FIRST MIDTERM

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

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

\[
\begin{align*}
V(A) &= k \frac{q}{a} + k \frac{q}{a} = \frac{kq}{a} + \frac{kq}{a} = 2 \frac{kq}{a} \\
V(B) &= k \frac{q}{a} + k \frac{q}{a} = \frac{kq}{a} + \frac{kq}{a} = 2 \frac{kq}{a}
\end{align*}
\]

\[V(B) - V(A) = 2 \frac{kq}{a} - \frac{kq}{a} = \frac{kq}{a} = 0.66 \times 10^{-9} \text{V}
\]

(b) Use the binomial expansion to calculate the coefficient of \( x^3 \) for the expression \( (1 - x)^{-4/3} \) with \( x \ll 1 \).

\[
(1-x)^{-4/3} = 1 + \frac{4}{3}x + \frac{4 \times 7}{3 	imes 3}x^2 + \frac{4 \times 7 \times 10}{3 	imes 3 \times 3}x^3 + \ldots
\]

\[
E = \frac{(4 \times 7 \times 10)}{3 \times 3 \times 3} = \frac{140}{27} = 5.19 \times 10^{-10} \text{J}
\]

(c) A very long thin wire has a total charge of \( 4.0 \times 10^{-6} \text{C} \) on a length of 30.0 m. Calculate the electric field 0.50 cm away from the center of the wire, at a point nowhere near its ends.

\[
E = \frac{kq}{4 \pi \varepsilon_0 r^2} = \frac{9 \times 10^9 \text{N} \cdot \text{m}^2 \cdot \text{C}^{-2}}{4 \pi \times 8.85 \times 10^{-12} \text{F/m} \times (0.0005 \text{m})^2} = 9.40 \times 10^9 \text{N/C}
\]

(d) Calculate a numerical value for the electric field a distance 3.00 \( \times 10^{-4} \text{m} \) from an electron.

\[
E = \frac{kq}{r^2} = \frac{9 \times 10^9 \text{N} \cdot \text{m}^2 \cdot \text{C}^{-2}}{(3 \times 10^{-4} \text{m})^2} = 9.40 \times 10^9 \text{N/C}
\]

(e) The nucleus of a carbon atom has exactly 6 elementary positive charges. Calculate the potential, in volts, a distance 1.00 \( \times 10^{-10} \text{m} \) from the center of the nucleus. (This is just outside the nucleus.)

\[
V = k \frac{q}{r} = \frac{9 \times 10^9 \text{N} \cdot \text{m}^2 \cdot \text{C}^{-2} \times (6 \times 1.6 \times 10^{-19} \text{C})}{1 \times 10^{-10} \text{m}} = 86.4 \times 10^4 = 8.64 \times 10^7 \text{V}
\]