Prabhu Classes

NEET 2020

Time : 75 Min	Phy : Electrostatics	Marks : 180

01) Two spherical conductors B and C having equal radii and carrying equal charges in them repel each other with a force F when kept apart at some distance. A third spherical conductor having same radius as that of B but uncharged is brought in contact with B, then brought in contact with C and finally removed away from both. The new force of repulsion between B and C is
A) 3F/4
B) F/4
C) 3F/8
D) F/8

02) A spherical conducting shell of inner radius r_1 and outer radius r_2 has a charge Q. A charge -q is placed at the centre of the shell. What will be the surface charge density on the inner and outer surfaces of the shell?
A) $\frac{-q}{4\pi r_1^2}$ and $\frac{Q+q}{4\pi r_2^2}$
B) $\frac{q}{4\pi r_1^2}$ and $\frac{Q}{4\pi r_2^2}$
C) $\frac{q}{4\pi r_1^2}$ and $\frac{Q-q}{4\pi r_2^2}$
D) 0 and $\frac{Q-q}{4\pi r_2^2}$

03) Force of attraction between two point charges Q and - Q separated by d metre is F_e. When these charges are placed on two identical spheres of radius R = 0.3 d whose centres are d metre apart, the force of attraction between them is
A) equal to F_e.
B) greater than F_e.
C) less than F_e.
D) less than F_e.

04) Two charges each of 1 coulomb are at a distance 1 km apart, the force between them is
A) 10^4 Newton
B) 9×10^3 Newton
C) 9×10^{-3} Newton
D) 1.1×10^{-4} Newton

05) Two charges placed in air repel each other by a force of 10^{-4} N. When oil is introduced between the charges, the force becomes 2.5×10^{-5} N. The dielectric constant of oil is
A) 4.0
B) 2.5
C) 2.0
D) 0.25

06) An electron of mass m_e initially at rest moves through a certain distance in a uniform electric field in time t_1. A proton of mass m_p also initially at rest takes time t_2 to move through an equal distance in this uniform electric field. Neglecting the effect of gravity, the ratio of t_2/t_1 is nearly equal to
A) $(m_p / m_e)^{1/2}$
B) $(m_e / m_p)^{1/2}$
C) 1836
D) 1

07) Two parallel plates have equal and opposite charge. When the space between them is evacuated, the electric field between the plates is 2×10^5 V/m. When the space is filled with dielectric, the electric field becomes 1×10^5 V/m. The dielectric constant of the dielectric material
A) 3
B) 2
C) 1
D) 1/2

08) The electric field near a conducting surface having a uniform surface charge density σ is given by
A) $\frac{2\sigma}{\varepsilon_0}$ and is normal to the surface.
B) $\frac{\sigma}{\varepsilon_0}$ and is normal to the surface.
C) $\frac{2\sigma}{\varepsilon_0}$ and is parallel to the surface.
D) $\frac{\sigma}{\varepsilon_0}$ and is parallel to the surface.

09) A charged drop of mass 3.2×10^{-12} g floats between two horizontal parallel plates maintained at potential difference of 980 V and separation between the plates 2 cm. Wht is the number of excess or deficient electrons on the drop?
A) 16
B) 8
C) 4
D) 2

10) A spherical conductor of radius 2 m is charged to a potential of 120 V. It is now placed inside another hollow spherical conductor of radius 6m. Calculate the potential to which the bigger sphere would be raised

A) 80 V
B) 60 V
C) 40 V
D) 20 V

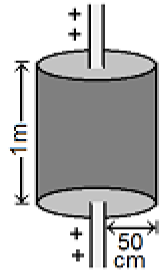
11) A point Q lies on the perpendicular bisector of an electrical dipole of dipole moment p. If the distance of Q from the dipole is r (much larger than the size of the dipole), then electric field at Q is proportional to
A) p and r^{-3}
B) p^{-1} and r^{-2}
C) p and r^{-2}
D) p^{-1} and r^{-2}

12) An electric dipole is placed along the x-axis at the origin O. A point P is at a distance of 20 cm from this origin such that OP makes an angle $\frac{\pi}{3}$ with the x-axis. If the electric field at P makes an angle θ with the x-axis, the value of θ would be
A) $\frac{\pi}{3}$
B) $\frac{2\pi}{3}$
C) $\tan^{-1}\left(\frac{\sqrt{3}}{2}\right)$
D) $\frac{\pi}{3}+\tan^{-1}\left(\frac{\sqrt{3}}{2}\right)$

13) If a spherical conductor comes out from the closed surface of the sphere, then total flux emitted from the surface will be
A) $\varepsilon_0 \times$(charge enclosed by surface)
B) $\frac{1}{\varepsilon_0}\times$(the charge enclosed by surface)
C) $\frac{1}{4\pi\varepsilon_0}\times$(charge enclosed by surface)
D) 0

14) A charge q is located at the center of a cube. The electric flux through any face is
A) $\frac{4\pi q}{6(4\pi\varepsilon_0)}$
B) $\frac{2\pi q}{6(4\pi\varepsilon_0)}$
C) $\frac{\pi q}{6(4\pi\varepsilon_0)}$
D) $\frac{q}{6(4\pi\varepsilon_0)}$

