Chemistry 2.4
Structure, bonding and Thermodynamics

Introduction to thermodynamics

Introduction to Thermodynamics

Thermodynamics is the study of the movement of chemical potential energy (also known as heat or enthalpy)

Thermo- *heat*

-dynamic *movement*

There are two possibilities

1) **Exothermic reactions**

Reactions that give off energy are **exothermic**

Exo- exit

2) **Endothermic reactions**

Reactions that take in (absorb) energy are **endothermic**

Endo- enter

1st Law of Thermodynamic

- **Energy cannot** be **created** or **destroyed**
- **Energy transforms** from one form to another
- Each substance at a particular state has a chemical potential energy also known as heat, or **enthalpy (H)**.
- The **change** in chemical potential energy (or enthalpy change) is represented by ΔH

$$H_{product} - H_{reactant} = \Delta H$$

Exothermic

- **Exothermic** reactions
  - The **reactants** have a **higher** chemical potential energy (**enthalpy**) (H) **than** the **products**.
  - Therefore the **energy** is **escaping** from the chemical system to some other form (such as **heat** or light).
  - The change in chemical potential energy **(ΔH) is negative**
    - Example: any reaction that **gives off heat**

Endothermic

- **Endothermic** reactions
  - The **reactants** have a **lower** chemical potential energy (enthalpy) (H) **than** the **products**.
  - Therefore **energy** is **entering** the chemical system from some other form (such as heat or light).
  - The change in chemical potential energy **(ΔH) is positive**
    - Example: any reactions that **absorb heat**

Energy diagram

- An energy diagram is a visual expression of the energy movement within the chemical system
- y-axis = Chemical potential energy

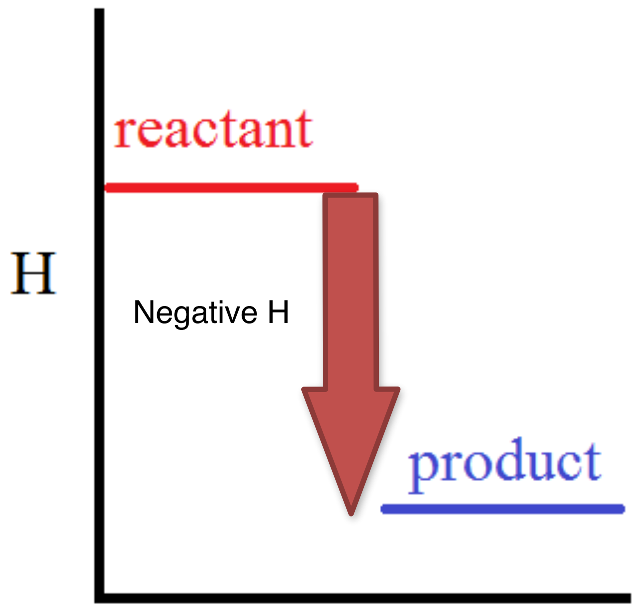
  or enthalpy

  H in $kJmol^{-1}$
- x-axis = Time

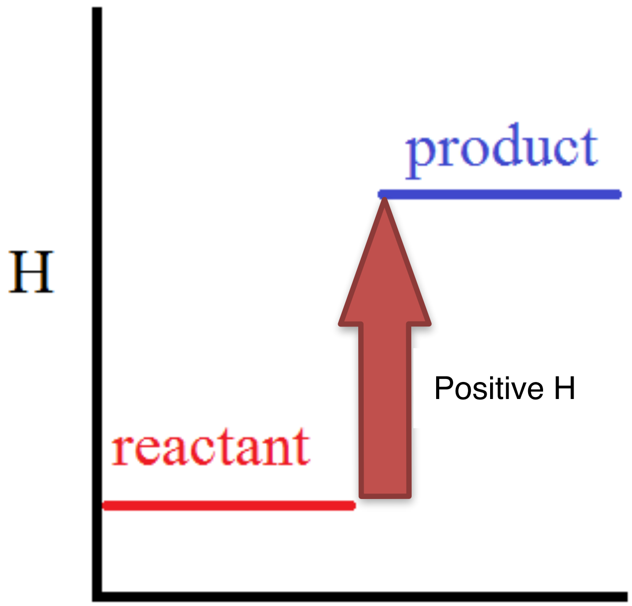
  The progress of reaction

Energy diagram (cont.)

- Exothermic



- Endothermic



Example #1- Physical change

- Particles have different amounts of potential energy when they are in different states
- As particles change from solid -> liquid -> gas, the particles increase in chemical potential energy (H)
- Freezing and condensation are
  - exo- or endo? processes **(ΔH) is ?**
- Melting and evaporation are
  - exo- or endo? processes **(ΔH) is ?**

