INTRODUCTION TO CHEMISTRY
(SC-230)

UNIT 9. THERMOCHEMISTRY

1. What is thermochemistry?
2. Energy types; calculating energy; and Law of conservation of energy
3. Heat: Enthalpy, heat capacity and specific heat.

UNIT 9. THERMOCHEMISTRY

1. What is thermochemistry?

- **Thermodynamics** **=** *The science of the relationship between heat and other forms of energy.*

- **Thermochemistry –***it is an area of thermodynamics that concerns the study of the quantity of heat absorbed or evolved by a chemical reaction*
  - Thermochemistry is the science that looks at the relationship between **heat** and **energy**; to study thermochemistry we need to understand the concept of **ENERGY** and **HEAT** (**ENTHALPY**)

2. Energy types; calculating energy; and Law of conservation of energy

- **Energy** = *Capacity or potential to move matter (or to do work*)

- Energy exists in many different forms.
  - Examples: light energy, heat energy, mechanical energy, gravitational energy, electrical energy, sound energy, chemical energy, nuclear or atomic energy and so on.
  - These forms of energy can be transferred and transformed between one another. This is of immense benefit to us.
    - For example: For a source of energy to end up as electricity it may undergo many transformations before it can power the light bulb in your home.
  - Although there are many specific types of energy, the two major forms are **KINETIC ENERGY** and **POTENTIAL ENERGY**.

1) KINETIC ENERGY

- **Kinetic energy** = *is the energy in moving objects or mass (energy of movement)*
  - Example: Wind energy -- the molecules of gas within the air, are moving giving them kinetic energy.

2) POTENTIAL ENERGY

- **Potential energy** = *is any form of energy that has stored potential that can be put to future use; .(it is stored energy)*
  - For example:

Water stored in a dam for hydroelectricity generation is a form of potential energy.

↓

Valves are opened the force of gravity cause water to begin to flow.

↓

Gravitational potential energy of the water is converting to kinetic energy.

↓

The flowing water can turn a turbine, which will further convert the kinetic energy of the water into useable mechanical energy.

↓

An alternator or generator then converts the mechanical energy from the turbine into electrical energy.

↓

This electricity is then sent to the electricity grid and to our homes where it is converted into light energy (lights and televisions), sound energy (televisions, stereos), heat energy (hot water, toasters, ovens), mechanical energy (fans, vacuum cleaners, fridge and air conditioner compressors) and so on.

3) **INTERNAL ENERGY (*U*)**

- **Internal Energy** = *The sum of the kinetic and potential energies of the particles making up a substance.*

4) **TOTAL ENERGY –** *sum of kinetic energy + potential energy + internal energy*

$$E_{tot} = E_K + E_P + U$$

- This leads us to the Law of Conservation of energy.

Law of conservation of energy

- **Law of conservation of energy** = *energy may be converted from one form to another, but the total quantity of energy remains constant.*

Example: The dam.

- When the water is released its potential energy is converted to kinetic energy.
- However the TOTAL ENERGY of the water remains the same. The energy remains constant.
- This is the LAW OF CONSERVATION OF ENERGY.

Calculating energy

The formulas for calculating kinetic energy and potential energy are the following;

$$\mathbf{E_k = \frac{1}{2} mv^2}$$

$$\mathbf{E_p = mgh}$$

Where;
E_k = kinetic energy
E_p = potential energy
m = mass (kg)
g = constant acceleration of gravity **(9.81 m/s^2 or 35.3 (km/h)/s).**
h = height (m)
v = velocity (m/s)

Calculating kinetic energy (E_k)

- The unit for kinetic energy is ***called the "joule"*** or "***calories***"

  1 cal = 4.184 J

- Kinetic energy is calculated using the following equation;

  $E_k = \frac{1}{2} mv^2$

  m = mass (kg)
  v = speed or velocity (m/s)

Example 1: Kinetic energy of a person whose mass is 59 kg and speed is 26.8 m/s.

