ENERGY

- thermodynamics: the study of energy transfer

Conservation of energy: In an isolated system, energy may change form, but the overall amount of energy remains constant.

"first law of thermodynamics"

- ... but what IS energy?

- energy is the ability to do "work"

motion of matter

Kinds of energy?

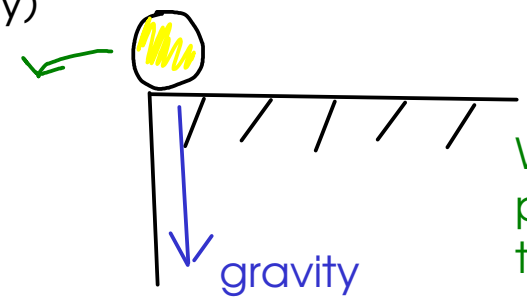
- Kinetic energy: energy of matter in motion

$$E_K = \frac{1}{2} m v^2$$

mass

velocity

- Potential energy: energy of matter that is being acted on by a field of force (like gravity)



When the ball falls, its potential energy is converted to kinetic!

- What sort of energy concerns chemists? Energy that is absorbed or released during chemical reactions.

- Energy can be stored in chemicals ... molecules and atoms.

INTERNAL ENERGY: "U"

related to the kinetic and potential energy of atoms, molecules, and their component parts.

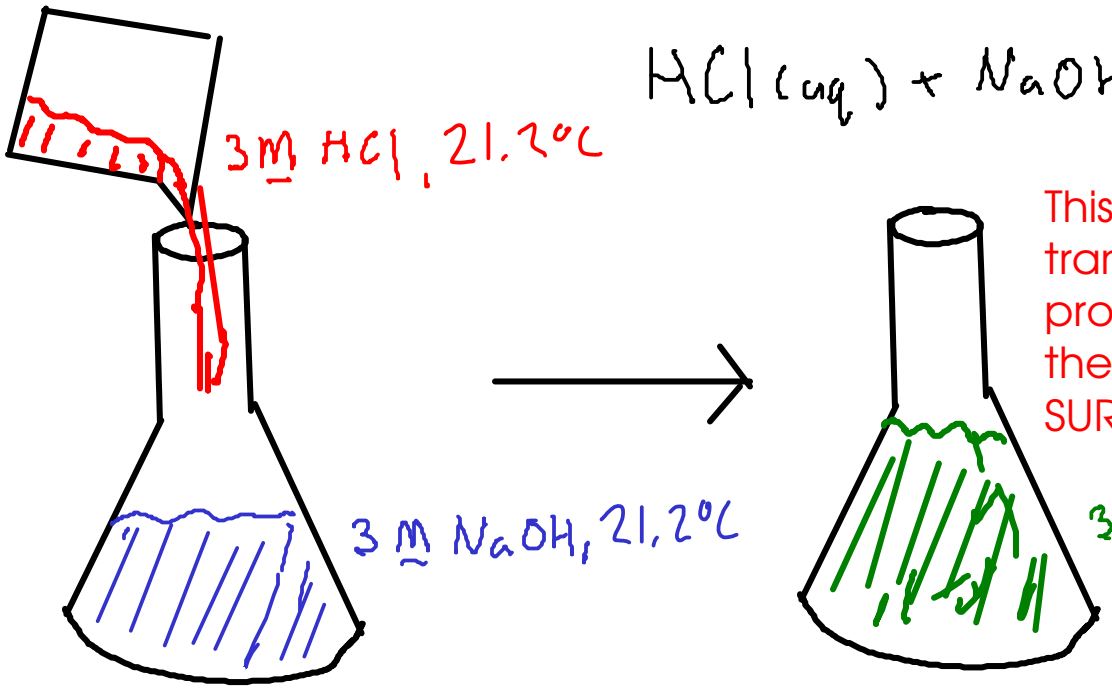
- We measure energy transfer ... which is called HEAT. (HEAT is the flow of energy from an area of higher temperature to an area of lower temperature)

