第十三章 热力学基础 C9041012 方亮

13-1 (B) 13-2 (B) 13-3 (C) 13-4 (B) 13-5 (B) 13-6 (A) 13-7 (D)

13-11 $W = P\cdot\Delta V = 1\times10^5\times(1.5\times10^{-2}-1\times10^{-2})\,J = 5\times10^2\,J$

$\Delta E = Q - W = 1.2\times10^3\,J$

13-12 $\nu = \frac{m}{M} = \frac{50}{9}\,mol$

(1) $Q_V = \nu C_{V,m}\cdot\Delta T = 3091.1\,J$ (2) $Q_p = \nu C_{p,m}\Delta T = 4023.3\,J$

13-14 (1) $C_{V,m} = \frac{i}{2}R = 20.775\ J\cdot mol^{-1}\cdot K^{-1}$ $C_{p,m} = C_{V,m}+R = 29.085\ J\cdot mol^{-1}\cdot K^{-1}$

(2) $\nu = \frac{PV}{RT} = 4.41\times10^{-2}\,mol$

(3) $Q_p = \nu C_{p,m}\Delta T = 128.21\,J$ $Q_V = \nu C_{V,m}\Delta T = 91.58\,J$

(2) 对等体 $\Delta E = Q_V + W_V$, $\Delta E = Q_V$ 故 $W_V = 0$.

等压 $\Delta E = Q_p - W_p = Q_V$ 故 $W_p = 36.62\,J$

13-15 有 $\Delta E_{ABC} = Q_1 - W_1$ 得 $\Delta E_{ABC} = 200J$

C→A过程 $\Delta E_{CA} = Q_2 - W_2 = -\Delta E_{ABC}$ 得 $Q = -252J$ 即放出热量 252J

13-19 (1) 等温过程 $Q_T = \nu RT_A \ln\frac{V_2}{V_1}$ 其中 $P_AV_A = \nu RT_A$ 得 $Q_T = 2.773\times10^3\,J$,

有 $\Delta E = Q_T - W_T = 0$ 得 $W_T = 2.773\times10^3\,J$, 吸收 2.773×10^3J, 做功 2.773×10^3J

(2) 等体过程+等压过程 ACB.

$W_2 = P_C(V_B - V_C) = 2\times10^3\,J$

$\Delta E = Q' - W_2 = 0$ 故 $Q' = 2\times10^3\,J$, 吸收 2×10^3J, 做功 2×10^3J

13-20 有 $P_1V_1^{\gamma} = P_2V_2^{\gamma}$ 得 $P_2 = 9.77\times10^5\,Pa$

$W = \frac{P_1V_1 - P_2V_2}{\gamma - 1} = -23.024J$

13-22 由 $PV = \nu RT$ 得 $P = 9.972\times10^4\,Pa$ $C_{V,m} = \frac{5}{2}R = 20.775\,J\,mol^{-1}\,K^{-1}$, $C_{p,m} = 29.085\ J\cdot mol^{-1}\cdot K^{-1}$

(1) 等压. $W = P\cdot\Delta V = P\cdot V = 2.49\times10^3\,J$. $Q_p = \nu C_{p,m}\cdot\Delta T = \nu C_{p,m}\cdot T = 8.73\times10^3\,J$

(2) 等温 $W = \nu RT\ln\frac{V_2}{V_1} = 1.73\times10^8\,J$ $\Delta E = Q_T - W = 0$ 得 $Q_T = 1.73\times10^8\,J$

(3) 绝热 $PV^{\gamma} = P'V'^{\gamma}$ 其中 $V' = 2V$ $\gamma = \frac{7}{5}$ 得 $P' = 3.778\times10^4\,Pa$

$W = \frac{P_1V_1 - P_2V_2}{\gamma - 1} = 1510J$

13-24 $\nu = \frac{m}{M} = 10mol$

对外做功 $W = W_{AB} + W_{CD} = \nu RT_1 \ln\frac{V_2}{V_1} + \nu RT_2 \ln\frac{V_1}{V_2} = \nu R(T_1 - T_2)\ln\frac{V_2}{V_1} = 5.76\times10^3 J$

吸收的热量仅在 AB, DA 段吸热.

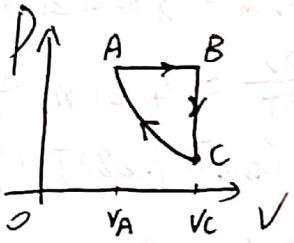
AB 段等温 $\Delta E = Q_{AB} - W_{AB} = 0$ 得 $Q_{AB} = W_{AB} = 1.728\times10^4 J$

DA 段 等体则 $\Delta E = Q_{DA} - W_{DA} = Q_{DA}$ $Q_{DA} = \Delta E = \nu\cdot\frac{5}{2}R[T_1 - T_2] = 2.077\times10^4 J$

则 $Q_{吸} = Q_{AB} + Q_{DA} = 3.81\times10^4 J$

$$\eta = \frac{W_{净}}{Q_{吸}} = 15.12\%$$

13-26 (1) 对应 P-V 图如图



正循环, 为热机循环.