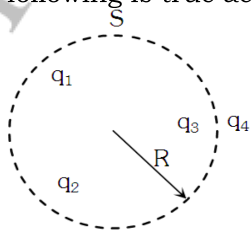
15) Electric charge is uniformly distributed along a long straight wire of radius 1 mm. The charge per cm length of the wire is Q coulomb. Another cylindrical surface of radius 50 cm and length 1 m symmetrically encloses the wire as shown in the figure below. The total electric flux passing through the cylindrical surface is



A) $\frac{10Q}{(\pi\varepsilon_0)}$
B) $\frac{100Q}{(\pi\varepsilon_0)}$
C) $\frac{Q}{\varepsilon_0}$
D) $\frac{100Q}{\varepsilon_0}$

16) A cylinder of radius R and length L is placed in a uniform electric field E parallel to the cylinder axis. The total flux for the surface of the cylinder is given by
A) Zero
B) $\pi R^2 / E$
C) $2\pi R^2 E$
D) $(\pi R^2 - \pi R) / E$

17) q_1, q_2, q_3, and q_4 are point charges located at points as shown in the figure and S is a spherical Gaussian surface of radius R. Which of the following is true according to the Gauss's law?

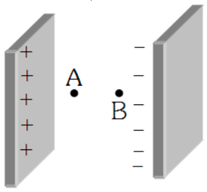


A) $\oint_s (\vec{E}_1+\vec{E}_2+\vec{E}_3).d\vec{A} = \frac{q_1+q_2+q_3}{2\varepsilon_0}$
B) $\oint_s (\vec{E}_1+\vec{E}_2+\vec{E}_3).d\vec{A} = \frac{(q_1+q_2+q_3+q_4)}{\varepsilon_0}$
C) $\oint_s (\vec{E}_1+\vec{E}_2+\vec{E}_3).d\vec{A} = \frac{(q_1+q_2+q_3)}{\varepsilon_0}$
D) None of the above

18) In a spherical condenser radius of the outer sphere is R. The difference in the radii of outer and inner sphere in x. Its capacity is proportional to
A) $\frac{R}{x}$
B) $\frac{R(R-x)}{x}$
C) $\frac{x(R-x)}{r}$
D) $\frac{xR}{(R-x)}$

19) N identical drops of mercury are charged simultaneously to 10 volt. When combined to form one large drop, the potential is found to be 40 volt, evaluate N.
A) 10
B) 8
C) 6
D) 4

20) Two protons A and B are placed in space between plates of a parallel plate capacitor charged up to V volts (See fig.). Forces on protons are F_A and F_B, then



A) $F_A = F_B$
B) $F_A > F_B$
C) $F_A < F_B$
D) Nothing can be said

21) The area of the plates of a parallel plate condenser is A and the distance between the plates is 10 mm. There are two dielectric sheets in it, one of dielectric constant 10 and thickness 6 mm and the other of dielectric constant 5 and thickness 4 mm. The capacity of the condenser is
A) $1500\,\varepsilon_0 A$
B) $\frac{2}{3}\varepsilon_0 A$
C) $\frac{12}{35}\varepsilon_0 A$
D) $\frac{5000}{7}\varepsilon_0 A$

22) A capacitor of capacity C is connected with a battery of potential V in parallel. The distance between its plates is reduced to half at once, assuming that the charge remains the same. Then to charge the capacitance upto the potential V again, the energy given by the battery will be
A) CV^2
B) $CV^2 / 2$
C) $CV^2 / 4$
D) $3CV^2 / 4$

23) The distance between the plates of a parallel plate capacitor is d. A metal plate of thickness d/2 is placed between the plates. The capacitance would then be
A) doubled.
B) zero.
C) halved.
D) unchanged.

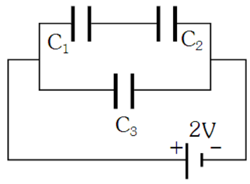
24) A parallel plate capacitor of plate area A and plate separation d is charged to potential V and then the battery is disconnected. A slab of dielectric constant k is then inserted between the plates of the capacitors so as to fill the space between the plates. If Q, E and W denote respectively, the magnitude of charge on each plate, the electric field between the plates (after the slab is inserted) and work done on the system in question in the process of inserting the slab, then state incorrect relation from the following.
A) $E = \frac{V}{kd}$
B) $Q = \frac{\varepsilon_0 AV}{d}$
C) $W = \frac{\varepsilon_0 AV^2}{2kd}$
D) $W = \frac{\varepsilon_0 AV^2}{2d}\left(1 - \frac{1}{k}\right)$

25) A parallel plate capacitor has plate area A and separation d. It is charged to a potential difference V_0. The charging battery is disconnected and the plates are pulled apart to three times the initial separation. The work required to separate the plates is
A) $\frac{\varepsilon_0 AV_0^2}{d}$
B) $\frac{\varepsilon_0 AV_0^2}{3d}$
C) $\frac{\varepsilon_0 AV_0^2}{2d}$
D) $\frac{3\varepsilon_0 AV_0^2}{d}$

