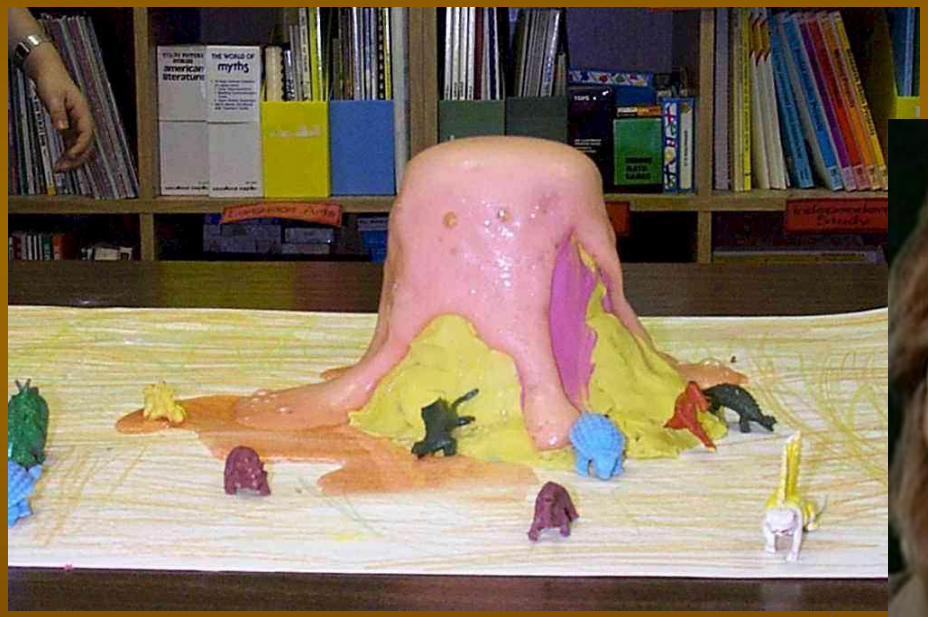
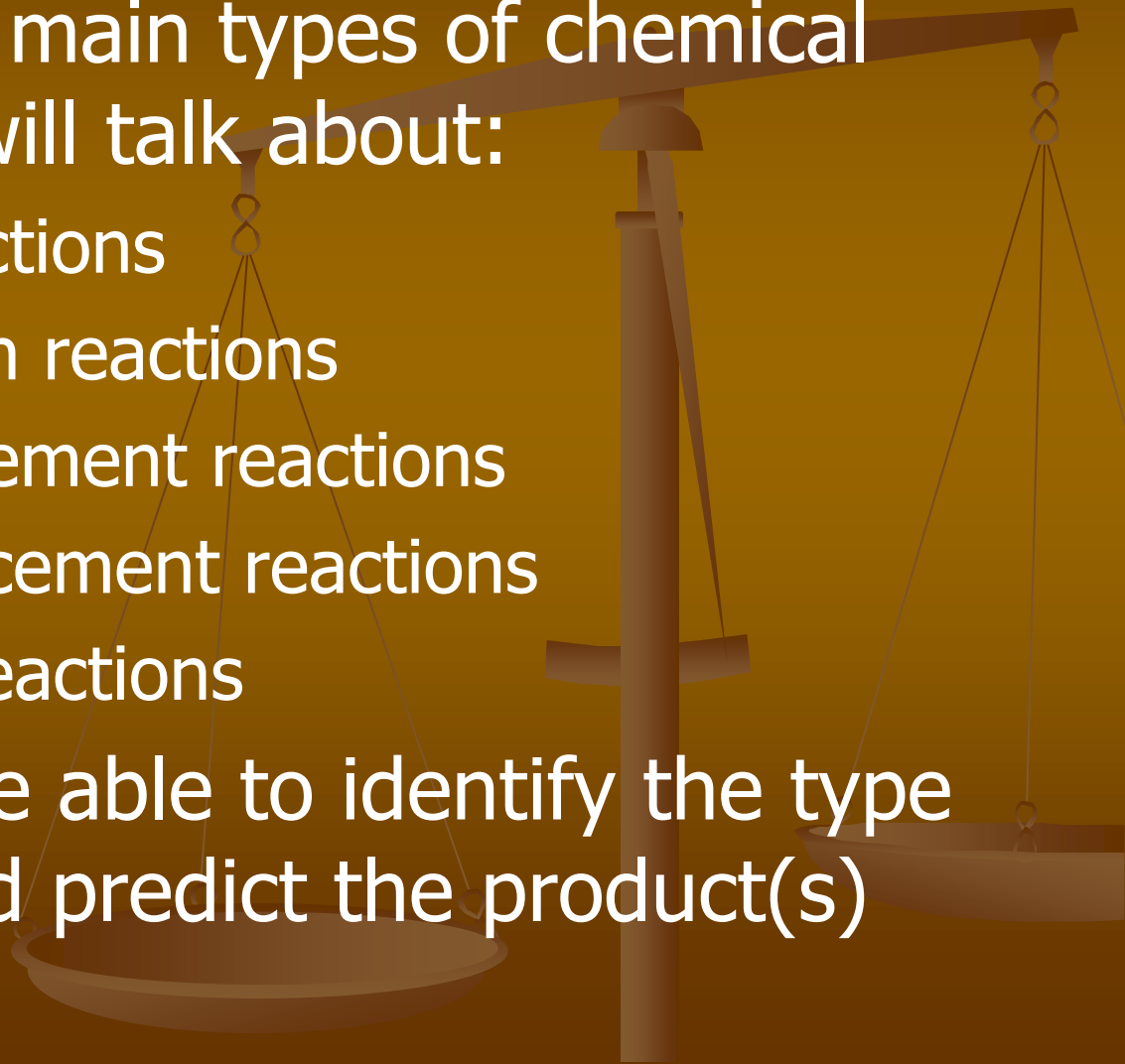
Chemical Reactions



Types of Reactions

- There are five main types of chemical reactions we will talk about:
  1. Synthesis reactions
  2. Decomposition reactions
  3. Single displacement reactions
  4. Double displacement reactions
  5. Combustion reactions
- You need to be able to identify the type of reaction and predict the product(s)



Steps to Writing Reactions

- Some steps for doing reactions
  1. Identify the type of reaction
  2. Predict the product(s) using the type of reaction as a model
  3. Balance it

Don't forget about the diatomic elements! (BrINClHOF) or (HOFBrINCl)

For example, Oxygen is O_2 as an element.

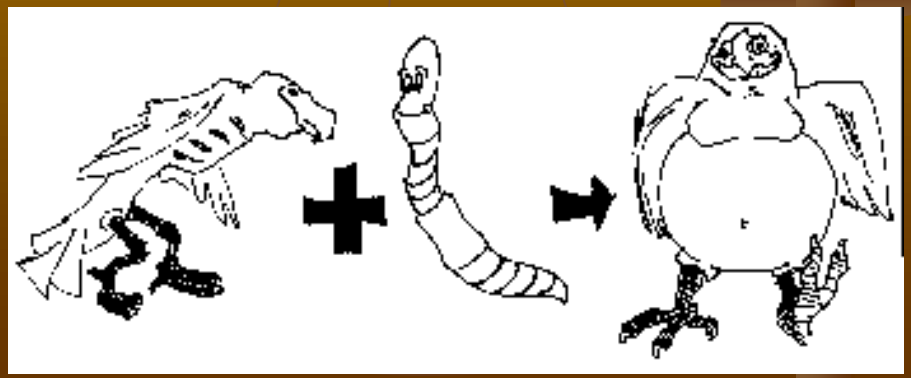
In a compound, it can't be a diatomic element because it's not an element anymore, it's part of a compound!

1. Synthesis reactions

- **Synthesis reactions** occur when two or more substances (generally **elements**) combine and form a compound. (Sometimes these are called combination or addition reactions.)

