Question Number	Answer
4	**The only correct answer is B** (391 kJ mol^{-1}) *A is not correct because 46* kJ mol^{-1} *has been deducted instead of added* *C is not correct because the value of the N ≡ N has not been divided by 2* *D is not correct because the value has not been divided by 3 to get the bond energy*

Question Number	Answer
7	**The only correct answer is B** ($\frac{1}{2}I_2(s) \rightarrow I(g)$) *A is not correct because two moles of atoms have been produced* *C is not correct because it should not be a gas on the LHS and two moles of atoms have been produced* *D is not correct because it should not be a gas on the LHS*

Question Number	Answer	Mark
3	**The only correct answer is D** (C_9H_{20}) *A is incorrect because the increment is ~630 kJ mol^{-1} so expected enthalpy change of combustion would be −4139 kJ mol^{-1}* *B is incorrect because the increment is ~630 kJ mol^{-1} so expected enthalpy change of combustion would be −4769 kJ mol^{-1}* *C is incorrect because the increment is ~630 kJ mol^{-1} so expected enthalpy change of combustion would be −5399 kJ mol^{-1}*	**(1)** **Computer**

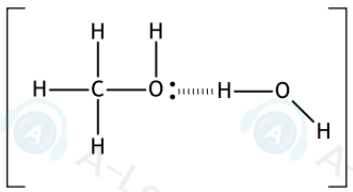
Question number	Answer	Mark
5	**The only correct answer is C** (cyclohexane molecules have a larger area of contact) *A is incorrect because the cyclohexane molecules have fewer electrons than hexane molecules* *B is incorrect because these molecules have negligible permanent dipole-permanent dipole forces* *D is incorrect because neither molecule forms hydrogen bonds*	**(1)**

Question Number	Answer	Mark
4	**The only correct answer is D** ($CH_3(CH_2)_7CH_3$) *A is not correct because $(CH_3)_4C$ has fewer electrons and a branched carbon chain* *B is not correct because $CH_3CH_2CH_2CH_2CH_3$ has fewer electrons* *C is not correct because $(C_2H_5)_4C$ has a branched carbon chain*	**(1)**

Question Number	Answer	Mark
4	**The only correct answer is D** (CF_4) *A is not correct because HF also has hydrogen bonds and permanent dipole-permanent dipole interactions* *B is not correct because OF_2 also has permanent dipole-permanent dipole interactions* *C is not correct because PF_3 also has permanent dipole-permanent dipole interactions*	(1)

Question Number	Answer	Mark
3	**The only correct answer is C** (PH_3) *A is not correct because NO has polar bonds* *B is not correct because $BeCl_2$ has polar bonds* *D is not correct because CI_4 is symmetrical and has only London forces between its molecules*	(1)

Question Number	Answer	Mark
3	**The only correct answer is A** ((0.5 × 436 + 0.5 × 242) − 431) *B is not correct because the bond enthalpies of the reactants have been subtracted from the bond enthalpy of the product and this is for the formation of two moles of HCl* *C is not correct because the bond enthalpies of the reactants have been subtracted from the bond enthalpy of the product* *D is not correct because this is for the formation of two moles of HCl*	(1)

Question number	Answer	Mark
7	**The only correct answer is A**  **B** *is incorrect because the O-----H—O bond angle should be 180°* **C** *is incorrect because the hydrogen atoms bonded to carbon atoms cannot form hydrogen bonds* **D** *is incorrect because the hydrogen atoms bonded to carbon atoms cannot form hydrogen bonds*	(1)

Question Number	Answer	Mark
2	**The only correct answer is A** (−554 − 394 + 1216) *B is incorrect because the sign of the enthalpy change of formation of the reactant is incorrect* *C is incorrect because the sign of the enthalpy change of formation of the products is incorrect*	(1) Computer

Question Number	Answer	Mark
2	**The only correct answer is B** ($H_2O(l) \rightarrow H_2O(g)$) ***A*** *is not correct because a covalent bond is being broken* ***C*** *is not correct because only London forces are being broken* ***D*** *is not correct because covalent bonds are being broken and formed*	**(1)**

