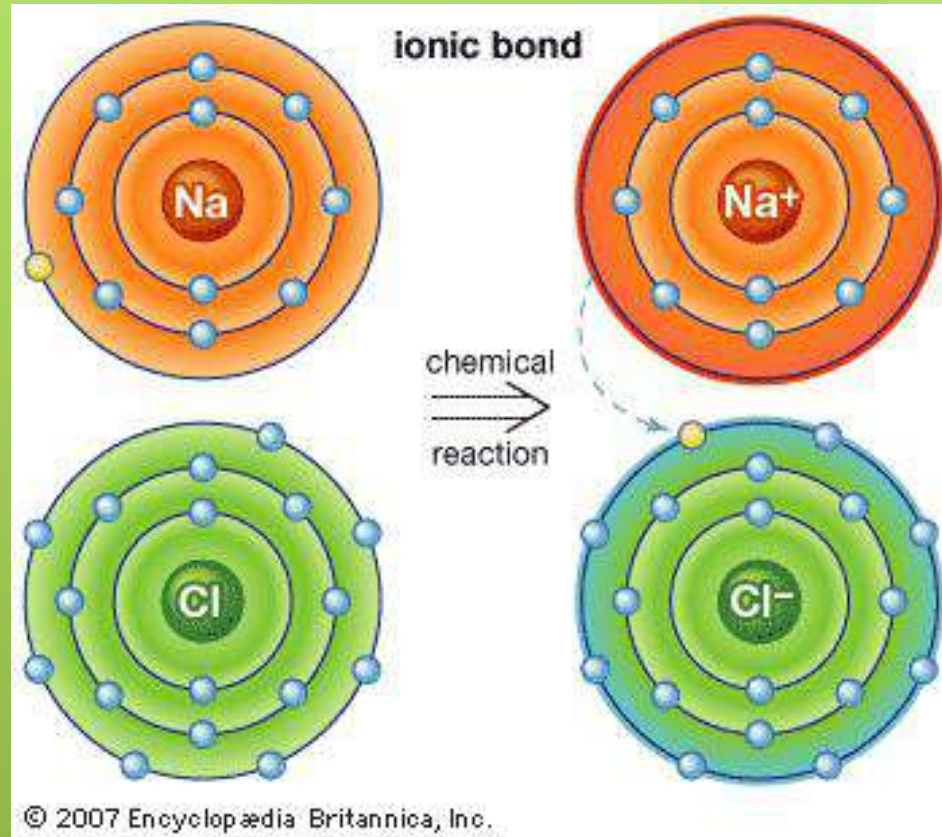


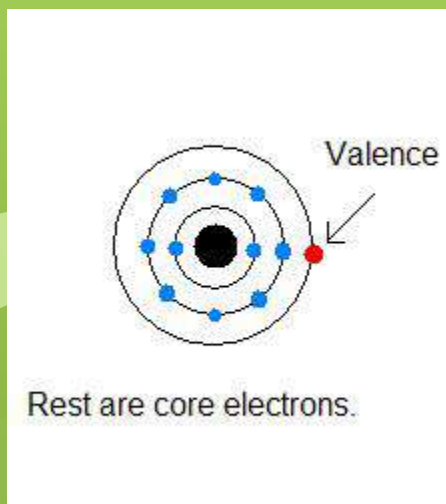
Chapter 7 – Ionic and Metallic Bonding



Augustine

Section 7.1 - Ions

- Valence electrons are the electrons in the highest occupied energy level.
- Valence electrons are the only electrons involved in chemical bonding.
- Elements in the same group have the same number of valence electrons.



Valence Electrons in Each Group

1																2
1	2									3	4	5	6	7	8	8
1	2									3	4	5	6	7	8	8
1	2									3	4	5	6	7	8	8
1	2									3	4	5	6	7	8	8
1	2									3	4	5	6			

Electron Dot Structures

- Electron dot structures are diagrams that show the symbol of the element surrounded by the valence electrons as dots.



H•						He••	
Li•	Be••	B••	•C••	•N••	•O••	•F••	•Ne••
Na•	Mg••	Al••	•Si••	•P••	•S••	•Cl••	•Ar••
K•	Ca••	Ga••	•Ge••	•As••	•Se••	•Br••	•Kr••
Rb•	Sr••	In••	•Sn••	•Sb••	•Te••	•I••	•Xe••
Cs•	Ba••	Tl••	•Pb••	•Bi••	•Po••	•At••	•Rn••
Fr•	Ra••						

Practice Problems

- Write the electron dot structure for the following elements:

P

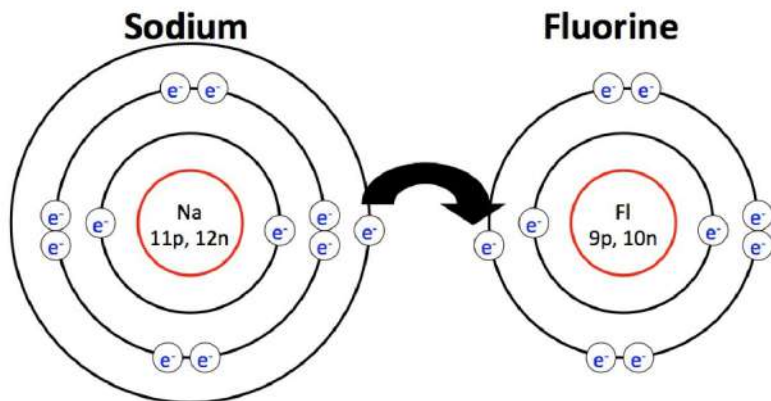
Ar

Mg

He

Octet Rule

- The octet rule states that atoms tend to achieve a stable configuration when they have 8 valence electrons.
- Metals tend to lose electrons to achieve noble-gas configuration. Nonmetals tend to gain electrons to achieve noble-gas configuration.



"In chemical compounds, atoms tend to have the electron configuration of a noble gas."



Cations

- A cation ion is a positive ion that has lost electrons.
- When writing the electron configuration for a cation, write the electron configuration for the atom and then subtract the electrons from the highest energy level.
- When you name a cation, the name of the element does not change. Ex: Ca^{+2} = calcium ion

Elemental Cations

																		+1																				
H	+2																																					He
Li	Be																				B	C	N	O	F	Ne												
Na	Mg	+3	variable charges										+1	+2	Al	Si	P	S	Cl	Ar																		
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr																					
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe																					
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn																					
Fr	Ra	Ac	Rf	Ha	Sg	Ns	Hs	Mt																														

Sample Problem

- Write the electron configuration and name for the following:



Strontium ion



Iron ion

Practice Problems

● Write the electron configurations and the name for the following:

● Zn^{+2}

$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$
Zinc ion

● Na^+

$1s^2 2s^2 2p^6$
Sodium ion

Anions

- Anions are negatively charged ions that have gained electrons.
- When writing the electron configuration for anions, write the electron configuration for the atom and then add the correct number of electrons.
- When naming an anion, you change the ending of the element to -ide. Ex: Cl^- = chlor**ide** ion

Elemental Anions

					He			
					-3	-2	-1	
B	C	N	O	F	Ne			
Al	Si	P	S	Cl	Ar			
Ga	Ge	As	Se	Br	Kr			
In	Sn	Sb	Te	I	Xe			
Tl	Pb	Bi	Po	At	Rn			

Sample Problems

- Write the electron configuration and name for the following:



$1s^2 2s^2 2p^6 3s^2 3p^6$
Phosphide ion



$1s^2 2s^2 2p^6$
Fluoride ion

Practice Problems

- Write the electron configuration and name for the following:



$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$
Bromide ion



$1s^2 2s^2 2p^6 3s^2 3p^6$
Sulfide ion

Section 7.1 Assessment

1. How can you determine the number of valence electrons in an atom of a representative element?
2. Atoms of which elements tend to gain electrons? Atoms of which elements tend to lose electrons?
3. How do cations form?
4. How do anions form?
5. How many valence electrons are in each atom?
 - a. Potassium
 - b. Carbon
 - c. Magnesium
 - d. Oxygen
6. Draw the electron dot structure for each element in question 5.

Section 7.1 Assessment

7. How many electrons will each element gain or lose in forming an ion?

- a. calcium
- b. fluorine
- c. aluminum
- d. oxygen

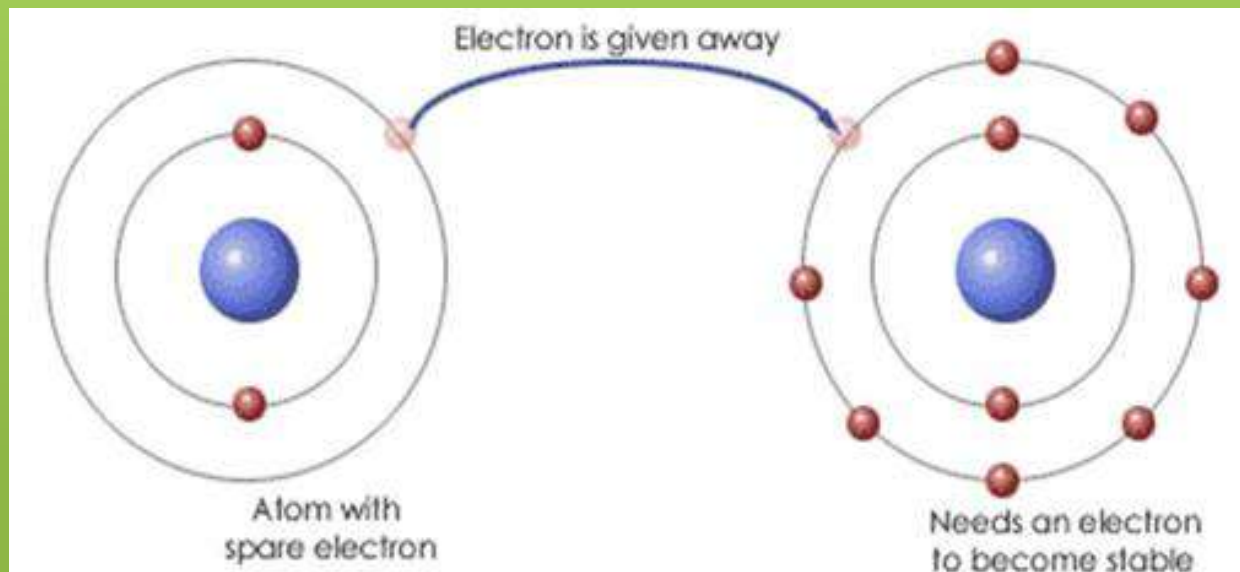
8. Write the name and symbol of the ion formed when

