Tutorial 3

Q1. $\eta = 1 - \frac{T_L}{T_H}$

$\eta = 1 - \frac{303}{973} = 0.6886$ //

Q2. $\frac{Q_L}{Q_H} = \frac{T_L}{T_H}$

$\frac{200}{300} = \frac{303}{T}$

$T = 454.5\ K$ //

Q3. $COP_{REF} = \frac{1}{\frac{Q_H}{Q_L} - 1}$

$= \frac{1}{\frac{1.5}{1.0} - 1}$

$\dot{Q}_H = 3 \times \frac{1800}{3600} = 1.5\ kW$

$\dot{Q}_L = \dot{Q}_H - \dot{W}_{in}$

$\dot{Q}_L = 1.0\ kW$

$COP_{REF} = \frac{1}{\frac{1.5}{1.0} - 1}$

$\dot{Q}_L = 3 \times \frac{1800}{3600} = 1.5\ kW$

$COP_{REF} = \frac{\dot{Q}_L}{W_{in}}$

$= \frac{1.5}{0.5}$

$COP_{REF} = 3$ //

Q4. Let the time taken be t seconds.

$\therefore \dot{Q}_L = \frac{mc\Delta\theta}{t} = \left(\frac{840}{t}\right) kW$

$COP_{REF} = \frac{\dot{Q}_L}{W_{in}}$

$2.5 = \frac{\left(\frac{840}{t}\right) \times 1000}{400}$

$t = 840\ s$ //

Q5. $W_{out} = \frac{55 \times 10^3}{3600} \times 27 \times \frac{20}{100}$

$= 82.5\ MW$ //

Q6. $COP_{REF,rev} = \frac{1}{1 - \frac{T_L}{T_H}} = \frac{1}{\frac{T_H}{T_L} - 1}$

$= \frac{1}{\frac{303}{253} - 1} = 5.06$

$\therefore COP_{REF} = 5.06 \times \frac{1}{4}$

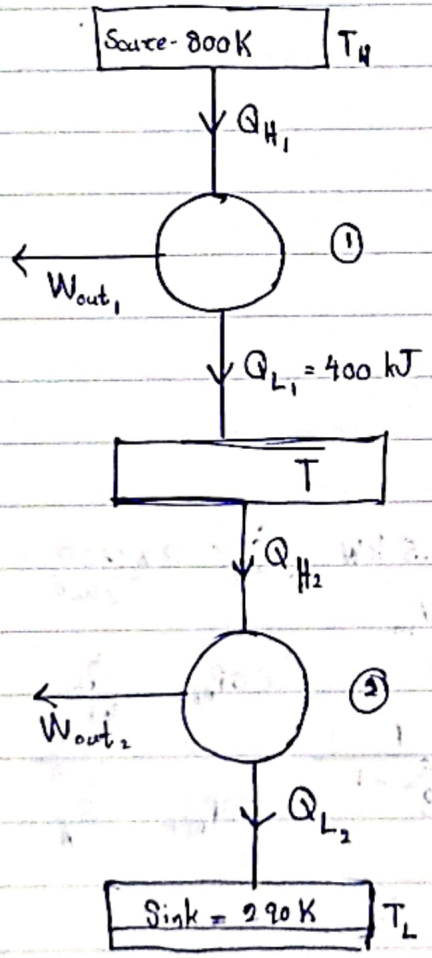
$= 1.265$

$COP_{REF} = \frac{Q_L}{W_{in}}$

$1.265 = \frac{\frac{30 \times 10^3}{60} \times 211}{W_{in}}$

$W_{in} = 83.4\ MW$ //

Q7.



