

Recognising Enthalpy Changes Involved in Born-Haber Cycles **ANSWERS**

Look at the following processes.

For each process, write the **name** and **symbol** for the enthalpy change and find its **value**.

- $\text{Ca}_{(s)} \rightarrow \text{Ca}_{(g)}$ name **enthalpy of atomisation** symbol $\Delta_{\text{at}}\text{H}(\text{Ca}) = +178 \text{ kJmol}^{-1}$
- $\text{S}^{-}_{(g)} + e^{-} \rightarrow \text{S}^{2-}_{(g)}$ name **2nd electron affinity of sulfur** symbol $\Delta_{\text{ea}2}\text{H}(\text{S}) = +649 \text{ kJmol}^{-1}$
- $\text{Al}^{2+}_{(g)} \rightarrow \text{Al}^{3+}_{(g)} + e^{-}$ name **3rd ionisation energy of aluminium** symbol $\Delta_{\text{IE}3}\text{H}(\text{Al}) = +2745 \text{ kJmol}^{-1}$
- $2\text{Na}_{(s)} + \frac{1}{2} \text{O}_{2(g)} \rightarrow \text{Na}_2\text{O}_{(s)}$ name **enthalpy of formation** symbol $\Delta_{\text{f}}\text{H}(\text{Na}_2\text{O}) = -414 \text{ kJmol}^{-1}$
- $\frac{1}{2} \text{Br}_{2(l)} \rightarrow \text{Br}_{(g)}$ name **enthalpy of atomisation** symbol $\Delta_{\text{at}}\text{H}(\text{Br}) = +111.9 \text{ kJmol}^{-1}$
- $\text{Mg}^{2+}_{(g)} + 2\text{Cl}^{-}_{(g)} \rightarrow \text{MgCl}_{2(s)}$ name **lattice enthalpy** symbol $\Delta_{\text{LE}}\text{H}(\text{MgCl}_2) = -2522 \text{ kJmol}^{-1}$
- $\text{Cl}_{(g)} + e^{-} \rightarrow \text{Cl}^{-}_{(g)}$ name **1st electron affinity of chlorine** symbol $\Delta_{\text{ea}1}\text{H}(\text{Cl}) = -346 \text{ kJmol}^{-1}$

Now work out values of the enthalpy changes of the following processes.

(Tip: You will need to think more carefully about these and consider signs!)

- $2\text{O}_{(g)} + 2e^{-} \rightarrow 2\text{O}^{-}_{(g)}$ symbol $2 \times \Delta_{\text{ea}1}\text{H}(\text{O}) = +1688 \text{ kJmol}^{-1}$
- $2\text{Cl}_{2(g)} \rightarrow 4\text{Cl}_{(g)}$ symbol $4 \times \Delta_{\text{at}}\text{H}(\text{Cl}_2) = +484 \text{ kJmol}^{-1}$
OR symbol $2 \times \Delta_{\text{d}}\text{H}(\text{Cl}_2) = +484 \text{ kJmol}^{-1}$
- $\text{N}_{2(g)} + 3\text{H}_{2(g)} \rightarrow 2\text{NH}_{3(g)}$ symbol $2 \times \Delta_{\text{f}}\text{H}(\text{NH}_3) = -92.2 \text{ kJmol}^{-1}$
- $3\text{Mg}^{+}_{(g)} \rightarrow 3\text{Mg}^{2+}_{(g)} + 3e^{-}$ symbol $3 \times \Delta_{\text{IE}2}\text{H}(\text{Mg}) = +4353 \text{ kJmol}^{-1}$
- $2\text{Rb}_{(g)} \rightarrow 2\text{Rb}_{(s)}$ symbol $2 \times -\Delta_{\text{at}}\text{H}(\text{Rb}) = -161.8 \text{ kJmol}^{-1}$
- $\text{F}^{-}_{(g)} \rightarrow \text{F}_{(g)} + e^{-}$ symbol $-\Delta_{\text{ea}1}\text{H}(\text{F}) = +328 \text{ kJmol}^{-1}$

- $\text{Br}_{2(l)} \rightarrow 2\text{Br}_{(g)}$ symbol $2 \times \Delta_{\text{at}}\text{H}(\text{Br}_2) = +223.8 \text{ kJmol}^{-1}$
- $\text{Br}_{2(g)} \rightarrow 2\text{Br}_{(g)}$ symbol $\Delta_{\text{d}}\text{H}(\text{Br}_2) = +192.9 \text{ kJmol}^{-1}$
- $\text{Br}_{2(l)} \rightarrow \text{Br}_{2(g)}$ symbol $\Delta_{\text{vap}}\text{H} = +30.9 \text{ kJmol}^{-1}$

Take care with these! A bit of thinking involved

Try to construct a simple **Hess Cycle** involving these last three enthalpy changes.

