Question Number	Answer	Mark
14(a)	**The only correct answer is A**  ***B*** *is incorrect because hydrogen peroxide is not concentrated enough to be toxic, nor is it flammable* ***C*** *is incorrect because hydrogen peroxide is not flammable* ***D*** *is incorrect because hydrogen peroxide is not concentrated enough to be toxic*	**(1)**

Question Number	Answer	Mark
14(b)	**The only correct answer is C** (II and III) ***A*** *is incorrect because using an alternative method that involves less hazardous materials would not work* ***B*** *is incorrect because working on a smaller scale has not been included* ***D*** *is incorrect because using an alternative method that involves less hazardous materials is not appropriate*	**(1)**

Question Number	Answer	Mark
7	**The only correct answer is C** (91.2) ***A*** *is not correct because this only takes into account the base peak* ***B*** *is not correct because this does not take into account the peak at 96* ***D*** *is not correct because this is the unweighted mean*	**(1)**

Question Number	Answer	Mark
13	**The only correct answer is B** (PCl_3F_2) ***A*** *is incorrect because this is not symmetrical so must have a dipole* ***C*** *is incorrect because this is not symmetrical as the central equatorial chlorines are asymmetrical so must have a dipole* ***D*** *is incorrect because this is not symmetrical so must have a dipole*	**(1)**

Question Number	Answer	Mark
6	**The only correct answer is C** (0.095 g) ***A*** *is incorrect because this has been divided by 1000 not 1000000* ***B*** *is incorrect because this is ten times too big* ***D*** *is incorrect because this is the mass of the solute in kg instead of g*	**(1)**

Question Number	Answer	Mark
13	**The only correct answer is A** (BF_3) ***B*** *is incorrect because there are four bonding pairs of electrons which repel equally* ***C*** *is incorrect because there are two bonding pairs of electrons which repel less strongly than the two lone pairs* ***D*** *is incorrect because there are three bonding pairs of electrons which repel less strongly than the lone pair*	**(1)** **Computer**

Question Number	Answer	Mark
11	**The only correct answer is D** (yellow blue) ***A** is incorrect because both the ions are moving in the wrong direction* ***B** is incorrect because only the copper(II) ions have been attracted to an electrode* ***C** is incorrect because only the chromate(VI) ions have been attracted to an electrode*	**(1)** **Computer**

Question Number	Answer	Mark
12	**The only correct answer is C** (touch screens) ***A** is not correct because this is a use of diamonds* ***B** is not correct because this is a use of graphite* ***D** is not correct because this use relies on graphene's strength*	**(1)**

Question Number	Answer	Mark
2	**The only correct answer is A** ($6.0\ cm^3$) ***B** is not correct because this is double the volume of butane required* ***C** is not correct because this is the volume of CO_2 released* ***D** is not correct because this is the total volume of reacting gases*	**(1)** **Computer**

Question Number	Answer	Mark
11	**The only correct answer is A** (ionic soluble high poor) ***B** is incorrect because ionic compounds usually have high melting temperatures and do not conduct as a solid* ***C** is incorrect because metallic structures are insoluble in water and usually have high melting temperatures* ***D** is incorrect because metallic stuctures have good electrical conductivity*	**(1)**

Question Number	Answer	Mark
7(a)	**The only correct answer is B** (64) ***A*** *is incorrect because the mass of bromide has been converted into moles* ***C*** *is incorrect because the mass of bromide in mg has been divided by the A_r of bromine before conversion to ppm* ***D*** *is incorrect because the mass of bromide ions has been taken as 64 g rather than 64 mg*	**(1)** **Computer**

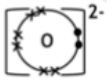
Question Number	Answer	Mark
7(b)	**The only correct answer is A** (2.4×10^{20}) ***B*** *is incorrect because the mass of solution has not been divided by 2* ***C*** *is incorrect because the mass of the ions has not been divided by the A_r of bromine* ***D*** *is incorrect because the mass of the ions has not been divided by the A_r of bromine and the mass of solution has not been divided by 2*	**(1)** **Computer**

