Reactions

Chemical Reaction Equations

Reactants
Everything on left

"yield"
react to form

Products
Everything on right

$$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(l)}$$

- (s)– chemical in solid form
- (l)– chemical is in liquid form
- (g)– chemical is in gaseous form
- (aq)– chemical is dissolved in water, a solution

Chemical Reaction Equations

Reactants	"yield"	Products
Everything on left	react to form	Everything on right

$$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(l)}$$

- Subscripts tell how many atoms of each element are present in a compound or molecule

- Coefficient (larger number)
  - tell how many molecules of each compound are present
  - is used to balance the number of atoms of each element in the reactants and products

Diatomic Molecules

- A diatomic molecule is a molecule made of two of the same type of atom.

- All of the following elements are found as diatomic molecules in nature:
  - Hydrogen
  - Nitrogen
  - Oxygen
  - Fluorine
  - Chlorine
  - Bromine
  - Iodine

Writing Equations

- Words to Symbols
  - Underline reactants, circle products
  - Write the formula for each compound or element
  - Add the symbol for the state of each compound or element
  - Put the arrow between
  - Add notes about reaction conditions if applicable

Writing Equations

- Example:

One way to form liquid water is to combine oxygen gas and hydrogen gas at higher than atmospheric pressure.

Writing Equations

- Symbols to Words
  - Underline the reactants, circle the products
  - Write names for each compound or element
  - Add words to describe the state of each compound or element
  - Add the phrase “reacts to form” and any specific reaction conditions if applicable

Writing Equations

- Example:

$$Pb(NO_3)_2\ (aq) + K_2CrO_4\ (aq) \rightarrow PbCrO_4(s) + 2KNO_3\ (aq)$$

Law of Conservation of Matter

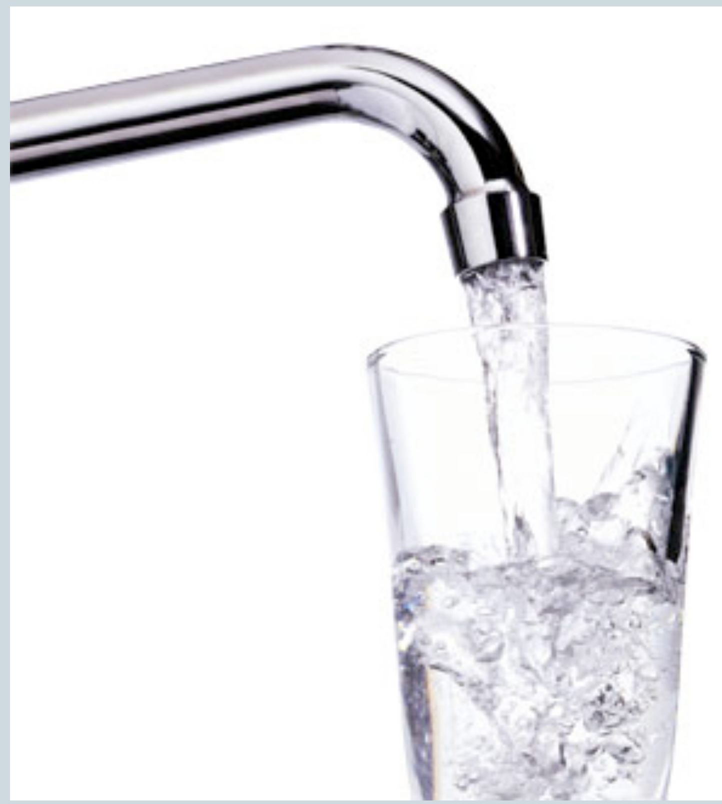
- Matter can neither be created nor destroyed
- Reaction equations are balanced to show that the law of conservation of matter is always followed
- Reactions are balanced by adding coefficients, not by changing subscripts

Why Coefficients?

H_2O

Why Coefficients?

$2\ H_2O$



Why Coefficients?

H_2O_2

Why Coefficients?

- Changing subscripts changes the chemical make up of a compound
- NEVER change the subscript on a compound in order to balance an equation
- ALWAYS addcoefficients until all atoms are balanced

Balancing Equations on Paper

- Step 1: Count the atoms of each element and make a list.

$$H_2 + O_2 \rightarrow H_2O$$

Balancing Equations on Paper

- Step 2: Change the coefficients <u>one at a time</u> to make the number of atoms the same on both sides of the equation for each element.

$$H_2 + O_2 \rightarrow H_2O$$

Balancing Equations on Paper

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$$H_2 + O_2 \rightarrow H_2O$$

Balancing Equations on Paper

- Step 3: Be sure the coefficients are in the lowest possible ratio.

$$4H_2 + 2O_2 \rightarrow 4H_2O$$

  - If all coefficients are divisible by a single number (usually 2), then divide each coefficient by that number.

