

Chemical Reactions

- we already know chemical reactions involve electrons
- when elements form compounds, changes occur in the arrangement of electrons
- atoms want to have a complete valence shell (like the noble gases)
- they achieve this by sharing or transferring electrons
- Why are noble gases stable?
 - they have full outer orbits



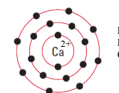
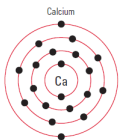
How can we give lithium a full outer shell?
 1) Add 7 electrons to the outer shell.
 2) Remove 1 electron from the outer shell.
 Which is easier?

What would the atom look like after losing that electron?

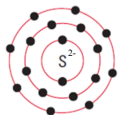
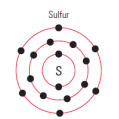


Protons +3
 Electrons -2
 Charge +1

The atom now has a charge and is called an ion.
 We write the charge as a superscript to the right of the symbol.



Protons +20
 Electrons -18
 Charge +2
 Metals tend to lose electrons to form positive ions.



Protons +16
 Electrons -18
 Charge -2
 Nonmetals tend to gain electrons to form negative ions.

We change their name to end in "-ide"

Try these:

Atom	ion
Fluorine	F^-
Bromine	Br^-
Oxygen	O^{2-}

Bohr Diagram Questions

1. What part of the atom is involved in making chemical bonds?
2. For the metallic elements sodium, magnesium, and aluminum, answer the following questions:
 - a) Draw a Bohr diagram for each element. How many electrons are in their outer orbits?
 - b) Do these metallic elements tend to gain or lose electrons? Give reasons for your answer.
 - c) What is the charge on each of the metal ions? (Include the ion symbol.)
3. For the nonmetallic elements nitrogen, oxygen, and fluorine, answer the following questions:
 - a) Draw a Bohr diagram for each element. How many electrons are in their outer orbits?
 - b) Do these nonmetallic elements tend to gain or lose electrons? Give reasons for your answer.
 - c) What is the charge on each of the nonmetal ions? (Include the ion symbol.)
4. Predict the names and charges of the ions that cesium, barium, and bromine might form.
5. Beryllium and fluorine react to form an ionic compound.
 - a) Which element is the metal and which is the nonmetal?
 - b) Draw Bohr diagrams of beryllium and fluorine.
 - c) How many electrons must each element gain or lose to form stable ions?
 - d) Draw sketches to show how this compound forms by transfer of electrons.
 - e) Indicate the ionic charges on the ions.
 - f) What is the overall charge on the compound?
 - g) What is the chemical formula of the compound?
6. Repeat question 2 for the compound formed by aluminum and fluorine.
7. a) How do metals form ionic compounds with nonmetals?
 b) Describe the process with an example.

Chemical Compounds

We will learn about two types of compounds:

Ionic – Electrons are *transferred* between metals and nonmetals

Molecular – Electrons are *shared* between nonmetals.

(covalent)

Let's try some examples.

Compound	Molecular or ionic
FeO ₂	ionic
KF	ionic
CO ₂	molecular
NaCl	ionic
H ₂ O	molecular

- both nonmetals

A **chemical formula** is a combination of symbols that represent a particular compound.

It shows us

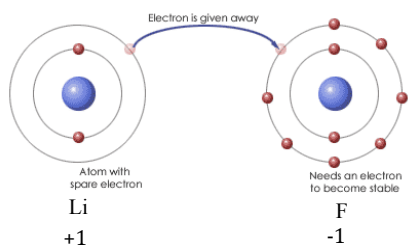
- what elements are in the compound
- the number of each atom present

Compound	#	Element	#	Element
FeO ₂	1	iron	2	oxygen
KF	1	potassium	1	fluorine
CO ₂	1	carbon	2	oxygen
NaCl	1	sodium	1	chloride
H ₂ O	2	hydrogen	1	oxygen

How do ionic compounds form?

