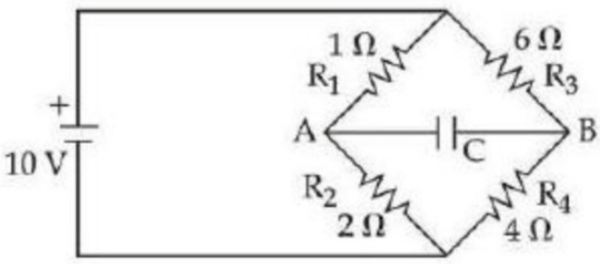
Electrostatic Potential and Capacitance

Question1

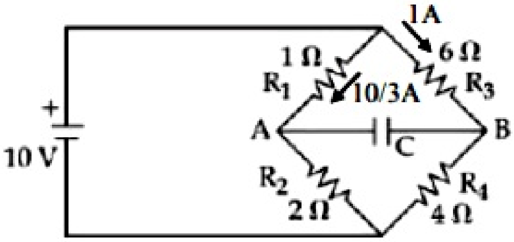
The charge accumulated on the capacitor connected in the following circuit is ____ μC (Given C = 150μF)



[27-Jan-2024 Shift 1]

Answer: 400

Solution:



$$V_A + \frac{10}{3}(1) - 6(1) = V_B$$

$$V_A - V_B = 6 - \frac{10}{3} = \frac{8}{3}\text{ volt}$$

$$Q = C(V_A - V_B)$$

$$= 150 \times \frac{8}{3} = 400\mu\text{C}$$

Question2

A capacitor of capacitance 100μF is charged to a potential of 12V and connected to a 6.4mH inductor to produce oscillations. The maximum current in the circuit would be :

[29-Jan-2024 Shift 1]

Options:

A.

3.2 A

B.

1.5 A

C.

2.0 A

D.

1.2 A

Answer: B

Solution:

By energy conservation

$$\frac{1}{2}CV^2 = \frac{1}{2}LI_{max}^{\ 2}$$

$$I_{max} = \sqrt{\frac{C}{L}}V$$

$$= \sqrt{\frac{100 \times 10^{-6}}{6.4 \times 10^{-3}}} \times 12$$

$$= \frac{12}{8} = \frac{3}{2} = 1.5A$$

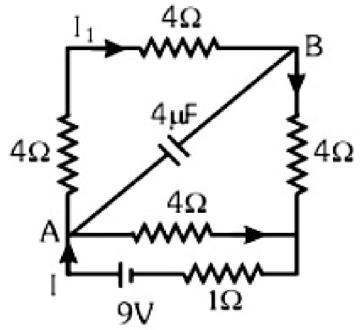
Question3

A 16Ω wire is bend to form a square loop. A 9V battery with internal resistance 1Ω is connected across one of its sides. If a 4μF capacitor is connected across one of its diagonals, the energy stored by the capacitor will be $\frac{x}{2}\mu J.$ where x =____

[29-Jan-2024 Shift 1]

Answer: 81

Solution:



$$I = \frac{V}{R_{eq}} I = \frac{V}{R_{eq}} = \frac{9}{1+\frac{12\times 4}{12+4}} = \frac{9}{4}$$

$$I_1 = \frac{9}{4}\times\frac{4}{16} = \frac{9}{16}$$

$$V_A - V_B = I_1 \times 8 = \frac{9}{16}\times 8 = \frac{9}{2}V$$

$$\therefore U = \frac{1}{2}\times 4\times\frac{81}{4}\mu J$$

$$\therefore U = \frac{81}{2}\mu J$$

$$\therefore x = 81$$

Question4

A capacitor of capacitance C and potential V has energy E. It is connected to another capacitor of capacitance 2C and potential 2V. Then the loss of energy is $\frac{x}{3}E$, where x is____

[30-Jan-2024 Shift 1]

Answer: 2

Solution:

$$\text{Energy loss} = \frac{1}{2}\frac{C_1C_2}{C_1+C_2}(V_1-V_2)^2$$

$$= \frac{2}{3}\cdot E$$

$$\therefore x = 2$$

Question5

A parallel plate capacitor with plate separation 5 mm is charged up by a battery. It is found that on introducing a dielectric sheet of

thickness 2mm, while keeping the battery connections intact, the capacitor draws 25% more charge from the battery than before. The dielectric constant of the sheet is____

[31-Jan-2024 Shift 1]

Answer: 2

Solution:

Without dielectric

$$Q = \frac{A\epsilon_0}{d}V$$

with dielectric

$$Q = \frac{A\epsilon_0 V}{d - t + \frac{t}{K}}$$

given

$$\frac{A\epsilon_0 V}{d - t + \frac{t}{K}} = (1.25)\frac{AE_0 V}{d}$$

$$\Rightarrow 1.25\left(3 + \frac{2}{K}\right) = 5$$

$$\Rightarrow K = 2$$

Question6

Two identical capacitors have same capacitance C. One of them is charged to the potential V and other to the potential 2V. The negative ends of both are connected together. When the positive ends are also joined together, the decrease in energy of the combined system is :

[1-Feb-2024 Shift 1]

Options:

A.

$\frac{1}{4}CV^2$

B.

$2CV^2$

C.

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

D.

$\frac{3}{4}CV^2$

Answer: A

Solution:

$$V_C = \frac{q_{net}}{C_{net}} = \frac{CV + 2CV}{2C}$$

$$V_C = \frac{3V}{2}$$

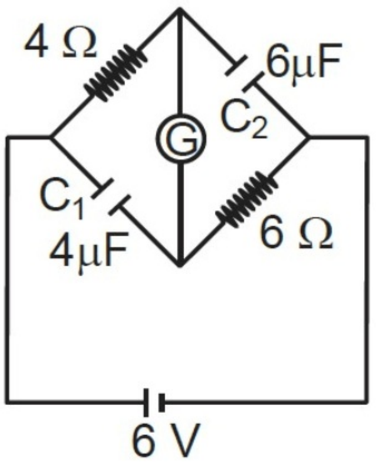
Loss of energy

$$= \frac{1}{2}CV^2 + \frac{1}{2}C(2V)^2 - \frac{1}{2}2C\left(\frac{3V}{2}\right)^2$$

$$= \left(\frac{CV^2}{4}\right)$$

Question7

A galvanometer (G) of 2Ω2 resistance 1 s connected in the given circuit. The ratio of charge stored in C_1 and C_2 is :



[1-Feb-2024 Shift 2]

Options:

A.

2/3

B.

3/2

C.

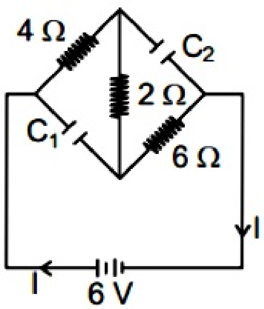
1

D.

1/2

Answer: D

Solution:



In steady state

$R_{eq} = 12\Omega$

$I = \frac{6}{12} = 0.5A$

P.D across $C_1 = 3V$

P.D acoross $C_2 = 4V$

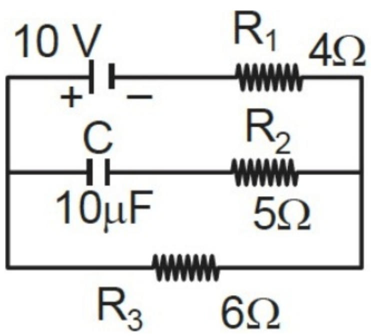
$q_1 = C_1V_1 = 12\mu C$

$q_2 = C_2V_2 = 24\mu C$

$\frac{q_1}{q_2} = \frac{1}{2}$

Question8

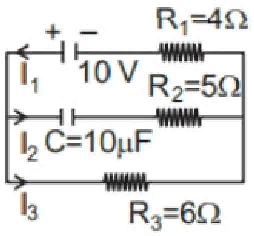
In an electrical circuit drawn below the amount of charge stored in the capacitor is μC.



[1-Feb-2024 Shift 2]

Answer: 60

Solution:



In steady state there will be no current in branch of capacitor, so no voltage drop across $R_2 = 5\Omega$

$I_2 = 0$

$I_1 = I_3 = \frac{10}{4+6} = 1A$

$V_{R_3} = V_c + V_{R_2}\quad V_{R_2} = 0$

$I_3R_3 = V_c$

$V_c = 1 \times 6 = 6\text{ volt}$

$q_c = CV_c = 10 \times 6 = 60\mu C$

Question9

A parallel plate capacitor with air between the plate has a capacitance of 15 pF. The separation between the plate becomes twice and the space between them is filled with a medium of dielectric constant 3.5. Then the capacitance becomes $\frac{x}{4}$ pF.
The value of x is
[24-Jan-2023 Shift 2]

Answer: 105

Solution:

$$C_0 = \frac{\in_0 A}{d} = 15\text{ pF}$$

$$C = \frac{K \in_0 A}{2d} = \frac{3.5}{2} \times 15\text{ pF} = \frac{105}{4}\text{ pF}$$

Question10

A parallel plate capacitor has plate area $40cm^2$ and plates separation 2 mm. The space between the plates is filled with a dielectric medium of a thickness 1 mm and dielectric constant 5 . The capacitance of the system is :
[25-Jan-2023 Shift 1]

Options:

A. $24\varepsilon_0 F$

B. $\frac{3}{10}\varepsilon_0 F$

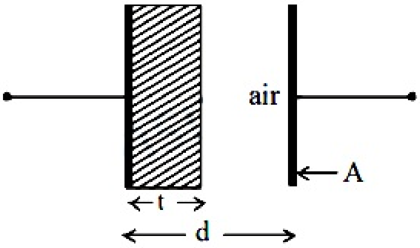
C. $\frac{10}{3}\varepsilon_0 F$

D. $10\varepsilon_0 F$

Answer: C

Solution:

Solution:



This can be seen as two capacitors in series combination so

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$= \frac{1}{\frac{K \in_0 A}{t}} + \frac{1}{\frac{E_0 A}{d-t}}$$

$$= \frac{t}{K \in_0 A} + \frac{d-t}{E_0 A}$$

$$= \frac{1 \times 10^{-3}}{5E_0 \times 40 \times 10^{-4}} + \frac{1 \times 10^{-3}}{E_0 40 \times 10^{-4}}$$

$$\frac{1}{C_{eq}} = \frac{1}{20E_0} + \frac{1}{4E_0}$$

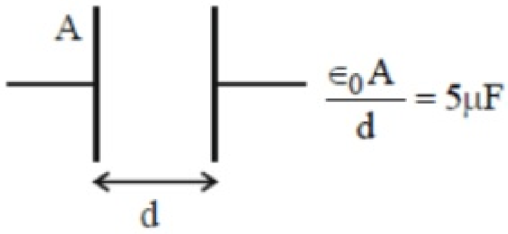
$$C_{eq} = \frac{20 \times 4E_0}{24} = \frac{10E_0}{3}F$$

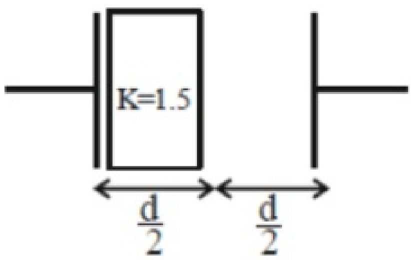
Question11

A capacitor has capacitance 5μF when it's parallel plates are separated by air medium of thickness d . A slab of material of dielectric constant 1.5 having area equal to that of plates but thickness $\frac{d}{2}$ is inserted between the plates. Capacitance of the capacitor in the presence of slab will be _______ μF.
[25-Jan-2023 Shift 2]

Answer: 6

Solution:





$$C_{new} = \frac{E_0 A}{\frac{\left(\frac{d}{2}\right)}{1.5} + \frac{\left(\frac{d}{2}\right)}{1}}$$

$$= \frac{E_0 A}{\left(\frac{d}{3} + \frac{d}{2}\right)} = \frac{6E_0 A}{5d}$$

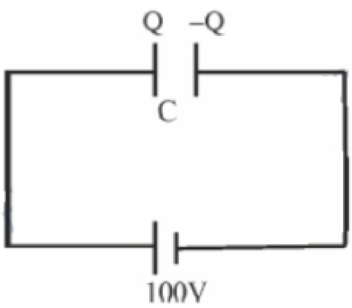
$$= \frac{6}{5} \times 5\mu F = 6\mu F$$

Question12

A capacitor of capacitance 900μF is charged by a 100V battery. The capacitor is disconnected from the battery and connected to another uncharged identical capacitor such that one plate of uncharged capacitor connected to positive plate and another plate of uncharged capacitor connected to negative plate of the charged capacitor. The loss of energy in this process is measured as $x \times 10^{-2}$J. The value of x is ______.
[30-Jan-2023 Shift 1]

Answer: 2.25

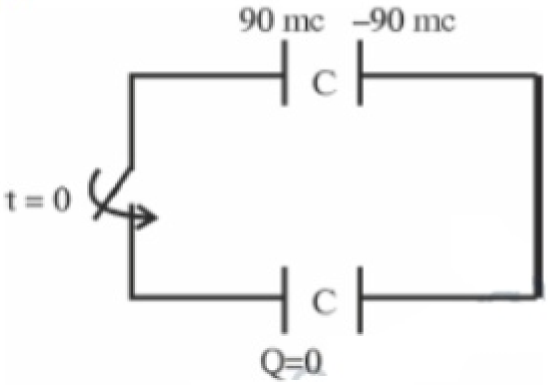
Solution:

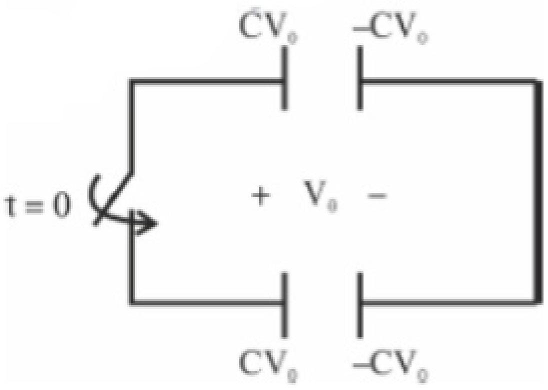


$C = 900\mu F$

$Q = CV = 900 \times 10^{-6} \times 100 = 9 \times 10^{-2} = 90\,MC$

Now





Common potential will be developed across both capacitors by kVL
Total charge on left plates of capacitors should be conserved.

$\therefore\ 90\,mc + 0 = 2cv_0$

$cv_0 = 45\,mc$

Heat dissipated $= U_i - U_f$ [Change in energy stored in the capacitors]

$= \frac{1}{2}\frac{(90\,mc)^2}{900\mu F} - 2\times\frac{1}{2}\frac{(45\,mc)^2}{900\mu F}\left[U = \frac{Q^2}{2c}\right]$

$= \frac{1}{2\times 900\times 10^{-6}}(8100 - 4050)\times 10^{-6}$

$= 2.25\,\text{Joule}$

OR

$\text{Heat} = \frac{1}{2}\frac{C_1C_2}{C_1 + C_2}(V_1 - V_2)^2$

$= \frac{1}{2}\frac{C^2}{2C}(100 - 0)^2$

$= \frac{1}{2}\frac{900\times 10^{-6}}{2}\times 10^4 = \frac{9}{4}\ \text{Joule} = 2.25\ \text{Joule}$

Question13

Two parallel plate capacitors C_1 and C_2 each having capacitance of 10μF are individually charged by a 100V D.C. source. Capacitor C_1 is kept connected to the source and a dielectric slab is inserted between it plates. Capacitor C_2 is disconnected from the source and then a dielectric slab is inserted in it. Afterwards the capacitor C_1 is also

disconnected from the source and the two capacitors are finally connected in parallel combination. The common potential of the combination will be _______ V. (Assuming Dielectric constant = 10)
[31-Jan-2023 Shift 2]

Answer: 55

Solution:

Solution:
Charge on $C_1 = KCV$
And charge on $C_2 = CV$
When they are connected in parallel charge will be equally divided so charge on one capacitor is
$q = \frac{K+1}{2} CV$
So, $V = \frac{q}{KC} = \frac{K+1}{2K} = 55V$

Question14

If two charges q_1 and q_2 are separated with distance ' d ' and placed in a medium of dielectric constant K. What will be the equivalent distance between charges in air for the same electrostatic force ?
[24-Jan-2023 Shift 1]

Options:

A. $d\sqrt{k}$

B. $k\sqrt{d}$

C. $1.5d\sqrt{k}$

D. $2d\sqrt{k}$

Answer: A

Solution:

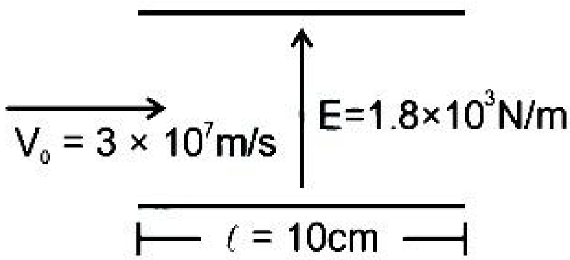
Solution:
$F = \frac{1}{(4\pi\varepsilon_0)} \frac{q_1 q_2}{kd^2}$ (in medium)
$F_{Air} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{d'^2}$
$F = F_{Air}$
$\frac{q_1 q_2}{4\pi\varepsilon_0 kd^2} = \frac{q_1 q_2}{4\pi\varepsilon_0 d'^2}$
$d' = d\sqrt{k}$

Question15

A stream of a positively charged particles having $\frac{q}{m} = 2 \times 10^{11} \frac{C}{kg}$ and velocity $\vec{v}_0 = 3 \times 10^7 \hat{i}$ m / s is deflected by an electric field $1.8 \hat{j}$ kV / m. The electric field exists in a region of 10 cm along x direction. Due to the electric field, the deflection of the charge particles in the y direction is ____mm.
[24-Jan-2023 Shift 1]

Answer: 2

Solution:



$a = \frac{F}{m} = \frac{qE}{m} = (2 \times 10^{11})(1.8 \times 10^3)$

$= 3.6 \times 10^{14} \text{m / s}^2$

Time to cross plates $= \frac{d}{v}$

$t = \frac{0.10}{3 \times 10^7}$

$y = \frac{1}{2}at^2 = \frac{1}{2}(3.6 \times 10^{14})\left(\frac{0.01}{9 \times 10^{14}}\right)$

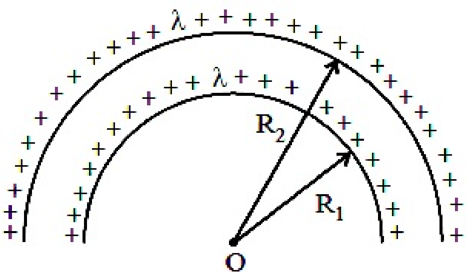
$= 0.2 \times 0.01$

$= 0.002$m

$= 2$ mm

Question16

The electric potential at the centre of two concentric half rings of radii R_1 and R_2, having same linear charge density λ is



[24-Jan-2023 Shift 2]

Options:

A. $\frac{2\lambda}{E_0}$

B. $\frac{\lambda}{2E_0}$

C. $\frac{\lambda}{4\in_0}$

D. $\frac{\lambda}{E_0}$

Answer: B

Solution:

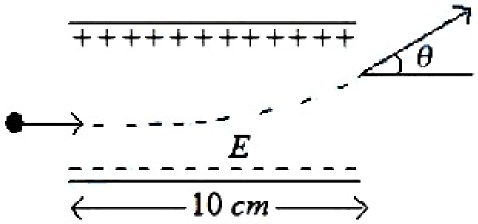
Solution:
Potential at centre

$$V = \frac{(\lambda \cdot \pi R_2)}{4\pi\varepsilon_0 R_2} + \frac{(\lambda \cdot \pi R_1)}{4\pi\varepsilon_0 R_1}$$

$$= \frac{\lambda}{2\varepsilon_0}$$

Question17

A uniform electric field of 10N / C is created between two parallel charged plates (as shown in figure). An electron enters the field symmetrically between the plates with a kinetic energy 0.5 eV. The length of each plate is 10 cm. The angle (θ) of deviation of the path of electron as it comes out of the field is ______ (in degree).



[25-Jan-2023 Shift 1]

Answer: 45

Solution:

$$0.5e = \frac{1}{2} m v_x^2 \Rightarrow v_x = \sqrt{\frac{e}{m}}$$

$$\text{Along } xL = v_x t = \sqrt{\frac{e}{m}}\, t$$

$$\text{Along } y \;\; v_y = \frac{eE}{m} t$$

$$\text{dividing } \frac{v_y}{L} = E\sqrt{\frac{e}{m}} = E v_x$$

$$\Rightarrow \operatorname{Tan}\theta = \frac{v_y}{v_x} = E \times L = 10 \times 0.1 = 1$$

$$\theta = 45^\circ$$

Question18

A point charge of 10μC is placed at the origin. At what location on the X-axis should a point charge of 40μC be placed so that the net electric field is zero at x = 2 cm on the X-axis ?
[25-Jan-2023 Shift 2]

Options:

A. $x = 6\,\text{cm}$

B. $x = 4\,\text{cm}$

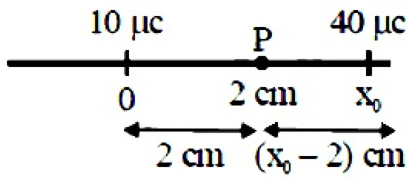
C. $x = 8\,\text{cm}$

D. $x = -4\,\text{cm}$

Answer: A

Solution:

Solution:



$$E_p = \frac{K \times 10}{2^2} - \frac{K \times 40}{(x_0 - 2)^2} = 0$$

$$\frac{1}{2} = \frac{2}{x_0 - 2}$$

$x_0 - 2 = 4$

$x_0 = 6\,\text{cm}$

Question19

Match List I with List II :

A. Gauss'sLaw inElectrostat ics	I. $\oint \overrightarrow{E} \cdot d\overrightarrow{l} = -\frac{d\varphi_B}{dt}$
B. Faraday'sLaw	II. $\oint \overrightarrow{B} \cdot d\overrightarrow{A} = 0$
C. Gauss'sLaw inMagnetism	III. $\oint \overrightarrow{B} \cdot d\overrightarrow{l} = \mu_0 i_c + \mu_0 \in_0 \frac{d\varphi_E}{dt}$
D. Ampere-MaxwellLaw	IV. $\oint \overrightarrow{E} \cdot d\overrightarrow{s} = \frac{q}{E_0}$

Choose the correct answer from the options given below :
[25-Jan-2023 Shift 2]

Options:

A. A-IV, B-I, C-II, D-III

B. A-I, B-II, C-III, D-IV

C. A-III, B-IV, C-I, D-II

D. A-II, B-III, C-IV, D-I

Answer: A

Solution:

Gauss's Law of electrostatic
$\varphi = \oint \overrightarrow{E} \cdot d\overrightarrow{s} = \frac{q}{E_0}$

Faraday's law $\oint \overrightarrow{E} \cdot d\overrightarrow{l} = \frac{-d\varphi_B}{dt}$

Gauss's law of magnetism $\oint \overrightarrow{B} \cdot d\overrightarrow{A} = 0$
Ampere's Maxwell law
$\oint \overrightarrow{B} \cdot d\overrightarrow{l} = \mu_0 i_C + \mu_0 \in_0 \frac{d\varphi_E}{dt}$
Where i_C : Conduction current
$E_0 \frac{d\varphi_E}{dt}$: Displacement current

Question20

In a cuboid of dimension 2L × 2L × L, a charge q is placed at the centre

of the surface ' S ' having area of $4L^2$. The flux through the opposite surface to ' S ' is given by
[29-Jan-2023 Shift 1]

Options:

A. $\frac{q}{12\varepsilon_0}$

B. $\frac{q}{3\varepsilon_0}$

C. $\frac{q}{2\varepsilon_0}$

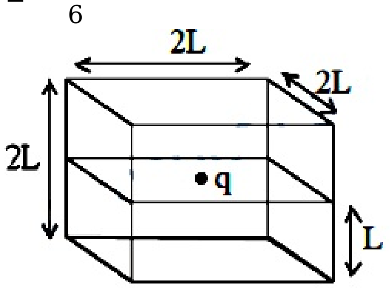
D. $\frac{q}{6\varepsilon_0}$

Answer: D

Solution:

Solution:

$\varphi = \frac{Q / \varepsilon_0}{6}$



Flux passing through shaded face $= \frac{q}{6\varepsilon_0}$

Question21

Ratio of thermal energy released in two resistor R and 3R connected in parallel in an electric circuit is :
[29-Jan-2023 Shift 1]

Options:

A. 3 : 1

B. 1 : 1

C. 1 : 3

D. 1 : 27

Answer: A

Solution:

$$H = \frac{V^2}{R} \times t$$

$$\frac{H_1}{H_2} = \frac{\frac{V^2 t}{R}}{\frac{V^2 t}{3R}} = 3:1$$

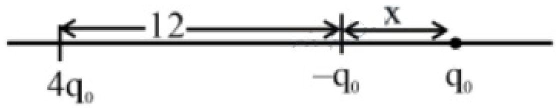
Question22

A point charge $q_1 = 4q_0$ is placed at origin. Another point charge $q_2 = -q_0$ is placed at $x = 12\,cm$. Charge of proton is q_0. The proton is placed on x-axis so that the electrostatic force on the proton in zero. In this situation,the position of the proton from the origin is ______ cm.
[29-Jan-2023 Shift 1]

Answer: 24

Solution:

Solution:



$$\frac{q_0}{x^2} = \frac{4q_0}{(x+12)^2}$$

$x + 12 = 2x$

$x = 12$

Distance from origin $= x + 12 = 24\,cm$.

Question23

A point charge $2 \times 10^{-2}C$ is moved from P to S in a uniform electric field of $30NC^{-1}$ directed along positive x-axis. If coordinates of P and S are $(1, 2, 0)$m and (0, 0, 0)m respectively, the work done by electric field will be
[29-Jan-2023 Shift 2]

Options:

A. $1200\,mJ$

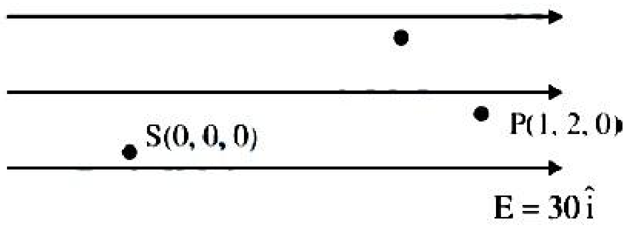
B. $600\,mJ$

C. $-600\,mJ$

D. $-1200\,mJ$

Answer: C

Solution:



$\omega_E = q\vec{E} \cdot \vec{S}$
$= 2 \times 10^{-2}[30\ \hat{i} \cdot (-\ \hat{i})]$
$= 2 \times 10^{-2}(-30)$
$= -60 \times 10^{-2}$
$= -\frac{60}{100} = -0.6J$
$= -600\,mJ$

Question24

For a charged spherical ball, electrostatic potential inside the ball varies with r as $V = 2ar^2 + b$.
Here, a and b are constant and r is the distance from the center. The volume charge density inside the ball is $-\lambda a\varepsilon$. The value of λ is _______.
$\varepsilon =$ permittivity of medium.
$\lambda = 12$
[29-Jan-2023 Shift 2]

Answer: 12

Solution:

Solution:
$E = -\frac{dV}{dr} = -4\,ar \equiv \frac{\rho r}{3\varepsilon_0}$ (compare)
Result inside uniformly charged solid sphere.
$\rho = -12a\varepsilon_0$

Question25

Two isolated metallic solid spheres of radii R and 2R are charged such that both have same charge density σ. The spheres are then connected by a thin conducting wire. If the new charge density of the bigger sphere is σ'. The ratio $\frac{\sigma'}{\sigma}$ is:
[30-Jan-2023 Shift 1]

Options:

A. $\frac{9}{4}$

B. $\frac{4}{3}$

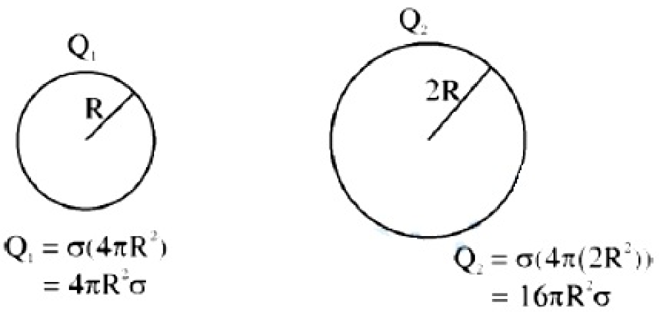
C. $\frac{5}{3}$

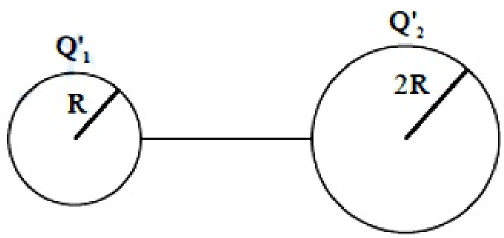
D. $\frac{5}{6}$

Answer: D

Solution:

Solution:





$$\frac{Q_1'}{4\pi\varepsilon_0 R} = \frac{Q_2'}{4\pi\varepsilon_0(2R)}$$

$\therefore\ Q_2' = 2Q_1'$

$Q_1' + Q_2' = Q_1 + Q_2$

$\therefore\ \frac{Q_2'}{2} + Q_2' = 20\pi R^2\sigma$

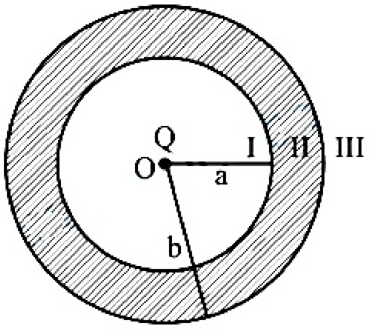
$\frac{3}{2}Q_2' = 20\pi R^2\sigma$

$\therefore\ \frac{Q_2'}{4\pi(2R)^2} = \frac{2}{3}\cdot\frac{20\pi R^2\sigma}{16\pi R^2}$

$\therefore\ \frac{\sigma'}{\sigma} = \frac{5}{6}$

Question26

As shown in the figure, a point charge Q is placed at the centre of conducting spherical shell of inner radius a and outer radius b. The electric field due to charge Q in three different regions I, II and III is given by : (I : r < a, II : a < r < b, III : r > b)



[30-Jan-2023 Shift 2]

Options:

A. $E_I = 0, E_{II} = 0, E_{III} \neq 0$

B. $E_I \neq 0, E_{II} = 0, E_{III} \neq 0$

C. $E_I \neq 0, E_{II} = 0, E_{III} = 0$

D. $E_I = 0, E_{II} = 0, E_{II} = 0$

Answer: B

Solution:

Solution:
Electric field inside material of conductor is zero.

Question27

A point source of 100W emits light with 5% efficiency. At a distance of 5m from the source, the intensity produced by the electric field component is :
[30-Jan-2023 Shift 2]

Options:

A. $\frac{1}{2\pi}\frac{W}{m^2}$

B. $\frac{1}{40\pi}\frac{W}{m^2}$

C. $\frac{1}{10\pi}\frac{W}{m^2}$

D. $\frac{1}{20\pi}\frac{W}{m^2}$

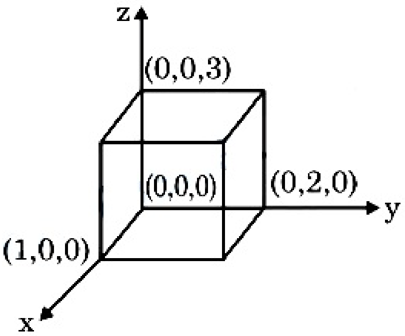
Answer: B

Solution:

$I_{EF} = \frac{1}{2} \times \frac{5}{4\pi \times 5^2}$
$= \frac{1}{40\pi} W / m^2$

Question28

As shown in figure, a cuboid lies in a region with electric field $E = 2x^2 \hat{i} - 4y \hat{j} + 6 \hat{k}$ N / C. The magnitude of charge within the cuboid is $n \in_0$ C. The value of n is ________ (if dimension of cuboid is $1 \times 2 \times 3 m^3$)

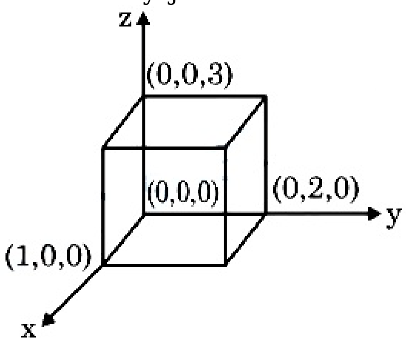


[30-Jan-2023 Shift 2]

Answer: 12

Solution:

Solution:
$\vec{E} = 2x^2 \hat{i} - 4y \hat{j} + 6 \hat{k}$



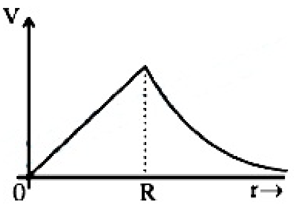
$\varphi_{net} = -8 \times 3 + 2 \times 6 = -12$
$-12 = \frac{q}{E_0}$
$| q | = 12E_0$

Question29

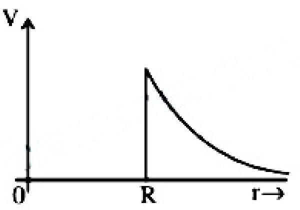
Which of the following correctly represents the variation of electric potential (V) of a charged spherical conductor of radius (R) with radial distance (r) from the centre?
[31-Jan-2023 Shift 1]

Options:

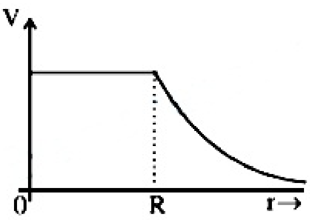
A.



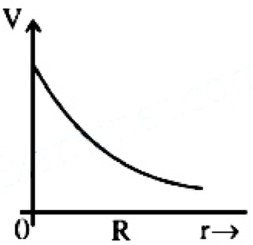
B.



C.



D.



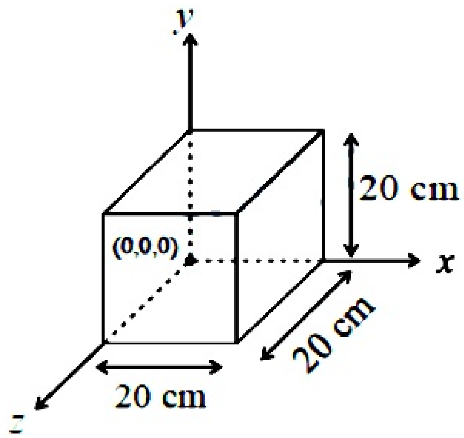
Answer: C

Solution:

Solution:
Conceptual

Question30

Expression for an electric field is given by $\vec{E} = 4000x^2\,\hat{i}\,\frac{V}{m}$. The electric flux through the cube of side 20 cm when placed in electric field (as shown in the figure) is ________ V cm.



[31-Jan-2023 Shift 1]

Answer: 640

Solution:

Solution:

Flux $= \vec{E} \cdot \vec{A}$

$= 4000(0 \cdot 2)^2 \frac{V}{m} \cdot (0 \cdot 2)^2 m^2$

$= 4000 \times 16 \times 10^{-4} Vm$

$= 640\,Vcm$

Ans. 640

Question31

Considering a group of positive charges, which of the following statements is correct?
[31-Jan-2023 Shift 2]

Options:

A. Net potential of the system cannot be zero at a point but net electric field can be zero at that point.

B. Net potential of the system at a point can be zero but net electric field can't be zero at that point.

C. Both the net potential and the net field can be zero at a point.

D. Both the net potential and the net electric field cannot be zero at a point

Answer: A

Solution:

Solution:

$V = \frac{\Sigma K Q_i}{r_i}$

Here, Q_i and r_i are positive.

$\therefore V > 0$
The correct statement is:
(A) Net potential of the system cannot be zero at a point but net electric field can be zero at that point.
Explanation:
In a group of positive charges, the net potential at a point is the sum of the potentials due to each individual charge. The potential due to a point charge is given by the Coulomb's law, which is non-zero except at the location of the charge itself. Therefore, the net potential due to a group of positive charges can never be zero at a point.
On the other hand, the net electric field at a point is the vector sum of the electric fields due to each individual charge. If the charges are arranged in such a way that their electric fields cancel out at a particular point, then the net electric field at that point can be zero, even though the charges are present. This can happen, for example, in a symmetrical arrangement of charges.

