1)

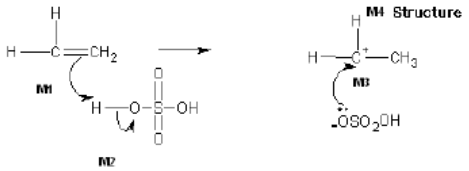
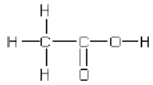
a	i	Splitting/ breaking C–X / bond(s) using / by (adding) / with water *OR* Splitting/ breaking the molecule / substance / compound using / by (adding) / with water	1	NOT simply the reaction of / with water NOT simply the addition or adding of water. NOT the "splitting of water" Accept any halogen bond, but penalise other specified bonds
a	ii	**M1** yellow ONLY **M2** $Ag^+ + I^- \longrightarrow AgI$ ($Ag^+ I^-$)	2	For M1, penalise cream(y) OR white Ignore pale or light or dark (yellow) For M2, ignore state symbols
a	iii	**M1** AgF OR silver fluoride is soluble / dissolves (in water) **M2** No result OR no precipitate OR no (visible) change would occur OR colourless solution	2	Accept "silver flouride" Mark independently Ignore reference to C – F bond breakage in M1 Ignore "no reaction" and "nothing"

2)

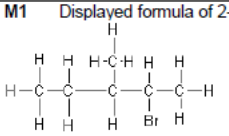
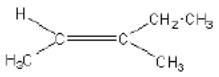
b	iii	By definition ***OR*** The standard / reference (value / isotope)	1	Ignore "element" Ignore "atom"

3)

a		to neutralise stomach acidity ***OR*** as an antacid ***OR*** eases indigestion / heartburn	1	Ignore milk of magnesia Credit suitable reference to indigestion / laxative / relief of constipation
b	i	an electron acceptor ***OR*** (readily) gains / accepts / receives electron(s)	1	NOT an electron pair acceptor Ignore removes / takes away / attracts electrons
b	ii	Br_2 ONLY	1	Ignore "bromine" Apply the list principle
b	iii	$H_2SO_4 + 2H^+ + 2e^- \longrightarrow SO_2 + 2H_2O$ ***OR*** $SO_4^{2-} + 4H^+ + 2e^- \longrightarrow SO_2 + 2H_2O$	1	Ignore state symbols Ignore absence of negative charge on electron Or multiples of equations

c	i	(acid) catalyst *OR* catalyses (the reaction) *OR* to speed up the reaction / increase the rate (of reaction)	1	Ignore "provides H^+ ions" Accept phonetic spelling
c	ii	 **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 (or accept H_2SO_3 here) 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 or H_2SO_3 **M2** must show the breaking of the O — H bond. **M3** 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. **M4** is for the structure of the carbocation. **NB The arrows here are double-headed**	4	M2 Ignore partial charges unless wrong M3 NOT HSO_4^- For M3, credit as shown or $^-OSO_3H$ ONLY with the negative charge anywhere on this ion OR correctly drawn out with the negative charge placed correctly on oxygen Max 3 marks for wrong reactant Do not penalise the use of "sticks"
c	iii	Primary *OR* 1° (alcohol)	1	
c	iv	Displayed formula for ethanoic acid, CH_3COOH 	1	All the bonds must be drawn out and this includes the O — H bond Ignore bond angles.

4)

a	i	3-bromo-3-methylpentane ONLY	1	Must be correct spelling but ignore hyphens and commas
a	ii	Electrophilic addition (reaction)	1	Both words needed Accept phonetic spelling
a	iii	**M1** Displayed formula of 2-bromo-3-methylpentane  **M2** Position(al) (isomerism)	2	All the bonds must be drawn out but ignore bond angles **Do not forget to award this mark**
a	iv	Structure of (E)-3-methylpent-2-ene 	1	The arrangement of groups around the double bond must be clear with the ethyl group attached in the correct order. Ignore bond angles. Accept C_2H_5 for ethyl Be lenient on C — C bonds. The main issue here is whether they have drawn an (E) isomer. Accept "sticks" for C — H bonds and correct skeletal formula
b	i	**M1** R is represented by **Spectrum 2** **M2** Spectrum 2 shows an infrared absorption / spike / dip / trough / peak with any value(s) / range within the range 1620 to 1680 (cm^{-1}) OR this range quoted / identified and this is due to C=C OR this information could be a correctly labelled absorption on the spectrum OR Spectrum 1 does not have an infrared absorption in range 1620 to 1680 (cm^{-1}) and does not contain C=C.	2	Award M1 if it is obvious that they are referring to the second spectrum (or the bottom one) M2 depends on a correct M1 Ignore other correctly labelled peaks Ignore reference to "double bond" or "alkene"
b	ii	Functional group (isomerism)	1	
b	iii	Cyclohexane *OR* Methylcyclopentane etc.	1	Named correctly Ignore structures and ignore numbers on the methyl group of methylcyclopentane