- formed by a metal ion and a nonmetal ion
- the metal atom loses electrons to form a positive cation
- the nonmetal gains electrons to become a negative anion
- the opposite charges cause the two ions to be attracted to each other
- this attraction is called an **ionic bond**
- the result is an electrically neutral compound

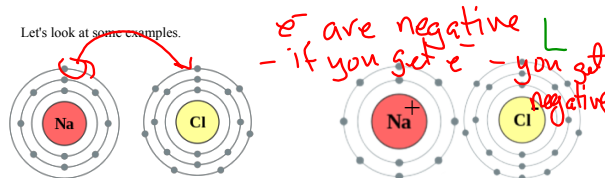
Resulting ionic compound?



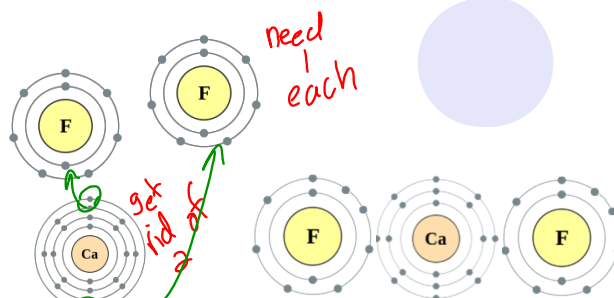
LiF

lithium fluoride

Let's look at some examples.



e- are negative - if you get e- you get negative



need 1 each

get rid of 2

*calcium fluoride
CaF₂*

Writing the Formula for Ionic Compounds

1. Temporarily write the ionic charge above each symbol.
2. Crisscross the ionic charges, using them as subscripts for the opposite ions.
3. Reduce the subscripts to the lowest numbers possible.

Let's try some examples.

What compound is formed from sodium and bromine?

Ionic charge

Symbol

Formula *How do you feel about those ones?*

What compound is formed from calcium and iodine?

Ionic charge

Symbol

Formula

What compound is formed from aluminum and sulfur?

Ionic charge

Symbol

Formula

What compound is formed from nickel and oxygen?

Ionic charge

Symbol

Formula *How do you feel about those twos?*

What compound is formed from tin and oxygen?

Ionic charge

Symbol

Formula *How do you feel about the two and four?*

Things to remember!

How do we name these compounds?

Write the name of the metal followed by the name of the nonmetal ending in "ide"

NaCl sodium chloride

CaF₂ calcium fluoride

K₂O potassium oxide

Practice!

Elements	Formula	Name
potassium and oxygen		
sodium and sulfur		
aluminum and iodine		
silver and sulfur		
calcium and nitrogen		

Give the name and chemical formula for each of the following:

- a) lithium and fluorine
- b) calcium and bromine
- c) sodium and nitrogen
- d) aluminum and nitrogen
- e) sodium and iodine
- f) beryllium and fluorine
- g) magnesium and oxygen
- h) gallium and sulfur

Try this one:

Write the formula for the compound formed by iron and iodine.

Ionic charge

Symbol

Formula

Naming compounds of polyvalent metals

Some metals can form more than one kind of ion – they are called **polyvalent metals**.

- write the name of the metal
- add a Roman numeral in parentheses after it to indicate its ionic charge
- use the "ide" ending for the nonmetal

26	Fe ³⁺
	iron (III)
	Fe ²⁺
	iron (II)

53	I ⁻
	iodide

Ionic charge 3+ 1-
 Symbol FeI₃
 Name iron (III) iodide

Number	Roman numeral
1	I
2	II
3	III
4	IV
5	V

Try this one: Fe₃N₂

More practice.

1. Write the formula for each of the following compounds:

- a) copper(I) bromide
- b) copper(II) bromide
- c) iron(II) sulfide

2. Write the name for each of the following compounds:

- a) SnCl₂
- b) SnCl₄
- c) PbBr₂

3. Write the formula and name of the compound formed by each of the following combinations of ions.

- a) Fe³⁺ and O²⁻ Fe₂O₃
- b) Ca²⁺ and F⁻ CaF₂
- c) Cu⁺ and S²⁻ Cu₂S

Polyatomic ion: atoms that tend to stay together and carry an overall ionic charge (e.g., Nitrate ion: NO₃⁻).

