PHYS 630 - Advanced Electricity and Magnetism

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Homework 1

Problem 1
Find the charge of the Earth (positive), in terms of elementary charges (the answer is just a number N of elementary charges), so that the gravity force on a proton at the surface of the Earth is counteracted by the Coulomb repulsion. Compare with Avogadro number N_A.

Solution. For the force of gravity on a proton at the surface of Earth to be counteracted by the Coulomb repulsion, the forces must have the same magnitude. Then

$$\begin{aligned}
F_g &= F_e \\
G\frac{m_E m_p}{r^2} &= k\frac{q_E q_p}{r^2} \\
Gm_E m_p &= kq_E q_p \\
q_E &= \frac{Gm_E m_p}{kq_p} \\
q_E &= \frac{\left(6.67\times10^{-11}\right)\left(5.97\times10^{24}\right)\left(1.67\times10^{-27}\right)}{\left(9\times10^{9}\right)\left(1.6\times10^{-19}\right)} \\
q_E &= \frac{\left(6.67\times10^{-11}\right)\left(5.97\times10^{24}\right)\left(1.67\times10^{-27}\right)}{\left(9\times10^{9}\right)\left(1.6\times10^{-19}\right)} \\
q_E &= 4.618\times10^{-4}\,\mathrm{C} \\
q_E &= 2.886\times10^{15}\,\mathrm{e}.
\end{aligned}$$

This number of elementary charges needed is much smaller than Avogadro's number, so it would take practically very little charged particles to counteract the gravitational force induced by Earth on a proton at surface level. ■