

## Chapter 5: Molecules and compounds

**Compound:** a pure substance that contains...

2 or more elements w/ fixed ratio  
(exact)

**Chemical formula:** ratio of elements

$H_2O$  : 2:1 ratio

**Law of constant composition:** ratio in a compound is consistent if the compound is pure

**Formula unit:** atoms represented by a chemical formula

One formula unit of  $Ca_3(PO_4)_2$  contains...

3 Ca atoms

2 P

8 O

## Molecular compounds

**Molecular compounds:** made of molecules (groups of bonded atoms)

Contains which type of elements? non metals only

H<sub>2</sub>O:  $\text{H}-\text{O}-\text{H}$  an H<sub>2</sub>O molecule

CO<sub>2</sub>:  $\text{O}=\text{C}=\text{O}$

C<sub>12</sub>H<sub>22</sub>O<sub>11</sub>: sucrose

H<sub>2</sub>:  $\text{H}-\text{H}$   H<sub>2</sub> molecule

H<sub>2</sub> is a **diatomic element** (exists as pairs of atoms)

There are 7 diatomic elements:

H<sub>2</sub>      N<sub>2</sub>    O<sub>2</sub>    F<sub>2</sub>

Cl<sub>2</sub>

Br<sub>2</sub>

I<sub>2</sub>

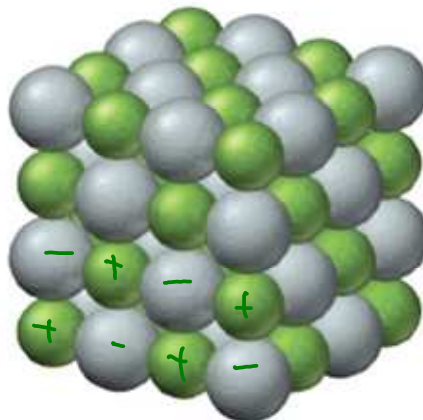
all other

elements are made of single atoms

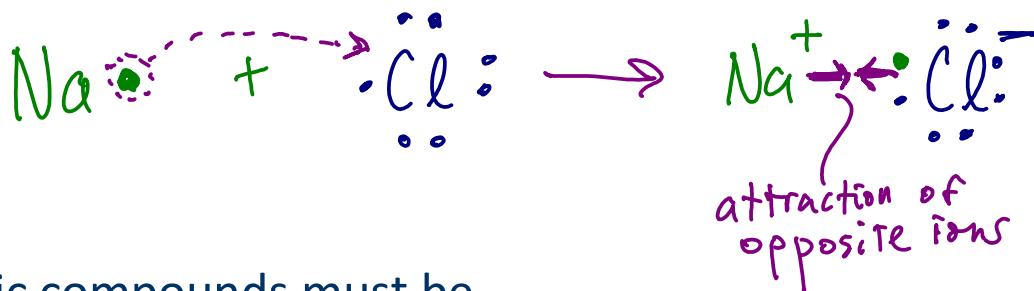
# Ionic compounds

**Ionic compounds:** contain positive and negative ions

- Usually 1 metal and 1 or more nonmetals
- Forms a 3-dimensional lattice of opposite ions



Formation of an ionic compound from Na and Cl:



Ionic compounds must be...

neutral overall

1:1 ratio Na:Cl  
Formula NaCl

What is the formula of the compound formed from calcium and chlorine? *met + nonmet = ionic*

Ca forms  $\text{Ca}^{2+}$  ion

Cl forms  $\text{Cl}^-$  ion

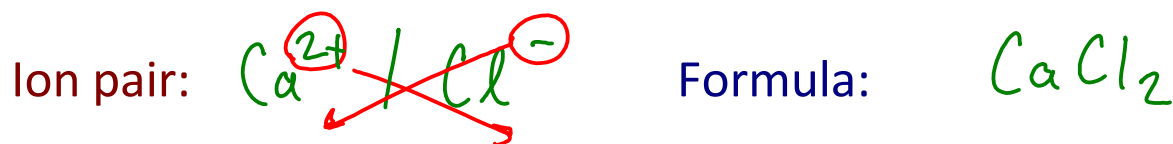
$1 (\text{Ca}^{2+}) = 2+$   
 $2 (\text{Cl}^-) = 2-$  } neutral overall

