DPP
DAILY PRACTICE PROBLEMS

Class : XIIth
Date :

Solutions

Subject : PHYSICS
DPP No. : 9

Topic :- ELECTROSTATIC POTENTIAL AND CAPACITANCE

1 **(a)**

Since the two spheres are joined by a wire, their potential are equal *ie*,

$$\frac{q_1}{4\pi\varepsilon_0 R_1}=\frac{q_2}{4\pi\varepsilon_0 R_2}\Rightarrow\frac{q_1}{q_2}=\frac{R_1}{R_2}$$

Now, $\sigma_1=\frac{q_1}{4\pi\varepsilon_0 R_1^2}$

And $\sigma_2=\frac{q_2}{4\pi\varepsilon_0 R_2^2}$,

Hence $\frac{\boldsymbol{\sigma_2}}{\boldsymbol{\sigma_1}}=\frac{\boldsymbol{\sigma_2}}{\boldsymbol{\sigma_1}}\times\frac{R_1^2}{R_2^2}=\left(\frac{R_2}{R_1}\right)\left(\frac{R_1}{R_2}\right)^2$

$\Rightarrow\ \frac{\sigma_2}{\sigma_1}=\frac{R_1}{R_2}$

2 **(d)**

(n-1) capacitors are made by n plates and all are connected in parallel because plates are connected alternately.

$\therefore$ Total capacitance $=(n-1)x$

3 **(c)**

The capacitance of air capacitor

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

When a dielectric slab of thickness $t=\frac{d}{2}$ is inserted between plates, the capacity becomes

$$C'=\frac{A\varepsilon_0}{d-\frac{d}{2}\left(1-\frac{1}{K}\right)}$$

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

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

$$3=4\left(\frac{1}{2}+\frac{1}{2K}\right)$$

or $\frac{4}{2K} = 3 - 2$

or $K = 2$

4 **(a)**

$r_b - r_a = 1\text{mm} = 10^{-3}\text{m}$

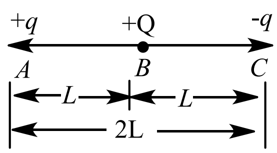
From $C = \frac{4\pi\varepsilon_0 r_a r_b}{r_b - r_a}$

$10^{-6} = \frac{1(r_b - 10^{-3})r_b}{9 \times 10^9 (10^{-3})}$

$r_b^2 = 9, r_b = 3\text{m}$

5 **(d)**

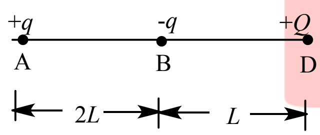
In Ist case, when charge $+Q$ is situated at C.



Electric potential energy of system

$$U_1 = \frac{1}{4\pi\varepsilon_0}\frac{(q)(-q)}{2L} + \frac{1}{4\pi\varepsilon_0}\frac{(-q)Q}{L} + \frac{1}{4\pi\varepsilon_0}.\frac{qQ}{L}$$

In IInd case, when charge $+Q$is moved from C to D.



Electric potential energy of system in that case

$$U_2 = \frac{1}{4\pi\varepsilon_0}.\frac{(q)(-q)}{2L} + \frac{1}{4\pi\varepsilon_0}.\frac{qQ}{3L} + \frac{1}{4\pi\varepsilon_0}\frac{(-q)(Q)}{L}$$

$\therefore$ Work done $= \Delta U = U_2 - U_1$

$$= \left(\frac{1}{4\pi\varepsilon_0}\frac{q^2}{2L} + \frac{1}{4\pi\varepsilon_0}\frac{qQ}{3L} - \frac{1}{4\pi\varepsilon_0}\frac{qQ}{L}\right)$$

$$-\left(\frac{1}{4\pi\varepsilon_0}\frac{q^2}{2L} + \frac{1}{4\pi\varepsilon_0}\frac{qQ}{L} + \frac{1}{4\pi\varepsilon_0}\frac{qQ}{L}\right)$$

$$= \frac{qQ}{4\pi\varepsilon_0}.\left[\frac{1}{3L} - \frac{1}{L}\right]$$

$$= \frac{qQ}{4\pi\varepsilon_0}\frac{(1-3)}{3L}$$

$$= \frac{-2qQ}{12\pi\varepsilon_0 L} = -\frac{qQ}{6\pi\varepsilon_0 L}$$

6 **(c)**

$C_0 = \frac{\varepsilon_0 A}{d} = 18$

$C_0 = \frac{K\varepsilon_0 A}{3d} = 72$

Dividing Eq. (ii) by Eq. (i)

$\frac{k}{3} = \frac{72}{18} = 4$

$K = 12$

7 **(d)**

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

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

Capacitance between A and B

$C_p = \frac{1}{3} + 1$

$\frac{4}{3}\mu\text{F} = 1.33\mu\text{F}$

9 **(c)**

Here,

$\vec{E} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 = \left(+\frac{\sigma}{2\varepsilon_0}\right)(-\hat{k}) + \left(\frac{2\sigma}{2\varepsilon_0}\right)(-\hat{k}) + \left(\frac{\sigma}{2\varepsilon_0}\right)(-\hat{k})$