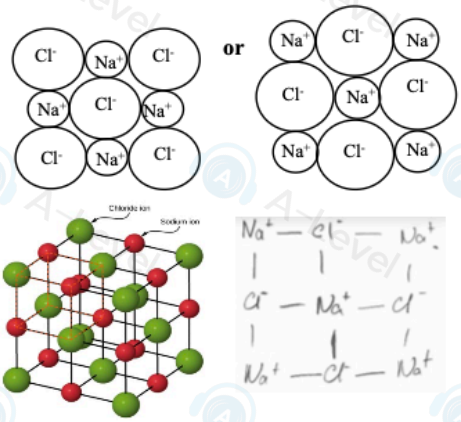
Question Number	Answer	Mark
5	**The only correct answer is D** ($NH_3(g)$) ***A*** *is incorrect because it is not a polar molecule* ***B*** *is incorrect because it is not a polar molecule* ***C*** *is incorrect because it is not a polar molecule*	**(1)**

Question Number	Answer	Mark
10	**The only correct answer is A** (1.167 g) ***B*** *is incorrect because they have used a 1:2 ratio not 1:1.* ***C*** *is incorrect because they have used the wrong concentration or volume of the barium chloride* ***D*** *is incorrect because they have used the wrong concentration or volume of the barium chloride and used a 1:2 ratio not 1:1.*	**(1)**

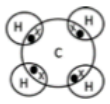
Question Number	Answer	Additional Guidance	Mark
23(a)(i)	An answer that makes reference to the following point: • (electrostatic force of) **attraction** between oppositely charged ions	Allow attraction between cations / positively charged metal ions and anions	(1)

Question Number	Answer	Additional Guidance	Mark
23(a)(ii)	An explanation that makes reference to the following points: • magnesium **ions** have a higher charge. **(1)** • magnesium ions have a smaller radius. **(1)**	Allow ORA about sodium ions Allow Mg^{2+} and Na^{+} Allow magnesium has a smaller ionic radius / magnesium ions are smaller If no other mark awarded allow one mark for Mg^{2+} / magnesium ion has a greater charge density Penalise any mention of covalent bonding or intermolecular forces once only.	(2)

Question Number	Answer	Additional Guidance	Mark
23(a)(iii)	An answer that makes reference to the following points: •  (1) •  (1)	**Mark independently** Allow eight electrons on outer shell instead of no electrons or no circle Allow single sodium ion Do not award Na^{+}_{2} Allow transferred electrons in any pattern Do not award all dots or all crosses for the oxide ion Ignore omission of square brackets	(2)

Question Number	Answer	Additional Guidance	Mark
23(a)(iv)	An answer that makes reference to the following points: • At least 9 correctly labelled sodium **and** chloride ions (1) • The correct structure of alternating sodium / positive and chloride / negative (ions) either in rows or 3D lattice (1)	 Ignore size of ions Do not award M1 if suggestion that sodium chloride is not NaCl	(2)

Question Number	Answer	Additional Guidance	Mark
23(b)(i)	An answer that makes reference to the following point: • (electrostatic force of) **attraction** between the **shared pair** of electrons and the nuclei (of two atoms)		**(1)**

Question Number	Answer		Additional Guidance	Mark
23(b)(ii)	An answer that makes reference to the following points:			**(3)**
	• structure of methane	**(1)**		
	• structure of ammonia	**(1)**		
	• structure of water	**(1)**		

Question Number	Answer		Additional Guidance	Mark
23(b)(iii)	An answer that makes reference to the following points:			**(3)**
	• shape and bond angle for methane	**(1)**		
	• shape and bond angle for ammonia	**(1)**		
	• shape and bond angle for water	**(1)**		

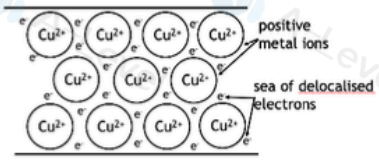
molecule	shape	bond angle
methane	tetrahedral	109.5°
ammonia	(trigonal) pyramidal	107°
water	non-linear / bent / V-shaped	104.5°

If no other mark scored 1 mark for either three correct bond angles or three correct shapes

Question Number	Answer		Additional Guidance	Mark
23(b)(iv)	An answer that makes reference to the following points: (Both ammonia and water have four pairs of electrons around the central atom)			**(2)**
	• ammonia has one lone pair and water has two lone pairs	**(1)**	Allow water has an extra lone pair	
	• lone pairs (of electrons) repel more than bonded pairs.	**(1)**	Ignore bond angles even if incorrect.	

