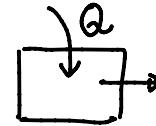


Class XI, Thermodynamics

REVERSIBLE PROCESS: A reversible process is one which can be reversed in such a way that all changes taking place in the direct process are exactly repeated in the reverse order and opposite sense, and no changes are left in any of the bodies taking part in the process or in the surrounding.



Conditions for a process to be reversible:

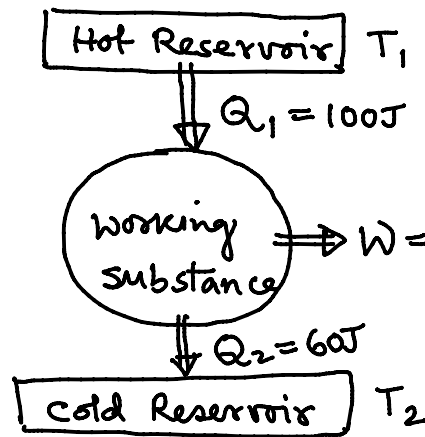
1. It free from all dissipative forces such as friction, viscosity, inelasticity, electrical resistance, magnetic hysteresis etc.
2. The process must take place infinitely slowly.

Irreversible Process: A process that is not a reversible process.

Heat Engine :

HEAT ENGINE: Heat engine is a device by which a system is made to undergo a cyclic process that results in conversion of heat to work.

1. Working substance : \rightarrow system.
2. Source or Hot Reservoir : Hot body maintained at a constant temp.
3. Sink or cold Reservoir : Body at lower temp (T_2)



$$W = Q_1 - Q_2 \quad \text{--- (1)}$$

Efficiency of Heat engine $\eta = \frac{W}{Q_1} \quad \text{--- (3)}$

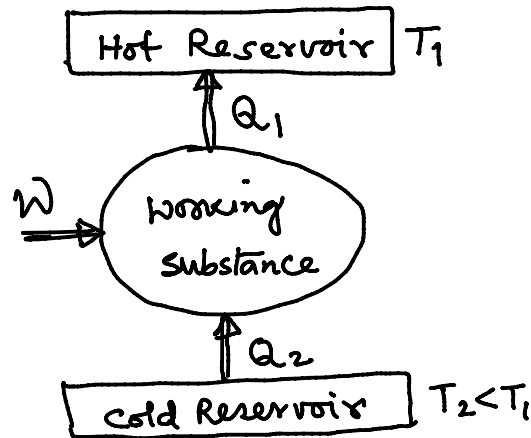
$$\eta = \frac{Q_1 - Q_2}{Q_1}$$

$$\eta = 1 - \frac{Q_2}{Q_1} \quad \text{--- (3)}$$

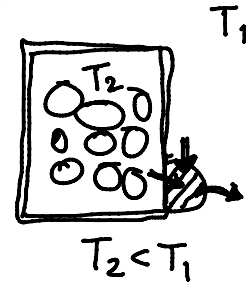
For efficiency to be 100% or for $\eta = 1$, it is necessary that $Q_2 = 0$

REFRIGERATORS AND HEAT PUMPS

Any device used for removing heat from a cold place and adding it to a hotter place is called a 'heat pump' or a 'refrigerator'.



$$Q_1 = Q_2 + W \quad \text{--- (1)}$$



Coefficient of performance

$$\alpha = \frac{Q_2}{W} \quad \text{--- (2)}$$

$$\alpha = \frac{Q_2}{Q_1 - Q_2} \quad \text{--- (3)}$$

No heat pump or refrigerator can have $\alpha = \infty$.

Second Law of Thermodynamics:

Kelvin-Planck statement:

"It is impossible to convert 'all' the heat extracted from a hot body into work". Or

✓✓ "No process is possible whose sole result is the absorption of heat from a reservoir and the complete conversion of the heat into work".

i.e it is impossible to construct a heat engine with 100% efficiency.

Clausius statement:

✓✓ "It is impossible to transfer heat from a cold body to a hot body without expenditure of work by an external energy source". Or

✓✓ No process is possible whose sole result is the transfer of heat from a colder object to a hotter object.

In a refrigerator the working substance (usually, in gaseous form) goes through the following steps : (a) sudden expansion of the gas from high to low pressure which cools it and converts it into a vapour-liquid mixture, (b) absorption of heat by the cold fluid from the region to be cooled. This converts it into vapour, (c) heating up of the vapour due to external work done on the system, and (d) release of heat by the vapour to the surroundings, bringing it to the initial state and completing the cycle.

Thus it continuously transfers heat from a cold body to a hot body at the expense of mechanical energy supplied to it by an external agent. The working substance (gas) used in it is called 'refrigerant'. Usually, **Freon**, a non-flammable aliphatic gasoline is used as refrigerant.