Question Number	Answer
15	**The only correct answer is A** (XWZY) ***B*** *is not correct because bromoalkanes have higher boiling temperatures than alkanes* ***C*** *is not correct because straight-chained molecules have higher boiling temperatures than branched ones.* ***D*** *is not correct because straight-chained molecules have higher boiling temperatures than branched ones.*

Question number	Answer	Mark
2(a)	**The only correct answer is C** (14.7 %)) ***A*** *is incorrect because ±7.37 is an uncertainty based on halving the difference between the experimental and data book values and taking this as a percentage of the data book value* ***B*** *is incorrect because ±8.65 is an uncertainty based on halving the difference between the experimental and data book values and taking this as a percentage of the experimental value* ***D*** *is incorrect because 17.3 compares the difference in values to the experimental rather than the data book value*	**(1)**

Question number	Answer	Mark
2(b)	**The only correct answer is B** (lowers the error in the final value obtained) ***A*** *is incorrect because increasing the specific heat capacity increases the magnitude of the final value which will then be closer to the data book value* ***C*** *is incorrect because the difference is 8.6% which is significant* ***D*** *is incorrect because 8.6% is large compared with the measurement uncertainties*	**(1)**

Question Number	Answer	Mark
5	**The only correct answer is C** ($(CH_3)_3COH$) ***A** is not correct because the electronegative nitrogen is not bonded directly to a hydrogen* ***B** is not correct because the electronegative fluorine is not bonded directly to a hydrogen* ***D** is not correct because the electronegative oxygen is not bonded directly to a hydrogen*	**(1)**

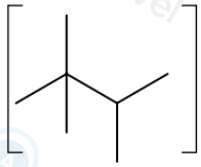
Question Number	Answer
6(a)	**The only correct answer is D** $\left(\frac{-\Delta T \times 4.2 \times 50}{2.5 \times 10^{-3}}\right)$ ***A** is not correct because it has the wrong sign, and the wrong number of moles* ***B** is not correct because it has the wrong sign and the incorrect mass of solution* ***C** is not correct because it has the wrong number of moles*

Question Number	Answer
6(b)	**The only correct answer is D** (25 cm^3 pipette) ***A** is not correct because the burette has to be read twice so the % uncertainty is 0.4%* ***B** is not correct because the % uncertainty is 2 %* ***C** is not correct because the % uncertainty is 0.4 %*

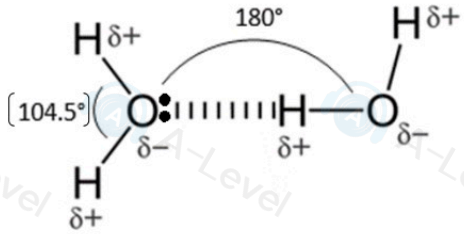
Question Number	Answer
2	**The only correct answer is A** (letter W) ***B** is not correct because X is the activation energy of the reverse reaction* ***C** is not correct because Y is the enthalpy change of the reaction* ***D** is not correct because Z is not a valid enthalpy change*

Question Number	Answer
11	**The only correct answer is A** (hexane) ***B*** *is not correct because pentane has a lower boiling temperature as it has fewer electrons* ***C*** *is not correct because 2-methylpentane has a lower boiling temperature as it is branched* ***D*** *is not correct because 2,3-dimethylbutane has a lower boiling temperature as it is branched*

Question Number	Answer
3	**The only correct answer is D** ($Cu(s) + C(s) + 1½O_2(g) \rightarrow CuCO_3(s)$) ***A*** *is not correct because the oxygen is not in its standard state* ***B*** *is not correct because the equation has been doubled* ***C*** *is not correct because the copper and carbon are not in their standard states*

Question number	Answer	Mark
4	**The only correct answer is D**  **A** *is incorrect because the alkane with the most carbon atoms will always have the highest boiling temperature* **B** *is incorrect because the alkane with the most carbon atoms will always have the highest boiling temperature* **C** *is incorrect because the alkane with the most carbon atoms will always have the highest boiling temperature*	**(1)**

