

Lattice Enthalpy and Born–Haber Cycles

Building ionic solids from their elements

Name _____ Class _____ Date _____

BORN–HABER DATA (KJ/MOL)

LiF: $\Delta H_f -616.0$ · sublimation Li $+159.3$ · IE_1 Li $+520.2$ · atomization $\frac{1}{2}F_2 +79.4$ · EA_1 F -328.2

KBr: $\Delta H_f -393.8$ · sublimation K $+89.0$ · IE_1 K $+418.8$ · $\frac{1}{2}Br_2(l) \rightarrow Br(g) +111.9$ · lattice -689.0

CaO: $\Delta H_f -634.9$ · sublimation Ca $+177.8$ · IE_1 Ca $+589.8$ · IE_2 Ca $+1145.4$ · atomization $\frac{1}{2}O_2 +249.2$ · EA_1 O -141.0 · lattice -3414

MgCl₂: $\Delta H_f -641.3$ · sublimation Mg $+147.1$ · IE_1 Mg $+737.7$ · atomization $\frac{1}{2}Cl_2 +121.3$ · EA_1 Cl -348.6

$\Delta H(\text{latt}) = \Delta H_f - (\text{sublimation} + \text{atomization} + \text{ionization energies} + \text{electron affinities})$. Show units in every step.

A. Definitions

1. (a) Define lattice enthalpy. (b) Write equations, with state symbols, for the lattice enthalpy and for the enthalpy of formation of potassium bromide.

2. State whether each step is endothermic or exothermic: (a) $Ca(s) \rightarrow Ca(g)$ (b) $O(g) + e^- \rightarrow O^-(g)$ (c) $O^-(g) + e^- \rightarrow O^{2-}(g)$ (d) $Ca(g) \rightarrow Ca^+(g) + e^-$ (e) $Ca^{2+}(g) + O^{2-}(g) \rightarrow CaO(s)$

B. Calculations

3. Calculate the lattice enthalpy of lithium fluoride.

4. Use the KBr data to calculate the first electron affinity of bromine.

C. Trends

5. Put KCl, CaO, NaCl and MgO in order of increasingly negative lattice enthalpy. Explain your order.

6. (a) Use the CaO data to calculate the second electron affinity of oxygen. (b) Explain why it has this sign.

D. Challenge

7. The lattice enthalpy of the hypothetical compound MgCl (containing Mg^+) is estimated to be -753.0 kJ/mol . (a) Calculate ΔH_f° for MgCl. (b) Calculate ΔH for $2 \text{ MgCl(s)} \rightarrow \text{Mg(s)} + \text{MgCl}_2\text{(s)}$. (c) Explain why magnesium chloride is MgCl_2 , not MgCl.

8. For NaCl, the Born–Haber lattice enthalpy and the value calculated from a purely ionic model agree within about 2 %. For silver iodide, the Born–Haber value is much more negative than the model predicts. Explain both observations.