A' Level Chemistry

Year 2

Unit 11: Thermodynamics BH Cycles

Summer Examination Revision Pack

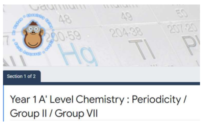
The questions in this pack should be attempted **AFTER** completing all other revision.

Grade Accelerator
Recall Definitions
Drawing Diagrams
Using Equations
Drawing Graphs

Quizlet

Quizlet Classes
Flashcard Based
Games
Tests & Quizzes
Keyword Spell Checker

Condensed Notes
Keywords & Definitions
Key Concepts
Application
Key Skills



Online Forms
Take Time to Answer
Use Paper & Calculator
Work It Out
Review Missed Marks

Use the 3 Wave Process when completing these revision packs.

1. Complete the questions without assistance
(Can't answer a question? Leave it and move on)
2. Use your notes to fill any gaps after step 1
3. Use the mark scheme to fill in any remaining gaps.

1. Having gaps after step 1 is normal, that's why we are doing revision!
2. If your notes don't help during step 2, they are not good enough!
(Change your note taking method and try to understand the problem)
3. If you don't understand why the mark scheme answer is correct, **see Andy.**

STOP If you struggle with the questions in the pack, **STOP!** and complete some more revision.

STOP If you come to a complete dead-end, **STOP!** and speak to **Andy** asap.

Do not write outside the box

Answer **all** questions in the spaces provided

0 1 This question is about silver iodide.

0 1 . 1 Define the term enthalpy of lattice formation.

[2 marks]

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0 1 . 2 Some enthalpy change data are shown in **Table 1**.

Table 1

	Enthalpy change / kJ mol^{-1}
$AgI(s) \rightarrow Ag^{+}(aq) + I^{-}(aq)$	+112
$Ag^{+}(g) \rightarrow Ag^{+}(aq)$	–464
$I^{-}(g) \rightarrow I^{-}(aq)$	–293

Use the data in **Table 1** to calculate the enthalpy of lattice formation of silver iodide.

[2 marks]

Enthalpy of lattice formation ______________________ kJ mol^{-1}

Do not write outside the box

0 1 . 3 A calculation of the enthalpy of lattice formation of silver iodide based on a perfect ionic model gives a smaller numerical value than the value calculated in Question **1.2**

Explain this difference.

[2 marks]

0 1 . 4 Identify a reagent that could be used to indicate the presence of iodide ions in an aqueous solution and describe the observation made.

[2 marks]

Reagent

Observation

8

Turn over for the next question

Question	Answers	Mark	Additional Comments/Guidance
01.1	Enthalpy change or heat energy change when 1 mol of solid ionic compound/substance or 1 mol of ionic lattice is formed from its gaseous ions.	1 1	Allow: enthalpy change for: $M^+ (g) + X^- (g) \rightarrow MX (s)$ or $Ag^+ (g) + I^- (g) \rightarrow AgI (s)$ CE=0/2 if describing wrong process (eg ΔH of lattice dissociation or ΔH of formation/ or heat energy required) Ignore heat energy released
01.2	lattice dissociation energy= (112 + 464 + 293) = + 869 ($kJmol^{-1}$) lattice formation energy = − 869 ($kJ\ mol^{-1}$)	1 1	(+)869 = 1 mark
01.3	AgI contains covalent character Forces/bonds (holding the lattice together) are stronger	1 1	CE=0/2 if atoms/molecules For M1, allow the following: not completely ionic / ions not spherical / ions distorted/ some covalent bonding Ignore covalent bonds stronger (than ionic bonds) Ignore electronegativity Ignore references to energy
01.4	$AgNO_3$ yellow ppt or Cl_2 or Br_2 brown solution/black ppt	1 1	Ignore ammonia/acidified/nitric acid/sulphuric acid M2 dependent on correct M1 but mark on from Ag^+ or Tollens
Total		**8**	

Do not write outside the box

Answer **all** questions in the spaces provided.

