Mark Scheme

Question	Answer	Marks	Guidance
1	D	**1**	
2	C	**1**	

Mark Scheme

Question			Answer	Marks		Guidance
3	(a)		*Please refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** A comprehensive conclusion, using all quantitative data, to calculate the energy change and ΔH values for reactions 3.1 and 3.2 **AND** linking ΔH data using Hess' Law *There is a well-developed line of reasoning which is clear and logically structured. The working throughout is clearly shown. All values calculated with reasonable numbers of SF and correct signs mostly shown, allowing for ECF.* **Level 2 (3–4 marks)** Attempts to describe all three scientific points but explanations may be incomplete. **OR** Explains two scientific points thoroughly with few omissions. *There is a line of reasoning with some logical structure. There may be minor errors in energy change and errors in the calculations of ΔH for reaction 3.1 or reaction 3.2.* **Level 1 (1–2 marks)** Processes raw mass and temperature data and obtains a calculated value for the energy change using $mc\Delta T$ **OR** attempts to obtain values for two scientific points but explanations may be incomplete *There is an attempt at a logical structure with a line of reasoning to obtain a value for energy change. There may be minor errors in calculation of energy change.* **0 marks –** *No response or no response worthy of credit.*	**6**		**Indicative scientific points may include:** **1. Masses and ΔT from raw results** • $m(Na_2O)$ = 1.24 (g) • m(solution) = 25.75 (g) • ΔT = 35.0 (ºC) **Energy change from $mc\Delta T$** • energy released in J **OR** kJ = 25.75 × 4.18 × 35.0 = 3767 (J) **OR** 3.767 (kJ) *(3.767225 unrounded)* --- **2. $\Delta_r H$ for reaction 3.2** • $n(Na_2O) = \frac{1.24}{62.0}$ = 0.0200 (mol) • $\Delta_r H$ value $-\frac{3767}{0.0200}$ = –188 (kJ mol^{-1}) *(–188.36125 unrounded)* --- **3. $\Delta_r H$ for reaction 3.1** • ΔH value for **reaction 3.1** clearly linked to ΔH for **reaction 3.2** and **reaction 3.3** in energy cycle or an expression: ΔH**(3.1)** = ΔH**(3.2)** + 2ΔH**(3.3)** • ΔH**(3.1)** = –188 + (2 × –57.6) = –188 – 115.2 = –303(.2) (kJ mol^{-1}) *(–303.56125 unrounded)* **Note** Throughout, **ALLOW ECF** from previous value **ALLOW** omission of trailing zeroes ---

Mark Scheme

Question			Answer	Marks		Guidance
	(b)		% uncertainties to at least *1 SF, rounded or truncated* --- **ONE** correct % uncertainty ✓ **BOTH** correct % uncertainties ✓ --- ***mass***: $\frac{0.005 \times 2}{1.24} \times 100$ = 0.8/0.81 **OR** 0.80 (truncated) ΔT: $\frac{0.1 \times 2}{35.0} \times 100$ = 0.6 / 0.57 (%) ✓ *Calculator values:* mass: 0.8064516129 ΔT: 0.5714285714	**2**		**ALLOW** error for uncertainty --- **ALLOW ECF** from mass and ΔT in **2(a)** **IGNORE** % uncertainty of mass of solution --- **ALLOW one** mark for: • 2 calculations with both ×2 factors missing i.e. mass 0.3% **AND** ΔT 0.4% • Not converting to %s using ×2 factors i.e. 0.008 **AND** 0.006
	(c)		**ALLOW** uncertainty **OR** error throughout Greater mass of Na_2O **OR** more Na_2O ✓ For mass, **ALLOW** amount/moles/quantity larger ΔT **OR** reduces % uncertainty in ΔT ✓	**2**		**ALLOW** up to 2 marks based on a single mass measurement: one mass measurement **OR** measure mass directly ✓ *e.g. tare balance* % uncertainty reduced by **half** ✓ --- **IGNORE** • repeat and take average • read to more figures *(same apparatus)* • increase volume (*reduces mass error but increases ΔT error*) • use a cooling curve • use a lid

