Topic:	**The Ionic Bonding**
Objective:	**FK_03_01**

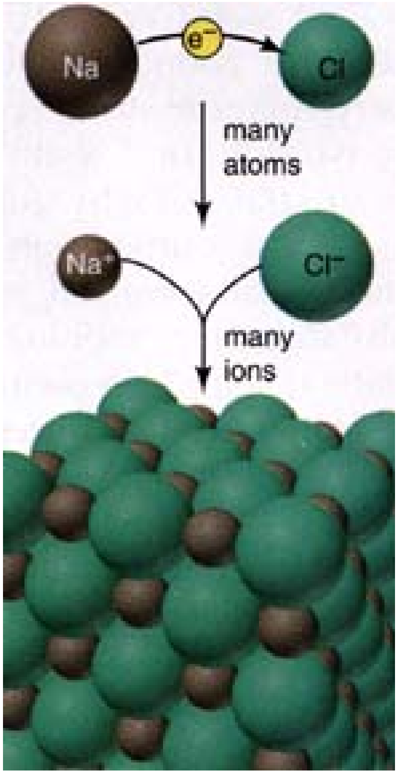
Given two elements (one of them a metal and the other a nonmetal)
the student must be capable of doing the following:

- depict the ions formed using the methods:
  - Lewis notation
  - Orbital diagram notation
- know the formula of the ionic substance formed
- predict the properties of the ionic substance

1 The Formation of an Ionic Bond

The central theme of the ionic bonding is the **transfer of electrons from metal to nonmetal** that come together in a solid ionic compound.

Look at the formation of sodium chloride.



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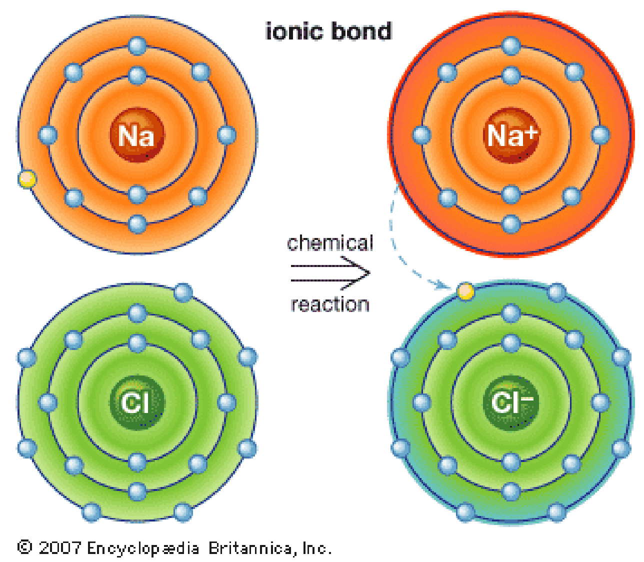
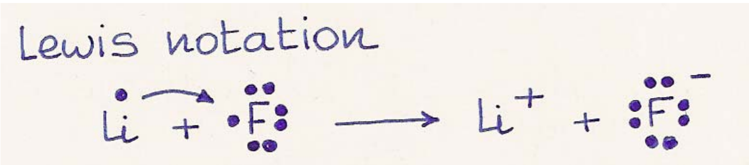
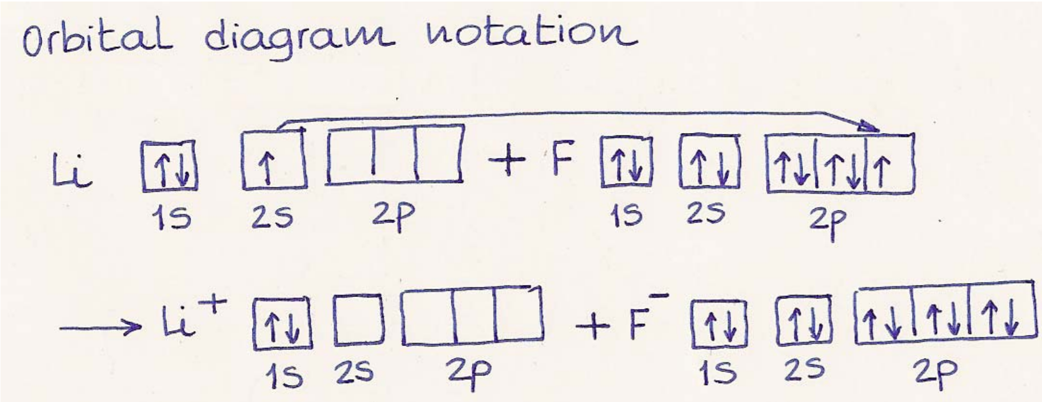


An atom of sodium (Na) donates one of its electrons to an atom of chlorine (Cl) in a chemical reaction. The resulting positive ion (Na^+) and negative ion (Cl^-) form a stable molecule (sodium chloride, or common table salt) based on this ionic bond.