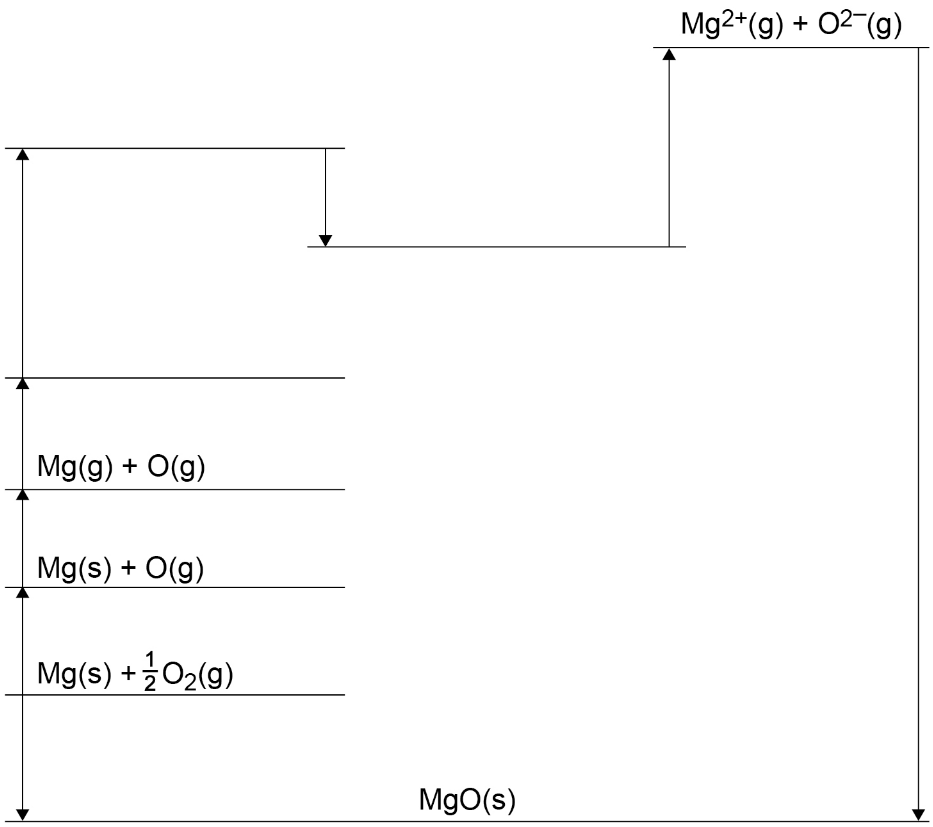
0 1 This question is about lattice enthalpies.

0 1 . 1 **Figure 1** shows a Born–Haber cycle for the formation of magnesium oxide.

Complete **Figure 1** by writing the missing symbols on the appropriate energy levels.

[3 marks]

Figure 1



Do not write outside the box

0 1 . 2 **Table 1** contains some thermodynamic data.

Table 1

	Enthalpy change / $kJ\ mol^{-1}$
Enthalpy of formation for magnesium oxide	–602
Enthalpy of atomisation for magnesium	+150
First ionisation energy for magnesium	+736
Second ionisation energy for magnesium	+1450
Bond dissociation enthalpy for oxygen	+496
First electron affinity for oxygen	–142
Second electron affinity for oxygen	+844

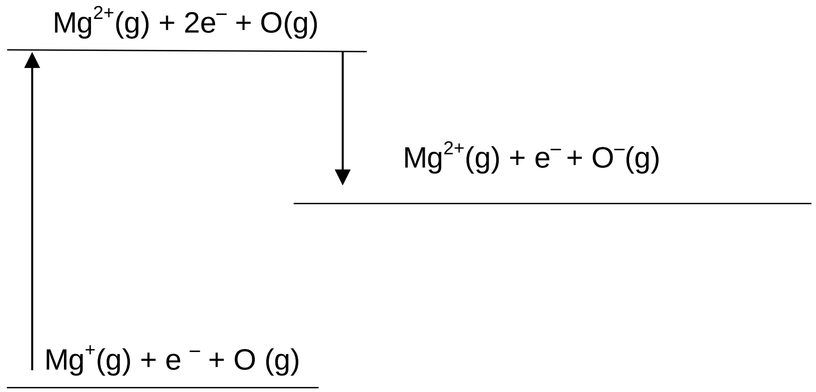
Calculate a value for the enthalpy of lattice formation for magnesium oxide.

