Problem 1
Consider a Carnot refrigeration cycle executed in a closed system in the saturated liquid–vapor mixture region using \( m = 0.96 \text{ kg} \) of refrigerant-134a as the working fluid. It is known that the maximum absolute temperature in the cycle is 1.2 times the minimum absolute temperature, and the net work input to the cycle is \( W_{\text{net in}} = 22 \text{ kJ} \).

1- If the refrigerant changes from saturated vapor to saturated liquid during the heat rejection process, determine the minimum pressure \( P_{\text{min}} \) in the cycle

[solution: \( P_{\text{min}} = 356 \text{ kPa} \)]

2- Using Matlab or Excel, plot the minimum pressure in the refrigeration cycle as a function of the net work input (\( 10 < W_{\text{net in}} < 30 \text{ kJ} \)) and discuss the results

Problem 2
A Carnot heat engine receives heat at \( T_H = 900 \text{ K} \) and rejects the waste heat to the environment at \( T_L = 300 \text{ K} \). The entire work output of the heat engine is used to drive a Carnot refrigerator that removes heat from the cooled space at \( T_c = -15^\circ \text{C} \) at a rate of \( \dot{Q}_c = 250 \text{ kJ/min} \) and rejects it to the same environment at \( T_L = 300 \text{ K} \).

1- Determine the rate of heat supplied to the heat engine (\( \dot{Q}_{H,HE} \))

2- Determine the total rate of heat rejection to the environment (\( \dot{Q}_{\text{rej}} \))

[solution: \( \dot{Q}_{\text{rej}} = 311 \text{ kJ/min} \)]

Problem 3
An insulated piston–cylinder device contains \( V = 5 \text{ L} \) of saturated liquid water at a constant pressure \( P = 150 \text{ kPa} \). An electric resistance heater inside the cylinder is now turned on, and an amount \( Q_{\text{elec}} = 2200 \text{ kJ} \) of energy is transferred to the steam.

Determine the entropy change of the water during this process [solution: \( \Delta S = 5.72 \text{ kJ/K} \)]