General Certificate of Education (A-level)
January 2013

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.

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.

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Question	Marking Guidance	Mark	Comments
1(a)(i)	Change in concentration (of a substance / reactant / product) in unit time / given time / per (specified) unit of time ***OR*** Amount of substance formed / used up in unit time / given time / per (specified) unit of time	1	This may be written mathematically ***OR*** may refer to the gradient of a graph of concentration / volume against time Ignore additional information including reference to collisions
1(a)(ii)	At **W** **M1 (QoL)** The rate / it is zero **M2** The magnesium has all reacted / has been used up ***OR*** No more collisions possible between acid and Mg ***OR*** Reaction is complete / it has stopped ***OR*** No more hydrogen / product is produced	2	Ignore reference to the acid being used up

1(a)(iii)	**M1** Twice / double as many particles / hydrogen ions (in a given volume) ***OR*** Twice / double as much hydrochloric acid **M2** Twice / double as many effective / successful collisions (in a given time) ***OR*** Twice / double as many collisions with either sufficient energy to react ***OR*** with E ≥ Ea ***OR*** double the successful / effective collision frequency	2	Penalise reference to (hydrochloric acid) molecules in **M1** Penalise reference to "HCl particles" in **M1**
1(b)(i)	The activation energy is the minimum energy for a reaction to go / start ***OR*** Minimum energy for a successful/ effective collision	1	
1(b)(ii)	**M1** Products lower than reactants on the profile **M2** Activation energy (E_a) shown and labelled correctly from reactants to peak of curve	2	Mark independently

1(c)(i)	$Ba + \mathbf{2}H_2O \longrightarrow Ba(OH)_2 + H_2$	1	$Ba + 2H_2O \longrightarrow Ba^{2+} + 2OH^- + H_2$ Allow multiples Ignore state symbols
1(c)(ii)	**M1** $Ba^{2+} + SO_4^{2-} \longrightarrow BaSO_4$ **M2** White precipitate / solid	2	Ignore state symbols in **M1** Not multiples in **M1** Extra ions must be cancelled Penalise contradictory observations in **M2**
1(c)(iii)	**M1** Barium meal / barium swallow / barium enema ***OR*** used in X-rays ***OR*** to block X-rays ***OR*** X-ray contrast medium ***OR*** CT scans **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 For **M2** NOT barium ions NOT barium NOT barium meal and NOT "It" Ignore radio-tracing

Question	Marking Guidance	Mark	Comments
2(a)	(If any factor is changed which affects an equilibrium), the (position of) equilibrium will shift / move so as to oppose / counteract the change. ***OR*** (When a system / reaction in equilibrium is disturbed), the (position of) equilibrium shifts / moves in a direction which tends to reduce the disturbance	1	Must refer to equilibrium Ignore reference to "system" alone A variety of wording will be seen here and the key part is the last phrase An alternative to shift / move would be the idea of changing / altering the position of equilibrium
2(b)(i)	**M1** A substance that speeds up the reaction / alters the rate but is chemically unchanged at the end / not used up **M2** Catalysts provide an alternative route / alternative pathway / different mechanism **M3** that has a lower activation energy / E_a ***OR*** lowers the activation energy / E_a	3	Both ideas needed for **M1** Credit can score for **M1**, **M2** and **M3** from anywhere within the answer
2(b)(ii)	(Time is) less / shorter / decreases / reduces	1	Credit "faster", "speeds up", "quicker" or words to this effect
2(b)(iii)	None	1	