[3 marks]

Enthalpy of lattice formation ____________________ $kJ\ mol^{-1}$

6

Turn over for the next question

Question	Answers	Additional Comments/Guidance	Mark
01.1		One mark for each level with correct state symbols	1 1 1
01.2	$\Delta_f H = \Delta_a H$ (Mg) + ½ $\Delta_{BD} H$ (O_2) + $\Delta_{1st\ IE} H$ (Mg) + $\Delta_{2nd\ IE} H$ (Mg) + $\Delta_{1st\ EA} H$ (O) + $\Delta_{2nd\ EA} H$(O) + $\Delta_{LE} H$ (MgO) - 602 = 150 + (½ x 496) + 736 +1450 – 142 + 844 + Δ_{LE}H (MgO) $\Delta_{LE} H$ (MgO) = -3888 / -3890 (kJ mol^{-1})	Allow answers to 2sf or more 1 mark for +3888 or +3890 1 mark for -4136 or -4140 (not 496 x 1/2)	1 1 1

Total			6

Do not write outside the box

Answer **all** questions in the spaces provided.

0 1 **Figure 1** shows an incomplete Born–Haber cycle for the formation of caesium iodide. The diagram is not to scale.

Figure 1

Table 1 gives values of some standard enthalpy changes.

Table 1

Name of enthalpy change	**ΔH° / kJ mol^{-1}**
Enthalpy of atomisation of caesium	+79
First ionisation energy of caesium	+376
Electron affinity of iodine	–314
Enthalpy of lattice formation of caesium iodide	–585
Enthalpy of formation of caesium iodide	–337

0 1 . 1 Complete **Figure 1** by writing the formulas, including state symbols, of the appropriate species on each of the two blank lines.

[2 marks]

0 1 . 2 Use **Figure 1** and the data in **Table 1** to calculate the standard enthalpy of atomisation of iodine.

[2 marks]

Standard enthalpy of atomisation of iodine ____________________ kJ mol^{-1}

Do not write outside the box

0 1 . 3 The enthalpy of lattice formation for caesium iodide in **Table 1** is a value obtained by experiment.
The value obtained by calculation using the perfect ionic model is –582 kJ mol^{-1}

Deduce what these values indicate about the bonding in caesium iodide.

[1 mark]

0 1 . 4 Use data from **Table 2** to show that this reaction is **not** feasible at 298 K

$$CsI(s) \rightarrow Cs(s) + \frac{1}{2}I_2(s) \qquad \Delta H^{\ominus} = +337 \text{ kJ mol}^{-1}$$

Table 2

	CsI(s)	**Cs(s)**	**I_2(s)**
$S^{\ominus}$ / J K^{-1} mol^{-1}	130	82.8	117

[4 marks]

9

Turn over ►

Question	Answers	Additional Comments/Guidelines	Mark
01.1	Top line $Cs^{+}(g) + e^{-} + I(g)$ Lower line $Cs(s) + \frac{1}{2}I_2(s)$		1 1
01.2	79 + x + 376 –314 = –337 +585 So enthalpy change = 107 ($kJmol^{-1}$)	Allow I mark for -107 ($kJmol^{-1}$) Allow answer to 2sf or more	1 1
01.3	(Almost/Mostly) purely/ perfectly ionic	If ionic not mentioned, allow no/little covalent bonding/character Penalise references to atoms/molecules Ignore electronegativity	1
01.4	M1 $\Delta S = [(82.8 + \frac{1}{2} \times 117) - 130] = \underline{11.3}$ ($J K^{-1} mol^{-1}$) M2 $\Delta G = \Delta H - T\Delta S$ M3 $\Delta G = 337 - 298 \times 11.3 \times 10^{-3}$ OR 337000 – 298 x 11.3 M4 ΔG = (+)334 <u>$kJ\ mol^{-1}$</u> or 334000 <u>$J\ mol^{-1}$</u>	M1 Correct entropy change value M2 equation or equation with numbers M3 for converting units: ΔS into $kJK^{-1} mol^{-1}$ or ΔH into $Jmol^{-1}$ M4 answer with correct units Any negative answer loses M4	1 1 1 1

