Forces between particles
chapter 4

How are atoms held together?

Chemical Bonding

Lewis Structures or symbols: electron-dot structures

Filled outer shell/subshell → atom stable

Outer shell called valence shell

Chemical Bonding

For most atoms, a outer shell contains 8 electrons an octet

Exceptions: hydrogen and helium have 2 electrons when filled

CHEMICAL BONDING

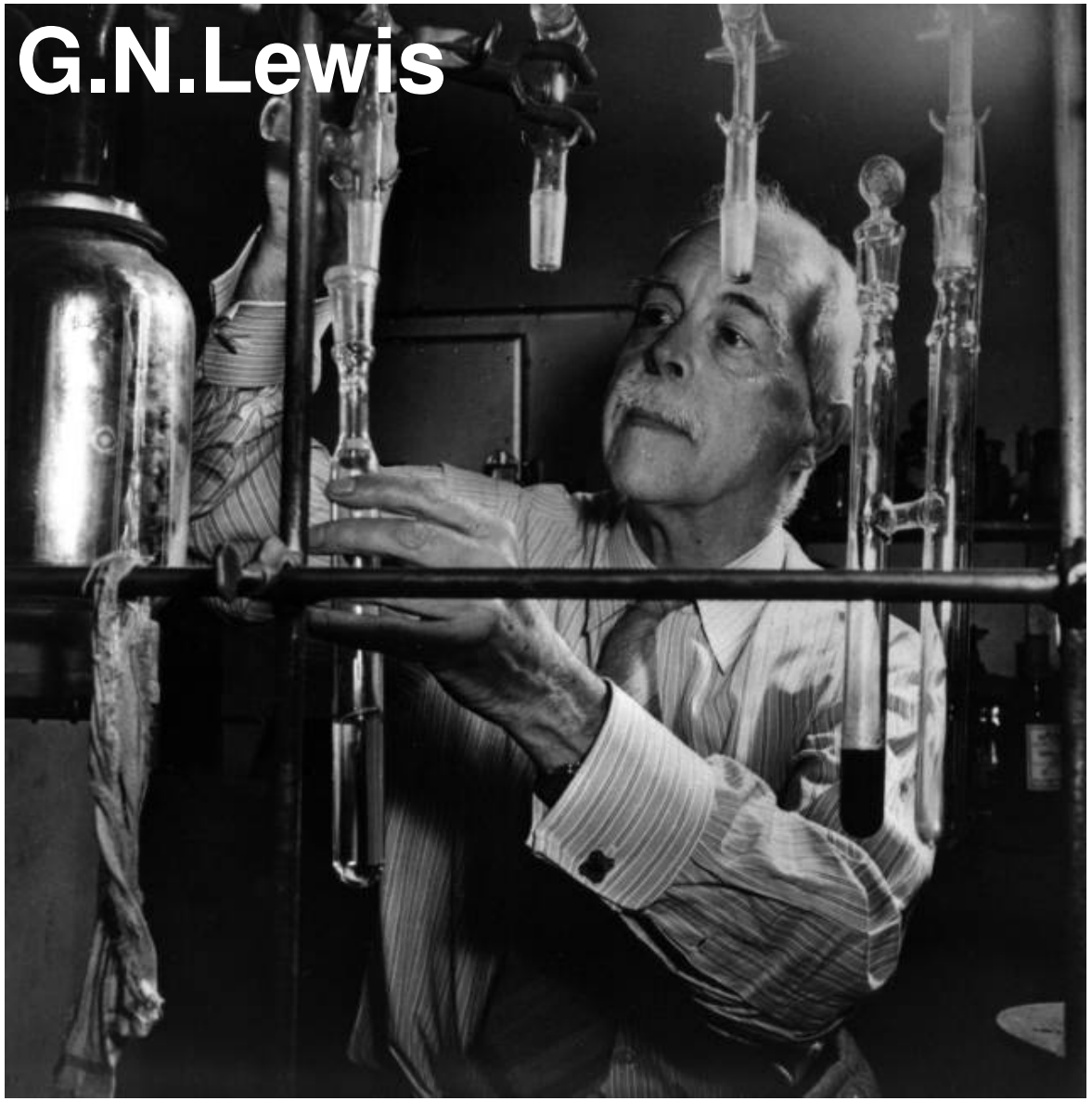
Atoms will do one of two things to fill valence shell:

