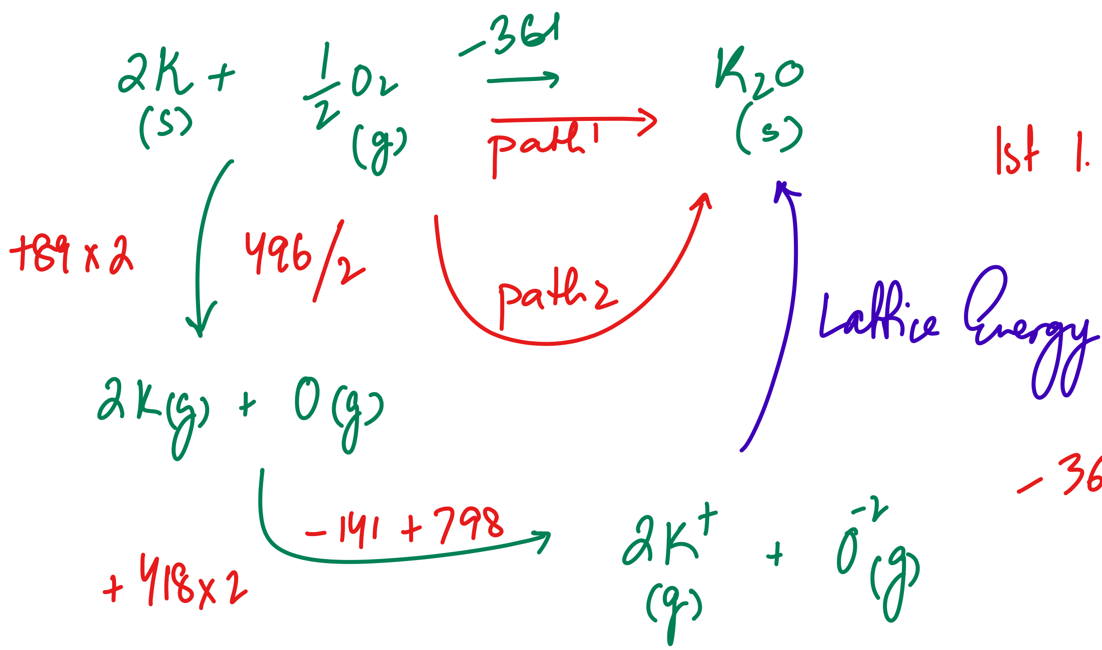
LATTICE ENERGY

1

(c) **(i)** Use the data in the table below, and relevant data from the *Data Booklet*, to calculate the lattice energy, $\Delta H^{\ominus}_{latt}$, of potassium oxide, $K_2O(s)$.

energy change	value / kJ mol⁻¹
enthalpy change of atomisation of potassium, $\Delta H^{\ominus}_{at}$ K(s)	+89 ✓
electron affinity of O(g)	–141
electron affinity of O^-(g)	+798
enthalpy change of formation of potassium oxide, $\Delta H^{\ominus}_{f}$ $K_2O(s)$	–361

(data booklet)
bond energy O=O
= 496
1st I.E of K = 418



$-361 = 2 \times 89 + \frac{496}{2} + 418 \times 2 - 141 + 798 + L.E$

$= -2280$

$\Delta H^{\ominus}_{latt}$ = ... kJ mol⁻¹ [3]

(ii) State whether the lattice energy of Na_2O would be more negative, less negative or the same as that of K_2O. Give reasons for your answer.