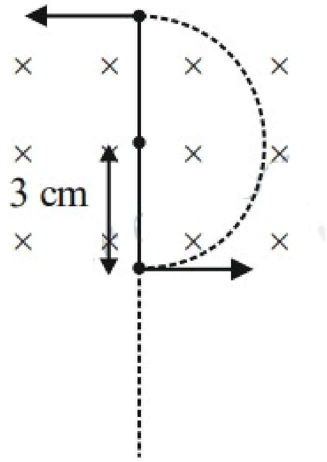
Question32

A charge particle of 2μC accelerated by a potential difference of 100V enters a region of uniform magnetic field of magnitude 4 mT at right angle to the direction of field. The charge particle completes semicircle of radius 3 cm inside magnetic field. The mass of the charge particle is ______ $\times 10^{-18}$ kg.
[1-Feb-2023 Shift 1]

Answer: 144

Solution:

$r = \frac{mv}{qB} = \frac{\sqrt{2km}}{qB}, m = \frac{r^2q^2B^2}{2k}$



$$m = \frac{\frac{1}{100} \times \frac{3}{100} \times 2 \times 2 \times 4 \times 10^{-3} \times 4 \times 10^{-3} \times 10^{-12}}{2 \times (100) \times 10^{-6}}$$
$= 144 \times 10^{-18}$ kg

Question33

Given below are two statements: One is labelled as Assertion A and the other is labelled as Reason R.
Assertion A : Two metallic spheres are charged to the same potential. One of them is hollow and another is solid, and both have the same

radii. Solid sphere will have lower charge than the hollow one.
Reason R: Capacitance of metallic spheres depend on the radii of spheres.
In the light of the above statements, choose the correct answer from the options given below.
[1-Feb-2023 Shift 2]

Options:

A. A is false but R is true

B. Both A and R are true and R is the correct explanation of A

C. A is true but R is false

D. Both A and R are true but R is not the correct explanation of A

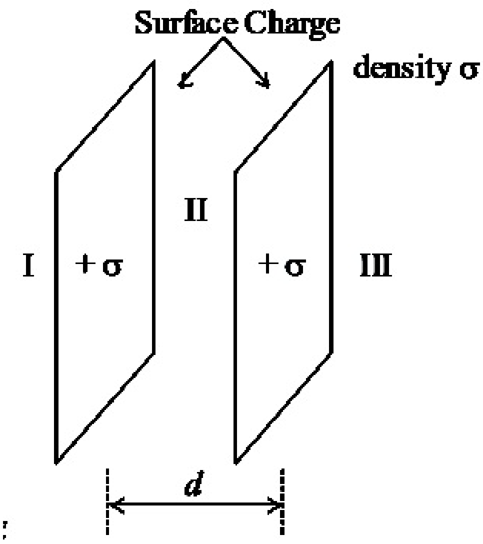
Answer: A

Solution:

Solution:
Potential of a conducting sphere is
$V = \frac{KQ}{R}$ (Solid as well as hollow)
$V_1 = V_2$ and $R_1 = R_2$
$\therefore Q_1 = Q_2$

Question34

Let σ be the uniform surface charge density of two infinite thin plane sheets shown in figure. Then the electric fields in three different region E_I, E_{II} and E_{III} are:



[1-Feb-2023 Shift 1]

Options:

A. $\vec{E}_I = \frac{2\sigma}{E_0}\hat{n}$, $\vec{E}_{II} = 0$, $\vec{E}_{III} = \frac{2\sigma}{E_0}\hat{n}$

B. $\vec{E}_{I} = 0, \vec{E}_{II} = \frac{\sigma}{E_0}\hat{n}, \vec{E}_{III} = 0$

C. $\vec{E}_{I} = \frac{\sigma}{2E_0}\hat{n}, \vec{E}_{II} = 0, \vec{E}_{III} = \frac{\sigma}{2E_0}\hat{n}$

D. $\vec{E}_{I} = -\frac{\sigma}{E_0}\hat{n}, \vec{E}_{II} = 0, \vec{E}_{III} = \frac{\sigma}{E_0}\hat{n}$

Answer: D

Solution:

Solution:

Assuming RHS to be $\hat{n}$

$\vec{E}_{I} = \frac{\sigma}{2E_0}(-\hat{n}) + \frac{\sigma}{2E_0}(-\hat{n}) = -\frac{\sigma}{E_0}\hat{n}$

$\vec{E}_{II} = 0$

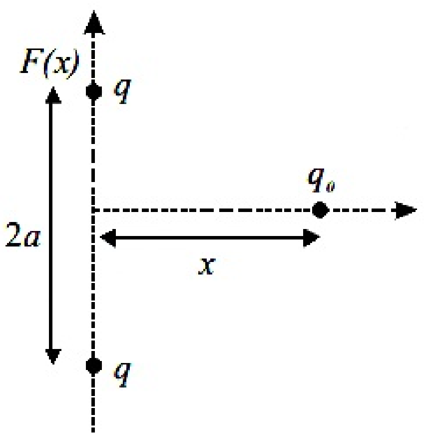
$\vec{E}_{III} = \frac{\sigma}{2E_0}(\hat{n}) + \frac{\sigma}{2E_0}(\hat{n}) = \frac{\sigma}{E_0}(\hat{n})$

Question35

Two equal positive point charges are separated by a distance 2a. The distance of a point from the centre of the line joining two charges on the equatorial line (perpendicular bisector) at which force experienced by a test charge q_0 becomes maximum is $\frac{a}{\sqrt{x}}$. The value of x is _______. [1-Feb-2023 Shift 1]

Answer: 2

Solution:



$$F = \frac{2K\,qq_0x}{(x^2 + a^2)^{3/2}}$$

For F to be maximum

$$\frac{dF}{dx} = 0$$

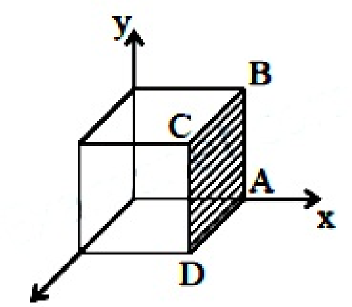
$$x = \frac{a}{\sqrt{2}}$$

Question36

A cubical volume is bounded by the surfaces
$x = 0, x = a, y = 0, y = a, z = 0, z = a$. The electric field in the region is given by $\vec{E} = E_0 \times \hat{i}$. Where $E_0 = 4 \times 10^4 NC^{-1}m^{-1}$. If $a = 2\,cm$, the charge contained in the cubical volume is $Q \times 10^{-14}C$. The value of Q is ______.
Take $E_0 = 9 \times 10^{-12}C^2 / Nm^2$)
[1-Feb-2023 Shift 2]

Answer: 288

Solution:



$\vec{E} = E_0 \times \hat{i}$

$\varphi_{net} = \varphi_{ABCD} = E_0 a \cdot a^2$

$\frac{q_{en}}{E_0} = E_0 a^3$

$q_{en} = E_0 E_0 a^3$

$= 4 \times 10^4 \times 9 \times 10^{-12} \times 8 \times 10^{-6}$

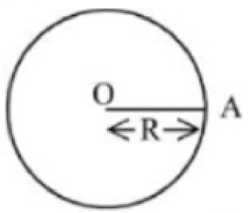
$= 288 \times 10^{-14} C$

$Q = 288$

Ans. 288

Question37

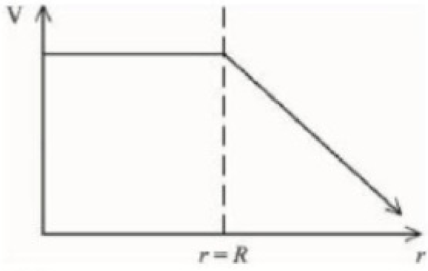
For a uniformly charged thin spherical shell, the electric potential (V) radially away from the entre (O) of shell can be graphically represented as -



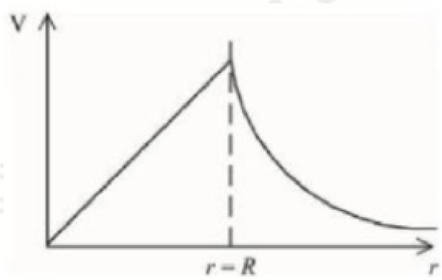
[6-Apr-2023 shift 1]

Options:

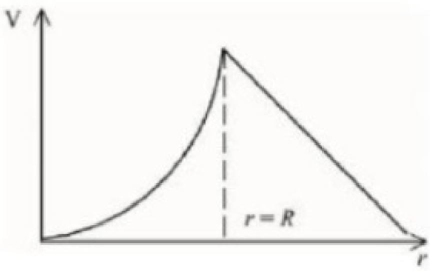
A.



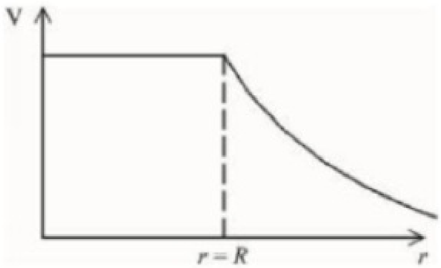
B.



C.



D.



Answer: D

Solution:

Solution:

For $r \leq R$, $V = \frac{KQ}{R}$, i.e., Constant everywhere inside.

For $r > R$, $V = \frac{KQ}{r}$, i.e., Decreases with r.

Question38

A dipole comprises of two charged particles of identical magnitude q and opposite in nature. The mass ' m ' of the positive charged particle is half of the mass of the negative charged particle. The two charges are

separated by a distance 'l'. If the dipole is placed in a uniform electric field ' $\overline{E}$ '; in such a way that dipole axis makes a very small angle with the electric field, ' $\overline{E}$ '. The angular frequency of the oscillations of the dipole when released is given by :
[6-Apr-2023 shift 2]

Options:

A. $\sqrt{\frac{4qE}{3ml}}$

B. $\sqrt{\frac{8qE}{ml}}$

C. $\sqrt{\frac{8qE}{3ml}}$

D. $\sqrt{\frac{4qE}{ml}}$

Answer: A

Solution:

Solution:
In this case, since masses of both charges are not same, therefore, we need to find center of mass (COM), about which dipole will oscillate and then we will find moment of Inertia about this axis, to find torque & hence ω. As we know, COM will divide length in the inverse ratio of the masses, therefore, COM will be at a distance of $\frac{L}{3}$ from $2m\&$ $\frac{2L}{3}$ from m

MI about this axis

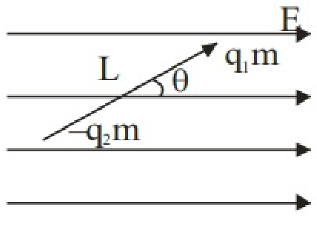
$I = 2m\left(\frac{L}{3}\right)^2 + \left(\frac{2L}{3}\right)^2$

Or I $= \frac{2mL^2}{a} + \frac{4mL^2}{a} = \frac{6mL^2}{a} = \frac{2mL^2}{3}$

Using $\omega = \frac{2mL^2}{3\&} p = qL$

$\omega = \sqrt{\frac{qLE}{\frac{2L^2}{3}}} = \sqrt{\frac{3qE}{2mL}}$

None of these given option is correct. (BONUS)



Question39

Experimentally it is found that 12.8 eV energy is required to separate a hydrogen atom into a proton and an electron. So the orbital radius of the electron in a hydrogen atom is $\frac{9}{x} \times 10^{-10}$m. The value of the x is _______ :

$\Big($ 1 eV = 1.6×10^{-19}J, $\frac{1}{4\pi E_0} = 9 \times 10^9 Nm^2 / C^{2.}$ and electronic charge

$= 1.6 \times 10^{-19} C$)
[6-Apr-2023 shift 2]

Answer: 16

Solution:

Using $E = \frac{ke^2}{2r}$

$r = \frac{Re^2}{2E}$

Given $E = 12.8\,eV = 12.8 \times e$ Joule

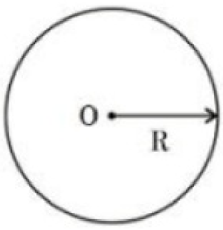
$r = \frac{9 \times 10^9 e^2}{2 \times 12.8e} = \frac{9 \times 10^9 \times 1.6 \times 10^{-19}}{2 \times 12.8}$

$r = \frac{9 \times 10^{-10}}{(2 \times 12.8 / 1.6)} = \frac{9 \times 10^{-10}}{10} m$

Therefore $x = 16$

Question40

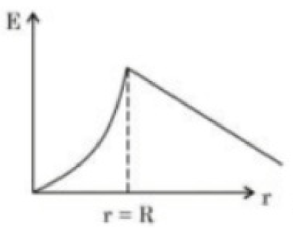
Graphical variation of electric field due to a uniformly charged insulating solid sphere of radius R, with distance r from the centre O is represented by:



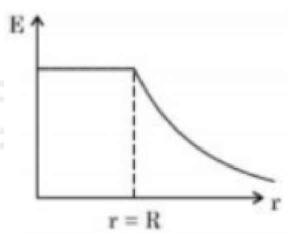
[8-Apr-2023 shift 1]

Options:

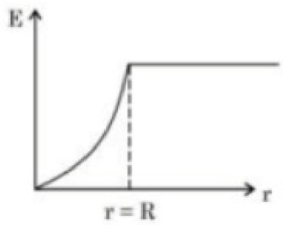
A.



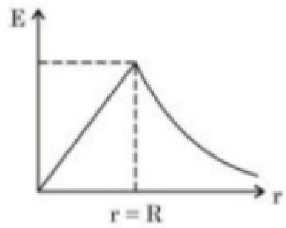
B.



C.



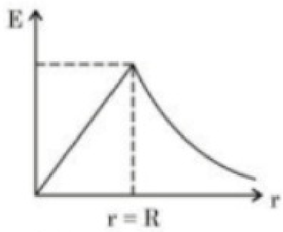
D.



Answer: A

Solution:

Solution:



Electric field due to uniformly charged insulating solid sphere

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Question41

An electric dipole of dipole moment is 6.0×10^{-6}Cm placed in a uniform electric field of $1.5 \times 10^{3}NC^{-1}$ in such a way that dipole moment is along electric field. The work done in rotating dipole by 180° in this field will be ______ mJ.
[8-Apr-2023 shift 1]

Answer: 18

Solution:

$W_{ext} = U_f - U_i \ \left\{ U = -\vec{P} \cdot \vec{E} \right\}$
$= -PE\cos\pi - (-PE\cos 0)$
$= 2PE$
$= 2 \times 6 \times 10^{-6} \times 1.5 \times 10^{3}$
$= 18\,mJ$

Question42

Electric potential at a point ' P ' due to a point charge of 5×10^{-9}C is 50V. The distance of ' P ' from the point charge is:
(Assume, $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^{+9}\mathrm{Nm^2C^{-2}}$)
[8-Apr-2023 shift 2]

Options:

A. 3 cm

B. 9 cm

C. 0.9 cm

D. 90 cm

Answer: D

Solution:

Solution:

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

$\Rightarrow r = \frac{9 \times 10^9 \times 5 \times 10^{-9}}{50}$

$\Rightarrow r = \frac{9}{10} \times 100\,\mathrm{cm}$

$r = 90\,\mathrm{cm}$

Question43

Three concentric spherical metallic shells X, Y and Z of radius a, b and c respectively [a < b < c] have surface charge densities σ, −σ and σ, respectively. The shells X and Z are at same potential. If the radii of X & Y are 2 cm and 3 cm, respectively. The radius of shell Z is ________ cm.
[10-Apr-2023 shift 1]

Answer: 5

Solution:

Solution:

$q_x = \sigma 4\pi a^2$

$q_y = -\sigma 4\pi b^2$

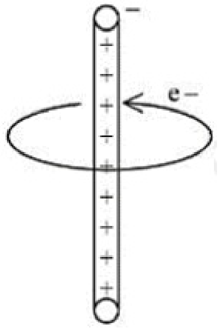
$q_z = \sigma 4\pi c^2$

Potential of y

$$\frac{q_x}{4\pi\varepsilon_0 a} + \frac{q_y}{4\pi\varepsilon_0 b} + \frac{q_z}{4\pi\varepsilon_0 c} = \frac{q_x}{4\pi\varepsilon_0 c} + \frac{q_y}{4\pi\varepsilon_0 c} + \frac{q_z}{4\pi\varepsilon_0 c}$$
$$\frac{\sigma 4\pi a^2}{a} - \frac{\sigma 4\pi b^2}{b} + \frac{\sigma 4\pi c^2}{c} = 4\pi\sigma\frac{(a^2 - b^2 + c^2)}{c}$$
$$c(a-b+c) = a^2 - b^2 + c^2$$
$$c(a-b) + c^2 = (a+b)(a-b)$$
$$c(a-b) = (a+b)(a-b)$$
$$c = a + b = 2 + 3$$
$$c = 5\,\text{cm} \quad \text{Ans.}$$

Question44

An electron revolves around an infinite cylindrical wire having uniform linear charge density $2 \times 10^{-8}\,\text{Cm}^{-1}$ in circular path under the influence of attractive electrostatic field as shown in the figure. The velocity of electron with which it is revolving is $\times 10^{6}\,\text{m s}^{-1}$. Given mass of electron $= 9 \times 10^{-31}\,\text{kg}$



[10-Apr-2023 shift 2]

Answer: 8

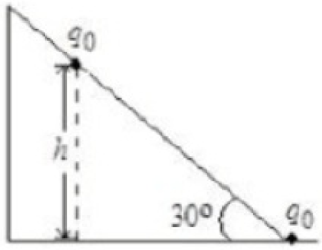
Solution:

Solution:
In uniform circular motion
$$F_c = ma_c$$
$$(q)\,(E) = \frac{mv^2}{r}$$
$$(e)\left(\frac{2k\lambda}{r}\right) = \frac{mv^2}{r}$$
$$v^2 = \frac{(e)(2k\lambda)}{m} = \frac{(1.6 \times 10^{-19}) \times 2 \times (9 \times 10^{9}) \times (2 \times 10^{-8})}{9 \times 10^{-31}}$$
$$= 1.6 \times 4 \times 10^{13}$$
$$V^2 = 16 \times 4 \times 10^{12} \Rightarrow v = 8 \times 10^{6}\,\text{m/s}$$
Ans. 8

Question45

As shown in the figure, a configuration of two equal point charges ($q_0 = +2\mu C$) is placed on an inclined plane. Mass of each point charge is

20g. Assume that there is no friction between charge and plane. For the system of two point charges to be in equilibrium (at rest) the height $h = x \times 10^{-3}$m. The value of x is ________.
(Take $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 Nm^2C^{-2}$, $g = 10ms^{-2}$)



[11-Apr-2023 shift 1]

Answer: 300

Solution:

Solution:
Point charge on equilibrium is at rest.

So $F_e = mg\sin\theta$

$$\frac{kq_0 \cdot q_0}{r^2} = mg\sin 30^\circ$$

$$\frac{kq_0{}^2}{\left(\frac{h}{\sin 30^\circ}\right)^2} = \frac{mg}{2}$$

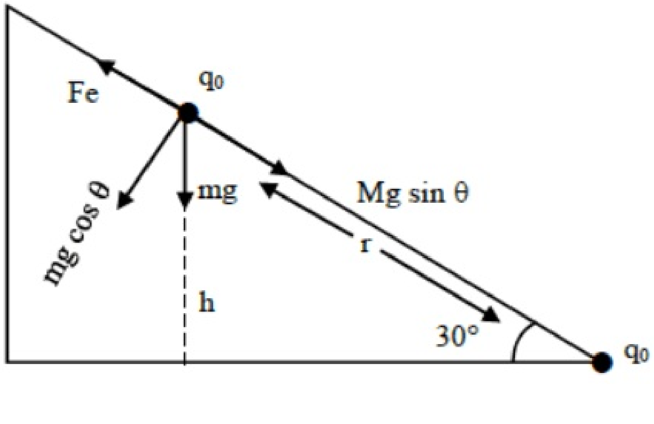
$$\frac{9 \times 10^9 \times (2 \times 10^{-6})^2}{4h^2} = \frac{20 \times 10^{-3} \times 10}{2}$$

$$\frac{9 \times 4 \times 10^9 \times 10^{-12}}{4h^2} = 10^{-1}$$

$h^2 = 9 \times 10^{-2}$ Ans.

$h = 0.3m = 300 \times 10^{-3}m$

$x = 300$ Ans.



Question46

If V is the gravitational potential due to sphere of uniform density on it's surface, then it's value at the center of sphere will be:-
[11-Apr-2023 shift 2]

Options:

A. $\frac{4}{3}V$

B. V

C. $\frac{3V}{2}$

D. $\frac{V}{2}$

Answer: C

Solution:

Solution:

$V = -\frac{GM}{R^3}(1.5R^2 - 0.5r^2)$

$V = -\frac{GM}{R}$[At the surface]

$V_{centre} = -\frac{3\,GM}{2R} = \frac{3}{2}V$

Question47

Given below are two statements : one is labelled as Assertion A and the other is labelled as Reason R
Assertion A : If an electric dipole of dipole moment 30×10^{-5}Cm is enclosed by a closed surface, the net flux coming out of the surface will be zero.
Reason R : Electric dipole consists of two equal and opposite charges.
In the light of above, statements, choose the correct answer from the options given below.
[12-Apr-2023 shift 1]

Options:

A. Both A and R are true but R is NOT the correct explanation of A

B. A is false but R is true

C. Both A and R are true and R is the correct explanation of A

D. A is true but R is false

Answer: C

Solution:

Solution:
(i) An electric dipole is enclosed in a closed question surface the total flux through the enclosed surface is zero.
(ii) net charge inside the enclosed surface is zero.

Question48

Two charges each of magnitude 0.01C and separated by a distance of 0.4 mm constitute an electric dipole. If the dipole is placed in an uniform electric field ' $\vec{E}$ ' of 10 dyne/C making 30° angle with $\vec{E}$, the magnitude of torque acting on dipole is
[13-Apr-2023 shift 1]

Options:

A. 1.5×10^{-9} Nm

B. 2.0×10^{-10} Nm

C. 1.0×10^{-8} Nm

D. 4.0×10^{-10} Nm

Answer: B

Solution:

Dipole moment, $P = qd$
$P = 0.01 \times 0.4 \times 10^{-3}$
$P = 4 \times 10^{-6} C - m$
Torque, $\tau = pE \sin \theta$
$\tau = 4 \times 10^{-6} \times (10 \times 10^{-5}) \times \sin 30^{\circ}$
$\tau = 4 \times 10^{-10} N - m$

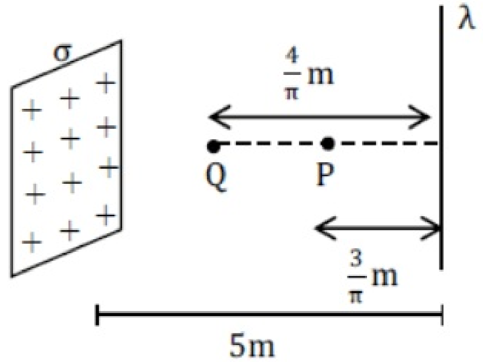
Question49

A thin infinite sheet charge and an infinite line charge of respective charge densities $+\sigma$ and $+\lambda$ are placed parallel at 5m distance from each other. Points ' P ' and ' Q ' are at $\frac{3}{\pi}$m and $\frac{4}{\pi}$m perpendicular distances from line charge towards sheet charge, respectively. ' E_P ' and ' E_Q ' are the magnitudes of resultant electric field intensities at point 'P' and 'Q' respectively. If $\frac{E_P}{E_Q} = \frac{4}{a}$ for $2|\sigma| = |\lambda|$, then the value of a is

____
[13-Apr-2023 shift 1]

Answer: 6

Solution:



$E_p = \frac{2K\lambda}{r} - \frac{\sigma}{2\varepsilon_0}$

$E_p = \frac{\sigma}{2\varepsilon_0} - \frac{\lambda}{2\pi\varepsilon_0\left(\frac{3}{\pi}\right)}$

$E_p = \frac{2\sigma}{2\varepsilon_0} - \frac{2\sigma}{6\varepsilon_0} = \frac{\sigma}{6\varepsilon_0}$

Similarly, $E_Q = \frac{\sigma}{2\varepsilon_0} - \frac{2\sigma}{2\pi\varepsilon_0\left(\frac{4}{\pi}\right)} = \frac{\sigma}{4\varepsilon_0}$

$\frac{E_p}{E_Q} = \frac{4}{6}$

a = 6

Question50

A 10μC charge is divided into two parts and placed at 1 cm distance so that the repulsive force between them is maximum. The charges of the two parts are:
[13-Apr-2023 shift 2]

Options:

A. 7μC, 3μC

B. 8μC, 2μC

C. 9μC, 1μC

D. 5μC, 5μC

Answer: D

Solution:

Solution:

Divide q = 10μ cinto parts (x) and (q − x)

$F = \frac{(K)(x)(q-x)}{r^2}$

For F to be maximum

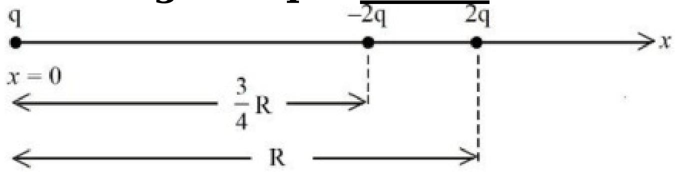
$\frac{dF}{dx} = 0$

$x = \frac{q}{2} = \frac{10\mu C}{2} = 5\mu C$

$q - x = 10\mu C - 5\mu C = 5\mu C$

Question51

Three point charges q, −2q and 2q are placed on x-axis at a distance $x = 0$, $x = \frac{3}{4}R$ and $x = R$ respectively from origin as shown. If $q = 2 \times 10^{-6}$C and R = 2 cm, the magnitude of net force experienced by the charge −2q is ______ N.

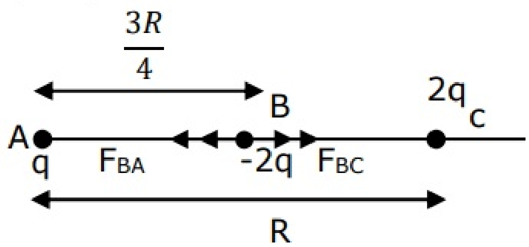


[13-Apr-2023 shift 2]

Answer: 5440

Solution:

Solution:



$F_{BA} = \frac{32kq^2}{9q^2}$ $F_{BC} = \frac{64kq^2}{R^2}$

$F_B = F_{BC} - F_{BA} = \frac{544kq^2}{9R^2}$

$= 5440N$

Question52

The electric field due to a short electric dipole at a large distance (r) from center of dipole on the equatorial plane varies with distance as : [15-Apr-2023 shift 1]

Options:

A. r

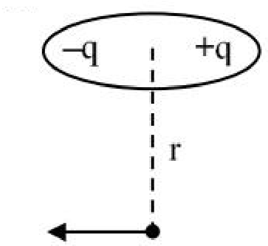
B. $\frac{1}{3}$

C. $\frac{1}{2}$

D. $\frac{1}{3}$

Answer: D

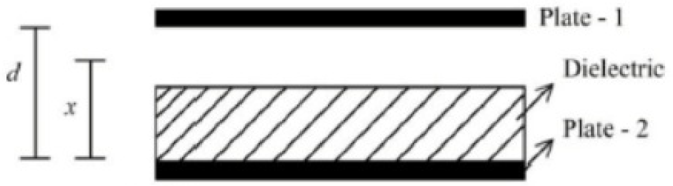
Solution:



$E = \frac{KP}{r^3} \propto \frac{1}{r^3}$

Question53

A parallel plate capacitor with plate area A and plate separation d is filed with a dielectric material of dielectric constant K = 4. The thickness of the dielectric material is x, where x < d.



Let C_1 and C_2 be the capacitance of the system for x = $\frac{1}{3}d$ and x = $\frac{2d}{3}$, respectively. If C_1 = 2μF the value of C_2 is ________ μF
[6-Apr-2023 shift 1]

Answer: 3

Solution:

Solution:

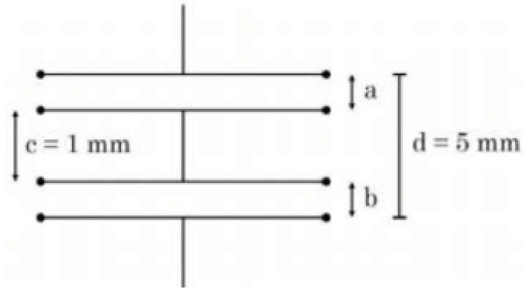
$$C_1 = \frac{\frac{E_0A}{\frac{2d}{3}} \times \frac{4E_0A}{\frac{d}{3}}}{\frac{E_0A}{2d/3} + \frac{4E_0A}{d/3}} = \frac{18}{\frac{3}{2}+12}\frac{E_0A}{d} = 18 \times \frac{2}{27}\frac{E_0A}{d} = \frac{4}{3}\frac{E_0A}{d}$$

According to qn, $\frac{4}{3}\frac{E_0A}{d} = 2 \Rightarrow \frac{E_0A}{d} = \frac{3}{2}$ ---- (i)

$$\text{Now, } C_2 = \frac{\frac{E_0A}{\frac{d}{3}} \times \frac{4E_0A}{\frac{2d}{3}}}{\frac{E_0A}{d/3} + \frac{4E_0A}{2d/3}} = \frac{18}{3+6}\frac{E_0A}{d} = 2 \times \frac{E_0A}{d} = 2 \times \frac{3}{2} = 3$$

Question54

As shown in the figure, two parallel plate capacitors having equal plate area of $200cm^2$ are joined in such a way that $\alpha \neq b$. The equivalent capacitance of the combination is $x\in_0$ F. The value of x is ______.



[6-Apr-2023 shift 2]

Answer: 5

Solution:

Solution:

As per the arrangement given, distance between the capacitor plates are a and b and $a \neq b$ using the diagram we can write $b = 5 - a - 1 = (4 - a)$ in mm

as we know capacitance of capacitor $C = \frac{\varepsilon_0 A}{d}$ and in series arrangement

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$\frac{1}{C_{eq}} = \frac{a}{\varepsilon_0 A} + \frac{4 - a}{\varepsilon_0 A} = \frac{4(\text{ in mm })}{\varepsilon_0 A}$$

or $C_{eq} = \frac{\varepsilon_0 A}{4(\text{mm})}$

Given $A = 200cm^2$

$$C_{eq} = \frac{\varepsilon_0 \times 200 \times 10^{-4}}{4 \times 10^{-3}}$$

$= \varepsilon_0 50 \times 10^{-1}$

or $C_{eq} = 5\varepsilon_0$ farad therefore $n = 5$

Question55

A 600 pF capacitor is charged by 200V supply. It is then disconnected from the supply and is connected to another uncharged 600 pF capacitor. Electrostatic energy lost in the process is ______ μJ
[8-Apr-2023 shift 2]

Answer: 6

Solution:

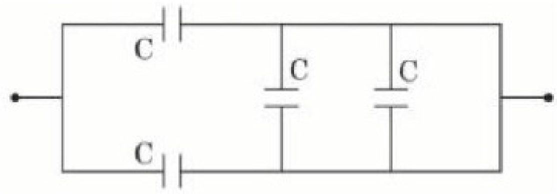
loss of strength $= \frac{1}{2}\frac{c \times c}{c + c}(v_1 - v_2)^2$

$= \frac{1}{2} \times \left[\frac{600 \times 10^{-12}}{2}\right] \times (200)^2$

$= 600 \times 10^{-12} \times 10^4 = 6 \times 10^{-6} = 6\mu J$

Question56

The equivalent capacitance of the combination shown is



[10-Apr-2023 shift 1]

Options:

A. 4C

B. $\frac{5}{3}C$

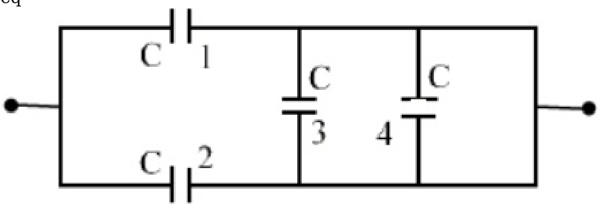
C. $\frac{C}{2}$

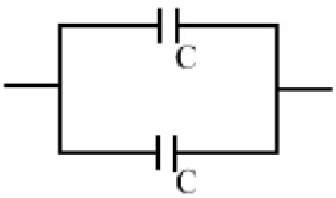
D. 2C

Answer: D

Solution:

Solution:
Capacitor (3) & (4) are short ckt
$\therefore C_1 \& C_2$ are in parallel
$C_{eq} = C + C = 2C$





Question57

The distance between two plates of a capacitor is d and its capacitance is C_1, when air is the medium between the plates. If a metal sheet of thickness $\frac{2d}{3}$ and of the same area as plate is introduced between the

plates, the capacitance of the capacitor becomes C_2. The ratio $\frac{C_2}{C_1}$ is [10-Apr-2023 shift 2]

Options:

A. 4 : 1

B. 3 : 1

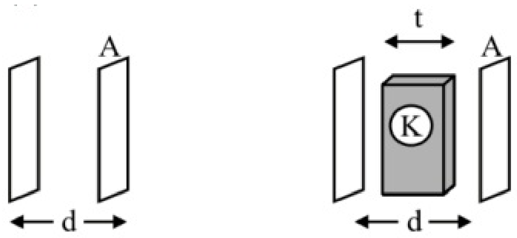
C. 2 : 1

D. 1 : 1

Answer: B

Solution:

Solution:



$t = \frac{2d}{3}$

$K = \infty$ for metals

$C_1 = \frac{\varepsilon_0 A}{d} \qquad C_2 = \frac{\varepsilon_0 A}{d - t + \frac{t}{k}} = \frac{\varepsilon_0 A}{d - \frac{2d}{3} + 0} = \frac{3\varepsilon_0 A}{d}$

$= \frac{C_2}{C_1} = \frac{\frac{3\varepsilon_0 A}{d}}{\frac{\varepsilon_0 A}{d}} = \frac{3}{1}$

Question58

The electric field in an electromagnetic wave is given as

$\vec{E} = 20 \sin \omega \left(t - \frac{x}{c} \right) \vec{j}\, NC^{-1}$

where ω and c are angular frequency and velocity of electromagnetic wave respectively. the energy contained in a volume of $5 \times 10^{-4} m^3$ will be (Given $\varepsilon_0 = 8.85 \times 10^{-12} c^2 / Nm^2$)

[11-Apr-2023 shift 1]

Options:

A. $88.5 \times 10^{-13} J$

B. $17.7 \times 10^{-13} J$

C. $8.85 \times 10^{-13} J$

D. $28.5 \times 10^{-13} J$

Answer: C

Solution:

Solution:

$\vec{E} = 20 \sin w \left[t - \frac{x}{c} \right]$

$E\ _o 2_o$

$\text{Energy density} \ = \frac{1}{2} \varepsilon_o E\ _o{}^2$

$= \frac{1}{2} \times 8.85 \times 10^{-12} \times 400$

$= 200 \times 8.85 \times 10^{-12} \times 5 \times 10^{-4}$

$= 8.85 \times 10^{-12} \times 10^{-4} \times 1000$

$\text{Energy} \ = 8.85 \times 10^{-13} \text{J}$

Question59

A parallel plate capacitor of capacitance 2F is charged to a potential V, The energy stored in the capacitor is E_1. The capacitor is now connected to another uncharged identical capacitor in parallel combination. The energy stored in the combination is E_2. The ratio E_2 / E_1 is :
[11-Apr-2023 shift 1]

Options:

A. 2 : 3

B. 1 : 2

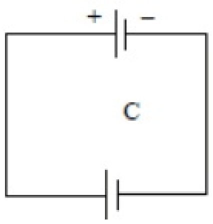
C. 1 : 4

D. 2 : 1

Answer: D

Solution:

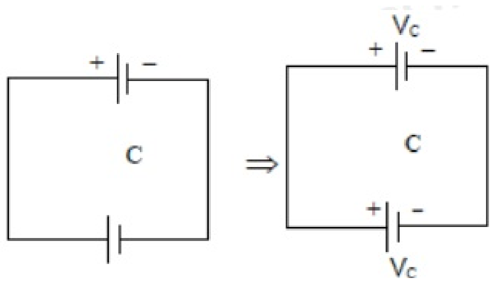
Solution:



$C = 2F$

$E1 = \frac{1}{2} CV^2 \ . . . (1)$

Now



$$V_C = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}$$
$$V_C = \frac{CV + O}{2C} = \frac{V}{2}$$
$$E_2 = CV_C^{\ 2} = C \cdot \frac{V^2}{4} \ . . . (2)$$
$$\frac{E_2}{E_1} = \frac{\left(\frac{CV^2}{4}\right)}{\left(\frac{CV^2}{2}\right)} = \frac{2}{1} \quad \text{option} \quad \rightarrow (4)$$

Question60

A capacitor of capacitance C is charge to a potential V. The flux of the electric field through a closed surface enclosing the positive plate of the capacitor is :
[11-Apr-2023 shift 2]

Options:

A. Zero

B. $\frac{CV}{\varepsilon_0}$

C. $\frac{2CV}{\varepsilon_0}$

D. $\frac{CV}{2\varepsilon_0}$

Answer: B

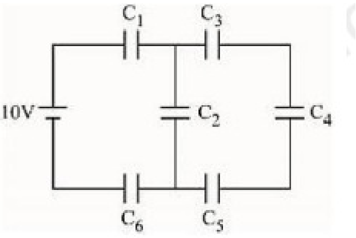
Solution:

Solution:

$$\varphi = \frac{q}{\varepsilon_0}$$
$$\varphi = \frac{CV}{\varepsilon_0}$$

Question61

In the given circuit,
$C_1 = 2\mu F$, $C_2 = 0.2\mu F$, $C_3 = 2\mu F$, $C_4 = 4\mu F$, $C_5 = 2\mu F$, $C_6 = 2\mu f$, The charge stored on capacitor C_4 is ________ μC.

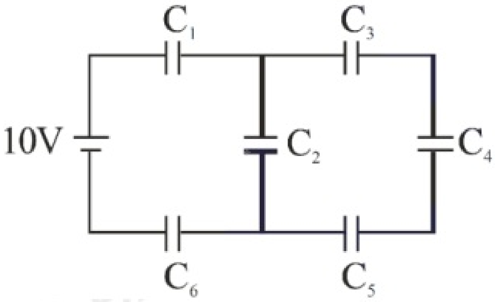


[11-Apr-2023 shift 2]

Answer: 4

Solution:

Solution:



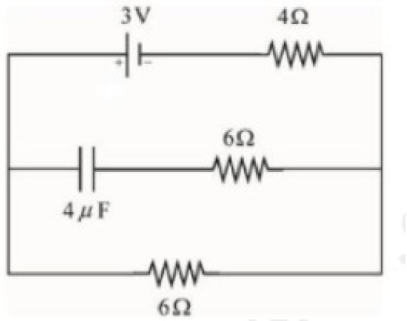
$C_{eq} = 0.5\mu F$

$Q = 0.5 \times 10 = 5\mu C$

$Q' = \dfrac{5\mu C \times 0.8}{0.8 + 0.2} = 4\mu C$

Question62

In the network shown below, the charge accumulated in the capacitor in steady state will be :



[13-Apr-2023 shift 2]

Options:

A. 4.8μC

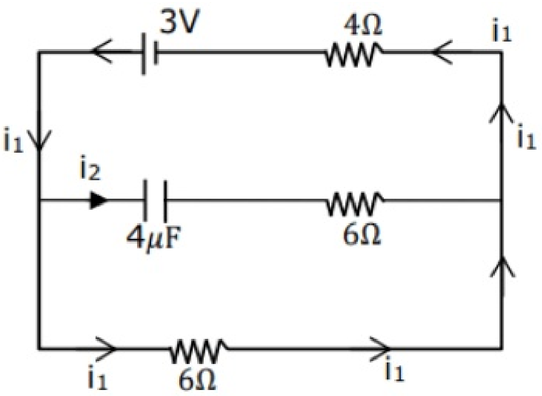
B. 12μC

C. 7.2μC

D. 10.3μC

Answer: C

Solution:



In steady state, no current will pass through capacitor hence capacitor will act as open circuit.

