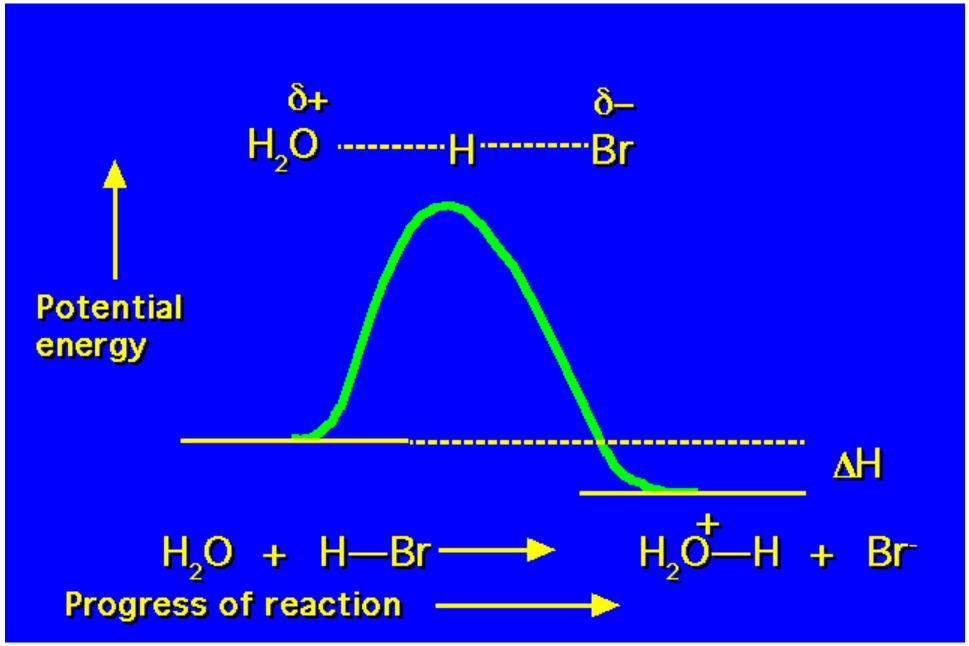
Compound Nomenclature and Formula Writing

Chemistry

Distance Learning Module 3

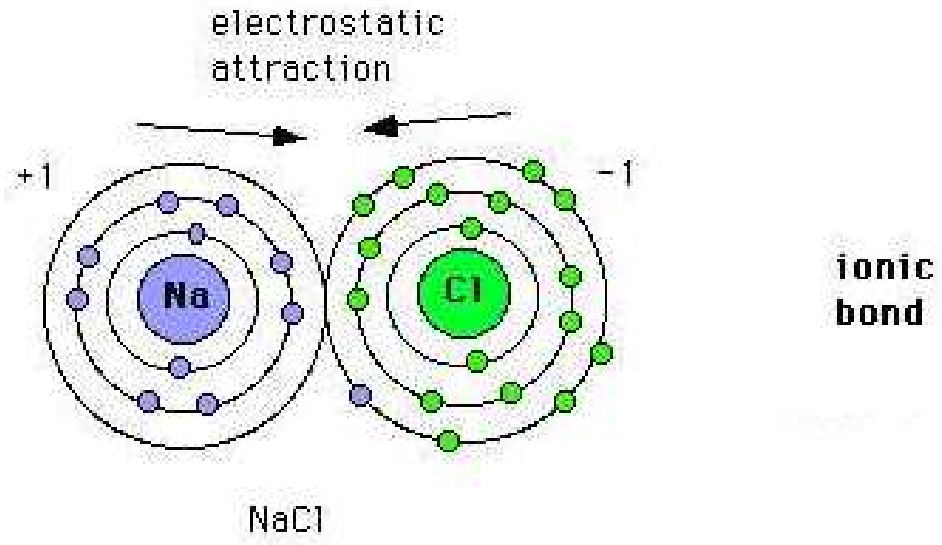
Chemical Bonds

- Chemical bonds form as a way for groups of atoms to minimize their potential energy.



