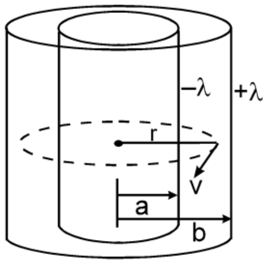
Self Practice Paper (SPP)

1. A sphere of radius 1 cm has potential of 8000 V. The energy density near the surface of sphere will be:
(1) 64×10^5 J/m^3 (2) 8×10^3 J/m^3 (3) 32 J/m^3 (4) 2.83 J/m^3

2. In the above question, the electric force acting on a point charge of 2 C placed at the origin will be :
(1) 2 N (2) 500 N (3) –5 N (4) –500 N

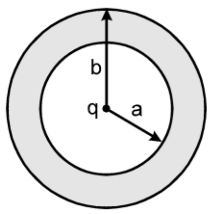
3. Figure shows two large cylindrical shells having uniform linear charge densities + λ and – λ. Radius of inner cylinder is 'a' and that of outer cylinder is 'b'. A charged particle of mass m, charge q revolves in a circle of radius r. Then, its speed 'v' is : (Neglect gravity and assume the radii of both the cylinders to be very small in comparison to their length.)



(1) $\sqrt{\dfrac{\lambda q}{2\pi \in_0 m}}$ (2) $\sqrt{\dfrac{2\lambda q}{\pi \in_0 m}}$ (3) $\sqrt{\dfrac{\lambda q}{\pi \in_0 m}}$ (4) $\sqrt{\dfrac{\lambda q}{4\pi\varepsilon_0 m}}$

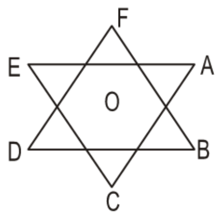
4. A charge q is uniformly distributed over a large plastic plate. The electric field at a point P close to the centre and just above the surface of the plate is 50 V/m. If the plastic plate is replaced by a copper plate of the same geometrical dimensions and carrying the same uniform charge q, the electric field at the point P will become:
(1) zero (2) 25 V/m (3) 50 V/m (4) 100 V/m

5. A point charge q is brought from infinity (slowly so that heat developed in the shell is negligible) and is placed at the centre of a conducting neutral spherical shell of inner radius a and outer radius b, then work done by external agent is:



(1) 0 (2) $\dfrac{k\,q^2}{2\,b}$ (3) $\dfrac{k\,q^2}{2\,b} - \dfrac{k\,q^2}{2\,a}$ (4) $\dfrac{k\,q^2}{2\,a} - \dfrac{k\,q^2}{2\,b}$

6. The magnitude of electric force on $2\,\mu c$ charge placed at the centre O of two equilateral triangles each of side 10 cm, as shown in figure is P. If charge A, B, C, D, E & F are $2\,\mu c$, $2\,\mu c$, $2\,\mu c$, $-2\,\mu c$, $-2\,\mu c$, $-2\,\mu c$ respectively, then P is:



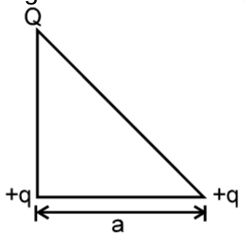
(1) 21.6 N (2) 64.8 N (3) 0 (4) 43.2 N

7. A tiny spherical oil drop carrying a net charge q is balanced in still air with a vertical uniform electric field of strength $\dfrac{81\pi}{7} \times 10^5$ Vm^{-1}. When the field is switched off, the drop is observed to fall with terminal

velocity 2×10^{-3} m s^{-1}. Given g = 9.8 m s^{-2}, viscosity of the air = 1.8×10^{-5} Ns m^{-2} and the density of oil = 900 kg m^{-3}, the magnitude of q is :
(1) 1.6×10^{-19} C (2) 3.2×10^{-19} C (3) 4.8×10^{-19} C (4) 8.0×10^{-19} C

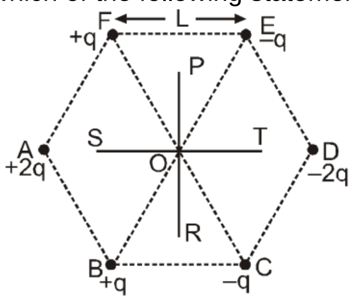
8. Identical charges (–q) are placed at each corners of a cube of side b, then the electrostatic potential energy of charge (+q) placed at the centre of the cube will be :
(1) $-\frac{4\sqrt{2}q^2}{\pi\varepsilon_0}$ (2) $\frac{8\sqrt{2}q^2}{\pi\varepsilon_0 b}$ (3) $-\frac{4q^2}{\sqrt{3}\pi\varepsilon_0 b}$ (4) $\frac{8\sqrt{2}q^2}{4\pi\varepsilon_0 b}$

9. Three charges Q, $+q$ and $+q$ are placed at the vertices of a right-angled isosceles triangle as shown. The net electrostatic energy of the configuration is zero if Q is equal to :



(1) $\frac{-q}{1+\sqrt{2}}$ (2) $\frac{-2q}{2+\sqrt{2}}$ (3) $-2q$ (4) $+q$

10. Six point charges are kept at the vertices of a regular hexagon of side L and centre O, as shown in the figure. Given that $K = \frac{1}{4\pi\varepsilon_0}\frac{q}{L^2}$, which of the following statement (s) is incorrect?



