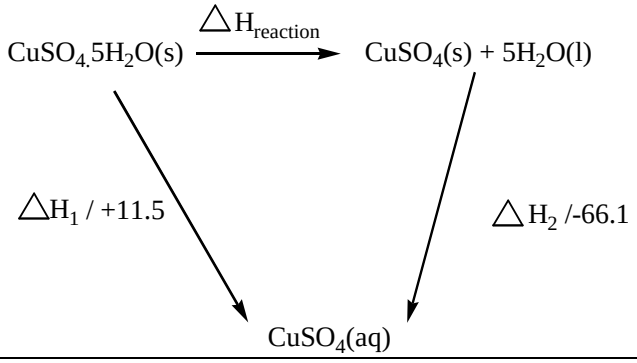
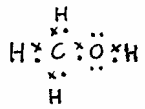
Question Number	Acceptable Answers	Reject	Mark
1 (a) (i	Product in box: $CuSO_4$**(aq) (1)** **Either** Mark the arrows and then the labels: Two downward arrows **(1)** labelled with symbols or values with or without units **(1)** **OR** Mark each arrow and label separately Downward arrow & ΔH_1 or value **(1)** Downward arrow & ΔH_2 or value **(1)** Allow reversed arrows **with** reversed signs on ΔH Ignore any other labels on the arrows. Ignore $5H_2O$ in bottom product  		**3**

Question Number	Acceptable Answers	Reject	Mark
1 (a)(ii)	**Award higher mark from:** **Route 1** **Mark the calculation based on their cycle** TE from (a)(i) ignoring incorrect bottom product **Route 2** **Mark a calculation which is independent of the cycle** $\triangle H_{reaction}$ = $\triangle H_1$ - $\triangle H_2$ stated or implied = +11.5 – (– 66.1) **(1)** = (+) 77.6 (kJ mol^{-1}) **(1)** Correct answer alone scores **(2)** **–**77.6 (kJ mol^{-1}) alone or from a correct addition scores **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
1 (b)	Dehydration reaction cannot be controlled OR temperature change (of dehydration reaction) cannot be measured OR $CuSO_4.5H_2O$ would need heating (so temperature change cannot be measured) OR impossible to add exact amount of water (to obtain value by reverse process) OR cannot mix solid with water to obtain perfect crystals	Temperature of solid / crystals cannot be measured	**1**

Question Number	Acceptable Answers	Reject	Mark
***1 (c)(i)**	First & second marks stand alone 1. Pipette/burette / measuring cylinder / balance to transfer (a known amount of) (water) **(1)** 2. to (expanded) polystyrene cup / calorimeter / any *insulated* container allow coffee / plastic cup **(1)** Third & fourth marks only awarded if correct chemicals **and** procedure used 3. add solid and **stir** (allow mix or shake) mixture **(1)** 4. measure initial **and** final temperature allow temperature change **(1)**	Just mass / volume measured Temperature **increase** unless exothermic penalised in (b)	**4**

Question Number	Acceptable Answers	Reject	Mark
1 (c)(ii)	Any three from: • heat transfer (from surroundings) (allow loss or gain) • approximation in (specific) heat capacity of solution • neglecting (specific) heat capacity of calorimeter/apparatus (allow energy absorbed by the apparatus) • reaction / dissolving may be incomplete/slow • temperature change is very small (and difficult to measure) • Density of solution is taken as the same as water • conditions not standard (allow)	Errors in calculation including adding mass of solid to mass of water loss of reagents / water incomplete combustion Just 'difficult to measure'	**3**

Question Number	Acceptable Answers	Reject	Mark
2 (a)	 **(1)** for around carbon and its hydrogens **(1)** for around oxygen and its hydrogen Allow all dots or all crosses Ignore circles around atoms		**2**