Do not write outside the box

Answer **all** questions in the spaces provided.

0 1 This question is about enthalpy changes.

0 1 . 1 **Figure 1** shows a Born–Haber cycle for the formation of strontium chloride, $SrCl_2$

Figure 1

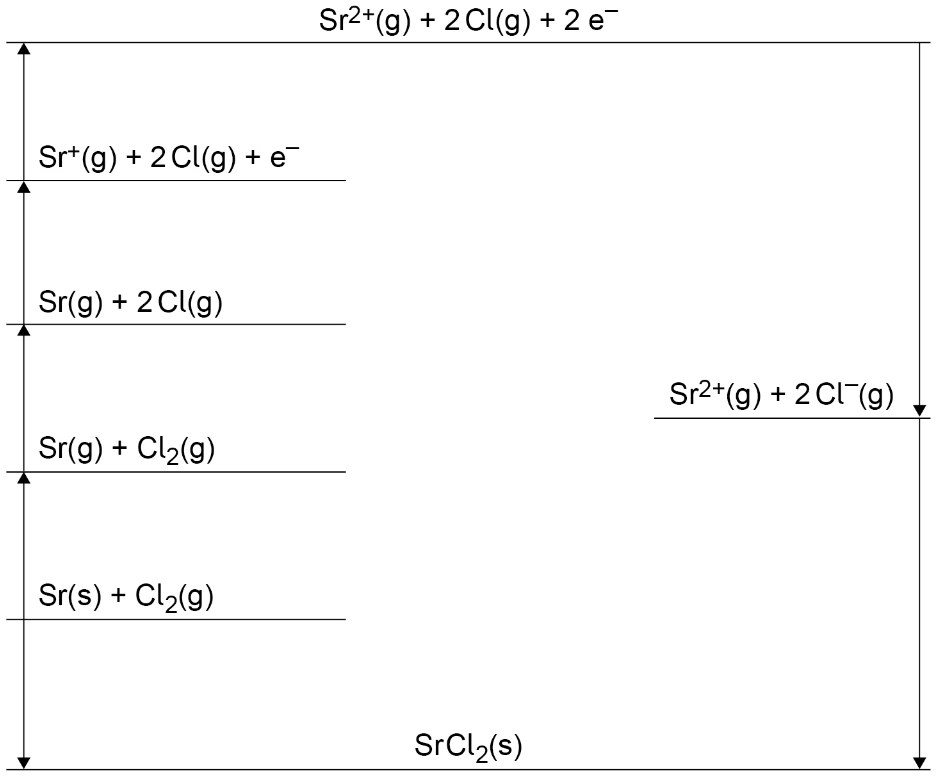


Table 1 shows some thermodynamic data.

Table 1

	Enthalpy change / kJ mol^{-1}
First ionisation energy of strontium	+548
Second ionisation energy of strontium	+1060
Enthalpy of atomisation of chlorine	+121
Enthalpy of atomisation of strontium	+164
Enthalpy of formation of strontium chloride	–828
Enthalpy of lattice formation of strontium chloride	–2112

Do not write outside the box

Use the data in **Table 1** to calculate a value for the electron affinity of chlorine.
[3 marks]

Electron affinity ____________________ kJ mol^{-1}

0 1 . 2 Draw a line from **each** substance to the enthalpy of lattice formation of that substance.
[1 mark]

Substance	**Enthalpy of lattice formation / kJ mol^{-1}**
$MgCl_2$	–2018
MgO	–2493
$BaCl_2$	–3889

Question 1 continues on the next page

Do not write outside the box

Table 2 shows the theoretical lattice enthalpy, based on a perfect ionic model, and an experimental value for the enthalpy of lattice formation of silver chloride.