1. **gain or lose electrons to achieve filled outer shell**
   metals + nonmetals
2. **share electrons**
   nonmetals + nonmetals

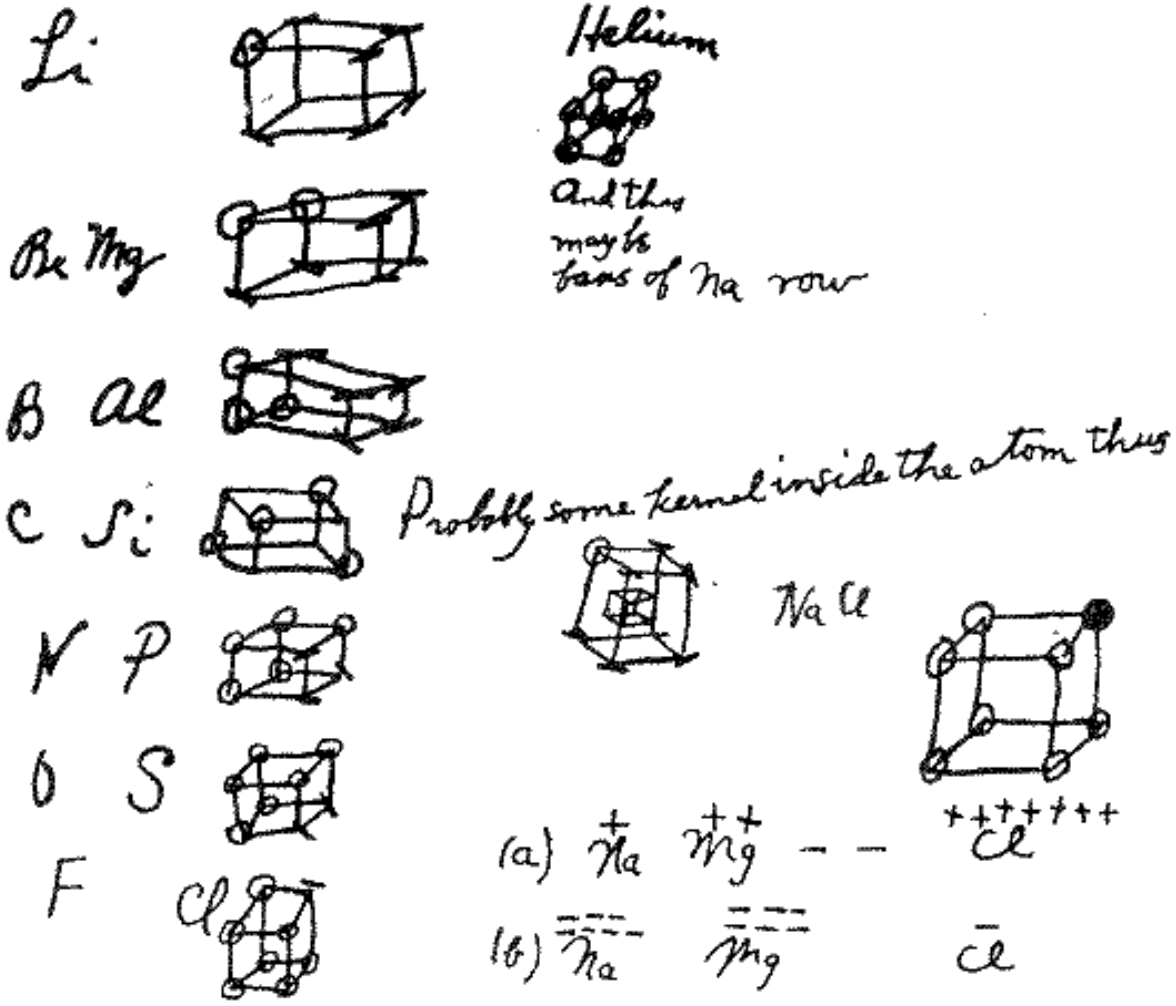
CHEMICAL BONDING

Keep track of electrons around atoms, ions and molecules

Lewis Structures


G.N.Lewis

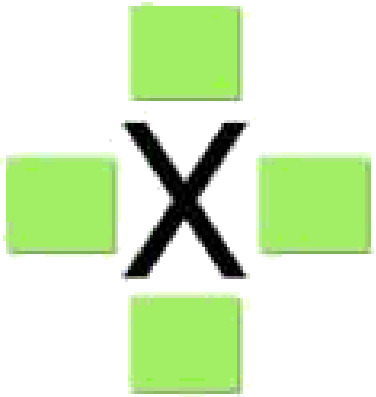
Early notes: G.N.Lewis



CHEMICAL BONDING

