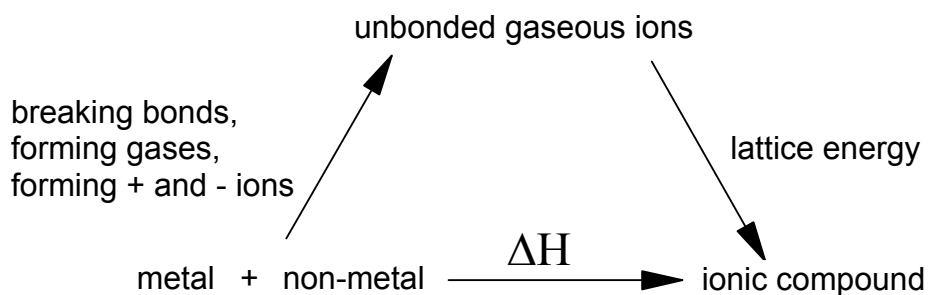
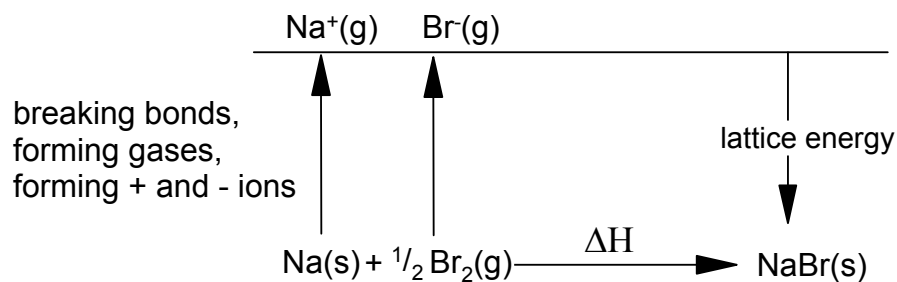


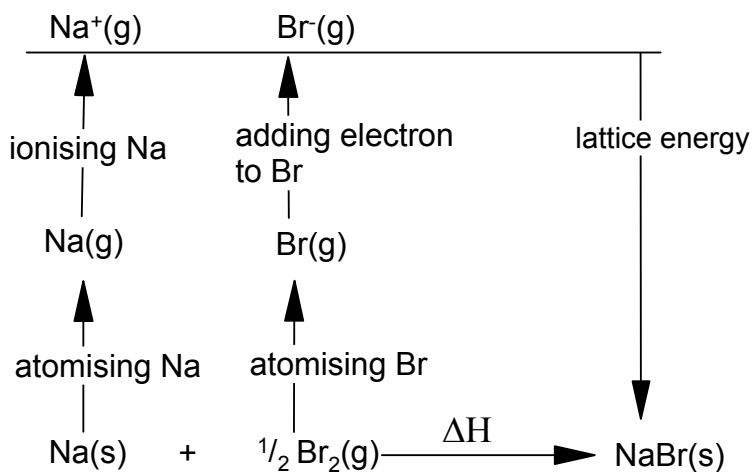
## Unit 4.1 Born Haber Cycles



Example: Sodium Bromide



*breaking down each of the stages*



### Example 1

Calculate the enthalpy change of the reaction  $\text{Na(s)} + \frac{1}{2}\text{Br}_2(\text{g}) \rightarrow \text{NaBr(s)}$

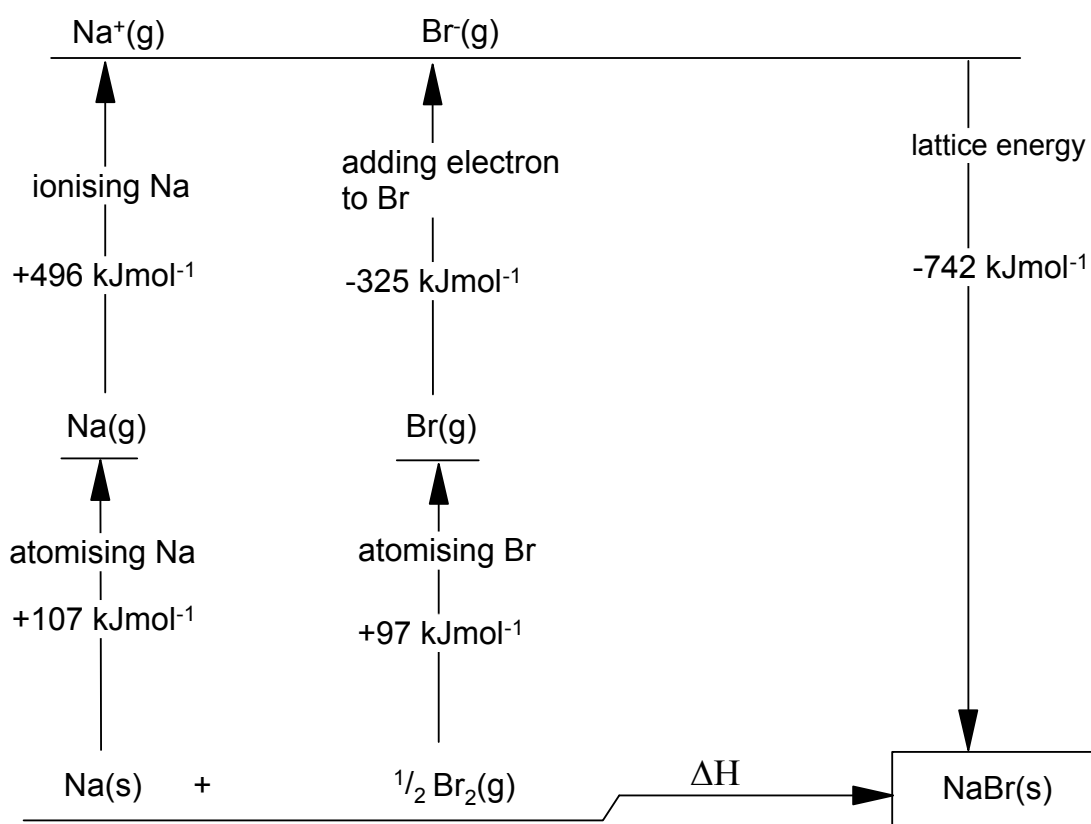
$$\Delta H \text{ atomisation}(\text{Na}) = +107 \text{ kJmol}^{-1}$$