(i) $\eta_1 = 1 - \frac{Q_L}{Q_H} = 1 - \frac{T}{800}$

$\eta_2 = 1 - \frac{290}{T}$

$\eta_1 = \eta_2$

$1 - \frac{T}{800} = 1 - \frac{290}{T}$

$T = 481.66\ K$ //

(ii) $\frac{Q_{L_1}}{Q_{H_1}} = \frac{481.66}{800}$

$Q_{H_1} = 664.37\ kJ$ //

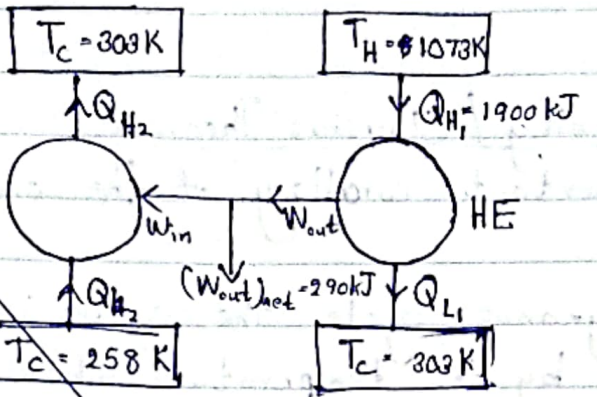
(iii) $W_{out_1} = Q_{H_1} - Q_{L_1} = 264.37\ kJ$ //

$\eta_1 = \eta_2 = 0.398$

$W_{out_2} = \eta_2 Q_{H_2}$

$W_{out_2} = 159.166\ kJ$ //

Q8.



$$\frac{Q_{H_1}}{Q_{L_1}} = \frac{T_H}{T_L}$$

$$\frac{1900}{Q_{L_1}} = \frac{1073}{303}$$

$$Q_{L_1} = 536.533\,kJ$$

$$W_{out} = 1363.467\,kJ$$

$$W_{in} = 1073.467\,kJ$$

$$Q_{H_2} = W_{in} + Q_{L_2} \quad \text{---(1)}$$

$$\frac{Q_{H_2}}{Q_{L_2}} = \frac{303}{258} \quad \text{---(2)}$$

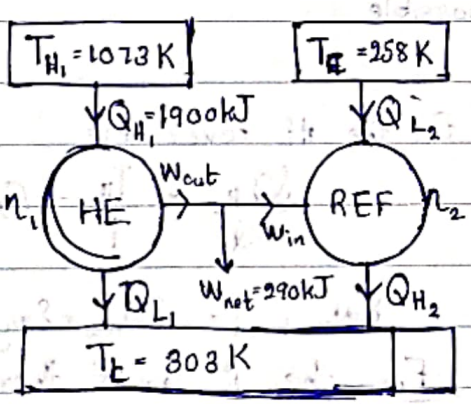
from (1), (2) $\quad \frac{303}{258} Q_{L_2} = 1073.467 + Q_{L_2}$

$$Q_{L_2} = 6154.544\,kJ$$

$$Q_{H_2} = 7228.011\,kJ$$

Eg,

Q8.



$$Q_{L_1} = 536.533\,kJ$$

~~$\eta_1 = \eta_2 ((\eta_{HE})_{rev})$~~

$$(\eta_{HE})_{rev}$$

$$\eta_{HE_{rev}} = 1 - \frac{303}{1073} = 0.7176$$

$$W_{out} = \eta_{HE_{rev}} Q_{H_1}$$

$$W_{out} = 1363.467\,kJ$$

$$W_{in} = W_{out} - W_{net}$$

$$W_{in} = 1073.467\,kJ$$

$$(COP)_{REF_{rev}} = \frac{1}{\frac{303}{258} - 1} = 5.7333$$

Heat transfer to the refrigerant, Q_{L_2}

$$Q_{L_2} = 6154.544\,kJ$$

$$5.7333 = \frac{Q_{L_2}}{1073.467}, \quad Q_{L_2} = 6154.544\,kJ$$

Total heat transfer to 30°C thermal reservoir, $Q_{H_2} = W_{in} + Q_{L_2} = 7228.011\,kJ$

$$Q_{total} = Q_{L_1} + Q_{H_2} = 7764.544\,kJ$$