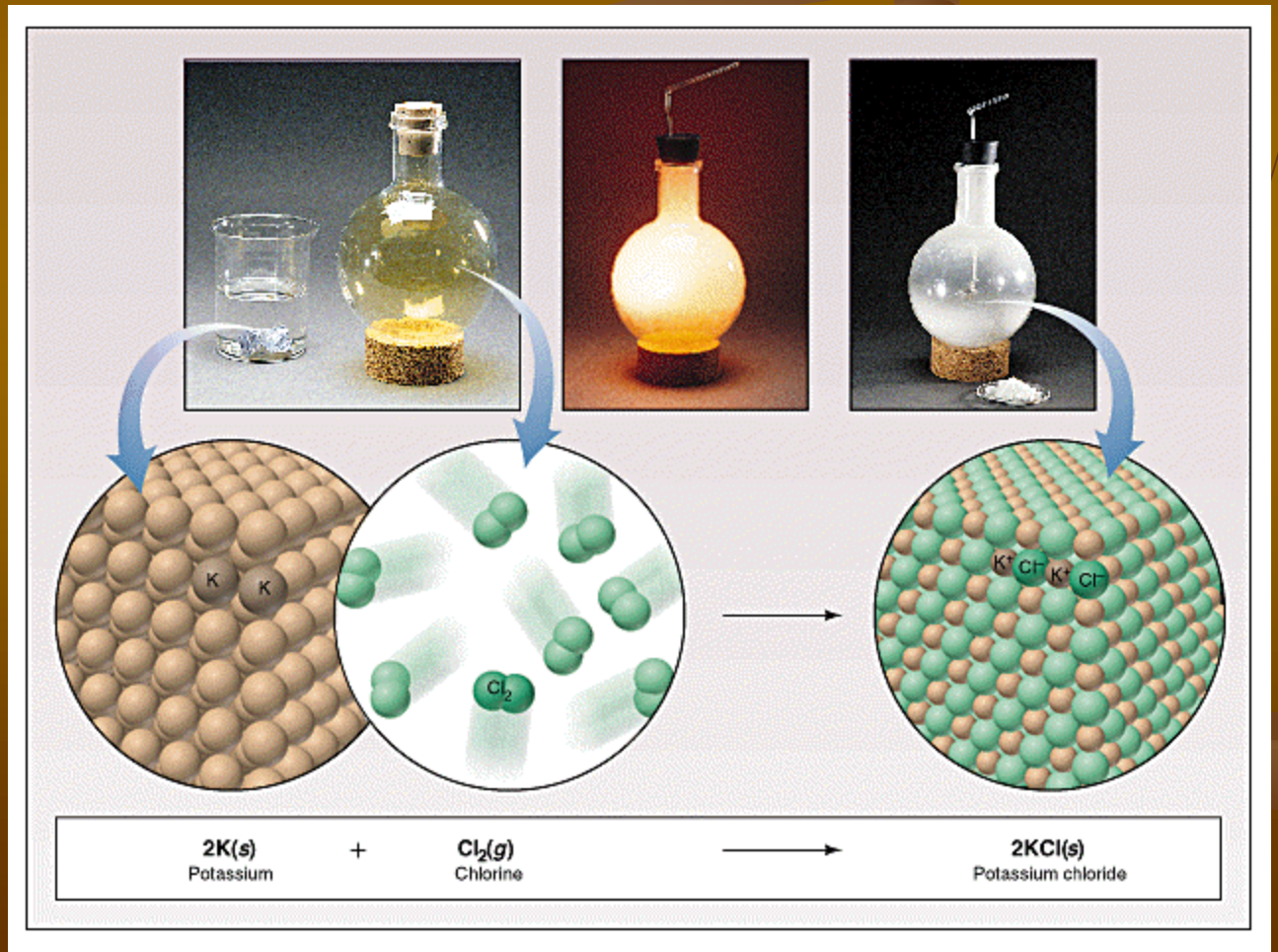
  reactant + reactant → 1 product

- Basically: A + B → AB
  - Example: $2H_2 + O_2 \rightarrow 2H_2O$
  - Example: $C + O_2 \rightarrow CO_2$



Synthesis Reactions

- Here is another example of a synthesis reaction



Practice

- Predict the products. Write and balance the following synthesis reaction equations.
- Sodium metal reacts with chlorine gas

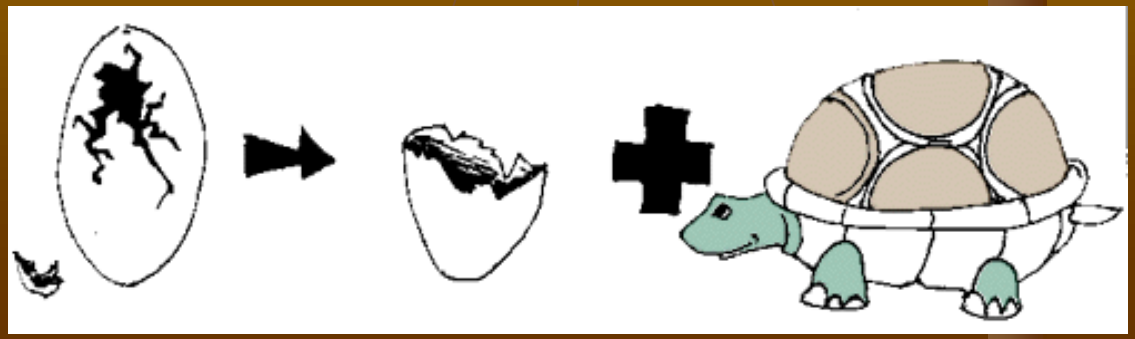
  $Na_{(s)} + Cl_{2(g)} \rightarrow$
- Solid Magnesium reacts with fluorine gas

