Version 1.2

**General Certificate of Education (A-level)**
**June 2012**

# 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 students' 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 students' 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) | **Award in either order for curve**<br>**M1** curve is steeper than original and starts at the origin<br>**M2** curve levels at the top line on the graph | 2 | "Steeper" requires line to be on the left of the original line, starting from the origin |
| 1(b) | **Award in either order for curve**<br>**M1** curve is shallower than original and starts at the origin<br>**M2** curve levels at the first line on the graph | 2 | "Shallower" requires line to be on the right of the original line, starting from the origin |
| 1(c) | **M1** curve would be steeper than original<br>**M2** curve levels at the same original volume of $O_2$ | 2 | "Steeper" requires line to be on the left of the original line, starting from the origin |
| 1(d) | **M1** The (concentration / amount of) $H_2O_2$ or reactant falls / decreases / used up<br>***OR***<br>The number of $H_2O_2$ or reactant molecules/ particles falls / decreases<br>**M2**<br>The rate of reaction / rate of decomposition / rate of formation of oxygen / frequency of collisions / (effective) collisions in a given time decreases / is slower | 2 | Mark independently |

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| 1(e)(i) | **2**$H_2O_2$ ⟶ **2**$H_2O$ + $O_2$ | 1 | Ignore state symbols<br>Accept only this equation or its multiples<br>Extra species must be crossed through |
| 1(e)(ii) | hydrogen bromide / it does not appear in the overall equation<br>***OR***<br>hydrogen bromide / it is not <u>used up</u> in the reaction / <u>unchanged at the end</u> of the reaction<br>***OR***<br>hydrogen bromide / it is regenerated / re-formed (in Step 2) | 1 | |

| Question | Marking Guidance | Mark | Comments |
|---|---|---|---|
| 2(a)(i) | **M1 (could be scored by a correct mathematical expression which <u>must</u> have <u>all</u> $\Delta H$ symbols and the $\sum$ or SUM)**<br>**M1** $\underline{\Delta H_r}$ = $\sum\Delta H_f$ (**products**) - $\sum\Delta H_f$ (**reactants**)<br>***OR*** a <u>correct cycle of balanced equations with 1C, $3H_2$ and $1O_2$</u><br>**M2** $\underline{\Delta H_r}$ = – 201 + (– 242) – (– 394)<br>$\underline{\Delta H_r}$ = – 201 – 242 + 394<br>$\underline{\Delta H_r}$ = – 443 + 394<br>(This also scores M1)<br>**M3** = **– 49** (kJ $mol^{-1}$)<br>**(Award 1 mark ONLY for + 49)** | 3 | Correct answer gains full marks<br>Credit 1 mark ONLY for + 49 (kJ $mol^{-1}$)<br>For other incorrect or incomplete answers, proceed as follows<br>• check for an arithmetic error (AE), which is either a transposition error or an incorrect multiplication; this would score 2 marks (**M1** and **M2**)<br>• If no AE, check for a correct method; this requires either correct cycle of balanced equations with 1C, $3H_2$ and $1O_2$<br>OR a clear statement of **M1** which could be in words and scores <u>only **M1**</u> |
| 2(a)(ii) | It is an element / elemental<br>***OR***<br>By definition | 1 | Ignore reference to “standard state” |

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| 2(b) | **M1** (The yield) increases / goes up / gets more<br><br>**M2**<br>There are <u>more moles / molecules</u> (of gas) on the left / of reactants<br>***OR*** <u>fewer moles / molecules</u> (of gas) on the right / products<br>***OR*** there are <u>4 moles / molecules</u> (of gas) on the left <u>and 2 moles / molecules</u> on the right.<br>***OR*** (equilibrium) shifts / moves <u>to the side with less moles / molecules</u><br><br>**M3: Can only score M3 <u>if M2 is correct</u>**<br>The (position of) <u>equilibrium shifts / moves</u> (from left to right) to <u>oppose the increase in pressure</u> | 3 | If M1 is given as “decreases” / “no effect” / ”no change” then CE= 0 for clip, but mark on only **M2** and **M3** from a blank M1<br><br>Ignore ”volumes”, “particles” “atoms” and “species” for **M2**<br><br>For **M3**, <u>not</u> simply “to oppose the change”<br>For **M3** credit the <u>equilibrium</u> <u>shifts / moves</u> (to right) to <u>lower / decrease the pressure</u><br>(There must be a <u>specific</u> reference to the change that is opposed) |

