Solutions:

1)(a)F b)T c) F d) T e)T

2) First the required work by the Carnot air-conditioning cycle is

W_ref= Q_air_L/ COP

Where COP = 1/(308/293-1) -→ W_ref= 600 MJ * (308/293-1)= 30.72 MJ

For the Carnot heat engine:

Thermal efficiency = 1- 308/573 = W_engine/ Q_engine_H

→Q_engine_H= W_engine / Thermal Efficiency = 30.72/ (1-308/573)=66.42 MJ

3) a) Thermal efficiency = 1- Q_{out}/Q_{in}

$$Q_{in} = \int_1^2 Tds + \int_2^3 Tds = 0 + \frac{500+300}{2}(0.3-0.1) = 80kJ$$

$$Q_{out} = \left|\int_3^4 Tds\right| + \left|\int_4^1 Tds\right| = \frac{500+100}{2}(0.3-0.25) + 100(0.25-0.1) = 30kJ$$

Thermal efficiency = 1- 30/80=0.625

b)

$$S_3 - S_2 = \Delta S_{23} = C_p \ln(\frac{T_3}{T_2}) - R\ln(\frac{P_3}{P_2})$$

$$-> \ln(\frac{P_3}{P_2}) = \frac{C_p}{R}\ln(\frac{T_3}{T_2}) - \frac{\Delta S_{23}}{R} = \frac{1.0}{0.3}\ln(\frac{500}{300}) - \frac{0.3-0.1}{0.3} = 1.036$$

$$-> \frac{P_3}{P_2} = 2.818$$

4) From superheated steam table, state 1: h1=3658.4 kJ/kg, s1=7.1677 kJ/kg-K.

Based on 1st law-> w= h1-h2 +q ; h2= h1-w-q = 3658.4- 1000 –200 =2458.4 kJ/kg

Check the saturation table at 10kpa, T=45.81 C; hf= 191.83 kJ/kg; hg=2584.7 kJ/kg, hfg=2392.82 kJ/kg; sf=0.6493 kJ/kg-K; sfg=7.5009 kJ/kg-K

Therefore the exit state is a saturated mixture of vapor and liquid.

For steady-state flow, s_gen= s2 –s1 – q/T_air

Need to find the quality at exit so that s2 can be determined.

Quality at exit: x = (h-hf)/hfg= (2458.4 – 191.83)/ 2392.8= 0.9472

s2=sf+ x* sfg= 0.6493 + 0.9472 *7.5009= 7.754 kJ/kg-K

s_gen= s2 –s1 – q/T_air= 7.754 – 7.1677 –(-200kJ/kg)/298K =1.2574 kJ/K

The mass flow rate is 1kg/s -> entropy generation rate = 1.2574 kJ/K-s