① 1st case, $\eta = 30\% = 0.3$, $T_C = 300K$, $T_H = ?$

$\eta = 1 - \frac{T_C}{T_H}$ or $0.3 = 1 - \frac{300}{T_H}$ or $T_H = 428.57\ K$

2nd case, $\eta' = 50\% = 0.5$, $T_C' = 300K$, $T_H' = ?$

$\eta' = 1 - \frac{T_C'}{T_H'}$ or $0.5 = 1 - \frac{300}{T_H'}$ or $T_H' = 600K$

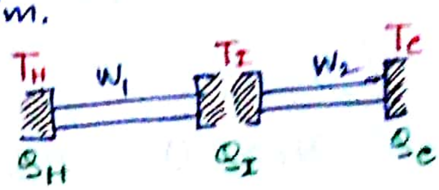
Increase in temperature of source $= 600 - 428.57 = 171.43\ K$

Carnot

Scanned by CamScanner

② $T_H = 600K$, $T_c = 300K$ $\quad \therefore \eta = 1 - \frac{T_c}{T_H} = 1 - \frac{300}{600} = 0.5 = 50\%$

According to Carnot's theorem, the maximum efficiency is 50% but the claim is 52%. So its not a valid claim.



③ (i) when work output is equal,

$W_1 = Q_H - Q_I$, $W_2 = Q_I - Q_c$

or $Q_H - Q_I = Q_I - Q_c$ or $\frac{Q_H}{Q_I} - 1 = 1 - \frac{Q_c}{Q_I}$

And $\frac{Q_H}{Q_I} = \frac{T_H}{T_I} = \frac{1200}{T_I}$, $\frac{Q_I}{Q_c} = \frac{T_I}{T_c} = \frac{T_I}{300}$

$\therefore \frac{1200}{T_I} - 1 = 1 - \frac{300}{T_I}$ or $T_I = 750K$

(ii) when efficiencies are equal, $\eta_1 = 1 - \frac{Q_I}{Q_H}$, $\eta_2 = 1 - \frac{Q_c}{Q_I}$

$\therefore 1 - \frac{Q_I}{Q_H} = 1 - \frac{Q_c}{Q_I}$ or $1 - \frac{T_I}{T_H} = 1 - \frac{T_c}{T_I}$ or $T_I^2 = T_c T_H$

or $T_I = \sqrt{T_c T_H} = 600K.$

④ Here $T_1 = 300K$, $T_2 = 273K$.

Points to remember,
80 Cal 1 gm ice melting.
80 Cal 1 gm water freezing
540 cal 1 gm water vapourization

$Q_1 = ?$, $Q_2 = 1000 \times 80 = 8 \times 10^4$ cal.

Heat rejected to room $\frac{Q_1}{Q_2} = \frac{T_1}{T_2}$ or $Q_1 = \frac{T_1}{T_2} Q_2 = \frac{300}{273} \times 8 \times 10^4$

$= 8.79 \times 10^4$ cal.

Work done by Refrigerator $W = Q_1 - Q_2$

$= (8.79 \times 10^4 - 8 \times 10^4) \times 4.2 J = 3.18 \times 10^4 J$

Coefficient of Performance $P = \frac{Q_2}{Q_1 - Q_2} = \frac{8 \times 10^4}{(8.79 - 8) \times 10^4} = 10.13$