UNIVERSITY OF MICHIGAN | JOINT INSTITUTE 交大密西根学院

HW 8.

Solution 1.

for solid: $\left(\frac{\partial U}{\partial T}\right)_p = \left(\frac{\partial U}{\partial T}\right)_v$.

$$C_p - C_v = \left(\frac{\partial Q}{\partial T}\right)_p - \left(\frac{\partial U}{\partial T}\right)_v = p\frac{\partial V}{\partial T}.$$

From the definition $\alpha = \alpha_{solid}/3 = \frac{1}{3V}\frac{\partial V}{\partial T}$.

We obtain $\frac{\partial V}{\partial T} = 3\alpha V = 3\alpha\frac{M}{\rho}$.

Then $C_p - C_v = 3\alpha\frac{M}{\rho}p$.

Solution 2.

(a) $W = \int_A^B p\,dV = RT_0\int_{V_0}^{2V_0} dV/V = RT_0 \ln 2$.

$Q = W = RT_0 \ln 2$.

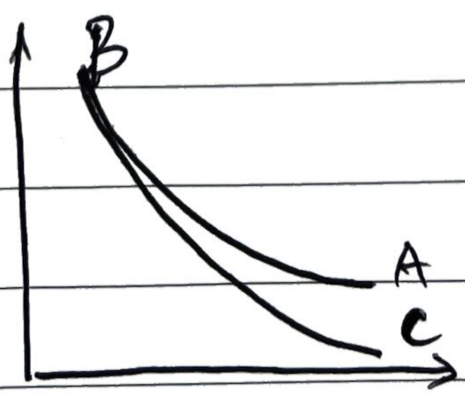
(b) $W = \int_{V_0}^{2V_0} p\,dV = RT_0$.

$\Delta U = C_v \Delta T = \frac{3}{2}RT_0$

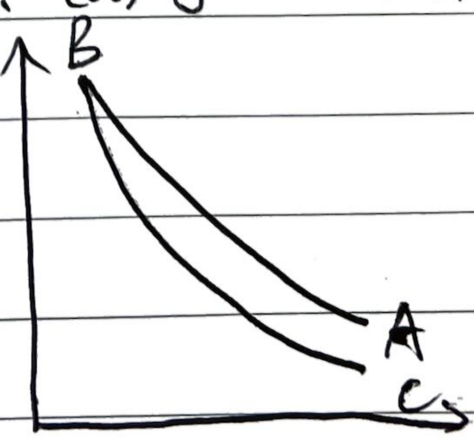
$Q = \Delta U + W = \frac{5}{2}RT_0$.

Solution 3.

Net work: (a) greater than (b)



(a) monatomic



(b) diatomic.

AB: Same. BC: (a) is lower than (b).

Solution 4.

$$\Delta S_1 = \int_{T_i}^{T_f} \frac{C_p dT}{T} = C_p \ln \frac{T_f}{T_i}$$

$$\Delta S_2 = \frac{\Delta Q}{T_f} = C_p \left(\frac{T_i}{T_f} - 1 \right)$$

$$\Delta S = \Delta S_1 + \Delta S_2 = C_p \left(\frac{T_i}{T_f} - 1 + \ln \frac{T_f}{T_i} \right) > 0.$$

Solution 5.

$$\Delta S = nC_v \ln \frac{T_f}{T_i} + nR \ln \frac{V_f}{V_i}$$

$$T_f = T_i \left(\frac{V_i}{V_f} \right)^g.$$

where $g = \frac{(n_1+n_2)R}{n_1C_{v1}+n_2C_{v2}}$.

$$P_f = P_i \left(\frac{V_i}{V_f} \right)^\gamma.$$

where $\gamma = \frac{n_1C_{p1}+n_2C_{p2}}{n_1C_{v1}+n_2C_{v2}}$

$\Rightarrow T_f = 302k.$ $\quad P_f = 2.0\times10^5\ N/m^2.$

Solution 6.

(a) $C_p = \frac{1}{m}\left(\frac{\partial Q}{\partial T}\right)_p = \frac{1}{m} T \left(\frac{\partial S}{\partial T}\right)_p.$

(b) $\Delta S = \int_{T_1}^{T_2} \frac{C_p}{T} dT - C_p \frac{T_2 - T_1}{T_2} = 0.044\ \text{Cal/g}\cdot\text{K}.$

(c) $\Delta S' = \boxed{\int_{T_1}^{T_2} \frac{C_p}{T} dT} - \frac{1\times(50-1)}{273+50} = 0.023\ \text{Cal/g}\cdot\text{K}$

(d) Devide the range [0°C, 100°C] into N parts. (N >> 1). At every points. the exists lage heat ~~...~~ reservoir. Making the process thermal constant quasi-static $\Rightarrow \Delta S = 0$.

Solution 7.

(a) $Q = (1000-500)\dfrac{400+300}{2} = 1.75\times 10^5$ J.

$W = (1000-500)\dfrac{400-300}{2} = 2.5\times 10^4$ J.

$\eta = W/Q = 14.3\%$.

(b) Equilibrium $T_3 = \dfrac{T_1+T_2}{2}$.

$\Delta S_1 = \int_{T_1}^{T_3} \dfrac{C_p\,dT}{T}$, $\Delta S_2 = \int_{T_2}^{T_3} \dfrac{C_p\,dT}{T}$.

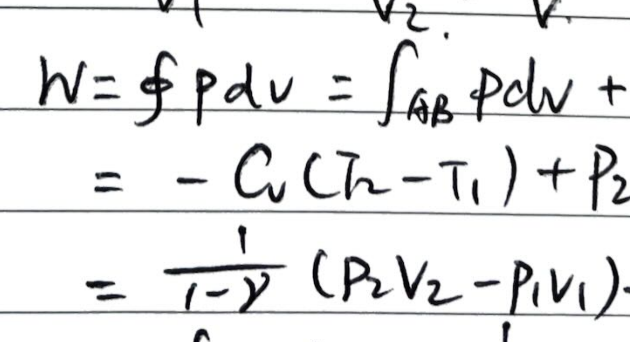
$\Delta S = C_p \ln \dfrac{(T_1+T_2)^2}{4T_1T_2} \geq 0$.

Solution 8.

(a) From $dS = \frac{1}{T}(du + p\,dV) = \frac{1}{T}(C_v\,dT + p\,dV)$.

$\Delta S = C_v \ln \dfrac{T_2}{T_1} + R \ln \dfrac{V_2}{V_1}$

(b)



$$W = \oint p\,dV = \int_{AB} p\,dV + P_2(V_1 - V_2)$$
$$= -C_v(T_2 - T_1) + P_2(V_1 - V_2)$$
$$= \frac{1}{1-\gamma}(P_2V_2 - P_1V_1) + P_2(V_1 - V_2)$$

$$Q = \int_{CA} T\,dS = \frac{1}{1-\gamma} V_1(P_2 - P_1)$$

$$\eta = \frac{W}{Q} = 1 - \gamma\,\frac{V_2/V_1 - 1}{P_1/P_2 - 1}.$$