$i_2 = 0$

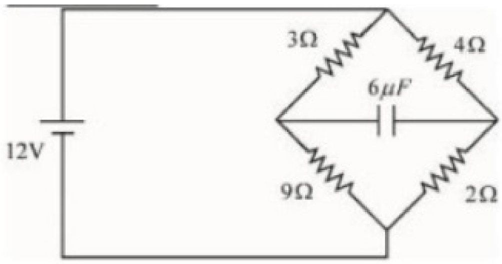
$i_1 = \frac{3}{6+4} = \frac{3}{10} A$

Potential difference on 6Ω resistor $= 6 \times \frac{3}{10} = 1.8$ volt capacitor will have same potential so charge

$= cv = 4 \times 1.8 = 7.2 \mu c$

Question63

In the circuit shown, the energy stored in the capacitor is nμJ . The value of n is

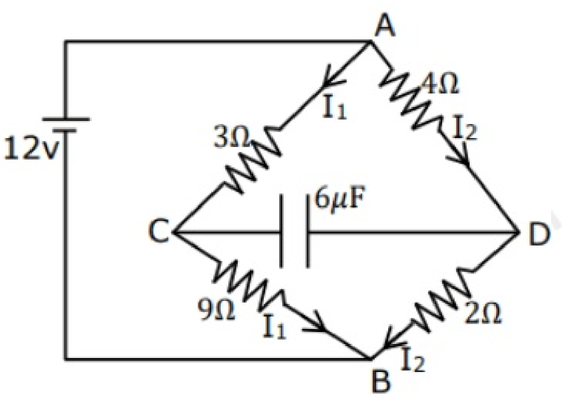


[13-Apr-2023 shift 2]

Answer: 75

Solution:

Solution:



$I_1 = \frac{12}{3+9} = 1A$

$I_2 = \frac{12}{4+2} = 2A$

$V_A - V_C = 3I_1 = 3V$

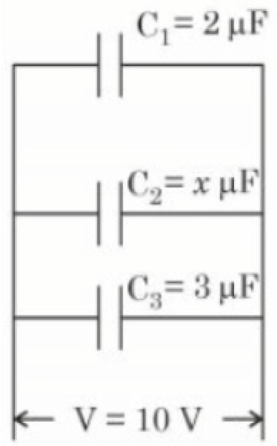
$V_A - V_D = 2 \times 4 = 8V$

So, $V_A - V_D = 5V$

$U = \frac{1}{2}CV^2 = \frac{1}{2} \times 6 \times 5^2 = 75\mu J$

Question64

In the given figure the total charge stored in the combination of capacitors is 100μC. The value of ' x ' is _______



[15-Apr-2023 shift 1]

Answer: 5

Solution:

Solution:

All the capacitors are in parallel

$C_{eq} = (5 + x)\mu F$

$Q = C_{aq}V$

$100 = (5 + x)(10)$

$x = 5$

Question65

A vertical electric field of magnitude $4.9 \times 10^5 N / C$ just prevents a water droplet of a mass 0.1g from falling. The value of charge on the droplet will be :

(Given : $g = 9.8m / s^2$)

[24-Jun-2022-Shift-1]

Options:

A. $1.6 \times 10^{-9}C$

B. $2.0 \times 10^{-9}C$

C. $3.2 \times 10^{-9}C$

D. $0.5 \times 10^{-9} C$

Answer: B

Solution:

Solution:
Since the droplet is at rest
$\Rightarrow$ Net force $= 0$
$\Rightarrow mg = qE$
$\Rightarrow q = \frac{mg}{E} = 2 \times 10^{-9} C$

Question66

Two identical charged particles each having a mass 10g and charge $2.0 \times 10^{-7} C$ are placed on a horizontal table with a separation of L between them such that they stay in limited equilibrium. If the coefficient of friction between each particle and the table is 0.25, find the value of L. [Use $g = 10 ms^{-2}$]
[24-Jun-2022-Shift-2]

Options:

A. 12 cm

B. 10 cm

C. 8 cm

D. 5 cm

Answer: A

Solution:

Solution:
According to given information:
$\frac{kQ^2}{L^2} = \mu mg$
Putting the values, we get
$L = 12 cm$

Question67

A long cylindrical volume contains a uniformly distributed charge of density ρ. The radius of cylindrical volume is R. A charge particle (q) revolves around the cylinder in a circular path. The kinetic energy of the particle is:
[24-Jun-2022-Shift-2]

Options:

A. $\frac{\rho q R^2}{4\varepsilon_0}$

B. $\frac{\rho q R^2}{2\varepsilon_0}$

C. $\frac{q\rho}{4\varepsilon_0 R^2}$

D. $\frac{4\varepsilon_0 R^2}{q\rho}$

Answer: A

Solution:

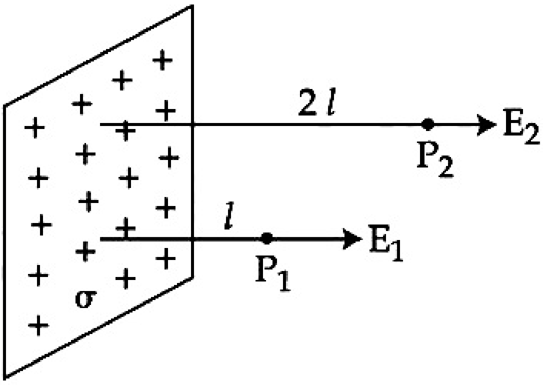
Solution:

$\frac{mv^2}{r} = \frac{2k\rho \times \pi R^2 q}{r}$

$\Rightarrow \frac{1}{2}mv^2 = \frac{\rho R^2 q}{4\varepsilon_0}$

Question68

In the figure, a very large plane sheet of positive charge is shown. P_1 and P_2 are two points at distance I and 2| from the charge distribution. If σ is the surface charge density, then the magnitude of electric fields E_1 and E_2 at P_1 and P_2 respectively are :



[25-Jun-2022-Shift-1]

Options:

A. $E_1 = \sigma / \varepsilon_0$, $E_2 = \sigma / 2\varepsilon_0$

B. $E_1 = 2\sigma / \varepsilon_0$, $E_2 = \sigma / \varepsilon_0$

C. $E_1 = E_2 = \sigma / 2\varepsilon_0$

D. $E_1 = E_2 = \sigma / \varepsilon_0$

Answer: C

Solution:

For an infinite charged plane $E = \frac{\sigma}{2\varepsilon_0}$ for any value of I

$\Rightarrow E_1 = E_2 = \frac{\sigma}{2\varepsilon_0}$

Question69

27 identical drops are charged at 22V each. They combine to form a bigger drop. The potential of the bigger drop will be_____ V. [25-Jun-2022-Shift-2]

Answer: 198

Solution:

Let the charge on one drop is q and its radius is r.
So for one drop $V = \frac{kq}{r}$
For 27 drops merged new charge will be $Q = 27q$ and new radius is $R = 3r$
So new potential is
$V' = \frac{kQ}{R} = 9\frac{kq}{r} = 9 \times 22V$
$= 198V$

Question70

Sixty four conducting drops each of radius 0.02m and each carrying a charge of 5μC are combined to form a bigger drop. The ratio of surface density of bigger drop to the smaller drop will be : [26-Jun-2022-Shift-2]

Options:

A. 1 : 4

B. 4 : 1

C. 1 : 8

D. 8 : 1

Answer: B

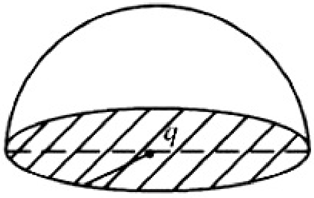
Solution:

$q' = 64q \ldots\ldots$ (i)
$A' = 16A \ldots.$ (ii)

Dividing (i) \& (ii),
$\sigma' = 4\sigma$
$\Rightarrow \frac{\sigma'}{\sigma} = \frac{4}{1}$

Question71

If a charge q is placed at the centre of a closed hemispherical non-conducting surface, the total flux passing through the flat surface would be :



[27-Jun-2022-Shift-2]

Options:

A. $\frac{q}{E_0}$

B. $\frac{q}{2\in_0}$

C. $\frac{q}{4E_0}$

D. $\frac{q}{2\pi E_0}$

Answer: B

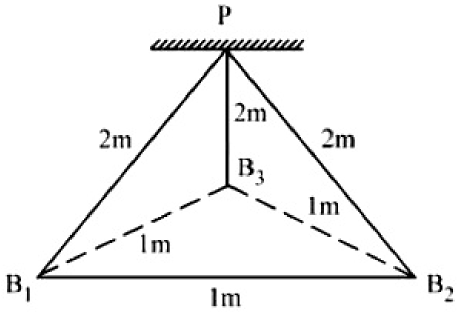
Solution:

Solution:
Flux passing through flat surface = Flux passing through curved surface.
So, $\varphi = \frac{q}{2\varepsilon_0}$
Remark : Electric flux through flat surface is zerobut no option is given, option is available forelectric flux passing through curved surface

----

Question72

Three identical charged balls each of charge 2C are suspended from a common point P by silk threads of 2m each (as shown in figure). They form an equilateral triangle of side 1m.
The ratio of net force on a charged ball to the force between any two charged balls will be:



[27-Jun-2022-Shift-2]

Options:

A. 1 : 1

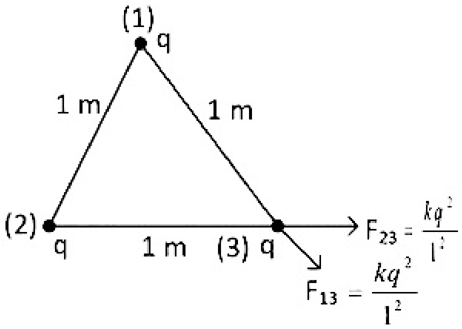
B. 1 : 4

C. $\sqrt{3}$: 2

D. $\sqrt{3}$: 1

Answer: D

Solution:



F_{net} on charge 3, $F_1 = \frac{\sqrt{3}kq^2}{1^2}$

Force between any 2 charges

$F_2 = \frac{kq^2}{1^2}$

So, $\frac{F_1}{F_2} = \sqrt{3}$

Question73

Given below are two statements :
Statement I : A point charge is brought in an electric field. The value of electric field at a point near to the charge may increase if the charge is positive.
Statement II : An electric dipole is placed in a non-uniform electric field. The net electric force on the dipole will not be zero.
Choose the correct answer from the options given below :
[28-Jun-2022-Shift-1]

Options:

A. Both Statement I and Statement II are true.

B. Both Statement I and Statement II are false.

C. Statement I is true but Statement II is false.

D. Statement I is false but Statement II is true.

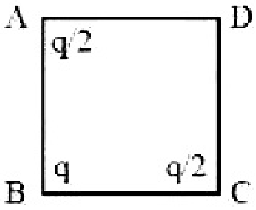
Answer: A

Solution:

Solution:
As one moves closer to a positive charge (isolated) the density of electric field line increases and so does the electric field intensity
⇒ Statement I is true
As opposite poles of an electric dipole would experience equal and opposite forces so net force on a dipole in a uniform electric field will be zero
⇒ Statement II is true

Question74

The three charges q / 2, q and q / 2 are placed at the corners A, B and C of a square of side 'a' as shown in figure. The magnitude of electric field (E) at the corner D of the square, is :



[28-Jun-2022-Shift-1]

Options:

A. $\frac{q}{4\pi \in_0 a^2}\left(\frac{1}{\sqrt{2}}+\frac{1}{2}\right)$

B. $\frac{q}{4\pi E_0 a^2}\left(1+\frac{1}{\sqrt{2}}\right)$

C. $\frac{q}{4\pi \in_0 a^2}\left(1-\frac{1}{\sqrt{2}}\right)$

D. $\frac{q}{4\pi \in_0 a^2}\left(\frac{1}{\sqrt{2}}-\frac{1}{2}\right)$

Answer: A

Solution:

Solution:
$$\left|E_{0}\right| = \frac{kq/2}{a^2}\sqrt{2}+\frac{kq}{(a\sqrt{2})^2}$$

$= \frac{kq}{\sqrt{2}a^2} + \frac{kq}{2a^2}$

$= \frac{kq}{a^2}\left(\frac{1}{\sqrt{2}} + \frac{1}{2}\right), k = \frac{1}{4\pi\varepsilon_0}$

Question75

Two point charges A and B of magnitude $+8 \times 10^{-6}$C and -8×10^{-6}C respectively are placed at a distance d apart. The electric field at the middle point O between the charges is $6.4 \times 10^4 NC^{-1}$. The distance ' d ' between the point charges A and B is :
[28-Jun-2022-Shift-2]

Options:

A. 2.0m

B. 3.0m

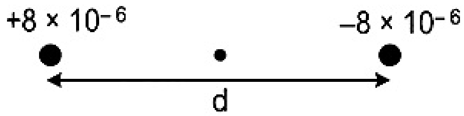
C. 1.0m

D. 4.0m

Answer: B

Solution:

Solution:



Electric field at P will be

$E = \frac{kq}{(d/2)^2} \times 2 = \frac{8kq}{d^2}$

So, $\frac{8 \times 9 \times 10^9 \times 8 \times 10^{-6}}{d^2} = 6.4 \times 10^4$

So, $d = 3m$

Question76

A positive charge particle of 100 mg is thrown in opposite direction to a uniform electric field of strength $1 \times 10^5 NC^{-1}$. If the charge on the particle is $40\mu C$ and the initial velocity is $200 ms^{-1}$, how much distance it will travel before coming to the rest momentarily :
[29-Jun-2022-Shift-1]

Options:

A. 1m

B. 5m

C. 10m

D. 0.5m

Answer: D

Solution:

Solution:
$v^2 - u^2 = 2as$

$\Rightarrow 0^2 - 200^2 = 2\left(\frac{-qE}{m}\right)(S)$

$\Rightarrow -200^2 = 2\left[\frac{-40 \times 10^{-6} \times 10^5}{100 \times 10^{-6}}\right][S]$

$\Rightarrow S = \frac{4}{2 \times 4} m = 0.5m$

Question77

At what temperature a gold ring of diameter 6.230 cm be heated so that it can be fitted on a wooden bangle of diameter 6.241 cm ? Both the diameters have been measured at room temperature (27°C).
(Given : coefficient of linear thermal expansion of gold
$\alpha_L = 1.4 \times 10^{-5} K^{-1}$)
[29-Jun-2022-Shift-2]

Options:

A. 125.7°C

B. 91.7°C

C. 425.7°C

D. 152.7°C

Answer: D

Solution:

Solution:

Question78

If the electric potential at any point (x, y, z)m in space is given by $V = 3x^2$ volt. The electric field at the point (1, 0, 3)m will be :
[29-Jun-2022-Shift-2]

Options:

A. $3Vm^{-1}$, directed along positive x-axis.

B. $3Vm^{-1}$, directed along negative x-axis.

C. $6Vm^{-1}$, directed along positive x-axis.

D. $6Vm^{-1}$, directed along negative x-axis.

Answer: D

Solution:

Solution:

$\vec{E} = -\frac{dV}{dx}\hat{i}$

$\vec{E} = -6x\hat{i}$

So, $\vec{E}$ at (1, 0, 3) is

$\vec{E} = -6\hat{i}V/m$

Question79

A parallel plate capacitor is formed by two plates each of area $30\pi cm^2$ separated by 1 mm. A material of dielectric strength $3.6\times10^7 Vm^{-1}$ is filled between the plates. If the maximum charge that can be stored on the capacitor without causing any dielectric breakdown is $7\times10^{-6}C$, the value of dielectric constant of the material is :

[Use . $\frac{1}{4\pi\varepsilon_0} = 9\times10^9 Nm^2C^{-2}$]

[24-Jun-2022-Shift-1]

Options:

A. 1.66

B. 1.75

C. 2.25

D. 2.33

Answer: D

Solution:

Solution:

Field inside the dielectric $= \frac{\sigma}{k\varepsilon_0}$

According to the given information,

$\frac{\sigma}{k\varepsilon_0} = 3.6\times10^7$

$\Rightarrow \frac{\frac{Q}{A}}{k\varepsilon_0} = 3.6\times10^7$

$\Rightarrow k = 2.33$

Question80

If the charge on a capacitor is increased by 2C, the energy stored in it increases by 44%. The original charge on the capacitor is (in C) [24-Jun-2022-Shift-2]

Options:

A. 10

B. 20

C. 30

D. 40

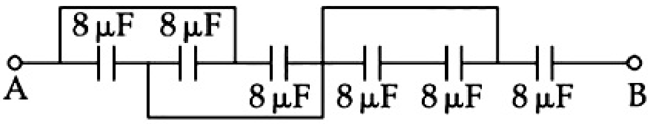
Answer: A

Solution:

Solution:
Let initially the charge is q so
$\frac{1}{2}\frac{q^2}{C} = U_i$
And $\frac{1}{2}\frac{(q+2)^2}{C} = U_f$
Given $\frac{U_f - U_i}{U_i} \times 100 = 44$
$\frac{(q+2)^2 - q^2}{q} = .44$
$\Rightarrow q = 10C$

Question81

The equivalent capacitance between points A and B in below shown figure will be _______μF



[25-Jun-2022-Shift-1]

Answer: 6

Solution:

Solution:
$C_{eq} = \frac{(3\times 8)\times 8}{(3\times 8)+8}$
$= \frac{24\times 8}{32}$
$= 6\mu F$

Question82

Two metallic plates form a parallel plate capacitor. The distance between the plates is ' d '. A metal sheet of thickness $\frac{d}{2}$ and of area equal to area of each plate is introduced between the plates. What will be the ratio of the new capacitance to the original capacitance of the capacitor?
[25-Jun-2022-Shift-2]

Options:

A. 2 : 1

B. 1 : 2

C. 1 : 4

D. 4 : 1

Answer: A

Solution:

Solution:

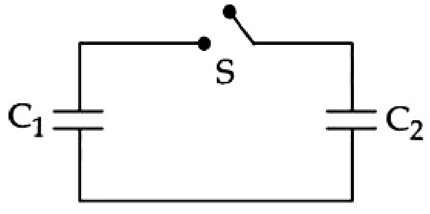
$$C_{eq} = \frac{\varepsilon_0 A}{d - \frac{d}{2} + \frac{d}{2k}} = \frac{\varepsilon_0 A}{\frac{d}{2}} = \frac{2\varepsilon_0 A}{d}$$

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

$\Rightarrow C_{eq} = 2C$ or $\frac{C_{new}}{C_{old}} = \frac{2}{1}$

Question83

Two capacitors having capacitance C_1 and C_2 respectively are connected as shown in figure. Initially, capacitor C_1 is charged to a potential difference V volt by a battery. The battery is then removed and the charged capacitor C_1 is now connected to uncharged capacitor C_2 by closing the switch S. The amount of charge on the capacitor C_2, after equilibrium, is :



[26-Jun-2022-Shift-1]

Options:

A. $\frac{C_1 C_2}{(C_1 + C_2)} V$

B. $\frac{(C_1 + C_2)}{C_1 C_2} V$

C. $(C_1 + C_2)V$

D. $(C_1 - C_2)V$

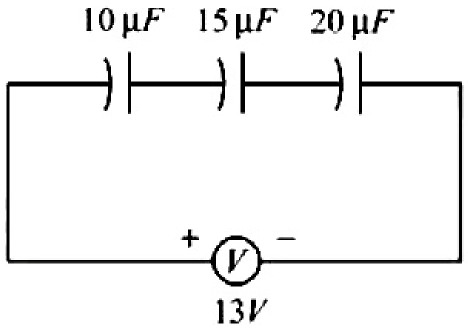
Answer: A

Solution:

Solution:
$V_{\text{common}} = \frac{C_1 V}{C_1 + C_2}$
⇒ Charge on capacitor C_2

Question84

The charge on capacitor of capacitance 15μF in the figure given below is :



[26-Jun-2022-Shift-2]

Options:

A. 60μc

B. 130μc

C. 260μc

D. 585μc

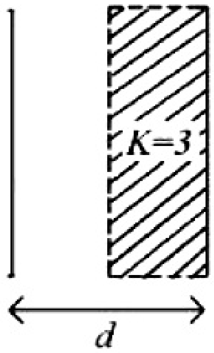
Answer: A

Solution:

Solution:
$C_{eq} = \frac{120}{26} \mu F$
$\Rightarrow Q_{\text{flown}}$ or $Q = \frac{13 \times 120}{26} \mu C = 60 \mu C$
⇒ Charge on 15μF capacitor = 60μC
As all the capacitors are in series.

Question85

A parallel plate capacitor with plate area A and plate separation d = 2m has a capacitance of 4μF. The new capacitance of the system if half of the space between them is filled with a dielectric material of dielectric constant K = 3 (as shown in figure) will be



[26-Jun-2022-Shift-2]

Options:

A. 2μF

B. 32μF

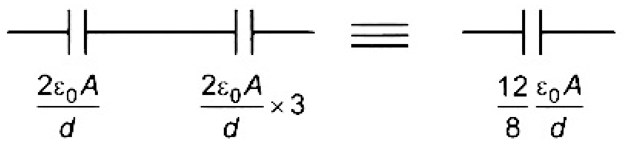
C. 6μF

D. 8μF

Answer: C

Solution:

Solution:



Now, $\frac{\varepsilon_0 A}{d} = 4\mu F$

$\Rightarrow \frac{12}{8}\frac{\varepsilon_0 A}{d} = 6\mu F$

Question86

A force of 10N acts on a charged particle placed between two plates of a charged capacitor. If one plate of capacitor is removed, then the force acting on that particle will be.
[27-Jun-2022-Shift-1]

Options:

A. 5N

B. 10N

C. 20N

D. Zero

Answer: A

Solution:

Solution:

E between two plates is $\frac{\sigma}{\varepsilon_0}$ and due to one plate is $\frac{\sigma}{2\varepsilon_0}$ so the force will be halved

So new force $F = 5N$

Question87

A capacitor of capacitance $50\,pF$ is charged by 100V source. It is then connected to another uncharged identical capacitor. Electrostatic energy loss in the process is____ nJ.
[27-Jun-2022-Shift-1]

Answer: 125

Solution:

Solution:

Electrical energy lost $= \frac{1}{2}\left(\frac{1}{2}CV^2\right)$

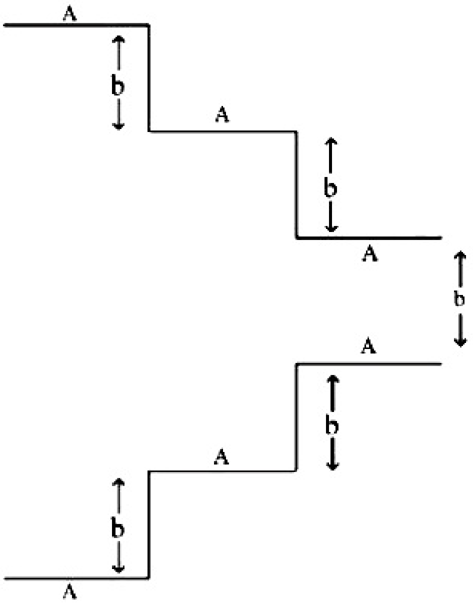
$= \frac{1}{2} \times \frac{1}{2} \times 50 \times 10^{-12} \times (100)^2$

$= \frac{500}{4}\,nJ$

$= 125\,nJ$

Question88

A parallel plate capacitor is made up of stair like structure with a plate area A of each stair and that is connected with a wire of length b, as shown in the figure. The capacitance of the arrangement is $\frac{x}{15}\frac{E_0 A}{b}$. The value of x is_____

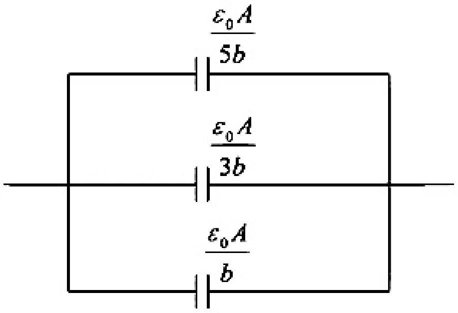


[27-Jun-2022-Shift-2]

Answer: 23

Solution:

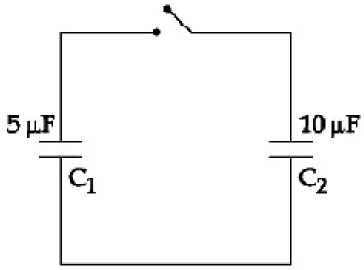
Solution:
The circuit is equivalent to 3 capacitors in parallel as shown



$C_{eq} = \frac{\varepsilon_0 A}{b}\left(1 + \frac{1}{3} + \frac{1}{5}\right) = \frac{23}{15}\frac{\varepsilon_0 A}{b}$
$\Rightarrow x = 23$

Question89

A capacitor C_1 of capacitance 5μF is charged to a potential of 30V using a battery. The battery is then removed and the charged capacitor is connected to an uncharged capacitor C_2 of capacitance 10μF as shown in figure. When the switch is closed charge flows between the capacitors. At equilibrium, the charge on the capacitor C_2 is ____μC

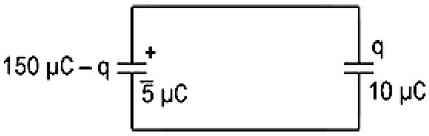


[28-Jun-2022-Shift-2]

Answer: 100

Solution:

Solution:



Let the charge q is flown in the circuit.
So using Kirchhoff's law,

$$\frac{q}{10} = \frac{150 - q}{5}$$

$q = 100\mu C$

Question90

A parallel plate capacitor filled with a medium of dielectric constant 10 , is connected across a battery and is charged. The dielectric slab is replaced by another slab of dielectric constant 15 . Then the energy of capacitor will : [29-Jun-2022-Shift-1]

Options:

A. increase by 50%

B. decrease by 15%

C. increase by 25%

D. increase by 33%

Answer: A

Solution:

Solution:

$$U = \frac{1}{2}(kC_0)V^2$$

$$\Rightarrow \frac{U'}{U} = 1.5$$

⇒ Energy increases by 50%

Question91

A capacitor is discharging through a resistor R. Consider in time t_1, the energy stored in the capacitor reduces to half of its initial value and in time t_2, the charge stored reduces to one eighth of its initial value. The ratio t_1 / t_2 will be
[29-Jun-2022-Shift-2]

Options:

A. 1 / 2

B. 1 / 3

C. 1 / 4

D. 1 / 6

Answer: D

Solution:

Solution:
For a discharging capacitor when energy reduces to half the charge would become $\frac{1}{\sqrt{2}}$ times the initial value.

$\Rightarrow \left(\frac{1}{2}\right)^{1/2} = e^{-t_1/\tau}$

Similarly, $\left(\frac{1}{2}\right)^{3} = e^{-t_2/\tau}$

$\Rightarrow \frac{t_1}{t_2} = \frac{1}{6}$

Question92

The displacement current of 4.425μA is developed in the space between the plates of parallel plate capacitor when voltage is changing at a rate of $10^6 Vs^{-1}$. The area of each plate of the capacitor is $40 cm^2$. The distance between each plate of the capacitor is $x \times 10^{-3} m$. The value of x is_____
(Permittivity of free space, $E_0 = 8.85 \times 10^{-12} C^2 N^{-1} m^{-2}$).
[29-Jun-2022-Shift-2]

Answer: 8

Solution:

Solution:

$4.425\mu A = \frac{E_0 A}{d} \times \frac{dV}{dt}$

$\Rightarrow d = \frac{8.85 \times 10^{-12} \times 40 \times 10^{-4}}{4.425 \times 10^{-6}} \times 10^6$

$\Rightarrow d = 8 \times 10^{-3} m$

$\Rightarrow x = 8$

Question93

The volume charge density of a sphere of radius 6m is $2\mu C cm^{-3}$. The number of lines of force per unit surface area coming out from the surface of the sphere is $\times 10^{10} N C^{-1}$.
[Given : Permittivity of vacuum $E_0 = 8.85 \times 10^{-12} C^2 N^{-1} - m^{-2}$)
[25-Jul-2022-Shift-1]

Answer: 45

Solution:

$\rho = 2\mu c / cm^3$

$R = 6m$

Number of lines of force per unit area = Electric field at surface.

$= \frac{KQ}{R^2}$

$= \frac{1}{4\pi\varepsilon_0} \frac{\rho \frac{4}{3}\pi R^3}{R^2}$

$= \frac{\rho R}{3E_0}$

$= \frac{2 \times 10^{-6} \times 10^6 \times 6}{3 \times 8.85 \times 10^{-12}}$

$= 0.45197 \times 10^{12}$

$= 45.19 \times 10^{10} N / C$

$\sim 45 \times 10^{10}$

Question94

Two uniformly charged spherical conductors A and B of radii 5 mm and 10 mm are separated by a distance of 2 cm. If the spheres are connected by a conducting wire, then in equilibrium condition, the ratio of the magnitudes of the electric fields at the surface of the sphere A and B will be :
[26-Jul-2022-Shift-2]

Options:

A. 1 : 2

B. 2 : 1

C. 1 : 1

D. 1 : 4

Answer: B

Solution:

Solution:

$V_A = V_B$

$\frac{KQ_A}{R_A} = \frac{KQ_B}{R_B}$

$\frac{Q_A}{Q_B} = \frac{R_A}{R_B} = \frac{1}{2}$

$E_A = \frac{KQ_A}{R_A^2}$; $E_B = \frac{KQ_B}{R_B^2}$

$\frac{E_A}{E_B} = \frac{Q_A}{Q_B} \times \frac{R_B^2}{R_A^2} = \frac{R_B}{R_A} = \frac{2}{1}$

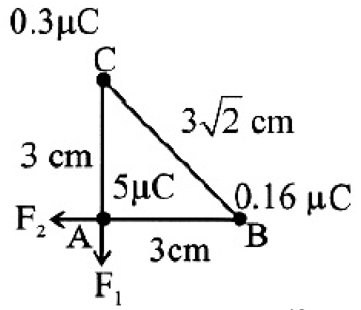
Question95

Three point charges of magnitude 5μC, 0.16μC and 0.3μC are located at the vertices A, B, C of a right angled triangle whose sides are $AB = 3\,cm$, $BC = 3\sqrt{2}\,cm$ and $CA = 3\,cm$ and point A is the right angle corner. Charge at point A experiences _________ N of electrostatic force due to the other two charges.
[26-Jul-2022-Shift-2]

Answer: 17

Solution:

Solution:



$F_1 = \frac{k \times 5 \times 0.3 \times 10^{-12}}{9 \times 10^{-4}}$

$= \frac{9 \times 10^9 \times 5 \times 0.3 \times 10^{-12}}{9 \times 10^{-4}}$

$= 1.5 \times 10 = 15N$

$F_2 = \frac{9 \times 10^9 \times 5 \times 0.16 \times 10^{-12}}{9 \times 10^{-4}} = 8N$

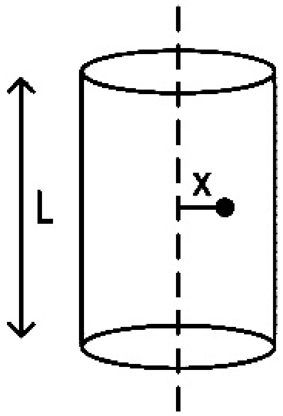
force experienced by charge at A = $\sqrt{F_1{}^2 + F_2{}^2}$

$= \sqrt{15^2 + 8^2}$

$= \sqrt{289} = 17N$

Question96

A long cylindrical volume contains a uniformly distributed charge of density ρCm^{-3}. The electric field inside the cylindrical volume at a distance $x = \frac{2\varepsilon_0}{\rho}$m from its axis is _______Vm^{-1}

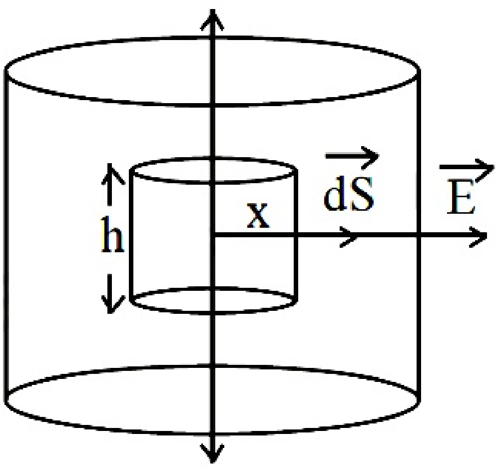


[27-Jul-2022-Shift-1]

Answer: 1

Solution:

Solution:



$\int E ds \cos 0 = \frac{q}{\varepsilon_0}$

$\Rightarrow E \cdot 2\pi xh = \frac{\rho \times \pi x^2 h}{\varepsilon_0}$

$\Rightarrow E = \frac{\rho x}{2\varepsilon_0}$

$\Rightarrow E = \frac{\rho}{2\varepsilon_0} \times \frac{2\varepsilon_0}{\rho} = 1$

Question97

A charge of 4μC is to be divided into two. The distance between the two divided charges is constant. The magnitude of the divided charges so that the force between them is maximum, will be :
[27-Jul-2022-Shift-2]

Options:

A. 1μC and 3μC

B. 2μC and 2μC

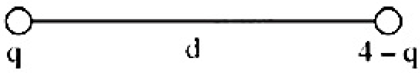
C. 0 and 4μC

D. 1.5μC and 2.5μC

Answer: B

Solution:

Solution:



$F = \frac{Kq(4-q)}{d^2}$

$\frac{dF}{dq} = \frac{K}{d^2}[4-2q] = 0$

$q = 2$

Question98

Two electric dipoles of dipole moments 1.2×10^{-30} Cm and 2.4×10^{-30} Cm are placed in two different uniform electric fields of strengths $5 \times 10^4 NC^{-1}$ and $15 \times 10^4 NC^{-1}$ respectively. The ratio of maximum torque experienced by the electric dipoles will be $\frac{1}{x}$. The value of x is ______.
[28-Jul-2022-Shift-1]

Answer: 6

Solution:

Solution:

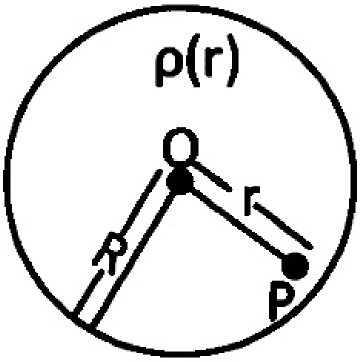
$|\tau|_{max} = PE$

$\frac{\tau_1}{\tau_2} = \frac{P_1E_1}{P_2E_2} = \frac{1 \cdot 2 \times 10^{-30} \times 5 \times 10^4}{2 \cdot 4 \times 10^{-30} \times 15 \times 10^4} = \frac{1}{6}$

Hence $x = 6$

Question99

A spherically symmetric charge distribution is considered with charge density varying as
Where, r(r < R) is the distance from the centre 0 (as shown in figure). The electric field at point P will be:



[29-Jul-2022-Shift-1]

Options:

A. $\frac{\rho_0 r}{4\varepsilon_0}\left(\frac{3}{4}-\frac{r}{R}\right)$

B. $\frac{\rho_0 r}{3\varepsilon_0}\left(\frac{3}{4}-\frac{r}{R}\right)$

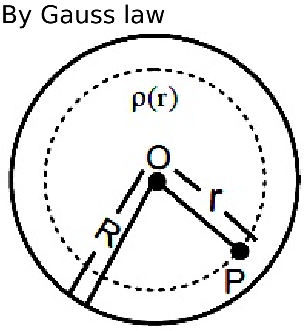
C. $\frac{\rho_0 r}{4\varepsilon_0}\left(1-\frac{r}{R}\right)$

D. $\frac{\rho_0 r}{5\varepsilon_0}\left(1-\frac{r}{R}\right)$

Answer: C

Solution:

Solution:
By Gauss law



$$\oint \vec{E} d\vec{s} = \frac{Q_{\in}}{\varepsilon_o}$$

$$E.4\pi r^2 = \frac{\int_0^r \rho_o\left(\frac{3}{4}-\frac{r}{R}\right)4\pi r^2\,dr}{\varepsilon_0}$$

$$E4\pi r^2 = \frac{\rho_o 4\pi}{\varepsilon_o}\left(\frac{3}{4}\frac{r^3}{3}-\frac{r^4}{4R}\right)$$

$$Er^2 = \frac{\rho_o r^3}{4\varepsilon_o}\left\{1-\frac{r}{R}\right\}$$

$$E = \frac{\rho_o r}{4\varepsilon_o}\left\{1 - \frac{r}{R}\right\}$$

Question100

Given below are two statements.
Statement I : Electric potential is constant within and at the surface of each conductor.
Statement II : Electric field just outside a charged conductor is perpendicular to the surface of the conductor at every point.
In the light of the above statements, choose the most appropriate answer from the options given below.
[29-Jul-2022-Shift-1]

Options:

A. Both Statement I and Statement II are correct

B. Both Statement I and Statement II are incorrect

C. Statement I is correct but Statement II is incorrect

D. Statement I is incorrect but Statement II is correct

Answer: A

Solution:

Solution:
(Properties of conductor)
Statement - I, true as body of conductor acts as equipotential surface.
Statement −2 True, as conductor is equipotential.
Tangential component of electric field should be zero. Therefore electric field should be perpendicular to surface.

Question101

Two identical metallic spheres A and B when placed at certain distance in air repel each other with a force of F. Another identical uncharged sphere C is first placed in contact with A and then in contact with B and finally placed at midpoint between spheres A and B. The force experienced by sphere C will be:
[29-Jul-2022-Shift-2]

Options:

A. 3F / 2

B. 3F / 4

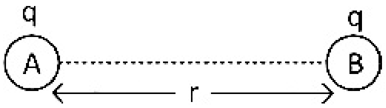
C. F

D. 2F

Answer: B

Solution:

Solution:



Let two identical spheres have charge q. And distance between them $= r$

$\therefore$ Force between the spheres $(F) = \frac{kq^2}{r^2}$

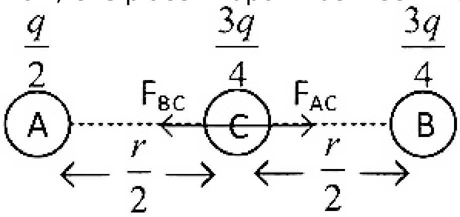
Now when an identical uncharged sphere C comes in contact with A, charge q on sphere A get's divided equally to both sphere.

So, both sphere A and C have charge $= \frac{q}{2}$

Now, C get's in contact with B. So their total charge $\left(q + \frac{q}{2}\right)$ gets divided equally.

So, charge on both B and C is $= \frac{q + \frac{q}{2}}{2} = \frac{3q}{4}$

Now, C is place midpoint between A and B.



Repulsion force between A and C,

$$F_{AC} = \frac{k\left(\frac{q}{2}\right)\left(\frac{3q}{4}\right)}{\left(\frac{r}{2}\right)^2} = \frac{4k \times 3q^2}{8r^2}$$

Repulsion force between B and C,

$$F_{BC} = \frac{k\left(\frac{3q}{4}\right)\left(\frac{3q}{4}\right)}{\left(\frac{r}{2}\right)^2} = \frac{4k \times 9q^2}{16r^2}$$

$\therefore$ Net force on C,

$F_{net} = F_{BC} - F_{AC}$

$= \frac{4k \times 9q^2}{16r^2} - \frac{4k \times 3q^2}{8r^2}$

$= \frac{kq^2}{r^2}\left(\frac{9}{4} - \frac{3}{2}\right)$

$= \frac{kq^2}{r^2} \times \frac{3}{4}$

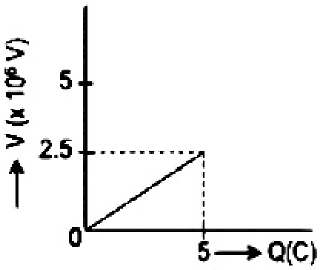
$= \frac{3}{4}F$ [. as $F = \frac{kq^2}{r^2}$]

Question102

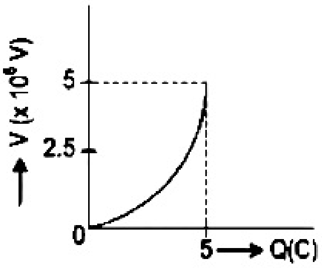
A condenser of 2μF capacitance is charged steadily from 0 to 5C. Which of the following graph represents correctly the variation of potential difference (V) across it's plates with respect to the charge (Q) on the condenser?
[25-Jul-2022-Shift-1]

Options:

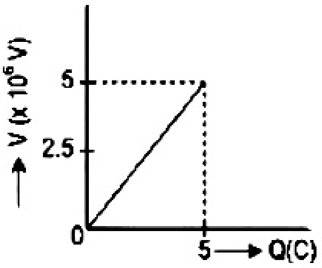
A.



