Chapter 5 - The Structure of Matter

Section 1 - Compounds and Molecules

Compounds vs Mixtures

Elements combine to form a **<u>compound</u>**, the compound has properties different from the elements that make it

- Na + Cl = NaCl

<u>Mixtures</u> are made of different substances that are just placed together

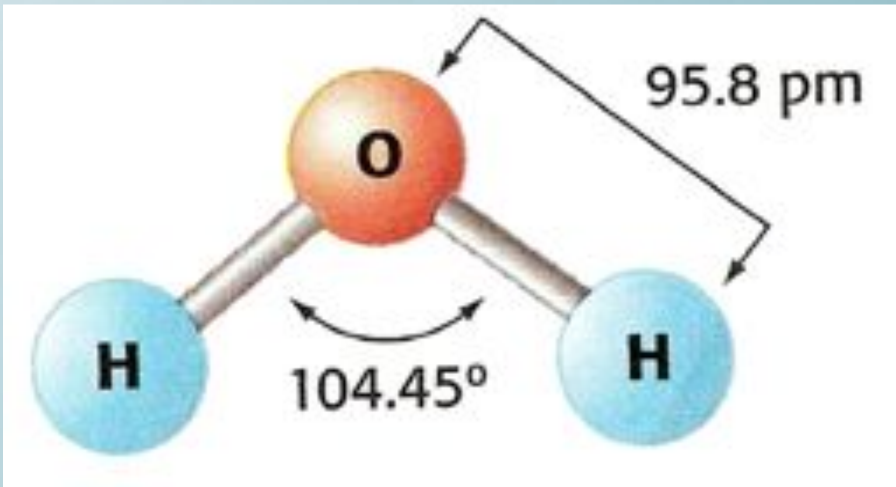
Compounds are held together by **chemical bonds**

Compounds always have the same **chemical formula**

Water = H_2O

Table Salt = NaCl

The **chemical structure** is the arrangement of atoms in a substance

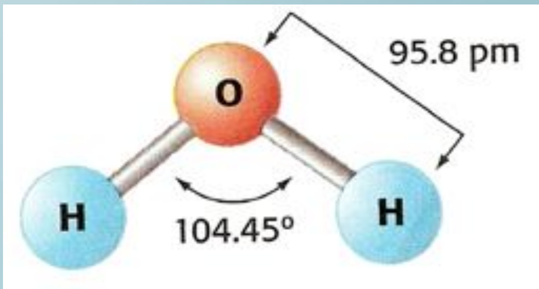


The **bond length** is the distance between nuclei of bonded atoms

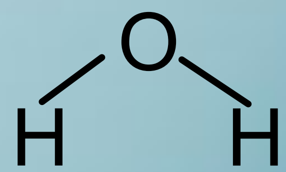
The **bond angle** show how atoms are oriented in the space of a substance

Models of Compounds

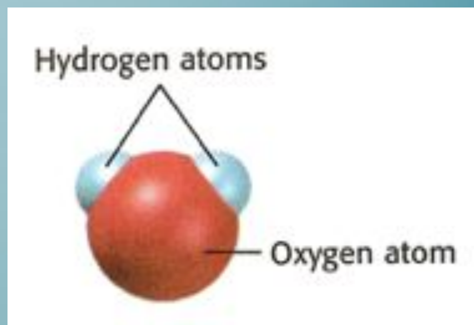
- Ball-and-stick Model



- Structural Formula



- Space-filling Model



Structure directly affects properties

Quartz = Large network of bonded atoms

Table Salt = Large network of bonded positive and negative ions

Water = Made up of many separate molecules

Compounds with network structures are strong solids

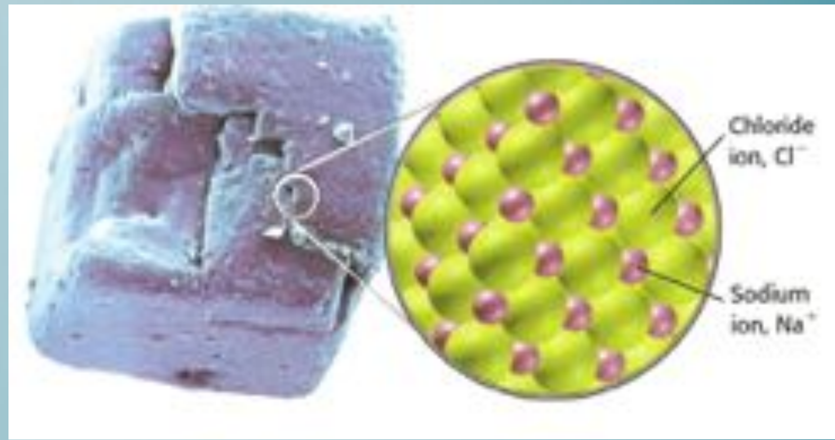
SiO2 (quartz, sand) has a very high melting point