Ionic Bonds

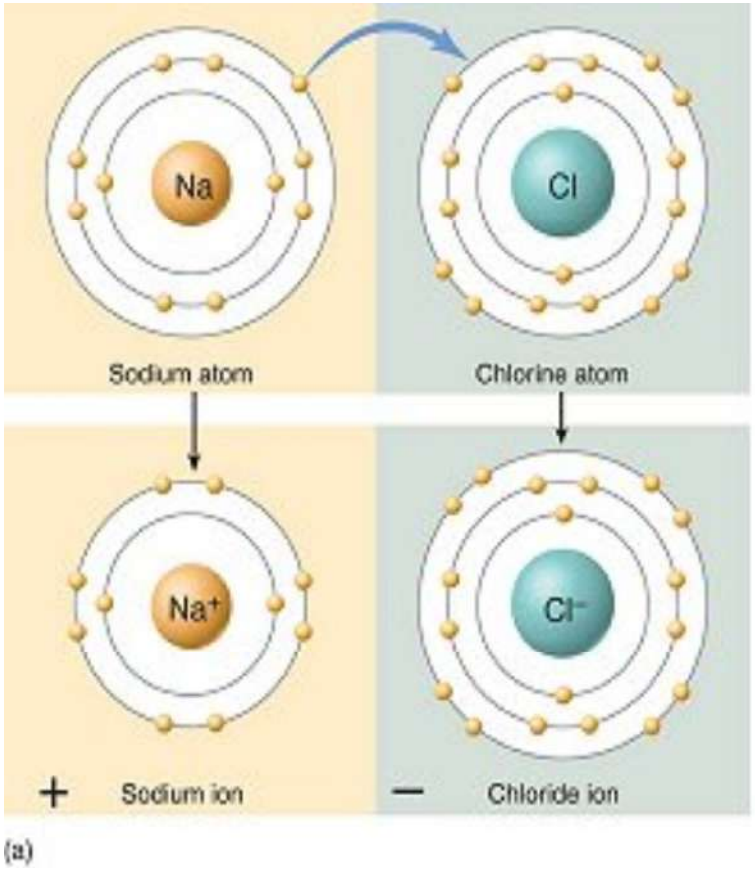
- Ionic bonds are formed when individual atoms transfer electrons between one another, forming ions of opposite charges, which are then held together by a difference in charge called electrostatic attraction.



Ionic Bonds

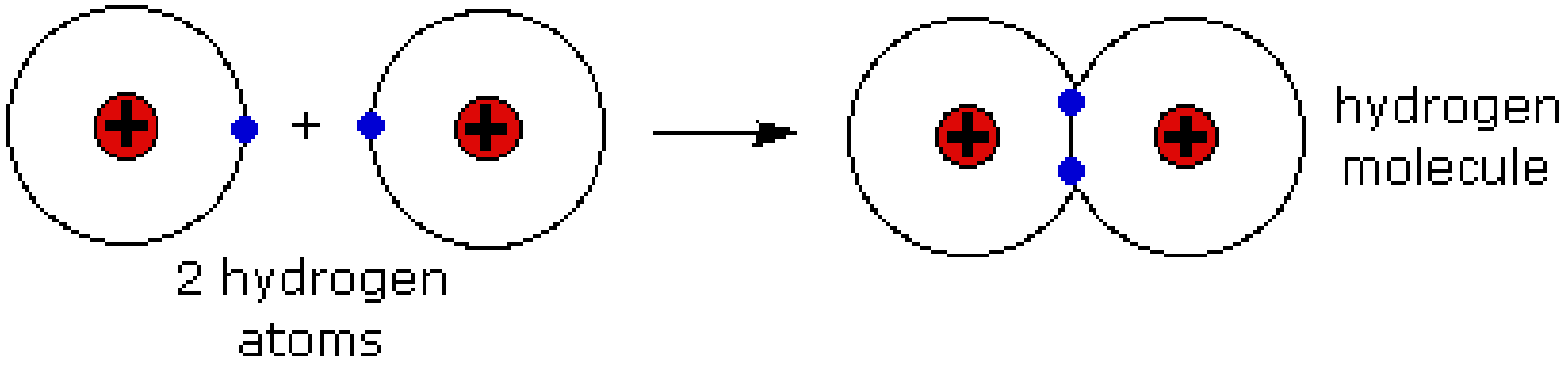
- Ionic bonds generally occur between metals and non-metals. Why?
  - Metals have weak attractions for their valence electrons due to larger atomic radii and lower electronegativity values, so they tend to lose electrons (form positively charged ions, aka cations) to achieve a stable octet.
  - Nonmetals have strong attractions for their valence electrons due to smaller atomic radii and higher electronegativity values, so they tend to gain electrons (form negatively charged ions, aka anions) to achieve a stable octet.
  - They are perfect partners for each other! They will transfer electrons between each other because of the large difference in their electronegativity values.

Ionic Bonding – A Closer Look!



Covalent Bonds

- Covalent bonds are formed when individual atoms share two or more electrons between them. The atoms are then held together by an overlapping of electron clouds.
  - Covalent bonds occur between non-metals of similar electronegativity values.



Compounds – a Review

- A compound results when two or more elements combine chemically through the formation of chemical bonds.
- There are two major types of compounds
  - Ionic
  - Covalent

Ionic Compounds – Cont'd

- Formulas are always written metal cation first, non-metal anion last!
- Examples:
  - NaCl
  - LiF
  - Ca_3P_2
  - MgI_2

Covalent Compounds – Cont'd

- Formulas generally written with most electronegative element at end of formula, or from left to right as they are found on the periodic table
- Examples:
  - H_2O
  - NO
  - CO_2
  - NF_3

Naming Compounds

- Now that we can differentiate between ionic and covalent compounds, we can learn how to name compounds according to specific rules.
- These rules are based on the type of bonding that occurs (ionic or covalent). Remember that *ionic compounds* are generally made up of *metal cations* and *nonmetal anions* whereas *covalent compounds* are made up of *only nonmetals*.

Simple Binary Ionic Compounds

- Simple binary ionic compounds consist of one type of metal bonded to one type of non-metal. Metals in these compounds are *univalent.*
- Univalent metals have only *one possible charge/valence*, predicted by how many electrons that metal must lose to achieve a stable octet, and they *generally* come from the s-block of the periodic table, though there are some metals of the p- and d-blocks also known to be univalent.

Simple Binary Ionic Compounds

Binary Ionic	Not Binary Ionic
$NaCl$	$MgSO_4$
K_2O	$Cu(NO_3)_2$
SrF_2	K_3PO_4
Li_3P	$CaSO_3$
$BaBr_2$	$Fe(OH)_3$
CaI_2	$NaC_2H_3O_2$
Na_2S	$K_2Cr_2O_7$
Mg_3N_2	$KMnO_4$

Rules for Naming Simple Binary Ionic Compounds

Name of simple binary ionic compound = *name of metal + name of non-metal changed to –ide ending/suffix.*

- NaCl = Sodium chloride
- RaF_2 = Radium fluoride
- MgO = Magnesium oxide
- KCl = Potassium chloride
- Li_3P = Lithium phosphide
- Mg_3N_2 = Magnesium nitride

Your Turn! Name the following:

LiI	Lithium iodide
MgS	Magnesium sulfide
K_3P	Potassium phosphide
CaO	Calcium oxide
RbF	Rubidium fluoride
$SrCl_2$	Strontium chloride

Multivalent Metals

- Some metals, particularly those of the d-block (and some from the p-block) with lots of electrons, have more than one way to achieve stability. Hence, they have more than one possible charge they can assume. This means that these metals can form more than one compound with the same nonmetal element. We call these metals ***multivalent*** metals.

Multivalent Metals – Cont'd

- For example, iron can form an ion with either a +2 or +3 charge. When it combines with the nonmetal chlorine, it can form two different compounds: $FeCl_2$ (iron with a +2 charge), or $FeCl_3$ (iron with a +3 charge). These compounds have different properties, so they are different compounds, even though they contain the same elements. They contain the elements iron and chlorine, but these elements occur in different ratios in the two different compounds. Since they are different compounds, we must have a way of naming them differently to reflect their unique identity.

Naming Binary Ionic Compounds with Multivalent Metals

- If the metal in the compound is a *multivalent* metal (a metal that can have more than one possible charge), the name must include information about its oxidation state (charge). Metals whose charges are unpredictable and their possible charges are found on the chart called Metals with Unpredictable Valences. You will need a copy before going any further. You should notice that these metals usually come from d block.

Naming Binary Ionic Compounds with Multivalent Metals

- If the metal has been determined to be a multivalent metal (by looking on the list of Metals with Unpredictable Valences), insert Roman numerals in parentheses after the name of the metal to indicate which oxidation state (charge) of the metal applies to the compound.

Examples

- $FeCl_2$ → iron (II) chloride
- CuO → copper (II) oxide
- NiN → nickel (III) nitride
- $CoBr_2$ → cobalt (II) bromide
- Cu_3P_2 → copper (II) phosphide
- Au_2S → gold (I) sulfide

But how did I know which charge to use in each of these names?

