Chemical Equations

- General form:

Reactants ⟶ *Products*

- For Example:

$2Na_{(s)} + Cl_{2(g)} \longrightarrow 2NaCl_{(s)}$

Coefficients
- from the balanced reaction

Subscripts
- based on the nature of the chemical

State Indicators
s (solid), l (liquid), g (gas), aq (aqueous)

Some Vocabulary:

- System:
  - The part of the universe being studied
- Open System:
  - A system where things (mass, energy) can enter and leave.
    - Think beaker on a hotplate

Closed System:
- A system where NOTHING can enter or leave.
  - Think Thermos

4 Conservation Laws: (all for closed systems)

The LAW OF CONSERVATION OF…

1) MASS

- The mass at the beginning and the end of a chemical reaction is the same (conserved)

2) ATOMS

- The total number and type of atoms in a closed system does not change during a chemical reaction.

3) ELECTRICAL CHARGE

- The total electrical charge in a closed system does not change during a chemical reaction.

4) ENERGY

- The total energy in a closed system does not change during a chemical reaction. (The amounts of the various **types** of energy may change, but the **total remains constant**.)

Writing Chemical Equations From Words

- Hydrochloric acid reacts with calcium carbonate crystals, producing aqueous calcium chloride, gaseous carbon dioxide and, liquid water.

  $2HCl_{(aq)} + CaCO_{3(s)} \rightarrow CaCl_{2(aq)} + CO_{2(g)} + H_2O_{(l)}$

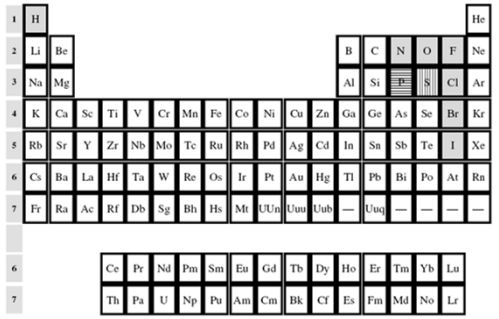
- Gaseous xenon hexafluoride reacts violently with water to form solid xenon trioxide and gaseous hydrogen fluoride

  $XeF_{6(g)} + 3H_2O_{(g)} \rightarrow XeO_{3(s)} + 6HF_{(g)}$

Don't Forget the Diatomics!

H_2, N_2, O_2, F_2, Cl_2, Br_2, I_2

S and P can sometimes also bond with itself



Some tips for Balancing Reactions…

- Start with any metals!
- Then, balance anything besides H and O.
  - H and O are often found several times in a reaction and usually cannot be balanced until everything else is first.
- Try to balance entire polyatomic groups (SO_4, NO_3, PO_4, etc.), if possible.
  - To do this, the polyatomic ion would have to be found on both sides of the reaction
- Diatomics can cause problems. If you get a fraction (eg. ½), multiply the equation by a whole number (eg. 2) which eliminates the fraction.

Try Some:

$\_\_(NH_4)_3PO_4 + \_\_NaOH \rightarrow \_\_Na_3PO_4 + \_\_NH_3 + \_\_H_2O$

$\_\_C_{19}H_{17}NO_3 + \_\_O_2 \rightarrow \_\_CO_2 + \_\_H_2O + \_\_N_2$

Try Some:

$(NH_4)_3PO_4 + 3NaOH \rightarrow Na_3PO_4 + 3NH_3 + 3H_2O$

$4C_{19}H_{17}NO_3 + 87O_2 \rightarrow 76CO_2 + 34H_2O + 2N_2$

The Six Basic Types of Reactions:

- **synthesis**
- **decomposition**
- **single replacement**
- **double replacement**
- **neutralization**
- **combustion**

1) Synthesis/Combination:

- General Equation:

  A + B → C
- one new substance is made (synthesized) by combining 2 or more reactants
- Example: $2H_2 + O_2 \longrightarrow 2H_2O$

You Try:

- $H_{2(g)} + F_{2(g)} \rightarrow 2HF_{(g)}$
- $2Al + 3S \rightarrow Al_2S_3$

2) Decomposition:

- General Equation:

  $A \rightarrow B + C$
- a reactant breaks down to form two or more products (decomposes)
- reverse of synthesis reaction
- heat or light is generally added as a catalyst for this reaction
  - (Note: catalyst = substance that speeds up a chemical reaction)
- Example: $2NH_3 \longrightarrow N_2 + 3H_2$

You Try:

- $2\ Ag_2O_{(s)} + \text{heat} \rightarrow\ 4\ Ag_{(s)} + O_{2(g)}$
- $2\ NO_{(g)} + \text{heat} \rightarrow\ N_{2(g)} + O_{2(g)}$

3) Single Replacement:

- General Equation:

  $A + BC \rightarrow B + AC$
- either the **cations** or the **anions** in the reactants "switch places" to form new products
- one element will be independent of other elements in the reactants and in the products
- Example: $CuSO_4 + Fe \longrightarrow FeSO_4 + Cu$

You Try:

- $CuCl_{2(aq)} + Fe_{(s)} \rightarrow FeCl_{2(aq)} + Cu_{(s)}$
- $2\,CaO + 2\,Cl_2 \rightarrow O_2 + 2CaCl_2$

4) Double Replacement:

- General Equation:

  AB + CD → AD + CB

- both the cations and the anions in the reactants "switch places" to form new products
- Example: $LiBr + NaF \longrightarrow LiF + NaBr$

You Try:

- $AgNO_{3(aq)} + NaCl_{(aq)} \rightarrow AgCl_{(s)} + NaNO_{3(aq)}$
- $2\,NaCl_{(aq)} + H_2SO_{4(aq)} \rightarrow 2HCl_{(g)} + Na_2SO_{4(aq)}$

5) Neutralization:

- General Equation:

  Acid + Base → Salt + H_2O

  or

  HX + MOH → MX + H_2O

- special case of a double replacement reaction
- note a salt (ionic compound) and water are produced
- Example: $2HCl + Ca(OH)_2 \longrightarrow CaCl_2 + 2H_2O$

You Try:

- $H_2SO_{4(aq)} + 2\,NaOH_{(aq)} \rightarrow Na_2SO_{4(aq)} + 2H_2O_{(l)}$
- $H_3PO_{4(aq)} + 3\,KOH_{(aq)} \rightarrow K_3PO_{4(aq)} + 3H_2O_{(l)}$

6) Combustion:

- General Equation:

  Hydrocarbon + O_2 → CO_2 + H_2O

- note: oxygen is a reactant, and carbon dioxide and water are **always** produced
- Example: $2C_2H_6 + 7O_2 \longrightarrow 4CO_2 + 6H_2O$

More Combustion:

- Sometimes other elements are involved in the hydrocarbon (we will only look at when oxygen or sulphur are included)
- Example:

  $C_5H_{12}O_{2(l)} + 7O_{2(g)} \rightarrow 5CO_{2(g)} + 6H_2O_{(l)}$

  $C_5H_{12}S_{(l)} + 9O_{2(g)} \rightarrow 5CO_{2(g)} + 6H_2O_{(l)} + SO_{2(g)}$