Answer on Question 73216, Physics, Molecular Physics, Thermodynamics

Question:

A carnot engine whose sink temperature of $300\ K$ has efficiency of 40%. By how much should source temperature be increased so as to increase efficiency to 60%?

Solution:

By the definition of the Carnot engine efficiency, we have:

$$\eta_1 = 1 - \frac{T_C}{T_{H1}},$$

here, $\eta_1 = 40\%$ is the Carnot engine efficiency, $T_C = 300\ K$ is the sink temperature, T_{H1} is the source temperature.

From this formula, we can find the source temperature, T_{H1}:

$$\eta_1 = 1 - \frac{T_C}{T_{H1}},$$

$$\frac{T_C}{T_{H1}} = 1 - \eta_1,$$

$$T_{H1} = \frac{T_C}{1 - \eta_1} = \frac{300\ K}{1 - 0.4} = 500\ K.$$

Then, we increase the efficiency to 60%. We can apply the same formula for the Carnot engine efficiency and find the new source temperature, T_{H2}:

$$\eta_2 = 1 - \frac{T_C}{T_{H2}},$$

$$\frac{T_C}{T_{H2}} = 1 - \eta_2,$$

$$T_{H2} = \frac{T_C}{1 - \eta_2} = \frac{300\ K}{1 - 0.6} = 750\ K.$$

Finally, we can find the change in the source temperature:

$$\Delta T_H = T_{H2} - T_{H1} = 750\ K - 500\ K = 250\ K.$$

Answer:

$\Delta T_H = 250\ K.$