Examples Explained!

- $FeCl_2$ → www.showme.com/sh/?h=tjTUUts
- CuO → www.showme.com/sh/?h=vrrwu00
- NiN → www.showme.com/sh/?hfubEZM0
- $CoBr_2$ → www.showme.com/sh/?h=yopl8E4
- Cu_3P_2 → www.showme.com/sh/?h=Fafpl6C
- Au_2S → www.showme.com/sh/?h=NJgJ528

Ionic Naming Practice

Name the following. All compounds are binary ionic, but some contain multivalent metals, whereas others do not. Use Roman numerals only when the compound contains a multivalent metal.

1. LiI	1. Lithium iodide
2. AlF_3	2. Aluminum fluoride
3. $FeCl_2$	3. Iron (II) chloride
4. CuO	4. Copper (II) oxide
5. BaF_2	5. Barium fluoride
6. PbS	6. Lead (II) sulfide
7. Na_3N	7. Sodium nitride
8. AgI	8. Silver iodide
9. Ca_2C	9. Calcium carbide
10. KH	10. Potassium hydride
11. Fe_2O_3	11. Iron (III) oxide

How to Determine a Formula from a Name – Ionic Compounds

1. Write out symbols for all of the ions present. Keep in mind that the ions may be polyatomic ions.
2. Write out the charges of each ion as superscripts (to the upper right-hand side of the ion symbol).
3. The sum of the charges must always be equal to zero because compounds are electrically neutral.
4. If the superscripts do not add up to zero, use the criss-cross method to determine the subscripts, dropping the sign on the charge. (i.e. subscripts will always be positive!)
5. The formula for the compound should be written in lowest terms, i.e., reduce all subscripts if possible. (Ca_2O_2 would reduce to CaO) NEVER REDUCE THE SUBSCRIPT PORTION OF A POLYATOMIC ION! (Na_2O_2, sodium peroxide, should NOT be reduced to NaO!)

Examples

Note: Click on a compound name below to connect to a video that will explain how to determine the formula for each compound.

- Calcium chloride
- Iron (II) bromide
- Magnesium oxide

Formula Practice

1. Beryllium oxide
2. Sodium sulfide
3. Aluminum chloride
4. Chromium (III) oxide
5. Iron (II) bromide
6. Cobalt (II) sulfide

1. BeO
2. Na_2S
3. $AlCl_3$
4. Cr_2O_3
5. $FeBr_2$
6. CoS

Covalent Compounds

- Unlike ionic compounds that consist of both metals and non-metals, covalent compounds are composed of ONLY non-metals (those elements to the right of the stair-step, plus hydrogen).
- We will only name BINARY covalent compounds, i.e. those consisting of only two different nonmetals.

Ionic vs. Covalent

Binary Ionic	Binary Covalent
NaCl	H_2O
MgO	CO_2
CaS	PCl_5
Li_3N	N_2O_5
K_2S	CCl_4

Rules for Naming Covalent Compounds

- Name of covalent compound = Name of the first element + the name of the second, using ***prefixes*** to indicate the number of each element present in the compound. The ending on the second element is changed to –ide because these compounds are binary.
- If there is only one of the first non-metal, you should omit its prefix.

- Essential prefixes:
  - Mono-1
  - Di-2
  - Tri-3
  - Tetra-4
  - Penta-5
  - Hexa-6
  - Hepta-7
  - Octa-8
  - Nona-9
  - Deca-10

Covalent Naming Practice

1. CCl_4
2. N_2O_4
3. H_2O
4. CO_2
5. PF_3

1. Carbon tetrachloride
2. Dinitrogen tetroxide
3. Dihydrogen monoxide
4. Carbon dioxide
5. Phosphorous trifluoride

- Determining the formula from the name:
  1. Write out all of the elements present.
  2. The prefix tells you how many of each element are present; this is the subscript.
  3. DO NOT reduce to lowest-terms.

1. Phosphorous triiodide.
2. Xenon hexafluoride.
3. Carbon tetrahydride.
4. Dinitrogen pentoxide.
5. Carbon monoxide.
6. Tetraphosphorous decoxide

1. PI_3
2. XeF_6
3. CH_4
4. N_2O_5
5. CO
6. P_4O_{10}