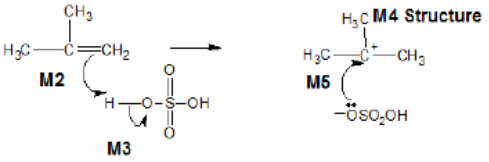
| Question | Marking Guidance | Mark | Comments |
|---|---|---|---|
| 1(a)(i) | **M1** (Yield) increases / goes up / gets more<br><br>**M2**<br>The (forward) reaction / to the right is exothermic or gives out / releases heat<br>*OR*<br>The reverse reaction / to the left is endothermic or takes in / absorbs heat<br><br>**M3 depends on correct M2 and must refer to temperature/heat**<br>The (position of ) equilibrium shifts / moves left to right to oppose the decrease in temperature | 3 | If **M1** is blank, mark on and seek to **credit the correct information in the explanation.**<br>If **M1** is incorrect CE=0 for the clip.<br><br>**M3** depends on a correct statement for **M2**<br><br>For **M3**, the equilibrium shifts/moves<br>to release heat *OR*<br>to raise the temperature *OR*<br>to heat up the reaction. |
| 1(a)(ii) | **M1** Concentration(s) (of reactants and products) remain or stay constant / the same<br><br>**M2** Forward rate = reverse / backward rate | 2 | For **M1** credit [ ] for concentration.<br><br>Not "equal concentrations".<br>Not "concentrations is / are the same".<br>Not "amount".<br><br>Ignore "dynamic" and ignore "speed".<br><br>Ignore "closed system".<br><br>It is possible to score both marks under the heading of a single feature. |
| 1(b) | $KBr + H_2SO_4 \longrightarrow KHSO_4 + HBr$ | 1 | Credit this equation in its ionic form.<br>Ignore state symbols.<br>Credit multiples. |
| 1(c) | **M1** $SO_2$ identified<br><br>**M2 correctly balanced equation (would also gain M1)**<br>$2HBr + H_2SO_4 \longrightarrow Br_2 + SO_2 + 2H_2O$<br><br>**Mark M3 independently**<br>**M3** Oxidising agent *OR* electron acceptor *OR* oxidant<br>*OR* to oxidise the bromide (ion) / HBr | 3 | Credit **M2** equation in its ionic form.<br>Ignore state symbols.<br>Credit multiples.<br>Not $H_2SO_3$ on the right-hand side.<br><br>**M3** Not "electron pair acceptor". |
| 1(d)(i) | **M1 Electrophilic addition**<br><br>  <br><br><br>**M2** must show an arrow from the double bond towards the H atom of the H – O bond / HO on a compound with molecular formula for $H_2SO_4$<br>**M2** could be to an H+ ion and **M3** an independent O – H bond break on a compound with molecular formula for $H_2SO_4$<br><br>**M3** must show the breaking of the O — H bond on $H_2SO_4$<br><br>**M4** is for the structure of the carbocation<br><br>**M5** must show an arrow from the lone pair of electrons on the correct oxygen of the negatively charged ion towards the positively charged carbon atom on their carbocation<br><br>**NB The arrows here are double-headed** | 5 | **M1** both words required.<br><br>**For the mechanism**<br>**M3** Penalise incorrect partial charges on O – H bond and penalise formal charges<br>Ignore partial negative charge on the double bond.<br><br>**M5** Not $HSO_4^-$<br><br>For **M5**, credit as shown or $^-OSO_3H$ ONLY with the negative charge anywhere on this ion<br>*OR* correctly drawn out with the negative charge placed correctly on oxygen.<br><br>Max any 3 of 4 marks **for a correct mechanism** using the wrong organic reactant or wrong organic product (if shown) or a primary carbocation.<br><br>Penalise once only in any part of the mechanism for a line and two dots to show a bond.<br><br>Credit the correct use of "sticks".<br><br>For **M5**, credit attack on a partially positively charged carbocation structure, but penalise **M4** |
| 1(d)(ii) | Hydrolysis | 1 | Credit "(nucleophilic) substitution" but do not accept any other prefix.<br>Credit phonetic spelling. |
| 1(d)(iii) | Catalyst | 1 | |

