Types of Compounds

Molecular

nonmetal + nonmetal

nonmetal atoms

covalent bonds

electrons shared

molecules

H_2O, CO_2, $HC_2H_3O_2$

Ionic

metal + nonmetal

Ions

Ionic bonds

electrons not shared

formula unit

$MgCl_2$, $NaCl$, Na_2CO_3

Basic Definitions from 6 grade

Compound: two or more atoms bonded together by chemical bonds.

Molecule: collection of atoms (2 or more) bonded together by covalent bonds

Note: Ionic compounds do not have molecules they have formula units.

Ions = charged particles

Ion: Is an element or collection of elements bonded by chemical bonds that have an imbalance of electrons (-1) compared to protons (+1)

For example

If an atom with eleven protons (+11, Na) has ten electrons (-10), then the difference, $+11 - 10 = +1$ means that this particular atom has a net charge of +1.

If an atom with nine protons (+9, F) has ten electrons, then the difference, $+9 - 10 = -1$ means that this particular atom has a net charge of -1.

Ions can be elemental (single type of atom) or molecular (collection nonmetals bonded by covalent bonds).

Examples: K^+, Mg^{+2} or CO_3^{-2}, $Cr_2O_7^{-2}$

elemental molecular

rxn = reaction

A. Elemental Ions

An atom with a different number of electrons than protons. Remember that the number of protons is fixed but electrons can be exchanged during chemical rxns.

Remember two fundamentals:

- Metals = give up electrons
- Nonmetals = take electrons

→ when a metal reacts with a nonmetal, electrons are transferred from the metal to the nonmetal, and oppositely charged ions are formed.

Salt: a neutral compound (net charge is zero) that contains a metal and nonmetal that are ionized (charged). The opposite charges cancel each other - net charge is zero.

Salt (continued)

e^- = electron

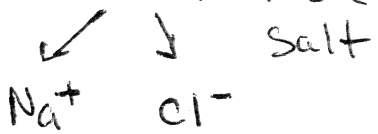
cation = (+) positive ion; lost e^-

anion = (−) negative ion; gained e^-

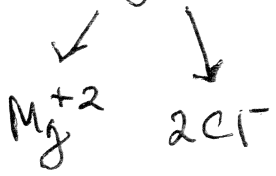
Salt = contains a **cation** and an **anion**.

Examples:

NaCl table salt



$MgCl_2$



First we will learn the **Main Group Ions**

Then we will see **how** they form.

Must commit to memory!

Metals

1A	2A
H^+	Be^{+2}
Li^+	Mg^{+2}
Na^+	Ca^{+2}
K^+	Sr^{+2}
Rb^+	Ba^{+2}
Cs^+	

Nonmetals (add -ide)

5A	6A	7A
N^{-3} nitride	O^{-2} oxide	F^- fluoride
P^{-3} phosphide	S^{-2} sulfide	Cl^- chloride
		Br^- bromide
		I^- iodide

oxide

Names:

use elemental name followed by the word **ion**.

Assume group 1A or 2A has reacted with 5A, 6A or 7A

e^- = electron

Where does the charge come from?

Metals give up e^-, so they typically have a (+) charge because the atom has more protons than electrons.

1A

For H^+ $+1p - 0e^- = +1$

Li^+ $+3p - 2e^- = +1$

Na^+ $+11p - 10e^- = +1$

K^+ $+19p - 18e^- = +1$

Rb^+ $+37p - 36e^- = +1$

Cs^+ $+55p - 54e^- = +1$

} gives up $1e^-$

2A

Be^{+2} $+4p - 2e^- = +2$

Mg^{+2} $+12p - 10e^- = +2$

Ca^{+2} $+20p - 18e^- = +2$

Sr^{+2} $+38p - 36e^- = +2$

Ba^{+2} $+56p - 54e^- = +2$

} gives up $2e^-$

Anions have a negative charge because they have more e^- than protons (+).