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| 2(c) | **M1** Yield increases / goes up<br>**M2** The (forward) reaction / to the right is endothermic OR takes in / absorbs heat<br>***OR***<br>The reverse reaction / to the left is exothermic OR gives out / releases heat<br>**Can only score M3 if M2 is correct**<br>**M3** The (position of) equilibrium shifts / moves (from left to right) to oppose the increase in temperature **(QoL)** | 3 | If M1 is given as "decrease" / "no effect" / "no change" then CE= 0 for clip, but mark on only **M2** and **M3** from a blank **M1**<br>For **M3**, not simply "to oppose the change"<br>For **M3**, credit the (position of) equilibrium shifts / moves **(QoL)**<br>to absorb the heat ***OR***<br>to cool the reaction ***OR***<br>to lower the temperature<br>(There must be a specific reference to the change that is opposed) |
| 2(d)(i) | An activity which has no net / overall (annual) carbon emissions to the atmosphere<br>***OR***<br>An activity which has no net / overall (annual) greenhouse gas emissions to the atmosphere.<br>***OR***<br>There is no change in the total amount / level of carbon dioxide / $CO_2$ carbon /greenhouse gas present in the atmosphere. | 1 | The idea that the carbon / $CO_2$ given out equals the carbon / $CO_2$ that was taken in from the atmosphere |
| 2(d)(ii) | $CH_3OH + \mathbf{1}\frac{1}{2}O_2 \longrightarrow CO_2 + \mathbf{2}H_2O$ | 1 | Ignore state symbols<br>Accept multiples |

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| 2(d)(iii) | **3**$H_2$ + **1½**$O_2$ ⟶ **3**$H_2O$<br>***OR***<br>**2**$H_2$ + $O_2$ ⟶ **2**$H_2O$ | 1 | Ignore state symbols<br>Accept multiples<br>Extra species must be crossed through |

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| 2(e) | **M1** q = m c ΔT<br>***OR*** q =140 x 4.18 x 7.5<br><br>**M2** = 4389 (J) OR 4.389 (kJ) OR 4.39 (kJ) OR 4.4 (kJ)<br>(also scores M1)<br><br>**M3** Using 0.0110 mol<br>therefore ΔH = **– 399** ($kJmol^{-1}$)<br>OR **– 400**<br><br>**+399 or +400 gains 2 marks** | 3 | Award full marks for correct answer<br>Ignore the case for each letter<br>Penalise **M3** ONLY if correct numerical answer but sign is incorrect; **+399 gains 2 marks**<br>Penalise **M2** for arithmetic error and mark on<br>In **M1**, do not penalise incorrect cases in the formula<br>If ΔT = 280.5; score q = m c ΔT only<br>If c = 4.81 (leads to 5050.5) penalise **M2** ONLY and mark on for **M3** = – 459<br><br>Ignore incorrect units |

