Energy

Energy: ability to do work or produce heat.

Types of energy

1) Potential energy - energy possessed by objects due to position or arrangement of particles.

Forms of potential energy - electrical, chemical, gravitational

2) Kinetic energy - energy of motion

3) Radiant energy - energy given off by subatomic particles (such as photons, electrons, neutrons, etc.) or chemical reactions.

First Law of Thermodynamics

Energy can not be created or destroyed, only changed into some other type of energy.

Any energy lost by a system is gained by the surroundings

Energy conversions can start or end up in potential energy (chemical or position), kinetic energy (mechanical) or radiant energy (thermal, electrical, light, sound).

Heat

Thermochemistry is the study of the changes in heat (radiant energy) in a chemical reaction.

Heat is usually measured in two units:

1) SI unit (derived): Joules (J) -very small

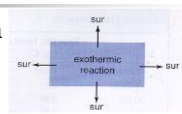
2) Non - SI unit: calorie (cal) - originally defined as the amount of energy needed to raise 1 g of water from 14.5 ^{O}C to 15.5 ^{O}C. Now:

$$1 \text{ cal} = 4.184 \text{ J}$$

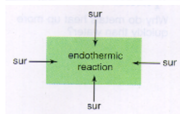
3) Food unit: Calorie (Cal) - nutritional unit = 1 kcal.

Exothermic & Endothermic

An exothermic reaction is a chemical reaction that releases heat.



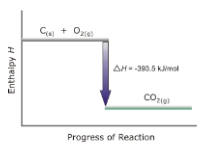
An endothermic reaction is a chemical reaction that absorbs heat.

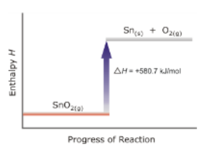


Heat of Reaction

The heat of a reaction depends on the chemical energy of the reactants in comparison to the chemical energy of the products

An energy diagram can show these changes in energy.





Enthalpy (Heat of Reaction)

Enthalpy is a measure of the heat (energy) absorbed and released in a reaction. The symbol for enthalpy is ⊗H.

The enthalpy is either included in the equation:

$2C_2H_6 + 7O_2$ --> $4CO_2 + 6H_2O$ + 3120 kJ

Or at the end of the reaction:

$2C_2H_6 + 7O_2$ --> $4CO_2 + 6H_2O$, ⊗H = -3120 kJ

A negative enthalpy means the is exothermic because the reactants have lost energy.

What type of reaction would exist if the heat energy were a reactant? If the enthalpy were positive?

Stoichiometry and Enthalpy

Knowing the enthalpy of a reaction, we can determine the heat given off or absorbed by the given mass of a reactant.

The molar coefficients are directly related to the enthalpy.

Example: How much energy is released through the combustion of 25.0 g of ethane according to the reaction on the previous slide?

Calorimetry

The study of heat flow and heat measurement

Calorimetry experiments determine the heat changes of reactions by making accurate measurements of temperature changes within a calorimeter.

Molar heat capacity - amount of heat needed to raise one mole of a substance by 1 K

Heat & Specific Heat

The temperature increases depends on the specific heat of the surroundings. The specific heat tells how much heat is required to increase the temperature of 1 gram of a material by 1 degree Kelvin.

The equation for finding the heat lost or gained is:

$q = mc\Delta T$, where c is the specific heat of the substance. (c_{water} = 4.184 J/g K)

The heat lost (gained) in the reaction is equal to the heat gained (lost) by the surroundings, or $q_{rxn} = -q_{sur}$

Hess's Law

Calculate the ΔH for the reaction 2 C (s) + H_2 (g) --> C_2H_2 (g), given the following reactions:

C_2H_2 (g) + 5/2 O_2 (g) --> 2 CO_2 (g) + H_2O (l) $\Delta H = -1299.6$ kJ

C (s) + O_2 (g) --> CO_2 (g) $\Delta H = -393.5$ kJ

H_2 (g) + 1/2 O_2 (g) --> H_2O (l) $\Delta H = -285.8$ kJ

Hess's Law

Calculate the ΔH for the reaction NO (g) + O (g) --> NO_2 (g), given the following reactions:

NO (g) + O_3 (g) --> NO_2 (g) + O_2 (g) $\Delta H = -198.9$ kJ

O_3 (g) --> 3/2 O_2 (g) $\Delta H = -142.3$ kJ

O_2 (g) --> 2 O (g) $\Delta H = +495.0$ kJ

Enthalpies of Formation

The amount of energy needed to create a compound from it's constituent elements.

The ΔH^o_f is the standard enthalpy of formation. It is determined for 1 mol of the substance in its standard state at 298 K. A list of these are in Appendix 4 in the back of the book.

Enthalpies of Reaction

If you know the standard enthalpy of formation (ΔH^o_f) for all materials in a reaction, you can determine the standard enthalpy of reaction (ΔH^o_{rxn}).

$$\Delta H^o_{rxn} = \Sigma[\Delta H^o_f \text{ (products)}] - \Sigma[\Delta H^o_f \text{ (reactants)}]$$

ΔH^o_f are found in Appendix 4.

Note: (Σ = sum of)