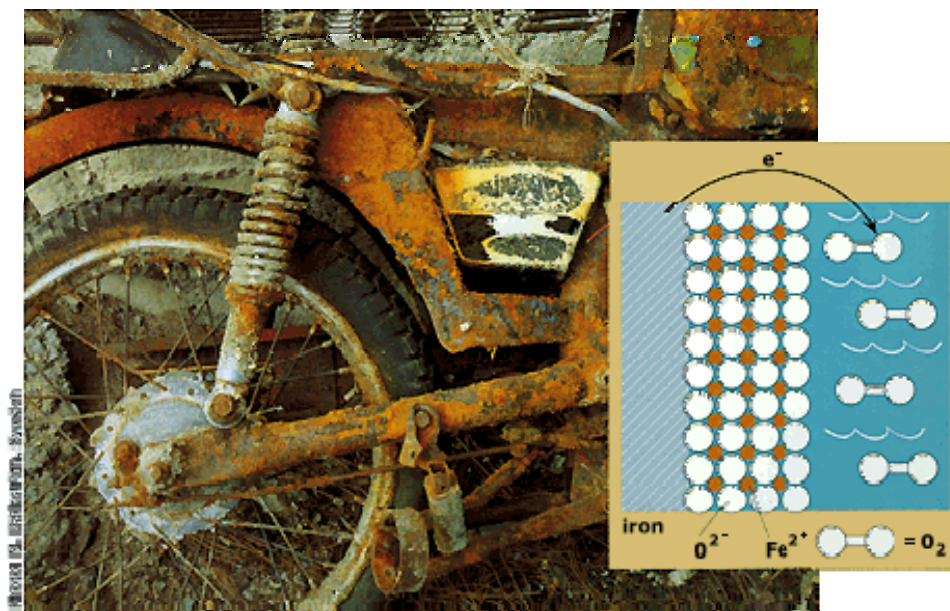


Compounds of Metals

Ionic Bonding and Inorganic Compounds



MODIFIED FROM Dr. Patricia Hill, Millersville University

Compounds of Metals

■ Ores

- Hematite
- Chalcopyrite
- Bauxite

hematite



bauxite



■ Corrosion

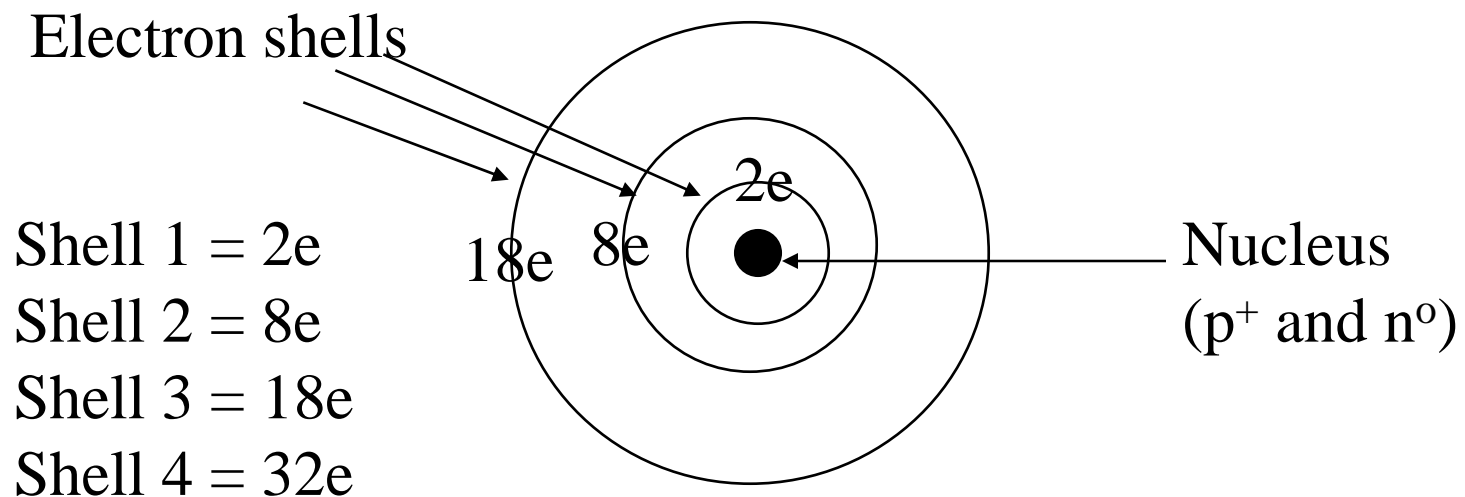
- Rust = iron oxide = Fe_2O_3
- Alumina = aluminum oxide = Al_2O_3
- Tarnish = silver sulfide = Ag_2S
- Darkened white paint = Lead sulfide = PbS

■ Metallic salts

- Sodium chloride = NaCl
- Copper chloride = CuCl_2 and CuCl

Bohr Model of the Atom

- **Planetary model** of electron location
- Energy **shells** contain maximum number of electrons — $2n^2$



