JSR IAS ACADEMY

GENERAL SCIENCE

PHYSICS

HEAT - 3

Change of state

- ❖ When you heat ice cubes, they become water and water on further heating changes into vapour.
- ❖ So, solid becomes liquid and liquid becomes gas, when heat is added.
- ❖ The reverse takes place when heat is removed.

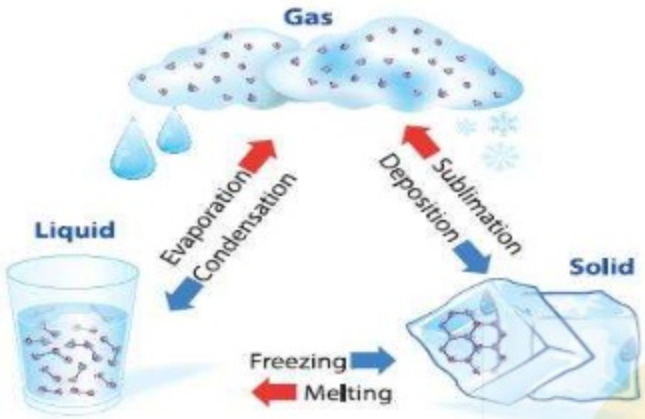

Figure 7.8 Change of state of matter

Melting – Freezing

- ❖ The process in which a solid is converted to liquid by absorbing heat is called melting or fusion.
- ❖ The reverse of melting is freezing. The process in which a liquid is converted to solid by releasing heat is called freezing.

Boiling-Condensation

- ❖ The process in which a liquid is converted to vapor by absorbing heat is called boiling or vaporization.
- ❖ The process in which a vapor is converted to liquid by releasing heat is called condensation.

Sublimation

- ❖ Some solids like dry ice, iodine, frozen carbon dioxide and naphthalene balls change directly from solid state to gaseous state without becoming liquid.
- ❖ The process in which a solid is converted to gaseous state is called sublimation.

One of the following transformations may take place due to heat energy.

1. Solid to Liquid (Melting)
2. Liquid to Gas (Vapourisation)
3. Solid to Gas (Sublimation)
4. Gas to Liquid (Condensation)
5. Liquid to Solid (Freezing)
6. Gas to Solid (Deposition)

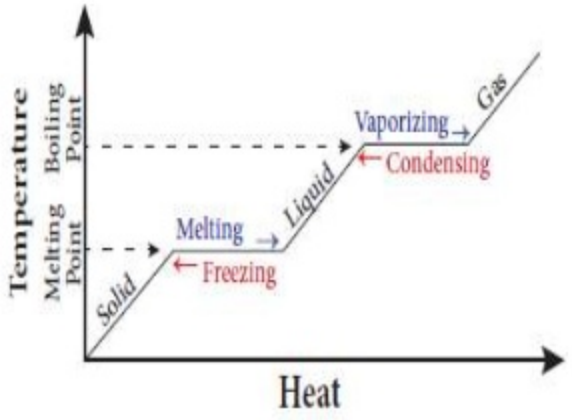

Figure 7.9 Various stages of conversion of state of matter

Latent heat

- ❖ The word, 'latent' means hidden.
- ❖ when a substance changes from one state to another, a considerable amount of heat energy is absorbed or liberated. This energy is called latent heat.
- ❖ It is denoted by the symbol L.
- ❖ If Q is the amount of heat energy absorbed or liberated by 'm' mass of a substance during its change of phase at a constant temperature, then specific latent heat is given as L = Q/m.

latent heat of fusion.

Heat energy is absorbed by the solid during melting and an equal amount of heat energy is liberated by the liquid during freezing, without any temperature change. It is called **latent heat of fusion.**

latent heat of vaporization.

In the same manner, heat energy is absorbed by a liquid during vaporization and an equal amount of heat energy is liberated by the vapor during condensation, without any temperature changes. This is called **latent heat of vaporization.**

Specific latent heat

- Thus, specific latent heat is the amount of heat energy absorbed or liberated by unit mass of a substance during change of state without causing any change in temperature.
- The SI unit of specific latent heat is J/kg.

How much heat energy is required to melt 5 kg of ice? (Specific latent heat of ice = 336 Jg^{-1})

Solution:

Given, m = 5 Kg = 5000g, L = 336 Jg^{-1}

Heat energy required = m × L

= 5000 × 336

= 1680000J or 1.68×10^6 J

Chemical changes:

- Since heat is a form of energy it plays a major role in chemical changes.
- These are all the chemical changes taking place due to heat.

DO YOU KNOW?

When a dog keeps out its tongue and breathes hard, the moisture on the tongue turns into water and it evaporates. Since, heat energy is needed to turn a liquid into a gas, heat is removed from dog's tongue. This helps to cool the body of the dog.

Calorimeter

- A calorimeter is a device used to measure the amount of heat gained or lost by a substance.

DO YOU KNOW?

The world's first ice-calorimeter was used in the year 1782 by Antoine Lavoisier and Pierre-Simon Laplace, to determine the heat generated by various chemical changes.

