Calorimetry

Calorimetry- The process of measuringenergy changes using a calorimeter which is a closed system.

We assume
Heat Lost=Heat Gained

So

water

$q_{system} = -q_{surroundings}$

Heat absorbed or released is called the change in enthalpy.

In our calorimeters, the water is the surroundings and the substance reacting or dissolving is the system.

$\Delta H = -q$

Calculating the change in temperature of the water caused by the reaction we can calculate the change in energy of the system.

water

$\Delta H = -mc\Delta t$ or $-vc\Delta t$

ΔH is negative for exothermic reactions and positive for endothermic ones.

3 assumptions of calorimetry:

1. No heat is transferred between the calorimeter and the outside environment.

2. Any heat transferred between the container and the system is negligible.

3. A dilute solution is assumed to have the same density and specific heat capacity as water.

What is the molar enthalpy of solution for 2.0g $CaCl_2$?

H

mass of $CaCl_2$ - 2.0g
volume of water- 25.0mL $\Delta H = nH^{-?}$
initial temp- 20.0°C
final temp- 27.0°C

a) is the reaction endo or exo thermic?

exothermic as temp. increases

b) using the equation $\Delta H = -mc\Delta t$ or $-vc\Delta t$ calculate the ΔH of the reaction.

$$\Delta H = -vc\Delta t = -(0.0250L \cdot 4.19\frac{KJ}{L \cdot °C} \cdot 7.0°C) = -0.733KJ$$

c) Calculate the moles of calcium chloride dissolved. Remember n=m/M

$$n = \frac{m}{M} = \frac{2.0g}{110.98g/mol} = 0.0180\,mol$$

$$H = \Delta H_{/n} = \frac{-0.733KJ}{0.0180mol} = -40.7\frac{KJ}{mol} \rightarrow -41\frac{KJ}{mol}$$

e. Write a balanced, dissociation equation including the energy term.

$$CaCl_{2(s)} \rightarrow Ca^{2+}_{(aq)} + 2Cl^{-}_{(aq)} + 41\,KJ$$

Example: In a calorimetry experiment, 4.24g of lithium chloride is dissolved in 100.0 ml of water at an initial temperature of 16.4°C. The final temperature of the solution is 25.1°C. Determine the molar enthalpy of Lithium chloride.

H $H = \frac{\Delta H}{n}$

a) is the reaction endo or exo thermic? exothermic

b) using the equation $\Delta H = -vc\Delta t$ calculate the ΔH of the reaction.

$\Delta H = -(0.1000L \cdot 4.19 kJ/L \cdot {}^{\circ}C \cdot 8.7 {}^{\circ}C) = -3.65 kJ$

c) Calculate the moles of lithium chloride dissolved. Remember n=m/M

$n = \frac{m}{M} = \frac{4.24g}{42.39 g/mol} = 0.100 mol$

d. How much heat would be released per one mole of LiCl? $H_{dissociation} = \Delta H_{dissociation}/n$

H $H = \frac{\Delta H}{n} = \frac{-3.65 kJ}{0.100 mol} = -36.5 \frac{kJ}{mol}$

$\hookrightarrow -37 kJ/mol$

e. Write a balanced, dissociation equation including the energy term.

$LiCl_{(s)} \rightarrow Li^{+}_{(aq)} + Cl^{-}_{(aq)} + 37 kJ$

Bomb calorimeters

-are used to measure enthalpy changes in combustion reactions.
-The substance is burned in a constant volume chamber.
-The heat released warms the water in the surrounding chamber.

$$\Delta H = -C_{bomb}\Delta t$$

where C_{bomb} is the known heat capacity of the calorimeter in kJ/°C.

Example: 1.50g of sucrose ($C_{12}H_{22}O_{11(s)}$) is burned in a bomb calorimeter with a heat capacity of 8.57 kJ/°C. The temperature change is 25.00°C to 27.88°C.

a) Is it endothermic or exothermic? exothermic

b) Calculate the amount of heat released.

$\Delta H = -C_{bomb}\Delta t$

$= -8.57\ kJ/°C \cdot 2.88°C = -24.7\ kJ$

$n = \frac{m}{M} = \frac{1.50\ g}{342.34\ g/mol} = 4.38 \times 10^{-3}\ mol$

c. How much heat would be released by the combustion of one mole of sucrose? $H = \frac{\Delta H}{n}$

$H = \frac{\Delta H}{n} = \frac{-24.7\ kJ}{4.38 \times 10^{-3}\ mol} = -5.64 \times 10^{3}\ kJ/mol$

d. Write the balanced combustion reaction including energy as a term.

$C_{12}H_{22}O_{11(s)} + 12O_{2(g)} \rightarrow 12CO_{2(g)} + 11H_2O_{(g)} + 5.64 \times 10^{3}\ kJ$

$1 \rightarrow 5$ $\quad n = \frac{m}{M}$ $\quad C = \frac{n}{V}$ ← L

mol/L