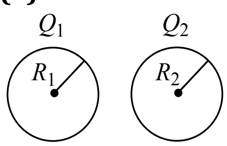
Class : XIIth
Date :

Solutions

Subject : PHYSICS
DPP No. :2

Topic :- Electric charges and fields

1 **(a)**



Let Q_1 and Q_2 are the charges on sphere of radii R_1 and R_2 respectively. Surface charge density $\sigma = \frac{\text{Charge}}{\text{Area}}$

According to given problem, $\sigma_1 = \sigma_2$

$$\frac{Q_1}{4\pi R_1^2} = \frac{Q_2}{4\pi R_2^2}$$

$\therefore \frac{Q_1}{Q_2} = \frac{R_1^2}{R_2^2}$ ...(i)

In case of a charged sphere, $V_s = \frac{1}{4\pi\varepsilon_0}\frac{Q}{R}$

$$\therefore V_1 = \frac{1}{4\pi\varepsilon_0}\frac{Q_1}{R_1}, V_2 = \frac{1}{4\pi\varepsilon_0}\frac{Q_2}{R_2}$$

$$\Rightarrow \frac{V_1}{V_2} = \frac{Q_1}{R_1} \times \frac{R_2}{Q_2} = \frac{Q_1}{Q_2} \times \frac{R_2}{R_1}$$

$= \left(\frac{R_1}{R_2}\right)^2 \times \left(\frac{R_2}{R_1}\right) = \frac{R_1}{R_2}$ ...[Using(i)]

2 **(c)**

The magnitude of electric field in the annular region of a charged cylindrical capacitor is given by $E = \frac{1}{2\pi\varepsilon_0}\frac{\lambda}{r}$ where λ is the charge per unit length and r is the distance from the axis of the cylinder. Thus $E \propto \frac{1}{r}$

3 **(c)**

Potential energy depends upon the charge at peaks of irregularities. Since every event in universe leads to the minimisation of energy

4 **(c)**

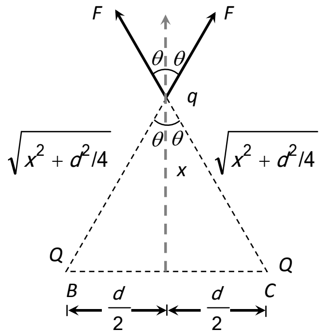
By using $Q = ne \Rightarrow Q = +2e = +3.2 \times 10^{-19} C$

5 **(c)**

Suppose third charge is similar to Q and it is q

So net force on it

$F_{net} = 2F\cos\theta$



Where $F = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Qq}{\left(x^2 + \frac{d^2}{4}\right)}$ and $\cos\theta = \frac{x}{\sqrt{x^2 + \frac{d^2}{4}}}$

$$\therefore F_{net} = 2 \times \frac{1}{4\pi\varepsilon_0} \cdot \frac{Qq}{\left(x^2 + \frac{d^2}{4}\right)} \times \frac{x}{\left(x^2 + \frac{d^2}{4}\right)^{1/2}}$$

$$= \frac{2Qqx}{4\pi\varepsilon_0\left(x^2 + \frac{d^2}{4}\right)^{3/2}}$$

For F_{net} to be maximum $\frac{dF_{net}}{dx} = 0$

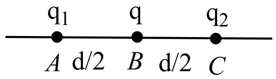
$$i.e. \frac{d}{dx}\left[\frac{2Qqx}{4\pi\varepsilon_0\left(x^2 + \frac{d^2}{4}\right)^{3/2}}\right] = 0$$

or $\left[\left(x^2 + \frac{d^2}{4}\right)^{-3/2} - 3x^2\left(x^2 + \frac{d^2}{4}\right)^{-5/2}\right] = 0$

$$i.e.\ x = \pm \frac{d}{2\sqrt{2}}$$

6 **(d)**

For equilibrium, we have



$$F_{AB} + F_{AC} = 0$$

or $\frac{1}{4\pi\varepsilon_0} \frac{q_1 q}{(d/2)^2} + \frac{1}{4\pi\varepsilon_0} \times \frac{q_1 q_2}{d^2} = 0$

Given, $q_1 = q_2 = -1\mu C$

So, $-\frac{q}{(d/2)^2} + \frac{1}{d^2} = 0$

or $q = \frac{1}{4} = 0.25$ C

7 **(a)**

Initial energy $= \frac{1}{2} \times 1 \times 10^{-6} \times (30)^2 = 450 \times 10^{-6}\, J$

Final energy $= \frac{1}{2}(C_1 + C_2)V_{common}^2$ $\left[\because V = \frac{V_1C_1 + V_2C_2}{C_1 + C_2}\right]$

$= \frac{1}{2} \times 3 \times 10^{-6} \times (10)^2$

$= 150 \times 10^{-6}\, J$

Loss of energy $= (450 - 150) \times 10^{-6} J = 300 \times 10^{-6}\, J$

$= 300\mu J$

8 **(a)**

From Gauss's law,

$\frac{\text{charge enclosed}}{\varepsilon_0}$

$=$Flux leaving the surface

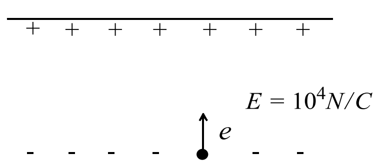
$\frac{q}{\varepsilon_0} = \phi_2 - \phi_1$