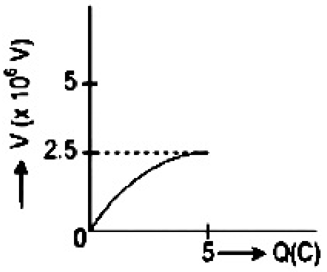
B.



C.



D.



Answer: A

Solution:

Solution:
Q = CV

As capacitance is constant $Q \propto V$ and $V_f = \frac{Q_f}{C} = \frac{5}{2 \times 10^{-6}} = 2.5 \times 10^6 V$

So correct graph will be A.

Question103

Capacitance of an isolated conducting sphere of radius R_1 becomes n times when it is enclosed by a concentric conducting sphere of radius R_2

connected to earth. The ratio of their radii $\left(\frac{R_2}{R_1}\right)$ is :

[25-Jul-2022-Shift-2]

Options:

A. $\frac{n}{n-1}$

B. $\frac{2n}{2n+1}$

C. $\frac{n+1}{n}$

D. $\frac{2n+1}{n}$

Answer: A

Solution:

Initially $= C_0 = 4\pi\varepsilon_0 R_1$

Finally $\frac{4\pi\varepsilon_0 R_1 R_2}{R_2 - R_1} = nC_0 = 4\pi\varepsilon_0 n R_1 \quad \frac{R_2}{R_2 - R_1} = n$

$$1 - \frac{R_1}{R_2} = \frac{1}{n}$$

$$\frac{R_1}{R_2} = \frac{n-1}{n}$$

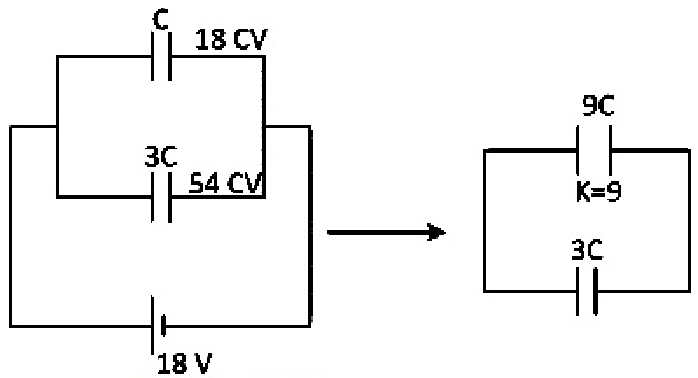
$$\frac{R_2}{R_1} = \frac{n}{n-1}$$

Question104

Two parallel plate capacitors of capacity C and 3C are connected in parallel combination and charged to a potential difference 18V . The battery is then disconnected and the space between the plates of the capacitor of capacity C is completely filled with a material of dielectric constant 9 . The final potential difference across the combination of capacitors will be ____V.
[25-Jul-2022-Shift-2]

Answer: 6

Solution:



$$V_{\text{common}} = \frac{18CV + 54CCV}{3C + 9C} = 6V$$

Question105

The total charge on the system of capacitors $C_1 = 1\mu F$, $C_2 = 2\mu F$, $C_3 = 4\mu F$ and $C_4 = 3\mu F$ connected in parallel is : (Assume a battery of 20V is connected to the combination) [26-Jul-2022-Shift-1]

Options:

A. 200μC

B. 200C

C. 10μC

D. 10C

Answer: A

Solution:

Equivalent $C = \sum C_i$
$= 10\mu F$
$\Rightarrow$ Charge $Q = CV$
$= 200\mu C$

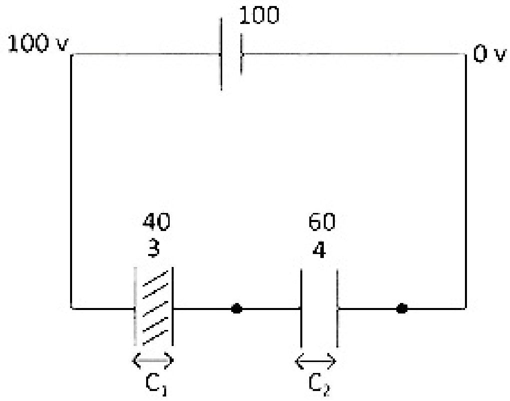
Question106

A composite parallel plate capacitor is made up of two different dielectric materials with different thickness (t_1. and .t_2) as shown in figure. The two different dielectric materials are separated by a conducting foil F. The voltage of the conducting foil is V.

[26-Jul-2022-Shift-1]

Answer: 60

Solution:



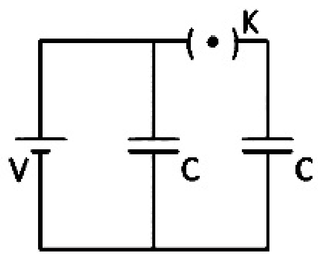
$$\frac{C_1}{C_2} = \frac{3 \times t_2}{t_1 \times 4} = \frac{3}{2}$$

$$\frac{q}{C_1} = v_1, \ \frac{q}{C_2} = v_2$$

$$\frac{v_1}{v_2} = \frac{C_2}{C_1} = \frac{2}{3}$$

Question107

A source of potential difference V is connected to the combination of two identical capacitors as shown in the figure. When key ' K ' is closed, the total energy stored across the combination is E_1. Now key ' K ' is opened and dielectric of dielectric constant 5 is introduced between the plates of the capacitors. The total energy stored across the combination is now E_2. The ratio E_1 / E_2 will be :



[26-Jul-2022-Shift-2]

Options:

A. $\frac{1}{10}$

B. $\frac{2}{5}$

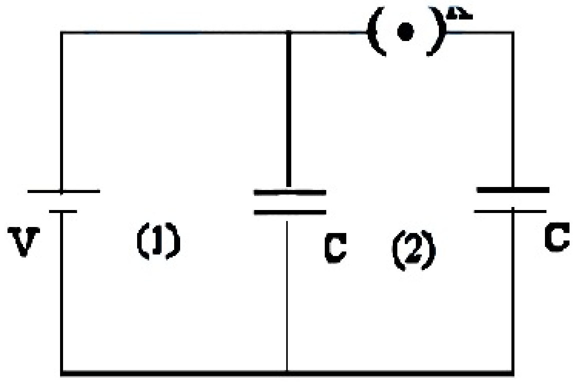
C. $\frac{5}{13}$

D. $\frac{5}{26}$

Answer: C

Solution:

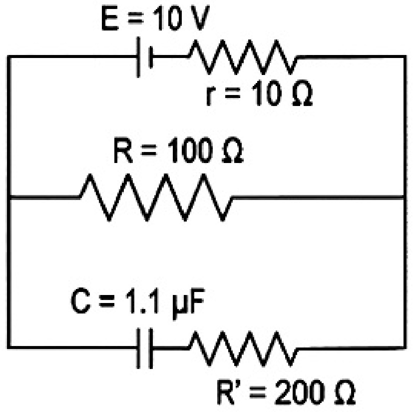
Solution:



(1) Switch is closed
$C_{eq} - 2C$
Energy $E_1 = \frac{1}{2}C_{eq}V^2 = \frac{1}{2}2C \times V^2$
$E_1 = CV^2$
(ii) When switch is opened charge on right capacitor remain CV while potential on left capacitor remain same
Dielectric $K = 5$
$C^{'} = KC$
$C^{'} = 5C$
$E_2 = \frac{1}{2}(5C)V^2 + \frac{(CV)^2}{2(5C)}$
$E_2 = \frac{5CV^2}{2} + \frac{CV^2}{10}$
$E_2 = \frac{13CV^2}{5}$
$\frac{E_1}{E_2} = \frac{CV^2}{\frac{13CV^2}{5}} = \frac{5}{13}$
$\frac{E_1}{E_2} = \frac{5}{13}$

Question108

As show in the figure, in steady state, the charge stored in the capacitor is _______ $\times 10^{-6}$C.



[27-Jul-2022-Shift-2]

Answer: 10

Solution:

Solution:

$q = CV_{100\Omega}$

$= (1.1 \times 10^{-6})\left(\frac{10}{R + r}R\right)$

$= 1.1 \times 10^{-6}\left(\frac{10}{110} \times 100\right)$

$= 10\mu C$

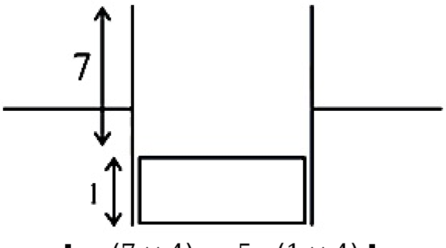
Question109

A parallel plate capacitor with width 4 cm, length 8 cm and separation between the plates of 4 mm is connected to a battery of 20V. A dielectric slab of dielectric constant 5 having length 1 cm, width 4 cm and thickness 4 mm is inserted between the plates of parallel plate capacitor. The electrostatic energy of this system will be _______ E_0J. (Where E_0 is the permittivity of free space)
[27-Jul-2022-Shift-2]

Answer: 240

Solution:

Solution:



$C_{eff} = \left[\frac{\varepsilon_0(7 \times 4)}{4 / 10} + \frac{5\varepsilon_0(1 \times 4)}{4 / 10}\right] \times 10^{-2}$

$C_{eff} = 1.2\varepsilon_0$

Energy $= \frac{1}{2}C_{eff}V^2$

$= \frac{1}{2}(1.2)\varepsilon_0(20)(20) = 240\varepsilon_0$

Question110

Two capacitors, each having capacitance 40μF are connected in series. The space between one of the capacitors is filled with dielectric material of dielectric constant K such that the equivalence capacitance of the system became 24μF. The value of K will be :
[28-Jul-2022-Shift-1]

Options:

A. 1.5

B. 2.5

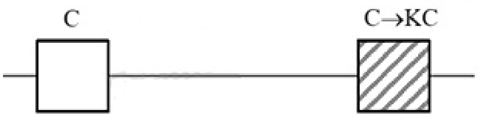
C. 1.2

D. 3

Answer: A

Solution:

Solution:



$$C_{eq} = \frac{C(KC)}{C + KC} = \frac{KC}{K + 1}$$

$$24 = \frac{K40}{K + 1}$$

$[K = 1 \cdot 5]$

Question111

A slab of dielectric constant K has the same cross-sectional area as the plates of a parallel plate capacitor and thickness $\frac{3}{4}$d, where d is the separation of the plates. The capacitance of the capacitor when the slab is inserted between the plates will be :
(Given C_0 = capacitance of capacitor with air as medium between plates.)
[28-Jul-2022-Shift-2]

Options:

A. $\frac{4K C_0}{3 + K}$

B. $\frac{3K C_0}{3 + K}$

C. $\frac{3 + K}{4K C_0}$

D. $\frac{K}{4 + K}$

Answer: A

Solution:

Solution:

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

$C = \frac{\varepsilon_0 A}{d - \frac{3d}{4} + \frac{3d}{4K}} = \frac{4\varepsilon_0 AK}{3d + Kd}$

$= \frac{4KC_0}{3 + K}$

Question112

Two identical thin metal plates has charge q_1 and q_2 respectively such that $q_1 > q_2$. The plates were brought close to each other to form a parallel plate capacitor of capacitance C. The potential difference between them is:
[29-Jul-2022-Shift-2]

Options:

A. $\frac{(q_1 + q_2)}{C}$

B. $\frac{(q_1 - q_2)}{C}$

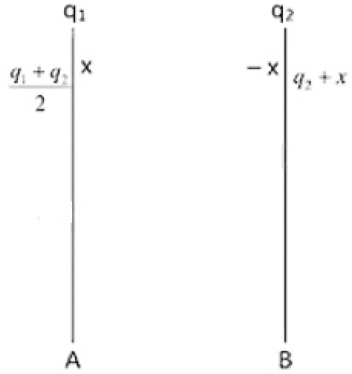
C. $\frac{(q_1 - q_2)}{2C}$

D. $\frac{2(q_1 - q_2)}{C}$

Answer: C

Solution:

Solution:



Charge on the left surface of plate A = $\frac{\text{Total charge}}{2} = \frac{q_1 + q_2}{2}$

Let right surface of plate A has charge $= x$

And total charge on plate A = q_1

$\therefore q_1 =$ Charge on left surface of plate A + Charge on right surface of plate A

$= \frac{q_1 + q_2}{2} + x$

$\Rightarrow x = q_1 - \dfrac{q_1 + q_2}{2}$

$= \dfrac{2q_1 - q_1 - q_2}{2}$

$= \dfrac{q_1 - q_2}{2}$

Let potential difference between two plates $= v$

For capacitor we know,

$q = CV$

$\therefore \dfrac{q_1 - q_2}{2} = CV$

$\Rightarrow V = \dfrac{q_1 - q_2}{2C}$

Question113

27 similar drops of mercury are maintained at 10V each. All these spherical drops combine into a single big drop. The potential energy of the bigger drop is .... that of a smaller drop.
[26 Feb 2021 Shift 2]

Answer: 243

Solution:

Solution:

Given, $n = 27$

$V_1 = 10V$

Let q_1 be the charge of one drop, r_1 be its radius, r be the radius of bigger drop and q be its charge.

As, volume remains constant.

$\text{Electric potential } (V) = \dfrac{3kq_1^2}{5r}$

$\therefore 4/3\pi r^3 = 4/3\pi r_1^3 \times 27$

$\Rightarrow r^3 = 27r_1^3$

$\Rightarrow r = 3r_1$

where, k is Coulomb constant. Therefore, potential energy of small drop,

$U_s = \dfrac{3}{5}\dfrac{kq_1^2}{r_1}$ . . . (i)

and potential energy of bigger drop, $U_B = \dfrac{3}{5}\dfrac{k(q_1^2 \times 27)^2}{r}$

$U_B = \dfrac{3}{5}\dfrac{k(27)^2 q_1^2}{3r_1}$. . . (ii)

On dividing Eq. (ii) by Eq. (i), we get

$\dfrac{U_B}{U_s} = \dfrac{27 \times 27}{3} = 243$

$U_B = 243U_s$

Hence, potential energy of big drop is 243 times of small drop.

Question114

512 identical drops of mercury are charged to a potential of 2V each.

The drops are joined to form a single drop. The potential of this drop is. [25 Feb 2021 Shift 1]

Answer: 128

Solution:

Solution:
Given, number of mercury drops, $n = 512$
Voltage of each drop, $V = 2V$ Let r, R be the radius of drop small and combined spherical drop, respectively.
Now, when all drops are joined into single drop, volume remains constant,
i.e. $512 \times \frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3$
$\because V = \frac{kq}{r} = 2 ...$ (i)
$\therefore V_{net} = \frac{kQ}{R}$
where, Q be the charge of bigger sphere.
$\Rightarrow V_{net} = \frac{k \times 512q}{8r} ...$ (ii)
On dividing Eq. (ii) by Eq. (i), we get
$\frac{V_{net}}{V} = \frac{k \times 512q \times r}{8r \times kq} = \frac{512}{8}$
$V_{net} = 2 \times \frac{512}{8} = 128V$

Question115

Consider the combination of two capacitors C_1 and C_2, with $C_2 > C_1$, when connected in parallel, the equivalent capacitance is 15 / 4 time the equivalent capacitance of the same connected in series. Calculate the ratio of capacitors $\frac{C_2}{C_1}$.
[26 Feb 2021 Shift 1]

Options:

A. $\frac{15}{11}$

B. $\frac{111}{80}$

C. $\frac{29}{15}$

D. None of above

E.

Answer: D

Solution:

(*) Let, equivalent capacitance of two capacitors C_1 and C_2 connected in parallel be C_a and equivalent capacitance of same, when connected in series be C_b.

According to given data,

$C_a = \frac{15}{4}C_b \ldots$ (i)

Since, equivalent capacitance in parallel combination,

$C_{eq} = C_1 + C_2$

$C_a = C_1 + C_2 \ldots$ (ii)

and equivalent capacitance in series combination,

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$\frac{1}{C_b} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{C_2 + C_1}{C_1 C_2}$$

$$C_b = \frac{C_1 C_2}{C_1 + C_2} \ldots \text{(iii)}$$

Substituting Eqs. (ii) and (iii) in Eq. (i), we get

$$C_1 + C_2 = \frac{15}{4}\frac{C_1 C_2}{C_1} + C_2$$

$4(C_1 + C_2)^2 = 15C_1C_2$

$\Rightarrow 4C_1{}^2 + 4C_2{}^2 + 8C_1C_2 = 15C_1C_2$

$\Rightarrow 4C_1{}^2 + 4C_2{}^2 - 7C_1C_2 = 0$

On dividing both sides by $C_1{}^2$, we get

$$4 + 4\left(\frac{C_2}{C_1}\right)^2 - 7\frac{C_2}{C_1} = 0$$

$$\text{or} \quad 4\left(\frac{C_2}{C_1}\right)^2 - 7\left(\frac{C_2}{C_1}\right) + 4 = 0$$

$$\text{If} \quad \frac{C_2}{C_1} = x, \quad \text{then} \quad 4x^2 - 7x + 4 = 0$$

By using the concept of quadratic equation,

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \Rightarrow x = \frac{7 \pm \sqrt{49 - 64}}{8}$$

$$\Rightarrow x = \frac{C_2}{C_1} = \frac{7 \pm \sqrt{-15}}{8} = \frac{7 \pm \sqrt{15}i}{8}$$

Question116

An electron with kinetic energy K_1 enters between parallel plates of a capacitor at an angle α with the plates. It leaves the plates at angle β with kinetic energy K_2. Then, the ratio of kinetic energies $K_1 : K_2$ will be
[25 Feb 2021 Shift 2]

Options:

A. $\frac{\cos\beta}{\cos\alpha}$

B. $\frac{\cos\beta}{\sin\alpha}$

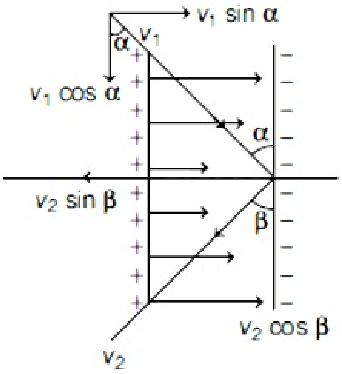
C. $\frac{\sin^2\beta}{\cos^2\alpha}$

D. $\frac{\cos^2\beta}{\cos^2\alpha}$

Answer: D

Solution:

Solution:
The given situation can be shown as below



Let, v_1 and v_2 be the incoming and outgoing velocities of electron into the capacitor and out of the capacitor, respectively. Since, electric field is along X-axis, hence electric force on electron along Y-axis, $(F_y) = 0$
∴ Change in momentum along Y-axis,
$\Delta p_y = 0$
i.e. $p_1 = p_2$ (along Y-axis)
⇒ $m_1 v_1 \cos\alpha = m_2 v_2 \cos\beta$
⇒ $v_1 / v_2 = \cos\beta / \cos\alpha$
∵ Kinetic energy $(K) = 1/2mv^2$
If mass is same, $K \propto v^2$

$$\therefore \frac{K_1}{K_2} = \left(\frac{v_1}{v_2}\right)^2 = \left(\frac{\cos\beta}{\cos\alpha}\right)^2 = \frac{\cos^2\beta}{\cos^2\alpha}$$

Question117

Two equal capacitors are first connected in series and then in parallel. The ratio of the equivalent capacities in the two cases will be : [24feb2021shift1]

Options:

A. 4 : 1

B. 2 : 1

C. 1 : 4

D. 1 : 2

Answer: C

Solution:

Solution:
Given, $C_1 = C_2 = C$
When both capacitors are connected in series, their equivalent capacitance will be

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

$$C_s = \frac{C}{2}$$

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

When both capacitors are connected in parallel, their equivalent capacitance will be

$C_p = C + C = 2C$

$\therefore$ The ratio of equivalent capacitance in series and parallel combination is

$$\frac{C_s}{C_p} = \frac{C/2}{2C} = \frac{1}{4}$$

$\Rightarrow C_s : C_p = 1 : 4$

Question118

A parallel plate capacitor has plate area $100m^2$ and plate separation of 10m. The space between the plates is filled upto a thickness 5m with a material of dielectric constant of 10 . The resultant capacitance of the system is xpF . The value of $\varepsilon_0 = 8.85 \times 10^{-12} f\,m^{-1}$. The value of x to the nearest integer is

[18 Mar 2021 Shift 1]

Answer: 161

Solution:

Solution:

Given,

The area of the parallel plate capacitor, $A = 100m^2$

The distance between the parallel plate of the capacitor, $d = 10m$

The dielectric constant of the material, $K = 10$

The thickness of the space between the plates,

$t = 5m$

As we know, the expression of the capacitor with dielectric constant

$$C = \frac{A\varepsilon_0}{\left(d - t + \frac{t}{K}\right)}$$

$$\Rightarrow C = \frac{100 \times 8.85 \times 10^{-12}}{\left(10 - 5 + \frac{5}{10}\right)}$$

$\Rightarrow C = 161 \times 10^{-12}F = 161pF$

Hence, the resultant capacitance of the system is $161pF$.

So, the value of x to the nearest integer is 161 .

Question119

A parallel plate capacitor whose capacitance C is 14pF is charged by a battery to a potential difference V = 12V between its plates. The charging battery is now disconnected and a porcelain plate with K = 7 is inserted between the plates, then the plate would oscillate back and forth between the plates with a constant mechanical energy of .... pJ. (Assume no friction)

[17 Mar 2021 Shift 1]

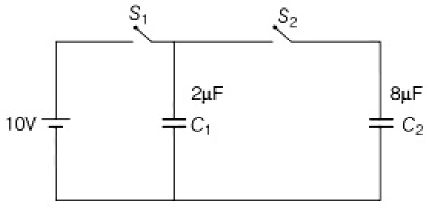
Answer: 864

Solution:

Solution:
Given, capacitance of capacitor, $C = 14pF$
Potential difference, $V = 12V$
Energy of capacitor, $E_i = \frac{1}{2}CV^2$
$= \frac{1}{2} \times 14 \times 12 \times 12 = 1008pJ$
Now, the charging battery is disconnected and a porcelain plate with $K = 7$ is inserted between the plates
$\therefore E_f = \frac{E_i}{7} \Rightarrow f = \frac{1008}{7}pj \Rightarrow f = 144pj$
Mechanical energy with which the plate would oscillate back and forth between the plates will be
$= (1008 - 144)pJ = 864pJ$

Question120

A 2μF capacitor C_1 is first charged to a potential difference of 10V using a battery. Then, the battery is removed and the capacitor is connected to an uncharged capacitor C_2 of 8μF . The charge in C_2 on equilibrium condition is μC. (Round off to the nearest integer)

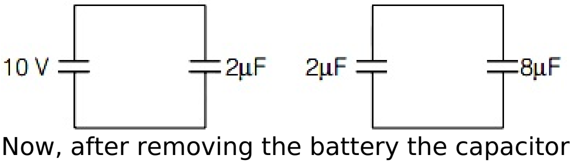


[17 Mar 2021 Shift 2]

Answer: 16

Solution:

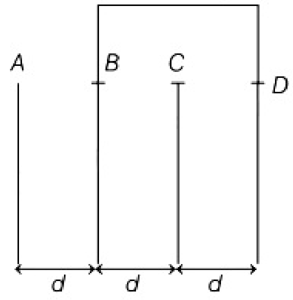
Solution:
Let V is the voltage across each capacitor,



Now, after removing the battery the capacitor is connected.
So, using the law of conservation of charge,
$2V + 8V = 2 \times 10 = 20$
$\Rightarrow 10V = 20 \Rightarrow V = 2V$
As we know, $Q = CV = 8 \times 2 = 16\mu C$
Hence, the magnitude of the charge in C_2 on equilibrium condition is $16\mu C$.

Question121

Four identical rectangular plates with length, $I = 2\text{cm}$ and breadth, $b = \frac{3}{2}\text{cm}$ are arranged as shown in figure. The equivalent capacitance between A and C is $\frac{x\varepsilon_0}{d}$. The value of x is ....
(Round off to the nearest integer)

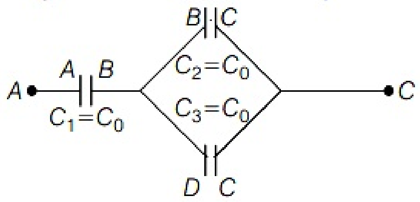


[17 Mar 2021 Shift 1]

Answer: 2

Solution:

Solution:
The given figure can be shown with capacitors as



Let C_0 be the capacitance of each capacitor.
In the above figure capacitance C_1 is in series combination with equivalent of parallel combination of capacitance C_2 and C_3.

$C_{eq}' = C_2 + C_3 \Rightarrow C_{eq}' = C_0 + C_0 = 2C_0$

$\Rightarrow \frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_{eq}'} = \frac{1}{C_0} + \frac{1}{2C_0} = \frac{3}{2C_0}$

$\Rightarrow C_{eq} = \frac{2C_0}{3}$....(i)

As, $C_0 = \frac{\varepsilon_0 A}{d}$...(ii)

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

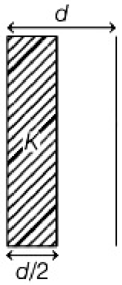
$C_{eq} = \frac{2}{3}\left(\frac{\varepsilon_0 A}{d}\right) \Rightarrow C_{eq} = \frac{2\varepsilon_0}{3d}(I \times b) = \frac{2\varepsilon_0}{3d}\left(2 \times \frac{3}{2}\right)$

$\Rightarrow C_{eq} = \frac{2\varepsilon_0}{d}$...(iii)

According to question, the equivalent capacitance between A and C is $\frac{x\varepsilon_0}{d}$.
So, comparing it with Eq. (iii), we get
x = 2

Question122

In a parallel plate capacitor set up, the plate area of capacitor is $2m^2$ and the plates are separated by 1m. If the space between the plates are filled with a dielectric material of thickness 0.5m and area $2m^2$ (see figure) the capacitance of the set-up will be ...... ε_0. (Dielectric constant of the material = 3.2)
(Round off to the nearest integer)



[16 Mar 2021 Shift 2]

Answer: 3

Solution:

Solution:
The equivalent capacitance of the capacitor when dielectric material is partially filled, is given as

$$C = \frac{\varepsilon_0 A}{(d - t) + \frac{t}{k}} = \frac{\varepsilon_0 A}{\left(d - \frac{d}{2}\right) + \frac{d/2}{k}} = \frac{\varepsilon_0 A}{\frac{d}{2k} + \frac{d}{2}}$$

where,
ε_0 = absolute electrical permittivity of free space,
A = area of the plates of capacitor = $2m^2$
K = dielectric constant = 3.2
t = thickness of dielectric material = $\frac{d}{2}$
and d = distance between the plates = 2m.

$$C = \frac{2\varepsilon_0 A}{\frac{d}{k} + d} = \frac{2 \times 2\varepsilon_0}{\frac{1}{3.2} + 1} = \frac{4 \times 3.2}{4.2}\varepsilon_0$$

$\Rightarrow C = 3.04\varepsilon_0$
The required value after rounding off to the nearest integer is 3 .

Question123

For changing the capacitance of a given parallel plate capacitor, a dielectric material of dielectric constant K is used, which has the same area as the plates of the capacitor. The thickness of the dielectric slab is $\frac{3}{4}d$, where d is the separation between the plates of parallel plate capacitor. The new capacitance (C') in terms of original capacitance (C_0) is given by the following relation
[16 Mar 2021 Shift 1]

Options:

A. $C' = \frac{3+K}{4K} C_0$

B. $C' = \frac{4+K}{3} C_0$

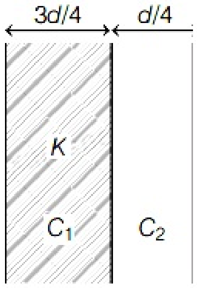
C. $C' = \frac{4K}{K+3} C_0$

D. $C' = \frac{4}{3+K} C_0$

Answer: C

Solution:

Solution:
As per question, the figure can be shown for a parallel plate capacitors



Initially, capacitance, $C_0 = \frac{\varepsilon_0 A}{d}$ ...(i)
where, $\varepsilon_0 =$ permittivity of free space, $A =$ area of plates and $d =$ distance between plates.
In presence of a dielectric medium between the plates, the capacitance will be
$C = \frac{\varepsilon_0 K A}{d}$...(ii)
Also, from the figure capacitors C_1 and C_2 are in series.
$\therefore$ Equivalent capacitance is given by $\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$

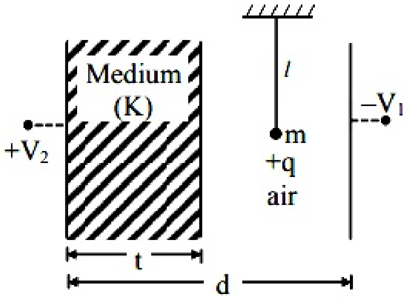
$\Rightarrow \frac{1}{C_{eq}} = \left(\frac{3d/4}{\varepsilon_0 K A} \right) + \left(\frac{d/4}{\varepsilon_0 A} \right)$ [using Eqs. (i) and (ii)]

$\Rightarrow \frac{1}{C_{eq}} = \frac{d}{4\varepsilon_0 A} \left(\frac{3+K}{K} \right)$

$\Rightarrow C_{eq} = \frac{4K C_0}{(3+K)}$ [using Eq.(i)]

Question124

A simple pendulum of mass 'm', length 'l' and charge '+q' suspended in the electric field produced by two conducting parallel plates as shown. The value of deflection of pendulum in equilibrium position will be



[27 Jul 2021 Shift 2]

Options:

A. $\tan^{-1}\left[\frac{q}{mg}\times\frac{C_1(V_2-V_1)}{(C_1+C_2)(d-t)}\right]$

B. $\tan^{-1}\left[\frac{q}{mg}\times\frac{C_2(V_2-V_1)}{(C_1+C_2)(d-t)}\right]$

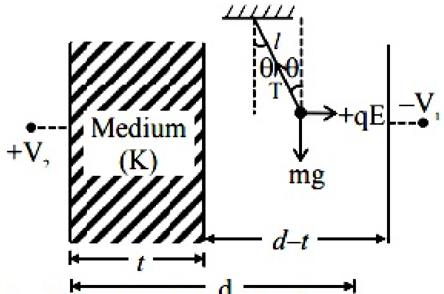
C. $\tan^{-1}\left[\frac{q}{mg}\times\frac{C_2(V_2+V_1)}{(C_1+C_2)(d-t)}\right]$

D. $\tan^{-1}\left[\frac{q}{mg}\times\frac{C_1(V_2+V_1)}{(C_1+C_2)(d-t)}\right]$

Answer: C

Solution:

Solution:

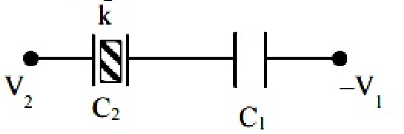


Let E be electric field in air

$T\sin\theta = qE$

$T\cos\theta = mg$

$\tan\theta = \frac{qE}{mg}$



$Q = \left[\frac{C_1C_2}{C_1+C_2}\right][V_1+V_2]$

$E = \frac{Q}{A\epsilon_0} = \left[\frac{C_1C_2}{C_1+C_2}\right]\frac{[V_1+V_2]}{A\epsilon_o}$

$C_1 = \frac{\epsilon_o A}{d-t} \Rightarrow E = \frac{C_2[V_1+V_2]}{(C_1+C_2)(d-t)}$

Now $\theta = \tan^{-1}\left[\frac{q.E}{mg}\right]$

$\theta = \tan^{-1}\left[\frac{q}{mg}\times\frac{C_2(V_2+V_1)}{(C_1+C_2)(d-t)}\right]$

Question125

Two capacitors of capacities 2C and C are joined in parallel and charged up to potential V. The battery is removed and the capacitor of capacity C is filled completely with a medium of dielectric constant K. The potential difference across the capacitors will now be :
[27 Jul 2021 Shift 1]

Options:

A. $\frac{V}{K+2}$

B. $\frac{V}{K}$

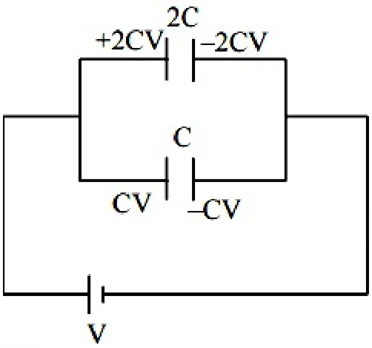
C. $\frac{3V}{K+2}$

D. $\frac{3V}{K}$

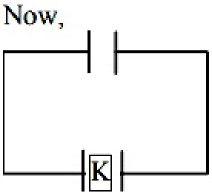
Answer: C

Solution:

Solution:



Now,



$V_C = \frac{2CV + CV}{KC + 2C}$

$= \frac{3V}{K+2}$

Question126

If q_f is the free charge on the capacitor plates and q_b is the bound charge on the dielectric slab of dielectric constant k placed between the capacitor plates, then bound charge q_b can be expressed as :
[25 Jul 2021 Shift 2]

Options:

A. $q_b = q_f\left(1 - \frac{1}{\sqrt{k}}\right)$

B. $q_b = q_f\left(1 - \frac{1}{k}\right)$

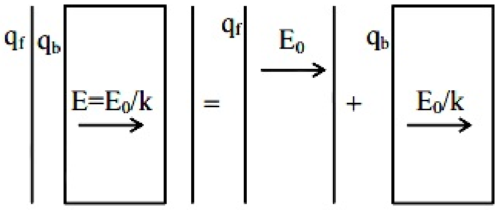
C. $q_b = q_f\left(1 + \frac{1}{\sqrt{k}}\right)$

D. $q_b = q_f\left(1 + \frac{1}{k}\right)$

Answer: B

Solution:

Solution:



When a dielectric is inserted in a capacitor

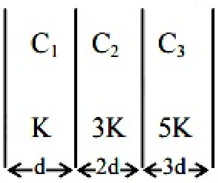
Due to free charge $\vec{E} = \vec{E}_0$ only

After dielectric $E' = \frac{E_0}{k}$

$q_B = q_f\left(1 - \frac{1}{k}\right)$

Question127

In the reported figure, a capacitor is formed by placing a compound dielectric between the plates of parallel plate capacitor. The expression for the capacity of the said capacitor will be : (Given area of plate = A)



[27 Jul 2021 Shift 1]

Options:

A. $\frac{15}{34}\frac{K\varepsilon_0 A}{d}$

B. $\frac{15}{6}\frac{K\varepsilon_0 A}{d}$

C. $\frac{25}{6}\frac{K\varepsilon_0 A}{d}$

D. $\frac{9}{6}\frac{K\varepsilon_0 A}{d}$

Answer: A

Solution:

Solution:

$\frac{1}{C_{eff}} = \frac{d}{K\varepsilon_0 A} + \frac{2d}{3K\varepsilon_0 A} + \frac{3d}{5K\varepsilon_0 A}$

$C_{eff} = \frac{15K\varepsilon_0 A}{34d}$

Question128

A parallel plate capacitor with plate area 'A' and distance of separation 'd' is filled with a dielectric. What is the capacity of the capacitor when permittivity of the dielectric varies as :

$\varepsilon(x) = \varepsilon_0 + kx$, for $\left(0 < x \le \frac{d}{2}\right)$

$\varepsilon(x) = \varepsilon_0 + k(d - x)$, for $\left(\frac{d}{2} \le x \le d\right)$

[25 Jul 2021 Shift 1]

Options:

A. $\left(\varepsilon_0 + \frac{kd}{2}\right)^{2/kA}$

B. $\frac{kA}{2\ln\left(\frac{2\varepsilon_0 + kd}{2\varepsilon_0}\right)}$

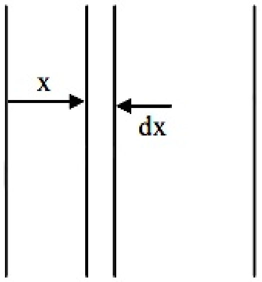
C. 0

D. $\frac{kA}{2}\ln\left(\frac{2\varepsilon_0}{2\varepsilon_0 - kd}\right)$

Answer: B

Solution:

Solution:



Taking an element of width dx at a distance $x(x < d/2)$ from left plate

$dc = \frac{(\varepsilon_0 + kx)A}{dx}$

Capacitance of half of the capacitor

$\frac{1}{C} = \int_0^{d/2} \frac{1}{dc} = \frac{1}{A}\int_0^{d/2} \frac{dx}{\varepsilon_0 + kx}$

$\frac{1}{C} = \frac{1}{kA}\ln\left(\frac{\varepsilon_0 + kd/2}{\varepsilon_0}\right)$

Capacitance of second half will be same

$C_{eq} = \frac{C}{2} = \frac{kA}{2\ln\left(\frac{2\varepsilon_0 + kd}{2\varepsilon_0}\right)}$

Question129

The average translational kinetic energy of N_2 gas molecules at .... °C becomes equal to the KE of an electron accelerated from rest through a potential difference of 0.1V.
[Given, $K_B = 1.38 \times 10^{-23} J / K$]
[1 Sep 2021 Shift 2]

Answer: 500

Solution:

Solution:
Given, the average translational kinetic energy of dinitrogen(N_2) = Kinetic energy of an electron ...(i)
Translational kinetic energy of dinitrogen (N_2)
$KE = \frac{3}{2} K_B T$
Here, T = temperature of the gas,
and K_B = Boltzmann constant.
Kinetic energy of an electron = eV
Given, the potential difference of an electron, V = 0.1 V
Substituting the values in the Eq. (i), we get
$\frac{3}{2} K_B T = eV$
$\Rightarrow \frac{3}{2} \times 1.38 \times 10^{-23} \times T = 1.6 \times 10^{-19} \times (0.1)$
$T = 773K = 773 - 273°C = 500°C$

Question130

Effective capacitance of parallel combination of two capacitors C_1 and C_2 is 10 μF. When these capacitors are individually connected to a voltage source of 1 V, the energy stored in the capacitor C_2 is 4 times that of C_1 . If these capacitors are connected in series, their effective capacitance will be:
[8 Jan. 2020 I]

Options:

A. 4.2 μF

B. 3.2 μF

C. 1.6 μF

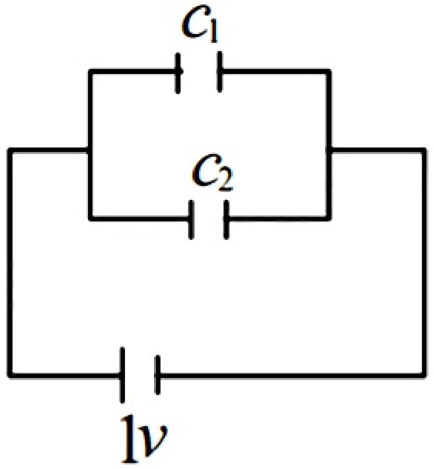
D. 8.4 μF

Answer: C

Solution:

Solution:

In parallel combination, $C_{eq} = C_1 + C_2 = 10\mu F$
When connected across $1V$ battery, then



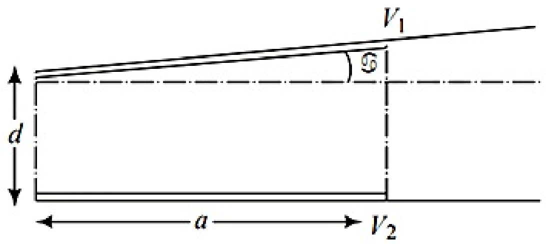
$$\frac{U_1}{U_2} = \frac{\left(\frac{1}{2}C_1V^2\right)}{\left(\frac{1}{2}C_2V^2\right)} = \frac{1}{4} \Rightarrow \frac{C_1}{C_2} = \frac{1}{4}$$

$\therefore C_2 = 8\mu F$ and $C_1 = 2\mu F$
Now C_1 and C_2 are connected in series combination,

$$\therefore C_{equivalent} = \frac{C_1C_2}{C_1 + C_2} = \frac{2 \times 8}{2 + 8} = \frac{16}{10} = 1.6\mu F$$

Question131

A capacitor is made of two square plates each of side ‘a’ making a very small angle a between them, as shown in figure. The capacitance will be close to:



[8 Jan. 2020 II]

Options:

A. $\frac{\in_0 a^2}{d}\left(1 - \frac{\alpha a}{2d}\right)$

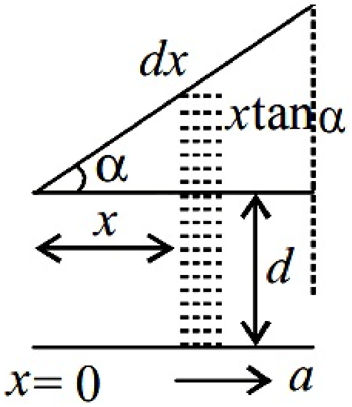
B. $\frac{\in_0 a^2}{d}\left(1 - \frac{\alpha a}{4d}\right)$

C. $\frac{\in_0 a^2}{d}\left(1 + \frac{\alpha a}{d}\right)$

D. $\frac{\in_0 a^2}{d}\left(1 - \frac{3\alpha a}{2d}\right)$

Answer: A

Solution:



Consider an infinitesimal strip of capacitor of thickness dx at a distance x as shown.

