DPP – 7 (Electrostatics)

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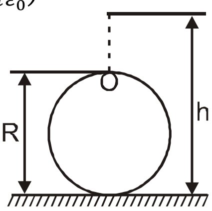
Q 1. A solid sphere of radius R is charged uniformly. At what distance from its surface is the electrostatic potential half of the potential at the centre?
(a) R (b) R/2 (c) R/3 (d) 2R

Q 2. A hollow metal sphere of radius 5 cm is charged such that the potential on its surface is 10 V. The potential at the centre of the sphere is
(a) zero
(b) 10 V
(c) same as at a point 5 cm away from the surface
(d) same as at a point 25 cm away from the surface

Q 3. A sphere of radius R is having charge Q uniformly distributed over it. The energy density of the electric field in the air, at a distance r (r > R) is given by (in J/m3) :
(a) $\frac{Q^2}{32\pi^2\epsilon_0 R^2 r^2}$ (b) $\frac{Q^2}{32\pi^2\epsilon_0 r^4}$
(c) $\frac{Q^2}{32\pi^2\epsilon_0 R^4}$ (d) $\frac{Q^2}{16\pi^2\epsilon_0 r^4}$

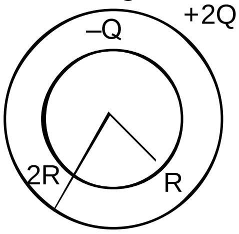
Q 4. An infinite large charge sheet with surface charge density s is placed in x – y plane. A uniformly charged spherical shell total charge Q of radius R is placed such that center of the shell is at (0, 0, 2R). consider points A and B with coordinates A(0,0, R/2) and B(0,0, 7R/2)
(a) $V_A - V_B = \frac{3\sigma R}{2\epsilon_0}$
(b) $V_A - V_B = \frac{\sigma R}{2\epsilon_0} + \frac{KQ}{2R}$
(c) Electric field inside shell is non zero and uniform
(d) Net force on hemispherical portion is $\frac{\sigma Q}{4\epsilon_0}$

Q 5. A charged liquid drop is released from a height (h–2R) above the opening of a spherical non-conducting shell of charge Q. The charge Q is uniformly distributed on the surface of the shell. Given: m is the mass of the drop and q is the charge. The value of Q . q so that the drop can enter the sphere is: $\left(k = \frac{1}{4\pi\varepsilon_0}\right)$



(a) $\frac{mgR(h-R)}{k}$ (b) $\frac{2mgR(h-R)}{k}$ (c) $\frac{mgR(h-R)}{2k}$ (d) $\frac{mgh.R}{k}$

Q 6. Charge – Q and 2Q are distributed uniformly on surface of two concentric spherical shells of radii 'R' and '2R' respectively as shown in the figure. Select correct alternative(s)



(a) the total electrostatic energy stored in the system is $\frac{Q^2}{8\pi\varepsilon_0 R}$

(b) electrostatic energy in the space between two shells is $\frac{Q^2}{16\pi\varepsilon_0 R}$

(c) electrostatic energy stored outside the system is $\frac{Q^2}{2\pi\varepsilon_0 R}$

(d) electrostatic energy in space between two shells is zero.

Q 7. Choose the correct alternative (s) :

(a) A conducting body with a total negative charge may have negative, zero or positive potential.

(b) When a total charge is distributed on two isolated conducting spheres such that the total electrical potential energy of system is minimum, no charge will flow when the two spheres are connected by a conducting wire.

(c) A ring contains non–uniformly distributed positive and negative charges. If sum of total charge is zero then electric field at any point on the axis is either perpendicular to axis of ring or equal to zero.

(d) A positive charge always moves from higher potential to lower potential

Q 8. A hollow sphere of radius 2R is charged to V volts and another smaller sphere of radius R is charged to V/2 volts. Now the smaller sphere is placed inside the bigger sphere without changing the net charge on each sphere. The potential difference between the two spheres would be:

(a) 3V/2 (b) V/4 (c) V/2 (d) V

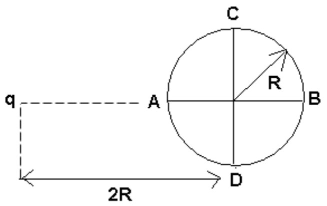
Q 9. A solid conducting sphere having a charge Q is surrounded by an uncharged concentric conducting hollow spherical shell. Let the potential difference between the surface of the solid sphere and that of the outer surface of the hollow shell be V. If the shell is now given a charge of —3Q, the new potential difference between the same two surfaces is:

(a) V (b) 2V (c) 4 V (d) – 2V

Q 10. A large solid sphere with uniformly distributed positive charge has a smooth narrow tunnel through its centre. A small particle with negative charge, initially at rest far from the sphere, approaches it along the line of the tunnel, reaches its surface with a speed v, and passes through the tunnel. Its speed at the centre of the sphere will be

(a) 0 (b) v (c) √2v (d) √1.5v

Q 11. A point charge 'q' is placed in front of a thin conducting spherical shell of radius 'R', at a distance '2R' from the center of sphere. Mark the correct statement [V_i stands for potential at point 'i']



(a) $V_A > V_B$ (b) $V_A - V_D = V_C - V_B$

(c) $V_A = \frac{1}{4\pi\varepsilon_0}\frac{q}{2R}$ (d) $V_B = \frac{1}{4\pi\varepsilon_0}\frac{q}{3R}$

Q 12. A point charge Q is placed at distance r from centre of neutral conductor solid sphere of radius R where r > R. Potential at centre of sphere due to induced charges on sphere is

(a) $\frac{kQ}{r}$ (b) $\frac{kQ}{R}$ (c) $\frac{kQ}{r-R}$ (d) Zero

Q 13. Mark the correct statement(s)

(a) At the surface of conductor electric field is perpendicular to surface only if there is no external charge.