2(c)(i)	R	1	
2(c)(ii)	T	1	
2(c)(iii)	R	1	
2(c)(iv)	P	1	
2(c)(v)	Q	1	

Question	Marking Guidance	Mark	Comments
3(a)(i)	**M1 (could be scored by a correct mathematical expression which <u>must</u> have <u>all</u> Δ*H* symbols and the ∑ or SUM)** **M1** <u>$\Delta H = \sum \Delta H_f$ (**products**) - $\sum \Delta H_f$ (**reactants**)</u> ***OR*** a <u>correct cycle of balanced equations</u> **M2** <u>ΔH</u> = 3(–394) – 3(–111) – (–971) (This also scores M1) **M3** = **<u>(+) 122</u>** (kJ mol^{-1}) **Award 1 mark ONLY for –122**	3	Correct answer gains full marks Credit 1 mark ONLY if **–122** (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 correct method; this requires either a correct cycle of balanced equations OR a clear statement of **M1** which could be in words and scores **<u>M1 only</u>**
3(a)(ii)	By definition ***OR*** Because it is an element / elemental	1	Ignore reference to “standard state”
3(b)(i)	$TiO_2 + \mathbf{2}Cl_2 + \mathbf{2}C \longrightarrow TiCl_4 + \mathbf{2}CO$ ***OR*** $TiO_2 + \mathbf{2}Cl_2 + C \longrightarrow TiCl_4 + CO_2$ **M1** use of Cl_2 <u>and</u> C **M2** a correct balanced equation	2	Allow multiples Ignore state symbols

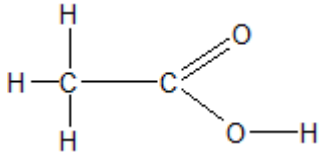
3(b)(ii)	$TiCl_4$ + **4**Na ⟶ Ti + **4**NaCl ***OR*** $TiCl_4$ + **2**Mg ⟶ Ti + **2**$MgCl_2$ **M1** use of Na ***OR*** Mg **M2** a correct balanced equation	2	Allow multiples Ignore state symbols
3(c)(i)	**4**$FeCr_2O_4$ + **8**Na_2CO_3 + **7**O_2 ⟶ **8**Na_2CrO_4 + 2Fe_2O_3 + 8CO_2	1	Allow multiples Ignore state symbols
3(c)(ii)	Cr_2O_3 + **2**Al ⟶ Al_2O_3 + **2**Cr	1	Allow multiples Ignore state symbols

Question	Marking Guidance	Mark	Comments
4(a)	The <u>enthalpy change</u> / <u>heat (energy) change</u> (at constant pressure) in a reaction is independent of the route / path taken (and depends only on the initial and final states)	1	Ignore the use of ΔH for enthalpy
4(b)	$\Delta H_{exp} + \Delta H_2 - \Delta H_1 = 0$ ***OR*** $\Delta H_{exp} + \Delta H_2 = \Delta H_1$ ***OR*** $\Delta H_1 = \Delta H_{exp} + \Delta H_2$ ***OR*** $\Delta H_{exp} = \Delta H_1 - \Delta H_2$ ***OR*** $\Delta H_{exp} = \Delta H_1 + (-\Delta H_2)$	1	Any correct mathematical statement that uses <u>all three terms</u>
4(c)	$\Delta H_{exp} = \Delta H_1 - \Delta H_2$ $\Delta H_{exp} = -156 - 12 =$ **–168** (kJ mol^{-1}) Award the mark for the correct answer without any working	1	Ignore units

4(d)(i)	**M1** q = m c ΔT OR calculation (25.0 x 4.18 x 14.0) **M2** = **1463** J OR **1.46** kJ (This also scores **M1**) **M3** must have both the correct value within the range specified **and** the minus sign For 0.0210 mol, therefore ΔH_1 = **– 69.67** to **– 69.52** (kJ mol^{-1}) **OR** ΔH_1 = **– 69.7** to **– 69.5** (kJ mol^{-1}) Accept answers to 3sf or 4sf in the range – 69.7 to – 69.5 Ignore -70 after correct answer	3	Award full marks for correct answer In **M1**, do not penalise incorrect cases in the formula Penalise **M3** ONLY if correct numerical value but sign is incorrect; e.g. **+69.5 to +69.7 gains 2 marks** (ignore +70 after correct answer) Penalise **M2** for arithmetic error but mark on ΔT = 287, score q = m c ΔT only If c = 4.81 (leads to 1684 J) penalise **M2** ONLY and mark on for **M3** = – 80.17 (range – 80.0 to – 80.2) Ignore incorrect units

