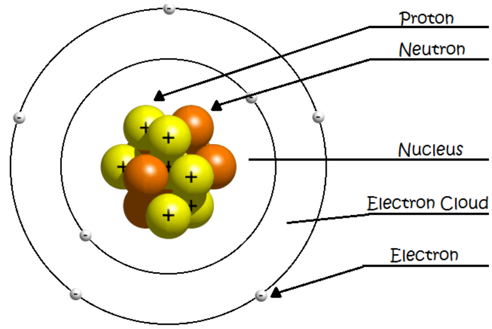
CHEMICAL REACTIONS

Science 10
Ms. Hayduk

The Atom



The Atom

- Protons: in the nucleus, positive charge, heavy
- Neutrons: in the nucleus, no charge, heavy
- Electrons: orbiting around the nucleus, negative charge, light

Periodic Table

- Periods: horizontal rows
  - 7 periods
- Groups (families): vertical columns
  - All elements have similar properties
  - 18 groups

Classes of Elements

- Metals – left side of periodic table
- Non-metals – right side of periodic table
- Semi-metals (metalloids) – along the staircase (B, Si, Ge, As, Sb, Te, Po, At)

Periodic Table Information

Atomic Number

- Number of protons in the nucleus
- Also, the number of electrons for an atom
- Determines the order of elements on the periodic table

Atomic Mass

- Mass of one atom of an element
- Measured in atomic mass units (amu)
- Atomic mass = # protons + # neutrons

Chemical Symbols

VERY IMPORTANT!
DON'T GUESS!
LOOK IT UP!

USE CAPITALS AND LOWERCASE PROPERLY

Example: Atoms

For LEAD:

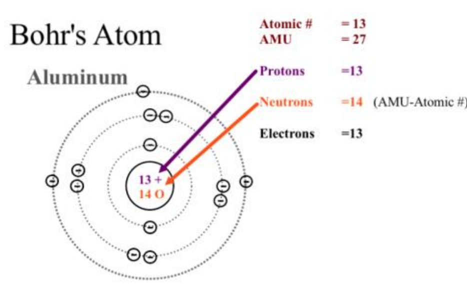
- What is the chemical symbol?
- What is the atomic number?
- What is the atomic mass?
- How many protons, electrons and neutrons?

Bohr Model of the Atom

- Electrons orbit the nucleus in "shells"
- Each shell has a specific energy level, and can fit a maximum number of electrons:

Shell	1	2	3	4
Electrons	2	8	8	18

Bohr-Rutherford Models



Examples: Bohr-Rutherford

Mg	F
K	P

Valence Electrons

- Valence shell is outside shell
- **Valence electrons** – electrons in outer shell
- Core electrons – electrons in inner shells
- Example: aluminum has <u>three</u> valence electrons and <u>ten</u> core electrons

Valence Electrons

- Can find out based on <u>group</u> – last number of group
- e.g. group 1 has 1 valence electron, group 13 has 3, group 18 has 8
- THIS IS REALLY IMPORTANT TO REMEMBER

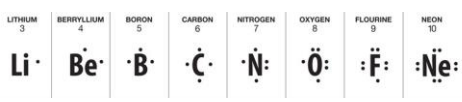
Example: Valence Electrons

How many valence electrons in…

As	Ba	Rn	K
Mg	Ga	Cl	I
O	P	Pb	H

Lewis Diagrams

- Show chemical symbol and valence electrons <u>only</u>, no circles
- Dots on each side <u>unpaired</u>, then start pairing



Examples: Lewis Diagrams

Draw a Lewis diagram for:

potassium	rubidium
selenium	bromine
radon	chlorine

Question…

Noble gases (group 18) are stable and unreactive. Why?

What does oxygen have to do to be stable?

Ions

- Only electrons can be added or removed to an atom (protons and neutrons are stuck in place)
- Atoms are stable ("happy") when they have a full valence shell, either by gaining or losing electrons

Example 1: Ions

For each atom, either <u>cross out</u> or <u>add</u> electrons to make it stable.

Question…

What happens to the atom when it gains or loses electrons?

How is it different for gaining/losing?

Ions

RULES

- Metals lose electrons and become positive – **CATIONS**
- Non-metals gain electrons and become negative – **ANIONS**
- Charge = protons – electrons

Example 2: Ions

What's the charge for each if it is an ion?

Mg	O	Cl	P
K	Li	Al	F
Ca	S	N	H

Ionic Notation

$$X^{\text{Charge}}$$

Example 3: Ions

Write each in ionic notation.