5A

N^{-3} $+7p - 10e^- = -3$

P^{-3} $+15p - 18e^- = -3$

} gained $3e^-$

6A

O^{-2} $+8p - 10e^- = -2$

S^{-2} $+16p - 10e^- = -2$

} gained $2e^-$

7A

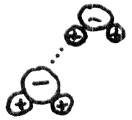
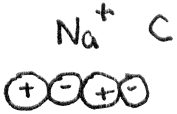
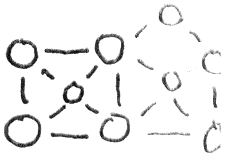
F^- $+9p - 10e^- = -1$

Cl^- $+17p - 18e = -1$

Br^- $+35 - 36e^- = -1$

I^- $+53 - 54e^- = -1$

} gained $1e^-$

	molecular	ionic	atomic	metallic	Network covalent
composed of:	molecules	ions	atoms	atoms	atoms
lattice sites in crystal:	molecules	ions	atoms	atoms	atoms
Bonding:	intermolecular forces (IMF)	ionic bonds	IMF	"metallic sea electrons"	covalent
Bp:	low	high	low	high	high
mp:	low	high	low	high	high
Examples:	H_2O mp = 0°C NH_3 mp = -77°C CS_2 mp = -110	NaCl mp = 801°C	Ne, Kr, Cl_2 ↓ Cl_2 mp = -151°C	Fe mp = 1109°C	→ mp = 3900°C C(s) diamond SiO_2
Conductivity:	not	only when melted or molten	not	solid and liquid is conductive	not
Bonding Example:					

Types of Compounds

Nomenclature = naming

Terms

Binary: two different parts

Binary ionic compounds: A compound that contains two different types of ions. An ionic compound will have a metal cation and either an elemental anion or a polyanion.

Type I Binary Compounds

Group 1A, 2A cations paired with 5A, 6A, 7A or polyanion. The elemental name of the metal is used followed by the name of the elemental anion using the -ide suffix or using the name of the polyanion.

LiCl = lithium chloride

↑

Salt = cation + anion

Type I

Naming Binary Ionics:

$NaCl$	Sodium chloride
$MgCl_2$	magnesium chloride
Al_2O_3	Aluminum oxide
LiF	lithium fluoride
Na_2S	sodium sulfide
CaF_2	calcium fluoride

Ionization Equations

Splitting Binary compounds apart:

$NaCl \rightarrow Na^{+} + Cl^{-}$

$MgCl_2 \rightarrow Mg^{+2} + 2Cl^{-}$

$Al_2O_3 \rightarrow 2Al^{+3} + 3O^{-2}$

$LiF \rightarrow Li^{+} + F^{-}$

$Na_2S \rightarrow 2Na^{+} + S^{-2}$

$CaF_2 \rightarrow Ca^{+2} + 2F^{-}$

note: you can reverse drop charge!

$Al_2O_3 \rightarrow Al^{+3} + O^{-2}$

Forming compounds: Drop charge method

Mg^{+2} Cl^{-1} $\rightarrow MgCl_2$

Al^{+3} O^{-2} $\rightarrow Al_2O_3$

Other types of ionic compounds

1. Group 1A or 2A with polyanions

1A	2A
H^+	Be^{+2}
Li^+	Mg^{+2}
Na^+	Ca^{+2}
K^+	Sr^{+2}
Rb^+	Ba^{+2}
Cs^+	

Polyanions (molecular ions)

- SO_4^{-2} sulfate
- OH^- hydroxide
- CO_3^{-2} carbonate
- CrO_4^{-2} chromate
- PO_4^{-3} phosphate
- NO_3^- nitrate
- MnO_4^- permanganate

} see previous packet for full list of 24 molecular ions

Naming Polyanion Compounds

these are salts. The cation + anion is equal to zero. overall charge on compound is zero.

Li_2SO_4	lithium sulfate
Na_2CO_3	sodium carbonate
$MgCrO_4$	magnesium chromate
Rb_3PO_4	rubidium phosphate
$KMnO_4$	potassium permanganate

Splitting apart

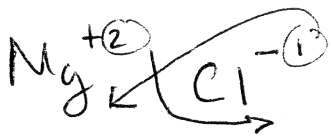
$KOH \rightarrow K^+ + OH^-$

$Ca(NO_3)_2 \rightarrow Ca^{+2} + 2NO_3^-$

$Li_2CrO_4 \rightarrow 2Li^+ + CrO_4^{-2}$

Drop charge method to make compounds:

$Al_2(CrO_4)_3$



$MgCl_2$

Na_2O

K_3PO_4

Net charge on compound is zero.