Question Number	Answer	Additional Guidance	Mark
23(b)(v)	An answer that makes reference to the following points: • ethene is a simple molecule • ethene has weak intermolecular forces • poly(ethene) is a polymer • poly(ethene) strong intermolecular forces All four bullet points scores 2 Two or three bullet points scores 1	Allow London / van der Waals / dispersion forces for intermolecular forces Ignore monomer Do not award reference to breaking covalent bonds Allow poly(ethene) is a macromolecule / giant molecule for polymer Do not award reference to breaking covalent bonds	(2)

Question Number	Answer	Additional Guidance	Mark
23(c)(i)	An answer that makes reference to the following point: • **electrostatic** (force of) **attraction** between the positive / metal ions and the (sea of delocalised) electrons.		(1)

Question Number	Answer	Additional Guidance	Mark
23(c)(ii)	An explanation that makes reference to the following points: • **delocalised** electrons are able to move / flow (through the lattice and carry a charge) **(1)** • diagram showing lattice of Cu^{2+} ions and (sea of) electrons interspersed within the structure – approximately twice as many electrons as ions **(1)**	Delocalised electrons may be labelled in the diagram  Do not award ions move	(2)

(Total for Question 23 = 21 marks)

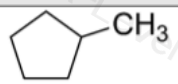
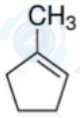
Question Number	Answer	Additional Guidance	Mark
19(a)(i)	• Expression for weighted mean for energy density **(1)** • calculation of energy density of sample to 2 or 3 SF **(1)**	example of calculation $\frac{(92.2 \times 46.5) + (29.7 \times 7.80)}{100}$ OR $(92.2\% \times 46.5) + (7.8\% \times 29.7)$ = 45.190 = 45 / 45.2 (MJ kg^{-1}) Allow 45000 kJ kg^{-1} / 45200 kJ kg^{-1} Correct answer with or without working scores 2 marks	**(2)**

Question Number	Answer	Additional Guidance	Mark
19(a)(ii)	• calculation of mass of sample	example of calculation 0.729 × 1500 = 1093.5 / 1094 / 1090 / 1100 (g) Do not award 1093 (g)	**(1)**

Question Number	Answer	Additional Guidance	Mark
19(a)(iii)	• calculation of energy released **and** correct units	example of calculation 1093.5 ÷ 1000 = 1.0935 45.190 × 1.0935 = 49.415 MJ Accept 49415 kJ Accept 4.9415×10^7 J OR 1093.5 ÷ 1000 = 1.0935 38.1 × 1.0935 = 41.662 MJ Accept 41662 kJ Accept 4.1662×10^7 J Allow TE from (i) and (ii) Allow use of rounded values from (i) and (ii) Ignore SF except 1 SF Ignore negative signs Correct answer with no working scores the mark Comment – if a value is given in (a)(i), candidates can still use 38.1 to access the mark here	**(1)**

Question Number	Answer	Additional Guidance	Mark
19(b)	An answer that makes reference to three of the following points: • (increased amount of) ethanol used could be bioethanol / ethanol sourced from plants **(1)** • from fermentation (of sugars / glucose using yeast) **(1)** • reducing CO_2 emissions (overall) / (some) CO_2 released in combustion offset by CO_2 used in photosynthesis **(1)** • less impact on global warming / climate change **(1)** • **uses less** of a finite resource (which can then be used in other processes e.g. manufacture of pharmaceuticals) **(1)** • less pollution from sulfur impurities / less SO_2 emissions **(1)**	Allow ethanol can be made from a renewable resource Ignore esterification of vegetable oils (biodiesel) Allow fermentation is a low energy process Allow bioethanol is (nearly) carbon neutral / has a lower carbon footprint Ignore 'crude oil is non-renewable' Comment – allow reverse arguments in context of E5	**(3)**

Question Number	Answer	Additional Guidance	Mark
19(c)(i)	An answer that makes reference to the following point: $C_6H_{14} \rightarrow C_6H_{12} + H_2$	Allow other types of correct formulae Allow $C_6H_{14} \rightarrow C_6H_{10} + 2H_2$ Allow multiples Ignore state symbols even if incorrect	**(1)**