(b) All points of a conductor have equal potential only if there is no external charge.

(c) Induced charges at the surface of neutral conductor do not produce electric field at any point.

(d) In a uniform charged solid nonconducting sphere magnitude of potential is maximum at centre.

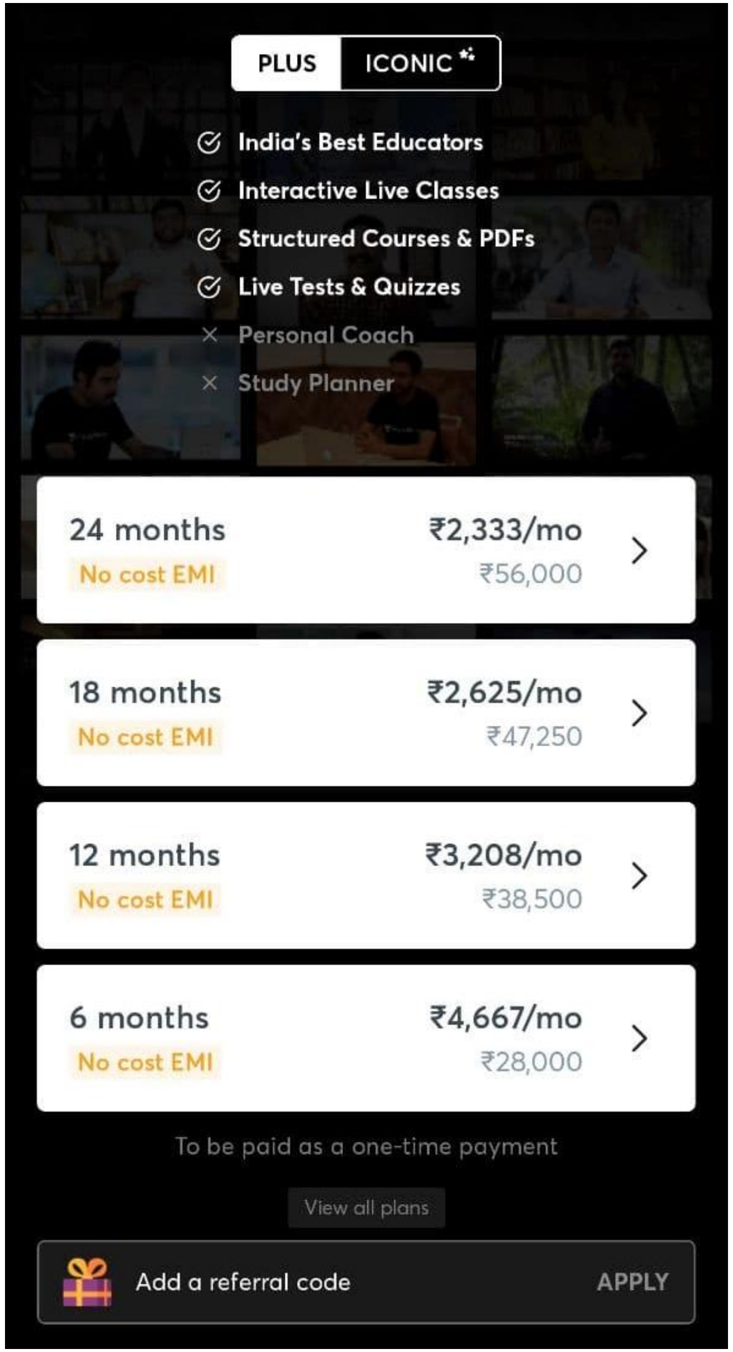
Q 14. A dipole is placed at distance r = 5R/3 from centre of neutral conductor sphere of radius R as shown in figure. Potential of point A is

(a) $\frac{3kp}{5R^2}$ (b) $\frac{9kp}{25R^2}$

(c) $\frac{27kp}{125R^2}$ (d) $\frac{36kp}{125R^2}$

Answer Key

Q.1 c	Q.2 b	Q.3 b	Q.4 a,c	Q.5 a
Q.6 a,b	Q.7 a, b, c, d	Q.8 b	Q.9 a	Q.10 d
Q.11 b,c	Q.12 d	Q.13 d	Q.14 d	



