

Second Law of Thermodynamics

Q. Give Kelvin-Planck statement and Clausius statement of second law of thermodynamics and explain its significance. Show that both these statements are equivalent.

Ans. - Second law of thermodynamics: It can be stated in a number of ways. We give below Kelvin Planck and Clausius statement of this law.

Kelvin-Planck statement: It is impossible to get a continuous supply of work from a body by cooling it to a temp. lower than the coldest of its surroundings.

Clausius statement: It is impossible for a self acting machine unaided by any external agency to convey heat from a body at a lower temp to a body at a higher temp.

Explanation: It is clear from the above definitions that heat cannot flow from a body at a lower temp to a body at a higher temp unless work is done by an external agency.

This is in accordance with our experience in other branches of Physics.

(i) A body cannot move from a lower to a higher level unless work is done on it by an external agency.

(ii) Electric current does not flow from a lower to a higher potential unless work is done on it. Heat can flow from a higher temp to a lower temp. A heat engine may absorb a certain amount of heat at higher temp to a lower temp, convert a part of it into mechanical work and give out the rest of it at a lower temp. Thus we see that a heat engine works essentially by destroying the temp difference between the source and the sink. This led Lord Kelvin to state the second law of thermodynamics in the following manner.

It is impossible to derive continuously supply of work by cooling a body to a temp lower than that of the coldest of its surroundings. The two statements are equivalent. The this ~~statement of second law may also be put as~~ is explained as under.

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Let there be an engine which gives a continuous supply of work by cooling the cold body (sink) below the lowest temp of the surroundings. This is against the Kelvin statement of second law. If the external work done by the engine is used to work a dynamo and the current produced by the dynamo generates heat in a coil immersed in a hot body (source), we have a machine which can make heat flow from a lower temp to a higher temp without the expenditure of energy. This is clearly a violation of second law of thermodynamics.

The statement of second law may also be put in the following form:
It is impossible to construct a heat engine which operating in a complete cycle will take heat from a single body and convert the whole of it into mechanical work, without leaving changes in the working substances.