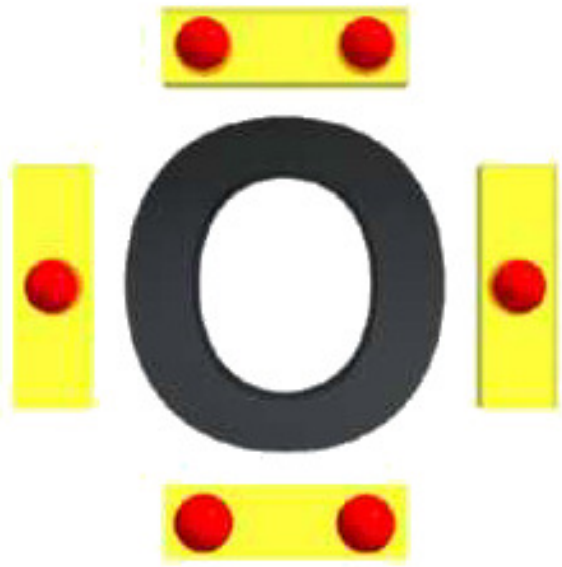
If the number of electrons in the valence shell of an atom is known, writing Lewis symbols is easy

CHEMICAL BONDING



- Draw the atomic symbol
- Count the electrons in the valence shell
- Treat each side as a box that can hold up to 2 electrons
- Start filling box - don't make pairs unless you have to

