1.

2.1 An monatomic ideal gas at 300 K has a volume of 15 liters at a pressure of 15 atm. Calculate

a. The final volume of the system
b. The work done by the system
c. The heat entering or leaving the system
d. The change in the internal energy
e. The change in the enthalpy when the gas undergoes
   i. A reversible isothermal expansion to a pressure of 10 atm
   ii. A reversible adiabatic expansion to a pressure of 10 atm

The constant-volume molar heat capacity of the gas, c_v, has the value $1.5\,R$.

i). reversible isothermal expansion. $\Rightarrow PV=nRT$ 일정.

a. $P_1V_1=P_2V_2 \rightarrow (15\text{atm})(15\text{L})=(10\text{atm})V_2$

$$V_2=\frac{15\text{atm}\cdot 15\text{L}}{10\text{atm}}=\boxed{22.5\text{L}}$$

b. $W=\int_{V_1}^{V_2}\frac{nRT}{V}dV=nRT\cdot\ln\left(\frac{V_2}{V_1}\right)$, $P_1V_1=nRT_1 \rightarrow n=\frac{P_1V_1}{RT_1}=\frac{15\cdot 15}{(0.0820)(300)}$

$=9.14\text{mol}$

$\therefore W=(9.14\text{mol})(0.0820\,\text{atm}\cdot\text{L/mol}\cdot\text{K})(300\text{K})\ln\left(\frac{22.5\text{L}}{15\text{L}}\right)\simeq\boxed{9260\text{J}}$

c. isothermal $\Rightarrow \Delta U=0$ $\therefore q-W=\Delta U=0 \rightarrow q=W$ $\therefore\boxed{9260\text{J}}$

d. $\boxed{\Delta U=0\ (\because nC_v\Delta T=0)}$

e. $\boxed{\Delta H=nC_p\Delta T=0}\ (\because \Delta T=0)$

ii). reversible adiabatic expansion

a. $P_1V_1^{\gamma}=P_2V_2^{\gamma}$, $\gamma=\frac{C_p}{C_v}=\frac{\frac{5}{2}R}{\frac{3}{2}R}=\frac{5}{3}$

$(15\text{atm})(15\text{L})^{\frac{5}{3}}=(10\text{atm})(V_2)^{\frac{5}{3}}$

$(V_2)^{\frac{5}{3}}=\frac{15\text{atm}}{10\text{atm}}(15\text{L})^{\frac{5}{3}} \Rightarrow V_2=\left(\frac{3}{2}(15\text{L})^{\frac{5}{3}}\right)^{\frac{3}{5}}$

$=\left(\frac{3}{2}\right)^{\frac{3}{5}}\cdot 15\text{L}=\boxed{19.1\text{L}}$

b. $\Delta U=\cancel{q}^{0}-W$ $\therefore -W=\Delta U$ / $W=-\Delta U=-nC_v\Delta T$

$=(-9.14\text{mol})\left(\frac{3}{2}R\right)\Delta T$

$T_2=\frac{P_2V_2}{nR}=\frac{(10\text{atm})(19.1\text{L})}{(9.14)(0.0821)}=255\text{K} \Rightarrow \Delta T=T_2-T_1=255\text{K}-300\text{K}=-45\text{K}$

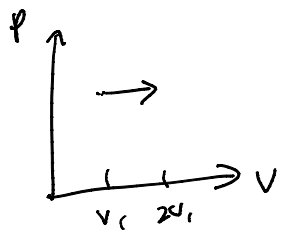
$\therefore W=(-9.14\text{mol})\left(\frac{3}{2}R\right)\cdot(-45\text{K})=506.6\,\text{atm}\cdot\text{L}$ (×101.325 J) $\therefore\boxed{W=5127\text{J}}$

c. adiabatic $\Rightarrow\boxed{q=0}$

d. $\Delta U=-W=\boxed{-5127\text{J}}$

e. $\Delta H=nC_p\Delta T=(9.14\text{mol})\left(\frac{5}{2}\cdot 0.0821\,\text{atm}\cdot\text{L/mol}\cdot\text{K}\right)(-45\text{K})$

$=-84.30\text{atm}\cdot\text{L} \rightarrow \therefore\boxed{-8543\text{J}}$



$PV = nRT$

2.

