Exercise walk-through

Enthalpies of solution and hydration ▪ 23.2

eXercise

You must be able to

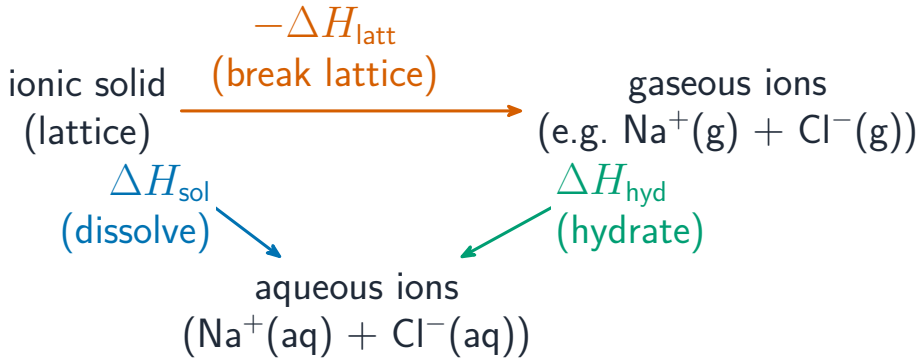
- define enthalpy of solution and enthalpy of hydration
- construct and use an energy cycle linking them with lattice energy
- explain the effect of ionic charge and radius on the magnitude of hydration enthalpy

Method — The dissolving cycle

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

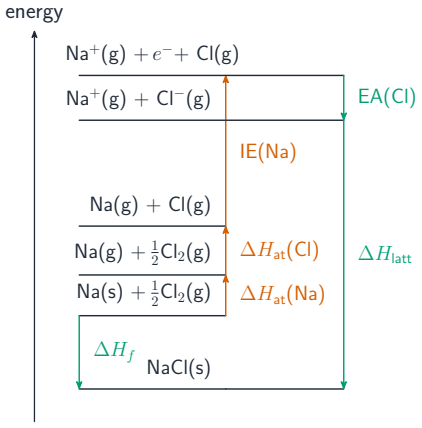
- $\Delta H_{\mathbf{hyd}}$ — change when 1 mol of gaseous ions is dissolved in water (always −, water attracts the ion).
- $\Delta H_{\mathbf{sol}}$ — change when 1 mol of solute dissolves to form a solution.

Method — The dissolving cycle



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

Method — The dissolving cycle



Lattice energy from a Born-Haber cycle

Method — Charge and radius

Hydration is **more exothermic** for ions with a **higher charge** and a **smaller radius** (higher charge density attracts the polar water more strongly).

Practice 2.1 ▪ 2 marks

Define **enthalpy change of hydration**.

Solution 2.1

Method: The dissolving cycle

Worked steps

the enthalpy change when 1 mol of gaseous ions B1 is dissolved in (a large amount of) water B1.

Practice 2.2 ▪ 2 marks

State **two** factors that make hydration of an ion more exothermic.

Solution 2.2

Method: Charge and radius

Worked steps

a higher ionic charge; a smaller ionic radius **B1** *each*.

Exam-style 3.1 ▪ 1 mark

Enthalpy of hydration is most exothermic for:

A a large, singly-charged ion

B a small, highly-charged ion

C a large, highly-charged ion

D a neutral atom

Solution 3.1

Method: Charge and radius

A a large, singly-charged ion

B a small, highly-charged ion ✓

C a large, highly-charged ion

D a neutral atom

Worked steps

B. A small, highly-charged ion has the highest charge density, so the most exothermic hydration.

Exam-style 3.2 ▪ 1 mark

Which equation correctly links the enthalpies?

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

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

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

D $\Delta H_{\text{sol}} = -\Delta H_{\text{hyd}}$

Solution 3.2

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

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

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

D $\Delta H_{\text{sol}} = -\Delta H_{\text{hyd}}$

Worked steps

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

Exam-style 3.3 ▪ 2 marks

For a salt, $\Delta H_{\text{latt}} = -780$ kJ mol^{-1} and the sum of the hydration enthalpies of its ions is -820 kJ mol^{-1}.

(a) Calculate the enthalpy change of solution.

(b) State whether the salt dissolving is exothermic or endothermic.

Solution 3.3

Method: The dissolving cycle

Worked steps

(a) $\Delta H_{\text{sol}} = -(-780) + (-820) = +780 - 820 = -40$ kJ mol^{-1} M1 A1.
(b) exothermic B1.

Exam-style 3.4 ▪ 2 marks

Explain why the hydration enthalpy of Mg^{2+} is more exothermic than that of Na^{+}.

Solution 3.4

Method: Charge and radius

Worked steps

Mg^{2+} has a higher charge and a smaller radius than Na^{+} M1, so a higher charge density that attracts the polar water molecules more strongly — more exothermic hydration A1.