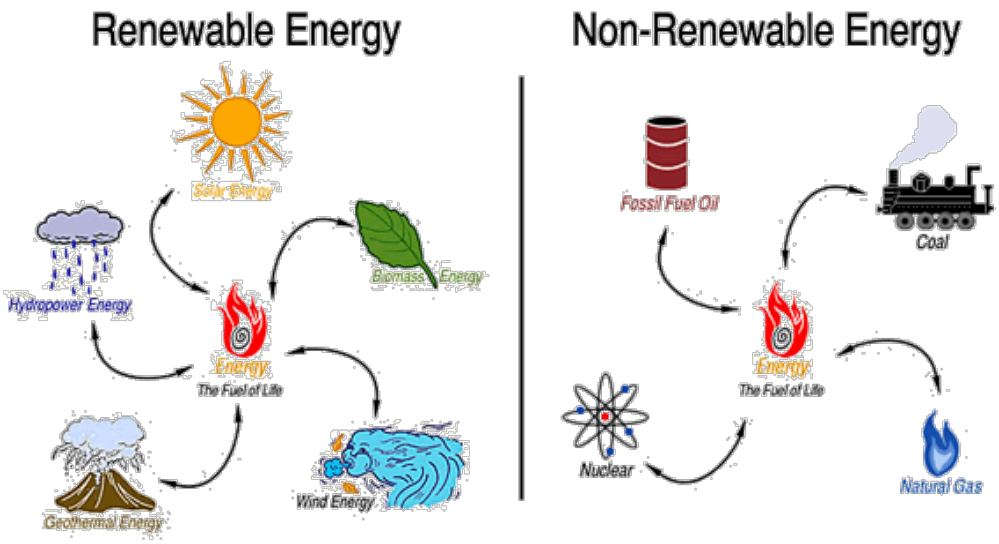
ENERGY



THERMODYNAMICS = the study of energy and energy transfer

THERMOCHEMISTRY = the study of NRG involved in chemical reactions

LAW OF CONSERVATION OF NRG

$\triangle E_{universe} = 0$

[NRG cannot be created nor destroyed,
only transferred into another form]

- NRG can be transferred from one substance to another

SYSTEM	SURROUNDINGS
Reac. ⟶ Prod.	
$\triangle E_{system}$ =	$- \triangle E_{surroundings}$

ie. $E_{lost} = E_{gain}$, but opposite signs

DEFINITIONS

Q = heat

= transfer of Kinetic Energy from warmer object to colder object

= measured in joules (J)

T = temperature

= measure of average Kinetic Energy of particles in a system

= measured in ^{o}C or K

0 K = -273.15 ^{o}C
273.15 K = 0 ^{o}C
293.15 K = 20 ^{o}C
373.15 K = 100 ^{o}C

H = enthalpy

= total internal energy of a substance at constant pressure
(not used much)

△H = enthalpy change

= heat change at constant pressure

= measured in kilojoules (kJ)

- **breaking bonds requires energy (like pulling apart magnets)**
- **forming bonds releases energy (bringing magnets together)**

REACTANTS ⟶ PRODUCTS

- break bonds - make bonds

- NRG absorbed - NRG released

If $NRG_{absorbed}$ **>** $NRG_{released}$, then **endothermic** (system absorbed E)

If $NRG_{absorbed}$ **<** $NRG_{released}$, then **exothermic** (system releases E)

$\triangle H_{rxn}$ -- enthalpy change of a chemical reaction

$\triangle H^{o}_{rxn}$ -- standard molar enthalpy of reaction

-- occurs at SATP = 25 ^{o}C and 100 kPa

OR $\triangle H^{o}$ -- also called heat of reaction

3 WAYS TO SHOW ENTHALPY CHANGES

- balance reaction first

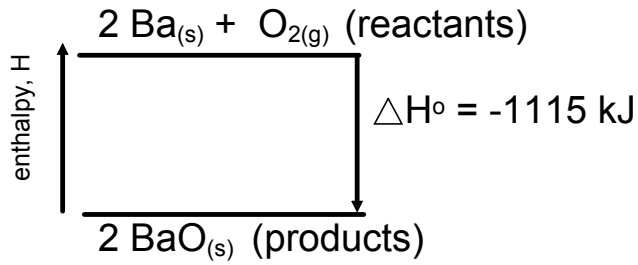
1. THERMOCHEMICAL EQUATION

eg. $2\ Ba_{(s)} + O_{2(g)} \longrightarrow 2\ BaO_{(s)} + 1115\ kJ$(exothermic)

2. THERMOCHEMICAL EXPRESSION

eg. $2\ Ba_{(s)} + O_{2(g)} \longrightarrow 2\ BaO_{(s)}\ \triangle H^o = -1115\ kJ$(exothermic)

3. ENTHALPY DIAGRAM



eg. Nitrogen gas and oxygen gas absorb 67.6 kJ of energy to produce nitrogen dioxide gas. Represent the enthalpy changes in 3 ways.

