37.39. **Model:** The nucleus of an atom is very small and it contains protons and neutrons.
Solve: **(a)** The electric force between two protons in the nucleus is

$$F_E = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{(2.0\text{ fm})^2} = \frac{\left(8.99\times10^9\text{ N m}^2/\text{C}^2\right)\left(1.60\times10^{-19}\text{ C}\right)^2}{\left(2.0\times10^{-15}\text{ m}\right)^2} = 57.6\text{ N}$$

(b) The gravitational force between two protons in the nucleus is

$$F_G = \frac{Gm^2}{(2.0\text{ fm})^2} = \frac{\left(6.67\times10^{-11}\text{ N m}^2/\text{kg}^2\right)\left(1.67\times10^{-27}\text{ kg}\right)^2}{\left(2.0\times10^{-15}\text{ m}\right)^2} = 4.65\times10^{-35}\text{ N}$$

Because $F_G \ll F_E$, gravitational force could not be the force to hold two protons together.
(c) The nuclear force must be very strong to overcome F_E and it must be independent of charge because both protons and neutrons are held in the nucleus very tightly. Furthermore, nuclear force is a very short range force since it is not felt outside the nucleus.