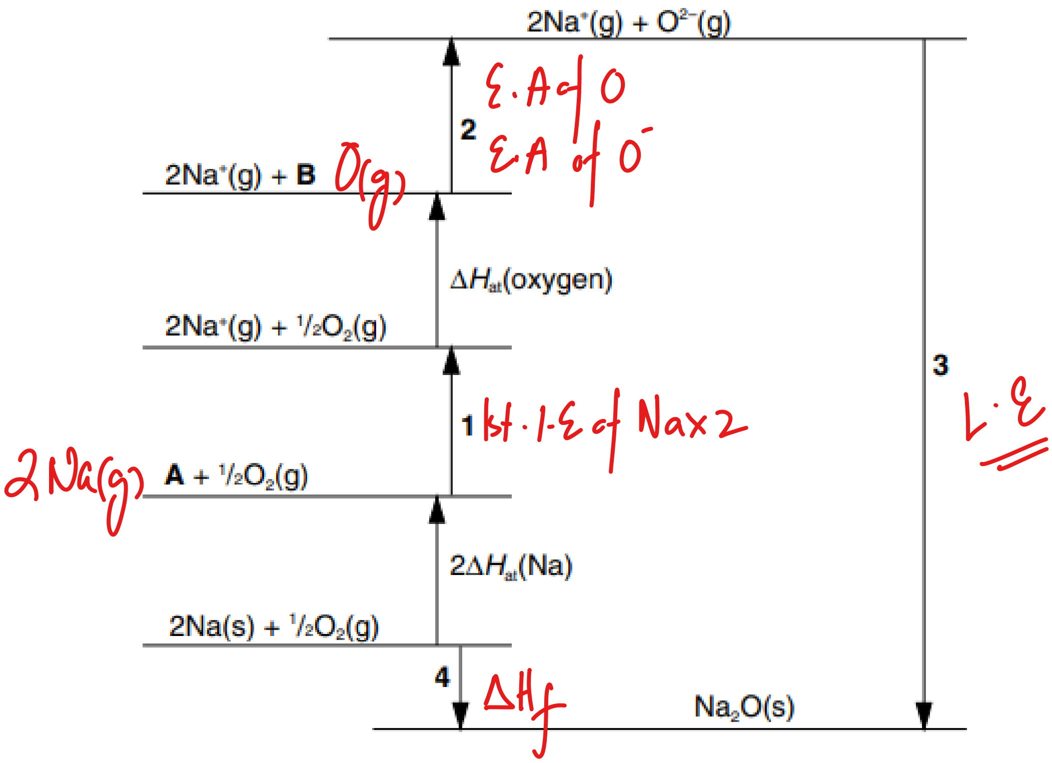
L.E of Na_2O is more exothermic, Na^+ has higher charge density as it has smaller ionic radii, so stronger ionic bonds in the lattice [1]

9701/42/M/J/17

2 **(a)** Write an equation to represent the lattice energy of sodium oxide, Na_2O.

....[1]

(b) The Born-Haber cycle shown may be used to calculate the lattice energy of sodium oxide.



(i) In the spaces below, identify the species **A** and **B** in the cycle, including the appropriate state symbols.

species **A** .... species **B** ....

(ii) Identify the enthalpy changes labelled by the numbers **1** to **4** in the cycle.

1 ....

2 ....

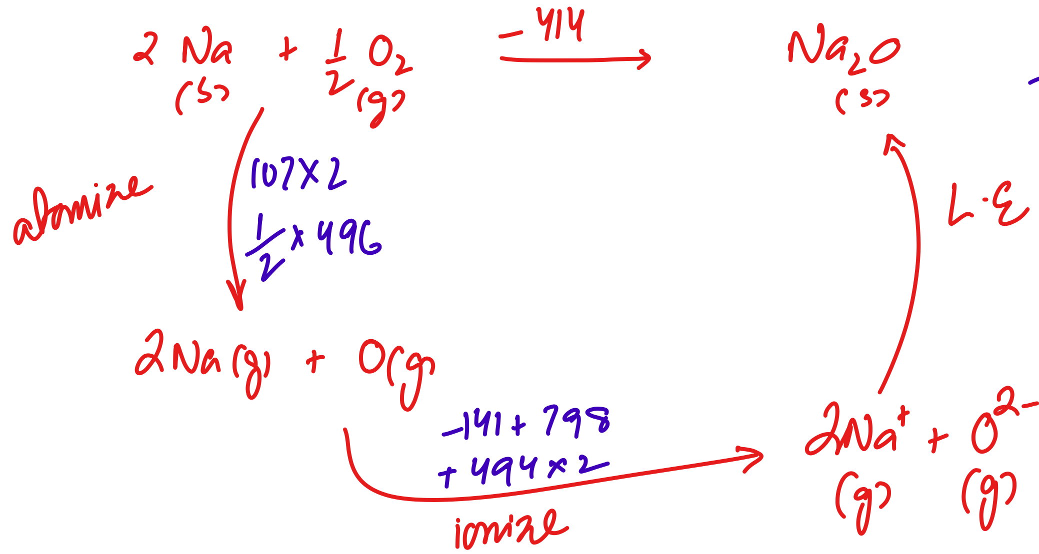
3 ....