Capacitance of parallel plate capacitor of area A is given by C = $\frac{\varepsilon_0 A}{t}$

[Here t = seperation between plates]
So, capacitance of thickness dx will be

$\therefore dC = \frac{\varepsilon_0 a\,dx}{d + x\tan\alpha}$

Total capacitance of system can be obtained by integrating with limits x = 0 to x = a

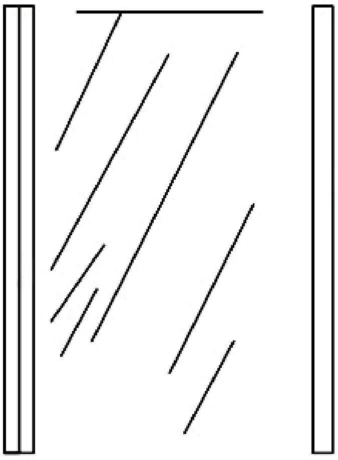
$\therefore C_{eq} = \int dC = a\varepsilon_0 \int_{x=0}^{x=a} \frac{dx}{x\tan\alpha + d}$ [By Binomial expansion]

$\Rightarrow C_{eq} = \frac{a\varepsilon_0}{d}\int_0^a \left(1 - \frac{x\tan\alpha}{d}\right)dx = \frac{a\varepsilon_0}{d}\left(x - \frac{x^2\tan\alpha}{2d}\right)_0^a$

$\Rightarrow C_{eq} = \frac{a^2\varepsilon_0}{d} = \left(1 - \frac{a\tan\alpha}{2d}\right) = \frac{\varepsilon_0 a^2}{d}\left(1 - \frac{\alpha a}{2d}\right)$

Question132

A parallel plate capacitor has plates of area A separated by distance ' d ' between them. It is filled with a dielectric which has a dielectric constant that varies as k(x) = K (1+ αx) where ′x ' is the distance measured from one of the plates. If (αd)< < 1, the total capacitance of the system is best given by the expression:



[7 Jan. 2020 I]

Options:

A. $\frac{AK\in_0}{d}\left(1 + \frac{\alpha d}{2}\right)$

B. $\frac{AK\in_0}{d}\left(1 + \left(\frac{\alpha d}{2}\right)^2\right)$

C. $\frac{A \in_0 K}{d}\left(1+\frac{\alpha^2 d^2}{2}\right)$

D. $\frac{AK \in_0}{d}(1+\alpha d)$

Answer: A

Solution:

Solution:
Given, $K(x) = K(1+\alpha x)$

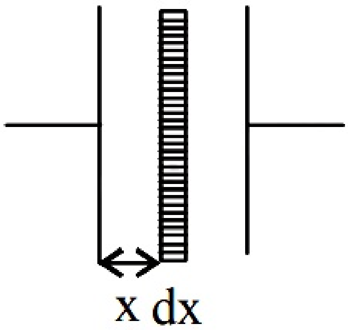
Capacitance of element, $C_{el} = \frac{K\varepsilon_0 A}{dx}$

$\Rightarrow C_{el} = \frac{\varepsilon_0 K(1+\alpha x)A}{dx}$

$\therefore \int d\left(\frac{1}{C}\right) = 1C_{el} = \int_0^d \left(\frac{dx}{\varepsilon_0 KA(1+\alpha x)}\right)$

$\Rightarrow \frac{1}{C} = \frac{1}{\varepsilon_0 KA\alpha}[\ln(1+\alpha x)]_0^d$

$\Rightarrow \frac{1}{C} = \frac{1}{\varepsilon_0 KA\alpha}\ln(1+\alpha d)\ [\alpha d << 1]$



$= \frac{1}{\varepsilon_0 KA\alpha}\left[\alpha d - \frac{\alpha^2 d^2}{2}\right]$

$= \frac{1}{\varepsilon_0 KA}\left[1 - \frac{\alpha d}{2}\right]$

$\therefore C = \frac{\varepsilon_0 KA}{d\left(1-\frac{\alpha d}{2}\right)} \Rightarrow C = \frac{\varepsilon_0 KA}{d}\left(1+\frac{\alpha d}{2}\right)$

Question133

A 60 pF capacitor is fully charged by a 20 V supply. It is then disconnected from the supply and is connected to another uncharged 60 pF capacitor in parallel. The electrostatic energy that is lost in this process by the time the charge is redistributed between them is (in nJ) [NA 7 Jan. 2020 II]

Answer: 6

Solution:

In the first condition, electrostatic energy is

$U_i = \frac{1}{2}CV_0{}^2 = \frac{1}{2} \times 60 \times 10^{-12} \times 400 = 12 \times 10^{-9}J$

In the second condition $U_F = \frac{1}{2}C'V'^2$

$U_f = \frac{1}{2}2C \cdot \left(\frac{V_0}{2}\right)^2 \left(\because C' = 2C, V' = \frac{V_0}{2}\right)$

$= \frac{1}{4} \times 60 \times 10^{-12} \times (20)^2 = 6 \times 10^{-9}J$

Energy lost $= U_i - U_f = 12 \times 10^{-9}J - 6 \times 10^{-9}J = 6nJ$

Question134

The parallel combination of two air filled parallel plate capacitors of capacitance C and nC is connected to a battery of voltage, V. When the capacitors are fully charged, the battery is removed and after that a dielectric material of dielectric constant K is placed between the two plates of the first capacitor. The new potential difference of the combined system is:
[9 April 2020 II]

Options:

A. $\frac{nV}{K+n}$

B. V

C. $\frac{V}{K+n}$

D. $\frac{(n+1)V}{(K+n)}$

Answer: D

Solution:

Solution:

$V\phi = \frac{CV + (nC)V}{kC + nC}$

$\frac{(n+1)V}{k+n}$

Question135

Ten charges are placed on the circumference of a circle of radius R with constant angular separation between successive charges. Alternate charges 1,3,5,7,9 have charge (+q) each, while 2,4,6,8,10 have charge (−q) each. The potential V and the electric field E at the centre of the circle are respectively :
(Take V = 0 at infinity)
[Sep. 05,2020 (II)]

Options:

A. $V = \frac{10q}{4\pi\varepsilon_0 R}$; $E = 0$

B. $V = 0$; $E = \frac{10q}{4\pi\varepsilon_0 R^2}$

C. $V = 0$; $E = 0$

D. $V = \frac{10q}{4\pi\varepsilon_0 R}$; $E = \frac{10q}{4\pi\varepsilon_0 R^2}$

Answer: C

Solution:

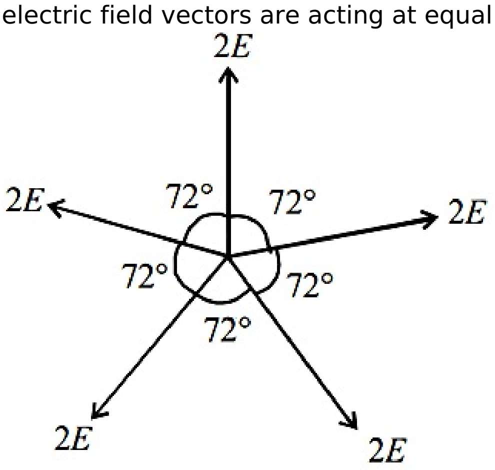
Solution:

Potential at the centre, $V_C = \frac{K\,Q_{net}}{R}$

$\because Q_{net} = 0$

$\therefore V_C = 0$

Let E be electric field produced by each charge at the centre, then resultant electric field will be $E_C = 0$, since equal electric field vectors are acting at equal angle so their resultant is equal to zero.



Question136

Two isolated conducting spheres S_1 and S_2 of radius $\frac{2}{3}R$and $\frac{1}{3}R$ have 12μC and −3μC charges, respectively, and are at a large distance from each other. They are now connected by a conducting wire. A long time after this is done the charges on S_1 and S_2 are respectively : [Sep. 03, 2020 (I)]

Options:

A. 4.5 μC on both

B. +4.5 μC and –4.5 μC

C. 3 μC and 6 μC

D. 6 μC and 3 μC

Answer: D

Solution:

Solution:
Total charge $Q_1 + Q_2 = Q'_1 + Q'_2$
$= 12\mu C - 3\mu C = 9\mu C$
Two isolated conducting sphres S_1 and S_2 are now connected by a conducting wire.
$V_1 = V_2 = \frac{K Q'_1}{\frac{2}{3}R} = \frac{K Q'_2}{\frac{R}{3}} = 12 - 3 = 9\mu C$
$Q_1' = 2Q_2' \Rightarrow 2Q_2' + Q_2' = 9\mu C$
$\therefore Q'_1 = 6\mu C$ and $Q'_2 = 3\mu C$

Question137

Concentric metallic hollow spheres of radii R and 4R hold charges Q_1 and Q_2 respectively. Given that surface charge densities of the concentric spheres are equal, the potential difference $V(R) - V(4R)$ is: [Sep. 03,2020 (II)]

Options:

A. $\frac{3Q_1}{16\pi\varepsilon_0 R}$

B. $\frac{3Q_1}{4\pi\varepsilon_0 R}$

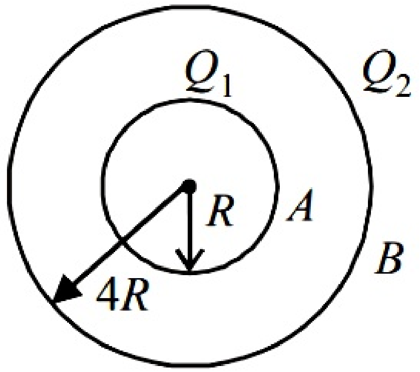
C. $\frac{Q_1}{4\pi\varepsilon_0 R}$

D. $\frac{3Q_1}{4\pi\varepsilon_0 R}$

Answer: A

Solution:

Solution:
We have given two metallic hollow spheres of radii R and 4R having charges Q_1 and Q_2 respectively.
Potential on the surface of inner sphere (at A)
$V_A = \frac{kQ_1}{R} + \frac{kQ_2}{4R}$
Potential on the surface of outer sphere (at B)
$V_B = \frac{kQ_1}{4R} + \frac{kQ_2}{4R}$ $\left(\text{Here, } k = \frac{1}{4\pi\varepsilon_0}\right)$

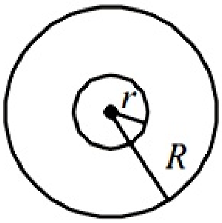


Potential difference,

$$\Delta V = V_A - V_B = \frac{3}{4} \cdot \frac{kQ_1}{R} = \frac{3}{16\pi \in_0} \cdot \frac{Q_1}{R}$$

Question138

A charge Q is distributed over two concentric conducting thin spherical shells radii r and R(R > r) . If the surface charge densities on the two shells are equal, the electric potential at the common centre is :



[Sep. 02, 2020 (II)]

Options:

A. $\frac{1}{4\pi\varepsilon_0}\frac{(R+r)}{2(R^2+r^2)}Q$

B. $\frac{1}{4\pi\varepsilon_0}\frac{(2R+r)}{(R^2+r^2)}Q$

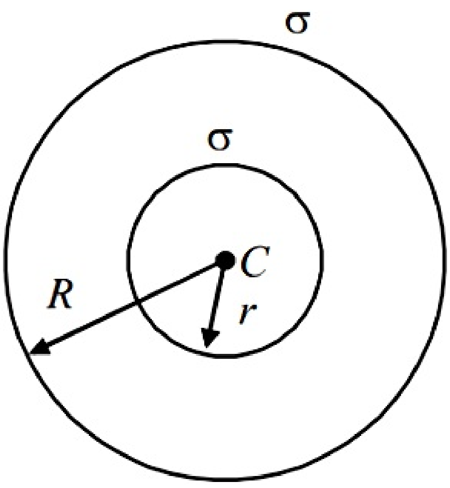
C. $\frac{1}{4\pi\varepsilon_0}\frac{(R+2r)}{2(R^2+r^2)}Q$

D. $\frac{1}{4\pi\varepsilon_0}\frac{(R+r)}{(R^2+r^2)}Q$

Answer: D

Solution:

Solution:
Let σ be the surface charge density of the shells.



Charge on the inner shell, $Q_1 = \sigma 4\pi r^2$
Charge on the outer shell, $Q_2 = \sigma 4\pi R^2$
∴ Total charge, $Q = \sigma 4\pi(r^2 + R^2)$

$$\Rightarrow \sigma = \frac{Q}{4\pi(r^2 + R^2)}$$

Potential at the common centre,

$V_C = \frac{KQ_1}{r} + \frac{KQ_2}{R} \left(\text{where } K = \frac{1}{4\pi\varepsilon_0}\right)$

$= \frac{K\sigma 4\pi r^2}{r} + \frac{K\sigma 4\pi R^2}{R}$

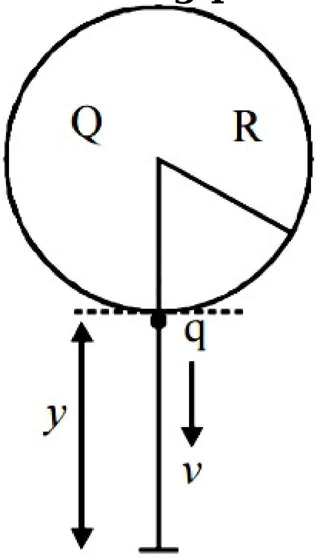
$= K\sigma 4\pi(r + R)$

$= \frac{KQ4\pi(r + R)}{4\pi(r^2 + R^2)}$

$= \frac{1}{4\pi\varepsilon_0}\frac{(R + r)}{(R^2 + r^2)}Q$

Question139

A solid sphere of radius R carries a charge Q + q distributed uniformly over its volume. A very small point like piece of it of mass m gets detached from the bottom of the sphere and falls down vertically under gravity. This piece carries charge q. If it acquires a speed v when it has fallen through a vertical height y (see figure), then : (assume the remaining portion to be spherical).



[Sep. 05, 2020 (I)]

Options:

A. $v^2 = y\left[\frac{qQ}{4\pi\varepsilon_0 R^2 ym} + g\right]$

B. $v^2 = y\left[\frac{qQ}{4\pi\varepsilon_0 R(R + y)m} + g\right]$

C. $v^2 = 2y\left[\frac{QqR}{4\pi\varepsilon_0 (R + y)^3 m} + g\right]$

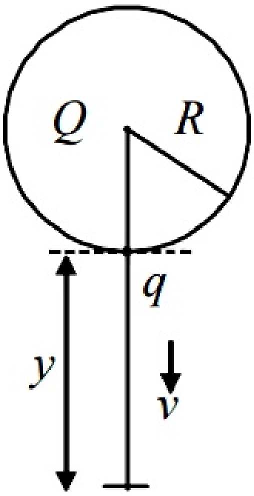
D. $v^2 = 2y\left[\frac{qQ}{4\pi\varepsilon_0 R(R + y)m} + g\right]$

Answer: D

Solution:

Solution:
By using energy conservation,

$\Delta K E + (\Delta PE)_{Electro} + (\Delta PE)_{gravitational} = 0$



$\frac{1}{2}mV^2 + \left(k\frac{Qq}{R+y} - k\frac{Qq}{R}\right) + (-mgy) = 0$

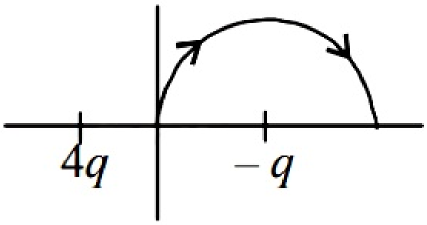
$\Rightarrow \frac{1}{2}mV^2 = mgy + kQq\left(\frac{1}{R} - \frac{1}{R+y}\right)$

$\Rightarrow V^2 = 2gy + \frac{2kQq}{m}\frac{y}{R(R+y)}$

or, $v^2 = 2y\left[\frac{qQ}{4\pi\varepsilon_0 R(R+y)m} + g\right]$

Question140

A two point charges 4q and $-$q are fixed on the x -axis at $x = -\frac{d}{2}$ and $x = \frac{d}{2}$, respectively. If a third point charge ' q ' is taken from the origin to $x = d$ along the semicircle as shown in the figure, the energy of the charge will :



[Sep. 04, 2020 (I)]

Options:

A. increase by $\frac{3q^2}{4\pi\varepsilon_0 d}$

B. increase by $\frac{2q^2}{3\pi\varepsilon_0 d}$

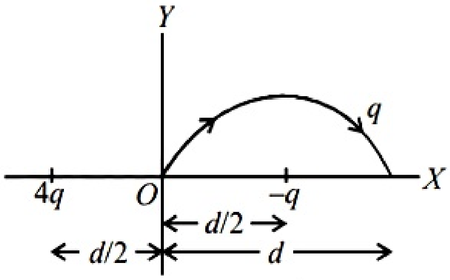
C. decrease by $\frac{q^2}{4\pi\varepsilon_0 d}$

D. decrease by $\frac{4q^2}{3\pi\varepsilon_0 d}$

Answer: D

Solution:

Solution:
Change in potential energy, $\Delta u = q(V_f - V_i)$
Potential of $-q$ is same as initial and final point of the path.



$\Delta u = q\left(\frac{k4q}{3d/2} - \frac{k4q}{d/2}\right) = -\frac{4q^2}{3\pi\varepsilon_0 d}$
–ve sign shows the energy of the charge is decreasing.

Question141

Hydrogen ion and singly ionized helium atom are accelerated, from rest, through the same potential difference. The ratio of final speeds of hydrogen and helium ions is close to : [Sep. 03, 2020 (II)]

Options:

A. 1 : 2

B. 10 : 7

C. 2 : 1

D. 5 : 7

Answer: C

Solution:

Solution:
According to work energy theorem, gain in kinetic energy is equal to work done in displacement of charge.
$\therefore \frac{1}{2}mv^2 = q\Delta V$
Here, ΔV = potential difference between two positions of charge q.
For same q and ΔV.
$v \propto \frac{1}{\sqrt{m}}$
Mass of hydrogen ion $m_H = 1$
Mass of helium ion $m_{He} = 4$
$\therefore \frac{v_H}{v_{He}} = \sqrt{\frac{4}{1}} = 2:1.$

Question142

Two capacitors of capacitances C and 2C are charged to potential differences V and 2V, respectively. These are then connected in parallel in such a manner that the positive terminal of one is connected to the

negative terminal of the other. The final energy of this configuration is : [Sep. 05, 2020 (I)]

Options:

A. $\frac{25}{6}CV^2$

B. $\frac{3}{2}CV^2$

C. zero

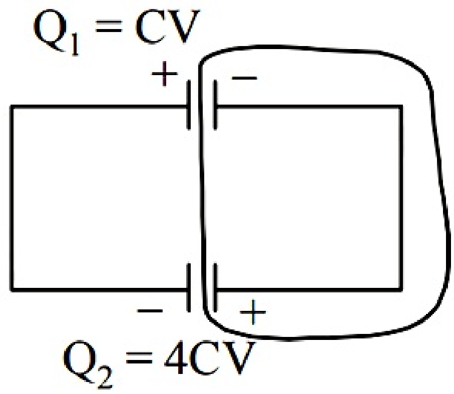
D. $\frac{9}{2}CV^2$

Answer: B

Solution:

Solution:
When capacitors C and 2C capacitance are charged to V and 2V respectively.

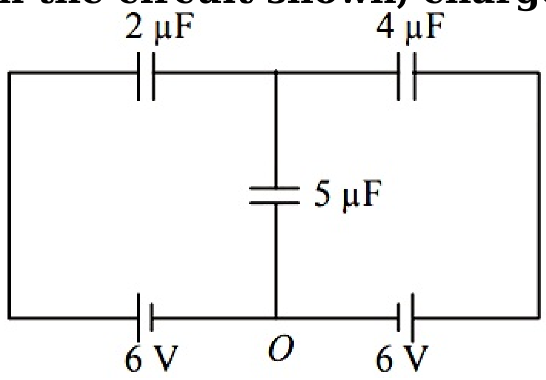
$Q_1 = CV \quad Q_2 = 2C \times 2V = 4CV$
When connected in parallel



By conservation of charge
$4CV - CV = (C + 2C)V_{common}$
$V_{common} = \frac{3CV}{3C} = V$
Therefore final energy of this configuration,
$U_f = \left(\frac{1}{2}CV^2 + \frac{1}{2} \times 2CV^2\right) = \frac{3}{2}CV^2$

Question143

In the circuit shown, charge on the 5 μF capacitor is :



[Sep. 05, 2020 (II)]

Options:

A. 18.00 μC

B. 10.90 μC

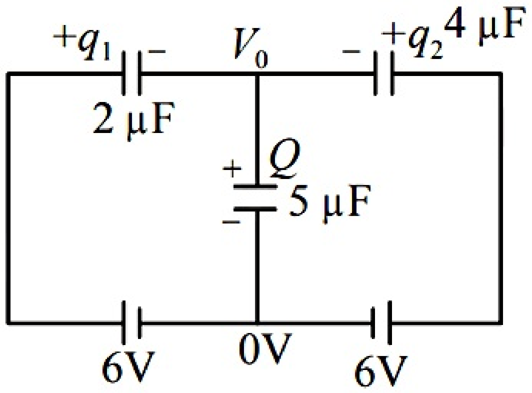
C. 16.36 μC

D. 5.45 μC

Answer: A

Solution:

Solution:



Let q_1 and q_2 be the charge on the capacitors of $2\mu F$ and $4\mu F$. Then charge on capacitor of $5\mu F$

$Q = q_1 + q_2$

$\Rightarrow 5V_0 = 2(6 - V_0) + 4(6 - V_0)$

$\Rightarrow 5V_0 = 12 - 2V_0 + 24 - 4V_0$

$\Rightarrow 11V_0 = 36 \Rightarrow V_0 = \frac{36}{11}V$

$\Rightarrow Q = 5V_0 = \frac{180}{11}\mu C$

Question144

A capacitor C is fully charged with voltage V_0. After disconnecting the voltage source, it is connected in parallel with another uncharged capacitor of capacitance $\frac{C}{2}$. The energy loss in the process after the charge is distributed between the two capacitors is :
[Sep. 04,2020 (II)]

Options:

A. $\frac{1}{2}CV_0^2$

B. $\frac{1}{3}CV_0^2$

C. $\frac{1}{4}CV_0^2$

D. $\frac{1}{6}CV_0^2$

Answer: D

Solution:

Solution:
When two capacitors with capacitance C_1 and C_2 at potential V_1 and V_2 connected to each other by wire, charge begins to flow from higher to lower potential till they acquire common potential. Here, some loss of energy takes place which is given by.

Heat loss, $H = \frac{C_1C_2}{2(C_1 + C_2)}(V_1 - V_2)^2$

In the equation, put $V_2 = 0$, $V_1 = V_0$

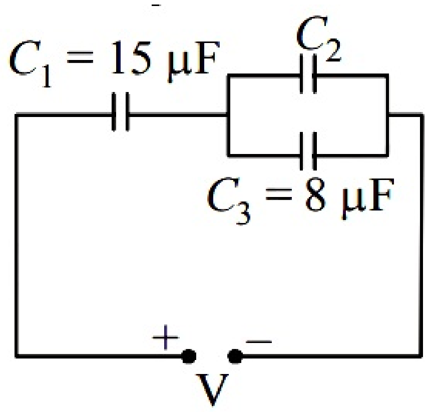
$C_1 = C$, $C_2 = \frac{C}{2}$

Loss of heat $= \frac{C \times \frac{C}{2}}{2\left(C + \frac{C}{2}\right)}(V_0 - 0)^2 = \frac{C}{6}V_0^2$

$H = \frac{1}{6}CV_0^2$

Question145

In the circuit shown in the figure, the total charge is 750μC and the voltage across capacitor C_2 is 20V . Then the charge on capacitor C_2 is :



[Sep. 03, 2020 (I)]

Options:

A. 450 μC

B. 590 μC

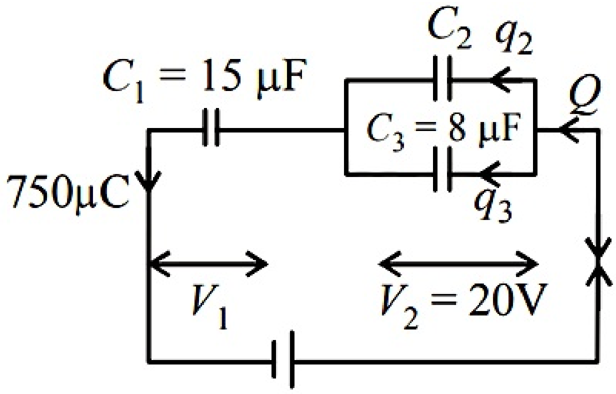
C. 160 μC

D. 650 μC

Answer: B

Solution:

Solution:
According to question,
$Q = 750\mu C = q_2 + q_3$



Capacitors C_2 and C_3 are in parallel hence,
Voltage across C_2 = voltage across C_3 = 20V
Change on capacitor C_3,
$q_3 = C_3 \times V_3 = 8 \times 20 = 160\mu C$
$\therefore q_2 = 750\mu C - 160\mu C = 590\mu C$

Question146

A 5μF capacitor is charged fully by a 220V supply. It is then disconnected from the supply and is connected in series to another uncharged 2.5μF capacitor. If the energy change during the charge redistribution is $\frac{X}{100}$ J then value of X to the nearest integer is ______.
[NA Sep. 02, 2020 (I)]

Answer: 4

Solution:

Solution:
Given, $C_1 = 5\mu F$ and $V_1 = 220$ Volt
When capacitor C_1 fully charged it is disconnected from the supply and connected to uncharged capacitor C_2.
$C_2 = 2.5\mu F$, $V_2 = 0$
Energy change during the charge redistribution,

$$\Delta U = U_i - U_f = \frac{1}{2}\frac{C_1C_2}{C_1 + C_2}(V_1 - V_2)^2$$
$$= \frac{1}{2} \times \frac{5 \times 2.5}{(5 + 2.5)}(220 - 0)^2 \mu J$$
$$= \frac{5}{2 \times 3} \times 22 \times 22 \times 100 \times 10^{-6} J$$
$$= \frac{5 \times 11 \times 22}{3} \times 10^{-4} J = \frac{55 \times 22}{3} \times 10^{-4} J$$
$$= \frac{1210}{3} \times 10^{-4} J = \frac{1210}{3} \times 10^{-3} J \simeq 4 \times 10^{-2} J$$

According to questions, $\frac{x}{100} = 4 \times 10^{-2}$
$\therefore x = 4$

Question147

A 10 μF capacitor is fully charged to a potential difference of 50 V. After

removing the source voltage it is connected to an uncharged capacitor in parallel. Now the potential difference across them becomes 20 V. The capacitance of the second capacitor is :
[Sep. 02, 2020 (II)]

Options:

A. 15 μF

B. 30 μF

C. 20 μF

D. 10 μF

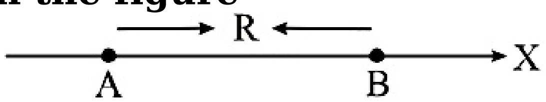
Answer: A

Solution:

Solution:
Given,
Capacitance of capacitor, $C_1 = 10\mu F$
Potential difference before removing the source voltage, $V_1 = 50V$
If C_2 be the capacitance of uncharged capacitor, then common potential is
$V = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}$
$\Rightarrow 20 = \frac{10 \times 50 + 0}{20 + C} \Rightarrow C = 15\mu F$

Question148

Two electric dipoles, A, B with respective dipole moments $\vec{d}_A = -4\ qa\ \hat{i}$ and $\vec{d}_B = -2\ qa\ \hat{i}$ are placed on the x -axis with a separation R, as shown in the figure



The distance from A at which both of them produce the same potential is :
[10 Jan. 2019 I]

Options:

A. $\frac{R}{\sqrt{2} + 1}$

B. $\frac{\sqrt{2}R}{\sqrt{2} + 1}$

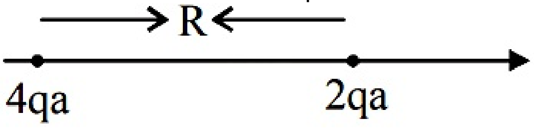
C. $\frac{R}{\sqrt{2} - 1}$

D. $\frac{\sqrt{2}R}{\sqrt{2} - 1}$

Answer: D

Solution:

Solution:
Let at a distance ‘x’ from point B, both the dipoles produce same potential



$\therefore \frac{4qa}{(R+x)} = \frac{2qa}{(x^2)}$

$\Rightarrow \sqrt{2x} = R + x \;\Rightarrow x = \frac{R}{\sqrt{2}-1}$

Therefore distance from A at which both of them produce the same potential

$= \frac{R}{\sqrt{2}-1} + R = \frac{\sqrt{2}R}{\sqrt{2}-1}$

Question149

The electric field in a region is given by $\vec{E} = (Ax + B)\hat{i}$ where E is in $N\,C^{-1}$ and x is in metres. The values of constants are A = 20SI unit and B = 10SI unit. If the potential at x = 1 is V_1 and that at x = −5 is V_2, then $V_1 - V_2$ is :
[8 Jan. 2019 II]

Options:

A. 320 V

B. – 48V

C. 180 V

D. – 520 V

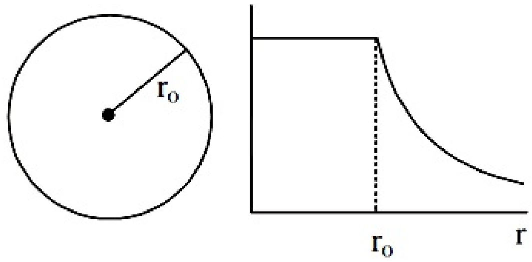
Answer: C

Solution:

Solution:
Given, $\vec{E} = (Ax + B)\hat{i}$
or quad $E = 20x + 10$
Using $V = \int E\,dx$, we have
$V_2 - V_1 = \int_{-5}^{1} (20x + 10)\,dx = -180V$
or $V_1 - V_2 = 180V$

Question150

The given graph shows variation (with distance r from centre) of :



[11 Jan. 2019 I]

Options:

A. Electric field of a uniformly charged sphere

B. Potential of a uniformly charged spherical shell

C. Potential of a uniformly charged sphere

D. Electric field of a uniformly charged spherical shell

Answer: B

Solution:

Solution:
Electric potential is constant inside a charged spherical shell.

Question151

A charge Q is distributed over three concentric spherical shells of radii a, b, c(a < b < c) such that their surface charge densities are equal to one another. The total potential at a point at distance r from their common centre, where r < a, would be:
[10 Jan. 2019 I]

Options:

A. $\frac{Q}{12\pi\epsilon_0}\frac{ab+bc+ca}{abc}$

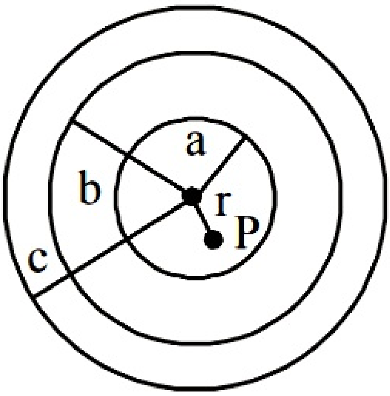
B. $\frac{Q(a^2+b^2+c^2)}{4\pi\epsilon_0(a^3+b^3+c^3)}$

C. $\frac{Q}{4\pi\epsilon_0(a+b+c)}$

D. $\frac{Q(a+b+c)}{4\pi\epsilon_0(a^2+b^2+c^2)}$

Answer: D

Solution:



Potential at point P, $V = \frac{kQ_a}{a} + \frac{kQ_b}{b} + \frac{kQ_c}{c}$

Since surface charge densities are equal to one another

i.e., $\sigma_a = \sigma_b = \sigma_c$

$\therefore Q_a : Q_b : Q_c : a^2 : b^2 : c^2$

$\therefore Q_a = \left[\frac{a^2}{a^2 + b^2 + c^2}\right] Q$

$Q_b = \left[\frac{b^2}{a^2 + b^2 + c^2}\right] Q$

$Q_c = \left[\frac{c^2}{a^2 + b^2 + c^2}\right] Q$

$\therefore V = \frac{Q}{4\pi\epsilon_0}\left[\frac{(a + b + c)}{a^2 + b^2 + c^2}\right]$

Question152

Consider two charged metallic spheres S_1 and S_2 of radii R_1 and R_2, respectively. The electric fields E_1(on S_1) and E_2(on S_2) on their surfaces are such that $E_1 / E_2 = R_1 / R_2$ Then the ratio V_1(on S_1) / V_2(on S_2) of the electrostatic potentials on each sphere is: [8 Jan. 2019 II]

Options:

A. R_1 / R_2

B. $(R_1 / R_2)^2$

C. (R_2 / R_1)

D. $\left(\frac{R_1}{R_2}\right)^3$

Answer: B

Solution:

Solution:

Electric field at a point outside the sphere is given by

$E = \frac{1Q}{4\pi \in_0 r^2}$ But $\rho = \frac{Q}{\frac{4}{3}\pi R^3}$

$\therefore E = \dfrac{\rho R^3}{3 \in_0 r^2}$

At surface $r = R$

$\therefore E = \dfrac{\rho R^3}{3 \in_0}$

Let ρ_1 and ρ_2 are the charge densities of two sphere.

$E_1 = \dfrac{\rho R_1}{3\varepsilon_0}$ and $E_2 = \dfrac{\rho_2 R_2}{3\varepsilon_0}$

$\because \dfrac{E_1}{E_2} = \dfrac{\rho_1 R_1}{\rho_2 R_2} = \dfrac{R_1}{R_2}$

This gives $\rho_1 = \rho_2 = \rho$

Potential at a point outside the sphere

$V = \dfrac{1}{4\pi\varepsilon_0}\dfrac{Q}{r} = \dfrac{\rho R^3}{3\varepsilon_0 r}\left(\because \rho = \dfrac{Q}{\frac{4}{3}\pi R^3}\right)$

At surface, $r = R$ $V = \dfrac{\rho R^2}{3\varepsilon_0}$ so, $V_1 = \dfrac{\rho {R_1}^2}{3\varepsilon_0}$ and $V_2 = \dfrac{\rho {R_2}^2}{3\varepsilon_0}$

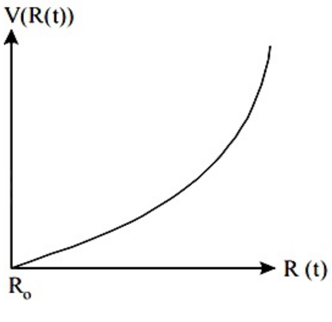
$\therefore \dfrac{V_1}{V_2} = \left(\dfrac{R_1}{R_2}\right)^2$

Question153

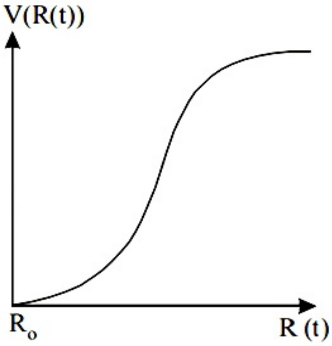
There is a uniform spherically symmetric surface charge density at a distance R_o from the origin. The charge distribution is initially at rest and starts expanding because of mutual repulsion. The figure that represents best the speed V (R(t)) of the distribution as a function of its instantaneous radius R(t) is: [12 Jan. 2019 I]

Options:

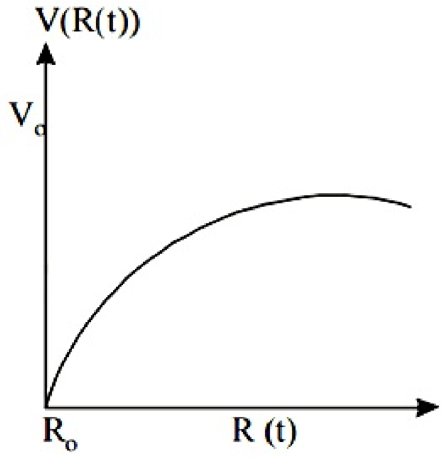
A.



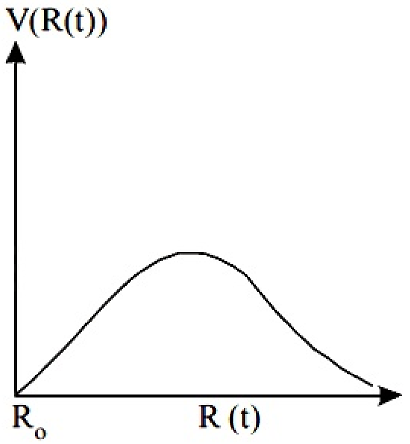
B.



C.



D.