Chemical Bonding



6 valence electrons

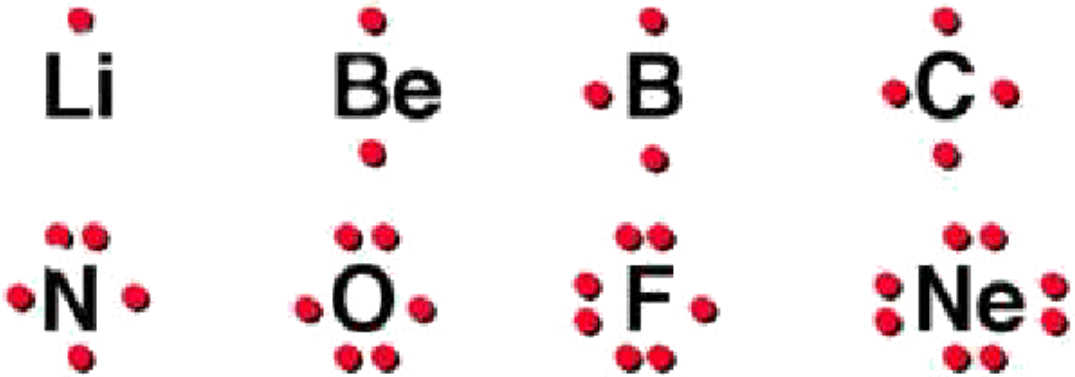
$O: 1s^2 2s^2 2p^4$

⇦ This is the Lewis symbol for oxygen

Chemical Bonding

no. dots = no. valence electrons

Lewis symbols for period 2 elements



CHEMICAL BONDING

When nonmetals join they share electrons

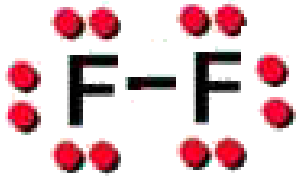
CHEMICAL BONDING

Two atoms of fluorine combine to give one molecule = F_2

dash represents shared electrons

CHEMICAL BONDING

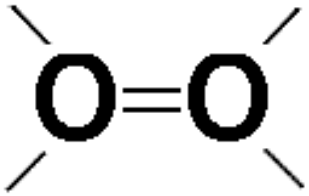
Electrons can be shared or unshared



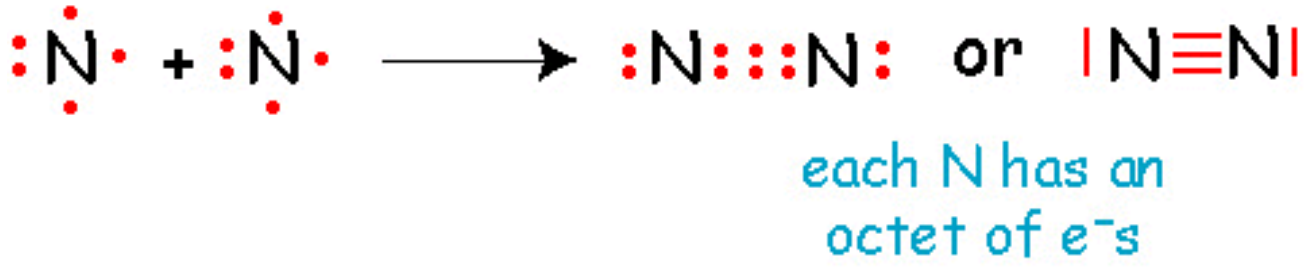
One pair of shared electrons equals a single covalent bond

CHEMICAL BONDING

Bonds can be double (2 dashes) bonds

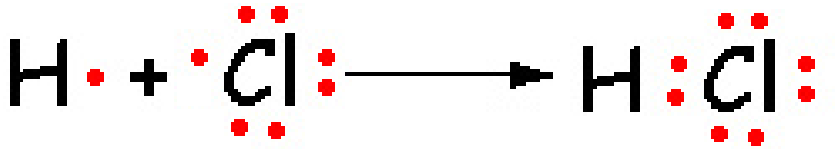


Bonds can be triple (3 dashes) bonds



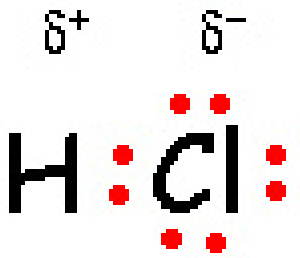
CHEMICAL BONDING

2 nonmetals share electrons
form covalent bonds
These are called covalent or molecular compounds



CHEMICAL BONDING

Atom's electronegativity determines which element shares the electrons the most. Produces a polar covalent bond

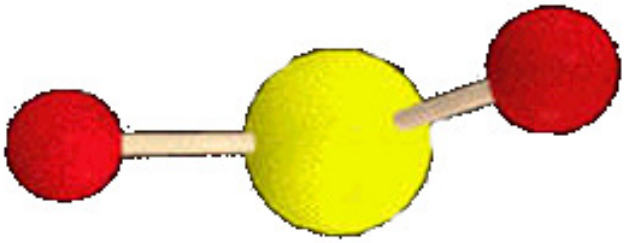


CHEMICAL BONDING

Molecules are not flat

Have 3D structure and shape

Linear shape for CO_2



Bent shape for H_2O

CHEMICAL BONDING

Ionic Compounds

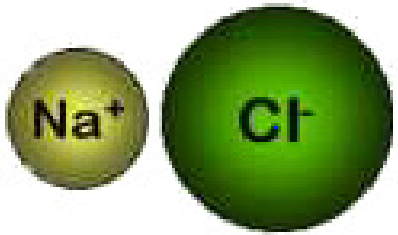
Bonds consist of attraction between a positive and negative ion