  $Mg_{(s)} + F_{2(g)} \rightarrow$
- Aluminum metal reacts with fluorine gas

  $Al_{(s)} + F_{2(g)} \rightarrow$

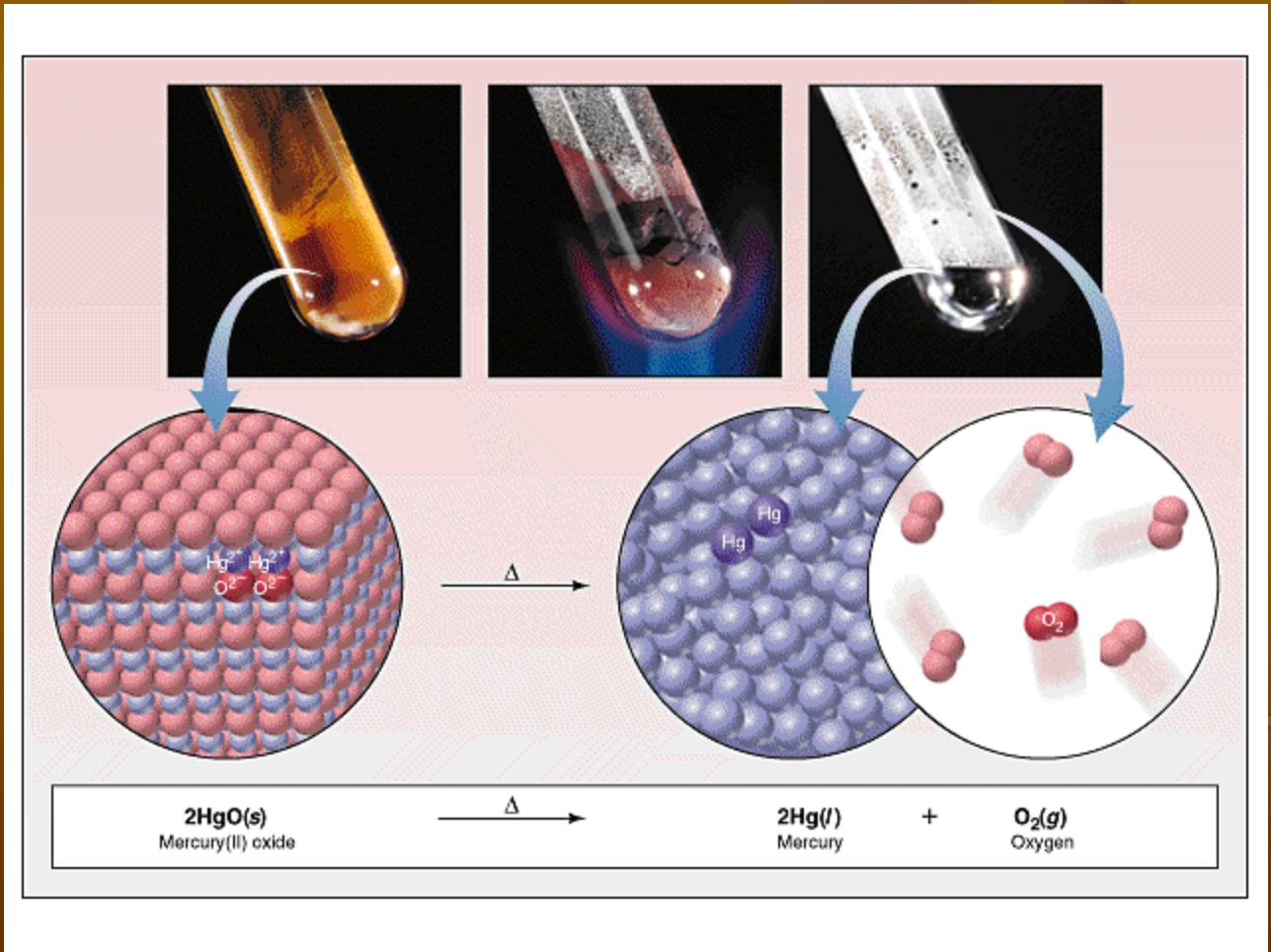
2. Decomposition Reactions

- **Decomposition reactions** occur when a compound breaks up into its elements or into a few simpler compounds
- **1 Reactant → Product + Product**
- In general: AB → A + B
- Example: 2 H_2O → 2H_2 + O_2
- Example: 2 HgO → 2Hg + O_2



Decomposition Reactions

- Another view of a decomposition reaction:



Decomposition Exceptions

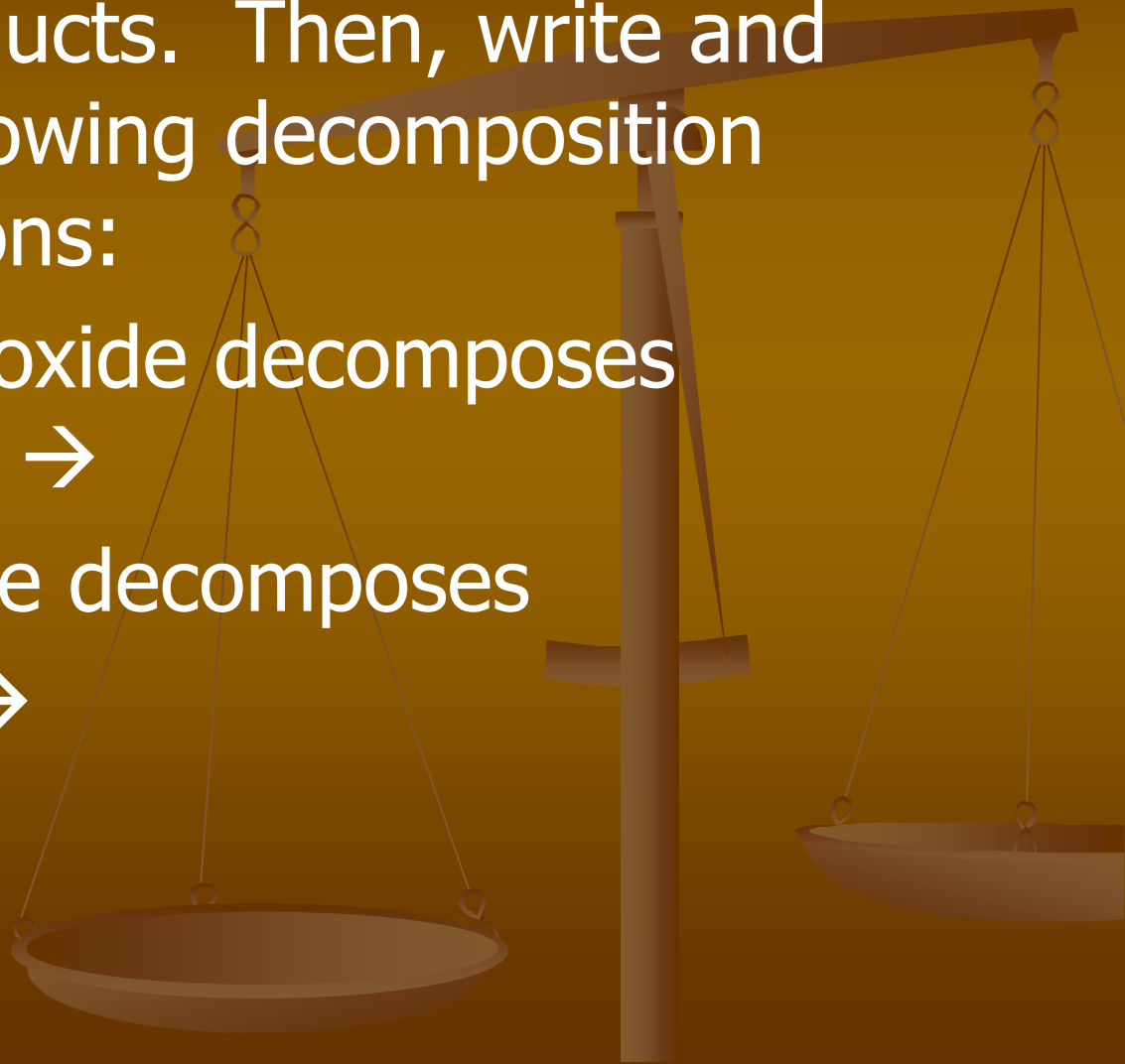
- Carbonates and chlorates are special case decomposition reactions that do not go to the elements.
  - Carbonates (CO_3^{2-}) decompose to carbon dioxide and a metal oxide
    - Example: $CaCO_3 \rightarrow CO_2 + CaO$
  - Chlorates (ClO_3^-) decompose to oxygen gas and a metal chloride
    - Example: $2\ Al(ClO_3)_3 \rightarrow 2\ AlCl_3 + 9\ O_2$
  - There are other special cases, but we will not explore those in Chemistry I

Practice

- Predict the products. Then, write and balance the following decomposition reaction equations:
- Solid Lead (IV) oxide decomposes

  $PbO_{2(s)} \rightarrow$
- Aluminum nitride decomposes

  $AlN_{(s)} \rightarrow$



Practice

Identify the type of reaction for each of the following synthesis or decomposition reactions, and write the balanced equation:

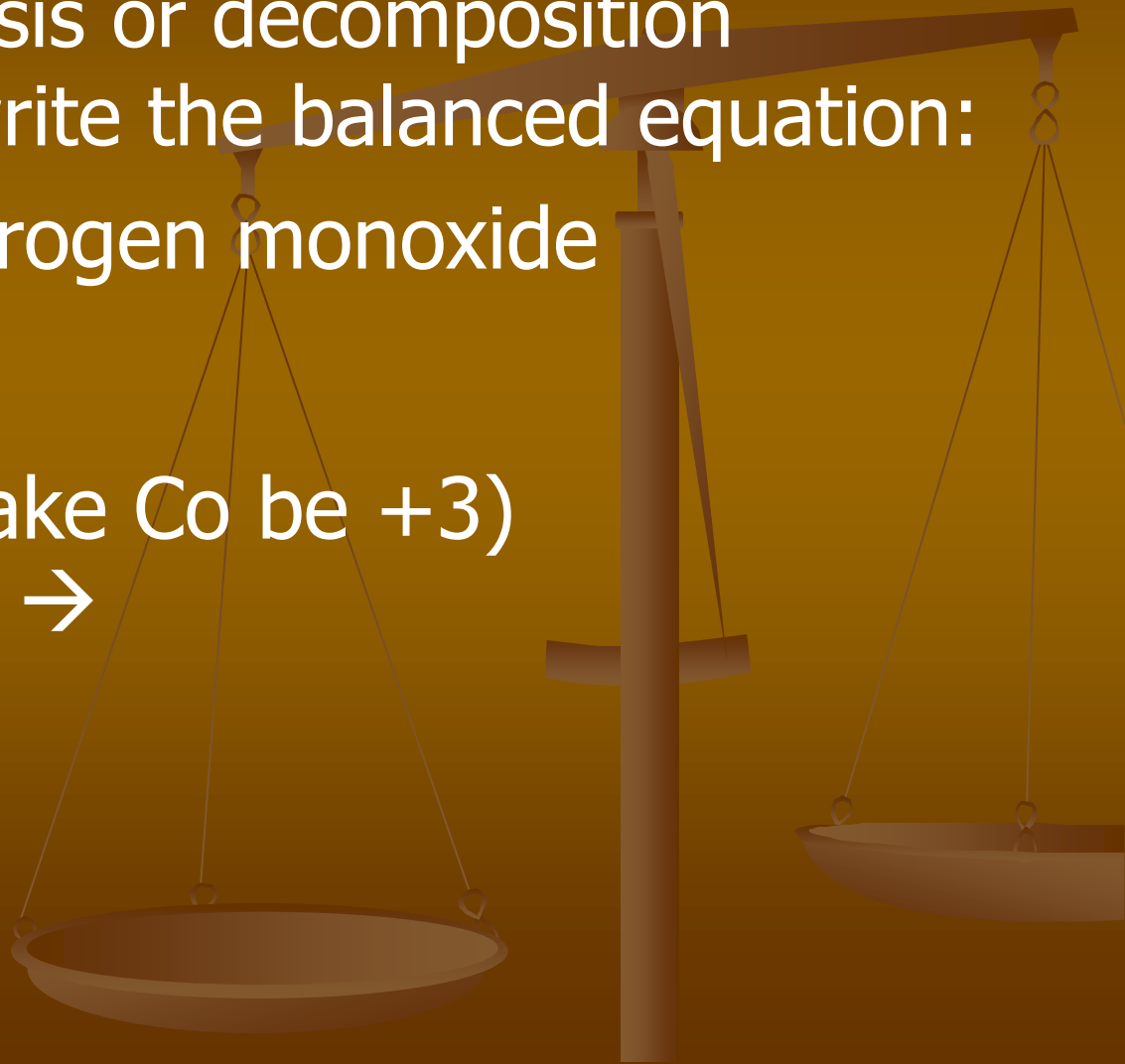
$N_{2(g)} + O_{2(g)} \rightarrow$ Nitrogen monoxide

$BaCO_{3(s)} \rightarrow$

$Co_{(s)} + S_{(s)} \rightarrow$ (make Co be +3)

$NH_{3(g)} + H_2CO_{3(aq)} \rightarrow$

$NI_{3(s)} \rightarrow$



3. Single Replacement/Displacement Reactions

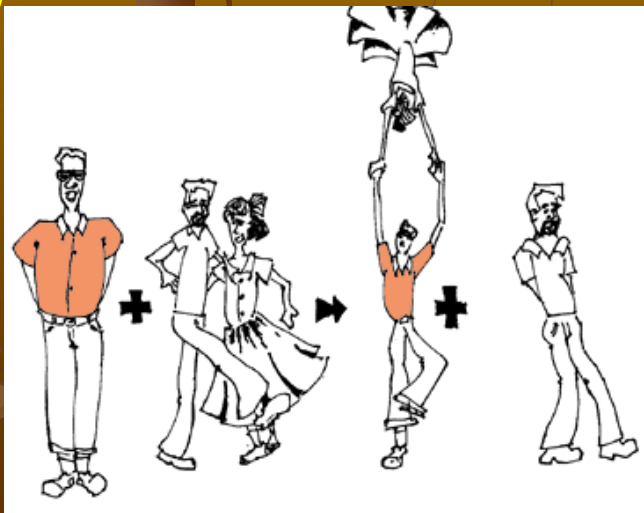
- **Single Replacement Reactions** occur when one element replaces another in a compound.
- A metal can replace a metal (+) **OR** a nonmetal can replace a nonmetal (-).
- **element + compound→ compound + element**

  A + BC → AC + B (if A is a metal) **OR**

  A + BC → BA + C (if A is a nonmetal)

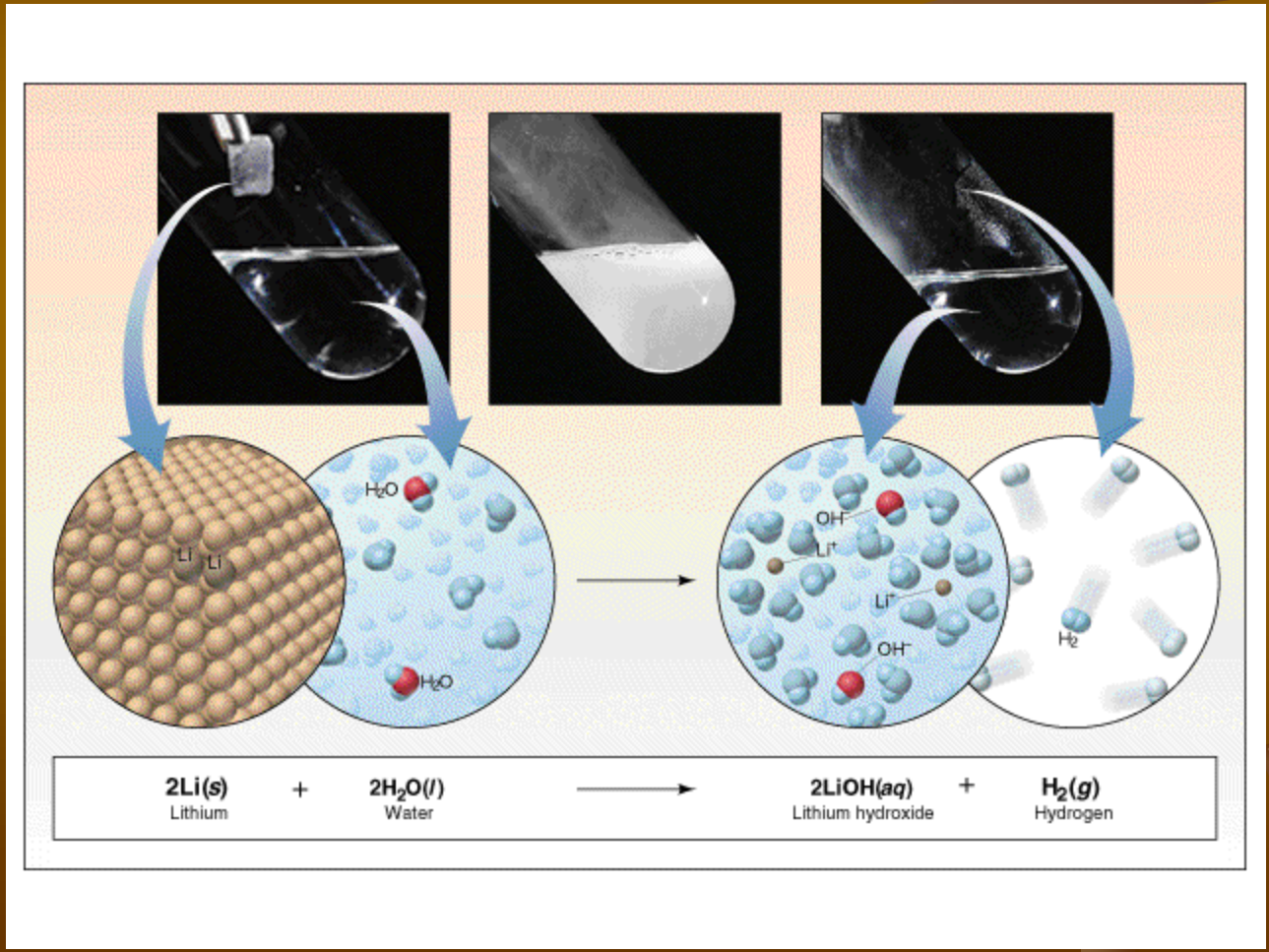
  (remember the cation always goes first!)

