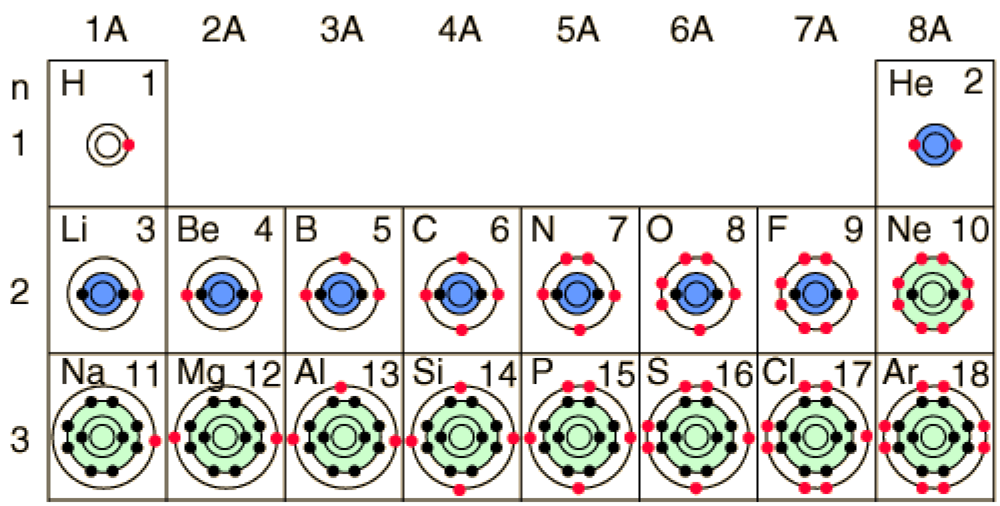
Chemistry

- ⇨ Elements, Compounds, subscript, superscript, coefficient
- ⇨ Periodic Table
    - o Periods, groups, etc.
    - o Metals
    - o Non-metals
    - o Metalloids

- ⇨ The patterns are related to the chemical properties of the element.
- ⇨ Patterns in the periodic table describe how substance behave during a chemical reaction.
- ⇨ Why do elements in the same group have similar chemical properties?
- ⇨ What is it about metals and non-metals that allows you to predict the kinds of compounds they are likely to form?

- ⇨ Electron Shells



- ⇨ Notice the **shells** and **valence** electrons.
- ⇨ Knowing the number of electrons helps you predict the formation of compounds, name the compounds, and write their chemical formulas.
- ⇨ A chemical bond forms between two atoms when electrons in the outer shell of each atom from a stable arrangement together.
- ⇨ Outer shell is called the **valence shell**, the electrons in the outer shell are the **valence electrons**.
- ⇨ Chemical properties are related to the energy changes that take place when their atoms lose, gain, or share electrons to obtain a filled valence shell.
- ⇨ Elements that easily gain or lose electrons are very reactive.

- ⇨ Cations:
  - Energy is added to the atom, which then (collides) releases an electron. – Write out symbol.
  - Reactivity increases down the group – farther from nucleus.
  - Want to have valence shell like that of a noble gas.
  - Group two not as reactive as group one, why is that?

- ⇨ Anions:
  - Electron joins the atom releasing energy. – Write out symbol.
  - Atoms gain electrons to have the valence shell of a noble gas.
  - Chemical reactivity decreases as you move down the group – why is that?

Writing Names of Formulas of Binary Ionic Compounds

- ⇨ Binary compound consist of only two elements.
- ⇨ Anions are named by changing their ending to "ide"
  - F^- → Fluor<u>ide</u>
  - O^{2-} → Ox<u>ide</u>
  - CO_2 → carbon diox<u>ide</u>
  - Cl^- →
- ⇨ The subscript in a formula is determined by the charges of the ions (are the valence shells filled? Does each element have a noble gas electron configuration?)
- ⇨ Name the following compounds:
  - LiO →
  - MgO →
  - K_2S →
  - KN_3 →
  - $AlBr_3$ →

Al^{3+} O^{2-}

⇨ Create formulas and check for a balanced charge using the "cross–over" method. The charge of the cation becomes the subscript for the anion, and vice–versa.

Al_2O_3

- Al^{3+} O^{2-} → Al_2O_3 Check charges: $2\times(3+) = 6+$;
  $3\times(2-) = 6-$

⇨ When the metal and non-metal have the same charge (different sign), always write the simplest ratio.

- Barium Oxide: Ba^{2+} O^{2-} → Ba_2O_2 → BaO

⇨ Use the "cross-over" method to write the formula of each of the following:

- Beryllium fluoride
- Sodium nitride
- Calcium sulfide
- Aluminum chloride
- Lithium oxide
- Magnesium nitride
- Gallium sulfide
- Barium bromide

⇨ The transition metals can form more than one ion. Given the formula for the compound we can work backwards to determine the charge of the ion; this method is called the "reverse cross–over" method.