Question Number	Answer	Additional Guidance	Mark
19(c)(ii)		Allow skeletal, displayed or hybrid formulae mark for (c)(ii) could be evident in c(i) Allow methylcyclopentenes if C_6H_{10} is given in (c)(i) e.g.  No TE from (c)(i)	**(1)**

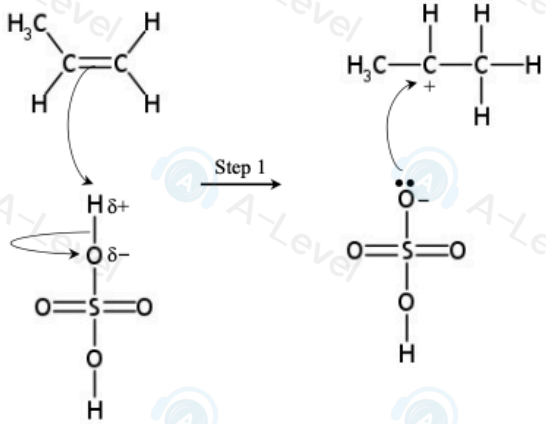
Question Number	Answer	Additional Guidance	Mark
19(d)(i)	An explanation that makes reference to the following points: • (to provide enough energy) to break Cl-Cl **bond(s)** / for homolytic fission of chlorine **(1)** • to form chlorine radicals / to form $Cl^{\bullet}$ **(1)**	Allow $Cl_2 \rightarrow 2Cl^{\bullet}$ for M2 Accept (to form chlorine radicals) without breaking the C-H bonds (in hexane) Do not award ions Do not award chloride radicals Comment  Scores M1 for LHS and M2 for RHS	**(2)**

Question Number	Answer	Additional Guidance	Mark
19(d)(ii)	An answer that makes reference to the following points: • equation for propagation step **(1)** • equation for termination step **(1)**	$Cl^{\bullet} + C_6H_{14} \rightarrow {}^{\bullet}C_6H_{13} + HCl$ $({}^{\bullet}C_6H_{13} + Cl_2 \rightarrow Cl^{\bullet} + C_6H_{13}Cl)$ $2{}^{\bullet}C_6H_{13} \rightarrow C_{12}H_{26}$ Allow $C_6H_{13}^{\bullet}$ for hexyl radical Do not award if additional termination equations are shown Penalise omission of unpaired electron once only Comment – if $C_{12}H_{26}$ used as the reactant alkane allow TE for M2 $2C_{12}H_{25}^{\bullet} \rightarrow C_{24}H_{50}$	**(2)**

(Total for Question 19 = 13 marks)

Question Number	Answer	Additional Guidance	Mark
19(a)(i)	An answer that makes reference to the following point: • electrophilic addition	Do not award substitution	(1)

Question Number	Answer	Additional Guidance	Mark
19(a)(ii)	An explanation that makes reference to the following points: • (because) the formation of 2-chloropropane / the major product proceeds via a secondary **carbocation** **(1)** • (but) the reaction / the formation of 1-chloropropane / the formation of the minor product proceeds via a primary **carbocation** **(1)** • (and) secondary carbocations are more stable than primary carbocations **(1)**	Do not award 2-chloropropane is a secondary carbocation Do not award 1-chloropropane is a primary carbocation Allow TE on incorrect type of carbocations used in M1 and M2 but must be in the correct order of stability (3° more stable than 2° more stable than 1°)	(3)

Question Number	Answer	Additional Guidance	Mark
19(b)	All 9 points scores (4) 7 or 8 points scores (3) 5 or 6 points scores (2) 3 or 4 points scores (1) • dipole on O–H bond • arrow from double bond to correct H or just in front of H • arrow from O–H bond to O • structure of intermediate carbocation ignoring any charge • positive charge on intermediate carbocation • structure of intermediate anion • single negative charge on intermediate anion • lone pair of electrons on relevant O • arrow from lone pair of electrons to correct carbon	Example of diagram:  Allow charge on the anion anywhere on the ion including outside a bracket	(4)

(Total for Question 19 = 8 marks)