4 ....

[3]

(c) Use your cycle, the following data, and further data from the *Data Booklet* to calculate a value for the lattice energy of sodium oxide.

Data:
- enthalpy change of atomisation for Na(s) $+107\ kJ\ mol^{-1}$
- first electron affinity of oxygen $-141\ kJ\ mol^{-1}$
- second electron affinity of oxygen $+798\ kJ\ mol^{-1}$
- enthalpy change of formation of $Na_2O(s)$ $-414\ kJ\ mol^{-1}$
- enthalpy change of atomisation for oxygen = half the bond energy for O_2.



[3]

(d) (i) How would you expect the magnitude of lattice energy of magnesium oxide to compare with that of sodium oxide? Explain your reasoning.

....

....

....

(ii) State a use of magnesium oxide, and explain how the use relates to your answer in part **(d) (i)**.

....

....

[4]

[Total: 11]

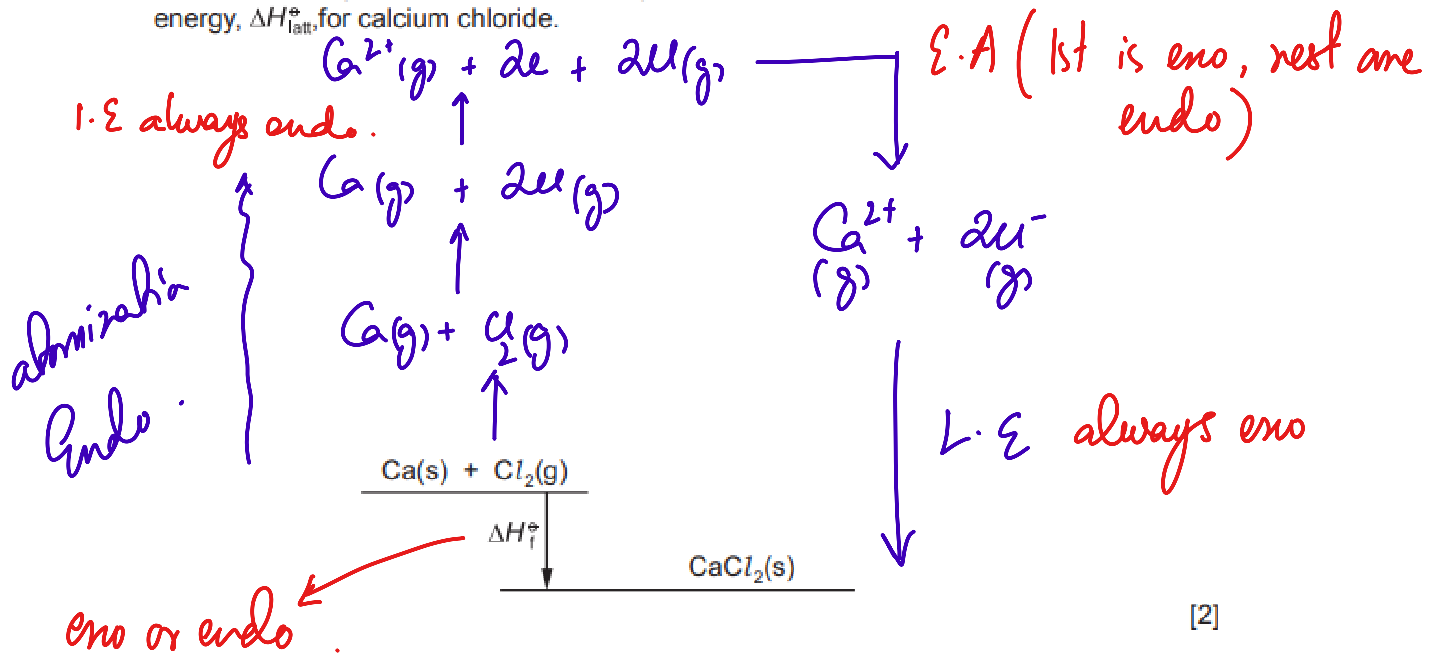
9701/4 O/N/02

2 **(a)** Calcium metal reacts with chlorine gas to form calcium chloride, $CaCl_2$.

