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Problems set # 1 **Physics 169** February 4, 2015

1. *(i)* Compare the electric force holding the electron in orbit ($r = 0.53 \times 10^{-10}$ m) around the proton nucleus of the hydrogen atom, with the gravitational force between the same electron and proton. What is the ratio of these two forces. *(ii)* Would life be different if the electron were positively charged and the proton were negatively charged? Does the choice of signs have any bearing on physical and chemical interactions? Explain.

2. The nucleus of ^{8}Be, which consists of 4 protons and 4 neutrons, is very unstable and spontaneously breaks into two alpha particles (helium nuclei, each consisting of 2 protons and 2 neutrons). *(i)* What is the force between the two alpha particles when they are 5.00×10^{-15} m apart, and *(ii)* what will be the magnitude of the acceleration of the alpha particles due to this force? Note that the mass of an alpha particle is 4.0026 u.

3. Suppose that 1.00 g of hydrogen is separated into electrons and protons. Suppose also that the protons are placed at Earth's North Pole and the electrons are placed at the South Pole. What is the resulting compressional force on Earth?

4. Three charge particles are placed at the corners of an equilateral triangle of side 0.500 m. The charges are +7.00 μC, +2.00 μC, and −4.00 μC. Calculate the magnitude and direction of the net force on the 7.00 μC charge. See Fig. 1.

5. A charge of 6.00×10^{-9} C and a charge of -3.00×10^{-9} are at a distance of 60.0 cm. Find the position at which a third charge of 12.0×10^{-9} C can be placed so that the net electrostatic force on it is zero.

6. An airplane is flying through a thundercloud at a height of $2,000$ m. (This is a very dangerous thing to do because of updrafts, turbulence, and the possibility of electric discharge.) If there are charge concentrations of +40.0 C at height $3,000$ m within the cloud and −40.0 C at height $1,000$ m, what is the electric field $\vec{E}$ at the aircraft?

7. Two positive point charges are a fixed distance apart. The sum of their charges is Q_T. What charge must each have in order to *(i)* maximize the electric force between them, and *(b)* minimize it?

8. An electron is released a short distance above Earths surface. A second electron directly below it exerts an electrostatic force on the first electron just great enough to cancel the gravitational force on it. How far below the first electron is the second?

9. *(i)* How much negative charge and how much positive charge are there on the electrons and the protons in a cup of water (0.25 kg)? Note Avogadro's number is $N_A = 6.022 \times 10^{23}$, and each

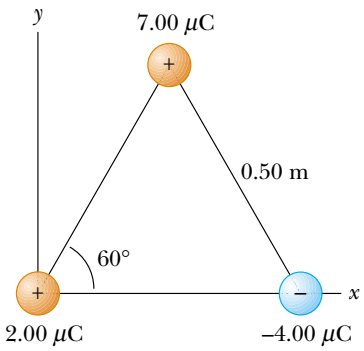

Figure 1: Problem 4.

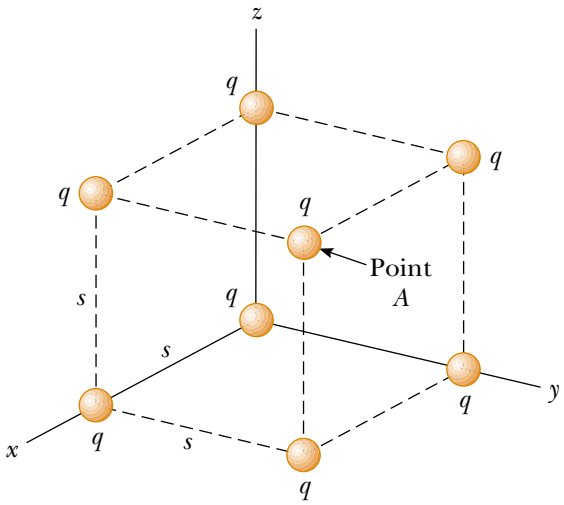

Figure 2: Problem 10.

oxygen atom has 8 electrons. *(ii)* What is the magnitude of the attractive force exerted by the electrons in a cup of water on the protons in a second cup of water at a distance of 10 m?

10. Eight point charges, each of magnitude q, are located on the corners of a cube of edge s, as shown in Fig. 2 *(i)* Determine the x, y, and z components of the resultant force exerted by the other charges on the charge located at point A. *(ii)* What are the magnitude and direction of this resultant force? *(iii)* Show that the magnitude of the electric field at the center of any face of the cube has a value of $2.18\frac{1}{4\pi\epsilon_0}\frac{q}{s^2}$. *(iv)* What is the direction of the electric field at the center of the top face of the cube?