Question Number	Correct Answer	Reject	Mark
1 (a)(i)			**2**

	$CH_2CHCHCH_2$	CO	H_2O	$HOOC(CH_2)_4COOH$
ΔH_f / kJ mol^{-1}	+109.9	**−110.5**	**−285.8**	−994.3
S / J mol^{-1} K^{-1}	278.7	**197.6**	**69.9**	250.0

4 values correct **(2)** marks

3 / 2 values correct **(1)** mark

0 / 1 values correct **(0)** marks

Question Number	Correct Answer	Reject	Mark
1 (a)(ii)	−994.3 − [+109.9 + (2 x −110.5) + (2 x −285.8)] **(1)** = − 311.6 (kJ mol^{-1}) **(1)** Allow TE from (a) **NOTE** If both −110.5 and −285.8 are not doubled, answer CQ = −707.9 (kJ mol^{-1}) for **1** mark Ignore SF except 1 SF		**2**

Question Number	Correct Answer	Reject	Mark
1 (a)(iii)	250(.0) − [278.7 + (2 x 197.6) + (2 x 69.9)] **(1)** = −563.7 (J mol^{-1} K^{-1}) **(1)** Allow TE from (a) **NOTE** If both 197.6 and 69.9 are not doubled, answer CQ = −296.2 (J mol^{-1} K^{-1}) for **1** mark Ignore SF except 1 SF		**2**

Question Number	Correct Answer	Reject	Mark
1 (a)(iv)	ΔS_{surr} at 298 K = −ΔH/T **(1)** = − (−311.6 x 1000) / 298 = (+) **1045.6** (J mol^{-1} K^{-1}) Allow TE from (a)(ii) e.g. ΔS_{surr} = (+)2375.5(0) (J mol^{-1} K^{-1}) scores (2) if no doubling in (a)(ii) **(1)** $\Delta S_{tot} = \Delta S_{surr} + \Delta S_{sys}$ / ΔS_{tot} = 1045.6 −563.7 / ΔS_{tot} = (+) **481.9** (J mol^{-1} K^{-1}) Allow TE from (a)(ii) and (a)(iii) **(1)** Allow correct answers given in **kJ mol^{-1} K^{-1}** e.g. 0.4819 **kJ mol^{-1} K^{-1}** Ignore SF except 1 SF If candidates forget to convert ΔH into J mol^{-1}, then ΔS_{tot} = −562.7 (J mol^{-1} K^{-1}) would score (2) if correct working is included		**3**

Question Number	Correct Answer	Reject	Mark
1 (a)(v)	(Decrease in T) **1st mark: consideration of ΔS_{system}** ΔS_{system} is not (significantly) changed / is unchanged / remains (approximately) constant **(1)** **2nd mark: consideration of ΔS_{surr}** ΔS_{surr} or $-\Delta H/T$ is more positive / larger / greater COMMENT ALLOW 'less negative' **(1)** **3rd mark: consideration of ΔS_{total}** (So) increases ΔS_{tot} / makes ΔS_{tot} more positive / makes ΔS_{tot} greater **(1)** **NOTE** IF no reference / an incorrect reference made to ΔS_{system}, then only the 2nd and 3rd marks can be awarded **NOTE** If candidate states that ΔS_{surr} becomes **less +ve**, no M2 But if **then** states CQ that ΔS_{tot} decreases award M3 as a TE		**3**

