

Electroneutrality

Consider a sphere radius a .

Capacitance is $4\pi\epsilon_0 a = (1.11 \times 10^{-10})a$

Charge for 1 volt is $4\pi\epsilon_0 a = (1.11 \times 10^{-10})a$

Number of unbalanced charges for 1v is $\frac{4\pi\epsilon_0 a = (1.11 \times 10^{-10})a}{1.61 \times 10^{-19}} = 6.951 \times 10^8 \times a$ charges

In a dielectric of dielectric constant ϵ_r , $6.951 \times 10^8 \times a$ charges $\times \epsilon_r$

Consider a 1 cm radius sphere of a 1 molar solution dielectric constant 78.8

Number of unbalanced charges is $\sim 5.57 \times 10^8$ charges for 1 v,
roughly 10,000,000 charges for 0.2 v in 1 cm sphere

Now, compare to total number of charges in a typical system

Volume of 1 cm radius sphere is $\frac{4}{3}\pi a^3 = 4.19 \times 10^{-6} \text{ m}^3$

Number of ions in 1 cm radius sphere of 1 mole is $4.19 \times 10^{-6} \text{ m}^3 \times 6.02 \times 10^{23} \frac{1 \text{ liter}}{\text{m}^3} = 2.52 \times 10^{21}$ ions.

Unbalanced charges are a small fraction, namely $\frac{5.57 \times 10^8}{2.52 \times 10^{21}} = 2.2 \times 10^{-13}$ for 0.2 v in 1 cm sphere.

General formula (for 1 mole salt at 1 v) is $\frac{4\pi\epsilon_r\epsilon_0 a}{\frac{4}{3}\pi a^3 N_A} = \frac{3\epsilon_r\epsilon_0}{a^2} \frac{1}{N_A} = \frac{3 \times 78.8 \times 8.85 \times 10^{-12}}{a^2 (6.02 \times 10^{23})} = \frac{3.47 \times 10^{-33}}{a^2}$