11. (a) The magnitudes of the gravitational and electrical forces must be the same:

$$\frac{1}{4\pi\varepsilon_0}\frac{q^2}{r^2} = G\frac{mM}{r^2}$$

where $q$ is the charge on either body, $r$ is the center-to-center separation of Earth and Moon, $G$ is the universal gravitational constant, $M$ is the mass of Earth, and $m$ is the mass of the Moon. We solve for $q$:

$$q = \sqrt{4\pi\varepsilon_0 GmM} \ .$$

According to Appendix C of the text, $M = 5.98 \times 10^{24}$ kg, and $m = 7.36 \times 10^{22}$ kg, so (using $4\pi\varepsilon_0 = 1/k$) the charge is

$$q = \sqrt{\frac{(6.67 \times 10^{-11}\,\mathrm{N \cdot m^2/kg^2})(7.36 \times 10^{22}\,\mathrm{kg})(5.98 \times 10^{24}\,\mathrm{kg})}{8.99 \times 10^9\,\mathrm{N \cdot m^2/C^2}}} = 5.7 \times 10^{13}\ \mathrm{C}\ .$$

We note that the distance $r$ cancels because both the electric and gravitational forces are proportional to $1/r^2$.

(b) The charge on a hydrogen ion is $e = 1.60 \times 10^{-19}$ C, so there must be

$$\frac{q}{e} = \frac{5.7 \times 10^{13}\,\mathrm{C}}{1.6 \times 10^{-19}\,\mathrm{C}} = 3.6 \times 10^{32}\,\text{ions}\ .$$

Each ion has a mass of $1.67 \times 10^{-27}$ kg, so the total mass needed is

$$(3.6 \times 10^{32})(1.67 \times 10^{-27}\,\mathrm{kg}) = 6.0 \times 10^5\ \mathrm{kg}\ .$$