Chemical Reactions

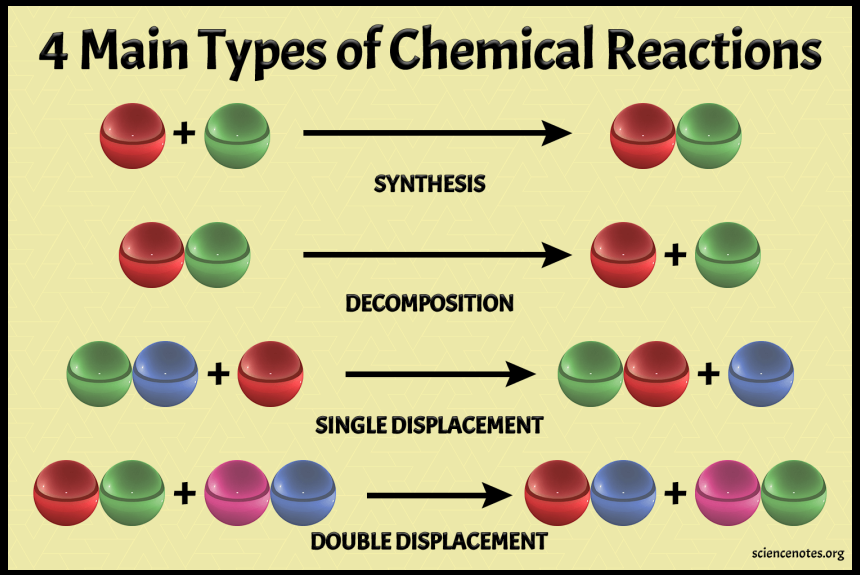
LPT

Types of Chemical Reactions

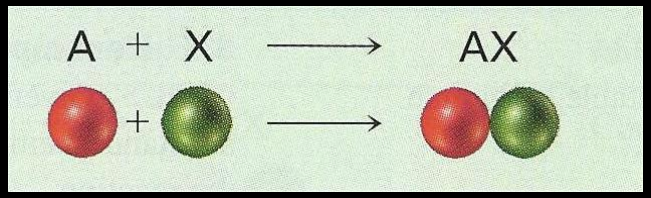
Knowledge of types useful for:

- **Predicting products from starting materials**
- **Estimating starting materials from analyzed products**
- **Evaluating potential health/safety issues**