When H_2O splits into ions, it splits into H^+ and OH^- (not H+ and O^{-2} !!)



Single Replacement Reactions

- Another view:



Single Replacement Reactions

- Write and balance the following single replacement reaction equation:
- Zinc metal reacts with aqueous hydrochloric acid

$$Zn_{(s)} + 2\ HCl_{(aq)} \rightarrow ZnCl_2 + H_{2(g)}$$

Note: Zinc replaces the hydrogen ion in the reaction

Single Replacement Reactions

- Sodium chloride solid reacts with fluorine gas

$$2\ NaCl_{(s)} + F_{2(g)} \rightarrow 2\ NaF_{(s)} + Cl_{2(g)}$$

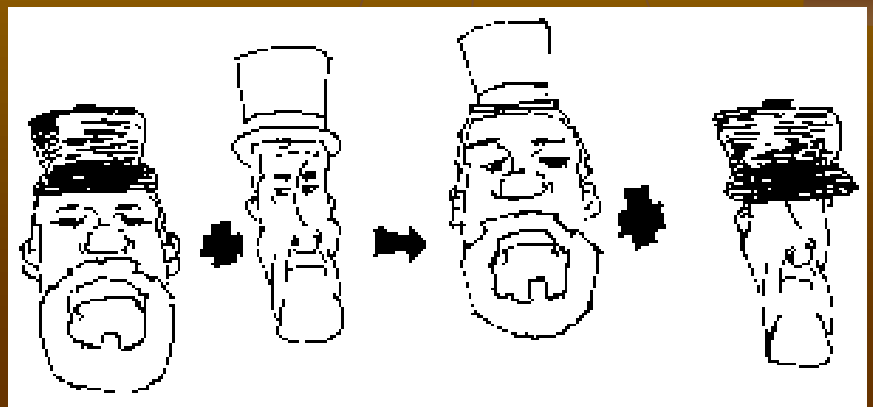
Note that fluorine replaces chlorine in the compound

- Aluminum metal reacts with aqueous copper (II) nitrate

$$Al_{(s)} + Cu(NO_3)_{2(aq)} \rightarrow$$

4. Double Replacement Reactions

- **Double Replacement Reactions** occur when a metal replaces a metal in a compound and a nonmetal replaces a nonmetal in a compound
- **Compound+compound→compound+ compound**
- AB + CD → AD + CB
- Neutralization is a special type of double replacement that has an acid and a base as the reactants and a salt and water as the products.



Double Replacement Reactions

- Think about it like "foil"ing in algebra, first and last ions go together + inside ions go together
- Example:

$$AgNO_{3(aq)} + NaCl_{(s)} \rightarrow AgCl_{(s)} + NaNO_{3(aq)}$$

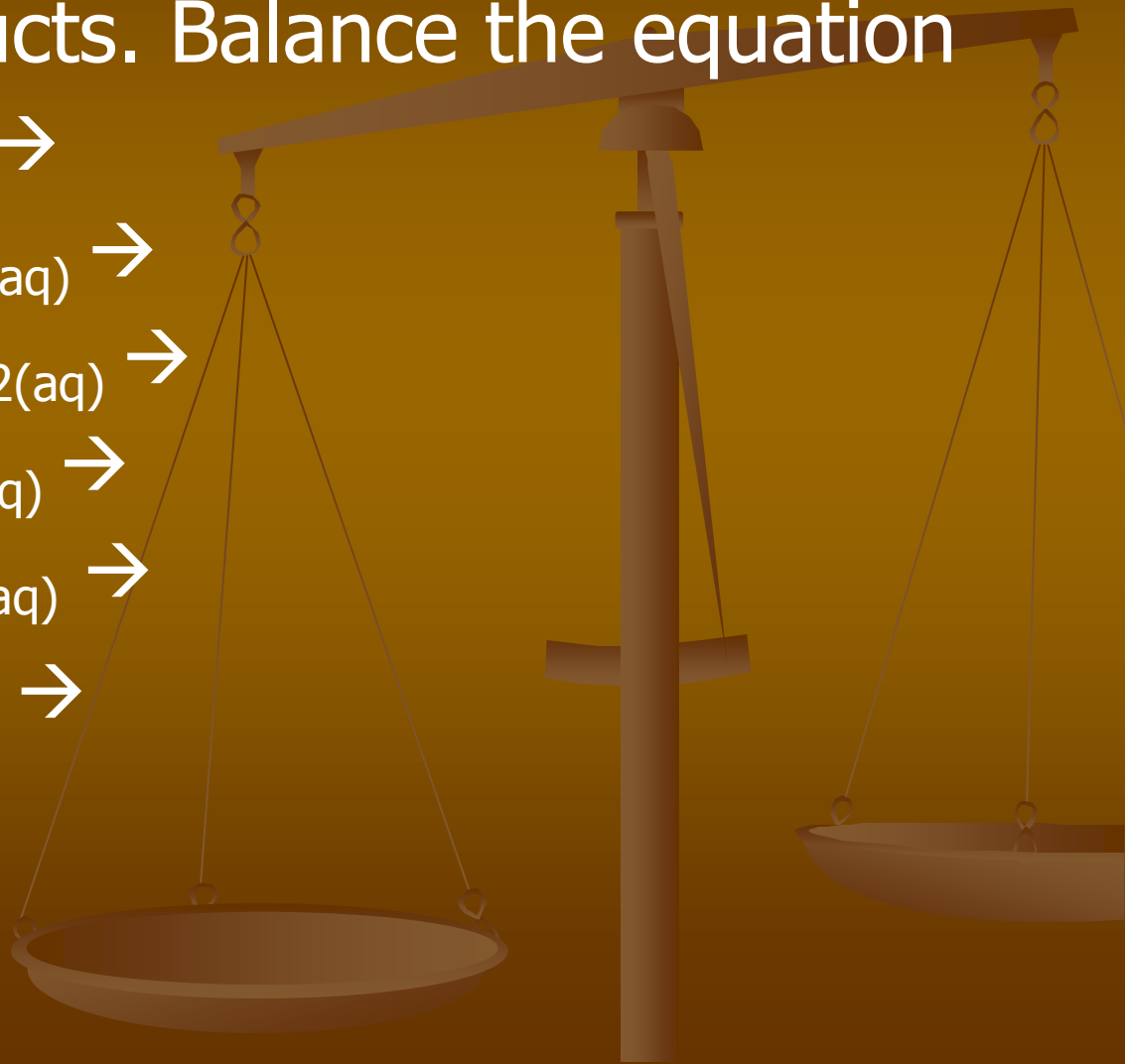
- Another example:

$$K_2SO_{4(aq)} + Ba(NO_3)_{2(aq)} \rightarrow 2\,KNO_{3(aq)} + BaSO_{4(s)}$$

Practice

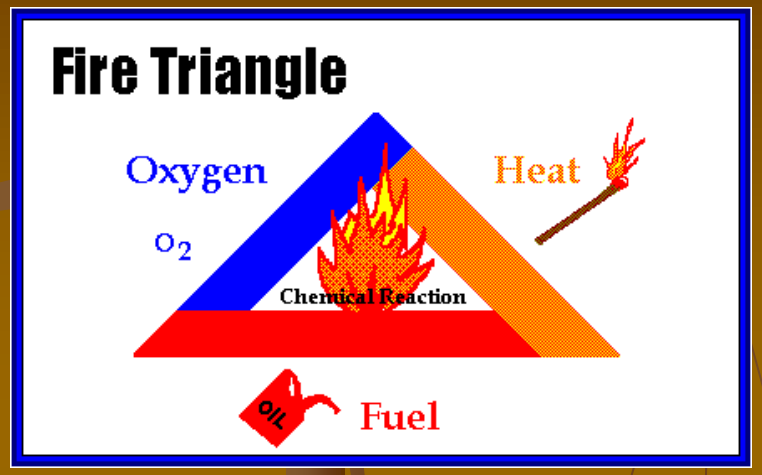
- Predict the products. Balance the equation

