

Chemical Energetics

A-Level Chemistry ■ Topic 23

A-Level Chemistry



What we will cover

1 Lattice energy & Born–Haber

2 Enthalpies of solution

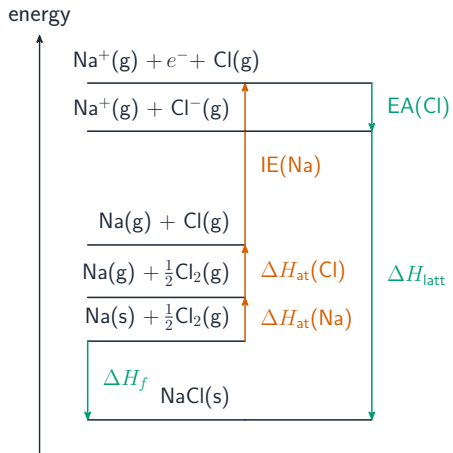
3 Entropy ΔS

4 Gibbs free energy ΔG



an ionic lattice

Lattice energy and Born–Haber



cold pack

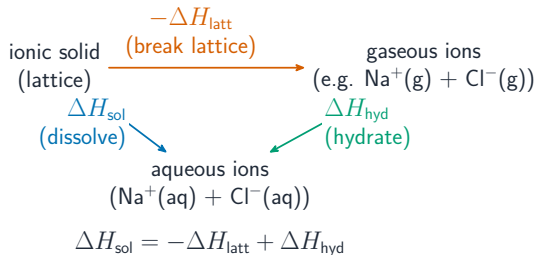
Lattice energy: worked example

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.

Enthalpies of solution and hydration



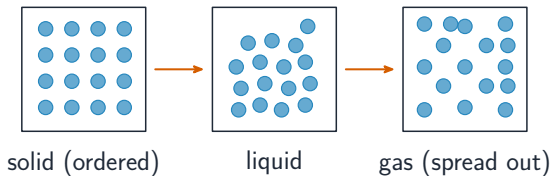
To dissolve, pull the lattice apart, then **hydrate** 水合 the ions:

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

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

Entropy ΔS

entropy increases: $\Delta S > 0$



Entropy 熵 measures the number of arrangements (“disorder”).

- solid $\rightarrow$ liquid $\rightarrow$ 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

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

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

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

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)