$E_k = \frac{1}{2} \times (59kg) \times (26.8\ m/s)^2$

$E_k = 2.12 \times 10^4\ kg\ m^2/s^2$ or joules (The unit kg m^2/s^2 is the **joule (J)**)

Example 2: A good pitcher can throw a baseball so it travels between 60-80 miles per hour. A regulation baseball weighs 143g (0.143kg) travels 75 miles per hour (33.5 m/s). What is the kinetic energy of this baseball in joules and calories?

$E_k = ½\ mv^2$

E_k = kinetic energy
m = mass
v = velocity

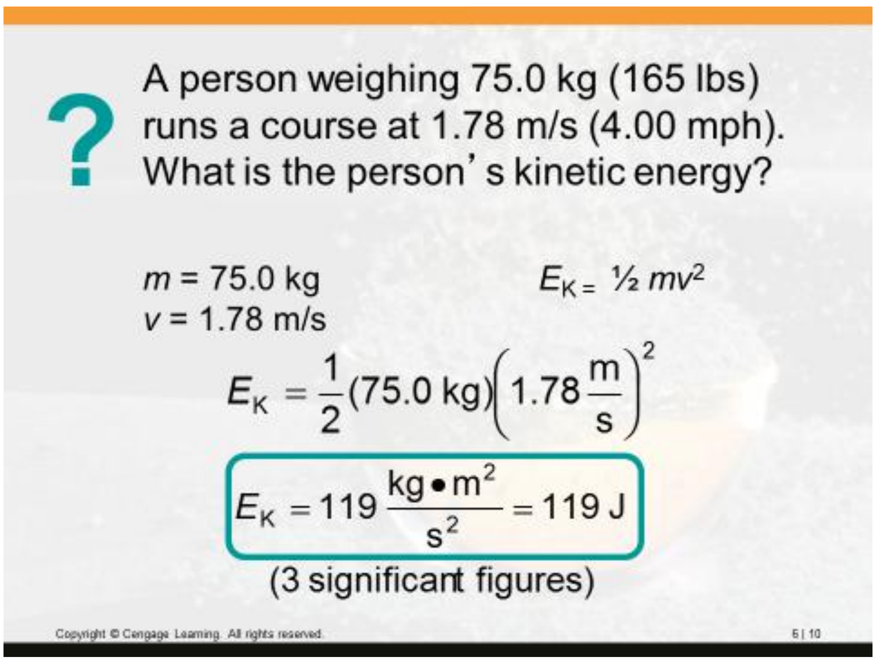
Procedure:

1) Substitute into the formula your values.
2) Do the calculation.
3) Use the conversion to calculate it in calories.

$E_k = ½\ mv^2$
$E_k = ½ \times 0.143\ kg \times (33.5\ m/s)^2$
$E_k =$ **80.2 J**

$80.2\ J \times \frac{1\ cal}{4.184\ J}$ = **19.2 cal**

Example 3:



3. Heat: Enthalpy, heat capacity and specific heat

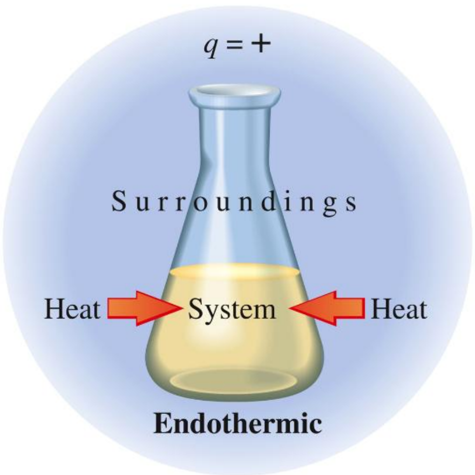
ENTHALPY

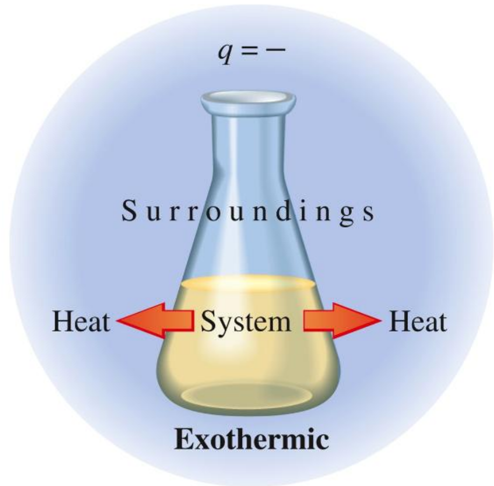
- **Enthalpy =** *the property of a substance that can be used to obtain the amount of heat absorbed or evolved during a chemical reaction.*

