23.1 Lattice energy and Born-Haber cycles

Name: ______________ Class: __________ Date: ____________ **Total: 11 marks**

KEY WORDS electron affinity 电子亲和能 • atomisation 原子化 • enthalpy change 焓变 • enthalpy change of atomi
• lattice energy 晶格能

Objective

Build the skills to answer exam questions on **lattice energy and Born–Haber cycles** — **atomisation** 原子化, **lattice energy** 晶格能, **electron affinity** 电子亲和能, and Born–Haber calculations.

You must be able to:

- define enthalpy of atomisation, lattice energy and first electron affinity
- explain the trends in electron affinity down Groups 16 and 17
- construct and use Born–Haber cycles to calculate an unknown step

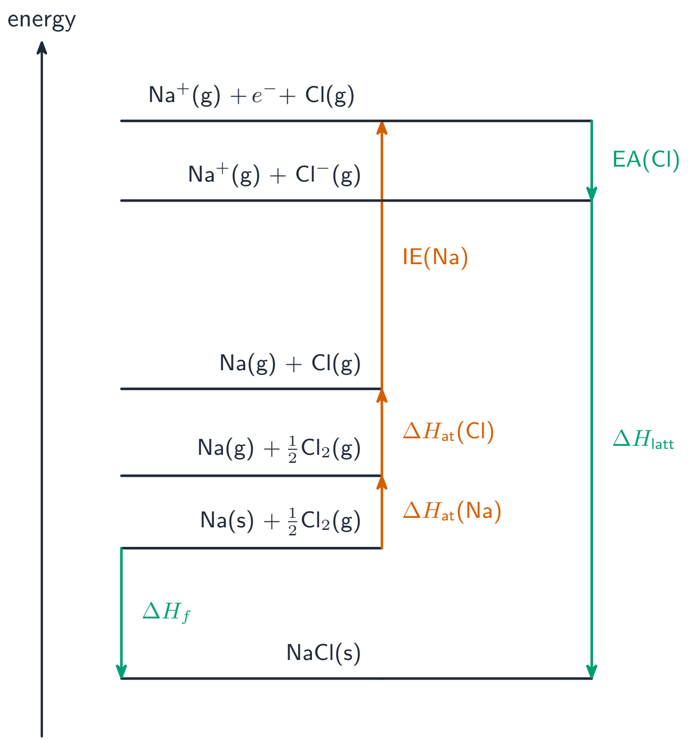
1 Worked examples

■ The key terms

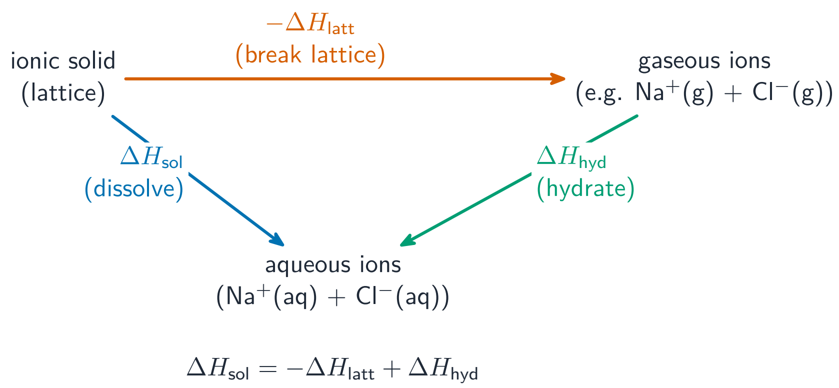
- $\Delta H_{\mathbf{at}}$ — energy to make 1 mol of gaseous atoms from an element (always +).
- $\Delta H_{\mathbf{latt}}$ — change when 1 mol of ionic solid forms from gaseous ions (always −).
- **first electron affinity (EA)** — change when 1 mol of gaseous atoms each gain an electron → 1 mol of 1− ions (usually −).

EA becomes **less exothermic** down Groups 16/17 (larger atom attracts the electron less).

■ Born–Haber cycle



By Hess's law, the direct route (ΔHf) equals the sum of the steps round the cycle — solve for any unknown



Born-Haber alongside the dissolving cycle

For NaCl: $\Delta H_f = \Delta H_{\text{at}}(\text{Na}) + \text{IE}_1(\text{Na}) + \Delta H_{\text{at}}(\text{Cl}) + \text{EA}_1(\text{Cl}) + \Delta H_{\text{latt}}$.

2 Practice

2.1 Define **lattice energy**. [2]

2.2 State why the first electron affinity of chlorine is exothermic. [1]

3 Exam-style questions

3.1 The enthalpy change of atomisation is always: [1]

- **A** negative
- **B** positive
- **C** zero
- **D** equal to the lattice energy

3.2 Down Group 17, the first electron affinity becomes: [1]

- **A** more exothermic
- **B** less exothermic
- **C** zero
- **D** positive

3.3 Use these data (kJ mol^{-1}) for NaCl: $\Delta H_f = -411$; $\Delta H_{\text{at}}(\text{Na}) = +107$; $\text{IE}_1(\text{Na}) = +496$; $\Delta H_{\text{at}}(\text{Cl}) = +122$; $\text{EA}_1(\text{Cl}) = -349$.

(a) Calculate the lattice energy of NaCl. [3]

(b) State why the lattice energy is negative. [1]

3.4 Explain why the lattice energy of MgO is more exothermic than that of $NaCl$. [2]

Solutions

2.1 the enthalpy change when 1 mol of an ionic solid (lattice) forms from its gaseous ions.

2.2 the atom gains an electron, and the attraction of the nucleus for the added electron releases energy.

3.1 B. Atomisation always requires energy (bonds break), so it is positive.

3.2 B. EA becomes less exothermic down the group.

3.3 (a) $\Delta H_{\text{latt}} = \Delta H_f - [\Delta H_{\text{at}}(\text{Na}) + \text{IE}_1 + \Delta H_{\text{at}}(\text{Cl}) + \text{EA}_1]$; $= -411 - [107 + 496 + 122 - 349]$ $= -411 - 376 = -787$ kJ mol^{-1}.
(b) strong electrostatic attractions form between the oppositely charged ions (energy released).

3.4 MgO has ions with higher charges (2+/2−) and smaller radii than NaCl; so the electrostatic attraction is much stronger, making the lattice energy more exothermic.