(1) The elecric field at O is 6K along OD
(2) The potential at O is zero
(3) The potential at all points on the line PR is same
(4) The potential at all points on the line ST is same.

11. Two non-conducting solid spheres of radii R and 2R, having uniform volume charge densities ρ_1 and ρ_2 respectively, touch each other. The net electric field at a distance 2R from the centre of the smaller sphere, along the line joining the centres of the spheres, is zero. The ratio $\frac{\rho_1}{\rho_2}$ can be ;
(1) –4 (2) 2 (3) $\frac{32}{25}$ (4) 4

12. Let $E_1(r)$, $E_2(r)$ and $E_3(r)$ be the respective electric fields at a distance r from a point charge Q, an infinitely long wire with constant linear charge density λ, and an infinite plane with uniform surface charge density σ. if $E_1(r_0) = E_2(r_0) = E_3(r_0)$ at a given distance r_0, then
(1) $Q = 4\sigma\pi r_0^2$ (2) $r_0 = \frac{\lambda}{2\pi\sigma}$ (3) $E_1(r_0/2) = 2E_2(r_0/2)$ (4) $E_2(r_0/2) = 4E_3(r_0/2)$

SPP Answers

1.	(4)	**2.**	(4)	**3.**	(1)	**4.**	(3)	**5.**	(3)	**6.**	(4)	**7.**	(4)

8. (3) **9.** (2) **10.** (4) **11.** (4) **12.** (3)

SPP Solutions

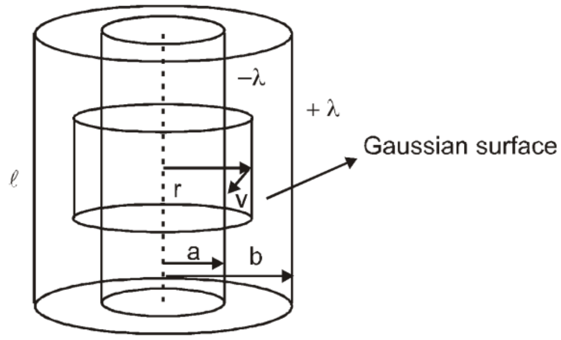
1. E = Field near sphere = $\frac{V}{R} = \frac{8000}{1\times10^{-2}}$ = 8 × 10^5 V/m .

∴ Energy density = $\frac{1}{2}\varepsilon_0 E^2 = \frac{4\pi\varepsilon_0}{8\pi}$ E^2 = $\frac{8\times8\times10^{10}}{8\pi\times9\times10^{9}} = \frac{80}{9\pi}$ = 2.83 J/m^3.

2. At origin, E = – $\frac{dV}{dr}$ = – 2.5 V/cm = – 250 V/m

∴ F = force on 2C = q E = 2 × (– 250) N = – 500 N.

3.



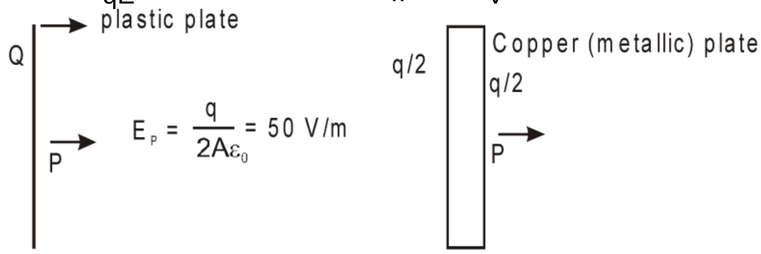
Using Gauss's law for Gaussian surface shown in figure.

$\oint \vec{E}.\vec{dA} = \frac{q_{in}}{\varepsilon_0}$; E. 2πrℓ = $\frac{\lambda\ell}{\varepsilon_0}$ ∴ E = $\frac{\lambda}{2\pi\varepsilon_0 r}$

For circular motion.

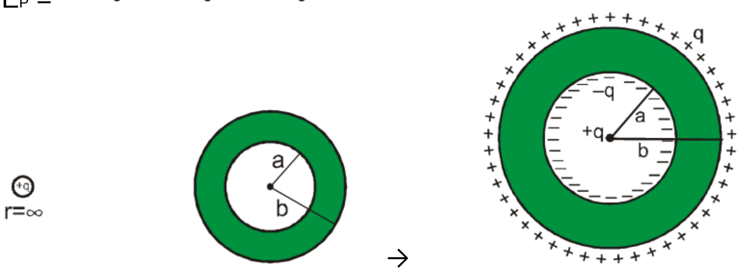
qE = $\frac{mV^2}{r} = \frac{q\lambda}{2\pi\varepsilon_0 r}$ ∴ V = $\sqrt{\frac{q\lambda}{2\pi\varepsilon_0 m}}$

4.



