Electrostatics **Marks: 60**

ANSWER KEY

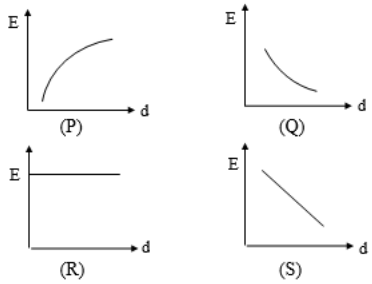
Physics

Q.1 C	Q.2 A	Q.3 D	Q.4 B	Q.5 C	Q.6 C	Q.7 C	Q.8 C
Q.9 A	Q.10 A	Q.11 D	Q.12 C	Q.13 A	Q.14 C	Q.15 C	Q.16 C
Q.17 B	Q.18 B	Q.19 C	Q.20 D	Q.21 B	Q.22 C	Q.23 A	Q.24 B
Q.25 D	Q.26 A	Q.27 A	Q.28 A	Q.29 A	Q.30 B	Q.31 C	Q.32 C
Q.33 C	Q.34 C	Q.35 C	Q.36 A	Q.37 D	Q.38 C	Q.39 A	Q.40 B
Q.41 C	Q.42 C	Q.43 B	Q.44 B	Q.45 A	Q.46 C	Q.47 B	Q.48 B
Q.49 C	Q.50 B	Q.51 A	Q.52 A	Q.53 B	Q.54 A	Q.55 B	Q.56 A
Q.57 B	Q.58 C	Q.59 A	Q.60 C				

KUNAL ACADEMY

Physics

Q.1 For a uniformly charged plane sheet, the variation of electric field (E) with distance (d) is correctly shown graphically by graph

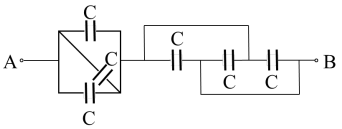


Correct option: (C)

Caution

Electric field due to uniformly charged infinite plane sheet is $\frac{\sigma}{2\varepsilon}$. It is independent of 'd'.

Q.2 In the given figure, the equivalent capacitance between points A and B is



Correct option: (A)

Both parts have capacitors in parallel.

The equivalent capacitor for each part is

$C_{eq} = C + C + C = 3C$

There are two 3C capacitances in series

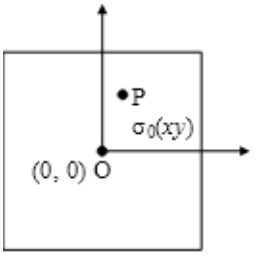
$\therefore \quad \frac{1}{C_{AB}} = \frac{1}{3C} + \frac{1}{3C}$

$\frac{1}{C_{AB}} = \frac{2}{3C}$

$\therefore \quad C_{AB} = 1.5\,C$

Q.3 A square is centered at origin having sides parallel to *x* and *y*-axis. It has surface charge density $\sigma(x, y) = \sigma_0 xy$ within its boundaries. The measure of charge of each side of square is Q. What is the total charge on the square?

Correct option: (D) Zero



Since the centre of the square lies at origin, hence each quadrant will have the charge that cancels the charge of diagonally opposite quadrant. This results in the zero net charge on square.

Q.4 The plates of a charged capacitor are connected to a voltmeter. If the distance between the plates is increased, then the reading of the voltmeter

Correct option: (B)

$C = \frac{Q}{V}$, $C = \frac{k\varepsilon_0}{d}$

$C \propto \frac{1}{V} \Rightarrow C \propto \frac{1}{d}$

$\therefore$ As 'd' increases, C decreases

Hence 'V' increases.

Q.5 The insulation property of air breaks down at $E = 3 \times 10^6$ volt/metre. The maximum charge that can be given to a sphere of diameter 5 m is approximately (in coulomb)

Correct option: (C)

$E = \frac{1}{4\pi\varepsilon_0} \times \frac{q}{r^2} = 9 \times 10^9 \times \frac{q}{r^2}$

$\therefore \quad q = \frac{E \times r^2}{9 \times 10^9} = \frac{3 \times 10^6 \times (2.5)^2}{9 \times 10^9}$

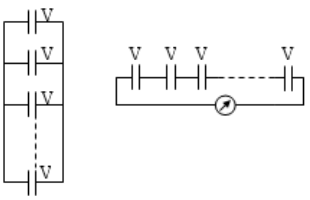
$= 2.0833 \times 10^{-3}$ C

q should be less than 2.0833×10^{-3} C. In the given set of options 2×10^{-3} C is the maximum charge which is smaller than 2.0833×10^{-3} C.

