer 1: decolourised / goes colourless / loses its colour **M3** Isomer 2: remains orange / red / yellow / brown / the same **OR** no reaction / no (observable) change **OR** reference to colour going to the cyclopentane layer **Alternatives** : **potassium manganate(VII)** **M1** $KMnO_4$ in acid **M2** colourless **M3** purple **M1** $KMnO_4$ in alkali / neutral **M2** brown solid **M3** purple Credit for the use of **iodine** **M1** iodine (solution / in KI) **M2** colourless **M3** (brown) to purple (credit no change) Credit for the use of **<u>concentrated</u> H_2SO_4** **M1** <u>concentrated</u> H_2SO_4 **M2** brown **M3** no change / colourless	3	If **M1**, has no reagent or an incorrect reagent, **CE=0** Ignore 'acidified'. For **M1** penalise Br (or incorrect formula of other correct reagent), but mark on. For **M1**, it must be a whole reagent and/or correct formula. If oxidation state given in name, it must be correct. If 'manganate' OR 'manganate(IV)' or incorrect formula, penalise **M1**, but mark on. Ignore 'goes clear'. Ignore 'nothing (happens)'. Ignore 'no observation'. No credit for combustion observations.

7(c)(i)	(Both infrared spectra show an absorption in range) **1620 to 1680** (cm^{-1})	1	Ignore reference to other ranges (eg for C–H or C–C).
7(c)(ii)	The fingerprint (region) / below 1500 cm^{-1} will be different **or** its fingerprinting will be different **OR** different absorptions / peaks are seen (in the region) below 1500 cm^{-1} (or a specified region within the fingerprint range)	1	Allow the words 'dip' **OR** 'spike' **OR** 'low transmittance' as alternatives for absorption. **QoL**
7(d)		1	All bonds must be drawn. Ignore bond angles.

7(e)(i)	**M1 Electrophilic addition**  **M2** must show an arrow from the double bond towards the H atom of the H–Br molecule **M3** must show the breaking of the H–Br bond **M4** is for the structure of the tertiary carbocation **M5** must show an arrow from the lone pair of electrons on the negatively charged bromide ion towards the positively charged carbon atom of either a secondary or a tertiary carbocation **NB The arrows here are double-headed**	5	**M1** both words needed. Penalise one mark from their total if half-headed arrows are used. **M2** Ignore partial negative charge on the double bond. **M3** Penalise incorrect partial charges on H–Br bond and penalise formal charges. Penalise **M4** if there is a bond drawn to the positive charge. Penalise once only in any part of the mechanism for a line and two dots to show a bond. **Max 3 of any 4 marks in the mechanism** for wrong organic reactant or wrong organic product (if shown) or secondary carbocation. **Max 2 of any 4 marks in the mechanism** for use of bromine. Do not penalise the correct use of 'sticks". For **M5**, credit attack on a partially positively charged carbocation structure but penalise **M4**

7(e)(ii)	**M1** Reaction goes via intermediate carbocations / carbonium ions **M2 (scores both marks and depends on M1)** Tertiary carbocation / carbonium ion is more stable (than the secondary carbocation / carbonium ion) **OR** Secondary carbocation / carbonium ion is less stable (than the tertiary carbocation / carbonium ion)	2	**M1** is a lower demand mark for knowledge that carbocations are involved. **M2** is of higher demand and requires the idea that the secondary carbocation is less stable or the tertiary carbocation is more stable. Reference to incorrect chemistry is penalised. A carbocation may be defined in terms of alkyl groups / number of carbon atoms, rather than formally stated.

