Specific Heat

Specific heat capacities of substance and specific heat

We know that when heat energy is absorbed by a substance, its temperature increases. If the same quantity of heat is given to equal masses of different substances, it is observed that the rise in temperature for each substance is different. This is due to the fact that different substances have different heat capacities.

So heat capacity of a substance is the quantity of the heat required to raise the temperature of the whole substance by one degree.

If the mass of the substance is unity then the heat capacity is called Specific heat capacity. OR the specific heat.

$$\mathbf{Q = C\ m\ \Delta t}$$

Where Q → quantity of heat absorbed by a body

m → mass of the body

Δt → Rise in temperature

C → Specific heat capacity of a substance it depends on the nature of the material of the substance.

S.I unit of specific heat $\mathbf{J\ kg^{-1}\ K^{-1}}$

NOTE: - Heat capacity = specific heat x mass

Its S.I unit is $\mathbf{J\ K^{-1}}$.

Specific heat of gases: -

When a gas is heated, it expands and the volume increases if we do not allow the gas to expand then the pressure will increase. By allowing the gas to expand the pressure is maintained a constant and gas does some amount of mechanical work against the atmospheric pressure at the cost of its heat energy.

∴ In the case of gases a change in temperature causes a considerable change in the pressure and volume .and hence there are two specific heats

1) Specific heat at constant pressure (C_p)
2) Specific Heat at constant Volume (C_V)

Specific heat at constant pressure (C_p): -

It is defined as the quantity of heat required to raise the temperature of 1mole of a gas through one kelvin at constant pressure.

Specific heat at constant volume (C_v): -

It is defined as the quantity of heat required to raise the temperature of 1mole of a gas through one Kelvin at constant volume.

NOTE: -

Think it over $C_p > C_v$

Mayer's Relation - $C_p - C_v = R$

Degrees of freedom of a particle : -

It is defined as the number of independent variables required to specify the position of that particle.

Law of equipartition of energy: -

It states that for a gas in thermal equilibrium the total thermal energy is equally divided among all the degrees of freedom of a molecule of the gas .

The energy associated with a molecule per degree of freedom is $\frac{1}{2}\ kT$

Where k → Boltzmann's constant

T → Its temperature

Note:-

$$\gamma = \frac{C_p}{C_v}$$

Where

γ → ratio of specific heat capacities

$$\gamma = 1 + \frac{2}{n}$$

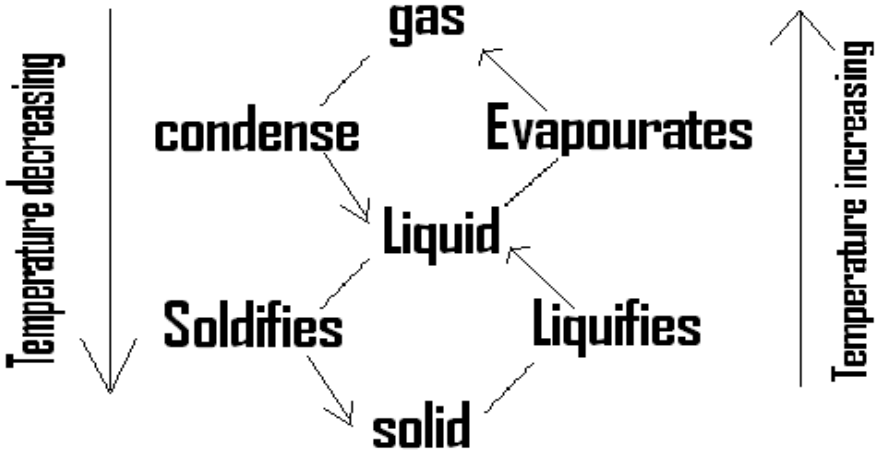
n is the number of degrees of freedom of a molecule

Change of state

The other important effect of heat is that it produces a change of state. As we know matter exists in any of the three states- solid, liquid or gas.

A change of matter from one physical state to another is called change of state.

The state of matter depends on its temperature and the pressure that is exerted on it.

