第十章.

10.2 已知: $E_a = 356J$, $E_b = 560J$, $A_{adb} = 220J$, $A_{ba} = -282J$

求: Q_{adb}, Q_{ba}.

解: $E_b - E_a = 560 - 356 = 204J$

$Q_{adb} = E_b - E_a + A_{adb} = 204 + 220 = 424J$

$Q_{ba} = E_a - E_b + A_{ba} = -486J$ (对外界放了486J热量)

10.5. 已知: [redacted] $P = 4\times10^5$, $\Delta T = 50°C$, $Q = 6\times10^4 J$.

求: V, ΔE, A, Q

解: 由 $Q = \nu C\Delta T = \nu\frac{i+2}{2}R\Delta T$ 得

$$\nu = \frac{2Q}{(i+2)R\Delta T} = \frac{2\times6\times10^4}{(5+2)\times8.31\times50} = 41.3\ mol$$

$\Delta E = \nu C_v\Delta T = \nu\times\frac{i}{2}R\Delta T = 41.3\times\frac{5}{2}\times8.31\times50 = 4.29\times10^4 J$.

$A = Q - \Delta E = (6.0-4.29)\times10^4 = 1.71\times10^4 J$.

$Q = \Delta E = 4.29\times10^4 J$.

10.15. 已知: $pV^n = 常量$.

解: (1) $n=0$, $pV^n = p = 常量$ $\Rightarrow$ 等压过程

$n=1$, $pV^n = pV = 常量$ $\Rightarrow$ 等温过程

$n=\gamma$, $pV^n = pV^\gamma = 常量$ $\Rightarrow$ 绝热过程

$n=\infty$, $p^{\frac{1}{\infty}}V = p^0V = V = 常量$ $\Rightarrow$ 等体过程

(2) $A' = -\int_{V_1}^{V_2} p\,dV = -\int_{V_1}^{V_2}\frac{C}{V^n}dV = \frac{C}{n-1}\left(V_2^{1-n} - V_1^{1-n}\right)$

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

(3) $Q = \Delta E + A = \Delta E - A' = C_{V,m}(T_2 - T_1) - \frac{R}{n-1}(T_2 - T_1)$

摩尔热容: $C_n = \frac{Q}{T_2 - T_1} = C_{V,m} - \frac{R}{n-1} = C_{V,m} - \frac{\gamma C_{V,m} - C_{V,m}}{n-1} = C_{V,m}\left(\frac{\gamma - n}{1-n}\right)$

$n=0$, 等压过程 $\Rightarrow C_{p,m} = \gamma C_{V,m}$

$n=1$, 等温过程 $\Rightarrow C_{T,m} = \infty$

$n=\gamma$, 绝热过程 $\Rightarrow C_{S,m} = 0$.

$n=\infty$, 等体过程 $\Rightarrow C_{V,m} = C_{V,m}$.

10.16. (1) A经历的是绝热过程，因为 $p_A V_A^\gamma = C = p_{A1} V_{A1}^\gamma = 1.013\times10^5 \times 0.02^{1.4} = 4.2\times10^3$

活塞上升过程中 $p_A = p_{B}$，$V_A = V - V_B = 0.04 - V_B$

$$\Downarrow$$

$$p_B (0.04 - V_B)^\gamma = 4.2\times10^3$$

12) $T_{A2} = T_{A1}\left(\frac{V_{A1}}{V_{A2}}\right)^{\gamma-1} = \frac{p_{A1}V_{A1}}{R}\left(\frac{V_{A1}}{V_{A2}}\right)^{\gamma-1} = \frac{1.013\times10^5\times0.02}{8.31}\times\left(\frac{0.02}{0.01}\right)^{0.4} = 322\ K$

$T_{B2} = \frac{5V_{B2}}{(0.04-V_{B2})^{1.4}} = \frac{5\times0.03}{(0.04-0.03)^{1.4}} = 965\ K$

13) $Q_B = \Delta E_B + A_B = \frac{i}{2}R(T_{B2}-T_{B1}) + \int_{V_{B1}}^{V_{B2}} p_B\, dV_B$

$= \frac{i}{2}R\left(T_{B2} - \frac{p_{B1}V_{B1}}{R}\right) + \int_{V_{B1}}^{V_{B2}} \frac{4.2\times10^3}{(0.04-V_B)^\gamma}\, dV_B$