Examples

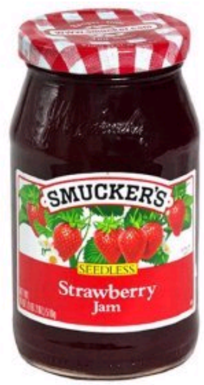
- $Na_2SO_{4(aq)} + CaCl_{2(aq)\,)} \rightarrow CaSO_{4(s)} + NaCl_{\,(aq)}$
- $Cu_{(s)} + AgNO_{3(aq)} \rightarrow Cu(NO_3)_2 + Ag_{(s)}$
- $Ca_{(s)} + H_2O_{(l))} \rightarrow Ca(OH)_2 + H_{2(g)}$

Classifying Reactions

- Synthesis Reactions
  - two elements combine to produce a new compound
  - General Equation: A + B = AB
  - Identifying characteristic: ONLY one product

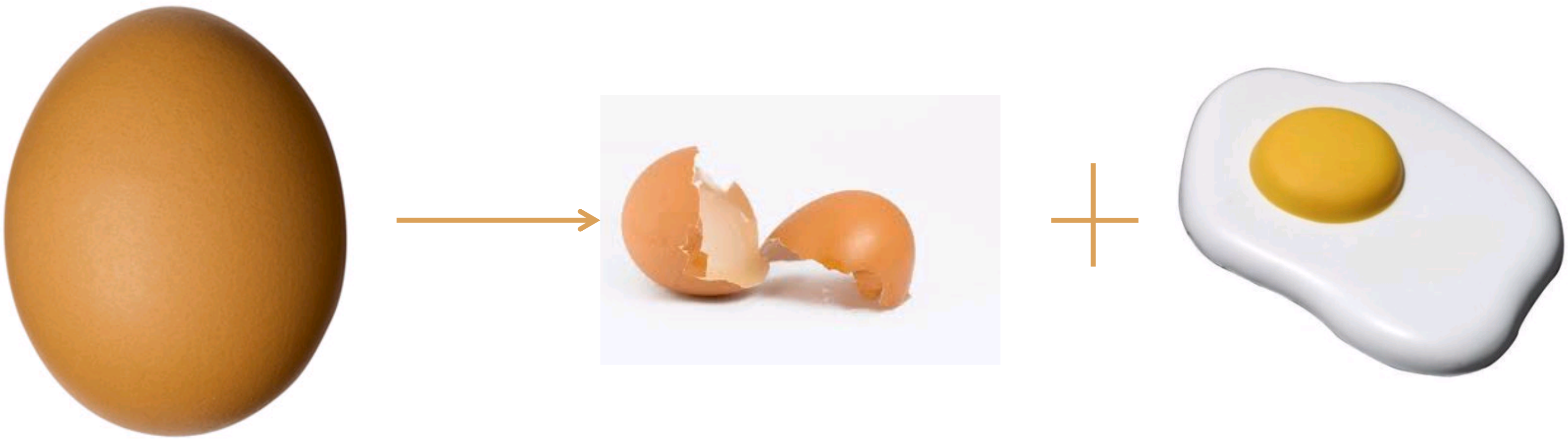
  - Examples:
    - $2Na_{(s)} + Cl_{2(g)} \rightarrow 2NaCl_{(s)}$
    - $CaO_{(s)} + H_2O_{(l)} \rightarrow Ca(OH)_{2(s)}$