Q.6 Initially n identical capacitors are joined in parallel and are charged to potential V. Now they are separated and joined in series. Then

Correct option: (C)

Energy will remain the same due to conservation of energy



KUNAL ACADEMY

In case 1, each capacitor is charged to p.d. V

So, when they are connected in series, the p.d. will be nV

Q.7 Choose the correct relation between polarization 'P' and electric susceptibility 'χ_e' of dielectric material. (E = electric field)

Correct option: (C)

Q.8 The magnitude of an electric intensity at a point which is at a distance 'r' from the centre of a charged spherical conductor of radius 'R' in terms of the surface charge density 'σ' is given by 'E' where

Correct option: (C)

Electric intensity at a distance r from the centre of a charged spherical conductor of radius R,

$E = \frac{q}{4\pi k\varepsilon_0 r^2}$ ….(i)

Since the charge is uniformly distributed on A, the surface density of charge on A will be

$\sigma = \frac{q}{4\pi R^2} \Rightarrow q = 4\pi R^2\sigma$

Substituting in eq. (i), we get

$E = \frac{4\pi R^2\sigma}{4\pi k\varepsilon_0 r^2} = \frac{\sigma R^2}{k\varepsilon_0 r^2}$

Q.9 Two spheres carrying charges +6 μC and +8 μC, separated by a distance d, experiences a force of repulsion F. When a charge of −4 μC is given to both the sphere and kept at the same distance as before, the new force of repulsion is

Correct option: (A)

$F \propto Q_1Q_2$ ….(∵ distance of separation is same in both cases)

$\therefore \frac{F}{F'} = \frac{Q_1Q_2}{Q'_1Q'_2}$

$= \frac{6\times 8}{(6-4)\times(8-4)} = 6$

$\Rightarrow F' = \frac{F}{6}$

Q.10 The electric field inside a spherical shell of uniform surface charge density is

Correct option: (A)

The electric field inside a spherical shell of uniform surface charge density is *zero*. This is because of Gauss's law, which states that the flux of the electric field through any closed surface is proportional to the enclosed charge. Inside the spherical shell, there is no enclosed charge, as all the charge resides on the surface. Therefore, the electric flux, and consequently the electric field, inside the shell is *zero*.

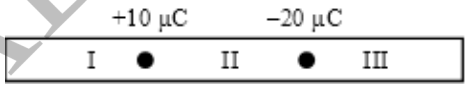
Q.11 If the magnitude of intensity of electric field at a distance x on axial line and at a distance y on equatorial line on a given dipole are equal, then x : y is

Correct option: (D)

$E_{axial} = E_{equatorial} \Rightarrow k\frac{2p}{x^3} = \frac{kp}{y^3}$

$\Rightarrow \frac{x}{y} = \frac{2^{1/3}}{1} = \sqrt[3]{2} : 1$

Q.12 Charges of + 10 μC and – 20 μC are placed as shown in figure. The force on a –5 μC charge is directed to the right everywhere



Correct option: (C)

$F \propto q_1q_2$ $F_A \propto (-5)(+10) = -50$

$F_R \propto (-5)(-20) = +100$

As $F_R > F_A$ In I → Left or Right depends on distance.

In II → Always Left

In III → Always Right

Q.13 Consider a sphere of radius R and cylinder of length L. If both have same charge density σ and E_s and E_c are electric intensity at a point at a distance r from axis of sphere and cylinder respectively, then E_s =

Correct option: (A)

Given that,

$\sigma_s = \sigma_c$

Now, $E_s = \frac{\sigma_s R^2}{\varepsilon r^2}$ and $E_c = \frac{\sigma_c R}{\varepsilon r}$

$\therefore E_s = \frac{\sigma R}{\varepsilon r} \times \frac{R}{r} = E_c\frac{R}{r}$

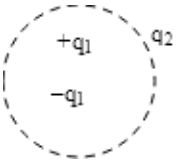
Q.14 Charge per unit area is called as _____.

Correct option: (C) surface charge density

KUNAL ACADEMY

Self Explanatory

Q.15 Consider the charge configuration and spherical Gaussian surface as shown in the figure. When calculating the flux of the electric field over the spherical surface, the electric field will be due to



Correct option: (C)

The electric field is due to all charges present whether inside or outside the given surface.