- a. a potassium atom loses one electron.
- b. a zinc atom loses two electrons.
- c. a fluorine atom gains one electron.

9. Write the electron configuration of Cd^{+2} .

Section 7.2 – Ionic Bonds and Ionic Compounds

- Compounds composed of cations and anions are called ionic compounds.
- Although they are composed of ions, ionic compounds are electrically neutral.
- The electrostatic forces that hold ions together are called ionic bonds.



Formulas

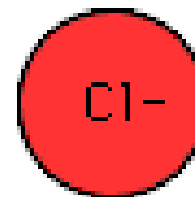
- A chemical formula shows the kinds and numbers of atoms in the smallest representative unit of a substance.
- A formula unit is the lowest whole-number ratio of ions in an ionic compound.



Subscript indicates that there are 8 carbon atoms in a molecule of octane.

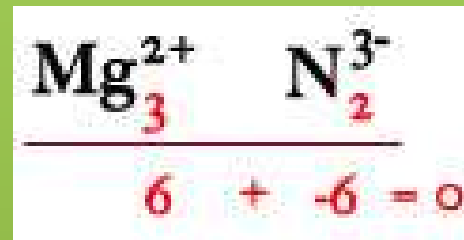
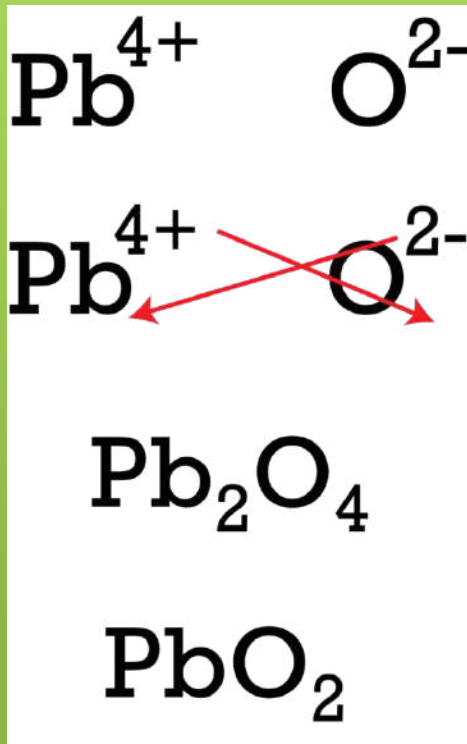
Subscript indicates that there are 18 hydrogen atoms in a molecule of octane.

Simplest Ratio



Balancing Charges

- When you balance charges to write the formula for an ionic compound, you must make the + charge and - charge equal by adding subscripts.
- The subscripts must be in the lowest ratio to be correct.



Sample Problems

- Write the formula for the compound formed between the following elements.

- Potassium and oxygen



- Magnesium and nitrogen



Practice Problems

- Write the formula for the compound when the following elements combine.

- Potassium and iodine



- Aluminum and oxygen



- Calcium and chlorine



- Barium and sulfur



Polyatomic Ions

- Polyatomic ions are a group of atoms with an overall charge.
- When balancing charges for polyatomic ions, you follow the same rule of cancelling the + and - charge.
- However, if you need to add a subscript to a polyatomic ion, then you have to put the polyatomic ion in parentheses. Ex: $\text{Ca}(\text{NO}_3)_2$

$\text{C}_2\text{H}_3\text{O}_2^-$	acetate		OH^-	hydroxide
NH_4^+	ammonium		ClO^-	hypochlorite
CO_3^{2-}	carbonate		NO_3^-	nitrate
ClO_3^-	chlorate		NO_2^-	nitrite
ClO_2^-	chlorite		$\text{C}_2\text{O}_4^{2-}$	oxalate
CrO_4^{2-}	chromate		ClO_4^-	perchlorate
CN^-	cyanide		MnO_4^-	permanganate
$\text{Cr}_2\text{O}_7^{2-}$	dichromate		PO_4^{3-}	phosphate
HCO_3^-	bicarbonate		SO_4^{2-}	sulfate
HSO_4^-	bisulfate		SO_3^{2-}	sulfite
HSO_3^-	bisulfate			