1. $HCl_{(aq)} + AgNO_{3(aq)} \rightarrow$
2. $CaCl_{2(aq)} + Na_3PO_{4(aq)} \rightarrow$
3. $Pb(NO_3)_{2(aq)} + BaCl_{2(aq)} \rightarrow$
4. $FeCl_{3(aq)} + NaOH_{(aq)} \rightarrow$
5. $H_2SO_{4(aq)} + NaOH_{(aq)} \rightarrow$
6. $KOH_{(aq)} + CuSO_{4(aq)} \rightarrow$



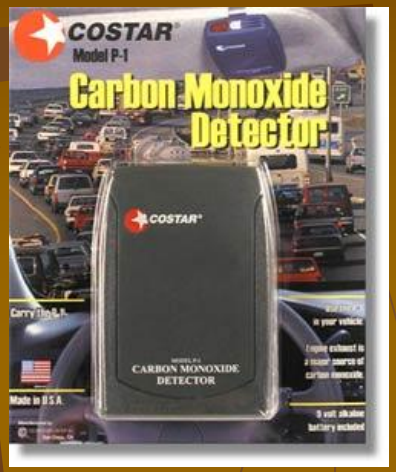
5. Combustion Reactions

- **Combustion reactions** occur when a hydrocarbon reacts with oxygen gas.
- This is also called burning!!! In order to burn something you need the 3 things in the "fire triangle":
  1) A Fuel (hydrocarbon)
  2) Oxygen to burn it with
  3) Something to ignite the reaction (spark)

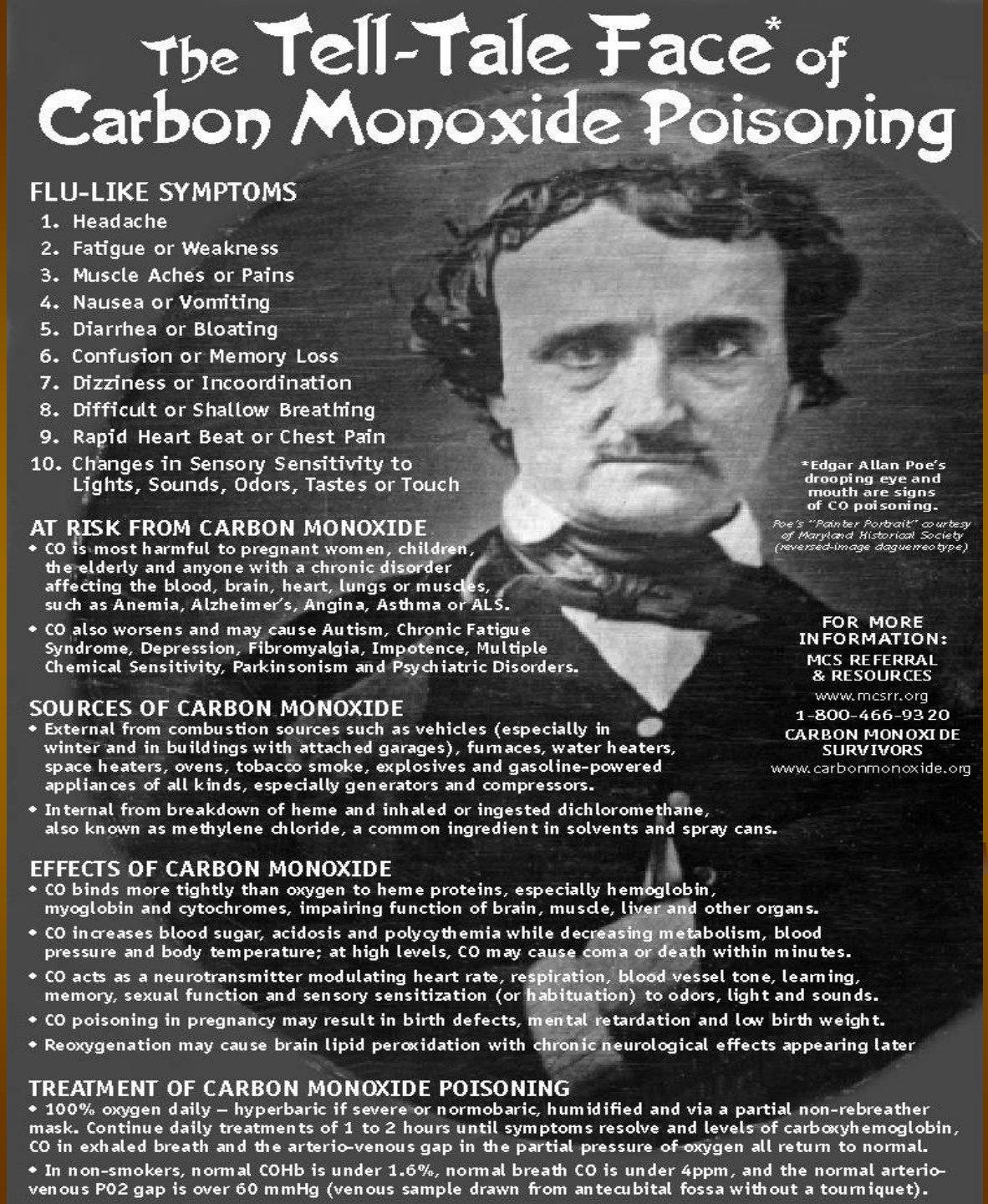


Combustion Reactions

- The general equation for **complete combustion:**
  $C_xH_y + O_2 \rightarrow CO_2 + H_2O$
- Products in complete combustion are ALWAYS carbon dioxide and water but in **incomplete combustion** there are some by-products like carbon and carbon monoxide
- Combustion is used to heat homes and run automobiles (which burn octane, C_8H_{18}, a component of gasoline)



The Tell-Tale Face* of Carbon Monoxide Poisoning



FLU-LIKE SYMPTOMS

1. Headache
2. Fatigue or Weakness
3. Muscle Aches or Pains
4. Nausea or Vomiting
5. Diarrhea or Bloating
6. Confusion or Memory Loss
7. Dizziness or Incoordination
8. Difficult or Shallow Breathing
9. Rapid Heart Beat or Chest Pain
10. Changes in Sensory Sensitivity to Lights, Sounds, Odors, Tastes or Touch

*Edgar Allan Poe's drooping eye and mouth are signs of CO poisoning.

Poe's "Painter Portrait" courtesy of Maryland Historical Society (reversed-image daguerreotype)

AT RISK FROM CARBON MONOXIDE

- CO is most harmful to pregnant women, children, the elderly and anyone with a chronic disorder affecting the blood, brain, heart, lungs or muscles, such as Anemia, Alzheimer's, Angina, Asthma or ALS.
- CO also worsens and may cause Autism, Chronic Fatigue Syndrome, Depression, Fibromyalgia, Impotence, Multiple Chemical Sensitivity, Parkinsonism and Psychiatric Disorders.

FOR MORE INFORMATION:
MCS REFERRAL & RESOURCES
www.mcsrr.org
1-800-466-9320
CARBON MONOXIDE SURVIVORS
www.carbonmonoxide.org

SOURCES OF CARBON MONOXIDE

- External from combustion sources such as vehicles (especially in winter and in buildings with attached garages), furnaces, water heaters, space heaters, ovens, tobacco smoke, explosives and gasoline-powered appliances of all kinds, especially generators and compressors.
- Internal from breakdown of heme and inhaled or ingested dichloromethane, also known as methylene chloride, a common ingredient in solvents and spray cans.