STOICHIOMETRY

$2\ H_{2(g)} + O_{2(g)} \longrightarrow 2\ H_2O_{(l)} + 571.6\ kJ$

$1\ H_{2(g)} + 1/2\ O_{2(g)} \longrightarrow 1\ H_2O_{(l)} + 285.8\ kJ$

EG. Solid aluminum reacts with chlorine gas to release 1408 kJ of energy and produce solid aluminum chloride. What is the enthalpy change when 1.00 kg of aluminum reacts completely with excess chlorine?

***STEPS*:** 1. Balance the reaction.

2. Convert mass of substance to moles.

3. Use conversion factors to solve for unknown quantity.

1. $2\ Al_{(s)} + 3\ Cl_{2(g)} \longrightarrow 2\ AlCl_{3(s)} \qquad \triangle H^o = -1408\ kJ$

2. $1.0\ kg\ Al = 1.0 \times 10^3\ g\ Al \times \dfrac{1\ mol}{26.98\ g\ Al} = 37.1\ mol\ Al$

3. $\triangle H = 37.1\ mol\ Al \times \dfrac{-1408\ kJ}{2\ mol\ Al} = -2.61 \times 10^4\ kJ$

EG. Hydrogen chloride gas absorbs 185 kJ of energy to produce hydrogen gas and chlorine gas. What is the enthalpy change when 27.3 grams of HCl decomposes?

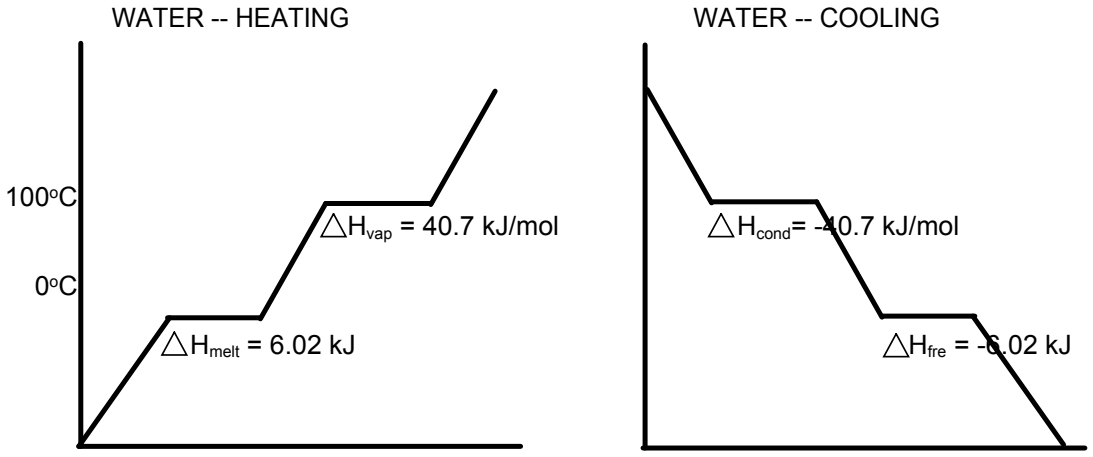
EXAMPLE:

Given the reaction of solid carbon and gaseous hydrogen produces benzene in an endothermic reaction involving 49.1 kJ of heat per mole, determine the following:

A) How much heat is required for 2.50 g of carbon?

B) What mass of benzene is produced from 9.00 kJ heat?

CHANGES OF STATE



NOTE: $\triangle H_{vap} = -\triangle H_{cond}$

$\triangle H_{melt} = -\triangle H_{fre}$

* **LATENT heat** is the amount of energy used up during a change of state.

-corresponds with horizontal segments in graphs above

Eg. COLD PACKS

$$NH_4NO_{3(s)} + \text{energy} \xrightarrow{+ H_2O} NH_4NO_{3(aq)}$$

Eg. Hot Packs

$$CaCl_{2(s)} \xrightarrow{+ H_2O} Ca^{2+}_{(aq)} + 2Cl^-_{(aq)} + \text{energy}$$

795.4 kJ