358.

Problem 30.62 (RHK)

A copper sphere whose radius is 1.08 cm *has a very thin surface coating of nickel. Some of the nickel atoms are radioactive, each atom emitting an electron as it decays. Half of these electrons enter the copper sphere, each depositing* 100 keV *of energy there. The other half of the electrons escape carrying away a charge of –e. the nickel coating has an activity of* 10.0 mCi (=10 millicuries $=3.70\times10^{8}$ *radioactive decays per second*). *The sphere is hung from a long, nonconducting string and insulated from its surroundings. We have to estimate the time in which the potential of the sphere will increase by* 1000 V.

Solution:

We are given a copper sphere of radius 1.08 cm. It has a very thin surface coating of nickel. Some of the nickel atoms are radioactive and emit electrons at the rate of $10.0\ \text{mCi}$, that is 3.70×10^{8} decays per second.

Recall that in a conductor surplus charge if any can reside on its surface. Copper sphere cannot contain surplus negative charge inside it as electric field inside a metallic conductor is always zero. As half of the electrons emitted by the nickel atoms leave the sphere, the surface acquires positive charge at the rate of

$$q = \frac{1}{2} \times 3.70 \times 10^{8} \times 1.6 \times 10^{-19} \text{ C} = 2.96 \times 10^{-11} \text{ C s}^{-1}.$$

Potential of the sphere will increase by 1000 V when the net amount of charge on the copper sphere becomes equal to

$$Q = 4\pi\varepsilon_0 rV = \frac{1.08 \times 10^{-2} \times 1000}{8.99 \times 10^{9}} \text{ C} = 1.20 \times 10^{-9} \text{ C}.$$

Time required for the potential of the copper sphere to increase by 1000 V will therefore be

$$t = \frac{1.20 \times 10^{-9}}{2.96 \times 10^{-11}} \text{ s} = 40.5 \text{ s}.$$