EFFECTS OF CARBON MONOXIDE

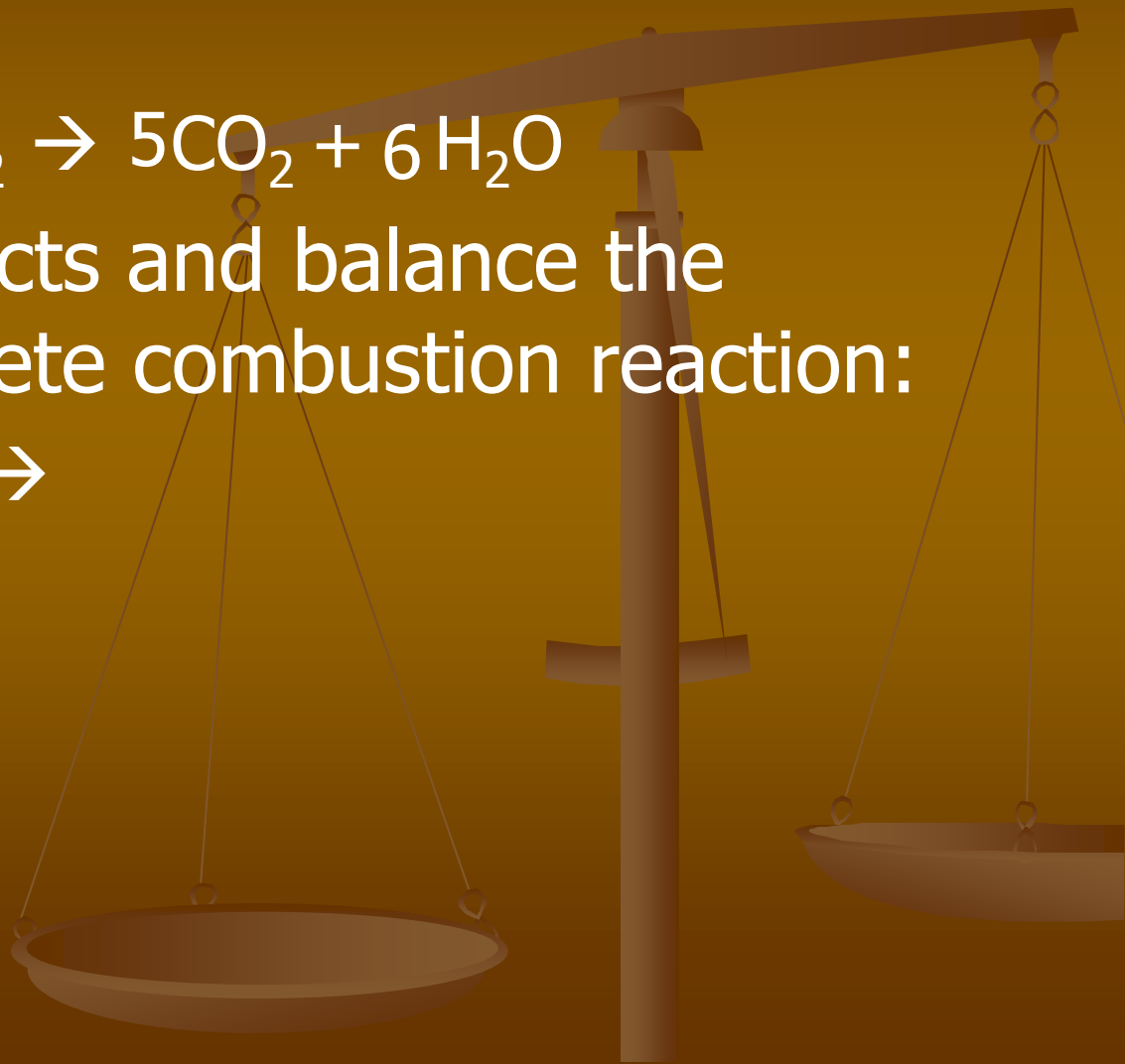
- CO binds more tightly than oxygen to heme proteins, especially hemoglobin, myoglobin and cytochromes, impairing function of brain, muscle, liver and other organs.
- CO increases blood sugar, acidosis and polycythemia while decreasing metabolism, blood pressure and body temperature; at high levels, CO may cause coma or death within minutes.
- CO acts as a neurotransmitter modulating heart rate, respiration, blood vessel tone, learning, memory, sexual function and sensory sensitization (or habituation) to odors, light and sounds.
- CO poisoning in pregnancy may result in birth defects, mental retardation and low birth weight.
- Reoxygenation may cause brain lipid peroxidation with chronic neurological effects appearing later

TREATMENT OF CARBON MONOXIDE POISONING

- 100% oxygen daily – hyperbaric if severe or normobaric, humidified and via a partial non-rebreather mask. Continue daily treatments of 1 to 2 hours until symptoms resolve and levels of carboxyhemoglobin, CO in exhaled breath and the arterio-venous gap in the partial pressure of oxygen all return to normal.
- In non-smokers, normal COHb is under 1.6%, normal breath CO is under 4ppm, and the normal arterio-venous P02 gap is over 60 mmHg (venous sample drawn from antecubital fossa without a tourniquet).

Complete Combustion

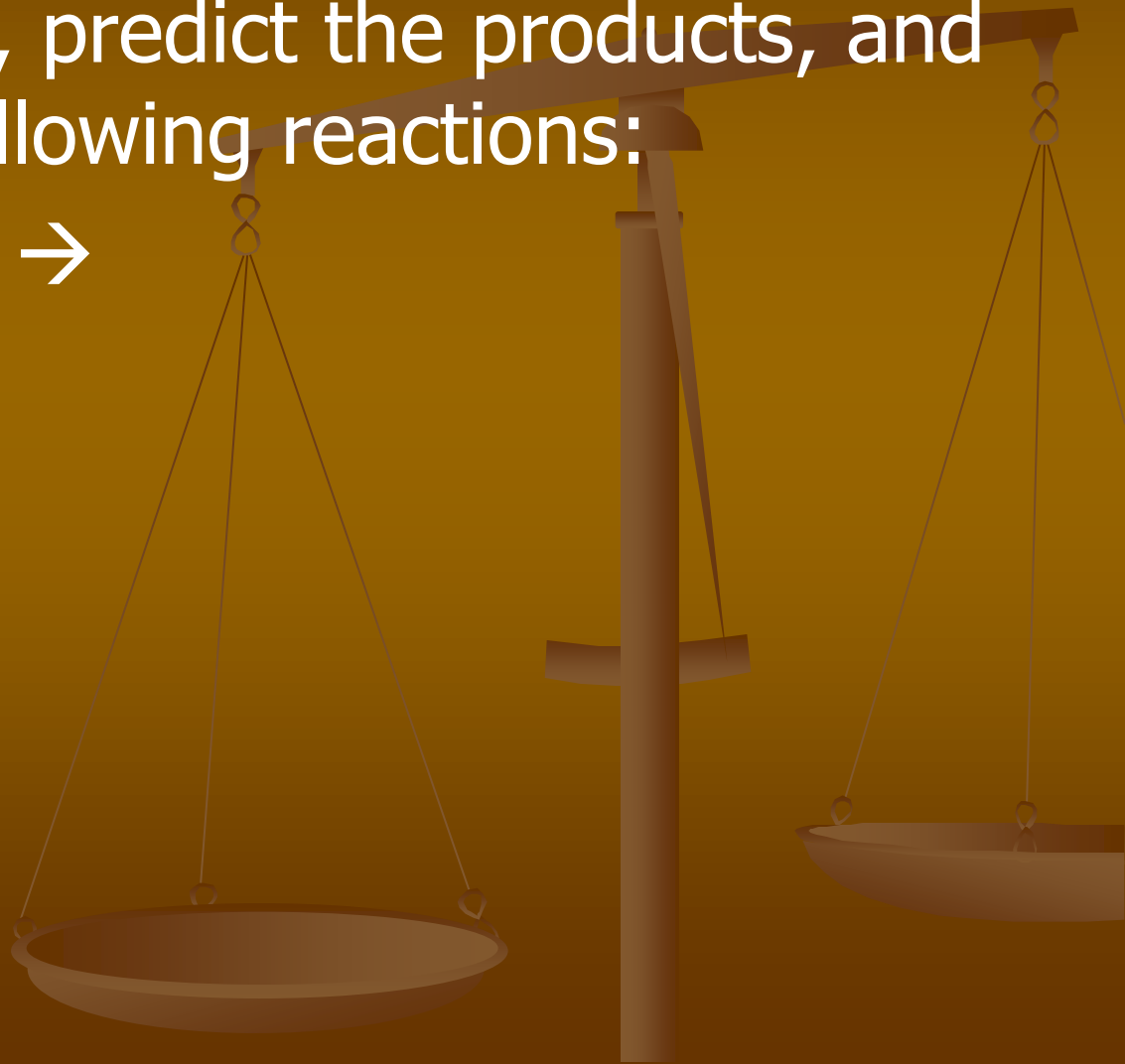
- Example
  - $C_5H_{12} + 8\,O_2 \rightarrow 5CO_2 + 6\,H_2O$
- Write the products and balance the following complete combustion reaction:
  - $C_{10}H_{22} + \quad O_2 \rightarrow$



