Bonding

Forces of attraction that hold atoms together making compounds

In summary...

- Ionic bonds are electrostatic attractions between cations and anions formed when electron(s) are transferred from the low IE, EA metal to the high IE, EA nonmetal

Ionic Compounds

1. Only exist as compounds in the solid state
2. Held together by ionic bonds
   - A strong attractive force
3. High melting points
   - Must break the bonds to melt the solid
   - The *higher the melting point*, the *stronger the ionic bonds*

Ionic Compounds

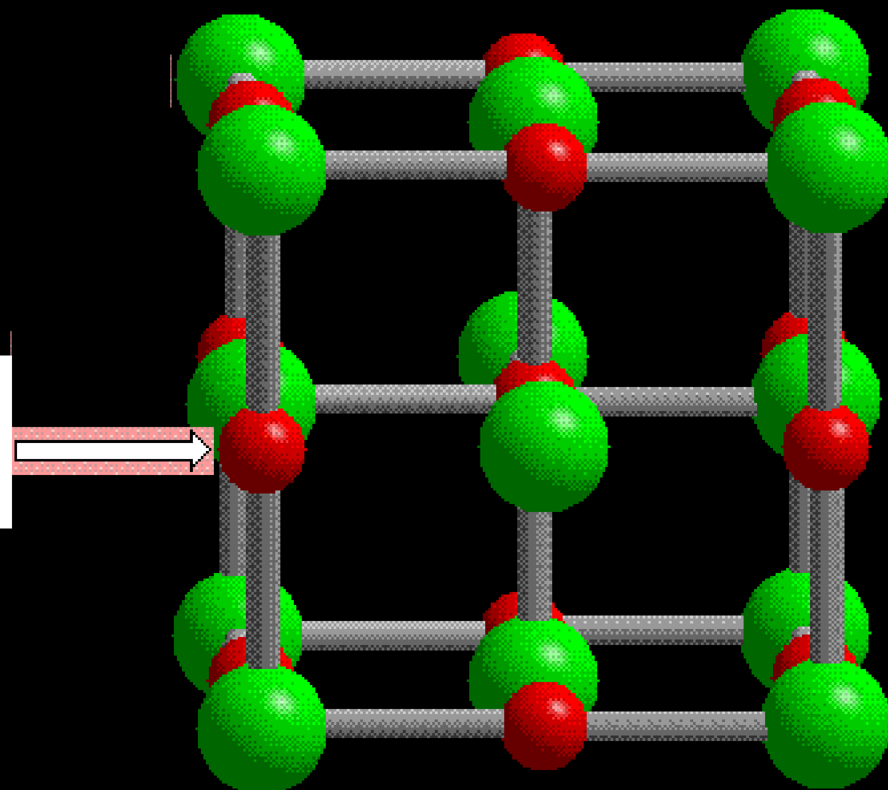
4. brittle solids
5. nonconducting as solids
   - No charges can flow
6. conduct electricity as liquids or aqueous
   - Ions are free to move

Ionic Compounds

- As solids, exist in a 3-D repeating pattern called a crystal “lattice”
- the **lattice energy** is the energy released when the bond is formed between the “free” ions
- Also a measure of the energy required to break apart the ionic compound once formed
- The greater the lattice energy, the stronger the force of attraction

Ionic compound = crystalline solid

Cation (+)



Ionic Bond Strength

- A measure of the attractive force between the ions
- smaller ions = stronger ionic bonds
- smaller atom:atom ratio = stronger bond
  - Ex: NaCl = 1:1, Na_2O = 2:1, $AlCl_3$ = 1:3
- larger charges = stronger bonds
- evidence: melting points

Coulomb's Law

$$F = k\frac{Q_1 Q_2}{r^2}$$

F = attractive force

Q_1, Q_2 = charges (size)

r = distance between charges

(related to ion size and ratio of cation:anion)

Compare the melting points:

- KCl : 776^{o}C
- KI : 723^{o}C
- Cl^{-} is smaller than I^{-}
- smaller ions = stronger bonds
- Stronger bond = higher melting point

Compare the melting points:

- $FeCl_3$: 306°C   1:3 ratio
- $FeCl_2$: 677°C   1:2 ratio
- smaller *atom:atom* ratio (closer to 1:1) result in stronger ionic bonds

Ion dissociation

- Many ionic compounds will dissolve in water if it results in lower E (more stability) than in the solid ionic compound
- the ions "dissociate" from each other
- Ex: $CaCl_{2(s)} + H_2O \rightarrow Ca^{2+}_{(aq)} + 2Cl^{-}_{(aq)}$

Types of compounds

- All compounds are made of two or more elements held together by chemical bonds
- Ions of opposite charges are held together by <u>ionic bonds</u>
  - Usually: a **metal** with a **nonmetal**
- Ionic bonding is *non-directional*
  - There are no "ionic molecules"
  - Formulas of ionic compounds show the ratio of cation to anion
- Ionic compounds only exist in the solid state, in a 3-D crystal lattice

Covalent Bonding

Covalent bonding involves the **sharing** of **electron *pairs***

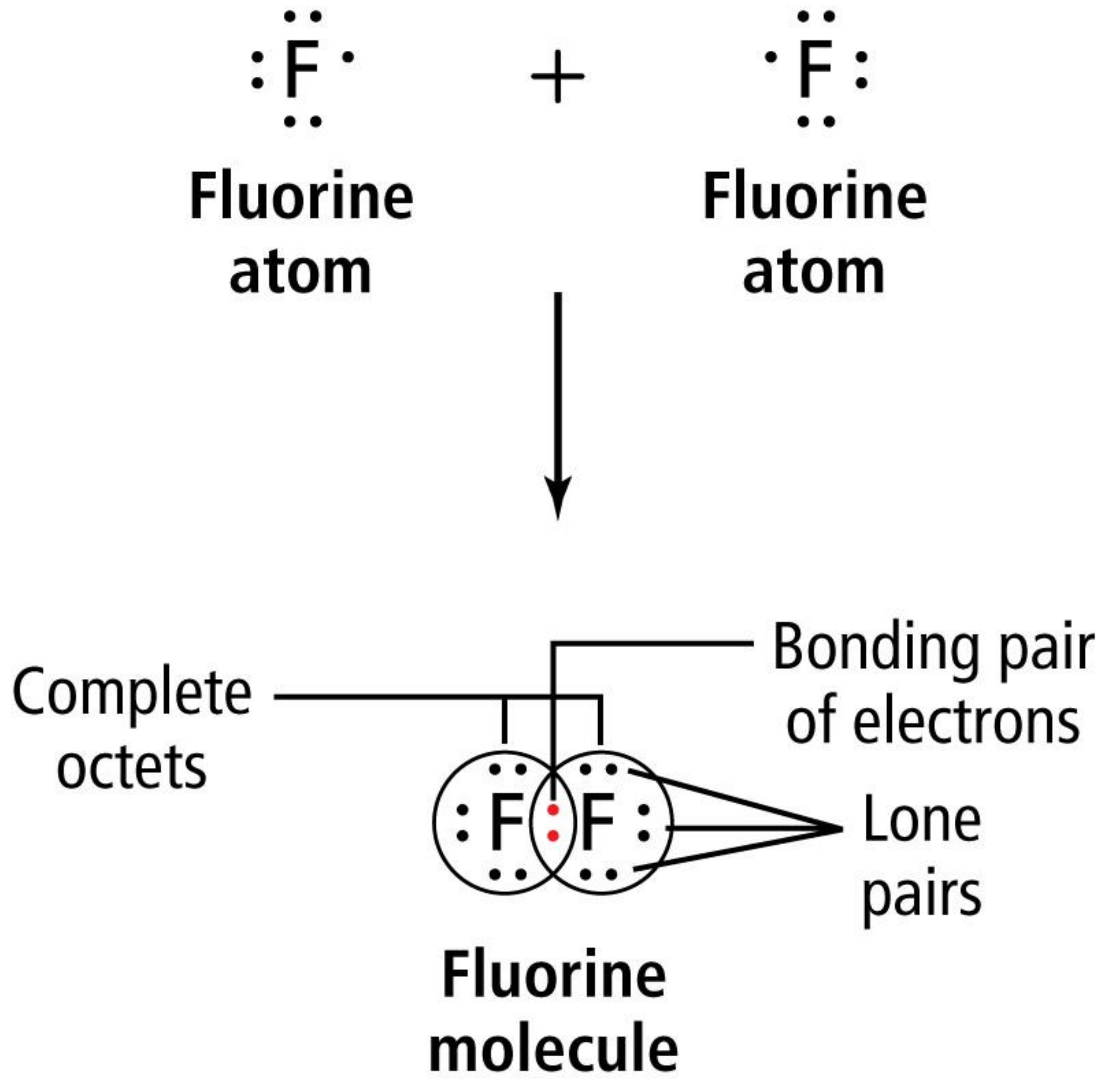
usually between **two nonmetals**

- high EA, high IE
  - both tend to gain more e^-'s, neither is willing to lose the e^-'s they have

Covalent Bonding

- A “covalent” bond is formed when two atoms share one or more pairs of electrons
- Both atoms “see” the electrons, so the electrons count as valence electrons on both atoms
- Satisfies the octet rule

Covalent Bonding



Types of compounds

- Covalent compounds are made of two or more elements held together by covalent bonds
- Covalent bonding is directional
  - Between two individual atoms
- A group of covalently bonded atoms is referred to as a "molecule"