Answer: C

Solution:

Solution:
Total energy of charge distribution is constant at any instant t.
$U_f + K_f = U_i + K_i$

i.e., $\frac{1}{2}mV^2 + \frac{KQ^2}{2R} = 0 + \frac{KQ^2}{2R_0}$

$\therefore \frac{1}{2}mV^2 = \frac{KQ^2}{2R_0} - \frac{KQ^2}{2R}$

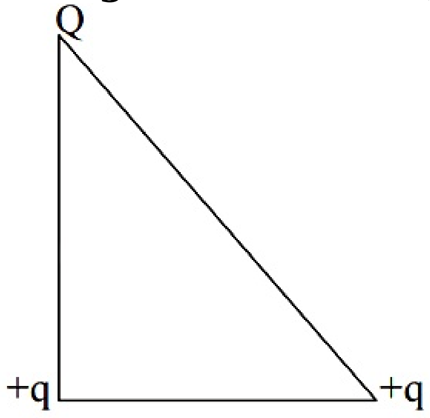
$\therefore V = \sqrt{\frac{2}{m}\frac{KQ^2}{2}\left(\frac{1}{R_0} - \frac{1}{R}\right)}$

$\therefore V = \sqrt{\frac{KQ^2}{m}\left(\frac{1}{R_0} - \frac{1}{R}\right)} = C\sqrt{\frac{1}{R_0} - \frac{1}{R}}$

Also the slope of V – R curve will go on decreasing.

Question154

Three charges Q, + q and + q are placed at the vertices of a right-angle isosceles triangle as shown below. The net electrostatic energy of the configuration is zero, if the value of Q is :



[11 Jan. 2019 I]

Options:

A. $+q$

B. $\frac{-\sqrt{2}q}{\sqrt{2}+1}$

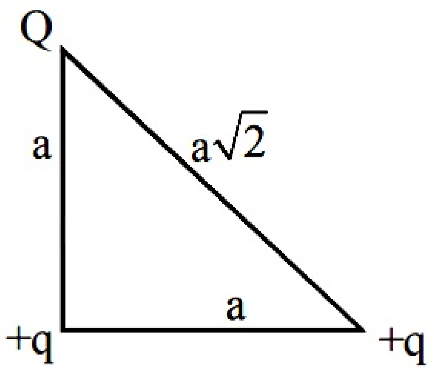
C. $\frac{-q}{1+\sqrt{2}}$

D. $-2q$

Answer: B

Solution:

Solution:
Net electrostatic energy for the system



$$U = K\left[\frac{q^2}{a} + \frac{Qq}{a} + \frac{Qq}{a\sqrt{2}}\right] = 0$$

$\Rightarrow q = -Q\left[1+\frac{1}{\sqrt{2}}\right]$

$\Rightarrow Q = \frac{-q\sqrt{2}}{\sqrt{2}+1}$

Question155

Four equal point charges Q each are placed in the xy plane at (0, 2), (4, 2), (4, – 2) and (0, – 2). The work required to put a fifth charge Q at the origin of the coordinate system will be:
[10 Jan. 2019 II]

Options:

A. $\frac{Q^2}{4\pi\varepsilon_0}\left(1+\frac{1}{\sqrt{3}}\right)$

B. $\frac{Q^2}{4\pi\varepsilon_0}\left(1+\frac{1}{\sqrt{5}}\right)$

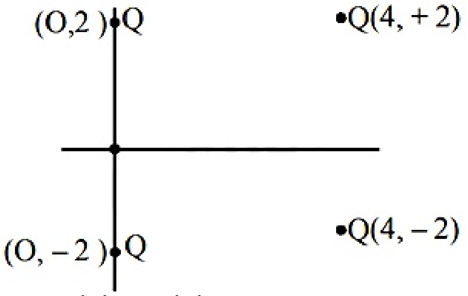
C. $\frac{Q^2}{2\sqrt{2}\pi\varepsilon_0}$

D. $\frac{Q^2}{4\pi\varepsilon_0}$

Answer: B

Solution:

Solution:



Potential at origin

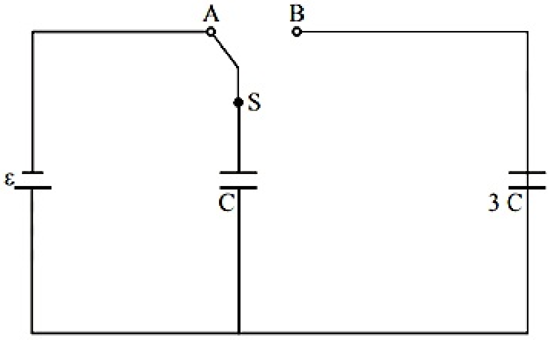
$v = \frac{KQ}{2}+\frac{KQ}{2}+\frac{KQ}{\sqrt{20}}+\frac{KQ}{\sqrt{20}}$

and potential at $\infty = 0 = KQ\left(1+\frac{1}{\sqrt{5}}\right)$

$\therefore$ Work required to put a fifth charge Q at origin $W = VQ = \frac{Q^2}{4\pi\varepsilon_0}\left(1+\frac{1}{\sqrt{5}}\right)$

Question156

In the figure shown, after the switch ‘S’ is turned from position ‘A’ to position ‘B’, the energy dissipated in the circuit in terms of capacitance ‘C’ and total charge ‘Q’ is:



[12 Jan. 2019 I]

Options:

A. $\frac{1}{8}\frac{Q^2}{C}$

B. $\frac{3}{8}\frac{Q^2}{C}$

C. $\frac{5}{8}\frac{Q^2}{C}$

D. $\frac{3}{4}\frac{Q^2}{C}$

Answer: B

Solution:

Solution:
Energy stored in the system initially

$U_i = \frac{1}{2}CE^2$

$U_f = \frac{1}{2}\frac{Q^2}{C_{eq}} = \frac{(CE)^2}{2 \times 4C} = \frac{1}{2}\frac{CE^2}{4}$

[As $Q = CE$, and $C_{eq} = 4C$]

$\Delta U = \frac{1}{2}CE^2 \times \frac{3}{4} = \frac{3}{8}CE^2 = \frac{3}{8}\frac{Q^2}{C}$

Question157

A parallel plate capacitor with plates of area $1m^2$ each, are at a separation of 0.1m. If the electric field between the plates is $100N/C$, the magnitude of charge on each plate is :

$\left(\textbf{Take } \epsilon_0 = 8.85 \times 10^{-12}\frac{C^2}{N-M^2}\right)$

[12 Jan. 2019 II]

Options:

A. $7.85 \times 10^{-10}C$

B. $6.85 \times 10^{-10}C$

C. $8.85 \times 10^{-10}C$

D. 9.85×10^{-10}C

Answer: C

Solution:

Solution:

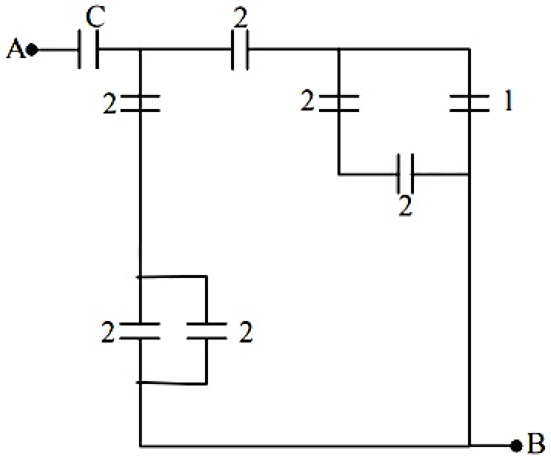
$E = \sigma\varepsilon_0 = \frac{Q}{A\varepsilon_0}$

$\therefore Q = \varepsilon_0 . E . A = 8.85 \times 10^{-12} \times 100 \times 1$

$= 8.85 \times 10^{-10}$C

Question158

In the circuit shown, find C if the effective capacitance of the whole circuit is to be 0.5 μF. All values in the circuit are in μF



[12 Jan. 2019 II]

Options:

A. $\frac{7}{11}$μF

B. $\frac{6}{5}$μF

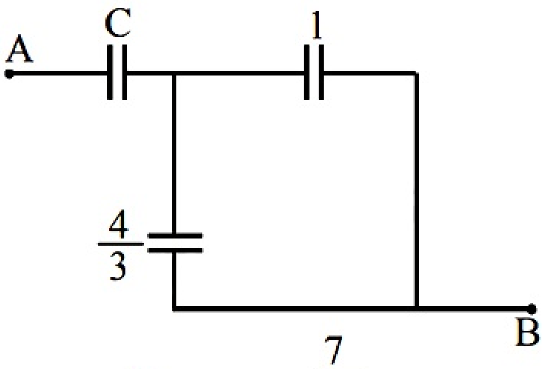
C. 4μF

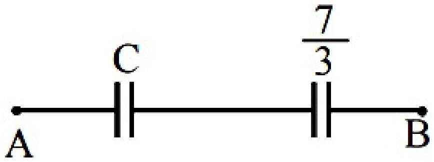
D. $\frac{7}{10}$μF

Answer: A

Solution:

Solution:





For series combination

$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$

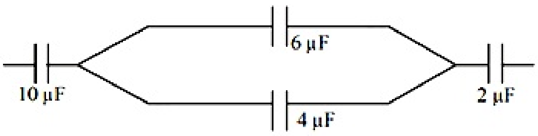
$\Rightarrow \frac{\frac{7C}{3}}{\frac{7}{3} + C} = \frac{1}{2}$

$\Rightarrow 14C = 7 + 3C$

$\Rightarrow C = \frac{7}{11} \mu F$

Question159

In the figure shown below, the charge on the left plate of the 10 μF capacitor is –30μC. The charge on the right plate of the 6μF capacitor is :



[11 Jan. 2019 I]

Options:

A. –12 μC

B. +12 μC

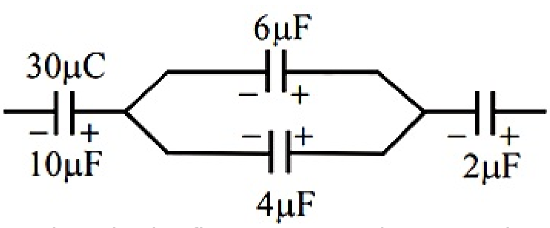
C. –18 μC

D. +18 μC

Answer: D

Solution:

Solution:



As given in the figure, $6\mu F$ and $4\mu F$ are in parallel. Now using charge conservation

Charge on $6\mu F$ capacitor $= \frac{6}{6+4} \times 30 = 18\mu C$

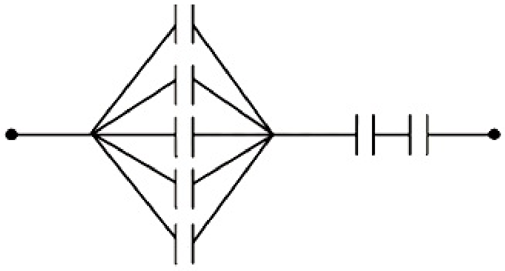
Since charge is asked on right plate therefore is $+18\mu C$

Question160

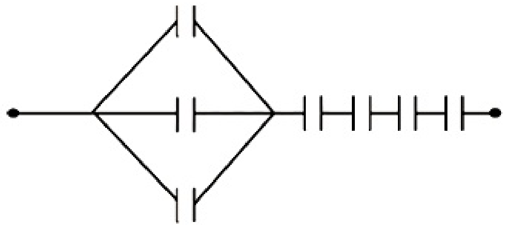
Seven capacitors, each of capacitance $2\mu F$, are to be connected in a configuration to obtain an effective capacitance of $\left(\frac{6}{13}\right)\mu F$. Which of the combinations, shown in figures below, will achieve the desired value?
[11 Jan. 2019 II]

Options:

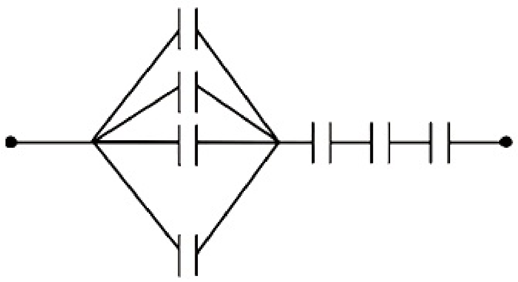
A.



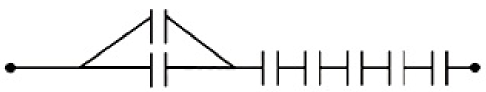
B.



C.



D.



Answer: 0

Solution:

As required equivalent capacitance should be

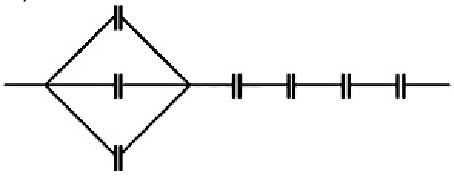
$C_{eq} = \frac{6}{13}\mu F$

Therefore three capacitors must be in parallel and 4 must be in series with it.

$\frac{1}{C_{eq}} = \left[\frac{1}{3C}\right] + \left[\frac{1}{C} + \frac{1}{C} + \frac{1}{C} + \frac{1}{C}\right]$

$C_{eq} = \frac{3C}{13} = \frac{6}{13}\mu F$ [as C = 2μF]

So, desired combination will be as below:



Question161

A parallel plate capacitor having capacitance 12 pF is charged by a battery to a potential difference of 10 V between its plates. The charging battery is now disconnected and a porcelain slab of dielectric constant 6.5 is slipped between the plates. The work done by the capacitor on the slab is: [10 Jan. 2019 II]

Options:

A. 692 pJ

B. 508 pJ

C. 560 pJ

D. 600 pJ

Answer: B

Solution:

Solution:

$W = -\Delta u$

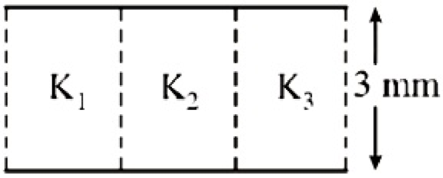
$= (-1)\left|\frac{(c\varepsilon)^2}{2kc} - \frac{(c\varepsilon)^2}{2c}\right|$

$= \frac{\varepsilon^2 c}{2}\frac{k-1}{k}$

$= 508J$

Question162

A parallel plate capacitor is of area $6cm^2$ and a separation 3mm. The gap is filled with three dielectric materials of equal thickness (see figure) with dielectric constants $K_1 = 10$, $K_2 = 12$ and $K_3 = 1(4)$ The dielectric constant of a material which when fully inserted in above capacitor, gives same capacitance would be:



[10 Jan. 2019 I]

Options:

A. 4

B. 14

C. 12

D. 36

Answer: C

Solution:

Let dielectric constant of material used be K.

$$\frac{k_1 \in_0 A_1}{d} + \frac{k_2 \in_0 A_2}{d} + \frac{k_3 \in_0 A_3}{d} = \frac{k \in_0 A}{d}$$

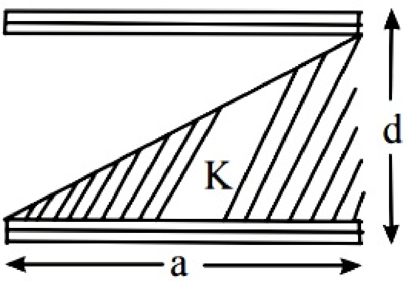
or $\frac{10 \in_0 A / 3}{d} + \frac{12 \in_0 A / 3}{d} + \frac{14 \in_0 A / 3}{d} = \frac{K \in_0 A}{d}$

$$\frac{\in_0 A}{d}\left(\frac{10}{3} + \frac{12}{3} + \frac{14}{3}\right) = \frac{K \in_0 A}{d}$$

$\therefore K = 12$

Question163

A parallel plate capacitor is made of two square plates of side ‘a’, separated by a distance d (d < < a). The lower triangular portion is filled with a dielectric of dielectric constant K, as shown in the figure. Capacitance of this capacitor is:



[9 Jan. 2019 I]

Options:

A. $\frac{K \in_0 a^2}{2d(K+1)}$

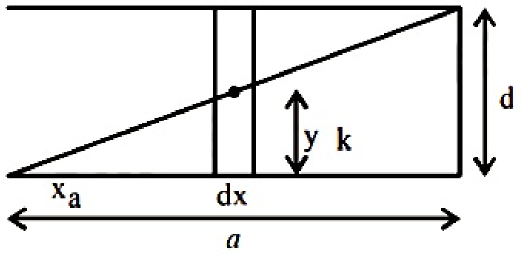
B. $\frac{K \in_0 a^2}{d(K-1)}$ In K

C. $\frac{K \in_0 a^2}{d}$ In K

D. $\frac{1}{2}\frac{K\in_0 a^2}{d}$

Answer: B

Solution:



From figure, $\frac{y}{x}=\frac{d}{a}\Rightarrow y=\frac{d}{a}x$

$dy=\frac{d}{a}(dx)\Rightarrow\frac{1}{dc}=\frac{y}{K\varepsilon_0 a\,dx}+\frac{(d-y)}{\varepsilon_0 a\,dx}$

$\frac{1}{dc}=\frac{y}{\varepsilon_0 abx}\left(\frac{y}{k}+d-y\right)$

$\int dc=\int\frac{\varepsilon_0 a\,dx}{\frac{y}{k}+d-y}$

$c=\varepsilon_0 a\cdot\frac{a}{d}\int_0^d\frac{dy}{d+y\left(\frac{1}{k}-1\right)}$

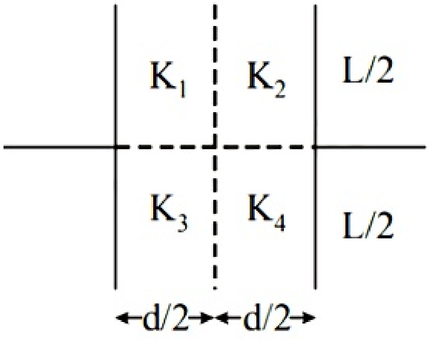
$=\frac{\varepsilon_0 a^2}{\left(\frac{1}{k}-1\right)d}\left[\ln\left(d+y\left(\frac{1}{k}-1\right)\right)\right]_0^d$

$=\frac{k\in_0 a^2}{(1-k)d}\ln\left(\frac{d+d\left(\frac{1}{k}-1\right)}{d}\right)$

$=\frac{k\in_0 a^2}{(1-k)d}\ln\left(\frac{1}{k}\right)=\frac{k\in_0 a^2\ln k}{(k-1)d}$

Question164

A parallel plate capacitor with square plates is filled with four dielectrics of dielectric constants K_1, K_2, K_3, K_4 arranged as shown in the figure. The effective dielectric constant K will be:



[9 Jan. 2019 II]

Options:

A. $K=\frac{(K_1+K_3)(K_2+K_4)}{K_1+K_2+K_3+K_4}$

B. $K = \frac{(K_1 + K_2)(K_3 + K_4)}{2(K_1 + K_2 + K_3 + K_4)}$

C. $K = \frac{(K_1 + K_2)(K_3 + K_4)}{K_1 + K_2 + K_3 + K_4}$

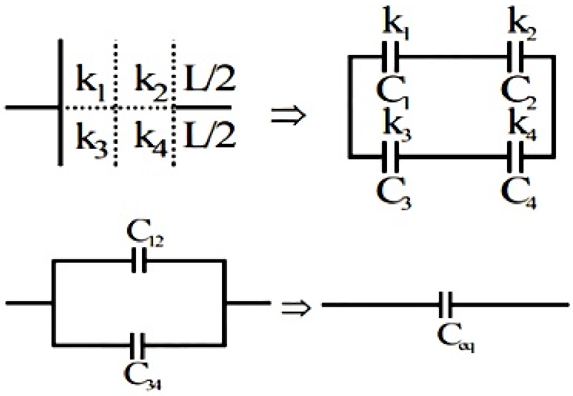
D. $K = \frac{(K_1 + K_4)(K_2 + K_3)}{2(K_1 + K_2 + K_3 + K_4)}$

E. (Bonus)

Answer: E

Solution:

Solution:



$$C_{12} = \frac{C_1C_2}{C_1 + C_2} = \frac{\frac{k_1 \in_0 \frac{L}{2} \times L}{d\ /2} \cdot \frac{k_2\left[\in_0 \frac{L}{2} \times L\right]}{d\ /2}}{(k_1 + k_2)\left[\frac{\in_0 \frac{L}{2} \times L}{d\ /2}\right]}$$

$$C_{12} = \frac{k_1k_2}{k_1 + k_2}\frac{\in_0 L^2}{d}$$

in the same way we get,

$$C_{34} = \frac{k_3k_4}{k_3 + k_4}\frac{\in_0 L^2}{d}$$

$$\therefore C_{eq} = C_{12} + C_{34} = \left[\frac{k_1k_2}{k_1 + k_2} + \frac{k_3k_4}{k_3 + k_4}\right]\frac{\in_0 L^2}{d} \text{ ....(i)}$$

Now if $k_{eq} = K$, $C_{eq} = \frac{k \in_0 L^2}{d}$ ......(ii)

on comparing equation (i) to equation (ii), we get

$$k_{eq} = \frac{k_1k_2(k_3 + k_4) + k_3k_4(k_1 + k_2)}{(k_1 + k_2)(k_3 + k_4)}$$

This does not match with any of the options so this must be a bonus.

Question165

A point dipole = $\vec{p} - p_o\hat{x}$ kept at the origin. The potential and electric field due to this dipole on the y-axis at a distance d are, respectively : (Take V = 0 at infinity) [12 April 2019 I]

Options:

A. $\frac{|\vec{p}|}{4\pi\varepsilon_0 d^2}, \frac{\vec{p}}{4\pi\varepsilon_0 d^3}$

B. $0, \frac{\vec{p}}{4\pi\varepsilon_0 d^3}$

C. $0, \frac{|\vec{p}|}{4\pi\varepsilon_0 d^3}$

D. $\frac{|\vec{p}|}{4\pi\varepsilon_0 d^2}, \frac{-\vec{p}}{4\pi\varepsilon_0 d^3}$

Answer: B

Solution:

Solution:
The electric potential at the bisector is zero and electric field is antiparallel to the dipole moment.

$\therefore V = 0$ and $\vec{E} = \frac{1}{4\pi\varepsilon_0}\left(\frac{-\vec{P}}{d^3}\right)$

Question166

A uniformly charged ring of radius 3a and total charge q is placed in xy-plane centred at origin. A point charge q is moving towards the ring along the z-axis and has speed v at z = 4a. The minimum value of v such that it crosses the origin is : [10 April 2019 I]

Options:

A. $\sqrt{\frac{2}{m}}\left(\frac{4}{15}\frac{q^2}{4\pi\varepsilon_0 a}\right)^{1/2}$

B. $\sqrt{\frac{2}{m}}\left(\frac{1}{5}\frac{q^2}{4\pi\varepsilon_0 a}\right)^{1/2}$

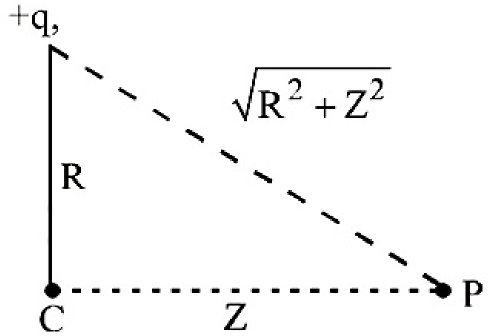
C. $\sqrt{\frac{2}{m}}\left(\frac{2}{15}\frac{q^2}{4\pi\varepsilon_0 a}\right)^{1/2}$

D. $\sqrt{\frac{2}{m}}\left(\frac{1}{15}\frac{q^2}{4\pi\varepsilon_0 a}\right)^{1/2}$

Answer: C

Solution:

Solution:
Potential at any point of the charged ring $V_p = \frac{Kq}{\sqrt{R^2 + Z^2}}$



R = 3a
Z = 4a
$l = \sqrt{R^2 + Z^2} = 5a$
The minimum velocity (v_0) should just sufficient to reach the point charge at the center, therefore

$\frac{1}{2}mv_0^{\ 2} = q[V_C - V_P]$

$= q\left[\frac{Kq}{3a} - \frac{Kq}{5a}\right]$

$v_0^{\ 2} = \frac{4Kq^2}{15ma} = \frac{4}{15}\frac{1}{4\pi\varepsilon_0}\frac{q^2}{ma}$

$\Rightarrow v_0 = \sqrt{\frac{2}{m}}\left(\frac{2q^2}{15 \times 4\pi\varepsilon_0 a}\right)^{\frac{1}{2}}$

Question167

A solid conducting sphere, having a charge Q, is surrounded by an uncharged conducting hollow spherical shell. Let the potential difference between the surface of the solid sphere and that of the outer surface of the hollow shell be V. If the shell is now given a charge of – 4 Q, the new potential difference between the same two surfaces is : [8 April 2019 I]

Options:

A. – 2V

B. 2 V

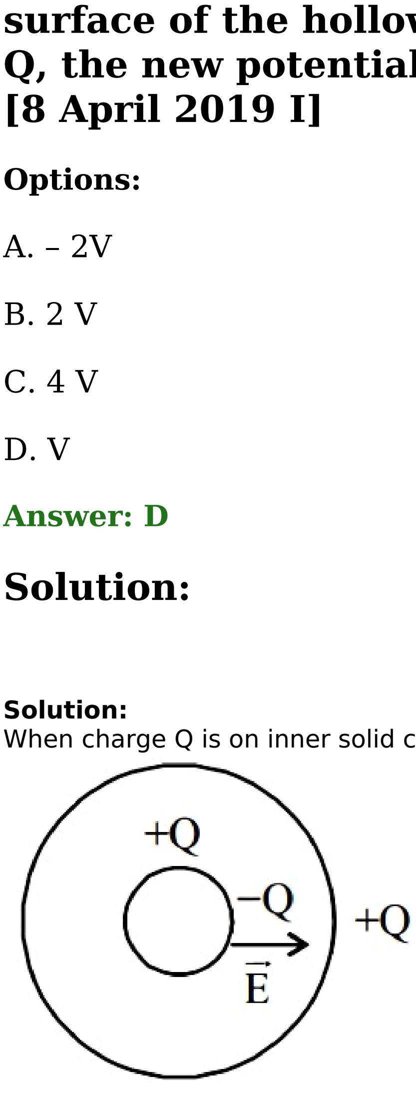
C. 4 V

D. V

Answer: D

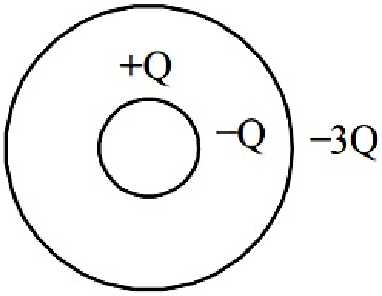
Solution:

Solution:
When charge Q is on inner solid conducting sphere



Electric field between spherical surface $\vec{E} = \frac{KQ}{r^2}$ So $\int \vec{E} \cdot d\vec{r} = V$ given

Now when a charge – 4Q is given to hollow shell



Electric field between surface remain unchanged.

$\vec{E} = \frac{KQ}{r^2}$

as, field inside the hollow spherical shell = 0

∴ Potential difference between them remain unchangedi.e. $\int \vec{E} \cdot d\vec{r} = V$

Question168

In free space, a particle A of charge 1 μC is held fixed at a point P. Another particle B of the same charge and mass 4 mg is kept at a distance of 1 mm from P. If B is released, then its velocity at a distance of 9 mm from P is : $\left[\text{Take } \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 Nm^2C^{-2}\right]$

[10 April 2019 II]

Options:

A. $1.0 m / s$

B. $3.0 \times 10^4 m / s$

C. $2.0 \times 10^3 m / s$

D. $1.5 \times 10^2 m / s$

Answer: C

Solution:

Solution:

Using conservation of energy

$U_i = U_F + \frac{1}{2}mv^2$

$\frac{kq_1q_2}{r_1} = \frac{kq_1q_2}{r_2} + \frac{1}{2}mv^2$

$\Rightarrow \frac{1}{2}mv^2 = kq_1q_2\left[\frac{1}{r_1} - \frac{1}{r_2}\right]$

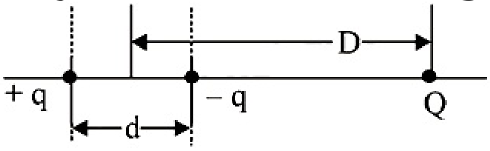
$v^2 = \frac{2kq_1q_2}{m}\left[\frac{1}{r_1} - \frac{1}{r_2}\right]$

$= \frac{2 \times 9 \times 10^9 \times 10^{-12}}{4 \times 10^{-6} \times 10^{-3}}\left[1 - \frac{1}{9}\right] = 4 \times 10^{+6}$

$v = 2 \times 10^3 m / s$

Question169

A system of three charges are placed as shown in the figure:



If D > > d, the potential energy of the system is best given by [9 April 2019 I]

Options:

A. $\frac{1}{4\pi\epsilon_0}\left[\frac{-q^2}{d}\frac{-qQd}{2D^2}\right]$

B. $\frac{1}{4\pi\epsilon_0}\left[\frac{-q^2}{d}+\frac{2qQd}{D^2}\right]$

C. $\frac{1}{4\pi\epsilon_0}\left[+\frac{q^2}{d}+\frac{qQd}{D^2}\right]$

D. $\frac{1}{4\pi\epsilon_0}\left[-\frac{q^2}{d}-\frac{qQd}{D^2}\right]$

Answer: D

Solution:

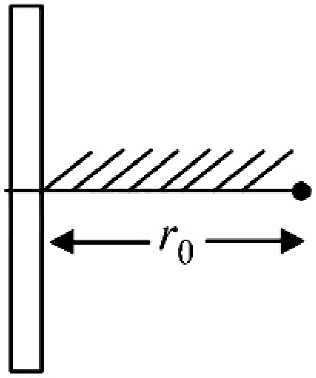
Solution:

$$U=\frac{1}{4\pi\epsilon_0}\left[\frac{q(-q)}{d}+\frac{qQ}{\left(D+\frac{d}{2}\right)}+\frac{(-q)Q}{\left(D-\frac{d}{2}\right)}\right]$$

$$=\frac{1}{4\pi\epsilon_0}\left[-\frac{q^2}{d}-\frac{qQd}{D^2}\right]$$, Ignoring $\frac{d^2}{4}$

Question170

A positive point charge is released from rest at a distance r_0 from a positive line charge with uniform density. The speed (v) of the point charge, as a function of instantaneous distance r from line charge, is proportional to :



[8 April 2019 II]

Options:

A. $v \propto e^{+r/r_0}$

B. $v \propto \sqrt{\ln\left(\frac{r}{r_0}\right)}$

C. $v \propto \ln\left(\frac{r}{r_0}\right)$

D. $v \propto \left(\frac{r}{r_0}\right)$

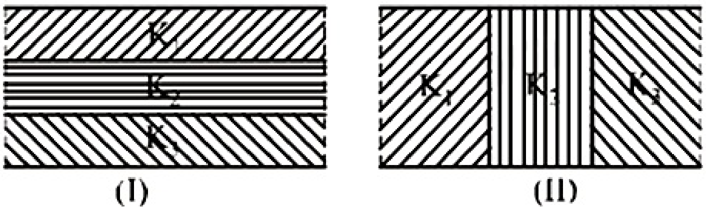
Answer: B

Solution:

Solution:
Using, $[K + U]_i = [K + U]_f$
or $0 + Vq = mv^2 + v'q$
or $mv^2 = (V - V')q$
$= -q\int_{r_0}^{r} E\,dr = q\int_{r_0}^{r} \frac{\lambda}{2\pi \in_0 r} dr = \frac{\lambda q}{2\pi \in_0}\left(\frac{\ln^3}{r_0}\right)$
$\Rightarrow v \propto \sqrt{\ln\frac{r}{r_0}}$

Question171

Two identical parallel plate capacitors, of capacitance C each, have plates of area A, separated by a distance d. The space between the plates of the two capacitors, is filled with three dielectrics, of equal thickness and dielectric constants K_1, K_2 and K_3. The first capacitors is filled as shown in Fig. I, and the second one is filled as shown in Fig. II. If these two modified capacitors are charged by the same potential V, the ratio of the energy stored in the two, would be (E_1. refers to capacitors (I) and E_2 to capacitors (II):



[12 April 2019 I]

Options:

A.

$\frac{E_1}{E_2} = \frac{K_1K_2K_3}{(K_1 + K_2 + K_3)(K_2K_3 + K_3K_1 + K_1K_2)}$

B.

$$\frac{E_1}{E_2}=\frac{(K_1+K_2+K_3)(K_2K_3+K_3K_1+K_1K_2)}{K_1K_2K_3}$$

C.

$$\frac{E_1}{E_2}=\frac{9K_1K_2K_3}{(K_1+K_2+K_3)(K_2K_3+K_3K_1+K_1K_2)}$$

D.

$$\frac{E_1}{E_2}=\frac{(K_1+K_2+K_3)(K_2K_3+K_3K_1+K_1K_2)}{9K_1K_2K_3}$$

Answer: C

Solution:

Solution:

$$\frac{1}{C_1}=\frac{d\ /\ 3}{k_1\varepsilon_0A}+\frac{d\ /\ 3}{k_2\varepsilon_0A}+\frac{d\ /\ 3}{k_3\varepsilon_0A}$$

or $C_1=\dfrac{3k_1k_2k_3\varepsilon_0A}{d\,(k_1k_2+k_2k_3+k_3k_1)}$

$$C_2=\frac{k_1\varepsilon_0(A\ /\ 3)}{d}+\frac{k_2\varepsilon_0(A\ /\ 3)}{d}+\frac{k_3\varepsilon_0(A\ /\ 3)}{d}$$

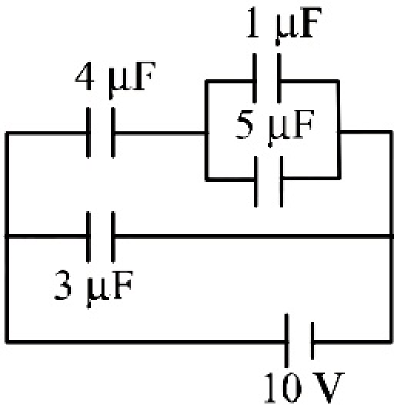
$$=\frac{(k_1+k_2+k_3)\varepsilon_0A}{3d}$$

$$\frac{U_1}{U_2}=\frac{\frac{1}{2}C_1V^2}{\frac{1}{2}C_2V^2}$$

$$=\frac{E_1}{E_2}=\frac{9K_1K_2K_3}{(K_1+K_2+K_3)(K_2K_3+K_3K_1+K_1K_2)}$$

Question172

In the given circuit, the charge on 4 μF capacitor will be :



[12 April 2019 II]

Options:

A. 5.4 μF

B. 9.6 μF

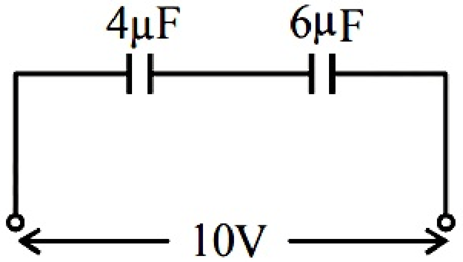
C. 13.4 μF

D. 24 μF

Answer: D

Solution:

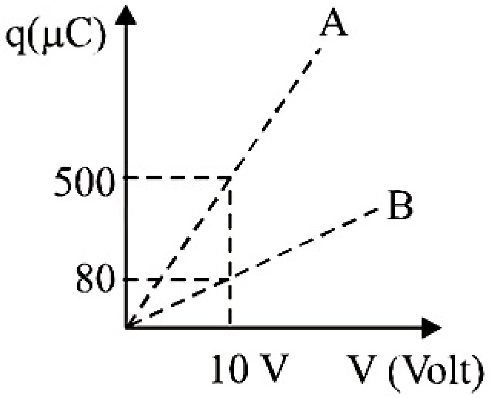
Solution:
$V_1 + V_2 = 10$



and $4V_1 = 6V_2$
On solving above equations, we get
$V_1 = 6V$
Charge on 4μf
$q = CV_1 = 4 \times 6 = 24μC$

Question173

Figure shows charge (q) versus voltage (V) graph for series and parallel combination of two given capacitors.
The capacitances are :



[10 April 2019 I]

Options:

A. 40 μF and 10 μF

B. 60 μF and 40 μF

C. 50 μF and 30 μF

D. 20 μF and 30 μF

Answer: A

Solution:

Equivalent capacitance in series combination (C') is given by

$\frac{1}{C'} = \frac{1}{C_1} + \frac{1}{C_2} \Rightarrow C' = \frac{C_1C_2}{C_1 + C_2}$

For parallel combination equivalent capacitance

$C" = C_1 + C_2$

For parallel combination

$q = 10(C_1 + C_2)$

$q_1 = 500\mu C$

$500 = 10(C_1 + C_2)$

$C_1 + C_2 = 50\mu F$ ....(i)

For Series Combination–

$q_2 = 10\frac{C_1C_2}{(C_1 + C_2)}$

$80 = 10\frac{C_1C_2}{50}$ From equation ....(ii)

$C_1\ C_2 = 400$ ....(iii)

From equation (i) and (ii)

$C_1 = 10\mu F\ C_2 = 40\mu F$

Question174

A capacitor with capacitance 5µF is charged to 5 µC. If the plates are pulled apart to reduce the capacitance to $2\frac{1}{4}$F , how much work is done? [9 April 2019 I]

Options:

A. 6.25×10^{-6}J

B. 3.75×10^{-6}J

C. 2.16×10^{-6}J

D. 2.55×10^{-6}J

Answer: B

Solution:

Solution:

$\omega = \omega_f - v_i = \frac{q}{2}\left(\frac{1}{C_f} - \frac{1}{C_i}\right)$

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

$= 3.75 \times 10^{-6}$J

Question175

Voltage rating of a parallel plate capacitor is 500 V. Its dielectric can withstand a maximum electric field of 10^6 V/m. The plate area is $10^{-4}m^2$. What is the dielectric constant if the capacitance is 15 pF ? (given $"_0 = 8.86 \times 10^{-12}C^2 / N\,m^2$) [8 April 2019 I]

Options:

A. 3.8

B. 8.5

C. 4.5

D. 6.2

Answer: B

Solution:

Solution:
Capacitance of a capacitor with a dielectric of dielectric constant k is given by
$C = \frac{k \in_0 A}{d}$
$\because E = \frac{V}{d} \quad \therefore C = \frac{k \in_0 AE}{V}$
$15 \times 10^{-12} = \frac{k \times 8.86 \times 10^{-12} \times 10^{-4} \times 10^{6}}{500}$
$k = 8.5$

Question176

A parallel plate capacitor has 1μF capacitance. One of its two plates is given + 2μC charge and the other plate, +4μC charge. The potential difference developed across the capacitor is : [8 April 2019 II]

Options:

A. 3 V

B. 1 V

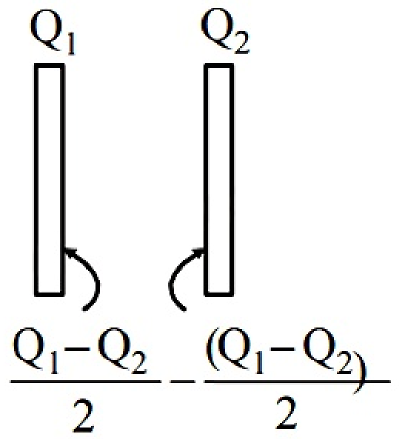
C. 5 V

D. 2 V

Answer: B

Solution:

Solution:



(b) $V = \frac{Q}{C}$

$= \left(\frac{Q_1 - Q_2}{2C}\right)$

$= \left(\frac{4 - 2}{2 \times 1}\right) = 1V$

Question177

Three concentric metal shells A, B and C of respective radii a, b and c (a < b < c) have surface charge densities +σ, –σ and + σ respectively. The potential of shell B is: [2018]

Options:

A. $\frac{\sigma}{\epsilon_0}\left[\frac{a^2 - b^2}{a} + c\right]$

B. $\frac{\sigma}{\epsilon_0}\left[\frac{a^2 - b^2}{b} + c\right]$

C. $\frac{\sigma}{\epsilon_0}\left[\frac{b^2 - c^2}{b} + a\right]$

D. $\frac{\sigma}{\epsilon_0}\left[\frac{b^2 - c^2}{c} + a\right]$

Answer: B

Solution:

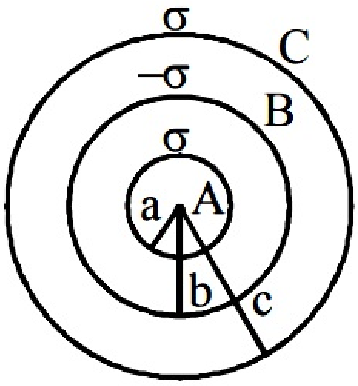
Solution:

Potential outside the shell, $V_{\text{outside}} = \frac{KQ}{r}$

where r is distance of point from the centre of shell

Potential inside the shell, $V_{\text{inside}} = \frac{KQ}{R}$

where 'R" is radius of the shell



$$V_B = \frac{K\,q_A}{r_b} + \frac{K\,q_B}{r_b} + \frac{K\,q_C}{r_c}$$

$$V_B = \frac{1}{4\pi\epsilon_0}\left[\frac{\sigma 4\pi a^2}{b} - \frac{\sigma 4\pi b^2}{b} + \frac{\sigma 4\pi c^2}{c}\right]$$

$$V_B = \frac{\sigma}{\epsilon_0}\left[\frac{a^2 - b^2}{b} + c\right]$$

Question178

A parallel plate capacitor of capacitance 90 pF is connected to a battery of emf 20V. If a dielectric material of dielectric constant k = $\frac{5}{3}$ is inserted between the plates, the magnitude of the induced charge will be: [2018]

Options:

A. 1.2 n C

B. 0.3 n C

C. 2.4 n C

D. 0.9 n C

Answer: A

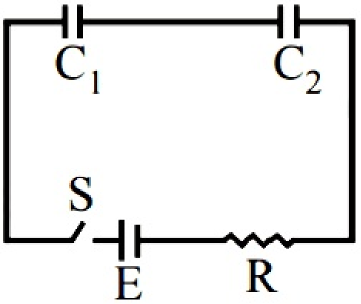
Solution:

Solution:
Charge on Capacitor, $Q_i = CV$
After inserting dielectric of dielectric constant $= K\ Q_f = (kC)V$
Induced charges on dielectric
$Q_{ind} = Q_f - Q_i = K\,CV - CV$
$(K - 1)CV = \left(\frac{5}{3} - 1\right) \times 90pF \times 2V = 1.2nc$

Question179

In the following circuit, the switch S is closed at t = 0. The charge on

the capacitor C_1 as a function of time will be given by $\left(C_{eq} = \frac{C_1 C_2}{C_1 + C_2}\right)$



[Online April 16, 2018]

Options:

A. $C_{eq}E\,[1 - \exp(-t / RC_{eq})]$

B. $C_1E\,[1 - \exp(-tR / C_1)]$

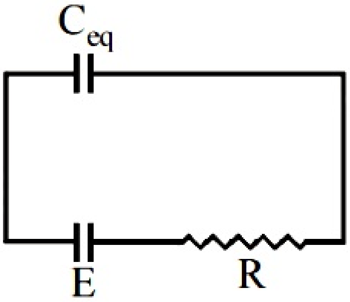
C. $C_2E\,[1 - \exp(-t / RC_2)]$

D. $C_{eq}E\ \exp(-t / RC_{eq})$

Answer: A

Solution:

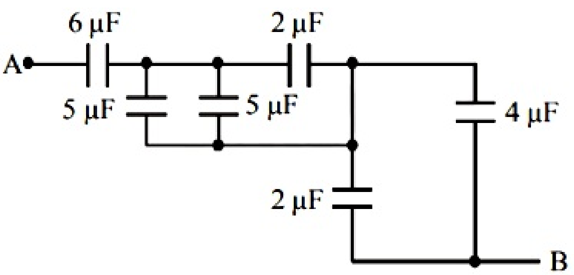
Solution:



During charging charge on the capacitor increases with time. Charge on the capacitor C_1 as a function of time,
$Q = Q_0(1 - e^{-t / RC})$
$Q = C_{eq}E\left[1 - e^{-t / RC_{eq}}\right]$
$(\because Q_0 = C_{eq}E\ )$
Both capacitor will have charge as they are connected in series .