Sample Problems

- Write the formula for the compound when the following ions combine:

- Sodium and phosphate



- Ammonium nitride



- Aluminum carbonate



Practice Problems

- Write the formula for the compound when the following ions combine:

- Barium nitrate



- Lithium phosphate

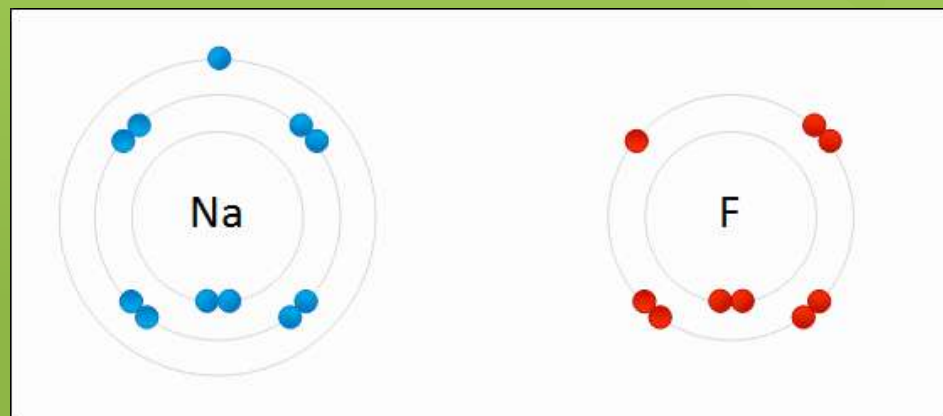
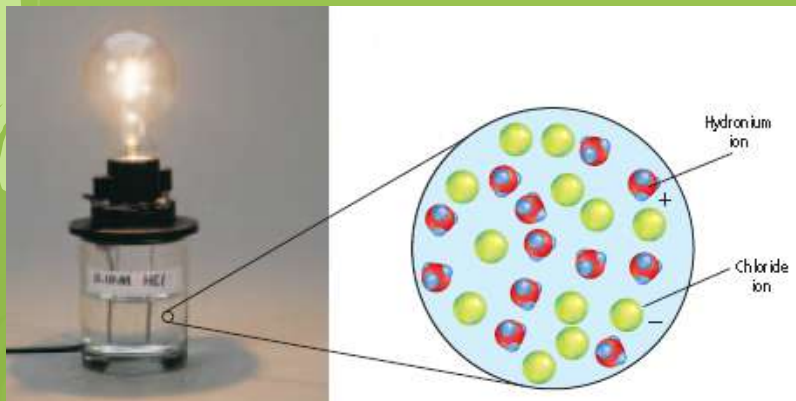
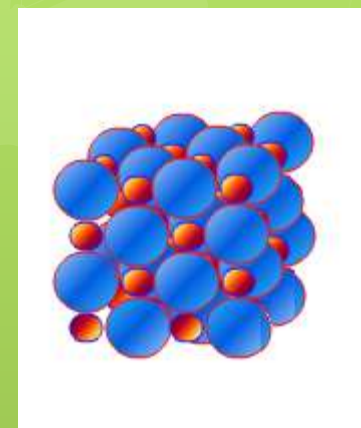


- Strontium sulfite



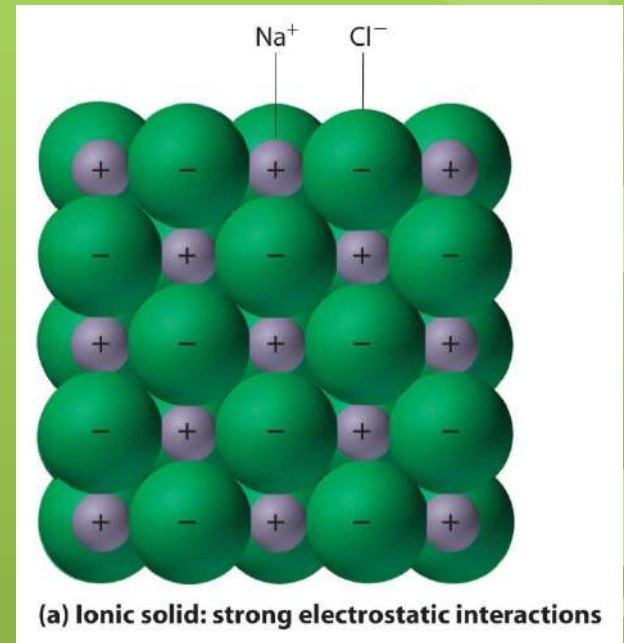
Properties of Ionic Compounds

- Properties of ionic compounds include the following:
- Crystalline solids
- High melting points
- Conduct electricity when molten or aqueous
- Made of metals and nonmetals
- Made of cations and anions
- Made of ionic bonds



Crystals

- A crystal is a substance with a 3-D repeating arrangement of particles called the crystal lattice.
- The coordination number of an ion is the number ions of opposite charge that surround the ion in a crystal.