Bonds commonly form between metals and nonmetals

CHEMICAL BONDING

Ionic Compounds

Sodium chloride NaCl



Chemical Bonding

Ionic Compounds

Sodium chloride NaCl

Cl^- **Na^+**

CHEMICAL BONDING

Ionic Compounds

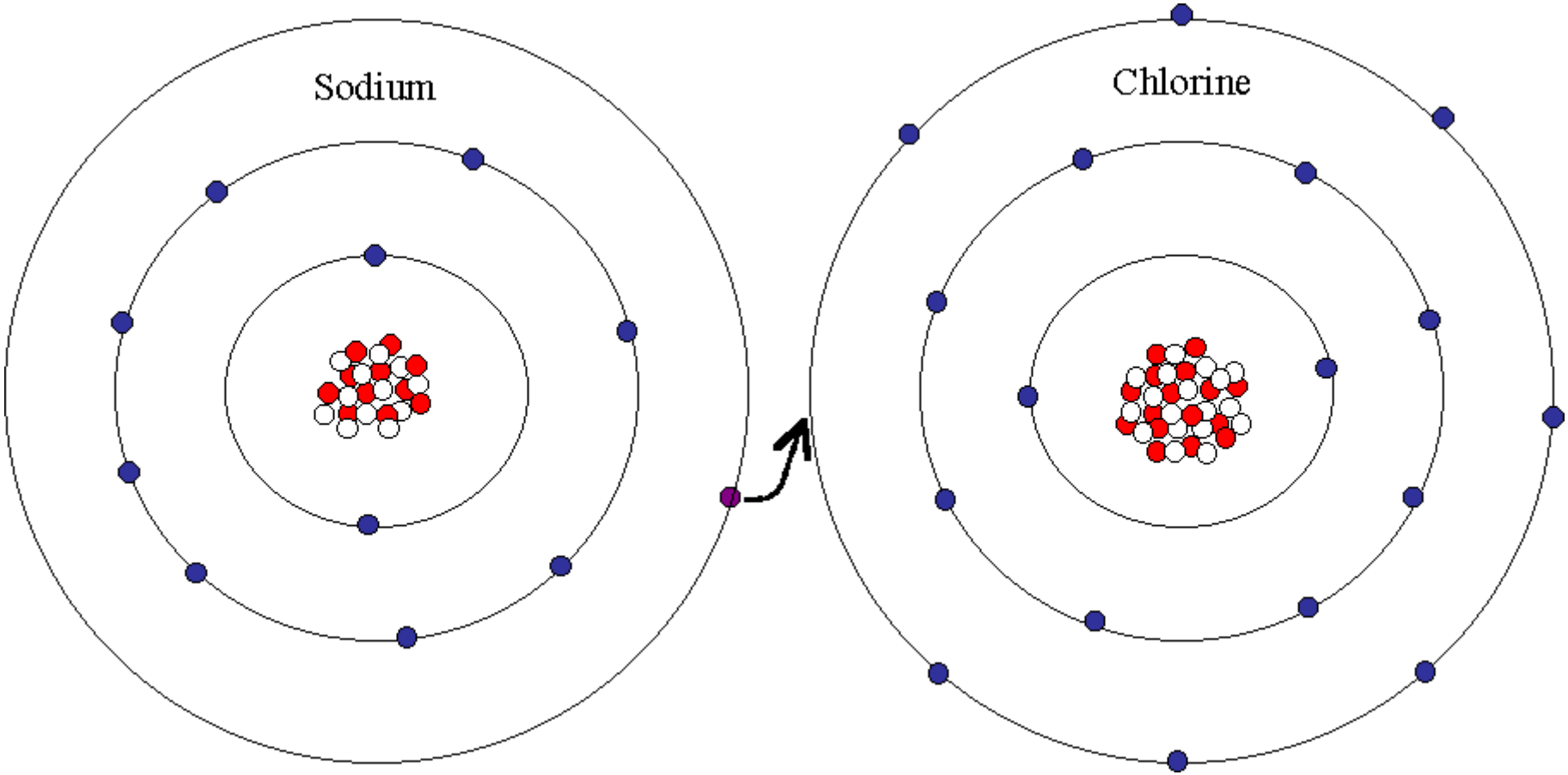
Ions are atoms that have gained or lost electrons to achieve an octet

metal $Na \rightarrow Na^+ + e^-$

nonmetal $Cl + e^- \rightarrow Cl^-$

CHEMICAL BONDING

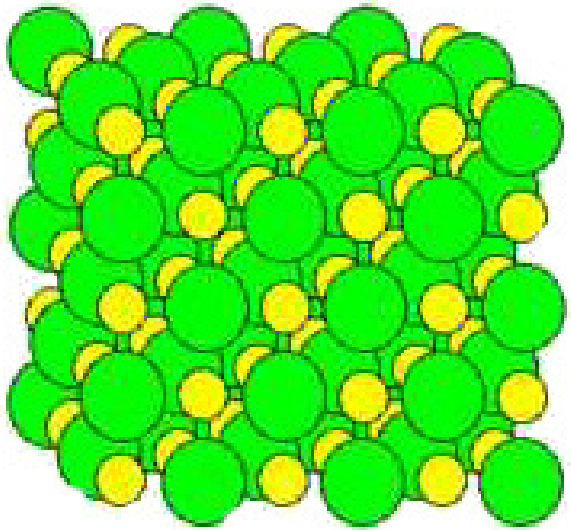
Ionic Compounds



CHEMICAL BONDING

Ionic Compounds

- Don't exist as individual molecules
- Tend to form crystals
- Ions touch many others