Q.16 The angle between electric field intensity $\vec{E}$ and the area vector $\vec{ds}$ at which the flux is maximum is

Correct option: (C)

Flux = $\oint \varepsilon \vec{E} \cdot d\vec{s}$

$= \oint \varepsilon E ds \cos\theta$

∴ Flux is maximum when, cos θ = 1

⇒ θ = 0°

Q.17 A parallel plate capacitor has plate area 'A' and charge 'Q'. The force on negatively charged plate due to charge on the other plate is (ε_0 = permittivity of free space)

Correct option: (B)

Electric field is given as $E = \frac{Q}{2A\varepsilon_0}$

And force is given as $F = QE$

$\therefore \quad F = \frac{Q^2}{2A\varepsilon_0}$

Q.18 A particle of mass 'm' and charge 'q' is placed at rest in a uniform electric field 'E' and then released, the kinetic energy attained by the particle after moving a distance 'Y' will be

Correct option: (B)

Force on charged particle in a uniform electric field is

F = Eq = ma

$\therefore \quad a = \frac{Eq}{m}$

From the third kinematic equation of motion, we have

$v^2 = u^2 + 2as = 0 + 2 \times \frac{Eq}{m} \times Y = \frac{2EqY}{m}$

The kinetic energy of the particle

K.E. = $\frac{1}{2}mv^2 = \frac{m}{2} \times \frac{2EqY}{m}$ = qEY

Q.19 A capacitor of capacitance C is charged to potential difference V and then disconnected from the battery. The air dielectric of capacitor is replaced by another dielectric of dielectric constant k. The fractional decrease in energy of the capacitor is

Correct option: (C)

$U = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$

Here, Q in both cases is same

$\therefore U_1 = \frac{Q^2}{2C_1}$ and

$U_2 = \frac{Q^2}{2C_2} = \frac{Q^2}{2kC_1}$

Now, $C \propto k \Rightarrow C_2 = kC_1$

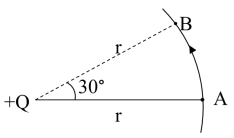
∴ Decrease in energy = $U_1 - U_2$

$= \frac{Q^2}{2C_1} - \frac{Q^2}{2kC_1} = \frac{Q^2}{2C_1} \times \left(1 - \frac{1}{k}\right)$

∴ Fractional decrease in energy = $\frac{U_1 - U_2}{U_1}$

$= \frac{\frac{Q^2}{2C_1} \times \left(1 - \frac{1}{k}\right)}{\left(\frac{Q^2}{2C_l}\right)} = 1 - \frac{1}{k}$

Q.20 In the electric field due to a charge 'Q', a charge 'q' moves from point A to B. The work done is (ε_0 = permittivity of vacuum)



Correct option: (D)

The points A and B are equipotential surfaces as both are at the same distance from the charge Q. Therefore, the work done is zero.

KUNAL ACADEMY

Q.21 The ratio of the forces between two small spheres with constant charge (a) in air (b) in a medium of dielectric constant K is

Correct option: (B)

$F_a = \frac{q_1 q_2}{4\pi\varepsilon_0 r^2}$, $F_b = \frac{q_1 q_2}{K 4\pi\varepsilon_0 r^2} \Rightarrow F_a : F_b = K : 1$

Q.22 An electric field over a certain region is given by $\vec{E} = 2E_0\hat{i} + 3E_0\hat{j} - 5E_0\hat{k}$, where $E_0 = 100\frac{N}{C}$. A rectangular surface of area 0.2 m^2 is kept in this region parallel to Y-axis. The flux passing through this surface is

Correct option: (C)

If area vector is taken parallel to Y – axis then

$\vec{ds} = 0.2\hat{j}m^2$

Flux $\phi = \vec{E} \cdot \vec{ds}$

$= \left(2E_0\hat{i} + 3E_0\hat{j} - 5E_0\hat{k}\right) \cdot \left(0.2\hat{j}\right)$

$= 0.6\ E_0$

$= 0.6 \times 100$ ….($\because E_0 = 100$ N/C)

$= 60\ Nm^2/C$

Q.23 Two point charges +e and +4 e are kept at a distance d units apart. Third point charge +q is placed between the two charges at a distance 'x' units from charge +e so as to be in equilibrium. The value of 'x' is

Correct option: (A)

Net force on q should be zero.

Forces due +e and +4e are opposite in direction. They should be equal in magnitude.