| Question | Marking Guidance | Mark | Comments |
|---|---|---|---|
| 3(a) | **2**$Ca_5F(PO_4)_3$ + $9SiO_2$ + **15**C ⟶ $9CaSiO_3$ + $CaF_2$ + **15**CO + **6**P | 1 | |
| 3(b) | **M1** ($P_4$ =) **0**<br>**M2** ($H_3PO_4$ =) **(+) 5** | 2 | Accept Roman numeral V for **M2** |
| 3(c) | $H_2SO_4$<br>$M_r$ = 2(1.00794) + 32.06550 + 4(15.99491)<br>= **98.06102 or 98.0610 or 98.061 or 98.06 or 98.1**<br>**and**<br>$H_3PO_4$<br>$M_r$ = 3(1.00794) + 30.97376 + 4(15.99491)<br>= **97.97722 or 97.9772 or 97.977 or 97.98 or 98.0** | 1 | **Both numbers** required<br>Calculations not required |
| 3(d)(i) | A substance that speeds up a reaction OR alters / increases the rate of a reaction **AND** is chemically unchanged at the end / not used up. | 1 | **Both ideas** needed<br>Ignore reference to activation energy or alternative route. |
| 3(d)(ii) | The addition of water (**QoL** ) to a molecule / compound | 1 | **QoL- for the underlined words** |

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| 3(d)(iii) | **M1** $CH_3CH=CH_2 + H_2O \longrightarrow CH_3CH(OH)CH_3$<br>$(C_3H_6)$<br>**M2** propan-2-ol | 2 | For **M1** insist on correct structure for the alcohol but credit correct equations using either $C_3H_6$ or double bond not given. |

| Question | | Mark | Comments |
|---|---|---|---|
| 4(a) | Ti is not produced<br>***OR***<br>TiC / <u>carbide</u> is produced OR titanium reacts with carbon<br>***OR***<br>Product is brittle<br>***OR***<br>Product is a poor engineering material | 1 | Penalise "titanium carbonate"<br>Ignore "impure titanium"<br>Credit "it / titanium is brittle" |
| 4(b)(i) | $FeTiO_3 + \mathbf{3}½Cl_2 + \mathbf{3}C \longrightarrow FeCl_3 + TiCl_4 + \mathbf{3}CO$ | 1 | Ignore state symbols<br>Credit multiples |
| 4(b)(ii) | $FeCl_3 + TiCl_4 + \mathbf{7}Na \longrightarrow \mathbf{7}NaCl + Fe + Ti$<br>**OR** (for example)<br>$2FeCl_3 + TiCl_4 + \mathbf{10}Na \longrightarrow \mathbf{10}NaCl + 2Fe + Ti$ | 1 | Ignore state symbols<br>Credit multiples including ratios other than 1:1<br>Ignore working |

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| 4(c) | Either order<br>**M1** The $Cu^{2+}$ / copper(II) ions / they have gained (two) electrons<br>***OR*** $Cu^{2+} + 2e^- \longrightarrow Cu$<br>***OR*** oxidation state / number decreases (or specified from 2 to 0)<br>**M2** The $\underline{Cu^{2+}\text{ / copper(II) ions / they}}$ have been <u>reduced</u> | 2 | Penalise reference to incorrect number of electrons in **M1**<br>For **M1**, accept "copper" if supported by correct half-equation or simplest ionic equation<br>Ignore charge on the electron<br>For **M2** do **not** accept "copper" alone |
| 4(d) | $\mathbf{2}O^{2-} \longrightarrow O_2 + \mathbf{4}e^-$ | 1 | Or multiples including<br>$\mathbf{3}O^{2-} \longrightarrow \mathbf{1.5}\ O_2 + \mathbf{6}e^-$<br>Ignore state symbols<br>Ignore charge on the electron<br>Credit the electrons being subtracted on the LHS |