Question Number	Answer
3	**The only correct answer is A** ($(CH_3)_3N$) ***B*** *is incorrect because this amine can form hydrogen bonds* ***C*** *is incorrect because this amine can form hydrogen bonds* ***D*** *is incorrect because this amine can form hydrogen bonds*

Question Number	Answer	Additional Guidance
18(a)	An answer that makes reference to the following points: • hydrogen bond shown from lone pair on the oxygen on one molecule to the hydrogen on the other **(1)** • linear O–H–O bond and labelled 180° **(1)** • δ+ on the hydrogen atom, δ– on the oxygen atom (in the hydrogen bond) **(1)**	Example of a diagram  Ignore other lone pairs Ignore H–O–H bond angles even if incorrect Allow dipole moments (⟶) on bonds Penalise O_2H once only

Question Number	Answer	Additional Guidance	Mark
18(b)	An explanation that makes reference to the following points: • molecules are a similar size / same number of electrons so the London forces are similar (and cannot account for big difference in boiling temperature) **(1)** • there are more **hydrogen bonds** between water molecules (than hydrogen bonds between ammonia molecules, resulting in water having a higher boiling temperature than ammonia) **(1)** • density of ammonia decreases between the two temperatures as it turns (from a liquid) to a gas **or** density of water increases between the two temperatures as it turns (from a solid) to a liquid **(1)**	Ignore comments on permanent dipole-dipole forces Accept for London forces instantaneous dipole-induced dipole/ dispersion forces Allow van der Waals' forces Allow M_r for size Accept converse Allow the hydrogen bonds in water are stronger than the hydrogen bonds in ammonia because oxygen is more electronegative than nitrogen Allow reference to two lone pairs on oxygen compared to one on nitrogen so more hydrogen bonds Allow reference to numbers of hydrogen bonds even if incorrect Allow M3 for a description of the expanded hydrogen bond structure of ice	**(3)**

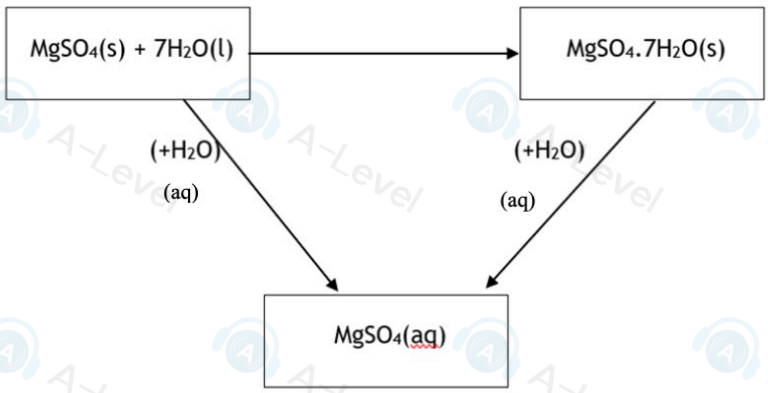
(Total for Question 18 = 6 marks)

Section B

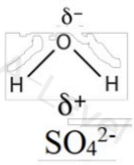
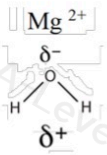
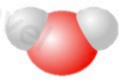
Question Number	Answer	Additional Guidance	Mark
16(a)(i)	An answer that makes reference to the following point: • **heat** to constant mass /**heat** until no change in mass	Allow weight for mass Ignore just constant mass Ignore until no more steam is given off Ignore heat for a long time Ignore any test for water Ignore dry with a filter paper Do not award any drying agent	**(1)**