Question Number	Acceptable Answers	Reject	Mark
2 (b)(i)	$C(s)$ / (graphite) + $2H_2(g)$ + $2O_2(g)$ Correct species **(1)** Allow oxygen above arrows rather than in box Balancing and state symbols **(1)** Second mark dependent on correct species except as below with either hydrogen or oxygen or both as atoms e. C(s) / (graphite) + 4H(g) + 4O(g) Scores second mark		**2**

Question Number	Acceptable Answers	Reject	Mark
2 (b)(ii)	Enthalpy / energy / heat(energy) change when one mole of a substance **(1)** Is formed from its elements (in their most stable / standard states) **(1)** Under standard conditions of 298K/ 25 °C / any **stated** temperature **AND** 1 atm pressure / 101 kPa / 100 kPa **(1)** Definitions based on lattice enthalpies may score third mark only	heat required / heat given out / heat taken in	**3**

Question Number	Acceptable Answers	Reject	Mark
2 (b)(iii)	$\Delta H^{\ominus}_c = -\Delta H_1^{\ominus} + \Delta H_2^{\ominus}$ **(1)** = (2 x −285.8 + −393.5) − (−239.1) = −726 **(1)** Ignore units Correct answer alone = 2 marks +726 = 1 -440.2 = 1 if omit multiply by 2		**2**

Question Number	Acceptable Answers	Reject	Mark
2 (c)(i)	20.7 x 200 x 4.18 = 17305(.2) (J) ignore sf except 1 sf i.e. 20000 **OR** 20.7 x 200 x 0.00418 = 17.305(2) kJ ignore sf except 1 sf i.e. 20 ignore signs ignore mol^{-1}		**1**

Question Number	Acceptable Answers	Reject	Mark
2 (c) (ii)	0.848/32 = 0.0265 (mol) ignore sf except 1 sf i.e. 0.03		**1**

Question Number	Acceptable Answers	Reject	Mark
2 (c)(iii)	17305.2/0.0265 = −653000 (J mol^{-1}) (3sf) **OR** −653 (kJ mol^{-1}) (3sf) Ignore missing units but penalise incorrect units Allow TE from (c)(i) & (ii)		**1**

Question Number	Acceptable Answers	Reject	Mark
2 (c)(iv)	Any two from As heat/energy absorbed by apparatus / heat/energy 'lost' to surroundings **(1)** methanol not completely burnt / incomplete combustion **(1)** methanol 'lost' by evaporation **(1)** cannot ensure all products are at standard conditions at end of reaction / water is produced as a gas / reaction not carried out in the standard conditions **(1)**	just heat/energy loss just incomplete reaction	**2**

<table>
<tr><th>Question Number</th><th>Correct Answer</th><th>Reject</th><th>Mark</th></tr>
<tr><td>3 (a)(i)</td><td>
<table>
<tr><th>Energy change</th><th>Letter</th><th>ΔH/kJ mol^{-1}</th></tr>
<tr><td>Lattice energy for sodium chloride</td><td>E</td><td>-77</td></tr>
<tr><td>Enthalpy change of atomization of sodium</td><td>C</td><td>+10</td></tr>
<tr><td>Enthalpy change of atomization of chlorine</td><td>A</td><td>+12</td></tr>
<tr><td>First ionization energy of sodium</td><td>B</td><td>+49</td></tr>
<tr><td>First electron affinity of chlorine</td><td>F</td><td></td></tr>
<tr><td>Enthalpy change of formation of sodium chloride</td><td>D</td><td>-41</td></tr>
</table>
6 correct letters (3)
5 or 4 correct letters (2)
3 or 2 correct letters (1)
1 or 0 correct letters (0)
</td><td></td><td>3</td></tr>
</table>

Question Number	Correct Answer	Reject	Mark
3 (a)(ii)	Expression such as: D = C + B + A + F + E - 411 = + 109 + 494 + 121 + F + (- 5) F = - 411 - 109 - 494 - 121 + 775 **(1)** Answer: F = −360 (kJ mol^{-1}) **(1)** *Check empty box in 22(a)(i), as answer may be written there.* Answer must follow from working Correct answer only **(2)** Correct answer with some consistent working **(2)**		**2**

