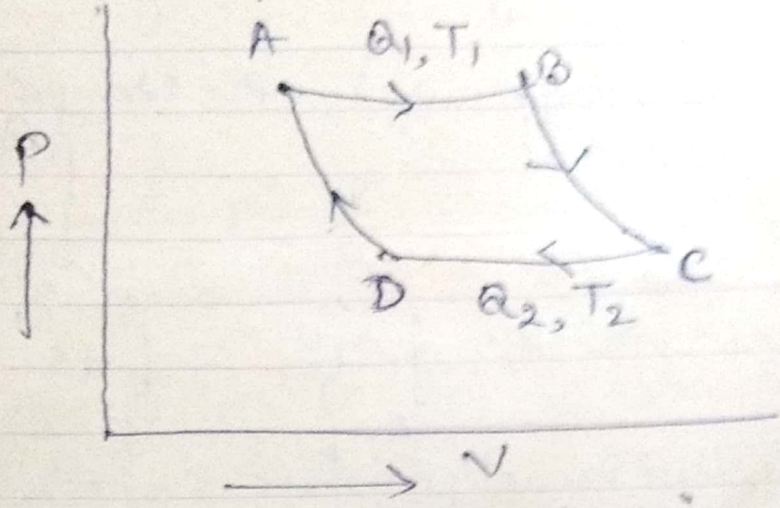
Change in Entropy in a Reversible Process

Considering a Carnot reversible cycle ABCDA on the P-V indicator diagram. From A to B, heat energy Q_1 is absorbed by the working substance at temperature T_1.



The gain in entropy of the working substance from A to B $= \frac{Q_1}{T_1}$. This is the decrease in entropy for the source from which the amount of heat Q_1 is drawn at a temperature T_1. From B to C, there is no change in entropy because BC is an adiabatic. From C to D, heat energy Q_2 is rejected by the working substance at a temperature T_2. The loss in entropy of the working substance from C to D $= \frac{Q_2}{T_2}$. This is the gain in entropy of the sink to which the amount of heat Q_2 is rejected at a temperature T_2

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From D to A, there is no change in entropy.

Thus the total gain in entropy by the working substance in the cycle ABCDA

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

But for a complete reversible process

$$\frac{Q_1}{T_1} = \frac{Q_2}{T_2}$$

Hence the total change in entropy of the working substance in a complete reversible process

$$= \oint ds = \frac{Q_1}{T_1} - \frac{Q_2}{T_2} = 0$$

<u>Change in entropy in an Irreversible Process</u>

In an irreversible process like conduction or radiation, heat is lost by the body at a higher temperature T_1 and is gained by the body at a lower temperature T_2. Here T_1 is greater than T_2.

Let the quantity of heat given out by a body at a temperature T_1 be Q and the heat gained by the body at a temperature T_2 be Q. Considering the hot and the cold bodies as one system.

Loss in entropy of the hot body $= \frac{Q}{T_1}$

Gain in entropy of the cold body $= \frac{Q}{T_2}$

Therefore, the total increase in entropy of the system $= \frac{Q}{T_2} - \frac{Q}{T_1}$

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It is a positive quantity because T_2 is less than T_1. Thus the entropy of the system increases in all irreversible process.