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H30 熱力学

[1] (ア) $PV^n = P_1V_1^n = P_2V_2^n = \text{const}$

$m = 1\,\text{kg}$, R, C_v, $\kappa = \text{const}$

$$W_{12} = \int_1^2 p\,dv = P_1v_1^n \int_1^2 \frac{dv}{v^n}$$

$$= P_1v_1^n \frac{1}{1-n}\left(\frac{1}{V_2^{n-1}} - \frac{1}{V_1^{n-1}}\right)$$

$$= \frac{1}{n-1}(P_1V_1 - P_2V_2)$$

$$\left(= \frac{R}{n-1}(T_1 - T_2) = \frac{\kappa-1}{n-1} C_v (T_1 - T_2) \right.$$

$$\left. = \frac{\kappa-1}{n-1}(u_1 - u_2) \right)$$

$\frac{C_p}{C_v} = \kappa$

$C_p - C_v = R$ より

$(\kappa-1)C_v = R$

$$Q_{12} = (u_2 - u_1) + W_{12}$$

$$= C_v(T_2 - T_1) + \frac{R}{n-1}(T_1 - T_2)$$

$$= C_v(T_2 - T_1) - \frac{\kappa-1}{n-1} C_v (T_2 - T_1)$$

$$= \frac{n-\kappa}{n-1} C_v (T_2 - T_1)$$

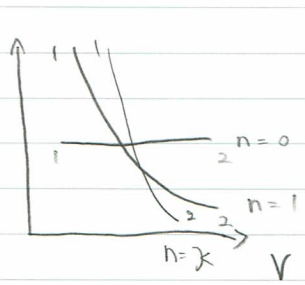
(2) $C = \frac{n-\kappa}{n-1} C_v$

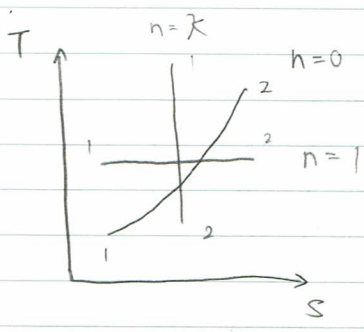
(3)

$$\Delta S = S_2 - S_1 = \int_1^2 \frac{dQ}{T} = \int_1^2 \frac{C}{T}\,dT$$

$$= C \ln \frac{T_2}{T_1}$$

(4)





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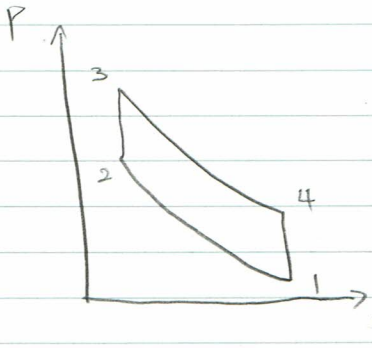
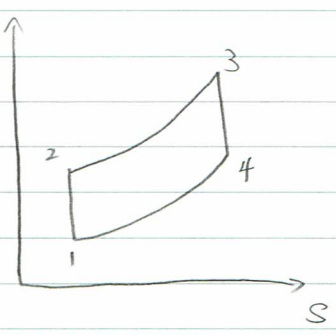
[2] (1)





(2) 供給熱量を Q_1, 放熱量を Q_2 とすると

$$Q_1 = Q_{23} = mC_v(T_3 - T_2)$$
$$Q_2 = Q_{41} = mC_v(T_4 - T_1)$$

(3) $\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\kappa-1}$ より $T_2 = T_1\varepsilon^{\kappa-1}$

また $\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\kappa-1} = \left(\frac{V_4}{V_3}\right)^{\kappa-1} = \frac{T_3}{T_4}$ より $T_3 = T_1\left(\frac{P_3}{P_2}\right)\varepsilon^{\kappa-1}$, $T_4 = \left(\frac{P_3}{P_2}\right)T_1$

(4) $\eta_{th} = 1 - \frac{Q_2}{Q_1} = 1 - \frac{T_4 - T_1}{T_3 - T_2} = 1 - \frac{T_1\left(T_4/T_1 - 1\right)}{T_2\left(T_3/T_2 - 1\right)}$

$$= 1 - \frac{T_1}{T_2} = 1 - \frac{1}{\varepsilon^{\kappa-1}}$$

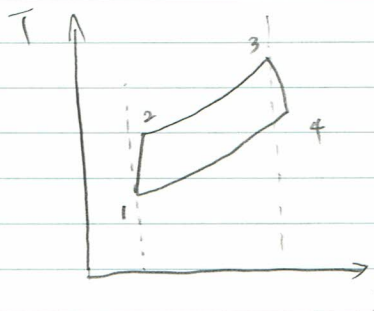
(5) $C_v = a + bT$

$S_2 - S_1 = 0$

$S_3 - S_2 = \int \frac{dQ}{T} = \int_2^3 \frac{mC_v}{T}dT = m\left(\int_2^3 \frac{a}{T}dT + \int_2^3 b\,dT\right)$

$= m\{a\ln\frac{T_3}{T_2} + b(T_3 - T_2)\}$

(6)



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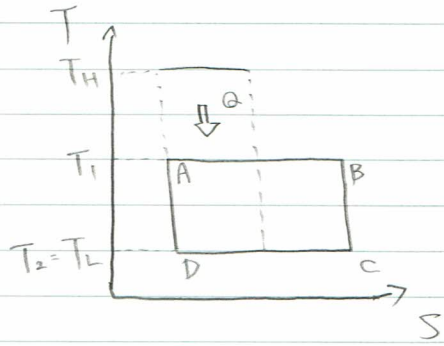
[3] (1)

$$\eta_{th} = 1 - \frac{Q_2}{Q_1} = 1 - \frac{T_2}{T_1} = 1 - \frac{300}{500} = \frac{2}{5} = 0.4$$

$$W_{12} = Q\eta_{th} = 5000 \times 0.4 = 2000\ kJ$$



(2) $$\eta_{th} = 1 - \frac{300}{1500} = \frac{4}{5} = 0.8$$

$$W_{12} = Q\eta_{th} = 5000 \times 0.8 = 4000\ kJ$$

(3) $$\eta_{ex} = \frac{0.4}{0.8} = 0.5$$

(4) $\eta_{ex} = \frac{e}{Q}$ より

$$e = 0.5 \times 5000 = 2500$$

$$b = 5000 - 2500 = 2500$$

?