Thermodynamics Introduction

Created/Edited by
Schweitzer

3-7-05

Objectives:

- What is energy?
- Why do reactions gain or lose energy?
- How much is entering/leaving a reaction
  - How would I calculate this?
  - How would I measure this in a lab!

What is energy?

- Energy has the ability to do work or transfer heat.
- Work is a scientific term defined later in this PowerPoint.

Energy starts with: Force

How is Force calcualted?

- Newton's second law of motion
  - Force
    - F = ma   (kg*m/s^2 = 1 Newton)
    - Newton is a unit of force. Much like your weight. The larger your mass the larger the force of gravity and the larger the weight.
    - The Zulke building is the tallest building in Appleton. At the top of that building you lose 2 pounds. Why?
  -

Work

- Work = Force over a distance
- 1 Newton*m = 1 Joule
  - If one applies a force of 1 Newton over the distance of 1 meter then one Joule of energy was consumed.
- Joule is the standard unit of energy

Power

- Work over a period of time.
  - Newton*meter/time
  - 1 Joules/second = 1 watt
  - Horse power
    - 1 hp = 745.6 W

Forms of Energy

- Kinetic energy: Energy of movement
  - K.E. = $1/2mv^2$ where m = mass (kg) v = velocity (m/s)
  - The energy of a loaded semi traveling at 55mph has the same as a family car traveling at Mach 4
- Potential energy: Energy relative to position. Ball at the top of a hill.
  - P.E = mgh where m= mass g = acceleration of gravity and h = height(m)

Forms of Energy— cont .

- Electrical: energy in the form of electrons trapped over a voltage.
  - Deference of charge
- Radiant: Electromagnetic spectrum
  - X-rays – visible – radio waves
  - E = hv where h = Planks constant and v = frequency of light.

Forms of Energy cont.

- Chemical Energy: Energy involved in bonds
- Heat energy
  - $q = c*m*\Delta T$ where q = energy m = mass

    c = specific heat

Specific heat: amount of energy needed to raise 1 gram of a substance 1 degree Celsius.

Conservation of Energy

- We just classified energy in many different ways.
- Conservation of energy: Energy can not be created nor destroyed just transformed from one form to another.

What is energy?
1st law of thermodynamics

- The combined amount of energy and matter in the universe is constant.
- Energy can not be created nor destroyed just transferred from one form to another.

Energy—Units (calorie)

- calorie: Amount of energy needed to raise 1g of water 1degree Celsius.

- Commercial calorie or kcal
  - 1000 cal = 1 kcal or Calorie (capital C)
  - Used for marketing reasons.
  - For example: a “Tic-Tac” has 1.5 Calories.

  Or 1500 calories. Not as pleasing.
  - Loaded Whopper, 1,000,000 calories

Energy Units
BTU – British thermal unit

- Amount of energy required to raise 1 pound of water 1 degree F.

Energy—Units (joule)

- Joule -- most common unit of energy.
  - 4.18 J = 1 calorie.

Why do reactions lose/gain energy?

- Although it may not seem like it any reaction that is running spontaneously is losing energy
- Lower energy = more stable.
- Nothing in nature will gain energy spontaneously.

Endothermic reactions

- $\Delta H = +$
  - Overall positive gain of heat energy from surroundings.
- The reaction is consuming heat as it proceeds.
- In other words, one will need to feed the reaction energy to keep it going.

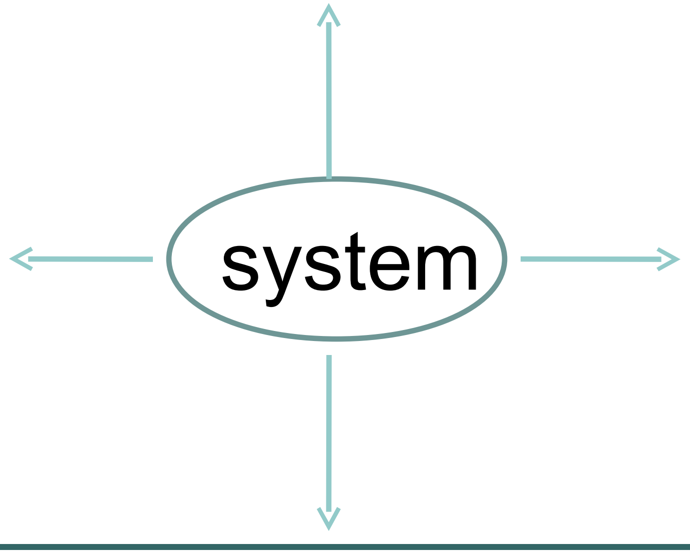
Exothermic reactions

- Reactants have high energy and simply need to release energy.
- $-\Delta H$ = exothermic
  - Overall loss of heat energy to surroundings

