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First law of Thermodynamics :-

Joule's law gives the relation between the work done and the heat produced. It is true when the whole of the work done is used in producing heat or vice versa. Here, $W = JH$ where J is the joule's mechanical equivalent of heat. But in practice, when a certain quantity of heat is supplied to a system the whole of heat energy may not be converted into work. Part of the heat may be used in doing external work and rest of the heat might be used in increasing the internal energy of molecules.

Let the quantity of heat supplied to a system be δH, the amount of external work done be δW and the increase in internal energy of the molecules be dU. The term U represents the internal energy of a gas due to the forces of inter-molecular attraction.

Mathematically,

$$\delta H = dU + \delta W \quad \text{— (i)}$$

Eqn (i) represents the first law of thermodynamics. All the quantities are measured in heat units. The first law of thermodynamics states that the amount of heat given to a system is equal to the sum of the increase in the internal energy of the system and the external work done.

For a cyclic process, the change in the internal energy of the system is zero because the system is brought back to the original condition.

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Therefore, for a cyclic process,

$$\oint dU = 0$$

and $\oint \delta H = \oint \delta W$ ——— (1)

This equation represents Joule's law.

For a system carried through a cyclic process, its initial and final internal energies are equal. From the first law of thermodynamics, for a system undergoing any number of complete cycles

$$U_2 - U_1 = 0$$

$$\oint \delta H = \oint dW$$

$$H = W$$

(Both are in heat units i.e. Joule)