

Homework 3

Chapter 20

Problem 1. (a) Calculate the speed of a proton that is accelerated from rest through a potential difference of $\Delta V = 120$ V.

(b) Calculate the speed of an electron that is accelerated through the same potential difference.

(a) Conserving energy

$$E_0 = \frac{1}{2}m_p v^2 = E_1 = e\Delta V \quad (1)$$

$$v = \sqrt{\frac{2e\Delta V}{m_p}} = \sqrt{\frac{2 \cdot 1.60 \cdot 10^{-19} \text{ C} \cdot 120 \text{ V}}{1.67 \cdot 10^{-27} \text{ kg}}} = 152 \text{ km/s} \quad (2)$$

(b) Replacing m_p with m_e

$$v = \sqrt{\frac{2e\Delta V}{m_e}} = \sqrt{\frac{2 \cdot 1.60 \cdot 10^{-19} \text{ C} \cdot 120 \text{ V}}{9.11 \cdot 10^{-31} \text{ kg}}} = 6.49 \text{ Mm/s} \quad (3)$$

Problem 11. The three charges in Figure P20.11 are at the vertices of an isosceles triangle. Calculate the electric potential at the midpoint of the base, taking $q = 7.00 \mu\text{C}$.

$$V = k_e \left(\frac{-q}{1.00 \text{ cm}} + \frac{-q}{1.00 \text{ cm}} + \frac{q}{\sqrt{4.00^2 - 1.00^2} \text{ cm}} \right) \cdot \frac{100 \text{ cm}}{1 \text{ m}} = -11.0 \text{ MV} \quad (4)$$

Problem 27. A uniformly charged insulating rod of length $L = 14.0$ cm is bent to form a semicircle. The rod has a total charge of $Q = -7.50 \mu\text{C}$. Find the electric potential at the center of the semicircle 0.

As in problem 2, we'll sum over all the charge bits, but in this case our bits are infinitesimal, so our sum is technically an integral. Defining the charge density $\lambda = Q/L$ we have

$$V = \int_0^L k_e \frac{\lambda dL}{r} = k_e \frac{\lambda}{r} \int_0^L dL = k_e \frac{Q}{r} \quad (5)$$

The same as for a point charge Q ! This is because electric potential is a scalar, and all the charges are the same distance from O . It doesn't matter if they are all gathered together at one point, or smeared out in a semicircle, spherical shell, or whatever, as long as they are all the same distance r from O .

We still need to find r , but we know that the arc length of a semicircle is πr , so $r = L/\pi$, and

$$V = k_e \frac{\pi Q}{L} = 8.99 \cdot 10^9 \text{ N m}^2/\text{C}^2 \frac{\pi \cdot (-7.50 \cdot 10^{-6} \text{ C})}{0.140 \text{ m}} = -1.51 \text{ MV} \quad (6)$$