- Covalent compounds are also referred to as "molecular" compounds

- A nonmetal will form as many covalent bonds as necessary to fulfill the octet rule
- example: C, with 4 valence e^-'s, will form 4 covalent bonds
- double bonding (two atoms sharing two pairs) and triple covalent bonding (sharing three pairs) is a possibility

Unless they are part of a "polyatomic ion"…

- C forms 4 bonds
- N forms 3 bonds
- O forms 2 bonds
- H,F forms 1 bond

Binary Molecular Nomenclature

- Two nonmetals
- no charges to balance
- multiple subscripts possible
  - ex: N_2O, NO, NO_2, N_2O_4, N_2O_5

Use prefixes to represent subscripts

- mono = 1
- di = 2
- tri = 3
- tetra = 4
- penta = 5
- hexa = 6
- hepta = 7
- octa = 8
- nona = 9
- deca = 10

Rules, continued..

- Change second name to end in "ide"
- do *not* use prefixes on the *first* word if the prefix is "mono"
- always use prefixes on the second name

NEVER, EVER, EVER, EVER, EVER, EVER, EVER,

USE ***PREFIXES*** WITH A **<u>METAL</u>**!

Examples...

- CO_2
- carbon = first word
- subscript = 1, so no prefix
- oxide = second word
- subscript = 2, so prefix = di
- carbon dioxide

Examples...

- CO
- carbon = first word
- subscript = 1, so no prefix
- oxide = second word
- subscript = 1, so prefix = mono
- carbon monoxide

Try to name these…

- **N_2O**

  dinitrogen monoxide

- **NO**

  nitrogen monoxide

- **NO_2**

  nitrogen dioxide

- **N_2O_4**

  dinitrogen tetroxide

- **N_2O_5**

  dinitrogen pentoxide

- **H_2O**

  dihydrogen monoxide

DHMO.org

Writing formulas...

- Dinitrogen tetroxide

✓di = 2, so two nitrogen's

✓tetra = 4, so 4 oxygens

✓N_2O_4

- Note: do **NOT** reduce subscripts for *molecular* compounds