Question Number	Answer		Additional Guidance	Mark
16(a)(ii)	• calculation of mass **and** moles of H_2O	**(1)**	Example of calculation: 6.92 – 6.04 = 0.88 g 0.88 ÷ 18 = 0.048889/ 4.8889 ×10 $^{-2}$ (mol)	**(3)**
	• calculation of moles of $MgSO_4$	**(1)**	6.04 ÷ 120.4 = 0.050166/ 5.0166 ×10 $^{-2}$ (mol)	
	• calculation of 1:1 ratio so x = 1	**(1)**	0.048889 ÷ 0.050166 ÷ = 0.97454 = 1:1 so x =1 Or 0.050166 ÷ 0.048889 = 1.0261 = 1:1 so x =1 Allow just 1:1	
	Alternative calculations 6.04 ÷ 120.4 = 0.05017 (mol)	**(1)**		
	6.92 ÷ 0.05017 = 137.94 and 137.94 – 120.4 = 17.54	**(1)**	Ignore intermediate rounding to 1SF Do not award more than 1 SF for x	
	17.54 ÷ 18 = 0.97454 = 1:1 so x =1 OR 6.04 ÷ 120.4 = 0.5017 (mol)	**(1)** **(1)**	Allow TE throughout	
	0.88 ÷ 0.05017 = 17.5	**(1)**		
	17.54 ÷ 18 = 0.97454 = 1:1 so x =1 OR 6.04 ÷ 120.4 = 0.05017 (mol)	**(1)** **(1)**		
	6.92 ÷ 0.05017 = 137.94 and 120 + 18x = 137.94	**(1)**		
	x =1	**(1)**		

Question Number	Answer		Additional Guidance	Mark
16(b)(i)	• temperature change	**(1)**	Example of calculation: 29.4 – 16.6 = 12.8 (°C)	**(4)**
	• energy change	**(1)**	100 × 4.18 × 12.8 = 5350.4/5.3504 × 10^3 (J)/ 5.3504 (kJ)	
	• enthalpy change per mole	**(1)**	5350.4 (J) ÷ 0.0628 = 85197/8.5197 × 10^4 (J mol $^{-1}$) Or 5.3504 (kJ) ÷ 0.0628 = 85.197 (kJ mol $^{-1}$)	
	• correct sign and units and 2 or 3 SF	**(1)**	– 85200 J mol $^{-1}$ /– 85000 J mol $^{-1}$/– 85.2 k J mol $^{-1}$ /– 85 k J mol $^{-1}$ Allow just mol $^{-}$ for mol $^{-1}$ Allow use of 4.2 instead of 4.18 Ignore case of J TE throughout Correct answer with sign and units and 2-3 SF scores 4	

Question Number	Answer	Additional Guidance	Mark
16(b)(ii)	A diagram that shows • both arrows pointing down (1) • correct species and states in the bottom box (1)	Example of diagram  Allow ions separated e.g. $Mg^{2+}(aq)$ and $SO_4^{2-}(aq)$ Ignore any additional water in the bottom box eg $7H_2O$ Ignore the values on arrow even if incorrect Do not award $MgSO_4$ + (aq)	(2)

Question Number	Answer	Additional Guidance	Mark
16(b)(iii)	• correct use of data (1) • correct sign and answer (1)	Example of calculation: (+) – 85.2 (kJ mol $^{-1}$) (–) + 15.8 (kJ mol $^{-1}$) – 101 (kJ mol $^{-1}$) + 101 (kJ mol $^{-1}$) score 1 Ignore units unless wrong and if mixed units are used max 1. Ignore SF TE on (b)(i) but no TE on an incorrect cycle in (b)(ii)	(2)

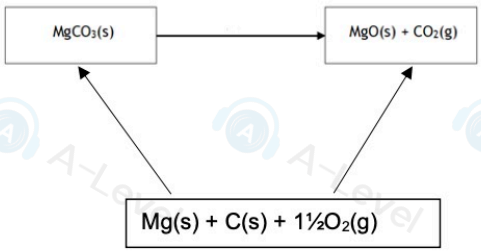
Question Number	Answer	Additional Guidance	Mark
16(c)(i)	An answer that makes reference to the following points: • diagram showing the H of water molecule adjacent to the sulfate ion  (1) • diagram showing O of the water molecule adjacent to the magnesium ion  (1)	Correct dipole on water must be seen at least once and the delta + and delta– can be seen on 2 different water molecules/ 2 different diagrams Allow any number of water molecules Allow just different sized unlabelled circles for water molecules or unlabelled ball and stick diagrams  Allow one water molecule attracted to both ions Penalise wrong charges on the ions only once Penalise missing dipoles or a full charge not a dipole only once Penalise labelled hydrogen bond only once	(2)