This is because each silicon atom in quarts is bonded to four oxygen atoms

It takes a lot of energy to break these bonds

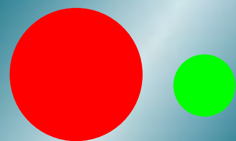
Compounds made of networks of bonded ions

Sodium Chloride (NaCl) also has a very high boiling point



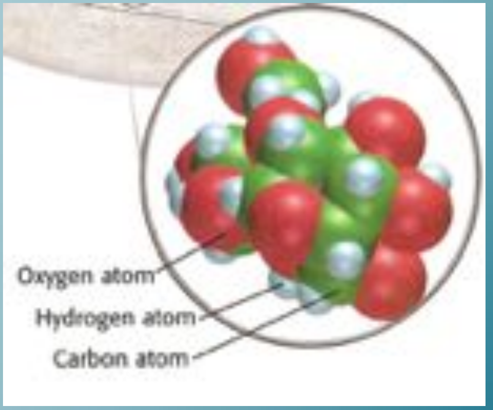
Sodium and Chlorine are held together due to opposite electrical charges

This is a very strong attraction, so it takes lots of energy to break it

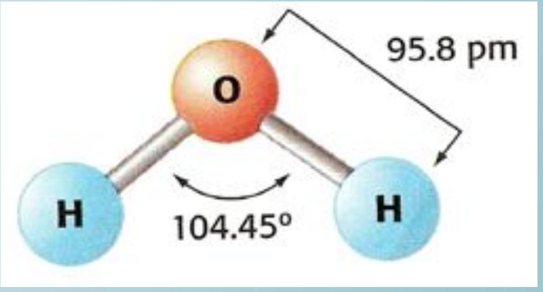


Some compounds are made of molecules

A sugar molecule is made of carbon, hydrogen, and oxygen atoms joined by bonds



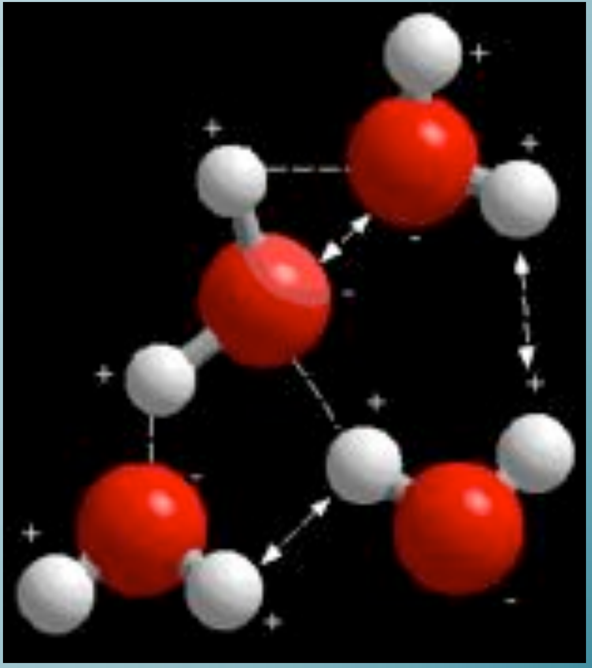
The individual molecules of sugar attract each other to form crystals



This attractions is much weaker than others, so it has a low melting point

Ionic, Covalent and Metallic Bonding

These are the 3 primary types of bonds in which atoms and molecules are joined together



