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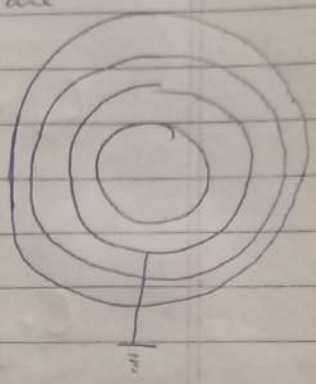
Physics presentation

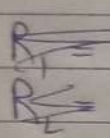
Q Four concentric metallic spherical shells (R, 2R, 3R, 4R) are kept such as that the second sphere is grounded and sphere 1, 3, 4 have charges +Q, -2Q, 4Q. Find the equivalent capacitance of this system if the other shells, sphere 1 & 4 are connected to a live wire.

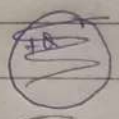


— Capacitance due to sphere

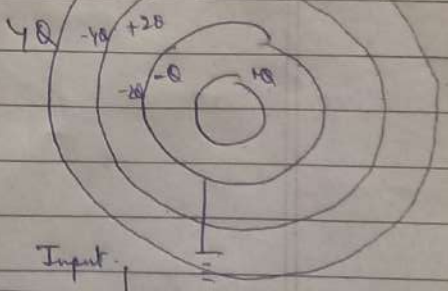
$$C = 4\pi\varepsilon_0\left(\frac{ab}{b-a}\right)$$

Let's first balance charges for conditions of a conductor.

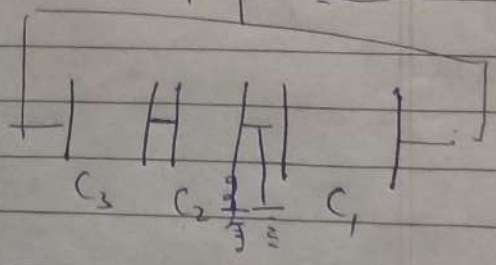




* Charge on sphere becomes = -3Q.
To make all surfaces at $\vec{E} = 0$.
[This is possible because shell 2 is grounded].



$C_1 = R_1 \& R_L$
$C_2 = R_2 \& R_3$
$C_3 = R_3 \& R_4$



∴ Configuration is
C_2 & C_3 in series,
C_1 & eq. of (C_2 & C_3) in parallel.

$$C_{eq} = \left(\frac{1}{\frac{1}{C_2} + \frac{1}{C_3}}\right) + C_1$$

$$C_1 = 4\pi\varepsilon_0\left(\frac{2R^2}{R}\right) \qquad \text{Let } 4\pi\varepsilon_0 R = k.$$

$$= 2(4\pi\varepsilon_0 R) = 2k$$

$$C_2 = 4\pi\varepsilon_0\left(\frac{6R^2}{R}\right)$$

$$= 6(4\pi\varepsilon_0 R) = 6k$$

$$C_3 = 4\pi\varepsilon_0\left(\frac{12R^2}{R}\right)$$

$$= 12(4\pi\varepsilon_0 R) = 12k.$$

$$C_{eq} = \frac{1}{\frac{1}{6k} + \frac{1}{12k}} + 2k.$$

$$= k\left[\frac{1}{\frac{1}{6} + \frac{1}{12}} + 2\right]$$

$$= 6k$$

$$= 24\pi\varepsilon_0 R.$$