TABLE OF POLYATOMIC IONS			
acetate	CH ₃ COO ⁻	dihydrogen phosphate	H ₂ PO ₄ ⁻
arsenate	AsO ₄ ³⁻	hydrogen carbonate	HCO ₃ ⁻
arsenite	AsO ₃ ³⁻	hydrogen oxalate	HC ₂ O ₄ ⁻
benzoate	C ₆ H ₅ COO ⁻	hydrogen sulfate	HSO ₄ ⁻
borate	BO ₃ ³⁻	hydrogen sulfide	HS ⁻
bromate	BrO ₃ ⁻	hydrogen sulfite	HSO ₃ ⁻
carbonate	CO ₃ ²⁻	hydroxide	OH ⁻
chlorate	ClO ₃ ⁻	hypochlorite	ClO ⁻
chloride	Cl ⁻	iodate	IO ₃ ⁻
chlorite	ClO ₂ ⁻	monohydrogen phosphate	HPO ₄ ²⁻
chromate	CrO ₄ ²⁻	nitrate	NO ₃ ⁻
cyanate	CNO ⁻	nitrite	NO ₂ ⁻
cyanide	CN ⁻	orthosilicate	SiO ₄ ⁴⁻
dichromate	Cr ₂ O ₇ ²⁻	oxalate	C ₂ O ₄ ²⁻
		perchlorate	ClO ₄ ⁻
		periodate	IO ₄ ⁻
		permanganate	MnO ₄ ⁻
		peroxide	O ₂ ²⁻
		phosphate	PO ₄ ³⁻
		pyrophosphate	P ₂ O ₇ ⁴⁻
		sulfate	SO ₄ ²⁻
		sulfite	SO ₃ ²⁻
		thiocyanate	SCN ⁻
		thiosulfate	S ₂ O ₃ ²⁻
		POSITIVE POLYATOMIC IONS	
		ammonium	NH ₄ ⁺
		hydronium	H ₃ O ⁺

Naming Compounds of Polyatomic Ions

Ions that contain more than one atom are called polyatomic ions.

- write the symbols for the metal and the polyatomic ion
- write the ionic charges above the symbols and crisscross them
- write the name of the metal first, then the polyatomic ion

Ionic charge $\overset{+1}{\text{Na}}$ $\overset{-2}{\text{SO}_4}$
 Symbol **Na** **SO₄**
 Formula Na_2SO_4 *How do you feel about the 2 and 4?*
 Name **Sodium sulfate**

Ionic charge $\overset{+2}{\text{Ba}}$ $\overset{-1}{\text{NO}_3}$ *How do we crisscross with a polyatomic?*
 Symbol **Ba** **NO₃**
 Formula $\text{Ba}(\text{NO}_3)_2$
 Name **Barium nitrate**

Try these:

a) $\overset{+3}{\text{Fe}}$ $\overset{-1}{\text{NO}_3}$ **Iron (III) nitrate**

b) $\overset{+4}{\text{Pb}}$ $\overset{-2}{\text{SO}_4}$ **Lead (IV) sulfate**

c) $\overset{+1}{\text{K}_2}$ $\overset{-3}{\text{CO}_3}$ **Potassium carbonate**

d) potassium hydroxide



e) lead(IV) carbonate



How do you feel about the 2 and 4?

