Chapter 21 - Discussion Problems

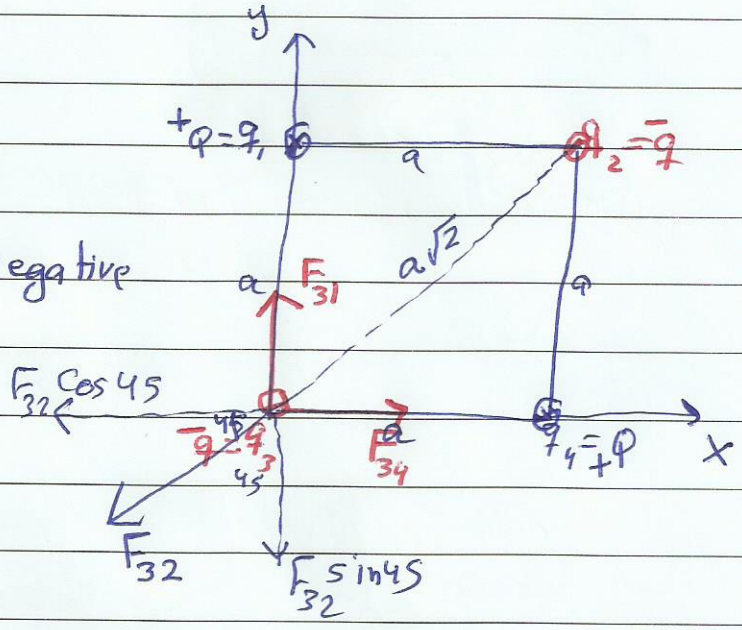
[21-2]

a) Find $\frac{Q}{q} = ?$ $\vec{F}_3 = 0$

Suppose Q is positive

then for $\vec{F}_3 = 0$ q must be negative

$\Rightarrow \frac{Q}{q} = (-)$?



$F_{31} = k\frac{Qq}{a^2}$ as shown

$F_{34} = k\frac{Qq}{a^2}$ as shown

$F_{32} = k\frac{q^2}{(a\sqrt{2})^2} = \frac{kq^2}{2a^2}$ as shown

$\vec{F}_3 = \vec{F}_{31} + \vec{F}_{32} + \vec{F}_{34}$

$(F_3)_x = 0 + -\frac{kq^2}{2a^2}\cos 45 + \frac{kqQ}{a^2}$

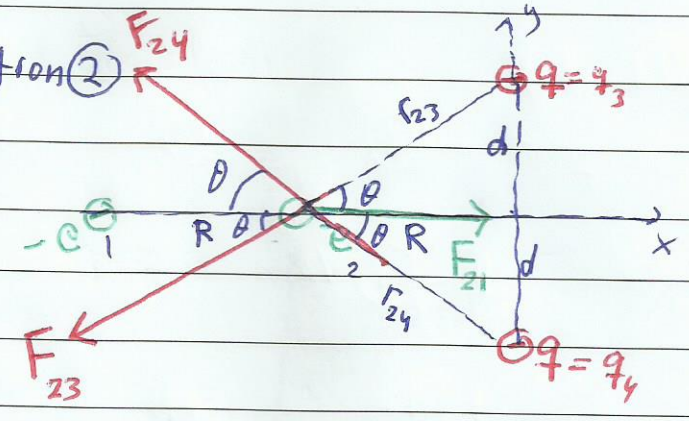
$0 = -\frac{kq^2}{2a^2}\cdot\frac{1}{\sqrt{2}} + \frac{kqQ}{a^2} \Rightarrow \frac{kq^2}{2a^2\sqrt{2}} = \frac{kqQ}{a^2} \Rightarrow$

$\frac{q}{2\sqrt{2}} = Q \Rightarrow \boxed{\frac{Q}{q} = \frac{-1}{2\sqrt{2}}}$

(21-9) $q = ne \Rightarrow n = \frac{q}{e} = \frac{8.2\times10^{-7}}{1.602\times10^{-19}}$

$n = 5.12\times10^{12}$ electrons acquired (اكتسبت) عدد الإلكترونات المفقودة من الكرة.

