Key Concepts

Chapter 6

Electric potential energy:
$\Delta U = \Delta V q_0$ (V·C)

Potential difference (voltage):
$V = Ed$ (V: N·m/C)
(parallel plate capacitor)

Impulse: $I = F_{av}\Delta t$ (kg·m/s)

Electric field: $F = q_0 E$

Takeaways

Memorizing a few equations can make even complex-sounding problems simple. Even if you are given several of these equations on Test Day, the familiarity from memorizing them and the comfort from using them will decrease the amount of time that questions like this will take.

Things to Watch Out For

Typically, the math isn't too difficult if you round the numbers. Be careful with the scientific notation.

Electrostatic Impulse

A +2*e* charge is sitting on the negative plate of a parallel-plate capacitor. A mechanical error accidentally reverses the charge on the plates such that the test charge is accelerated towards the other plate. In the 7 s that it takes for the technician to correct this mistake, the test charge traverses the entire 20 mm distance between the plates. If the test charge loses 3.2×10^{-16} J of potential energy, what was the impulse created by the electric force?
($1\ e = 1.6 \times 10^{-19}$ C)

1) Find the potential difference for the drop in electric potential.

$$\Delta V = \frac{\Delta U}{q_0}$$

$$\Delta V = \frac{3.2\times10^{-16}\text{ J}}{(2)(1.6\times10^{-19}\text{ C})} = 1{,}000 \text{ volts}$$

The +2*e* charge is equal to two fundamental units of charge. Thus, the test charge q_0 is 3.2×10^{-19} coulombs.

---

2) Find the electric field between the plates.

$\Delta V = Ed$

$1{,}000\text{ V} = E(0.02\text{ m}) \rightarrow E = 5 \times 10^4\text{ V/m}$

Once again, we only need to plug in the data appropriate to the equation.

---

3) Find the electric force.

$F = Eq_0$

$F = (5 \times 10^4\text{ V/m})(3.2 \times 10^{-19}\text{ C}) = 1.6 \times 10^{-14}\text{ N}$

Substitute for the relevant quantities and constants.

Remember: *Use dimensional analysis to check your work. In this case, we see that* $\frac{F}{q_0} = E$. *From the previous step, we found the electric field to have the unit V/m. However, looking at the equation here, we see that the electric field will also have the unit N/C. This means that V/m = N/C. Recognizing this allows us to find alternative ways of defining the units V and C, for instance.*

---

4) Find the impulse.

$J = F_{av}\Delta t$

$J = (1.6 \times 10^{-14}\ \text{N})(7\ \text{s}) = 1.12 \times 10^{-13}\ \text{N·s}$

Plug and chug.

Remember: *The impulse on an object is equal to the change in the object's momentum. It is similar to work, as in the equation* $W = P\Delta t$.

Similar Questions

1) Three positive charges, $+1e$, $+2e$, and $+3e$, are sitting in a row with 5 mm between them. What is the potential energy of the system? ($k = 9 \times 10^9\ \text{Nm}^2/\text{C}^2$)
2) A $-6e$ charge experiences an electric force upwards when it is fired through a parallel plate capacitor. If the potential difference experienced by the test charge is 1,000 V and the plates are 2 cm apart, what is the force?
3) If a $+1e$ test charge loses 1 J of electric potential energy in moving from equipotential line a to b, which is closer to the positive point charge that creates the field, V_a or V_b?