1. Write the formulas for the following compounds:

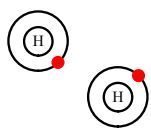
- (a) sodium phosphate Na_3PO_4
- (b) calcium sulfate CaSO_4
- (c) potassium chlorate KClO_3
- (d) aluminum hydroxide $\text{Al}(\text{OH})_3$
- (e) beryllium nitrate $\text{Be}(\text{NO}_3)_2$
- (f) magnesium hydrogen carbonate $\text{Mg}(\text{HCO}_3)_2$
- (g) nickel carbonate NiCO_3

2. Write the names for the following compounds:

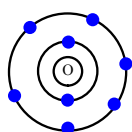
- a) K_2CO_3 **Potassium carbonate**
- b) Na_2SO_4 **Sodium sulfate**
- c) $\text{Al}(\text{HCO}_3)_2$ **Aluminum bicarbonate**
- d) AgNO_3 **Silver nitrate**

Molecular Compounds

- most common compounds do not contain ions
- they contain *neutral* groups of atoms called **molecules**.
- a molecule (or molecular compound) is made of nonmetals that are *sharing electrons*
- the shared electrons form a **covalent bond**



How many electrons does H need?

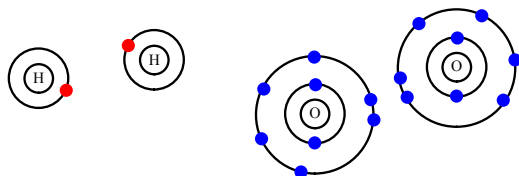


How many electrons does O need?

Diatomic Molecules are elements that exist naturally as molecules made of two atoms.

- H_2 , N_2 , O_2 , F_2 , Cl_2 , Br_2 , I_2

Geez! How can I remember those?



1 H																	2 He
3 Li	4 Be											7 N	8 O	9 F	10 Ne		
11 Na	12 Mg											15 P	16 S	17 Cl	18 Ar		
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	* Lu	57 Hf	58 Ta	59 W	60 Re	61 Os	62 Ir	63 Pt	64 Au	65 Hg	66 Tl	67 Pb	68 Bi	69 Po	70 At	71 Rn
87 Fr	88 Ra	* * *	89-102 Lr	103 Rf	104 Db	105 Sg	106 Bh	107 Hs	108 Mt	109 Uu	110 Uu	111 Uu	112 Uu	113 Uu	114 Uu	115 Uu	116 Uu

* Lanthanide series

57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb
89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No

** Actinide series

The **combining capacity** (or **valency**) is the number of covalent bonds that a nonmetal needs to form a stable molecule.



Combining capacity?

Combining capacity?

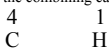
How can you know the combining capacity of an element?
- it's the number of groups away from a noble gas.

e.g., What compound is formed from carbon and hydrogen?

Step 1: Write the left-most element first then the right



Step 2: Write the combining capacities above the element symbols



Step 3: Crisscross the combining capacities to get subscripts



Step 4: Reduce the subscripts if possible



Step 5: Remove any "1" subscripts - they're not needed



Element	Combining capacity
C	4
F	1
Cl	1
S	2
O	2

Prefixes indicate the number of atoms present.

If there is only one atom of the first element listed, the prefix MONO is not needed.

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

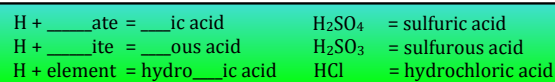
- How can you tell the difference between ionic compounds and molecular compounds?
- What kinds of atoms form molecular compounds?
 - How do the atoms in molecular compounds form stable electron configurations?
 - What type of bond holds atoms together in molecules?
- Name the following compounds:
 - CBr_4 _____
 - NI_3 _____
 - OF_2 _____
 - SiCl_4 _____
- Write chemical formulas for and name the molecular compounds formed by the following pairs of elements:

a) silicon & oxygen	b) nitrogen & hydrogen
c) phosphorus & chlorine	d) sulfur & bromine
e) oxygen & fluorine	f) carbon & chlorine

Ionic Compounds - NAMING

- Acids form when hydrogen atoms combine with certain ions
 - The hydrogen ion has an ionic charge of $1+$ (H^+).
 - Acids have the subscript aq (aqueous) after their formula.

- To name acids, follow these simple guidelines:



- An **oxyacid** is simply an acid formed when H^+ combines with polyatomic ions that contain oxygen.