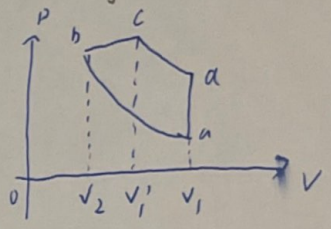
$= \frac{i}{2}R\left(T_{B2} - \frac{p_{B1}V_{B1}}{R}\right) + \frac{4.2\times10^3}{1-\gamma}\times\left[(0.04-V_{B1})^{1-\gamma} - (0.04-V_{B2})^{1-\gamma}\right]$

$= \frac{5}{2}\times8.31\times\left(965 - \frac{1.013\times10^5\times0.02}{8.31}\right) + \frac{4.2\times10^3}{1-1.4}\left[0.02^{-0.4} - 0.01^{-0.4}\right]$

$= 1.66\times10^4\ J$

10.18. bc过程吸热：$Q_1 = \nu C_{p,m}(T_c - T_b)$

da过程放热：$Q_2 = \nu C_{V,m}(T_d - T_a)$.



$$\eta = 1 - \frac{Q_2}{Q_1} = 1 - \frac{C_{V,m}(T_a - T_d)}{C_{p,m}(T_c - T_b)} = 1 - \frac{1}{\gamma}\frac{\frac{T_d}{T_a} - 1}{\frac{T_b}{T_a}\left(\frac{T_c}{T_b} - 1\right)}$$

由cd为绝热过程：$\frac{T_d}{T_a} = \left(\frac{V_1}{V_1'}\right)^{\gamma-1}$，ab绝热过程：$\frac{T_b}{T_a} = \left(\frac{V_1}{V_2}\right)^{\gamma-1}$

bc为等压过程：$\frac{T_c}{T_b} = \frac{V_1'}{V_2}$，$\therefore \frac{T_d}{T_a} = \frac{T_a}{T_c}\times\frac{T_b}{T_a}\times\frac{T_c}{T_b} = \left(\frac{V_1'}{V_1}\right)^\gamma$，

代入上式：

$$\eta = 1 - \frac{\left(\frac{V_1'}{V_2}\right)^\gamma - 1}{\gamma\left(\frac{V_1}{V_2}\right)^{\gamma-1}\left(\frac{V_1'}{V_2} - 1\right)}$$

10.19. ab过程吸热：$Q_{ab} = \nu RT\ln\frac{V_b}{V_a}$；cd过程吸热：$Q_{cd} = \nu RT_2\ln\frac{V_d}{V_c}$；ef过程放热：$Q_{ef} = \nu RT_1\ln\frac{V_f}{V_e}$

由绝热过程得：$TV_b^{\gamma-1} = T_2V_c^{\gamma-1}$，$T_2 = T_1\left(\frac{V_e}{V_d}\right)^{\gamma-1}$，$T = T_1\left(\frac{V_f}{V_a}\right)^{\gamma-1}$

$$\Downarrow$$

$$\frac{V_b}{V_a} = \frac{V_eV}{V_fV_d}$$

因 $Q_{cd} = Q_{ef}$：$\frac{\ln\left(\frac{V_d}{V_c}\right)}{\ln\left(\frac{V_e}{V_f}\right)} = \frac{T_1}{T_2}$

效率：$\eta = 1 - \frac{Q_{ef}}{Q_{ab}+Q_{cd}} = 1 - \frac{\nu RT_1\ln\frac{V_e}{V_f}}{\nu R\left[T\ln\frac{V_b}{V_a} + T_2\ln\frac{V_d}{V_e}\right]}$

$= 1 - \frac{T_1T_2}{T(T_2-T_1)+T_1T_2}$

10.21. (1) $\eta = 1 - \frac{T_2}{T_1} = 1 - \frac{278}{298} = 6.7\%$

(2) 由 $\eta = 1 - \frac{Q_2}{Q_1}$

$= 1 - \frac{Q_2}{A+Q}$ $\Rightarrow Q_2 = \frac{A(1-\eta)}{\eta}$

$= \frac{10^6 \times (1-0.067)}{0.067}$

$= 14 \times 10^6 J.$

[3] 电站以14MW的速率排出废热.

(3) $Q_1 = A + Q_2 = C m \Delta T$

$m = \frac{A+Q_2}{C\Delta T}$

$m = \frac{1 \times 10^6 + 14 \times 10^6}{4.18 \times 10^3 (25-5)}$

$m = 1.8 \times 10^2 kg.$

[3] $1 \times 1.8 \times 10^2 kg/s = 6.5 \times 10^2 t/h$ 的速率取用表层水.