4(d)(ii)	The idea of heat loss ***OR*** Incomplete reaction (of the copper sulfate) ***OR*** Not all the copper sulfate has dissolved	1	NOT impurity NOT incompetence NOT incomplete combustion

4(e)	Impossible to add / react the <u>exact / precise amount</u> of water ***OR*** Very difficult to measure the temperature rise <u>of a solid</u> ***OR*** Difficult to prevent solid dissolving ***OR*** (Copper sulfate) solution will form	1	Not just “the reaction is incomplete”

Question	Marking Guidance	Mark	Comments
5(a)(i)	CH_2O	1	Atoms in any order Accept a clear indication that $C_6H_{12}O_6$ yields CH_2O as the answer
5(a)(ii)	No peak / no absorption / no C=O in the **range 1680 to 1750** (cm^{-1}) (suggesting no evidence of C=O)	1	Allow the words “dip”, “spike”, “low transmittance” and “trough” as alternatives for absorption Ignore references to other wavenumbers
5(b)	**M1** $C_6H_{12}O_6 \longrightarrow$ **2**CH_3CH_2OH (C_2H_5OH) + **2**CO_2 Either order **M2** (enzymes from) yeast or zymase **M3** 25 °C ≤ T ≤ 42 °C OR 298 K ≤ T ≤ 315 K	3	Penalise C_2H_6O Allow multiples of the equation in **M1** For **M2** and **M3** Ignore “aqueous” Ignore “anaerobic/absence of oxygen” Ignore “controlled pH” Ignore “warm”
5(c)(i)	Displayed formula for CH_3COOH 	1	All bonds must be drawn out, but ignore bond angles

5(c)(ii)	$O_2 + 4H^+ + 4e^- \longrightarrow 2H_2O$	1	Ignore state symbols Negative charge on electron not essential Accept multiples Accept electrons subtracted from RHS
5(c)(iii)	$CH_3CH_2OH + H_2O \longrightarrow CH_3COOH + 4H^+ + 4e^-$ (C_2H_6O or C_2H_5OH)	1	Ignore state symbols Negative charge on electron not essential Accept multiples Accept electrons subtracted from LHS
5(c)(iv)	**M1** Acidified potassium or sodium dichromate ***OR*** H_2SO_4 / $K_2Cr_2O_7$ OR H^+ / $K_2Cr_2O_7$ etc. ***OR*** correct combination of formula and name **M2 (requires an attempt at M1)** orange to green Possible alternative **M1** (acidified) potassium manganate(VII) ***OR*** $KMnO_4$ / H_2SO_4 **M2** purple to colourless	2	For **M1**, it must be a whole reagent and/or correct formulae Do not penalise incorrect attempt at formula if name is correct or vice versa If oxidation state given in name, it must be correct, but mark on from an incorrect attempt at a correct reagent. Credit **acidified** potassium chromate(VI) / $H_2SO_4 + K_2CrO_4$ Other alternatives will be accepted but **M2** is dependent on **M1** in every case **M2** requires an attempt at a correct reagent for **M1** Ignore reference to states

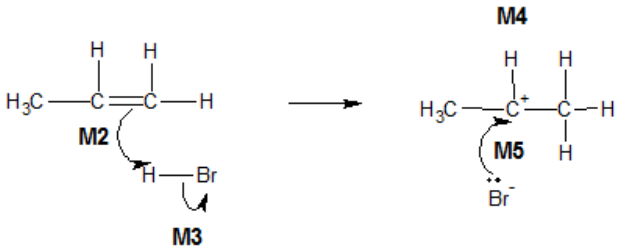
5(d)(i)	An activity which has no net / overall (annual) carbon emissions to the atmosphere / air ***OR*** An activity which has no net / overall (annual) greenhouse gas emissions to the atmosphere / air. ***OR*** There is no change in the total amount of carbon dioxide / carbon /greenhouse gas present in the atmosphere / air	1	The idea that the carbon / CO_2 given out equals the carbon / CO_2 that was taken in from the atmosphere / air Answer must refer to the atmosphere or air
5(d)(ii)	Renewable / sustainable ONLY	1	Ignore references to global warming or greenhouse gases