Bohr Diagrams of Atoms

■ Need to know

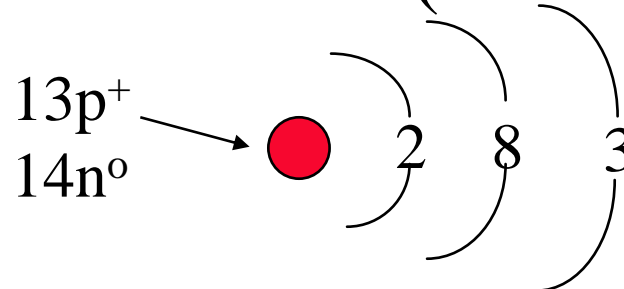
Symbol of element

Number of p^+ , n^0 , and e^-

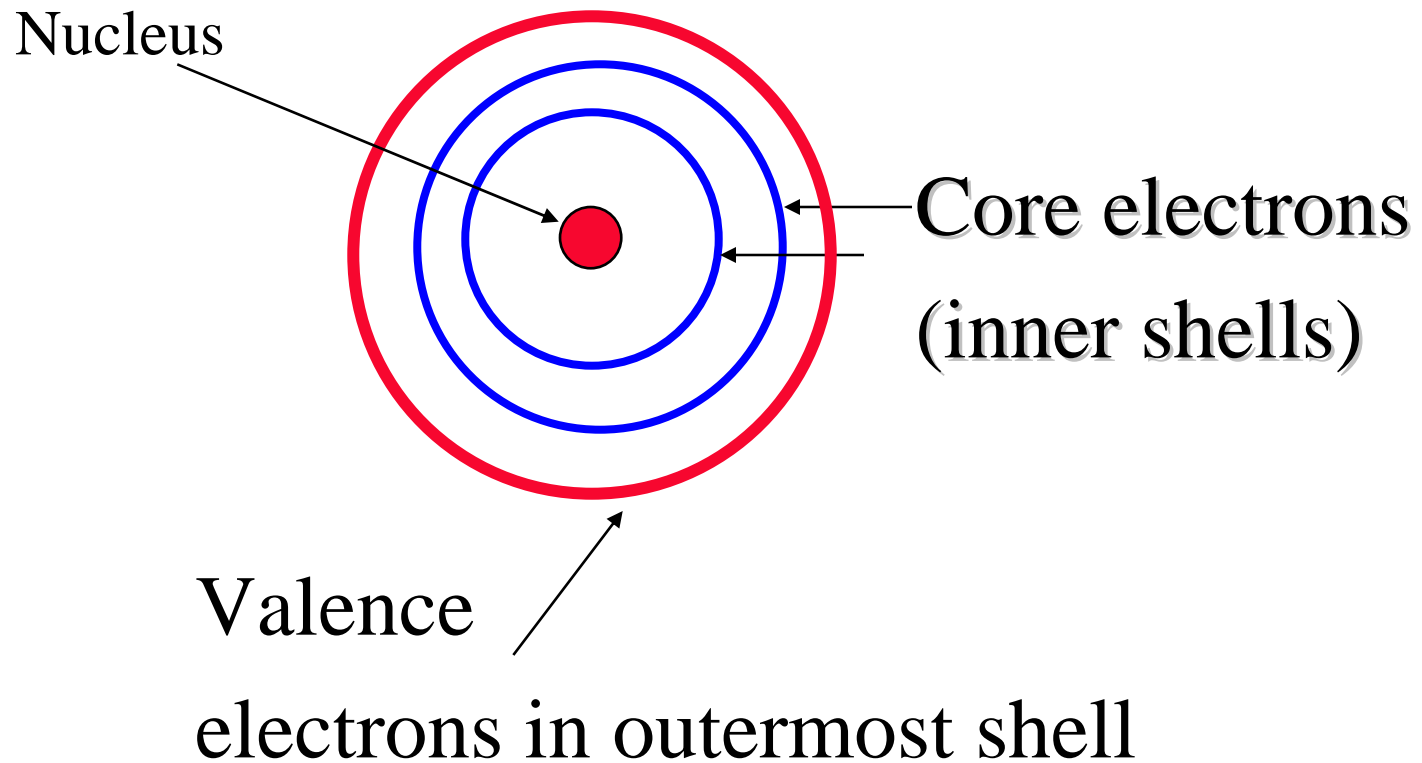
How many electrons in each shell

■ Aluminum

Al ($Z = 13$, $A = 27$)



What Are Valence Electrons?



	I A s1	II A s2	Transition elements										III A s2 p1	IV A s2 p2	V A s2 p3	VI A s2 p4	VII A s2 p5	VIII A s2 p6	0	
1	1 H																			2 He
2	3 Li	4 Be	← Transition elements →										5 B	6 C	7 N	8 O	9 F	10 Ne		
3	11 Na	12 Mg	← VIII →										13 Al	14 Si	15 P	16 S	17 Cl	18 Ar		
4	19 K	20 Ca	d1 s2	d2 s2	d3 s2	d5 s1	d5 s2	d6 s2	d7 s2	d8 s2	d10 s1	d10 s2	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr		
5	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		
6	55 Cs	56 Ba	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn		
7	87 Fr	88 Ra	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Uub	113 Uut	114 Uuq	115 Uup	116 Uuh				

Inner Transition Elements														
Lanthanides	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
Actinides	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

Legend	
Metals	Metalloids
Non-Metals	Inert Gases

Periodic Table of the Elements

1 IA

H 1
Hydrogen
1.00794
 $1s^1$

Group, new → 1 IA ← Group, old

Symbol → **K** 19 ← Atomic number

Name → **Potassium** ← Atomic mass (averaged according to occurrence on earth)

Electron configuration → $4s^1$

18 VIIA

He 2
Helium
4.00260
 $1s^2$

Metals										Nonmetals							
13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
B 5 Boron 10.81 $2p^1$	C 6 Carbon 12.011 $2p^2$	N 7 Nitrogen 14.0067 $2p^3$	O 8 Oxygen 15.9994 $2p^4$	F 9 Fluorine 18.9984 $2p^5$	Ne 10 Neon 20.179 $2p^6$	B 5 Boron 10.81 $2p^1$	C 6 Carbon 12.011 $2p^2$	N 7 Nitrogen 14.0067 $2p^3$	O 8 Oxygen 15.9994 $2p^4$	F 9 Fluorine 18.9984 $2p^5$	Ne 10 Neon 20.179 $2p^6$	B 5 Boron 10.81 $2p^1$	C 6 Carbon 12.011 $2p^2$	N 7 Nitrogen 14.0067 $2p^3$	O 8 Oxygen 15.9994 $2p^4$	F 9 Fluorine 18.9984 $2p^5$	Ne 10 Neon 20.179 $2p^6$
Al 13 Aluminum 26.9815 $3p^1$	Si 14 Silicon 28.0855 $3p^2$	P 15 Phosphorus 30.9738 $3p^3$	S 16 Sulfur 32.06 $3p^4$	Cl 17 Chlorine 35.453 $3p^5$	Ar 18 Argon 39.948 $3p^6$	Al 13 Aluminum 26.9815 $3p^1$	Si 14 Silicon 28.0855 $3p^2$	P 15 Phosphorus 30.9738 $3p^3$	S 16 Sulfur 32.06 $3p^4$	Cl 17 Chlorine 35.453 $3p^5$	Ar 18 Argon 39.948 $3p^6$	Al 13 Aluminum 26.9815 $3p^1$	Si 14 Silicon 28.0855 $3p^2$	P 15 Phosphorus 30.9738 $3p^3$	S 16 Sulfur 32.06 $3p^4$	Cl 17 Chlorine 35.453 $3p^5$	Ar 18 Argon 39.948 $3p^6$
K 19 Potassium 39.0983 $4s^1$	Ca 20 Calcium 40.078 $4s^2$	Sc 21 Scandium 44.955910 $3d^1 4s^2$	Ti 22 Titanium 47.88 $3d^2 4s^2$	V 23 Vanadium 50.9415 $3d^3 4s^2$	Cr 24 Chromium 51.9961 $3d^5 4s^1$	Mn 25 Manganese 54.93805 $3d^5 4s^2$	Fe 26 Iron 55.847 $3d^6 4s^2$	Co 27 Cobalt 58.93320 $3d^7 4s^2$	Ni 28 Nickel 58.69 $3d^8 4s^2$	Cu 29 Copper 63.546 $3d^{10} 4s^1$	Zn 30 Zinc 65.39 $3d^{10} 4s^2$	Ga 31 Gallium 69.723 $4p^1$	Ge 32 Germanium 72.61 $4p^2$	As 33 Arsenic 74.92159 $4p^3$	Se 34 Selenium 78.96 $4p^4$	Br 35 Bromine 79.904 $4p^5$	Kr 36 Krypton 83.80 $4p^6$
Rb 37 Rubidium 85.4678 $5s^1$	Sr 38 Strontium 87.62 $5s^2$	Y 39 Yttrium 88.90585 $4d^1 5s^2$	Zr 40 Zirconium 91.224 $4d^2 5s^2$	Nb 41 Niobium 92.90638 $4d^4 5s^1$	Mo 42 Molybdenum 95.94 $4d^5 5s^1$	Tc 43 Technetium (98) $4d^5 5s^2$	Ru 44 Ruthenium 101.07 $4d^7 5s^1$	Rh 45 Rhodium 102.90550 $4d^8 5s^1$	Pd 46 Palladium 106.42 $4d^{10} 5s^0$	Ag 47 Silver 107.8682 $4d^{10} 5s^1$	Cd 48 Cadmium 112.411 $4d^{10} 5s^2$	In 49 Indium 114.82 $5p^1$	Sn 50 Tin 118.710 $5p^2$	Sb 51 Antimony 121.75 $5p^3$	Te 52 Tellurium 127.60 $5p^4$	I 53 Iodine 126.905 $5p^5$	Xe 54 Xenon 131.30 $5p^6$
Cs 55 Cesium 132.90543 $6s^1$	Ba 56 Barium 137.327 $6s^2$	57 - 71 Lanthanide series	Hf 72 Hafnium 178.49 $5d^2 6s^2$	Ta 73 Tantalum 180.9479 $5d^3 6s^2$	W 74 Tungsten 183.85 $5d^4 6s^2$	Re 75 Rhenium 186.207 $5d^5 6s^2$	Os 76 Osmium 190.2 $5d^6 6s^2$	Ir 77 Iridium 192.22 $5d^7 6s^2$	Pt 78 Platinum 195.08 $5d^9 6s^1$	Au 79 Gold 196.96654 $5d^{10} 6s^1$	Hg 80 Mercury 200.59 $5d^{10} 6s^2$	Tl 81 Thallium 204.3833 $6p^1$	Pb 82 Lead 207.2 $6p^2$	Bi 83 Bismuth 208.98037 $6p^3$	Po 84 Polonium (209) $6p^4$	At 85 Astatine (210) $6p^5$	Rn 86 Radon (222) $6p^6$
Fr 87 Francium (223) $7s^1$	Ra 88 Radium (226) $7s^2$	89 - 103 Actinide series	Uuq 104 Ununquadium (261) $6d^7 7s^2$	Uup 105 Ununpentium (262) $6d^7 7s^2$	Uuh 106 Ununhexium (263) $6d^7 7s^2$	Uus 107 Ununseptium (262)	108	109									

