phys. midterm

Electric Charge and Electric Fields

1. Scaling Problem

a) some point charge produces an E-field $E_c = 2.00 \times 10^{-3}$ V/m at a distance of 7 mm. What is the value of E_c at 5mm produced by the same charge?

$E = k$

b) A 1 μC charge produces an E-field $E = 8.00 \times 10^{3}$ V/m at some distance. What is the value of E_c at the same distance if the charge is 3 μC

2. The classic Millikan oil drop experiment was the first to measure electron charge. Oil drops were suspended against the gravitational force by an electric field. Suppose the drops have a mass of 4×10^{-16} kg and the E field is oriented downward, and has a value of 6131.25 N/C. With this exact value, the drops remain suspended in air.

a) How many electrons are on the drops?

$$\frac{4 \times 10^{-16} \cdot 9.8}{\text{[redacted]}} = \text{[redacted]} \text{ electrons}$$

6131.25

b) Suppose a cosmic ray comes along and removes an electron from a drop. What will the acceleration of the drop be?

$$\frac{4 \times 10^{-16}}{9.1 \times 10^{-3}} = 4.39 \times 10^{14}$$

Potential Energy and voltage, Capacitors

1. A mass spectrometer is a device used to accelerate ions to determine atomic mass of chemicals. Suppose two conducting plates with potential difference $\Delta V = 4kV$ are used to accelerate both hydrogen ions and helium ions. Hydrogen have charge +1qe, and helium have charge +2qe.

a) What is the total kinetic energy (in electron Volts) gained by the hydrogen and helium ions?

$KE_{Hydrogen} = 1.6\times10^{-19} \cdot 4\times10^{3} = 6.4\times10^{-16}\ J$

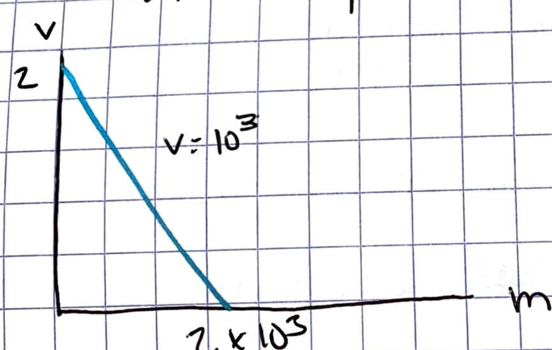
$KE_{Helium} = 2(1.6\times10^{-19}) \cdot 4\times10^{3} = 12.8\times10^{-16}\ J$

b) If plate separation is $\Delta x = 5$ cm, what is the electric field

$$\frac{\Delta V}{\Delta X} = \frac{4\times10^{3}}{5\times10^{-2}} = 8\times10^{4}\ V/m$$

-2 bc cm → m

2. Suppose a parallel plate capacitor has an internal E-field of 1 kV/m and a plate separation of 2mm. Draw the voltage as a function of distance between the negative and the positive plates. Make sure to label the axes with proper units, and mark the X-value of each plate



3. Suppose a parallel plates in the previous problem have an area of 1 cm^2.

a) What is the capacitance of the system

Capacitance = (C) $\frac{\epsilon_0 A}{d}$ $\quad C = \frac{(8.85\times10^{-12})(1\times10^{-4})}{2\times10^{-3}}$

$= 4.425\times10^{-13}$

b) How much energy in Joules is stored in this capacitor if the voltage is 5V

$\frac{1}{2}(4.425\times10^{-13})(5) = 1.106\times10^{-11}$

4. Suppose we need a system that can store more energy for the same voltage (in other words, more capacitance)

a) Should we connect an identical capacitor to the first series or in parallel

- An identical capacitor should be connected in parallel as it will store more energy ✓

Current, Resistance, and DC Circuits

1. When dealing with AA batteries, we can connect them "end to end" or in parallel. Suppose that the internal resistances of the batteries $r_1 = r_2 = 2\,\Omega$ and that the emf's of the two batteries are both $\varepsilon_1 = \varepsilon_2 = 1.5\,V$. Finally, let $R = 50\,\Omega$. Suppose R represents a small device that will work at 1.5 V or 3 V.

a) Using Kirchoffs rules, find the current through R for the serial case.

$$I = \frac{3V}{r_1 + r_2 + R} = \frac{3}{54} = 55.56\,mA$$

$$I = \frac{1.5V}{r_1 + r_2 + R} = \frac{1.5}{54} = 27.77\,mA$$

b) What is the power consumption

$[(55.56)^2 \cdot 2] + [(55.56)^2 \cdot 2] + [(55.56)^2 \cdot 50] / 1000$

6.17 W　　6.17 W　　154.34 W

3V → Power consumption = 166.7 W

$[(27.77)^2 \cdot 2] + [(27.77)^2 \cdot 2] + [(27.77)^2 \cdot 50] / 1000$