Table 2

	Theoretical	**Experimental**
Enthalpy of lattice formation / kJ mol^{-1}	–770	–905

0 1 . 3 State why there is a difference between the theoretical and experimental values.

[1 mark]

0 1 . 4 **Table 3** shows enthalpy of hydration values for ions of some Group 1 elements.

Table 3

	$Li^+(g)$	**$Na^+(g)$**	**$K^+(g)$**
Enthalpy of hydration / kJ mol^{-1}	–519	–406	–322

Explain why the enthalpy of hydration becomes less exothermic from Li^+ to K^+

[2 marks]

Do not write outside the box

0 1 . 5 Calcium bromide dissolves in water.

Table 4 shows some enthalpy data.

Table 4

	Enthalpy change / kJ mol^{-1}
Enthalpy of solution of calcium bromide	–110
Enthalpy of lattice formation of calcium bromide	–2176
Enthalpy of hydration of calcium ions	–1650

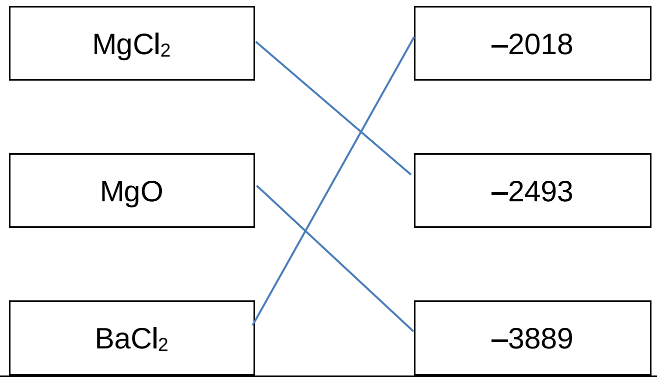
Use the data in **Table 4** to calculate the enthalpy of hydration, in kJ mol^{-1}, of bromide ions.

[3 marks]

Enthalpy of hydration of bromide ions ____________________ kJ mol^{-1}

10

Turn over for the next question

Question	Answers	Additional comments/Guidelines	Mark
01.1	M1 $\Delta_f H = \Delta_a H$ (Sr) + $2\Delta_a H$ (Cl) + $\Delta_{1st\ IE} H$ (Sr) + $\Delta_{2nd\ IE} H$ (Sr) + $2\Delta_{EA} H$ (Cl) + $\Delta_{LE} H$ (Sr) Or – 828 = 164 + (2 x 121) + 548 + 1060 + (2 x $\Delta_{EA}H$) + (– 2112)		1
	M2 2 x $\Delta_{EA}H$ = – 730		1
	M3 $\Delta_{EA}H$ = – 365 (kJ mol^{-1})	Allow M3 = M2÷2 (+) 365, –304.5, and –730 = 2 marks (+) 304.5, (+) 730 and –609 = 1 mark (+) 609 = 0 marks	1
01.2	 	All three lines must be shown	1

01.3	(Has) covalent character or partial covalent bonding (as well as ionic bonding)	Allow chloride **ion** has been polarised or chloride **ion** distorted Ignore not perfectly ionic Ignore ions are not spheres Do not allow references to molecules or ions with covalent character Do not allow it is covalently bonded alone	1