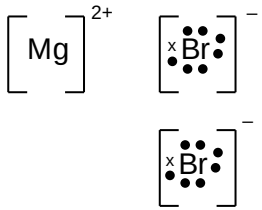
Mark Scheme

Question			Answer	Marks		Guidance
	(d)	(i)	sodium nitrate(III)	1		**ALLOW** sodium nitrite **OR** sodium nitrite(III)
	(d)	(ii)	Sodium/Na oxidised from 0 to +1 ✓ Nitrogen/N reduced from +3 to 0 ✓	2		**ALLOW** 1+ for +1 and 3+ for +3 **ALLOW** N_2 for nitrogen **ALLOW** 1 mark for elements **AND** all oxidation numbers correct, but N on oxidised line and Na on reduced line '+' is required in +3 and +1 oxidation numbers
	(d)	(iii)	$2NaNO_2 + 6Na \rightarrow 4Na_2O + N_2$ ✓ **IGNORE** state symbols	1		**ALLOW** multiples, e.g. $NaNO_2 + 3Na \rightarrow 2Na_2O + ½N_2$
			Total	14		

Mark Scheme

Question	Answer	Marks	AO element	Guidance
4	**B**	**1**	AO1.1	
5	**A**	**1**	AO2.2	

Mark Scheme

Question			Answer	Marks	AO element	Guidance
6	(a)		(The mean/average mass) taking into account the relative abundancies of the isotopes ✓	1	1.1	**ALLOW** sum of (isotopic mass × %abundance) sum of (isotopic mass × abundance) / total abundance **DO NOT ALLOW** average mass of the isotopes
		(i)	 Mg with no (or 8) outer electrons **AND** 2 × Br with '*dot-and-cross*' outer octet ✓ Correct charges ✓	2	1.2 2.5	**ALLOW** 8 electrons in Mg^{2+} **BUT** 'extra' electron in Br^- must match symbol for electrons in Mg^{2+} **IGNORE** inner shells and circles **ALLOW** 1 mark if both electron arrangements and charges are correct but only one Br is drawn. **ALLOW** $2[Br^-]$, $2[Br]^-$ (brackets not required)
		(ii)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 1.71×10^{22} award 3 marks** --- $n(MgBr_2) = \frac{1.74}{184.1} = 0.00945\ldots..$ mol ✓ Moles of ions = 0.00945…. × 3 = 0.0283…. mol ✓ Number of ions = 0.0283... × 6.02×10^{23} = 1.71×10^{22} ✓ **3SF** required	3	2.2×3	**ALLOW ECF** Calculator answer = $9.451385117 \times 10^{-3}$ **ALLOW ECF** from incorrect moles of ions. e.g. 0.00945 Common error 5.69×10^{21} no × 3 2 marks

Mark Scheme

Question	Answer	Marks	AO element	Guidance
(c)*	*Refer to marking instructions on page 5 of mark scheme for guidance on marking this question.* **Level 3 (5–6 marks)** Explains all three melting point values and conductivities in terms of structure, bonding, particles and relative strengths of the forces. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Attempts to explain all three melting point values and conductivities in terms of the structure, bonding, particles of all three substances, but explanations may be incomplete or may contain only some correct statements or comparisons. **OR** Correctly explains two of the melting point values and conductivities in terms of the structure, bonding, particles. *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** Identifies only some of the structures, forces and particles **AND** Attempts to explain the melting point values **OR** conductivities in terms of the structure, bonding, particles *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*	**6**	1.1×3 2.1×3	**Indicative scientific points may include:** **<u>Structure and bonding</u>** **Magnesium** • Structure: giant lattice • Metallic bonding • **Delocalised** electrons **Bromine** • Structure: simple molecular • induced dipole dipole forces **(**London forces) • (Between) molecules **DO NOT ALLOW** (between) atoms **Magnesium bromide** • Structure: giant lattice • Ionic bonding • (Between) oppositely charged ions **<u>Comparison of bond strengths</u>** • Metallic and ionic bonds are stronger than London forces **OR** Metallic and Ionic bonds need more energy to break than London forces **<u>Conductivity</u>** • Magnesium: conducts due to delocalised electrons can move/mobile. **IGNORE** 'Carry' charge for movement • Magnesium bromide: In solid IONS cannot move; in solution IONS can move. **DO NOT ALLOW** electrons. • Bromine: Does not conduct as no mobile charge carriers.

