DPP

DAILY PRACTICE PROBLEMS

Class : XIIth
Date :

Solutions

Subject : PHYSICS
DPP No. : 3

Topic :- ELECTROSTATIC POTENTIAL AND CAPACITANCE

1 **(b)**

Capacitance of two capacitors each of area $\frac{A}{2}$, plate separation d but dielectric constants K_1 and K_2 respectively joined in parallel

$$C_1 = \frac{K_1\varepsilon_0\left(\frac{A}{2}\right)}{d/2} + \frac{K_2\varepsilon_0\left(\frac{A}{2}\right)}{d/2} = \frac{(K_1+K_2)\varepsilon_0 A}{d}$$

It is in series with a capacitor of plate area A, plate separation $d/2$ and dielectric constant K_3 $ie, C_2 = \frac{K_3\varepsilon_0 A}{d/2}$.

If resultant capacitance be taken as $C = \frac{K\,\varepsilon_0 A}{d}$,

Then $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$

$\therefore \frac{d}{K\varepsilon_0 A} = \frac{d}{(K_1+K_2)\varepsilon_0 A} + \frac{d/2}{K_3\varepsilon_0 A}$

$$\Rightarrow \frac{1}{K} = \frac{1}{K_1+K_2} + \frac{1}{2K_3}$$

2 **(b)**

For a charged sphere or shell of charge potential

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

Hence, charge on both the spheres will be equal.

3 **(b)**

Potential at the centre of hollow metallic sphere

$$V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{R}$$

4 **(a)**

Potential difference between two points in a electric fields is,

$$V_A - V_B = \frac{W}{q_0}$$

Where W is work done by moving charge q_0 from point A to B.

So,

$$V_A - V_B = \frac{2}{20}$$

(Here $W = 2, q_0 = 20C$)=0.1V

5 **(d)**

$C_p = 1 + 1 + 1 = 3\mu$ F

$\frac{1}{C_s} = \frac{1}{3} + \frac{1}{1} = \frac{4}{3}$

$\therefore C_s = \frac{3}{4}\mu$ F

6 **(a)**

$$\phi_E = \frac{q}{K\varepsilon_0} = \frac{0.5}{10 \times 8.85 \times 10^{12}} = 5.65 \times 10^9$$

7 **(b)**

Common potential of system

$$V = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}$$

$$40 = \frac{10 \times 100 + C_2 \times 0}{10 + C_2}$$

or $40(10 + C_2) = 1000$

$\Rightarrow$ $C_2 = 15\ \mu$F

8 **(d)**

Variation of different variables (Q , C, V, E and U) of parallel plate capacitor when dielectric (K) is introduced when battery is removed is

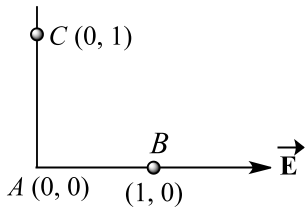
$C' = KC\ E' = E/K$

$Q' = Q U' = U/K$

$V' = V/K$

9 **(b)**

As electric field is along positive x-axis and $E = -\frac{dV}{dx}$, hence potential at A must be greater than that at B ie, $V_A > V_B$



10. **(c)**

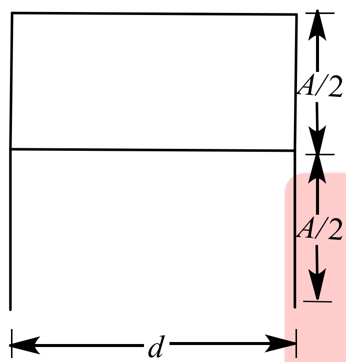
Energy given to conductor $= \frac{1}{2}CV^2$

$= \frac{1}{2} \times 5 \times 10^{-6} \times (800)^2$

$= 1.6$ J

11. **(c)**

The dielectric is introduced such that, half of its area is occupied by It.



In the given case the two capacitors are in parallel.

$\therefore \quad C' = C_1 + C_2$

$C_1 = \frac{A\varepsilon_0}{2d}$

And $\quad C_2 = \frac{KA\varepsilon_0}{2d}$

Thus, $\quad C' = \frac{A\varepsilon_0}{2d} + \frac{KA\varepsilon_0}{2d}$

$C' = \frac{C}{2}(1 + K)$

12. **(a)**

The material suitable for use as dielectric must have high dielectric strength X and large dielectric constant K.

13. **(a)**

The energy stored is given by

$E = \frac{1}{2}CV^2$

When capacitors are connected in parallel, resultant capacitance is

$C' = C_1 + C_2$

$= 2\mu F + 2\mu F = 4\mu F$

$V = 100$ volt

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

$E = 0.02\text{J}$

14. **(d)**

With $S_1$and S_3 closed, the capacitors C_1 and C_2 are in series arrangement. In series arrangement potential difference developed across capacitors are in the inverse radio of their capacities. Hence,