(i) Write an equation, including state symbols, to represent the lattice energy of calcium chloride, $CaCl_2$.

.... [1]

(ii) Complete a fully labelled Born-Haber cycle that could be used to calculate the lattice energy, $\Delta H^{\ominus}_{latt}$, for calcium chloride.



[2]

(iii) Use your answer to **(ii)** and the following data, together with relevant data from the *Data Booklet*, to calculate a value for $\Delta H^{\ominus}_{latt}$ for calcium chloride.

standard enthalpy change of formation of $CaCl_2$(s), $\Delta H^{\ominus}_f$	$-796\,kJ\,mol^{-1}$
standard enthalpy change of atomisation of Ca(s), $\Delta H^{\ominus}_{at}$	$+178\,kJ\,mol^{-1}$
electron affinity of chlorine atoms	$-349\,kJ\,mol^{-1}$

$\Delta H^{\ominus}_{latt}$ = ... $kJ\,mol^{-1}$ [3]

9701/42/F/M/16

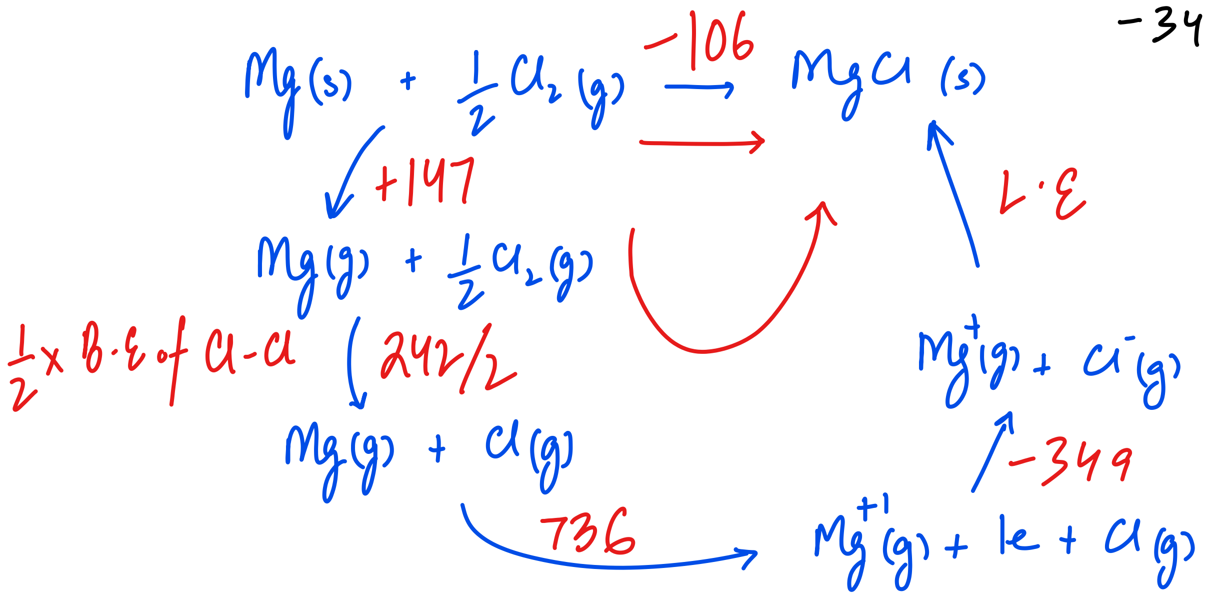
(c) **(i)** The equation for which ΔH is the lattice energy for $MgCl$ is shown.