2.2 One mole of a monatomic ideal gas, in the initial state $T = 273$ K, $P = 1$ atm, is subjected to the following three processes, each of which is conducted reversibly:

a. A doubling of its volume at constant pressure,
b. Then a doubling of its pressure at constant volume,
c. Then a return to the initial state along the path $P = 6.643 \times 10^{-4} V^2 + 0.6667$.

Calculate the heat and work effects which occur during each of the three processes.

a. $C_p = \frac{5}{2}R$ $V_2 = 2V_1$ $T_1 = 273K$ $P_1 = P_2 = 1atm$, $n = 1mol$. / $T_2 = \frac{P_2V_2}{nR} = \frac{(1atm)\cdot(44.8L)}{(1mol)(0.0820)} = 546K$

$P_1V_1 = nRT_1$ / $V_1 = \frac{nRT_1}{P_1} = \frac{(1mol)(0.0820)(273K)}{1atm} = 22.4L$ $V_2 = 44.8L$ $\Delta T = 273$

$\therefore V_2 - V_1 = 22.4L$

$\therefore$ Constant pressure $\Rightarrow W = -\int P dV = -(1atm)(-22.4L) = 22.4\ atm\cdot L \Rightarrow (22.4)\cdot(101.325J) \cong 2270J$

$q = nC_p\cdot\Delta T = (1mol)\left(\frac{5}{2}\cdot 0.0820\ atm\cdot L/mol\cdot K\right)(273K) = 56.0\ atm\cdot L \Rightarrow (56.0)(101.325J)$
$\cong 5671J$

b. Constant volume / $V_1 = V_2 = 44.8L \rightarrow \Delta V = 0 \therefore W = 0$ $P_1 = 1atm$, $P_2 = 2atm$

$q_V = nC_V\Delta T = (1mol)\left(\frac{3}{2}\cdot 8.314\right)(547K) = 6821J$

$T_1 = 546K$,

$T_2 = \frac{P_2V_2}{nR} = \frac{(2atm)(44.8L)}{(1mol)(0.0820)} = 1093K$ $\Delta T = 546K$

c. $W_3 = \int P dV = \int_{V_1}^{V_2}(6.643\times10^{-4}V^2 + 0.6667)dV$

$= \frac{1}{3}(6.643\times10^{-4})(V_2^3 - V_1^3) + 0.6667(V_2 - V_1)$

$= \frac{1}{3}(6.643\times10^{-4})(22.4^3 - 44.8^3) + (0.6667)(-22.4)$

$\cong -3278J$

$\Delta U_{cycle} = 0 \therefore q_{cycle} - W_{cycle} = 0 \rightarrow q_{cycle} = W_{cycle}$

$\Delta U_1 + \Delta U_2 + \Delta U_3 = \Delta U_{cycle} = 0$ / $\Delta U_3 = -(\Delta U_1 + \Delta U_2) = -(3401 + 6821) = -10222$

($q_1 - W_1 = 3401$) ($q_2 - W_2 = 6821$)

$q_3 = \Delta U_3 + W_3 = -10222 + (-3278) = -13500J$

3.

