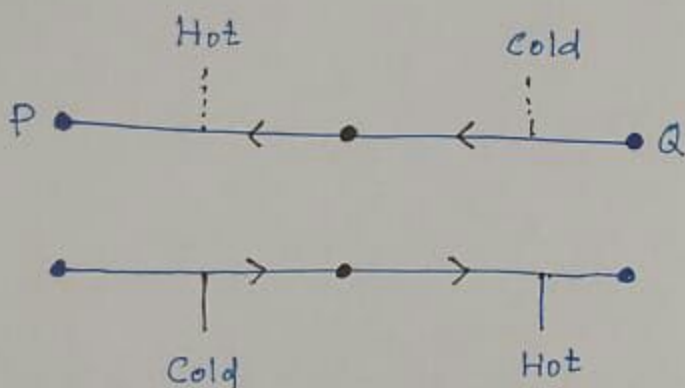Ques :- What is Thomson effect ? Define Thom-son Co-efficient.

Thomson observed that if the tempera-ture of the two ends of the conductor be kept same and the temperature of middle point of the conductor is above the temp-erature of the two ends and the current was sent through it, the half portion of the wire becomes cooled and the next half becomes heated. When the direction of curre-nt is reversed, the hot and cold junction is also reversed. This is called Thomson effect.

(fig.)

Thomson Coefficient is the amount of heat energy absorbed or evolved when unit current flows for one second between two points of conductor
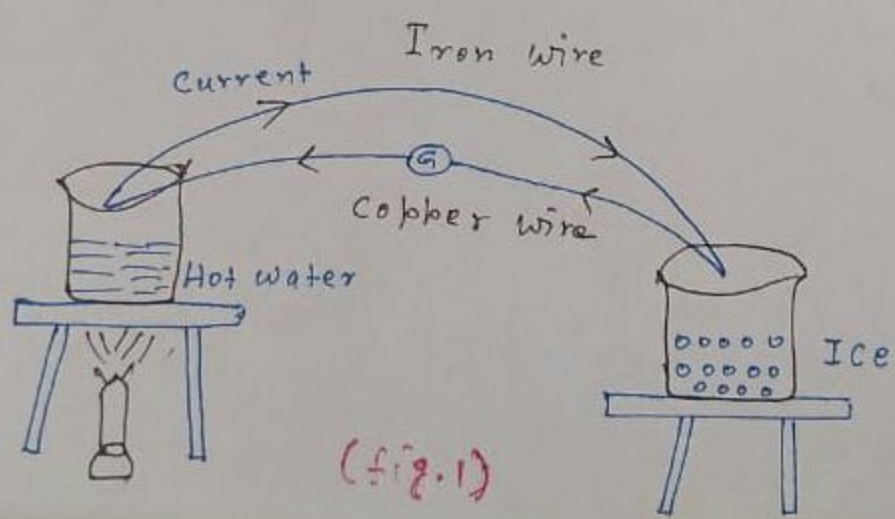
at a difference of temperature of $1°C$.

If H Joule be the amount of heat energy absorbed or evolved by pass-age of q Coulomb of charge through two points having temperature difference $1°C$, then

Thomson co-efficient, $\sigma = \dfrac{H}{q}$

The unit of σ is volt.

Ques:- Explain seebeck effect.

Seebeck observed that if two dissimilar metals are joined so as to form closed circuit and if the junctions are kept at different temperatures, an e.m.f. is prod-uced and electric current flows in the circuit. The effect is called seebeck effect and the couples of different metals whi-ch show seebeck effect is called the thermocouple.

(fig.1)

1·2. Equation of a progressive wave

A plane progressive harmonic wave is the simplest wave in which the particles of the medium perform simple harmonic motion.

Let the source of simple harmonic disturbance be situated at the origin O, and the wave travels in the positive direction of X-axis in a continuous homogeneous medium. As the wave proceeds onward, each successive particle of the medium is set in simple
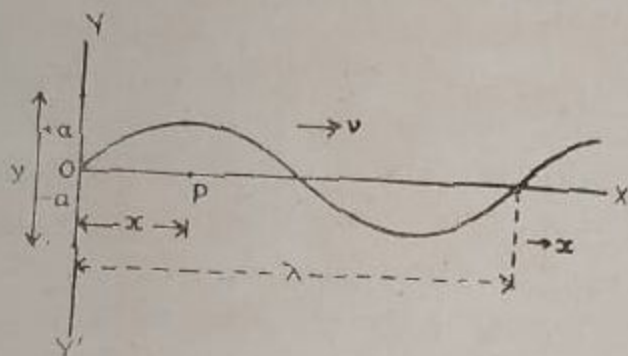

fig. (1.1)

harmonic oscillation. Fig (1 1) shows the displacements (y) of particles against their positions (x) at a particular instant. If we measure time from the instant when the particle at O is passing through its mean position, then the displacement of this particle at any instant t along y-axis is given by

$$y = a \sin \omega t.$$

$$= a \sin \frac{2\pi t}{T} \quad \left[\because \quad \omega = \frac{2\pi}{T} \right]$$

...(1·1)

where a is the amplitude of the particles and T the periodic time, which is the time taken by the wave to cover a distance λ.

The displacement at the same instant of a particle P at a distance x from O towards the right can be written as

$$y = a \sin (\omega t - \phi),$$

...(1.2)

where ϕ is the phase lag, since it is evident that the particle situated towards the right of O must be always behind the particle at O in phase if the wave is travelling towards the right.