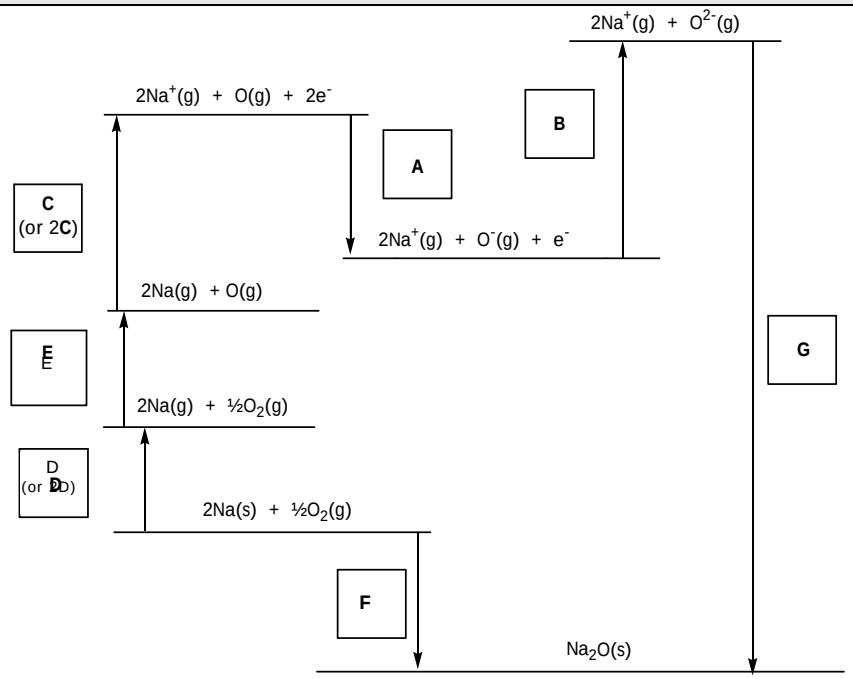
Question Number	Correct Answer	Reject	Mark
1 (b)	**DIMINISHING:** (Peak between) **1669 – 1645** (cm^{-1}) (due to C=C) **OR** (Peak between) **3095 – 3010** (cm^{-1}) (due to alkene C-H) **(1)** **INCREASING:** (Peak between) **1725 – 1700** (cm^{-1}) (due to C=O in carboxylic acid) **OR** (Peaks due to alkane C–H bonds at) EITHER **2962 – 2853** (cm^{-1}) OR **1485** – **1365** (cm^{-1}) **ALLOW** (Peak between) **3300 – 2500** (cm^{-1}) (due to O–H in carboxylic acid) **(1)**	**1740 – 1720** **3750 – 3200**	**2**

Question Number	Correct Answer	Reject	Mark
1 (c)	(Makes it taste) sour / sharp / tart IGNORE 'acidic' / 'bitter' NOTE Contradictory answers (e.g. 'sharp and sweeter') score **(0)**	fruity sweet(er) none	**1**

Question Number	Correct Answer	Reject	Mark
1 (d) (i)	**1st mark:** (% of oxygen =) **43.9** (%) **(1)** **2nd mark:** Amount of C = 49.3/12 = 4.1 (mol) Amount of H = 6.8/1 = 6.8 (mol) Amount of O = 43.9/16 = 2.7 (mol) **(1)** **3rd mark:** Ratio **1.5 C : 2.5 H : 1 O** (≡3 C : 5 H : 2 O) ALLOW for 3rd mark:- Decimal values that round up to these values (e.g. **1.497 C : 2.478 H : 1 O** scores the 3rd mark) **(1)** **ALLOW** M_r of $C_3H_5O_2$ = 73 (g mol^{-1}) **(1)** %C = $\frac{36}{73}$ x 100 = 49.3% **and** %H = $\frac{5}{73}$ x 100 = 6.8% **(1)** %O = 43.9% ALLOW 43.8% **(1)**		**3**

<table>
<tr><th>Question Number</th><th>Correct Answer</th><th>Reject</th><th>Mark</th></tr>
<tr><td>1 (d) (ii)</td><td>For ‘Chemical shift’ column, allow any range or any single value within range
<table>
<tr><th>Feature of compound Q</th><th>Chemical shift / ppm</th><th>Splitting pattern</th></tr>
<tr><td>CH_3</td><td>0.1 – 1.9</td><td>Triplet (1)
Allow (splits into) three</td></tr>
<tr><td>CH_2</td><td>1.7 – 3(.0) (1)</td><td>Quartet (1)
Allow quadruplet / (splits into) four</td></tr>
<tr><td>OH</td><td>10(.0) – 12(.0) (1)</td><td>singlet</td></tr>
</table></td><td></td><td>4</td></tr>
</table>