$$\Delta H \text{ atomisation}(\text{Br}) = +97 \text{ kJmol}^{-1}$$

$$\Delta H \text{ first ionisation energy}(\text{Na}) = +496 \text{ kJmol}^{-1}$$

$$\Delta H \text{ first electron affinity}(\text{Br}) = -325 \text{ kJmol}^{-1}$$

$$\Delta H \text{ lattice energy}(\text{NaBr}) = -742 \text{ kJmol}^{-1}$$



$$\begin{aligned}\Delta H &= 107 + 496 + 97 - 325 - 742 \\ &= \underline{\underline{-367 \text{ kJmol}^{-1}}}\end{aligned}$$

## Example 2

Which ions are present in MgO(s)?  $Mg^{2+}$   $O^{2-}$

Calculate the enthalpy change for the reaction  $Mg(s) + \frac{1}{2}O_2(g) \longrightarrow MgO(s)$

What kind of enthalpy change is this? *standard enthalpy of formation of MgO*

$$\Delta H_{\text{atm(O)}} = +249 \text{ kJmol}^{-1}$$

$$\Delta H_{\text{atm(Mg)}} = +148 \text{ kJmol}^{-1}$$

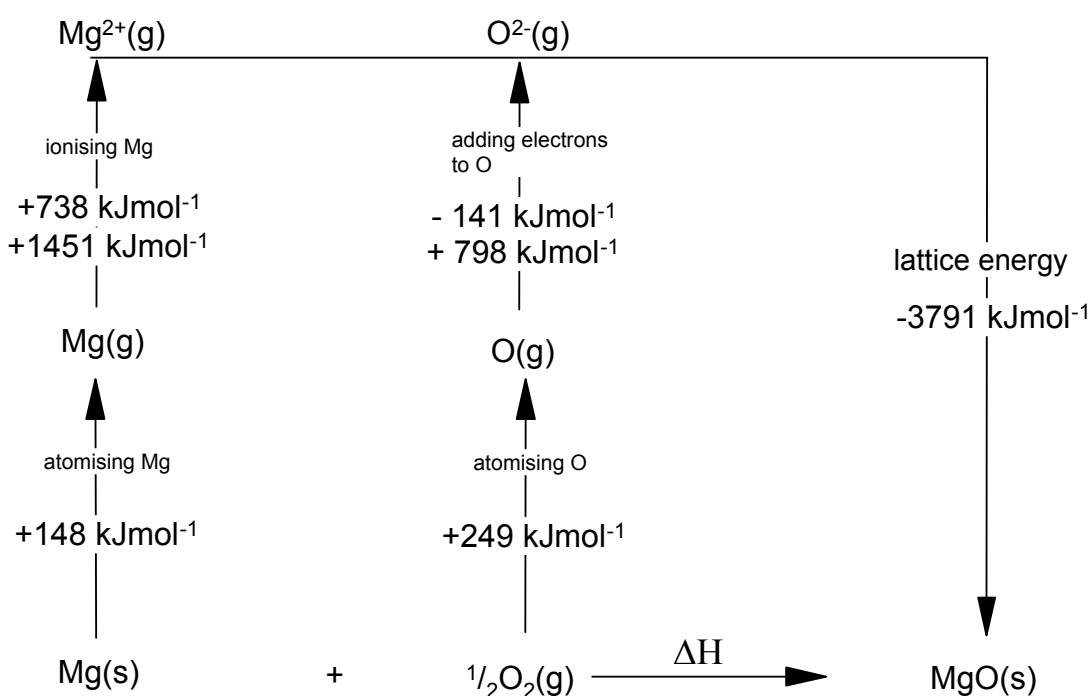
$$\Delta H_{\text{1st ionisation energy(Mg)}} = +738 \text{ kJmol}^{-1}$$

$$\Delta H_{\text{2nd ionisation energy(Mg)}} = +1451 \text{ kJmol}^{-1}$$

$$\Delta H_{\text{1st electron affinity(O)}} = -141 \text{ kJmol}^{-1}$$

$$\Delta H_{\text{2nd electron affinity(O)}} = +798 \text{ kJmol}^{-1}$$

$$\Delta H_{\text{lattice energy(MgO)}} = -3791 \text{ kJmol}^{-1}$$



$$\begin{aligned}\Delta H &= (148+1451+738) + (249+798-141) - 3791 \\ &= 2337 + 906 - 3791 \\ &= \underline{\underline{-548 \text{ kJmol}^{-1}}}\end{aligned}$$

The actual value for this reaction is  $-602 \text{ kJmol}^{-1}$

This is because there is a degree of covalent bonding in MgO. Therefore the bonds formed are slightly stronger than those predicted by a purely ionic model.

### Example 3

Construct a Born-Haber cycle and use it to calculate the first electron affinity of chlorine.

$$\Delta H_{\text{atm(Cl)}} = + 122 \text{ kJmol}^{-1}$$

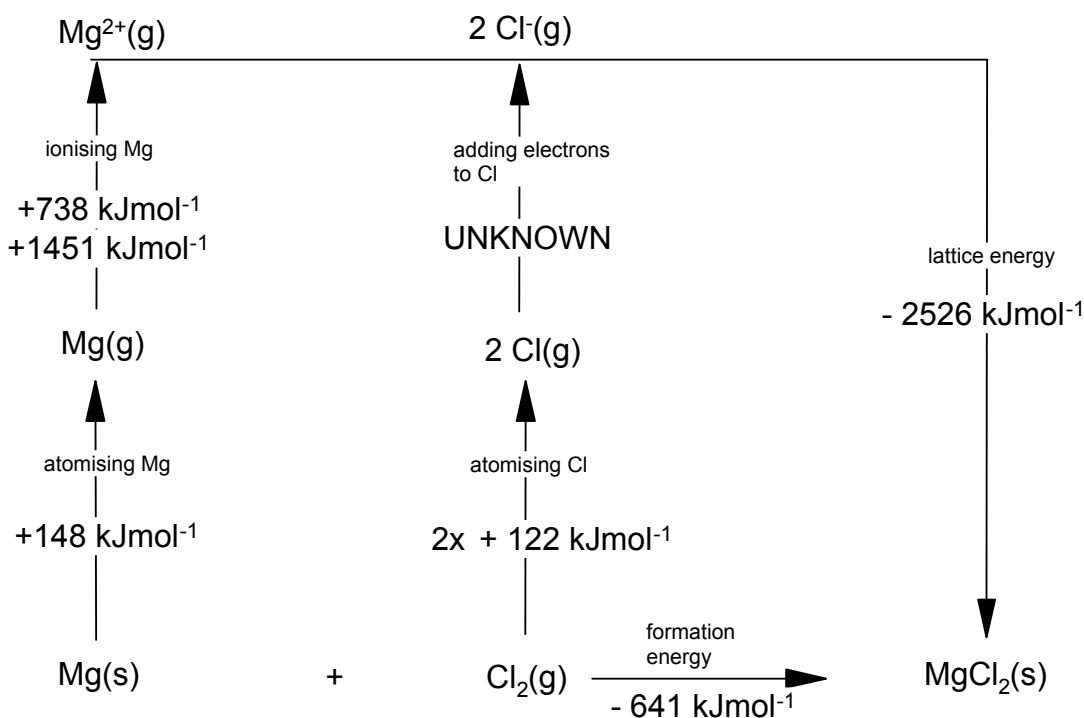
$$\Delta H_{\text{atm(Mg)}} = +148 \text{ kJmol}^{-1}$$

$$\Delta H_{\text{1st ionisation energy(Mg)}} = +738 \text{ kJmol}^{-1}$$

$$\Delta H_{\text{2nd ionisation energy(Mg)}} = +1451 \text{ kJmol}^{-1}$$

$$\Delta H_{\text{lattice energy(MgCl}_2)} = - 2526 \text{ kJmol}^{-1}$$

$$\Delta H_{\text{formation(MgCl}_2)} = - 641 \text{ kJmol}^{-1}$$



$$148 + 1451 + 738 + (2 \times 122) + \text{UNKNOWN} - 2526 = - 641$$

$$2581 + \text{UNKNOWN} - 2526 = - 641$$

$$55 + \text{UNKNOWN} = -641$$

$$\text{UNKNOWN} = -641 - 55$$

$$= - 696$$

This is for 2 moles of Cl.

Therefore the 1st electron affinity of chlorine is

$$-696/2$$

$$= - 348 \text{ kJmol}^{-1}$$