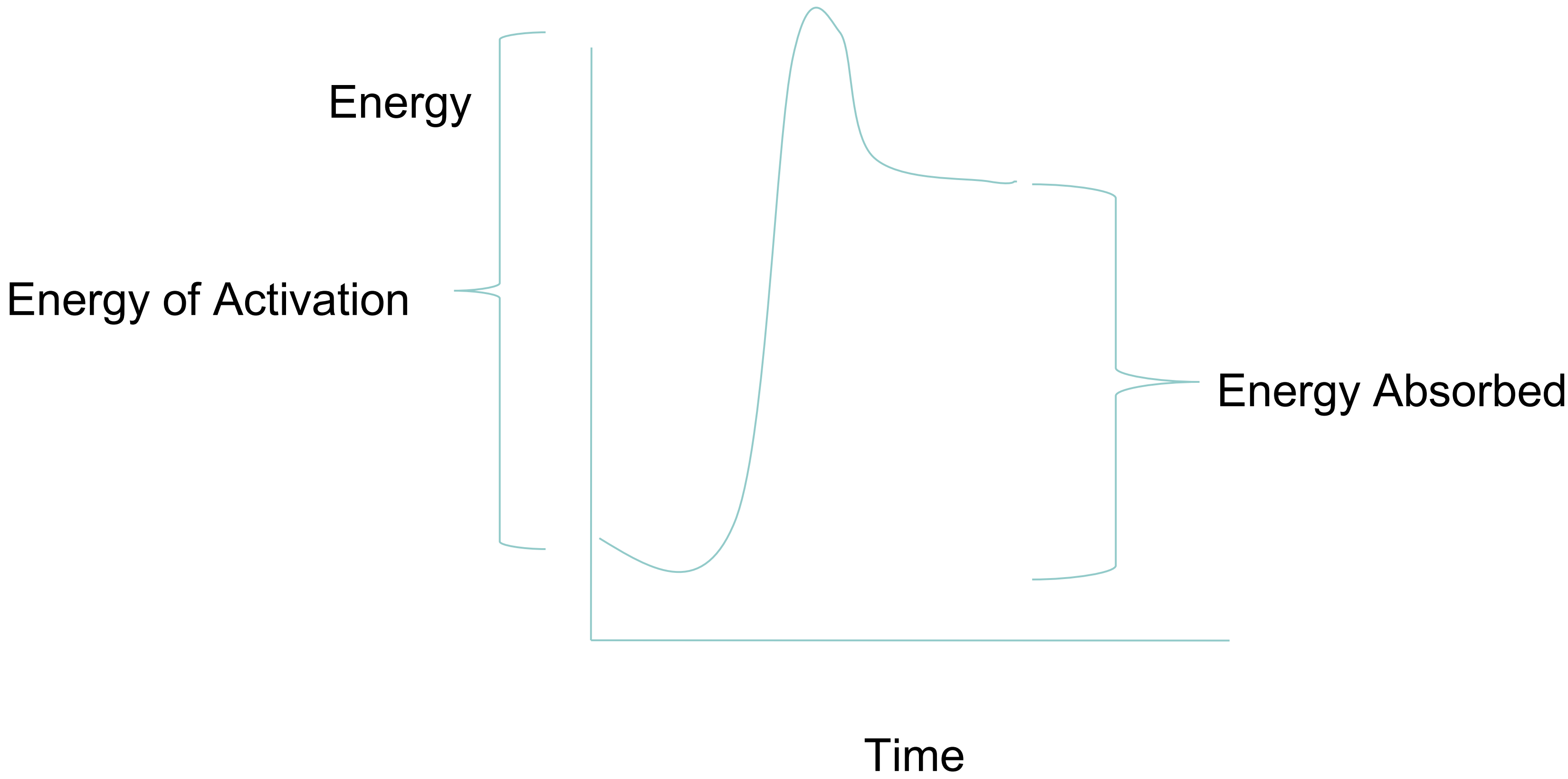
Enthalpy

- Enthalpy = ΔH or change in heat
- $-\Delta H$ = Exothermic

Surroundings

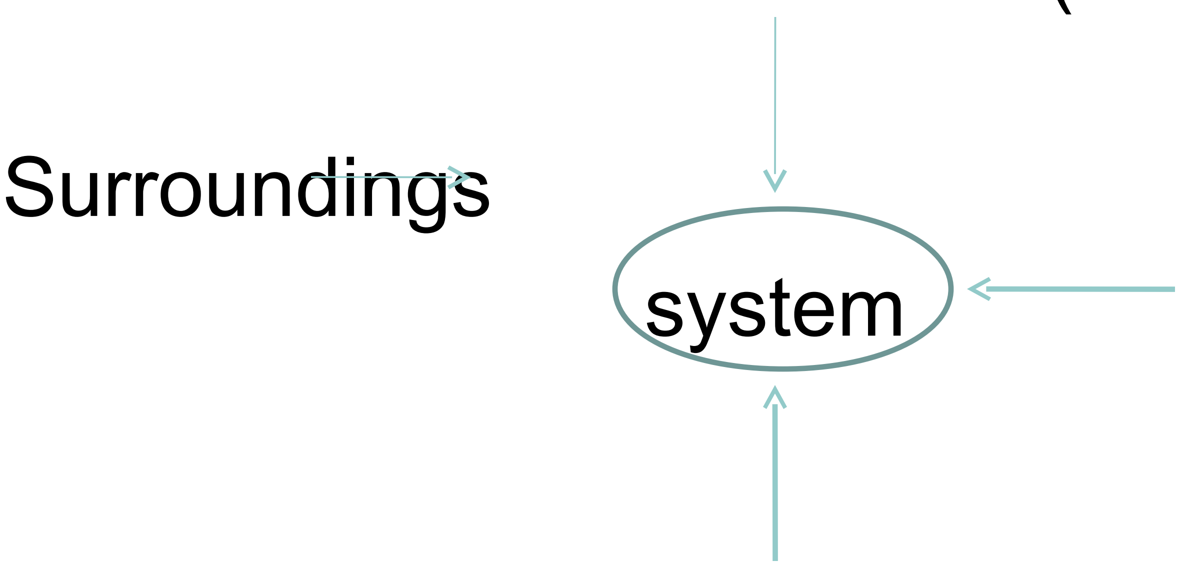


Endothermic reaction

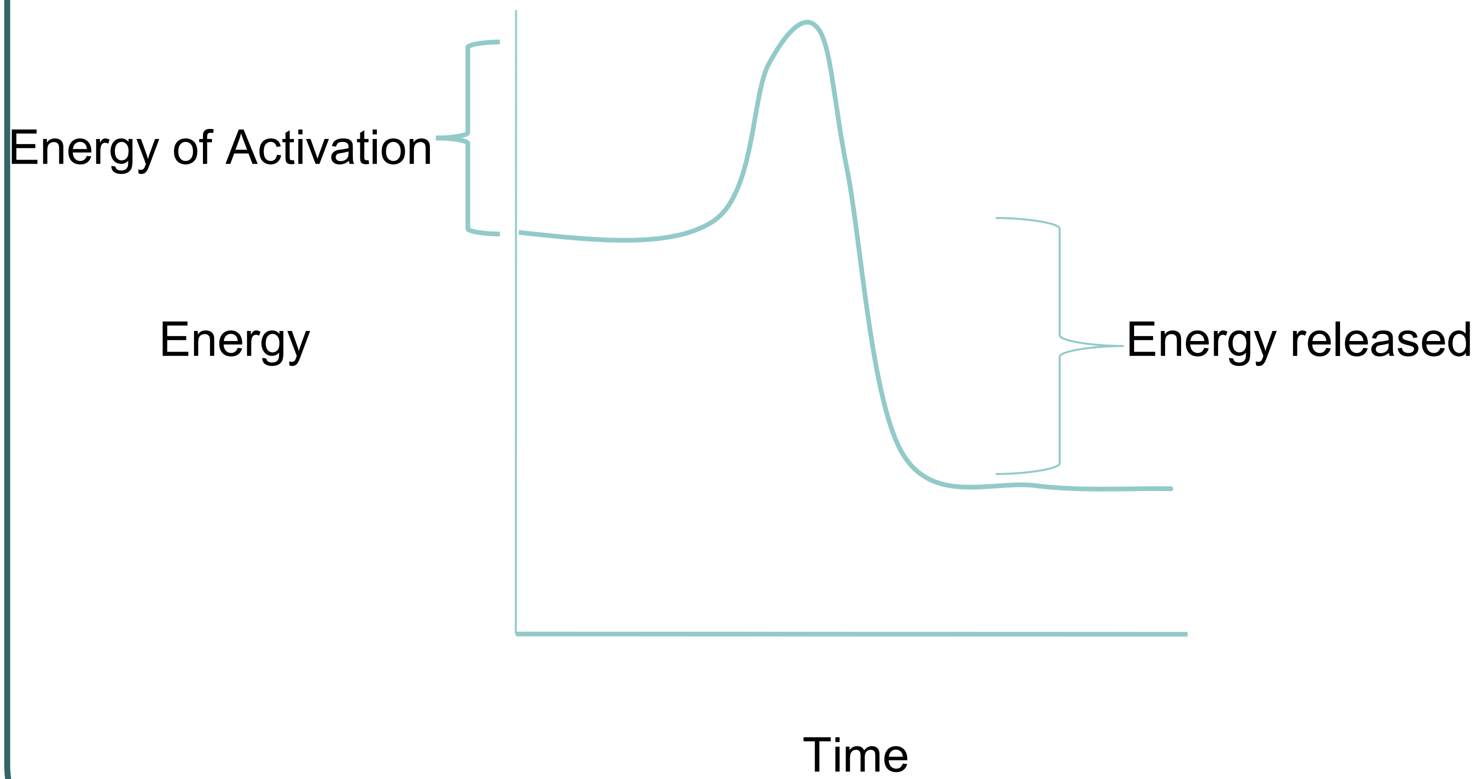


Enthalpy

- Enthalpy = ΔH or change in heat
- $+\Delta H$ = Endothermic
- You will feel the loss of heat (cold)

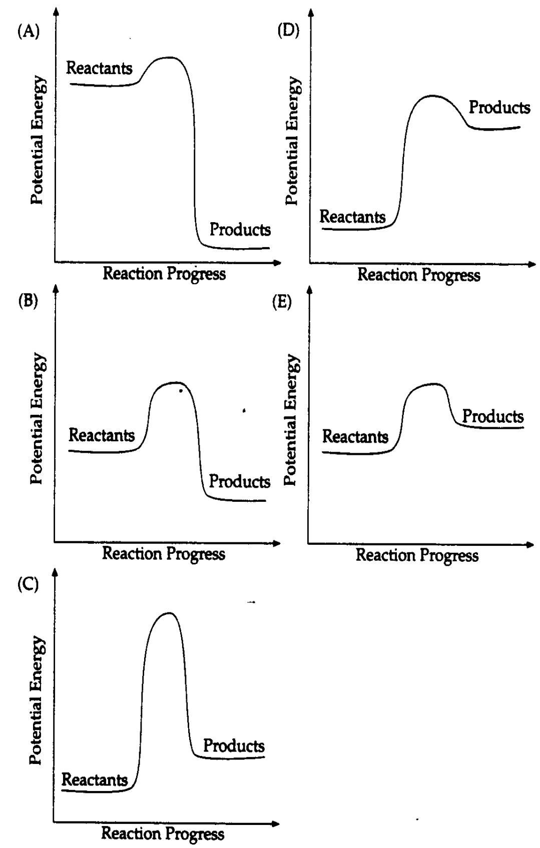


Exothermic reaction



AP Questions

- This reaction has the largest activation energy?
- This is the most exothermic reaction?
- This reaction has the largest positive ΔH



Thermodynamic equations

- Stoichiometric relationship of Heat energy lost or gained.