The **metal loses its outer electrons** (1 electron in the case of alkali metals, 2 electrons in the case of alkaline earth metals, 3 in the case of aluminium…) and the **nonmetal gains the electrons needed** to fill the outer "s" and "p" orbits (**to form an octet**): one electron in the case of halogens, 2 electrons in the case of nonmetals of group 16…

Take a look at the formation of the ionic compound from the point of view of Lewis notation and orbital-diagram notation.



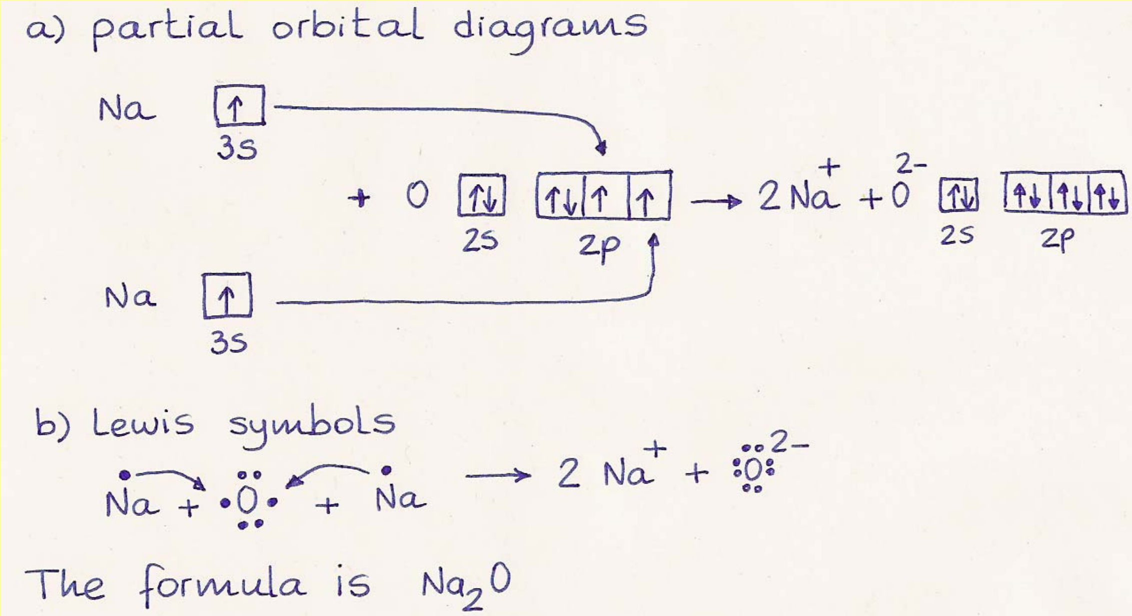


In all cases of ionic bonding, **the total number of electrons lost by the metal atoms equals the total number of electrons gained by the nonmetal atoms**.

2	Exercises: Depicting Ion Formation

Use partial orbital diagrams and Lewis symbols to depict the formation of ions from the the atoms and determine the formula of the compound.