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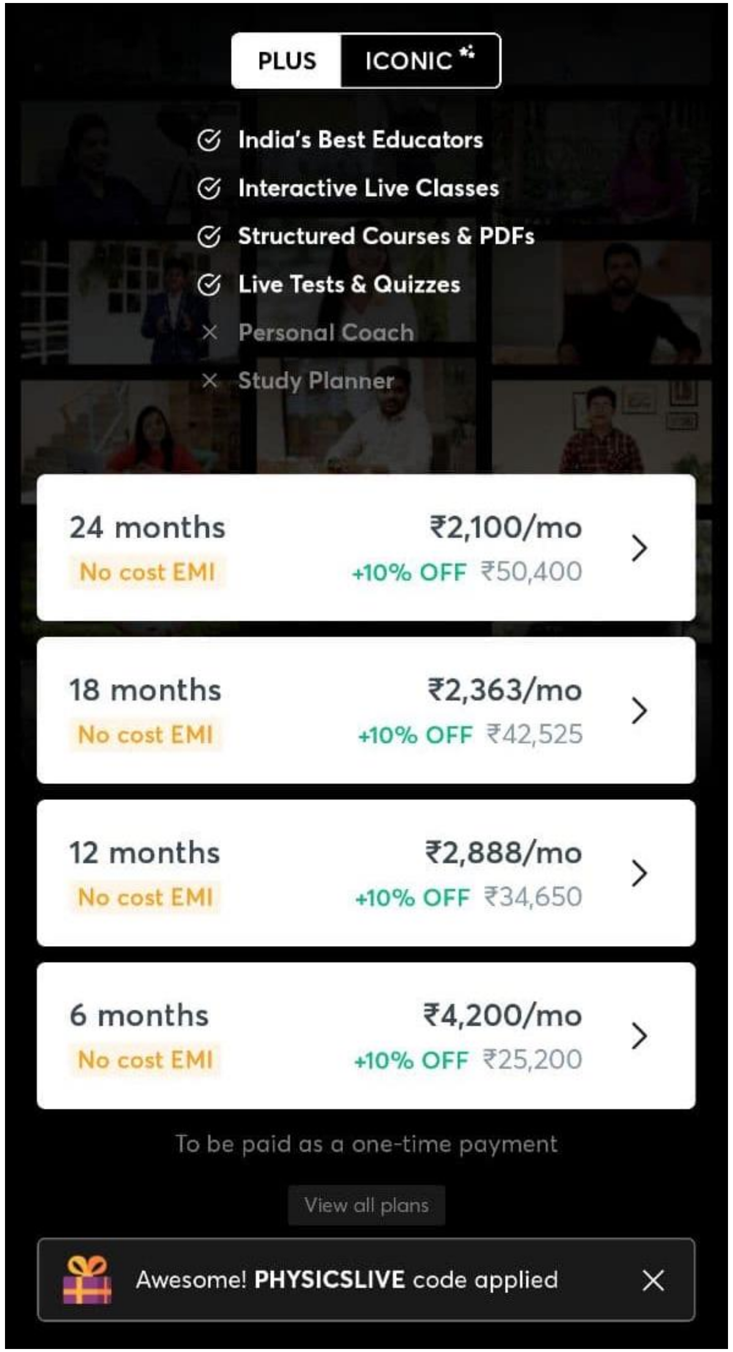


Written Solution

DPP- 7 Electrostatics : Properties of Conductor, Energy Density , Self Energy

By Physicsaholics Team

Q) A solid sphere of radius R is charged uniformly. At what distance from its surface is the electrostatic potential half of the potential at the centre?

$$V_{surface} = \frac{KQ}{R}$$

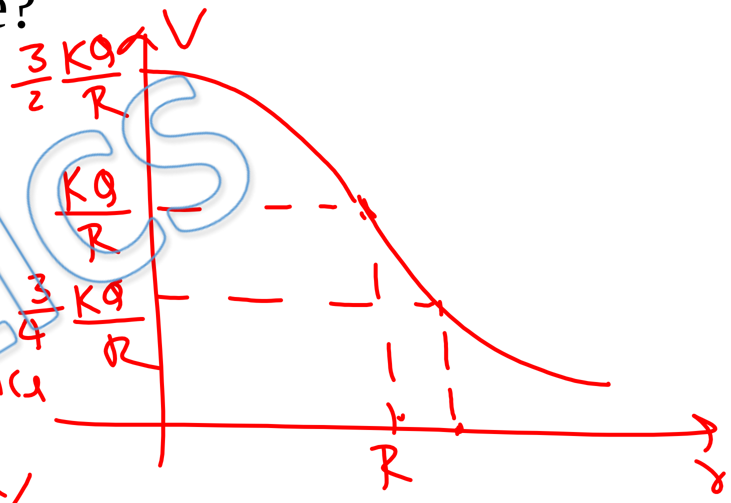
$$V_{centre} = \frac{3}{2}\frac{KQ}{R}$$