(21-10) Find θ, which keep electron (2) at rest $\Rightarrow \vec{F}_2 = 0$



$$\vec{F}_2 = \vec{F}_{21} + \vec{F}_{23} + \vec{F}_{24}$$

$F_{21} = \frac{k e^2}{R^2}$ as shown

$F_{23} = F_{24} = \frac{k q e}{(d^2 + R^2)}$ as shown

$r_{23} = r_{24} = \sqrt{d^2 + R^2}$

$\cos\theta = \frac{R}{r_{23}}$

$r_{23} = \frac{R}{\cos\theta}$

$$(F_2)_x = +F_{21} - F_{24}\cos\theta - F_{23}\cos\theta$$

$$0 = \frac{k e^2}{R^2} - 2\left[\frac{k q e}{d^2 + R^2}\cos\theta\right]$$

$$\frac{2q\cos\theta}{d^2 + R^2} = \frac{e}{R^2} \Rightarrow \frac{2q\cos\theta}{r_{23}^2} = \frac{e}{R^2}$$

$$\frac{2q\cos\theta}{R^2/\cos^2\theta} = \frac{e}{R^2} \Rightarrow 2q\cos^3\theta = e$$

$$\cos^3\theta = \frac{e}{2q}$$

$$\cos\theta = \left(\frac{e}{2q}\right)^{1/3}, \quad q = ne, \quad n = 1, 2, 3, 4, 5$$

$$= \left(\frac{e}{2ne}\right)^{1/3}$$

$$= \left(\frac{1}{2n}\right)^{1/3}, \quad n = 1, 2, 3, 4, 5$$

for $n = 1$

$\cos\theta_1 = \left(\frac{1}{2}\right)^{1/3} = 0.793700 \Rightarrow \theta_1 = 37.5^\circ$

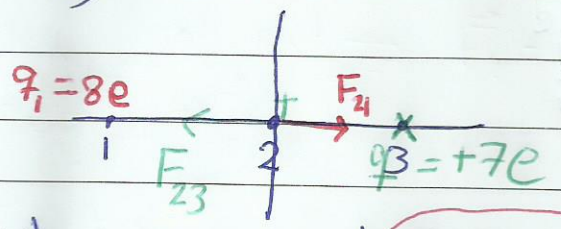
for $n = 2$

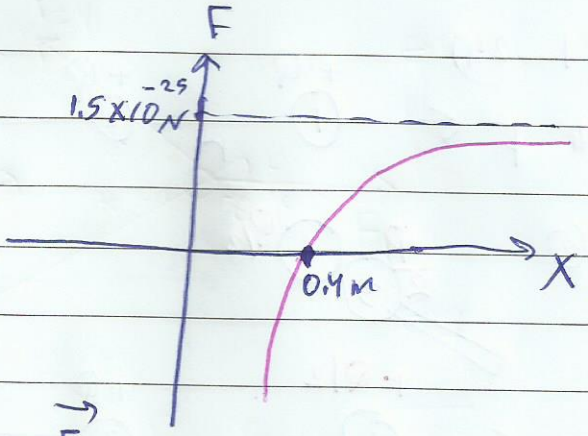
$\cos\theta_2 = \left(\frac{1}{4}\right)^{1/3} = 0.629960 \Rightarrow \theta_2 = 50.95^\circ$

for $n = 3$

$\cos\theta_3 = \left(\frac{1}{6}\right)^{1/3} \Rightarrow \theta_3 = 56.6^\circ$

(21-30)





When $q_3 = +7e$ at $X = 0.4\ m$

$$\vec{F}_2 = 0 \Rightarrow \vec{F}_{21} + \vec{F}_{23} = 0 \Rightarrow \vec{F}_{21} = -\vec{F}_{23}$$

q_1 must be (+)

$$F_{21} = F_{23}$$

$$\frac{k q_2 q_1}{r_{21}^2} = \frac{k q_2 q_3}{(0.4)^2} \Rightarrow \frac{q_1}{r_{21}^2} = \frac{q_3}{(0.4)^2}$$

$$r_{21}^2 = \frac{q_1}{q_3}(0.4)^2 \Rightarrow$$

$$r_{21} = 0.4\sqrt{\frac{q_1}{q_3}} = 0.4\sqrt{\frac{8e}{7e}} = (0.4)\left(\frac{8}{7}\right)^{1/2}$$

$$r_{21} = 1.069\ m$$

as q_3 goes ~~to~~ ∞ $\vec{F}_{2,n} = 1.5 \times 10^{-25}\ N$

as q_3 goes ~~to~~ $\infty \Rightarrow F_{23} = 0 \Rightarrow$

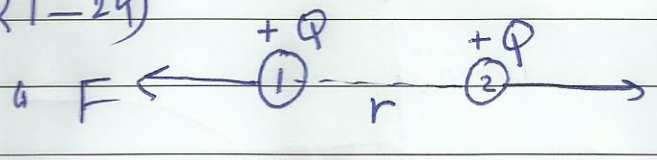
$$\vec{F}_{2,net} = 1.5 \times 10^{-25}\ N = F_{21}$$

$$F_{21} = \frac{k q_1 q_2}{(r_{21})^2} \Rightarrow 1.5 \times 10^{-25} = \frac{9 \times 10^9 (8e)(q_2)}{(1.069)^2}$$