Example: Na + O



1	K + F
2	Ca + O

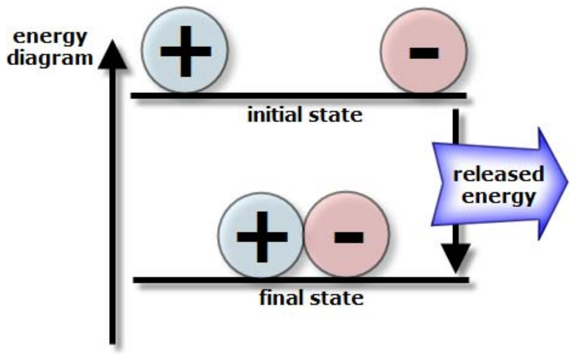
3	Al + S

3	**Names of ions**

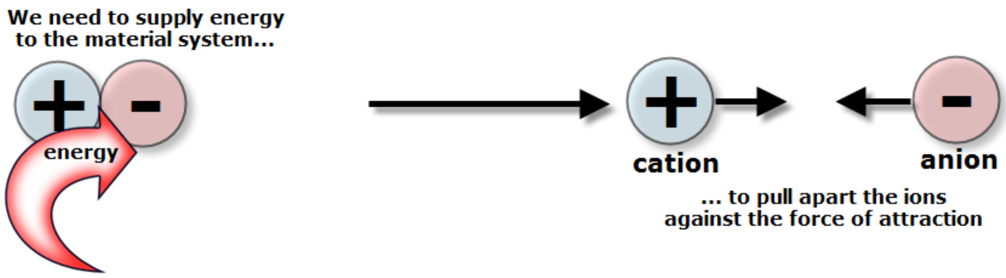
Al^{3+}	aluminum ion	Br^{-}	bromide
Be^{2+}	beryllium ion	Cl^{-}	chloride
Ca^{2+}	calcium ion	F^{-}	fluoride
H^{+}	hydrogen ion	H^{-}	hydride
K^{+}	potassium ion	I^{-}	iodide
Li^{+}	lithium ion	N^{3-}	nitride
Na^{+}	sodium ion	O^{2-}	oxide
Mg^{2+}	magnesium ion	S^{2-}	sulfide

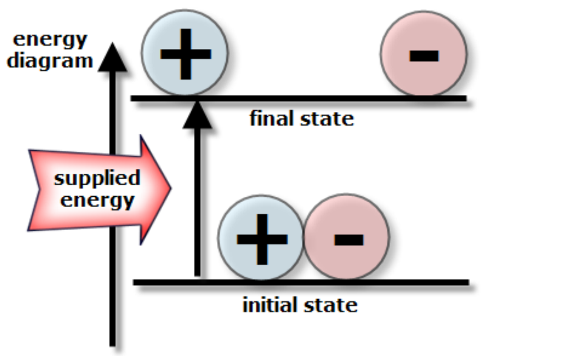
4 Energy considerations: lattice energy and periodic trends

When two opposite charged particles attract each other, energy is released in the process.



If we want to break apart two ions, we need to supply energy.

