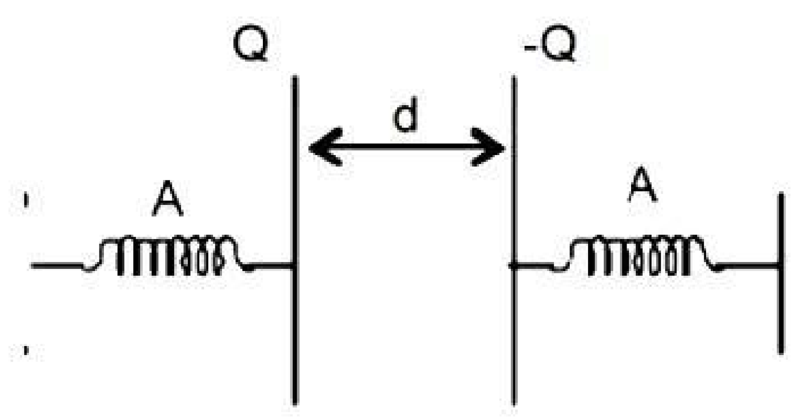
[SINGLE CORRECT CHOICE TYPE]

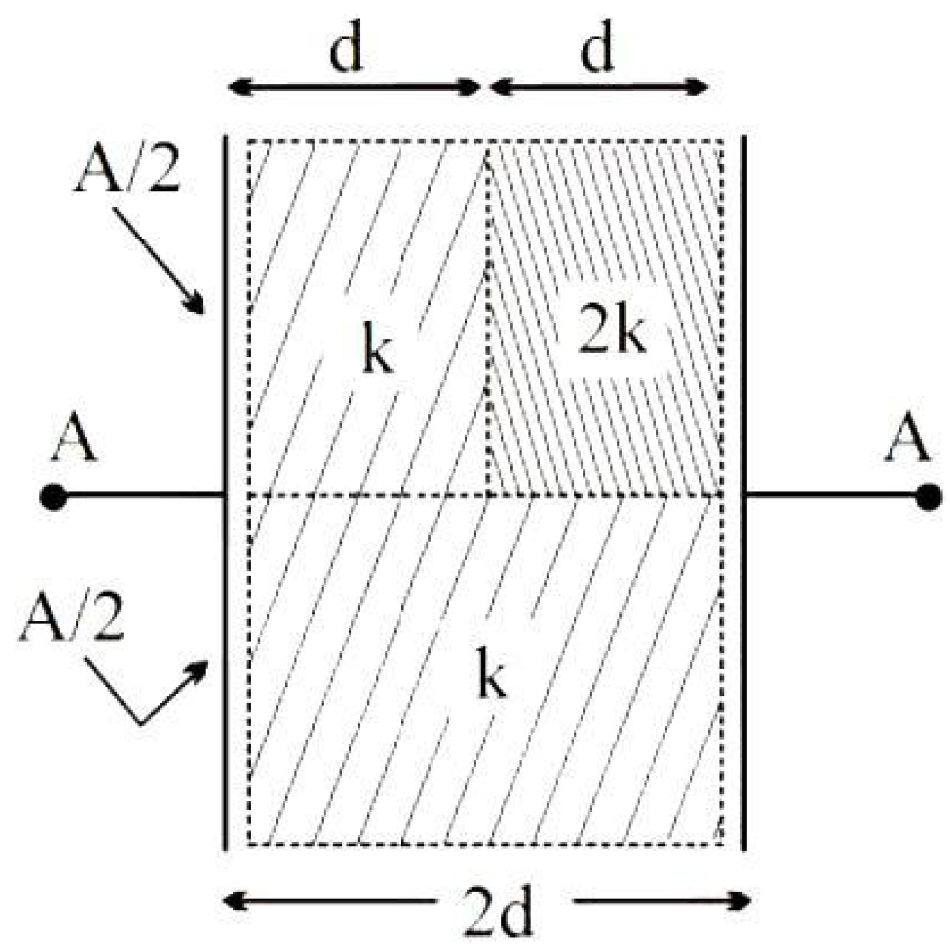
Q.1 Two large metallic plates having area A and charge Q and –Q each are separated by a small distance d and are connected by two springs of spring constant k , as shown in the figure. The energy stored in any one of the springs in equilibrium condition is



