Chapter 5 Problem 42 [†]

Given
$m = 2.5\ g$
$Q = 4.0 \times 10^{-9}\ C$
$q_e = -1.602 \times 10^{-19}\ C$
$AM_{Cu} = 63.55\ u$
$N_A = 6.022 \times 10^{23}$

Solution
a) How many electrons are removed from the penny?

Since the charge on the penny is positive, it means that electrons (negative charge) were removed. Since the charge of the electron is known, divide the total charge by the magnitude of the charge of an electron (positive charge is what is left).

$$N_{ionized} = \frac{Q}{|q_e|} = \left(\frac{4.0 \times 10^{-9}\ C}{1.602 \times 10^{-19}\ C}\right) = 2.50 \times 10^{10}$$

b) What percentage of the copper atoms are ionized? (Assume at most one electron is removed per atom.)

First we need to determine how many copper atoms there are. We have the mass of the penny assuming it is pure copper, which it isn't (It is only 2.5% copper and 97.5% zinc). Treat this like a unit conversion problem, where we know the atomic mass of copper. Convert mass to moles of copper using the atomic number of copper. Next use Avagadro's number to convert moles into number of atoms.

$$N_{Cu} = (2.5\ g)\left(\frac{1\ mole\ Cu}{63.55\ g}\right)\left(\frac{6.02 \times 10^{23}\ atoms\ Cu}{1\ mole\ Cu}\right) = 2.37 \times 10^{22}\ atoms\ Cu$$

The percentage of ionized copper atoms is then

$$\%ionized = \frac{N_{ionized}}{N_{Cu}} \times 100\% = \frac{2.50 \times 10^{10}}{2.37 \times 10^{22}} \times 100\% = 1.06 \times 10^{-10}\%$$

(Not very many are ionized.)

[†]Problem from Univesity Physics by Ling, Sanny and Moebs (OpenStax)