{ B·Sc (Part I), Physics Hons
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Question:→ (a) Give two statement of the 2^{nd} law of thermodynamics.

(b) Prove the clausius inequality $\sum_i \frac{Q_i}{T_i} \leq 0$

Ans :- (a) Second law of thermodynamics is the direct consequence of Carnot's theorem. This involves the principle of convertibility of heat to work which arose out of carnot's speculations.

Lord Kelvin stated the law in this form:→

" It is impossible to derive mechanical effect from any portion of matter by cooling it below the temperature of the coldest of the surrounding objects."

Clausius stated in the form :-

It is impossible for a self along machine unaided by any external agency to convey heat from any body to another at a higher temperature, a heat can not itself pass from a colder to warmer body."

(b) Let η and η' be the efficiencies of a reversible and irreversible cycle operating between same two limits of temp. T_1 and T_2 respectively.

Then $\eta = \frac{Q_1 - Q_2}{Q_1} = \frac{T_1 - T_2}{T_1}$ and since $\eta' < \eta$

$$\frac{Q_1 - Q_2}{Q_1} < \frac{T_1 - T_2}{T_1}$$

or $\frac{Q_1}{T_1} - \frac{Q_2}{T_2} < 0$ and taking account of the sign we get

$$\frac{Q_1}{T_1} + \frac{Q_2}{T_2} < 0$$

In general $\oint \frac{dQ_1}{T_1} < 0$

Therefore combining the expression for reversible and irreversible process we get

$$\int \frac{dQ}{T_1} \leq 0 \quad \left\{ \because \int \frac{dQ_r}{T_1} = 0 \right\}$$

This equation is known as clausius equation of inequality.

Let us consider a system whose particles can exchange energy and intract only with one another such a system neither losses nor gains energy from outside and is therefore known as an isolated system. If all the parts of the system are at the same temp, it is said to in thermal equilibrium. This means that the system is in the state of maximum thermodynemic probability. The ~~prop~~ probability of the system existing in a microstate having even a small deviation from the state of maximum probability is negligible. Hence if the system initially exists in come to the equlibriem state due to natural collision between the particles constituting the system. The entropy 'S' of a system is proportional to the thermodymemic probability W. Hence the system is moving from a state of lower probability to the state of maximum entropy. It is not possible for the system ~~it~~ to itself move in opposite direction when the system is in equilebrium entropy S has the maximum value.

For the state of equilibrium change in entropy

$$\Delta S = 0$$

when moves from a state of lower probability to the state of maximum probability there is ~~an~~ an increase in entropy.

Hence the entropy of an isolated system remain constant or increasing according as the change its undergoes are reversible or irreversible.