Chemical Nomenclature

Different systems for naming compounds

Organic compounds

Inorganic componds

Inorganic Nomenclature

Names based on formulas

NaCl - sodium chloride

CO_2 - carbon dioxide

Na_2CO_3 - sodium carbonate

Inorganic Nomenclature

Traditional or common names

H_2O - water

NH_3 - ammonia

Chemical Names and Formulas

H_2O NaCl

both examples of binary compounds

Binary Compounds

1) Two Non-metals

covalent compounds

Ending of second element changed to end in -ide

Binary Compounds

1) Two Non-metals

CO_2 ➜ carbon dioxide

CO_2 ➜ carbon **di**oxide

Binary Compounds

1) Two Non-metals

PCl_3 ➜ phosphorus trichloride

PCl_3 ➜ phosphorus tri**chloride**

Binary Compounds

1) Two Non-metals

N_2O ⇨ dinitrogen oxide

N_2O ⇨ dinitrogen oxide

TABLE 4.6 Greek numerical prefixes

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

Writing formulas from names

Phosphorus pentabromide

P 5 Br → PBr_5

Dichlorine heptasulfide Cl_2S_7

Binary Compounds

2) Metal + Non-metal

Ionic compounds

NAMING IONIC COMPOUNDS

Name the cation first
Name the anion second

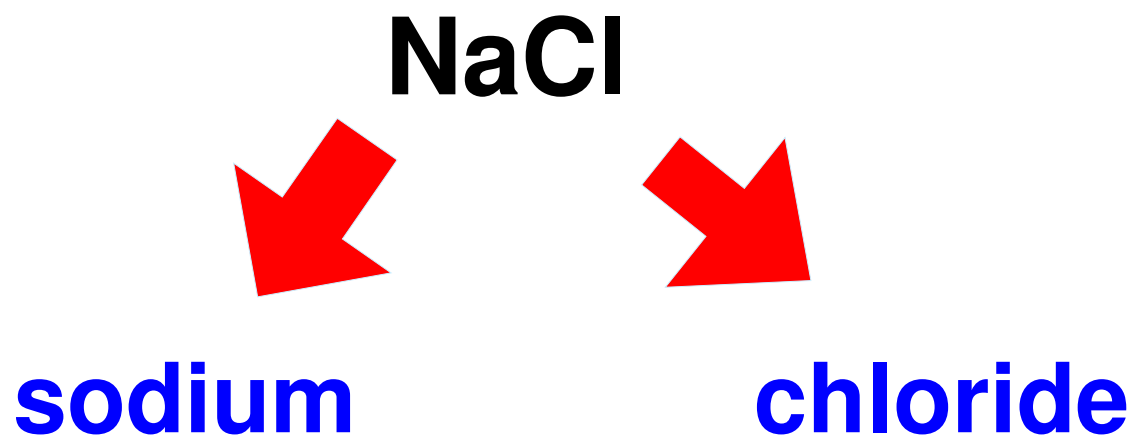
Monoatomic cations take their name from the element name