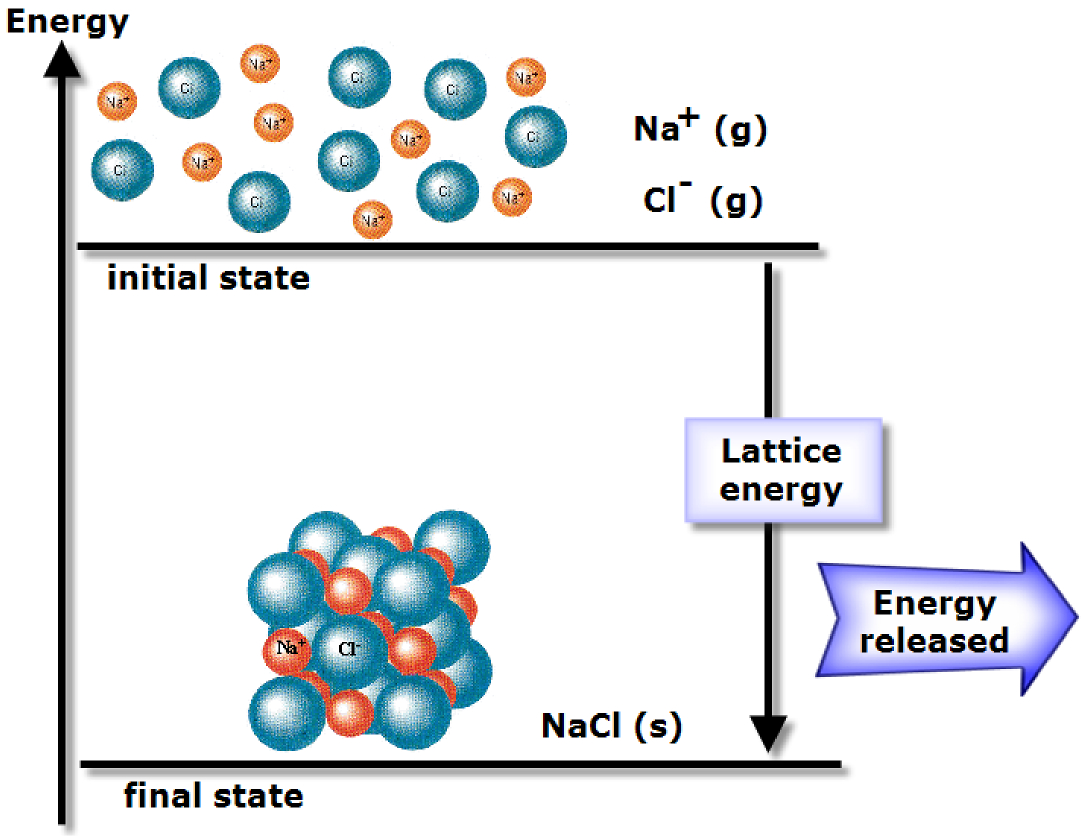




Lattice energy is the energy (enthalpy) change (energy **released**) that accompanies gaseous ions (isolated ions) coalescing into an ionic solid:

$$M^{+}\ (g) + X^{-}\ (g) \rightarrow MX\ (s)\quad \text{Lattice energy} < 0$$

Since this process is exothermic (releases energy) lattice energy is always negative.



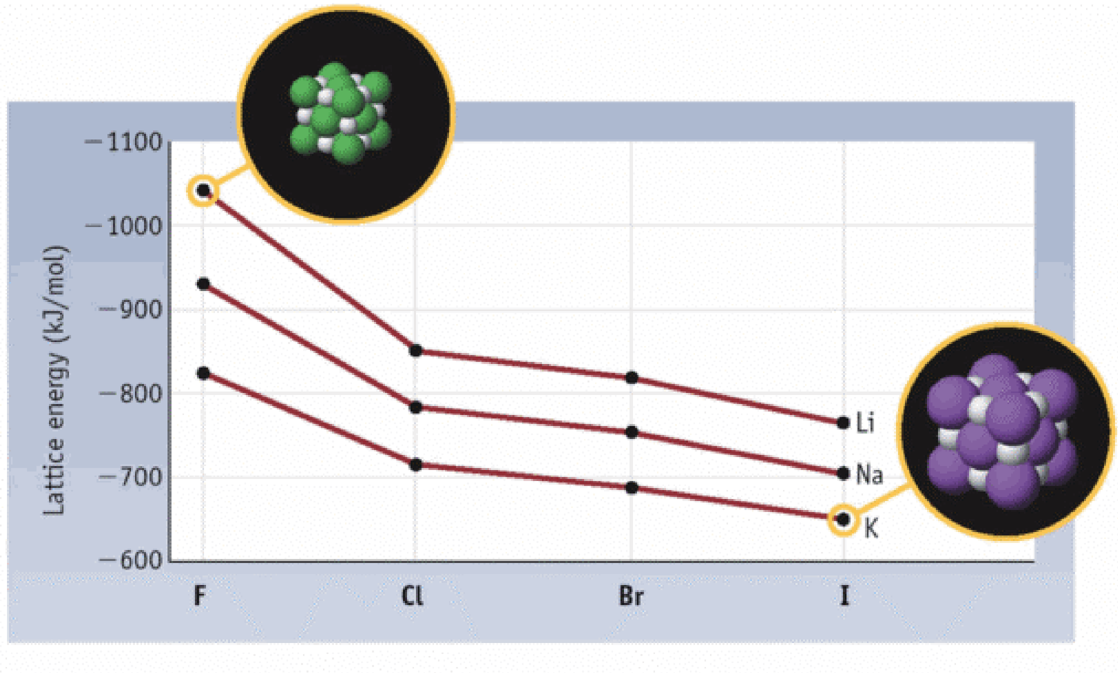
Lattice energy = Energy (final state) - Energy (initial state)
= Energy [NaCl(s)] - Energy [Na^+ (g) + Cl^- (g)] < 0 (negative)

Since the lattice energy is the result of electrostatic interactions among ions, we expect its magnitude to depend on several factors, including

- ionic size
- ionic charge
- ionic arrangement in the solid

according to the following equation:

$$\text{Electrostatic energy} \propto \frac{\text{charge ion A} * \text{charge ion B}}{\text{distance}}$$



- **Effect of ionic size**. When the size of ions (anions and cations) increase (as we move down a group) the energy of attraction decreases and the lattice energy decreases.

- **Effect of ionic charge**. When the charge of ions increase the energy of attraction increases and the lattice energy increases.

ionic size ↓ / ionic charge ↑ } attraction energy ↑ and lattice energy ↑