Answer Key
10/06/25

Thermochemistry

A chemical reaction requires energy

What is the first law of thermodynamics?

Energy can be converted from one form to another, but it is neither created nor destroyed

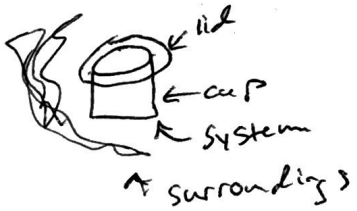
What is an open system, and what is a closed system?

Ex: cup w/ no lid — open system: Exchanges heat & mass w/ surroundings

Ex: cup w/ lid — closed system: only exchange heat w/ surroundings; not mass

System = part being studied

Surroundings = Everything else



What is the SI unit for energy?

$$1\,J = 1\,\frac{kg \cdot m^2}{s^2}$$

What are the three parts of thermodynamic quantities?

1) Number

2) Unit

3) Sign (+ or −) + = absorbed E − = E released

What is the equation for change in internal energy in reference to the system and surroundings?

$$\Delta E = q + w$$

ΔE = change in energy

q = heat

w = work

* Memorize *

Table 5.1 Sign Conventions for q, w, and ΔE

For q	+ means system *gains* heat	− means system *loses* heat
For w	+ means work done *on* system	− means work done *by* system
For ΔE	+ means *net gain* of energy by system	− means *net loss* of energy by system

The system loses 1150J of heat, and the surroundings do 480J of work on the system. What is the change in internal energy of the system?

$\Delta E = q + w$ $\quad \Delta E = ?$

$q = -1150\,J$

$w = +480\,J$

$\Delta E = (-1150\,J) + (480\,J)$

$\boxed{-670\,J}$

What is the change in internal energy if the system absorbs 140J of heat from the surroundings and does 85J of work on the surroundings?

$\Delta E = q + w$ $\quad \Delta E = ?$

$q = +140\,J$

$w = -85\,J$

$\Delta E = (+140\,J) + (-85\,J)$

$= \boxed{55\,J}$

Internal energy is a state function

State function = depends on the state of matter

Heat and work are not state functions

What is enthalpy?

Heat change of a rxn @ constant pressure

What is heat of reaction or enthalpy change? ΔH

Measure of the amount of heat that flows into (absorbed) or out of (gain of) a system as a rxn takes place

$+\Delta H$

$\Delta H > 0$

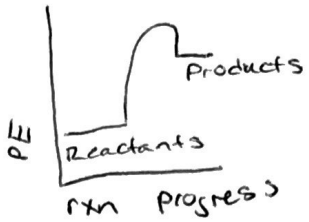
What does endothermic mean?

Absorbs heat

- system gets warmer +

Surroundings get cooler

- Bonds breaking



Products are less stable than reactants

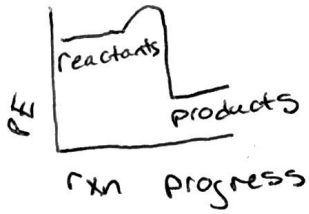
What does exothermic mean? $\Delta H < 0$

Release heat $-\Delta H$

- system gets cooler

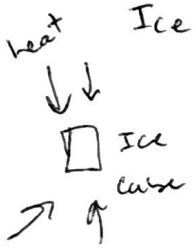
+ surroundings get warmer

- Bond forming



products are more stable than reactants

Is it endothermic or exothermic? Ice cube melts and butane is combusted to give complete combustion.



Ice cube melts = endothermic

system = ice cube

surroundings = heat

$+\Delta H$

melt = solid → liquid

- has to get warmer

Butane combusted = exothermic

system = butane

combusted = release energy

What are all the ways to calculate enthalpy?

1) Stoichiometry
2) Calorimetry
3) Hess' Law
4) Heats of formation
5) Bond enthalpy

What is the equation for enthalpy of reaction?

H = enthalpy

rxn = reaction

$$\Delta H_{rxn} = H \text{ products} - H \text{ reactants}$$

When to use stoichiometry
- BCE + ΔH
- given grams, mole, or particle amount

Stoichiometry

Calculate the quantity of heat released when 5.00g of H_2O_2(l) decomposes at constant pressure.

$2H_2O_2(l) \longrightarrow 2H_2O(l) + O_2(g)$ $\Delta H = -196kJ$

$$\frac{5.00\text{g } H_2O_2}{1} \left| \frac{1 \text{ mol } H_2O_2}{34.014\text{g } H_2O_2} \right| \frac{-196 \text{ kJ}}{2 \text{ mol } H_2O_2} = \boxed{-14.4 \text{ kJ}}$$

Stoichiometry

Determine what mass of NO can be made if 558 kJ of energy are supplied given the following chemical equation:

$N_2(g) + O_2(g) \longrightarrow 2NO(g)$ $\Delta H = 180.6$ kJ

$$\frac{558 \text{ kJ}}{1} \left| \frac{2 \text{ mol NO}}{180.6 \text{ kJ}} \right| \frac{30.006\text{g NO}}{1 \text{ mol NO}} = \boxed{185\text{g NO}}$$

What is calorimetry?

The measurement of heat flow

What is the equation for specific heat capacity?

$q = m \times c \times \Delta T$ or $q = mc\Delta T$

q = heat (J)

m = mass (g)

c = specific heat for that substance J/g°C or J/g K

ΔT = temp final − temp initial

Calorimetry

How much heat is needed to warm 250g of water from 22°C to 98°C? Specific heat for water is 4.184J/g °C. What is the molar heat capacity of water?

$q = ?$

$m = 250\text{g}$

$\Delta T = 98°C - 22°C = 76°C$

$c = 4.184 \text{ J/g°C}$

$q = mc\Delta T$

$q = (250\text{g})(4.184 \text{ J/g°C})(76°C)$

$= 79496$

$\boxed{7.9 \times 10^4 \text{ J}}$

molar heat capacity for H_2O

$$\frac{4.184 \text{ J}}{1 °C} \left| \frac{18.015\text{g } H_2O}{1 \text{ mol } H_2O} \right.$$

$= 75.37 \text{ J/mol°C}$

↑ amount of heat to raise 1 mole of a substance