In an **Ionic Bond**, one atom completely donates its electron to the other

The resulting charged ions then "stick" together due to opposite charges

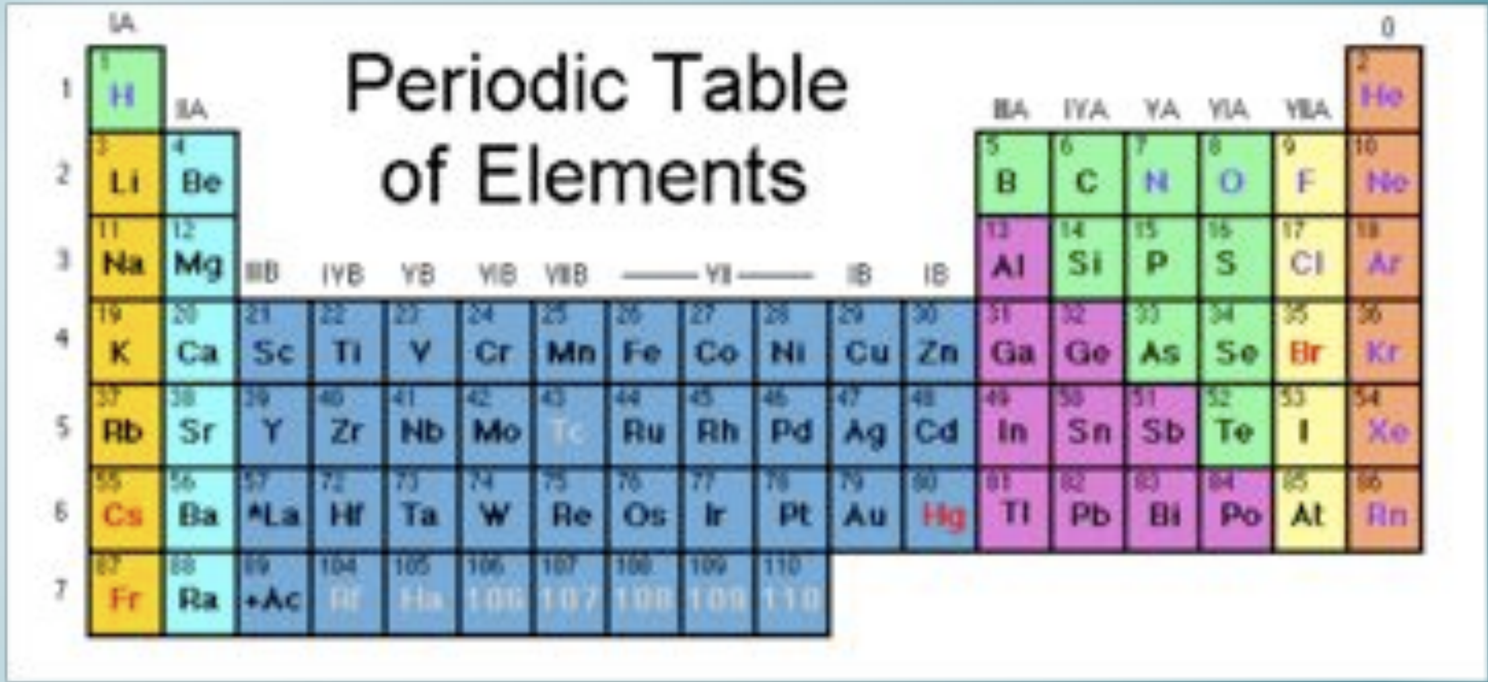
Forms networks, not molecules

● Electrons

Ionic Bonding

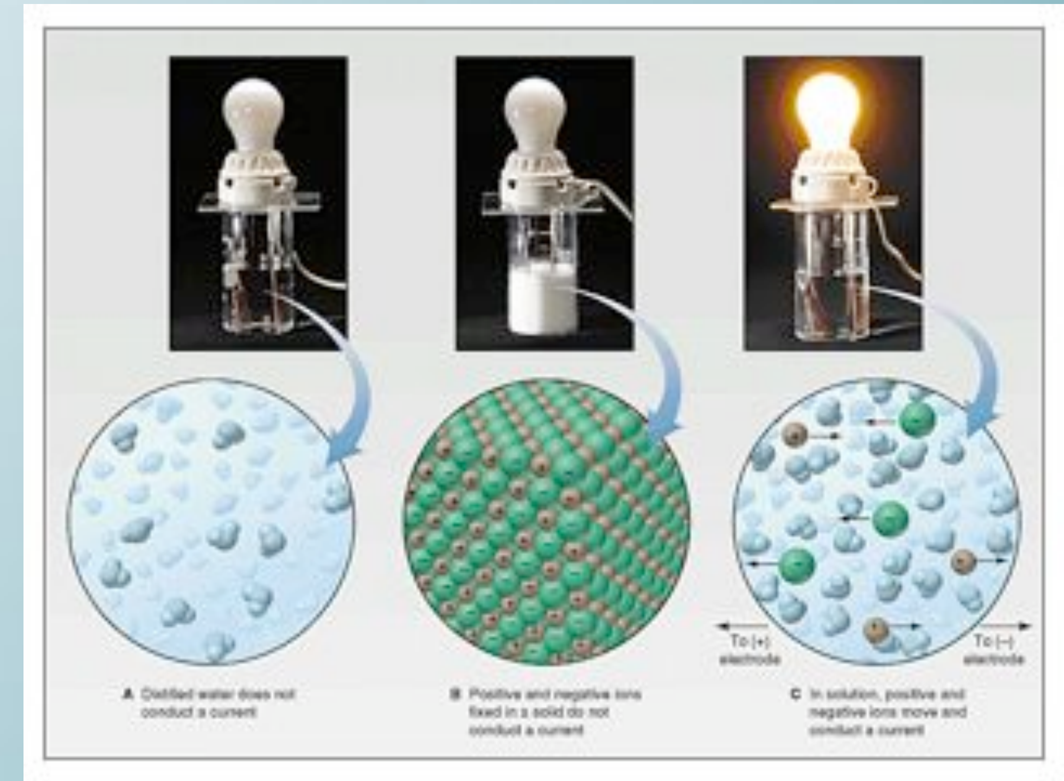
Group 1 elements bond with Group ___ elements

Group 2 elements bond with Group ___ elements



Basically things on the left side of the table, like to form ionic bonds with thing on the right side

