Problem 23.7

a.) The magnitude of the force between two protons:

$$F = k\frac{q_p q_p}{r^2}$$

$$= \left(8.99\text{x}10^{9}\ \text{N}\bullet\text{m}^2/\text{C}^2\right)\frac{\left[\left(1.60\text{x}10^{-19}\ \text{C/p}^{+}\right)\right]^2}{\left(3.80\text{x}10^{-10}\ \text{m}\right)^2}$$

$$= 1.59\text{x}10^{-9}\ \text{N}$$

where the force is a repulsion.

b.) The magnitude of the gravitational force between the two protons:

$$\left|F_g\right| = G\frac{m_p m_p}{r^2}$$

$$= \left(6.67\text{x}10^{-11}\ \text{N}\bullet\text{m}^2/\text{kg}^2\right)\frac{\left[\left(1.67\text{x}10^{-27}\ \text{kg}\right)\right]^2}{\left(3.80\text{x}10^{-10}\ \text{m}\right)^2}$$

$$= 1.29\text{x}10^{-45}\ \text{N}$$

c.) If the forces are equal, the charge to mass ratio becomes:

$$k\frac{q_p q_p}{r^2} = G\frac{m_p m_p}{r^2}$$

$$\Rightarrow \quad \frac{q_p^{\,2}}{m_p^{\,2}} = \frac{G}{k}$$

$$\Rightarrow \quad \frac{q_p}{m_p} = \left(\frac{G}{k}\right)^{1/2}$$

$$= \left(\frac{6.67\text{x}10^{-11}\ \text{N}\bullet\text{m}^2/\text{kg}^2}{8.99\text{x}10^{9}\ \text{N}\bullet\text{m}^2/\text{C}^2}\right)^{1/2}$$

$$= 8.61\text{x}10^{-11}\ \text{C/kg}$$