- Chemical reactions can be **exothermic** or **endothermic** depending on whether heat is absorbed or evolved.\
  - **Exothermic =** *a chemical reaction or physical change in which heat is evolved/released (temperature increases).*
  - **Endothermic** = *a chemical reaction or physical change in which heat is absorbed (temperature decreases).*

Type of reaction	Experimental effect	Result on the system
Endothermic	Reaction vessel cools (heat is absorbed)	Energy added
Exothermic	Reaction vessel warms (heat is evolved or released)	Energy subtracted

Diagram p176





HEAT CAPACITY AND SPECIFIC HEAT

- These are used to measure heats of reaction.

- **Heat capacity (C) =** *quantity of heat needed to raise the temperature of the sample of substance 1^{o}C (or 1 Kelvin).*

$$\mathbf{q = C}\ \Delta t$$

q = heat
C = Heat capacity
Δt = delta t => difference in temperature

  - (if the resulting q value is negative, the reaction is exothermic; if the q value is positive, it is an endothermic reaction)

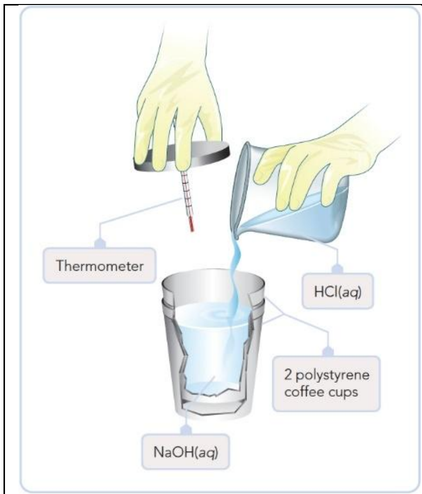
- **Specific heat (s) =** *the quantity of heat required to raise the temperature of 1g of a substance by 1^{o}C (or 1 Kelvin) at constant pressure.*

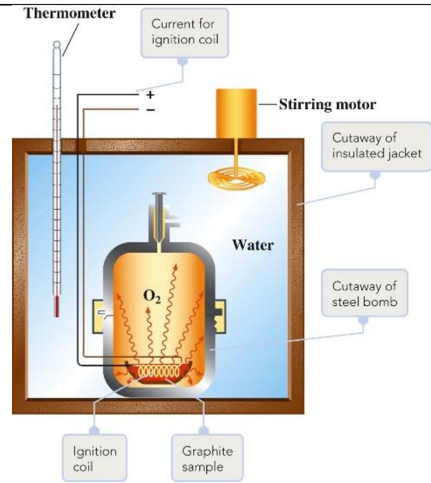
  - To find how much heat (q) is required to raise the temperature of a sample you multiply the specific heat of the substance (s) by the mass in grams (m) and the temperature change (Δt);

$$\mathbf{q = s \times m \times \Delta t}$$

q = heat
s = specific heat of the substance
m = mas (in grams)
Δt = delta t => difference in temperature

- A **calorimeter** is a device used to measure the heat absorbed or evolved during a physical or chemical change. Two examples are shown below





<u>Example</u>: Calculate the heat absorbed by 15 g of water to raise its temperature from 20 to 50^{o}C (at constant pressure). The specific heat of water is 4.18 J/(g·°C)

Use: $q = s \times m \times \Delta t$

Where:
s = 4.18 J/(g·°C)
m = 15g
$\Delta t = 50 – 20 = 30^{o}C$

$q = 4.18$ J/(g·°C) x 15g x (+30^{o}C) = **1.88×10^{3} J**

Example 2: