Born-Haber cycles and lattice enthalpy

AQA 7405 · Full A-level

Show your working where needed. Check the worked answers when you finish.

Name _____ Date _____

1. Lattice formation and dissociation

Define lattice enthalpy of formation and write the equation for NaCl, with state symbols.

Write the corresponding dissociation equation and relate the two enthalpy changes.

2. Find the lattice enthalpy of KF

Standard enthalpies in kJ mol^{-1}: formation of KF −567, atomisation of K +89 and F +79, first ionisation of K +419, first electron affinity of F −328.

Construct a Born-Haber cycle and use it to calculate the lattice enthalpy of formation of KF.

3. Lattice enthalpy of strontium chloride

For $SrCl_2$, use these enthalpies in kJ mol^{-1}: formation −829, atomisation of Sr +164 and Cl +121, first and second ionisation of Sr +550 and +1064, first electron affinity of Cl −349.

Calculate the lattice enthalpy of formation. State the gaseous ions and their coefficients.

Scan to try fresh questions online

Try a core or harder question. Use clues and worked answers.

chemistryhelp.co.uk/worksheets/aqa-born-haber-lattice-enthalpy

Born-Haber cycles and lattice enthalpy

AQA 7405 · Full A-level

4. Second electron affinity of oxygen

Use the data in kJ mol^{-1} for CaO: formation −635, atomisation of Ca +178 and O +249, first and second ionisation of Ca +590 and +1145, first electron affinity of O −141, lattice formation −3436.

Calculate the second electron affinity of O. Explain its sign.

5. Dissolving potassium bromide

Use these enthalpy changes in kJ mol^{-1}: lattice formation of KBr −671, hydration of K^+ −322, hydration of Br^- −335.

Calculate the enthalpy change of solution. Predict the initial temperature change when KBr dissolves in water in an insulated cup.

6. Hydration of calcium ions

For $CaCl_2$, the lattice enthalpy of formation is −2250 kJ mol^{-1}. The enthalpy change of solution is −81 kJ mol^{-1} and the enthalpy change of hydration of Cl^- is −364 kJ mol^{-1}.

Calculate the enthalpy change of hydration of Ca^{2+}.

Scan to try fresh questions online

Try a core or harder question. Use clues and worked answers.

chemistryhelp.co.uk/worksheets/aqa-born-haber-lattice-enthalpy

Born-Haber cycles and lattice enthalpy

AQA 7405 · Full A-level

7. Compare two oxide lattices

Which has the more exothermic lattice enthalpy of formation, MgO or CaO? Explain your choice.

8. Compare two estimates for silver chloride

For AgCl, a Born-Haber cycle gives a lattice enthalpy of formation of −915 kJ mol^{-1}. A perfectly ionic model gives a lattice enthalpy of dissociation of +770 kJ mol^{-1}.

Compare the two magnitudes. Explain what the difference suggests about bonding in AgCl.

9. Extra challenge · Two models for lithium bromide

For LiBr, the enthalpy of solution is −48 kJ mol^{-1}. The hydration enthalpies of Li^+ and Br^- are −520 and −335 kJ mol^{-1} respectively.

Calculate the lattice enthalpy of dissociation. A perfectly ionic model gives +758 kJ mol^{-1}. Compare the values and explain why there could be a difference.

Scan to try fresh questions online

Try a core or harder question. Use clues and worked answers.

chemistryhelp.co.uk/worksheets/aqa-born-haber-lattice-enthalpy

Worked answers

Born-Haber cycles and lattice enthalpy · AQA 7405 · Full A-level

1. Lattice formation and dissociation

Formation of one mole of sodium chloride from its gaseous ions: $Na^+(g) + Cl^-(g) \rightarrow NaCl(s)$.

Dissociation of one mole of sodium chloride into gaseous ions: $NaCl(s) \rightarrow Na^+(g) + Cl^-(g)$. Reversing the process reverses the sign of the enthalpy change.

2. Find the lattice enthalpy of KF

Start at $K(s) + \frac{1}{2}F_2(g)$. The direct arrow to KF(s) is −567. The route via K(g), F(g) and then $K^+(g)$, $F^-(g)$ sums to 89 + 79 + 419 − 328 = +259 kJ mol^{-1}.

The final arrow is from $K^+(g) + F^-(g)$ to KF(s). By Hess's law its enthalpy change is −567 − 259 = −826 kJ mol^{-1}.

3. Lattice enthalpy of strontium chloride

The ions are $Sr^{2+}(g)$ and $2Cl^-(g)$. The gaseous-ion route costs 164 + 550 + 1064 + 2(121) + 2(−349) = +1322 kJ mol^{-1}.

Lattice enthalpy of formation = −829 − 1322 = −2151 kJ mol^{-1}. The Cl atomisation and electron affinity values each apply to one mole of Cl atoms.

4. Second electron affinity of oxygen

Let x be the second electron affinity. The cycle gives −635 = 178 + 249 + 590 + 1145 − 141 + x − 3436, so x = +780 kJ mol^{-1}.

The added electron is repelled by the already negative O^- ion. Energy is required.

Scan to try fresh questions online

Try a core or harder question. Use clues and worked answers.

chemistryhelp.co.uk/worksheets/aqa-born-haber-lattice-enthalpy

Worked answers

Born-Haber cycles and lattice enthalpy · AQA 7405 · Full A-level

5. Dissolving potassium bromide

Dissociating the solid costs +671 kJ mol^{-1}. Hydrating its ions releases 322 + 335 = 657 kJ mol^{-1}.

ΔH of solution = 671 − 657 = +14 kJ mol^{-1}. Dissolution takes in energy, so the temperature initially falls.

6. Hydration of calcium ions

$CaCl_2(s) \rightarrow Ca^{2+}(g) + 2Cl^-(g)$ costs +2250 kJ mol^{-1}.

−81 = 2250 + ΔH of hydration of Ca^{2+} + 2(−364). Thus ΔH of hydration of Ca^{2+} = −1603 kJ mol^{-1}.

7. Compare two oxide lattices

MgO. Both have 2+ cations and O^{2-} anions. Mg^{2+} is smaller than Ca^{2+}, so the oppositely charged ions can approach more closely and their electrostatic attraction is stronger.

8. Compare two estimates for silver chloride

The magnitudes are 915 and 770 kJ mol^{-1}, a difference of 145 kJ mol^{-1}.

the Born-Haber value indicates a stronger attraction. Ag^+ distorts the electron cloud of Cl^-. Some electron density is shared, giving the bonding covalent character.

9. Extra challenge · Two models for lithium bromide

Dissolving LiBr breaks the lattice, then hydrates both ions. So −48 = ΔH(dissociation) − 520 − 335, giving ΔH(dissociation) = +807 kJ mol^{-1}.

The value is 49 kJ mol^{-1} more endothermic than the ionic model. Li^+ can polarise the electron cloud of Br^-. The resulting partial covalent character increases the attraction.

Scan to try fresh questions online

Try a core or harder question. Use clues and worked answers.

chemistryhelp.co.uk/worksheets/aqa-born-haber-lattice-enthalpy