Ionic compounds often "dissociate" (break apart into ions) when placed in water



When ionic compounds are dissolved in water they can conduct electricity!

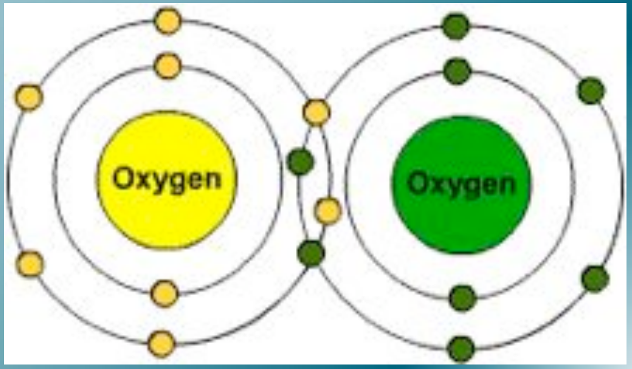
In a **Covalent Bond**, atoms share electrons

Some electrons spend half of their time around each atom in the molecule

● Electrons

Forms molecules

Atoms often share more than one pair of electrons



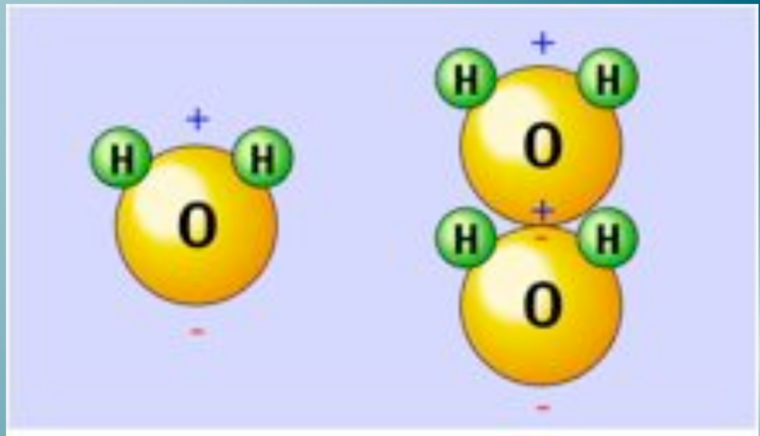
If only 2 atoms covalently bonded, they will each share the electron(s) evenly

