Thermodynamics

Calorimetry and Joule's Law

1. When two substances at different temperatures re mixed the heat lost by the hot body is equal to the heat gained by the cold body.
2. The transfer of heat takes place until the temperature of the two substances become equal.
3. Water can not be converted in ice by using ice.
4. Water can not be converted into steam by mere passing steam into it.
5. Steam causes severe burns than water at 100^0C as it contains more heat as latent heat.
6. To extinguish the fire, hot water is perfectible to cold water because it readily converts into steam which forms a layer above the fire and acts as a bad conductor of heat and prevents the supply of oxygen.
7. When equal amount of water and steam are mixed the resultant temperature is always 100^0C.
8. Ice at 0^0C produces more cooling effect than water at 0^0C
9. m rams of ice at $-t^0C$ is converted into steam at 100^0C. $Q = m\left(720 + \frac{t}{2}\right)$
10. $s = \frac{m_1s_1 + m_2s_2 + m_3s_3 + ..}{m_1 + m_2 + m_3 + ...}$ (For an alloy)
11. $\theta = \frac{s_1\theta_1 + s_2\theta_2 + s_3\theta_3 + ..}{s_1 + s_2 + s_3 + ...}$ (For n liquids of same mass)

12. Thermal capacity:

The amount of heat required to raise the temperature of a substance through $1\,^oC$ (or) 1 K is called the thermal capacity (or) Heat capacity.

Heat capacity = Q = ms or $ms = \frac{dQ}{dt}$

Unit: cal / ^{o}C (or) J/k DF: $\left[ML^2T^{-2}K^{-1}\right]$

Thermal capacity per unit mass is called specific heat. $s = \frac{1}{m}\frac{dQ}{dt}$

13. Water equivalent:

The amount of water which requires the same amount of heat for the same rise of temperature as that of a body is called water equivalent.

Thermal capacity and water equivalent are equal numerically in is system.

Units: gm (or) kg

14. Latent Heat

The amount of heat required to change the state of a one gram of a without changing the temperature is called the latent heat.

15. Latent Heat of fusion

The amount of heat required to change the one gram of ice in to water without changing the temperature is called the latent heat of fusion of ice.

Q= mL

L of ice = 80 cal/gm $= 336 \times 10^3 J/kg$ DF $\left[M^0L^2T^{-2}\right]$

16. Latent Heat of Vaporization

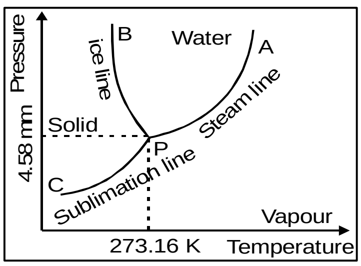
The amount of heat required to change the one gram water into steam without the change in temperature is called the latent heat of vaporization of water.

L of steam = 540cal/gm = $2.26 \times 10^6 J/kg$

17. Regalation: Melting of ice under pressure and resolidification when pressure is removed is called regulation. Ex: Skating.

18. Phase Diagram:

In the diagram OA is steam line, OB is ice line and OC is hoarfrost line



a) Vaporization curve (steam line)

i. It shows the variation of B.P. with pressure.

ii. As pressure increases B.P.of water increases. This is the principle of pressure cooker.

iii. The slope of the curve is positive.

iv. Each point on the curve shows a set of values of pressure and temperature at which the liquid and gaseous (vapor) states co-exist.

v. At any particular temperature, if the pressure is increased, the vapour will immediately condense into the liquid

b) Fusion curve (Ice line)

i. As the pressure increases m.p. of ice decreases. (Regalation: skating and iceberg melts at the bottom).

ii. The slope of the curve is negative.

iii. Each point on the ice line shows a set of values of pressure and temperature at which solid and liquid phases co-exist.

iv. At any particular temperature, if the pressure is increased the solid will melt into the liquid.

c) Sublimation curve (Hoar froast line)

i. As the pressure increases, the sublimation point increases.

ii. The slope of the curve is positive.

iii. Each point in the curve gives a set of value of pressure and temperature at which the solid and the vapour states co-exists.

iv. At any particular temperature if the pressure is increased, the vapour changes into solid.

d) Triple point

The three curves meet at the point ‘O’ called triple point. At this temperature all the three states namely solid, liquid, and vapour states coexists.

For water: 273.16K at 610.42pa (4.6mm of Hg)

For Co_2 : 216.65K at 3.88mm of Hg

For Iodine: 387K at 90mm of Hg.

19. Specific heat

a. It is defined as the amount of heat required to raise the temperature of 1kg of a substance through 1K (or)1^0C.

Unit: cal/gm/^0C (or) J/kg/k D.F: $\left[M^0L^2T^{-2}K^{-1}\right]$

b. If Q is the amount of heat required to raise the temperature of a substance of mass m through t^0C, then $s=\frac{Q}{mt}$ (or) $Q = mst$

20. Joule's Law

- If W is the work done and H the quantity of heat produced, then $W \;\alpha\; H$ (or) W= J H

  Where J is a constant called mechanical equivalent of heat (or) Joule's constant.

  "The mechanical equivalent of heat may be defined as the quantity of work to be expended in order to produce unit amount of heat".

  $J = 4.185\times10^7 erg/cal = 4.185\,joule/cal$

- J has no significance if both heat and work are measured in SI system. J has no DF
- For a water fall, mgh =Jmst $\Rightarrow t=\frac{gh}{Js}$
- For complete melting of an ice block falling from certain height , mgh = JmL

  $\Rightarrow h=\frac{JL}{g}$ = 34.2km

  This height is independent of mass of ice.
- If the ice block falls from lesser height than 34.2km, a part of ice that is melted is

  $mgh = JxL \Rightarrow x=\frac{mgh}{JL}$
- If an ice block is dragged in horizontal rough surface $\mu mgs = JmL$
- If a metal block is dragged an a horizontal surface, then the rise in temperature of the block $Jmst = \mu ms\Delta$ $\Rightarrow t=\frac{\mu gs}{J\Delta}$