Section 7.2 Assessment

1. How can you describe the electrical charge of an ionic compound?
2. What properties characterize ionic compounds?
3. Write the correct chemical formula for the compounds formed by each pair of ions.
 - a. K^+ , S^{-2}
 - b. Ca^{+2} , O^{-2}
 - c. Na^+ , O^{-2}
 - d. Al^{+3} , N^{-3}

Section 7.2 Assessment

4. Write formulas for each compound.

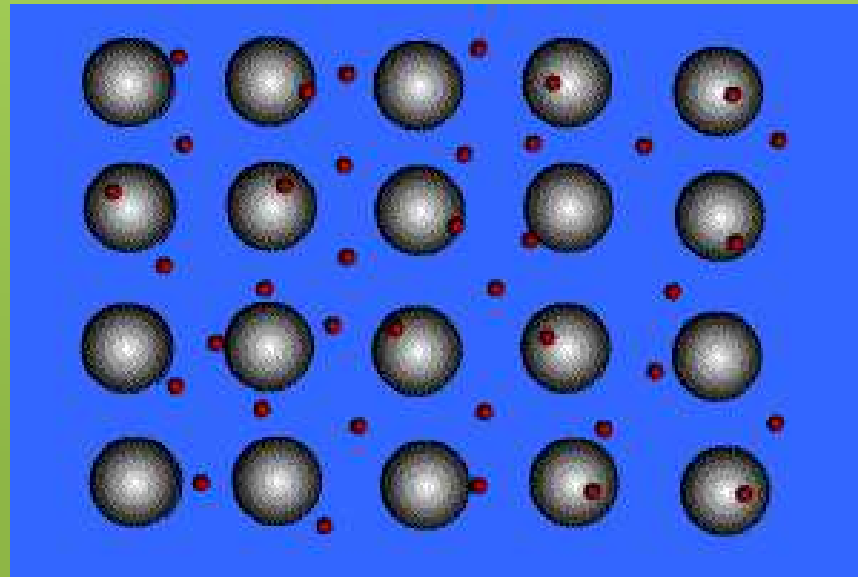
- a. barium chloride
- b. Magnesium oxide
- c. Lithium oxide
- d. Calcium fluoride

5. Which pairs of elements are likely to form ionic compounds?

- a. Cl, Br
- b. Li, Cl
- c. K, He
- d. I, Na

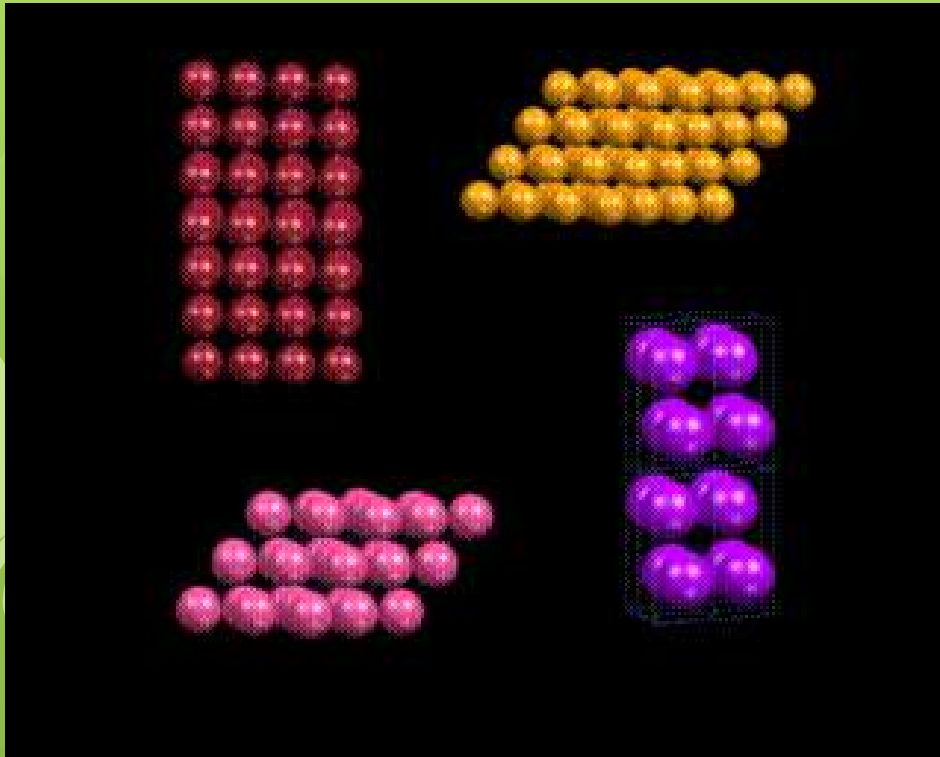
Section 7.3 – Bonding in Metals

- The valence electrons of metal atoms can be modeled as a sea of electrons.
- Metallic bonds consist of the attraction of the free-floating valence electrons for the positively charged metal ions.
- Metals are good conductors and malleable because of their mobile electrons.