need 1:2 ratio  
to be neutral

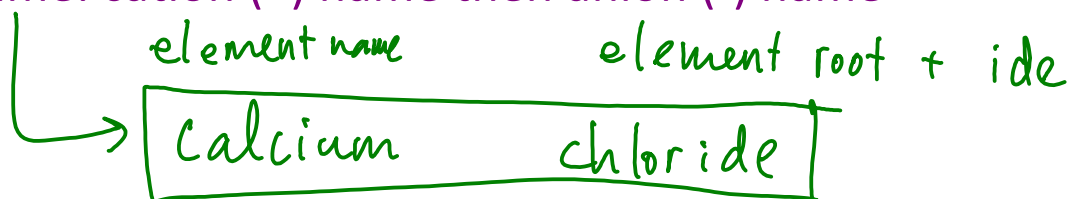
$\text{CaCl}_2$  = formula

## Naming ionic compounds

Write the name and formula of the compound formed from calcium and chlorine



Name: cation (+) name then anion (-) name



### Anion names:

VA

$\text{N}^{3-}$  nitride

$\text{P}^{3-}$  phosphide

VIA

$\text{O}^{2-}$  oxide

$\text{S}^{2-}$  sulfide

$\text{Se}^{2-}$  selenide

VIIA

$\text{F}^{-}$  fluoride

$\text{Cl}^{-}$  chloride

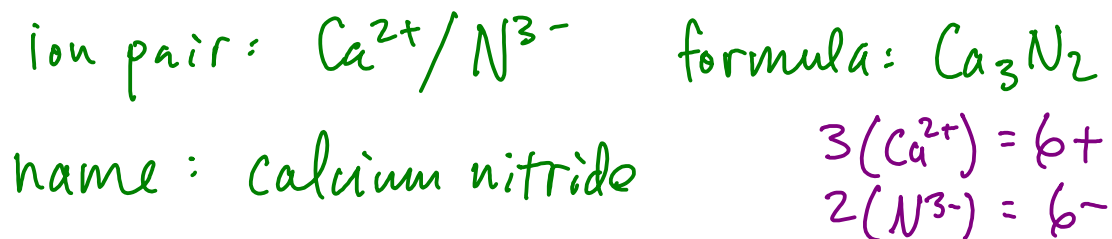
$\text{Br}^{-}$  bromide

$\text{I}^{-}$  iodide

Write the name and formula of the cpd with Mg and Br:

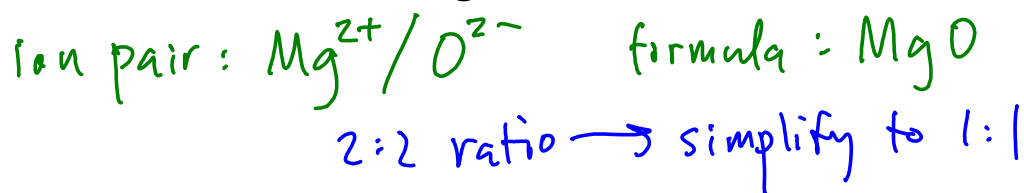


Write the name and formula of the cpd with Ca and N:



## Naming ionic compounds

Write the formula for magnesium oxide



	<u>Ion pair</u>	<u>Formula</u>
aluminum selenide	$Al^{3+}/Se^{2-}$	$Al_2Se_3$
lithium phosphide	$Li^+/P^{3-}$	$Li_3P$
barium sulfide	$Ba^{2+}/S^{2-}$	$BaS$
barium chloride	$Ba^{2+}/Cl^-$	$BaCl_2$

## Types of binary compounds (two elements only):

	<u>Type I</u>	<u>Type II</u>	<u>Type III (molecular)</u>
Ions?	ionic (fixed charge)	ionic (variable charge)	molecular
Elements?	main group met + nonmetal	transition met + nonmet	
Example:	calcium chloride $CaCl_2$	iron(II) chloride $FeCl_2$	