$$\frac{1}{2}V_{centre} = \frac{3}{4}\frac{KQ}{R}$$

$$V = \frac{KQ}{r} = \frac{3}{4}\frac{KQ}{R}$$

$$r = \frac{4R}{3}$$

distance from surface $= \frac{4R}{3} - R = R/3$



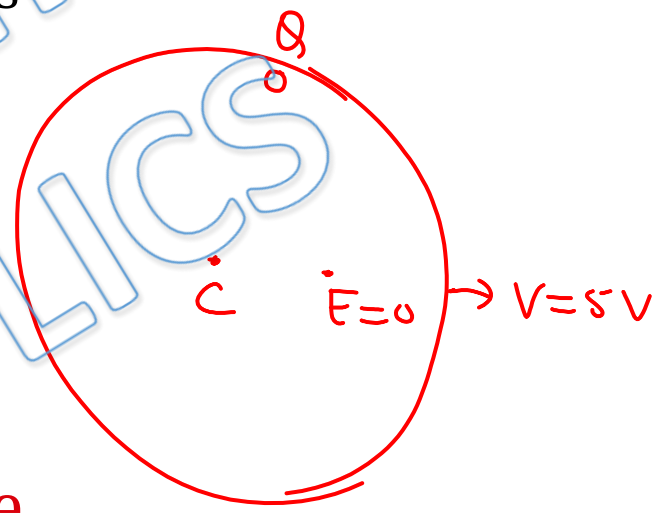
(a) R (b) R/2 (c) R/3 (d) 2R

Q) A hollow metal sphere of radius 5 cm is charged such that the potential on its surface is 10 V. The potential at the centre of the sphere is

$E = 0$

$\Rightarrow V = \text{Constant}$

$\Rightarrow V_{centre} = 10V$



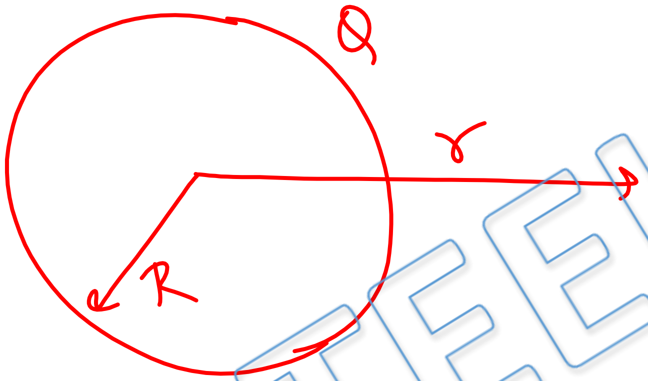
(a) zero

(b) 10 V

(c) same as at a point 5 cm away from the surface

(d) same as at a point 25 cm away from the surface

Q) A sphere of radius R is having charge Q uniformly distributed over it. The energy density of the electric field in the air, at a distance r (r > R) is given by (in J/m3) :



$$E = \frac{Q}{4\pi\epsilon_0 r^2}$$

(a) $\frac{Q^2}{32\pi^2\epsilon_0 R^2 r^2}$

(b) $\frac{Q^2}{32\pi^2\epsilon_0 r^4}$

(c) $\frac{Q^2}{32\pi^2\epsilon_0 R^4}$

(d) $\frac{Q^2}{16\pi^2\epsilon_0 r^4}$

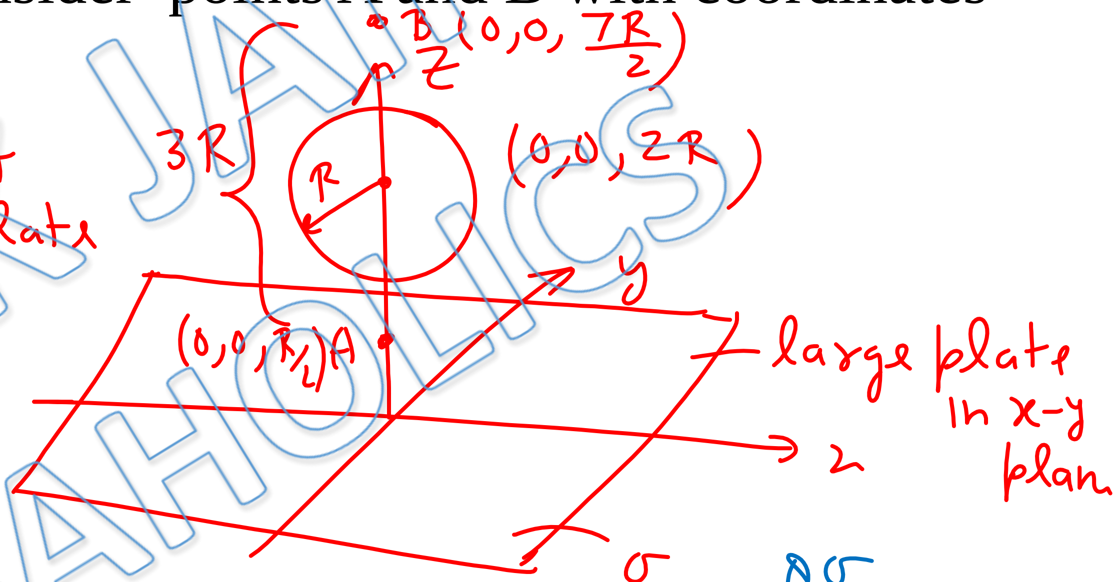
$$U_E = \frac{1}{2}\epsilon_0 E^2 = \frac{\epsilon_0}{2}\frac{Q^2}{16\pi^2\epsilon_0^2 r^4}$$

$$= \frac{Q^2}{32\pi^2\epsilon_0 r^4}$$

Q) An infinite large charge sheet with surface charge density σ is placed in x – y plane. A uniformly charged spherical shell total charge Q of radius R is placed such that center of the shell is at (0, 0, 2R). consider points A and B with coordinates A(0,0, R/2) and B(0,0, 7R/2)

