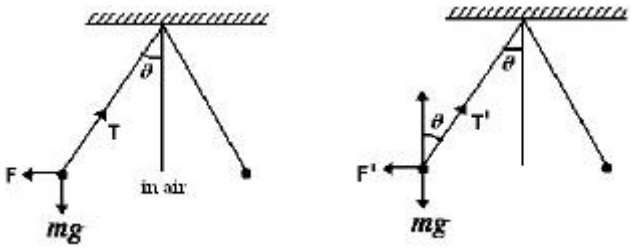
Answer on Question #41705, Physics, Electrodynamics

Two identical charged spheres are suspended in air by strings of equal lengths and make an angle of 30° with each other. When suspended in a liquid of density 0.8 gm cm–3, the angle remains the same. What is the dielectric constant of the liquid? Take density of material of the sphere = 1.6 gm cm–3

(1) 2 (2) 5 (3) 10 (4) None of the above

Solution

Let T and T' be the tensions in the string when spheres are in air and in liquid.



$T\sin\theta = F$ $\qquad$ $T'\sin\theta = F'$

$T\cos\theta = mg$ $\qquad$ $B + T'\cos\theta = mg$

We have $F = mg\tan\theta$ and $F' = (mg - B)\tan\theta$.

F is the electrostatic repulsion force in the air:

$$F = \frac{q^2}{4\pi\varepsilon_0 a^2}.$$

In the liquid this force is F' and is given as

$$F' = \frac{q^2}{4\pi\varepsilon_0 k a^2},$$

where k is the dielectric constant of the liquid.

We can see that $F' = \frac{F}{k}$. From the force diagram:

$$\frac{F}{F'} = \frac{mg}{mg - B},$$

where B is the Buoyant force. So

$$k = \frac{Vdg}{Vdg - Vfg} = \frac{d}{d - f} = \frac{1.6}{1.6 - 0.8} = 2.$$

Answer: (1) 2.