$$Mg^{+}(g) + Cl^{-}(g) \rightarrow MgCl(s)$$

Use the equation, the following data, and relevant data from the *Data Booklet* to calculate a value for the lattice energy of $MgCl$. You might find it helpful to construct an energy cycle.

electron affinity of $Cl(g)$ = –349 kJ mol^{-1}
enthalpy change of atomisation of $Mg(s)$ = +147 kJ mol^{-1}
enthalpy change of formation of $MgCl(s)$ = –106 kJ mol^{-1}

$-106 = +147 + \frac{242}{2} + 736 - 349 + LE$



lattice energy $MgCl$ = −761 kJ mol^{-1} [3]

(ii) Suggest how the lattice energies of $MgCl_2$ and $NaCl$ will compare to that of $MgCl$. Explain your answers.

$MgCl_2$ and $MgCl$: $MgCl_2$ ΔH_{LE} is more exothermic, Mg^{2+} has greater charge density than Mg^{+} (Mg^{2+} has more charge and smaller radii)

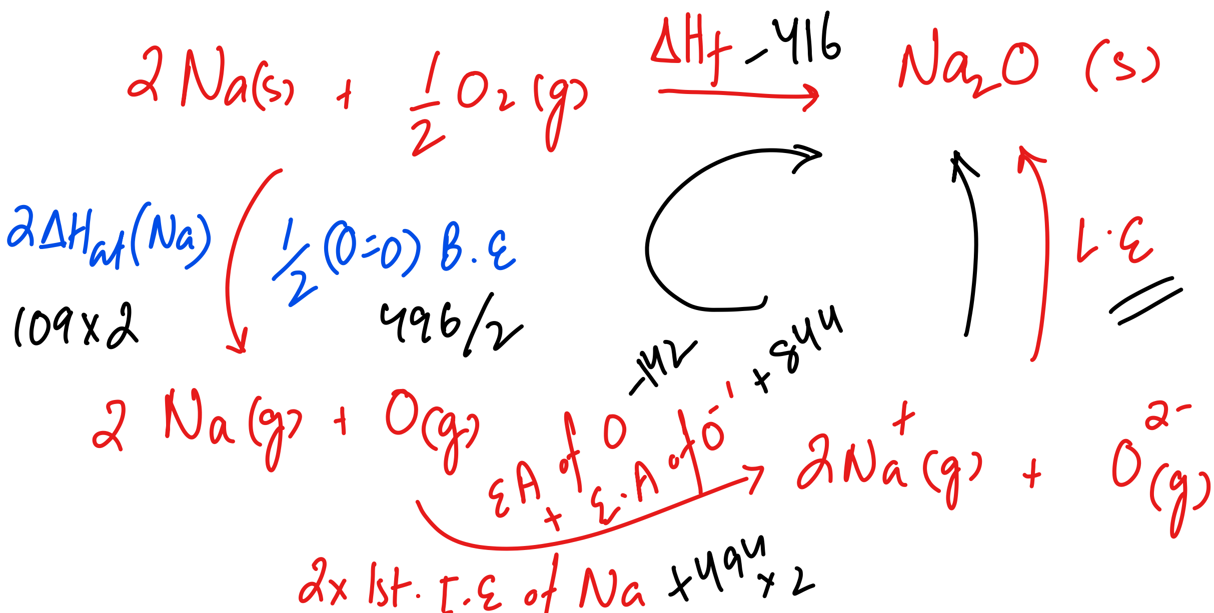
$NaCl$ and $MgCl$: $NaCl$ will have ΔH_{LE} more exothermic, Na^{+} is smaller than Mg^{+1}
2,8 2,8,1

