DPP – 9 (Electrostatics)

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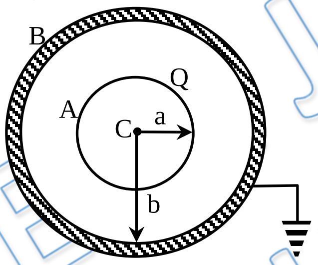
Q 1. A, B & C are three concentric metallic shells. Shell A is the inner most and shell C is the outermost. A is given some charge and shell C is earthed-
(a) The inner surfaces of B & C will have the same charge
(b) The inner surface of B & C will have same charge density
(c) The outer surface of A, B & C will have the same charge
(d) The outer surface of C will have no charge density

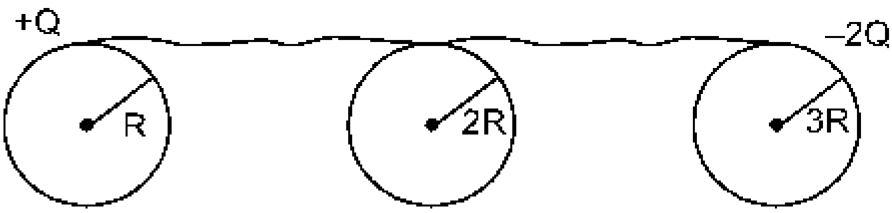
Q 2. A conducting sphere A of radius a, with charge Q, is placed concentrically inside a conducting shell B of radius b. B is earthed. C is the common centre of A and B -



(a) The field at a distance r from C, where a ≤ r ≤ b, is $\frac{KQ}{r^2}$
(b) The potential at a distance r from C, where a ≤ r ≤ b, is $\frac{KQ}{r}$
(c) The potential difference between A and B is $KQ\left(\frac{1}{a}-\frac{1}{b}\right)$
(d) The potential at a distance r from C, where a ≤ r ≤ b, is $KQ\left(\frac{1}{r}-\frac{1}{b}\right)$

Comprehension (Q3 to Q5)

Two conducting spheres of radius R and 3R carry charges Q and –2Q. Between these spheres a neutral conducting sphere of radius 2R is connected. The separation between the sphere is considerably large. Charge flows through conducting wire due to potential difference.



Q 3. The final charge on initially neutral conducting sphere is:
(a) $-\frac{Q}{6}$ (b) $-\frac{Q}{3}$ (c) $\frac{Q}{3}$ (d) $-\frac{Q}{2}$

Q 4. The decrease in electric potential energy of sphere of radius R is:
(a) $\frac{kQ^2}{4R}$ (b) $\frac{35kQ^2}{72R}$ (c) $\frac{kQ^2}{72R}$ (d) none

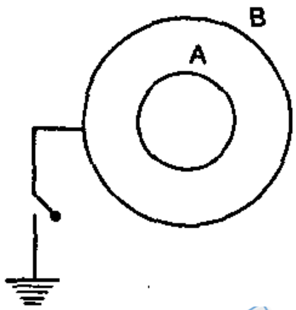
Q 5. The final electric potential of sphere of radius 3R will be:

(a) $-\frac{kQ}{6R}$ (b) $-\frac{kQ}{2R}$ (c) $-\frac{2kQ}{3R}$ (d) $-\frac{3kQ}{R}$

Q 6. A solid conducting sphere of radius 10 cm is enclosed by a thin metallic shell of radius 20 cm. A charge q = 20μC is given to the inner sphere. Find the heat generated in the process, the inner sphere is connected to the shell by a conducting wire

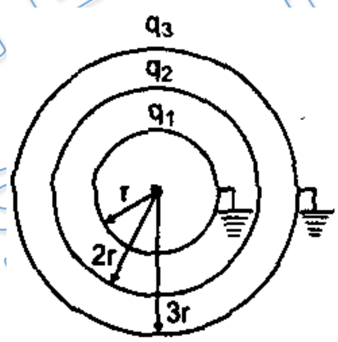
(a) 12 J (b) 9 J (c) 24 J (d) zero

Q 7. Two concentric shells have radii R and 2R charges q_A and q_B and potentials 2V and (3/2)V respectively. Now shell B is earthed and let charges on them become q'_A and q'_B. Then:



(a) q_A / q_B = 1/2
(b) q'_A / q'_B = 1
(c) potential of A after earthing becomes (3/2) V
(d) Potential difference between A and B after earthing becomes V/2

Q 8. Three concentric conducting spherical shells have radii r, 2r and 3r and charges q_1 , q_2 and q_3 respectively. Innermost and outermost shells are earthed as shown in figure. Select the correct alternative(s)

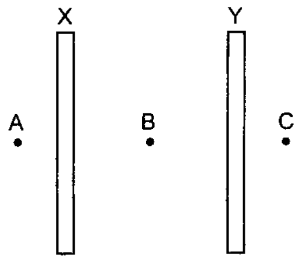


(a) $q_1 + q_3 = -q_2$ (b) $q_1 = -\frac{q_2}{4}$
(c) $\frac{q_3}{q_1} = 3$ (d) $\frac{q_3}{q_2} = -\frac{1}{3}$

Q 9. There are two concentric metal shells of radii r_1 and $r_2(>r_1)$. If the outer shell has a charge q and the inner shell is grounded, the charge on the inner shell is

(a) zero (b) $-(r_1 / r_2)$q
(c) $r_1 r_2$q (d) infinity

Q 10. X and Y are large, parallel conducting plates close to each other. Each face has an area A. X is given a charge Q. Y is without any charge. Points A, B and C are as shown in the figure.



(a) The field at B is $\frac{Q}{2\varepsilon_0 A}$
(b) The field at B is $\frac{Q}{\varepsilon_0 A}$
(c) The fields at A, B and C are of the same magnitude.
(d) The fields at A and C are of the same magnitude, but in opposite directions.

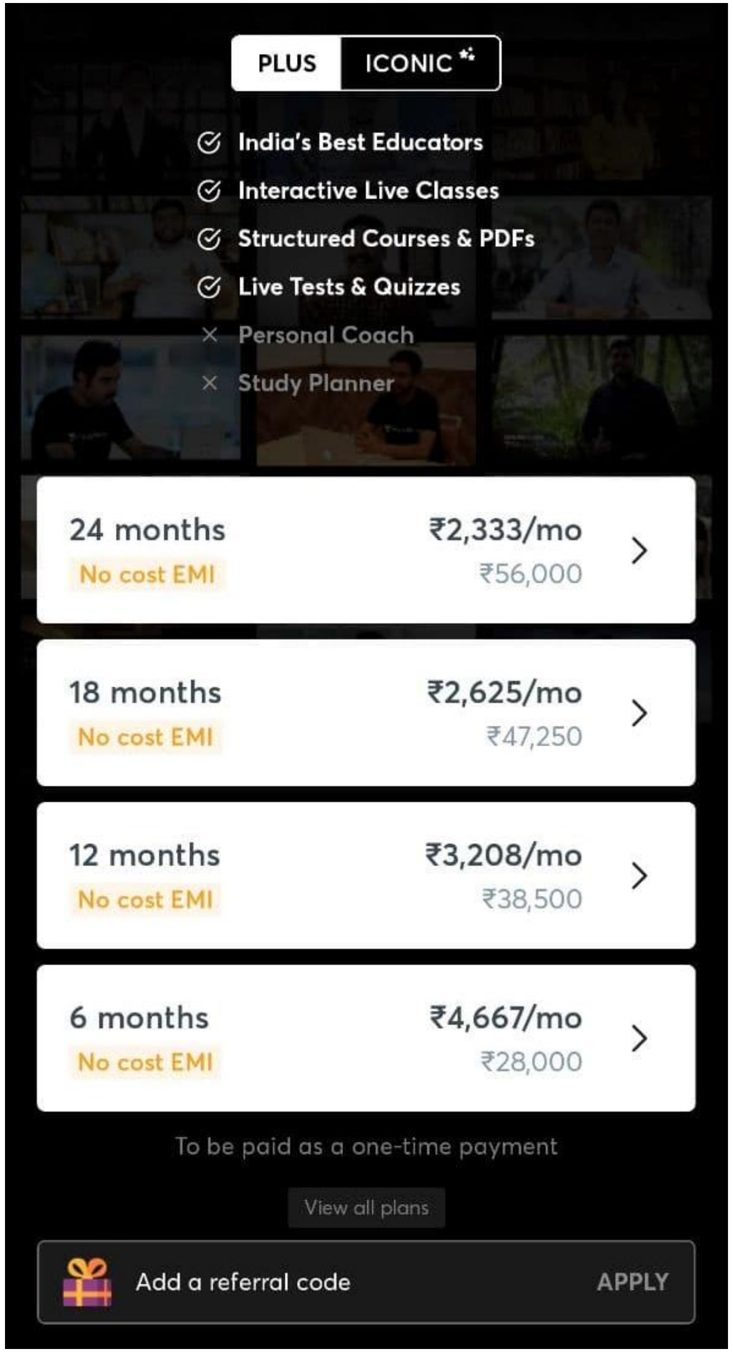
Q 11. A conducting sphere of radius R, carrying charge Q, lies inside an uncharged conducting shell of radius 2R. If they are joined by a metal wire,
(a) Q/3 amount of charge will flow from the sphere to the shell
(b) 2Q/3 amount of charge will flow from the sphere to the shell
(c) Q amount of charge will flow from the sphere to the shell
(d) k$\frac{Q^2}{4R}$amount of heat will be produced