(A) $\frac{Q^2}{4A^2\varepsilon_0^2 k} d$ (B) $\frac{Q^2}{2A\varepsilon_0^2} d$ (C) $\frac{Q^4}{8A^2\varepsilon_0^2 k}$ (D) none of these

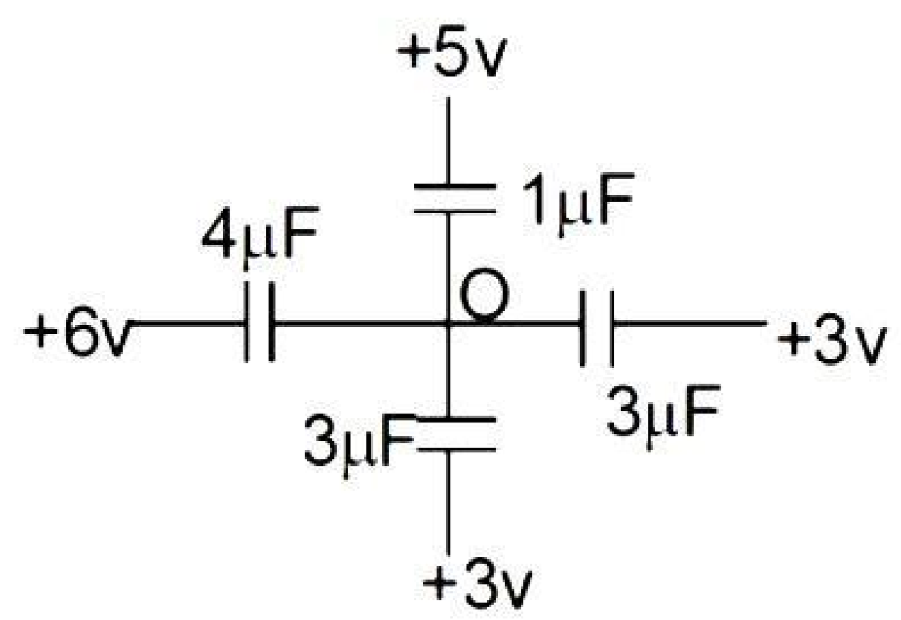
Q.2 A parallel plate capacitor is charged and the charging battery is then disconnected. If the plates of the capacitor are moved further apart by means of insulating handles. Which statement is incorrect ?
(A) The charge on the capacitor increases.
(B) The voltage across the plates increases.
(C) The capacitance decreases.
(D) The electrostatic energy stored in the capacitor increases.

Q.3 The capacitance of capacitor, of plate area A and separation 2d with dielectrics inserted as shown is



(A) $\frac{3k \epsilon_0 A}{2d}$ (B) $\frac{5k \epsilon_0 A}{12A}$ (C) $\frac{7k \epsilon_0 A}{12d}$ (D) $\frac{k \epsilon_0 A}{d}$

Q.4 What is the potential at point O ?