| Question | Marking Guidance | Mark | Comments |
|---|---|---|---|
| 5(a)(i) | Ba + **2**$H_2O$ ⟶ $Ba(OH)_2$ + $H_2$ | 1 | Ignore state symbols<br>Credit multiples and correct ionic equations |
| 5(a)(ii) | (Reactivity with water) increase(s) / increasing / increased (down the Group / from Mg to Ba) | 1 | Accept "greater" or "gets more" or similar words to that effect.<br>Ignore reference to "increase in solubility / gets more soluble" |
| 5(b) | $Mg(OH)_2$ | 1 | Accept $Mg^{2+}(OH^-)_2$ / $Mg(HO)_2$<br>Insist on brackets and correct case |
| 5(c) | **M1** Barium meal / barium swallow / barium enema or (internal) X-ray or to block X-rays<br>**M2** $BaSO_4$ / barium sulfate is insoluble (and therefore not toxic) | 2 | Accept a correct reference to **M1** written in the explanation in **M2**, unless contradictory<br>For **M2** NOT barium ions<br>NOT barium<br>NOT barium meal and NOT "It"<br>Ignore radio-tracing |

| Question | Marking Guidance | Mark | Comments |
|---|---|---|---|
| 6(a)(i) | **M1 Initiation**<br>$Cl_2 \longrightarrow 2Cl\bullet$<br><br>**M2 First propagation**<br>$Cl\bullet + CH_2Cl_2 \longrightarrow \bullet CHCl_2 + HCl$<br><br>**M3 Second propagation**<br>$Cl_2 + \bullet CHCl_2 \longrightarrow CHCl_3 + Cl\bullet$ | 3 | Penalise absence of dot once only.<br>Penalise + or – charges every time<br>Accept dot anywhere on $CHCl_2$ radical but if the structure is drawn out, the dot must be on the carbon atom. Penalise this error once only<br>Penalise once only for a line and two dots to show a bond.<br>Penalise once only for double headed curly arrows<br>Mark independently |
| 6(a)(ii) | **M1 Condition**<br>ultra-violet / uv / sun light<br>***OR*** high temperature<br>***OR*** $400^oC \leq T \leq 900\ ^oC$<br><br>**M2 Type of mechanism**<br>(free-) radical substitution (mechanism) | 2 | |
| 6(b)(i) | $CHCl_3 + Cl_2 \longrightarrow CCl_4 + HCl$ | 1 | Allow X as alternative to $CCl_4$ only if X is clearly identified as $CCl_4$ |

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| 6(b)(ii) | **M1** <u>Trichloromethane / $CHCl_3$ has a C–H bond</u><br>***OR***<br><u>X / $CCl_4$ / it has no C-H bond</u><br><br>**M2** The infrared spectrum shows<br>(absorption / peak for C–H in range) <u>**2850 to 3300** **(** $cm^{-1}$)<br>is missing</u> | 2 | **M1** must refer to presence or absence of the <u>C–H bond in a compound</u><br><br>**M2** answer must refer to / imply the spectrum<br>Allow the words "dip" OR "spike" OR "low transmittance" as alternatives for absorption.<br>Ignore references to other absorptions. |

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| 6(c) | **M1 a statement about bond breakage / formation of Cl•**<br>C-Cl / carbon-chlorine bond breakage occurs<br>***OR*** Cl• ***/*** chlorine (free) radical forms<br>***OR*** correct equation $CHClF_2 \longrightarrow Cl\bullet + \bullet CHF_2$<br><br>**M2** $Cl\bullet + O_3 \longrightarrow ClO\bullet + O_2$<br>**M3** $ClO\bullet + O_3 \longrightarrow Cl\bullet + 2O_2$<br>**M4**<br>$CHClF_2$ / chlorine-containing compounds/ CFCs damage / react with / decrease the ozone layer<br>***OR***<br>this overall decomposition occurs; $2O_3 \longrightarrow 3O_2$<br>***OR***<br>without an ozone layer or with a decreased ozone layer, uv radiation is not being "filtered" / prevented from passing through the atmosphere or there is a concern about an increase in skin cancer etc.<br>***OR***<br>Cl• catalyses the decomposition of ozone / a single Cl• causes (chain) reaction / decomposition of many ozone molecules / ozone layer | 4 | Penalise **M1**, if Cl• is formed from $Cl_2$ as the only reaction or an additional reaction<br>Do not penalise an incorrect equation using $CHClF_2$ if correct reference is made to Cl• formation or C-Cl / carbon-chlorine bond breakage<br><br>**M2** and **M3** either order<br>Penalise absence of dot once only.<br>Accept dot anywhere on ClO radical<br><br>Award **M4** for the general idea behind the EU justification for banning the use of CFCs as refrigerants<br>Penalise **M4** if overall ozone decomposition equation is incorrect<br><br>Ignore "greenhouse effect", "global warming" etc. |

