Topic 6 - Chemical Compounds

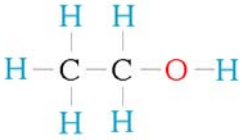
When any of the 112 elements combine into groups of 2 or more they form compounds. If an atom of an element transfers electrons to another atom of a different element, an ionic compound is formed. If atoms of elements are shared, a molecular compound is formed.

Understanding Formulas for Compounds

The combination of elements to form compounds has a chemical formula and a chemical name. The chemical formula uses symbols and numerals to identify which elements and how many atoms of each element are present in the compound.

For example:

ethanol (C_2H_6O) has **2** carbon atoms, **6** hydrogen atoms and **1** oxygen atom



To determine a chemical name, a standardized chemical naming system, or nomenclature, is used. Guyton de Morveau in France developed it in 1787. The metal name is always first. Since 1920, the **IUPAC** (*International Union of Pure and Applied Chemistry*) is responsible for determining the appropriate name for each compound.

If you know the formula for a compound you can determine its chemical name
If you know its name, you can determine its formula.

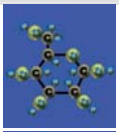
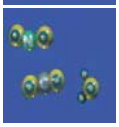
Write the **chemical formula** as determined by the **name** of the compound.
(If a poly atomic ion is part of the formula, keep the poly-atomic ion intact)

Aluminum oxide	2 - Al	3 - O	Al_2O_3
Calcium nitrite	1 - Ca	2 - NO_2	$Ca(NO_2)_2$
Sodium Chloride	1 - Na	2 – Cl_2	NaCl

If the compound contains a metal the compound is ionic.
If the compound does not contain a metal, it is molecular.

Write the **name** of the compound as determined by the **chemical formula.**

Al_2O_3	2 - Al	3 - O	Aluminum oxide
$Ca(NO_2)_2$	1 - Ca	2 - NO_2	Calcium nitrite
NaCl	1 - Na	2 – Cl_2	Sodium Chloride

Chemical Name & Physical State	Atomic model	Chemical Formula
Glucose (s) - solid		**$C_6H_{12}O_6$** The chemical formula for glucose tells us that each molecule is made of 6 carbon atoms, 12 hydrogen atoms, and 6 oxygen atoms.
Nitrogen dioxide (g) - gas **Carbon dioxide** (g) - gas **Water** (l) – liquid		**NO_2** **CO_2** **H_2O**

(aq) – **aqueous solution** This is used when substances are dissolved in water.
A saltwater solution would be **NaCl** (aq)

Molecular Compounds

A molecule is the smallest independent unit of a pure substance. Diatomic molecules are molecules made up of 2 atoms of the same element (oxygen O_2, nitrogen N_2, hydrogen H_2). Most molecular compounds do not form large structures.

When *non-metals* combine, they produce a pure substance called a molecule, or molecular compound. They can be solids, liquids, or gases at room temperature. The bonding between atoms is strong, but the attraction between the molecules is weak.

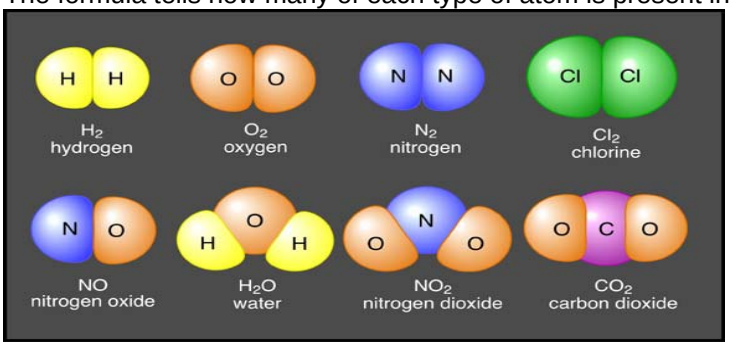
Examples: sugar ($\mathbf{C_{12}H_{22}O_{11(s)}}$)
acetylene, water

Properties of **molecular compounds**
- Low melting point
- Low boiling point
- Good insulators
- Poor conductors
- Distinct crystal shape

Of the 10 million compounds discovered so far, about 9 million are molecular compounds

Writing Formulas For Molecular Compounds

The formula tells how many of each type of atom is present in the molecule.