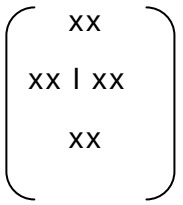
Question Number	Acceptable Answers	Reject	Mark
2(a)	(The energy / enthalpy change that accompanies the formation of) **one mole** of a(n ionic) compound **(1)** ALLOW as alternative for compound: lattice /crystal / substance / solid / product / salt from (its) **gaseous ions** **(1)** IGNORE References to 'standard conditions' or any incorrect standard conditions **ALTERNATIVE RESPONSE** If no mark(s) already awarded from above, can answer by giving:- energy change / enthalpy change **per mole** **(1)** $2Na^{+}(g) + O^{2-}(g) \rightarrow Na_2O(s)$ **(1)** **NOTE** If lattice energy of dissociation is given (e.g. "energy required to break down 1 mol of an ionic lattice into its gaseous ions") max (1) for the 2nd scoring point 'gaseous ions'	'energy required' / 'energy needed' / 'energy it takes' 'from **one mole of gaseous ions**' (no 2nd mark) 'from gaseous **elements**' (no 2nd mark)	**2**

Question Number	Acceptable Answers	Reject	Mark
2(b)(i)	 All seven letters correct **(3)** Five **OR** six letters correct **(2)** Three **OR** four letters correct **(1)** ALLOW Either D or 2D Either C or 2C ALLOW Correct numerical values (see question paper) may be given as an alternative to the correct letters		**3**

Question Number	Acceptable Answers	Reject	Mark
2(b)(ii)	**FIRST, CHECK THE FINAL ANSWER** **IF answer = −2520 (kJ mol^{-1}) then** **award (2) marks, with or without working** Otherwise look for −414 = (2 × 108) + 249 + (2 × 496) + (−141) + 790) + ΔH_{LE} **OR** ΔH_{LE} = −414 − [(2 × 108) + 249 + (2 × 496) + (−141) + 790] **OR** A correct expression using letters e.g. F = (2)D + E + (2)C + A + B + G **(1)** (=−414 − 2106) = −**2520** (kJ mol^{-1}) **(1)** NOTE **ALLOW** for **1 mark**: −1692 (wrong sign for 414) −1916 (2 × 108 and 2 × 496 not used for Na^+) −2412 (2 × 108 not used for Na^+) −2024 (2 × 496 not used for Na^+) +2520 (wrong sign for final answer) −2802 (sign changed for 1st electron affinity of oxygen) −2395.5 (atomization of oxygen halved) NOTE Penalise incorrect units (e.g. kJ mol) ONCE only **NO ECF** from incorrect answers to (b)(i)	−1088 (kJ mol^{-1}) scores **(0)** overall (as two errors) (+)1088 (kJ mol^{-1}) also scores **(0)** overall (as several errors)	**2**

Question Number	Acceptable Answers	Reject	Mark
***2(c)**	ALLOW reverse argument where appropriate **First mark** MgO more exothermic (than MgS) IGNORE 'greater' / 'higher' / 'larger' **(1)** **Second mark** S^{2-} larger than O^{2-} **(1)** **Third mark** Charges on O^{2-} and S^{2-} same OR Charges on (all) ions same OR S^{2-} smaller **charge density** than O^{2-} NOTE This mark is awarded if both formulae for the ions O^{2-} and S^{2-} are mentioned **(1)** **Fourth mark** O^{2-} (forms) **stronger** (electrostatic) **attractions** (than S^{2-}) IGNORE just 'stronger (ionic) bonds' **(1)** **Penalise ONCE ONLY** the use of the word 'atom(s)' or 'molecule(s)'/ use of **formulae** such as 'Mg' 'O' 'O_2', etc. AND/OR **Penalise ONCE ONLY** use of **words** such as **just '**magnesium' (instead of magnesium ions/Mg^{2+}) and/or **just '**oxygen' (instead of oxide ions/O^{2-}) **Mark each point independently**	"**MgS** is larger than **MgO**" S^{2-} has a larger **atomic** radius than O^{2-}	**4**

(Total for Question = 11 marks)

Question Number	Acceptable Answers	Reject	Mark
3 (a)	$[:Li]^+$ (1)  (1) Accept all or mixture of dots and crosses **Check inner electrons present on lithium** If no element symbols but fully correct with Li first give **1 max** If no / incorrect charge(s) if the electrons are correct **1 max** If arrow drawn from third / outer shell electron on lithium to join electrons in iodine / iodide with correct charges scores **1 max** Brackets are not essential		**2**