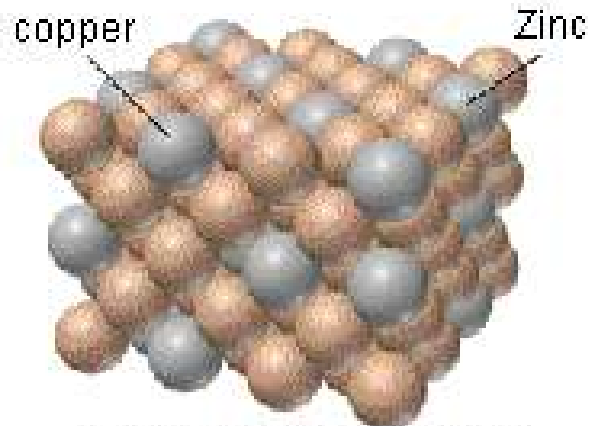
Metals

- Metals are the most simple crystals because they contain one type of element.

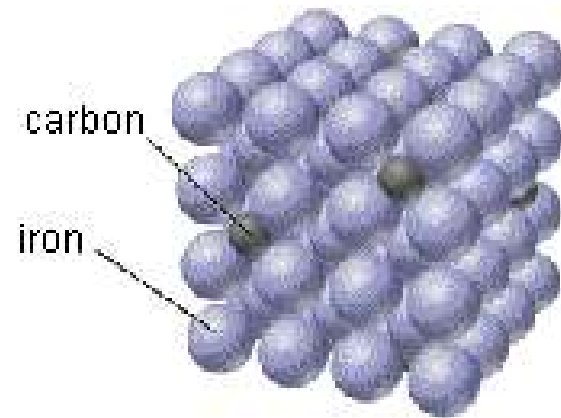


Alloys

- An alloy is a mixture with metallic properties.
- A substitutional alloy is made when atoms of one metal replace atoms of another metal.
- An interstitial alloy is made when smaller metal atoms are inserted in between larger metal atoms.



Brass (substitutional alloy)



Carbon steel (interstitial alloy)

Section 7.3 Assessment

1. How do chemists model the valence electrons in metal atoms?
2. How can you describe the arrangement of atoms in metals?
3. Why are alloys more useful than pure metals?
4. Describe what is meant by ductile and malleable.

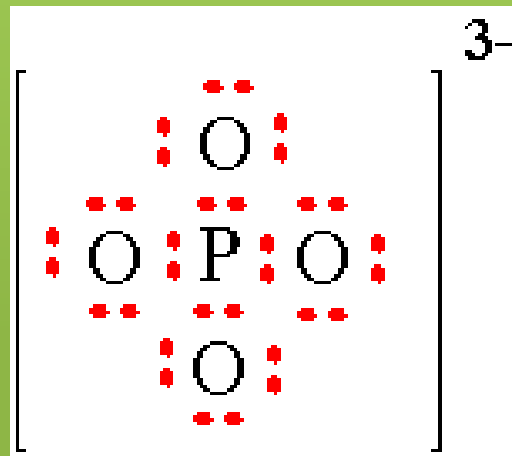
Section 9.1 – Naming with Regular Metals

- A monatomic ion is a single atom with a charge. Ex: Na^+ or O^{2-}
- When naming a cation, the name of the element does not change. Ex: K^+ = potassium
- When naming an anion, the ending of the element changes to -ide. Ex: O^{2-} = **oxide**



Polyatomic Ions

- A polyatomic ion is a group of atoms with an overall charge. Ex: SO_4^{-2}
- Most polyatomic ions end in -ate or -ite. The ending does not change when naming a compound (unless it is an acid which we will talk about later).
- The -ate suffix indicates that the polyatomic ion contains one more oxygen than the polyatomic ion with the -ite suffix. (Ex: sulfate = SO_4^{-2} , sulfite = SO_3^{-2})