Focus on type recognition (pattern recognition), NOT individual reactions



Combination (Synthesis) Reactions



2 or more substances combine to form 1 single product

$2\ Na + Cl_2 \rightarrow 2\ NaCl$

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

$Br_2 + PBr_3 \rightarrow PBr_5$

$MgO + CO_2 \rightarrow MgCO_3$

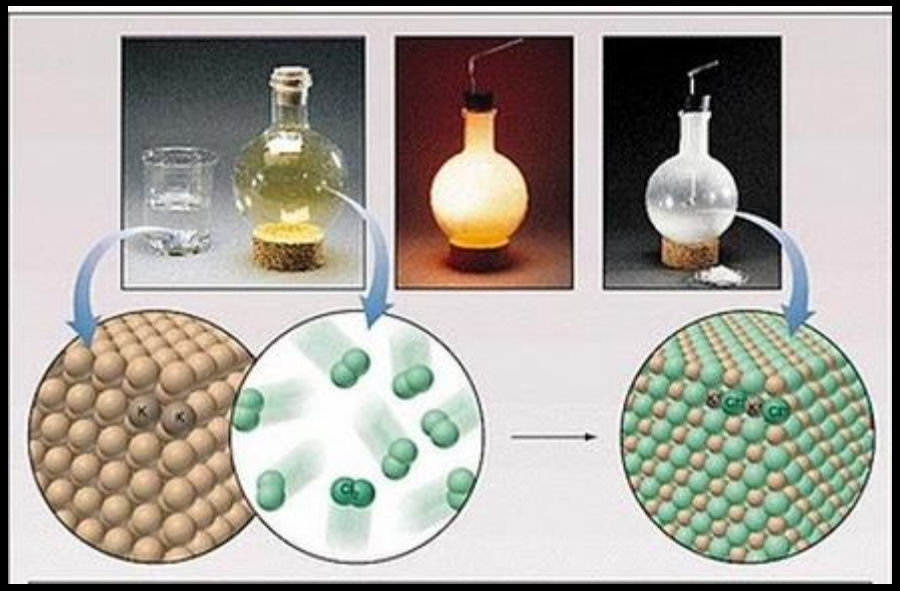
$6\ Li + N_2 \rightarrow 2\ Li_3N$

$N_2 + 3\ H_2 \rightarrow 2\ NH_3$

$CaO + H_2O \rightarrow Ca(OH)_2$

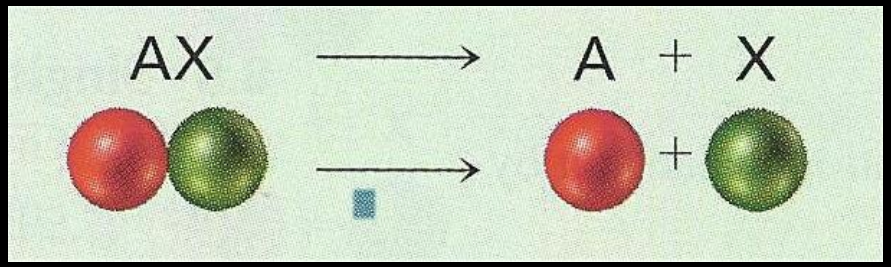
$2\ Al + 3\ Br_2 \rightarrow 2\ AlBr_3$

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



$2\ Na + Cl_2 \rightarrow 2\ NaCl$

Decomposition Reactions



Opposite of combination reaction

1 compound breaks down into simpler substances

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

$2\ H_2O_2 \rightarrow 2\ H_2O + O_2$

$CaCO_3 \rightarrow CaO + CO_2$

$PCl_5 \rightarrow PCl_3 + Cl_2$

$2\ HgO \rightarrow 2\ Hg + O_2$

$2\ KClO_3 \rightarrow 2\ KCl + 3\ O_2$

$2\ Cl_2O_5 \rightarrow 2\ Cl_2 + 5\ O_2$

$2\ N_2O_5 \rightarrow O_2 + 4\ NO_2$

$2\ NaCl \rightarrow 2\ Na + Cl_2$

Burning or Complete Combustion

$$C_xH_yO_z + O_2 \rightarrow CO_2 + H_2O$$

One reactant is organic (contains C & H; sometimes N & O)

Other reactant is always O_2

Products are always $CO_2 + H_2O$

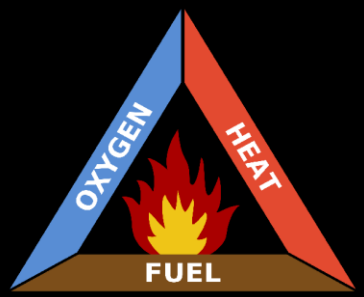
$CH_4 + 2\,O_2 \rightarrow CO_2 + 2\,H_2O$ (methane)

$C_3H_8 + 5\,O_2 \rightarrow 3\,CO_2 + 4\,H_2O$ (propane)

$2\,C_2H_2 + 5\,O_2 \rightarrow 4\,CO_2 + 2\,H_2O$ (acetylene)

$C_2H_5OH + 3\,O_2 \rightarrow 2\,CO_2 + 3\,H_2O$ (ethanol)

$C_6H_{12}O_6 + 6\,O_2 \rightarrow 6\,CO_2 + 6\,H_2O$ (glucose)



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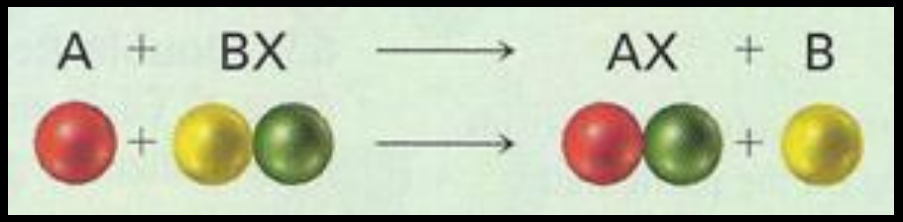
Single Replacement (Displacement)



