Thermochemistry Notes

Heat changes that occur during a chemical reaction

What is Thermochemistry?

- The study of heat changes in chemical reactions and physical states.
  - Law of Conservation of Energy
  - Calorimetry
  - Temperature
  - Heat
  - Heat Capacity
  - Specific Heat

Energy

- The capacity for doing work or supplying heat

- Energy is weightless, colorless, and odorless

- Energy that is stored in the bonds of chemical substances is called **chemical potential energy**. (Example: gasoline)

Forms of Energy

- Potential
  - stored energy
- Kinetic
  - Energy of motion
- Work
  - energy used in a process
- **Enthalpy**
  - Heat energy lost or gained in a process

What is work and heat?

- **Work** = when a force is used to move an object

- **Heat** = energy that is transferred from one object to another, because of a temperature difference. *(q)*

  - Heat flows from warm to cold until equilibrium is reached

When describing the flow of heat:

- Heat flow into a system is an endothermic process (+q)
- Heat flow out of a system is an exothermic process (-q)

(Calorimeter—an instrument that measures heat changes in a closed system)

What is a calorie?

The quantity of heat required to raise 1 gram of water 1 °C.

The SI unit of measurement for heat is the joule.

1 joule = 0.2390 calories
1 Calorie = 4.184 joules
1 Calorie = 1000 calories

- The amount of heat needed to raise 1 g of a substance 1 °C.
- Table 1 pg 533
- Heat capacity depends upon the mass and the composition of the object.

Specific Heat Capacity (Specific Heat)

Examples

Water has the highest specific heat capacity. It absorbs a lot of heat before finally increasing temperature.

Metals have the lowest specific heat capacity. A small amount of absorbed energy immediately changes temperature

There is a calculation that can be performed to determine the specific heat of an object.

$$q = C \times m \times \Delta T$$

C = Specific Heat (J/g°C or cal/g°C)

q = heat (J or cal)

m = mass (g)

ΔT = T final – T initial (°C)

Sample Problems

Reminder:

For a phase change use → $Q = m\Delta H$

Non-phase change use → $q = C \times m \times \Delta T$

When 435 J of heat is added to 3.4 grams of olive oil at 21°C, the temperature increases to 85°C. What is the specific heat of olive oil?

C = ?

q = 435 J

m = 3.4 g

ΔT = Tfinal – Tinitial = 85°C – 21°C = 64 °C

$$q = C \times m \times \Delta T$$

$C = ?$

$q = 435\ J$

$m = 3.4\ g$

$\Delta T = T_{final} – T_{initial} = 85°C – 21°C = 64\ °C$

$q = C \times m \times \Delta T$

Solve for C

$C = q / (m \times \Delta T)$

$C = 435\ J / (3.4\ g \times 64\ °C) =$ <u>2.0 J/g°C</u>

Remember…

- Heat flow out of a system is an <u>exothermic process</u> (-q)
- Heat flow into a system is an <u>endothermic process</u> (+q)

q = (0.14 J/g°C)(250.0 g)(52 °C) = <u>1800 J</u>

Positive = Endothermic

Enthalpy

- H=Heat of substance at a constant pressure

$$q = \Delta H = C \times m \times \Delta T$$

ΔH = enthalpy

C = Specific Heat (J/g°C or cal/g°C)

q = heat (J or cal)

m = mass (g)

ΔT = T final – T initial (°C)

Enthalpy

+ ΔH = endothermic rxn

- ΔH = exothermic rxn

Enthalpy of Reaction

- The quantity of energy transferred as heat during a chemical reaction.
  - $\Delta H = H_{products} - H_{reactants}$

Thermochemical Reactions

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

- Heat of Reaction – the heat required or released in a reaction (coefficients are mole quantities)

Exothermic Reaction

$CaO\ (s) + H_2O\ (l) \rightarrow Ca(OH)_2\ (aq) + \mathbf{65.2\ kJ}$

$\Delta H = -65.2$ kJ (heat is released)

See graph page 536

Endothermic Reaction

$NaHCO_3(s) + \mathbf{129\ kJ} \rightarrow Na_2CO_3\ (s) + H_2O\ (g) + CO_2(g)$

$\Delta H = +129$ kJ (heat absorbed)

Practice

$2NaHCO_3$ (s) + **129 kJ** → Na_2CO_3(s) + H_2O(g) + CO_2(g)

1) Calculate the Δ H of the reaction.

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

$\Delta H = 129\ kJ - 0\ kJ = +129\ kJ$

2) Calculate the kJ of heat required to decompose 2.24 mol $NaHCO_3$(s).

$$2.24\ mol\ NaHCO_3 \times \frac{(+129\ kJ)}{2\ mol\ NaHCO_3} = 144\ kJ$$

More Practice

$2NaHCO_3(s) + 129\text{ kJ} \rightarrow Na_2CO_3(s) + H_2O(g) + CO_2(g)$

3) How much energy is absorbed when 25g of $NaHCO_3$ decomposes?

$$25\text{g } NaHCO_3 \times \frac{1 \text{ mol } NaHCO_3}{84\text{g } NaHCO_3} \times \frac{129 \text{ kJ}}{2 \text{ mol } NaHCO_3} = 19.2 \text{ kJ}$$