| Question | Marking Guidance | Mark | Comments |
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| 2(a) | **M1** concentrated sulfuric acid OR c(onc) $H_2SO_4$<br><br>**M2** (cream solid) turns orange<br>*OR* orange / red / brown fumes / gas / vapour<br><br>**M3** (yellow solid) turns black<br>*OR* purple fumes / gas / vapour<br>*OR* correct reference to $H_2S$ observation (eg bad egg smell)<br><br>***OR* as an alternative**<br><br>**M1** concentrated ammonia *OR* c(onc) $NH_3$<br><br>**M2** (cream solid) dissolves / solution formed<br><br>**M3** precipitate remains / does not dissolve / insoluble<br>*OR* no reaction / no change / (yellow solid) turns to white solid | 3 | If no reagent or incorrect reagent in **M1**, CE= 0 and no marks for **M2** or **M3**<br><br>If dilute sulfuric acid OR "aq" (alone) **CE=0**<br><br>If $H_2SO_4$ / sulfuric acid given but not stated whether dilute or concentrated, penalise **M1** and mark on for **M2** and **M3**<br>If incorrect formula for the acid, penalise **M1** but mark **M2** and **M3**<br><br>If $NH_3$ / ammonia / aq ammonia given, but not stated as concentrated *OR* if dilute ammonia given, penalise **M1** but mark on for **M2** and **M3**<br>Ignore "partially" and ignore "clear" in **M2**<br><br>If incorrect formula for ammonia, penalise **M1** but mark **M2** and **M3**<br><br>In **M3** for ammonia.<br>Ignore "nothing (happens)".<br>Ignore "no observation". |
| 2(b) | **M1** $AgNO_3$ *OR* silver nitrate *OR* any soluble silver salt<br><br>**M2** white precipitate or white solid / white suspension<br><br>**M3** remains colourless *OR* no reaction *OR* no (observed) change<br>*OR* no precipitate<br><br>Credit alternative test for nitrate ions | 3 | If no reagent or incorrect reagent in **M1**, CE= 0 and no marks for **M2** or **M3**<br>An insoluble silver salt OR Tollens' *OR* Ag *OR* ammoniacal silver nitrate or HCl / $AgNO_3$ CE= 0 for the clip.<br><br>For **M1**<br>Credit acidified (or $HNO_3$) silver nitrate for **M1** and mark on.<br>If silver ions or incorrect formula for silver nitrate, penalise **M1** but mark **M2** and **M3**<br><br>For **M2**<br>Ignore "cloudy solution" *OR* "suspension".<br><br>For **M3**<br>Ignore "nothing (happens)".<br>Ignore "no observation".<br>Ignore "clear".<br>Ignore "dissolves". |
| 2(c) | **M1** $Br_2$ *OR* bromine (water) *OR* bromine (in $CCl_4$ / organic solvent)<br><br>**Either order**<br>**M2** (stays) orange / red / yellow / brown / the same<br>*OR* no reaction *OR* no (observed) change<br>*OR* reference to colour going to cyclohexane layer<br><br>**M3** decolourised / goes colourless / loses its colour<br><br>***OR* as an alternative**<br><br>**Use $KMnO_4/H_2SO_4$**<br>**M1** acidified potassium manganate(VII) or $KMnO_4/H_2SO_4$<br>*OR* $KMnO_4/H^+$ *OR* acidified $KMnO_4$<br>**M2** (stays) purple or no reaction or no (observed) change<br><br>**M3** purple to colourless solution *OR* goes colourless<br><br>Credit alternative test using **iodine** (for **M1**)<br>**M2** (brown) to purple or accept no change, **M3** colourless<br>Credit alternative test using concentrated $H_2SO_4$<br>**M2** no change, **M3** brown | 3 | If no reagent or incorrect reagent in **M1**, CE= 0 and no marks for **M2** or **M3**<br>No credit for combustion observations; CE=0<br>For **M2 in every case.**<br>Ignore "nothing (happens)".<br>Ignore "no observation".<br>Ignore "clear".<br><br>**With bromine (water)**<br>**For M1**, it must be a whole reagent and/or correct formula.<br>If oxidation state given in name, it must be correct.<br>**For M1** penalise incorrect formula, but mark **M2** and **M3**<br><br>**With potassium manganate(VII)**<br>**For M1**<br>If "manganate" or "manganate(IV)" or incorrect formula or no acid, penalise **M1** but mark **M2** and **M3**<br><br>Credit alkaline/neutral $KMnO_4$ for possible full marks but **M3** gives brown precipitate or solution goes green. |

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

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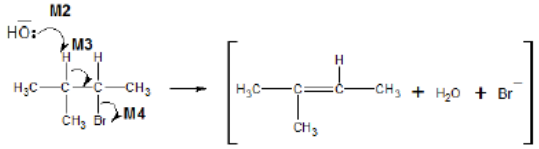
| **3** (a)(i) | **M1 Elimination**<br>  <br><br>**M2** must show an arrow from the lone pair on the oxygen of a negatively charged hydroxide ion to a correct H atom<br><br>**M3** must show an arrow from a correct C–H bond adjacent to the C–Br bond to a correct C–C bond. Only award if an arrow is shown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