One free element replaces another element

Reactant & Product side have different free element

Metal replaces another Metal

$Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$

$Fe + Cu(NO_3)_2 \rightarrow Cu + Fe(NO_3)_2$

$Zn_{(s)} + 2\,Au(CN)_2 \rightarrow 2\,Au_{(s)} + Zn(CN)_{4\,(aq)}$

Metal replaces Hydrogen

$Mg + 2\,HCl \rightarrow MgCl_2 + H_2$

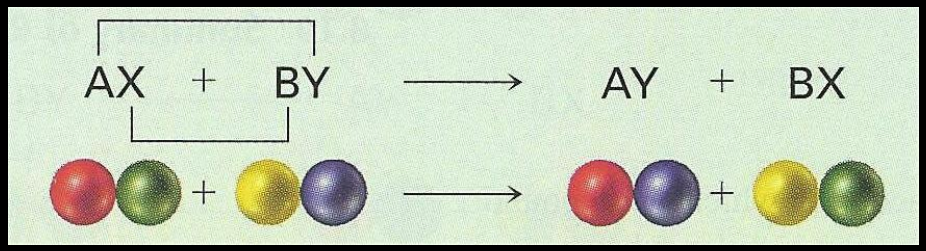
$Zn + 2\,HCl \rightarrow ZnCl_2 + H_2$

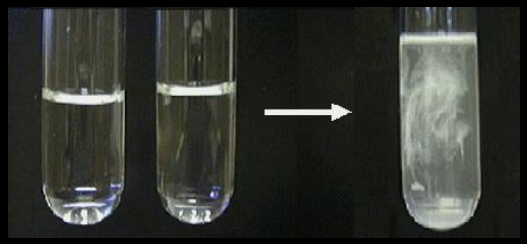
Non-Metal replaces another Non-Metal

$Cl_2 + 2\,NaBr \rightarrow 2\,NaCl + Br_2$

$Br_2 + 2\,KI \rightarrow 2\,KBr + I_2$

Double Replacement (Displacement) Reactions





Precipitation

Precipitation: (+) and (–) ions switch partners ; AY insoluble

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

$CuSO_{4(aq)} + 2\ NaOH_{(aq)} \rightarrow Cu(OH)_{2(s)} + Na_2SO_{4(aq)}$

$AgNO_{3(aq)} + KCl_{(aq)} \rightarrow AgCl_{(s)} + KNO_{3(aq)}$

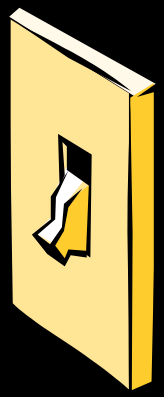
$2\ AgNO_{3(aq)} + CaCl_{2(aq)} \rightarrow 2\ AgCl_{(s)} + Ca(NO_3)_{2(aq)}$

$CaCl_{2(aq)} + Na_2SO_{4(aq)} \rightarrow CaSO_{4(s)} + 2\ NaCl_{(aq)}$

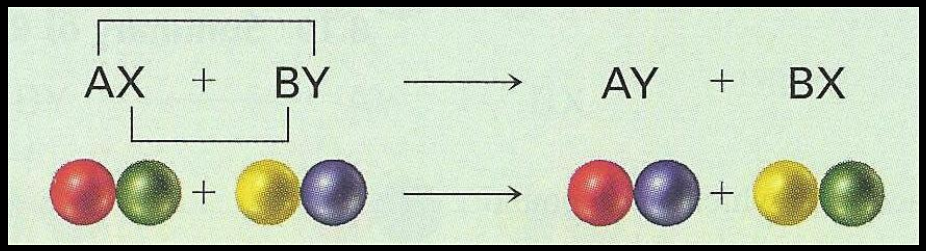
$BaCl_{2(aq)} + Na_2SO_{4(aq)} \rightarrow BaSO_{4(s)} + 2\ KCl_{(aq)}$