Q 12. In Given figure all three conductor plates are parallel and identical. Magnitude of charge which will move through switch after closing switch is

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

Answer Key

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



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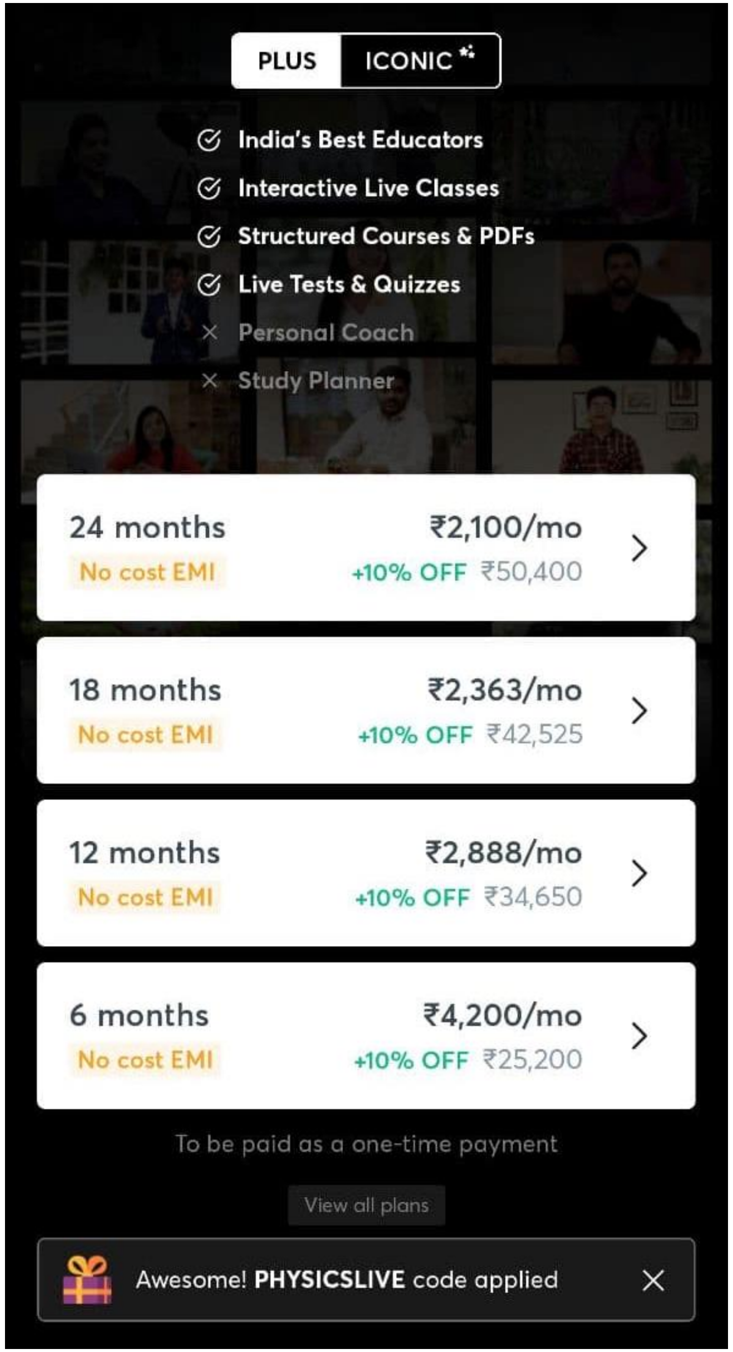