Mark Scheme

Question			Answer	Marks	AO element	Guidance
	(d)	(i)	$Mg^{2+}(g) + 2Br(g) + 2e^{-}$ ✓ $Mg(s) + Br_2(l)$ ✓	2	1.2× 2	State symbols required. **CARE:** Liquid state symbol for Br_2
		(ii)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = –346.5 award 2 marks** --- $2\Delta H$ hyd = – 525 – 186 – (2 x 112) – 148 – 736 – 1450 + (2 x -325) + 1926 **OR** – 525 – 186 – 224 – 148 – 736 – 1450 + 650 + 1926 **OR** = – 693 ✓ ΔH hyd = –346.5 (kJ mol^{-1}) ✓	2	2.2×2	**ALLOW -347** (kJ mol^{-1}) for 2 marks. **ALLOW** for 1 mark **ONE** error with sign **OR** use of 2: –693 (not divided by 2 at the end) 346.5 (wrong sign on answer) **Common errors for 1 mark** –2272.5 (–1926 instead of 1926) -1386 (**2** x -693 instead of -693) –996.5 (–650 instead of 650) –509 (**2** × 325 not used) –290.5 (**2** × 112 not used) –198.5 (148 instead of –148) –160.5 (186 instead of –186) –122.5 (224 instead of –224) 178.5 (525 instead of –525) 389.5 (736 instead of –736) 1103.5 (1450 instead of –1450) **For other answers**, check for a **single** transcription error or calculation error which could merit 1 mark **DO NOT ALLOW** any answer which involves two errors e.g. –453 (**2** × 325 not used **AND 2 x** 112 not used)

Mark Scheme

Question			Answer	Marks	AO element	Guidance
		(iii)	**Equation:** $Mg^{2+}(g) + 2Br^{-}(g) \rightarrow MgBr_2(s)$ ✓ **CHECK THE ANSWER ON ANSWER LINE** **If answer = –2433 award 2 marks** --- Lattice enthalpy = $\Delta_{hy}H(Mg^{2+}) + 2 \times \Delta_{hy}H(Br^{-}) - \Delta_{sol}H(MgBr_2)$ **OR** -1926 + (2 x -346.5) – (-186) **OR** $\Delta_fH(MgBr_2) - 2\Delta_{at}H(Br) - \Delta_{at}H(Mg)$ – 1st IE(Mg) – 2nd IE(Mg) – $2\Delta_{ea}H(Br)$ **OR** -525 – (2 x 112) – 148 – 736 – 1450 – (2 x -325) ✓ **Lattice enthalpy** = –2433 kJ mol^{-1} ✓	**3**	1.2 2.2 x 2	State symbols required **For other answers**, check for a **single** transcription error or calculation error which could merit 1 mark **DO NOT ALLOW** any answer which involves two errors **ALLOW ECF** from incorrect answer to d(ii)
			Total	**18**		