- Iron Oxide: Fe_2O_3 → Fe^{3+} O^{2-}

- Copper Oxide: $Cu_2O \rightarrow Cu^+ O^{2-}$

- Name the following compounds:
  - Cu_2S
  - PbO_2
  - $NiCl_2$
  - CrN
  - HgO
  - Cu_3P_2

- <u>The Stock Naming System</u>: For use with *transition metals*.
  - The charge on the cation is written, in parenthesis, as Roman numeral after the name of the metal.
  - Transition metals can bond with different amounts of electrons (can have a different ionic charge), but remember that the anions will always gain the same number of electrons no matter what the compound is.
  - $FeCl_3 \rightarrow Fe^{3+} Cl^- \rightarrow$ iron (III) chloride
  - $FeO \rightarrow Fe2^+ O^{2-} \rightarrow$
  - $Cu_2S \rightarrow Cu^+ S^{2-} \rightarrow$
  - $PbO_2 \rightarrow$
- Write the chemical formulas for each of the following compounds:
  - Copper(I) oxide

- Lead(IV) bromide
- Iron(III) sulfide
- Nickel(III) fluoride
- Manganese(IV) sulfide

Writing Names of Formulas of Binary Molecular Compounds

- ⇨ Binary molecular compounds consist of covalent bonds of two different non-metals.
- ⇨ Three rules to writing names and formulas:
  - The name of the compound ends in "ide" (like that for the ionic compounds).
  - Name and formula (usually) begins with the element that is more to the left on the periodic table.
  - Use a prefix to specify the number of atoms of each element that are present in the molecule. (Pg. 162)

Prefix	Number it Represents
mono	1
di	2
tri	3
tetra	4
penta	5
hexa	6
hepta	7

octa	8
nona	9
deca	10

⇨ Examples: Name the following molecular compounds.

- N_2O →
- N_2O_3 →
- C_3H_8 →
- H_2O →
- BCl_5 →

⇨ Examples: Write the formulas for the following compounds.

- Dihydrogen dioxide
- Hydrogen chloride
- Tricarbon disulfide
- Dinitrogen monophosphide
- Carbon tetrahydride

Names and Formulas for Polyatomic Ions

⇨ Ions that consist of two or more different non-metal atoms (joined by covalent bonds)

⇨ An example is the hydroxide ion, OH^- formed one a covalent bond of water is broken.

⇨ Only one polyatomic cation: ammonium ion, NH_4^+

- ⇨ Except for the hydroxide ion, many polyatomic ions end in the suffix “ate” rather than “ide”. Other than that the procedure for writing the names and formulas is the same as that for ionic compounds.
- ⇨ Writing the formulas follow the same technique, but the polyatomic ion is written in parentheses (when there is more than one of them).

Name	**Chemical Formula**
Ammonium ion	NH_4^+
Hydroxide ion	OH^-
Carbonate	CO_3^{2-}
Nitrate	NO^{3-}
Sulfate	SO_4^{2-}
Hydrogen Carbonate	HCO^{3-}
Hydrogen Sulfate	HSO_4^-
Phosphate	PO_4^{3-}

- ⇨ Iron (III) hydroxide → Fe^{3+} OH^- → $Fe(OH)_3$
- ⇨ What is the formula for ammonium phosphide?
  - NH_4^+ and P^{3-} → $(NH_4)_3P$
- ⇨ What is the name of $Ag(PO_4)$?

- $Ag(PO_4)$ → Ag^{+} and PO_4^{-} → Ag3+ and PO_4^{3-} → Silver(III) Phosphate

⇨ *Ferrum* = Iron(I), *Ferrous* = Iron(II), *Ferric* = Iron(III)

<u>Writing and Balancing Chemical Equations</u>

⇨ In a chemical reaction mass is conserved (except a nuclear reaction in which energy is conserved).

⇨ The simplest form of a chemical equation is a <u>word equation</u>.

- Sodium + Chlorine → Sodium chloride
- + means reacts with, → means produces
- left: reactants; right: products

⇨ Writing the chemical formulas in place of the names creates a <u>skeleton equation</u>.

- $Na + Cl_2 \rightarrow NaCl$

⇨ The equation contains more atoms of reactants than products, so as is, mass is not conserved.

⇨ We will use <u>coefficients</u> to balance the equation so that there are the same number of atoms on both sides.

⇨ This produces a <u>balanced equation</u>.

- $2Na + Cl_2 \rightarrow 2NaCl$

⇨ Example: Iron reacts with water to form ferric oxide and hydrogen. Write out the balanced chemical equation.

- $Fe + H_2O \rightarrow Fe_2O_3 + H_2$
- Remember: diatomic elements must always include two of the atoms.
- Step 1: Only the hydrogen is balanced to begin. There is 1 Fe on the left and 2 on the right, so balance the iron by writing 2Fe,
- $2Fe + H_2O \rightarrow Fe_2O_3 + H_2$
- That leaves the oxygen unbalanced. Balance if by writing a 3 in front of the water,
- $2Fe + 3H_2O \rightarrow Fe_2O_3 + H_2$
- We have unbalanced the hydrogen! Re-balance them by writing $3H_2$,
- $2Fe + 3H_2O \rightarrow Fe_2O_3 + 3H_2$

⇨ As a general rule, leave diatomic elements to the last.