Mg	O	Cl	P
K	Li	Al	F
Ca	S	N	H

Naming Ions

- Metals keep their name + ion
  - *e.g. sodium ion, magnesium ion, aluminum ion*
- Non-metals get the ending "-ide" + ion
  - *"-ine" ending becomes "-ide"*
  - *selenium becomes selenide*
  - *All others take first syllable + "-ide"*

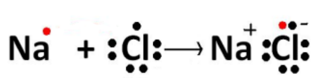
Example 4: Ions

Name these ions.

H^+	Mg^{2+}	N^{3-}	S^{2-}	F^-
O^{2-}	Se^{2-}	K^+	Sr^{2+}	Cl^-
Br^-	Na^+	P^{3-}	I^-	Ba^{2+}

Ionic Compounds

- Contain a **metal** and a **non-metal**
- Formed when cation (+) and anion (-) are attracted to form a **compound**
- Electrons from metal are **transferred** (given) to non-metal
- e.g. sodium chloride



Naming Ionic Compounds

- Metal ion name + non-metal ion name
- e.g. SrF_2 is strontium fluoride

Example: Naming Ionic Compounds

Write the name for each ionic compound:

K_2S	AlP
$CaCl_2$	NaH
MgO	RbI_2

Ionic Formulas

- Metal first, then non-metal
- Number of each ion is a **subscript**

Al_2O_3

Aluminum oxide

Question…

How do you know how many of each ion there is?

Ionic Formulas

- Total charge must equal zero!

\# electrons <u>lost by metals</u>

=

\# electrons <u>gained by non-metals</u>

Example 1: Ionic Formulas

For each pair of ions, build the compound, draw it, then write the formula:

K^+ and I^-

Mg^{2+} and Cl^-

Ca^{2+} and N^{3-}

Example 2: Ionic Formulas

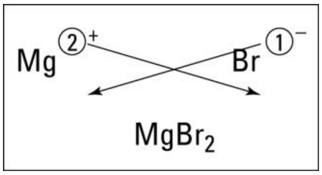
For each name, determine the ion charges, build the compound, draw it, then write the formula:

strontium oxide

magnesium phosphide

calcium sulfide

Ionic Formula Trick



Important: reduce! (Ca^{2+} and O^{2-} is CaO, **not** ~~Ca_2O_2~~)

Steps for Ionic Formulas from Names

1. Determine ion charges
2. Write each ion in ionic notation
3. "Draw" compound OR cross charges
4. Write formula with symbols and subscripts

Example: Ionic Formulas

Write the formula for potassium nitride.

Multivalent Ions

- **Transition metals**: elements in groups 3-12
- Some have only one charge, some have more than one
- **Multivalent**: ions that can have more than one charge
- e.g. iron can be 2+ or 3+

Example: Multivalent Ions

Is this multivalent? List the charge(s).

copper	zinc	gold
chromium	silver	manganese

Naming Multivalent Ions

- Metal name + charge in **ROMAN NUMERALS** + ion
- e.g. iron(II) ion, copper(I) ion
- **MULTIVALENT IONS MUST HAVE A CHARGE**

1	I
2	II
3	III
4	IV
5	V
6	VI
7	VII

*Note that not all possible charges are listed on ion PT

Example: Multivalent Ions

Write the name for each:

Pd^{2+} Mn^{7+} Cr^{6+}

Sn^{4+} Au^{3+} Cu^{+}

Example: Ionic Formulas with Multivalent Ions

Write the formula for each:

copper(II) fluoride

lead(IV) oxide

nickel(III) nitride

Question…

What is the charge of each ion in CoO?

Determining Charge

1. Determine charge of anion (non-metal) – only one possibility
2. Multiply charge by number of anions to get total <u>negative charge</u>
3. Multiply by -1 to get total <u>positive charge</u>
4. Divide total positive charge by number of cations (metal)

Example 1: Determining Charge

CrO

Example 2: Determining Charge

$FeCl_2$

Example 3: Determining Charge

Ti_2S_3

Example: Naming Multivalent Compounds

Write the name for each compound. Don't forget Roman numerals for charge!

PdO	MnN	SnF_2
Cu_2S	Au_3P	Mn_2O_7

Example: Mixed Naming

Write the name for each compound.