Question Number	Acceptable Answers	Reject	Mark
3 (b)	Li(s) **and** $Li^+(g)$ **and** $I^-(g)$ **(1)** $\frac{1}{2}I_2(s)$ **and** I(g) **(1)** (ΔH_{at})**[**$\frac{1}{2}I_2(s)$**]** **(1)** Notice the square brackets are essential for this mark If wrong state for iodine element ie if $\frac{1}{2}I_2(g/l)$ and consistent $(\Delta H_{at})[\frac{1}{2}I_2(g/l)]$ allow third mark If I(s) given for element and (ΔH_{at}) [I(s)] allow third mark If wrong state with monatomic iodine both the last two marks lost If $Li^+(g)$ + e appears ignore electron		**3**

Question Number	Acceptable Answers	Reject	Mark
3 (c)	**First mark for one of:** −270 = + 159 + 107 + 520 + electron affinity − 759 Or Electron affinity = −270 − (159 + 520 + 107 − 759) **(1)** OR Electron affinity = −270 - 159 - 520 - 107 + 759 **(1)** **Second mark for:** (Electron affinity =) −297 (kJ mol^{-1}) **(1)** −297 (kJ mol^{-1}) alone scores **(2)** NB providing method is recognisable with one transcription error eg 795 for 759 and the final answer is consistent **1 max** NB (+) 297 (kJ mol^{-1}) **1 max**	Wrong unit e.g.	**2**

Question Number	Acceptable Answers	Reject	Mark
3 (d)	(Experimental lattice energy is) more negative / exothermic **(1)** OR Theoretical lattice energy is less negative / exothermic **(1)** OR Recognition that more energy **released** **(1)** Irrespective of first answer then, any two from: Due to a degree of covalency **(1)** Deviation from pure ionic model (in experimental value) OR The theoretical model is pure ionic bonding **(1)** **Polarization / distortion** of the iod**ide** / negative ions (by the lithium ion). Can be shown by diagram **(1)** Iodine/ I / I_2 ion is not acceptable but iodine / I **anion** is allowed Note I_2 anion is not allowed	Greater / less Increase / decrease alone	**3**

Question Number	Acceptable Answers	Reject	Mark
3 (e)	Electron affinities become less negative / less exothermic / more positive (going down Group 7) **(1)** As (added) **electron** further from the nucleus OR **More** shielding / shielded (from the nucleus) **(1)** Second mark stands alone Ignore larger (ionic) radius / atom / ion / charge density	Greater / less / Increase / decrease alone Any indication of ionization/ removing an electron	**2**

Number

41(a)1	$MgCO_3(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l) + CO_2(g)$ ALLOW $MgCO_3(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + CO_2(g) + H_2O(l)$ All formulae and balancing (1) State symbols – mark independently; can be given even if eg $MgCl_2$ formula incorrect or for $H_2CO_3(aq)$(1) $CO_3^{2-}(s) + 2H^+(aq) \rightarrow CO_2(g) + H_2O(l)$ (1 mark max) ALLOW 1 missing/incorrect state symbol		**2**

Question Number	Acceptable Answers	Reject	Mark
41(b)1	Any two from Bubbles (of gas)/ fizzing/ effervescence (1) Solid disappears/ disintegrates /gets smaller /dissolves OR $MgCO_3$ disappears (if given as solid in (i)) (1) IGNORE clear solution forms Mixture gets warmer/cooler OR temperature change occurs/ heat change occurs(1)	 Carbon dioxide /gas given off Precipitate forms (no TE for $MgCl_2(s)$) Just "exothermic"	**2**

Question Number	Acceptable Answers	Reject	Mark
41(c)1(i)1	Moles acid = ((25 x 2/ 1000)) = 0.05/0.050 / $5x10^{-2}$ Ignore units and sf		**1**

Question Number	Acceptable Answers	Reject	Mark
41(c)1(ii)1	Mass Mg CO_3 = ((0.05 x 84.3÷2)) = 2.1075/ 2.108 /2.11/2.1 (g) ALLOW TE from (c)(i) and (a) ALLOW Moles acid x 84.3 ÷2 for TE(from (i) (1) (4.2(15)) if factor of 2 missing for TE from (a)) Ignore sf except 1 sf Ignore units	2 / 2.12(g)	**1**