Question180

The equivalent capacitance between A and B in the circuit given below is:



[Online April 15, 2018]

Options:

A. 4.9 μF

B. 3.6 μF

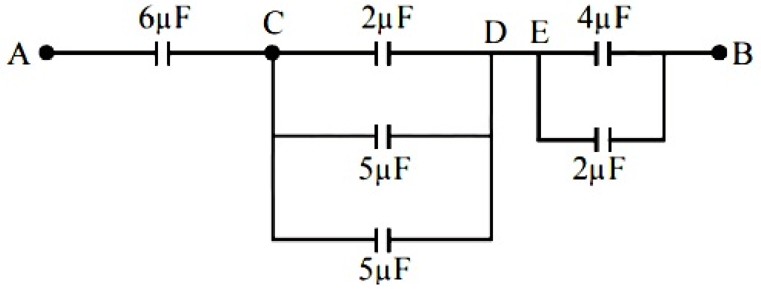
C. 5.4 μF

D. 2.4 μF

Answer: D

Solution:

Solution:
The simplified circuit of the circuit given in question as follows:



The equivalent capacitance between C&D capacitors of $2\mu F$, $5\mu F$ and $5\mu F$ are in parallel.
$\therefore C_{CD} = 2 + 5 + 5 = 12\mu F$ (because In parallel grouping $C_{eq} = C_1 + C_2 + \ldots.. + C_n$)
Similarly equivalent capacitance between E & B $C_{EB} = 4 + 2 = 6\mu F$
Now equivalent capacitance between A&B
$\frac{1}{C_{eq}} = \frac{1}{6} + \frac{1}{12} + \frac{1}{6} = \frac{5}{12}$
$\Rightarrow C_{eq} = \frac{12}{5} = 2.4\mu F$ ($\because$ In series grouping,
$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots\ldots + \frac{1}{C_n}$)

Question181

A parallel plate capacitor with area $200 cm^2$ and separation between the plates 1.5cm, is connected across a battery of emfV. If the force of attraction between the plates is $25 \times 10^{-6} N$, the value of V is approximately.
$$\left(\varepsilon_0 = 8.85 \times 10^{-12} \frac{C^2}{N.m^2} \right)$$
[Online April 15, 2018]

Options:

A. 150V

B. 100V

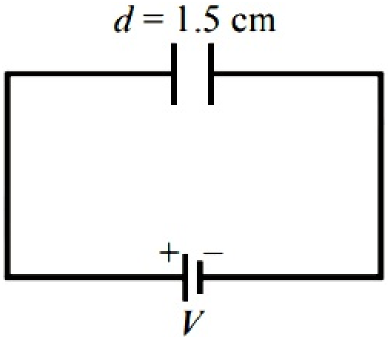
C. 250V

D. 300V

Answer: C

Solution:

Solution:
Given area of Parallel plate capacitor, $A = 200cm^2$
Separation between the plates, $d = 1.5cm$
Force of attraction between the plates, $F = 25 \times 10^{-6}N$
$F = QE$
$F = \frac{Q^2}{2A\in_0}$ (E due to parallel plate $= \frac{\sigma}{2\in_0} = \frac{Q}{A2\in_0}$)



But $Q = CV = \frac{\in_0 A(V)}{d}$

$\therefore F = \frac{(\in_0 AV)^2}{d^2 \times 2A\in_0}$

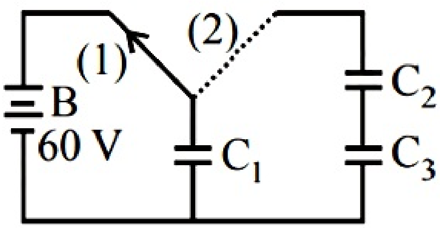
$= \frac{(\in_0 A)^2 \times V^2}{d^2 \times 2 \times (A\in_0)} = \frac{(\in_0 A) \times V^2}{d^2 \times 2}$

or, $25 \times 10^{-6} = \frac{(8.85 \times 10^{-12}) \times (200 \times 10^{-4}) \times V^2}{2.25 \times 10^{-4} \times 2}$

$\Rightarrow V = \sqrt{\frac{25 \times 10^{-6} \times 2.25 \times 10^{-4} \times 2}{8.85 \times 10^{-12} \times 200 \times 10^{-4}}} \approx 250V$

Question182

A capacitor C_1 is charged up to a voltage $V = 60V$ by connecting it to battery B through switch (1), Now C_1 is disconnected from battery and connected to a circuit consisting of two uncharged capacitors $C_2 = 3.0\mu F$ and $C_3 = 6.0\mu F$ through a switch (2) as shown in the figure. The sum of final charges on C_2 and C_3 is:



[Online April 15, 2018]

Options:

A. $36\mu C$

B. $20\mu C$

C. $54\mu C$

D. 40μC

Answer: A

Solution:

Solution:
The sum of final charges on C_2 and C_3 is 36 μC

Question183

There is a uniform electrostatic field in a region. The potential at various points on a small sphere centred at P, in the region, is found to vary between in the limits 589.0 V to 589.8 V. What is the potential at a point on the sphere whose radius vector makes an angle of 60° with the direction of the field ?
[Online April 8, 2017]

Options:

A. 589.5 V

B. 589.2 V

C. 589.4 V

D. 589.6 V

Answer: C

Solution:

Solution:
Potential gradient is given by,
$\Delta V = E \cdot d$
$0.8 = E\, d\, (\max)$
$\Delta V = E\, d\, \cos\theta = 0.8 \times \cos 60 = 0.4$
Hence, maximum potential at a point on the sphere $= 589.4V$

Question184

A capacitance of 2 μF is required in an electrical circuit across a potential difference of 1.0 kV. A large number of 1 μF capacitors are available which can withstand a potential difference of not more than 300 V. The minimum number of capacitors required to achieve this is
[2017]

Options:

A. 24

B. 32

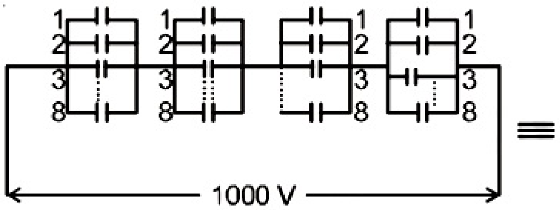
C. 2

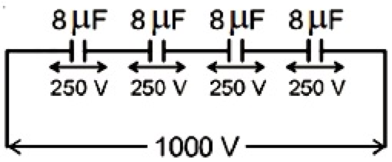
D. 16

Answer: B

Solution:

Solution:
To get a capacitance of $2\mu F$ arrangement of capacitors of capacitance $1\mu F$ as shown in figure 8 capacitors of $1\mu F$ in parallel with four such branches in series i.e., 32 such capacitors are required.

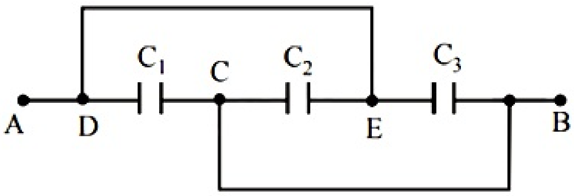




$\frac{1}{C_{eq}} = \frac{1}{8} + \frac{1}{8} + \frac{1}{8} + \frac{1}{8} \therefore C_{eq} = 2\mu F$

Question185

A combination of parallel plate capacitors is maintained at a certain potential difference.



When a 3 mm thick slab is introduced between all the plates, in order to maintain the same potential difference, the distance between the plates is increased by 2.4 mm. Find the dielectric constant of the slab. [Online April 9, 2017]

Options:

A. 3

B. 4

C. 5

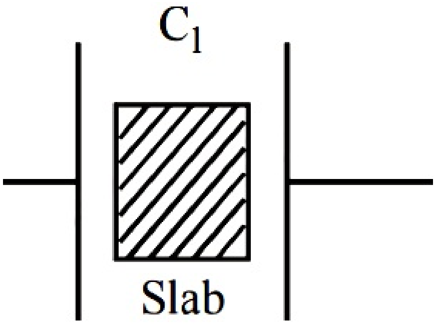
D. 6

Answer: C

Solution:

Before introducing a slab capacitance of plates $C_1 = \frac{\varepsilon_0 A}{3}$

If a slab of dielectric constant K is introduced between plates then $C = \frac{K\,\varepsilon_0 A}{d}$ then $C'_1 = \frac{\varepsilon_0 A}{2.4}$



C_1 and C_1 are in series hence,

$$\frac{\varepsilon_0 A}{3} = \frac{k\frac{\varepsilon_0 A}{3} \cdot \frac{\varepsilon_0 A}{2.4}}{k\frac{\varepsilon_0 A}{3} + \frac{\varepsilon_0 A}{2.4}}$$

$3k = 2.4k + 3$

$0.6k = 3$

Hence, the dielectric constant of slap is given by

$k = \frac{30}{6} = 5$

Question186

The energy stored in the electric field produced by a metal sphere is 4.5 J. If the sphere contains 4 μC charge, its radius will be : [Take : $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 N - m^2 / C^2$]

[Online April 8, 2017]

Options:

A. 20 mm

B. 32 mm

C. 28 mm

D. 16 mm

Answer: D

Solution:

Energy of sphere $= \frac{Q^2}{2C}$

$4.5 = \frac{16 \times 10^{-12}}{2C}$

$C = \frac{16 \times 10^{-12}}{9} = 4\pi\varepsilon_0 R$ (capacity of spherical conductor)

$R = \frac{16 \times 10^{-12}}{9} \times 14\pi\varepsilon_0 \because \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$

$= 9 \times 10^9 \times \frac{16}{9} \times 10^{-12} = 16mm$

Question187

Within a spherical charge distribution of charge density $\rho(r)$, N equipotential surfaces of potential $V_0, V_0+\Delta V, V_0+2\Delta V, \ldots\ldots\ldots V_0+N\Delta V$ ($\Delta V > 0$), are drawn and have increasing radii $r_0, r_1, r_2, \ldots\ldots\ldots r_N$, respectively. If the difference in the radii of the surfaces is constant for all values of V_0 and ΔV then : [Online April 10, 2016]

Options:

A. $\rho(r) =$ constant

B. $\rho(r) \propto \frac{1}{r^2}$

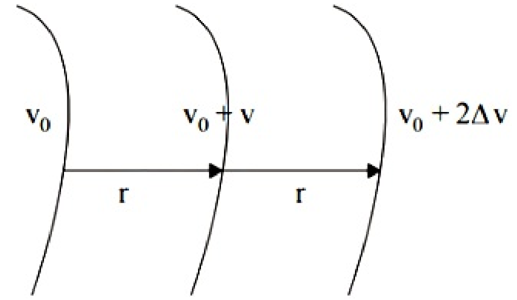
C. $\rho(r) \propto \frac{1}{r}$

D. $\rho(r) \propto r$

Answer: C

Solution:

Solution:



As we know electric field, $E = \frac{-dv}{dr}$

E = constant ∴ dv and dr same

$E = \frac{K\phi}{r^2} = c$

$\Rightarrow \phi \propto r^2$

$\therefore \phi = \int_0^r \rho 4\pi r^2 dr$

$\Rightarrow \rho \propto \frac{1}{r}$

Question188

The potential (in volts) of a charge distribution is given by
$V(z) = 30 - 5z^2$ for $|z| \leq 1m$
$V(z) = 35 - 10|z|$ for $|z| \geq 1m$
V (z) does not depend on x and y. If this potential is generated by a constant charge per unit volume ρ0 (in units of ε_0) which is spread over a certain region, then choose the correct statement.
[Online April 9, 2016]

Options:

A. $\rho_0 = 20\varepsilon_0$ in the entire region

B. $\rho_0 = 10\varepsilon_0$ for $|z| \leq 1$m and $p_0 = 0$ elsewhere

C. $\rho_0 = 20\varepsilon_0$ for $|z| \leq 1$ m and $p_0 = 0$ elsewhere

D. $\rho_0 = 40\varepsilon_0$ in the entire region

Answer: B

Solution:

Solution:

$\Sigma_1 = \frac{-dv}{dr} = 10|z|$

$\Sigma 2 = \frac{-dv}{dr} = 10$ (constant: E)

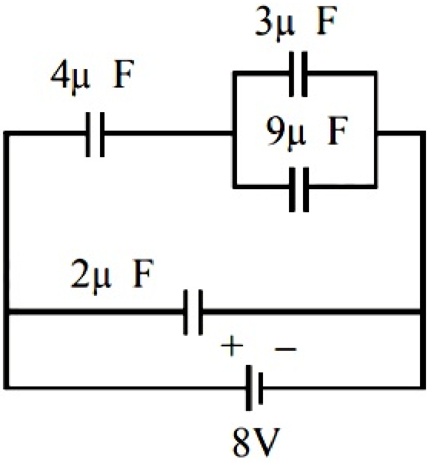
∴ The source is an infinity large non conducting thick plate of thickness 2m.

$\therefore 10Z \ . 10A = \frac{\rho . A \propto Z}{\varepsilon_0}$

$r_0 = 10e_0$ for $|z| \leq 1$m.

Question189

A combination of capacitors is set up as shown in the figure. The magnitude of the electric field, due to a point charge Q (having a charge equal to the sum of the charges on the 4 μF and 9 μF capacitors), at a point distance 30 m from it, would equal :



[2016]

Options:

A. 420 N/C

B. 480 N/C

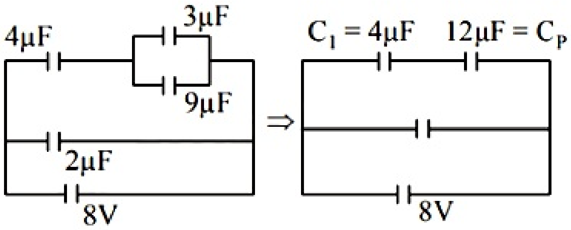
C. 240 N/C

D. 360 N/C

Answer: A

Solution:

Solution:



Charge on C_1 is $q_1 = \left[\left(\frac{12}{4+12}\right) \times 8\right] \times 4 = 24μC$

The voltage across C_p is $V_P = \frac{4}{4+12} \times 8 = 2V$

∴ Voltage across 9μF is also 2V

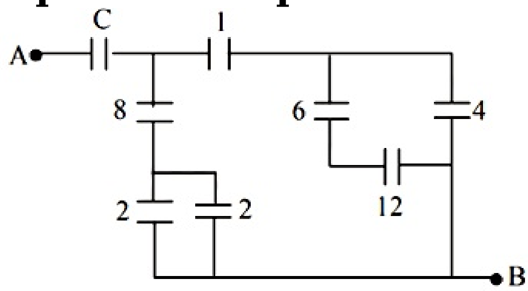
∴ Charge on 9μF capacitor $= 9 \times 2 = 18μC$

∴ Total charge on 4μF and 9μF $= 42μC$

$\therefore E = \frac{KQ}{r^2} = 9 \times 10^9 \times \frac{42 \times 10^{-6}}{30 \times 30} = 420 N C^{-1}$

Question190

Figure shows a network of capacitors where the numbers indicates capacitances in micro Farad. The value of capacitance C if the equivalent capacitance between point A and B is to be 1 μF is :



[Online April 10, 2016]

Options:

A. $\frac{32}{23}μF$

B. $\frac{31}{23}μF$

C. $\frac{33}{23}μF$

D. $\frac{34}{23}μF$

Answer: A

Solution:

Solution:

Capacitors 2μF and 2μF are parallel, their equivalent $= 4μF$

6μF and 12μF are in series, their equivalent $= 4μF$

Now 4 μF (2 and 2μF) and 8μF in series $= \frac{3}{8}μF$

And 4μF (12 &6 μF) and 4μF in parallel $= 4 + 4 = 8μF$

$8\mu F$ in series with $1\mu F = \frac{1}{8} + 1 \Rightarrow \frac{8}{9}\mu F$

Now $C_{eq} = \frac{8}{9} + \frac{8}{3} = \frac{32}{9}$

C_{eq} of circuit $= \frac{32}{9}$

With $C - \frac{1}{C_{eq}} = \frac{1}{C} + \frac{9}{32} = 1 \Rightarrow C = \frac{32}{23}$

Question191

Three capacitors each of 4 μF are to be connected in such a way that the effective capacitance is 6μF. This can be done by connecting them : [Online April 9, 2016]

Options:

A. all in series

B. all in parallel

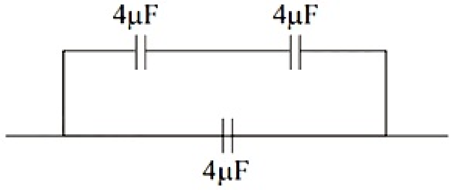
C. two in parallel and one in series

D. two in series and one in parallel

Answer: D

Solution:

Solution:
To get effective capacitance of 6 μF two capacitors of 4 μF each connected in series and one of 4 μF capacitor in parallel with them.



Two capacitances in series

$\therefore \frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{1}{4} + \frac{1}{4} = \frac{1}{2}$

capacitor in parallel

$\therefore C_{eq} = C_3 + C = 4 + 2 = 6\mu F$

Question192

A uniformly charged solid sphere of radius R has potentia! V_0 (measured with respect to ∞) on its surface. For this sphere the equipotential surfaces with potentials $\frac{3V_0}{2}$, $\frac{5V_0}{4}$, $\frac{3V_0}{4}$ and $\frac{V_0}{4}$ have radius R_1, R_2, R_3 and R_4 respectively. Then [2015]

Options:

A. $R_1 = 0$ and $R_2 < (R_4 - R_3)$

B. $2R = R_4$

C. $R_1 = 0$ and $R_2 > (R_4 - R_3)$

D. $R_1 \neq 0$ and $(R_2 - R_1) > (R_4 - R_3)$

Answer: A

Solution:

Solution:

We know, $V_0 = \frac{Kq}{R} = V$ surface

Now, $V_i = \frac{Kq}{2R^3}(3R^2 - r^2)$ [For $r < R$]

At the centre of sphere $r = 0$. Here $V = \frac{3}{2}V_0$

Now, $\frac{5}{4}\frac{Kq}{R} = \frac{Kq}{2R^3}(3R^2 - r^2)$

$\Rightarrow R_2 = \frac{R}{\sqrt{2}}$

$\frac{3}{4}\frac{Kq}{R} = \frac{Kq}{R^3}$

$\frac{1}{4}\frac{Kq}{R} = \frac{Kq}{R_4}$

$R_4 = 4R$

Also, $R_1 = 0$ and $R_2 < (R_4 - R_3)$

Question193

An electric field $\vec{E} = \left(25\hat{i} + 30\hat{j}\right) N\,C^{-1}$ exists in a region of space. If the potential at the origin is taken to be zero then the potential at x = 2m, y = 2m is: [Online April 11, 2015]

Options:

A. –110 J

B. –140 J

C. –120 J

D. –130 J

Answer: A

Solution:

Solution:

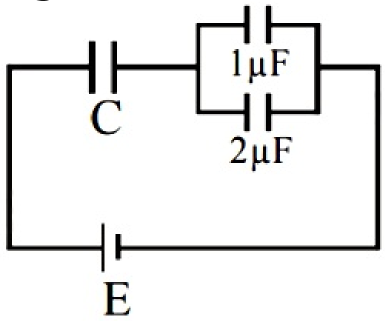
As we know, $E = -\frac{dv}{dx}$

Potential at the point $x = 2m, y = 2m$ is given by :

$$\int_0^V dV = -\int_0^{2,2} (25dx + 30dy)$$
on solving we get, $V = -110$ volt.

Question194

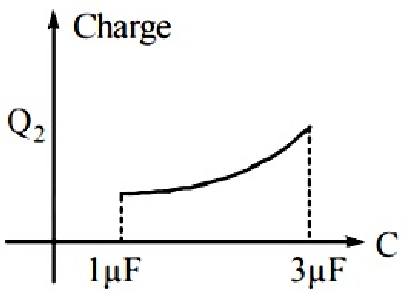
In the given circuit, charge Q_2 on the 2μF capacitor changes as C is varied from 1μF to 3μF. Q_2 as a function of 'C' is given properly by: (figures are drawn schematically and are not to scale)



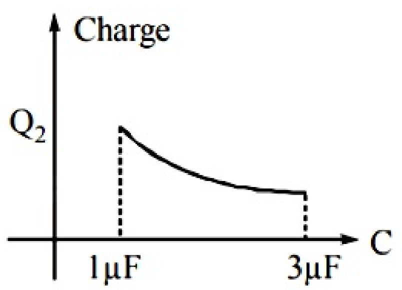
[2015]

Options:

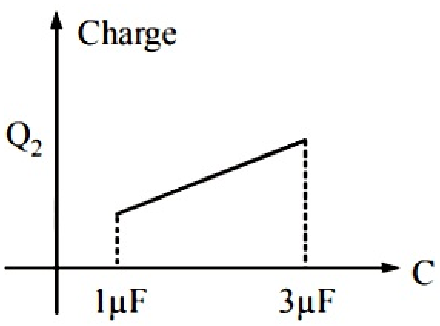
A.



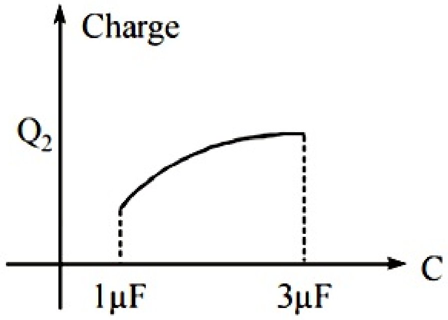
B.



C.



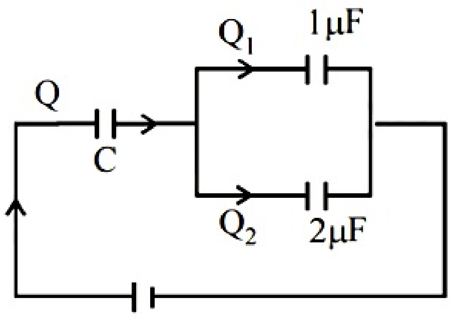
D.



Answer: D

Solution:

Solution:

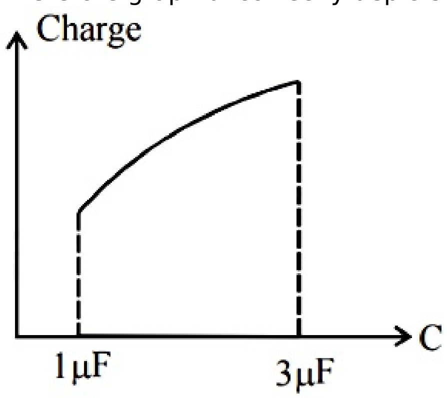


From figure, $Q_2 = \frac{2}{2+1}Q = \frac{2}{3}Q$

$Q = E\left(\frac{C \times 3}{C+3}\right)$

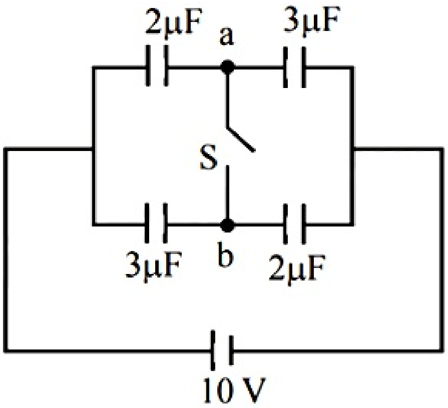
$\therefore Q_2 = \frac{2}{3}\left(\frac{3CE}{C+3}\right) = \frac{2CE}{C+3}$

Therefore graph d correctly depicts.



Question195

In figure a system of four capacitors connected across a 10 V battery is shown. Charge that will flow from switch S when it is closed is :



[Online April 11, 2015]

Options:

A. 5 μC from b to a

B. 20 μC from a to b

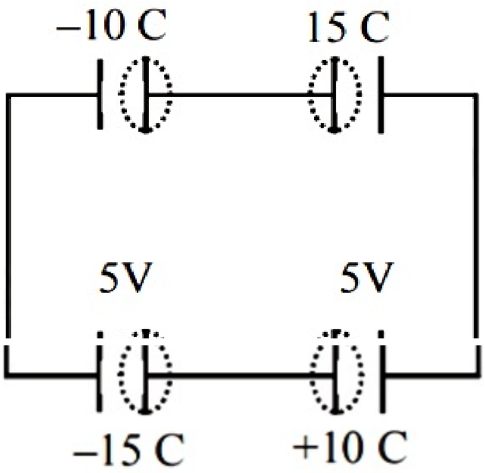
C. zero

D. 5 μC from a to b

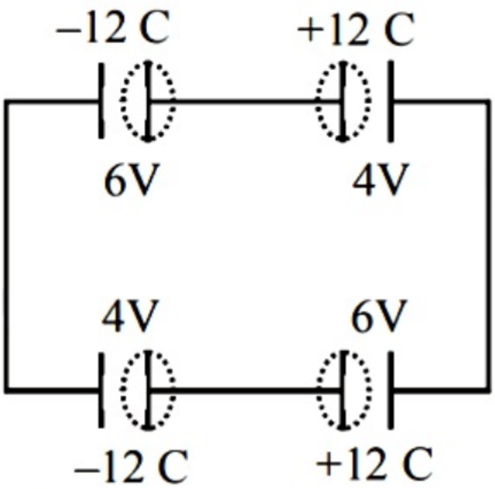
Answer: A

Solution:

when switch is closed



When switch is open



Charge of 5μc flows from b to a

Question196

Assume that an electric field $\vec{E} = 30x^2\hat{i}$ exists in space. Then the potential difference $V_A - V_O$, where V_O is the potential at the origin and V_A the potential at x = 2m is:
[2014]

Options:

A. 120 J/C

B. –120 J/C

C. –80 J/C

D. 80 J/C

Answer: C

Solution:

Potential difference between any two points in an electric field is given by,

$dV = -\vec{E}\cdot d\vec{x}$

$\int_{V_O}^{V_A} dV = -\int_0^2 30x^2 dx$

$V_A - V_O = -[10x^3]_0^2 = -80J / C$

Question197

A parallel plate capacitor is made of two circular plates separated by a distance 5mm and with a dielectric of dialectric constant 2.2 between them. When the electric field in the dielectric is $3 \times 10^4 V / m$ the charge density of the positive plate will be close to:
[2014]

Options:

A. $6 \times 10^{-7} C / m^2$

B. $3 \times 10^{-7} C / m^2$

C. $3 \times 10^4 C / m^2$

D. $6 \times 10^4 C / m^2$

Answer: A

Solution:

Electric field in presence of dielectric between the two plates of a parallel plate capaciator is given by,

$E = \frac{\sigma}{K\varepsilon_0}$

Then, charge density

$\sigma = K\varepsilon_0 E$
$= 2.2 \times 8.85 \times 10^{-12} \times 3 \times 10^4$
$\approx 6 \times 10^{-7} C / m^2$

Question198

The gap between the plates of a parallel plate capacitor of area A and distance between plates d, is filled with a dielectric whose permittivity varies linearly from $\in_1$ at one plate to $\in_2$ at the other. The capacitance of capacitor is: [Online April 19, 2014]

Options:

A. $\in_0(\in_1+\in_2)A / d$

B. $\in_0(\in_1+\in_2)A / 2d$

C. $\in_0 A / [d \ln(\in_2/\in_1)]$

D. $\in_0(\in_2-\in_1)A / [d \ln(\in_2/\in_1)]$

Answer: D

Solution:

Solution:

Question199

The space between the plates of a parallel plate capacitor is filled with a 'dielectric' whose 'dielectric constant' varies with distance as per the relation: $K(x) = K_o + \lambda x$ (λ = a constant) The capacitance C, of the capacitor, would be related to its vacuum capacitance C_0 for the relation : [Online April 12, 2014]

Options:

A. $C = \frac{\lambda d}{\ln(1 + K_o \lambda d)} C_o$

B. $C = \frac{\lambda}{d \cdot \ln(1 + K_o \lambda d)} C_o$

C. $C = \frac{\lambda d}{\ln(1 + \lambda d / K_o)} C_o$

D. $C = \frac{\lambda}{d \cdot \ln(1 + K_o / \lambda d)} C_o$

Answer: C

Solution:

Solution:
The value of dielectric constant is given as,
$K = K_0 + \lambda x$

And, $V = \int_0^d E\,dr \Rightarrow V = \int_0^d \frac{\sigma}{K} dx$

$= \sigma \int_0^d \frac{1}{(K_0 + \lambda x)} dx = \frac{\sigma}{\lambda}[\ln(K_0 + \lambda d) - \ln K_0]$

$= \frac{\sigma}{\lambda} \ln\left(1 + \frac{\lambda d}{K_0}\right)$

Now it is given that capacitance of vacuum = C_0 .

Thus, $C = \frac{Q}{V}$

$= \frac{\sigma . S}{V}\Big($ Let surface area of plates $= s)$

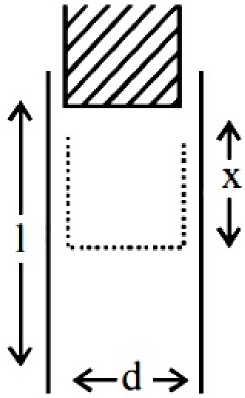
$= \frac{\sigma . S}{\frac{\sigma}{\lambda} \ln\left(1 + \frac{\lambda d}{K_0}\right)}$

$= s\lambda . \frac{d}{d} \frac{1}{\ln\left(1 + \frac{\lambda d}{K_0}\right)}$ (∵ in vacuum $\varepsilon_0 = 1$)

$c = \frac{\lambda d}{\ln\left(1 + \frac{\lambda d}{K_0}\right)} . C_0$(here, $C_0 = \frac{s}{d}\Big)$

Question200

A parallel plate capacitor is made of two plates of length 1 width w and separated by distance d. A dielectric slab (dielectric constant K) that fits exactly between the plates is held near the edge of the plates. It is pulled into the capacitor by a force $F = -\frac{U}{x}$ where U is the energy of the capacitor when dielectric is inside the capacitor up to distance x (See figure). If the charge on the capacitor is Q then the force on the dielectric when it is near the edge is :



[Online April 11, 2014]

Options:

A. $\frac{Q^2 d}{2\omega l^2 \varepsilon_0} K$

B. $\frac{Q^2\omega}{2dl^2\varepsilon_0}(K-1)$

C. $\frac{Q^2 d}{2\omega l^2\varepsilon_0}(K-1)$

D. $\frac{Q^2 w}{2dl^2\varepsilon_o}K$

Answer: C

Solution:

Solution:

Question201

Three capacitors, each of 3 μF, are provided. These cannot be combined to provide the resultant capacitance of:
[Online April 9, 2014]

Options:

A. 1 μF

B. 2 μF

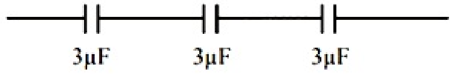
C. 4.5 μF

D. 6 μF

Answer: D

Solution:

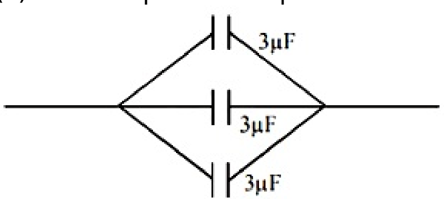
Solution:
Possible combination of capacitors
(i) Three capacitors in series combination



$\frac{1}{C_{eq}} = \frac{1}{3} + \frac{1}{3} + \frac{1}{3}$

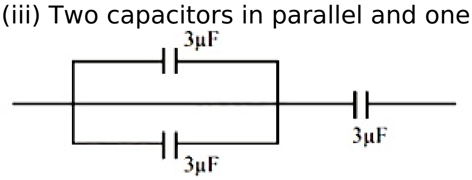
$\therefore \frac{1}{C_{eq}} = 1\mu F$

(ii) Three capacitors in parallel combination

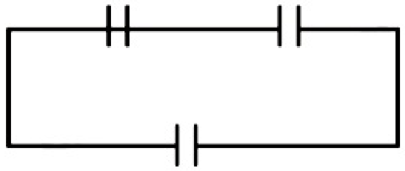


$C_{eq} = 3 + 3 + 3 = 9\mu F$

(iii) Two capacitors in parallel and one is in series



$C_{eq} = 2\mu F$
(iv) Two capacitors in series and one is in parallel



$C_{eq} = 4.5\mu F$

Question202

Consider a finite insulated, uncharged conductor placed near a finite positively charged conductor. The uncharged body must have a potential :
[Online April 23, 2013]

Options:

A. less than the charged conductor and more than at infinity.

B. more than the charged conductor and less than at infinity.

C. more than the charged conductor and more than at infinity.

D. less than the charged conductor and less than at infinity

Answer: A

Solution:

Solution:
The potential of uncharged body is less than that of the charged conductor and more than at infinity.