Lanthanide series

La 57 Lanthanum 138.9055 $5d^1 6s^2$	Ce 58 Cerium 140.115 $4f^1 5d^1 6s^2$	Pr 59 Praseodymium 140.90765 $4f^3 6s^2$	Nd 60 Neodymium 144.24 $4f^4 6s^2$	Pm 61 Promethium (145) $4f^5 6s^2$	Sm 62 Samarium 150.36 $4f^6 6s^2$	Eu 63 Europium 151.965 $4f^7 6s^2$	Gd 64 Gadolinium 157.25 $4f^7 5d^1 6s^2$	Tb 65 Terbium 158.92534 $4f^9 6s^2$	Dy 66 Dysprosium 162.50 $4f^{10} 6s^2$	Ho 67 Holmium 164.93032 $4f^{11} 6s^2$	Er 68 Erbium 167.26 $4f^{12} 6s^2$	Tm 69 Thulium 168.93421 $4f^{13} 6s^2$	Yb 70 Ytterbium 173.04 $4f^{14} 6s^2$	Lu 71 Lutetium 174.967 $4f^{14} 5d^1 6s^2$
--	---	--	--	--	---	--	--	---	--	--	--	--	---	--

Actinide series

Ac 89 Actinium (227) $6d^1 7s^2$	Th 90 Thorium 232.0381 $6d^2 7s^2$	Pa 91 Protactinium 231.03688 $5f^2 6d^1 7s^2$	U 92 Uranium 238.0289 $5f^3 6d^1 7s^2$	Np 93 Neptunium (237) $5f^4 6d^1 7s^2$	Pu 94 Plutonium (244) $5f^6 6d^1 7s^2$	Am 95 Americium (243) $5f^7 6d^1 7s^2$	Cm 96 Curium (247) $5f^8 6d^1 7s^2$	Bk 97 Berkelium (247) $5f^9 6d^1 7s^2$	Cf 98 Californium (251) $5f^{10} 6d^1 7s^2$	Es 99 Einsteinium (252) $5f^{11} 6d^1 7s^2$	Fm 100 Fermium (257) $5f^{12} 6d^1 7s^2$	Md 101 Mendelevium (258) $5f^{13} 6d^1 7s^2$	No 102 Nobelium (259) $6d^1 7s^2$	Lr 103 Lawrencium (260) $6d^1 7s^2$
--	--	---	--	--	--	--	---	--	---	---	--	--	---	---

Importance of Valence Electrons

- **Valence** electrons — in outermost shell
 - Account for chemical properties and reactivity of elements
 - Allow atoms to form chemical bonds
 - Group number of A elements

Lewis Dot Structures of Elements

Hydrogen



Aluminum



- Show only the valence electrons
- Need to know
 - Symbol of element
 - Number of valence electrons

Lewis Dot Structures

■ Draw the correct dot structures for

Sodium

Calcium

Carbon

Chlorine

Oxygen

Nitrogen

Chemical Bonding

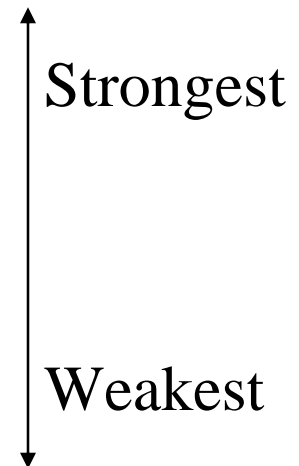
- Holds all matter together
- The key players are

VALENCE electrons

What Are Chemical Bonds?

■ 5 Types of chemical bonds hold all matter together

- * **Covalent Bonding**
- * **Ionic Bonding**
- * **Metallic Bonding**
- * **Hydrogen Bonding**
- * **Van der Waals Forces**



Strongest

Weakest

The Top Three Types of Bonds

- covalent bonds = sharing of electrons
- ionic bonds = exchange of electrons
- metallic bonds = delocalization of electrons

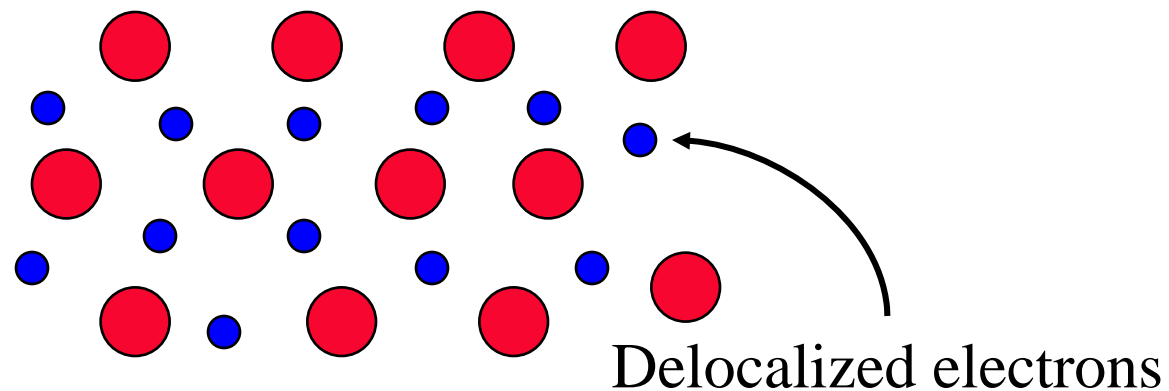
Metallic Bonding

Periodic Table of the Elements 2006

See "It's Elemental: The Periodic Table" <http://pubs.ocs.org/cen/80th/elements.html>

Molecular Research Institute

- Metals have 1, 2, or 3 valence electrons
- Valence electrons shared by all metal atoms
- metal **cations** arranged in regular array



- “**sea of electrons**” surround metal **cations**

Delocalized Electrons in Metals

- Provide metallic properties
 - conduction and luster
 - density and strength
 - crystalline structure
 - ability to easily form alloys



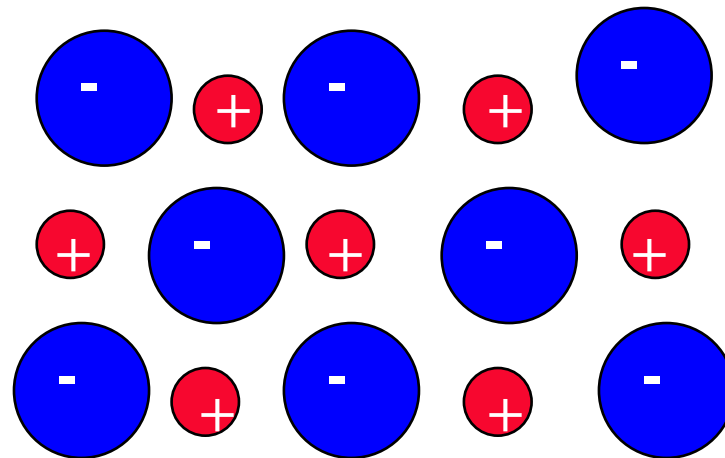
Grains in steel

Metallic Salts—Ionic Bonding

- **Octet Rule** — atoms prefer to have a filled valence shell containing 8 electrons (except He)
- To obtain an octet atoms **lose**, **gain** or **share electrons**
- Ionic bonds result when one element loses electrons and the other element gains electrons