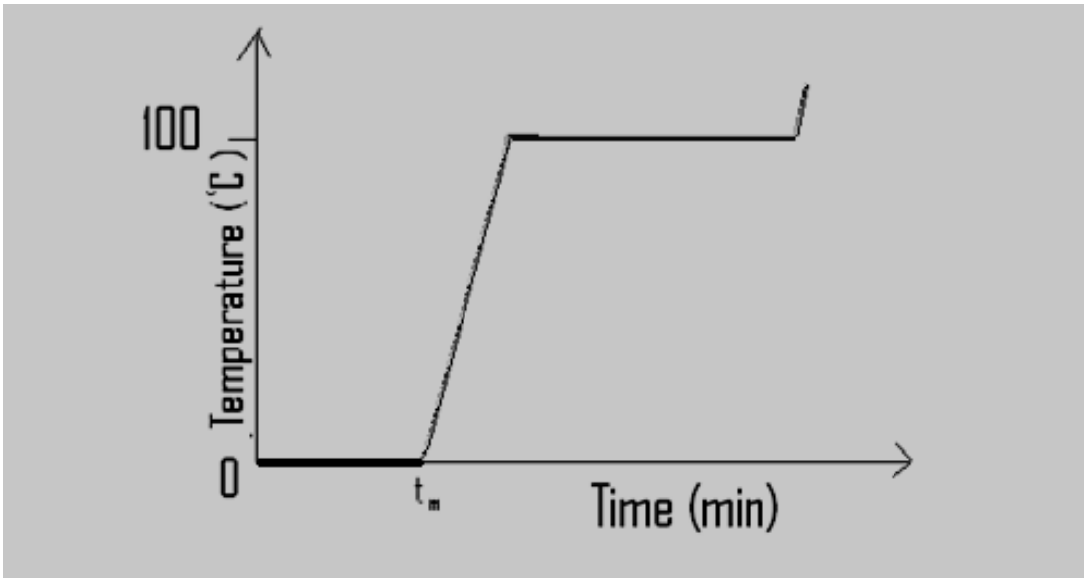


To study how a given substance can change its state on heating or cooling, let us perform the following activity.

Activity

Take some crystal of ice in a beaker, note the temperature of the ice [suppose it is at 0^oC]. Start heating it slowly on a constant heat source .Note the temperature after every 5 minutes. Draw a graph between the temperature and time as you heat the ice, initially there will be no rise in temperature. You should continuously stir the mixture of water and ice so that the temperature is

uniform throughout the mixture. As long as there is some ice in the beaker you will not observe any change in the temperature.

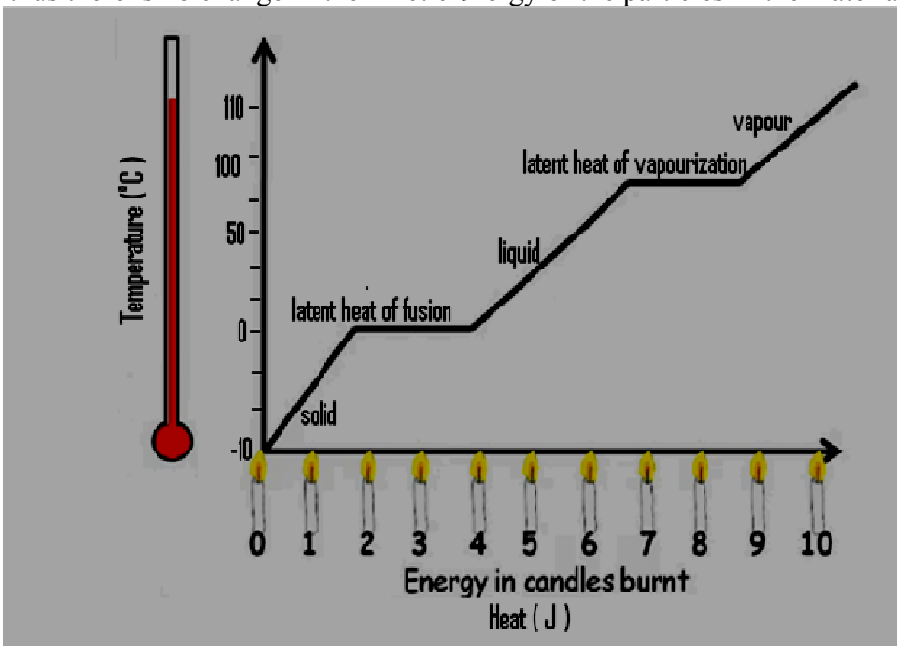


Graph of temperature vs time showing the changes in the state of ice on heating .