$= -\left(\frac{2\sigma}{\varepsilon_0}\right).\hat{k}$

10 **(a)**

$V = \frac{\sum q}{4\pi\varepsilon_0 r} = \frac{-10+10}{4\pi\varepsilon_0 r} = 0$

11 **(b)**

Linear momentum of electron, $p_e = \sqrt{2m_e eV}$

Linear momentum of photon, $p_p = \sqrt{2m_p eV}$

$\frac{p_e}{p_p} = \frac{\sqrt{2m_e eV}}{\sqrt{2m_p eV}}$

$\frac{p_e}{p_p} = \sqrt{\frac{m_e}{m_p}}$

12 **(a)**

Number of capacitors to be connected in series

$$V=\frac{\text{valtage rating required}}{\text{voltage rating of given capacitor}}=\frac{700}{200}=3.5 ie, 4$$

$$C_{\text{eq}}=\frac{10}{4}=2.5\mu\text{F}$$

Number of rows required

$$=\frac{\text{capacitor required}}{\text{capacity of each row}}=\frac{10}{2.5}=4$$

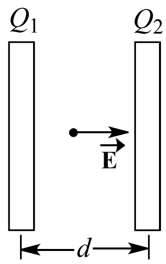
$\therefore$ total number of capacitors required $=4\times4=16$

14 **(a)**

Net capacity of 5 capacitors joined in parallel $=5\times2=10$ μF. now it is connected with two capacitors of 2 μF each in series, hence equivalent capacitance is $\frac{10}{11}$μF.

15 **(d)**

On bringing the changed metal plates closer, electric field $\vec{E}$ in the intervening space is



$$E=\frac{\sigma_1}{2\varepsilon_0}-\frac{\sigma_2}{2\varepsilon_0}=\frac{\sigma_1}{2A\varepsilon_0}-\frac{\sigma_2}{2A\varepsilon_0}$$

Or $E=\frac{Q_1-Q_2}{2A\varepsilon_0}=\frac{V}{d}$ or $V=\frac{(Q_1-Q_2)d}{2A\varepsilon_0}$

$\Rightarrow$ $V=\frac{Q_1-Q_2}{2C}$ $\left(\therefore C=\frac{\varepsilon_0 A}{d}\right)$

16 **(c)**

Potential energy

$$U=\frac{q_1q_2}{4\pi\varepsilon_0 r}$$

Or $U\propto\frac{1}{r}$

When r decreases U increases and $vice-versa$. Moreover, potential energy as well as force is positive, if there is repulsion between the particles and negative if there is attraction.

17 **(b)**

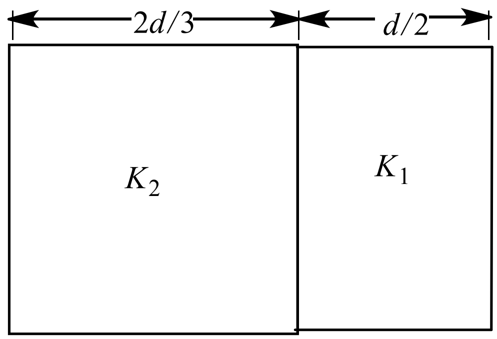
Work done =potential energy of configuration of charges

$$\frac{1}{4\pi\varepsilon_0 a}[q(-q)+(9-q)q+q(-q)+(-q)(q)]+\frac{(-q)(-q)+q^2}{4\pi\varepsilon_0 a\sqrt{2}}$$

$$= \frac{1}{4\pi\varepsilon_0}\left[-\frac{4q^2}{a} + \frac{2q^2}{a\sqrt{2}}\right] = -\frac{2.6}{4\pi\varepsilon_0}\frac{q^2}{a}$$

18 **(c)**

$C = \frac{C_1C_2}{C_1 + C_2}$ ...(i)



where $C_1 = \frac{K_1\varepsilon_0 A}{d/3}$ ...(ii)

And $C_2 = \frac{K_2\varepsilon_0 A}{2d/3}$ ...(iii)

It is given that $\frac{\varepsilon_0 A}{d} = 9\text{pF}$

On substituting Eqs. (ii)and (iii)in Eq. (i), we get the result

$C_{\text{eq}} = 40.5\mu\text{F}$

19 **(b)**

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

After inserting the slab

$$C' = \frac{A\varepsilon_0}{(d-b)} = \frac{A\varepsilon_0}{d - \frac{d}{2}}$$

$C' = \frac{2A\varepsilon_0}{d}$ $\therefore \frac{C'}{C} = \frac{2}{1}$

20 **(d)**

Net electric flux of surface

$$(\phi_2 - \phi_1) = \frac{1}{\varepsilon_0}(q) \Rightarrow q = \varepsilon_0(\phi_2 - \phi_1)$$

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