DPP
DAILY PRACTICE PROBLEMS

Class : XIIth
Date :

Solutions

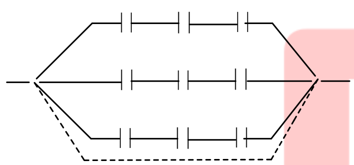
Subject : PHYSICS
DPP No. : 6

Topic :- ELECTROSTATIC POTENTIAL AND CAPACITANCE

1 **(b)**

Let m rows of n series capacitor be taken then minimum number of capacitors required is

$N = m \times n$



Also effective voltage is

$$V' = 1000 = n \times 250$$

$$\Rightarrow \quad n = \frac{1000}{250} = 4$$

Also these four capacitor are connected in series then effective capacitance is

$$\frac{1}{C'} = \frac{1}{8} + \frac{1}{8} + \frac{1}{8} + \frac{1}{8} = \frac{4}{8}$$

$$\Rightarrow \quad C' = 2\mu\text{F}$$

$$\therefore \quad C'' = 16 = 2 \times m$$

$$\Rightarrow \quad m = \frac{16}{2} = 8$$

Hence $N = m \times n = 8 \times 4 = 32$

2 **(b)**

The electric field intensity of a point in an electric field in a given direction is equal to the negative potential gradient in that direction, *ie*,

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

The negative sign signifies that the potential decreases in the direction of electric field, *ie*, electric lines of force flow from higher potential region to lower potential region.

Since, AB is perpendicular to field lines, so A and B are at same potential.

Hence, $V_A = V_B > V_C$

3 **(c)**

Original capacity, with air

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

When dielectric plate (medium) of thickness $t$is introduced between the plates, then capacity becomes

$$C' = \frac{\varepsilon_0 A}{d' - t\left(1 - \frac{1}{K}\right)}$$

but as given, $C' = C$

$\therefore \quad \frac{\varepsilon_0 A}{d} = \frac{\varepsilon_0 A}{d' - t\left(1 - \frac{1}{K}\right)}$

or $\quad d = d' - t + \frac{t}{K}$

or $\quad 8 = d' - 4 + \frac{4}{2}$

or $\quad 8 = d' - 2$

or $\quad d' = 10 \text{ mm}$

4 **(b)**

Charge on each plate of each capacitor

$Q = \pm CV = \pm 25 \times 10^{-6} \times 200$

$= \pm 5 \times 10^{-3} \text{C}$

5 **(b)**

Common potential $= \frac{C_1 V_0 + C_2 \times 0}{C_1 + C_2} = \frac{C_2 V_0}{C_1 + C_2}$

$U_{\text{before}} = \frac{1}{2} C_1 V_0^2$

$U_{\text{after}} = \frac{1}{2} C_1 \left[\frac{C_1 V_0}{C_1 + C_2}\right]^2 + \frac{1}{2} C_2 \left[\frac{C_1 V_0}{C_1 + C_2}\right]^2$

$= \frac{1}{2}\left[\frac{C_1 V_0}{C_1 + C_2}\right]^2 (C_1 + C_2)$

$\Rightarrow \quad \frac{U_{\text{before}}}{U_{\text{after}}} = \frac{C_1 + C_2}{C_1}$

Here, $\quad C_1 = C_2 = C$

$\therefore \quad \frac{U_{\text{before}}}{U_{\text{after}}} = \frac{2C}{C}$

$\Rightarrow \quad U_{\text{after}} = \frac{U}{2}$

6 **(a)**

Electric field $E = \frac{V}{d}$

$\therefore \quad V \propto d$

As the distance between the plates of the capacitor increases potential difference also increases.

7 **(d)**

As $\frac{4}{3}\pi R^3 = n \times \frac{4}{3}\pi r^3 \ \therefore R = n^{1/3} r$

New potential $V' = \frac{nq}{4\pi\varepsilon_0 r} = n^{2/3}\mathrm{V}$

8 **(b)**

Potential inside the sphere will be same as that on its surface

$$ie, \ \ V = V_{\text{surface}} = \frac{q}{10}\,\text{stat} - \text{volt}$$

$$\mathrm{V_{out}} = \frac{\mathrm{q}}{15}\,\text{stat} - \text{volt}$$

$$\therefore \frac{\mathrm{V_{out}}}{\mathrm{V}} = \frac{2}{3}$$

$$\Longrightarrow \mathrm{V_{out}} = \frac{2}{3}\mathrm{V}$$

9 **(a)**

When plates of capacitor are separated by a dielectric medium of dielectric constant K, its capacity

$$C_m = \frac{K\varepsilon_0 A}{d} = KC_0$$

$ie, \quad C_m = KC_0$

Here, $\ C_0 = C$

$\therefore \quad C_m = KC$

Now, two capacitors of capacities KC and C are in series, their effective capacitance

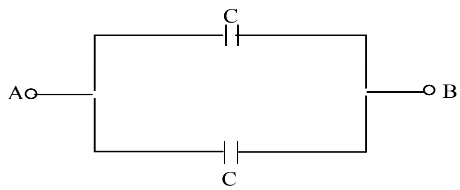
$$\frac{1}{C'} = \frac{1}{KC} + \frac{1}{C}$$

or $\quad \frac{1}{C'} = \frac{1+K}{KC}$

$$\therefore \ C' = \frac{KC}{K+1}$$

10 **(a)**

The given circuit is equivalent to a parallel combination of two identical capacitors.