In the above process, the temperature of the system does not change even though heat is being continuously supplied. The heat supplied is being utilized in changing solid to the liquid. [The quantity of heat required to completely change 1 kg of ice into water without any change in temperature is known as latent heat of fusion of ice. This amount of heat is 335 kJ/kg.]

Latent heat: -

Latent heat means hidden heat. Which is not noticed by the thermometer? Heat absorbed or released during a phase change is called latent heat. There is no temperature change during a phase change, thus there is no change in the kinetic energy of the particles in the material.



Description of Phase change	Term for Phase change
Solid to liquid	Melting
Liquid to solid	Freezing to fusion
Liquid to gas	Vaporization which includes boiling and evaporation
Gas to liquid	Condensation
Solid to gas	Sublimation

The specific latent heat of fusion of a solid substance is the heat required to change one kilogram of it from solid to liquid without any temperature change.

The specific latent heat of vaporization of a liquid substance is the heat required to change one kilogram of it from liquid to vapor without any temperature change.

Note: -

The Value of melting point, latent heat of melting and latent heat of vaporization of some of the common substances (at normal atmospheric pressure)

Substance	Melting point (^{o} C)	Boiling point (^{o} C)	Latent heat of melting (kJ /kg)	Latent heat of vaporization (kJ /kg)
Water	0	100	335	2260
Mercury	-39	357	11.7	272
Air	-212	-191	23.0	213
Hydrogen	-259	-252	58.6	452
Oxygen	-219	-184	13.8	213
Helium	-271	-268	--	25.1
Aluminum	658	1800	322	--
Gold	1063	`2500	67.0	--

Calorimetry:-

Calorimetry is the science associated with determining the changes in energy of a system by measuring the heat exchanged with the surroundings.

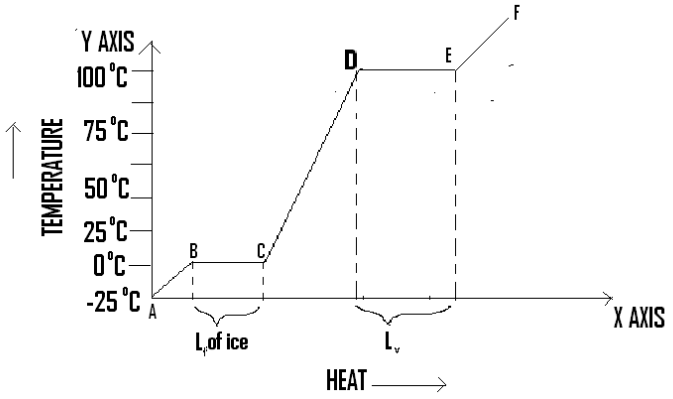
Principle of calorimetry

When two bodies (one being solid and other liquid or both being liquid) at different temperatures are mixed, heat will be transferred from body at higher temperature to body at lower temperature till both acquire same temperature. The body at higher temperature releases heat while body at lower temperature absorbs it, so that:

Heat lost by hot body = Heat gained by cold body,

QUESTIONS:-

1) Which of these will cause severe burn injuries water at 100^{o}C or Steam at the same temperature why?
2) Observe the graph carefully and answer the following questions



a. Which part of the graph indicates that the ice is melting ?
b. What situation are indicated by the part of the graph CD
c. What part of the graph shows that substance is changing from liquid state to vapour state?
d. What parts of the graph indicates that the temperature is not increasing despite heat being added? What is happening to the heat added during this stage?
e. For what purpose the added heat is utilized during the stage represented by BC.

3) What happens if the latent heat of ice is only 4 J/kg ?
4) Can water be made to boil at 15^{o}C ? Give reason for your answer.
5) Which takes more time to get heated oil or water?

Answers

1) Steam : - Free movement of molecules of steam and more kinetic energy
2) a) BC
   b) Latent heat of fusion of ice
   c) Ef
   d) BC , DE
   e) change of state from ice to water
3) Remains as ice
4) Yes by decreasing pressure
5) Oil