$V_A - V_B = \Delta V$ due to sphere + ΔV due to plate

$= \left(\frac{2KQ}{3R} - \frac{2KQ}{3R}\right) + \frac{\sigma}{2\epsilon_0} \times 3R$

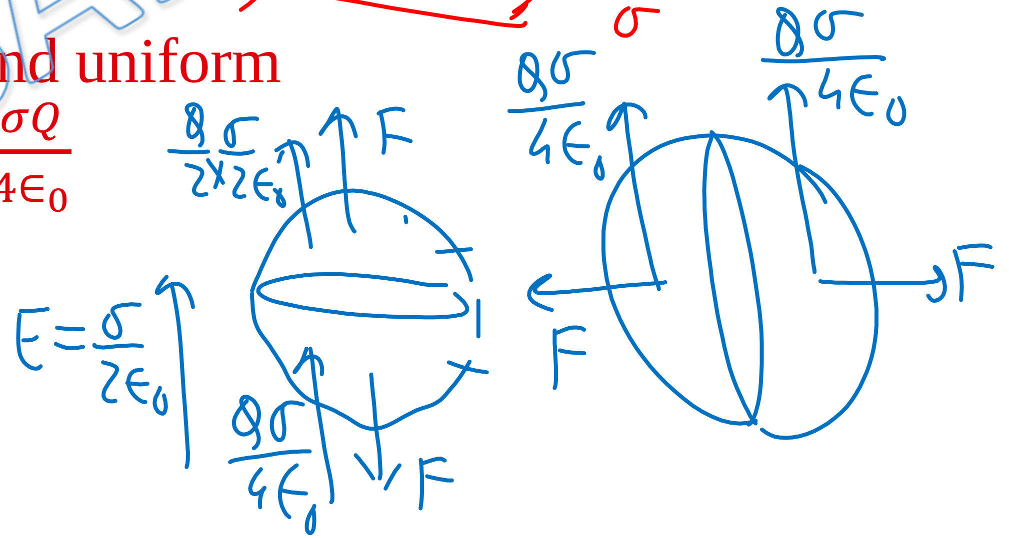


(a) $V_A - V_B = \frac{3\sigma R}{2\epsilon_0}$

(b) $V_A - V_B = \frac{\sigma R}{2\epsilon_0} + \frac{KQ}{2R}$

(c) Electric field inside shell is non zero and uniform

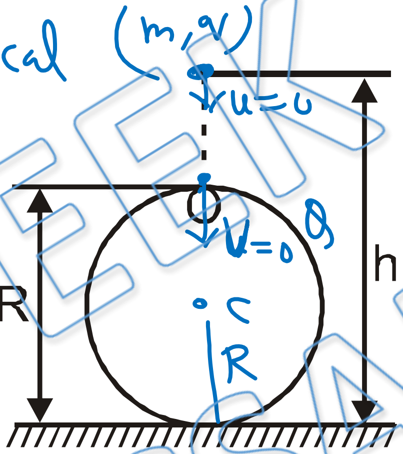
(d) Net force on hemispherical portion is $\frac{\sigma Q}{4\epsilon_0}$



Q) A charged liquid drop is released from a height (h–2R) above the opening of a spherical non-conducting shell of charge Q. The charge Q is uniformly distributed on the surface of the shell.Given: m is the mass of the drop and q is the charge. The value of Q . q so that the drop can enter the sphere is : $\left(k = \frac{1}{4\pi\varepsilon_0}\right)$

by Conservation of mechanical energy →

$$mgh + \frac{KQq}{h-R} = mg \times 2R + \frac{KQq}{R}$$



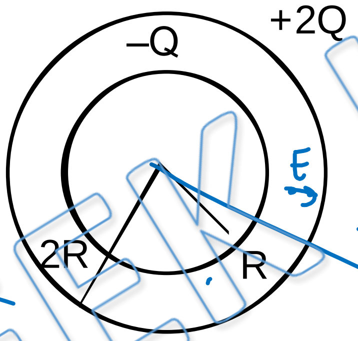
$$Qq = \frac{mgR(h-R)}{K}$$

(a) $\frac{mgR(h-R)}{k}$ (b) $\frac{2mgR(h-R)}{k}$ (c) $\frac{mgR(h-R)}{2k}$ (d) $\frac{mgh.R}{k}$

$$mg(h-2R) = KQq\left(\frac{1}{R} - \frac{1}{h-R}\right) = KQq\left(\frac{h-R-R}{R(h-R)}\right)$$

$$mg(h-2R) = \frac{KQq}{R(h-R)}(h-2R)$$

Q) Charge – Q and 2Q are distributed uniformly on surface of two concentric spherical shells of radii ‘R’ and ‘2R’ respectively as shown in the figure. Select correct alternative(s)



$$U = \frac{K(-Q)2Q}{2R} + \frac{KQ^2}{2R} + \frac{K(2Q)^2}{4R} = \frac{KQ^2}{2R}$$