26) A parallel plate capacitor is charged to a potential difference of 50 volts. It is then discharged through a resistance for 2 seconds and its potential drops by 10 volts. Estimate the fraction of energy stored in the capacitance.
A) 0.64
B) 0.50
C) 0.25
D) 0.14

27) Eight drops of mercury of equal radii possessing equal charges combine to form a big drop. Then the capacitance of bigger drop compared to each individual small drop is
A) 32 times
B) 8 times
C) 4 times
D) 2 times

28) Two capacitors $C_1 = 2\,\mu F$ and $C_2 = 6\,\mu F$ in series, are connected in parallel to a third capacitor $C_3 = 4\,\mu F$. This arrangement is then connected to a battery of e. m. f. = 2 V, as shown in the figure. How much energy is lost by the battery in charging the capacitors?



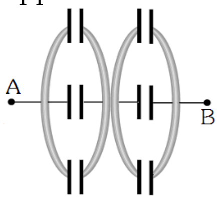
A) 11×10^{-6} J

B) 22×10^{-6} J

C) $\left(\frac{16}{3}\right)\times10^{-6}$ J

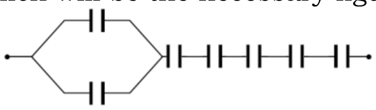
D) $\left(\frac{32}{3}\right)\times10^{-6}$ J

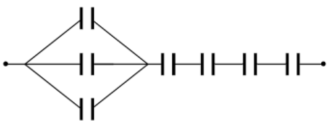
29) All six capacitors shown are identical, Each can withstand maximum 200 volts between its terminals. The maximum voltage that can be safely applied between A and B is

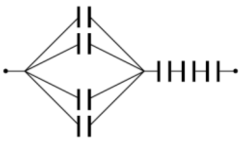


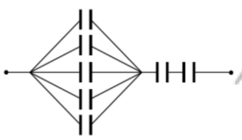
A) 200 V
B) 400 V
C) 800 V
D) 1200 V

30) Seven capacitors each of capacity $2\mu F$ are to be so connected to have a total capacity $\frac{10}{11}\mu F$. Which will be the necessary figure as shown?

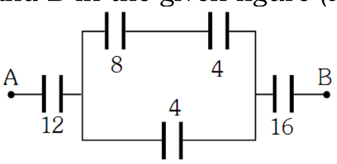
A) 

B) 

C) 

D) 

31) What is the equivalent capacitance between A and B in the given figure (all are in farad)?



A) $\frac{1}{31}$F

B) $\frac{13}{18}$F

C) $\frac{48}{13}$F

D) $\frac{240}{71}$F

32) Two capacitors of $1\,\mu F$ and $2\,\mu F$ are connected in series, the resultant capacitance will be

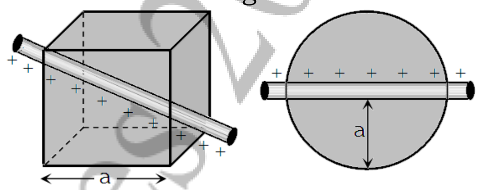
A) $3\,\mu F$

B) $\frac{3}{2}\,\mu F$

C) $\frac{2}{3}\,\mu F$

D) $4\,\mu F$

33) A linear charge having linear charge density λ, penetrates a cube diagonally and then it penetrate a sphere diametrically as shown. What will be the ratio of flux coming out of cube and sphere?



A) $\frac{1}{1}$

B) $\frac{1}{2}$

C) $\frac{2}{\sqrt{3}}$

D) $\frac{\sqrt{3}}{2}$

34) A positively charged ball hangs from a silk thread. We put a positive test charge q_o at a point and measure F/q_o, then it can be predicted that the electric field strength E

A) < F/q_o
B) > F/q_o
C) = F/q_o
D) Cannot be estimated

35) An arc of radius r carries charge. The linear density of charge is λ and the arc subtends a angle $\frac{\pi}{3}$ at the centre. What is electric potential at the center is

A) $\frac{\lambda}{16\varepsilon_0}$

B) $\frac{\lambda}{12\varepsilon_0}$

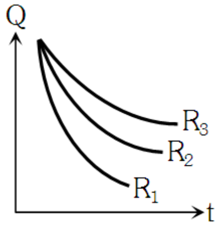
C) $\frac{\lambda}{8\varepsilon_0}$

D) $\frac{\lambda}{4\varepsilon_0}$

36) In a parallel plate capacitor the separation between the plates is 3 mm with air between them.