Type II Binary Compounds

Transition metals (cations) combine with 5A, 6A, 7A or polyanions to make compounds. The naming is different because transition elements can have more than one charge. For example, Cu can be Cu^{+} and Cu^{+2}, Fe can be Fe^{+2} and Fe^{+3}.

roman III for Fe^{+3}

$FePO_4$ is iron (III) phosphate

$Fe_3(PO_4)_2$ is iron (II) phosphate

Examples Transition elements & various anions

$MnSO_4$ → manganese (II) sulfate → $Mn^{+2}\ SO_4^{-2}$

$Pb(NO_3)_2$ → lead (II) nitrate → $Pb^{+2}\ NO_3^-$

SnF_4 → tin (IV) fluoride → $Sn^{+4}\ F^-$

$NiPO_4$ → nickel (III) phosphate → $Ni^{+3}\ PO_4^{-3}$

HgI_2 → mercury (II) iodide

$NiCO_3$ → nickel (II) carbonate → $Ni^{+2}\ CO_3^{-2}$

Fe_2O_3 → iron (III) oxide $Fe^{+3} + O^{-2}$

$CuSO_4$ → copper (II) sulfate → $Cu^{+2}\ SO_4^{-2}$

$Ti(OH)_2$ → titanium (II) hydroxide → $Ti^{+2} + 2OH^-$

Cu_2SO_4 → copper (I) sulfate → $Cu^+\ SO_4^{-2}$

Molecular Ions

poly cation

NH_4^+ ammonium

poly anions

NO_3^- nitrate

NO_2^- nitrite

SO_4^{-2} sulfate

SO_3^{-2} sulfite

PO_4^{-3} phosphate

PO_3^{-3} phosphite

HSO_4^- bisulfate
hydrogen sulfate

CO_3^{-2} carbonate

HCO_3^- bicarbonate
hydrogen carbonate

OH^- hydroxide

CN^- cyanide

$C_2H_3O_2^-$ acetate

$H_2PO_4^-$ dihydrogen phosphate

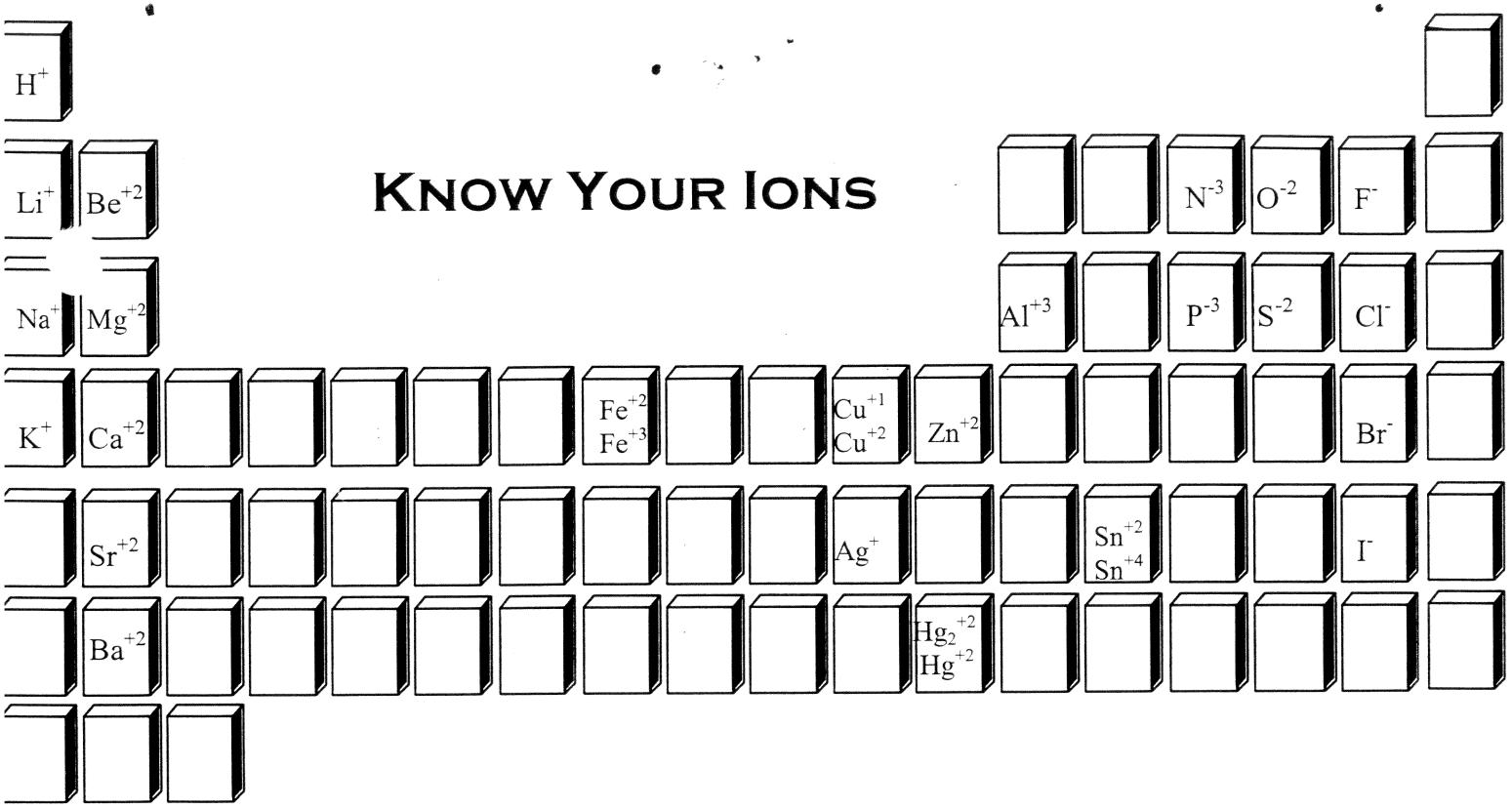
ClO^- hypochlorite

ClO_2^- chlorite

ClO_3^- chlorate

ClO_4^- perchlorate

KNOW YOUR IONS



Hydrogen	H^+	Magnesium	Mg^{+2}	Zinc	Zn^{+2}	Sulfide	S^{-2}
Lithium	Li^+	Calcium	Ca^{+2}	Aluminum	Al^{+3}	Fluoride	F^-
