

EXERCISES

Section 20.1 Electric Charge

13. **INTERPRET** We'll estimate the charge your body would carry if the electron charge slightly differed from the proton charge.

DEVELOP Since the human body is about 60% water, let's assume that the number of protons/electrons per kilogram in your body is the same as that of a water molecule. Water is 2 hydrogen atoms (with one proton and one electron each) and one oxygen atom (with 8 protons and 8 electrons). If the charges on the electrons and protons are different by one part in a billion, then the net charge on a water molecule would be

$$|\Delta q| = 10|q_{\text{proton}} - q_{\text{electron}}| = 10(10^{-19} e) = 10(1.60 \times 10^{-19} \text{ C}) = 1.60 \times 10^{-18} \text{ C}$$

The mass of a water molecule is the mass of two hydrogens and one oxygen: $1u + 1u + 16u = 18u$, where $1 u = 1.66 \times 10^{-27} \text{ kg}$. Therefore, the net charge-to-mass ratio for a water molecule would be:

$$\left(\frac{|\Delta q|}{m}\right)_{\text{w/c}} = \frac{1.60 \times 10^{-18} \text{ C}}{18(1.66 \times 10^{-27} \text{ kg})} = 0.05 \text{ C/kg}$$

EVALUATE We'll assume your mass is 65 kg. If we approximate this mass as pure water, then the total charge on your body would be approximately

$$|\Delta q| \approx m \left(\frac{|\Delta q|}{m}\right)_{\text{w/c}} = (65 \text{ kg})(0.05 \text{ C/kg}) \approx 3 \text{ C}$$

ASSESS This is a huge amount of charge. Imagine half of the charge was in your head/chest and the other half was in your legs, about a meter away. Then the magnitude of the force of repulsion between the upper and lower parts of your body would be

$$F_{\text{el}} = \frac{kq_1q_2}{r^2} = \frac{(9.0 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2)(\frac{1}{2}3 \text{ C})^2}{(1 \text{ m})^2} \approx 2 \times 10^{10} \text{ N}$$

This would rip you apart!

14. **INTERPRET** This problem deals with quantity of charge in a typical lightning flash. We want to express the quantity in terms of the elementary charge e .
- DEVELOP** Since the magnitude of elementary charge e is $e = 1.6 \times 10^{-19} \text{ C}$, the number N of electrons involved in the lightning flash is given by $N = Q/e$.

EVALUATE Substituting the values given in the problem statement, we find

$$N = Q/e = \frac{25 \text{ C}}{1.6 \times 10^{-19} \text{ C}} \approx 1.6 \times 10^{20}$$

ASSESS Since 1 coulomb is about 6.35×10^{18} elementary charges, our result has the right order of magnitude.

15. **INTERPRET** This problem asks us to find the combination of u and d quarks needed to make a proton, which has a positive unit charge e , and a neutron, which has zero charge.

Section 20 Electric Charge Study Guide Answers

RJ Shavelson



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