How Are Molecular Compounds Named?

A compound made from two elements is called a binary compound.

Rules for naming binary molecular compounds:

1. The first element in the compound uses the element name
2. The second element has a suffix – **ide** –
3. When there is more than 1 atom in the formula, a prefix is used which tells how many atoms there are:
4. Exception to #3 above – when the first element has only 1 atom the prefix mono is not used

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

Examples: $\mathbf{CO_{2(g)}}$ carbon **di**oxide $\mathbf{CCl_{4(l)}}$ carbon **tetra**chloride $SiO_{2(s)}$ Silicon **di**oxide

If you are changing from the written name to the chemical symbol:
1. Write the symbols for the elements in the same order as they appear in the name.
2. Use subscripts to indicate the numbers of each type of atom.

Some molecular compounds are better known by their common names rather than their chemical names, example: water H_2O is actually dihydrogen oxide, propane C_3H_8 is tricarbon octahydride. The bracketed symbol following the chemical formula represents what state (solid, liquid, gas) the compound is in. (aq) means aqueous (water) solution.

Ionic Compounds

Ionic compounds are pure substances formed as a result of the attraction between particles of opposite charges, called **ions**. When an atom gains or loses electrons, the atom is no longer neutral – it is an ion, either positively or negatively charged.

Properties of ionic compounds
- High melting point
- Good electrical conductivity
- Distinct crystal shape
- Solid at room temperature

Sodium Chloride (table salt) – **NaCl** – is an **ionic compound**. When it is dissolved in water, the metal (**Na**) loses an electron – to become positively charged - and the nonmetal (**Cl_2**) gains an electron – to be negatively charged - forming an aqueous solution of ions. Conductivity is the ability of a substance to carry an electric current. The ionic salt solution provides good conductivity. Positive sodium ions attract negative chloride ions to form a cube-shaped arrangement (ionic model). The force holding them together is called ionic bonds.

Ion Charges

A superscript (**+**) or a (**–**) are used to indicate the charge. **Na^+** and **Cl^-**
Some ions can also form when certain atoms of elements combine. These ions are called **polyatomic** ions (*poly* meaning "*many*"). Polyatomic atoms are a group of atoms acting as one.
Example:

1 carbon atom reacting with 3 oxygen atoms produces
1 carbonate group of atoms, which act as one. **CO_3^{2-}**

Then, when carbonate ions react with calcium atoms they produce calcium carbonate, or known by its common name - limestone. **Ca CO_3^{2-}**

How Are Ionic Compounds Named?

Two rules:
1. The chemical name of the metal or positive ion goes first, followed by the name of the non-metal or negative ion.
2. The name of the non-metal negative ion changes its ending to **ide**.

NB: *one exception* – Where negative ions are polyatomic ions, the name remains unchanged.
Some elements with *more than one ion charge* use a roman numeral in its chemical name to clearly show which ion is being used. **Cu(II)SO_4** (Copper II Sulfate)

Using Ion Charges and Chemical Names To Write Formulas

Step 1 – Print the metal element's name, symbol and ion charge, then the non-metals name, symbol and ion charge
Step 2 – Balance the ion charges (the positive ion must balance with the negative ion
Step 3 – Write the formula by indicating how many atoms of each element are in it.

Ca^{2+} Cl^{1-}
Ca^{2+} Cl^{1-} Cl^{1-}
$CaCl_2$

Periodic Table Patterns:	ion charge
Alkali metals	1+
Halogens	1 -
Generally elements in a group all have the same ion charge (most consistency at either end of the table)	

All ionic compounds have ***distinct*** (different) ***crystal shapes***.