Ionic Bond

- **Cations** and **anions** are formed and held together by strong (+) and (-) charges

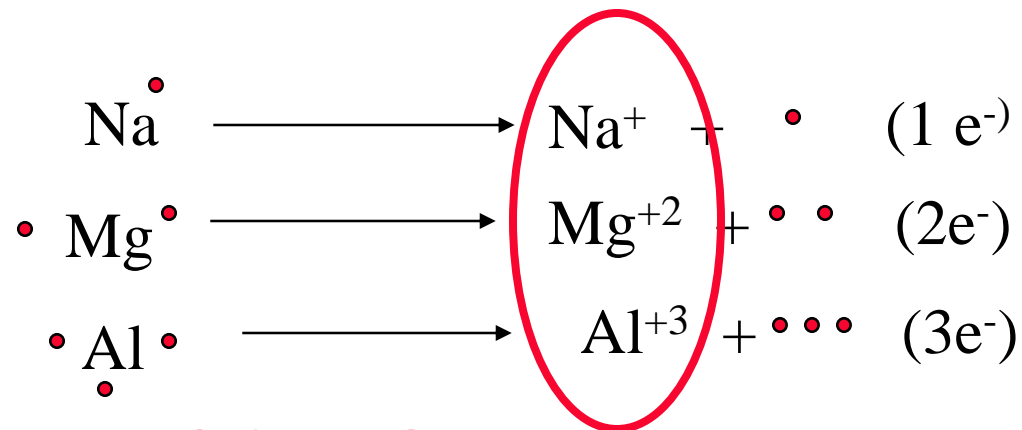


Ionic Bonding

- Results in **IONIC COMPOUNDS**
- Basic unit formed is called a **FORMULA**
- Ionic compounds formed between
 - Metals** - Groups I, II, III
 - Nonmetals** - Groups V, VI, VII

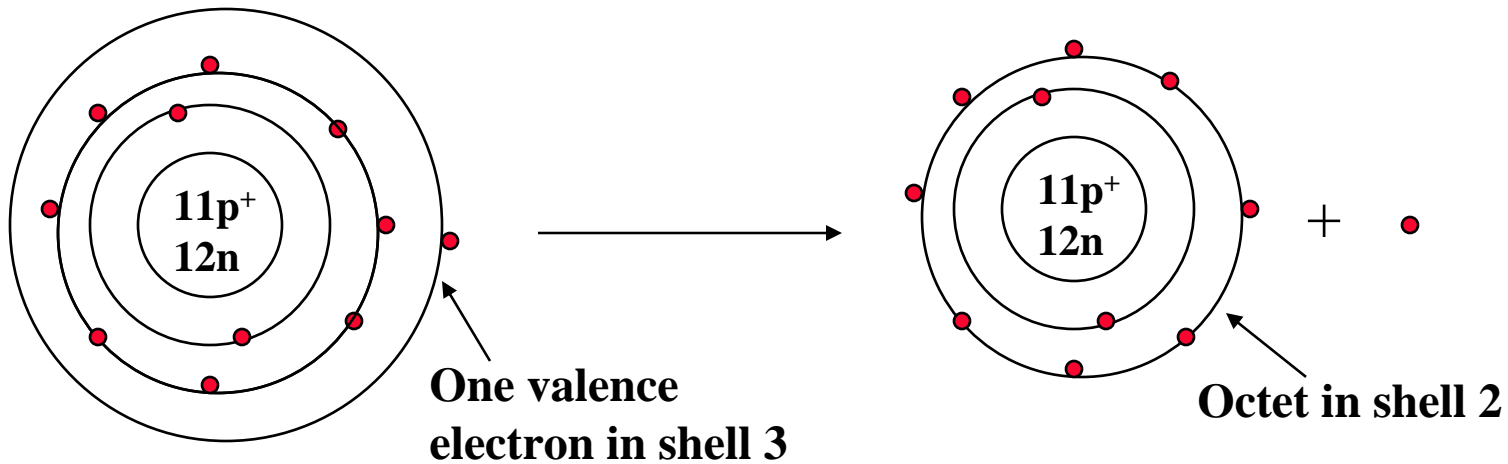
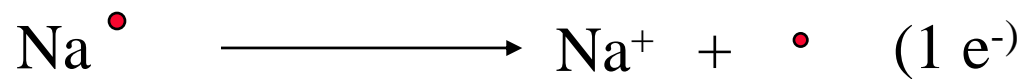
Formation of **Positive Ions**

- Metal elements in Groups 1, 2 and 3A can easily lose 1, 2 or 3 valence electrons to obtain an “octet”



- Results in **CATION** formation
- Called an **OXIDATION** reaction (**OIL**)