$\therefore \quad \frac{1}{4\pi\varepsilon_0} \cdot \frac{eq}{x^2} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{4eq}{(d-x)^2}$

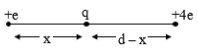
$\therefore \quad \frac{1}{x^2} = \frac{4}{(d-x)^2}$

$\therefore \quad \frac{1}{x} = \frac{2}{d-x}$

$\therefore \quad 2x = d - x$

$\therefore \quad 3x = d$

$\therefore \quad x = \frac{d}{3}$



Q.24 A hollow charged metal sphere has radius 'R'. If the potential difference between its surface and a point at a distance '5R' from the centre is V, then magnitude of electric field Intensity at a distance '5R' from the centre of sphere is

Correct option: (B)

Potential,

$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{R} - \frac{1}{4\pi\varepsilon_0}\frac{q}{5R}$

$= \frac{1}{4\pi\varepsilon_0}\frac{q}{R}\left(1 - \frac{1}{5}\right)$

$= \frac{1}{4\pi\varepsilon_0}\frac{q}{R}\frac{4}{5}$

Electric field, $E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{25R^2}$

$\therefore \quad \frac{E}{V} = \frac{1}{20R} \Rightarrow E = \frac{V}{20R}$

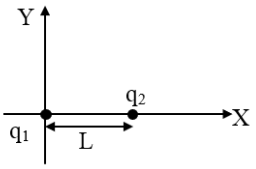
Q.25 A charge Q is enclosed by a Gaussian surface of radius R (near the centre). If the radius is halved, then the outward electric flux will

Correct option: (D)

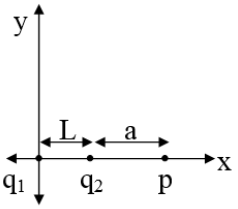
$\phi_E = \frac{Q_{enclosed}}{\varepsilon_0}$

As $Q_{enclosed}$ is unchanged, flux will remain the same.

Q.26 Two charges $q_1 = +6_q$ and $q_2 = -3q$ placed as shown in figure. A proton is placed on x-axis away from q_2. To remain proton in equilibrium, the distance between q_1 and proton is



Correct option: (A)



Let 'a' be the distance between q_2 and p

From figure,

Distance between q_1 and p = L + a

For proton to be in equilibrium, it should be placed at point where electric field due to q_1 and q_2 is zero.

KUNAL ACADEMY

$E_1 + E_2 = 0$

$\therefore \quad \frac{kq_1}{r_1^2} + \frac{kq_2}{r_2^2} = 0$

$\therefore \quad \frac{+6q}{(L+a)^2} + \frac{(-3q)}{a^2} = 0$

$\therefore \quad \frac{6q}{(L+a)^2} = \frac{3q}{a^2}$

$\therefore \quad \frac{2}{(L+a)^2} = \frac{1}{a^2}$

$\therefore \quad \frac{\sqrt{2}}{L+a} = \frac{1}{a}$ ….(Taking sq. root)

$\therefore \quad \sqrt{2}a = L + a$

$\Rightarrow \sqrt{2}a - a = L$

$\Rightarrow a = \frac{L}{\sqrt{2}-1}$

$\therefore$ Distance between q_1 and p = L + a

$= L + \frac{L}{\sqrt{2}-1} =$

$\frac{(\sqrt{2}-1)L + L}{\sqrt{2}-1} = \frac{\sqrt{2}L}{\sqrt{2}-1}$

$= \frac{\sqrt{2}L}{\sqrt{2}-1}$

Q.27 The electric flux for Gaussian surface A that enclose the charged particles in free space is (given q_1 = –14 nC, q_2 = 78.85 nC, q_3 = – 56 nC)

Correct option: (A)

Total flux = (–14 + 78.85 – 56)nC / ε_0

$= 8.85 \times 10^{-9}\ C \times \frac{4\pi}{4\pi\varepsilon_0}$

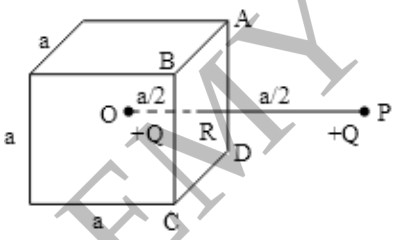
$= 8.85 \times 10^{-9} \times 9 \times 10^9 \times 4\pi$

$= 1000\ Nm^2C^{-1}$

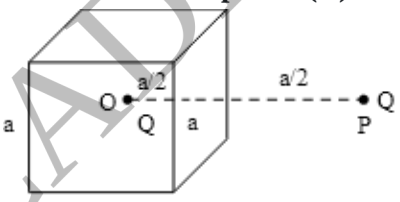
Q.28 The dielectric slab is introduced between the plates of a parallel plate charged capacitor. Which one of the following quantities will not change?

Correct option: (A)

Q.29 Consider a region in free space bounded by the surfaces of an imaginary cube having sides of length 'a' as shown in the diagram. A charge +Q is placed at the centre 'O' of the cube. P is such a point outside the cube that the line OP perpendicularly intersects the surface ABCD at R and also OR = RP = a/2. A charge +Q is placed at point P also. What is the total electric flux through the five faces of the cube other than ABCD?



