BALANCING CHEMICAL EQUATIONS

Diatomic Elements :

I → iodine
Bring → bromine
Cookies → chlorine
For → fluorine
Our → oxygen
New → nitrogen
Home → hydrogen

having 2 atoms in 1 molecule
these elements are only seen bonded with another like atom or with another compound
↳ due to the high electronegativity

Ex. chlorine gas : Cl_2

Balancing : only change coefficients, not subscripts
coefficient : # of seperate molecules
subscript : # of atoms that are BONDED together
law of conservation of matter - matter is not created or destroyed
↳ # of atoms is same on both sides

reactants → products

(s) : solid
(l) : liquid
(g) : gas
(aq) : aqueos → dissolved in H_2O
↳ solution

Words to Equation : use covalent/ionic naming rules to convert word problem to equation
ionic : cation + anion
covalent : binary compound : 2 non-metals

TYPES OF CHEMICAL REACTIONS

Decomposition : one compound breaks into 2 or more pieces
$AX \rightarrow A + X$ (heat / electricity is needed)

Binary compound → element + element
Metal carbonate → metal oxide + CO_2

* : some metal

$*_2CO_3 \rightarrow *_2O + CO_2$ → carbonate : CO_3^{2-} so, split into metal + CO_3^{2-} and donate one O atom from CO_3^{2-} to metal

Metal hydroxide → metal oxide + H_2O
$2*OH \rightarrow *_2O + H_2O$ → remember to balance equation
think of H_2O as HOH (hydrogen hydroxide)

Metal Chlorates → metal chlorine + oxygen (O_2)
$2*ClO_3 \rightarrow 2*Cl + 3O_2$ → remember to balance equation
think of it as oxygen completely seperating

Ionic → metal + nonmetal

Synthesis : 2 or more things combine to form one
$A + X \rightarrow AX$ (opposite of decomposition)

all rules for decomposition apply to synthesis but reversed
Ex. metal + non metal → ionic

Combustion : fuel (carbon-hydrogen compound) + $O_2 \rightarrow CO_2 + H_2O$
incomplete combustion can give CO when not enough O_2 was present

Single Replacement: one element replaces another element in a compound

$A + BX \rightarrow AX + B$ (when A and B are metals)

$A + BX \rightarrow BA + X$ (when A and X are nonmetals)

only like elements switch places.

only occur when element A is more reactive than element B

☆ if the more active element is already in place no reaction

☆ reactivity is based on how willing an element is to loose/gain e^-

Active metal replaces less active metal

Ex. $Mg + Zn(NO_3)_2 \rightarrow Mg(NO_3)_2 + Zn$

Active halogen replaces less active halogen (group 17 with fluorine)

Ex. $Cl_2 + 2NaBr \rightarrow 2NaCl + Br_2$

Very active metal replaces hydrogen in water (forming H_2 + metal hydroxide)

↳ hydrogen is pretty reactive ↳ metal should be down hydrogen on table

Ex. $2Na + 2H_2O \rightarrow 2NaOH + H_2$

Active metal replaces Hydrogen in acids (forming H_2 + metal compound)

Ex. $Zn + 2HCl \rightarrow ZnCl_2 + H_2$

Double replacement: cations switch places in compounds

$AX + BY \rightarrow AY + BX$ (ionic reactions)

reactions only occur in aqueous solutions. Reaction only occurs if...

- water is product
- precipitate forms
- gas forms

if both products are aqueous, then no reaction

if following is one product, it decomposes further:

- $NH_4OH \rightarrow NH_3 + H_2O$ (ammonium hydroxide)
- $H_2CO_3 \rightarrow CO_2 + H_2O$ (hydrogen carbonate)
- $H_2SO_3 \rightarrow SO_2 + H_2O$ (hydrogen sulfite)

all decompose to H_2O ☆

COLLISION THEORY

collision theory: atoms have to collide in order to react

↳ they will collide when they have enough energy and proper orientation

↳ atoms need enough energy to collide hard enough to make an impact

atoms have to collide at the right place, or else no reaction

increased concentration, adding heat, increase surface area, and catalyst can change rate of chemical reaction.

catalyst: lowers the activation energy needed to have chemical reaction by orienting the atoms correctly. (not as much energy needed)

not used in the reaction

Activation Energy: there is an amount of energy great enough to break the bonds of compounds.
The atoms need to collide with enough force to break bonds

concentration: increasing the concentration of the reactants makes the rate faster
there is more particles in a small space which increases the chance of collision
there are more particles that can react.

temperature: increasing the temp (adding heat) speeds up the reaction
because the atoms are moving faster they have enough speed to collide with force enough to break the bonds.
they collide more often and makes reaction faster.

* the atoms are closer together when there is less heat, but the slowness of the atoms don't collide with enough force to break bonds and react.

surface area: increasing surface area (grinding up solids) speeds up reactions
there are more points of contact and more interaction
makes it more easier to collide with other atoms.

HEAT VS. TEMPERATURE

heat: energy that is transfered from one body to another as the result of a difference in temperature.
Unit: Joules
measure of how many atoms there are in a substence multiplied by how much energy each atom possesses
has the ability to do work

temperature: a measure of hotness / coldness expressed in scales such as C° or F°
units- F° C° K
temp is related to how fast the atoms within a substence are moving.
↳ determines heat flow.
can only be measured.

CALORIMETER

System: part of the universe we are focused on
↳ usually a chemical reaction

heat goes from hot to cold areas

Surroundings: everything except the system

recap: $Q = mC\Delta T$ and $\Delta H = \frac{Q}{\text{moles}}$ ΔH = amount of energy absorbed

$$Q = mC\Delta T$$

heat energy (J) → Q; mass (g) → m; heat capacity (J/g °C) → C; chang in temp (C°) → ΔT

$C = \left(\frac{4.18\ J}{g\ C°}\right)$ ↳ constant

specific heat of water.