Written Solution

DPP- 9 Electrostatics : Charge Distribution on Parallel Plates ,Sharing of Charge, Earthing

By Physicsaholics Team

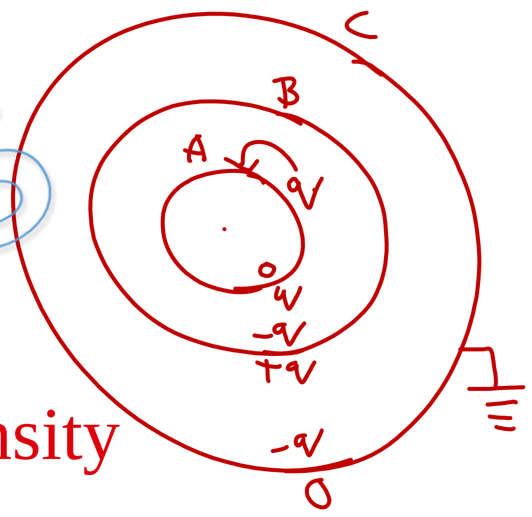
Q1) A, B & C are three concentric metallic shells. Shell A is the inner most and shell C is the outermost. A is given some charge and shell C is earthed-

(a) The inner surfaces of B & C will have the same charge

(b) The inner surface of B & C will have same charge density

(c) The outer surface of A, B & C will have the same charge

(d) The outer surface of C will have no charge density



Q2) A conducting sphere A of radius a, with charge Q, is placed concentrically inside a conducting shell B of radius b. B is earthed. C is the common centre of A and B -

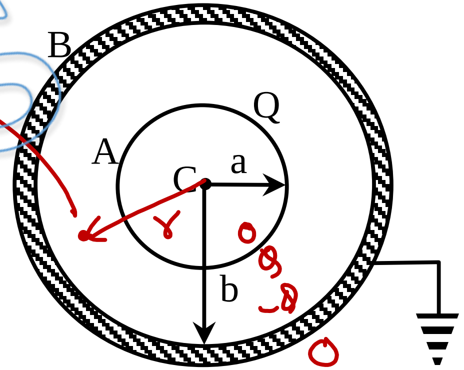
$V_B = 0$ (due to earthing)