[3]

9701/42/O/N/17

(d) Use the data below, and other suitable data from the *Data Booklet*, to calculate the lattice energy of sodium oxide, $\Delta H^{\ominus}_{latt}$ $Na_2O(s)$.

energy change	value / $kJ\,mol^{-1}$
standard enthalpy change of formation of sodium oxide, $\Delta H^{\ominus}_{f}$ $Na_2O(s)$	–416 ✓
standard enthalpy change of atomisation of sodium, $\Delta H^{\ominus}_{at}$ $Na(s)$	+109 ✓
electron affinity of O(g)	–142
electron affinity of $O^{-}(g)$	+844



$\Delta H^{\ominus}_{latt}$ $Na_2O(s)$ = ... $kJ\,mol^{-1}$ [4]

L.E = +142 − 844 − 494×2 − 109×2 − 496/2 − 416

−2572

(e) State how $\Delta H^{\ominus}_{latt}$ $Na_2S(s)$ differs from $\Delta H^{\ominus}_{latt}$ $Na_2O(s)$.
Indicate this by placing a tick (✓) in the appropriate box in the table.

$\Delta H^{\ominus}_{latt}$ $Na_2S(s)$ is more exothermic than $\Delta H^{\ominus}_{latt}$ $Na_2O(s)$	$\Delta H^{\ominus}_{latt}$ $Na_2S(s)$ is the same as $\Delta H^{\ominus}_{latt}$ $Na_2O(s)$	$\Delta H^{\ominus}_{latt}$ $Na_2S(s)$ is less exothermic than $\Delta H^{\ominus}_{latt}$ $Na_2O(s)$
		✓

Explain your answer.

Na_2S Na_2O

stronger lattice / more exo.

O^{-2} high charge density

compared S^{-2}, O^{-2} is a smaller ion

[2]

(c) **(i)** Write a chemical equation representing the lattice energy of AgBr.

$Ag^+(g) + Br^-(g) \rightarrow AgBr(s)$

(ii) Use the following data to calculate a value for the lattice energy of AgBr(s).

first ionisation energy of silver	=	+731 kJ mol^{-1}
electron affinity of bromine	=	–325 kJ mol^{-1}
enthalpy change of atomisation of silver	=	+285 kJ mol^{-1} ✓
enthalpy change of atomisation of bromine	=	+112 kJ mol^{-1} ✓
enthalpy change of formation of AgBr(s)	=	–100 kJ mol^{-1}

$Ag(s) + \frac{1}{2}Br_2(l) \xrightarrow{\Delta H_f} AgBr(s)$ −100

+112   +285   L.E

$Ag(g) + Br(g) \rightarrow Ag^+(g) + Br^-(g)$ 731   −325

L.E = −731 + 325 −112 −285 −100

= −903

(iii) How might the lattice energy of AgC*l* compare to that of AgBr? Explain your answer.

$\frac{1}{2}Cl_2(g) \rightarrow Cl(g)$ ΔH_{at} (Cl)

$\frac{1}{2}$(Cl–Cl) B.E

AgCl   AgBr

more exo

[4]

In photography a bromide ion absorbs a photon and releases an electron which reduces a silver ion to a silver atom.