$\Delta T = T_f - T_i$

↳ final temp - initial temp

Q = the amount of heat gained/lost by chemical reaction

$\Delta H = \frac{Q}{\text{moles}}$ — ΔH: enthalapy chang; Q → heat energy (J)

moles ↳ $\text{gram} \times \frac{1\ \text{mole}}{\text{molar mass (g)}}$

☆ |heat gained| = |heat lost|

☆ there is a difference between Q and ΔH.
Q = energy needed in the reaction (energy in transit)
heat that has flown into or out of the reaction
ΔH = total amount of energy that is involed in the system.

EXOTHERMIC AND ENDOTHERMIC REACTIONS

Exothermic: energy is given off by a reaction
↳ that same energy is absorbed by the surroundings

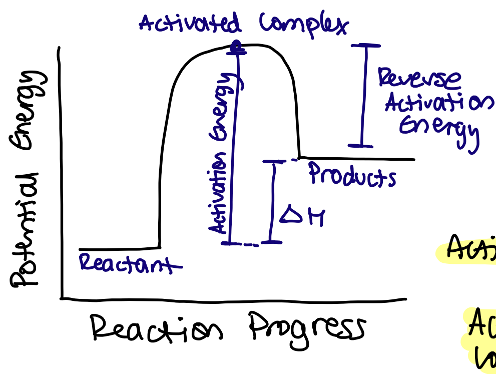
Endothermic: energy is absorbed by the reaction
↳ energy is taken from the surroundings

The ΔH in an exothermic reaction is -ve (the system loses energy, so it has less energy than it began with)
↳ the heat is on the reactant side

The ΔH in an endothermic reaction is +ve (the system gains energy, so it has more energy than it began with)
↳ the heat is on the product side.

If surrounding temp drops, it is endothermic (takes energy from surroundings)
If surrounding temp goes up, it's exothermic (gives energy to surroundings)

Endothermic Diagram:

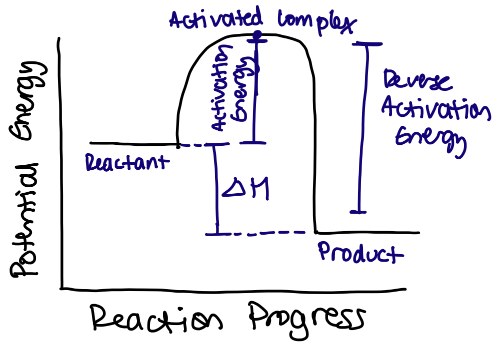


Activation Energy: the minimum amount of energy needed to start the reaction

Reverse Activation Energy = Activation energy for the reverse reaction

Activated Complex: a short-lived unstable arrangement of atoms that break/re-form in reaction

Exothermic Diagram :



The ΔH enthalpy is the difference between the potential energy of the products and reactants

The products have less potential energy than the reactants in an exothermic reactions

Energy is released during the process, which is why the products have less energy than the reactants in exothermic reaction

EQUILIBRIUM

Reversible reaction : a chemical reaction in which the products can react to reform the reactants (back-and-forth) $A \leftrightarrow B$

Chemical Equilibrium : the rate at which the forward and reverse reaction take place at the same rate so there is no further change in amounts of reactants and products

Le Chateliers Principle : when a stress (external force) is placed on a system, the reaction shifts to relive that stress

1) **Adding a reactant / removing a products makes the reaction shift forward**
Adding a reactant increases the concentration of that reactant. The reaction will try to consume the extra reactant to establish a new equilibrium. It tries to reduce the concentration of that reactant

Removing a product decreases the concentration of that product. The reaction will try to make more product to establish a new equilibrium

2) **Removing reactant / adding product makes the reaction shift in reverse direction**
The reaction will try to make more reactants. The products will be used to make more reaction to decrease the amount of products and increase the amount of reactants to restore the equilibrium

3) **Adding heat to endothermic reaction / removing heat in exothermic reaction makes the reaction shift forward**
Technically, heat is a reactant in an endothermic reaction and a product in an exothermic reaction. Heat is needed for the reaction in endothermic. And heat is released in exothermic. The rule #1 applies here.

4) **Adding heat to exothermic reaction / removing heat in endothermic reaction makes the reaction shift in the reverse direction**
Rule #2 applies here if we think heat in terms of reactant/product

These help minimize the stress caused by a change in product/reactant to make it stable.

when temp. increases, the reaction favors the side that has no heat
when temp decreases, the reaction favors the side that has heat

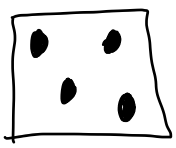
Collision theory: adding reactants increases the chance of reactants colliding with each other and making more products
removing products decreases the chance of them colliding with each other making more reactants likely to collide

When there is equilibrium, there is no net change. The reactions go back and forth so fast that we can't see it happening

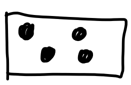
solids/liquids do not impact equilibrium. Only increasing/decreasing concentration of aqueous/gas changes the equilibrium

Solids/liquids concentration remains constant during the reaction
solids/liquids have high densities and have their molecules closely packed together. the density of a small amount of solid is the same as a big amount of a big solid

5) **Increasing pressure or decreasing the volume will make the reaction shift toward the side with fewer moles of gas**



→ $\frac{4 \text{ mol}}{1 \text{ L}} = 4$ when we decrease the volume/increase the pressure, the molecules are packed closer together



= $\frac{4 \text{ mol}}{0.5 \text{ L}} = 8$ → the reaction is faster because there is a higher concentration

The reaction will try to use up more of the concentration by making more molecules of the compounds that have less moles.