VE230 — Electromagnetics I

Homework 5

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P. 5-7

a)

$$\exp\left[-\frac{\sigma}{\varepsilon}t\right] = 0.01,$$

$$t = -\frac{\varepsilon_0\varepsilon_r}{\sigma}\ln 0.01 \approx 4.89 \times 10^{-12}\,\text{s}.$$

b)

$$\Delta W = \exp\left[-\frac{\sigma}{\varepsilon}t\right]^2 = 1 \times 10^{-4}.$$

The energy are transformed into heat energy.

c)

$$\frac{Q}{\varepsilon_0} = E \cdot 4\pi r^2,$$

$$E = \frac{Q}{4\pi r^2 \varepsilon_0},$$

$$W = \int_0^{Q_0} V dQ = \int_0^{Q_0}\int_R^{\infty} -E dr dQ = \int_0^{Q_0} \frac{Q}{4\pi R\varepsilon_0} dQ = \frac{Q_0^2}{8\pi R\varepsilon_0} \approx 4.494 \times 10^4\,\text{J}.$$

P. 5-10

P. 5-16

$$\frac{1}{R^2(1+k/R)} = \frac{1}{R(R+k)} = \frac{1}{k}\left(\frac{1}{R} - \frac{1}{R+k}\right),$$

$$R = \int_{R_1}^{R_2} \frac{1}{4\pi R^2\sigma} dR = \frac{1}{4\pi\sigma_0 k}\int_{R_1}^{R_2}\left(\frac{1}{R} - \frac{1}{R+k}\right) dR = \frac{1}{4\pi\sigma_0 k}\ln\frac{R}{R+k}\Big|_{R_1}^{R_2} = \frac{1}{4\pi\sigma_0 k}\ln\frac{R_2(R_1+k)}{R_1(R_2+k)}.$$