In order to illustrate that matter is electrically neutral to a very high degree, consider two Cu spheres of radii 0.1 cm that are 1 m apart. Thus they look like point charges. Even if the charge magnitudes of the proton and electron differ by 1 part in $10^8$, a measurable force would be observed, as below. You may use the following: the atomic number of Cu is 29, the atomic mass is 63.5 g/mol, the mass density is 8.9 g/cm$^3$, Avogadro’s number is $6.02 \times 10^{23}$ mole$^{-1}$, the proton charge is $e= 1.60 \times 10^{-19}$ C, and $\frac{1}{4\pi\epsilon_0} = 8.988 \times 10^9$ N(m/C)$^2$.

1) What is the mass of each sphere in kg?
   a) 0.37 b) $0.37 \times 10^{-1}$ c) $0.37 \times 10^{-3}$ d) none of these

M(sphere) = mass density x volume = $(8.9)((4/3)\pi(0.1)^3)$ g = $0.037 \times 10^{-3}$ kg. So the correct choice is (d) none of these.

2) What is the mass of 1 Cu atom in kg?
   a) 1.1 b) $1.1 \times 10^{-26}$ c) $1.1 \times 10^{-13}$ d) none of these

From the atomic mass, 1 mole of Cu has a mass of 63.5 g. However, Avogadro’s number is the number of Cu atoms/mole. So, $m(\text{atom}) = 63.5/(6.02 \times 10^{23}) = 10.5 \times 10^{-23}$ g = $1.05 \times 10^{-25}$ kg. So the correct choice is (d) none of these.

3) How many Cu atoms are in each sphere?
   a) $3.5 \times 10^{18}$ b) $3.5 \times 10^{20}$ c) $3.5 \times 10^{22}$ d) none of these

$N(\text{atoms})m(\text{atom}) = M(\text{sphere})$, so $N = 0.037 \times 10^{-3}/1.05 \times 10^{-25} = 3.5 \times 10^{20}$ atoms, (b).
4) If the electron charge is \(-1.00 \times 10^{-8}\)e, what is the net charge on a sphere in C?

a) \(1.6 \times 10^{-3}\)  b) \(1.6 \times 10^{-5}\)  c) \(1.6 \times 10^{-1}\)  d) none of these

Since the atomic number is 29, that is the number of protons and electrons. Thus, the total charge on the sphere is \((3.5 \times 10^{20})(29)[1.00 - (1.00 - 10^{-8})](1.60 \times 10^{-19}) = 1.62 \times 10^{-5} = 1.6 \times 10^{-5}\) C, (b).

5) What force would one sphere exert on the other in N?

a) 2.4  b) \(2.4 \times 10^{3}\)  c) \(2.4 \times 10^{5}\)  d) none of these

Use Coulomb’s law, \(F = \frac{(q/D)^2}{4\pi\epsilon_0} = 8.988 \times 10^9(1.62 \times 10^{-5}/1)^2 = 2.36 = 2.4\) N, (a).