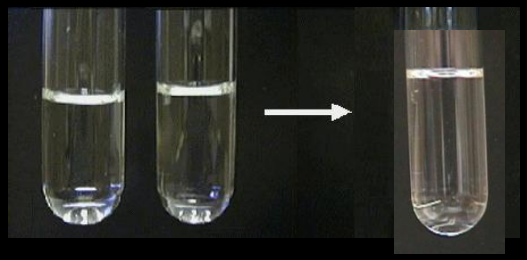
$K_2CO_3 + CaCl_2 \rightarrow CaCO_{3(ppt)} + 2\ KCl$

$Pb(NO_3)_2 + 2\ KI \rightarrow PbI_2\downarrow + 2\ KNO$



Double Replacement (Displacement) Reactions





A = H^+ Y = OH^-

Neutralization

Heat Evolved

Neutralization Reactions:

H^+ (Acid) combines with OH^- (Base) to form HOH (H_2O)

$HCl + NaOH \rightarrow NaCl + HOH$

$HNO_3 + NaOH \rightarrow NaNO_3 + H_2O$

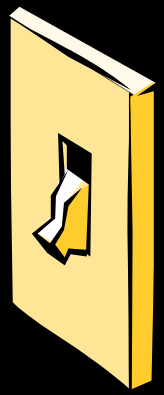
$H_2SO_4 + 2\ NaOH \rightarrow Na_2SO_4 + 2\ H_2O$

$Ca(OH)_2 + 2\ HNO_3 \rightarrow Ca(NO_3)_2 + 2\ H_2O$

$Ca(OH)_2 + H_3PO_4 \rightarrow Ca_3(PO_4)_2 + H_2O$

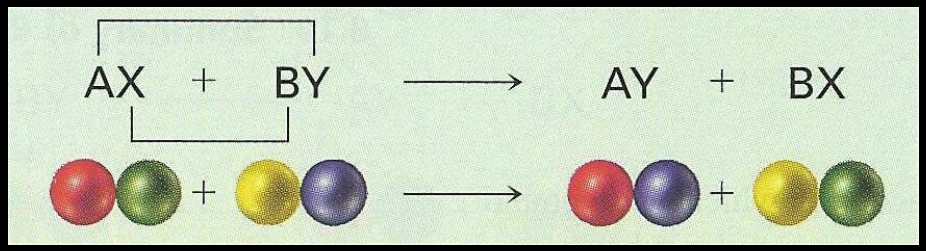
$Co(OH)_3 + HNO_3 \rightarrow Co(NO_3)_3 + H_2O$

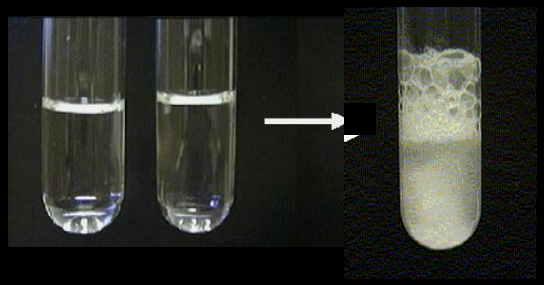
$Al(OH)_3 + H(C_2H_3O_2) \rightarrow Al\ (C_2H_3O_2)_3 + H_2O$



Salt = product of acid & base

Double Replacement (Displacement) Reactions





Gas Forming

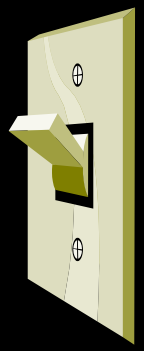
Gas Forming:

(+) and (–) ions switch partners; BX Breaks down to a gas

$K_2CO_3 + 2\ HCl \rightarrow 2\ KCl + H_2CO_3$

$H_2CO_3 \rightarrow H_2O + CO_{2\ (g)}$

Written as: $K_2CO_3 + 2\ HCl \rightarrow 2\ KCl + H_2O + CO_{2\ (g)}$



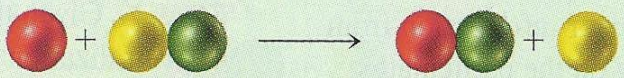
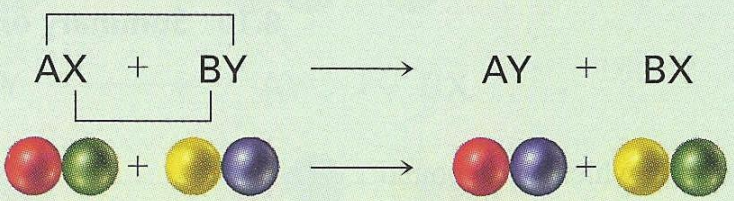
$Na_2CO_3 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O + CO_{2\ (g)}$