Question203

Two small equal point charges of magnitude q are suspended from a common point on the ceiling by insulating mass less strings of equal lengths. They come to equilibrium with each string making angle θ from the vertical. If the mass of each charge is m, then the electrostatic potential at the centre of line joining them will be $\left(\frac{1}{4\pi\epsilon_0} = k\right)$
[Online April 22, 2013]

Options:

A. $2\sqrt{kmg\tan\theta}$

B. $\sqrt{kmg\tan\theta}$

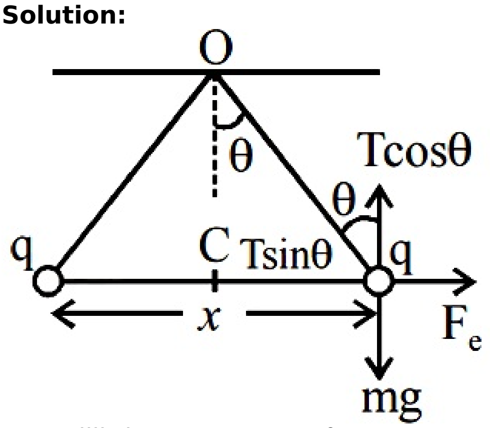
C. $4\sqrt{kmg / \tan\theta}$

D. $\sqrt{kmg / \tan\theta}$

Answer: C

Solution:

Solution:



In equilibrium, $F_e = T\sin\theta$

$mg = T\cos\theta$

$\tan\theta = \frac{F_e}{mg} = \frac{q^2}{4\pi\in_0 x^2 \times mg}$

$\therefore x = \sqrt{\frac{q^2}{4\pi\in_0 \tan\theta\, mg}}$

Electric potential at the centre of the line

$V = \frac{kq}{x/2} + \frac{kq}{\frac{x}{2}} = 4\sqrt{kmg/\tan\theta}$

Question204

A point charge of magnitude + 1 μC is fixed at (0, 0, 0). An isolated uncharged spherical conductor, is fixed with its center at (4, 0, 0). The potential and the induced electric field at the centre of the sphere is : [Online April 22, 2013]

Options:

A. $1.8 \times 10^5 V$ and $-5.625 \times 10^6 V/m$

B. $0V$ and $0V/m$

C. $2.25 \times 10^5 V$ and $-5.625 \times 10^6 V/m$

D. $2.25 \times 10^5 V$ and $0V/m$

Answer: C

Solution:

Solution:

$q = 1\mu C = 1 \times 10^{-6} C$

$r = 4cm = 4 \times 10^{-2} m$

Potential $V = \frac{kq}{r} = \frac{9 \times 10^9 \times 10^{-6}}{4 \times 10^{-2}} = 2.25 \times 10^5 V$.

Induced electric field $E = -\frac{kq}{r^2}$

$$= \frac{9 \times 10^9 \times 1 \times 10^{-6}}{16 \times 10^{-4}} = -5.625 \times 10^6 \mathrm{V} / \mathrm{m}$$

Question205

Statement 1 : No work is required to be done to move a test charge between any two points on an equipotential surface.
Statement 2 : Electric lines of force at the equipotential surfaces are mutually perpendicular to each other.
[Online April 25, 2013]

Options:

A. Statement 1 is true, Statement 2 is true, Statement 2 isthe correct explanation of Statement 1.

B. Statement 1 is true, Statement 2 is true, Statement 2 isnot the correct explanation of Statement 1.

C. Statement 1 is true, Statement 2 is false.

D. Statement 1 is false, Statement 2 is true.

Answer: C

Solution:

Solution:
The work done in moving a charge along an equipotential surface is always zero.
The direction of electric field is perpendicular to the equipotential surface or lines.

Question206

A parallel plate capacitor having a separation between the plates d, plate area A and material with dielectric constant K has capacitance C_0 . Now one-third of the material is replaced by another material with dielectric constant 2K, so that effectively there are two capacitors one with area $\frac{1}{3}$A, dielectric constant 2K and another with area $\frac{2}{3}$A and dielectric constant K. If the capacitance of this new capacitor is C then $\frac{C}{C_0}$ is
[Online April 25, 2013]

Options:

A. 1

B. $\frac{4}{3}$

C. $\frac{2}{3}$

D. $\frac{1}{3}$

Answer: B

Solution:

Solution:

$C_0 = \frac{k \in_0 A}{d}$

$C = \frac{k \in_0 2}{3d} + \frac{2k \in_0 A}{3d} = \frac{4}{3}\frac{k \in_0 A}{d}$

$\therefore \frac{C}{C_0} = \frac{\frac{4}{3}\frac{k \in_0 A}{d}}{\frac{k \in_0 A}{d}} = \frac{4}{3}$

Question207

To establish an instantaneous current of 2 A through a 1 μF capacitor ; the potential difference across the capacitor plates should be changed at the rate of :
[Online April 22, 2013]

Options:

A. 2×10^4 V/s

B. 4×10^6 V/s

C. 2×10^6 V/s

D. 4×10^4 V/s

Answer: C

Solution:

Solution:

As, $C = \frac{Q}{V} = \frac{I\,t}{V}$

$\Rightarrow \frac{V}{t} = \frac{I}{C} = \frac{2}{1 \times 10^{-6}}$

$= 2 \times 10^6 V\ /\ s$

Question208

A uniform electric field $\vec{E}$ exists between the plates of a charged condenser. A charged particle enters the space between the plates and perpendicular to $\vec{E}$. The path of the particle between the plates is a :
[Online April 9, 2013]

Options:

A. straight line

B. hyperbola

C. parabola

D. circle

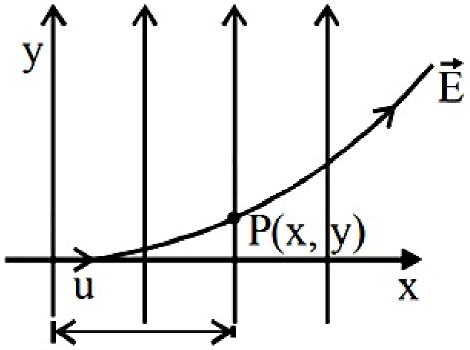
Answer: C

Solution:

Solution:
When charged particle enters perpendicularly in an electric field, it describes a parabolic path

$y = \frac{1}{2}\left(\frac{QE}{m}\right)\left(\frac{x}{4}\right)^2$

This is the equation of parabola



Question209

A charge of total amount Q is distributed over two concentric hollow spheres of radii r and R (R > r) such that the surface charge densities on the two spheres are equal. The electric potential at the common centre is [Online May 19, 2012]

Options:

A. $\frac{1}{4\pi\varepsilon_0}\frac{(R-r)Q}{(R^2+r^2)}$

B. $\frac{1}{4\pi\varepsilon_0}\frac{(R+r)Q}{2(R^2+r^2)}$

C. $\frac{1}{4\pi\varepsilon_0}\frac{(R+r)Q}{(R^2+r^2)}$

D. $\frac{1}{4\pi\varepsilon_0}\frac{(R-r)Q}{2(R^2+r^2)}$

Answer: C

Solution:

Let q_1 and q_2 be charge on two spheres of radius 'r' and ' R ' respectively
As, $q_1 + q_2 = Q$
and $\sigma_1 = \sigma_2$ [Surface charge density are equal]
$\therefore \frac{q_1}{r\pi r^2} = \frac{q_2}{4\pi R^2}$
So, $q_1 = \frac{Qr^2}{R^2 + r^2}$ and $q_2 = \frac{QR^2}{R^2 + r^2}$
Now, potential, $V = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1}{r} + \frac{q_2}{R}\right]$
$= \frac{1}{4\pi\varepsilon_0}\left[\frac{Qr}{R^2 + r^2} + \frac{QR}{R^2 + r^2}\right]$
$= \frac{Q(R + r)}{R^2 + r^2}\frac{1}{4\pi\varepsilon_0}$

Question210

The electric potential $V(x)$ in a region around the origin is given by $V(x) = 4x^2$ volts. The electric charge enclosed in a cube of 1m side with its centre at the origin is (in coulomb)
[Online May 7, 2012]

Options:

A. $8\varepsilon_0$

B. $-4\varepsilon_0$

C. 0

D. $-8\varepsilon_0$

Answer: C

Solution:

Solution:
Charges reside only on the outer surface of a conductor with cavity.

Question211

An insulating solid sphere of radius R has a uniformly positive charge density ρ . As a result of this uniform charge distribution there is a finite value of electric potential at the centre of the sphere, at the surface of the sphere and also at a point outside the sphere. The electric potential at infinite is zero.
Statement -1 When a charge q is taken from the centre to the surface of the sphere its potential energy changes by $\frac{q\rho}{3\varepsilon_0}$.
Statement -2 The electric field at a distance $r(r < R)$ from the centre of the sphere is $\frac{\rho r}{3\varepsilon_0}$.
[2012]

Options:

A. Statement 1 is true, Statement 2 is true; Statement 2 is not the correct explanation of statement 1.

B. Statement 1 is true Statement 2 is false.

C. Statement 1 is false Statement 2 is true.

D. Statement 1 is true, Statement 2 is true, Statement 2 is the correct explanation of Statement 1

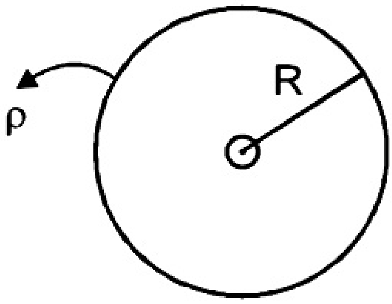
Answer: C

Solution:

Solution:

The potential energy at the centre of the sphere $U_c = \frac{3}{2}\frac{KQq}{R}$

The potential energy at the surface of the sphere $U_s = \frac{KqQ}{R}$



Now change in the energy

$\Delta U = U_c - U_s$

$= \frac{KQq}{R}\left[\frac{3}{2} - 1\right] = \frac{KQq}{2R}$

Where $Q = \rho \cdot V = \rho \cdot \frac{4}{3}\pi R^3$

$\Delta U = \frac{2K}{3}\frac{\pi R^3 \rho q}{R}$

$\Delta U = \frac{2}{3} \times \frac{1}{4\pi \in_0}\frac{\pi R^3 \rho q}{R}$

$\Delta U = \frac{R^2 \rho q}{6 \in_0}$

Using Gauss's law

$\int \vec{E} \cdot d\vec{A} = \frac{q_{en}}{E_0} = \frac{\beta \times \frac{4}{3}\pi R^3}{E_0}$

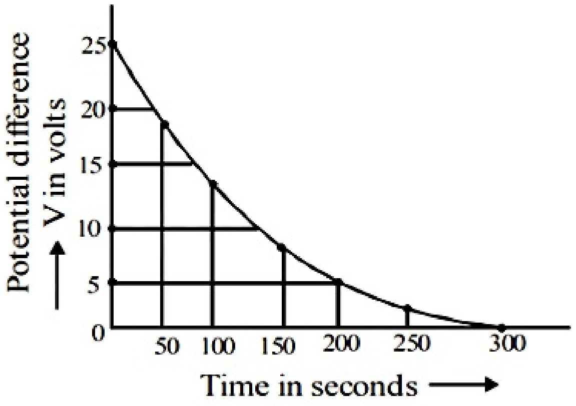
$\Rightarrow \int E\, dA(\cos\theta) = \frac{\beta \times 4\pi R^3}{3E_0}$

$\Rightarrow E\,(4\pi R^2) = \beta \times \frac{4}{3}\pi R^3 \times \frac{1}{E_0}$

$\Rightarrow E = \frac{\beta r}{3E_0}(r < R)$

Question212

The figure shows an experimental plot discharging of a capacitor in an RC circuit. The time constant τ of this circuit lies between :



[2012]

Options:

A. 150 sec and 200 sec

B. 0 sec and 50 sec

C. 50 sec and 100 sec

D. 100 sec and 150 sec

Answer: D

Solution:

Solution:
The discharging of a capacitor is given as
$q = q_0 \exp[-t / RC]$
RC = time constant $= \tau$
$q = q_0 e^{-t / \tau}$
If e is the capacitance of the capacitor
$q = CV$ and $q = CV_0$
Thus, CV $= CV_0 e^{t / \tau}$
$V = V_0 e^{-t / \tau}$ ......(i)
From the graph (given in the problem
when t = 0.5, V = 25 i.e.,
$V_0 = 25$ volt.
and when t = 200, V = 5 volt
Thus equation (i) becomes
$5 = 25 e^{-200 / \tau}$
$\Rightarrow 1 / 5 = e^{-200 / \tau}$
Taking $\log_e$ on both sides
$\log_e \frac{1}{5} = -200 / \tau \Rightarrow -\frac{200}{\tau} = \log e^5$
$\tau = \frac{200}{\log_e 5}$
or $\tau = \frac{200}{\log_e \left(\frac{10}{2}\right)} = \frac{200}{\log_e 10 - \log_e 2}$
$\tau = \frac{200}{2.302 - 0.693} = \frac{200}{1.609} = 124.300$
Which lies between 100 s and 150 s

Question213

The capacitor of an oscillatory circuit is enclosed in a container. When the container is evacuated, the resonance frequency of the circuit is 10

kHz. When the container is filled with a gas, the resonance frequency changes by 50 Hz. The dielectric constant of the gas is
[Online May 26, 2012]

Options:

A. 1.001

B. 2.001

C. 1.01

D. 3.01

Answer: C

Solution:

Solution:
The dielectric constant of the gas is 1.01

Question214

Statement 1: It is not possible to make a sphere of capacity 1 farad using a conducting material.
Statement 2: It is possible for earth as its radius is 6.4×10^6 m.
[Online May 26, 2012]

Options:

A. Statement 1 is true, Statement 2 is true, Statement 2 isthe correct explanation of Statement 1.

B. Statement 1 is false, Statement 2 is true.

C. Statement 1 is true, Statement 2 is true, Statement 2 isnot the correct explanation of Statement 1.

D. Statement 1 is true, Statement 2 is false.

Answer: D

Solution:

Solution:
Capacitance of sphere is given by :

$C = 4\pi \in_0 r$
If, $C = 1F$ then radius of sphere needed:
$r = \frac{C}{4\pi \in 0} = \frac{1}{4\pi \times 8.85 \times 10^{-12}}$
or, $r = \frac{10^{12}}{4\pi \times 8.85} = 9 \times 10^9 m$
$9 \times 10^9 m$ is very large, it is not possible to obtain such a large sphere. Infact earth has radius $6.4 \times 10^6 m$ only and capacitance of earth is $711 \mu F$.

Question215

A series combination of n_1 capacitors, each of capacity C_1 is charged by source of potential difference 4V. When another parallel combination of n_2 capacitors each of capacity C_2 is charged by a source of potential difference V, it has the same total energy stored in it as the first combination has. The value of C_2 in terms of C_1 is then [Online May 12, 2012]

Options:

A. $16\frac{n_2}{n_1}C_1$

B. $\frac{2C_1}{n_1 n_2}$

C. $2\frac{n_2}{n_1}C_1$

D. $\frac{16C_1}{n_1 n_2}$

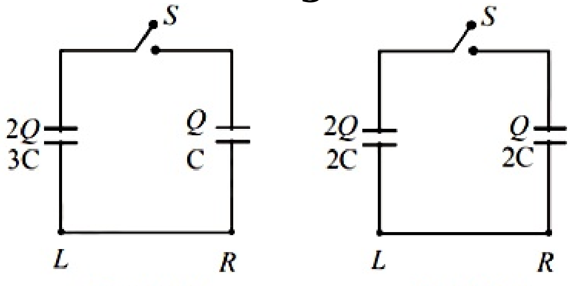
Answer: D

Solution:

Solution:
Equivalent capacitance of n_2 number of capacitors each of capacitance C_2 in parallel $= n_2C_2$
Equivalent capacitance of n_1 number of capacitors each of capacitances C_1 in series.
Capacitance of each is $C_1 = \frac{C_1}{n_1}$
According to question, total energy stored in both the combinations are same
i.e., $\frac{1}{2}\left(\frac{C_1}{n_1}\right)(4V)^2 = \frac{1}{2}(n_2C_2)V^2$
$\therefore C_2 = \frac{16C_1}{n_1 n_2}$

Question216

Two circuits (a) and (b) have charged capacitors of capacitance C, 2C and 3C with open switches. Charges on each of the capacitor are as shown in the figures. On closing the switches



Circuit (a) Circuit (b)

[Online May 7, 2012]

Options:

A. No charge flows in (a) but charge flows from R to L in

B. (b) Charges flow from L to R in both (a) and (b)

C. Charges flow from R to L in (a) and from L to R in (b)

D. No charge flows in (a) but charge flows from L to R in (b)

Answer: C

Solution:

Solution:
Charge (or current) always flows from higher potential to lower potential.
Potential $= \frac{\text{Charge}}{\text{Capacitance}}$

Question217

The electrostatic potential inside a charged spherical ball is given by $\phi = ar^2 + b$ where r is the distance from the centre and a, b are constants. Then the charge density inside the ball is: [2011]

Options:

A. $-6a\varepsilon_0 r$

B. $-24\pi a\varepsilon_0$

C. $-6a\varepsilon_0$

D. $-24\pi a\varepsilon_0 r$

Answer: C

Solution:

Solution:
Electric field
$E = -\frac{d\phi}{dr} = -2ar$ ....(i)
By Gauss's theorem
$E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$........(ii)
From (i) and (ii),
$Q = -8\pi\varepsilon_0 ar^3$
$\Rightarrow dq = -24\pi\varepsilon_0 ar^2 dr$
Charge density, $\rho = \frac{dq}{4\pi r^2 dr} = -6\varepsilon_0 a$

Question218

Two positive charges of magnitude ‘q’ are placed, at the ends of a side (side 1) of a square of side ‘2a’. Two negative charges of the same magnitude are kept at the other corners.
Starting from rest, if a charge Q moves from the middle of side 1 to the centre of square, its kinetic energy at the centre of square is
[2011 RS]

Options:

A. zero

B. $\frac{1}{4\pi\varepsilon_0}\frac{2qQ}{a}\left(1+\frac{1}{\sqrt{5}}\right)$

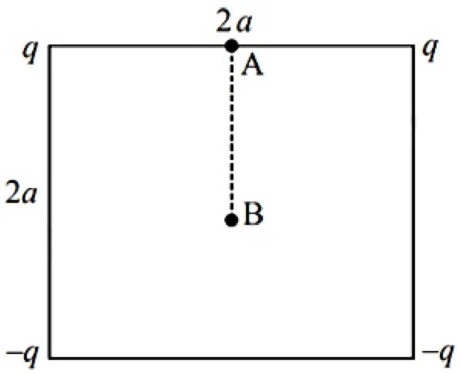
C. $\frac{1}{4\pi\varepsilon_0}\frac{2qQ}{a}\left(1-\frac{2}{\sqrt{5}}\right)$

D. $\frac{1}{4\pi\varepsilon_0}\frac{2qQ}{a}\left(1-\frac{1}{\sqrt{5}}\right)$

Answer: D

Solution:

Solution:
Initial potential of the charge,
$V_A = \frac{2kq}{a} - \frac{2kq}{a\sqrt{5}}$
$\Rightarrow V_A = \frac{1}{4\pi E}\frac{2q}{a}\left(1-\frac{1}{\sqrt{5}}\right)$
(Here potential due to each $q = \frac{kq}{a}$ and potential due to each $-q = \frac{-kq}{a\sqrt{5}}$)



Final potential of the charge
$V_B = 0$
(∵ Point B is equidistant from all the four charges)
∴ Using work energy theorem,
$(W_{AB})_{electric} = Q(V_A - V_B)$
$= \frac{2qQ}{4\pi E_0 a}\left[1-\frac{1}{\sqrt{5}}\right]$
$= \left(\frac{1}{4\pi\varepsilon_0}\right)\frac{2Qq}{a}\left[1-\frac{1}{\sqrt{5}}\right]$

Question219

Let C be the capacitance of a capacitor discharging through a resistor R. Suppose t_1 is the time taken for the energy stored in the capacitor to reduce to half its initial value and t_2 is the time taken for the charge to reduce to one-fourth its initial value. Then the ratio t_1 / t_2 will be [2010]

Options:

A. 1

B. $\frac{1}{2}$

C. $\frac{1}{4}$

D. 2

Answer: C

Solution:

Solution:

Initial energy of capacitor, $E_1 = \frac{q_1^2}{2C}$

Final energy of capacitor,

$E_2 = \frac{1}{2}E_1 = \frac{q_1^2}{4C} = \frac{\left(\frac{q_1}{\sqrt{2}}\right)^2}{2C}$

$\therefore t_1 =$ time for the charge to reduce to $\frac{1}{\sqrt{2}}$ of its initial value

and $t_2 =$ time for the charge to reduce to $\frac{1}{4}$ of its initial value

We have, $q_2 = q_1 e^{-\frac{t}{C}R} \Rightarrow \ln\left(\frac{q_2}{q_1}\right) = -\frac{t}{CR}$

$\therefore \ln\left(\frac{1}{\sqrt{2}}\right) = \frac{-t_1}{CR}$ ....(1)

and $\ln\left(\frac{1}{4}\right) = \frac{-t_2}{CR}$ ....(2)

By(1) and (2), $\frac{t_1}{t_2} = \frac{\ln\left(\frac{1}{\sqrt{2}}\right)}{\ln\left(\frac{1}{4}\right)} = \frac{1}{2}\frac{\ln\left(\frac{1}{2}\right)}{2\ln\left(\frac{1}{2}\right)} = \frac{1}{4}$

Question220

Two points P and Q are maintained at the potentials of 10 V and -4~V, respectively. The work done in moving 100 electrons from P to Q is: [2009]

Options:

A. 9.60×10^{-17}J

B. -2.24×10^{-16}J

C. 2.24×10^{-16}J

D. -9.60×10^{-17}J

Answer: C

Solution:

Solution:
Work done, $W_{PQ} = q(V_Q - V_P)$
$= (-100 \times 1.6 \times 10^{-19})(-4 - 10)$
$= +2.24 \times 10^{-16}$J

Question221

A parallel plate capacitor with air between the plates has capacitance of 9 pF. The separation between its plates is 'd'. The space between the plates is now filled with two dielectrics. One of the dielectrics has dielectric constant $k_1 = 3$ and thickness $\frac{d}{3}$ while the other one has dielectric constant $k_2 = 6$ and thickness $\frac{2d}{3}$. Capacitance of the capacitor is now
[2008]

Options:

A. 1.8 pF

B. 45 pF

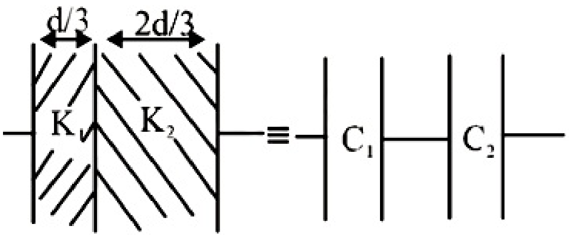
C. 40.5 pF

D. 20.25 pF

Answer: C

Solution:

Solution:



The capacitance with air between the plates
$C = \frac{\varepsilon_0 A}{d} = 9\text{pF}$
On introducing two dielectric between the plates, the given capacitance is equal to two capacitances connected in series where
$C_1 = \frac{k_1 \in_0 A}{d / 3} = \frac{3 \in_0 A}{d / 3}$
$= \frac{3 \times 3 \in_0 A}{d} = \frac{9 \in_0 A}{d}$ and $C_2 = \frac{k_2 \in_0 A}{2d / 3} = \frac{3k_2 \in_0 A}{2d}$
$= \frac{3 \times 6 \in_0 A}{2d} = \frac{9 \in_0 A}{d}$

The equivalent capacitance C_{eq} is

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$= \frac{d}{9 \in_0 A} + \frac{d}{9 \in_0 A} = \frac{2d}{9 \in_0 A}$$

$$\therefore C_{eq} = \frac{9}{2}\frac{\in_0 A}{d} = 92 \times 9pF \quad = 40.5pF$$

Question222

An electric charge $10^{-3}\mu C$ is placed at the origin (0,0) of $X - Y$ co-ordinate system. Two points A and B are situated at $(\sqrt{2}, \sqrt{2})$ and (2,0) respectively. The potential difference between the points A and B will be [2007]

Options:

A. 4.5 volts

B. 9 volts

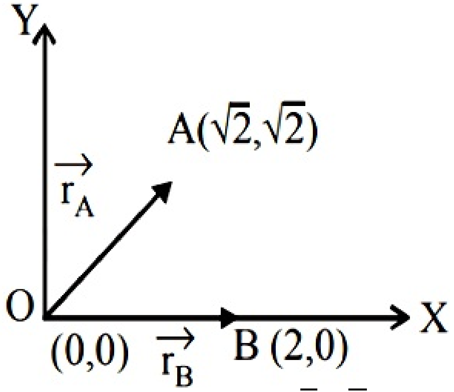
C. Zero

D. 2 volt

Answer: C

Solution:

Solution:



The distance of point $A(\sqrt{2}, \sqrt{2})$ from the origin,
$r_A = \sqrt{(\sqrt{2})^2 + (\sqrt{2})^2} = \sqrt{4} = 2$ units.
The distance of point $B(2, 0)$ from the origin,
$r_B = \sqrt{(2)^2 + (0)^2} = 2$ units
Now, potential at A, due to charge $\theta = 10^{-3}\mu C$

$$V_A = \frac{1}{4\pi\in_0} \cdot \frac{Q}{(r_A)}$$

Potential at B, due to charge $Q = 10^{-3}QCV_B = \frac{1}{4\pi\in_0} \cdot \frac{Q}{(r_B)}$

∴ Potential difference between the points A and B is given by

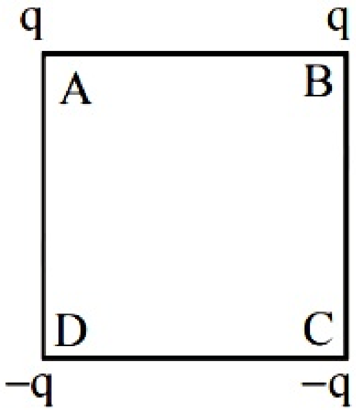
$$V_A - V_B = \frac{1}{4\pi\in_0} \cdot \frac{10^{-3}}{r_A} - \frac{1}{4\pi\in_0} \cdot \frac{10^{-3}}{r_B}$$

$$= \frac{10^{-3}}{4\pi\in_0}\left(\frac{1}{r_A} - \frac{1}{r_B}\right) = \frac{10^{-3}}{4\pi\in_0}\left(\frac{1}{2} - \frac{1}{2}\right)$$

$$= \frac{Q}{4\pi\in_0} \times 0 = 0$$

Question223

Charges are placed on the vertices of a square as shown. Let $\vec{E}$ be the electric field and V the potential at the centre. If the charges on A and B are interchanged with those on D and C respectively, then



[2007]

Options:

A. $\vec{E}$ changes, V remains unchanged

B. $\vec{E}$ remains unchanged, V changes

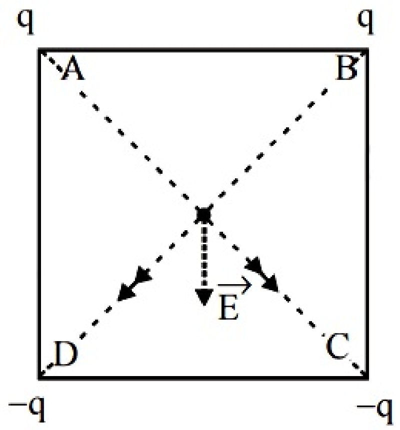
C. both $\vec{E}$ and V change

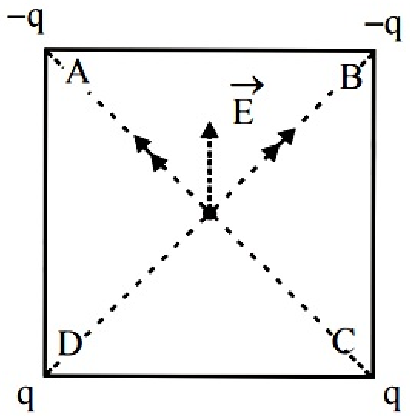
D. $\vec{E}$ and V remain unchanged

Answer: A

Solution:

As shown in the figure, the resultant electric fields before and after interchanging the charges will have the same magnitude, but opposite directions.
As potential is a scalar quantity, So the potential will be same in both cases.





Question224

The potential at a point x (measured in μ m) due to some charges situated on the x-axis is given by V (x) = 20 / (x^2–4) volt. The electric field E at x = 4 μ m is given by [2007]

Options:

A. (10/9) volt/ μ m and in the +ve x direction

B. (5/3) volt/ μ m and in the –ve x direction

C. (5/3) volt/ μ m and in the +ve x direction

D. (10/9) volt/ μ m and in the –ve x direction

Answer: A

Solution:

Solution:

Given, potential $V(x) = \frac{20}{x^2 - 4}$ volt

Electric field $E = -\frac{dV}{dx} = -\frac{d}{dx}\left(\frac{20}{x^2 - 4}\right)$

$\Rightarrow E = +\frac{40x}{(x^2 - 4)^2}$

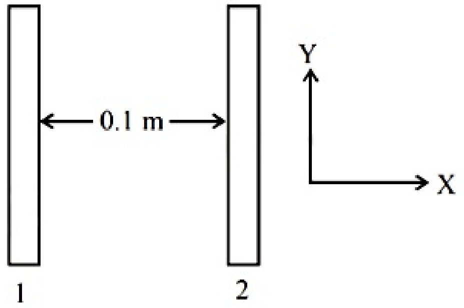
At $x = 4\mu m$

$E = +\frac{40 \times 4}{(4^2 - 4)^2} = +\frac{160}{144} = +\frac{10}{9}$ volt /μm

Positive sign indicates that $\vec{E}$ is in +ve x-direction.

Question225

A parallel plate condenser with a dielectric of dielectric constant K between the plates has a capacity C and is charged to a potential V volt. The dielectric slab is slowly removed from between the plates and then reinserted. The net work done by the system in this process is



[2007]

Options:

A. zero

B. $\frac{1}{2}(K-1)CV^2$

C. $\frac{CV^2(K-1)}{K}$

D. $(K-1)CV^2$

Answer: A

Solution:

Solution:

The potential energy of a charged capacitor is given by $U=\frac{Q^2}{2C}$.

When a dielectric slab is introduced between the plates the energy is given by $\frac{Q^2}{2KC}$ where K is the dielectric constant. Again, when the dielectric slab is removed slowly its energy increases to initial potential energy. Thus, work done is zero.

Question226

Two insulating plates are both uniformly charged in such a way that the potential difference between them is $V_2-V_1=20V$. (i.e., plate 2 is at a higher potential). The plates are separated by $d=0.1m$ and can be treated as infinitely large. An electron is released from rest on the inner surface of plate 1. What is its speed when it hits plate 2?($e=1.6\times10^{-19}C$, $m_e=9.11\times10^{-31}kg$)

[2006]

Options:

A. $2.65 \times 10^{6} \mathrm{m} / \mathrm{s}$

B. $7.02 \times 10^{12} \mathrm{m} / \mathrm{s}$

C. $1.87 \times 10^{6} \mathrm{m} / \mathrm{s}$

D. $32 \times 10^{-19} \mathrm{m} / \mathrm{s}$

Answer: A

Solution:

Solution:
Gain in kinetic energy = work done by potential difference

$$eV = \frac{1}{2} m v^{2} \Rightarrow v = \sqrt{\frac{2eV}{m}}$$

$$= \sqrt{\frac{2 \times 1.6 \times 10^{-19} \times 20}{9.1 \times 10^{-31}}} = 2.65 \times 10^{6} \mathrm{m} / \mathrm{s}$$

Question227

Two thin wire rings each having a radius R are placed at a distance d apart with their axes coinciding. The charges on the two rings are +q and -q. The potential difference between the centres of the two rings is [2005]

Options:

A. $\frac{q}{2\pi \epsilon_{0}}\left[\frac{1}{R}-\frac{1}{\sqrt{R^{2}+d^{2}}}\right]$

B. $\frac{qR}{4\pi \epsilon_{0} d^{2}}$

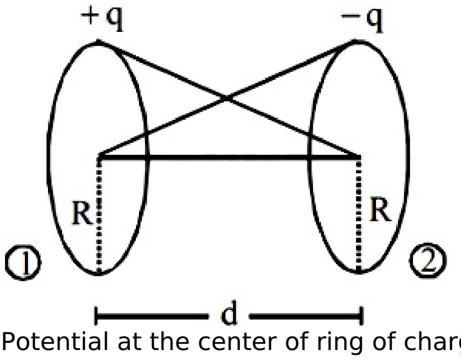
C. $\frac{q}{4\pi \epsilon_{0}}\left[\frac{1}{R}-\frac{1}{\sqrt{R^{2}+d^{2}}}\right]$

D. zero

Answer: A

Solution:

Solution:



Potential at the center of ring of charge +q = potential due to it self + potential due to other ring of charge –q.

$\Rightarrow V_1 = \frac{1}{4\pi\varepsilon_0}\left[\frac{q}{R} - \frac{q}{\sqrt{R^2 + d^2}}\right]$

Potential at the centre of ring of charge –q = potential due to itself + potential due to other ring of charge +q.

$\Rightarrow V_2 = \frac{1}{4\pi\varepsilon_0}\left[\frac{-q}{R} + \frac{q}{\sqrt{R^2 + d^2}}\right]$

$\Delta V = V_1 - V_2$

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

$= \frac{1}{2\pi\varepsilon_0}\left[\frac{q}{R} - \frac{q}{\sqrt{R^2 + d^2}}\right]$

Question228

A parallel plate capacitor is made by stacking n equally spaced plates connected alternatively. If the capacitance between any two adjacent plates is ‘C’ then the resultant capacitance is [2005]

Options:

A. (n + 1) C

B. (n – 1) C

C. nC

D. C

Answer: B

Solution:

Solution:
As n plates are joined alternately positive plate of all(n – 1) capacitor are connected to one point and negative plate of all (n – 1) capacitors are connected to other point.
It means (n – 1) capacitors joined in parallel.
∴ Resultant capacitance = (n – 1)C

Question229

A fully charged capacitor has a capacitance ‘C’. It is discharged through a small coil of resistance wire embedded in a thermally insulated block of specific heat capacity ‘s’ and mass ‘m’. If the temperature of the block is raised by ‘ΔT’, the potential difference ‘V’ across the capacitance is [2005]

Options:

A. $\frac{mC\Delta T}{s}$

B. $\sqrt{\frac{2mC\Delta T}{s}}$

C. $\sqrt{\frac{2ms\Delta T}{C}}$

D. $\frac{ms\Delta T}{C}$

Answer: C

Solution:

Solution:
Applying conservation of energy,
Electric potential energy of capacitor = heat absorbed
$\frac{1}{2}CV^2 = m \,.\, s\Delta t;\ V = \sqrt{\frac{2m \,.\, s \,.\, \Delta t}{C}}$

Question230

A charged particle ‘q’ is shot towards another charged particle ‘Q’ which is fixed, with a speed ‘v’. It approaches ‘Q’ upto a closest distance r and then returns. If q were given a speed of ‘2v’ the closest distances of approach would be
[2004]

Options:

A. r/2

B. 2 r

C. r

D. r/4

Answer: D

Solution:

Solution:
$\frac{1}{2}mv^2 = \frac{kQq}{r}$
$\Rightarrow \frac{1}{2}m(2v)^2 = \frac{kqQ}{r'} \Rightarrow r' = \frac{r}{4}$

Question231

A thin spherical conducting shell of radius R has a chargeq. Another charge Q is placed at the centre of the shell.
The electrostatic potential at a point P, a distance $\frac{R}{2}$ from the centre of

the shell is
[2003]

Options:

A. $\frac{2Q}{4\pi\varepsilon_o R}$

B. $\frac{2Q}{4\pi\varepsilon_o R} - \frac{2q}{4\pi\varepsilon_o R}$

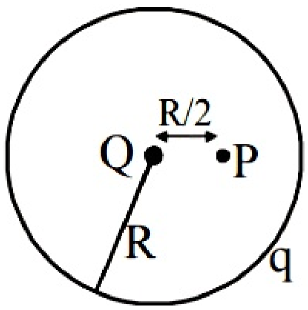
C. $\frac{2Q}{4\pi\varepsilon_o R} + \frac{q}{4\pi\varepsilon_o R}$

D. $\frac{(q+Q)2}{4\pi\varepsilon_o R}$

Answer: C

Solution:

Solution:
Electric potential due to charge Q at point P is



$V_1 = \frac{1}{4\pi\varepsilon_o}\frac{Q}{R/2} = \frac{1}{4\pi\varepsilon_o}\frac{2Q}{R}$

Electric potential due to charge q inside the shell is

$V_2 = \frac{1}{4\pi\varepsilon_o}\frac{q}{R}$

∴ The net electric potential at point P is

$V = V_1 + V_2 = \frac{1}{4\pi\varepsilon_0}\frac{2Q}{R} + \frac{1}{4\pi\varepsilon_o}\frac{q}{R}$

Question232

A sheet of aluminium foil of negligible thickness is introduced between the plates of a capacitor. The capacitance of the capacitor [2003]

Options:

A. decreases

B. remains unchanged

C. becomes infinite

D. increases

Answer: B

Solution:

Solution:

The capacitance without aluminium foil is $C = \frac{\varepsilon_0 A}{d}$

Here, d is distance between the plates of a capacitor
A = Area of plates of capacitor
When an aluminium foil of thickness t is introduced between the plates.

Capacitance, $C' = \frac{\varepsilon_0 A}{d - t}$

If thickness of foil is negligible $50d - t \sim d$. Hence, C = C′.

Question233

The work done in placing a charge of 8×10^{-18} coulomb on a condenser of capacity 100 micro-farad is [2003]

Options:

A. 16×10^{-32} joule

B. 3.1×10^{-26} joule

C. 4×10^{-10} joule

D. 32×10^{-32} joule

Answer: D

Solution:

Solution:
The work done is stored in the form of potential energy which is given by

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

$\therefore U = \frac{1}{2} \times \frac{(8 \times 10^{-18})^2}{100 \times 10^{-6}} = 32 \times 10^{-32} J$

Question234

On moving a charge of 20 coulomb by 2 cm, 2 J of work is done, then the potential difference between the points is [2002]

Options:

A. 0.1 V

B. 8 V

C. 2 V

D. 0.5 V

Answer: A

Solution:

Solution:
By using
$W = q(V_B - V_A)$
$\therefore V_B - V_A = \frac{2J}{20C} = 0.1J / C = 0.1V$

Question235

If there are n capacitors in parallel connected to V volt source, then the energy stored is equal to [2002]

Options:

A. CV

B. $\frac{1}{2}nCV^2$

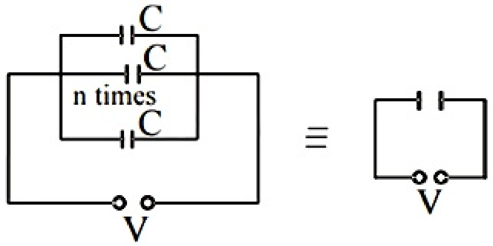
C. CV^2

D. $\frac{1}{2n}CV^2$

Answer: B

Solution:

Solution:
In parallel, equivalent capacitance of n capacitor of capacitance C
C' = nC
Energy stored in this capacitor
$E = \frac{1}{2}C^1V^2$
$\Rightarrow E = \frac{1}{2}(nC)V^2 = \frac{1}{2}nCV^2$



Question236

Capacitance (in F) of a spherical conductor with radius 1 m is [2002]

Options:

A. 1.1×10^{-10}

B. 10^{-6}

C. 9×10^{-9}

D. 10^{-3}

Answer: A

Solution:

Capacitance of spherical conductor $= 4\pi E_0 R$
Here, R is radius of conductor
$\therefore C = 4\pi \in_0 R = \frac{1}{9 \times 10^9} \times 1 = 1.1 \times 10^{-10} F$