CuI	ZnO	Fe_3N_2
AgBr	CaS	SnO_2

Polyatomic Ions

- Group of atoms bonded together that has an overall charge
- poly = more than one
- e.g. hydroxide ion is OH^-
- Name as written on ion PT

Example: Naming Polyatomic Ions

Name these polyatomic ions:

SCN^-	SO_4^{2-}	PO_4^{3-}
BrO_3^-	NO_3^-	NH_4^+

Writing Polyatomic Formulas

- Overall charge for all atoms, so must be written **exactly as shown – do not get rid of numbers!!!!**
- For more than one, must put brackets around whole ion
  - e.g. $(\mathbf{NH_4})_2O$, $Ca(\mathbf{NO_3})_2$

Example: Polyatomic Formulas

Write the formula for each:

sodium nitrate

calcium phosphate

iron(III) hydroxide

Naming with Polyatomics

- Follow all rules from before!
  - Write cation name (metal or polyatomic), including multivalent charge only if needed
  - Write anion name (non-metal or polyatomic)

Example: Naming Polyatomics

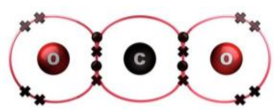
Write the name for each compound.

$CaCO_3$ $CuNO_3$ $Zn(OH)_2$

NH_4Cl $Pb(C_2H_3O_2)_2$

Covalent Compounds

- Contain all **non-metals**
- Formed when non-metals **bond** to form a **molecule**
- Electrons are **shared** between non-metals so each has a full valence shell
- e.g. carbon dioxide



Example 1: Ionic / Covalent

Ionic or covalent?

potassium iodide

lead(II) hydroxide

nitrogen monoxide

hydrogen sulfide

silver nitrate

carbon tetrachloride

Example 2: Ionic / Covalent

Ionic or covalent?

$Fe(C_2H_3O_2)_2$

HBr

XeF_2

Al_2O_3

$(NH_4)_3PO_4$

CH_4

Naming Covalent Compounds

- Name elements in order – first is full element name, second is "ion" name (e.g. sulfide)
- Second element has a **prefix**
- First element only has a prefix if its more than one

Covalent Prefixes

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

Example: Naming Covalent

Name these:

PCl_5

N_2O_3

H_2O

SF_6

P_4O_{10}

Special Covalent Names

Memorize these ones!

- Water (H_2O)
- Methane (CH_4)
- Ammonia (NH_3)
- **Diatomic** elements (X_2)

H_2 O_2 F_2 Br_2 I_2 N_2 Cl_2

Writing Covalent Formulas

- Write elements, in order of name
- Prefix tells how many of each
- Example: **di**nitrogen **pent**oxide

N_2O_5

Example: Writing Covalent Formulas

Write the formula for each:

dinitrogen tetrasulfide

nitrogen triiodide

xenon hexafluoride

bromine

carbon tetrachloride

diphosphorus pentoxide

Naming and Formulas for Mixed Compounds

FIGURE OUT IF IT IS IONIC OR COVALENT FIRST!

IONIC DOES NOT HAVE PREFIXES – COVALENT DOES!!

Help Ms. Hayduk keep her sanity!

Chemical Reactions

- Chemical changes – one or more NEW substances are produced from one or more other substances
- Original substances are REACTANTS
- New substances are PRODUCTS
- Atoms are rearranged

Chemical Equations

- Three types: word equations, skeleton equations, balanced chemical equations
- General form:
  Reactant A + Reactant B → Products

(It's like math but more exciting.)

Word Equations

- All substances are written using WORDS
- Use correct names for all compounds!
- Use + between reactants and between products and → to separate reactants and products

Example 1: Word Equations

sodium + water → sodium hydroxide + hydrogen gas

a. How do you know this is a chemical reaction?
b. What are the reactants?
c. What are the products?
d. READ THIS REACTION!

Example 2: Word Equations

Write word equations for each of these:

a. Copper(II) oxide reacts with sulfuric acid to make copper(II) sulfate and water.
b. Zinc and hydrochloric acid react to make zinc chloride and hydrogen gas.
c. Magnesium and chlorine react to make magnesium chloride.

Example 3: Word Equations

Write word equations for:

a. $Zn + O_2 \rightarrow ZnO$

b. $Fe + CuCl_2 \rightarrow FeCl_2 + Cu$

c. $Mn(NO_3)_2 + Na_3PO_4 \rightarrow NaNO_3 + Mn_3(PO_4)_2$

Example 4: Word Equations

What's missing?