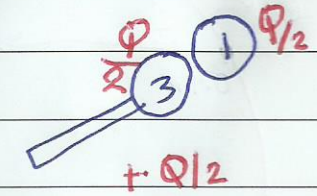
$$q_2 = \frac{(1.5 \times 10^{-25})(1.069)^2}{(9 \times 10^9)(8 \times 1.6 \times 10^{-19})} = +1.48 \times 10^{-17}$$

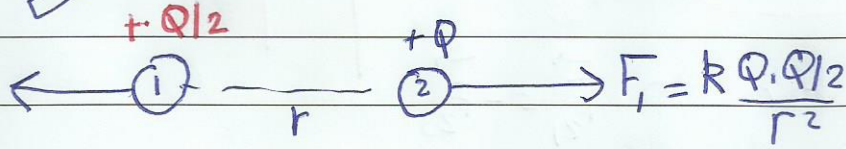
$$q_2 = 93e$$

(21–24)

a 

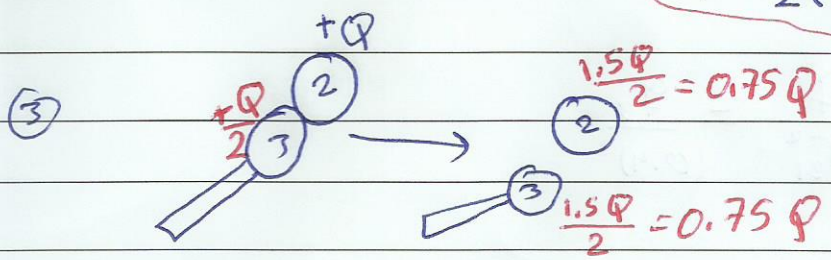
$$F = \frac{kQ^2}{r^2}$$

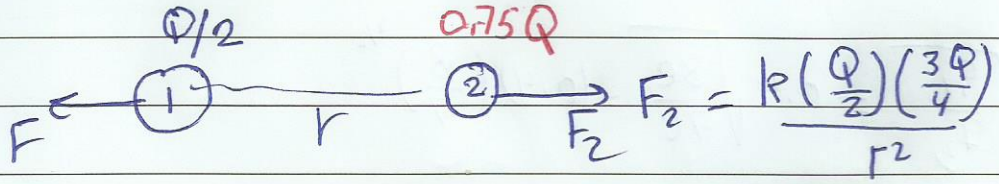
② 



$$F_1 = k\frac{Q \cdot Q/2}{r^2}$$

$$F_1 = \frac{1}{2}\left(\frac{kQ^2}{r^2}\right) = \frac{1}{2}F$$

③ 



$$F_2 = \frac{k\left(\frac{Q}{2}\right)\left(\frac{3Q}{4}\right)}{r^2}$$

$$= \left(\frac{3}{8}\right)\frac{kQ^2}{r^2}$$

$$F_2 = \frac{3}{8}F$$

Remember:

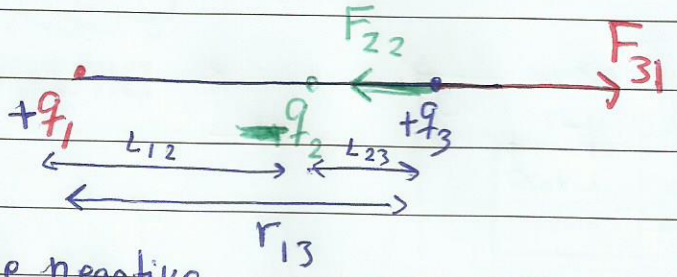
When 2 Conducting identical spheres are connected the total charge will be distributed equally between them

(21-35)

$L_{12} = 2L_{23}$

Suppose q_3 is positive and

Suppose q_1 is +positive



For $\vec{F}_{3,net} = 0$ q_2 must be negative

Find $\frac{q_1}{q_2}$ for $\vec{F}_{3,net} = 0 \Rightarrow \frac{q_1}{q_2} = (-)?$

$\vec{F}_{31} + \vec{F}_{32} = 0 \Rightarrow \vec{F}_{31} = -\vec{F}_{32} \Rightarrow$

$F_{31} = F_{32}$

$$\frac{k q_3 q_1}{(r_{13})^2} = \frac{k q_3 q_2}{(r_{23})^2}$$

, $r_{23} = L_{23}$

$r_{13} = L_{12} + L_{23}$

$= 2L_{23} + L_{23}$

$= 3L_{23}$

$$\frac{q_1}{(3L_{23})^2} = \frac{q_2}{(L_{23})^2}$$

$$\frac{q_1}{q_2} = \left(\frac{3L_{23}}{L_{23}}\right)^2 = 9$$

$\frac{q_1}{q_2} = -9 \Rightarrow$ means $q_1 \rightarrow +$, $q_2 \rightarrow -$ (or) means $q_1 \rightarrow -$, $q_2 \rightarrow +$