01.4	M1 (From Li^+ to K^+) size (of ion) increases OR charge density (of ion) decreases M2 (Electrostatic) attraction between metal ion and $O^{\delta-}$ of water decreases or attraction between lone pair on O and + ion decreases	M1 Allow K+ has more shells or larger distance between nucleus and outer electrons or larger ionic radius Do not allow atomic radius or molecules M2 Not dependent on M1 Allow converse arguments	1 1
01.5	M1 $\Delta_{sol}H = \Delta_{LEdissociation}H + \Delta_{hyd}H$ (Ca^{2+}) + 2x $\Delta_{hyd}H$ (Br^-) or M1 – 110 = 2176 + (– 1650) + 2x $\Delta_{hyd}H$ (Br^-) M2 (2x $\Delta_{hyd}H$ (Br^-)) = – 636 M3 $\Delta_{hyd}H$ (Br^-) = – 318 (kJ mol^{-1})	Allow M3 = M2 ÷ 2 (+)1858, (+)318 and –636 = 2 marks +3716, –1858 and (+)636 = 1 mark –3716 = 0 marks	1 1 1

Do not write outside the box

Answer **all** questions in the spaces provided.

0 1 This question is about enthalpy changes for calcium chloride and magnesium chloride.

0 1 . 1 State the meaning of the term enthalpy change.

[1 mark]

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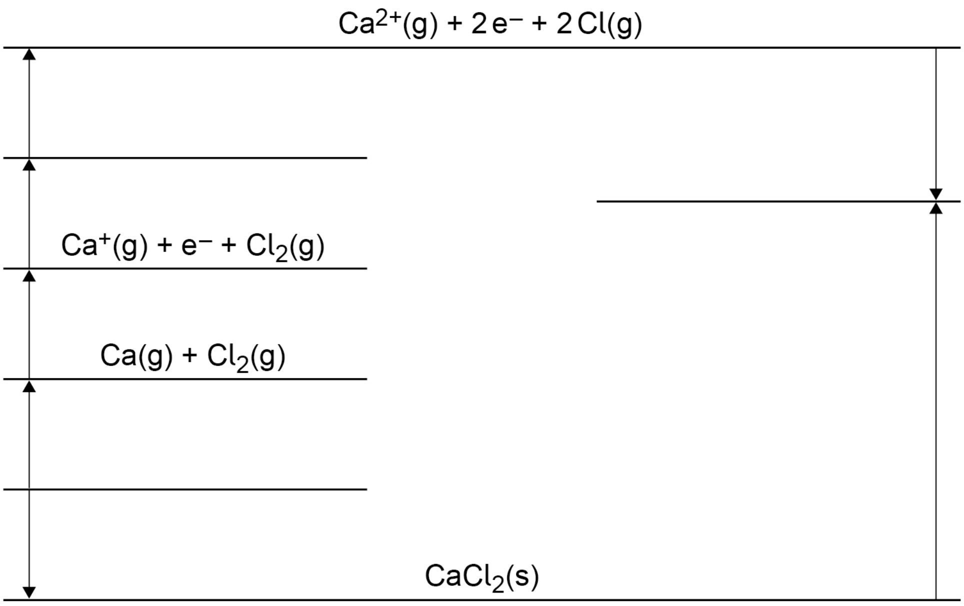
Figure 1 shows an incomplete Born–Haber cycle for the formation of calcium chloride.

Figure 1



0 1 . 2 Complete **Figure 1** by writing the formulas, including state symbols, of the appropriate species on each of the three blank lines.

[3 marks]

Do not write outside the box

0 1 . 3 **Table 1** shows some enthalpy data.

Table 1

	Enthalpy change / kJ mol^{-1}
Enthalpy of formation of calcium chloride	–795
Enthalpy of atomisation of calcium	+193
First ionisation energy of calcium	+590
Second ionisation energy of calcium	+1150
Enthalpy of atomisation of chlorine	+121
Electron affinity of chlorine	–364

Use **Figure 1** and the data in **Table 1** to calculate a value for the enthalpy of lattice dissociation of calcium chloride.

[2 marks]

Enthalpy of lattice dissociation ____________________ kJ mol^{-1}

Question 1 continues on the next page

Turn over ►

Do not write outside the box

0 1 . 4 Magnesium chloride dissolves in water.

Give an equation, including state symbols, to represent the process that occurs when the enthalpy of solution of magnesium chloride is measured.

