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B.Sc. I^st (Hon. & Subsidiary)

Numerical Problems based on Carnot Engine

EX:- 3) A carnot Engine absorbs 6×10^5 cal. at 227°C calculate work done per cycle by the engine if it's sink is maintained at 127°C.

Solution:- Here, $Q_1 = 6 \times 10^5$ cal.

$T_1 = 227°C = 227 + 273 = 500K$

$T_2 = 127°C = 127 + 273 = 400K$

Work done / cycle, $W = ?$.

As

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

$$Q_2 = \frac{T_2}{T_1} \times Q_1 = \frac{400}{500} \times 6 \times 10^5$$

$$= 4.8 \times 10^5 \text{ cal.}$$

As,

$$W = Q_1 - Q_2 = 6 \times 10^5 - 4.8 \times 10^5$$

$$\therefore W = 1.2 \times 10^5 \text{ cal.}$$

$$= 1.2 \times 10^5 \times 4.2 \text{ J.}$$

$$\therefore W = 5.04 \times 10^5 \text{ J}$$ Ans.

Ex:- 04.> A carnot engine absorbs 1000 J. of Heat Energy a reservoir at 127°C and reject 600 J of heat energy during each cycle. Calculate

(i) Efficiency of engine (ii) Temperature of Sink (iii) Amount of useful work done per cycle.

Solution :- Here,

$$Q_1 = 1000\,J, \quad Q_2 = 600\,J$$

$$T_1 = 127°C = 127 + 273 = 400\,k$$

$$\eta = ?, \quad T_2 = ?, \quad W = ?$$

From,

$$\frac{Q_2}{Q_1} = \frac{T_2}{T_1}, \quad T_2 = \frac{Q_2}{Q_1} \times T_1$$

$$T_2 = \frac{600}{1000} \times 400 = 240\,k$$

$$= 240 - 273 = -33°C$$

$$\eta = 1 - \frac{T_2}{T_1} = 1 - \frac{240}{400} = 0.4$$

$$= 40\,\%$$

Also, $W = Q_1 - Q_2 =$

$$= 1000 - 600$$

$$= 400\,J.$$ Ans.

EX:- 5). A Carnot Engine whose heat sink is at 27°C has an efficiency of 40%. By how many degress should the temperature of source be changed to increase the efficiency by 10% of the original efficiency ?.

Solution :- Here,

$T_2 = 27°C = 27 + 273 = 300\,k$

$\eta = 40\%, \quad T_1 = ?$

From,

$$\eta = 1 - \frac{T_2}{T_1}$$

$$\frac{T_2}{T_1} = 1 - \eta = 1 - \frac{40}{100} = \frac{60}{100} = \frac{3}{5}$$

$$T_1 = \frac{5}{3} T_2 = \frac{5}{3} \times 300 = 500\,k$$

Increase in efficiency = 10% of 40% = 4%

∴ New efficiency $\eta' = 40 + 4 = 44\%$

Let T_1' be the new temperature of the source.

$$\eta = 1 - \frac{T_2}{T_1}$$

$$\therefore \frac{T_2}{T_1} = 1 - \eta' = 1 - \frac{44}{100} = \frac{56}{100}$$

$$T_1 = \frac{100}{56} T_2 = \frac{100}{56} \times 300 = 535.7\,K$$

∴ Increase in temp. of source

$= 535.7 - 500 = 35.7\,K$ Ans.

Thank you

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