7(f)	**M1 Elimination**  **M2** must show an arrow from the <u>lone pair on oxygen</u> of a <u>negatively charged hydroxide</u> ion <u>to a correct</u> 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 <u>original molecule</u> **BUT penalise M2, M3 and M4 if nucleophilic substitution** shown Award full marks for an E1 mechanism in which **M2** is on the correct carbocation **NB The arrows here are double-headed** **M5** hydroxide ion behaves as a <u>base</u> / <u>proton acceptor</u> / <u>electron pair donor</u> / <u>lone pair donor</u>	5	**M1** credit 'base elimination' but no other qualifying prefix. Penalise one mark from <u>their</u> total if half-headed arrows are used. Penalise **M2** if covalent KOH Penalise **M4** for formal charge on C or Br of the C–Br bond or incorrect partial charges on C–Br Penalise **M4** if an additional arrow is drawn from the Br of the C–Br bond to, for example, K^+ Ignore other partial charges. Penalise **once only** in any part of the mechanism for a line and two dots to show a bond. **<u>Max 2 of any 3 marks in the mechanism</u>** for wrong reactant <u>or</u> wrong organic product (if shown) <u>or</u> a correct mechanism that leads to the alkene 2-methylbut-2-ene Credit the correct use of "sticks" for the molecule except for the C–H being attacked. Penalise **M5** if 'nucleophile'.

Question	Marking Guidance	Mark	Comments
8(a)(i)	**M1** double-headed curly arrow from the lone pair of the bromide ion to the C atom of the CH_2 **M2** double-headed arrow from the bond to the O atom As follows 	2	Penalise additional arrows.
8(a)(ii)	**M1** <u>nucleophilic substitution</u> **M2** 1-bromo(-2-)methylpropane	2	**M1** both words needed (allow phonetic spelling). **M2** Require correct spelling in the name but ignore any hyphens or commas.

8(b)	**M1** hydrolysis **M2** C≡N with absorption range 2220–2260 (cm^{-1}) **M3** O–H(acids) with absorption range 2500–3000 (cm^{-1}) **OR** C=O with absorption range 1680–1750 (cm^{-1}) **OR** C–O with absorption range 1000–1300 (cm^{-1})	3	For **M1** give credit for 'hydration' on this occasion only. Credit 1 mark from **M2** and **M3** for identifying C≡N **and** either O–H(acids) **or** C=O **or** C–O without reference to wavenumbers or with incorrect wavenumbers. Apply the list principle to **M3**
8(c)(i)	**M1** Yield / product **OR** ester increases / goes up / gets more **M2** (By Le Chatelier's principle) the position of equilibrium is driven / shifts / moves to the right / L to R / in the forward direction / to the product(s) **M3 – requires a correct statement in M2** (The position of equilibrium moves) to oppose the increased concentration of ethanol to oppose the increased moles of ethanol to lower the concentration of ethanol to oppose the change and decrease the ethanol	3	If no reference to **M1**, marks **M2** and **M3** can still score BUT if **M1** is incorrect CE=0 If there is reference to 'pressure' award **M1** ONLY.

8(c)(ii)	**M1** Catalysts provide an alternative route / pathway / mechanism **OR** surface adsorption / surface reaction occurs **M2** that has a lower / reduced activation energy **OR** lowers / reduces the activation energy	2	For **M1**, not simply 'provides a surface' as the only statement. **M1** may be scored by reference to a specific example. Penalise **M2** for reference to an increase in the energy of the molecules. For **M2**, the student may use a definition of activation energy without referring to the term. Reference to an increase in successful collisions in unit time alone is not sufficient for **M2** since it does not explain why this has occurred.