Copper carbonate + hydrogen sulfate →
___________ sulfate + carbon dioxide + water

Copper + ________ nitrate →
copper(II) nitrate + silver

Skeleton Equations

- All compounds written as <u>correct</u> formulas
- Keep + and → where they were in the word equation
- May also include <u>states</u>:
  - solid (s)
  - liquid (l)
  - gas (g)
  - aqueous (aq)

Aqueous vs. Liquid

Aqueous is something dissolved in water
… like SALT WATER, which is NaCl (aq)…

Liquid is a pure substance in liquid form
… like WATER, which is H_2O (l)…

Example: Skeleton Equations

Write these as skeleton equations.

a. iron(III) chloride + sodium hydroxide → iron(III) hydroxide + sodium chloride

b. methane + oxygen → carbon dioxide + water

c. ammonium dichromate → chromium (III) oxide + nitrogen + water

Example: Skeleton Equations

Write the word and skeleton equations. Include states in the skeleton equation.

A solution of hydrogen chloride reacts with solid sodium carbonate to produce carbon dioxide, a sodium chloride solution and water.

Question…

How many of each type of atom are in the reactants and products of this reaction?

$Fe + O_2 \rightarrow Fe_2O_3$

Law of Conservation of Mass

- In a chemical reaction, total mass of reactants equals total mass of products
- Why?
  - Atoms are not "lost" – just rearranged
  - Number of reactant atoms = number of product atoms
  - Mass of each type of atom is constant

Question…

How many of each type of atom are in the reactants and products of this reaction?

$4\ Fe + 3\ O_2 \rightarrow 2\ Fe_2O_3$

Balanced Chemical Equations

- **Coefficient**: number added to indicate number of particles of each substance in reaction
- Coefficients multiply by subscripts in a formula
  - *e.g. $2H_2O$ has 4 H and 2 O*

Example: Balancing

___ CH_4 + ___ O_2 ___ CO_2 + ___ H_2O

Steps to Balance

1. Balance the metals.
2. Balance the non-metals that are not hydrogen or oxygen.
3. Balance hydrogen and oxygen.
4. After each step, recheck the previous steps and be sure to double check all numbers at the end!

Example: Balancing

___ Al + ___ Cl_2 → ___ $AlCl_3$

Example: Balancing

___ C_2H_6 + ___ O_2 → ___ CO_2 + ___H_2O

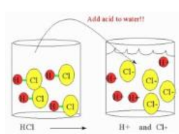
Example: Balancing

___ H_3PO_4 + ___ NaOH → ___ Na_3PO_4 + ___ H_2O

Example: Balancing

__ $Ca(AlO_2)_2$ + __ HCl → __ $AlCl_3$ + __ $CaCl_2$ + __H_2O

Acids



- Covalent compounds that dissolve in water to make H^+ ions
- Why is this weird?

www.youtube.com/watch?v=0cPFx0wFuVs

- Acids are <u>in between</u> covalent and ionic – so they have their own naming rules!

Binary Acids

- H + one element or polyatomic **without** oxygen
- Name: hydro_____ic acid
- Example: HCl = hydrochloric acid

Example 1: Binary Acids

Name each acid:

HBr

HF

HCN

HI

H_2S

Example 2: Binary Acids

Write the formula for each:

hydrochloric acid

hydroiodic acid

hydrosulfuric acid

hydrocyanic acid

hydrofluoric acid

Oxyacids

- H + O + one other element
- Naming depends on number of oxygens relative to polyatomic ion
- Example: nitric acid, HNO_3

Naming Rules

+1	0	-1	-2
ClO_4^-	ClO_3^-	ClO_2^-	ClO^-
perchlorate	chlorate	chlorite	hypochlorite
$HClO_4$	$HClO_3$	$HClO_2$	HClO
perchloric acid	chloric acid	chlorous acid	hypochlorous acid

Naming Rules for Sulfate

+1	0	-1	-2

Naming Oxyacids

1. Identify "base" polyatomic
2. Find out how many more or fewer oxygens
3. Name:
   - +1 oxygen = per____ic acid
   - base = ____ic acid
   - -1 oxygen = _____ ous acid
   - -2 oxygen = hypo____ous acid

Example: Oxyacids

Name these oxyacids:

H_3PO_4

HNO_2

$HBrO$

H_2CO_3

HIO_4

Example: Naming Acids

Name all of these acids:

$HClO$

HF

H_2SO_3

$HBrO_2$

HCN

Properties of Acids