(a) the total electrostatic energy stored in the system is $\frac{Q^2}{8\pi\varepsilon_0 R}$

(b) electrostatic energy in the space between two shells is $\frac{Q^2}{16\pi\varepsilon_0 R}$

(c) electrostatic energy stored outside the system is $\frac{Q^2}{2\pi\varepsilon_0 R}$

(d) electrostatic energy in space between two shells is zero.

Energy stored $= \frac{KQ^2}{4R}$ → energy store outside shell

Energy stored b/w shells $= \frac{KQ^2}{2R} - \frac{KQ^2}{4R} = \frac{KQ^2}{4R}$

Q) Choose the correct alternative (s) :

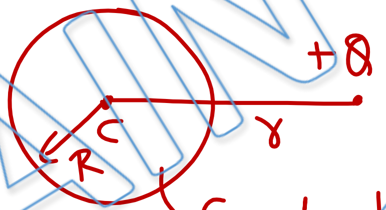
(a) A conducting body with a total negative charge may have negative, zero or positive potential.

(b) When a total charge is distributed on two isolated conducting spheres such that the total electrical potential energy of system is minimum, no charge will flow when the two spheres are connected by a conducting wire.

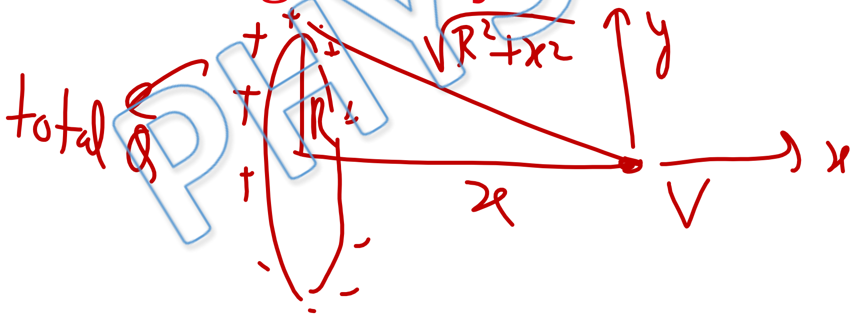
(c) A ring contains non–uniformly distributed positive and negative charges. If sum of total charge is zero then electric field at any point on the axis is either perpendicular to axis of ring or equal to zero.

(d) A positive charge always moves from higher potential to lower potential.

$V_c = \frac{-Kq}{R} + \frac{KQ}{r}$



$U = qV$

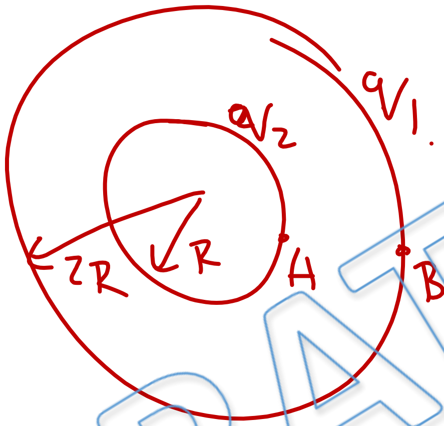


$V = \frac{KQ}{\sqrt{R^2+x^2}}$ if $Q = 0$ $\Rightarrow$ V on axis $= 0$

$E_x = \frac{\partial V}{\partial x} = 0$

$\frac{V}{2} = \frac{Kq_2}{R} \Rightarrow q_2 = \frac{VR}{2K}$ $V = \frac{Kq_1}{2R} \Rightarrow q_1 = \frac{2RV}{K}$

Q) A hollow sphere of radius 2R is charged to V volts and another smaller sphere of radius R is charged to V/2 volts. Now the smaller sphere is placed inside the bigger sphere without changing the net charge on each sphere. The potential difference between the two spheres would be:



$V_A - V_B = \Delta V \text{ due to } q_1 + \Delta V \text{ due to } q_2$

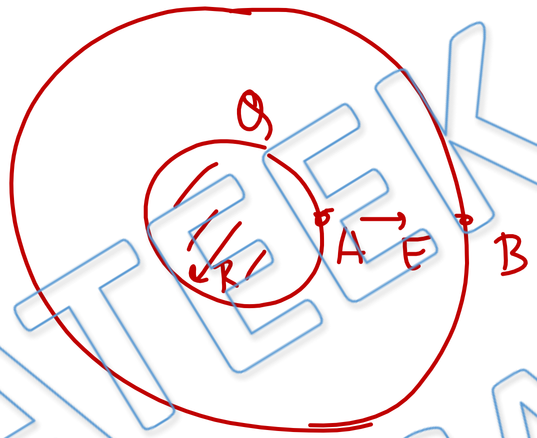
$= 0 + \frac{Kq_2}{R} - \frac{Kq_2}{2R}$