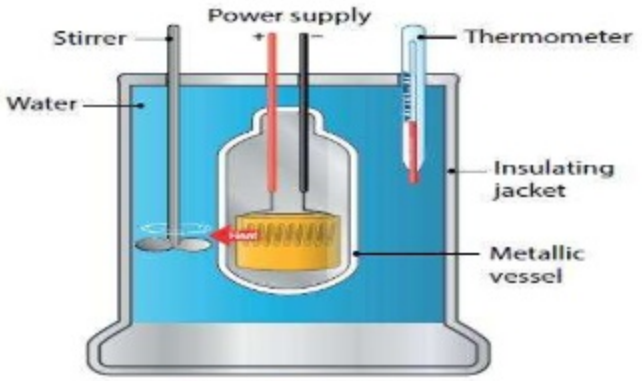

Figure 1.7 Calorimeter

Thermostat

- A thermostat is a device which maintains the temperature of a place or an object constant.
- The word thermostat is derived from two Greek words, 'thermo' meaning heat and 'static' meaning staying the same.
- Devices which use thermostat include building heater, central heater in a room, air conditioner, water heater, as well as kitchen equipments including oven and refrigerators.

Thermos Flask(Vacuum Flask)

- The thermos flask (Vacuum flask) is an insulating storage vessel that keeps its content hotter or cooler than the surroundings for a longer time.
- It is primarily meant to enhance the storage period of a liquid by maintaining a uniform temperature and avoiding possibilities of getting a bad taste.

DO YOU KNOW?

The vacuum flask was invented by Scottish scientist Sir James Dewar in 1892. In his honour it is called Dewar flask. It's also known as Dewar bottle.

Working of Thermos flask

- A thermos flask has double walls, which are evacuated. It is silvered on the inside.
- The vacuum between the two walls prevents heat being transferred from the inside to the outside by conduction and convection.

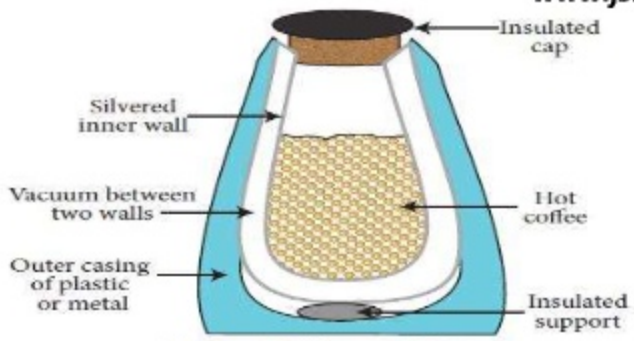

Figure 1.9 Thermos flask

- ❖ With very little air between the walls, there is almost no transfer of heat from the inner wall to the outer wall or vice versa.
- ❖ Conduction can only occur at the points where the two walls meet, at the top of the bottle and through an insulated support at the bottom.
- ❖ The silvered walls reflect radiated heat back to the liquid in the bottle.

Heat capacity

In general, the amount of heat energy gained or lost by a substance is determined by three factors. They are:

1. Mass of the substance
2. Change in temperature of the substance
3. Nature of the material of the substance

Heat capacity is defined as the amount of heat energy required by a substance to raise its temperature by 1°C or 1 K. It is denoted by the symbol C'.

$$\text{Heat Capacity} = \frac{\text{Quantity of heat required}}{\text{Raise in Temperature}}$$

$$C' = Q/T$$

SI unit of heat capacity is **J/K**. It is also expressed in **cal/oC, kcal/oC or J/oC.**

DO YOU KNOW?

Water in its various form, has different specific heat capacities.

Water (Liquid state) $= 4200\ JKg^{-1}\ K^{-1}$
Ice (Solid state) $= 2100\ JKg^{-1}\ K^{-1}$
Steam (Gaseous state) $= 460\ JKg^{-1}\ K^{-1}$

An iron ball requires 5000 J heat energy to raise its temperature by 20 K. Calculate the heat capacity of the iron ball.

Solution:

Given, $Q = 5000\ J$, $\Delta T = 20\ K$

$$\text{Heat Capacity, } C = \frac{\text{Heat energy required, } Q}{\text{Rise in temperature, } \Delta T}$$

$$= \frac{5000}{20} = 250\ JK^{-1}$$

Specific heat capacity

When the heat capacity of a substance is expressed for unit mass, it is called specific heat capacity.

Specific heat capacity of a substance is defined as the amount of heat energy required to raise the temperature of 1 kilogram of a substance by 1°C or 1 K.

It is denoted by the symbol C.

$$= \frac{\text{Amount of heat energy required (Q)}}{\text{Mass} \times \text{Raise in temperature } (\Delta T)}$$

$$\text{Therefore, } C = Q / m \times \Delta T$$

The SI unit of specific heat capacity is $J\ Kg^{-1}\ K^{-1}$.

- ❖ The most commonly used units of specific heat capacity are J/kg°C and J/g°C.
- ❖ Among all the substances, water has the highest specific heat capacity and its value is 4200 J/kg°K. So, water absorbs a large amount of heat for unit rise in temperature.
- ❖ Thus, water is used as a coolant in car radiators and factories to keep engines and other machinery parts cool.

An energy of 84000 J is required to raise the temperature of 2 kg of water from 60°C to 70°C. Calculate the specific heat capacity of water.

Solution

Specific heat capacity, $C = Q / m \times \Delta T$

Here, $Q = 84000\ J$

$m = 2\ kg$

$\Delta T = 70°C - 60°C = 10°C = 10\ K$

$C = 84000 / 2 \times 10 = 4200\ J\ Kg^{-1}\ K^{-1}$

The Specific heat capacity of water is $4200\ J\ Kg^{-1}\ K^{-1}$.