

ELECTROSTATICS PROBLEMS

1. Metal boxes will not allow electrostatic effects inside - no electrical fields can exist inside when the box is charged - why not?
2. a) Calculate the Electrostatic Field Strength 0.5m from a van de Graaff generator which carries a charge of $+1.6 \times 10^{-4}$ coulomb. ($5.76 \times 10^6 \text{ NC}^{-1}$ radially away)

b) If an electron of charge $-1.6 \times 10^{-19} \text{ C}$ is placed at that point, fully specify the electric force on the electron and calculate its initial acceleration. ($9.22 \times 10^{-13} \text{ N}$ towards van de Graaff, acceleration = $1.01 \times 10^{18} \text{ ms}^{-2}$)
3. a) Calculate the Electrostatic field strength 0.53 nm from an isolated proton. Hence what is the force of attraction between a proton and electron in a hydrogen atom. ($5.1 \times 10^9 \text{ NC}^{-1}$ away, $8.2 \times 10^{-10} \text{ N}$ attraction)

b) Give an approximate potential difference between the 0.53nm radius of the first orbit and the 2.12nm radius of the second orbit. (Hint: assume that the field is approximately uniform. ~ 8 volts)
3. a) Two charges of $+2 \mu\text{C}$ and $-4 \mu\text{C}$ exist 4 cm apart. Calculate the Field strength at a point 4 cm from both at the corner of an equilateral triangle. ($1.95 \times 10^7 \text{ NC}^{-1}$, 30° to vector of $-4 \mu\text{C}$ field)

b) Sketch the total field around the two charges. (Soln see well below)
4. An animal cell has an outer membrane enclosing its contents of thickness 100nm and 3 mV. Calculate the electric field strength across the cell wall. Calculate the electric force on a K^+ ion in the cell wall. (This process forms the basis of cell to cell communication, eg the brain communicating with the hands. Such physics is typical of the “small” but crucial physics research occurring around the world.) ($4.8 \times 10^{-15} \text{ N}$)
5. a) An electron falls between a cathode and anode with PD of 20 kV. Calculate the speed with which it strikes the anode. ($8.38 \times 10^7 \text{ ms}^{-1}$)

b) The electron now enters a uniform E field midway between plates 2mm apart and 4mm long. The plates are at a PD of 3000V. Calculate the angle of emergence. (8.48°)
6. Air breaks down from insulator to conductor at a field strength of about $3 \times 10^6 \text{ Nm}^{-1}$.

a) Estimate the potential difference between your finger and a car door handle if a spark occurs when your finger is 2mm from the handle. (about 6000V)

b) Estimate the potential difference between cloud and Earth in a thunderstorm if lightning occurs when the gap is 300m. What is the likely effect of rain on the possibility of lightning in a storm? (About 10^9 volts)
Sketch of 3b. Note the negative charge, being larger, dominates the E field lines
From a suitably large distance, the combination will look as if only $-2\mu\text{C}$ exists instead of two sets of charges.

