1 Theory

Answer BOTH of the following questions:

1.1 When a positive charge moves in the direction of an electric field,

(a) the charge (increases, decreases, does not change).

(b) the charge (gains, loses) potential energy.

(c) the charge (does work on, has work done on it by) the field.

(d) the charge (loses, gains) kinetic energy.

(e) the charge moves towards a (higher, lower) potential.

1.2 Which of the following integrals does NOT represent an electric potential due to a distribution of charge?

(a) $\dfrac{k_e Q}{\sqrt{a^2 + x^2}}$

(b) $\pi k_e \sigma \displaystyle\int_0^R \frac{2r\,dr}{\sqrt{r^2 + x^2}}$

(c) $k_e \dfrac{Q}{l} \ln\left(\dfrac{l + \sqrt{a^2 + l^2}}{a}\right)$

(d) $2\pi k_e \sigma \left[1 - \dfrac{x}{\sqrt{R^2 + x^2}}\right]$

(e) $k_e \displaystyle\int \frac{dq}{r}$

...please turn over...

2 Practice

Choose ONE of the following problems:

2.1 A Li^{2+} ion consists of three protons and a single electron. When the electron is $r = 3 \times 10^{-11}$ m from the nucleus, what is the electrical potential energy of the ion? Treat the nucleus as a point charge, and express your answer in electron volts (eV).

SOLUTION

We first find the potential at $r = 3 \times 10^{-11}$ due to the nuclear charge:

$$V = \frac{kq}{r} \tag{1}$$

$$= \frac{(9 \times 10^9)(3e)}{(3 \times 10^{-11})} \tag{2}$$

$$= 144. \tag{3}$$

To find the potential energy, we simply multiply our result by the magnitude of the charge at that potential, in this case e. The answer is thus 144 eV.

2.2 Use Gauss' Law to find the electric field a distance h away from an infinite line of uniform charge density λ.

SOLUTION

A coaxial cylinder of length l and radius h is the appropriate Gaussian surface for this problem. The flux through its surface is

$$\Phi = \oint \mathbf{E} \cdot d\mathbf{A} = \frac{q_{\text{inside}}}{\epsilon_0} \tag{4}$$

$$E \oint dA = \frac{\lambda l}{\epsilon_0} \tag{5}$$

$$E 2\pi h \cancel{l} = \frac{\lambda \cancel{l}}{\epsilon_0} \tag{6}$$

$$E = \frac{\lambda}{2\pi\epsilon_0 h}. \tag{7}$$

3 Extra Credit

In Question 1.2 of this quiz, one of the choices (*the correct choice!*) does not represent a potential. What does it represent? You get one point of extra credit for a general answer. You get *two* points for a specific answer!

SOLUTION

It is the electric field on the axis of a uniformly charged disk.