$\frac{V'_1}{V'_2} = \frac{C_2}{V_1} = \frac{3pF}{3pF} = \frac{3}{2}$and

$V'_1 + V'_2 = V_1 + V_2 = 30 + 20 = 50V$

On simplification, we get $V'_1 = V_1 = 30V$ and $V'_2 = V_2 = 20\ V$

15. **(b)**

$$E = \frac{\lambda}{2\pi\varepsilon_0 r}$$

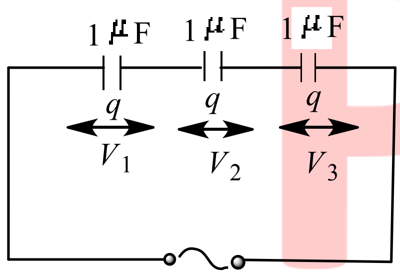
$\lambda = 2\pi\varepsilon_0 r\ E$

$$= \frac{1}{2 \times 9 \times 10^9} \times 2 \times 10^{-2} \times 9 \times 0^4$$

$= 10^{-7}\,\text{Cm}^{-1}$

16. **(d)**

Let potential difference between the plates of the capacitors C_1,C_2 and C_3 be V_1, V_2 and V_3 and q be the charge.



Then, $V = \frac{q}{C_1}, V_2 = \frac{q}{C_2}, V_3 = \frac{q}{C_3}$

The total potential difference $V = 11$volt

$\therefore \qquad V = V_1 + V_2 + V_3$

$$\Rightarrow \qquad V = \frac{q}{C_1} + \frac{q}{C_2} + \frac{q}{C_3} = 11$$

Given, $C_1 = 1\mu\text{F}$, $C_2 = 2\mu\text{F}$,$C_3 = 3\mu\text{F}$

$$\therefore \qquad 11 = q\left(\frac{1}{1} + \frac{1}{2} + \frac{1}{3}\right)$$

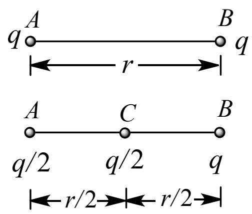
$$\Rightarrow \qquad 11 = \frac{11q}{6}$$

$\Rightarrow \qquad q = 6\mu c$

$\therefore \qquad V_1 = \frac{q}{C_1} = \frac{6}{1} = 6\text{ V}$

17. **(b)**

Initially, $F_{AB} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q.q}{r^2} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q^2}{r^2}$



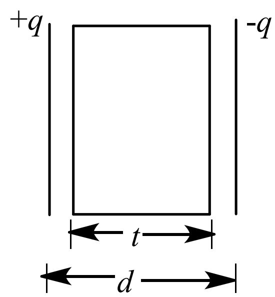
Finally, force on

$$F_C = F_{AB} - F_{CA} = \frac{1}{4\pi\varepsilon_0}\cdot\frac{\left(\frac{q}{2}\right)(q)}{\left(\frac{r}{2}\right)^2} - \frac{1}{4\pi\varepsilon_0}\cdot\frac{\left(\frac{q}{2}\right)\left(\frac{q}{2}\right)}{\left(\frac{r}{2}\right)^2} = \frac{1}{4\pi\varepsilon_0}\cdot\frac{q^2}{r^2}$$

$\Rightarrow \quad F_C = F_{AB}$

18. **(b)**

The capacitance C of a capacitor of area A and distance between plates is d, then



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

When a dielectric slab of thickness t is placed between the plates, we have

$$C' = \frac{\varepsilon_0 A}{d - t + \frac{t}{K}}$$

Given, $C = 20\mu\text{F} = 20 \times 10^{-6}\text{F}$,

$d = 2\text{ mm} = 2 \times 10^{-3}\text{m}, t = 1\text{mm}$

$= 1 \times 10^{-3}\text{m}, K = 2$

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

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

$\Rightarrow \quad C' = 1.33 \times 20 \times 10^{-6} = 26.6\ \mu\text{F}$

19. **(b)**

$\vec{E}_1 = \frac{1}{4\mu\pi\varepsilon_0}\cdot\frac{2\vec{P}}{r^3}$ and

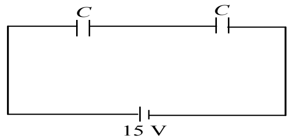
$$\vec{E}_2 = -\frac{1}{4\pi\varepsilon_0}\cdot\frac{\vec{P}}{(2r^3)} = -\frac{1}{4\pi\varepsilon_0}\cdot\frac{\vec{P}}{8r^3}$$

$$\Rightarrow \vec{E}_2 = -\frac{\vec{E}_1}{16}$$

(Here negative sign means direction)

20 **(c)**

Let capacitance of each capacitor is C.



Then equivalent capacitance in series is

$$\frac{1}{C'} = \frac{1}{C} + \frac{1}{C} = \frac{2}{C}$$

$\Rightarrow$ $$C' = \frac{C}{2}$$

Charge $$Q = C'V = \frac{C}{2}.15 \quad \text{...(i)}$$

When filled with dielectric

$$C_1 = 4C,\ C_2 = C$$

$$\frac{1}{C'} = \frac{1}{4C} + \frac{1}{C} = \frac{5}{4C}$$

$\Rightarrow$ $$C' = \frac{4C}{5}$$

Since, charge is conserved

$$Q = C'V' = \frac{4C}{5}V' \quad \text{...(ii)}$$

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

$$\frac{C}{2} \times 15 = \frac{4C}{5} \times V'$$

$\Rightarrow$ $$V' = \frac{15 \times 5}{4 \times 2} = 9.4\text{V}$$

$$\approx 10\text{ V}$$

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