$= \frac{Kq_2}{2R} = \frac{K}{2R} \times \frac{VR}{2K}$

$= V/4$

(a) 3V/2 (b) V/4 (c) V/2 (d) V

Q) A solid conducting sphere having a charge Q is surrounded by an uncharged concentric 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 —3Q, the new potential difference between the same two surfaces is:



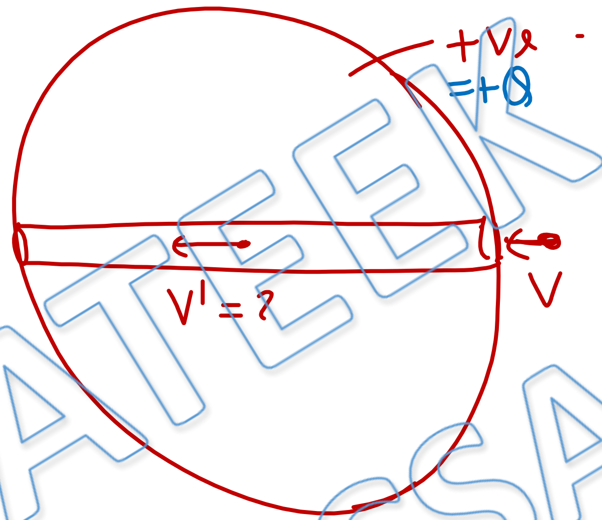
$\Delta V = -\int \vec{E} \cdot d\vec{r}$

E will not change on giving −3Q charge to shell

⇒ ΔV will not change

(a) V (b) 2V (c) 4 V (d) – 2V

Q) A large solid sphere with uniformly distributed positive charge has a smooth narrow tunnel through its centre. A small particle with negative charge, initially at rest far from the sphere, approaches it along the line of the tunnel, reaches its surface with a speed v, and passes through the tunnel. Its speed at the centre of the sphere will be



(a) 0 (b) v (c) √2v (d) √1.5v

by Conservation of mechanical energy from $x = \infty$ to surface →

$$0 + 0 = \frac{1}{2}mv^2 - q\left(\frac{KQ}{R}\right)$$

$$\frac{1}{2}mv^2 = \frac{KQq}{R} \quad \text{--- (1)}$$

by COM Energy from $x = \infty$ to Centre! –

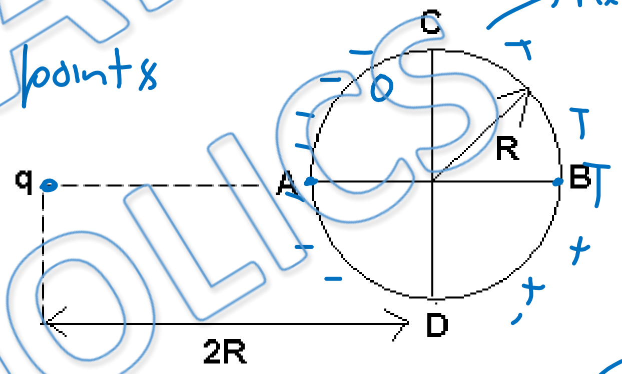
$$0 + 0 = \frac{1}{2}mv'^2 - q\left(\frac{3}{2}\frac{KQ}{R}\right) \Rightarrow \frac{1}{2}mv'^2 = \frac{3}{2}\frac{KQq}{R}$$

$$\Rightarrow \frac{1}{2}mv'^2 = \frac{3}{2} \times \frac{1}{2}mv^2$$

Q) A point charge ‘q’ is placed in front of a thin conducting spherical shell of radius ‘R’, at a distance ‘2R’ from the center of sphere. Mark the correct statement [V_i stands for potential at point ‘i’]

Potential of Conductor is same at all points

$V_A = V_B = V_C = V_D$

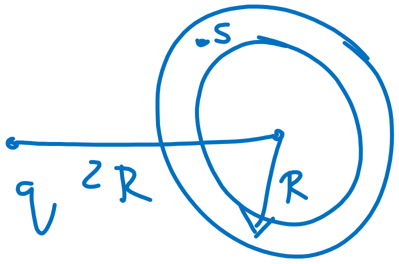


(a) $V_A > V_B$

(b) $V_A - V_D = V_C - V_B$

(c) $V_A = \frac{1}{4\pi\varepsilon_0}\frac{q}{2R}$

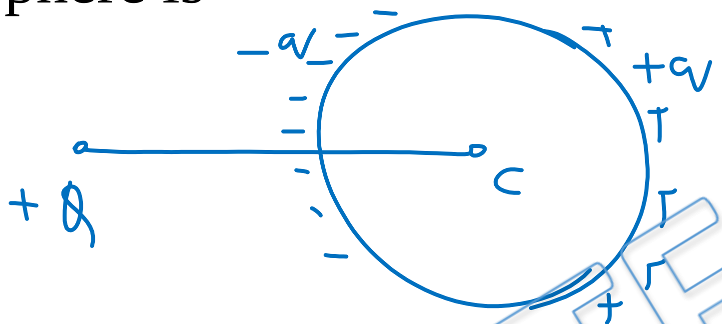
(d) $V_B = \frac{1}{4\pi\varepsilon_0}\frac{q}{3R}$