Now a
1 mm thick layer of a material of dielectric constant 2 is introduced between the plates due to which the capacity increases. In order to bring its capacity to the original value the separation between the plates must be made
A) 4.5 mm
B) 3.5 mm
C) 2.5 mm
D) 1.5 mm

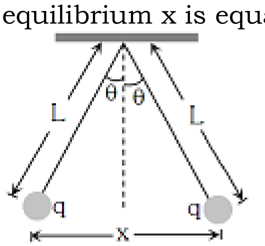
37) Three identical capacitors are given a charge Q each and they are then allowed to discharge through resistance R_1, R_2 and R_3. Their charges, as a function of time shown in the following graph. The smallest of the three resistance is



A) R_1
B) R_2
C) R_3
D) Cannot be predicted

38) A $4\,\mu F$ capacitor, a resistance of $2.5\ M\Omega$ is in series with 12 V battery. Find the time after which the potential difference across the capacitor is 3 times the potential difference across the resistor. [Given ln (2) = 0.693]
A) 14 s
B) 13.86 s
C) 7 s
D) 6.93 s

39) In the given figure two tiny conducting balls of identical mass m and identical charge q hang from non-conducting threads of equal length L. Assume that θ is so small that $\tan\theta \approx \sin\theta$, then for equilibrium x is equal to



A) $\left(\dfrac{q^2L}{4\pi\varepsilon_0 mg}\right)^{\frac{1}{3}}$

B) $\left(\dfrac{q^2L^2}{4\pi\varepsilon_0 mg}\right)^{\frac{1}{3}}$

C) $\left(\dfrac{qL^2}{2\pi\varepsilon_0 mg}\right)^{\frac{1}{3}}$

D) $\left(\dfrac{q^2L}{2\pi\varepsilon_0 mg}\right)^{\frac{1}{3}}$

40) A non-conducting solid sphere of radius R is uniformly charged. The magnitude of the electric field due to the sphere at a distance r from its centre
A) decreases as r increases for $R < r < \infty$.
B) decreases as r increases for $0 < r < \infty$.
C) increases as r increases for r < R.
D) both (1) and (3).

41) A negatively charged plate has charge density of 2×10^{-6} C/m^2. The initial distance of an electron which is moving towards plate, cannot strike the plate, if it is having energy of 200 ev
A) 3.51 cm
B) 1.77 cm
C) 3.51 mm
D) 1.77 mm

42) Charge q is uniformly distributed over a thin half ring of radius R. The electric field at the centre of the ring is

A) $\dfrac{q}{2\pi\varepsilon_0 R^2}$

B) $\dfrac{q}{4\pi\varepsilon_0 R^2}$

C) $\dfrac{q}{2\pi^2\varepsilon_0 R^2}$

D) $\dfrac{q}{4\pi^2\varepsilon_0 R^2}$

43) A piece of cloud having area 25×10^6 m^2 and electric potential of 10^5 volts. If the height of cloud is 0.75 km, then energy of electric field between earth and cloud will be
A) 1475 J
B) 1225 J
C) 750 J
D) 250 J

44) A capacitor of capacitance $C_1 = 1\,\mu F$ can withstand maximum voltage V_1 = 6 kV (kilo-volt) and another capacitor of capacitance $C_2 = 3\,\mu F$ can withstand maximum voltage V_2 = 4 kV. When the two capacitors are connected in series, the combined system can withstand a maximum voltage of
A) 10 kV
B) 8 kV
C) 6 kV
D) 4 kV

45) Capacitance of a capacitor made by a thin metal foil is $2\,\mu F$. If the foil is folded with paper of thickness 0.15 mm, dielectric constant of paper is 2.5 and width of paper is 400 mm, then length of foil will be
A) 33.9 m
B) 13.4 m
C) 1.33 m
D) 0.34 m

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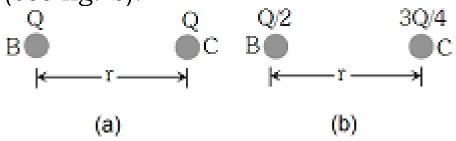
Hints and Solutions

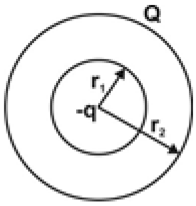
01) Ans: **C)** 3F/8

Sol: Initially, force $F = k.\frac{Q^2}{r^2}$ (see fig. a). Finally when a third spherical conductor comes in contact alternately with B and C then removed, thus charges on B and C are Q/2 and 3Q/4 respectively (see fig. b).



Now, force $F' = k.\frac{\left(\frac{Q}{2}\right)\left(\frac{3Q}{4}\right)}{r^2} = \frac{3}{8}F$

02) Ans: **C)** $\frac{q}{4\pi r_1^2}$ and $\frac{Q-q}{4\pi r_2^2}$



Sol:
As the charge -q is placed at the centre of the shell, therefore it will induce a charge +q on the inner surface and charge -q on the outer surface of the shell.
Surface charge density on the inner surface of the shell, $\sigma_1 = \frac{q}{4\pi r_1^2}$

Total charge on the outer surface of the shell=Q-q
Hence, surface charge density on the outer surface of the shell, $\sigma_2 = \frac{Q-q}{4\pi r_2^2}$

03) Ans: **B)** greater than F_e.
Sol: Separation between the spheres is not too large when compared to their radius thus due to induction effect redistribution of charge takes place. Therefore effective charge separation decreases so force increases.