$Br^- \rightarrow Br + e^-$

~~$Ag^+ + e^- \rightarrow Ag$~~

more energy needed

$Cl^- \rightarrow Cl + e$

~~$Ag^+ + e^- \rightarrow Ag$~~

(d) Predict whether it would require **more** energy or **less** energy to initiate this process in a AgC*l* emulsion, compared to a AgBr emulsion. Explain your answer.

more energy needed to remove e⁻ from Cl⁻

Cl^- smaller ionic radius

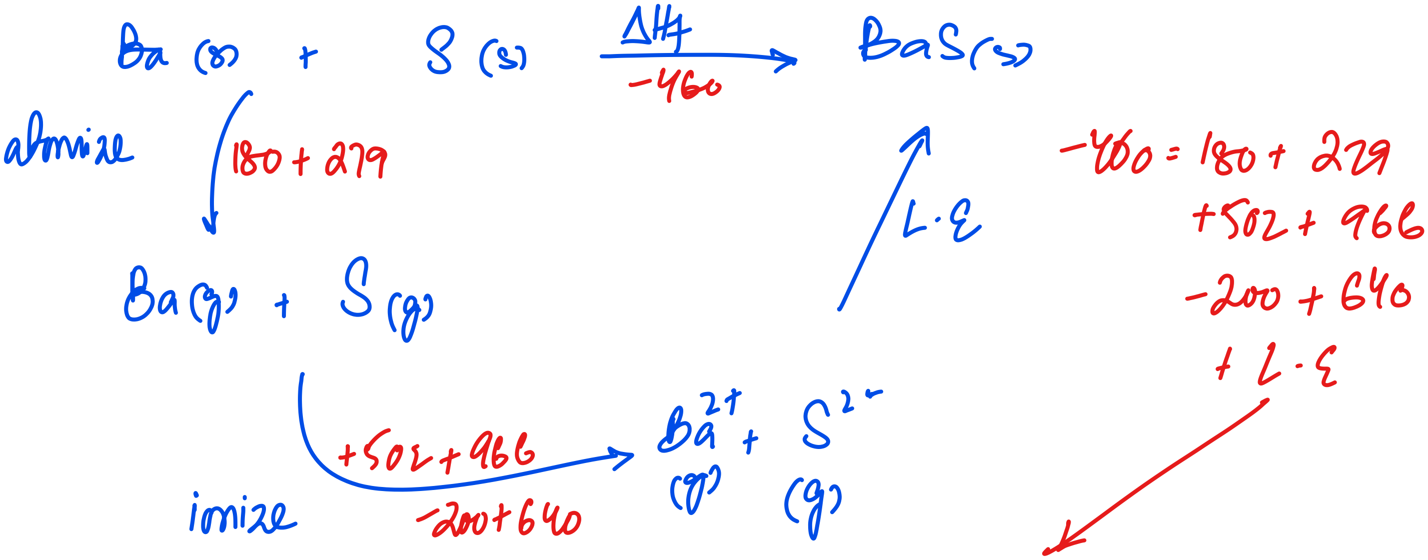
less shielded

[1]

(c) (i) Use the following data and data from the *Data Booklet* to construct a Born-Haber cycle and calculate the lattice energy of BaS.

standard enthalpy change of formation of BaS(s)	–460 kJ mol^{-1}
standard enthalpy change of atomisation of Ba(s)	+180 kJ mol^{-1}
standard enthalpy change of atomisation of S(s)	+279 kJ mol^{-1}
electron affinity of the sulfur atom	–200 kJ mol^{-1}
electron affinity of the S^- ion	+640 kJ mol^{-1}

I.E of Ba from databooklet



lattice energy = -2827 kJ mol^{-1}

(ii) Explain whether the magnitude of the lattice energy of BaS is likely to be greater or less than that of BaO.

$\Delta H_{L.E}$ would be less exothermic for BaS.
S^{2-} has lower charge density than O^{2-}
as it has bigger radii

[4]

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