KING FHAD UNIVERSITY OF PETROLEUM & MINERALS
DEPARTMENT OF PHYSICS

PHYSICS 102 (992)
SOLUTIONS (CHAPTER 25)

Q.1 In a given lightning flash, the potential difference between a cloud and the ground is 1.0×10^9 V and the quantity of charge transferred is 30 C. (a) What is the change in energy of that transferred charge? (b) If all the energy released by transfer could be used to accelerate a 1000 kg automobile from rest, what would be the automobile's final speed? (c) If the energy could be used to melt ice, how much ice would it melt at 0^0? The heat of fusion of ice is 3.33×10^5 J/kg.

(a) $\Delta E = q\Delta V = (30)(1.0 \times 10^9) = \boxed{30 \times 10^9 \text{ J}}$

(b) $\Delta K = \frac{1}{2} m v^2 = 30 \times 10^9$

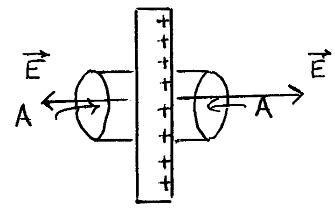
$$v = \sqrt{\frac{2(30 \times 10^9)}{1000}} = \boxed{7{,}746 \text{ m/s}}$$

(c) mass of ice that can be melted

$$\frac{Q}{L_f} = \frac{30 \times 10^9 \text{ J}}{3.33 \times 10^5 \text{ J/kg}} = \boxed{90 \times 10^3 \text{ kg or } 90 \text{ tons}}$$

Q.2 An infinite non-conducting sheet has a surface charge density $\sigma = 0.10$ $\mu C/m^2$ on one side. How far apart are equipotential surfaces whose potentials differ by 50 V?

Use Gauss's law



$$E\,2A = \frac{\sigma A}{\epsilon_0}$$

$$E = \frac{\sigma}{2\epsilon_0} = \frac{0.10\times10^{-6}}{(2)(8.8\times10^{-12})}$$

$$E = 5.65\times10^{3}\ N/C$$ (The electric field is uniform)

$$E.d = V = 50,\quad d = \frac{50}{5.65\times10^{3}} = 8.85\ mm$$

Q.3 In Figure 25.3, what is the net potential at a point P due to the four point charges, if V = 0 at infinity?

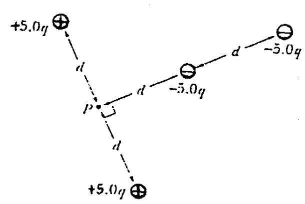


FIGURE 25.3

$$V_P = 2\frac{k(5q)}{d} + \frac{k(-5q)}{d} + \frac{k(-5q)}{2d}$$

$$V_P = \frac{kq}{d}\left(10 - 5 - 5/2\right) = \boxed{\frac{5kq}{2d}}$$

Q.4 In a certain situation, the electric potential varies along the x-axis as shown in the graph of Figure 25.4. For each of the intervals ab, bc, cd, de, ef, fg, and gh, determine the x component of the electric field, and then plot E_x versus x. (Ignore behavior at the interval end points).

$$E_x = -\frac{dV}{dx} = -\frac{\Delta V}{\Delta x}$$

$$E_{ab} = -\frac{12}{2} = -6\ N/C = \boxed{-6\ V/m}$$

$$E_{bc} = \boxed{0}, \quad E_{cd} = E_{de} = -\left(\frac{-12}{4}\right) = \boxed{3\ V/m}$$

$$E_{ef} = -\left(\frac{-7.5}{0.5}\right) = \boxed{15\ V/m}, \quad E_{fg} = 0, \quad E_{gh} = -\frac{7.5}{2.5} = \boxed{-3\ V/m}$$

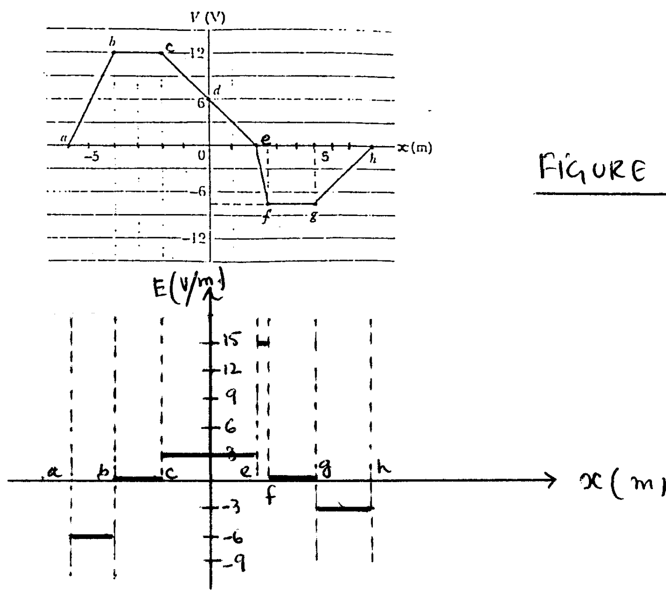


FIGURE 25.4

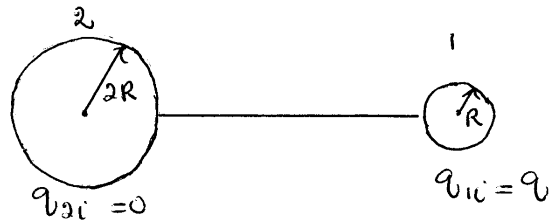
Q.5 Two charged, parallel, flat conducting surfaces are spaced d = 1.00 cm apart and produce a potential difference ΔV = 625 V between them. An electron is projected from one surface directly toward the second. What is the initial speed of the electron if it comes to rest just at the second surface?

$$\Delta U + \Delta K = 0$$

$$\left(0 - \frac{1}{2} m v^2\right) + (-e)(-625) = 0$$

$$v = \sqrt{\frac{2(1.6 \times 10^{-19})(625)}{9.11 \times 10^{-31}}} = \boxed{1.48 \times 10^{7}\ m/s}$$

Q.6 Consider two widely separated conducting spheres, 1 and 2, the second having twice the diameter of the first. The smaller sphere initially has a positive charge q, and the larger one is initially uncharged. You now connect the spheres with a long thin wire. (a) How are the final potentials V_1 and V_2 of the spheres related? Find the final charge q_1 and q_2 on the spheres in terms of q. (c) What is the ratio of final charge density of sphere 1 to that of sphere 2?



(a) The two surfaces plus the surface of the wire form equipotential surface, therefore

$$\boxed{V_1 = V_2}$$

(b) $$\frac{Kq_2}{2R} = \frac{Kq_1}{R} = \frac{K(q - q_2)}{R} \quad (\text{since } q_1 + q_2 = q)$$

$$q - q_2 = \frac{1}{2} q_2 , \quad \frac{3}{2} q_2 = q , \quad \boxed{q_2 = \frac{2}{3} q}$$

$$q_1 = q - q_2 = \boxed{\frac{1}{3} q}$$

$$\sigma_1 = \frac{(1/3)q}{4\pi R^2} = \frac{q}{12\pi R^2} , \quad \sigma_2 = \frac{(2/3)q}{4\pi (2R)^2} = \frac{2q}{48\pi R^2}$$

$$\frac{\sigma_2}{\sigma_1} = \frac{(2q/48\pi R^2)}{(q/12\pi R^2)} = \frac{24}{48} = \boxed{\frac{1}{2}}$$