NS 4.1 (pg 1 of 1) Compare and Contrast − Three Types of Substances

Ionic Bonding − Molecular Bonding – Metallic Bonding

Name____________________

Since there are two different types of elements: metals and nonmetals, there are three possible combinations of those two types of elements:

A. **metals + nonmetals** these combine to form ionic compounds and will the focus of this chapter 4

B. **nonmetals + nonmetals** these combine to form molecular compounds which are held together by covalent bonds. Electrons are shared rather than transferred. We will name *binary molecular compounds* in this unit, and then come back to understand the bonding mechanism further in chapter 12

C. **metals + metals** metals do not *chemically* combine to form compounds, they simply *mix* together to form alloys just as we formed the alloy in LAD 4.2 The type of bonding that holds metal atoms frozen together is discussed below (and on page 459 in your text).

Use the chart below to compare and contrast (B above) ionic compounds with (C above) molecular compounds.

Compare and Contrast:	**Ionic Compounds (B above)**	**Molecular Compounds (C above)**
Made of?	metal + nonmetal	nonmetal + nonmetal
What are the electrons doing?	transfer electrons metals lose and become + ion (cation) nonmetals gain and become − ion (anion)	electrons are shared no ions are formed
Formulas?	always written in lowest whole # ratio	may not always be lowest ratio
order of formula?	metal (positive ion) first nonmetal (negative ion) second	central atom usually written first, though there are many exceptions, and it really doesn't matter
Using roman #'s?	transition & "six-under-staircase" metals require roman numeral to indicate the charge	no roman numerals used since the atoms do NOT have charges.
Using prefixes?	prefixes not used (except within a few polyatomic ions)	prefixes are used to indicate the number of atoms present in the compound
Naming?	metal keeps its name nonmetal ends in –ide polyatomics end in –ate and –ite (a few in –ide)	for binary compounds, the second element listed ends in –ide
Particles are called?	individual particles are called units	individual particles are called molecules
Polyatomic ions	end in –ite and –ate (a few end in –ide)	NA (not applicable)
Diatomic molecules	NA (not applicable)	diatomic gases: H_2, N_2, O_2, F_2, Cl_2, Br_2, I_2

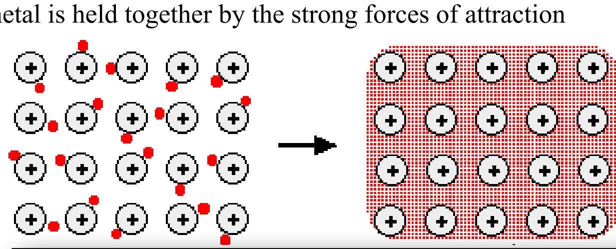
What about metals with metals (C in the list at the top)?

Let's use sodium metal as an example. Sodium has the electronic structure $1s^22s^22p^63s^1$. When sodium atoms stick together as a solid lump of metal, the electron in the 3s atomic orbital of one sodium atom shares (overlaps) space with the corresponding electron on a neighboring atom to form a molecular orbital − in much the same sort of way that a molecular bond is formed.

The difference, however, is that each sodium atom is being touched by eight other sodium atoms − and the sharing occurs between the central atom and the 3s orbitals on all of the eight other atoms. And each of these eight is in turn being touched by eight sodium atoms, which in turn are touched by eight atoms − and so on and so on, until you have taken in all the atoms in that lump of sodium.

All of the 3s valence orbitals on all of the atoms overlap to give a vast number of valence orbitals which extend over the whole piece of metal.

The electrons can move freely within these valence orbitals, and so each s^1 electron becomes detached from its parent atom. The electrons are said to be **delocalized** (not local to its own atom). The metal is held together by the strong forces of attraction between the positive nuclei and the delocalized electrons. This is sometimes described as "an array of positive ions in a sea of valence electrons."



The left view represents the electrons as localized – each e- hanging with its own inner core of e- and nucleus.
In the right view the solid red area is representing the loose valence electrons – delocalized electrons – the "sea of electrons."

This "sea of loose electrons" model is used explain to metallic properties such as

- good conductors of electricity
- good conductors of heat
- low ionization energies
- easily oxidized
- malleable and ductile
- shiny luster

When viewing the diagram above, beware! Is a metal made up of atoms or ions? It is made of **atoms.** Each positive center in the diagram represents all the rest of the atom apart from the outer electron, but that valence electron hasn't been lost − it may no longer have an attachment to a particular atom, but it's still there in the structure. Sodium metal is therefore written as Na, not Na^{+1}