Correct option: (A)



Flux due to charge at O,

$\phi_1 = 5 \times \frac{Q}{6\varepsilon_0}$

Flux due to charge at P

$\phi_2 = \frac{Q}{6\varepsilon_0}$

$\therefore \phi = \phi_1 + \phi_2 = \frac{Q}{\varepsilon_0}$

Q.30 A parallel plate capacitor of 6 μF is connected across 18 V battery and charged. The battery is then disconnected and oil of dielectric constant k = 2.1 is introduced between the plates. What will be the charge on capacitor?

Correct option: (B)

$Q = CV = 6 \times 10^{-6} \times 18 = 108\ \mu C$

Q.31 A charge 12 C is placed at the centre of a cube of edge 30 cm. The electric flux passing through one of the faces of the cube is

Correct option: (C)

KUNAL ACADEMY

The cube has six surfaces and the charge is at its centre. Hence, it will produce equal number of lines of force through each surface.

The charge of Q will produce in all $\frac{Q}{\varepsilon_0}$ lines of force.

∴ Each surface will allow $\left(\frac{Q}{6\varepsilon_0}\right) = \frac{12}{6\varepsilon_0} = \frac{2}{\varepsilon_0}$

Q.32 An electric dipole consisting of two opposite charges of 2×10^{-6} C separated by a distance of 3 cm placed in an electric field of 2×10^5 N/C then the maximum torque acting on dipole is

Correct option: (C)

Dipole moment $p = q \times 2l = 2 \times 10^{-6} \times 3 \times 10^{-2}$

$= 6 \times 10^{-8}$ Cm

∴ $\tau_{max} = \rho E \sin\theta = pE\sin 90°$

$= 6 \times 10^{-8} \times 2 \times 10^5 \times 1$

$= 12 \times 10^{-3}$ Nm

Q.33 A slab of material of dielectric constant K has the same area as the plates of a parallel plate capacitor but has a thickness $\left(\frac{3}{4}\right)d$,

where d is the separation of the plates. The ratio of the capacitance C (in the presence of the dielectric) to the capacitance C_0 (in the absence of the dielectric) is

Correct option: (C)

The capacitance of a parallel plate capacitor in the absence of the dielectric is

$C_0 = \frac{\varepsilon_0 A}{d}$ ….(i)

The capacitance of a parallel plate capacitor in the presence of dielectric slab of thickness t and dielectric constant k, is

$$C = \frac{\varepsilon_0 A}{(d-t)+\left(\frac{t}{k}\right)} = \frac{\varepsilon_0 A}{\left(d-\frac{3}{4}d\right)+\left(\frac{3d}{4k}\right)}$$

$$C = \frac{\varepsilon_0 A}{\left(\frac{d}{4}+\frac{3d}{4k}\right)} = \frac{4k\varepsilon_0 A}{d(k+3)} \quad \text{….(ii)}$$

Dividing equation (ii) by equation (i) we get,

$$\frac{C}{C_0} = \frac{4k\varepsilon_0 A}{d(k+3)} \times \frac{d}{\varepsilon_0 A} = \frac{4k}{k+3}$$

Q.34 Assertion: A parallel plate capacitor is connected across battery through a key. A dielectric slab of constant k is introduced between the plates. The energy which is stored becomes k times.

Reason: The surface density of charge on the plate remains constant or unchanged.

Correct option: (C)

Here, V is constant.

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

$C' \rightarrow kC \Rightarrow$ energy stored will become k times

$q = CV \Rightarrow$ q will become k times

∴ Surface charge density, $\sigma' = \frac{kq}{A} = k\sigma_0$

Q.35 Infinite charges of magnitude 3 C each are lying at x = 1, 2, 4, 8, …. metre on x-axis. The value of intensity of electric field at point x = ∞ due to these charges will be

Correct option: (C)

$$E = \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{1^2}+\frac{1}{2^2}+\frac{1}{4^2}+\ldots\ldots\right]$$

Using Binomial theorem,

$$E = \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{1-\frac{1}{4}}\right] = 3 \times 9 \times 10^9 \times \frac{4}{3} = 36 \times 10^9 \text{ N/C}$$

Q.36 In a parallel plate capacitor, the capacity increases, if

Correct option: (A)

Q.37 In parallel arrangement of capacitors,

i. the p. d. across individual capacitor is same.

ii. the charge is shared by the capacitor in the ratio of the capacitance.

iii. the resultant capacitance is equal to sum of the capacitance of capacitors used.