$V_A = \frac{KQ}{a} - \frac{KQ}{b} = KQ\left(\frac{1}{a} - \frac{1}{b}\right)$

$V_A - V_B = KQ\left(\frac{1}{a} - \frac{1}{b}\right)$

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

$V = \frac{KQ}{r} - \frac{KQ}{b}$



(a) The field at a distance r from C, where a ≤ r ≤ b, is $\frac{KQ}{r^2}$

(b) The potential at a distance r from C, where a ≤ r ≤ b, is $\frac{KQ}{r}$

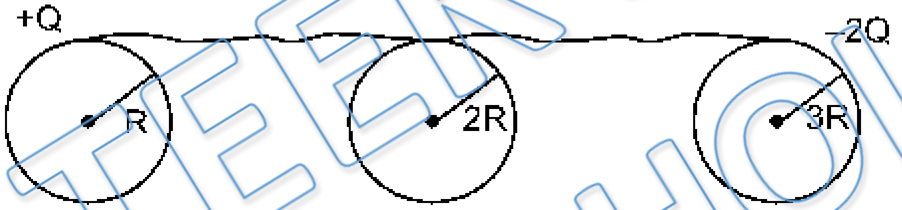
(c) The potential difference between A and B is $KQ\left(\frac{1}{a} - \frac{1}{b}\right)$

(d) The potential at a distance r from C, where a ≤ r ≤ b, is $KQ\left(\frac{1}{r} - \frac{1}{b}\right)$

Comprehension: Q3 to Q5

Two conducting spheres of radius R and 3R carry charges Q and –2Q. Between these spheres a neutral conducting sphere of radius 2R is connected. The separation between the sphere is considerably large. Charge flows through conducting wire due to potential difference.

$V = \frac{kq}{R} \Rightarrow q = \frac{VR}{k}$



final potential: V, V, V

final charge: q_1, q_2, q_3

$q_1 = \frac{VR}{k}$ $\quad q_2 = \frac{2VR}{k}$ $\quad q_3 = \frac{3VR}{k}$

Q3) The final charge on initially neutral conducting sphere is :

by Conservation of charge →

$$Q - 2Q = q_1 + q_2 + q_3$$

$$-Q = \frac{6VR}{K}$$

$$V = -\frac{KQ}{6R}$$

(a) $-\frac{Q}{6}$ (b) $-\frac{Q}{3}$ ✓ (c) $\frac{Q}{3}$ (d) $-\frac{Q}{2}$

$$q_2 = \frac{2VR}{K} = \frac{2R}{K}\left(-\frac{KQ}{6R}\right)$$

$$= -Q/3$$

Q4) The decrease in electric potential energy of sphere of radius R is :

$$U_1 = \frac{KQ^2}{2R}$$

final charge $= q_1 = \frac{VR}{K} = \left(-\frac{KQ}{6R}\right)\frac{R}{K} = -Q/6$

$$U_f = \frac{K(-Q/6)^2}{2R} = \frac{KQ^2}{72R}$$

(a) $\frac{kQ^2}{4R}$ ✓(b) $\frac{35kQ^2}{72R}$ (c) $\frac{kQ^2}{72R}$ (d) none

decrease in PE $= \frac{KQ^2}{2R} - \frac{KQ^2}{72R}$

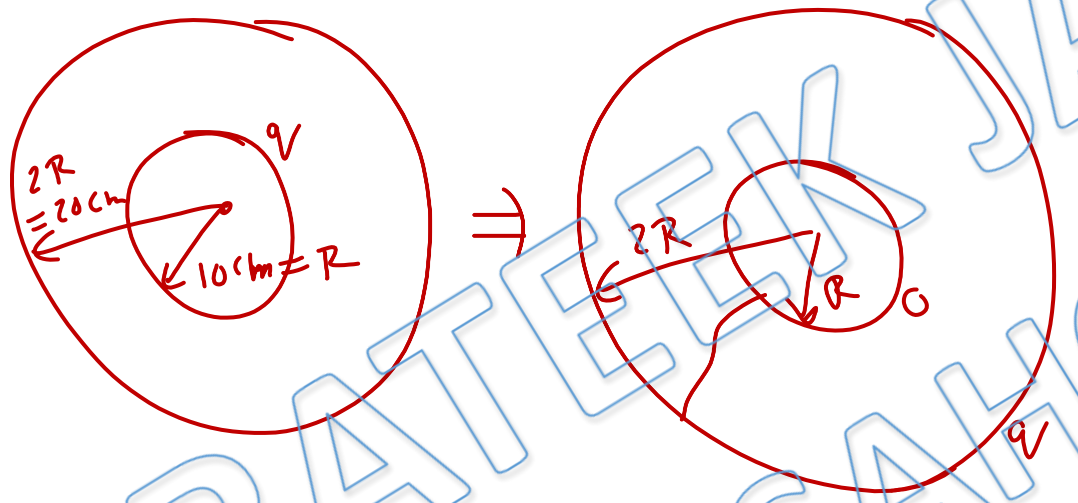
$$= \frac{KQ^2}{R}\left[\frac{36-1}{72}\right] = \frac{35}{72}\frac{KQ^2}{R}$$

