HOMEWORK 8 SOLUTIONS

1. Auto engine (HE)

$$\dot{Q}_H = 28 \frac{\text{liters fuel}}{\text{hr}} * 0.8 \frac{\text{kg}}{\text{liter fuel}} * 44000 \frac{\text{kJ}}{\text{kg}} * \frac{1\,\text{hr}}{3600\,\text{s}} = 273.8\,\text{kW}$$

($\dot{V}$, ρ, q)

$$\dot{W}_{net} = 60\,\text{kW}$$

$$\eta = \frac{60\,\text{kW}}{273.8\,\text{kW}} = \boxed{21.9\%}$$

2. No. K-P only governs producing work from heat. Work can be produced from other forms of work (mechanical work from electricity and vice versa) or from potential / kinetic energy (hydropower), etc

3. HE, $\eta = 0.40$, $q_L = 1000\,\text{kJ/kg}$

$$\eta = 1 - \frac{q_L}{q_H} = 0.4 = 1 - \frac{1000}{q_H}$$

$$0.4 q_H = q_H - 1000$$

a) $$\boxed{q_H = 1{,}666.7 \frac{\text{kJ}}{\text{kg}}}$$

b) $$\eta = \frac{50\,\text{mW}}{\dot{m} q_H} = 0.4 = \frac{50\,\text{MW} \times 10^3\,\text{kW/MW}}{\dot{m}\,(1666.7)\,\text{kJ/kg}}$$

$$\boxed{\dot{m} = 75.0\,\text{kg/s}}$$

4. Refrigeration cycle

$$COP_R = \frac{\dot{Q}_L}{\dot{W}} \qquad \dot{Q}_{net} = \dot{W}_{net}$$

$$\dot{W} = 15000 - 22000 = -7000 \text{ kJ/hr}$$

$$COP_R = \left|\frac{15000}{7000}\right| = \boxed{2.14}$$

5. $COP_{HP} = \dfrac{\dot{Q}_H}{\dot{W}}$ $\qquad \dot{W} = 1.2\text{ kW}, \dot{m} = 0.018 \text{ kg/s}$

a) $COP_{HP} = \dfrac{0.018\frac{kg}{s}\left(180.98\frac{kJ}{kg}\right)}{1.2\text{ kW}}$ $\qquad q_H = h_2 - h_1$ @ 800 kPa

$h_1 = 276.45 \frac{kJ}{kg}$ (A-13)

$h_2 = 95.47 \frac{kJ}{kg}$ (A-12)

$-q_H = 276.45 - 95.47 = 180.98 \frac{kJ}{kg}$

$COP_{HP} = \boxed{2.71}$

b) $\dot{Q}_L = -1.2\text{kW} - (-180.98)(0.018) = \boxed{2.06\text{ kW}}$

6. $\eta_{carnot} = 0.3$ $\qquad \dot{m} = 3 \text{ kg/s}$

$q_H = h_{fg}$ @ 275°C = 1574.5

$$\dot{W}_{net} = (\dot{m} q_H)\eta = 3\text{kg}\left(1574.5\frac{kJ}{kg}\right)(0.3)$$

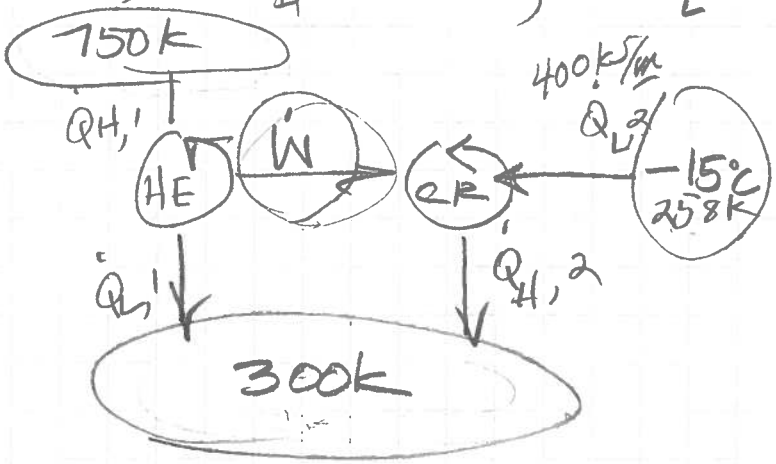
$$= 1417 \text{ kW}$$

$$\eta_{carnot} = 1 - \frac{T_L}{T_H} = 1 - \frac{T_L}{(273+275)} = 0.3$$

$-T_L = 0.3(548) - 548$, $T_L = 0.7(548) = 383.6\text{k}$

$= 110.6°C$

7. CHE, $T_H = 750K$, $T_L = 300K$



$$\eta = 1 - \frac{T_L}{T_H} = 1 - \frac{300}{750} = 0.60$$

$$COP_R = \frac{1}{\frac{T_H}{T_L} - 1} = \frac{1}{\left(\frac{300}{258}\right) - 1} = 6.14$$

$$6.14 = \frac{400\ kJ/min}{\dot{W}}, \quad W_1 = 65.1\ kJ/min$$

$$= 1.09\ kW$$

a) $$0.60 = \frac{1.09\ kW}{\dot{Q}_H}, \quad \dot{Q}_H = \boxed{1.81\ kW}$$

$Q_H + Q_L = W$

b) CR: $\dot{Q}_{H2} = \dot{W} - \dot{Q}_{L2} = -1.09\ kW - \left(\frac{400}{60}\right) = -7.76\ kW$

HE $\dot{Q}_{L1} = \dot{W} - \dot{Q}_{H1} = 1.09\ kW - 1.81\ kW$

$$= -0.72\ kW$$

$$\dot{Q}_{rejected} = -7.76 - 0.72 = \boxed{-8.48\ kW}$$