1. Consider the Carnot cycle occurring in a piston-cylinder device containing refrigerant-12 with operating conditions given below:

**Process A:** Isothermal heat addition at \( T_H = 30^\circ C \) to convert saturated liquid to saturated vapor

**Process B:** Isentropic and adiabatic expansion to \( T_L = -20^\circ C \)

**Process C:** Isothermal heat removal at \(-20^\circ C\)

**Process D:** Isentropic and adiabatic compression back to the initial state

With R-12 as the working fluid for this cycle calculate the thermal efficiency using

\[
\eta_{th} = \frac{W_{net}}{Q_{in}}
\]

Compare this to the ideal Carnot cycle efficiency given by

\[
\eta_{Carnot} = 1 - \frac{T_L}{T_H}
\]