Q5) The final electric potential of sphere of radius 3R will be :

$$V = -\frac{KQ}{6R}$$

(a) $-\frac{kQ}{6R}$ (b) $-\frac{kQ}{2R}$ (c) $-\frac{2kQ}{3R}$ (d) $-\frac{3kQ}{R}$

Q6) A solid conducting sphere of radius 10 cm is enclosed by a thin metallic shell of radius 20 cm. A charge q = 20μC is given to the inner sphere. Find the heat generated in the process, the inner sphere is connected to the shell by a conducting wire



Initial energy $= \frac{Kq^2}{2R}$

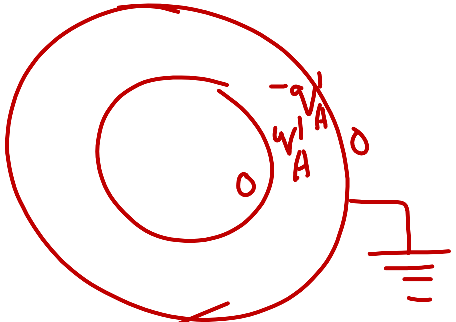
final energy $= \frac{Kq^2}{4R}$

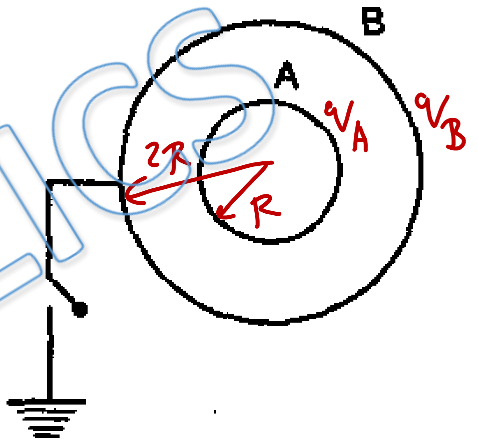
(a) 12 J (b) 9 J (c) 24 J (d) zero

Heat produced $= \frac{Kq^2}{2R} - \frac{Kq^2}{4R} = \frac{Kq^2}{4R} = \frac{9\times10^9\times400\times10^{-12}}{4\times\cdot1}$

$= 9J$

Q7) Two concentric shells have radii R and 2R charges q_A and q_B and potentials 2V and (3/2)V respectively. Now shell B is earthed and let charges on them become q'_A and q'_B. Then:





$V_B = \frac{3V}{2} = \frac{K(q_A + q_B)}{2R}$

$V_A = 2V = \frac{Kq_A}{R} + \frac{Kq_B}{2R}$

$V_A = 2V = \frac{K(2q_A + q_B)}{2R}$

$\frac{V_B}{V_A} = \frac{3}{4} = \frac{q_A + q_B}{2q_A + q_B} \Rightarrow 6q_A + 3q_B = 4q_A + 4q_B$