<u>Fractional Coefficients to Balance Chemical Equations</u>

⇨ The group of diatomic elements are sometimes the most difficult to balance. In such a case we are able to use a fraction coefficient to simplify the procedure.

⇨ Example 1.

- $Al + H_3PO_4 \rightarrow H_2 + AlPO_4$ there is an odd number of hydrogen atoms on one side and an even number on the other, so write $\frac{1}{2}H_2$
- $Al + H_3PO_4 \rightarrow \frac{1}{2}H_2 + AlPO_4$ now there is 3 on the left and one on the right, so multiply the $\frac{1}{2}H_2$ by 3.
- $Al + H_3PO_4 \rightarrow \frac{3}{2}H_2 + AlPO_4$ the equation is balanced, but we don't want fractions in our answer. Multiply every term by 2.
- $2Al + 2H_3PO_4 \rightarrow 3H_2 + 2AlPO_4$

Equations Where Polyatomic Ions are Conserved

⇨ The general rule is to treat the polyatomic ions as if they are one element.

⇨ Example 1: $KI + Pb(NO_3)_2 \rightarrow PbI_2 + KNO_3$

- To start, we'll balance the iodine.
- $2KI + Pb(NO_3)_2 \rightarrow PbI_2 + KNO_3$
- The lead (Pb) is balanced, but there are 2 nitrate ions on the left and only one on the right. Since the nitrate ion did not change we can balance it the

same way as a single atom. $2KNO_3$ balances the equation.

- $KI + Pb(NO_3)_2 \rightarrow PbI_2 + 2KNO_3$

⇨ Example 2: $Al + H_2SO_4 \rightarrow Al_2(SO_4)_3 + H_2$

- Balance the Al: $2Al + H_2SO_4 \rightarrow Al_2(SO_4)_3 + H_2$
- Now the sulfate groups: with $3H_2SO_4$

$$2Al + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + H_2$$

- Balance the hydrogen atoms with $3H_2$

$$2Al + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + 3H_2$$

⇨ Example 3: $Cu(NO_3)_2 + NH_4OH \rightarrow Cu(OH)_2 + NH_4NO_3$

- There are three polyatomic ions: NO_3^-, OH^-, and NH_4^+. All of the ions are conserved, so we balance the equation like the polyatomic ions are single atoms.
- Two nitrates on the left and one on the right:

$$Cu(NO_3)_2 + NH_4OH \rightarrow Cu(OH)_2 + 2NH_4NO_3$$

- Balance the ammonium ions, which will also balance the hydroxide ions:

$$Cu(NO_3)_2 + 2NH_4OH \rightarrow Cu(OH)_2 + 2NH_4NO_3$$

Acids & Bases

Properties of acids

- ⇨ sour-tasting, water-soluble.
- ⇨ many react with metal to produce H_2.
- ⇨ Good conductors of electricity (H^+ is released into the water).
- ⇨ Easily recognized by their formula because it begins with hydrogen (H_2SO_4, H_3PO_4, HCl, H_2CO_3)
- ⇨ Used in industry
    - sulfuric acid: very reactive and combines with many other materials.
    - Used in fertilizers, explosives, refining oil, and electroplating.
    - Sulfuric and hydrochloric acid are very corrosive.

Properties of Bases

- ⇨ bitter-tasting, water-soluble and feel slippery.
- ⇨ Good conductors of electricity because they release hydroxide ions (OH^-) when they dissolve in water.
- ⇨ React with protein to break them down.

- ⇨ More difficult to identify by their names; but any containing the hydroxide ion, or that react with water to form hydroxide ions are bases.
  - NaOH → sodium hydroxide
  - KOH → potassium hydroxide
  - HCO_3^- → forms an OH- in water.

The pH Scale

- ⇨ Compares the concentration of hydrogen ions in various solutions.
- ⇨ used to represent how acidic or basic a solution is.
- ⇨ Ranges from 0 to 14, with 7 (pure water) being neutral.
- ⇨ Bases have a high pH (above 7), acids are lower in pH (below 7).
- ⇨ Logarithmic scale
  - A change of 1 on the scale means one substance is 10 times more acid/basic.
  - An acid of pH = 2 is ten times more acidic than an acid of pH = 3.
  - A base of pH = 13 is ten times more basic than an acid of pH = 12.

⇨ Examples:
- How many times more acidic is an acid of pH = 3 than water (pH = 7)?
- Which is the stronger base: pH = 9 or pH = 14? How many times stronger (basic) is it?
- Be careful: pH = 2, and a pH = 2.5; logarithms are not linear, a difference of 0.5 in pH does not mean 5 times as powerful.

⇨ Problems 1 – 7, 9, and 10.

Neutralization Reactions

⇨ Mixing an acid and a base results in a neutralization reaction.

⇨ The products are a salt and (often) water. There may also be other products (like a gas, CO_2).

⇨ Water is formed by combining the H^+ from the acid and the OH^- from the base: HOH, or H_2O.

⇨ Acid – base reactions are used all the time:
- Many cleaners use this property.
- Baking soda as an ingredient in food.
- Antacids to settle a stomach that is too acidic or reacting with the stomach or esophagus lining.