Home Problem Set #11 Due : November 3, 2014

1. Calculate the mobility of the oxygen ions in UO_2 at 700 K. The diffusion coefficient of O^{2-} at this temperature is 10^{-13} cm^2/s. Compare this mobility with electron or hole mobilities in semiconductors (see Appendix 4). Discuss the difference! (*Hint*: O^{2-} has two charges!)

$\mu_{ion} = \frac{De|z|}{k_B T} = \frac{10^{-13} \cdot 1 \cdot |2|}{8.616 \times 10^{-5} \cdot 700} = 3.32 \times 10^{-12}\ (cm^2/V \cdot s)$

Si 의 $\mu_{el} = 1.5 \times 10^3\ (cm^2/V \cdot s)$, $\mu_{hole} = 48 \times 10^2\ (cm^2/V \cdot s)$ GaAs 의 $\mu_{el} = 8.5 \times 10^3\ (cm^2/V \cdot s)$, $\mu_{hole} = 4 \times 10^2\ (cm^2/V \cdot s)$

700 K, UO_2 에서의 O^{2-} 의 mobility 는 semiconductor 에서의 electron 과 hole 의 mobility 보다 훨씬 작다. (온도 자체 강한 의존도) 이는 ion 이 electron 이나 hole 보다 질량이 훨씬 크기 때문에, (effective mass) 같은 field 하에서 작은 속력을 가지 때문이다. ∴ mobility 가 작다.

2. Calculate the activation energy for ionic conduction for a metal ion in an ionic crystal at 300 K. Take Do = 10^{-3} m^2/s and D = 10^{-17} m^2/s.

$D = D_0 \exp\left(\frac{-Q}{k_B T}\right) \rightarrow \ln \frac{D}{D_0} = \frac{-Q}{k_B T}$ ∴ $Q = -k_B T \ln \frac{D}{D_0}$

$= -8.616 \times 10^{-5} \cdot 300 \cdot \ln(10^{-17}/10^{-3}) = 0.833\ (eV)$

3. Show that $E = E_{vac}/\varepsilon$ [Eq. (9.13)] by combining Eqs. (7.3), (9.9), and (9.11) and their equivalents for vacuum.

$E = V/L$ (7.3)

$C = q/V$ (9.9)

$\varepsilon = C/C_{vac}$ (9.11)

$E = V/L = q/LC$ ← 일정한 전하량 q 에 대하여,

$= C_{vac} \cdot V_{vac}/L \cdot C$ $q = CV = C_{vac} \cdot V_{vac}$ → equivalents for vacuum

$= E_{vac}/\varepsilon$ //

4. Show that the dielectric polarization is $P = (\varepsilon - 1)\varepsilon_0 E$. What values do P and D have for vacuum?

$D = \varepsilon\varepsilon_0 E$ (9.14)

$D = \varepsilon_0 E + P$ (9.15)

$\rightarrow \varepsilon\varepsilon_0 E = \varepsilon_0 E + P \rightarrow P = (\varepsilon - 1)\varepsilon_0 E$

for vacuum : $\varepsilon = 1$ (교재의 notation, 일반적인 표현으로 $\varepsilon_r = 1$)

∴ $D = \varepsilon_0 E$, $P = 0$