Q1. An engine develops 80 kW of work output when heat supplied is at rate of 240 kW. Find effi. of engine & heat rejected to atmosphere. Draw, sketch? 1

Ans: Given;

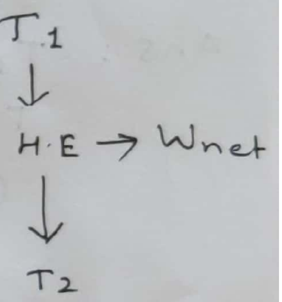
$W_{net} = 80\,kW$.

Q_1 = heat supplied = 240 kW or kJ/s

$$\therefore \eta_{Th} = \frac{\text{Work o/p}}{\text{Heat supplied}} = \frac{W_{net}}{Q_1} \times 100$$

$$= \frac{80}{240} \times 100$$

$$= \underline{\underline{33.3\,\%}}$$



$\therefore Q_2 =$

$W_{net} = Q_1 - Q_2$

$80 = 240 - Q_2$

$Q_2 = \underline{\underline{160\,kW}}$.

Q.2 A refrigerator with COP of 1.5 absorbs heat from food compartment at rate of 360 kJ/min. Draw sketch & find ① Power, ② heat rejected.

Ans. Given;

$[COP]_{ref} = 1.5$

$Q_2 = 360\,kJ/min$

$= \frac{360}{60}$

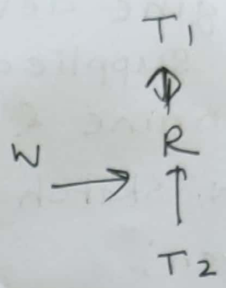
$= 6\cancel{0}\,kJ/s$.

$$[COP]_{ref} = \frac{Q_2}{W_{net}} = \frac{60}{W_{net}}$$

1.5

$W_{net} = \underline{\underline{3.333\,kW}}$.

$W_{net} = Q_1 - Q_2$



$Q_1 = 3.33 + 6$

$\underline{Q_1 = 9.33 \text{ kW}}$

$\therefore Q_1 = 9.33 \times 60$

$= \underline{559.98 \text{ kJ/min}}$

Q.3 A heat engine operates bet^w source & sink temp. of 225°C & 25°C resp. If heat engine receives 40 kW from source, find net work done by engine, heat rejected to sink by engine & η of engine. Draw sketch.

Ans : $T_1 = 225 + 273 = 498 \text{ K}$

$T_2 = 25 + 273 = 298 \text{ K}$

$Q_1 = 40 \text{ kW}$

$$\eta = \frac{W_{net}}{\text{Heat supplied}} = \frac{T_1 - T_2}{T_1} = \frac{498 - 298}{498}$$

$$= \underline{40.16\%}$$

Heat rejected.

$$\eta_{HE} = \frac{Q_1 - Q_2}{Q_1}$$

$$40.16 = \frac{40 - Q_2}{40}$$

$$Q_2 = 23.936 \text{ kW}$$

$W_{net} = Q_1 - Q_2$

$= 40 - 23.93$

$= \underline{16.064 \text{ kW}}$

Q.4. A household refrigerator with COP of 1.8 remove heat from refrigerated space at rate of 90 kJ/min. Determine, Electrical power consumed, Amount of heat rejected. 2

Ans. $COP_{ref} = 1.8$

$Q_2 = 90 \text{ kJ/min}$

$= \frac{90}{60}$

$= 1.5 \text{ kJ/s}.$

$$[COP]_{ref} = \frac{R.E}{Work} = \frac{Q_2}{Q_1 - Q_2}$$

$$= \frac{Q_2}{Work}$$

$$\begin{array}{c} T_1 \\ \uparrow \\ R \leftarrow W = Q_1 - Q_2 \\ \uparrow \\ T_2 \end{array}$$

$$Work = \frac{1.5}{1.8}$$

$$= \underline{\underline{0.833 \text{ kW}}}.$$

$Work = Q_1 - Q_2$

$0.83 = Q_1 - 1.5$

$Q_1 = \underline{\underline{2.33}} \text{ kW}.$

$Q_1 = \underline{\underline{139.80}} \text{ kJ/min}$

Q5 A heat pump is used to maintain house at 23°C. House is losing heat to outside air through walls at 60,000 kJ/hr. Heat generated by various appliances inside house is 4000 kJ/hr. for COP of 1.5, find power input in kW supplied to H.P?