O_2, N_2

nonpolar covalent bond

polar covalent bond

If 3 or more atoms covalently bonded,there may be unequal sharing of electrons



Polyatomic Ions

Polyatomic Ions are groups of covalently bonded atoms that have either lost or gained electrons

Common Polyatomic Ions			
$C_2H_3O_2^-$	acetate	OH^-	hydroxide
NH_4^+	ammonium	ClO^-	hypochlorite
CO_3^{2-}	carbonate	NO_3^-	nitrate
ClO_3^-	chlorate	NO_2^-	nitrite
ClO_2^-	chlorite	$C_2O_4^{2-}$	oxalate
CrO_4^{2-}	chromate	ClO_4^-	perchlorate
CN^-	cyanide	MnO_4^-	permanganate
$Cr_2O_7^{2-}$	dichromate	PO_4^{3-}	phosphate
HCO_3^-	bicarbonate	SO_4^{2-}	sulfate
HSO_4^-	bisulfate	SO_3^{2-}	sulfite
HSO_3^-	bisulfite		

Polyatomic Ions act the same as other ions

When writing the chemical formula, parentheses group the atoms of the polyatomic ions

Ammonium = NH_4^+

Sulfate = SO_4^{-2}

$N_2H_8SO_4$

$(NH_4)_2SO_4$

Naming polyatomic ions

ate = more oxygen
ite = less oxygen

Common Polyatomic Ions			
$C_2H_3O_2^-$	acetate	OH^-	hydroxide
NH_4^+	ammonium	ClO^-	hypochlorite
CO_3^{2-}	carbonate	NO_3^-	nitrate
ClO_3^-	chlorate	NO_2^-	nitrite
ClO_2^-	chlorite	$C_2O_4^{2-}$	oxalate
CrO_4^{2-}	chromate	ClO_4^-	perchlorate
CN^-	cyanide	MnO_4^-	permanganate
$Cr_2O_7^{2-}$	dichromate	PO_4^{3-}	phosphate
HCO_3^-	bicarbonate	SO_4^{2-}	sulfate
HSO_4^-	bisulfate	SO_3^{2-}	sulfite
HSO_3^-	bisulfite		

Section 3 - Compound Names and Formulas

Naming Ionic Compounds

Cation = (+) charge ion

Anion = (-) charge ion

Cation name comes first, anion second

The cation portion of the name is simply the name of the element + ion

Calcium ion
Potassium ion

The anion portion of the name is changed slightly

The suffix is changed to -ide

Flourine	Flouride ion
Iodine	Iodide Ion
Oxygen	Oxide Ion
Nitrogen	Nitride ion

What is the name of the following?

$NaCl$

MgO

FeO

Fe_2O_3

Transition metals may form several different cations

In these cases, the cation portion of the name must show the charge of the cation (with Roman Numerals)

FeO

Fe_2O_3

Naming Covalent Compounds

Different naming rules are used

1	mono
2	di
3	tri
4	tetra
4	penta

For two-element covalent compounds, numerical prefixes tell how many atoms of each element are in the molecule

If there is only one atom of the first element, it does not get a prefix

Whichever element is farther to the right of the periodic table is named second and ends in **-ide**

BF_3

N_2O_4

Emeralds = $Be_3Al_2Si_6O_{18}$

How do they know this? They start by measuring the mass of each element in the compound

They can then figure out the **empirical formula**, or a compounds simplest formula

An empirical formula cannot be reduced any further

H_2O → Ratio of two hydrogen atoms to each oxygen atom

Determining Empirical Formulas

If a 142 g sample of an unknown compound contains 62 grams of P (phosphorus) and 80 grams of O (oxygen), what is its empirical formula?

We need to calculate the number of **moles** of each element

Some compounds have the same empirical formulas, even though they are very different

Compound	Empirical Formula	Molar Mass	Molecular Formula
Formaldehyde	CH_2O	30.03 g/mol	CH_2O
Acetic Acid	CH_2O	60.06 g/mol	$C_2H_4O_2$
Glucose	CH_2O	180.18 g/mol	$C_6H_{12}O_6$

Calculate Molecular Formula

$$\frac{\text{Molar Mass}}{\text{Empirical Formula Mass}} = \text{Molecular Formula Multiple}$$

Sometimes the empirical formula and molecular formula are the same: Water, Formaldehyde