- $H_2S(g) + 3/2\ O_2(g) \rightarrow H_2O(l) + SO_2(g)$ $\Delta H = -562.6$ kJ/mol
- How much energy would be released or absorbed:
  - 1 mole H_2S:
  - 1 mole O_2:
  - 50 g H_2O:

Thermodynamic equations answers

- Stoichiometric relationship of Heat energy lost or gained.
- $H_2S(g)$ + 3/2 $O_2(g) \rightarrow$ 1$H_2O(l)$ + $SO_2(g)$ ΔH = -562.6 kJ/mol

- How much energy would be released or absorbed:
  - 1 mole H_2S: 562.6 kJ released
  - 1 mole O_2: 1 mol O_2 * (562kj/1.5 molO_2) = 374.6 kJ released
  - 50 g H_2O: 50g * (1mol/18g) * 562kJ/1 mol = 1561 kJ released

Manipulation of Thermodynamic Equations

- $H_2S(g) + 3/2\ O_2(g) \rightarrow 1H_2O(l) + SO_2(g)$ $\Delta H = -562.6$ kJ/mol
- Multiplying Coefficients by 2 increases the ΔH by 2
  - $2H_2S(g) + 3\ O_2(g) \rightarrow 2H_2O(l) + 2SO_2(g)$ $\Delta H = -1125$kj kJ/mol
- Reversing the equation
  - Energy in equals energy out. Simply change the sign
  - $2H_2O(l) + 2SO_2(g) \rightarrow 2H_2S(g) + 3\ O_2(g)$ $\Delta H = +1125$kj kJ/mol

Manipulation of Equilibrium Constants

- 2 NH_3(g) = N_2(g) + 3H_2(g) Kp = 6.8E 10^4
- Multiplying coefficients by 2 raises Kp^2
  - 4NH_3(g) = 2N_2(g) + 6H_2(g) Kp = $(6.8E\ 10^4)^2$ = 4.6 E9
- Inverting Reaction inverts the K value (1/K)
  - N_2(g) + 3H_2(g) = 2NH_3(g) Kp = 1/6.8E 10^4 = 1.47E-5