Periodic Table for Naming

hydrogen 1 H 1.00794																	helium 2 He 4.002602										
lithium 3 Li 6.941	beryllium 4 Be 9.012182																										
sodium 11 Na 22.98977	magnesium 12 Mg 24.3050																										
potassium 19 K 39.0983	calcium 20 Ca 40.078	scandium 21 Sc 44.95591	titanium 22 Ti 47.867	vanadium 23 V 50.9415	chromium 24 Cr 51.9961	manganese 25 Mn 54.93805	iron 26 Fe 55.845	cobalt 27 Co 58.9332	nickel 28 Ni 58.6934	copper 29 Cu 63.546	zinc 30 Zn 65.409	gallium 31 Ga 69.723	germanium 32 Ge 72.64	arsenic 33 As 74.9216	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.798										
rubidium 37 Rb 85.4678	strontium 38 Sr 87.62	yttrium 39 Y 88.90585	zirconium 40 Zr 91.225	niobium 41 Nb 92.90638	molybdenum 42 Mo 95.94	technetium 43 Tc [98]	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.9055	palladium 46 Pd 106.42	silver 47 Ag 107.8682	cadmium 48 Cd 112.411	indium 49 In 114.818	tin 50 Sn 118.710	antimony 51 Sb 121.760	tellurium 52 Te 127.60	iodine 53 I 126.9045	xenon 54 Xe 131.293										
cesium 55 Cs 132.90545	barium 56 Ba 137.327	lutetium 71 Lu 174.967	hafnium 72 Hf 178.49	tantalum 73 Ta 180.9479	tungsten 74 W 183.84	rhenium 75 Re 186.207	osmium 76 Os 190.23	iridium 77 Ir 192.217	platinum 78 Pt 195.078	gold 79 Au 196.96655	mercury 80 Hg 200.59	thallium 81 Tl 204.3833	lead 82 Pb 207.2	bismuth 83 Bi 208.980	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]										
francium 87 Fr [223]	radium 88 Ra [226]	lawrencium 103 Lr [262]	rutherfordium 104 Rf [261]	dubnium 105 Db [262]	seaborgium 106 Sg [266]	bohrium 107 Bh [264]	hassium 108 Hs [269]	meitnerium 109 Mt [268]	darmstadtium 110 Ds [271]	roentgenium 111 Rg [272]	ununbium 112 Uub [285]	ununquadium 114 Uuq [289]															
lanthanum 57 La 138.9055	cerium 58 Ce 140.116	praseodymium 59 Pr 140.90765	neodymium 60 Nd 144.24	promethium 61 Pm [145]	samarium 62 Sm 150.36	europium 63 Eu 151.964	gadolinium 64 Gd 157.25	terbium 65 Tb 158.9253	dysprosium 66 Dy 162.50	holmium 67 Ho 164.930	erbium 68 Er 167.259	thulium 69 Tm 168.934	ytterbium 70 Yb 173.04	actinium 89 Ac [227]	thorium 90 Th 232.038	protactinium 91 Pa 231.0359	uranium 92 U 238.0289	neptunium 93 Np [237]	plutonium 94 Pu [244]	americium 95 Am [243]	curium 96 Cm [247]	berkelium 97 Bk [247]	californium 98 Cf [251]	einsteinium 99 Es [252]	fermium 100 Fm [257]	mendelevium 101 Md [258]	nobelium 102 No [259]

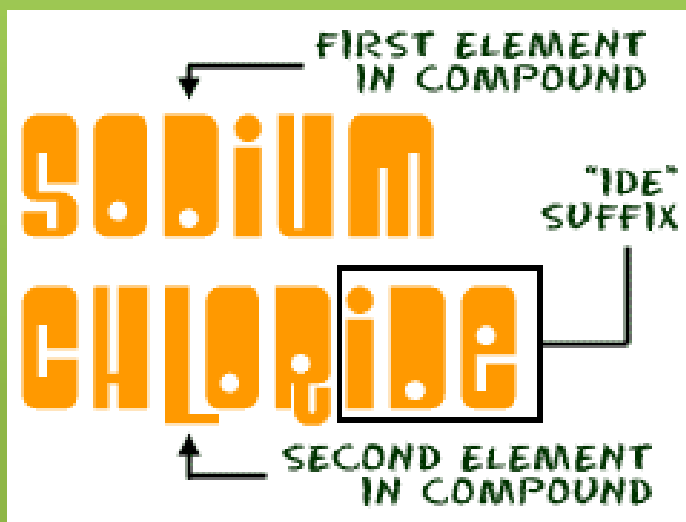
Hydrogen
Regular Metals
Transition Metals
Nonmetals

Key:

element name
atomic number
symbol
atomic weight

Naming with Regular Metals

- The regular metals are located in groups 1 and 2 (except for H). Aluminum is also a regular metal.
- When naming a compound that starts with a regular metal, you name the metal (cation) and add -ide to the nonmetal (anion). Ex: NaCl = sodium chlor**ide**
- If the anion is a polyatomic ion, then you do not change the ending. Ex: CaCO₃ = calcium carbonate



Sample Problems

● Name the following compounds:



Sodium oxide



Aluminum bromide



Lithium sulfate

Practice Problems

● Name the following compounds:



Lithium nitrate



Calcium phosphate



Ammonium oxide

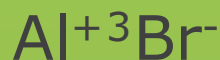
Writing the Formula with Regular Metals

- When writing the formula of a compound that starts with a regular metal, you must BALANCE THE CHARGES.

