12. (a) For ^{55}Mn the mass density is

$$\rho_m = \frac{M}{V} = \frac{0.055\,\text{kg/mol}}{(4\pi/3)[(1.2\times10^{-15}\,\text{m})(55)^{1/3}]^3(6.02\times10^{23}/\text{mol})} = 2.3\times10^{17}\ \text{kg/m}^3\ ,$$

and for ^{209}Bi

$$\rho_m = \frac{M}{V} = \frac{0.209\,\text{kg/mol}}{(4\pi/3)[(1.2\times10^{-15}\,\text{m})(209)^{1/3}]^3(6.02\times10^{23}/\text{mol})} = 2.3\times10^{17}\ \text{kg/m}^3\ .$$

(b) For ^{55}Mn the charge density is

$$\rho_q = \frac{Ze}{V} = \frac{(25)(1.6\times10^{-19}\,\text{C})}{(4\pi/3)[(1.2\times10^{-15}\,\text{m})(55)^{1/3}]^3} = 1.0\times10^{25}\ \text{C/m}^3\ ,$$

and for ^{209}Bi

$$\rho_q = \frac{Ze}{V} = \frac{(83)(1.6\times10^{-19}\,\text{C})}{(4\pi/3)[(1.2\times10^{-15}\,\text{m})(209)^{1/3}]^3} = 8.8\times10^{24}\ \text{C/m}^3\ .$$

(c) Since $V \propto r^3 = (r_0A^{1/3})^3 \propto A$, we expect $\rho_m \propto A/V \propto A/A \approx$ const. for all nuclides, while $\rho_q \propto Z/V \propto Z/A$ should gradually decrease since $A > 2Z$ for large nuclides.