Q : heat

SYSTEM: the object or material under study

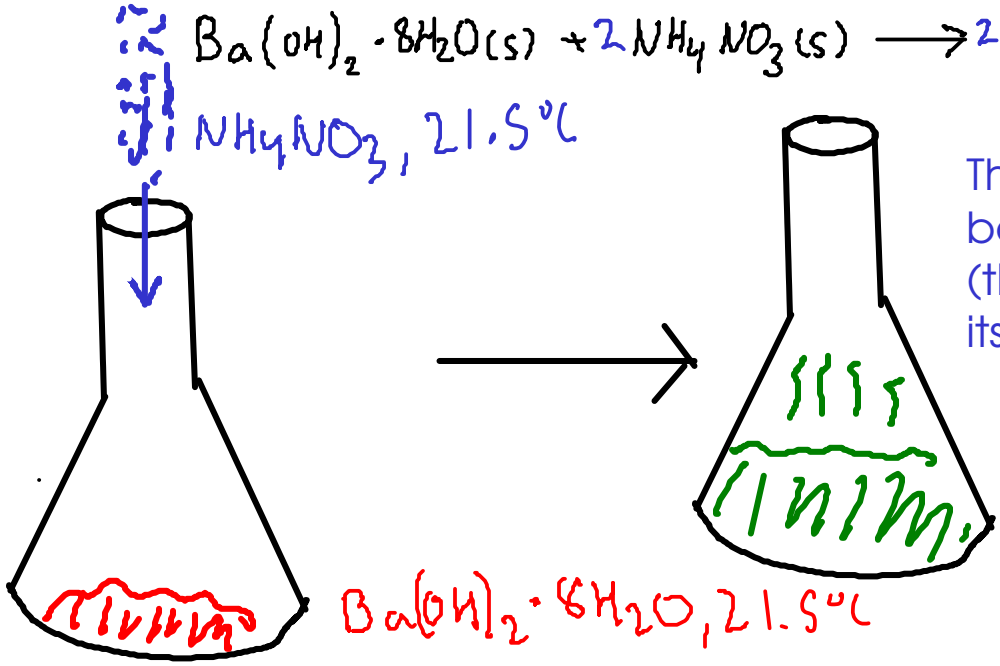
SURROUNDINGS: everything else

Type of process	Energy is ...	Sign of Q	Temp of SURROUNDINGS ...
ENDOTHERMIC	transferred from SURROUNDINGS to SYSTEM	+	decreases
EXOTHERMIC	transferred from SYSTEM to SURROUNDINGS	−	increases



$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$$

This reaction is EXOTHERMIC. Energy is transferred from the reactants and products (the SYSTEM) to the water in the flask, the flask, etc. (the SURROUNDINGS)

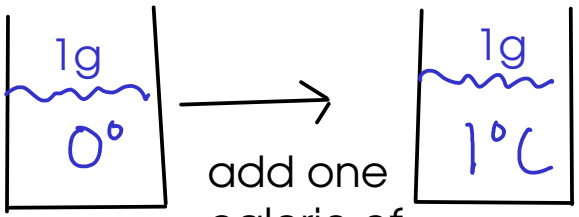


$$Ba(OH)_2 \cdot 8H_2O(s) + 2NH_4NO_3(s) \longrightarrow 2NH_3(aq) + 10H_2O(l) + Ba(NO_3)_2(aq)$$

This reaction is ENDOTHERMIC. Energy is being transferred from the room/flask/etc. (the SURROUNDINGS) to the reaction itself (the SYSTEM).

ENERGY UNITS

- calorie (cal): the amount of energy required to change the temperature of one gram of water by one degree Celsius (or Kelvin)



$1\,g \approx 1\,mL$ for water

- Calories in food? The "Calorie" that is given on American food labels is actually the kilocalorie (kcal)

- Joule (J): SI unit for energy. It's defined based on the equation for kinetic energy.

$1\,J = 1\,\frac{kg\,m^2}{s^2}$, from

$E_K = \frac{1}{2} m v^2$

E_K: kinetic energy; m: mass; v: velocity

4.184 J = 1 cal

- the Joule is a small unit. For most reactions at lab scale, we'll use kilojoules (kJ).

SPECIFIC HEAT AND HEAT CAPACITY

- a measured quantity. The amount of energy required to change the temperature of one gram of a particular substance by one degree Celsius.

- Specific heat information for common substances is readily available. For water,

$4.184 \frac{J}{g^{\circ}C}$ or $1.000 \frac{cal}{g^{\circ}C}$

$$Q = m \times S \times \Delta T$$

m = mass
s = specific heat
Δ T = Tfinal - Tinitial

This is ALWAYS final temp minus initial temp!

- For objects, like reaction vessels, you might know the HEAT CAPACITY, which is the amount of energy required to change the temperature of an object by one degree Celsius

Units: $J/^{\circ}C$ or $cal/^{\circ}C$

$$Q = C \times \Delta T$$

c = heat capacity