Question	Marking Guidance	Mark	Comments
9(a)	**M1** $C_6H_{12}O_6 \longrightarrow$ **2**CH_3CH_2OH (**2**C_2H_5OH) + **2**CO_2 **M2** and **M3** Any **two** conditions **in any order** for **M2** and **M3** from • (enzymes from) yeast or zymase • 25 °C ≤ T ≤ 42 °C OR 298 K ≤ T ≤ 315 K • anaerobic / no oxygen / no air OR neutral pH **M4** (fractional) distillation or GLC **M5** Carbon-neutral **in this context** means There is no net / overall (annual) carbon dioxide / CO_2 emission to the atmosphere **OR** There is no change in the total amount / level of carbon dioxide / CO_2 present in the atmosphere	5	Penalise C_2H_6O for ethanol in **M1** Mark **M2** and **M3** independently. A lack of oxygen can mean either without oxygen or not having enough oxygen and does not ensure no oxygen, therefore only credit "lack of oxygen" if it is qualified. Penalise 'bacteria', 'phosphoric acid', 'high pressure' using the list principle. Ignore reference to 'aqueous' or 'water' (ie not part of the list principle). For **M5** – must be about CO_2 and the atmosphere. The idea that the carbon dioxide / CO_2 given out equals the carbon dioxide / CO_2 that was taken in from the atmosphere.

9(b)	**M1** q = m c ΔT (this mark for correct mathematical formula) **M2** = (75 × 4.18 × 5.5) 1724 (J) **OR** 1.724 (kJ) **OR** 1.72 (kJ) **OR** 1.7 (kJ) (also scores **M1**) **M3** Using 0.0024 mol therefore ΔH = **– 718** (kJ mol^{-1}) (Accept a range from –708 to –719 but do not penalise more than 3 significant figures) **M4** and **M5** in any order Any **two** from • incomplete combustion • heat loss • heat capacity of Cu not included • some ethanol lost by evaporation • not all of the (2.40×10^{-3} mol) ethanol is burned / reaction is incomplete	5	Full marks for **M1**, **M2** and **M3** for the correct answer. In **M1**, do not penalise incorrect cases in the formula. Ignore incorrect units in **M2** Penalise **M3** ONLY if correct numerical answer but sign is incorrect. Therefore **+718 gains two marks.** If units are quoted in **M3** they must be correct If ΔT = 278.5, CE for the calculation and penalise **M2** and **M3** If c = 4.81 (leads to 1984) penalise **M2** ONLY and mark on for **M3** = – 827

9(c)(i)	**M1** enthalpy / heat / energy change (at constant pressure) or enthalpy / heat / energy needed in <u>breaking / dissociating (a) covalent bond(s)</u> **M2** <u>averaged</u> for that type of bond over <u>different / a range of molecules / compounds</u>	2	Ignore bond making. Ignore reference to moles.

9(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) – 4B(C=O) – 6B(O–H) = ΔH = –1279 **M2** (also scores **M1**) 348+360+463+5(412)+ 3B(O=O) (**3231**) (or **2768** if O–H cancelled) – 4(805) – 6(463) = ΔH = – 1279 (**5998**) (or **5535** if O–H cancelled) 3B(O=O) = **1488** (kJ mol^{-1}) **M3** B(O=O) = **496** (kJ mol^{-1}) Award 1 mark for –496 **Students may use a cycle and gain full marks**	3	Correct answer gains full marks. Credit **1 mark for – 496** (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 $2CO_2$ and $3H_2O$ OR a clear statement of **M1** which could be in words and scores **only M1**. Credit a maximum of one mark if the only scoring point is bonds formed adds up to **5998 (or 5535) OR** bonds broken includes the calculated value of **3231 (or 2768)**.

General principles applied to marking CHEM2 papers by CMI+ (June 2014)

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.**

1. The "List principle" and the use of "ignore" in the mark scheme

If a question requires **one** answer and a student 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.

NB 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.

2. 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.

3. 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.

NB 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.

4. 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.

5. Reagents

The command word "Identify", allows the student 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 student 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.

6. Oxidation states

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

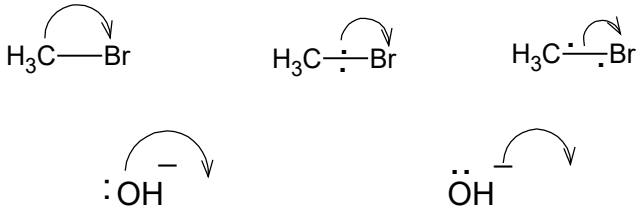
7. Marking calculations

In general

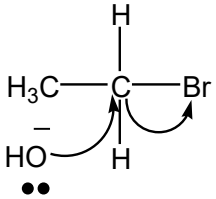
- A correct answer alone will score **full marks** unless the necessity to show working is specifically required in the question.
- An arithmetic or transposition error will result in a one mark penalty if further working is correct.
- A chemical error will usually result in at least a two mark penalty; often no marks are awarded.