Other Common Gasses Evolved

$H_2SO_3 \rightarrow H_2O + SO_{2\ (g)}$

$NH_4OH \rightarrow NH_{3\ (g)} + H_2O$

Summary of Types of Reactions and Equations

Reactants	Reaction Type	Equation Type	Products
Any combination of elements and compounds that form one product	Combination	$A + X \longrightarrow AX$ 	One compound
One compound	Decomposition	$AX \longrightarrow A + X$ 	Any combination of elements and compounds
Element + ionic compound or acid	Single-replacement	$A + BX \longrightarrow AX + B$ 	Element + ionic compound
Solutions of two compounds, each with positive and negative ions	Double-replacement	$AX + BY \longrightarrow AY + BX$ 	Two new compounds, which may be a solid, water, an acid, or an aqueous ionic compound

Fuel + Oxygen $\quad C_xH_yO_z + O_2 \rightarrow CO_2 + H_2O \quad CO_2 + H_2O$

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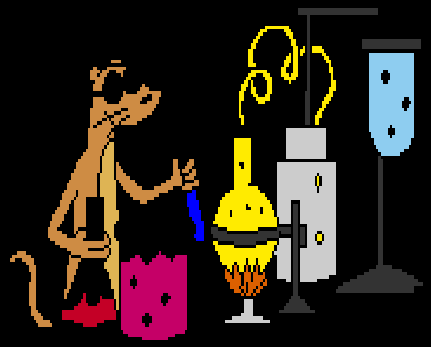
Chemical Reactions Lab

LPT

Reactions Lab



Purpose:

observe a number of chemical reactions
note the signs that a chemical change has occurred,
classify chemical reactions, and
communicate chemical changes

Procedure:

The lab is a combination of instructor demos and student run reactions
The data is the observations
The data is already provided for you since this is a virtual class.

All you need to do to complete and balance the listed chemical reactions

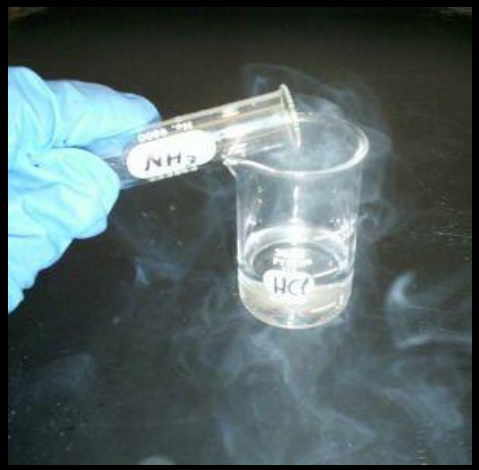
Combination Reactions

Metals + Oxygen reactions can be quite hot!

