일반물리 I. Chapter 18.

15. $\Delta E_{int} = Q + W \rightarrow$

$\frac{dQ_{out}}{dt} = 68\,kW$ (열 출력, 빠져나가는 열의 비율)

$\frac{dE_{int}}{dt} = \frac{dQ}{dt} + \frac{dW}{dt}$

문제에서 $\frac{dE_{int}}{dt} = 0$ 이므로 $\frac{dW}{dt} = -\frac{dQ}{dt}$, 총 에너지 비율은 $\frac{dW}{dt}$

$(0.17)\frac{dQ_{in}}{dt} = \frac{-dW}{dt}$ (총 에너지의 17%가 계에 저장되는 비율)

$\frac{dW}{dt} = -\frac{dQ}{dt} = \frac{dQ_{out}}{dt} - \frac{dQ_{in}}{dt} = 68kW + \frac{1}{0.17}\frac{dW}{dt}$

$(1 - \frac{1}{0.17})\frac{dW}{dt} = 68kW \rightarrow \frac{dW}{dt} = \frac{68kW}{(1 - 1/0.17)}$

$\therefore \frac{dW}{dt} = -1392.7108kW$ (약 $-1kW$) : 역학적 출력

16.

$$W = -\int_{V_1}^{V_2} p\,dV = -\int_{V_1}^{2V_1} p\,dV \quad (\text{기체에 해준 일})$$

$$W = \int_{V_1}^{2V_1} p\,dV \quad (\text{기체가 한 일})$$

$$= p_1V_1 + \frac{1}{2}p_1V_1 = \boxed{\frac{3}{2}p_1V_1}$$

43.

A-B : $Q = -W$, $W = -nRT\ln\left(\frac{V_2}{V_1}\right)$, $pV = \text{const}$

A에서 $(60\,kPa)(5L) =$ B에서 $(P_b)(1L)$

$\boxed{P_b = 300\,kPa}$ (a)

$$W_{gas} = nRT\ln\left(\frac{1L}{3L}\right) = nRT\ln(5) \quad (\text{기체가 한 일})$$

$pV = nRT = 300J$

$\therefore W_{AB} = (300J)\ln(5) = \text{약 } 493J$ (b)

51. $C_V = \frac{5}{2}R$

$n = 3.50\ mol$, $T = 255\ K$, $p = 101\ kPa$

$Q = 1.75\ kJ$

(a). 등온과정 : 최종온도 255K, $Q = -W = -1.75\ kJ$

(b). 등압과정 :

$W_{gas} = p(V_2 - V_1) = (101\ kPa)(V_2 - V_1)$

$Q = nC_p\Delta T$, $C_p = C_V + R = \frac{7}{2}R$

$$\Delta T = \frac{1.75\ kJ}{(3.50\ mol)(7/2)R} = \text{약 } 17K$$

최종온도 : 272K

$pV_1 = nR(255K)$, $pV_2 = nR(272K)$

$V_1 = \frac{nR}{p}(255K)$, $V_2 = \frac{nR}{p}(272K)$

$W = nR\Delta T = \text{약 } 495J\ (500J)$

(c). 단열과정 (내부에너지를 1.95 kJ만큼 변화시킴)

$\Delta E_{내부} = nC_v\Delta T \Rightarrow 1.95\text{kJ} = (3.50\text{mol})\frac{5}{2}R(\Delta T)$

$\Delta T = 24.06\ K$

$\Delta E_{내부} = W$ 이므로,

최종온도 279K, $W = 1.95\text{kJ}$

53. $\gamma = 1.67$

$A \to B: \quad P_A V_A^{\gamma} = P_B V_B^{\gamma} \to P_B = P_A\left(\frac{V_A}{V_B}\right)^{\gamma}$

$B \to C: \quad P_C = \frac{P_A V_A}{V_C}$

$W_{AB} = \frac{P_B V_B - P_A V_A}{\gamma - 1}$, $W_{CA} = -nRT_A \ln\left(\frac{V_A}{V_C}\right)$

$P_B = \left(\frac{V_A}{V_B}\right)^{\gamma} P_A = (250\text{kPa})\left(\frac{1}{3}\right)^{1.67} = 약\ 70\text{kPa}$

$$P_C = P_A \cdot \frac{1}{3} = \frac{250\,kPa}{3} = \text{약 } \boxed{83\,kPa}$$

$$W_{AB} = \frac{(40\,kPa)(3m^3) - (250\,kPa)(1m^3)}{0.67}$$

$$= \text{약 } -195\,kJ$$

$$W_{CA} = -(250\,kJ)\ln\left(\frac{1}{3}\right) = \text{약 } 275\,kJ$$

$$\therefore W_{net} = W_{AB} + \underbrace{W_{BC}}_{0} + W_{CA} = \boxed{80\,kJ}$$