Correct option: (D)

In a parallel arrangement of capacitors, the potential difference across each capacitor remains the same. This is because they are connected to the same voltage source.

The charge on each capacitor is proportional to its capacitance. This means that a larger capacitor will hold more charge than a smaller capacitor when connected in parallel to the same voltage source. The ratio of the charges on the capacitors is the same as the ratio of their capacitances.

KUNAL ACADEMY

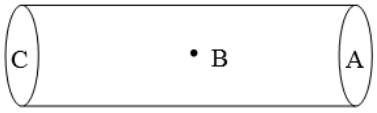
The total capacitance of capacitors connected in parallel is simply the sum of the individual capacitances. This is because the total charge stored in the circuit is equal to the sum of the charges stored on each capacitor.
Therefore, all three statements are correct.

Q.38 Electric lines of force about negative point charge are _____.

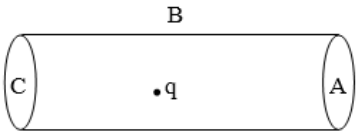
Correct option: (C) radial and inward

Self Explanatory

Q.39 A hollow cylinder has charge 'q' C within it. If 'ϕ' is the electric flux associated with the curved surface B, the flux linked with the plane surface A will be



Correct option: (A)



As per Gauss' law the net flux through closed surface is,

$\phi_A + \phi_B + \phi_C = \frac{q}{\varepsilon_0}$

Due to symmetry, the same flux passes through plane surfaces A and C, i.e., $\phi_A = \phi_C$

$\therefore \quad 2\phi_A + \phi = \frac{q}{\varepsilon_0}$ ….(Given: $\phi_B = \phi$)

$$\phi_A = \frac{1}{2}\left(\frac{q}{\varepsilon_0} - \phi\right)$$

Q.40 A soap bubble is given a negative charge, then its radius

Correct option: (B) increases.

Self Explanatory

Q.41 Two point charges q_1 and q_2 are '*l*' distance apart. If one of the charges is doubled and distance between them is halved. The magnitude of force becomes n times, where n is

Correct option: (C)

Initially $F = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{l^2}$

After doubling a charge and reducing the distance,

$$F' = \frac{1}{4\pi\varepsilon_0} \cdot \frac{2q_1 q_2}{\left(\frac{l}{2}\right)^2} = 8F$$

Q.42 The electric flux over a sphere of radius 'r' is 'ϕ'. If the radius of the sphere is halved and the charge on it is doubled, the electric flux through the surface of the sphere will be

Correct option: (C)

$\phi \propto q$

$\therefore \quad \frac{\phi_2}{\phi} = \frac{2q}{q} = 2$

$\therefore \quad \phi_2 = 2\phi$

Q.43 A parallel plate air capacitor has capacity 'C' farad, potential 'V' volt and energy 'E' joule. When the gap between the plates is completely filled with dielectric, by keeping the charge constant,

Correct option: (B)

Q.44 A 100 microfarad capacitor is to have an energy content of 50 J in order to operate a flash lamp. The voltage required to charge the capacitor is

Correct option: (B) 1000 V

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

$\therefore V = \sqrt{\frac{2u}{C}} = \sqrt{\frac{2 \times 50}{100 \times 10^{-6}}} = \sqrt{10^6}$

$\therefore V = 10^3 \text{ V} = 1000 \text{ V}$

Q.45 The distance between the two charges 25 μC and 36 μC is 11 cm. At what point on the line joining the two, the intensity will be zero?

Correct option: (A)

Shortcut 2 : If two like charges q_1 and q_2 are separated by distance r, then distance x between charge q_1, and null point (point where net electric field due to both the charges is zero) is, $x = \frac{r}{\sqrt{\frac{q_2}{q_1}} + 1}$

$x_1 = \frac{x}{1+\sqrt{\frac{Q_2}{Q_1}}} = \frac{11}{1+\sqrt{\frac{36}{25}}} = 5 \text{ cm}$

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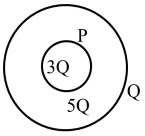
Q.46 P and Q are two concentric spheres enclosing charges 3Q and 5Q respectively. The ratio of electric flux through P and Q is



Correct option: (C)

From Gauss' law,

$\phi = \frac{Q}{\varepsilon_0}$

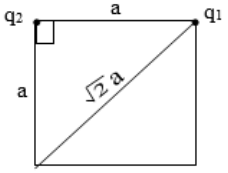
$\therefore$ Flux on P, $\phi_1 = \frac{3Q}{\varepsilon_0}$

Flux on Q, $\phi_2 = \frac{3Q + 5Q}{\varepsilon_0} = \frac{8Q}{\varepsilon_0}$

$\therefore \quad \frac{\phi_1}{\phi_2} = \frac{\left(\frac{3Q}{\varepsilon_0}\right)}{\left(\frac{8Q}{\varepsilon_0}\right)} = \frac{3}{8}$

Q.47 Three identical charges are placed on three vertices of a square. If the force acting between q_1 and q_2 is F_{12} and between q_1 and q_3 is F_{13} then $\frac{F_{12}}{F_{13}}$= _____.