8. 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.

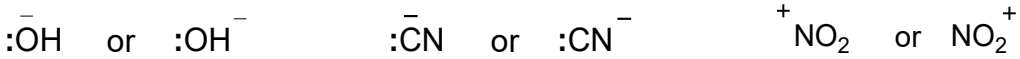


For example, the following would score zero marks



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.

The following are acceptable representations of ions, both in equations and in mechanisms:



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

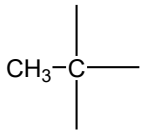
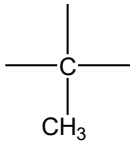
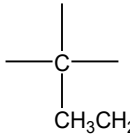
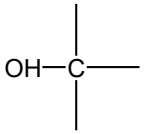
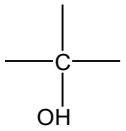
In mass spectrometry fragmentation equations, the absence of a radical dot on the molecular ion and on the free-radical fragment would be considered to be two independent errors and both would be penalised if they occurred within the same clip.

9. 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. This principle applies in all cases where the attached functional group contains a carbon atom, e.g nitrile, carboxylic acid, aldehyde and acid chloride. The carbon-carbon bond should be clearly shown. Wrongly bonded atoms will be penalised **on every occasion**. (see the examples below)
- The same principle should also be applied to the structure of alcohols. For example, if students 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 alkyl groups, given that CH_3─ is considered to be interchangeable with H_3C─ even though the latter would be preferred.
- Similar latitude should be given to the representation of amines where NH_2─ C will be allowed, although H_2N─ C would be preferred.
- Poor presentation of vertical C ─ CH_3 bonds or vertical C ─ NH_2 bonds should **not** be penalised. For 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.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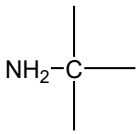	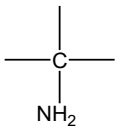	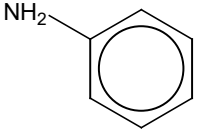	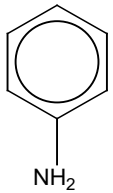	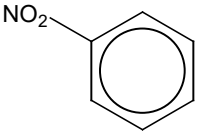
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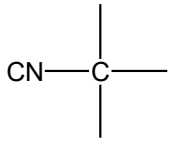	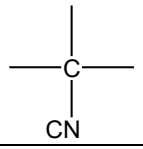	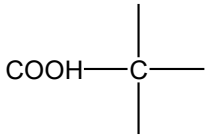	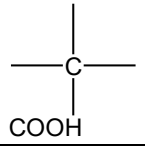	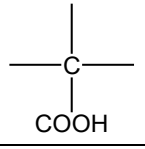	
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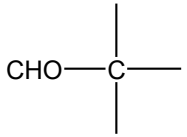	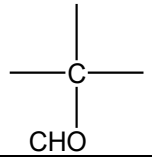	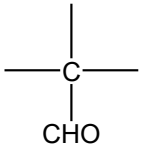	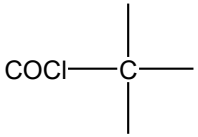	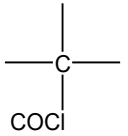	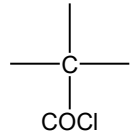
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- In most cases, the use of "sticks" to represent C ─ H bonds in a structure should **not** be penalised. The exceptions will include structures in mechanisms when the C ─ H bond is essential (e.g. elimination reactions in haloalkanes) and when a displayed 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	ethane

NB 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, $CH_3CH(OH)CH_3$

10. 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**