[1 mark]

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0 1 . 5 **Table 2** shows some enthalpy data.

Table 2

	Enthalpy change / kJ mol^{-1}
Enthalpy of lattice dissociation of $MgCl_2$	+2493
Enthalpy of hydration of Mg^{2+}(g)	–1920
Enthalpy of hydration of Cl^{-}(g)	–364

Use your answer to Question **01.4** and the data in **Table 2** to calculate a value for the enthalpy of solution of magnesium chloride.

[2 marks]

Enthalpy of solution ____________ kJ mol^{-1}

0 1 . 6 The enthalpy of hydration of Ca^{2+}(g) is –1650 kJ mol^{-1}

Suggest why this value is less exothermic than that of Mg^{2+}(g)

[2 marks]

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11

Question	Answers	Additional comments/Guidelines	Mark
01.1	Heat (energy) change at constant pressure	Ignore conditions even if wrong Ignore energy change	1

Question	Answers	Additional comments/Guidelines	Mark
01.2	M2 $Ca^{2+}(g) + 2e^{-} + Cl_2(g)$	Alternative M2 $Ca^{+}(g) + e^{-} + 2Cl(g)$	1
	M3 $Ca^{2+}(g) + 2Cl^{-}(g)$		1
	M1 $Ca(s) + Cl_2(g)$		1

Question	Answers	Additional comments/Guidelines	Mark
01.3	M1 –795 + LE = 193 + 590 +1150 + (**2** x 121) + (**2** x –364)	Numbers and factors used correctly from cycle	1
	M2 LE = (+) 2242 (kJ mol^{-1})	Rearrangement to calculate LE If one or both factors of 2 missing award 1 mark for (+) 2485, (+)2121 or (+)2606 (kJ mol^{-1}) Allow 1 mark for – 2242 (kJ mol^{-1})	1

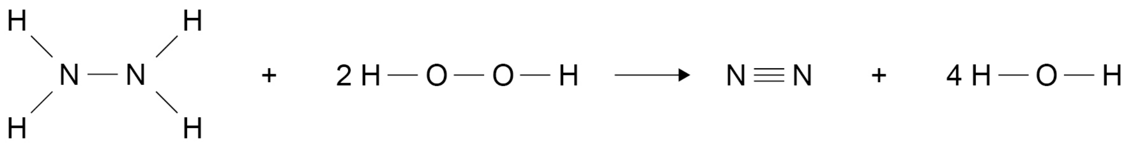
Question	Answers	Additional comments/Guidelines	Mark
01.4	$MgCl_2(s) \rightarrow Mg^{2+}(aq) + 2Cl^{-}(aq)$	Allow $MgCl_2(s) \rightleftharpoons Mg^{2+}(aq) + 2Cl^{-}(aq)$ Allow $MgCl_2(s) + aq \rightleftharpoons Mg^{2+}(aq) + 2Cl^{-}(aq)$	1

Question	Answers	Additional comments/Guidelines	Mark
01.5	M1 Δ*H* soln $MgCl_2$ = Δ*H* latt diss+ Δ*H* hyd Mg^{2+} + **2**Δ*H* hyd Cl^- **OR** 2493 –1920 + (**2** x –364) M2 = – 155 (kJ mol^{-1})	M1 for expression with or without numbers M2 for answer If factor of 2 missing for Δ*H* hyd Cl^-, allow 1 mark for 209	1 1

Question	Answers	Additional comments/Guidelines	Mark
01.6	M1 Ca^{2+} (ion) bigger/lower charge to size ratio (than Mg^{2+}) M2 weaker attraction/bond to ($O^{\delta-}$ in) water	Allow converse answers M1 Do not accept Ca^{2+} is a bigger atom/molecule M1 Allow Ca^{2+} has more shells/ more distance of outer e to nucleus Ignore more shielding	1 1

Do not write outside the box

0 3 . 5 Hydrazine (N_2H_4) is used as a rocket fuel that is oxidised by hydrogen peroxide.
The equation for this reaction in the gas phase is



The enthalpy change for this reaction, ΔH = –789 kJ mol^{-1}

Table 3 shows some mean bond enthalpy values.

