ELECTRIC AND MAGNETIC FIELDS

ASSIGNMENT 4

Q1: A spherical uniform charge distribution of total charge +0.02 C and radius 3cm is placed at the origin of the x, y, z co-ordinate system, and an electron is located at position (-2, 0, 0) cm . The electron is moved to a new position, (5, 4, 5) cm. Assume that the zero position for the electric potential is at infinity.

(a) Find the potential at the two positions of the electron, and the potential difference between them.
(b) Does the electron gain or lose potential energy in moving to the new position?
(c) How much potential energy is gained or lost? Express the answer both in electron Volts and Joules.

Hints: (i) Potential depends only on the position, not on the path taken to get there.
(ii) Remember the formula(s) for potential at distance r from a spherical charge distribution.
(iii) Remember the relationship between potential and work.
(iv) Work done is positive if one would need to **push** the charge from the initial to the final position, and negative if the field tends to **pull** it.

Q2: An infinite plane of surface charge density 14μC m^{-2} is in the x-y plane.

(a) What is the direction of the electric field for positive values of z?
(b) What is the direction of the electric field for negative values of z?
(c) Point A has coordinates (1,0,5) cm and B has coordinates (1,-1,6) cm. What are the values of the electric field and the electric potential at these two points? Take the zero of potential to be on the x-y plane.
(d) How much work must be done to move a charge of -3 μC from A to B? Explain why work must be done **on** the charge.
(e) The -3 μC charge is moved from B to point C whose coordinates are (5,5,4). How much work is done?

Q3: A thin insulating shell or radius R carries a total charge +Q distributed uniformly over its surface. The zero of potential is assumed to be at infinity.

(a) Use the relationship between the electric field and potential to find the potential as a function of radial distance, r, from the centre for (i) r > R and (ii) r < R. Sketch the variation of both the electric field and potential with radius.

(b) A point charge -q, of mass m, is initially held at a distance 2R from the centre of the shell, and is then released. Show that when it reaches the surface of the shell, its speed, v, is given by

$$v = \left[\frac{qQ}{4\pi\varepsilon_0 Rm} \right]^{1/2} .$$

Hint: Apply the law of conservation of energy: the total energy (PE + KE) is the same at the two positions.