

Chapter 1 (HW1)

- 1- (a) Two protons in a molecule are separated by 3.80×10^{-10} m. Find the electric force exerted by one proton on the other. (b) How does the magnitude of this force compare to the magnitude of the gravitational force between the two protons? (c) **What If?** What must be the charge-to-mass ratio of a particle if the magnitude of the gravitational force between two of these particles equals the magnitude of electric force between them?

Charge and Mass of the Electron, Proton, and Neutron		
Particle	Charge (C)	Mass (kg)
Electron (e)	$-1.602\,191\,7 \times 10^{-19}$	$9.109\,5 \times 10^{-31}$
Proton (p)	$+1.602\,191\,7 \times 10^{-19}$	$1.672\,61 \times 10^{-27}$
Neutron (n)	0	$1.674\,92 \times 10^{-27}$

$$K_e = 8.99 \times 10^9 \text{ N} \cdot \text{m}^2 / \text{C}^2$$

$$G = 6.67 \times 10^{-11} \text{ N} \cdot \text{m}^2 / \text{kg}^2$$

$$(a) \quad F_e = \frac{k_e q_1 q_2}{r^2} = \frac{(8.99 \times 10^9 \text{ N} \cdot \text{m}^2 / \text{C}^2) (1.60 \times 10^{-19} \text{ C})^2}{(3.80 \times 10^{-10} \text{ m})^2} = \boxed{1.59 \times 10^{-9} \text{ N}} \text{ (repulsion)}$$

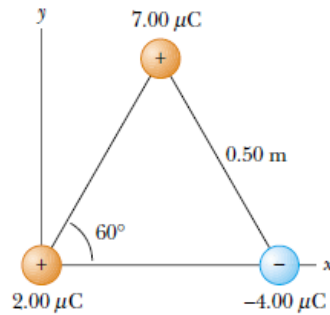
$$(b) \quad F_g = \frac{G m_1 m_2}{r^2} = \frac{(6.67 \times 10^{-11} \text{ N} \cdot \text{m}^2 / \text{kg}^2) (1.67 \times 10^{-27} \text{ kg})^2}{(3.80 \times 10^{-10} \text{ m})^2} = \boxed{1.29 \times 10^{-45} \text{ N}}$$

The electric force is $\boxed{\text{larger by } 1.24 \times 10^{36} \text{ times}}$.

$$(c) \quad \text{If } k_e \frac{q_1 q_2}{r^2} = G \frac{m_1 m_2}{r^2} \text{ with } q_1 = q_2 = q \text{ and } m_1 = m_2 = m, \text{ then}$$

$$\frac{q}{m} = \sqrt{\frac{G}{k_e}} = \sqrt{\frac{6.67 \times 10^{-11} \text{ N} \cdot \text{m}^2 / \text{kg}^2}{8.99 \times 10^9 \text{ N} \cdot \text{m}^2 / \text{C}^2}} = \boxed{8.61 \times 10^{-11} \text{ C/kg}}.$$

- 2- Three point charges are located at the corners of an equilateral triangle as shown in the figure. Calculate the resultant electric force on the $7.00 \mu\text{C}$ charge.



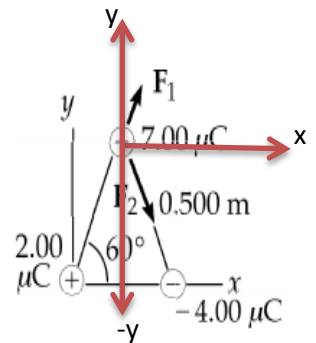
$$F_1 = k_e \frac{q_1 q_2}{r^2} = \frac{(8.99 \times 10^9 \text{ N} \cdot \text{m}^2 / \text{C}^2) (7.00 \times 10^{-6} \text{ C}) (2.00 \times 10^{-6} \text{ C})}{(0.500 \text{ m})^2} = 0.503 \text{ N}$$

$$F_2 = k_e \frac{q_1 q_2}{r^2} = \frac{(8.99 \times 10^9 \text{ N} \cdot \text{m}^2 / \text{C}^2) (7.00 \times 10^{-6} \text{ C}) (4.00 \times 10^{-6} \text{ C})}{(0.500 \text{ m})^2} = 1.01 \text{ N}$$

$$F_x = 0.503 \cos 60.0^\circ + 1.01 \cos 60.0^\circ = 0.755 \text{ N}$$

$$F_y = 0.503 \sin 60.0^\circ - 1.01 \sin 60.0^\circ = -0.436 \text{ N}$$

$$\mathbf{F} = (0.755 \text{ N})\hat{\mathbf{i}} - (0.436 \text{ N})\hat{\mathbf{j}} = \boxed{0.872 \text{ N at an angle of } 330^\circ}$$



Were

$$F = \sqrt{(F_x^2) + (F_y^2)} \quad ,$$

$$\text{and the angle of force direction: } \Theta = \tan^{-1} \frac{F_y}{F_x}$$

- 3- Two identical conducting small spheres are placed with their centers 0.300 m apart. One is given a charge of 12.0 nC and the other a charge of -18.0 nC. (a) Find the electric force exerted by one sphere on the other. (b) **What If?** The spheres are connected by a conducting wire. Find the electric force between the two after they have come to equilibrium.

- (a) The force is one of attraction. The distance r in Coulomb's law is the distance between centers. The magnitude of the force is

$$F = \frac{k_e q_1 q_2}{r^2} = (8.99 \times 10^9 \text{ N} \cdot \text{m}^2 / \text{C}^2) \frac{(12.0 \times 10^{-9} \text{ C})(18.0 \times 10^{-9} \text{ C})}{(0.300 \text{ m})^2} = \boxed{2.16 \times 10^{-5} \text{ N}}.$$

- (b) The net charge of $-6.00 \times 10^{-9} \text{ C}$ will be equally split between the two spheres, or $-3.00 \times 10^{-9} \text{ C}$ on each. The force is one of repulsion, and its magnitude is

$$F = \frac{k_e q_1 q_2}{r^2} = (8.99 \times 10^9 \text{ N} \cdot \text{m}^2 / \text{C}^2) \frac{(3.00 \times 10^{-9} \text{ C})(3.00 \times 10^{-9} \text{ C})}{(0.300 \text{ m})^2} = \boxed{8.99 \times 10^{-7} \text{ N}}.$$

- 4- In the Bohr Theory of the hydrogen atom, an electron moves in a circular orbit about a proton, where the radius of the orbit is 0.529×10^{-10} m. (a) Find the electric force between the two. (b) If this force causes the centripetal acceleration of the electron, what is the speed of the electron?

$$(a) \quad F = \frac{k_e e^2}{r^2} = (8.99 \times 10^9 \text{ N} \cdot \text{m}^2 / \text{C}^2) \frac{(1.60 \times 10^{-19} \text{ C})^2}{(0.529 \times 10^{-10} \text{ m})^2} = \boxed{8.22 \times 10^{-8} \text{ N}}$$

$$(b) \quad \text{We have } F = \frac{mv^2}{r} \text{ from which}$$

$$v = \sqrt{\frac{Fr}{m}} = \sqrt{\frac{8.22 \times 10^{-8} \text{ N}(0.529 \times 10^{-10} \text{ m})}{9.11 \times 10^{-31} \text{ kg}}} = \boxed{2.19 \times 10^6 \text{ m/s}} .$$