04) Ans: **B)** 9×10^3 Newton
Sol: Here,
$F = \frac{kQ^2}{r^2} \Rightarrow F = 9\times10^9\times1^2\times\frac{1}{(1000)^2} = 9\times10^3 N$

05) Ans: **A)** 4.0

Sol: Here, by using $K = \frac{F_a}{F_m} \Rightarrow K = \frac{10^{-4}}{2.5\times10^{-5}} = 4$

06) Ans: **A)** $(m_p / m_e)^{1/2}$

Sol: Here, for electron, $s = \frac{eE}{m_e}\times t_1^2$, and

for proton, $s = \frac{eE}{m_p}\times t_2^2$

$\therefore \frac{t_2^2}{t_1^2} = \frac{m_p}{m_e} \Rightarrow \frac{t_2}{t_1} = \sqrt{\frac{m_p}{m_e}} = \left(\frac{m_p}{m_e}\right)^{1/2}$

07) Ans: **B)** 2
Sol: Dielectric constant,
$K = \frac{E_{\text{without di-electric}}}{E_{\text{with di-electric}}} = \frac{2\times10^5}{1\times10^5} = 2$

08) Ans: **B)** $\frac{\sigma}{\varepsilon_0}$ and is normal to the surface.

Sol: The electric field near the conductor surface is given by $\frac{\sigma}{\varepsilon_0}$ and it is perpendicular to surface.

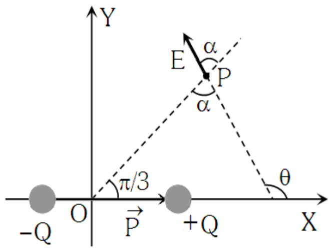
09) Ans: **C)** 4
Sol: Here, $m = 3.2\times10^{-12} g = 3.2\times10^{-15}$ kg
$V = 980 V, d = 2 cm = 2\times10^{-2}$ m
In equilibrium,
Force on drop due to electric field =Weight of the drop
$qE = mg \Rightarrow (ne)\left(\frac{V}{d}\right) = mg$ or $n = \frac{mgd}{eV}$
By substituting the given values, we get
$n = \frac{3.2\times10^{-15}\times9.8\times2\times10^{-2}}{(1.6\times10^{-19})(980)} = 4$

10) Ans: **C)** 40 V
Sol: If charge acquired by the smaller sphere is Q, then it's potential i.e. $120 = \frac{kQ}{2}$ (given) ..... (i)
Also potential of the outer sphere is
$V = \frac{kQ}{6}$ .....(ii)
From equation (i) and (ii), V = 40 volt

11) Ans: **A)** p and r^{-3}
Sol: We know, $E_{equatorial} = \frac{kp}{r^3}$

$\Rightarrow E \propto p$ and $E \propto r^{-3}$.

12) Ans: **D)** $\frac{\pi}{3}+\tan^{-1}\left(\frac{\sqrt{3}}{2}\right)$

Sol: 

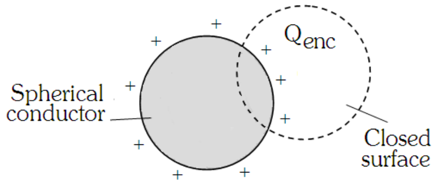
Here, from the figure, $\theta=\frac{\pi}{3}+\alpha$, and

$\tan\alpha=\frac{1}{2}\tan\frac{\pi}{3}$

$\Rightarrow \alpha=\tan^{-1}\sqrt{3}/2 \qquad \therefore \theta=\frac{\pi}{3}+\tan^{-1}\sqrt{3}/2$

13) Ans: **B)** $\frac{1}{\varepsilon_0}\times$ (the charge enclosed by surface)

Sol: We know, $\phi_{surface}=\frac{1}{\varepsilon_0}(Q_{enclosed})$



14) Ans: **A)** $\frac{4\pi q}{6(4\pi\varepsilon_0)}$

Sol: Here, $\phi_{face}=\frac{q}{6\varepsilon_0}=\frac{4\pi q}{6(4\pi\varepsilon_0)}$.

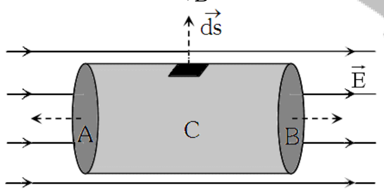
15) Ans: **D)** $\frac{100Q}{\varepsilon_0}$

Sol: Charge enclosed by cylindrical surface (length 100 cm) is $Q_{enc}=100Q$.
Now, according to Gauss's law

$\phi=\frac{1}{\varepsilon_0}(Q_{enc.})=\frac{1}{\varepsilon_0}(100Q)$

16) Ans: **A)** Zero

Sol: Flux through surface A, $\phi_A=E\times\pi R^2$ and that of surface B, $\phi_B=-E\times\pi R^2$



Thus, flux through curved surface C

$=\int \vec{E}.\vec{ds}\int E\,ds\cos 90^\circ = 0$

$\therefore$ Total flux through cylinder $=\phi_A+\phi_B+\phi_C = 0$

17) Ans: **C)** $\oint_s(\vec{E}_1+\vec{E}_2+\vec{E}_3).d\vec{A}=\frac{(q_1+q_2+q_3)}{\varepsilon_0}$

Sol: Using, $\int \vec{E}\cdot\vec{dA}=\frac{1}{\varepsilon_0}(Q_{enc})$.