Formation of **Cations**

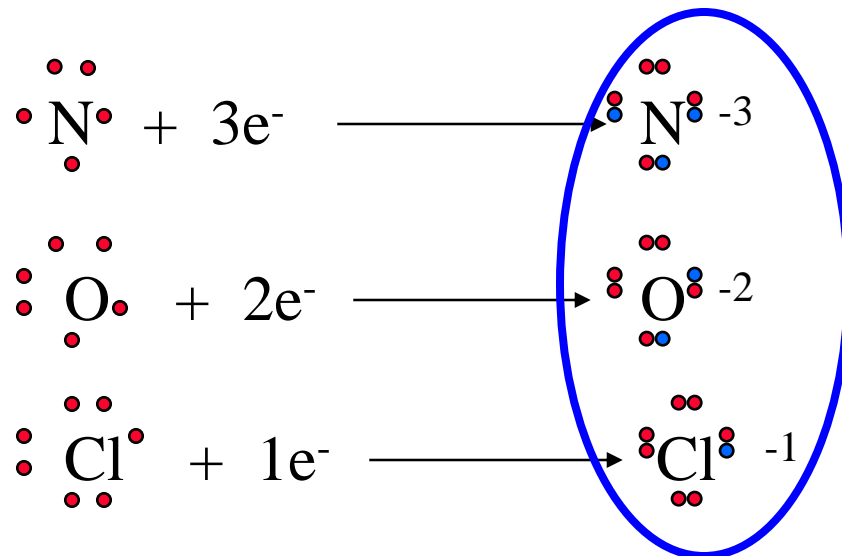


$$\begin{array}{r} 11 + \\ \underline{11 -} \\ 0 \text{ charge} \end{array}$$

$$\begin{array}{r} 11 + \\ \underline{10 -} \\ +1 \text{ charge} \end{array}$$

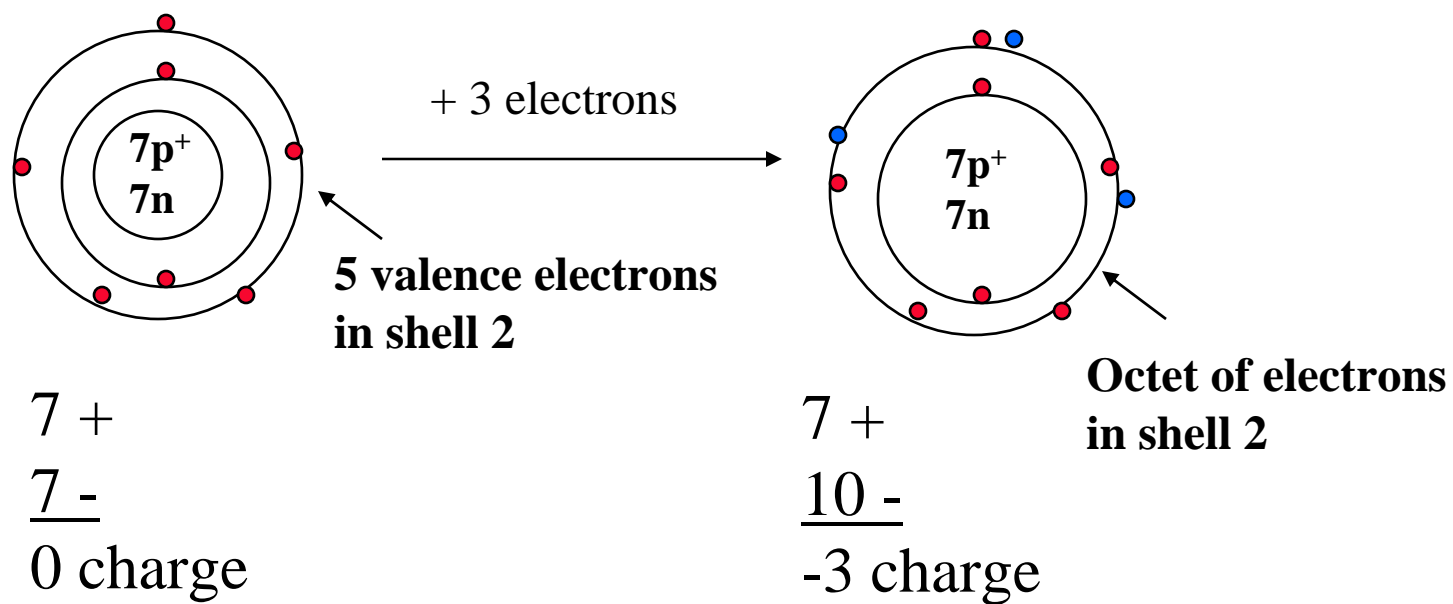
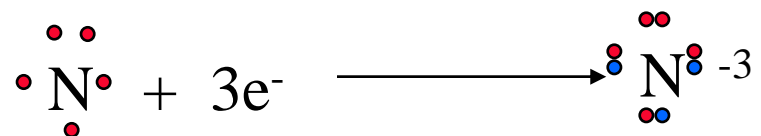
Formation of **Negative Ions**

- Nonmetal elements in groups VA, VIA, and VIIA can easily gain 1, 2, or 3 electrons to obtain an “octet”

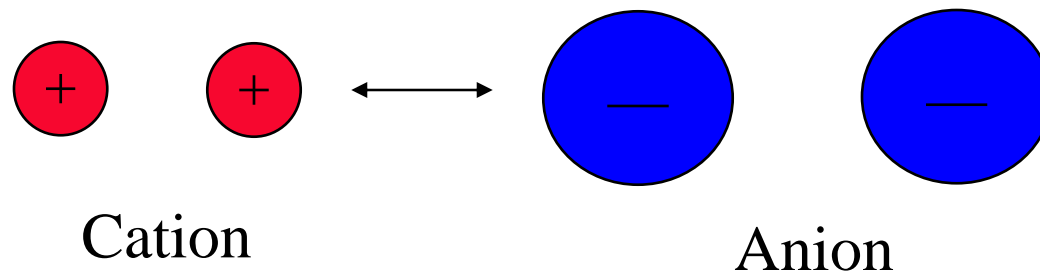


- result in **ANION** formation - **REDUCTION**
(RIG)

Formation of Anions



Ionic Bonds — Ionic Compounds



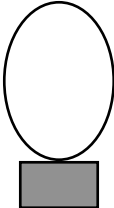
Electrostatic attraction = ionic bond
Ionic compounds

crystalline solids with high mp

usually water soluble

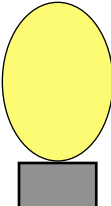
electrolytes (conduct electricity)

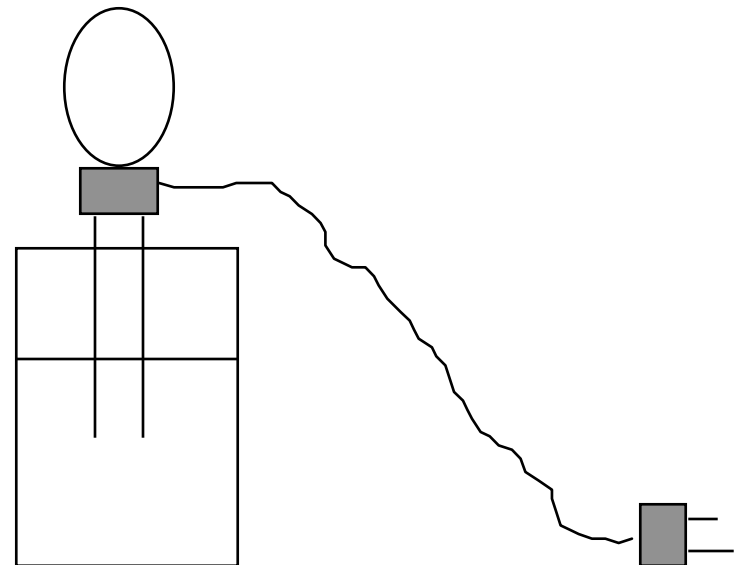
Do Ions Really Exist?

pure H_2O = 

$\text{H}_2\text{O} + \text{NaCl}$ = 

$\text{H}_2\text{O} + \text{Sugar}$ = 

Tap water = 



Conductivity tester

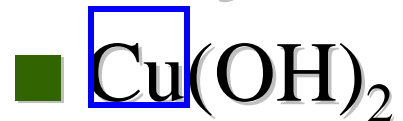
Binary Compounds

- composed of **only 2 different elements**
- may be **ionic** or **covalent** compounds

IONICS = a metallic element is usually present

COVALENTS = contain only nonmetallic elements

Ionic or Covalent?



Metal + Nonmetal = Ionic

Binary **Ionic** Compounds

■ **Writing correct names from formulas**

1. Metal ions gets its element name and is put first
2. Nonmetal ion is named second and the ending of its name is changed to **—IDE**



Sodium chlor**IDE**

Calcium chlor**IDE**

Aluminum chlor**IDE**

Binary Covalent Compounds

■ Writing correct names from formulas

1. First element gets its elemental name
2. The ending of the name of the second element is changed to **—IDE**
3. If numerical subscripts are present
 - use **prefixes** to indicate how many atoms are present



Hydrogen chlor**IDE**



Dihydrogen sulf**IDE**



Carbon **tetra**chlor**IDE**

Comparing Ionics & Covalents

■ Binary **Ionics** (metallic element)

NaCl	Sodium chlor IDE
CaCl ₂	Calcium chlor IDE
AlCl ₃	Aluminum chlor IDE

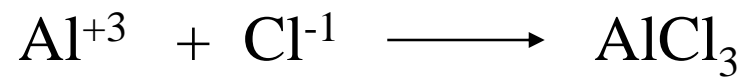
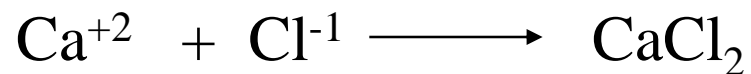
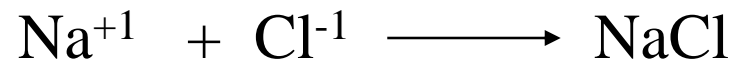
■ Binary **Covalents** (no metallic elements)

