

Changes in Matter and Energy

Chapter 5.1

Energy is the capacity to do work

- **Thermal energy** is the energy associated with the random motion of atoms and molecules
- **Chemical energy** is the energy stored within the bonds of chemical substances
- **Nuclear energy** is the energy stored within the collection of neutrons and protons in the atom
- **Electrical energy** is the energy associated with the flow of electrons
- **Potential energy** is the energy available by virtue of an object's position



Energy Changes in Chemical Reactions

Heat is the transfer of **thermal energy** between two bodies that are at different temperatures.

Temperature is a measure of the **thermal energy**.



Temperature \neq Thermal Energy



90°C



40°C

greater thermal energy

Thermochemistry is the study of heat change in chemical reactions.

The **system** is the specific part of the universe that is of interest in the study.

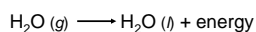
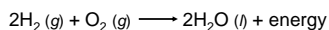


Exchange: mass & energy

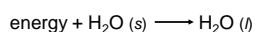
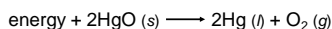
closed energy

isolated nothing

Exothermic process is any process that gives off heat – transfers thermal energy from the system to the surroundings.



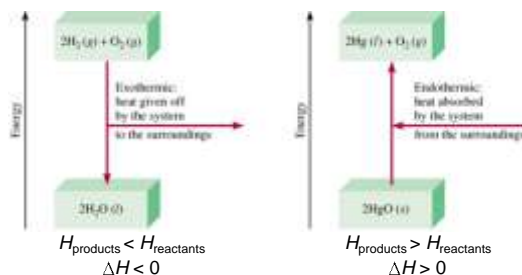
Endothermic process is any process in which heat has to be supplied to the system from the surroundings.



Enthalpy (H) is used to quantify the heat flow into or out of a system in a process that occurs at constant pressure.

$$\Delta H = H(\text{products}) - H(\text{reactants})$$

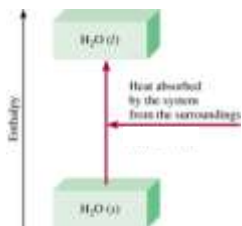
ΔH = heat given off or absorbed during a reaction **at constant pressure**



$$H_{\text{products}} < H_{\text{reactants}} \\ \Delta H < 0$$

$$H_{\text{products}} > H_{\text{reactants}} \\ \Delta H > 0$$

Thermochemical Equations

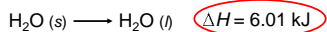
Is ΔH negative or positive?

System absorbs heat

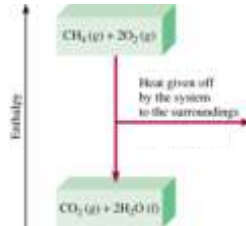
Endothermic

$$\Delta H > 0$$

6.01 kJ are absorbed for every 1 mole of ice that melts at 0°C and 1 atm.



Thermochemical Equations

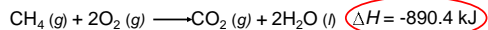
Is ΔH negative or positive?

System gives off heat

Exothermic

$$\Delta H < 0$$

890.4 kJ are released for every 1 mole of methane that is combusted at 25°C and 1 atm.



The **specific heat** (s) of a substance is the amount of heat (q) required to raise the temperature of **one gram** of the substance by **one degree** Celsius.

The **heat capacity** (C) of a substance is the amount of heat (q) required to raise the temperature of a **given quantity** (m) of the substance by **one degree** Celsius.

$$C = ms$$

Heat (q) absorbed or released:

$$q = ms\Delta t$$

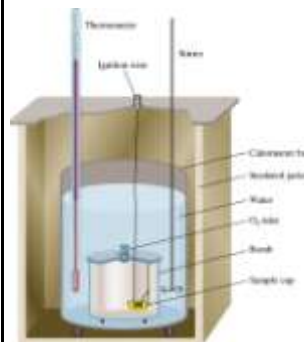
$$q = C\Delta t$$

$$\Delta t = t_{\text{final}} - t_{\text{initial}}$$

Table 6.1 The Specific Heats of Some Common Substances

Substance	Specific heat (J/g · °C)
Al	0.900
Au	0.129
C (graphite)	0.720
C (diamond)	0.502
Cr	0.385
Fe	0.444
Hg	0.139
H ₂ O	4.184
C ₂ H ₅ OH (ethanol)	2.46

Constant-Volume Calorimetry



$$q_{\text{sys}} = q_{\text{water}} + q_{\text{bomb}} + q_{\text{rxn}}$$

$$q_{\text{sys}} = 0$$

$$q_{\text{rxn}} = -(q_{\text{water}} + q_{\text{bomb}})$$

$$q_{\text{water}} = ms\Delta t$$

$$q_{\text{bomb}} = C_{\text{bomb}}\Delta t$$

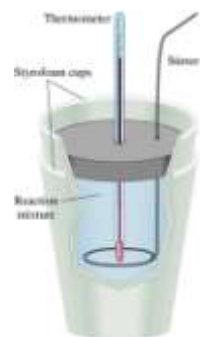
Reaction at Constant V

$$\Delta H \neq q_{\text{rxn}}$$

$$\Delta H - q_{\text{rxn}}$$

No heat enters or leaves!

Constant-Pressure Calorimetry



$$q_{\text{sys}} = q_{\text{water}} + q_{\text{cal}} + q_{\text{rxn}}$$

$$q_{\text{sys}} = 0$$

$$q_{\text{rxn}} = -(q_{\text{water}} + q_{\text{cal}})$$

$$q_{\text{water}} = ms\Delta t$$

$$q_{\text{cal}} = C_{\text{cal}}\Delta t$$

Reaction at Constant P

$$\Delta H = q_{\text{rxn}}$$

No heat enters or leaves!