2. Two metal spheres are 3.0 cm in radius and carry charges of \(+1.0 \times 10^{-8} \text{ C}\) and \(-3.0 \times 10^{-8} \text{ C}\), respectively, assumed to be uniformly distributed. If their centers are 2.0 m apart, calculate

(a) the potential of the point halfway between their centers and
(b) the potential of each sphere.

\(a\) Since the charge is uniformly distributed, the spheres can be considered as point charges. Then, we can use the potential for a point charge:

\[
V = \frac{q}{4\pi \varepsilon_0 \ r}
\]

Then, the potential halfway between the center of the spheres is

\[
V = \frac{1.0 \times 10^{-8} \text{ C N m}^{-2}}{4\pi \varepsilon_0 \ (1.0 \text{ m})^2} - \frac{3.0 \times 10^{-8} \text{ C N m}^{-2}}{4\pi \varepsilon_0 \ (1.0 \text{ m})^2} = -1.8 \times 10^2 \text{ N m} \cdot \frac{\text{C}}{\text{C}}
\]

which is the potential due to both spheres at the halfway point.

\(b\) To find the potential on a sphere of radius \(r_0\), consider the sphere as a point charge. Then, the potential of the sphere due to that sphere alone is

\[
V = \frac{\Phi}{4\pi \varepsilon_0 r_0}
\]

But on this problem, the potential contribution from the other sphere is not negligible. Hence, the total contribution to the potential is, for spheres one and two:

\[
V_1 = \frac{\Phi_1}{4\pi \varepsilon_0 r_0} + \frac{\Phi_2}{4\pi \varepsilon_0 d}
\]

\[
V_2 = \frac{\Phi_2}{4\pi \varepsilon_0 r_0} + \frac{\Phi_1}{4\pi \varepsilon_0 d}
\]

where \(d\) is the separation between spheres (2.0 m), (3.0 cm, 2.0 cm)

Thus

\[
V_1 = \frac{1.0 \times 10^{-8} \text{ C N m}^{-2}}{4\pi \varepsilon_0 \ (3.0 \times 10^2 \text{ cm})^2} - \frac{3.0 \times 10^{-8} \text{ C N m}^{-2}}{4\pi \varepsilon_0 \ (1.0 \text{ m})^2} = -2.9 \times 10^2 \text{ Volts}
\]

\[
V_2 = \frac{-3.0 \times 10^{-8} \text{ C N m}^{-2}}{4\pi \varepsilon_0 \ (3.0 \times 10^2 \text{ cm})^2} + \frac{1.0 \times 10^{-8} \text{ C N m}^{-2}}{4\pi \varepsilon_0 \ (1.0 \text{ m})^2} = -8.9 \times 10^2 \text{ Volts}
\]

**Point breakdown:**

- Part \(a\) 10 pts
- Part \(b\) 10 pts if you neglected the contribution to the potential from the "other" sphere, 5 points if you included this contribution, thus the total possible on \(b\) was 15 pts.
- Points were also lost by significant errors, units, and wrong derivations of \(V\).