The Best Tasting Peanut Butter
SKIPPY
SPREAD THE FUN!
CREAMY
Peanut Butter


SMUCKER'S
SEEDLESS
Strawberry
Jam

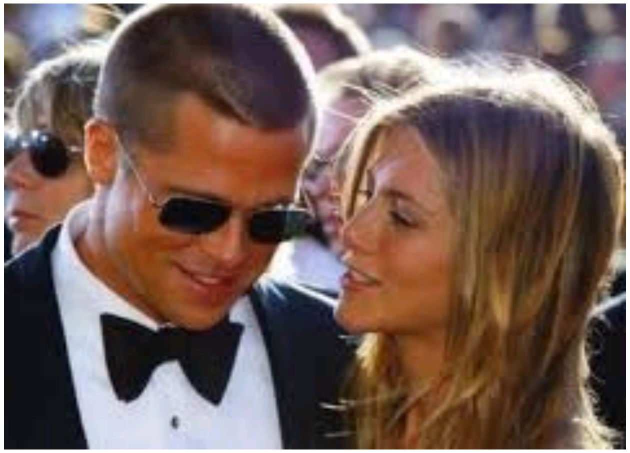
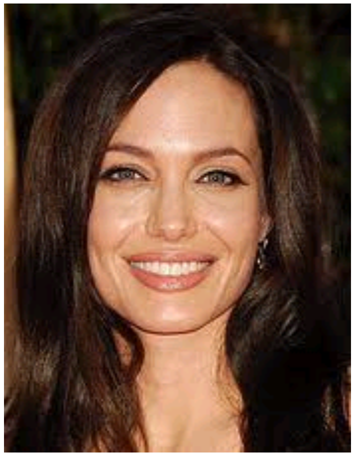
Classifying Reactions

- Decomposition Reactions
  - A single compound breaks down into two or more atoms or new compounds
  - General Equation: $AB \rightarrow A + B$
  - Identifying characteristic: ONLY one reactant
  - Examples:
    - $NH_4NO_{3(s)} \rightarrow N_2(g) + 2H_2O_{(g)}$
    - $2NaN_{3(s)} \rightarrow 2Na_{(s)} + 3N_{2(g)}$



