1. THERMAL EFFECTS

Reference: Heinemann Physics 1 4th Edition Chapters 1 & 2 Page 1.

1.1 Kinetic Particle Model

Much of our understanding of matter depends on the kinetic particle model (kinetic theory). This model is a representation that describes the system. The kinetic particle model works on the following assumptions.

- All matter is made up of very small particles.
- The particles are in constant motion.
- No kinetic energy is lost during the collisions between particles.
- There are forces of attraction and repulsion between the particles in a material.
- The distances between particles in a gas are large compared to the size of the particles.

The kinetic particle model explains the states of matter in the following way.

Solids
There is a balance between the repulsive and attractive forces holding the particles in fixed positions. There is some vibration in the particles

Liquids
In this state the particles are able to move around more and will take up the shape of the container. Some collisions occur.

Gas
The particles are in random motion colliding with each other and the sides of the container. The speed of the particles is high enough that when the particles collide the attractive forces are not strong enough to hold them.

1.2 Sources of Thermal Energy

The Earth's main source of thermal energy is the Sun. There are many other sources of thermal energy some of these are: burning of oil, gas, coal, wood, etc; nuclear reactors, friction, volcanoes, etc.

1.3 Temperature and Heat

Video: Heat and Temperature

1.3.1 Heat

Heat is a measure of the amount of thermal energy transferred between the particles of an object. Heat and temperature are related but should not be confused. A small object such as a pin can have a very high temperature if heated but does not have much heat (energy) because it will cool down quickly. On the other hand a warm drink will have a relatively low temperature but a large amount of heat (energy) since it will take a lot longer to cool down.

Heat is defined as the amount of thermal energy transferred from an object at a higher temperature to an object of lower temperature and is measured in joule (J).

1.3.2 Temperature (T)

Temperature (T) is related to the average kinetic energy of the particles in an object. The faster the particles move the higher the temperature of the substance.
Temperature (T) is measured in degrees and there are a number of temperature scales. Fahrenheit, Celsius and Kelvin are three common ones.
Degrees Celsius (°C) and degrees Fahrenheit (°F) are related by the following formula

$$°F = \left(\frac{9}{5}\right)°C + 32$$

Degrees Celsius (°C) and degrees Kelvin (K) are related by the following formula

$$K = °C + 273.15$$

(approx. °C + 273) and one Kelvin degree equals one Celsius degree.
Kelvin is significant because it is the temperature scale used by scientists in their work. 0 K is the lowest possible temperature that can exist.

1.4 The Laws of Thermodynamics

Video: Thermodynamics

1.4.1 The Zeroth Law

This law relates to thermal equilibrium and thermal contact. Two objects of differing temperatures in thermal contact will have a flow of energy between them. Eventually this will stop and they are in thermal equilibrium. Two objects in thermal equilibrium must be the same temperature.

1.4.2 The First Law

This law state that energy changes from one form to another and the total energy in the system is constant. It is conservation of energy.

Any change to the internal energy (U) of a system will occur if one of two things occurs.

If heat (Q) is added to (heating) or removed (cooling) from the system.
If work (W) is done on or by the system.

Change in internal energy = Heat added **to** the system – Work done **by** the system

Symbolically this can be written as:

$$\Delta U = Q - W$$

Note: Work done on the system is considered negative.

Example 1

A 1 litre beaker of water has 25 kJ of work done on it and also loses 30 kJ of thermal energy to the surroundings. What is the change in energy of the water?

Loses thermal energy $Q = -30$ kJ
Work done on it $W = -25$ kJ
$\Delta U = Q - W$
$\Delta U = -30 - -25$
$\Delta U = -30 + 25$
$\Delta U = -5$ kJ

Example 2

A student places a heating element and a paddle wheel in an insulated container of water. She calculates that the water 2530 J of thermal energy and the paddle wheel does 240 J of work on the water. Calculate the change in internal energy of the water.

$Q = 2530$ $W = -240$

$\Delta U = Q - W$
$\Delta U = 2530 - -240$
$\Delta U = 2770$ J

Problem Set #1: Text Page 9 All Questions