

Chemical Energetics

A-Level Chemistry • Topic 23

A-Level Chemistry



Chemical Energetics

What we will cover

- 1 Lattice energy & Born-Haber
- 2 Enthalpies of solution
- 3 Entropy ΔS
- 4 Gibbs free energy ΔG



an ionic lattice

1 Lattice energy

Chemical Energetics

└ Lattice energy

Lattice energy and Born-Haber

Lattice energy 晶格能 is the enthalpy change when 1 mol of an ionic solid forms from gaseous ions. It is always **exothermic**. A **Born-Haber cycle** 玻恩-哈伯循环 applies Hess's law around the formation of the solid: atomisation → ionisation → electron affinity → lattice energy, closing with ΔH_f .

More negative (stronger) for a **higher ionic charge** and a **smaller ionic radius**.

Chemical Energetics

└ Lattice energy

Lattice energy: worked example

NaCl from the cycle

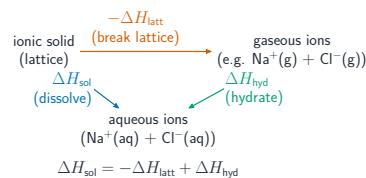
$$\Delta H_{\text{latt}} = \Delta H_f - (\Delta H_{\text{at}} + \text{IE} + \text{EA}) = -411 - (107 + 122 + 496 - 349) = -787 \text{ kJ mol}^{-1}$$

Lattice energy is **more negative** (stronger) for a **higher ionic charge** and a **smaller ionic radius** – both strengthen the attraction.

Chemical Energetics

└ Lattice energy

Enthalpies of solution and hydration



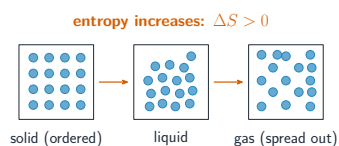
To dissolve, pull the lattice apart, then **hydrate** 水合 the ions:

$$\Delta H_{\text{sol}} = -\Delta H_{\text{latt}} + \Delta H_{\text{hyd}}$$

Hydration 水合焓变 is more exothermic for higher charge & smaller radius.

2 Entropy and free energy

Entropy ΔS



Entropy 熵 measures the number of arrangements ("disorder").

- solid → liquid → gas, dissolving: $\Delta S > 0$
 - more gas molecules: $\Delta S > 0$
- $$\Delta S^\ominus = \sum S^\ominus_{\text{products}} - \sum S^\ominus_{\text{reactants}}$$

Gibbs free energy ΔG

	ΔS positive	ΔS negative
ΔH neg.	feasible at all temperatures	feasible only at low temperature
ΔH pos.	feasible only at high temperature	never feasible

$\Delta G = \Delta H - T\Delta S$; feasible when $\Delta G \leq 0$

Gibbs free energy 吉布斯自由能:

$$\Delta G^\ominus = \Delta H^\ominus - T\Delta S^\ominus$$

A reaction is **feasible** 可行 when $\Delta G \leq 0$. Whether it is can depend on temperature.

ΔG : worked example

$$\Delta H = +120 \text{ kJ mol}^{-1}, \Delta S = +0.200 \text{ kJ K}^{-1} \text{ mol}^{-1}$$

$$\text{at } 298 \text{ K: } \Delta G = 120 - 298 \times 0.200 = +60 \text{ kJ mol}^{-1} \text{ (not yet feasible)}$$

$$\text{Set } \Delta G = 0: T = \frac{\Delta H}{\Delta S} = \frac{120}{0.200} = 600 \text{ K} - \text{feasible above } 600 \text{ K.}$$

3 Recap

Topic 23 – key takeaways

1 Born-Haber

Hess cycle to find lattice energy

2 Lattice

stronger for high charge, small radius

3 Entropy

$\Delta S > 0$ for more disorder/gas

4 Gibbs

feasible when $\Delta G = \Delta H - T\Delta S \leq 0$

Check yourself

- 1 Is lattice energy positive or negative?
- 2 What makes a lattice energy stronger?
- 3 Sign of ΔS when a gas forms?
- 4 A reaction is feasible when ΔG is what?



Answers 1. negative 2. higher charge & smaller radius 3. positive 4. negative (or zero)