18) Ans: **B)** $\frac{R(R-x)}{x}$

Sol: As $C\propto\frac{ab}{b-a}$ and given a = R - x, b = R

$\therefore C\propto\frac{R(R-x)}{x}$

19) Ans: **B)** 8

Sol: mercury $=N\times$ volume of smaller drop

or $\frac{4}{3}\pi R^3=N\times\frac{4}{3}\pi r^3$ or $N=\left(\frac{R}{r}\right)^3$ ...(i)

Charge is conserved. Hence Q =Nq

Capacity of bigger drop $=4\pi\varepsilon_0 R$

Capacity of smaller drop $=4\pi\varepsilon_0 r$

$\therefore (4\pi\varepsilon_0 R)\times 40=N(4\pi\varepsilon_0 r)\times 10$ or $4R=Nr$

or $\frac{R}{r}=\frac{N}{4}$ ...(ii)

From (i) and (ii), we get $N=\left(\frac{N}{4}\right)^3=\frac{N^3}{64}$ or $N^2=64$

or $N=8$

20) Ans: **A)** $F_A = F_B$

Sol: $F_A = F_B$; as an uniform electric field is produced between the plates.

21) Ans: **D)** $\frac{5000}{7}\varepsilon_0 A$

Sol: Capacity, $C=\frac{\varepsilon_0 A}{\left(\frac{t_1}{k_1}+\frac{t_2}{k_2}\right)}$

$\Rightarrow C=\frac{\varepsilon_0 A}{\frac{6\times10^{-3}}{10}+\frac{4\times10^{-3}}{5}}=\frac{5000}{7}\varepsilon_0 A$

22) Ans: **A)** CV^2

Sol: Extra charge Q = (2CV - CV) = CV flows through potential V of the battery.
Hence, W = QV = CV^2.

23) Ans: **A)** doubled.

Sol: From given in the problem,

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

24) Ans: **C)** $W=\frac{\varepsilon_0 AV^2}{2kd}$

Sol: After inserting the dielectric slab,

New capacitance $C'=K.C=\frac{K\varepsilon_0 A}{d}$

New potential difference $V'=\frac{V}{K}$

New charge $Q'=C'V'=\frac{\varepsilon_0 AV}{d}$

and New electric field $E' = \frac{V'}{d} = \frac{V}{Kd}$

Work done (W) = Final energy - Initial energy

$$W = \frac{1}{2}C'V'^2 - \frac{1}{2}CV^2 = \frac{1}{2}(KC)\left(\frac{V}{K}\right)^2 - \frac{1}{2}CV^2$$

$$\Rightarrow W = \frac{1}{2}CV^2\left(\frac{1}{K}-1\right) = -\frac{1}{2}CV^2\left(1-\frac{1}{K}\right)$$

$$\Rightarrow W = -\frac{\varepsilon_0 AV^2}{2d}\left(1-\frac{1}{K}\right) \qquad \therefore |W| = \frac{\varepsilon_0 AV^2}{2d}\left(1-\frac{1}{K}\right)$$

25) Ans: **A)** $\frac{\varepsilon_0 AV_0^2}{d}$

Sol: Work done, $W = U_f - U_i$

$$U_i = \frac{1}{2}CV_0^2 \text{ and } U_f = \frac{1}{2}\frac{(C)}{3}.(3V_0)^2 = 3\times\frac{1}{2}CV_0^2$$

$$\therefore W = \frac{\varepsilon_0 AV_0^2}{d}$$

26) Ans: **A)** 0.64

Sol: Initial energy stored in the capacitor,

$$U_i = \frac{1}{2}CV^2 = \frac{1}{2}\times C\times(50)^2 = \frac{1}{2}C(50)^2 \quad ...(i)$$

After 2 s, when the potential drops by 10 V, the final potential is 40 V.

Final energy stored in the capacitor,

$$U_f = \frac{1}{2}C(40)^2 \quad ...(ii)$$

Fraction of energy

$$\text{stored} = \frac{U_f}{U_i} = \frac{\frac{1}{2}C(40)^2}{\frac{1}{2}C(50)^2} = \left(\frac{40}{50}\right)^2 = 0.64$$

27) Ans: **D)** 2 times

Sol: From the problem,

volume of 8 small drops = Volume of big drop

$$\Rightarrow 8\times\frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3 \Rightarrow R = 2r$$

Since the capacitance of small drop is r, thus capacitance of big drop becomes 2 times.

28) Ans: **A)** 11×10^{-6} J

Sol: From the figure,

$$C_{eq} = \frac{C_1C_2}{C_1+C_2} + C_3 = \frac{2\times6}{2+6} + 4 = 5.5\ \mu F$$

and energy supplied, $(E) = QV = CV^2 = 22\times10^{-6}$ J

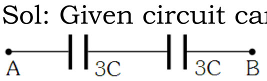
$\therefore$ P. E. stored,

$$(U) = \frac{1}{2}C_{eq}V^2 = \frac{1}{2}\times5.5\times(2)^2 = 11\times10^{-6}\ J$$

$\Rightarrow$ Energy lost $= E - U = 11\times10^{-6}$ J

29) Ans: **B)** 400 V

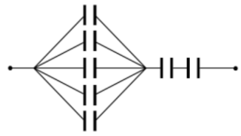
Sol: Given circuit can be simplified as follows



(where, C is capacitance of each capacitor)

The capacitor 3 C and 3 C shown in figure can withstand maximum 200 V.