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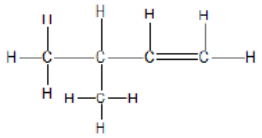
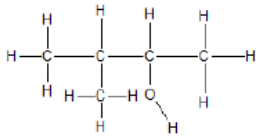
| (a)(ii) | Displayed formula for 3-methylbut-1-ene  | 1 | All bonds and atoms must be drawn out, but ignore bond angles. |
| (a)(iii) | Position(al) (isomerism or isomer) | 1 | Penalise any other words that are written in addition to these. |
| (b)(i) | Displayed formula for 3-methylbutan-2-ol  | 1 | All bonds and atoms must be drawn out, but ignore bond angles. |
| (b)(ii) | Any **one** from<br>• Lower / decreased temperature *OR* cold<br>• Less concentrated (comparative) *OR* dilute KOH<br>• Water (as a solvent) / (aqueous conditions) | 1 | Ignore "pressure". |
| (b)(iii) | Nucleophilic substitution | 1 | Both words needed – credit phonetic spelling. |
| (b)(iv) | (Strong / broad) absorption / peak in the range **3230 to 3550** $cm^{-1}$ or specified value in this range or marked correctly on spectrum | 1 | Allow the words "dip" ***OR*** "spike" ***OR*** "trough" ***OR*** "low transmittance" as alternatives for absorption. |

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

| Question | Marking Guidance | Mark | Comments |
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| 5 (a) | **Initiation**<br>$Cl_2 \longrightarrow 2Cl\bullet$<br><br>**First propagation**<br>$Cl\bullet + CH_3Cl \longrightarrow \bullet CH_2Cl + HCl$<br><br>**Second propagation**<br>$Cl_2 + \bullet CH_2Cl \longrightarrow CH_2Cl_2 + Cl\bullet$<br><br>**Termination (must make 1,2-dichloroethane)**<br>$2 \bullet CH_2Cl \longrightarrow CH_2ClCH_2Cl$ | 4 | Penalise absence of dot once only.<br><br>Credit the dot anywhere on the radical.<br><br>Penalise $C_2H_4Cl_2$ |
| (b)(i) | (chlorine free) radical | 1 | Ignore formula. |
| (b)(ii) | **M1** $Cl\bullet + O_3 \longrightarrow ClO\bullet + O_2$<br>**M2** $ClO\bullet + O_3 \longrightarrow Cl\bullet + 2O_2$ | 2 | **M1** and **M2** could be in either order.<br>Credit the dot anywhere on the radical.<br>Penalise absence of dot once only.<br>Individual multiples acceptable but both need to be doubled if two marks are to be awarded. |

| Question | Marking Guidance | Mark | Comments |
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| 6 (a) | Structure for 3-methylbut-1-ene<br>$H_2C{=}CHCH(CH_3)_2$ | 1 | Any correct structural representation.<br>Credit "sticks" and require the double bond. |
| (b) | Structure for 2-methylpropan-2-ol<br>$(CH_3)_3COH$ | 1 | Any correct structural representation.<br>Credit "sticks". |
| (c) | Structure for propene<br>$H_2C{=}CHCH_3$ | 1 | Any correct structural representation.<br>Credit "sticks" and require the double bond. |
| (d) | Structure for 2-aminobutane<br>$CH_3CH_2CH(NH_2)CH_3$ | 1 | Any correct structural representation.<br>Credit "sticks". |

| Question | Marking Guidance | Mark | Comments |
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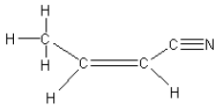
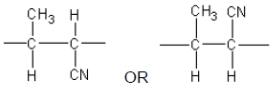
| 7 (a)(i) | Structure of (Z)-but-2-enenitrile with or without either or both of the $CH_3$ and the CN groups displayed  | 1 | Penalise C–NC<br>Do not penalise C–$H_3$C<br>Ignore bond angles. |
| (a)(ii) | Restricted rotation / no (free) rotation about the double bond / about the C=C ***OR*** does not rotate (about the double bond) | 1 | Must use the word rotate / rotation. |
| (b) | Repeating unit of polyalkene  | 1 | All the bonds relevant to the unit must be drawn out including those on either side of the unit. There is no need to expand either the $CH_3$ or the CN<br>Penalise C–NC<br>Penalise "sticks".<br>Ignore brackets.<br>Penalise "n" |
| (c) | **Feature 1**<br>Absorption / peak in the range **2220 to 2260** $cm^{-1}$ or specified value in this range or marked correctly on spectrum<br>**and**<br>(characteristic absorption / peak for) **C≡N / CN** group / **nitrile / cyanide** group<br><br>**Feature 2**<br>Absorption / peak in the range **1620 to 1680** $cm^{-1}$ or specified value in this range or marked correctly on spectrum<br>**and**<br>(characteristic absorption / peak for) **C=C** group / **alkene** / **carbon-carbon double bond** | 2 | Allow the words "dip" ***OR*** "spike" ***OR*** "trough" ***OR*** "low transmittance" as alternatives for absorption.<br>Allow a peak at 2200 $cm^{-1}$ to 2220 $cm^{-1}$ **in this case.**<br>Ignore reference to other absorptions eg C-H<br>Either order. |