Enthalpy

Section 5.2

Enthalpy (H) is a measure of the total energy in a system.

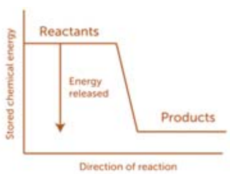
Includes:

- kinetic energy of the particles
- potential energy of the nucleus
- potential energy of the chemical bonds

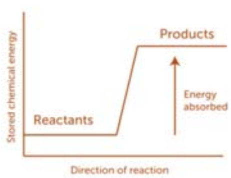
All physical/chemical changes result in changes in energy, therefore producing **changes in enthalpy, ΔH**.

$$\Delta H_{system} = H_{products} - H_{reactants}$$

$\Delta H_{system} < 0$, exothermic reaction



$\Delta H_{system} > 0$, endothermic reaction



Every ΔH value has THREE parts:

1. unit – J or kJ
2. number – the magnitude
3. sign (+/-) - to show the direction
   + value, energy is ABSORBED
   - value, energy is RELEASED

It is IMPOSSIBLE to accurately measure ΔH

- BUT…heat transfer in/out of a system can be used to infer ΔH
- make the assumption…

$$\Delta H_{system} = |q_{system}|$$

Types of Enthalpy Changes

MAGNITUDE	TYPE	DESCRIPTION
↓	Physical	• Energy is used to overcome, or allow, IMF • Particles remain unchanged
	Chemical	• Energy overcomes the chemical bonds within the particles • New substances & chemical bonds
	Nuclear	• Energy changes overcome the forces between protons and neutrons in nuclei

Molar Enthalpies

Molar Enthalpy, ΔH_r – The enthalpy change associated with a physical, chemical, or nuclear change involving ONE MOLE of a substance

Example:
When 1 mol of H_2 is combusted, 241.8 kJ is released
∴ for H_2, ΔH_{comb} = -241.8 kJ/mol

Type of molar enthalpy change (ΔH_r)	Example of change (relevant substance shown in red)
solution (ΔH_{sol})	$NaBr(s) \rightarrow Na^+(aq) + Br^-(aq)$
combustion (ΔH_c)	$CH_4(g) + 2\,O_2(g) \rightarrow CO_2(g) + H_2O(l)$
vaporization (ΔH_{vap})	$CH_3OH(l) \rightarrow CH_3OH(g)$
formation (ΔH_f)	$C(s) + 2\,H_2(g) + \frac{1}{2}\,O_2(g) \rightarrow CH_3OH(l)$
neutralization (ΔH_{neut})*	$2\,NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2\,H_2O(l)$
neutralization (ΔH_{neut})*	$NaOH(aq) + \frac{1}{2}\,H_2SO_4(aq) \rightarrow \frac{1}{2}\,Na_2SO_4(aq) + H_2O(l)$

*Enthalpy of neutralization can be written per mole of base or acid.

The total enthalpy change for a reaction will depend on the amount of substance that is reacting.

Example: combustion, $Mg\,(s) + ½\,O_2\,(g) \rightarrow MgO\,(s) + 607.10\text{ kJ}$

Combusting 2 mol of Mg will release TWICE as much energy

$$\Delta H = n \cdot \Delta H_r$$

ΔH	n	ΔH_r
total enthalpy change (kJ)	moles of substance (mol)	molar enthalpy (kJ/mol)

Example 4.

The molar enthalpy of vaporization of Freon-12 (M=120.91 g/mol) is 34.99 kJ/mol. If 500.0 g of refrigerant is vaporized, **what is the expected enthalpy change, ΔH?**

Method 1
Thermochemical equation – Include the energy term in the chemical equation:

$$CH_3OH + 3/2\,O_2 \rightarrow CO_2 + 2\,H_2O + 726\text{ kJ}$$

Method 2
Write a chemical equation, then state the energy change

$$CH_3OH + 3/2\,O_2 \rightarrow CO_2 + 2\,H_2O \qquad \Delta H = -726\text{ kJ}$$

Representing Enthalpy Changes

Method 1

Thermochemical equation – Include the energy term in the chemical equation:

$$CH_3OH + 3/2\,O_2 \rightarrow CO_2 + 2\,H_2O + 726\text{ kJ}$$

Method 2

Write a chemical equation, then **state the energy change**

$$CH_3OH + 3/2\,O_2 \rightarrow CO_2 + 2\,H_2O \qquad \Delta H = -726\text{ kJ}$$

Method 3

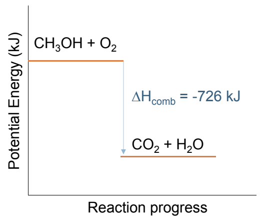
State the molar enthalpy of a specific reaction

*You MUST show the equation for only 1 mol of the substance!

$$\Delta H_{comb} = 726\text{ kJ/mol}$$

Method 4

Draw a **potential energy diagram**



Summary

- Under constant pressure, the enthalpy change of a reaction ΔH, equals the thermal energy absorbed or released by the system:

$$\Delta H = q_{system}$$

- Theoretical values for ΔH can be obtained by using molar enthalpy values, ΔH_r :

$$H = n\ \Delta H_r$$

Homework

- Pg. 301 Practice #1-4
- Pg. 304 Practice #1-4
- Pg. 306 #3-7