HCl	Hydrogen chlor IDE
H ₂ S	Di hydrogen sulf IDE
CCl ₄	Carbon tetra chlor IDE

Binary Ionic Compounds

■ Writing correct formulas

1. Metal symbol written first
2. Nonmetal symbol second
3. Appropriate subscripts so that amount of (+) equals amount of (-)



Finding Charges for **Cations**

1

Periodic Table of the Elements 2006

1 H 1.01																	2 He 4.00						
3 Li 6.94	4 Be 9.01																	5 B 10.81	6 C 12.01	7 N 14.01	8 O 15.99	9 F 19.00	10 Ne 20.18
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
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	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 65.41	31 Ga 69.72	32 Ge 72.64	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80						
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29						
55 Cs 132.91	56 Ba 137.33	57 La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)						
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (270)	109 Mt (268)	110 Ds (281)	111 Rg (272)	<p>See "It's Elemental: The Periodic Table" http://pubs.acs.org/cen/80th/elements.html</p>												



58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.97	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	71 Lu 174.97
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)	103 Lr (262)

Finding Charges for Anions

1

Periodic Table of the Elements 2006

1 H 1.01																	2 He 4.00						
3 Li 6.94	4 Be 9.01																	5 B 10.81	6 C 12.01	7 N 14.01	8 O 15.99	9 F 19.00	10 Ne 20.18
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
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	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 65.41	31 Ga 69.72	32 Ge 72.64	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80						
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29						
55 Cs 132.91	56 Ba 137.33	57 La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)						
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (270)	109 Mt (268)	110 Ds (281)	111 Rg (272)	<p>See "It's Elemental: The Periodic Table" http://pubs.acs.org/cen/80th/elements.html</p>												



58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.97	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	71 Lu 174.97
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)	103 Lr (262)

Ions of Transition Metals

- can form several different charged ions
- important ones to know

Fe Fe^{+2} and Fe^{+3}

Cu Cu^{+1} and Cu^{+2}

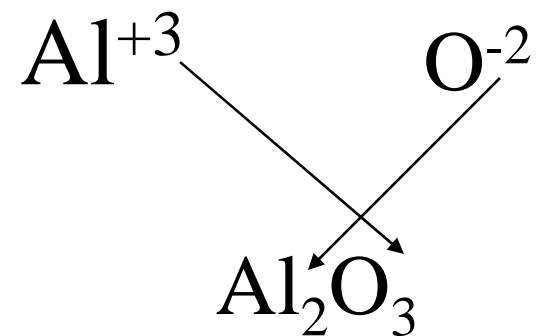
Sn Sn^{+2} and Sn^{+4}

Ag = +1

Cr, Co, Ni, Zn, Cd, Hg, Pb = +2

The “Cross-over” Method

- Quick way to write formulas for ionic compounds



- The value of the charge on one ion becomes the subscript for other ion

Obtaining Metals from Ores

Never occur “Free”

Lithium
Potassium
Barium
Strontium
Calcium
Sodium
Magnesium
Beryllium
Aluminum
Manganese
Zinc
Chromium

Rarely found “Free”

Iron
Cadmium
Cobalt
Nickel
Tin
Lead
HYDROGEN
Antimony
Bismuth
Arsenic

Often found “Free”

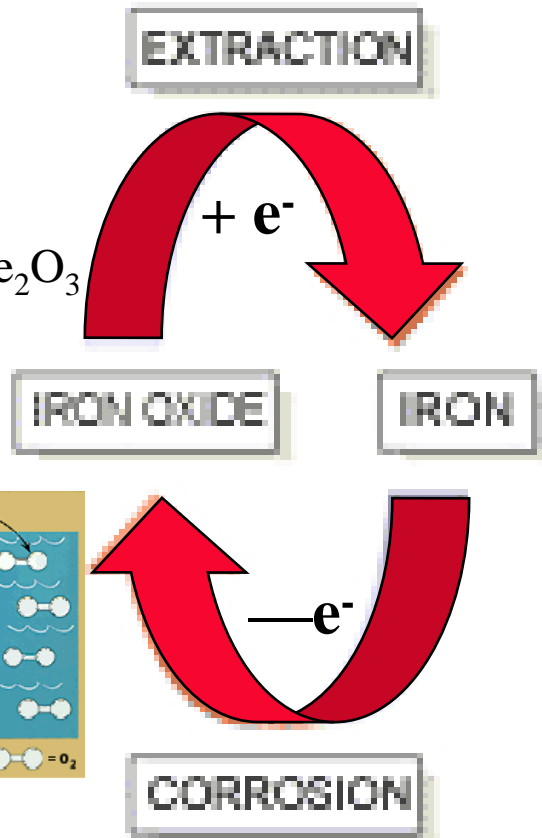
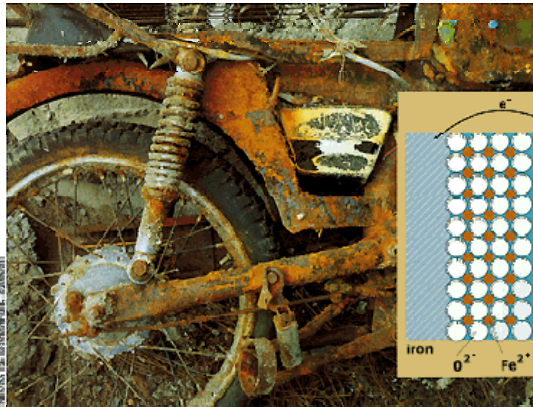
Copper
Mercury
Silver
Platinum
Gold

The *Redox* Cycle



Hematite (iron ore) = Fe_2O_3

Rust = Fe_2O_3



Reduction(RIG)

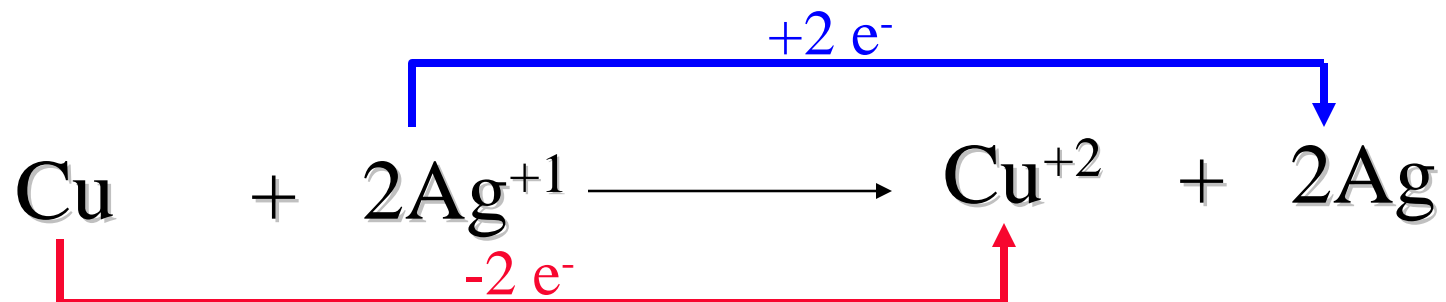


Oxidation(OIL)

Spontaneous Redox Reaction



Copper metal disappears and silver metal appears.



Copper metal loses electrons to form copper cations (**oxidation**).

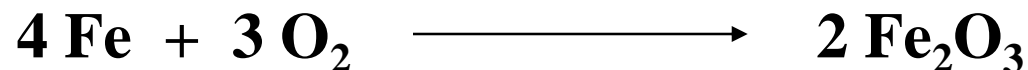
Silver ions gain electrons to form silver metal (**reduction**).