Given;- Room temp = 23°C = 296 K

COP = 1.5

$Q_{out} = \frac{60,000}{3600} \text{ kJ/hr.} = 16.687 \text{ kJ/s}$

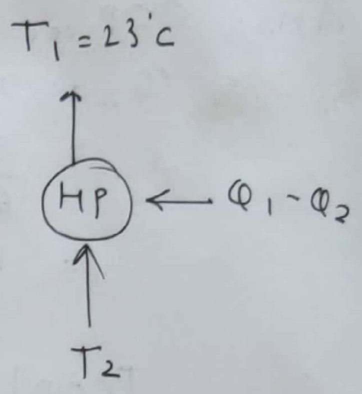
Heat generated by Heat appliances

$Q_{gen} = 4000 \text{ kJ/hr}$

$= \frac{4000}{3600}$

$= 1.1112 \text{ kJ/s}$

$= 1.112 \text{ kW}.$



Q_1 = Heat loss − Heat gen

$= \underline{\underline{15.555}} \text{ kJ/s}$

$= \underline{\underline{15.55}} \text{ kW}$

$[COP]_{HP} = \frac{Q_1}{W_{net}}$

$1.5 = \frac{15.555}{W_{net}}$

$\underline{\underline{W_{net} = 10.37 \text{ kW}}}$

Q.6 A reservoir heat engine working as refrigerator absorbed heat from loss temp. region of 650 KJ when work input is 250 KJ. Find COP & heat transfer to corresponding if reversed H.E works as heat pump. find COP. & η.

Given :- $Q_1 = Q_2 = \underline{\underline{650}} \text{ KJ}$

$W_{net} = \underline{250} \text{ KJ}$

$COP_R = \frac{Q_2}{W_{net}}$

$= \frac{650}{250} = \underline{\underline{2.6}}.$

$$W_{net} = Q_1 - Q_2$$

$$Q_1 = W_{net} + Q_2$$

$$= \underline{\underline{900 \text{ KJ}}}$$

$$[COP]_{HP} = [COP]_R + 1$$

$$= 2.6 + 1$$

$$= \underline{\underline{3.6}}$$

$$\eta_{HE} = \frac{W_{net}}{Q_4}$$

$$= \frac{250}{900}$$

$$= 0.2778 \quad \text{----- std formula.}$$

$$= 27.78\%$$

Given:

Q.7. A heat pump is used to maintain house at 24 °C. House is losing heat at 1800 kJ/min to surrounding. Heat pump is driven by an electric motor of power rating 12 kW.

Find, ⓐ amount of heat absorbed from surrounding.

ⓑ COP of heat pump.

ⓒ sketch.

Ans: $T_1 = 24\ °C = 24 + 273 = \underline{297\,K}$.

$Q_1 = 1800\ kJ/min$

$= \frac{1800}{60}$ $\qquad W = 12\ kW$

$= \underline{30\ kJ/s}$

$$COP_{HP} = \frac{Q_1}{Q_1 - Q_2}$$

$$= \frac{Q_1}{W}$$

$$= \frac{30}{12}$$

$$= \underline{2.5}$$

$W = Q_1 - Q_2$

$12 = 30 - Q_2$

$\boxed{Q_2 = 18\ kW}$

Q.8 A reversible heat engine develops 30 kW of work output with efficiency of 30%. Find heat supplied to engine & heat rejected from engine. If engine is reversed to act as given refrigerator with same rate of energy transfer, find its COP?

Ans: Given;

$$W = 30\,kW$$

$$\eta = 30\% = 0.30$$

$$\eta = \frac{W}{Q_1}$$

$$0.3 = \frac{30}{Q_1}$$

$$Q_1 = 100\,kW$$

$$\eta = \frac{Q_1 - Q_2}{Q_1}$$

$$0.3 = \frac{100 - Q_2}{100}$$

$$Q_2 = 70\,kW.$$

$$COP_{engine} = \frac{Q_2}{Q_1 - Q_2}$$

$$= \frac{70}{100-70}$$

$$= 2.33$$

Q.9. A fish freezing plant is to be maintained at $-10\,°C$. If power required to drive the plant is 30 kW & $COP_{Ref} = 3$. Find.

(a) heat sucked (absorbed) from freezing plant.

(b) heat rejected to sorrounding?

Given;

$T_2 = -10^{\circ}C = 263\ K.$

$W_{net} = 30kW$

$COP = 3.$

$\therefore COP = \frac{Q_1}{W_{net}}$

$Q_1 = 3 \times 30$

$= 90\ kW$

$W_{net} = Q_2 - Q_1$

$Q_2 = W_{net} + Q_1$

$Q_2 = 120\ kW$