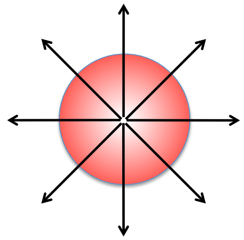
Problem 24.24



Determine the electric field generated by a lead-208 atom at its surface. Assume the lead nuclei's volume is 208 times that of a proton with a radius of $1.2\text{x}10^{-15}\,\text{m}$.

$$\int_A \vec{E}\bullet d\vec{A} = \frac{q_{enclose}}{\varepsilon_o}$$

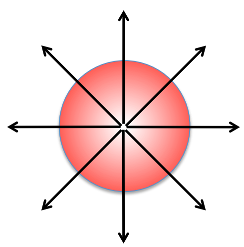
$$\int_A E\,dA\cos 0^o = \frac{82q_{proton}}{\varepsilon_o}$$

$$\Rightarrow \quad E\int_A dA = \frac{82q_{proton}}{\varepsilon_o}$$

$$\Rightarrow \quad E\left(4\pi R^2\right) = \frac{82q_{proton}}{\varepsilon_o}$$

$$\Rightarrow \quad E = \frac{82q_{proton}}{4\pi\varepsilon_o R^2}$$

$$\Rightarrow \quad E = \frac{82\left(1.6\text{x}10^{-19}C\right)}{4\pi\varepsilon_o R^2}$$



We know that:

$$\frac{1}{4\pi\varepsilon_o} = 9\text{x}10^9\ N\bullet m^2/C^2$$

Also, the volume of the sphere enclosing the nucleus is 208 times the volume of one proton. The volume of a sphere is: $V = \frac{4}{3}\pi R^3$

We can write:

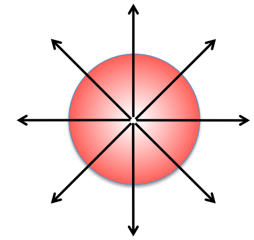
$$V_{nucleus} = 208 \quad V_{proton}$$

$$\frac{4}{3}\pi R_n^3 = 208\left[\frac{4}{3}\pi \quad R_p^3\right]$$

$$\frac{4}{3}\pi R_n^3 = 208\left[\frac{4}{3}\pi\left(1.2\text{x}10^{-15}\right)^3\right]$$

$$\Rightarrow \quad R_n = (208)^{1/3}\left(1.2\text{x}10^{-15}\right)$$

$$\Rightarrow \quad R_n = 7.1\text{x}10^{-15}\ \text{meters}$$



Putting it all together, we get:

$$E = k\frac{82q_{proton}}{R_n^2}$$

$$\Rightarrow \quad E = \left(9\text{x}10^9 N\bullet m^2/C^2\right)\frac{82\left(1.6\text{x}10^{-19}C\right)}{\left(7.1\text{x}10^{-15}m\right)^2}$$

$$\Rightarrow \quad E = 2.3\text{x}10^{21}\ N/C$$

As the charge producing the E-fld is positive, the electric field direction will be radially outward.