Question Number	Answer	Additional Guidance	Mark
16(c)(ii)	An answer that makes reference to the following points: • (the barium ions are removed from solution by) precipitation of insoluble barium sulfate **(1)** • ionic equation with all state symbols **(1)**	Allow the barium ions precipitate out Allow insoluble barium sulfate is formed Allow solid barium sulfate is formed Ignore any reference to displacement/neutralisation reactions Ignore the non-toxicity of barium sulfate $Ba^{2+}(aq) + SO_4^{2-}(aq) \longrightarrow BaSO_4(s)$ Do not award if any other ions are present eg Mg^{2+} on both side of the equation	**(2)**

(Total for Question 16 = 16 Marks)

Section B

Question Number	Answer	Additional Guidance	Mark
18(a)	• M1 calculation of change of mass **and** moles of CO_2 **(1)** • M2 calculation of moles of magnesium carbonate **(1)** • M3 % calculation **(1)** Alternative M2 and M3 • M2 calculation of mass MgO that decomposes • M3 % calculation	<u>Example of calculation</u> 4.17(g) – 2.35(g) = 1.82(g) 1.82÷44 = 0.041364/ 4.1364 ×10 $^{-2}$ (mol) 4.17÷84.3 = 0.049466/ 4.9466 ×10 $^{-2}$ (mol) 0.041364 ÷ 0.049466 × 100 = 83.620 % 0.041364 × 84.3 = 3.4870(g)) 3.4870 (g) ÷ 4.17(g) × 100 = 83.620 % Ignore SF except 1 SF	**(3)**

Question Number	Answer	Additional Guidance	Mark
18(b)(i)	An explanation that makes reference to the following points: • both arrows pointing up **(1)** • correct species, balanced and states in the bottom box **(1)**	 Allow C(graphite) for C(s) Allow 2 arrows on the RHS Ignore labels on the arrows	**(2)**

Question Number	Answer	Additional Guidance	Mark
18(b)(ii)	• correct use of data **(1)** • calculation of energy required with sign and units **(1)**	Example of calculation (–)–1095.8 – 601.7 – 393.5 = ((+) 100.6 (kJ mol^{-1})) (+) 100.6 kJ mol^{-1} kJ/mol Allow rounding to 101 kJ/mol – 100.6 kJ mol^{-1} will score 1 Correct answer with no working scores 2 No TE on wrong cycle	**(2)**

Question Number	Answer	Additional Guidance	Mark
18(c)	An answer that makes reference to the following points: • the enthalpy change (of calcium carbonate) would be more positive/endothermic **(1)** • Ca^{2+} is larger than Mg^{2+} **(1)** • so Ca^{2+} is less polarising / CO_3^{2-} less distorted (so more heat needed to decompose it) **(1)**	Allow larger, greater or higher Allow more heat/energy needed Allow thermal decomposition greater Do not award if there is any reference to exothermic or heat given out Do not award if there is any reference London forces or any intermolecular force Allow Ca ion larger than Mg ion Ignore Ca is larger than Mg Ignore atomic radius Ions must be mentioned at least once in M2 and M3, but only penalise once. Allow reverse argument for all points	**(3)**

(Total for Question 18 = 10 Marks)

Section C

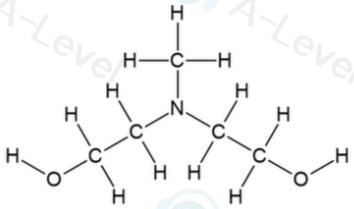
Question Number	Answer	Additional Guidance	Mark
22(a)(i)	An answer that makes reference to one of the following points: • shifts position of equilibrium to the right OR increases the (equilibrium) yield (of H_2)	Ignore to increase rate (of forward reaction) Ignore cheaper to have steam in excess Ignore to react with most of the CH_4 Allow to increase yield (of CO / products) Do not award so all of the CH_4 reacts / so reaction goes to completion Do not award to increase the moles of gas/pressure	**(1)**

Question Number	Answer	Additional Guidance	Mark
22(a)(ii)	An answer that makes reference to the following points: • T_1 (is higher) **and** (first reaction is) endothermic	**Accept reverse argument** Allow positive enthalpy change for endothermic Allow (first reaction) absorbs (heat) energy for endothermic Ignore just +206 for endothermic Ignore correct reference to effect of temperature on equilibrium yields Do not award absorbs more energy to break (reactant) bonds	**(1)**

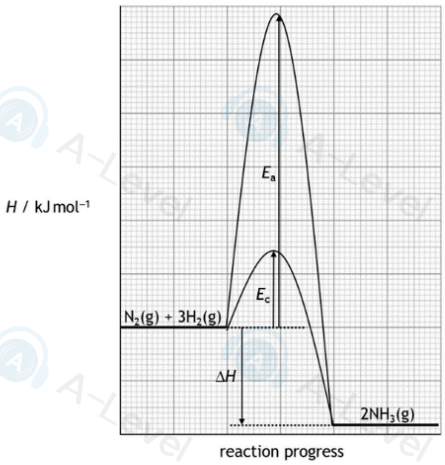
Question Number	Answer	Additional Guidance	Mark
22(a)(iii)	An answer that makes reference to the following point: • overall equation for Stage 1	Example of correct equation: $CH_4 + 2H_2O \rightarrow 4H_2 + CO_2$ Allow $\rightleftharpoons$ for $\rightarrow$ Allow multiples Ignore state symbols even if incorrect Ignore working Do not award uncancelled CO	**(1)**

Question Number	Answer	Additional Guidance	Mark
22(b)(i)	An answer that makes reference to one of the following points: • to reduce greenhouse gas emissions OR to sell (to increase profit) OR to prevent poisoning of the catalyst(s) in later stages	Ignore any reference to position of equilibrium in Stage 1 reactions Allow CO_2 / it is a greenhouse gas Allow CO_2 / it causes global warming / climate change Ignore (to make the process more) carbon neutral / to reduce carbon footprint Ignore CO_2 is harmful to the environment Ignore just to reduce air pollution Do not award reference to ozone layer	**(1)**

Question Number	Answer	Additional Guidance	Mark
22(b)(ii)	An answer that makes reference to the following point: • neutralisation	Accept acid-base Ignore addition Ignore reversible Ignore formation Do not award hydration Do not award redox	**(1)**

Question Number	Answer	Additional Guidance	Mark
22(b)(iii)	An answer that makes reference to the following points: • displayed formula of N-methyldiethanolamine	Example of displayed formula:  Allow OH for O–H Ignore bond angles and bond lengths Do not award C–HO connectivity	**(1)**

Question Number	Answer	Additional Guidance	Mark
22(c)	An answer that makes reference to the following points: • advantage of using high pressure **(1)** • disadvantage of using high pressure **(1)**	Examples of advantage: shifts position of equilibrium to right / products OR increases (equilibrium) yield (of NH_3) OR increases rate OR increases occupation of catalyst active sites Ignore any reference to collisions Examples of disadvantage: requires more energy OR costs more for energy/fuel OR requires expensive/specialist equipment (to withstand pressure) Ignore just expensive / costs more Ignore dangerous / risk of explosion	**(2)**

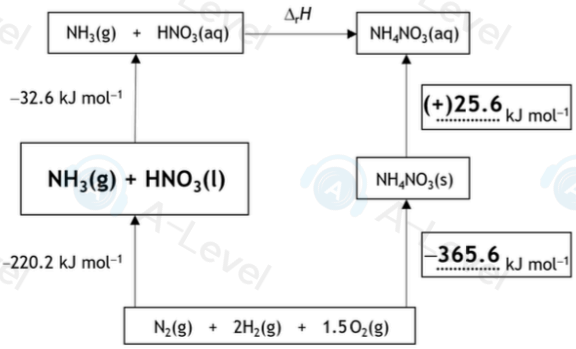
Question Number	Answer	Additional Guidance	Mark
22(d)(i)	An answer that makes reference to the following points: • ΔH labelled **and** arrow pointing downwards **(1)** • **labelled** reaction profiles for uncatalysed **and** catalysed reactions **(1)** • correct scale for activation energies **(1)**	Example of labelled reaction profile:  Allow arrows to start/end within one small square of correct placement and penalise incorrect placement once only Allow –92 / 'enthalpy change' for ΔH Do not award double headed arrow Allow any form of unambiguous labelling, eg values Allow double headed arrows Do not award downward arrows Do not award $E_{cat} > E_a$ Accept accuracy of ± one small square Ignore scale shown on y-axis	**(3)**

Question Number	Answer	Additional Guidance	Mark
22(d)(ii)	An answer that makes reference to one of the following points: • less energy (needed) / (works at a) lower temperature OR less fuel (required)	 Ignore lowers E_a Ignore catalyst can be reused Ignore reduces carbon footprint / carbon emissions	**(1)**

Question Number	Answer	Additional Guidance	Mark
22(e)(i)	An answer that makes reference to one of the following points: • increase rate OR rate is slow at low temperature OR catalyst does not work at low temperature OR so more reactants/collisions have $E \geq E_a$ OR to break O=O/N–H bonds	Do not award to increase yield Do not award to shift position of equilibrium (to left / right) Do not award reverse reaction is endothermic Allow to increase the number of successful collisions Ignore to increase collision frequency Allow catalyst more efficient at high temperature Allow to activate the catalyst Accept (to reach) high activation energy Allow to break bonds in oxygen/ammonia/reactants	**(1)**

Question Number	Answer	Additional Guidance	Mark
22(e)(ii)	An answer that makes reference to the following points: • (forward reaction is highly) exothermic OR (forward reaction) releases (a lot of) heat (energy)	 Ignore any reference to catalysis Allow thermal energy for heat Do not award NH_3 from Stage 2 is hot Do not award 1100 K is not very high	**(1)**

Question Number	Answer	Additional Guidance	Mark
22(f)	An explanation that makes reference to the following points: • NO_2 removed (in second reaction) **(1)** • shifting position of equilibrium (in first reaction) to right **and** increasing the yield (of NO_2) **(1)**	 Allow (as) NO formed (in second reaction) Ignore HNO_3 is formed (in second reaction) Ignore reaction is irreversible Ignore NO_2 dissolves Allow shifting reaction to right **and** increasing yield (of NO_2)	**(2)**

Question Number	Answer	Additional Guidance	Mark
22(g)(i)	An answer that makes reference to the following points: • left hand side of enthalpy cycle **(1)** • right hand side of enthalpy cycle **(1)**	Example of completed enthalpy cycle:  Do not award omission/incorrect state symbols Do not award multiples Do not award numbers in opposite order Do not award –25.6 Do not award +365.6 / 365.6	**(2)**

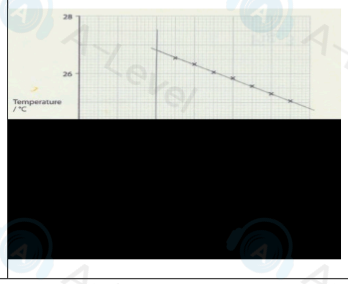
Question Number	Answer	Additional Guidance	Mark
22(g)(ii)	An answer that makes reference to the following point: • calculation of $\Delta_r H$	Example of calculation: $\Delta_r H = -(-32.6) - (-220.2) + (-365.6) + 25.6$ $= -87.2 / -87$ (kJ mol^{-1}) Allow omission of units Allow kJ TE on cycle in (g)(i)	**(1)**

Question Number	Answer	Additional Guidance	Mark
22(h)	An answer that makes reference to two of the following points: • cheaper to produce H_2/NH_3/NO/HNO_3 than to purchase (from other suppliers) **(1)** OR • (better) knowledge of chemical purity / chemical quality **(1)** OR • lower transportation / travel costs (between sites) **(1)** OR • prevents (more) chemical waste through transfer losses **(1)** OR • energy produced in exothermic reactions can be used (in endothermic processes) **(1)** OR • smaller workforce required **(1)** OR • less land required **(1)** OR • saves time so cheaper operational costs **(1)**	**Ignore just cheaper (operational costs)** **Ignore just less energy required** **Ignore just saves time / makes product faster** Ignore just chemicals need transporting Ignore just chemical lost through transportation Ignore just higher yield Do not award higher atom economy Allow lower energy costs Allow reduces carbon footprint Allow lower workforce costs Allow saves building / maintenance costs	**(2)**