Lighting Mg

Thermite - Welder

Sparklers



$$2\ Mg + O_2 \rightarrow 2\ MgO$$

$$NH_3 + HCl \rightarrow NH_4Cl$$

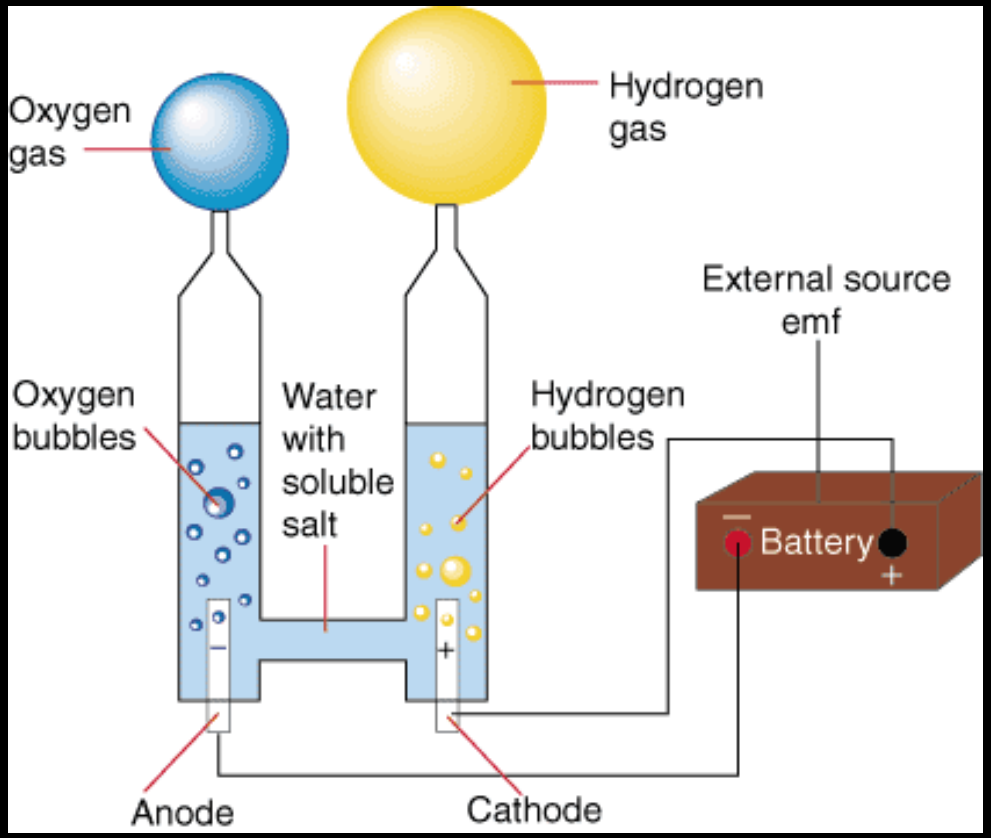
Decomposition Reaction

Hydrogen Peroxide

$$2\ H_2O_2 \rightarrow 2\ H_2O + O_2$$

- Oxygen kills anaerobic microbes
  - Considered extremely potent for certain infections
- Foaming result catalase enzyme decomposing peroxides
  - Peroxides (ROS's) are very destructive to cellular components
  - Catalase is one method of protecting cells
    - One of highest "turnovers" known
    - Catalase runs reaction on 40 million molecules / second

Decomposition Reaction



Electrical decomposition (Electrolysis) of water
Provides source of hydrogen and oxygen

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

Burning or Complete Combustion

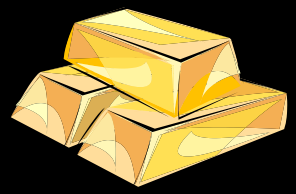
Note color of Bunsen Burner flame with complete & incomplete combustion

Place several drops of ethanol on a watch glass:
ignite it with a lighted match

Burning
Anything organic (contains C & H)
Puts Carbon Dioxide into the air

Single Replacement (Displacement)

Put 20 drops of copper(II) sulfate solution into a small test tube
Add a small piece of zinc.
Observe the reaction for several minutes
Put the test tube aside and observe again after 30 minutes