Sodium	Na^+	Strontium	Sr^{+2}	Nitride	N^{-3}	Chloride	Cl^-
Potassium	K^+	Barium	Ba^{+2}	Phosphide	P^{-3}	Bromide	Br^-
Beryllium	Be^{+2}	Silver	Ag^+	Oxide	O^{-2}	Iodide	I^-

SOME METALS THAT FORM TWO IONS

Copper (I)	[Cuprous]	Cu^+	Mercury (I)	[Mercurous]	Hg_2^{+2}
Copper (II)	[Cupric]	Cu^{+2}	Mercury (II)	[Mercuric]	Hg^{+2}
Iron (II)	[Ferrous]	Fe^{+2}	Tin (II)	[Stannous]	Sn^{+2}
Iron (III)	[Ferric]	Fe^{+3}	Tin (IV)	[Stannic]	Sn^{+4}

OTHER CATIONS

Ammonium	NH_4^+

OTHER ANIONS

Acetate	$C_2H_3O_2^-$
Chromate	CrO_4^{-2}
Dichromate	$Cr_2O_7^{-2}$
Cyanide	CN^-
Hydroxide	OH^-
Oxalate	$C_2O_4^{-2}$
Peroxide	O_2^{-2}

Perbromate	BrO_4^-	Perchlorate	ClO_4^-	Periodate	IO_4^-		
Bromate	BrO_3^-	Chlorate	ClO_3^-	Iodate	IO_3^-	Nitrate	NO_3^-
Bromite	BrO_2^-	Chlorite	ClO_2^-	Iodite	IO_2^-	Nitrite	NO_2^-
Hypobromite	BrO^-	Hypochlorite	ClO^-	Hypoiodite	IO^-		
Carbonate	CO_3^{-2}	Sulfate	SO_4^{-2}	Phosphate	PO_4^{-3}	Permanganate	
		Sulfite	SO_3^{-2}	Phosphite	PO_3^{-3}		MnO_4^-

BI-ANIONS

Bicarbonate	HCO_3^-	Bisulfite	HSO_3^-
Bisulfate	HSO_4^-	Bisulfide	HS^-

THIO-ANIONS

Thiocyanate	SCN^-
Thiosulfate	$S_2O_3^{-2}$

Memorize

(A) Acids

HCl	hydrochloric acid
HBr	hydrobromic acid
HI	hydroiodic acid
H_2SO_4	sulfuric acid
HNO_3	nitric acid
$HClO_4$	perchloric acid

(B) Bases

$NaOH$	sodium hydroxide
KOH	potassium hydroxide
$Ca(OH)_2$	calcium hydroxide
$Sr(OH)_2$	strontium hydroxide
$Ba(OH)_2$	barium hydroxide

(C) Diatomic Molecules

N_2 = nitrogen

O_2 = oxygen

H_2 = hydrogen

Cl_2 = chlorine

F_2 = fluorine

Br_2 = bromine

I_2 = iodine