Mark Scheme

Question			Answer	Marks	AO element	Guidance
7	(a)	(i)	**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF $\Delta_c H$ = –1860 OR –1850 (kJ mol^{-1}) with evidence of working, award 3 marks** **IF $\Delta_c H$ = –1862, award 2 marks (not 3 SF)** --- ***Energy released in J OR kJ*** = 100 × 4.18 × 24.5 = ±10241 (J) **OR** ±10.241 (kJ) ✓ ***3 SF minimum required*** ***Calculates n(C_3H_8)*** $= \frac{0.242}{44(.0)} = 0.0055(0)$ (mol) ✓ ***Calculates $\Delta_c H$ with – sign AND 3 SF (appropriate)*** $\Delta_c H = \frac{10241}{0.0055 \times 1000} = -1862$ **No mark** = –1860 **OR** –1.86 × 10^3 (kJ mol^{-1}) ✓ **– sign AND 3 SF required**	**3**	2.4 2.4 2.8	***FULL ANNOTATIONS MUST BE USED*** --- **ALLOW ECF** throughout **DO NOT ALLOW** c = 4.2 → 10290 Next 2 marks available by ECF → –1870 **ALLOW** 10240/10200 J **OR** 10.24/10.2 kJ **IGNORE** units **ALLOW ECF** from initial 3 **SF** rounding to 10.2 kJ: $\pm\frac{10200}{0.0055 \times 1000} \rightarrow \pm 1854.545455$ ✓ → 1850 ✓ --- **Common errors** ΔH = **–54.6 OR –54.7** ***2 marks*** *by ECF from $mc\Delta T$* *m* wrong as 0.242 and ΔT wrong as 297.5 K) → *$mc\Delta T$* wrong as 300.9391 (J) ΔH = **–4.51** ***2 marks*** *by ECF from $mc\Delta T$* *m* wrong as 0.242 and ΔT correct as 24.5) → *$mc\Delta T$* wrong as 24.78322 (J) ΔH = **–22600** ***2 marks*** *by ECF from $mc\Delta T$* *m* correct as 100 and ΔT wrong as 297.5) → *$mc\Delta T$* wrong as 124355 (J)
	(a)	(ii)	**Any two from:** **1 MARK ONLY** ✓ • Heat loss/released to surroundings • Incomplete combustion/reaction with oxygen or air **OR** not everything burns • Evaporation of water	**1**	1.2	**IGNORE** incomplete 'reaction' *Needs link to combustion/burning/reaction with air/O_2* **IGNORE** evaporation of C_3H_8

Mark Scheme

Question	Answer	Marks	AO element	Guidance
(b)*	*Refer to marking instructions on page 5 of mark scheme for guidance on marking this question.* **Level 3 (5-6 marks)** Calculates $\Delta_r H$ for **reaction 3.1** correctly with correct sign **AND** Calculates a value for $\Delta_c H^{\ominus}$ of propane using $\Delta_r H$ **AND** $\pm 4 \times \Delta_{vap} H$ *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3-4 marks)** Calculates $\Delta_r H$ for **reaction 3.1** correctly with correct sign **OR** Calculates bonds broken **OR** bonds made correctly to obtain a value of $\Delta_r H$ for **reaction 3.1** **AND** attempts to link $\Delta_r H$ with $\Delta_{vap} H$ **OR** calculates $4 \times \Delta_{vap} H$ *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1-2 marks)** Uses bond enthalpies for bonds broken and bonds made but may contain errors or omissions **AND** obtains a value for $\Delta_r H$. **OR** Calculates bonds broken **OR** bonds made correctly. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** No response or no response worthy of credit.	**6**	2.4×2 3.1×2 3.2×2	**Indicative scientific points may include:** **Bond enthalpy calculation of $\Delta_r H$** **Bonds broken** $= (2 \times 347) + (8 \times 413) + (5 \times 498)$ $= (694) + (3304) + (2490)$ $= \pm 6488$ kJ mol^{-1} **Bonds made** $= (6 \times 805) + (8 \times 464)$ $= (4830) + (3712) = \pm 8542$ kJ mol^{-1} $\Delta_r H = 6488 - 8542 = -2054$ kJ mol^{-1} **NOTE:** 3 C–C → 6835 for bond broken: $\Delta H = -1707$ 2 C–C omitted from bonds broken gives: $\Delta H = -2748$ --- **Determination of $\Delta_c H(C_3H_8)$** $\Delta_c H^{\ominus}$ of propane using $\Delta_r H$ **AND** $\pm 4 \times \Delta_{vap} H$ **Correct** $\Delta_c H(C_3H_8) = \Delta_r H - 4 \times \Delta_{vap} H$ $= -2054 - (4 \times 40.65)$ $= -2054 - 162.6$ $= -2216.6$ / -2217 kJ mol^{-1} **Incorrect** $\Delta_c H(C_3H_8) = -2054 + (4 \times 40.65)$ $= -2054 + 162.6$ $= -1891.4$ / -1891 kJ mol^{-1} ***NOTE**: A clear and logically structured response would include a **correct** energy cycle for $\Delta_c H(C_3H_8)$ using $\Delta_r H$ **AND** $4 \times \Delta_{vap} H$ in energy cycle or expression:* **ALLOW** trailing zeroes **OR** minor slips
	Total	**10**		