Mixed Practice

- State the type, predict the products, and balance the following reactions:

1. $BaCl_2 + H_2SO_4 \rightarrow$
2. $C_6H_{12} + O_2 \rightarrow$
3. $Zn + CuSO_4 \rightarrow$
4. $Cs + Br_2 \rightarrow$
5. $FeCO_3 \rightarrow$



Total Ionic Equations

- Once you write the molecular equation (synthesis, decomposition, etc.), you should check for reactants and products that are soluble or insoluble.
- We usually assume the reaction is in water
- We can use a solubility table to tell us what compounds dissolve in water.
- If the compound is soluble (does dissolve in water), then splits the compound into its component ions
- If the compound is insoluble (does NOT dissolve in water), then it remains as a compound

Solubility Table

	acetate	arsenate	bromide	carbonate	chloride	chromate	hydroxide	iodide	nitrate	dichromate	oxide	phosphate	sulfate	sulfide	sulfite
Al	S	I	S		S		I	S	S		I	I	S		
NH_4^+	S	S	S	S	S	S	S	S	S	S		S	S	S	S
Ba	S	I	S	I	S	I	s	S	S	I	s	I	I	d	I
Bi		s	d	I	d		I	I	d	I	I	s	d	I	
Ca	S	I	S	I	S		I (s)	S	S	I	I	I	I	d	I
Co^{2+}	S	I	S	I	S	I	I	S	S	I	I	I	S	I	I
Cu^{2+}	S	I	S	I	S	I	I		S	I	I	I	S	I	
Fe^{2+}	S	I	S	s	S		I	S	S	I	I	I	S	I	s
Fe^{3+}	I	I	S	I	S		I		S	S	I	I	S	I	
Pb^{2+}	S	I	I	I	I	I	I	I	S	I	I	I	I	I	I
Mg	S	d	S	I	S	S	I	S	S	I	I	I	S		s
Hg^{2+}	S	I	I	I	S	s		I	S	I	I	I	d	I	
K	S	s	S	S	S	S	S	S	S	S	S	S	S	S	S
Ag^+	I	I	I	I	I	I	d	I	S	I	I	I	I (s)	I	I
Na	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Zn^{2+}	S	I	S	I	S	I	I	S	S	I	I	I	S	I	I

Solubilities Not on the Table!

- Gases only slightly dissolve in water
- Strong acids and bases dissolve in water
  - Hydrochloric, Hydrobromic, Hydroiodic, Nitric, Sulfuric, Perchloric Acids
  - Group I hydroxides (should be on your chart anyway)
- Water slightly dissolves in water! (H+ and OH-)
- For the homework… $SrSO_4$ does NOT dissolve in water
- There are other tables and rules that cover more compounds than your table!

Total Ionic Equations

Molecular Equation:

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

Soluble Soluble Insoluble Soluble

Total Ionic Equation:

$2\ K^+ + CrO_4^{-2} + Pb^{+2} + 2\ NO_3^- \rightarrow$

$PbCrO_4\ (s) + 2\ K^+ + 2\ NO_3^-$

Net Ionic Equations

- These are the same as total ionic equations, but you should cancel out ions that appear on BOTH sides of the equation

Total Ionic Equation:

$2\ K^{+} + CrO_4^{-2} + Pb^{+2} + 2\ NO_3^{-} \rightarrow PbCrO_4\ (s) + 2\ K^{+} + 2\ NO_3^{-}$

Net Ionic Equation:

$CrO_4^{-2} + Pb^{+2} \rightarrow PbCrO_4\ (s)$

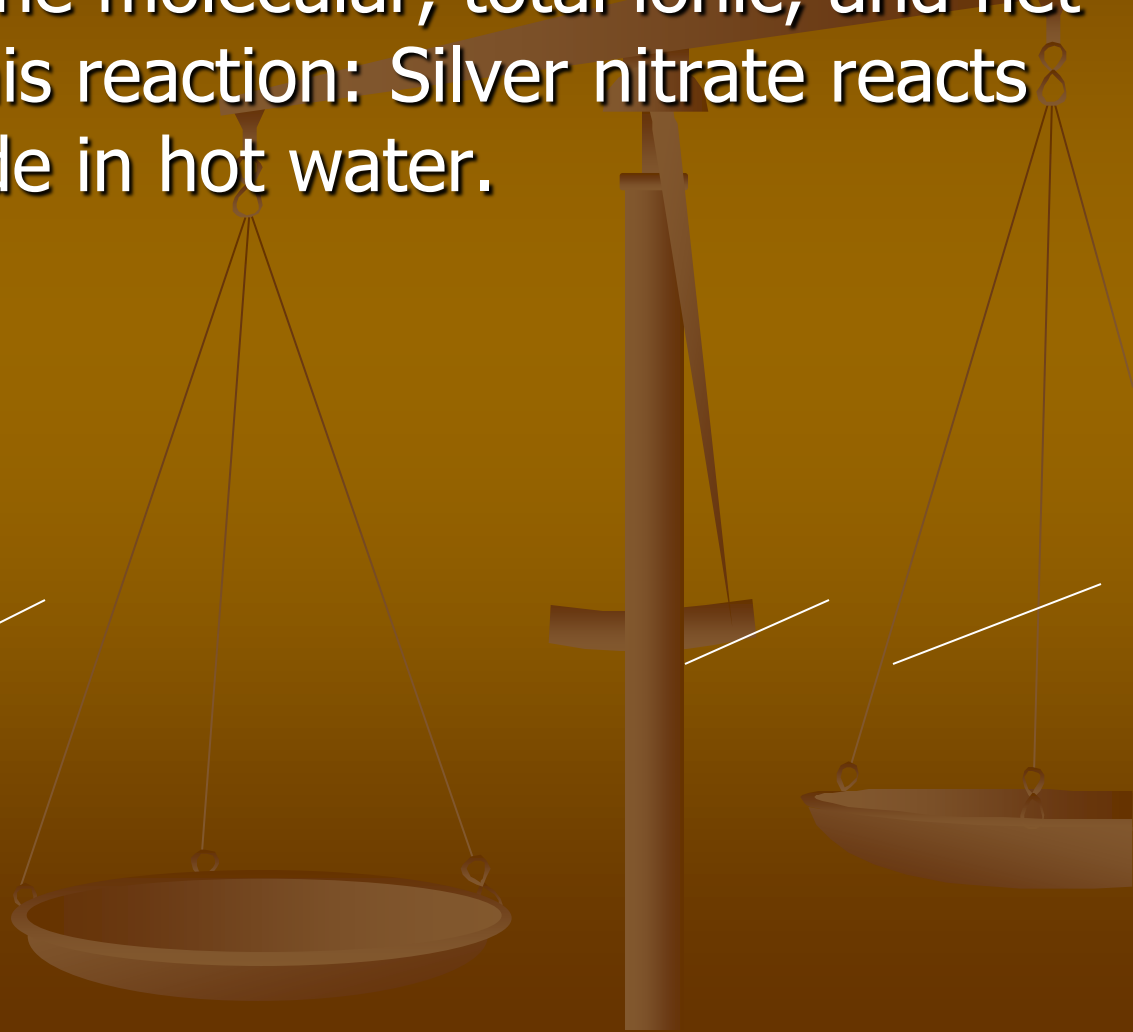
Net Ionic Equations

- Try this one! Write the molecular, total ionic, and net ionic equations for this reaction: Silver nitrate reacts with Lead (II) Chloride in hot water.

Molecular:

Total Ionic:

Net Ionic:



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