Obtaining Metals from Ores

- Iron occurs most frequently as Fe_2O_3 and not as “native iron”
- Ores are “**oxidized metals**”
- Fe^{+3} is “oxidized iron” — it has...

lost electrons

gained oxygen



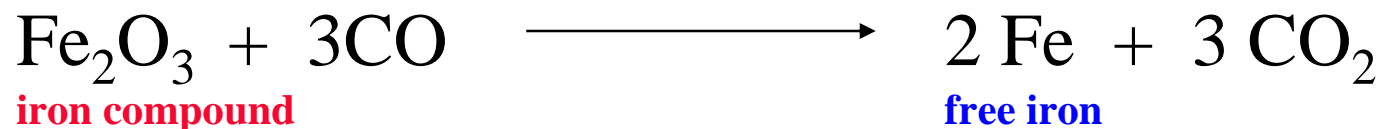
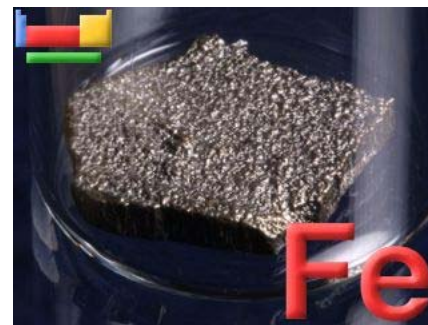
Oxidation-Reduction Reactions

- To obtain iron metal the Fe must be forced to ...
to ...

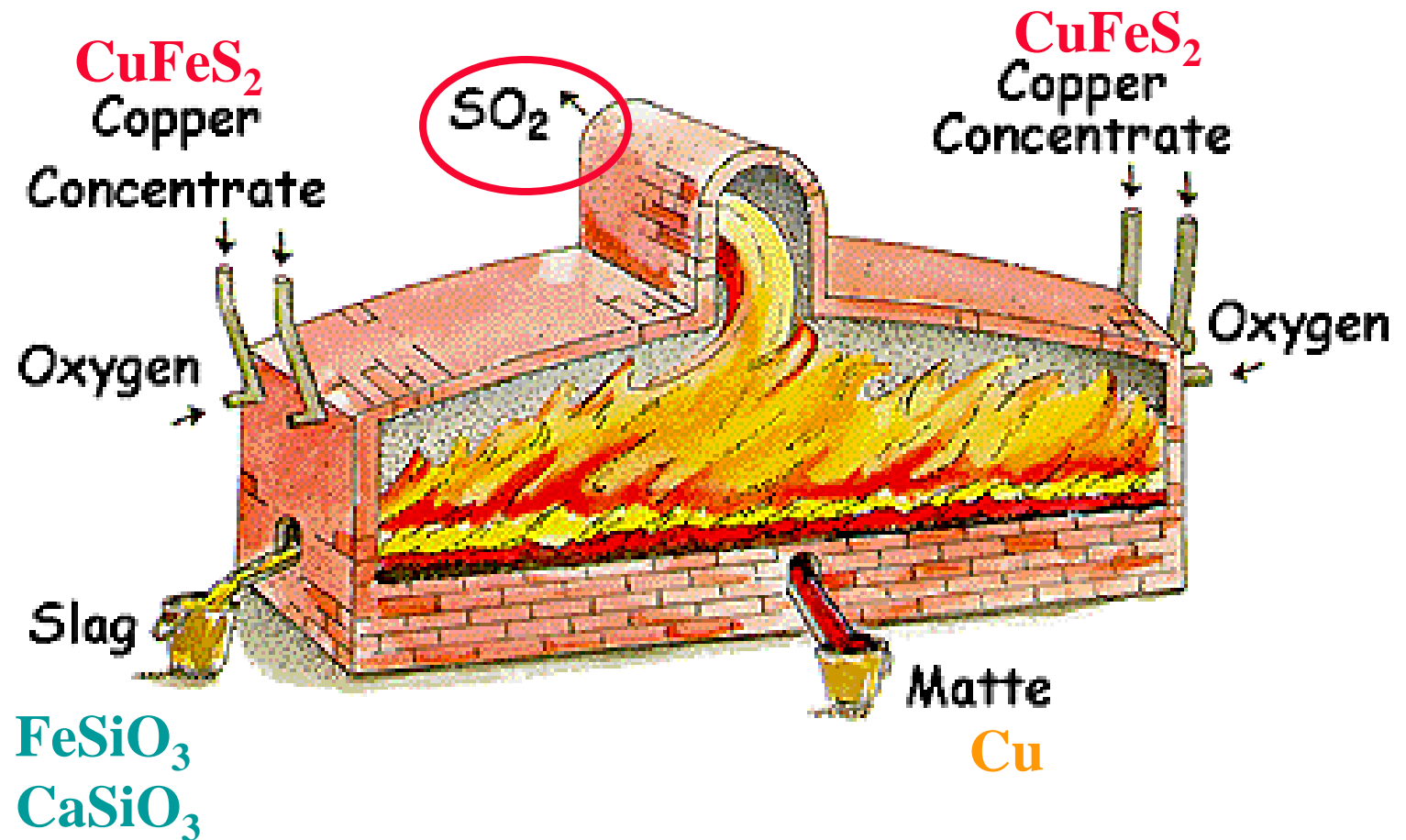


Hematite (iron ore) = Fe_2O_3

gain electrons
lose oxygen



Copper from Chalcopyrite



Redox and Metallurgy

- **Refining** of metals — supplying electrons to produce “reduced metals”

iron from Fe_2O_3 (hematite)

aluminum from Al_2O_3 (bauxite)

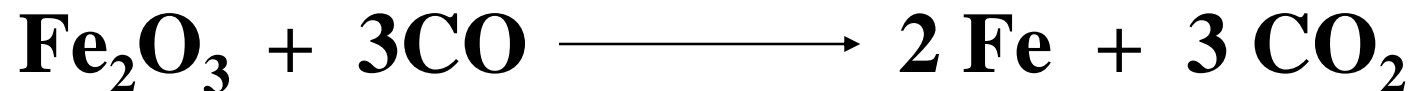
copper from CuS , Cu_2O , CuFeS_2

- **Electrolysis** and **Electroplating**

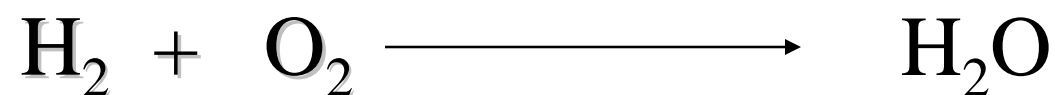
use of electricity to produce oxidation-reduction reactions with metals

Balanced Chemical Equations

- Matter cannot be created or destroyed!
- Total number and types of atoms must be the **same on both sides** of the arrows
- The arrangement and combinations of atoms are different on each side of the arrow



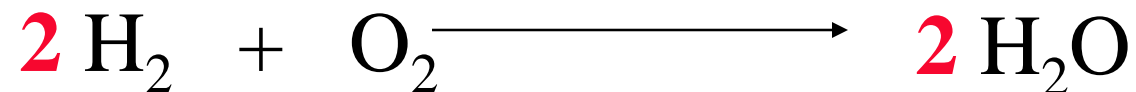
Balancing Simple Equations



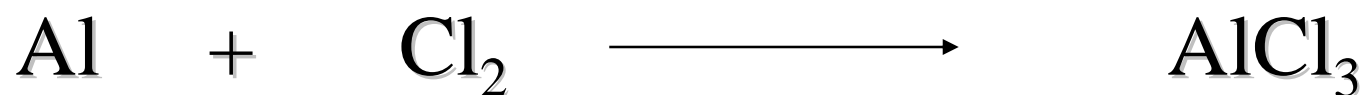
Count up atoms on each side of arrow.



