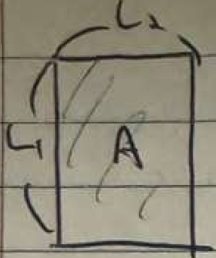
1. 

$\boxed{U \text{ 가 최소가 되는 조건}}$

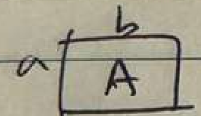
$$U = \int \gamma \, dl = 2\int_0^{L_1} \gamma_1 \, dl + 2\int_0^{L_2} \gamma_2 \, dl$$

$$= 2\gamma_1 L_1 + 2\gamma_2 L_2$$

$$\left(L_1 L_2 = A \rightarrow L_2 = \frac{A}{L_1} \right)$$

$$\rightarrow \frac{\partial U}{\partial L_1} = 2\gamma_1 - \frac{2\gamma_2 A}{L_1^2} = 0 \rightarrow L_1 = \sqrt{\frac{\gamma_2 A}{\gamma_1}}, \quad L_2 = \sqrt{\frac{\gamma_1 A}{\gamma_2}}$$

$$\rightarrow \frac{L_1}{L_2} = \frac{\gamma_2}{\gamma_1}$$

2. $\varepsilon_i = \frac{h^2}{8m}\left(\frac{n_x^2}{a^2} + \frac{n_y^2}{b^2}\right)$ 

$$Z = \sum e^{-\varepsilon_i/kT} = \int_0^\infty e^{-\frac{h^2}{8mkT}\left(\frac{n_x^2}{a^2}\right)} dn_x \int_0^\infty e^{-\frac{h^2}{8mkT}\left(\frac{n_y^2}{b^2}\right)} dn_y$$

$$= \frac{a}{2}\sqrt{\frac{8\pi mkT}{h^2}} \, \frac{b}{2}\sqrt{\frac{8\pi mkT}{h^2}} = A\frac{2\pi mkT}{h^2}$$

$$\rightarrow \ln Z = \ln A + \ln T + \ln\left(\frac{2\pi mk}{h^2}\right)$$

$$\rightarrow \begin{cases} p = -\left(\frac{\partial F}{\partial A}\right)_T = \frac{nkT}{A} & \rightarrow pA = nkT \\ U = NkT^2\left(\frac{\partial F}{\partial T}\right)_A = NkT & \rightarrow U = NkT \end{cases}$$

3. $Z = \sum g_i e^{-\varepsilon_i/kT} \longleftarrow g_i = {}_{N-1}C_n, \ \varepsilon_i = n\varepsilon$

$= \left(1+e^{-\frac{\varepsilon}{kT}}\right)^{N-1} \quad \left(\because \sum_{n=0}^{N} {}_nC_r x^r = (1+x)^N\right)$

$\rightarrow$ 평균길이 $= \frac{1}{Z} \sum (N-n) a \, {}_{N-1}C_n \, e^{-n\varepsilon/kT}$

$= Na - \frac{a}{Z} \sum_{n=0}^{N-1} n \, {}_{N-1}C_n e^{-n\varepsilon/kT}$

$= Na + akT \frac{\partial}{\partial \varepsilon} (\ln Z)$

$\rightarrow Na - (N-1) a \left(\frac{1}{1+e^{\varepsilon/kT}}\right)$

6. $\Delta G = \Delta H - T\Delta S = 454 \times 4.2 - 298 \times (0.58 - 1.31) \times 4.2$

$= 2896 \ J$

$V_g = \frac{12}{2.22} = 5.405 \ cm^3/mol$

$V_d = \frac{12}{3.515} = 3.415 \ cm^3/mol$

$\rightarrow \Delta V = -1.99 \ cm^3/mol$

$\left(\frac{\partial G}{\partial P}\right)_T = \Delta V \rightarrow \Delta G_{(P,\ T=298K)} = \Delta G_{(P=1,\ T=298K)} + \int_1^P \Delta V dp$

$= 2896 + (-1.99 \times 0.1013)(P-1) = 0$

$\rightarrow P = 14367 \ atm$