10.8

(1) $pV^{\gamma} = C$

$T = \dfrac{P_0 V_0}{\nu R} = 324.91\ K$

$P_0 V_0^{1.4} = P_m \left(\frac{1}{2} V_0\right)^{1.4}$

$\Rightarrow P_m = 2^{1.4} \times P_0 = 5.28\ atm$

$\dfrac{P_0 V_0}{T} = \dfrac{P_m \frac{1}{2} V_0}{T_2} \Rightarrow T_2 = T \cdot \dfrac{\frac{1}{2} P_m}{P_0} = 2^{0.4} \times 324.91 = 428.73K$

(2)

$\Delta E = \frac{i}{2} \nu R \Delta T = 6.48 \times 10^3 J$

$Q = \int_1^2 p dV + \int_2^3 p dV$

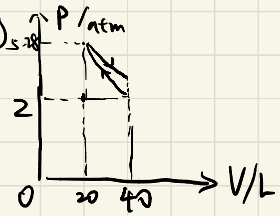
$= \int_1^2 \dfrac{P_0 V_0^{1.4}}{V^{1.4}} dV + \int_2^3 \dfrac{\nu R T}{V} dV$

$= \dfrac{-1}{0.4} \left(V_2^{-0.4} - V_1^{-0.4}\right) + \nu R T_2 \ln \dfrac{V_3}{V_2}$

$= 7.4 \times 10^3 J$

$A = Q - \Delta E = 9.3 \times 10^2 J$

(3)



10.9

(1) $T_1 = \dfrac{P_1 V_1}{\frac{m}{M} R} = 390K$

$\Rightarrow T_2 = T_1 = 390K$

$P_2 = P_1 \dfrac{V_1}{V_2} = \frac{4}{3} atm$

$P_2 V_2^{1.4} = P_3 V_3^{1.4}$

$\Rightarrow P_3 = 0.65\ atm$

$T_3 = \dfrac{P_3 V_3}{\frac{m}{M} R} = 317K$

(2) $\Delta E = \frac{i}{2} \nu R \Delta T$

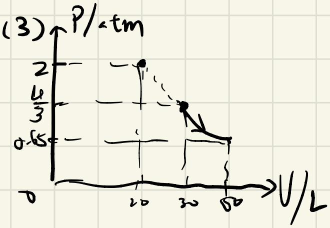
$= \frac{5}{2} \nu R \times (T_3 - T_2)$

$= -1.9 \times 10^3 J$

绝热，$Q = 0$

$\Rightarrow A = -\Delta E = 1.9 \times 10^3 J$

(3)



10.16

(1) $P_A V_A^{1.4} = P_{A0}(V_{A0})^{1.4} = 4.2\times10^2$

$P_A = P_B$, $V_A + V_B = 0.04m^2$

$\Rightarrow P_B(0.04-V_B)^{1.4} = 4.2\times10^2$

$P_B V_B = \nu R T_B \longrightarrow \frac{4.2\times10^2}{(0.04-V_B)^{1.4}} V_B = 1\times8.314\times T_B$

$\Rightarrow T_B(0.04-V_B)^{1.4} = 50.5\,V_B$

(2) 最后：$V_B = 0.03\,m^3$，$V_A = 0.01m^3$

代入得：$T_B = 965\,K$，$T_A = \left(\frac{V_{A0}}{V_A}\right)^{\gamma-1} T_{A0} = \left(\frac{V_{A0}}{V_A}\right)^{\gamma-1}\cdot\frac{P_{A0}V_{A0}}{\nu R}$

$= 322K$

(3) $\Delta E = \frac{5}{2}\nu R\,\Delta T = \frac{5}{2}\times1\times8.314\times\left(965 - \frac{1.013\times10^5\times0.02}{1\times8.314}\right) = 14992\,J$

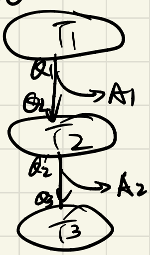
$A = \int_0^1 P_B\,dV_B = 4.2\times10^2\int_{0.02}^{0.03}\frac{1}{(0.04-V_B)^{1.4}}\,dV_B$

$= 4.2\times10^2\times\frac{-1}{0.4}(0.04-V_B)^{-0.4}\Big|_{0.03}^{0.02}$

$= 1604\,J$

$Q = \Delta E + A = 1.66\times10^4\,J$

10.20



$T_1 > T_2 > T_3$

① $\eta = \frac{A_1+A_2}{Q_1}$

$\eta_1 = \frac{A_1}{Q_1}$

$\eta_2 = \frac{A_2}{Q_2}$

$\eta_1 + (1-\eta_1)\eta_2$

$= \frac{A_1}{Q_1} + \frac{\cancel{Q_1-A_1}}{Q_1}\cdot\frac{A_2}{\cancel{Q_2}}$

$= \frac{A_1+A_2}{Q_1} = \eta$

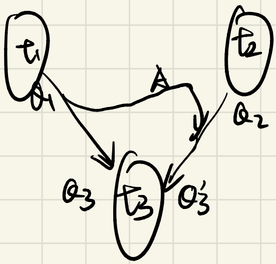
② $\eta = 1 - \frac{T_3}{T_1}$

$\eta_1 = 1-\frac{T_2}{T_1}$，$\eta_2 = 1-\frac{T_3}{T_2}$

$\eta_1 + (1-\eta_1)\eta_2$

$= 1-\frac{T_2}{T_1} + \frac{T_2}{T_1}\cdot\left(1-\frac{T_3}{T_2}\right) = 1-\frac{T_3}{T_1} = \eta$

10.24



$$\left.\begin{aligned} Q_1 &= 3.34\times10^7\ J \\ \eta_1 &= 1-\frac{T_3}{T_1} = 0.3 \end{aligned}\right\} \Rightarrow \begin{aligned} A &= 1.0\times10^7\ J \\ Q_3 &= 2.34\times10^7\ J \end{aligned}$$

$$w = \frac{T_2}{T_3-T_2} = 6.4 = \frac{Q_2}{A} \Rightarrow Q_2 = 6.4\times10^7\ J$$

$$Q_3' = Q_2 + A = 7.4\times10^7\ J$$

$$\Rightarrow Q_{3总} = 9.8\times10^7\ J$$

11.1

$$A = S_{abc} = 13\times10^5\times10^{-3}\ J = 1.3\times10^3\ J$$

$$Q = \Delta E + A = \frac{3}{2}\nu R\Delta T + A$$

$$= \frac{3}{2}(P_cV_c - P_aV_a) + A = 2.8\times10^3\ J$$

$$\Delta S = \int_a^c \frac{dQ}{T} = \int_a^c \frac{3}{2}\nu R\frac{dT}{T} + \int_a^c \frac{p\,dV}{T} = \frac{3}{2}\nu R\ln\frac{T_c}{T_a} + \int_a^c \frac{\nu R\,dV}{V}$$

$$= \frac{3}{2}\nu R\ln\frac{T_c}{T_a} + \nu R\ln\frac{V_c}{V_a}$$

$$= \frac{3}{2}\nu R\ln\frac{P_cV_c}{P_aV_a} + \nu R\ln\frac{V_c}{V_a}$$

$$= 23.5\ J/K$$

11.2

冰升温

$$\Delta S_1 = \int_1^2 \frac{dQ}{T} = \int_1^2 \frac{c_1 m\,dT}{T} = c_1 m\ln\frac{T_2}{T_1}$$

冰熔化

$$\Delta S_2 = \int_2^3 \frac{dQ}{T} = \frac{1}{T_2}\cdot\lambda m$$

水升温

$$\Delta S_3 = \int_3^4 \frac{dQ}{T} = c_2 m\ln\frac{T_4}{T_3}$$

水汽化

$$\Delta S_4 = \int_0^5 \frac{dQ}{T} = \frac{1}{T_4}Lm$$

$$\Delta S = \Delta S_1 + \Delta S_2 + \Delta S_3 + \Delta S_4 = 2083\ J/K$$

11.5

$$\text{速率}=\frac{dS}{dt}=\int\frac{dQ}{dt\,T}=\frac{W}{T}=70\ \mathrm{J/(K\cdot s)}$$

11.6

$$\frac{dS}{dt}=\frac{W}{T}=\frac{(1500\times10^3)\times9.8\times74}{273+12}=3.8\times10^6\ \mathrm{J/K}$$

11.7

(1) $\Delta S_{水}=\int\frac{dQ}{T}=c_{水}\times1\times\ln\frac{273+100}{273}=1306\ \mathrm{J/K}$

$$\Delta S_{库}=\int\frac{dQ}{T_{100}}=\frac{-cm(T_{100}-T_0)}{T_{100}}=\frac{-4.18\times10^3\times1\times100}{373}=1121\ \mathrm{J/K}$$