Example #2- Chemical change

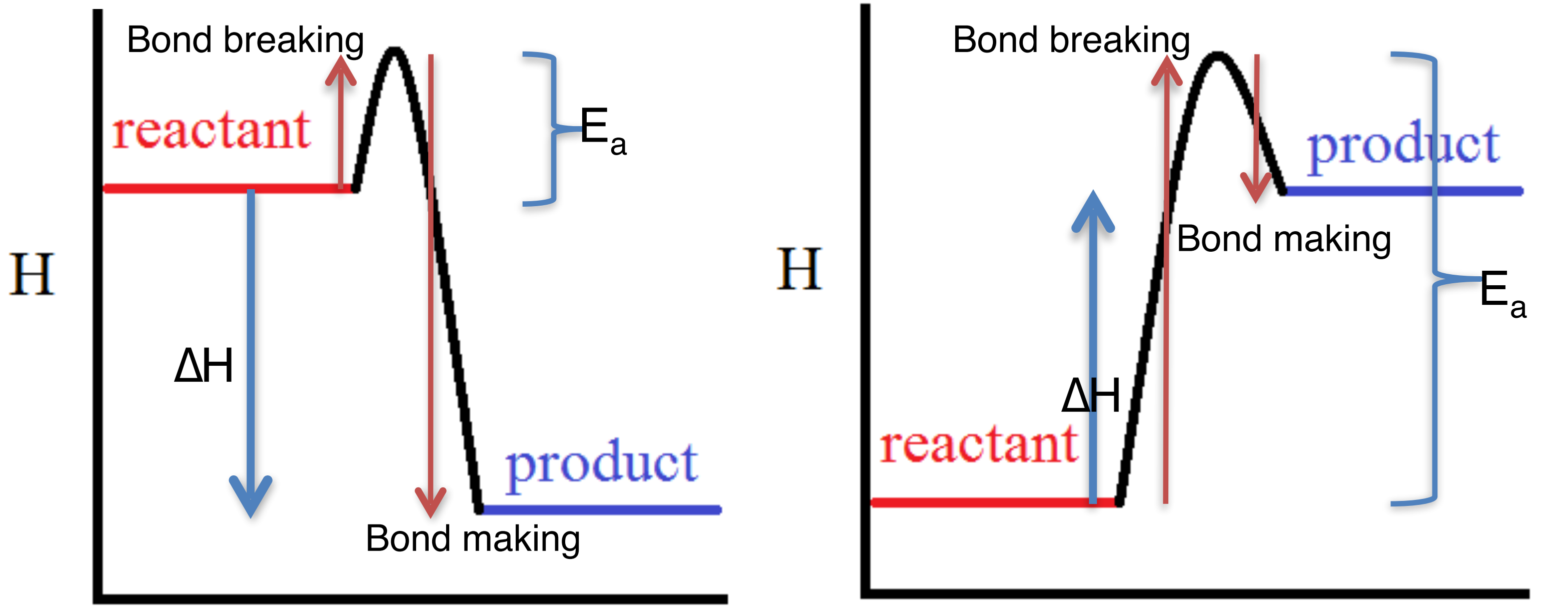
- Photosynthesis and respiration
- Sugar and oxygen have a higher chemical potential energy than carbon dioxide and water
- In photosynthesis, carbon dioxide and water are the reactants while sugar and oxygen are the products. **(ΔH) is ?**
  - **(exo- or endo-)**
- In respiration, sugar and oxygen are the reactants while carbon dioxide and water are the products. **(ΔH) is ?**
  - **(exo- or endo-)**

Activation Energy

- **Activation energy (E_a)** is the energy required to start the reaction.
- There are two processes in a chemical reaction.
  - Bond breaking which absorbs energy (endothermic)
  - Bond making which releases energy (exothermic)
- Activation energy is the energy required to break the chemical bonds for the reaction to start.

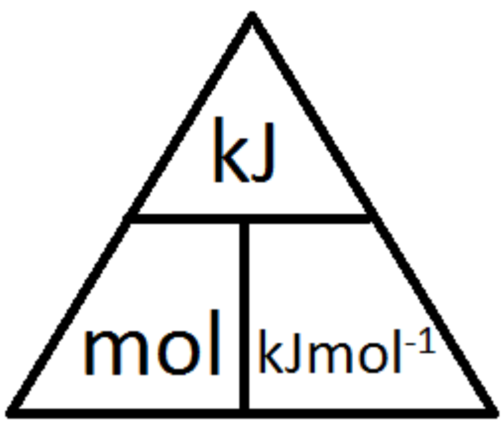
E_a in energy diagram

- exothermic
- endothermic



Calculations

- The unit for Enthalpy is $kJmol^{-1}$
- This means one can calculate the amount of energy absorb or release in a chemical reaction



Example #1

$2Mg_{(s)} + O_{2(g)} \rightarrow 2MgO_{(s)}$ $\Delta_r H = -1200 kJmol^{-1}$

Calculate how much energy is released when 15.4 g of oxygen gas reacts

1) Convert the g to mol (g / $gmol^{-1}$ = mol)
2) Identify the amount of oxygen gas in the equation
3) Multiply the mol with $kJmol^{-1}$ to get kJ

Example #2

$2Mg_{(s)} + O_{2(g)} \rightarrow 2MgO_{(s)}$ $\Delta_r H = -1200\ kJmol^{-1}$

Calculate the mass of magnesium that must react to release 98.2kJ of energy

- Identify how many mole of magnesium is needed
- $kJ / kJmol^{-1} = mol$
- X 2 since there are two magnesium in the equ
- Determine the mass ($g = mol \times gmol^{-1}$)