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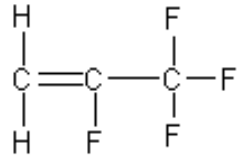
| 6(d)(i) |  | 1 | All bonds must be drawn out |
| 6(d)(ii) | 2,3,3,3-tetrafluoropropene / it does not contain chlorine (atoms) / C-Cl (bonds)<br>***OR***<br>It does not produce Cl• / does not produce chlorine (free) radical(s)<br>***OR***<br>chlorodifluoromethane does contain chlorine / does produce Cl• / does produce chlorine (free) radical(s)<br>***OR***<br>C–F is too strong and does not break / create radicals<br>***OR***<br>C–F is stronger than C–Cl | 1 | Ignore “chlorine molecules” |

| Question | Marking Guidance | Mark | Comments |
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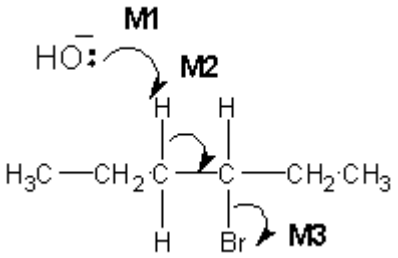
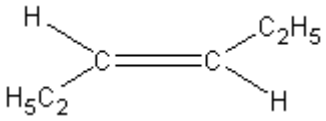
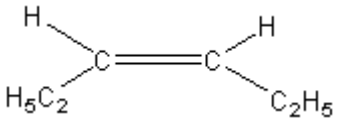
| 7(a)(i) |  <br>**M1** must show an arrow from the lone pair on oxygen of a negatively charged hydroxide ion <u>to the correct</u> H atom<br>**M2** must show an arrow from the correct C-H bond to the correct C-C bond. Only award if an arrow is shown <u>attacking</u> the H atom of the correct C-H bond in **M1**<br>**M3** is independent but **CE=0 if nucleophilic substitution**<br>**N.B these are double- headed arrows** | 3 | Penalise one mark from <u>their</u> total if half-headed arrows are used<br>Penalise **M3** for formal charge on C of the C-Br or incorrect partial charges on C-Br<br>Ignore other partial charges<br>Penalise once only in any part of the mechanism for a line and two dots to show a bond. |
| 7(a)(ii) | **M1** E isomer<br>  <br>**M2** Z isomer<br>  | 2 | Award 1 mark if both correct stereoisomers but in the wrong places<br>Accept no other alkenes.<br>Be reasonably lenient on the bonds to ethyl (or to $CH_2CH_3$) since the question is about E and Z positions but penalise once only if connection is clearly to the $CH_3$ of $CH_2CH_3$<br>Accept linear structures |

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| 7(a)(iii) | **M1** (Compounds / molecules with) the <u>same structural formula</u><br>**M2** with <u>atoms/bonds/groups</u> arranged <u>differently in space</u><br>***OR***<br><u>atoms/bonds/groups</u> that have <u>different spatial arrangements / different orientation</u>. | 2 | Penalise **M1** if "same structure"<br>Ignore references to " same molecular formula" or "same empirical formula" or any reference to "displayed formula"<br>Mark independently |

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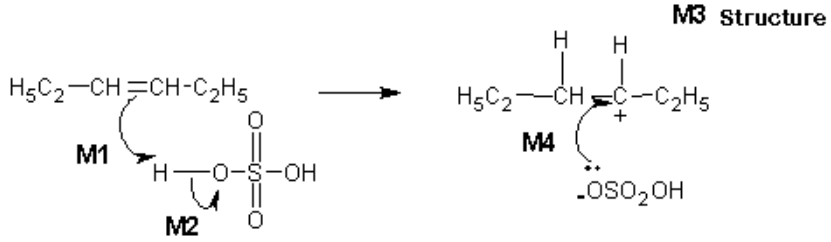
| 7(b) |  <br><br>**M1**must show an arrow from the double bond towards the H atom of the H – O bond OR HO on a compound with molecular formula for $H_2SO_4$<br>M1 could be to an H+ ion and M2 an independent O – H bond break on a compound with molecular formula for $H_2SO_4$<br>**M2** must show the breaking of the O ─ H bond.<br>**M3** is for the structure of the carbocation.<br>**M4** must show an arrow from the lone pair of electrons on the correct oxygen of the negatively charged ion towards a correct (positively charged) carbon atom.<br>**NB The arrows here are double-headed** | 4 | **M1** Ignore partial negative charge on the double bond.<br>**M2** Penalise partial charges on O – H bond if wrong way and penalise formal charges<br>In M2 do not penalise incorrect structures for $H_2SO_4$<br>**M4** NOT $HSO_4^-$<br>For **M4**, credit <u>as shown</u> or <u>$^-$:OSO$_3$H</u> ONLY with the negative charge anywhere on this ion<br>OR <u>correctly</u> drawn out with the negative charge placed correctly on oxygen<br>Penalise once only in any part of the mechanism for a line and two dots to show a bond<br><u>Max 3 of any 4 marks</u> for wrong organic reactant or wrong organic product (if shown)<br>Accept the correct use of "sticks" |

| Question | Marking Guidance | Mark | Comments |
|---|---|---|---|
| 8(a) | **M1 Safety (in Process 1)**<br>Sodium hydroxide / alkali is corrosive / harmful / caustic<br>or sodium hydroxide is alkali(ne)<br>***OR***<br>Bromine compounds are toxic / poisonous<br><br>**M2 Environmental**<br>Process 2 could be used as a carbon sink / for carbon capture<br>***OR***<br>uses waste / recycled $CO_2$ / $CO_2$ from the factory / $CO_2$ from the bioethanol (or biofuel) production<br>***OR***<br>reduces or limits the amount of $CO_2$ released / given out (into the atmosphere)<br>***OR***<br>Process 2 uses renewable glucose ***/*** renewable resource(s) | 2 | Ignore references to chromium compounds<br><br>"Carbon-neutral" alone is insufficient for **M2**<br><br>Ignore references to greenhouse gases |

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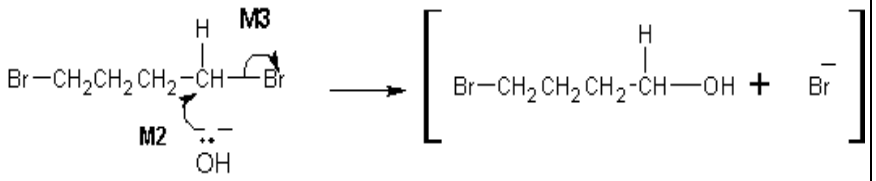
| 8(b)(i) | **M1** <u>nucleophilic substitution</u><br>  <br>**M2** must show an arrow from the lone pair of electrons on the oxygen atom of the negatively charged hydroxide ion to the C atom.<br>**M3** must show the movement of a pair of electrons from the C─ Br bond to the Br atom. Mark **M3** independently provided it is from the <u>original molecule</u><br>For **M2** and **M3** award full marks for an $S_N1$ mechanism<br>**NB The arrows here are double-headed** | 3 | For **M1**, **both words** required<br>Penalise **M2** if covalent NaOH / KOH is used<br>Penalise one mark from **M2** or **M3** if half-headed arrows are used<br>Penalise **M3** for formal charge on C of the C-Br or incorrect partial charges on C-Br<br>Penalise once only for a line and two dots to show a bond.<br>For **M2** and **M3**, maximum 1 of 2 marks for the mechanism if wrong reactant is used.<br>Penalise **M3** if an extra arrow is drawn from the Br of the C-Br bond to, for example, $K^+$<br>Accept the correct use of "sticks |

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| 8(b)(ii) | **M1** B<br>**M2** C<br>**M3** A | 3 | |

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| 8(c) | **M1** <u>fermentation</u><br>**Three conditions <u>in any order</u> for M2 to M4**<br>**M2** (enzymes from) yeast or zymase<br>**M3** 25°C ≤ T ≤ 42°C OR 298 K ≤ T ≤ 315 K<br>**M4** anaerobic / no oxygen / no air OR neutral pH | 4 | Mark **M2** to **M4** independently<br>Penalise "bacteria" and "phosphoric acid" using the list principle<br>Ignore reference to "aqueous" or "water", "closed container", "pressure, "lack of oxygen", "concentration of ethanol" and "batch process" (i.e. not part of the list principle) |
| 8(d) | **M1** primary OR $1^{o}$ (alcohol)<br>**M2** <u>acidified potassium or sodium dichromate</u><br>***OR*** $H_2SO_4$ / $K_2Cr_2O_7$ OR $H^+$ / $K_2Cr_2O_7$<br>***OR*** correct combination of formula and name<br>**M3**<br>$HOCH_2CH_2CH_2CH_2OH + \mathbf{4}[O] \longrightarrow HOOCCH_2CH_2COOH + \mathbf{2}H_2O$ | 3 | Mark independently<br>For **M2,** it must be a whole reagent and/or correct formulae<br>Do not penalise incorrect attempt at formula if name is correct or *vice versa*<br>Accept phonetic spelling<br>If oxidation state given in name, it must be correct.<br>For **M2** accept acidified potassium manganate(VII)<br>For **M3** structures must be correct and not molecular formula |

| Question | Marking Guidance | Mark | Comments |
|---|---|---|---|
| 9(a)(i) | **M1** iodine ***OR*** $I_2$ ***OR*** $I_3^-$<br><br>**M2** $Cl_2 + \mathbf{2}I^- \longrightarrow \mathbf{2}Cl^- + I_2$<br>***OR***<br>$\frac{1}{2}Cl_2 + I^- \longrightarrow Cl^- + \frac{1}{2}I_2$<br><br>**M3** redox or reduction-oxidation or displacement | 3 | Ignore state symbols<br>Credit **M1** for "iodine solution"<br><br>Penalise multiples in M2 except those shown<br><br>**M2** accept correct use of $\mathbf{I_3^-}$ |
| 9(a)(ii) | **M1** **(**the white precipitate is) <u>silver chloride</u><br><br>**M2** $Ag^+ + Cl^- \longrightarrow AgCl$<br><br>**M3** (white) precipitate / it <u>dissolves</u><br>***OR*** <u>colourless solution</u> | 3 | **M1** <u>must be named</u> and for <u>this mark</u> ignore incorrect formula<br><br>For **M2** ignore state symbols<br>Penalise multiples<br>Ignore references to "clear" alone |
| 9(b)(i) | **M1** $H_2SO_4 + \mathbf{2}Cl^- \longrightarrow \mathbf{2}HCl + SO_4^{2-}$<br>***OR*** $H_2SO_4 + Cl^- \longrightarrow HCl + HSO_4^-$<br>***OR*** $H+ + Cl^- \longrightarrow HCl$<br><br>**M2** hydrogen chloride ***OR*** HCl ***OR*** hydrochloric acid | 2 | For **M1** ignore state symbols<br>Penalise multiples for equations and apply the list principle |

| | | | |
|---|---|---|---|
| 9(b)(ii) | **M1 and M2 in either order**<br>**M1** $2I^- \longrightarrow I_2 + 2e^-$<br>***OR***<br>$8I^- \longrightarrow 4I_2 + 8e^-$<br>**M2** $H_2SO_4 + 8H^+ + 8e^- \longrightarrow H_2S + 4H_2O$<br>**OR**<br>$SO_4^{2-} + 10H^+ + 8e^- \longrightarrow H_2S + 4H_2O$<br>**M3** <u>oxidising agent</u> / <u>oxidises the iodide</u> (ions)<br>***OR***<br><u>electron acceptor</u><br>**M4** sulfur ***OR*** S ***OR*** $S_2$ ***OR*** $S_8$ ***OR*** sulphur | 4 | For **M1** and **M2**, ignore state symbols and credit multiples<br>Do not penalise absence of charge on the electron<br>Credit electrons shown correctly on the other side of each equation<br>Additional equations should not contradict |

| | | | |
|---|---|---|---|
| 9(b)(iii) | **M1** The NaOH / $OH^-$ / (sodium) hydroxide reacts with / neutralises the $H^+$ / acid / HBr (lowering its concentration)<br>***OR*** a correct neutralisation equation for $H^+$ or HBr with NaOH or with hydroxide ion<br><br>**M2** **Requires a correct statement for M1**<br>The (position of) equilibrium moves / shifts (from L to R)<br>• to replace the $H^+$ / acid / HBr that has been removed / lost<br>• ***OR*** to increase the $H^+$ / acid / HBr concentration<br>• ***OR*** to make more $H^+$ / acid / HBr / product(s)<br>• ***OR*** to oppose the loss of $H^+$ / loss of product(s)<br>• ***OR*** to oppose the decrease in concentration of product(s)<br><br>**M3** The (health) benefit outweighs the risk or wtte<br>***OR***<br>a clear statement that once it has done its job, little of it remains<br>***OR***<br>used in (very) dilute concentrations / small amounts / low doses | 3 | Ignore reference to NaOH reacting with bromide ions<br>Ignore reference to NaOH reacting with HBrO alone<br>In **M2**, answers must refer to the (position of) equilibrium shifts / moves and is not enough to state simply that it / the system / the reaction shifts to oppose the change. |

## General principles applied to marking CHEM2 papers by CMI+ June 2012

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**.

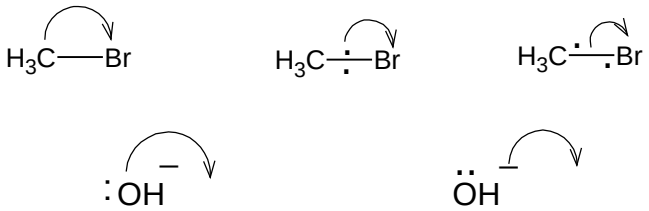
All other values **gain no credit** except

- 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.

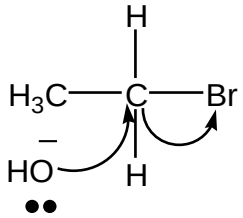
### H. Organic reaction mechanisms

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

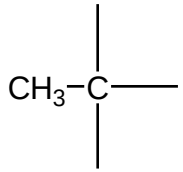
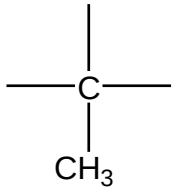
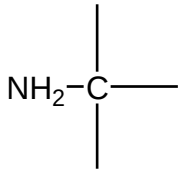
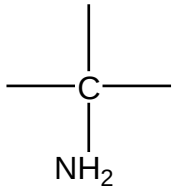
In mass spectrometry fragmentation equations, the absence of a radical dot on the molecular ion and on the free-radical fragment would be considered to be two independent errors and both would be penalised if they occurred within the same clip.

## 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 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** |