Topic 15 Energetics (HL)

Syllabus:

15.1 Energy cycles

Representative equations (e.g. $M^+(g) \rightarrow M^+(aq)$) can be used for enthalpy/ energy of hydration, ionization, atomization, electron affinity, covalent bond and solution.

Enthalpy of solution, hydration enthalpy and lattice enthalpy are related in an energy cycle.

Construction of Born-Haber cycles for group 1 and 2 oxides and chlorides.

15.2 Entropy and spontaneity

Entropy (S) refers to the distribution of available energy among the particles.

The more ways the energy can be distributed the higher the entropy.

Gibbs free energy (G) relates the energy that can be obtained from a chemical reaction to the change in enthalpy to the change in enthalpy (ΔH), change in entropy (ΔS), and absolute temperature(T).

Entropy of gas > liquid > solid under same conditions.

15.1 Energy cycles

(A) Born-Haber cycle

1. First ionization energy

- The first ionization energy is the energy required to remove one mole of electrons from one mole of atoms in gaseous state.
- $M(g) \rightarrow M^+(g) + e^-$
- $Na(g) \rightarrow Na^+(g) + e^-$ $\Delta H = +496$ kJ mol^{-1}

2. Electron affinity

- The first electron affinity is the enthalpy change when an electron is added to a gaseous atom.
- $M(g) + e^- \rightarrow M^-(g)$
- $Cl(g) + e^- \rightarrow Cl^-(g)$ $\Delta H = -349$ kJ mol^{-1}

3. lattice enthalpy

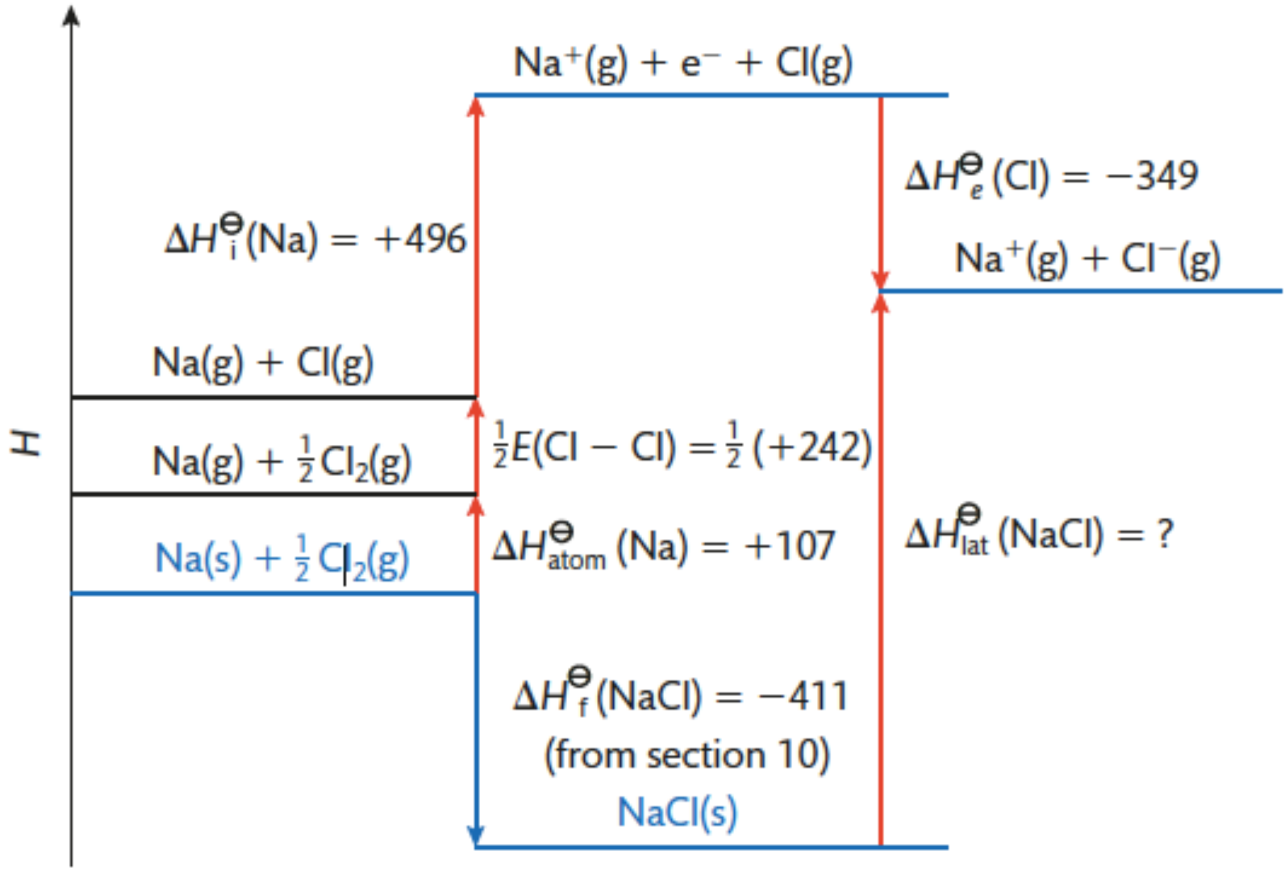
- Lattice energy is the energy required to break one mole of ionic compound into gaseous ions.
- $NaCl(s) \rightarrow Na^+(g) + Cl^-(g)$ $\Delta H = +790$ kJ mol^{-1}

4. Enthalpy change of atomization

- Enthalpy change of atomization is the enthalpy change when one mole of gaseous atom is formed from the element in its standard state.
- Can use the data booklet Table 11. Bond enthalpies
- Bond enthalpy of Cl_2: $Cl_2(g) \rightarrow 2Cl(g)$ $\Delta H = +242\ kJ\ mol^{-1}$
- Enthalpy change of atomization of Cl: $\frac{1}{2}Cl_2(g) \rightarrow Cl(g)$ $\Delta H = +121\ kJ\ mol^{-1}$

Example

Born-Haber cycle for NaCl



$\Delta H^\ominus{}_f$ [NaCl] = $+107 + \frac{1}{2}(242) + 496 - 349 - \Delta H^\ominus{}_{lat}$ [NaCl]

$-411 = +107 + \frac{1}{2}(242) + 496 - 349 - \Delta H^\ominus{}_{lat}$ [NaCl]

$\Delta H^\ominus{}_{lat}$ [NaCl] = + 786 kJ mol^{-1}

Question 1

Construct a Born-Haber cycle for magnesium oxide, and calculate the lattice energy of magnesium oxide, using section 8 and 11 of the IB data booklet and the following data.

Given that enthalpy change of atomization of magnesium = +148 kJ mol^{-1}

second ionization energy of magnesium = +1451 kJ mol^{-1}

enthalpy change of formation of magnesium oxide = –602kJ mol^{-1}

Question 2

Construct a Born-Haber cycle for calcium bromide, and calculate the lattice energy of calcium bromide.

Given that enthalpy change of atomization of calcium = +178 kJ mol^{-1}

second ionization energy of calcium = +1145 kJ mol^{-1}

enthalpy change of formation of calcium bromide = –683 kJ mol^{-1}