

Question	Answer	Marks	Guidance
1	C	1	

Question	Answer	Marks	Guidance
2 (a)	FIRST, CHECK THE ANSWER ON ANSWER LINE IF answer = –110.5, Award 3 marks. ----- Correct expression $-13.5 = (4 \times -393.5) - (-1118.5 + 4 \times \Delta_f H(\text{CO})) \checkmark$ Correct subtraction using ΔH and $\Delta_f H(\text{Fe}_3\text{O}_4)$ $4 \times \Delta_f H(\text{CO}) = (4 \times -393.5) - (-1118.5) + 13.5$ $= -442(.0) \text{ (kJ mol}^{-1}\text{)} \checkmark$ Calculation of $\Delta_f H(\text{CO})$ formation $\Delta_f H(\text{CO}) = -\frac{442}{4} = -110.5 \text{ (kJ mol}^{-1}\text{)} \checkmark$	3	For answer, ALLOW –111 (kJ mol⁻¹) ----- NOTE: IF any values are omitted, DO NOT AWARD any marks. e.g. –393.5 OR –13.5 may be missing ----- Common errors (+)110.5 <i>wrong/omitted sign</i> 2 marks (+)184.625 / 184.63 / 184.6 / 185 2 marks <i>No 4CO₂</i> (+)738.5 / 739 <i>No 4CO₂ and no CO/4</i> 1 mark –117.25 / –117.3 / –117 <i>Wrong cycle</i> 2 marks –469 <i>Wrong cycle, no CO/4</i> 1 mark (+)177.875 / 177.88 / 177.9 / 178 1 mark <i>Wrong cycle, no 4CO₂</i> –360.5 <i>Used 118.5</i> 2 marks Any other number: CHECK for ECF from 1st marking point for expressions using ALL values with ONE error only e.g. one transcription error:, e.g. 395.3 for 393.5

Question			Answer	Marks	Guidance
3	(a)	(i)	Average bond enthalpy Breaking of one mole of bonds ✓ In gaseous molecules ✓	2	IGNORE energy required OR energy released IGNORE heterolytic / homolytic DO NOT ALLOW bonds formed DO NOT ALLOW ionic bonds IGNORE species for molecules
	(a)	(ii)	FIRST, CHECK ANSWER ON ANSWER LINE IF answer = (+) 158 award 3 marks ----- Bond enthalpy of F–F $(\Delta H \text{ for (O–H) bonds broken} =)$ 1856 OR $4 \times 464 \text{ (kJ mol}^{-1}\text{)} \checkmark$ $(\Delta H \text{ for bonds made} =) 2770 \text{ (kJ mol}^{-1}\text{)}$ OR 498 AND 2272 $\text{(kJ mol}^{-1}\text{)}$ OR 498 AND $4 \times 568 \text{ (kJ mol}^{-1}\text{)} \checkmark$ $(\text{bond enthalpy}) \text{ F–F} = \frac{2770 - 1856 - 598}{2}$ = (+)158 $\text{(kJ mol}^{-1}\text{)} \checkmark$	3	ANNOTATE ANSWER WITH TICKS AND CROSSES IGNORE sign IGNORE sign ALLOW ECF Common errors Award 2 marks for; –158 (Wrong sign) (±)316 (No ÷ 2) (+) 622 (use of 2×464) (+) 457 (omitting – 598) (+) 756 (use of +598) Award 1 mark for; (+) 970 (use of 2×464 and +598)

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4	(a)	(i)	More energy is released by forming bonds than energy required when breaking bonds OR bond enthalpy of bonds being made is higher than bond enthalpy of bonds being broken ✓	1	1.2	Response needs link between energy , breaking and making bonds Eg 'bond breaking is endothermic' AND 'bond making is exothermic' AND 'exothermic change outweighs endothermic change'

