HW#4 20212568 강승연

1 (a) nucleation rate

$$I = f_0 N_0 \exp\left[-\frac{\Delta G^*}{kT}\right]$$

$$\ln I = \ln f_0 N_0 - \left(\frac{\Delta G^*}{k}\right)\frac{1}{T}$$

Slope

$$\therefore \frac{-\Delta G^*}{1.38\times10^{-23}\,J/K} = -23.8\times10^3 K.$$

$$\Rightarrow \Delta G^* = 3.2844\times10^{-19} J$$

$$\Delta G = -\frac{4}{3}\pi r^3 \Delta G_v + 4\pi r^2 \cdot \gamma$$

$$\left.\frac{d\Delta G}{dr}\right)_{r=r^*} = -4\pi (r^*)^2 \cdot \Delta G_v + 8\pi r^* \gamma = 0$$

$$\therefore r^* = \frac{2\gamma}{\Delta G_v} \Rightarrow \Delta G^* = \frac{16}{3}\pi \cdot \frac{\gamma^3}{(\Delta G_v)^2}$$

$$3.2844\times10^{-19} J = \frac{16}{3}\pi \cdot \frac{\gamma^3}{(-10^8 J\cdot m^{-3})^2}$$

$$\gamma^3 = 3.2844\times10^{-19} J \cdot \frac{3}{16\pi} \cdot 10^{16} \cdot J^2 \cdot m^{-6}$$

$$= 1.960\,(J\cdot m^{-2})^3$$

$$\therefore \boxed{\gamma = 0.058\ J\cdot m^{-2}}$$

(b) $$r^* = \frac{2\gamma}{\Delta G_v} = \frac{2(0.058 J/m^2)}{10^8 J/m^3} = 1.16\times10^{-9} m = \boxed{1.16 nm}$$

(c) $$\Delta G = -n\,v\cdot\Delta G_v + (36\pi)^{\frac{1}{3}} \cdot n^{\frac{2}{3}} \cdot v^{\frac{2}{3}} \cdot \gamma$$

↑ molecular Volume ↑ # of atoms n-cluster

↳ $$v = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi \cdot (1.5\times10^{-10} m)^3 = 1.414\times10^{-29} m^3$$

$$\left.\frac{\partial \Delta G}{\partial n}\right)_{n=n^*} = -v\cdot\Delta G_v + (36\pi)^{\frac{1}{3}} \cdot \frac{2}{3}(n^*)^{-\frac{1}{3}} \cdot v^{\frac{2}{3}} \cdot \gamma = 0$$

$$\Rightarrow \therefore n^* = \frac{32\pi}{3v} \cdot \left(\frac{\gamma}{\Delta G_v}\right)^3 = \frac{32\pi}{3\times(1.414\times10^{-29} m^3)} \left(\frac{0.059 J/m^2}{10^8 J/m^{-3}}\right)^3 \simeq \boxed{462 개}$$

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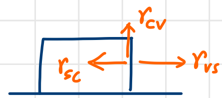
$\Delta G = -V_{solid} \cdot \Delta G_v + \sum A_i \gamma_i$

$V_{solid} = l^2 h$

- new interfacial energy : $l^2(\gamma_{sc} + \gamma_{cv}) + 4lh \cdot \gamma_{cv}$
- disappeared interfacial energy : $l^2 \gamma_{vs}$

$\therefore \Delta G = -l^2 h \cdot \Delta G_v + l^2(\gamma_{sc} + \gamma_{cv} - \gamma_{vs}) + 4lh\,\gamma_{cv}$

$= -l^2 h \cdot \Delta G_v + \gamma_{cv} \cdot (l^2 + 4lh)$



힘평형 조건; $\gamma_{sc} = \gamma_{vs}$

critical size

$\Rightarrow \frac{\partial \Delta G}{\partial h} = 0$ & $\frac{\partial \Delta G}{\partial l} = 0$

↳ $\frac{\partial \Delta G}{\partial h} = -l^2 \Delta G_v + 4l\gamma_{cv} = 0$ $\quad \therefore l^* = \frac{4\gamma_{cv}}{\Delta G_v}$

대입

↳ $\frac{\partial \Delta G}{\partial l} = -2lh \cdot \Delta G_v + \gamma_{cv} \cdot (2l + 4h)$

$= -8h \cdot \gamma_{cv} + \gamma_{cv} \cdot \left(\frac{8\gamma_{cv}}{\Delta G_v} + 4h\right) = 0$ $\quad \therefore h^* = \frac{2\gamma_{cv}}{\Delta G_v}$

$\Rightarrow h = \frac{1}{2} l$

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$\Delta G^* = -l^{*2} h^* \cdot \Delta G_v + \gamma_{cv} \cdot (l^{*2} + 4l^* h^*) = \frac{16\gamma_{cv}^3}{\Delta G_v^2}$