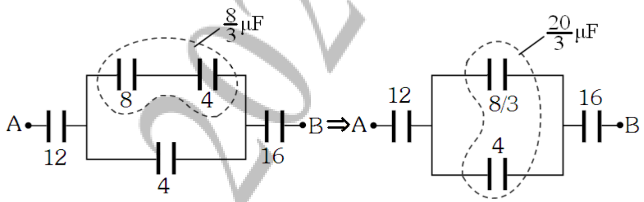
Therefore, maximum voltage that can be applied across A and B equally shared. Hence, maximum voltage applied cross A and B be equally shared. Thus, maximum voltage applied across A and B will be (200 + 200) = 400 volt.



30) Ans: **D)**

31) Ans: **D)** $\frac{240}{71}$F

Sol: The given circuit can be simplified as shown below :



Thus, the equivalent capacitance between A and B,

$$\frac{1}{C_{AB}} = \frac{1}{12} + \frac{1}{20/3} + \frac{1}{16} \Rightarrow C_{AB} = \frac{240}{71}F$$

32) Ans: **C)** $\frac{2}{3}\mu F$

Sol: The resultant capacitance,

$$\frac{1}{C_{eq}} = \frac{1}{1} + \frac{1}{2} \Rightarrow C_{eq} = \frac{2}{3}\mu F$$

33) Ans: **D)** $\frac{\sqrt{3}}{2}$

Sol: Flux coming out of the cube is given by

$$\phi_1 = \frac{\lambda . a\sqrt{3}}{\varepsilon_0} \quad ....(i)$$

and that from sphere is $\phi_2 = \frac{\lambda\cdot 2a}{\varepsilon_0}$ ....(ii)

$$\therefore \frac{\phi_1}{\phi_2} = \frac{\sqrt{3}}{2}$$

34) Ans: **B)** > F/q_o

Sol: Due to the presence of positive test charge q_0 in front of positively charged ball, charge on the ball will be redistributed, less charge on the front half surface and more charge on the back half surface. As a result of this net force F between ball and point charge will decrease means actual electric field will be greater than F/q_o.

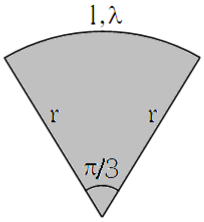
35) Ans: **B)** $\frac{\lambda}{12\varepsilon_0}$

Sol: the length of an arc $= r\theta = \frac{r\pi}{3}$

Charge on the arc $= \frac{r\pi}{3}\times\lambda$

$\therefore$ Potential at center,

$V=\frac{kq}{r} \Rightarrow V=\frac{1}{4\pi\varepsilon_0}\times\frac{r\pi}{3}\frac{\lambda}{r}=\frac{\lambda}{12\varepsilon_0}$



36) Ans: **B)** 3.5 mm
Sol: We know,

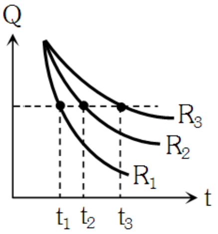
$K=\frac{t}{t-d'} \Rightarrow 2=\frac{1}{1-d'} \Rightarrow d'=\frac{1}{2}mm$

$\therefore$ New distance $=3+\frac{1}{2}=3.5$ mm

37) Ans: **A)** R_1
Sol: During discharging of a capacitor through a resistance. charge at any instant is $Q=Q_0e^{-t/CR}$.

$\Rightarrow \frac{Q_0}{Q}=e^{t/CR} \Rightarrow t=CR\log_e\frac{Q_0}{Q}$

If $Q\to$ constant, then $t \propto R$.



Now, draw a line parallel to the time axis as shown above. Let this line cut the graphs at points 1, 2 and 3. Corresponding time are t_1, t_2 and t_3 respectively. Thus, from graph $t_1 < t_2 < t_3$.
$\Rightarrow R_1 < R_2 < R_3$

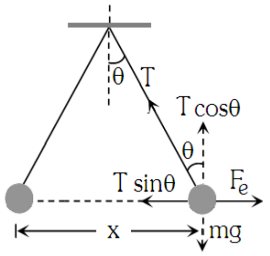
38) Ans: **B)** 13.86 s

Sol: Here, $V_R=\frac{V_0}{4}=V_0e^{-\frac{t}{RC}} \Rightarrow \frac{1}{4}=e^{-\frac{t}{10}}$

$\Rightarrow 4=e^{\frac{t}{10}} \Rightarrow \log_e 4=\frac{t}{10} \Rightarrow t=10\log 4=13.86$ s

(RC = 2.5 x 10^6 x 4 x 10^{-6} = 10)

