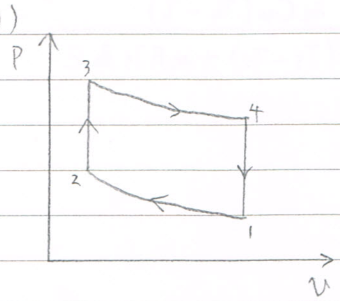
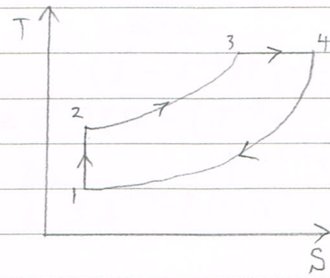
Date . . No.

熱力学 4回目

[1] (1)





(2) ・2 → 3：定容変化より，$dv = 0$

熱力学第一法則より，$dq = du + pdv$ より

$dq = du$

$\therefore Q_1 = Q_{23} = \boxed{mC_v(T_3 - T_2)}$

・3 → 4；等温変化より，$dT = 0$

$dq = du + pdv$ より，$dq = pdv$

$\therefore Q_2 = Q_{34} = \int_3^4 Pdv = p_3v_3\int_3^4 \frac{dv}{v} = p_3v_3 \ln\left(\frac{v_4}{v_3}\right) = mRT_3 \ln\left(\frac{v_1}{v_2}\right) = \boxed{mRT_3 \ln \varepsilon}$

・4 → 1；定容変化より，$dv = 0$

$dq = du + pdv$ より，$dq = du$

$\therefore Q_3 = -Q_{41} = \boxed{mC_v(T_4 - T_1)}$

(3) ・1 → 2；断熱変化より，$dq = 0$

$pv^\kappa = const$；理想気体の状態方程式；$pv = mRT \rightarrow p = mRT/v$ より，

$Tv^{\kappa-1} = const$

$T_1v_1^{\kappa-1} = T_2v_2^{\kappa-1}$

$T_2 = \left(\frac{v_1}{v_2}\right)^{\kappa-1} T_1 = \varepsilon^{\kappa-1} T_1$

・2 → 3；定容変化より，$dv = 0$

$T/p = const$ より，

$T_2/p_2 = T_3/p_3$

$T_3 = \frac{p_3}{p_2} T_2 = \xi\varepsilon^{\kappa-1} T_1$

・3 → 4；等温変化より，$dT = 0$

$\rightarrow T_4 = T_3 = \xi\varepsilon^{\kappa-1} T_1$

$$\eta_{th} = \frac{W}{Q} = \frac{Q_1+Q_2-Q_3}{Q_1+Q_2} = 1-\frac{Q_3}{Q_1+Q_2} = 1-\frac{mC_v(T_4-T_1)}{mC_v(T_3-T_2)+mRT_3\ln\varepsilon}$$

$$= 1-\frac{\frac{R}{\kappa-1}(\xi\varepsilon^{\kappa-1}T_1 - T_1)}{\frac{R}{\kappa-1}(\xi\varepsilon^{\kappa-1}T_1-\varepsilon^{\kappa-1}T_1)+R\xi\varepsilon^{\kappa-1}T_1\ln\varepsilon}$$

$$= \boxed{1-\frac{\xi\varepsilon^{\kappa-1}-1}{\varepsilon^{\kappa-1}(\xi-1)+(\kappa-1)\xi\varepsilon^{\kappa-1}\ln\varepsilon}}$$

(4) $$\eta_{th} = 1-\frac{2.0\cdot 10^{1.4-1}-1}{10^{1.4-1}(2.0-1)+(1.4-1)\cdot 2.0\cdot 10^{1.4-1}\ln 10}$$

$$= 1-\frac{2.0\cdot 2.5-1}{2.5\cdot 1+0.4\cdot 2.0\cdot 2.5\cdot 2.3}$$

$$= 1-\frac{4}{2.5+4.6} \fallingdotseq 1-0.563 = 0.437 \fallingdotseq \boxed{0.44}$$

[2] (1) $T_1 = 212.37\,(^\circ C)$, $s_1 = 2.44686\,(kJ/kgK)$

(2) $T_2 = T_1 = 212.37\,(^\circ C)$

$T_{s2} = 179.88 < T_2 \longrightarrow \boxed{過熱蒸気}$

(3) $T_2' = 210\,(^\circ C)$, $s_2' = 6.7427$

$T_2'' = 220\,(^\circ C)$, $s_2' = 6.7911$

$x_2 = \frac{T_2-T_2'}{T_2''-T_2'} = 0.237 \longrightarrow s_2 = 6.7556\,(kJ/kgK)$

$s_3 = s_2 = 6.7556$

$s_3' = 0.15099$, $s_3'' = 8.90196$ $\quad s_3' < s_3 < s_3'' \longrightarrow \boxed{湿り蒸気}$

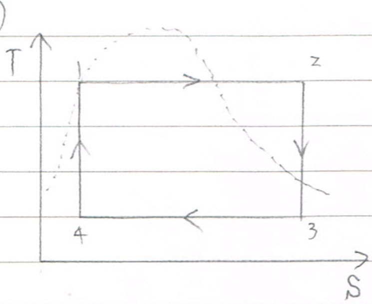
$P_3 = P_s = \boxed{1.2270\,(kPa)}$

(4) $T_4 = 10\,(^\circ C)$, $s_4 = s_1 = 2.44686\,(kJ/kgK)$

$s_1' = 0.15099$, $s_1'' = 8.90196$

$s_1' < s_1 < s_1''$ より, $\boxed{湿り蒸気}$

(5)



$\boxed{\text{カルノーサイクル}}$

[3] (1) 開いた系のエネルギ式より,

$$m\left(h_1 + \frac{1}{2}w_1^2\right) = m\left(h_2 + \frac{1}{2}w_2^2\right)$$

$$\therefore w_2 = \boxed{\sqrt{2(h_1 - h_2) + w_1^2}}$$

(2) ジュール・トムソン効果, 下降する

(3) $m\left(h_1 + \frac{1}{2}w_1^2\right) = m\left(h_2 + \frac{1}{2}\cdot 0^2\right)$

$$\frac{1}{2}w_1^2 = h_2 - h_1$$

$h_2 - h_1 = C_p \Delta T$ より

$$C_p \Delta T = \frac{1}{2}w_1^2$$

$$\therefore \Delta T = \boxed{\frac{w_1^2}{2C_p}}$$