$\Delta S=\Delta S_{水}+\Delta S_{库}=185\ \mathrm{J/K}$

(2)

$$\left.\begin{aligned}\Delta S_{水1}&=c_{水}m\ln\frac{T_2}{T_1}\\ \Delta S_{水2}&=c_{水}m\ln\frac{T_3}{T_2}\\ \Delta S_{库1}&=\frac{-c_{水}m(T_2-T_1)}{T_2}\\ \Delta S_{库2}&=\frac{-c_{水}m(T_3-T_2)}{T_3}\end{aligned}\right\}\Rightarrow \Delta S=\Delta S_{水1}+\Delta S_{水2}+\Delta S_{库1}+\Delta S_{库2}=98\ \mathrm{J/K}$$

11.8

(1) $Q=-\lambda\Delta m$

$$\Delta S_{水冰}=\int\frac{dQ}{T}=\frac{1}{T}Q=\frac{-\lambda\Delta m}{T}=-1.1\times10^3\ \mathrm{J/K}$$

$$\Delta S_{库}=\frac{-Q}{T}=\frac{\lambda\Delta m}{T}=1.1\times10^3\ \mathrm{J/K}$$

$\Delta S=0$

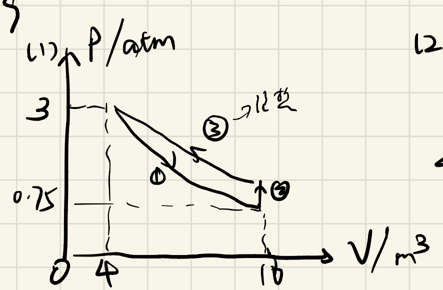
$$\frac{i+2}{i}-1=\frac{2}{i}$$

(2) $\Delta S'_{库}=\frac{-Q}{T'}=-8.1\times10^2\ \mathrm{J/K}$

$\Delta S=\Delta S_{水冰}+\Delta S'_{库}=2.9\times10^2\ \mathrm{J/K}$

11.9

(1)



(2) $A_1=\nu RT_1\ln\frac{V_2}{V_1}=1.7\times10^6\ \mathrm{J}$

$\Delta S_1=\frac{Q}{T_1}=\nu R\ln\frac{V_2}{V_1}=5.6\times10^3\ \mathrm{J/K}$

$A_2=0$

$\Delta S_2=\nu C_V\ln\frac{T_3}{T_2}=\nu C_V\ln\left(\frac{V_1}{V_2}\right)^{\gamma-1}=\nu(\gamma-1)C_V\ln\frac{V_1}{V_2}=\nu R\ln\frac{V_1}{V_2}=-5.6\times10^3\ \mathrm{J/K}$

$A_3=\frac{1}{\gamma-1}(P_2V_2-P_1V_1)=-1.3\times10^6\ \mathrm{J}$

$\Delta S_3=0$

11.10

$$T = \frac{T_1+T_2}{2}$$

$$\left.\begin{aligned} \Delta S_1 &= \int_{T_1}^{T} \frac{mc_p}{T}\,dT \\ \Delta S_2 &= \int_{T_2}^{T} \frac{mc_p}{T}\,dT \end{aligned}\right\} \Rightarrow \Delta S = mC_p \ln \frac{T_0^2}{T_1T_2} = mC_p \ln \frac{(T_1+T_2)^2}{T_1T_2} > 0$$

11.11

$$\frac{1}{2}\nu C_v T + \frac{1}{2}\nu C_v T = \frac{1}{2}(\nu+\nu)C_v T'$$

$$\Rightarrow T' = T$$

$$V' = \frac{V_1+V_2}{2}$$

$$p = \frac{2\nu RT}{V_1+V_2} = \frac{2\nu RT}{\frac{\nu RT}{p_1}+\frac{\nu RT}{p_2}} = \frac{2p_1p_2}{p_1+p_2}$$

$$\Delta S = \nu R\left(\ln\frac{V'}{V_1}+\ln\frac{V'}{V_2}\right) = \nu R \ln\frac{(V_1+V_2)^2}{4V_1V_2} = \nu R\ln\frac{(p_1+p_2)^2}{4p_1p_2}$$

11.13

(1) $T_1 = 95K$

(2) $T_2 = 65K$

(3) $T_3 = 20K$