39) Ans: **D)** $\left(\frac{q^2L}{2\pi\varepsilon_0 mg}\right)^{\frac{1}{3}}$



Sol:
From the figure,
In equilibrium, $F_e = T\sin\theta$ ... (i)
and $mg = T\cos\theta$ ... (ii)

$\tan\theta=\frac{F_e}{mg}=\frac{q^2}{4\pi\varepsilon_o x^2\times mg}$ also $\tan\theta\approx\sin\theta=\frac{x/2}{L}$

$\therefore \frac{x}{2L}=\frac{q^2}{4\pi\varepsilon_o x^2\times mg}$

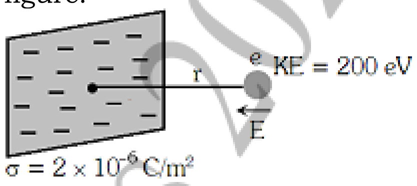
$\Rightarrow x^3=\frac{2q^2L}{4\pi\varepsilon_o mg} \Rightarrow x=\left(\frac{q^2L}{2\pi\varepsilon_o mg}\right)^{1/3}$

40) Ans: **D)** both (1) and (3).
Sol: For non-conducting solid sphere, $E_{in}\propto r$ and

$E_{out}\propto\frac{1}{r^2}$

It means for r < R, E increases as r increases and for R < r < ∞, E decreases as r increases.

41) Ans: **D)** 1.77 mm
Sol: Suppose an electron is projected towards the plate from the r distance as shown in the following figure.



It will not strike the plate if and only if $KE\le e(E\times r)$ (where E is Electric field due to charge plate $=\frac{\sigma}{2\varepsilon_0}$)

$\Rightarrow r\ge\frac{KE}{eE}$. Thus the minimum value of r is given

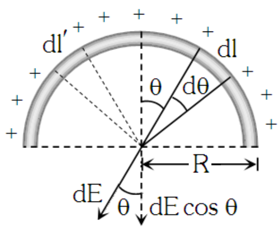
by $r=\frac{KE}{eE}=\frac{200\ eV}{e\times\frac{\sigma}{2\varepsilon_0}}=\frac{400\times8.86\times10^{-12}}{2\times10^{-6}}=1.77$ mm

42) Ans: **C)** $\frac{q}{2\pi^2\varepsilon_0R^2}$

Sol: From the following figure $dl = R\,d\theta$;

Charge on dl = $\lambda R\,d\theta$ $\left\{\lambda=\frac{q}{\pi R}\right\}$

Electric field at center due to dl is $dE=k.\frac{\lambda Rd\theta}{R^2}$.



Considering only the component $dE\cos\theta$, as the component $dE\sin\theta$ will cancel out because of the field at C due to the symmetrical element dl'.

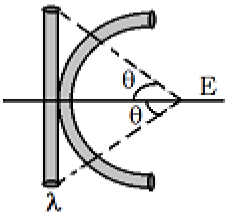
Total field at center $=2\int_0^{\pi/2}dE\cos\theta$

$\Rightarrow=\frac{2k\lambda}{R}=\frac{2k\lambda}{R}=\frac{q}{2\pi^2\varepsilon_0R^2}\int_0^{\pi/2}\cos\theta\,d\theta$

Another method : As we know, electric field due to a finite length charged wire on it's perpendicular bisector is given by $E=\frac{2k\lambda}{R}\sin\theta$.

If it is bent in the form of a semicircle, then
$\theta = 90°$.

$$\Rightarrow E = \frac{2k\lambda}{R} = 2 \times \frac{1}{4\pi\varepsilon_0}\left(\frac{q/\pi R}{R}\right) = \frac{q}{2\pi^2\varepsilon_0 R^2}$$



43) Ans: **A)** 1475 J
Sol: Here, energy

$$E = \frac{1}{2}\varepsilon_0 E^2 \times (A \times d) = \frac{1}{2}\varepsilon_0\left(\frac{V^2}{d^2}\right)Ad$$

$$\Rightarrow E = \frac{1}{2} \times \frac{8.85 \times 10^{-12} \times (10^5)^2 \times 25 \times 10^6}{0.75 \times 10^3} = 1475 \text{ J}$$

44) Ans: **B)** 8 kV
Sol: As we know, Q = CV,
$(Q_1)_{max} = 10^{-6} \times 6 \times 10^3 = 6$ mC
While $(Q_2)_{max} = 3 \times 10^{-6} \times 4 \times 10^3 = 12$ mC
However, charge is same in series, thus maximum charge on C_2 will also be 6 mC (and not 12 mC) and potential difference across it V_2
= 6 mC/3 μF = 2 KV and as in series $V = V_1 + V_2$
$\therefore V_{max}$ = 6 K V + 2 K V = 8 K V

45) Ans: **A)** 33.9 m
Sol: If length of the foil is l, then capacitance

$$C = \frac{k\varepsilon_0(l \times b)}{d}$$

$$\Rightarrow 2 \times 10^{-6} = \frac{2.5 \times 8.85 \times 10^{-12}(l \times 400 \times 10^{-3})}{0.15 \times 10^{-3}}$$

$\Rightarrow$ l = 33.9 m