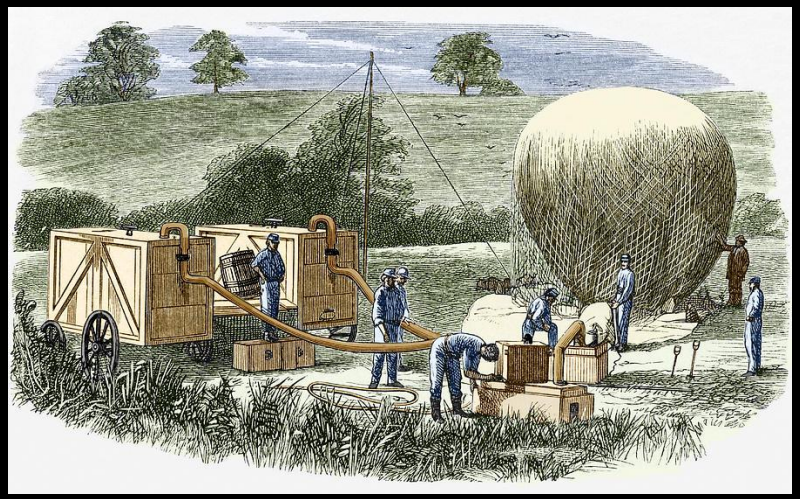


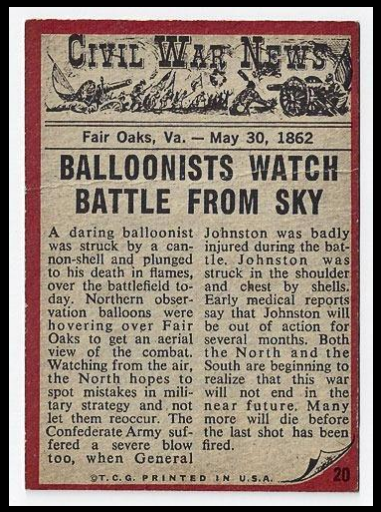
Put 20 drops of hydrochloric acid into a test tube
Add a small piece of magnesium metal
Observe the reaction for several minutes

$Zn + CuSO_4 \rightarrow Cu + ZnSO_4$

$Mg + 2\ HCl \rightarrow H_2 + MgCl_2$

Single Replacement (Displacement)





CIVIL WAR NEWS

Fair Oaks, Va. — May 30, 1862

BALLOONISTS WATCH BATTLE FROM SKY

A daring balloonist was struck by a cannon-shell and plunged to his death in flames, over the battlefield today. Northern observation balloons were hovering over Fair Oaks to get an aerial view of the combat. Watching from the air, the North hopes to spot mistakes in military strategy and not let them reoccur. The Confederate Army suffered a severe blow too, when General Johnston was badly injured during the battle. Johnston was struck in the shoulder and chest by shells. Early medical reports say that Johnston will be out of action for several months. Both the North and the South are beginning to realize that this war will not end in the near future. Many more will die before the last shot has been fired.

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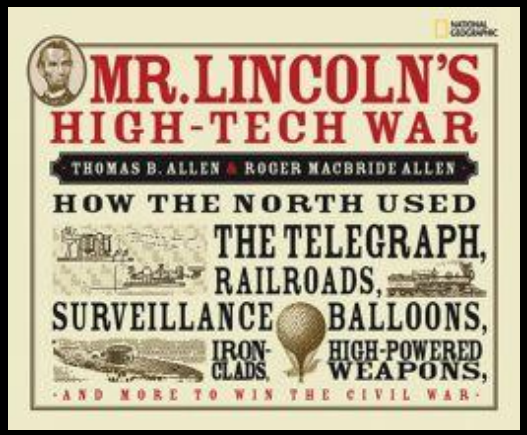
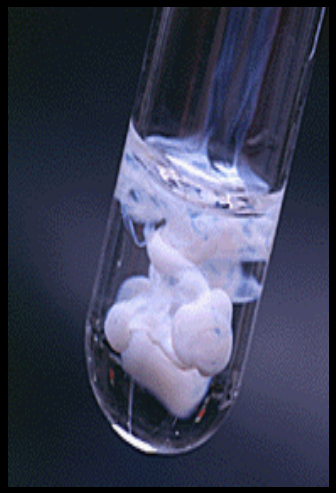
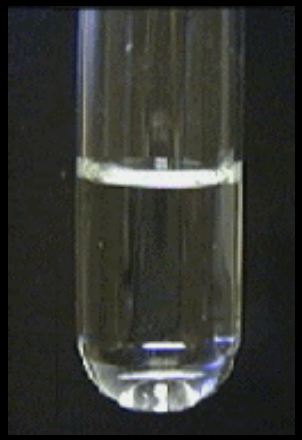