5)

a	i	**M1 Initiation** $Cl_2 \longrightarrow 2Cl\bullet$ **M2 First propagation** $Cl\bullet + CH_3CH_3 \longrightarrow \bullet CH_2CH_3 + HCl$ C_2H_6 **M3 Second propagation** $Cl_2 + \bullet CH_2CH_3 \longrightarrow CH_3CH_2Cl + Cl\bullet$ C_2H_5Cl **M4 Termination (must make C_4H_{10})** $2 \bullet CH_2CH_3 \longrightarrow C_4H_{10}$ or $CH_3CH_2CH_2CH_3$	4	Penalise absence of dot once only. Penalise + or – charges <u>every time</u> Penalise incorrect position of dot on ethyl radical once only. Penalise $C_2H_5\bullet$ once only Accept $CH_3CH_2\bullet$ with the radical dot above / below / to the side of <u>the CH_2</u> Mark independently
a	ii	**M1** ultra-violet / uv / sun light OR (very) high temperature OR 500 °C ≥ T ≤1000 °C **M2** (free-)<u>radical substitution</u>	2	Ignore "heat" for M1 Both words needed for M2 For M2, ignore the word "mechanism"
b	i	$Cl_2 + H_2O \longrightarrow HClO + HCl$ *OR* $Cl_2 + H_2O \longrightarrow 2H^+ + ClO^- + Cl^-$	1	Accept HOCl or ClOH Accept other ionic or mixed representations Ignore state symbols
b	ii	**M1** Any one from • in swimming pools • in drinking water • to sterilise / disinfect / sanitise water • in water treatment **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	Ignore the manufacture of bleach Ignore "to clean water" Ignore "water purification" Mark independently but M1 can score from (M2) explanation
b	iii	<u>Sodium chlorate(I)</u> or sodium hypochlorite	1	Must be named Ignore (in)correct formulae Insist on the (I) in the name
c	i	$Cl_2 + 2Br^- \longrightarrow Br_2 + 2Cl^-$	1	Or half this equation <u>Ignore state symbols</u>
c	ii	**M1 The relative size (of the molecules/atoms)** Bromine is <u>larger</u> than chlorine OR has more electrons/electron shells *OR* It is larger / It has a larger atomic radius / it is a larger molecule / atom **M2 How size of the <u>intermolecular force</u> affects energy needed** The forces <u>between</u> bromine / Br_2 <u>molecules</u> are stronger (than the forces <u>between</u> chlorine / Cl_2 <u>molecules</u> leading to more energy needed to separate the <u>molecules</u>) (or converse) *OR* bromine / Br_2 has <u>stronger / more</u> (VdW) <u>intermolecular</u> forces. (or converse)	2	For M1 ignore whether it refers to molecules or atoms. CE=0 for reference to (halide) ions Ignore molecular mass QoL for clear reference to the difference in size <u>of the force between molecules</u> Penalise M2 if covalent bonds are broken

6)

a		**Three conditions <u>in any order</u> for M1 to M3** **M1** yeast or zymase **M2** 30°C ≥ T ≤ 42 °C **M3** anaerobic / no oxygen / no air OR neutral pH **M4** $C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2$ OR $2C_6H_{12}O_6 \longrightarrow 4C_2H_5OH + 4CO_2$	4	Mark independently Penalise "bacteria" and "phosphoric acid" using the list principle Ignore reference to "aqueous" or "water" (i.e. not part of the list principle) Or other multiples
b		**M1** Carbon-neutral **M2** <u>6 (mol / molecules) CO_2 / carbon dioxide taken in / used / used up</u> (to form glucose or in photosynthesis) **M3** <u>6 (mol / molecules) CO_2 / carbon dioxide</u> given out <u>due to **2** (mol / molecules) CO_2 / carbon dioxide from fermentation / Process 2 and **4** (mol / molecules) CO_2 / carbon dioxide from combustion / Process 3</u>	1 1 1	Ignore "biofuel" It is NOT sufficient in M2 and M3 for equations alone without commentary or annotation or calculation