3.1 The initial state of 1 mole of a monatomic ideal gas is $P = 10$ atm and $T = 300$ K. Calculate the change in the entropy of the gas for

a. An isothermal decrease in the pressure to 5 atm

b. A reversible adiabatic expansion to a pressure of 5 atm

c. A constant-volume decrease in the pressure to 5 atm

a. $V_1 = \frac{nRT_1}{P_1} = \frac{(1\text{mol})(0.0820)(300\text{K})}{10\text{atm}} = 2.46\text{L}$ / $V_2 = \frac{nRT_2}{P_2} = \frac{(1\text{mol})(0.0820)(300\text{K})}{5\text{atm}} = 4.92\text{L}$

isothermal $\Rightarrow \Delta U = 0 \therefore q = w = nRT\ln\left(\frac{V_2}{V_1}\right)$

$\Delta S = \frac{q}{T} = \frac{nRT\ln\left(\frac{V_2}{V_1}\right)}{T} = nR\cdot\ln\left(\frac{V_2}{V_1}\right) = (1\text{mol})\left(8.314\text{J/mol}\cdot\text{K}\right)\ln\left(\frac{4.92}{2.46}\right) = \boxed{5.76\text{J/K}}$

b. adiabatic: $q = 0$

$\therefore \boxed{\Delta S = \int \frac{dq_{rev}}{T} = 0} \ (\because \int q = 0)$

c. $V_1 = V_2 = 2.46\text{L}$, $\Delta V = 0 \Rightarrow \therefore w = 0$ (팽창일 = 외부에 한 일). $\therefore \Delta U = q - w = q$

$q_v = nC_v\Delta T \ (\int q_v = nC_v dT)$ / $T_2 = \frac{P_2V_2}{nR} = \frac{(5\text{atm})(2.46\text{L})}{(1\text{mol})(0.082)} = 150\text{K}$

$\Delta S = \int_{T_1}^{T_2}\frac{dq_v}{T} = \int_{T_1}^{T_2}\frac{1}{T}\cdot nC_v dT = nC_v\cdot\ln\left(\frac{T_2}{T_1}\right) \Rightarrow (1\text{mol})\cdot\frac{3}{2}R\cdot\ln\left(\frac{150\text{K}}{300\text{K}}\right) = (1\text{mol})\cdot\frac{3}{2}\cdot(8.314\text{J/mol}\cdot\text{K})\cdot\ln\frac{1}{2} = \boxed{-8.644\text{J/K}}$

4.

3.4 Calculate the change in the enthalpy and the change in entropy when 1 mole of SiC is heated from 25°C to 1000°C. The constant-pressure molar heat capacity of SiC varies with temperature as

$$\left[c_p = 50.79 + 1.97\times10^{-3}T - 4.92\times10^{6}T^{-2} + 8.20\times10^{8}T^{-3}\ \text{J/mole}\cdot\text{K}\right]$$

$T_1 = 25°C = 298K$ $T_2 = 1000°C = 1273K$ $P_1 = P_2$, $\Delta T = 975K$

i) $\Delta H = nC_p\Delta T$ ($\because dH = nC_p dT$) /

$\therefore dH = (1\text{mol})\cdot(50.79 + (1.97\times10^{-3}T) - (4.92\times10^{6}T^{-2}) + (8.20\times10^{8}T^{-3}\ \text{J/mol-K}))\cdot dT$

$\int dH = \int_{T_1}^{T_2}(50.79 + (1.97\times10^{-3}T) - (4.92\times10^{6}T^{-2}) + (8.20\times10^{8}T^{-3}\ \text{J/mol-K}))dT$, $T_1 = 298K$ $T_2 = 1273K$

$\simeq$ 42790 J (rounded) : ΔH

ii). $\Delta S = \int_{T_1}^{T_2}\frac{1}{T}dq$, $dq = dH$ ($\because$ constant pressure process)

$\therefore \Delta S = \int_{T_1}^{T_2}\frac{1}{T}dH = \int_{T_1}^{T_2}(50.79T^{-1} + (1.97\cdot10^{-3}) - (4.92\times10^{6}T^{-3}) + (8.20\times10^{8}T^{-4})\ \text{J/mol-K})dT$ / $T_1 = 298K$, $T_2 = 1273K$

$\simeq$ 59.7 J/K (rounded) : ΔS