

Bonding Day 1: Can you hold it together??

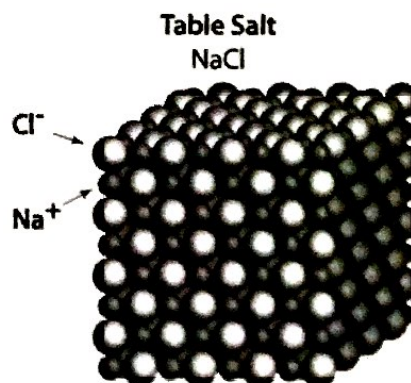
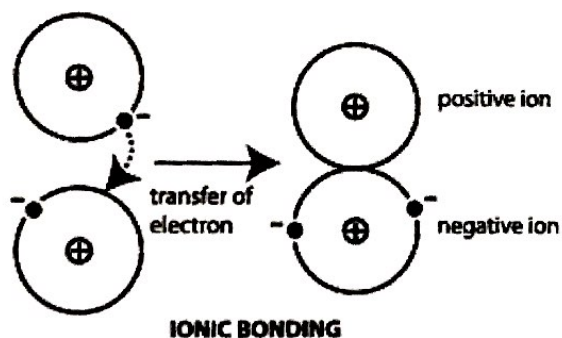
Bonding: The attractive forces that hold groups of atoms together are called chemical bonds.

- Bonds tend to form so that each atom, by gaining, losing, or sharing electrons has **eight** electrons in its valence level (this is called the octet rule).
- The goal of bonding is to achieve the lowest possible energy state.

Types of Bonds		
Ionic	Covalent	Metallic
metal + non-metal	non-metal + non-metal	metal \bar{c}

Ionic Bonding: Metal + Nonmetal(s) (atoms with very different electronegativities)

- Electrons are transferred from the metal to the non-metal.
- Electrical attraction between a cation (+) (metal) and an anion (-) (nonmetal).
- Ionic compounds form a solid, regular array of cations and anions called a crystal lattice.
- **Lattice energy:** how much energy it takes to break apart a solid ionic compound.



Ionic Bond Properties

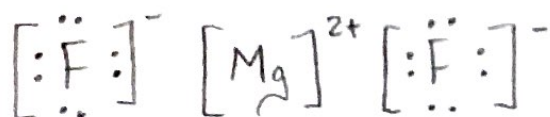
- High melting points and boiling points.
 - hard and brittle
 - conduct electricity when liquid or aqueous (dissolved in water) but not when solid
- mobile charges!*

Lewis Dot Structures of Binary Ionic Compounds

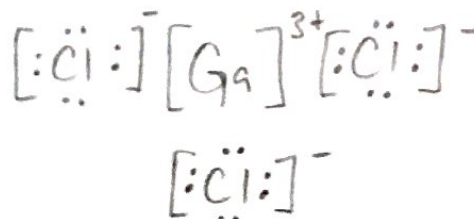
Metal ions are always naked!

Non-metal ions are always stuffed!

1) magnesium fluoride MgF_2



2) gallium chloride $GaCl_3$



Key Formulas and Relationships

When answering questions about ionic bond strength, justify your response using Coulomb's Law:

$$\text{Lattice Energy} = k\left(\frac{Q_1 Q_2}{d}\right)$$

Use Coulomb's Law to justify melting point, solubility, and lattice energy differences between two ionic compounds.

→ The more highly charged the ions OR the smaller the ions, the **GREATER** the attraction!

Lattice energy: energy released when the solid crystal forms from separate ions in the gas phase

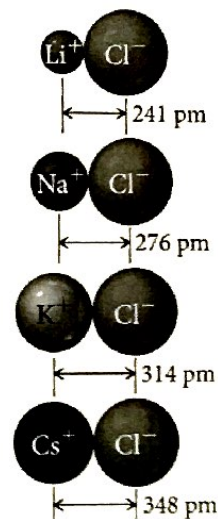
- Directly dependent on size of charges
- Inversely dependent on distance between ions
- **ion charge** is generally MORE important than **ion size**

Greater lattice energy = ↑ energy required to separate ions

→ Stronger ionic bond

→ ↑ melting point

→ ↓ solubility (ions must separate/dissociate from one another and attach to water to dissolve)



Metal Chloride	Lattice Energy kJ/mol
LiCl	-834
NaCl	-788
KCl	-701
CsCl	-657

Let's Practice!

1. Arrange the following ionic compounds NaF, MgF₂, MgO, KF

a. in order of increasing lattice energy: $KF < NaF < MgF_2 < MgO$

b. in order of increasing melting point: " " " "

c. in order of increasing solubility: $MgO < MgF_2 < NaF < KF$

2. Would the lattice energy of lithium fluoride be larger or smaller than the lattice energy of potassium bromide.

Explain in terms of Coulomb's Law.

The lattice energy of LiF is > that of KBr, b/c both Li⁺ and F⁻ are smaller than K⁺ and Br⁻ (respectively). According to Coulomb's law, decreasing the distance between charged particles increases their energy of attraction.

Percent Ionic Character:

- The greater the difference in electronegativity between two bonded atoms, the greater the ionic character of the bond.
- The more similar in electronegativity, the greater the covalent character of the bond.

Dipole moment: a measure of bond polarity; \uparrow dipole moment means \uparrow ionic character!

→ Represented by an arrow pointing in the direction of greater electron density $\overset{+}{\text{H}}-\overset{-}{\text{F}}$

TABLE 9.2 Dipole Moments of Several Molecules in the Gas Phase

Molecule	ΔEN	Dipole Moment (D)
Cl ₂	0	0
ClF	1.0	0.88
HF	1.9	1.82
LiF	3.0	6.33

Let's Practice! Given the dipole moments listed in the table above, arrange the four molecules:

- in order of increasing ionic character: $\text{Cl}_2 < \text{ClF} < \text{HF} < \text{LiF}$
- in order of increasing covalent character: $\text{LiF} < \text{HF} < \text{ClF} < \text{Cl}_2$

Multiple Choice Practice

- A crystalline solid has a melting point of 502°C, and it conducts electricity in an aqueous solution, but not while solid. Which of the following is most likely to be the identity of the substance?
 - I₂(s)
 - (b)** LiCl(s)
 - C₁₂H₂₂O₁₁(s)
 - Ni(s)
- Which of the pairs of ions listed below will form a salt with the greatest melting point?
 - K⁺ and Cl⁻
 - (c)** Ca²⁺ and S²⁻] \uparrow charge, \downarrow size
 - Rb⁺ and Cl⁻
 - Sr²⁺ and S²⁻
- Which of the following substances has the greatest ionic character?
 - XeF₂
 - (b)** GaBr₂
 - AsP₃
 - PCl₅