DPP
DAILY PRACTICE PROBLEMS

Class : XIIth
Date :

**Solutions**

Subject : PHYSICS
DPP No. : 5

# Topic :- ELECTROSTATIC POTENTIAL AND CAPACITANCE

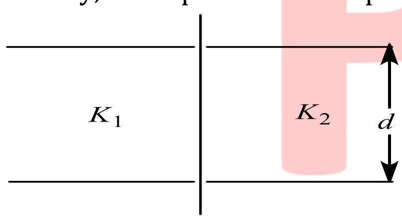
1 **(a)**

Potential gradient relates with electric field according to the relation, $E=-\frac{dV}{dr}$

$$=-\frac{10}{20\times 10^{-2}}=50\ \text{Vm}^{-1}$$

2 **(b)**

Initially, the capacitance of capacitor




$$C=\frac{\varepsilon_0 A}{d}$$

$\therefore \quad \frac{\varepsilon_0 A}{d}=1\mu\text{F} \qquad$ ...(i)

When it is filled with dielectric of dielectric constant $K_1$ and $K_2$ as shown, then there are two capacitors connected is parallel. So,

$$C'=\frac{K_1\varepsilon_0\left(\frac{A}{2}\right)}{d}+\frac{K_2\varepsilon_0\left(\frac{A}{2}\right)}{d}$$

(as area becomes half)

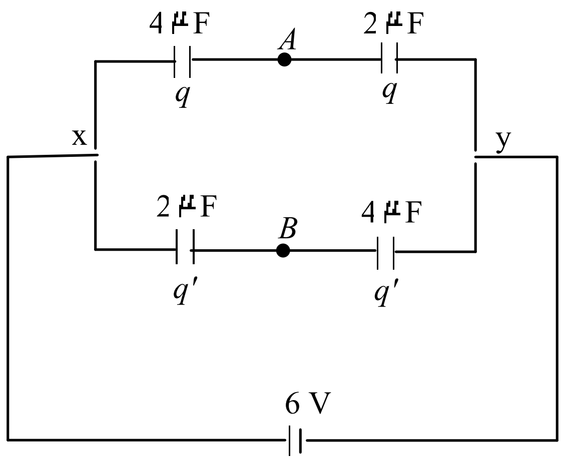
$$C'=\frac{4\varepsilon_0 A}{2d}+\frac{6\varepsilon_0 A}{2d}=\frac{2\varepsilon_0 A}{d}+\frac{3\varepsilon_0 A}{d}$$

Using Eq. (i), we obtain

$$C'=2\times 1+3\times 1=5\ \mu\text{F}$$

3 **(a)**

Consider the charge distribution as shown. Considering the branch on upper side, we have




$$\frac{q}{V_x - V_A} = 4 \times 10^{-6}$$

$$\frac{q}{V_A - V_y} = 2 \times 10^{-6}$$

Here, $V_x = 6$ volt, $V_y = 0$

$\therefore \quad \frac{q}{6 - V_A} = 4 \times 10^{-6}$ ...(i)

$\frac{q}{V_A - 0} = 2 \times 10^{-6}$ ...(ii)

From Eqs. (i) and (ii), we get

$$\frac{V_A}{6 - V_A} = 2$$

$\therefore \quad V_A = 4$volt

Similarly for the lower side branch

$\frac{q'}{6 - V_B} = 2 \times 10^{-6}$ ...(iii)

$\frac{q'}{V_B - 0} = 4 \times 10^{-6}$ ...(iv)

From Eqs. (iii) and (iv)

$$\frac{V_B}{6 - V_B} = \frac{1}{2}$$

$\therefore \; V_B = 2$ volt

$\therefore V_A - V_B = 4 - 2 = 2$ volt

4 **(a)**

The system will be equivalent to series combination of two capacitors of half thickness *ie*. ,each of capacity 2 C

$$\therefore \quad \frac{1}{C_s} = \frac{1}{2c} + \frac{1}{2c} = \frac{1}{c} \, or \; C_s = c$$

$\therefore$ capacity remains the same

6 **(b)**

In parallel, potential is same, say $V$

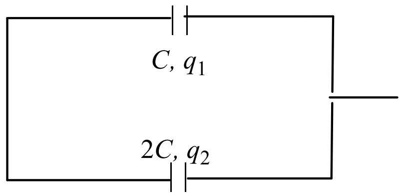
$$\frac{Q_1}{Q_2} = \frac{C_1 V}{C_2 V} = \frac{C_1}{C_2}$$

7 **(c)**

The charge $q_1 = CV_0$

or

$V_0 = \frac{q_1}{C}$ ...(i)




∴

Capacitors are in parallel, in parallel $V_0$ is same for all capacitors.

$\therefore$ For second capacitor $V_0 = \frac{q_2}{2C}$ ...(ii)

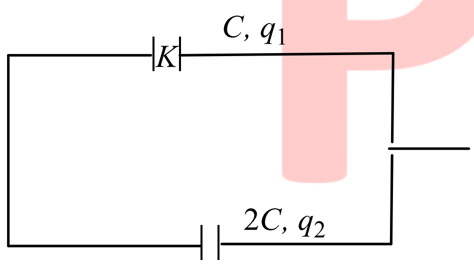
From Eqs. (i) and (ii),

$$q_2 = 2q_1 \quad \text{...(iii)}$$

After disconnecting the battery, the region between the plates of the capacitor $C$ is completely filled with a material of dielectric constant $(K = 2)$.