Table 3

	N–H	**N–N**	**N≡N**	**O–H**
Mean bond enthalpy / kJ mol^{-1}	388	163	944	463

Define the term mean bond enthalpy.

Use the equation and the data in **Table 3** to calculate a value for the O–O bond enthalpy in hydrogen peroxide.

[5 marks]

Definition ____

____

Bond enthalpy ____________________ kJ mol^{-1}

17

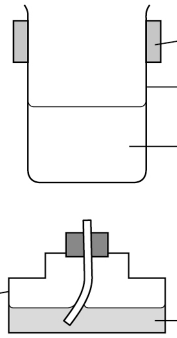
Question	Answers	Additional Comments/Guidelines	Mark
03.5	M1 enthalpy (change) to break <u>1 mol</u> bonds (in gaseous state)	allow heat energy (change) to break <u>1 mol</u> bonds allow the enthalpy needed to break <u>1 mol</u> bonds do **not** accept enthalpy released	1
	M2 averaged over a range of compounds / molecules		1
	M3 –789 = 4(388) + 163 + 4(463) + 2(O–O) – 944 – 8(463) **or** –789 = 4(388) + 163 + 2(O–O) – 944 – 4(463) **or** –789 = 3567 + 2(O–O) – 4648 **or** –789 = 1715 + 2(O–O) – 2796		1
	M4 2(O–O) = <u>292</u> (kJ mol^{-1})		1
	M5 O–O = 146 (kJ mol^{-1})	M5 = M4 ÷ 2	1 AO1 AO2

Do not write outside the box

0 3 A student does an experiment to determine a value for the enthalpy of combustion of heptane.

Figure 2 shows some of the apparatus used.

Figure 2



0 3 . 1 Design a table to record all the readings necessary to determine an experimental value for the enthalpy of combustion for heptane in this experiment.

[2 marks]

0 3 . 2 The student considered using a glass beaker on a tripod and gauze instead of the clamped copper calorimeter.

Suggest **two** disadvantages of using a glass beaker on a tripod and gauze.

[2 marks]

Disadvantage 1 ______________________________

____

Disadvantage 2 ______________________________

____

Do not write outside the box

0 3 . 3 Suggest **two** reasons why the value of enthalpy of combustion from this experiment is less exothermic than a data book value.

[2 marks]

Reason 1 ____

____

Reason 2 ____

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0 3 . 4 Suggest **one** addition to this apparatus that would improve the accuracy of the enthalpy value obtained.

[1 mark]

____

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7

Turn over for the next question

<table>
<tr><th>Question</th><th>Answers</th><th>Additional Comments/Guidelines</th><th>Mark</th></tr>
<tr><td>03.1</td><td><table><tr><td></td><td>Temp/ °C</td><td></td><td>Mass /g</td></tr><tr><td>Initial</td><td></td><td>Burner before</td><td></td></tr><tr><td>Final</td><td></td><td>Burner after</td><td></td></tr><tr><td>(ΔT)</td><td></td><td>(Mass heptane burned)</td><td></td></tr></table></td><td>M1 for Temperature data including units
M2 for Burner mass data including units
If either unit missing MAX 1</td><td>M1
M2</td></tr>
</table>

Question	Answers	Additional Comments/Guidelines	Mark
03.2	Any two from: Glass is a poorer conductor than copper Tripod and gauze would reduce heat transfer Tripod and gauze would have a fixed height above the flame	Heat capacity of metal is less than glass or vice versa	M1 M2

Question	Answers	Additional Comments/Guidelines	Mark
03.3	Heat loss to surroundings or to copper/calorimeter Incomplete combustion		M1 M2

Question	Answers	Additional Comments/Guidelines	Mark
03.4	Use a wind shield(to reduce heat loss)	Allow use a lid Insulate the sides of the calorimeter	1