Chapter 5 Problem 47 [†]

Given
$m = 4.00\ kg = 4000\ g$
$q_p = 1.602 \times 10^{-19}\ C$
$AM_{Pu} = 244\ u$
$AN_{Pu} = 94\ u$
$N_A = 6.022 \times 10^{23}$

Solution
How many coulombs of positive charge is in 4.00 kg of plutonium?

First we need to determine how many plutonium atoms there are. Treat this like a unit conversion problem, where we know the atomic mass of plutonium. Convert mass to moles of plutonium using the atomic number of plutonium. Next use Avagadro's number to convert moles into number of atoms.

$$N_{Pu} = (4000\ g)\left(\frac{1\ mole\ Pu}{244\ g}\right)\left(\frac{6.02 \times 10^{23}\ atoms\ Pu}{1\ mole\ Pu}\right) = 9.87 \times 10^{24}\ atoms\ Pu$$

The atomic number gives the number or protons per atom. Therefore, the total number of protons is

$$N_p = (9.87 \times 10^{24}\ atoms)(94\ protons/atom) = 9.28 \times 10^{26}\ protons$$

Finally determine the total charge by multiplying by the charge of a single proton.

$$Q = N_p \times q_p = (9.28 \times 10^{26}\ protons)(1.602 \times 10^{-19}\ C/proton) = 1.49 \times 10^{8}\ C$$

Holding this much charge together would require huge amounts of energy. However, for every proton there is an electron orbiting the atom. As a result, each atom has no net charge. It is, therefore, quite easy to put together a 4.00 kg block of plutonium if you had the material and the radioactive element did not reach critical mass, thus generating a nuclear explosion.

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