Chemistry 1000 Lecture 12: Ionic compounds

Marc R. Roussel

September 25, 2018

Naming cations

1. Name of cation = name of metal + word "ion"

   Examples: sodium ion (Na^+), magnesium ion (Mg^{2+})

2. When there is more than one possible ion (most transition metals, p-block metals), the charge of the ion is represented by a Roman numeral in parentheses "glued" onto the metal name.

   Examples: iron(II) ion for Fe^{2+}
   iron(III) ion for Fe^{3+}

Naming monatomic anions

Replace suffix in element name by *-ide*.
The word "ion" may be used at times, but isn't strictly necessary.

Examples: fluoride (ion) (F^-), oxide (ion) (O^{2-})

Naming ionic compounds

Name the cation first, dropping the word "ion", then the anion.

No account is taken of the numbers of ions of each type since these numbers are known from the charges of the ions.

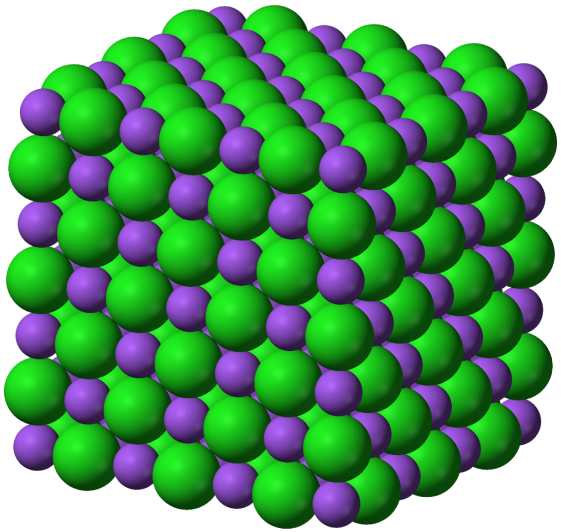
Exercises:

Name AgI, MgF_2, Fe_2O_3

Give the formulas for iron(II) chloride, magnesium nitride

Structures of ionic compounds

NaCl structure

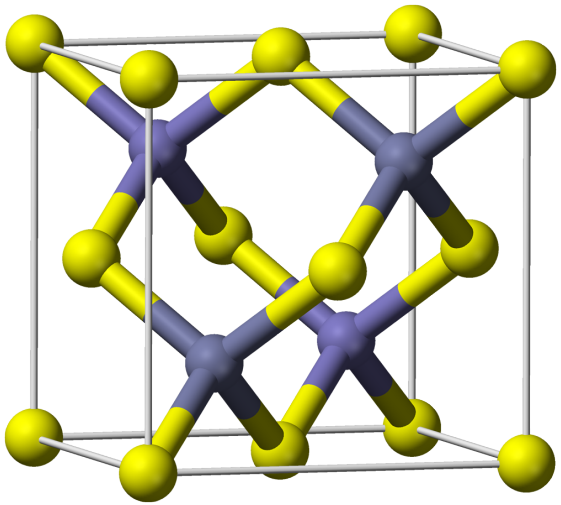


Source: `https://commons.wikimedia.org/wiki/File:Sodium-chloride-3D-ionic.png`

- fcc lattice of Cl^- ions with Na^+ ions in the octahedral holes

Structures of ionic compounds

ZnS (zincblende) structure

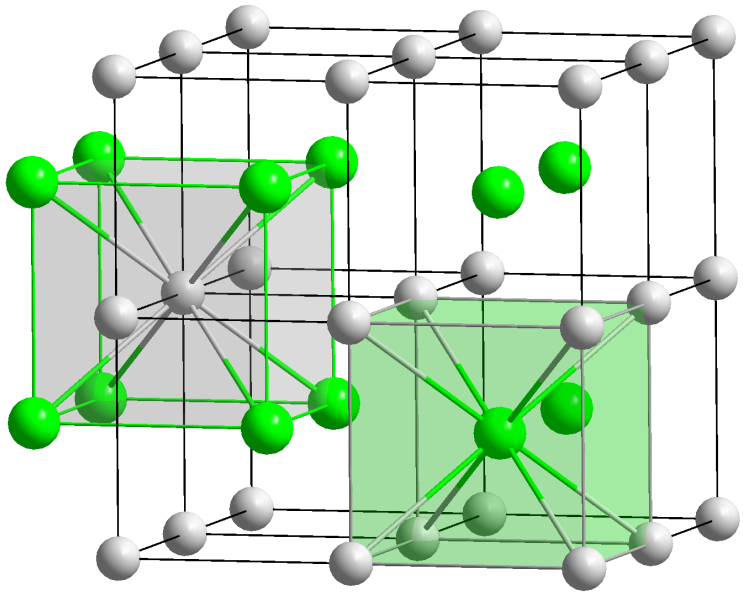


Source: `https://commons.wikimedia.org/wiki/File:Sphalerite-unit-cell-3D-balls.png`

- fcc lattice of S^{2-} ions with Zn^{2+} ions in half the tetrahedral holes

Structures of ionic compounds

CsCl structure



Source: `https://commons.wikimedia.org/wiki/File:CsCl_polyhedra.png`

- simple cubic lattice of Cl^- ions with Cs^+ ions in the centre

Lattice energy (enthalpy)

Definition: enthalpy change when an ionic compound is broken up into the corresponding gaseous ions.