E_P = $\frac{q/2}{2A\varepsilon_0} + \frac{q/2}{2A\varepsilon_0} = \frac{q}{2A\varepsilon_0} = 50V/m$

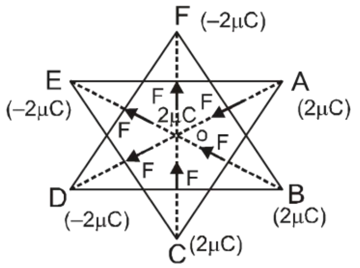
5.



Work done by external agent :

$W_{ext} = U_F - U_i$ ∴ W_{ext} = $\left(\frac{Kq^2}{2a} + \frac{Kq^2}{2b} + \frac{K(+q)(-q)}{(a)} + \frac{K(-q)(+q)}{b} + \frac{K(+q)(+q)}{b}\right) - 0$ = $\frac{Kq^2}{2b} - \frac{Kq^2}{2a}$

6.



The given figure shows force diagram for charge at O due to all other charges with r = $\frac{10}{\sqrt{3}}$ cm

∴ $F_{net} = 2F + 4F \cos 60^o = 4F$

$= \frac{4k(2\mu c)(2\mu c)}{\left(\frac{10}{\sqrt{3}100}\right)^2} = \frac{4\times 9\times 10^9\times 2\times 2\times 10^{-12}}{\left(\frac{1}{300}\right)}$ $= 36 \times 4 \times 300 \times 10^{-3}$ N = 43.2 N. (Towards E)

7. In equilibrium, $mg = qE$

In absence of electric field,

$mg = 6\pi\eta rv$

⇒ $qE = 6\pi qrv$

$m = \frac{4}{3}\pi Rr^3d. = \frac{qE}{g}$

$\frac{4}{3}\pi\left(\frac{qE}{6\pi\eta v}\right)^3 d = \frac{qE}{g}$

After substituting value we get,

$q = 8 \times 10^{-19}$ C **Ans.**

8. Electrostatic potential energy of charge +q placed at the centre of cube is

$U = 8 \times \frac{1}{4\pi\varepsilon_0} \times \frac{q(-q)}{\text{half}-\text{diagonal distace}} = 8 \times \frac{1}{4\pi\varepsilon_0}\frac{-q^2}{b\frac{\sqrt{3}}{2}} = \frac{-4q^2}{\sqrt{3}\pi\varepsilon_0 b}$

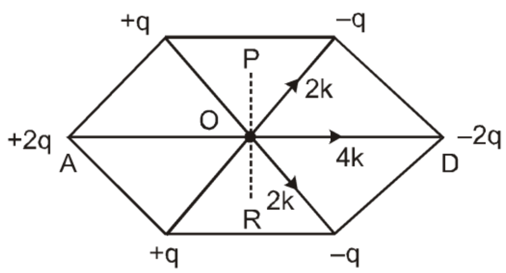
9. Net electrostatic energy of the configuration will be

$U = K\left[\frac{q.q}{a} + \frac{Q.q}{\sqrt{2}a} + \frac{Q.q}{a}\right]$ Here $K = \frac{1}{4\pi\epsilon_0}$

U = 0 gives

$Q = \frac{-2q}{2+\sqrt{2}}$

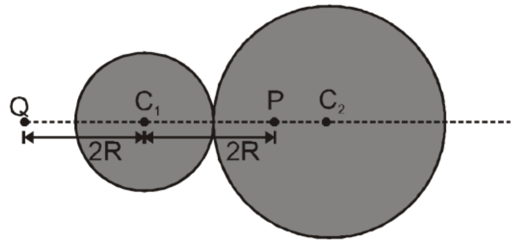
10.



$E_0 = 6$ K (along OD)

$V_0 = 0$

Potential on line PR is zero



11.

At point P

If resultant electric field is zero

then

$$\frac{KQ_1}{4R^2} = \frac{KQ_2}{8R^3}R$$

$$\frac{\rho_1}{\rho_2} = 4$$

At point Q

If resultant electric field is zero

then

$$\frac{KQ_1}{4R^2} + \frac{KQ_2}{25R^2} = 0$$

$$\frac{\rho_1}{\rho_2} = -\frac{32}{25}$$ (ρ_1 must be negative)

12. $$\frac{Q}{4\pi \in_0 r_0^2} = \frac{\lambda}{2\pi \in_0 r_0} = \frac{\sigma}{2 \in_0}$$

$Q = 2\pi\sigma r_0^2$ A incorrect

$r_0 = \frac{\lambda}{\pi\sigma}$ B incorrect

$$E_1\left(\frac{r_0}{2}\right) = \frac{4E_1(r_0)}{1}$$

$E_2\left(\frac{r_0}{2}\right) = 2E_2(r_0) \Rightarrow$ C correct

$E_3\left(\frac{r_0}{2}\right) = E_3(r_0) = E_2(r_0)$ D incorrect