$2q_A = q_B \Rightarrow q_A/q_B = 1/2$

(a) $q_A / q_B = 1/2$

(b) $q'_A / q'_B = 1$

(c) potential of A after earthing becomes (3/2) V

(d) Potential difference between A and B after earthing becomes V/2

$q'_A = q_A$

$q'_B = -q'_A$

$V'_A = \frac{Kq_A}{R} - \frac{Kq_A}{2R} = \frac{Kq_A}{2R}$

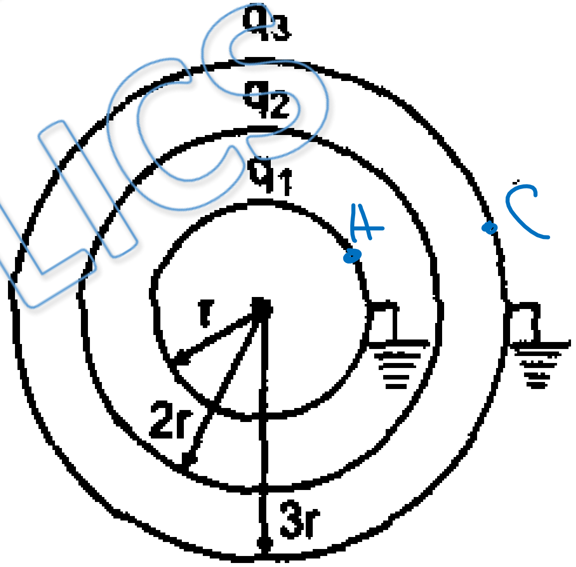
$\frac{3V}{2} = \frac{3Kq_A}{2R}$

$V'_A = V/2$

Q8) Three concentric conducting spherical shells have radii r, 2r and 3r and charges q_1 , q_2 and q_3 respectively. Innermost and outermost shells are earthed as shown in figure. Select the correct alternative(s)

$$V_A = \frac{Kq_1}{r} + \frac{Kq_2}{2r} + \frac{Kq_3}{3r} = 0$$

$$6q_1 + 3q_2 + 2q_3 = 0 \quad \text{--- (1)}$$



$$V_C = 0 = \frac{K(q_1+q_2+q_3)}{3r}$$

$$\Rightarrow q_1 + q_2 + q_3 = 0 \quad \text{--- (11)}$$

(a) $q_1 + q_3 = -q_2$ ✓

(b) $q_1 = -\frac{q_2}{4}$ ✓

(c) $\frac{q_3}{q_1} = 3$ ✓

(d) $\frac{q_3}{q_2} = -\frac{1}{3}$ ✓

$$4q_1 + q_2 = 0$$

$$\frac{q_1}{q_2} = -1/4$$

$$3q_1 - q_3 = 0$$

$$\frac{q_3}{q_1} = 3$$

$$\frac{q_1}{q_2} \times \frac{q_3}{q_1} = -\frac{3}{4}$$

Q9) There are two concentric metal shells of radii r_1 and $r_2 (> r_1)$. If the outer shell has a charge q and the inner shell is grounded, the charge on the inner shell is

$V_A = 0$

$\Rightarrow \frac{Kq_A}{r_1} + \frac{Kq}{r_2} = 0$

$\Rightarrow q_A = -\frac{q r_1}{r_2}$

(a) zero

(b) $-(r_1 / r_2)q$

(c) $r_1 r_2 q$

(d) infinity

Q10) X and Y are large, parallel conducting plates close to each other. Each face has an area A. X is given a charge Q. Y is without any charge. Points A, B and C are as shown in the figure.

