Problem statement:

The compression ratio of an air-standard Otto cycle is 9.5. Prior to the isentropic compression process, the air is at 100kPa, 35°C, and 600 cm³. The temperature at the end of the isentropic expansion process is 800 K. Determine the highest temperature and pressure in the cycle; the amount of heat supplied per cycle (in kJ); the thermal efficiency; and the mean effective pressure. Perform the calculations assuming 1) cold air standard conditions and 2) air standard conditions.
Given:

Otto cycle, \( r = 9.5 \)

State 1:
\( p_1 = 100 \text{ kPa}; \ T_1 = 35^\circ \text{C}; \ V_1 = 600 \text{ cc} \)

State 4:
\( T_4 = 800 \text{ K} \)

Assumptions: 
Method 1) cold air standard 
Method 2) air standard

To find:

a) \( T_{\text{max}}, \ P_{\text{max}} \)  
b) \( Q_H (\text{kJ}) \)  
c) \( \eta_{th} \)  
d) MEP
Solution:

System mass:

Method 1) Cold air standard

Isentropic process(1 – 2), ideal gas:
Isentropic process (3 – 4), ideal gas:

Note that $T_{\text{max}} = T_3 = 1970\text{K}$

$\therefore p_{\text{max}} = ?\text{kPa}$
Heat transferred:

First law: \( U_3 - U_2 = Q_{2-3} - W_{2-3} \)

but,

\( Q_H = ? \) ←
By the same logic,

\[ Q_c = ? \]

Conservation of energy,

Efficiency of a heat engine,

\[ \eta = \frac{W}{Q_H} = ? \]
Mean effective pressure (MEP)
Method 2) Air standard

Recall system mass, \( m = 6.79 \times 10^{-4} \text{ kg} \)

Recall BDC volume, \( V_1 = V_4 = 6.00 \times 10^{-4} \text{ m}^3 \)

Recall TDC volume, \( V_1 = V_4 = 6.32 \times 10^{-5} \text{ m}^3 \)

Isentropic process \((1 \rightarrow 2)\), ideal gas:

\[
\frac{v_r(T_2)}{v_r(T_1)} = \frac{v_2}{v_1} = ?
\]

Interpolating from the table for ideal gas properties for air:

\( T_1 = 308 K \Rightarrow u(T_1) = ? \text{kJ/kg} \) and \( v_r(T_1) = ? \)

\( v_r(T_2) = ? \)

\[ \Rightarrow T_2 = ? K \quad \text{and} \quad u(T_2) = ? \text{kJ/kg} \]
Isentropic process (3 - 4), ideal gas:

\[ \frac{v_r(T_3)}{v_r(T_4)} = \frac{v_3}{v_4} = \frac{1}{r} \]

From the table for ideal gas properties for air:

\[ T_4 = 800K \Rightarrow u(T_4) = ? \]

\[ v_r(T_3) = ? \quad \Rightarrow T_3 = ?K \quad \& \quad u(T_3) = ?kJ/kg \]

and

\[ v_r(T_4) = ? \]
T_{max} = T_{3} = ? K \leftarrow

\begin{align*}
p_{\text{max}} &= p_{3} = \frac{mRT_{3}}{V_{3}} = ? \\
\Rightarrow p_{\text{max}} &= ? \text{kPa} \leftarrow
\end{align*}

Heat added per cycle:

\[ Q_{H} = ? \text{kJ/kg} \]
Cycle efficiency:

$$\eta_{th} = 1 - \frac{Q_C}{Q_H} = ?$$

Mean effective pressure:

$$MEP = \frac{W}{V_1 - V_2} = ? \text{kPa}$$