School of Basic and Applied Science

Course Code : MEV303 **Course Name: Techniques in Environmental Sciences**

Calorimetry

Theory

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Prerequisites

- Concept of thermal flow
- Concept of Internal energy and enthalpy
- Concepts of adiabatic and isothermal reaction

Objectives

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- ***<u>At the end of this Section you should be able to:</u>***
- *** Understand the theory involve in calorimetry***

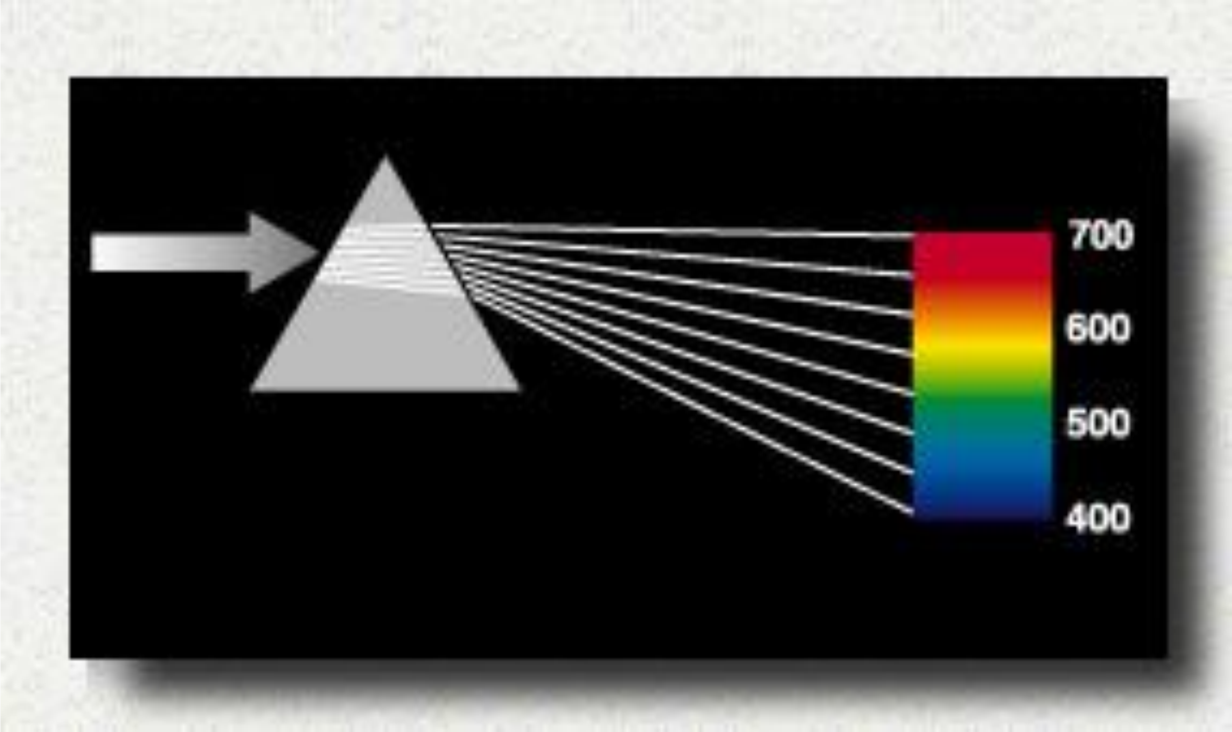
Useful Terminology

- **Colorimetry** is the use of the human eye to determine the concentration of colored species.

- **Spectrophotometry** is the use of instruments to make the same measurements. It extends the range of possible measurements beyond those that can be determined by the eye alone.

Colorimetry

- **Visual Observations** – Because colorimetry is based on inspection of materials with the human eye, it is necessary to review aspects of visible light.
- **Visible light** is the narrow range of electromagnetic waves with the wavelength of **400-700 nm**.



Calorimetry

Calorimetry is a means to measure heat transfer during chemical or physical processes.

Since it is hard to directly measure “heat”, heat transfer is measured in terms of temperature changes.

Calorimetry

In a calorimetric experiment, the heat lost or gained in the reaction is related to the temperature change of the calorimeter.

As shown in the equation, the amount of heat released (or absorbed) by the reaction is exactly equal to the amount of heat absorbed (or released) by the calorimeter, except opposite in sign.

Heat Flow and Temperature

When heat flows into an object, it makes sense that its temperature increases.

How *much* the object increases in temperature is dependent on its *heat capacity.*

General Definition of Heat Capacity (C)

The heat capacity (C) can be define as the quantity of heat required to increase the temperature of "something" 1 K.

$$q = C\Delta T \qquad \text{where } \Delta T = T_f - T_i$$

Tf is the final temperature of the object,
Ti is its initial temperature.

Specific Heat Capacity (cs)

The specific heat capacity (also known as cs, aka "specific heat") can be define as the quantity of heat required to increase the temperature of 1 gram of a substance 1 K.

$$q = mcs\,\Delta T \quad \Delta T = Tf - Ti$$

where m is the mass of the substance (in g)

cs is the specific heat capacity of the substance (given in a table).

Molar Heat Capacity (cn)

The molar heat capacity (cn) can be define as quantity of heat required to increase the temperature of 1 mole of a substance 1 K or 1 °C.

$$q = ncn \, \Delta T \quad \Delta T = Tf - Ti$$

where n is the moles of the substance

cn is the molar heat capacity of the substance (found in a table).

Two Main Types of Calorimeters

Bomb Calorimeter- A calorimeter that maintains *constant volume* during the process (i.e., constant volume calorimetry).

Constant pressure calorimeter- (e.g., a "coffee cup calorimeter) The calorimeter maintains constant pressure, but volume changes may occur.

Bomb Calorimeters

Bomb Calorimeter- A calorimeter *constant volume* has been maintained during the reaction.

As the volume is constant, $w=P \Delta V$ work is done during the process will be zero.

Therefore change in internal energy ΔU_{rxn} is measured.

Bomb Calorimetry and ΔU

For the closed calorimeter system

$$\Delta U = q + 0 = q_v$$

$$q_v = C\Delta T,$$

here C is the heat capacity of the bomb calorimeter and $\Delta T = T_f - T_i$

Constant Pressure Calorimetry

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ΔH is the heat at constant pressure.

Therefore, constant pressure calorimeters measure ΔH directly.

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