Question	Answer	Marks	AO element	Guidance
4 (a)	(ii) <i>Using Both $\Delta_c H^\theta$ values multiplied by 2</i> $2 \times (-296.8)$ or -593.6 AND $2 \times (-285.8)$ or -571.6 ($= -1165.2$) ✓ <i>Use of -1125 and correctly processed:</i> $2\Delta_f H(\text{H}_2\text{S}) = [2 \times (-296.8) + 2 \times (-285.8)] - (-1125)$ $= -40.2 \text{ (kJ mol}^{-1}\text{)} \checkmark$ <i>Division by 2</i> $\Delta_f H(\text{H}_2\text{S}) = -20 \text{ (kJ mol}^{-1}\text{)} \checkmark$			First mark may be awarded from data on a cycle ALLOW $-20.1(0)$ ALLOW ECF: third mark is for dividing by 2 and use of all three values Common errors Two marks for $(+)20(.1)$ ALLOW ecf if no multiplication by two occurred $[(-296.8) + (-285.8)] - (-1125) = (+)542.4$ for 2nd mark Leading to $\Delta_f H(\text{H}_2\text{S}) = (+) 271(.2)$ for 3rd mark ALLOW $-296.8 - 285.8 = -582.6$ for 1st mark if $-1125/2$ OR -562.5 is seen in 2nd mark

Question	Answer	Marks	AO	Guidance
5	A	1	2.2	

Question	Answer	Marks	AO element	Guidance
6	B	1	AO2.2	

Question			Answer	Marks	AO	Guidance
7	(a)	(i)	$n(\text{H}_2\text{SO}_4) = 1.60 \times \frac{25.0}{1000} = 0.04(00) \text{ (mol)}$ AND $n(\text{NaOH}) = 1.50 \times \frac{55.0}{1000} = 0.0825 \text{ (mol)} \checkmark$ 0.04(00) mol H_2SO_4 reacts with 0.08(00) mol NaOH OR 1 mol H_2SO_4 reacts with 2 mol NaOH $\checkmark$	2	AO2.2 ×2	ALLOW 0.0825>0.08

Question			Answer	Marks	AO element	Guidance
	(a)	(ii)	$q = mc\Delta T = 80.0 \times 4.18 \times 13.0$ $= 4347.2 \text{ (J) OR } 4.3472 \text{ (kJ) } \checkmark$ $\Delta H_1 = (-) \frac{4.3472}{0.0400} = (-)108.68 \text{ kJ mol}^{-1} \checkmark$ $\Delta_{\text{neut}}H = (-) \frac{108.68}{2} = (-)54.34 \text{ kJ mol}^{-1} \checkmark$ – sign for ΔH <i>value(s)</i> $\checkmark$	4	AO2.4 ×4	FULL ANNOTATIONS MUST BE USED ----- ALLOW 3 SF up to calculated answer throughout ALLOW ECF from q DO NOT ALLOW division by $n(\text{NaOH})$ ALLOW $\Delta_{\text{neut}}H$ from $\Delta H_1 / 2$ ALLOW alternative methods
	(a)	(iii)	The same OR $13^\circ\text{C} \checkmark$ (Double the moles so) double the energy is spread over double the volume	2	AO3.1 ×2	ALLOW explanation that uses a calculation based on moles, volumes ALLOW mass for volume

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8	A	1	2.2	

Question			Answer	Marks	AO element	Guidance
9	(a)	(i)	FIRST, CHECK THE ANSWER ON ANSWER LINE IF $T = 52.4\text{ }^{\circ}\text{C}$ OR $52.5\text{ }^{\circ}\text{C}$ award 4 marks IF $T = 32.4\text{ }(^{\circ}\text{C})$ award 3 marks Correctly calculates $n(\text{AgNO}_3)$ $= 0.400 \times \frac{100.0}{1000}$ OR $0.04(00)$ (mol) ✓ Energy released per mole of AgNO_3 in J OR kJ $= \frac{678 \times 0.0400}{2}$ OR 13.56 (kJ) OR 13560 (J) ✓ Correctly calculates ΔT $\Delta T = \frac{13560}{100 \times 4.18}$ OR 32.4 ($^{\circ}\text{C}$) ✓ Maximum temperature reached $= 32.4... + 20.0 = 52.4\text{ }^{\circ}\text{C}$ ✓ 3 SF required	4		FULL ANNOTATIONS MUST BE USED ALLOW ECF throughout AO1.2 AO2.4 ALLOW 13.6 kJ OR 13600 J (to 3SF) DO NOT ALLOW < 3 SF IGNORE any sign and units <i>i.e. ALLOW correctly calculated value in J OR kJ</i> AO2.8 AO2.8 ALLOW ECF ONLY from calculated $\Delta T + 20\text{ }^{\circ}\text{C}$ Common errors 3 marks $84.9\text{ }^{\circ}\text{C}$ (not divided $\frac{\Delta H}{2}$)

	(a)	(ii)	Maximum temperature is the same AND Half the energy/ moles AND half the mass/volume	1	AO3.4	ALLOW response that links the same proportionality/ratio of volume/mass and energy/moles ALLOW if seen by a calculation
	(b)	(i)	(Enthalpy change) when 1 mole of a compound is formed from its elements ✓	1	AO1.1 ×1	ALLOW energy required OR energy released ALLOW one mole of product/substance DO NOT ALLOW 1 mole of element DO NOT ALLOW is formed from its gaseous elements when 1 mole of a solid compound when 1 mole of a gaseous compound
		(ii)	FIRST, CHECK THE ANSWER ON ANSWER LINE If answer = (+)90 award 2 marks ----- $4(\Delta_f H^\ominus . \text{NO}) = -1172 - 6(-286) + 4(-46)$ $= -1172 + 1716 - 184$ $= (+)360 \text{ (kJ mol}^{-1}\text{)} \checkmark$ $\Delta_f H^\ominus . \text{NO} = \frac{360}{4} = (+)90 \text{ (kJ mol}^{-1}\text{)} \checkmark$	2	AO2.2 ×2	ALLOW ECF providing all values are used ALLOW one transcription error in the values used for M2 Common error 1 mark -90 (wrong sign)

Question			Answer	Marks	AO element	Guidance
10	(a)		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = -4950 award 3 marks ----- $q = mc\Delta T$ $= 150 \times 4.18 \times 10.5$ $= 6583.5 \text{ (J)}$ OR 6.5835 (kJ) ✓ $n(\text{C}_7\text{H}_{16})$ $= \frac{0.133}{100} = 1.33 \times 10^{-3}$ ✓ $\Delta_c H = q \div n$ $= \frac{6.5835}{1.33 \times 10^{-3}}$ $= -4950 \text{ kJ mol}^{-1}$ – sign required ✓	3	AO2.4 ×1 AO2.8 ×2	ALLOW 3 SF up to the calculated value Ignore RE after 3SF IGNORE sign ALLOW ECF from incorrect q and/or n Common errors for 2 marks +4950 kJ mol⁻¹ (wrong sign) -5077 (use of 0.0013 and 6.6 2SF) -5064 (use of 0.0013 2SF) -4962 (use of 6.6kJ use of 2SF)
	(b)		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = -3535 award 2 marks ----- 186 = $\Delta_c H(\text{C}_9\text{H}_{20}) - \Delta_c H(\text{C}_5\text{H}_{12}) - 2 \Delta_c H(\text{C}_2\text{H}_4)$ OR From Hess cycle with all numerical values used and correct multiples used/labelled $\begin{array}{c} +186 \\ \text{C}_9\text{H}_{20}(\text{g}) \rightarrow \text{C}_5\text{H}_{12}(\text{g}) + 2\text{C}_2\text{H}_4(\text{g}) \\ \downarrow -6171 \quad \downarrow \Delta_c H(\text{C}_5\text{H}_{12}) \quad \downarrow 2 \times -1411 \\ \text{common combustion products} \end{array}$ ✓ $\Delta_c H(\text{C}_5\text{H}_{12}) = (-6171) - 2(-1411) - 186$ $= -3535 \text{ kJ mol}^{-1}$ ✓	2	AO2.2 ×2	IGNORE any incorrect combustion products on bottom line. Common errors for 1 mark +3535 (wrong sign for final answer) +8807 (use of +6171) -9179 (use of +1411) -4946 (use of 1 x -1411) -3163 (use of +186) For other answers, check for a single transcription error or calculation error using all values which could merit 1 mark

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11	C	1	

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12	(a)	(i)	Iron is an <u>element</u> (in its standard state) ✓	1	Takes no energy to make an <u>element</u> from an <u>element</u> (under standard conditions)
		(ii)	$(\Delta H =) 3(-394) + 0 - (-824) - 3(-111)$ ✓ $(\Delta H =) -25 \text{ kJ mol}^{-1}$ ✓	2	ALLOW ECF for one transcriptional error Common Errors 1 mark (+) 763 (no 3 x -394) (+) 25 (incorrect sign) -247 (no 3 x -111) -2339 (+ for - (-824 + 3 x -111))