Balance unbalanced elements by placing small whole number coefficients in front of formulas. Recount.



Balancing Simple Equations

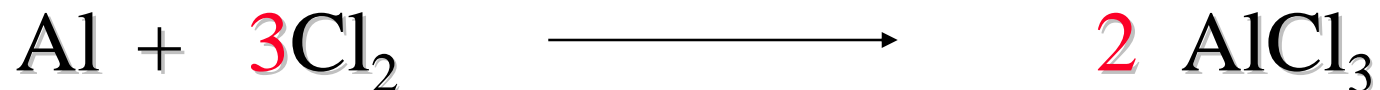


Al 1

Cl 2

Al 1

Cl 3

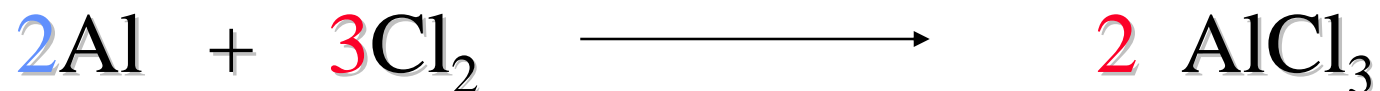


Al 1

Cl 6

Al 2

Cl 6



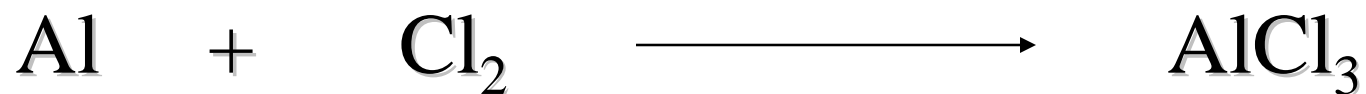
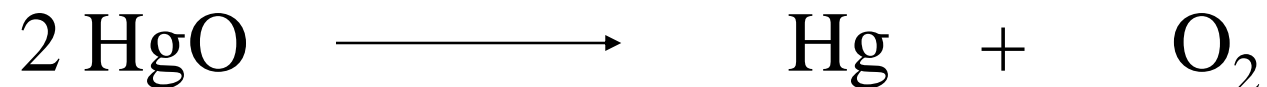
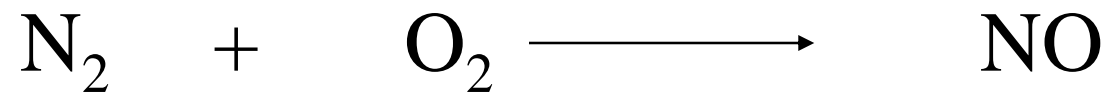
Al 2

Cl 6

Al 2

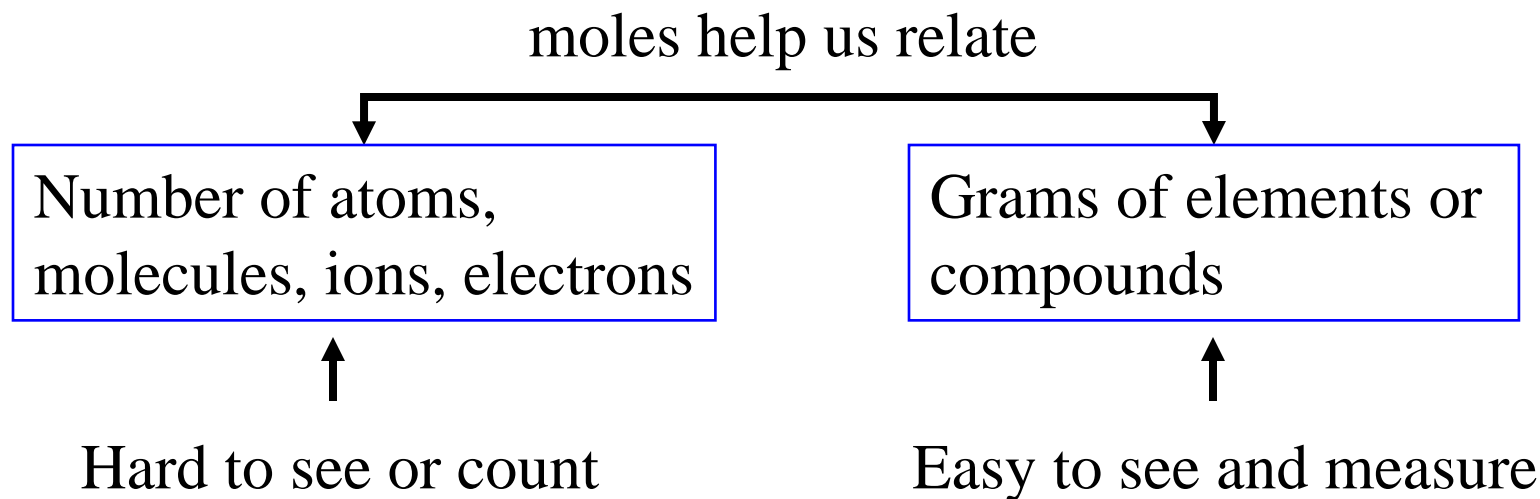
Cl 6

Are these equations balanced?

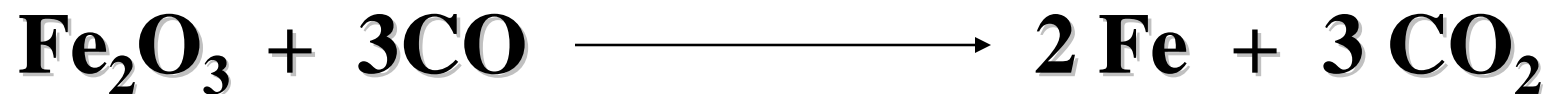


Large-Scale Reactions

- Impossible to measure out atoms and molecules.
- Chemists use **MOLES** instead of molecules



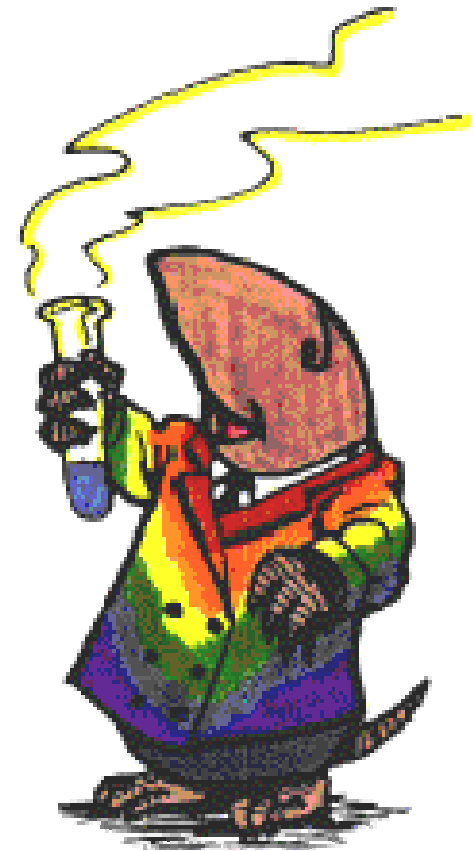
Molar Quantities in Equations



1 mole of iron(III) oxide
plus
3 moles of carbon monoxide
produce
2 moles of elemental iron
and
3 moles of carbon dioxide

What is a Mole?

- 1 mole = 6.02×10^{23} things
- The “things” can be
 - Atoms
 - Molecules
 - Ions
 - Electrons



Practically a mole is...

- 1 mole of an element = atomic weight of the element in grams
- 1 mole of a compound = sum of atomic weights of all elements in the compound in grams

12 g C = 6.02×10^{23} atoms of carbon

18 g H₂O = 6.02×10^{23} molecules of water