- Ex: aluminum bromide



balance charges



cation	anion	compound
Ca^{+2}	Cl^{-1}	CaCl_2
Ba^{+2}	O^{-2}	BaO
K^{+1}	S^{-2}	K_2S
Fe^{+3}	Br^{-1}	FeBr_3
Cr^{+3}	O^{-2}	Cr_2O_3

Sample Problems

● Write the formula for the following compounds:

● Aluminum chloride



● Calcium acetate



● Lithium fluoride



Practice Problems

● Write the formula for the following compounds:

● Calcium carbonate



● Aluminum oxide



● Cesium oxalate



Section 9.1 Assessment

1. What are the usual ending for the names of polyatomic ions?
2. How does a polyatomic ion differ from a monatomic ion?
3. Write the formula for these binary compounds.
 - a. Beryllium chloride
 - b. Cesium sulfide
 - c. Sodium iodide
 - d. Strontium oxide

Section 9.1 Assessment

4. Write the formula for these compounds.

a. sodium perchlorate

b. magnesium hydrogen carbonate

c. calcium acetate

5. Identify any incorrect formulas. Explain your answer.

a. $\text{Mg}_2(\text{SO}_4)_3$

b. Rb_3As

c. BeCl_3

d. NaF

Section 9.2 – Naming with Transition Metals

- Transition metals can have multiple charges, so you cannot tell the charge based on the group it is in.
- Since transition metals can have multiple charges, we use a roman numeral to indicate the charge.
- Review of Roman Numerals

1 = I

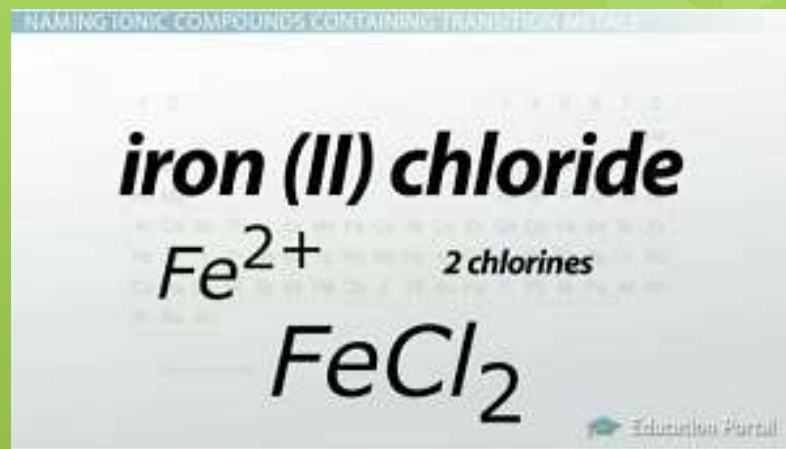
2 = II

3 = III

4 = IV

5 = V

**You should not use a roman numeral over 5.



Transition Metals

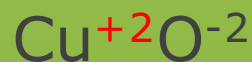
- When naming compounds that start with a transition metal, you should balance charges to figure out the charge of the transition metal.
- Remember add -ide to the anion if it is not a polyatomic ion.

● Ex: CuO

we know that O has a -2 charge.



to cancel out a -2, Cu must be +2



so the name would be **copper (II) oxide**.

Sample Problems

● Write the names for the following:



Copper (I) oxide



Iron (III) chloride



Lead (II) sulfate

Practice Problems

● Write the name of the following:



Lead (IV) sulfide



Zinc (II) acetate



Silver (I) phosphite

Old Names for Transition Metals

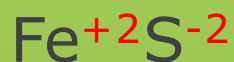
- For the old naming system for transition metals, the old Latin names are used with the suffix -ic or -ous.

Ion	Old Name
Fe^{3+}	ferric
Fe^{2+}	ferrous
Cu^{2+}	cupric
Cu^{+}	cuprous
Co^{3+}	cobaltic
Co^{2+}	cobaltous
Sn^{4+}	stannic
Sn^{2+}	stannous
Pb^{4+}	plumbic
Pb^{2+}	plumbous
Hg^{2+}	mercuric
Hg_2^{2+}	mercurous

Old Names for Transition Metals

- The -ic ending indicates a higher charge, and the -ous ending indicates a lower charge.
- When writing the name for a compound, you figure out the charge for the transition metal and then find the old name on the chart.

● Ex: FeS



Fe^{+2} = ferrous

FeS = ferrous sulfide



Practice Problems

● Write the old names for the following:



Cuprous phosphide



Ferric nitrate



Plumbous sulfide

Writing the Formulas for Transition Metals

- When writing the formula for a compound that starts with a transition metal, you must BALANCE THE CHARGES.

- Ex: vanadium (V) fluoride



balance charges



REMEMBER THE ROMAN NUMERAL IS THE CHARGE, NOT THE SUBSCRIPT!!!!!!!!!!!!!!!!!!!!

Sample Problems

● Write the formula for the following:

● Tin (II) permanganate



● Mercury (I) oxide



● Cobaltic carbonate



Practice Problems

● Write the formula for the following:

● Gold (II) iodide



● Vanadium (IV) nitrite



● ferrous chromate



Section 9.2 Assessment

1. Write the formula for chromium (III) nitrite.

THE END