$V_S = V$ due to q + V due to induced

$= \frac{Kq}{2R} + 0$

Q) A point charge Q is placed at distance r from centre of neutral conductor solid sphere of radius R where r > R. Potential at centre of sphere due to induced charges on sphere is

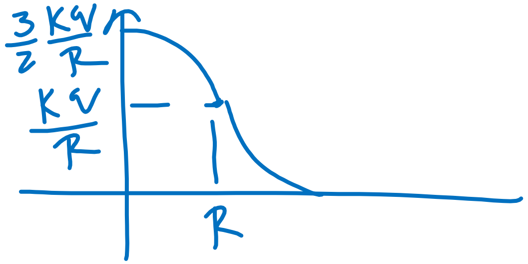


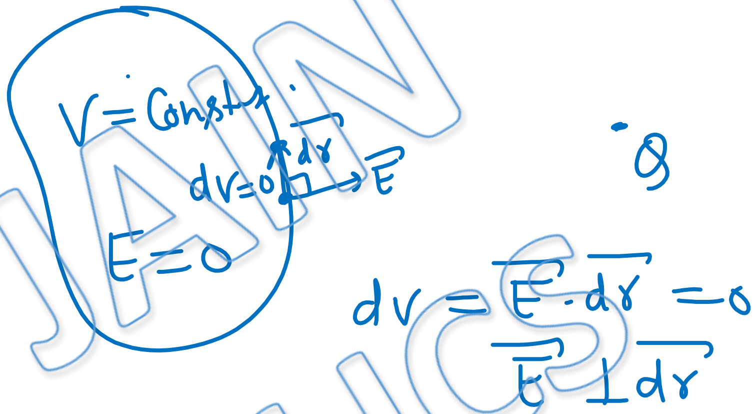
Net charge at surface = $-q + q = 0$

V at centre due to induced charges $= 0$

(a) $\frac{kQ}{r}$ (b) $\frac{kQ}{R}$ (c) $\frac{kQ}{r-R}$ (d) Zero

Q) Mark the correct statement(s)





(a) At the surface of conductor electric field is perpendicular to surface only if there is no external charge.

(b) All points of a conductor have equal potential only if there is no external charge.

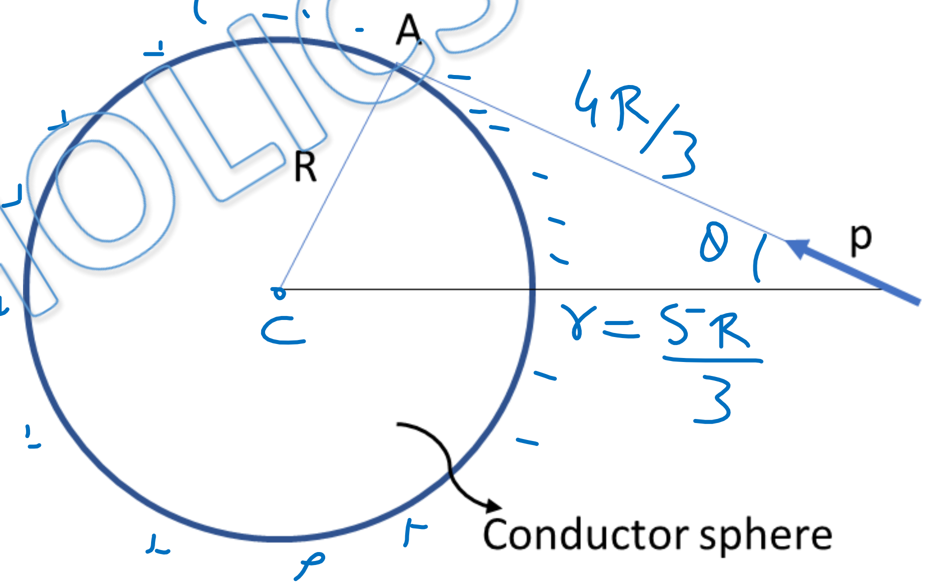
(c) Induced charges at the surface of neutral conductor do not produce electric field at any point.

(d) In a uniformy charged solid nonconducting sphere magniotude of potential is maximum at centre.

Q) A dipole is placed at distance r = 5R/3 from centre of neutral conductor sphere of radius R as shown in figure. Potential of point A is

(a) $\frac{3kp}{5R^2}$ (b) $\frac{9kp}{25R^2}$

(c) $\frac{27kp}{125R^2}$ (d) $\frac{36kp}{125R^2}$



$V_A = V_c = (V_{\text{due to dipole}} + V_{\text{due to induced charges}})$ (Net = 0)

$= \frac{KP\cos\theta}{r^2} + 0$

$= \frac{KP \times 4/5}{25R^2/9}$

$= \frac{36KP}{125R^2}$

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Chalo Niklo