Then, $V_1 = \frac{q_1}{CK} = \frac{q_1}{2C}$

and $V_1 = \frac{q_2}{2C} = \frac{2q_1}{2C} = \frac{q_1}{C}$ [from Eq. (iii)]




Charge will flow from 2 to 1 till

$\frac{q_2'}{2C} = \frac{q'_1}{KC}$

$\frac{q_2'}{2C} = \frac{q_1'}{2C}$

$ie,\ q_1' = q_2'$

Earlier potential $V_0 = \frac{q_1}{C}$

Now it is $V_0 = \frac{q_1'}{2C}$

Now, $q_1 + q_2 = 3q_1$ [from Eq.(iii)]

and $q_1' + q_2' = 3q_1$

or $2q_1' = 3q_1$ or $q_1' = \frac{3q_1}{2}$

$\therefore$ Now potential $\frac{q_1'}{2C} = \frac{3q_1}{4C}$

$V=\frac{3V_0}{4}$

$[\because q_1=V_0C]$

8 **(c)**

Electric flux may be due to the charges present inside the Gaussian surface, but for the purpose of calculation of electric field $E$ at any point we shall have to consider contribution of all the charges.

9 **(d)**

Frequency $n=50\text{Hz}$

Time period $T=\frac{1}{50}\text{ s}$

Time taken for voltage to change from its peak value to zero

$=\frac{T}{4}=\frac{1}{4\times 50}=\frac{1}{200}=5\times 10^{-3}\text{s}$

10 **(d)**

$E=\left(\frac{1}{2}\right)CV^2$ ...(i)

The energy stored in capacitor is lost in form of heat energy

$H=ms\,\Delta T$ ...(ii)

From Eqs. (i) and (ii), we have

$ms\,\Delta T=\left(\frac{1}{2}\right)CV^2$

$V=\sqrt{\frac{2\,ms\Delta T}{C}}$

11 **(b)**

As the electrostatic force are conservative, work done is independent of path .

$W=\vec{\text{F}}.\ \overrightarrow{\text{ds}}=q\,E\hat{\text{i}}.\left[(0-a)\hat{\text{i}}+(0-b)\hat{\text{j}}\right]$

$=-q\,E\,a$

12 **(d)**

$E_1=\frac{1}{2}C_1V^2$

$=\frac{1}{2}\times 2\times 10^{-6}\times 100^2=0.01\text{J}$

$E_1=\frac{1}{2}C_2V^2$

$\frac{1}{2}\times 10\times 10^{-6}\times(100)^2=0.05\text{ J}$

Energy change $=E_2-E_2$

$=0.05-0.01=0.04\text{J}=4\times 10^{-2}\text{J}$

13 **(a)**

Potential energy of electric dipole, $U=-\vec{\text{p}}\,.\,\vec{\text{E}}=-pE\cos\theta$.

In Fig. (a), $\theta = \pi$ rad hence $U = -pE\cos\pi = +pE =$ maximum.

14 **(a)**

$$C_s = \frac{10 \times 20}{10 + 20} = \frac{200}{30} = \frac{20}{3}\ \mu\text{F}$$

$$Q = C_s V$$

$$Q = \frac{20}{3}\mu\text{F} \times 200\text{V}$$

$$Q = \frac{4000}{3}\mu\text{C}$$

Now, $V = \frac{4000\ \mu\text{C}}{3 \times 30\ \mu\text{F}} = \frac{4000}{90}\text{V} = \frac{400}{9}\text{ V}$

15 **(b)**

Electrostatic potential energy of system of two electrons

$$U = \frac{1}{4\pi\varepsilon_0}\frac{(-e)(-e)}{r} = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r}$$

Thus, as $r$ decreases, potential energy $U$ increases.

16 **(b)**

Electrical pressure (force/area)

$\Rightarrow p = \frac{1}{2}\varepsilon_0 E^2$ *and* $E = \frac{V}{r}$ $\therefore p = \frac{1}{2}\varepsilon_0\frac{V^2}{r^2}$

17 **(a)**

Bob will experience an additional force $F = q\,E$ in vertically upward direction and hence effective acceleration due to gravity is reduced from g to $(g - a) = \left(g - \frac{qE}{m}\right)$.

Consequently, time period of oscillation will become $T = 2\pi\sqrt{\frac{l}{(g-a)}}$ *ie*, time period will increase.

18 **(d)**

The three capacitors are in parallel hence, their equivalent capacitance $= 3C$

19 **(c)**

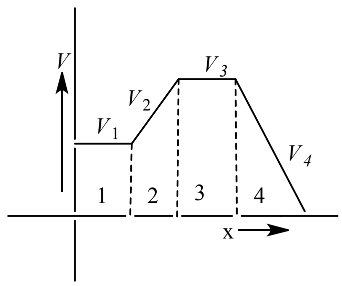
Electric potential inside the hollow conducting sphere is constant and equal to potential at the surface of the sphere $= \frac{Q}{4\pi\varepsilon_0 R}$.

20 **(b)**

Electric field

$E=-\frac{dV}{dx}$

For I region, $V_1$=constant




$\therefore \quad \frac{dV_1}{dx}=0$

$\therefore \quad E_1=0$

For II region,

$V_2=+\text{ve}=+f(x)$

$\therefore E_2=-\frac{dV_2}{dx}=-\text{ve}$

For III region.

$V_3$=constant

$\therefore \quad \frac{dV_3}{dx}=0$

$\therefore \quad E_3=0$

For IV region, $V_1=-f(x)$

$\therefore \quad E_4=-\frac{dV_4}{dx}=+\text{ve}$

From these values, we have

$E_2>E_4>E_1=E_3$

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