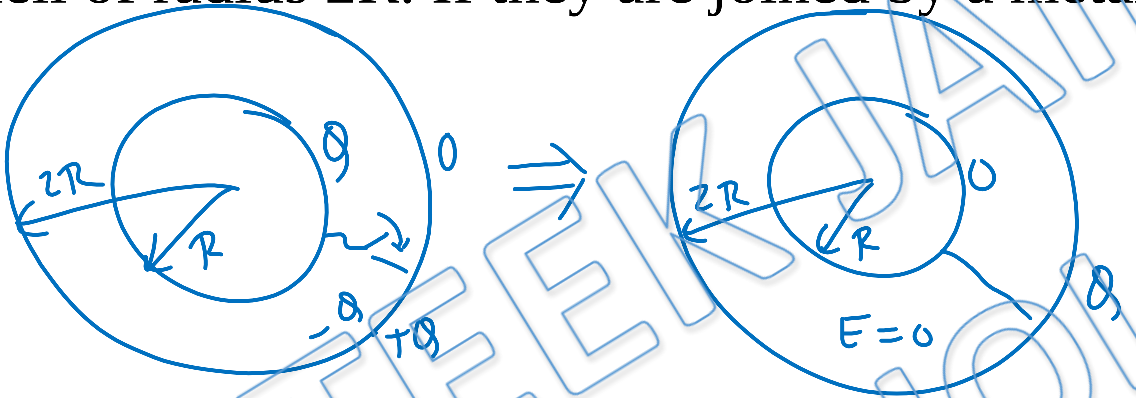
(a) The field at B is $\frac{Q}{2\varepsilon_0 A}$

(b) The field at B is $\frac{Q}{\varepsilon_0 A}$

(c) The fields at A, B and C are of the same magnitude.

(d) The fields at A and C are of the same magnitude, but in opposite directions.

Q11) A conducting sphere of radius R, carrying charge Q, lies inside an uncharged conducting shell of radius 2R. If they are joined by a metal wire,



(a) Q/3 amount of charge will flow from the sphere to the shell

(b) 2Q/3 amount of charge will flow from the sphere to the shell

(c) Q amount of charge will flow from the sphere to the shell

(d) $k\frac{Q^2}{4R}$ amount of heat will be produced

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

$U_f = \frac{KQ^2}{4R}$

Heat produced

$= \frac{KQ^2}{2R} - \frac{KQ^2}{4R}$

$= \frac{KQ^2}{4R}$.

Q12) In Given figure all three conductor plates are parallel and identical. Magnitude of charge which will move through switch after closing switch is

$\Delta V = 0$

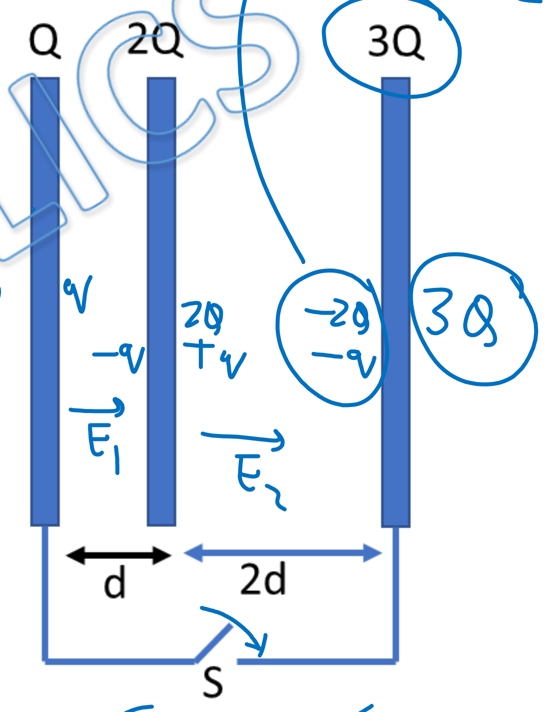
$\Rightarrow -E_1 d - E_2 \times 2d = 0$

$\Rightarrow E_1 + 2E_2 = 0$

$\Rightarrow \frac{q}{A\epsilon_0} + 2\frac{(2Q+q)}{A\epsilon_0} = 0$

$\Rightarrow q + 4Q + 2q = 0$

$q = -\frac{4Q}{3}$



$-2Q + \frac{4Q}{3} = \frac{-6Q+4Q}{3} = -\frac{2Q}{3}$

$2Q/3$

(a) Q

(b) 2Q/3

(c) 4Q/3

(d) Q/3

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Chalo Niklo