$M = 120\ mg\ He \Rightarrow n = \frac{.120\ g}{4\ g/mole} = 0.03$ moles

Monatomic $\Rightarrow C_V = \frac{3}{2}R$ and $C_p = \frac{5}{2}R$

a.) at 1:

$P_1 = 1\ atm = 1.013\times10^5\ Pa$

$V_1 = 1000\ cm^3 = 1000\times10^{-6}\ m^3$

$T_1 = \frac{P_1 V_1}{nR} = 406.3\ K$

at 2:

$V_2 = V_1$

$P_2 = 5\ atm = 5.065\times10^5\ Pa$

$T_2 = \frac{P_2 V_2}{nR} = 2032\ K$

at 3:

$T_3 = T_2$

$P_3 = P_1$

$V_3 = V_{max} = \frac{nRT_3}{P_3} = 5\times10^{-3}\ m^3$

b.) $\underline{1 \to 2}$ $\quad W_s = 0$

$$\Delta E_{th} = Q = n c_v \Delta T = \frac{3}{2} nR(T_2 - T_1)$$

$$= 607.9 \text{ J.}$$

$\underline{2 \to 3}$ $\quad \Delta E_{th} = 0$

So, $W_s = Q = \int_{V_2}^{V_3} P\,dV = nRT_2 \ln\left(\frac{V_3}{V_2}\right)$

$$W_s = Q = 815.3 \text{ J.}$$

$\underline{3 \to 1}$ $\quad \Delta E_{th} = n c_v \Delta T = \frac{3}{2} nR(T_1 - T_3)$

$$= -607.9 \text{ J.}$$

$$Q = n c_p \Delta T = \frac{5}{2} nR(T_1 - T_3)$$

$$= -1013 \text{ J.}$$

$$W_s = P\Delta V = P_1(V_1 - V_3) = -405.2 \text{ J.}$$

Now, $W_{out} = W_{12} + W_{23} + W_{31} = 410.1 \text{ J.}$

$Q_H = |Q_{12}| + |Q_{23}| = 1423 \text{ J.}$

$\therefore \quad \eta = \frac{W_{out}}{Q_H} = 0.288 = \underline{28.8\%}$

c.) $T_H = T_{max} = T_2 = 2032 \text{ K}$

$T_C = T_{min} = T_1 = 406.3 \text{ K}$

$\therefore \quad \eta_C = 1 - \frac{T_C}{T_H} = \underline{0.80 = 80\%}$