Correct option: (B)



$F_{12} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q^2}{a^2}$ and $F_{13} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q^2}{(a\sqrt{2})^2}$

$\therefore \quad \frac{F_{12}}{F_{13}} = \frac{2}{1}$

Q.48 A charge 'Q' is enclosed by a Gaussian spherical surface of radius 'R'. If the radius is doubled, then the outward electric flux will

Correct option: (B)

$\phi_E = \frac{Q_{enclosed}}{\varepsilon_0}$; As $Q_{enclosed}$ is unchanged, flux will remain the same.

Q.49 If 3 charges are placed at the vertices of equilateral triangle of charge 'q' each. What is the net potential energy, if the side of equilateral Δ is *l*?

Correct option: (C) $\frac{1}{4\pi\varepsilon_0}\frac{3q^2}{l}$

$U = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r}$;

$\therefore$ net potential energy $U_{net} = 3 \times \frac{1}{4\pi\varepsilon_0}\frac{q^2}{l}$

Q.50 When two capacitors are connected in series, the equivalent capacitance is $\frac{15}{4}$ μF. When they are connected in parallel, the equivalent capacitance is 16 μF. The individual capacitances are

Correct option: (B)

When two capacitors are connected in series combination,

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

$\therefore C_S = \frac{C_1 C_2}{C_1 + C_2} = \frac{15}{4}$ μF

$15 (C_1 + C_2) = 4 C_1 C_2$ ….(i)

When two capacitors are connected in parallel combination,

$C_1 + C_2 = 16$ ….(ii)

Substituting eq. (ii) in eq. (i),

$15 \times 16 = 4 C_1 C_2$

$\therefore 15 \times 4 = C_1 C_2$

$60 = C_1 C_2$

$\therefore C_1 (16 - C_1) = 60$ ….[From (ii)]

$C_1^2 - 16C_1 + 60 = 0$

$\therefore C_1^2 - 10C_1 - 6C_1 + 60 = 0$

$\therefore (C_1 - 10)(C_1 - 6) = 0$

$\therefore C_1 = 10$ μF or $C_1 = 6$ μF

Hence, values of capacitors are 6 μF and 10 μF.

Q.51 A charge 17.7×10^{-4} C is distributed uniformly over a large sheet of area 200 m^2. The electric field intensity at a distance 20 cm from it in air will be [$\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/Nm^2]

Correct option: (A)

The surface charge density is given by,

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$$\sigma = \frac{q}{A} = \frac{17.7 \times 10^{-4}}{200} = 8.85 \times 10^{-6} \text{C/m}^2$$

The electric field intensity at a distance of 20 cm in air is,

$$E = \frac{\sigma}{2\varepsilon_0} = \frac{8.85 \times 10^{-6}}{2 \times 8.85 \times 10^{-12}} = 5 \times 10^5 \text{N/C}$$

Q.52 A series combination of N_1 capacitors (each of capacity C_1) is charged to potential difference '3V'. Another parallel combination of N_2 capacitors (each of capacity C_2) is charged to potential difference 'V'. The total energy stored in both the combinations is same. The value of C_1 in terms of C_2
Correct option: (A)

When connected in series,

$$(C_{eq})_1 = \frac{C_1}{N_1};\ V_1 = 3V$$

When connected in parallel,

$$(C_{eq})_2 = N_2C_2;\ V_2 = V$$

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

$$\therefore \frac{1}{2}(C_{eq})_1 V_1^2 = \frac{1}{2}(C_{eq})_2 V_2^2$$

$$\frac{1}{2}\frac{C_1}{N_1}9V^2 = \frac{1}{2}N_2C_2V^2$$

$$C_1 = \frac{C_2N_1N_2}{9}$$

Q.53 Consider a long uniformly charged cylinder having constant volume charge density 'λ' and radius 'R'. A Gaussian surface is in the form of a cylinder of radius 'r' such that vertical axis of both the cylinders coincide. For a point inside the cylinder $(r < R)$, electric field is