(2) 做功 $W = P_A(V_C - V_A) + \nu RT\ln\frac{V_A}{V_C}$

$= P_A V_A(1 - \ln 2)$

$Q_{吸} = C_{p,m}\cdot\nu\cdot(T_B - T_A) = \frac{5}{2}R\nu(T_B - T_A)$.

$$\eta = \frac{W}{Q_{吸}} = \frac{1-\ln 2}{\frac{5}{2}} = 12.3\%$$

13-28 (1) 知仅在 AB, DA 吸热, CD 放热

则有 $Q_{放} = \nu C_{p,m}(T_C - T_D)$ $Q_{吸} = \nu C_{p,m}(T_B - T_A)$

有 $P_A^{1-\lambda}T_A^{\lambda} = P_D^{1-\lambda}T_D^{\lambda}$ 得 $T_D = \sqrt[\lambda]{\left(\frac{P_A}{P_D}\right)^{1-\lambda}}\cdot T_A$

同理 $T_C = \sqrt[\lambda]{\left(\frac{P_B}{P_C}\right)^{1-\lambda}}\cdot T_B$

$$\eta = 1 - \frac{Q_{放}}{Q_{吸}} = 1 - \frac{T_C - T_D}{T_B - T_A} = 1 - \frac{T_C}{T_B}\left(1 - \frac{T_D}{T_C}\right)/\left(1 - \frac{T_A}{T_B}\right) = 1 - \frac{T_C}{T_B}$$

(2) 卡诺循环为等温等绝热过程组成, 比循环非卡诺循环.

13-30.

证明: B-C 放热 有 $Q_{放} = \nu C_{p,m}(T_B - T_C)$

C-A 吸热 $Q_{吸} = \nu C_{V,m}(T_A - T_C)$.

$$\eta = 1 - \frac{Q_{放}}{Q_{吸}} = 1 - \gamma\frac{T_B - T_C}{T_A - T_C} = 1 - \gamma\frac{\frac{T_B}{T_C} - 1}{\frac{T_A}{T_C} - 1} = 1 - \gamma\frac{\frac{V_1}{V_2} - 1}{P_1/P_2 - 1}$$ 得证

13-31 (1) 热机循环效率 $\eta = \because\frac{W}{Q_1} = \frac{Q_1 - Q_2}{Q_1} = 1 - \frac{Q_2}{Q_1}$

(1) $\eta_1 = 1 - \frac{T_2}{T_1} = 1 - \frac{27+273}{227+273} = 40\%$ $W_1 = 2000J$ 得 $Q_1 = 5kJ$. $Q_2 = 3kJ$

知在低温热源温度不变, Q_2 不变即 $Q_2' = Q_2 = 3kJ$,

$W' = Q_1' - Q_2'$ 得 $Q_1' = 6kJ$ 得 $\eta_2 = 1 - \frac{Q_2'}{Q_1'} = 50\%$

(2) $\eta_2 = 1 - \frac{T_2'}{T_1'} = 0.5$ 故 $T_2' = 600K$

13-37 ab等温吸热, bc等容降压, 放热, ca无热交换.

$Q_{吸} = \nu R T_A \ln \frac{V_B}{V_A}$ $\quad Q_{放} = \nu C_{V,m} (T_B - T_C)$

其中 $T_A \cdot V_A^{\gamma-1} = T_C V_C^{\gamma-1}$

(1) $\eta = 1 - \frac{Q_{放}}{Q_{吸}} = 1 - \frac{\nu \cdot \frac{5}{2} R (T_B - T_C)}{\nu R T_A \ln 3} = 1 - \frac{5}{2\ln 3}\left(1 - \frac{1}{3}\right)^{\frac{2}{5}} = 19.08\%$

(2) $\Delta S = \int_b^c \frac{dQ}{T} = \int_{T_b}^{T_c} \frac{\nu C_{V,m}\, dT}{T} = \nu C_{V,m} \ln \frac{T_c}{T_b} = -0.913\ J \cdot K^{-1}$

13-38 根据 $S = k \ln W$

$\Delta S = k \ln \frac{W_2}{W_1} = k \ln \left(\frac{V_2}{V_1}\right)^N = kN \ln \frac{V_2}{V_1} = \nu R \ln \frac{V_2}{V_1} = 11.52\ J \cdot K^{-1}$