Question Number	Correct Answer	Reject	Mark
3 (b)(i)	(Bonding in NaCl) 100% ionic **OR** almost completely ionic **OR** no covalent character/(very) little covalent character	'Molecule' **(0)**	**1**

Question Number	Correct Answer	Reject	Mark
3 (b)(ii) QWC	AgI has (a degree of) covalent character **(1)** due to polarization or distortion (of the anion) **(1)**		**2**

Question Number	Correct Answer	Reject	Mark
3 (c) QWC	Any **two** of the following*:* • (outermost) electron further from the nucleus/atoms get bigger/more shells • (outermost) electron more shielded (by inner shells of e^-) • (force of) attraction between nucleus and (outermost) electron decreases (down the Group) **OR** (outermost) electron held less strongly (down the Group) **OR** (outermost) electron becomes easier to remove (down the Group) *IGNORE* any references to(effective) nuclear charge or more protons.	**"ions"** get bigger (down Group)	**2**

Question Number	Correct Answer	Reject	Mark
4 (a)(i)	$\frac{2.90}{58}$ = 0.05(00) (mol) correct answer only **(1)**		**1**

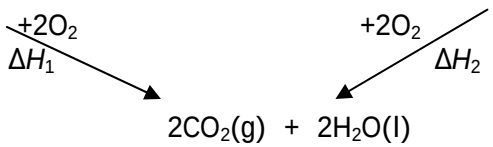
Question Number	Correct Answer	Reject	Mark
4 (a)(ii)	200 x 4.18 x **58.2** = 48655 (J) **OR** 48.655 kJ **(1)** for correct ΔT **(1)** *IGNORE* sf *IGNORE* signs at this stage		**2**

Question Number	Correct Answer	Reject	Mark
4 (a)(iii)	$-\frac{48655}{0.0500} = -973\ 100$ (J mol^{-1}) $= -973$ kJ mol^{-1} (3 s.f.) / -973000 J mol^{-1} (3 s.f.) answer **(1)** sign and units **(1)** [Do not award sign and units mark **if units given are just** "kJ" or **just** "J"] **three sig figs (1)** *CQ on (a)(i) & (ii)*		**3**

Question Number	Correct Answer	Reject	Mark
4 (b)(i)	Heat loss/energy loss **Accept** Incomplete combustion OWTTE *IGNORE* "experimental error"/ "departure from standard conditions"	Anything related to "average values" **(0)**	**1**

Question Number	Correct Answer	Reject	Mark
4 (b)(ii)	**Difference:** less exothermic / less negative *IGNORE* "higher" **if** written **with** less exothermic/less negative **Accept just "**lower"/ "less" **(1)** **Justification:** energy taken in to form gas/energy required to form gas/energy needed to form gas/takes heat in to form gas/heat required to form gas **Or reverse argument** **(1)** *Mark these two points independently*	**Just** "higher" (**0**) **Just** "$H_2O(g)$ is not water's standard state"	**2**

Question Number	Correct Answer	Reject	Mark
4 (c)(i)	Enthalpy / energy / heat (energy) change (when) one mole of a substance/one mole of a compound **(1)** is formed from its elements (in their most stable states) **(1)** 298K / 25°C / a stated temperature **AND** 1 atm pressure/100 kPa **(1)** *IGNORE* any references to concentration	"energy required" **OR** "energy released" "one mole of **product(s)**" is formed from its **reactants** room temperature/rtp	**3**

Question Number	Correct Answer	Reject	Mark
4 (c)(ii)	Cycle or formula expression  $\Delta H^{\theta}_{f} = \Delta H_1 - \Delta H_2$ = (2 x - 394) + (2 x - 286) - (- 870) = **−490** (kJ mol^{-1}) • correct expression or cycle **(1)** • evidence for doubling **both** ΔH^{θ}_{c} [C] **and** ΔH^{θ}_{c} [H_2] **(1)** • answer **(1)** Correct answer with no working scores full marks		**3**