(Total for Question 22 = 21 marks)
(Total for Section C = 21 marks)
(Total for Paper = 80 marks)

Question Number	Answer	Additional Guidance	Mark
18(a)(i)	An answer that makes reference to the following point: 1. balanced ionic equation	$H^+ + OH^- \rightarrow H_2O$ Accept $H_3O^+ + OH^- \rightarrow 2H_2O$ Accept multiples Ignore full equation as working Ignore state symbols even if incorrect Do not award uncancelled spectator ions	**(1)** **Graduate**

18(a)(ii)	An answer that makes reference to the following points: 1. heat energy released under standard conditions **(1)** 2. (when) 1 mol of **water** is produced (by the reaction of acid with alkali) **(1)**	Allow enthalpy change under standard conditions Allow for standard conditions 1 atm / 1(.01) x10^5Pa and a stated temperature / 298K / 25°C Ignore standard states Do not award energy required	**(2)** **Expert**

Question Number	Answer	Additional Guidance	Mark
18(b)(i)	An answer that makes reference to the following points: 3. two lines of best fit drawn **(1)** 4. value ±0.2 **(1)**	Cooling may be shown as straight line or smooth curve $\Delta T = 26.8 - 22.4 = 4.4^{O}C$ Accept value between 4.2 ^{O}C and 4.6 ^{O}C from a correct vertical extrapolation at 120s Example of extrapolation 	**(2)** **Expert**

18(b)(ii)	An answer that makes reference to the following points: 5. energy transferred to solutions **(1)** 6. moles of water formed **(1)** 7. enthalpy change of neutralisation with negative sign and units **(1)**	<u>Example of calculation:</u> $0.05 \times 4.2 \times 4.4 = 0.924$ (kJ) $50 \times 4.2 \times 4.4 = 924$ (J) $(25 \div 1000) \times 0.8 = 0.02$(mol) $0.924 \div 0.02 = -46.2$ kJ mol^{-1} /−46,200 J mol^{-1} TE on b(i) and throughout b(ii) Ignore SF except 1 SF	**(3)** **Expert**

Question Number	Answer	Additional Guidance	Mark
18(b)(iii)	An explanation that makes reference to the following points: 1. (because the calculation has not taken into account the) energy required to heat the calorimeter/ the (total) heat capacity would be greater **(1)** 2. the value(of the enthalpy change of neutralisation) would be more exothermic/more negative **(1)**	Ignore references to the relative heat capacity of copper/water(solution) Allow higher/ increase/ greater	**(2)** **Expert**

Question Number	Answer	Additional Guidance	Mark
18(c)(i)	An answer that makes reference to the following points: nucleophilic **and** substitution(reaction)	Allow nucleophile substitution	**(1)** **Clerical**

Question Number	Answer	Additional Guidance	Mark
18(c)(ii)	An answer that makes reference to the following points: 3. dipole on C-Br bond 4. lone pair on O of OH^- 5. curly arrow from lone pair to **C of C-Br**. If no lone pair shown, allow curly arrow from O 6. arrow from C-Br to Br or just beyond 7. organic product 8. Br^-	Example of mechanism Allow product as structural formula Allow NaBr Ignore Na^+ Do not award HBr 6 points correct scores (3) 4 /5 points correct scores (2)	**(3)** **Expert**
		2 / 3 points correct scores (1) Ignore intermediate/ transition state if shown	

Question Number	Answer	Additional Guidance	Mark
18(c)(iii)	An answer that makes reference to the following points: 1. elimination **(1)** 2. ethanol / alcohol **(1)**	Do not award addition/substitution/dehydration/acid/base Allow ethanolic /alcoholic solution	**(2)** **Graduate**

(Total for Question 18 = 16 marks)