Hydrogen was used in the civil war for observation balloons

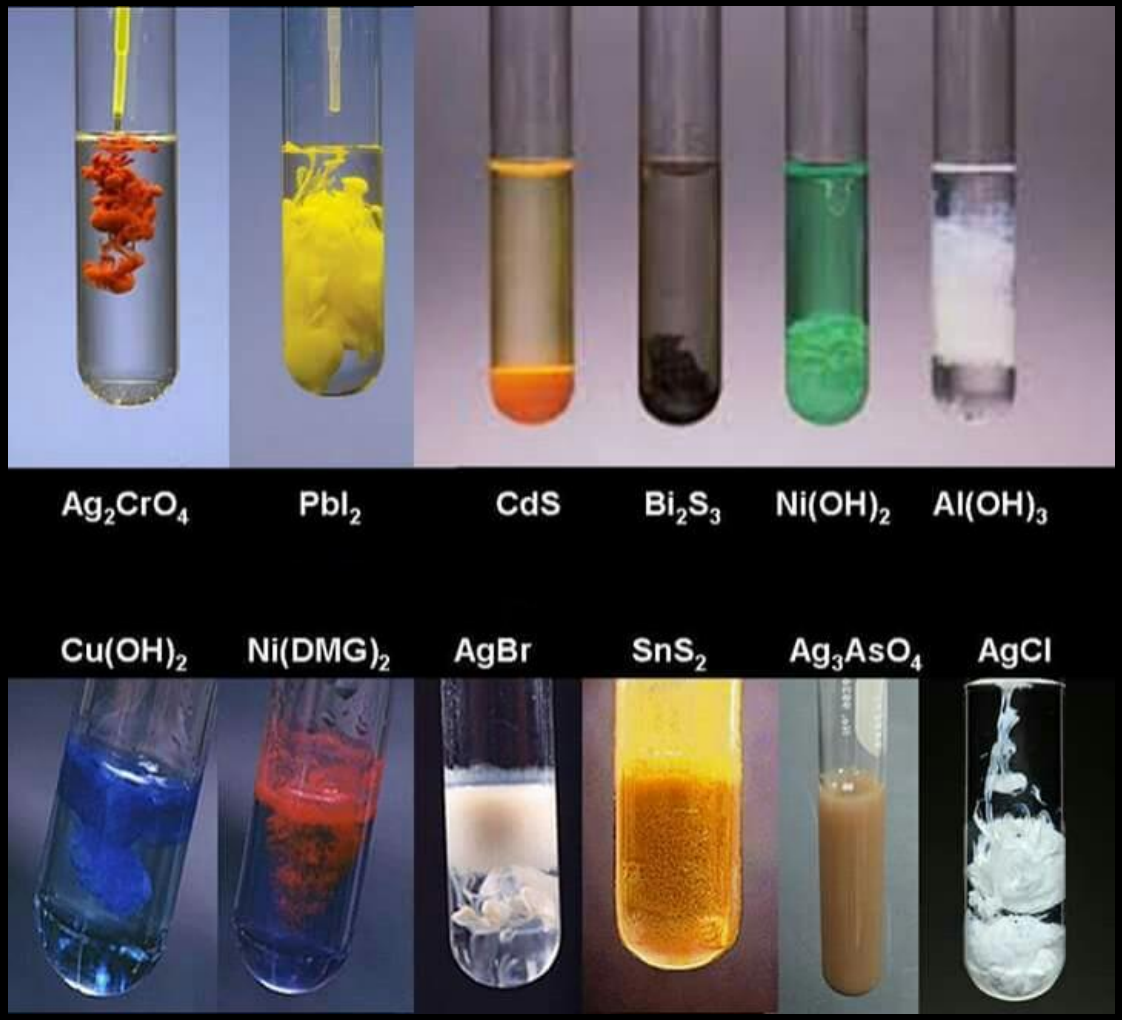
Double Replacement (Displacement) Reactions

Reactant A	Reactant B
Precipitation Reaction	
Copper(II) sulfate	Sodium hydroxide
Calcium chloride	Sodium sulfate
Potassium carbonate	Calcium chloride
Gas-Forming Reaction	
Potassium carbonate	Hydrochloric acid
Sulfuric acid	Sodium carbonate
Neutralization Reaction	
Nitric acid	Sodium hydroxide
Sulfuric acid	Sodium hydroxide



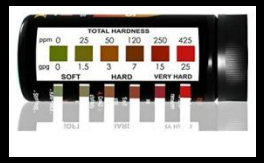


Double Replacement: Precipitation



Double Replacement: Precipitation

Hard Water: Dissolved Minerals Form Precipitates



Test Strips

Test Meters

Let’s Boldly Go Explore Today’s Lab