Multiple Choice

1. In a certain region of space, the electric field is zero. From this fact, what can you conclude about the electric potential in this region?

(a) It is zero.

(b) It is constant.

(c) It is positive.

(d) It is negative.

(e) None of these answers is necessarily true.

2. A particle with charge $-40\,\text{nC}$ is on the $x$ axis at the point with coordinate $x = 0$. A second particle, with charge $-20\,\text{nC}$, is on the $x$ axis at $x = 500\,\text{mm}$. Is there a point at finite distance where the electric potential is zero?

(a) Yes; it is to the left of $x = 0$.

(b) Yes; it is between $x = 0$ and $x = 500\,\text{mm}$.

(c) Yes; it is to the right of $x = 500\,\text{mm}$.

(d) No.

3. A metallic sphere $A$ of radius 1 cm is several centimeters away from a metallic spherical shell $B$ of radius 2 cm. Charge 450 nC is placed on $A$, with no charge on $B$ or anywhere nearby. Next, the two objects are joined by a long, thin, metallic wire, and finally the wire is removed. How is the charge shared between $A$ and $B$?

(a) 0 on $A$, 450 nC on $B$.

(b) 50 nC on $A$, 400 nC on $B$, with equal volume charge densities

(c) 90 nC on $A$, 360 nC on $B$, with equal surface charge densities

(d) 150 nC on $A$, 300 nC on $B$. 
Short Answer

Consider a proton.

(a) Find the potential at a distance of 1.00 cm from a proton.

(b) What is the potential difference between two points that are 1.00 cm and 2.00 cm from a proton?

Now, suppose one proton was fixed in space and a second was positioned at $r_0 = 1.00$ cm from the first. Then the second proton is released.

(c) What is the second proton’s speed at $r = 2.00$ cm?

(d) What is the second proton’s speed as $r \to \infty$?

Part (a)

Following the usual formula, at 1.00 cm the potential is

$$V_1 = \frac{k_e q}{r} = \frac{8.99 \times 10^9 \text{Nm}^2/\text{C}^2 (1.60 \times 10^{-19} \text{C})}{1.00 \times 10^{-2} \text{m}} = 1.44 \times 10^{-7} \text{V}.$$ 

Part (b)

At 2.00 cm the potential is

$$V_2 = \frac{k_e q}{r} = \frac{8.99 \times 10^9 \text{Nm}^2/\text{C}^2 (1.60 \times 10^{-19} \text{C})}{2.00 \times 10^{-2} \text{m}} = 0.719 \times 10^{-7} \text{V}.$$ 

Thus the difference in potential between the two points is

$$\Delta V = V_2 - V_1 = -7.19 \times 10^{-8} \text{V}.$$ 

Part (c)

We already have the potential difference from $r = 1.00$ cm to $r = 2.00$ cm. The difference in potential energy is $\Delta U = q\Delta V$. By conservation of energy,

$$0 = \Delta K + \Delta U = \frac{1}{2}m_p(v_2^2 - v_1^2) + q\Delta V.$$ 

We set $v_1 = 0$ and solve for $v_2$:

$$\frac{1}{2}m_p v_2^2 = -q\Delta V$$

$$v_2 = \sqrt{\frac{2q\Delta V}{m_p}} = \sqrt{\frac{2(1.60 \times 10^{-19} \text{C})(-7.19 \times 10^{-8} \text{V})}{(1.673 \times 10^{-27} \text{kg})}}$$

$$v_2 = 3.71 \text{ m/s}.$$
Part (d)

This time, the final potential goes to 0. Therefore, $\Delta V = -V_1$. The rest of part (c)’s answer still applies, so substituting $\Delta V = -V_1$, we get

$$v_2 = \sqrt{\frac{2q\Delta V}{m_p}} = \sqrt{\frac{2 (1.60 \times 10^{-19} \text{C})(-1.44 \times 10^{-7} \text{V})}{1.673 \times 10^{-27} \text{kg}}}$$

$$v_2 = 5.25 \text{ m/s}.$$