Hence, equivalent capacitance between points A and B is

$$C = \frac{\varepsilon_0 A}{d} + \frac{\varepsilon_0 A}{d} = \frac{2\varepsilon_0 A}{d}$$

11 **(c)**

Energy given by the cell

$$E = CV^2$$

Here, C = capacitance of capacitor $= \frac{A\varepsilon_0}{d}$

V = potential difference across the plates $= Ed$

Therefore, $E = \left(\frac{A\varepsilon_0}{d}\right)(Ed)^2 = A\varepsilon_0 E^2 d$

12 **(a)**

When a positive charge is moved from one point to another in an electric of magnetic field, then under the influence of the field force acts on the particle and an external agent will have to do work against this force. But in the given case the charge moves under influence of no field, hence it does not experience any force therefore, no work is done.

$W_A = W_B = W_C = 0$

13 **(a)**

The capacitor with air as the dielectric has capacitance

$$C_1 = \frac{\varepsilon_0}{d}\left(\frac{3A}{4}\right) = \frac{3\varepsilon_0 A}{4d}$$

Similarly, the capacitor with K as the dielectric constant has capacitance

$$C_2 = \frac{\varepsilon_0 K}{d}\left(\frac{A}{4}\right) = \frac{\varepsilon_0 AK}{4d}$$

Since, $C_1$and C_2 are in parallel

$$C_{\text{net}} = C_1 + C_2$$
$$= \frac{3\varepsilon_0 A}{4d} + \frac{\varepsilon_0 AK}{4d}$$
$$= \frac{\varepsilon_0 A}{d}\left[\frac{3}{4} + \frac{K}{4}\right]$$
$$= \frac{C}{4}(K+3)$$

14 **(c)**

On sharing of charges loss in electrical energy,

$\Delta U = \frac{C_1 C_2}{2(C_1 + C_2)}(V_1 - V_2)$. In present case $C_1 = C_2 = C$

$$\therefore\ \Delta U = \frac{C^2}{2(2C)}\ (V_1 - V_2)^2 = \frac{1}{4}C(V_1 - V_2)^2$$

15 **(b)**

Energy of a charged capacitor,

$$E = \frac{1}{2}\frac{Q^2}{C}$$

$$C = \frac{2\pi\varepsilon_0 L}{\log_e\left(\frac{b}{a}\right)}$$

$$E' = \frac{1}{2}\frac{Q^2}{2\pi\varepsilon_0 L}\log_e\left(\frac{b}{a}\right) \quad \text{...(i)}$$

For a cylindrical capacitor.

where L= length of the cylinders

a and b = radii of two concentric cylinders

$$C' = \frac{2\pi\varepsilon_0(2L)}{\log_e\left(\frac{b}{a}\right)}$$

$$E' = \frac{1}{2}\frac{(2Q)^2}{C'}$$

$$= \frac{1}{2}\frac{(2Q)^2}{2\pi\varepsilon_0(2L)}\log_e\left(\frac{b}{a}\right) \quad ...(ii)$$

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

$$E' = 2E$$

16 **(d)**

$$C = \frac{\varepsilon_0 A}{\frac{d_1}{K_1} + \frac{d_2}{K_2}}$$

$$= \frac{\varepsilon_0 A}{\frac{d}{2}\left(\frac{1}{1} + \frac{1}{2}\right)} = \frac{4\varepsilon_0 A}{3d}$$

17 **(a)**

Inside the hollow sphere, $V =$ constant =potential on the surface of the sphere. Outside the sphere, $V \propto \frac{1}{r}$. Hence figure (a) represents the correct graph.

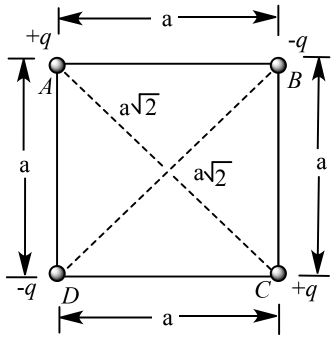
18 **(d)**

In a uniform electric field, field line should be straight but line of force cannot pass through the body of metal sphere and must end/start from the sphere normally. All these conditions are fulfilled only in plot (d).

19 **(a)**

Work is required to set up the four charge configuration

$q_1 = +q, q_2 = -q, q_3 = +q$ and $q_4 = -q$



$$W=\frac{1}{4\pi\varepsilon_0}\left[\frac{(+q)(-q)}{AB}+\frac{(-q)(+q)}{BC}+\frac{(+q)(-q)}{CD}+\frac{(-q)(+q)}{DA}+\frac{(+q)(+q)}{AC}+\frac{(-q)(-q)}{BD}\right]$$

$$W=\frac{1}{4\pi\varepsilon_0}\left[-\frac{q^2}{a}-\frac{q^2}{a}-\frac{q^2}{a}-\frac{q^2}{a}+\frac{q^2}{a\sqrt{2}}+\frac{q^2}{a\sqrt{2}}\right]$$

$$W=\frac{1}{4\pi\varepsilon_0}\frac{q^2}{a}[-4+\sqrt{2}]=\frac{1}{4\pi\varepsilon_0}\frac{q^2}{a}[-4+1.414]$$

$$W=-0.21\times\frac{q^2}{\varepsilon_0 a}\qquad\text{(approx.)}$$

20 **(d)**

In series arrangement potential difference is the sum of the individual potential difference of each capacitor.

ie, $V=V_1+V_2+V_3+\dots$

$\therefore\quad 600=x\times 200$

$x=3$

So, there should be 3 capacitors in series to obtain the required potential difference.

The equivalent capacitance of the 3 capacitors in series is

$$\frac{1}{C_{\text{eq}}}=\frac{1}{6}+\frac{1}{6}+\frac{1}{6}$$

$$C_{\text{eq}}=2$$

Now, we require 18 μF capacitance, for this we need 9 such combinations is parallel.

Hence, $9\times 3=27$

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