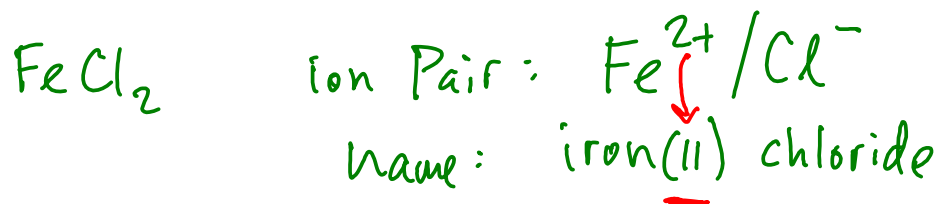
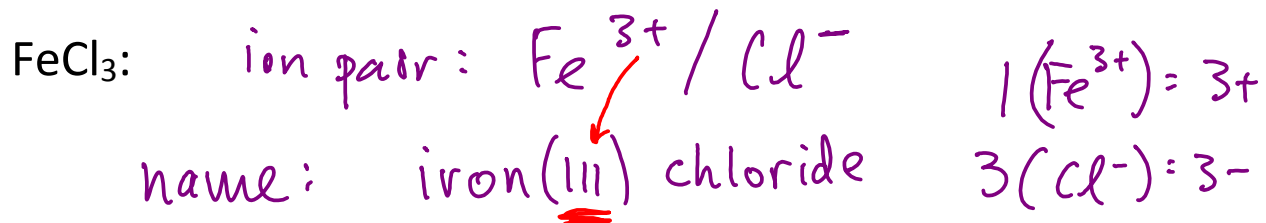
## Type II ionic compounds

- Transition metals:**
- do not form a single stable ion like nonmetals do
  - can form multiple different stable ions

For instance, the iron cation can be  $\text{Fe}^{2+}$  or  $\text{Fe}^{3+}$

iron chloride is an incomplete name

could be  $\text{FeCl}_2$  or  $\text{FeCl}_3$



## Type II ionic compounds

<u>Name</u>	<u>Ion pair</u>	<u>Ratio</u>	<u>Formula</u>
titanium(IV) chloride	$Ti^{4+}/Cl^{-}$	1:4	$TiCl_4$
titanium(IV) oxide	$Ti^{4+}/O^{2-}$	1:2	$TiO_2$

<u>Formula</u>	<u>Ratio</u>	<u>Ion pair</u>	<u>Name</u>
$WF_6$	1:6	$W^{6+}/F^{-}$	tungsten(VI) fluoride
$MnP_2$	1:2	$Mn^{6+}/P^{3-}$	manganese(VI) phosphide
$Cu_2O_3$	2:3	$Cu^{3+}/O^{2-}$	copper(III) oxide

$$6(F^{-}) = 6-$$

$$1(W^{6+}) = 6+$$

$$2(P^{3-}) = 6- \quad 2(Cu^{3+})$$

$$1(Mn^{6+}) = 6+ \quad 3(O^{2-})$$

<u>Formula</u>	<u>Type</u>	<u>Ratio</u>	<u>Ion pair</u>	<u>Name</u>
$K_2O$	I	2:1	$K^{+}/O^{2-}$	potassium oxide
$CrO_2$	II	1:2	$Cr^{4+}/O^{2-}$	chromium(IV) oxide
$MgI_2$	I	1:2	$Mg^{2+}/I^{-}$	magnesium iodide
$Ni_2O$	II	2:1	$Ni^{+}/O^{2-}$	nickel(I) oxide

Type I or Type II?

**Type I:** fixed charge metal  
most are main-group

**Type II:** variable charge metal  
Most are transition

A few important exceptions...

**Periodic Table of the Elements**

Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	IA	IIA	IIIB	IVB	VB	VIB	VII B	VIII B	VIII B	VIII B	IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
1	1 H 1.008																	2 He 4.003
2	3 Li 6.939	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
3	11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
4	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.90	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.96	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.4	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.29
6	55 Cs 132.91	56 Ba 137.33	57-70 * Lu 174.97	71 Hf 178.49	72 Ta 180.95	73 W 183.84	74 Re 186.21	75 Os 190.23	76 Ir 192.22	77 Pt 195.08	78 Au 196.97	79 Hg 200.59	80 Tl 204.38	81 Pb 207.2	82 Bi 208.98	83 Po (209)	84 At (210)	85 Rn (222)
7	87 Fr (223)	88 Ra (226)	89-102 ** Lr (257)	103 Rf (261)	104 Db (262)	105 Sg (271)	106 Bh (272)	107 Hs (270)	108 Mt (276)	109 Ds (281)	110 Rg (280)	111 Uub (285)	112 Uut (284)	113 Uuq (289)	114 Uup (288)	115 Uuh (292)	116 Uuo (294)	117 Uuo (294)
			57 * La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (147)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04		
			89 ** Ac (227)	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)		

Reference: <http://www.webelements.com>