FIRST MIDTERM

REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES!
Use the conversion constants and data given on the front page.

(a) Calculate the electric force (in Newtons) between two electrons a distance $3.00 \times 10^{-11}$ m apart.

\[
E = \frac{ke^2}{r^2} = \left(9 \times 10^9 \text{ N m}^2 \text{ C}^{-2}\right) \left(1.6 \times 10^{-19} \text{ C}\right)^2 \approx 2.56 \times 10^{-7} \text{ N}
\]

(b) Assume a proton has a radius of $1.00 \times 10^{-13}$ m (about right). It has a positive charge equal in magnitude to that of the electron. Calculate the charge density, assumed to be uniform.

\[
\rho = \frac{2}{V} = \frac{1.6 \times 10^{-19}}{4 \pi \left(1.0 \times 10^{-13}\right)^3} = 3.07 \times 10^7 \frac{\text{C}}{\text{m}^3}
\]

(c) Given a potential function $V = B x^2 y^4 z^2$. Calculate the y-component of the electric field at the point $x = 2.00$, $y = 3.00$, $z = 1.00$.

\[
E_y = \frac{\partial \nabla V}{\partial y} = -B x^2 4 y^3 z^2 = -B (10^3)(10^3) = -432 B
\]

(d) Calculate the term in $x^8$ using the binomial expansion for the expression $(1 - x^3)^{3/2}$.

\[
\binom{n}{n-1}(n-2) a^{n-3} (x^2)^3 = \left(\frac{1}{16}\right) x^6 = +0.0625 x^6
\]

(e) For the arrangement shown, what is the potential difference $V(B) - V(A)$?

\[
V_B = k \left(\frac{-3q}{a} + \frac{2q}{2a}\right) = -\frac{3q}{a}
\]

\[
V_A = k \left(\frac{-2q}{a} + \frac{-3q}{2a}\right) = \frac{kq}{2a}
\]

\[
V_B - V(x) = -\frac{5kq}{2a}
\]