directly proportional to
Correct option: (B)

$$\lambda = \frac{q}{v}$$

$$\therefore \quad q = \lambda V$$

$$\therefore \quad q = \lambda \pi r^2 L$$

$$\oint \vec{E} \cdot d\vec{A} = \frac{q}{\varepsilon_0}$$

$$\therefore \quad E \int dA = \frac{\lambda \pi r^2 L}{\varepsilon_0}$$

$$\therefore \quad E(2\pi rL) = \frac{\lambda \pi r^2 L}{\varepsilon_0}$$

$$\therefore \quad E = \frac{\lambda r}{2\varepsilon_0}$$

$$\therefore \quad E \propto r$$

Q.54 The flux entering and leaving a closed surface are 5×10^5 and 4×10^5 MKS units respectively, then the charge inside the surface will be
Correct option: (A)

$$q = (\phi_2 - \phi_1)\varepsilon_0 = (4 - 5)10^5 \times 8.85 \times 10^{-12}$$
$$= -8.85 \times 10^{-7} \text{ C}$$

Q.55 Unit of surface charge density is
Correct option: (B) C/m^2

Self Explanatory

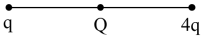
Q.56 A cylinder of radius 4 mm and surface density of charge 0.25 μC/m^2 is surrounded by a medium of dielectric constant 6.28. The magnitude of electric field at a point 2 m away from the axis of the cylinder is
Correct option: (A)

$$E = \frac{\sigma R}{k\varepsilon_0 r} = \frac{\sigma R 4\pi}{4\pi\varepsilon_0 \times k \times r}$$

$$= \frac{0.25 \times 10^{-6} \times 4 \times 10^{-3} \times 4 \times 3.14 \times 9 \times 10^9}{6.28 \times 2}$$

$$= 9 \text{ V/m}$$

Q.57 Three charges q, Q and + 4q are placed in a straight line of length 'd' at points at distances 0, d/2 and d respectively. In order to make the net force on q to be zero, the value of Q should be
Correct option: (B)



Force on q due to Q is

$$F_1 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{qQ}{\left(\frac{d}{2}\right)^2} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{4qQ}{d^2}$$

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Force on q due to $4q$ is

$$F_2 = \frac{1}{4\pi\varepsilon_0}\frac{q \times 4q}{d^2} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{4q^2}{d^2}$$

For net force to be zero,

$F_2 = -F_1$

$$\frac{1}{4\pi\varepsilon_0} \cdot \frac{4q^2}{d^2} = -\frac{1}{4\pi\varepsilon_0} \cdot \frac{4qQ}{d^2}$$

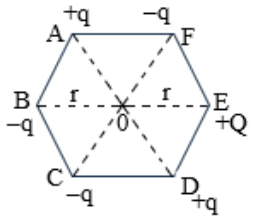
$\therefore$ Q = –q

Q.58 Two charges q_1 and q_2 repel each other with a force of 0.1 N. What will be the force exerted by q_1 on q_2, when a third charge is placed near them ?

Correct option: (C)

Force between the two charges is independent of the charges in its surroundings.

Q.59 Six point charges are placed at the vertices of a regular hexagon ABCDEF as shown in figure. The electric field at the centre of hexagon 'O' due to the five charges at A, B, C, D and F is thrice the electric field at centre O due to charge +Q at E alone. The value of Q is



Correct option: (A)

Electric field at 'O' due to charge 'Q' is given by,

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

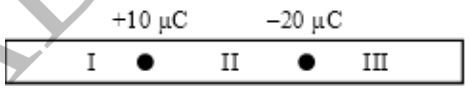
Electric field at 'O' due to charges +q at A and D are equal and opposite and hence they will cancel each other. Similarly electric field at 'O' due to charges –q at F and C will also cancel each other. Electric field at 'O' due to charge –q at B is given by,

$$E' = \frac{kq}{r^2}$$

Now, $E' = 3E$

$$\therefore \quad \frac{kq}{r^2} = \frac{3kQ}{r^2} \Rightarrow Q = \frac{q}{3}$$

Q.60 Charges of + 10 μC and – 20 μC are placed as shown in figure. The force on a –6 μC charge is directed to the right everywhere



Correct option: (C)

$F \propto q_1q_2$ $F_A \propto (–6)\ (+10) = –60$

$F_R \propto (–6)\ (–20) = +120$

As $F_R > F_A$ In I $\rightarrow$ Left or Right depends on distance.

In II $\rightarrow$ Always Left

In III $\rightarrow$ Always Right

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