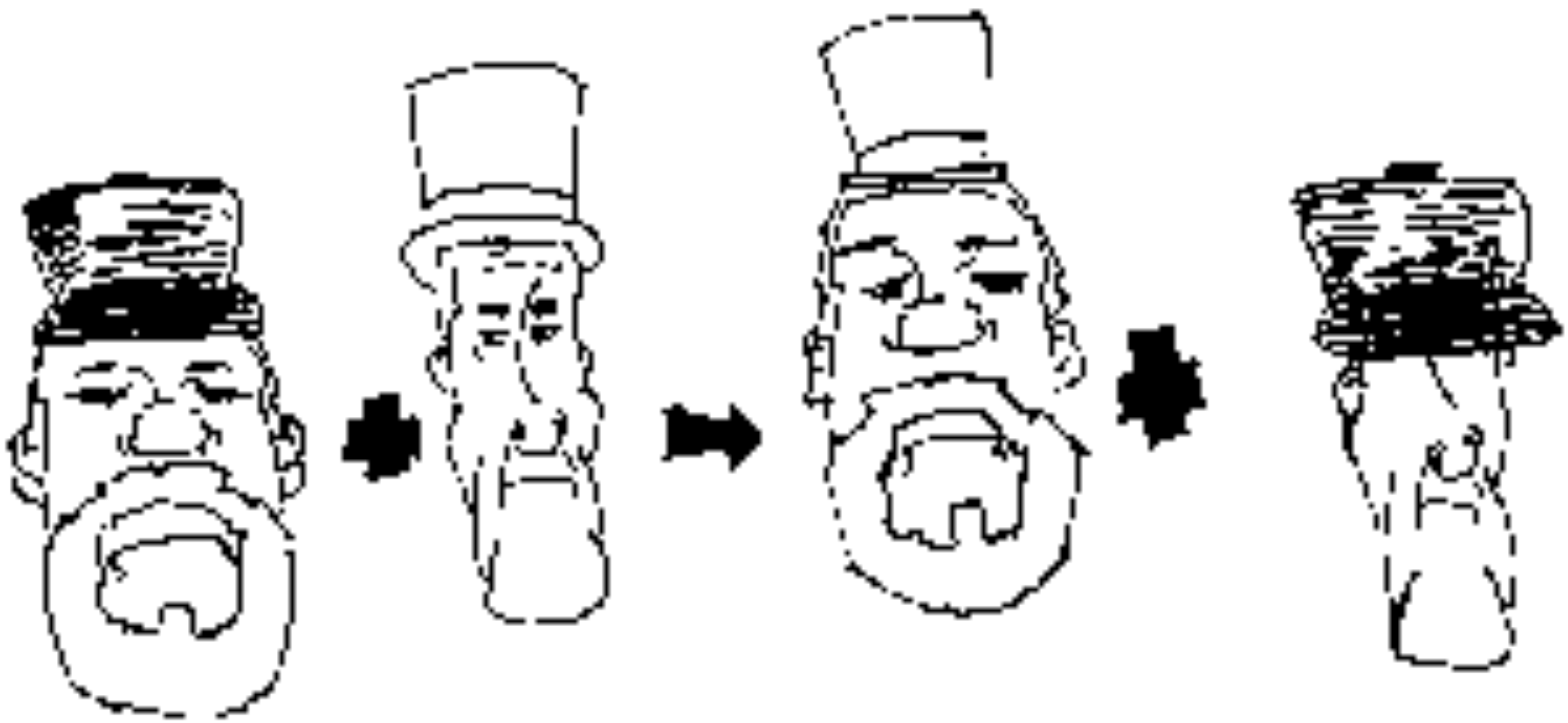
Classifying Reactions

- Single Displacement Reactions
  - Atoms of one element replace the atoms of another element in a compound
  - General Equation: A +BX → AX +B
  - Identifying Characteristic: Reactants and products have one single element and one compond
  - Examples:
    - $2Li_{(s)} + 2H_2O_{(l)} \rightarrow 2LiOH_{(aq)} + H_{2(g)}$
    - $Cu(s) + 2AgNO_3 \rightarrow 2Ag_{(s)} + Cu(NO_3)_{2(aq)}$

Classifying Reactions

- Double Displacement Reactions
  - A reaction in which the positive and negative ions of two compounds switch places
  - General Equation: $AX + BY \rightarrow AY + BX$
  - Identifying Characteristic: Two compounds for reactants, two compounds for products
  - Example:
    - $2NaOH_{(aq)} + CuCl_{2(aq)} \rightarrow 2NaCl_{(aq)} + Cu(OH)_{2(aq)}$



Classifying Reactions

- Combustion Reactions
  - Oxygen combines with a substances and releases energy in the form of heat and light
  - General Equation: hydrocarbon + $O_{2(g)} \rightarrow CO_{2(g)} + H_2O_{(g)}$
  - Identifying Characteristic: ALWAYS O_2 as one reactant, ALWAYS CO_2 and H_2O as products
  - Examples:
    - $CH_{4(g)} + O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(g)}$

Predicting Products of Single Displacement Reactions

- Check the activity series
- If the single metal is higher, it will replace another metal cation in solution (the one that is part of the compound)
- If the reaction happens, write the products
- If not write NR for no reaction

Activity Series

Lithium	Most Active
Rubidium	
Potassium	
Sodium	
Magnesium	
Aluminum	
Manganese	
Zinc	
Iron	
Nickel	
Tin	
Lead	
(Hydrogen)	
Copper	
Silver	
Platinum	Least Active
Gold	

Predicting Products of Single Displacement Reactions

Examples:

$Mg + Cu(NO_3)_2 \rightarrow$

- this reaction

$Cu + Mg(NO_3)_2 \rightarrow$

- this reaction

Predicting Products of Double Displacement Reactions

- Determine what ions are present in the solution

- Ionization- when ionic compounds are placed in water, they break apart into cations and anions

  - Example: If you have the following reactants, what ions will be present in solution?
    - $Pb(NO_3)_{2(aq)} + Na_2CO_{3\,(aq)} \rightarrow$

Predicting Products of Double Displacement Reactions

- Predict the products by rearranging the cations and anions to form possible products
  - Example: Pb^{+2} NO_3^{-1} + Na^{+1} $CO_3^{-2} \rightarrow$

Predicting Products of Double Displacement Reactions

- Check the solubility of both products on the solubility table and note it beside each product
  - Example: $PbCO_3$ + $NaNO_3$

Predicting Products of Double Displacement Reactions

Example: $PbCO_3$ (s) + $NaNO_3$ (aq)

- Make a final determination about the reaction:
  - If one product is insoluble, the reaction DOES happen and we call that solid product the <u>precipitate</u>
    - We also may say that it "precipitates" out of solution
  - If all products are soluble, there is NO REACTION (NR)

Net Ionic Equations

- Only deal with the ions that change state (from aqueous to solid, gas, or decompose)
- Any ions that start in solution and stay in solution are left out of net ionic equations
- Any ions that start in solution but become solids, gasses, or decompose are included.

Net Ionic Equations

- $Pb(NO_3)_{2(aq)} + Na_2CO_{3\,(aq)} \rightarrow PbCO_{3\,(s)}\ +2\ NaNO_{3\,(aq)}$
- Write all the ions in solution
- Keep any that change state, leave out those that do not (show solid as a compound, not ions)
- Net Ionic:

Examples

- For the following reactions:
  - Predict the products
  - If the reaction happens, write the products
  - Write the net ionic equation for the reaction

- $Al(NO_3)_{3\,(aq)} + H_2SO_{4\,(aq)} \rightarrow$