

## Unit 3: Energy Changes and Rates of Reaction

### 5.1 Changes in Matter and Energy

- Thermochemistry: the study of the energy changes that accompany physical or chemical changes in matter.
- Thermal energy: energy available from a substance as a result of the motion of its molecules.
- System: The event that is being studied ex. Chemical system: a set of reactants and products, usually represented by a chemical equation.
- Surroundings: all matter around the system that is capable of absorbing or releasing thermal energy.
- Heat (q): amount of energy transferred between substances.
  - A substance does not contain heat.
  - Heat is the transfer of thermal energy.
- Exothermic: releasing thermal energy as heat flows out of the system.
- Endothermic: absorbing thermal energy as heat flows into the system.
- Temperature: average kinetic energy of the particles in a sample of matter.
- Open system: a system which both matter and energy can move in or out.
- Isolated system: a system which neither matter nor energy can move in or out.
- Closed system: a system which energy can move in or out, but not matter.

- **Calorimetry:** the technological process of measuring energy changes in a chemical system.
- Calculation of heat transferred:  $q = mc\Delta T$

$\Delta T$  = change in temperature  
 $c$  = specific heat capacity

**Endothermic** = + q

- The quantity of heat required to raise the temperature of a unit mass of a substance 1°C or 1K.
  - Need to know for  $\text{H}_2\text{O}_{(l)}$   $c = 4.18 \text{ J}/(\text{g} \cdot ^\circ\text{C}) = 1 \text{ calorie}$
  - Other values – table 1 page 301, appendix page 798

- Burning Cheezie Demonstration (Based on “Try This” on page 297)

mass of junk food item: \_\_\_\_\_g

mass of 25 mL of water: use the density of water

$$m = 25 \text{ mL} \times 1.00 \text{ g/mL} = 25 \text{ g}$$

$$c = 4.18 \text{ J/(g} \cdot ^\circ\text{C)}$$

$$\Delta T = \text{final} - \text{initial} = \underline{\hspace{1cm}}^{\circ}\text{C} - \underline{\hspace{1cm}}^{\circ}\text{C}$$

$$q = ?$$

$$q = mc\Delta T$$

## Heat Transfer and Enthalpy Change

- Chemical systems have many different forms of energy, both kinetic and potential. These include the kinetic energies of
  - moving electrons within atoms;
  - the vibration of atoms connected by chemical bonds;
  - the rotation and translation of molecules that are made up of these atoms.
- More importantly, they also include
  - nuclear potential energy of protons and neutrons in atomic nuclei; and
  - electronic potential energy of atoms connected by chemical bonds.
- The total energy value of a system is known as **enthalpy**
- You cannot measure the sum of all the kinetic and potential energies of a system so chemists study enthalpy change ( $\Delta H$ ).
- Enthalpy change ( $\Delta H$ ) = the difference in enthalpies of products compared to the reactants during after a physical, chemical or nuclear change.

**For an exothermic event,  $\Delta H$  is a negative (-) value.**

**For an endothermic event,  $\Delta H$  is a positive (+) value**

- See figure 6 on page 303 for visual representation of the flow of energy in a reaction.
- See table 2 on page 304 for types of enthalpy changes.
- Physical change: a change in the form of a substance, in which no chemical bonds are broken.
- Chemical change: a change in the chemical bonds between atoms, resulting in the rearrangement of atoms into new substances.
- Nuclear change: a change in the protons or neutrons in an atom, resulting in the formation of new atoms.

## Homework

- Practice 1,2,3,4,5,8,9,10,11,12,13,14,15
- Questions 1,2,3,4,5

## **5.1 Changes in Matter and Energy**

- **Thermochemistry:** the study of the energy changes that accompany physical or chemical changes in matter.
- **Thermal energy:** energy available from a substance as a result of the motion of its molecules.
- **System:** The event that is being studied ex. Chemical system: a set of reactants and products, usually represented by a chemical equation.
- **Surroundings:** all matter around the system that is capable of absorbing or releasing thermal energy.
- **Heat (q):** amount of energy transferred between substances.
  - A substance does not contain heat.
  - Heat is the transfer of thermal energy.
- **Exothermic:** releasing thermal energy as heat flows out of the system.
- **Endothermic:** absorbing thermal energy as heat flows into the system.
- **Temperature:** average kinetic energy of the particles in a sample of matter.
- **Open system:** a system which both matter and energy can move in or out.
- **Isolated system:** a system which neither matter nor energy can move in or out.
- **Closed system:** a system which energy can move in or out, but not matter.

## Measuring Energy Changes:

- **Calorimetry:** the technological process of measuring energy changes in a chemical system.
- Calculation of heat transferred:

where,  $q$  = heat transferred       $\Delta T$  = change in temperature  
 $m$  = mass       $c$  = specific heat capacity

**Exothermic** =  $-q$

**Endothermic** =  $+q$

(Heat energy entering a system adds energy to the system and hence its positive value. A negative value indicates a loss of heat energy by the system)

## Specific Heat Capacity

- The quantity of heat required to raise the temperature of a unit mass of a substance  $1^{\circ}\text{C}$  or  $1\text{K}$ .
  - Need to know for  $\text{H}_2\text{O}_{(l)}$      $c = 4.18 \text{ J}/(\text{g}\cdot^{\circ}\text{C}) = 1 \text{ calorie}$
  - Other values – table 1 page 301, appendix page 798
- [Hot Metals in water](#)
- Burning Cheezie Demonstration (Based on “Try This” on page 297)

mass of junk food item: \_\_\_\_\_g

mass of 25 mL of water: use the density of water

$$m = 25 \text{ mL} \times 1.00 \text{ g/mL} = 25 \text{ g}$$

$$c = 4.18 \text{ J}/(\text{g}\cdot^{\circ}\text{C})$$

$$\Delta T = \text{final} - \text{initial} = \text{ \_\_\_\_\_\_ }^{\circ}\text{C} - \text{ \_\_\_\_\_\_ }^{\circ}\text{C}$$

$$q = ?$$

$$q = mc\Delta T$$

## Heat Transfer and Enthalpy Change

- Chemical systems have many different forms of energy, both kinetic and potential. These include the kinetic energies of
  - moving electrons within atoms;
  - the vibration of atoms connected by chemical bonds;
  - the rotation and translation of molecules that are made up of these atoms.
- More importantly, they also include
  - nuclear potential energy of protons and neutrons in atomic nuclei; and
  - electronic potential energy of atoms connected by chemical bonds.
- The total energy value of a system is known as **enthalpy**
- You cannot measure the sum of all the kinetic and potential energies of a system so chemists study **enthalpy change ( $\Delta H$ )**.
- Enthalpy change ( $\Delta H$ ) = the difference in enthalpies of products compared to the reactants during after a physical, chemical or nuclear change.

**For an exothermic event,  $\Delta H$  is a negative (-) value.**

**For an endothermic event,  $\Delta H$  is a positive (+) value**

- See figure 6 on page 303 for visual representation of the flow of energy in a reaction.
- See table 2 on page 304 for types of enthalpy changes.

- **Physical change:** a change in the form of a substance, in which no chemical bonds are broken.
- **Chemical change:** a change in the chemical bonds between atoms, resulting in the rearrangement of atoms into new substances.
- **Nuclear change:** a change in the protons or neutrons in an atom, resulting in the formation of new atoms.

### **Homework**

- Practice 1,2,3,4,5,8,9,10,11,12,13,14,15
- Questions 1,2,3,4,5