$\Rightarrow q = (\phi_2 - \phi_1)\varepsilon_0$

9 **(a)**

The force acting on the electron $= e.E$

Acceleration of the electron $= \frac{eE}{m}$



$u = 0, v = ?\ \ v^2 - u^2 = 2aS$

$S = 2 \times 10^{-2} m$

$\therefore v^2 = 2\left(\frac{e}{m}\right)E \times 2 \times 10^{-2} m$

$\frac{e}{m} = 1.76 \times 10^{11}$ coulomb$/kg$

$\therefore v^2 = 2 \times 1.76 \times 10^{11} \times 10^4 \times 2 \times 10^{-2}$

$= 7.04 \times 10^{13} = 70.4 \times 10^{12}$

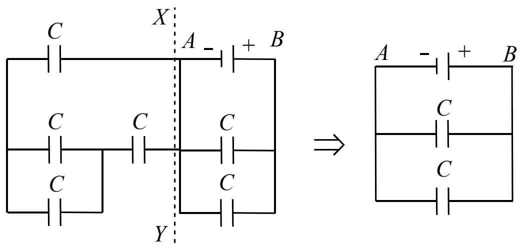
$\therefore v \approx 0.85 \times 10^7\ m/s$

10 **(d)**

The work done is given by $=q(V_2-V_1)=0$

11 **(d)**

All capacitor lying in left side of line XY are short circuited so circuit can be reduced as follows



$C_{AB}=2C$

12 **(c)**

The energy will be minimum in this case and every system tends to possess minimum energy

13 **(c)**

Work done $=\frac{1}{2}\left(\frac{3C}{2}\right).V^2=\frac{3CV^2}{4}$

14 **(a)**

$$U=\frac{1}{2}CV^2=\frac{1}{2}\left(\frac{\varepsilon_0 A}{x}\right)V^2$$

$$\therefore \frac{dU}{dt}=\frac{1}{2}\varepsilon_0 AV^2\left(-\frac{1}{x^2}\frac{dx}{dt}\right)\Rightarrow\frac{dU}{dt}\propto x^{-2}$$

15 **(d)**

As $\sigma_1=\sigma_2$

$$\therefore \quad \frac{Q_1}{4\pi r_1^2}=\frac{Q_2}{4\pi r_2^2}$$

Or $\frac{Q_1}{4\pi\varepsilon_0 r_1^2}=\frac{Q_2}{4\pi\varepsilon_0 r_2^2}$

$\therefore \quad E_1=E_2$ or $E_1/E_2=1$

16 **(a)**

The total energy before connection

$$=\frac{1}{2}\times 4\times 10^{-6}\times(50)^2+\frac{1}{2}\times 2\times 10^{-6}\times(100)^2$$

$=1.5\times 10^{-2}J$

When connected in parallel

$$4 \times 50 + 2 \times 100 = 6 \times V \Rightarrow V = \frac{200}{3}$$

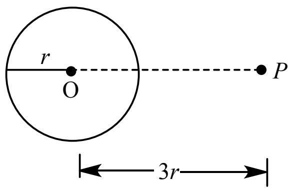
Total energy after connection

$$= \frac{1}{2} \times 6 \times 10^{-6} \times \left(\frac{200}{3}\right)^2 = 1.33 \times 10^{-2} J$$

18 **(d)**

The potential at a distance r, due to charge q is

$$V = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r}$$



Potential at a distance $(3r)$ is

$$V = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{3r}$$

Difference in potential

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{r} - \frac{1}{3r}\right]$$

$$\Rightarrow V = \frac{2q}{4\pi\varepsilon_0 \times 3r}$$

Intensity of electric field

$$E = \frac{q}{4\pi\varepsilon_0} \frac{1}{(3r)^2}$$

$$\therefore \frac{E}{V} = \frac{q}{4\pi\varepsilon_0 q r^2} \times \frac{4\pi\varepsilon_0 3r}{2q}$$

$$\Rightarrow \frac{E}{V} = \frac{1}{6r}$$

$$\Rightarrow E = \frac{V}{6r}$$

20 **(c)**

$$E=\frac{1}{4\pi\varepsilon_0}.\left[\frac{5\times10^{-9}}{(1\times10^{-2})^2}-\frac{5\times10^{-9}}{(2\times10^{-2})^2}+\frac{5\times10^{-9}}{(4\times10^{-2})^2}-\frac{(5\times10^{-9})}{(8\times10^{-2})^2}+\ldots\cdots\right]$$

$$\Rightarrow E=\frac{9\times10^9\times5\times10^{-9}}{10^{-4}}\left[1-\frac{1}{(2)^2}+\frac{1}{(4)^2}-\frac{1}{(8)^2}+\cdots\right]$$

$$\Rightarrow E=45\times10^4\left[1+\frac{1}{(4)^2}+\frac{1}{(16)^2}+\cdots\right]$$

$$-45\times10^4\left[\frac{1}{(2)^2}+\frac{1}{(8)^2}+\frac{1}{(32)^2}+\cdots\right]$$

$$\Rightarrow E=45\times10^4\left[\frac{1}{1-\frac{1}{16}}\right]-\frac{45\times10^4}{(2)^2}\left[1+\frac{1}{4^2}+\frac{1}{(16)^2}+..\right]$$

$$E=48\times10^4-12\times10^4=36\times10^4 N/C$$

ANSWER-KEY										
Q.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
A.	**A**	**C**	**C**	**C**	**C**	**D**	**A**	**A**	**A**	**D**
Q.	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
A.	**D**	**C**	**C**	**A**	**D**	**A**	**A**	**D**	**C**	**C**