DPP
DAILY PRACTICE PROBLEMS

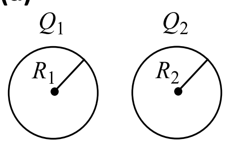
Class : XIIth
Date :

Solutio

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, $\sigma_1 = \sigma_2$

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

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

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

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

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

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

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)**

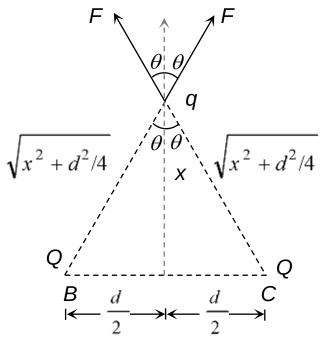
By using $Q = ne \Rightarrow Q = +2e = +3.2 \times 10^{-19} C$

5 **(c)**

Suppose third charge is similar to Q and it is q

So net force on it

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



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

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

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

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

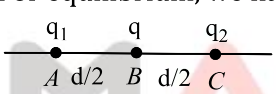
$$i.e.\frac{d}{dx}\left[\frac{2Qqx}{4\pi\varepsilon_0\left(x^2+\frac{d^2}{4}\right)^{3/2}}\right]=0$$

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 $\frac{1}{4\pi\varepsilon_0}\frac{q_1q}{(d/2)^2}+\frac{1}{4\pi\varepsilon_0}\times\frac{q_1q_2}{d^2}=0$

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 $=\frac{1}{2}\times1\times10^{-6}\times(30)^2=450\times10^{-6}\,J$

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

$=\frac{1}{2}\times3\times10^{-6}\times(10)^2$

$=150\times10^{-6}\,J$

Loss of energy $=(450-150)\times10^{-6}J=300\times10^{-6}\,J$

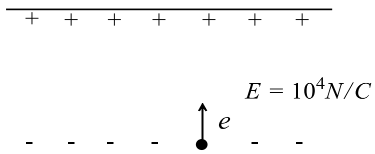
$=300\mu J$

8 **(a)**

From Gauss's law,

$$\frac{\text{charge enclosed}}{\varepsilon_0}$$
=Flux leaving the surface
$\frac{q}{\varepsilon_0} = \phi_2 - \phi_1$
$\Rightarrow q = (\phi_2 - \phi_1)\varepsilon_0$

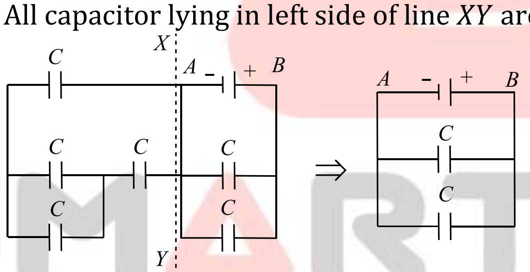
9 **(a)**
The force acting on the electron $= e.E$
Acceleration of the electron $= \frac{eE}{m}$



$u = 0, v = ?\ \ v^2 - u^2 = 2aS$
$S = 2 \times 10^{-2} m$
$\therefore v^2 = 2\left(\frac{e}{m}\right) E \times 2 \times 10^{-2} m$
$\frac{e}{m} = 1.76 \times 10^{11}$ 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)**
$U = \frac{1}{2}CV^2 = \frac{1}{2}\left(\frac{\varepsilon_0 A}{x}\right)V^2$
$\therefore \frac{dU}{dt} = \frac{1}{2}\varepsilon_0 A V^2 \left(-\frac{1}{x^2}\frac{dx}{dt}\right) \Rightarrow \frac{dU}{dt} \propto x^{-2}$

15 **(d)**
As $\sigma_1 = \sigma_2$

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

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

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

16 **(a)**

The total energy before connection

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

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

When connected in parallel

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

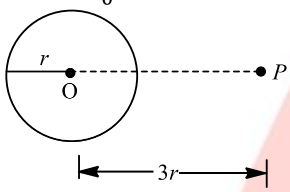
Total energy after connection

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

18 **(d)**

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

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



Potential at a distance $(3r)$ is

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

Difference in potential

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

$\Longrightarrow V = \dfrac{2q}{4\pi\varepsilon_0 \times 3r}$

Intensity of electric field

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

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

$\Longrightarrow \dfrac{E}{V} = \dfrac{1}{6r}$

$\Longrightarrow E = \dfrac{V}{6r}$

20 **(c)**

$E = \dfrac{1}{4\pi\varepsilon_0} \cdot \left[\dfrac{5 \times 10^{-9}}{(1 \times 10^{-2})^2} - \dfrac{5 \times 10^{-9}}{(2 \times 10^{-2})^2} + \dfrac{5 \times 10^{-9}}{(4 \times 10^{-2})^2} - \dfrac{(5 \times 10^{-9})}{(8 \times 10^{-2})^2} + \cdots\cdots\right]$

$\Rightarrow E = \dfrac{9 \times 10^9 \times 5 \times 10^{-9}}{10^{-4}}\left[1 - \dfrac{1}{(2)^2} + \dfrac{1}{(4)^2} - \dfrac{1}{(8)^2} + \cdots\right]$

$$\Rightarrow E = 45 \times 10^4 \left[1 + \frac{1}{(4)^2} + \frac{1}{(16)^2} + \cdots\right]$$

$$-45 \times 10^4 \left[\frac{1}{(2)^2} + \frac{1}{(8)^2} + \frac{1}{(32)^2} + \cdots\right]$$

$$\Rightarrow E = 45 \times 10^4 \left[\frac{1}{1 - \frac{1}{16}}\right] - \frac{45 \times 10^4}{(2)^2}\left[1 + \frac{1}{4^2} + \frac{1}{(16)^2} + ..\right]$$

$$E = 48 \times 10^4 - 12 \times 10^4 = 36 \times 10^4 N/C$$

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