Let us evaluate the phase constant ϕ in terms of the wave length and the distance x of the particle P from O.

We know that a change of 2π in phase occurs between two particles separated by a distance λ, hence we see that a change of ϕ in phase corresponding to a distance x is given by the relation

$$\frac{2\pi}{\lambda} = \frac{\phi}{x}$$

$$\therefore \qquad \phi = \frac{2\pi x}{\lambda}$$

Substituting this value in equation (1·2), we get

$$y = a \sin\left(\frac{2\pi t}{T} - \frac{2\pi x}{\lambda}\right)$$

$$= a \sin\left(\frac{2\pi v t}{\lambda} - \frac{2\pi x}{\lambda}\right) \qquad \left[\because \quad \frac{1}{T} = \frac{v}{\lambda}\right]$$

$$= a \sin \frac{2\pi}{\lambda}(vt - x) \qquad\qquad \dots(1·3)$$

This equation gives us the complete form of a wave of amplitude a propagating with a velocity v, in the positive direction of X-axis. When x is measured against the direction of propagation of the wave (i.e., negative direction of X-axis) the above equation becomes

HEISENBERG's UNCERTAIN
PRINCIPLE → The principle states

that the product of the uncertainties in determining the position and momentum of the particle is approximately equal to a number of the order $\hbar$, where $\hbar = h/2\pi$, h being Planck's constant,

$$i.e. \quad \Delta p \, \Delta q \simeq \hbar \qquad — (1)$$

where Δp is the uncertainty in determining the momentum and Δq is the uncertainty in determining the position of the particle. The above relation shows that it is impossible to determine simultaneously both the position and momentum of the particle accurately. Clearly this relation is fundamental since it sets a limit to the accurate and simultaneous measurement of position & momentum.

The relation is universal and holds for all the canonically conjugate physical quantities like position & momentum, energy and time, angular momentum and angle, etc. whose product has dimensions of action (Joule-sec). Thus if ΔE is the uncertainty in determining the energy of the system and Δt is the uncertainty in determining the time to which this determination refers, then we must have

$$\Delta E \, \Delta t \simeq \hbar \qquad — (2)$$

Classical partition function → The normali-
zation constant $1/A$ is defined by either
⑧ or ⑩ is called the canonical partiti-
-on function (or integral over the states). Let
us denote it by Q_N, then

$$Q_N = \sum_N e^{-E_n/kT} \quad (quantum) \longrightarrow ⑪$$

$$Q_N = \int e^{-E(q,p)/kT} dq\, dp \quad (classical) \longrightarrow ⑫$$

In order to make Q_N
dimensionless the volume element $dq\, dp$ is
is expressed into corresponding number of
quantum states by dividing it by h^{3N}
where N is the number of particles in
the system.

Further we divide (12) by $N!$ in
accordance with the rule of correct Bolt-
-zmann counting since the particles are
distinguishable. Thus the partition function
in classical statistics is strictly defined
as,

$$Q_N = \frac{1}{N!\, h^{3N}} \int e^{-E(q,p)/kT} dq\, dp \longrightarrow ⑬$$

Then $f_n = e^{-E_n/kT}/N Q_N \longrightarrow ⑭$

$$f(q,p) = e^{-E(q,p)/kT}/Q_N \longrightarrow ⑮.$$

Thermodynamical functions → The energy is
given by

$$S = k.\log \Delta\Gamma \longrightarrow ①.$$

where $\Delta\Gamma$ is the statistical weight
and related with the distribution function as

$$f(\langle E \rangle) \Delta \Gamma = 1 \quad \text{——} \quad ②.$$

According to Gibbs distribution, we have,

$$f(\langle E \rangle) = \frac{e^{-\langle E \rangle / RT}}{Q_N} \quad \text{——} \quad ③$$

where Q_N is the canonical partition fund-ion, substituting ② & ③ in ①, we get,

$$S = - k \log f(\langle E \rangle)$$
$$= \frac{\langle E \rangle}{T} + k \log Q_N$$

or, $\langle E \rangle - ST = -k \log Q_N$.

where

$\langle E \rangle = U$ is the internal energy

and $A = U - ST$ is called Halmholtz free energy. Thus $A = -RT \log Q_N$ ——④

④ is the basic relationship of the statistical thermodynamics. The other thermodynamics properties of the system can be obtained from the free energy. Thus the pressure is,

$$P = -\left(\frac{\partial A}{\partial V}\right)_{N,T} = kT \left(\frac{\partial}{\partial V} \log Q_N\right). \quad \text{——} ⑤.$$

The entroy S is,

$$S = -\left(\frac{\partial A}{\partial T}\right)_{N,V} = k \left(\frac{\partial}{\partial T} [T \log Q_N]\right)_{N,V} \quad ⑥.$$

The internal energy U is,

$$U = A + ST.$$

The second postulate affirming the constancy of the velocity of light as well as its independence from the relative velocity of source and observer appears to represent a simple experimental fact. It is this postulate which draws a demarkation line between the classical theory and the theory of relativity given by Einstein.

To pass from the coordinates which describe a physical event in one system to the coordinates which describe the same event in another system moving uniformly and rectilinearly with respect to the first, without violating in any way the principle of equivalence, the universal constancy of light in both systems must be used. From such a combination of the two postulates thus follows a series of very important deductions, such as the futility of ether, the intrinsic quantum nature of radiations, the variation of the mass of a moving body with its velocity, and the universal mass-energy relation.

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