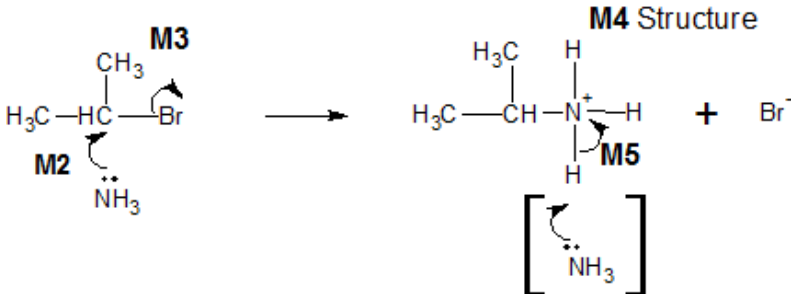
5(d)(iii)	**Any one statement <u>about this process</u> from** Subject to weather / climate ***OR*** Depletes <u>food</u> supply OR the land use <u>for</u> (specified) <u>food</u> ***OR*** Requires use of / uses more fossil fuels ***OR*** Not carbon-neutral OR CO_2 produced during a named process (eg harvest, transport etc.) ***OR*** Slow process / slow rate of reaction / takes a long time (to grow crops) ***OR*** This route leads to the production of a mixture of water and ethanol / impure ethanol <u>that requires separation / further processing</u>	1	Ignore “batch”

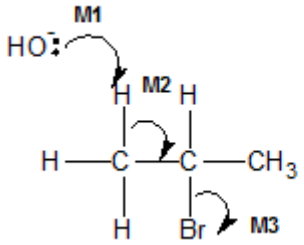
Question	Marking Guidance	Mark	Comments
6(a)	$3N_2H_4 \longrightarrow 4NH_3 + N_2$	1	Or multiples Ignore state symbols
6(b)	**M1** <u>enthalpy / heat (energy)</u> <u>change / required / needed</u> to <u>break</u> / <u>dissociate</u> a <u>covalent bond (or a specified covalent bond)</u> **M2** <u>average / mean</u> over <u>different molecules / compounds / substances</u>	2	Ignore bond making Ignore standard conditions **M2** requires an attempt at **M1**
6(c)	**M1** $\sum$ (bonds broken) – $\sum$ (bonds formed) = ΔH ***OR*** <u>Sum</u> of bonds broken – <u>Sum</u> of bonds formed = ΔH **M2** (also scores **M1**) 4(+388) + 163 + 2(146) + 4(463) – 944 – 8(463) = ΔH OR broken +3859 (2007) formed – 4648 (2796) **M3** ΔH = **<u>– 789</u>** (kJ mol^{-1}) Award 1 mark for + 789 Students may use a cycle and gain full marks	3	**M1** could stand alone <u>Award full marks for correct answer</u> Ignore units Two marks can score with an arithmetic error in the working Credit **one mark only** for calculating <u>either</u> the sum of the bonds broken <u>or</u> the sum of the bonds formed provided this is <u>the only mark that is to be awarded</u>

Question	Marking Guidance	Mark	Comments
7(a)(i)	(Free-) radical substitution	1	Both underlined words are required Penalise a correct answer if contradicted by an additional answer
7(a)(ii)	**Initiation** $F_2 \longrightarrow 2F\bullet$ **First propagation** $F\bullet + CH_3F \longrightarrow \bullet CH_2F + HF$ **Second propagation** $F_2 + \bullet CH_2F \longrightarrow CH_2F_2 + F\bullet$ **Termination (must make 1,2-difluoroethane)** $2\ \bullet CH_2F \longrightarrow CH_2FCH_2F$	4	Penalise absence of dot once only Penalise + or – charges every time Accept dot anywhere on CH_2F radical Mark independently Use of half-headed arrows must be correct to score, but if not correct then penalise once only in this clip
7(a)(iii)	$CH_3CH_3 + \mathbf{5}F_2 \longrightarrow CF_3CHF_2 + \mathbf{5}HF$ (C_2H_6) (C_2HF_5)	1	
7(b)	1,1,1,2-tetrachloro-2,2-difluoroethane ***OR*** 1,2,2,2-tetrachloro-1,1-difluoroethane	1	Accept phonetic spelling eg “fluro, cloro” Penalise “flouro” and “floro”, since **QoL** Ignore commas and hyphens