c		**M1** **(could be scored by a correct mathematical expression)** (Sum of) bonds broken – (Sum of) bonds made / formed = ΔH *OR* (Σ) $B_{reactants}$ – (Σ) $B_{products}$ = ΔH (where B = bond enthalpy / bond energy) **M2** Reactants = (+) 4719 *OR* Products = (–) 5750 **M3** Overall + 4719 –5750 = **–1031** ($kJmol^{-1}$) **(This is worth 3 marks)** **Award 1 mark ONLY for +1031** Candidates may use a cycle and gain full marks. **M4** Mean bond enthalpies are not specific for this reaction *OR* they are average values from many different compounds / molecules	3 1	For M1 there must be a correct mathematical expression using ΔH or "enthalpy change" Award full marks for correct answer. Ignore units. M2 is for either value underlined M3 is NOT consequential on M2 **Do not forget to award this mark**

d		**M1** q = m c ΔT (this mark for correct mathematical formula) **M2** = 6688 (J) OR 6.688 (kJ) OR 6.69 (kJ) OR 6.7 (kJ) **M3** 0.46g is 0.01 mol therefore ΔH = – 669 $kJmol^{-1}$ OR – 670 $kJmol^{-1}$ OR – 668.8 $kJmol^{-1}$ **M4** Incomplete combustion	4	Award M1, M2 and M3 for correct answer to the calculation Penalise M3 ONLY if correct answer but sign is incorrect In M1, do not penalise incorrect cases in the formula If m = 0.46 or m = 200.46 OR if ΔT = 281, CE and penalise M2 and M3 If c = 4.81 (leads to 7696) penalise M2 ONLY and mark on for M3 = – 769.6 OR – 770 Ignore incorrect units in M2 **Do not forget to award this mark. Mark independently**

7)

1(a)	**M1 (could be scored by a correct mathematical expression)** **M1** ΔH = $\sum\Delta H_f$**(products)** - $\sum\Delta H_f$**(reactants)** *OR* a correct cycle of balanced equations **M2** = – 1669 – 3(– 590) = –1669 + 1770 (This also scores M1) **M3** = + 101 ($kJ\ mol^{-1}$) **Award 1 mark ONLY for – 101** **M4 – Using powders** Any one from • To increase collision frequency / collisions in a given time / rate of collisions • To increase the surface contact / contact between the solids / contact between (exposed) particles **M5 Major reason for expense of extraction** Any one from • Aluminium is extracted by electrolysis OR aluminium extraction uses(large amounts of) electricity • Reaction / process / It /the mixture requires heat • It is endothermic	5	Correct answer to the calculation gains all of **M1**, **M2** and **M3** Credit 1 mark for – 101 ($kJ\ mol^{-1}$) For other incorrect or incomplete answers, proceed as follows • check for an arithmetic error (AE), which is either a transposition error or an incorrect multiplication; this would score 2 marks (**M1** and **M2**) • If no AE, check for a correct method; this requires either a correct cycle with 3Sr and 2Al OR a clear statement of **M1** which could be in words and scores only **M1** Ignore dividing final answer by 3 Penalise **M4** for reference to molecules.

(b)	Calcium has a higher melting point than strontium, because **Correct reference to size of cations/proximity of electrons** **M1** (For Ca) delocalised <u>electrons closer to cations / positive ions / atoms / nucleus</u> *OR* <u>cations / positive ions / atoms are smaller</u> *OR* <u>cation / positive ion / atom or it has fewer (electron) shells / levels</u> **Relative strength of metallic bonding** **M2** (Ca) has <u>stronger</u> attraction between the <u>cations / positive ions / atoms / nucleus</u> and the <u>delocalised electrons</u> *OR* <u>stronger metallic</u> bonding (assume argument refers to Ca but credit converse argument for Sr)	2	Ignore general Group 2 statements. Penalise **M1** if either of Ca or Sr is said to have <u>more or less</u> delocalised electrons OR the same nuclear charge. Ignore reference to shielding. CE= 0 for reference to molecules or Van der Waals forces or intermolecular forces or covalent bonds.
(c)	**M1** $2Mg + O_2 \longrightarrow 2MgO$ **M2** $Mg + 2H_2O \longrightarrow Mg(OH)_2 + H_2$ **M3** Magnesium hydroxide is used as an antacid / relieve indigestion (heartburn) / neutralise (stomach) acidity / laxative	3	Credit multiples of the equations. Not simply "milk of magnesia" in **M3**