Thermodynamics 8.3

Calorimetry

Calorimetry

- Calorimetry
  - The measurement of heat flow
- Calorimeter
  - The device used to measure heat flow

But, we cannot measure heat flow directly…

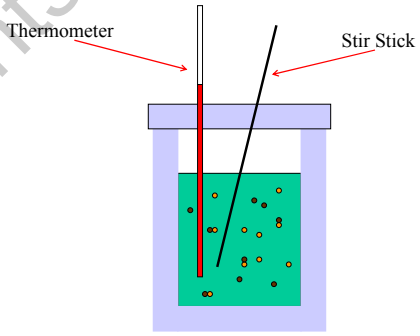
Coffee Cup Calorimetry

- Specific Heat Capacity
  - The amount of heat required to raise the temperature of 1 g of a substance by 1 K.
  - A large value for water (4.184 J/g•K)
    - It takes a lot of heat to increase the temperature of water.
  - A small value for iron (0.84 J/g•K)
    - It takes much less heat to raise the temperature of iron.

$$\Delta q = m\, c\, \Delta T$$

- Δq: Heat lost or gained by water
- m: Mass of water
- c: Specific heat capacity of water
- ΔT: Temperature change of water. $\Delta T = T_f - T_i$

Coffee Cup Calorimeter



Coffee Cup Calorimetry

When measuring the heat lost or gained in a reaction that takes place in a coffee cup calorimeter, we use the water as the basis for our calculations.

$$\Delta q = m\, c\, \Delta T$$

- Δq: Heat lost or gained by the water in the reaction
- m: Mass of the water
- c: Specific heat of the water
- ΔT: Temperature change of the water. $\Delta T = T_f - T_i$

Coffee Cup Calorimetry

- The heat lost or gained by the water is equal, but opposite in sign to, the heat lost or gained in the reaction.

e.g.) If you calculated Δq_w (water) to be +568 J, the water gained heat. This means that the reaction was exothermic, as the heat gained by the water is equal to the heat lost in the reaction (Δq_{rxn} = -568 J).

Ex) Coffee Cup Calorimetry Problem

Ex) **0.075 mol HCl** and **0.075 mol NaOH** are added to **150.0 mL of water** in a coffee cup calorimeter. The temperature of the solution increases from **23.0°C to 29.9°C**. Calculate the enthalpy change for the formation of **1.0 mol H_2O** in this reaction. Assume that no heat is lost to the surroundings.

$$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$$

Step 1. Find Δq_w

Ex) Coffee Cup Calorimetry Problem

Step 2. Find Δq_{rxn}

- The water absorbed heat.
- The heat gained by the water is equal to the heat lost in the reaction.

The reaction is **exothermic** as heat is releases to the water.

Ex) Coffee Cup Calorimetry Problem

Step 3. Find ΔH_{rxn}

$$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$$

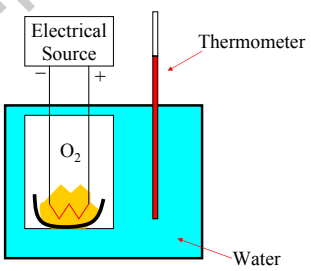
Δq_{rxn} vs. ΔH_{rxn}

Δq_{rxn} = the heat lost or gained in the experiment that took place in the calorimeter.

ΔH_{rxn} = the heat lost or gained in the balanced chemical equation.

Bomb Calorimeter

- Measures the heat released in combustion reactions.



Bomb Calorimeter

- Measures the heat released in combustion reactions.
- To determine the heat lost, we must know the heat capacity of the calorimeter itself.
  - The heat capacity of a calorimeter is the amount of heat required to raise the temperature of the calorimeter by 1 K.

$$\Delta q = C \cdot \Delta T$$

Heat lost or gained by the calorimeter in the reaction

Heat capacity of the calorimeter

Temperature change of the water.

$\Delta T = T_f - T_i$

Ex) Bomb Calorimetry

Ex) A medium size flour tortilla is burned in a bomb calorimeter with a specific heat of 12.151 kJ/K. The temperature of the calorimeter increases from 21.0°C to 55.5°C. Determine the number of Calories in this tortilla shell. (1 Cal = 4.184 kJ)

Step 1. Find Δq_w

Ex) Calorimetry Problem (cont.)

Step 2. Find Δq_{rxn}

- The calorimeter absorbed heat.
- The heat gained by the calorimeter is equal to the heat lost in the reaction.

The reaction is **exothermic** as heat is releases to the calorimeter.

Ex) Calorimetry Problem (cont.)

Step 3. Convert to Calories