

## Calorimetry

Calorimetry- The process of measuring energy changes using a calorimeter which is a **closed system**.

We assume

Heat Lost = Heat Gained

So

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

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.

$$\Delta H = -mc\Delta t \text{ or } -Vc\Delta t$$

$\Delta H$  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<sub>2</sub>?

H

mass of CaCl<sub>2</sub> - 2.0g  
 volume of water - 25.0mL  
 initial temp - 20.0°C  
 final temp - 27.0°C

$$\Delta H = nH^{-?}$$

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  $\Delta H$  of the reaction.

$$\Delta H = -Vc\Delta t = -(0.0250L \cdot 4.19 \frac{kJ}{L \cdot ^\circ C} \cdot 7.0^\circ C)$$

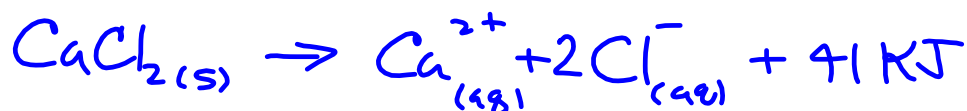
$$= -0.733kJ$$

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.



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  $\Delta H$  of the reaction.

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

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

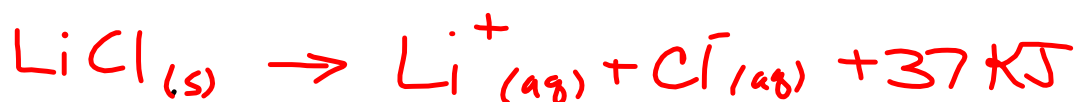
$$n = \frac{m}{M} = \frac{4.24 g}{42.39 g/mol} = 0.100 mol$$

d. How much heat would be released

per one mole of LiCl?  $H_{\text{dissociation}} =$

$$\Delta H_{\text{dissociation}}/n \quad H = \frac{\Delta H}{n} = \frac{-3.65 kJ}{0.100 mol} = \frac{-36.5 kJ}{mol} \rightarrow -37 \frac{kJ}{mol}$$

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



**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.

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

where  $C_{\text{bomb}}$  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.

- Is it endothermic or exothermic? *exothermic*
- Calculate the amount of heat released.

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

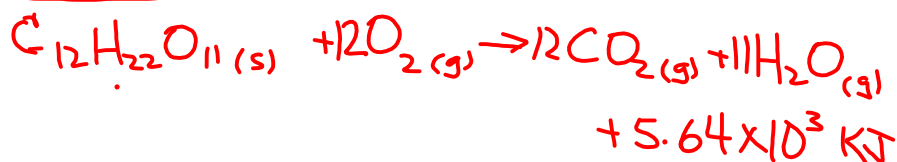
$$= -8.57 \text{ kJ/}^\circ\text{C} \cdot 2.88^\circ\text{C} = -24.7 \text{ kJ}$$

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

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

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

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



1 → 5

$$n = \frac{m}{M}$$

$$C = \frac{H}{V} \leftarrow L$$

mol  
L