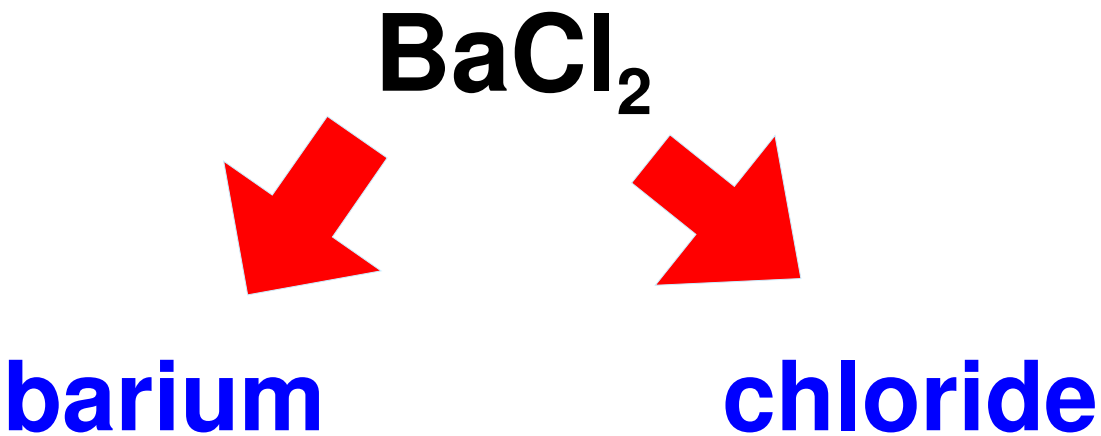
Na^+ = sodium
Al^{3+} = aluminum

Monoatomic anions take their names from the first part of the element name and then add "-ide"

TABLE 4.2 Stem names and ion formulas of common nonmetallic elements

Element	Stem	Formula of ion
Bromine	brom-	Br^-
Chlorine	chlor-	Cl^-
Fluorine	fluor-	F^-
Iodine	iod-	I^-
Nitrogen	nitr-	N^{3-}
Oxygen	ox-	O^{2-}
Phosphorus	phosph-	P^{3-}
Sulfur	sulf-	S^{2-}


NaCl
sodium
chloride



Note: no prefixes

Name the following.....

Li_2O	lithium oxide
ZnO	zinc oxide
$AlCl_3$	aluminum chloride
Ba_3N_2	barium nitride

Some metal cations have fixed charge

Some have variable charge

Monatomic Cation Charges

Gp 1: (+1) Li^+ Na^+ K^+

Gp 2: (+2) Mg^{2+} Ba^{2+} Ca^{2+}

Others: Al^{3+} Zn^{2+} Ag^+ NH_4^+

Ammonium ion

Monatomic Anion Charges

Gp 17:	-1	F^-	Cl^-	Br^-
Gp 16:	-2	O^{2-}	S^{2-}	
Gp 15:	-3	N^{3-}	P^{3-}	
Others:		H^-		

Variable charge metal ions to know:

Cobalt:	Co^{2+}	Co^{3+}
Iron:	Fe^{2+}	Fe^{3+}
Chromium:	Cr^{2+}	Cr^{3+}
Lead:	Pb^{2+}	Pb^{4+}
Copper:	Cu^{+}	Cu^{2+}

Name the following.....

CuO	copper(II) oxide
$FeCl_3$	iron(III) chloride
Cr_2O_3	chromium (III) oxide

Total charge cation = total charge anion

ZnO	$Zn^{2+}\ O^{2-}$
$AlCl_3$	$Al^{3+}\ \ (Cl^{-})_3$
Ba_3N_2	$(Ba^{2+})_3\ (N^{3-})_2$

Won’t use -ic and -ous endings

Common Polyatomic Ions

NH_4^+ ammonium

NO_3^- nitrate

SO_4^{2-} sulfate

CO_3^{2-} carbonate

PO_4^{3-} phosphate

OH^- hydroxide

CN^- cyanide

$C_2H_3O_2^-$ acetate

HCO_3^- hydrogen carbonate

Table 4.7, p 121

Name the following.....

$NaOH$	sodium hydroxide
$Ca(CN)_2$	calcium cyanide
K_2SO_4	potassium sulfate
$Pb(CO_3)_2$	lead(IV) carbonate

Also need to be able to give formula from a name

Give formulas for the following.....

lithium nitrate $LiNO_3$

sodium sulfate Na_2SO_4

iron(II) carbonate $FeCO_3$

ACIDS

all acids contain hyrdogen

In water they produce the hydrogen ion: H^+

ACIDS

Two types

1. **hydrogen + nonmetal**
2. **hydrogen + nonmetal + oxygen**

Common acids

HCl	hydrochloric
H_2SO_4	sulfuric acid
HNO_3	nitric acid

H_3PO_4 phosphoric acid

$HC_2H_3O_2$ acetic acid

Common Names

dry ice

baking soda

marble

laughing gas

gypsum

saltpeter