7(c)(i)	**2**O_3 ⟶ **3**O_2	1	ONLY this equation or a multiple Ignore NO over the arrow Other species must be cancelled
7(c)(ii)	O + NO_2 ⟶ NO + O_2	1	ONLY this answer and NOT multiples Ignore any radical dot on the O atom

Question	Marking Guidance	Mark	Comments
8(a)	**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 secondary carbocation **M5** must show an arrow from the lone pair of electrons on the negatively charged bromide ion towards the correct (positively charged) carbon atom **NB These are double-headed arrows**	5	For **M1**, both words required Accept phonetic spelling **For the mechanism** **M2** Ignore partial negative charge on the double bond **M3** Penalise partial charges on H–Br bond if wrong way and penalise formal charges Penalise once only in any part of the mechanism for a line and two dots to show a bond **Maximum any 3 of 4 marks for the mechanism** for wrong (organic) reactant ***OR*** wrong organic product (if shown) ***OR*** primary carbocation Accept the correct use of sticks

Question	Marking Guidance	Mark	Comments
8(b)	**M1** **Nucleophilic substitution**  **M2** must show an arrow from the lone pair of electrons **on the nitrogen atom** of an ammonia molecule to the correct C atom **M3** must show the movement of a pair of electrons from the C–Br bond to the Br atom. Mark **M3** independently provided it is from <u>their original molecule</u> **M4** is for the structure of the alkylammonium ion, which could be a condensed formula. A positive charge **must** be shown on/or close to, the N atom **M5** is for an arrow from the N–H bond to the N atom Award full marks for an S_N1 mechanism in which **M2** is the attack of the ammonia on the intermediate carbocation **NB These are double-headed arrows**	5	For **M1**, both words required Accept phonetic spelling **For the mechanism** Penalise **M2** if NH_3 is negatively charged Penalise **M3** for formal charge on C of the C-Br or incorrect partial charges on C-Br Penalise **M3** for an additional arrow from the Br to something else The second mole of ammonia is not essential for **M5**; therefore ignore any species here Penalise once only for a line and two dots to show a bond **<u>Maximum any 3 of 4 marks</u>** **<u>for the mechanism</u>** for wrong organic reactant ***OR*** wrong organic product if shown Accept the correct use of “sticks”

Question	Marking Guidance	Mark	Comments
8(c)	**M1** (addition) polymerisation OR poly-addition **M2** poly(propene) / polypropene	2	Ignore “additional” Credit polyprop-1-ene and polypropylene Penalise “condensation polymerisation”
8(d)	 **M1** must show an arrow from the lone pair on the oxygen of a negatively charged hydroxide ion to a correct H atom **M2** must show an arrow from a correct C–H bond adjacent to the C–Br bond to the appropriate C–C bond. Only award if an arrow is shown attacking the H atom of a correct C-H bond in **M1** **M3** is independent provided it is from their original molecule, but **CE=0 if nucleophilic substitution** Award full marks for an E1 mechanism in which **M3** is on the correct carbocation. **NB These are double-headed arrows**	3	Penalise **M1** if covalent KOH Penalise **M3** for formal charge on C 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 wrong organic reactant Accept the correct use of “sticks” for the molecule except for the C–H being attacked

Question	Marking Guidance	Mark	Comments
9	**M1 and M2 (either order)** **Any two from** • purple <u>vapour/gas</u> • (white solid goes to) black or black/grey or black/purple <u>solid</u> • bad <u>egg smell</u> or words to this effect **M3** The <u>iodide ion(s) / they lose (an) electron(s)</u> ***OR*** $2I^- \longrightarrow I_2 + 2e^-$ **M4** Oxidation state of S changes from **<u>+6 to –2</u>** or **<u>changes by 8</u>** **M5** $H_2SO_4 + \mathbf{8}H^+ + \mathbf{8}e^- \longrightarrow H_2S + \mathbf{4}H_2O$ ***OR*** $SO_4^{2-} + \mathbf{10}H^+ + \mathbf{8}e^- \longrightarrow H_2S + \mathbf{4}H_2O$	5	Ignore misty white fumes Ignore yellow solid Ignore purple solid Ignore “goes (dark) brown” Or multiples for possible equation in **M3** Accept “changes by – 8”

Question	Marking Guidance	Mark	Comments
10(a)	**M1** Cl_2 + **2**Br^- ⟶ **2**Cl^- + Br_2 **M2** solution goes <u>orange / yellow</u> (from colourless)	2	Accept a correct equation using ½ Cl_2 but no other multiples Ignore reference to brown colour Penalise incorrect observations eg fumes, precipitates
10(b)	**M1** Cl_2 + 2NaOH ⟶ NaClO + NaCl + H_2O (NaOCl) **M2** bleach or kills bacteria / bacteriacide / micro-organisms / microbes **M3** <u>sodium chlorate(I)</u> ONLY	3	Or a correct ionic equation Ignore reference to “swimming pools” and to “disinfectant”
10(c)	**M1** Cl_2 + H_2O ⇌ HClO + HCl (HOCl) **M2** The (health) benefit outweighs the risk or wtte ***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	2	Equilibrium symbol **<u>required</u>** in **M1** Accept ionic RHS

10(d)	**M1** Silver nitrate OR $AgNO_3$ (with or without nitric acid) **M2** **(depends on M1)** white precipitate / white solid **M3** $Ag^+ + Cl^- \longrightarrow AgCl$	3	For **M1** If only the formula is written then it must be correct If both the formula and the name are written then ignore incorrect attempt at the formula, but penalise an incorrect name If the reagent is incomplete eg Ag+ ions, penalise **M1** and mark on Penalise both **M1** and **M2** for alkaline $AgNO_3$ ***OR*** for the use of HCl to acidify the silver nitrate ***OR*** for Tollens' reagent

General principles applied to marking CHEM2 papers by CMI+ January 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 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.

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 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.

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

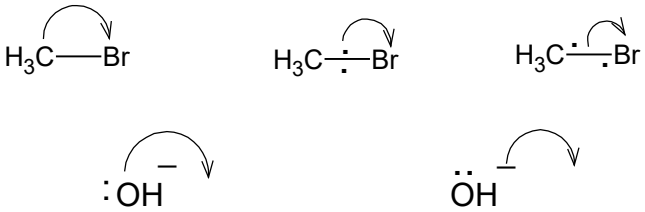
- The sign for an enthalpy change will be assumed to be positive unless specifically shown to be negative.
- A correct answer alone will score **full marks** unless the necessity to show working is specifically required in the question.
- A correct numerical value with the **wrong sign** will usually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

All other values **gain no credit** except

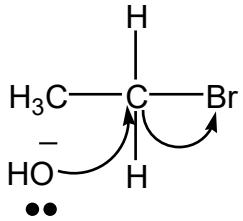
- Two marks can be awarded for correct chemistry with an arithmetic error.
- One mark can be awarded for a correct mathematical statement (or cycle) for the method.

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

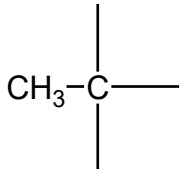
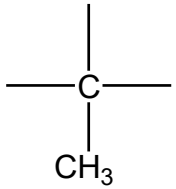
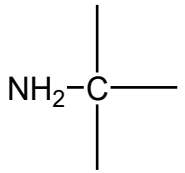
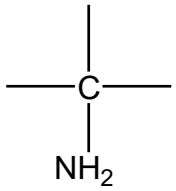
- The absence of a radical dot should be penalised **once only** within a clip.
- The use of double-headed arrows or the incorrect use of half-headed arrows in free-radical mechanisms should be penalised **once only** within a clip

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 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 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**
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**