Question Number	Acceptable Answers	Reject	Mark
41(c)1(iii)1	To ensure all **acid** reacts/ all **acid** is used up / to ensure product is neutral/ it (HCl) is neutralised	All reactants used up To ensure reaction is complete (without reference to HCl) To ensure yield is high To ensure magnesium carbonate is in excess	**1**

Question Number	Acceptable Answers	Reject	Mark
41(c)1(iv)1	Filter ALLOW centrifuge/ decant/ pour off / (use) filter paper Ignore comments about heating solution first to concentrate it	Sieve Collect $MgCl_2$ in filter paper Use filter paper to dry crystals Evaporate	**1**

Question Number	Acceptable Answers	Reject	Mark
41(c)1(v)1	100% yield = (203.3 x 0.025) /5.08(25)g) (1) yield = $\frac{3.75}{5.08}$ x 100) = **74 %** (1) OR Mol magnesium chloride = $\frac{(3.75}{203.3)}$ = 0.018445/0.01845/0.0184/0.018 (1) yield = $\frac{(100 \text{ X } 0.01845)}{0.025}$ = **74 %** (1) Second mark can be given as TE if expected yield or number of moles is wrong. ALLOW 73.82/73.78/73.8 /73.6 /other answers rounding to 74 % from earlier approximations /72 (from 0.018 moles) Allow TE from (a) and or (c)(i) and or (c)(ii) If the ratio HCl to $MgCl_2$ is 1:1 ans 37 % (2) If moles of HCl in (c)(i) are wrong (2) If (a) and (c)(i) are correct 37 % scores (1) If moles $MgCO_3$ = 0.05 allow TE giving 37/ 36.9% Ignore sf except 1 sf	70	**2**

Question Number	Acceptable Answers	Reject	Mark
41(c)1(vi)1	Some stays in solution / losses on transferring from one container to another/ loss on filtering /crystals left behind/some left on filter paper etc Any one ALLOW correct answers with other comments which are not incorrect eg "there may be some spillage and also ……."	Incomplete reaction/side reaction Lost as waste products Lost to environment Lost in manipulation? Hydrolysis Weighing errors Just "spillage"	**1**

Question Number	Acceptable Answers	Reject	Mark
41(d)(i)1	Not 100% ionic /almost completely ionic OR (partial) covalent character/ almost no covalency OR Discrepancy in BH values indicates polarisation (of ions) (1) *Mark can be given if answer here refers to bond strength and the answer above is included in (ii)*	Magnesium chloride is covalent Magnesium chloride is partially ionic Just "polarity of ions"	**1**

Question Number	Acceptable Answers	Reject	Mark
41(d)(ii)1	QWC I^- larger (than Cl^-) (1) so (ion) easier to polarise /distort (1) ALLOW for 2nd mark increases covalent character / more covalent than $MgCl_2$ / converse for $MgCl_2$ / description of polarisation instead of the term If clearly ions, allow reference to iodine instead of iodide ("iodine has a larger ion") Read in conjunction with (i). Direct comparison not needed if (i) covers bonding in chloride.	Size of atoms rather than ions I_2 is larger than Cl_2 I_2 molecules are polarised Mg^{2+} is polarised Iodine more electronegative than chlorine	**2**

Question Number	Acceptable Answers	Reject	Mark
41(e)1(i)1	$\frac{(100}{10^6} \times 20) = 2 \times 10^{-3}$(g) ALLOW 0.002(g) 1/500 (g) 2×10^{-6} kg IGNORE % as unit	$2 \times 10^{-3} = 0.0002$	**1**

Question Number	Acceptable Answers	Reject	Mark
41(e)1(ii)1	(More) soluble (in water)/ (more) soluble in blood stream/ can be given as solution/ won't produce gas in stomach / won't react with stomach acid/ doesn't produce CO_2 Converse answers for $MgCO_3$ ~~Or other valid answers~~ ALLOW can be given in liquid form	$MgCl_2$ is a liquid $MgCO_3$ is too reactive	**1**