Symbol: $\Delta_{\text{lattice}}H$ (often written as E_{lattice})

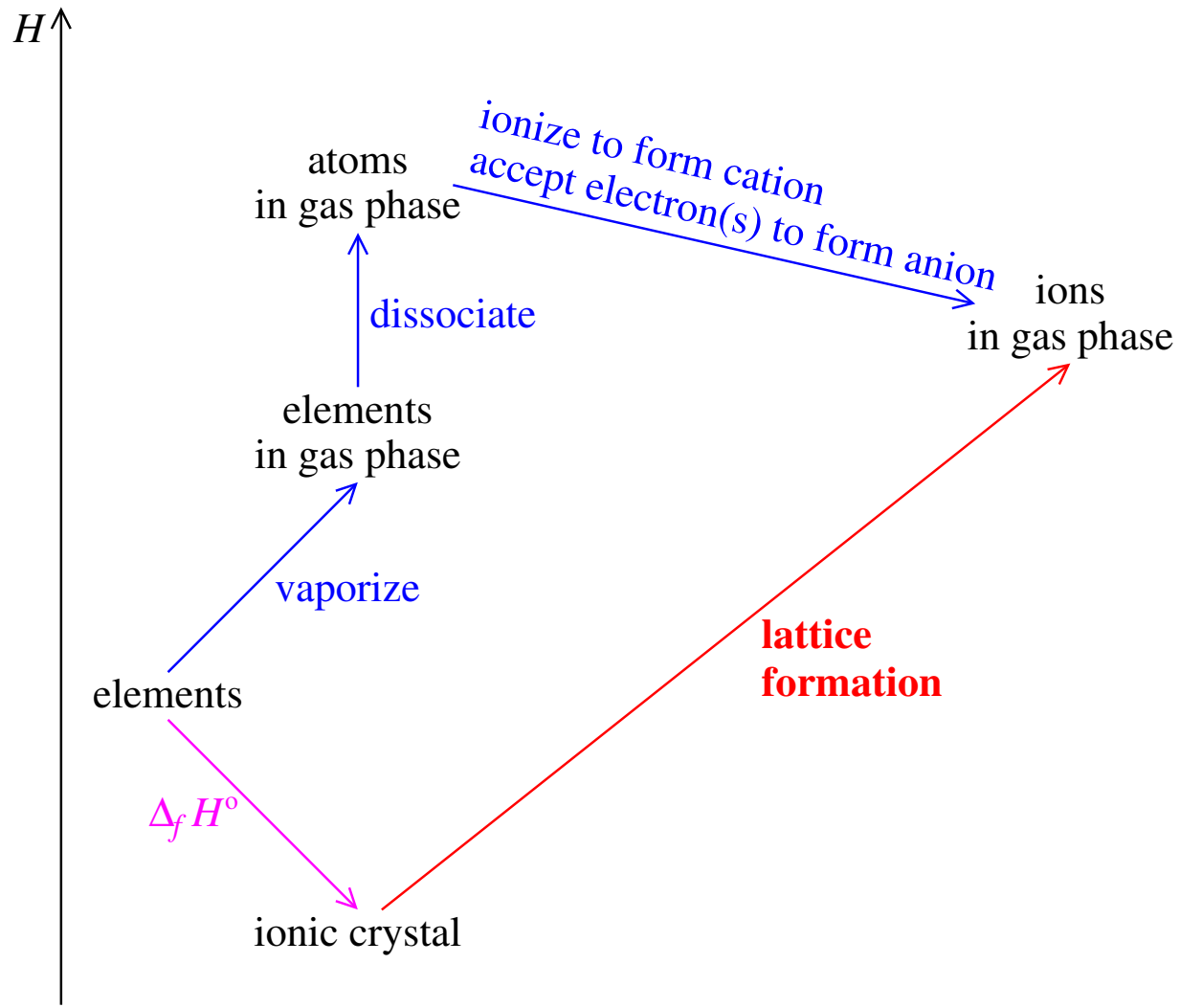
Example: For NaCl, $\Delta_{\text{lattice}}H$ is ΔH for the reaction

$$\text{NaCl}_{(s)} \rightarrow \text{Na}^+_{(g)} + \text{Cl}^-_{(g)}$$

What is this for? This is a measure of the strength of ionic bonding in the solid state.

Enthalpy of lattice formation is not directly measurable.

Born-Haber cycle



Madelung constant

- Another approach developed by Madelung involves summing the forces between the ions, assuming that they are point charges occupying their respective lattice sites.
- Result:

$$\Delta_{\text{lattice}} H \approx -M \frac{N_A q_+ q_-}{4\pi\epsilon_0 r_0}$$

where

q_+ and q_- are the charges on the two ions

r_0 is the nearest-neighbor distance between ions, and

M is the Madelung constant (depends on the lattice type)

Some enthalpies of lattice formation

Compound	Structure	$\Delta_{\text{lattice}}H/\text{kJ mol}^{-1}$	m.p./°C
MgO	NaCl	3850	2852
CaO	NaCl	3461	2572
LiF	NaCl	1049	848
NaF	NaCl	926	993
KF	NaCl	821	858
NaF	NaCl	926	993
NaCl	NaCl	787	801
NaBr	NaCl	752	747
KCl	NaCl	717	770
$CdCl_2$	$CdCl_2$	2565	564
CdI_2	$CdCl_2$	2455	387
ZnI_2	$CdCl_2$	2619	446