(A) 4.27 V (B) 17 V (C) zero (D) 34V

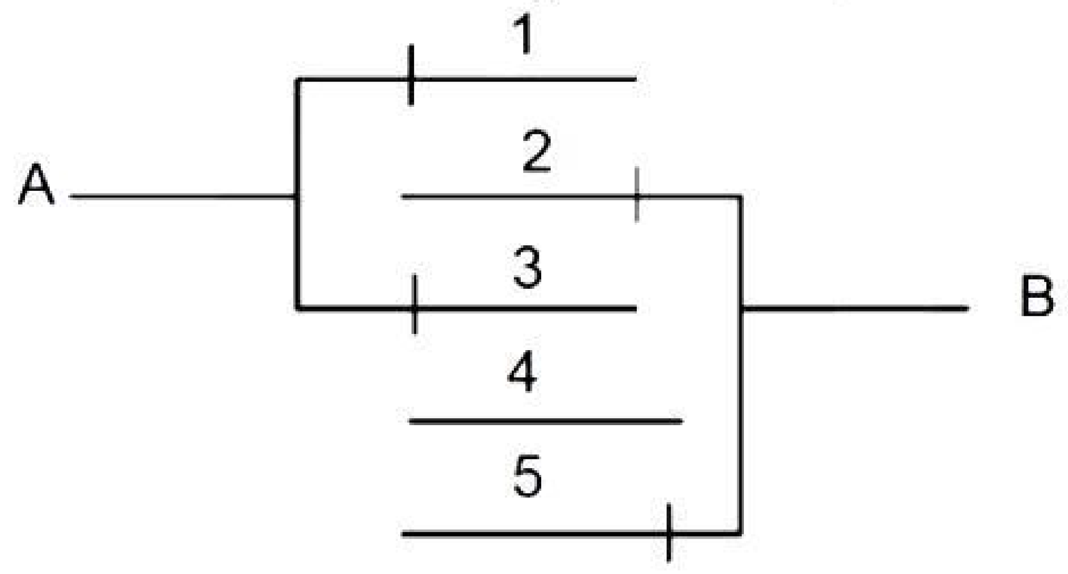
Q.5 A capacitor of capacitance 1μF and charge 1μC is connected to a 2μF capacitor charged to 4 μC with the terminals of unlike sign together. The final charge on the two capacitors is

(A) $\frac{1}{3}$ μC and $\frac{1}{3}$ μC (B) 1μC and 2μC (C) $\frac{1}{3}$ μC and 1μC (D) $\frac{2}{3}$ μC and $\frac{2}{3}$ μC

Q.6 A parallel plate capacitor of capacitance C with air as dielectric is connected across a battery of emf E. If space between plates is filled by a dielectric slab of dielectric constant K, then further charge drawn from the battery is

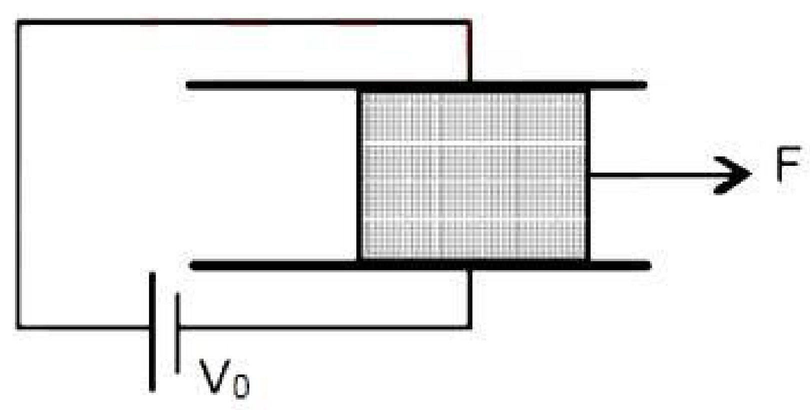
(A) KEC (B) (K–1) EC (C) KEC/2 (D) zero

Q.7 Five identical conducting plates of area A and separation between the plates d are connected as shown in figure. If A & B are connected to a battery of emf E, the charge drawn from the battery is



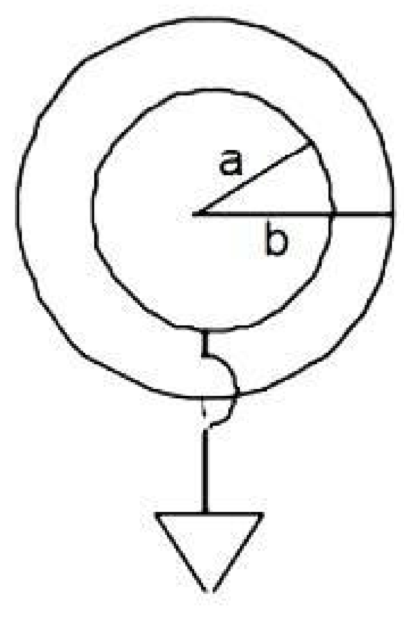
(A) $\frac{2\varepsilon_0 A}{d}E$ (B) $\frac{\varepsilon_0 A}{2d}E$ (C) $\frac{3\varepsilon_0 A}{2d}E$ (D) none of the above

Q.8 A capacitor having square plates of cross sectional area a^2 is connected with a cell of emf V_0 volts. A dielectric material of dielectric constant k is inserted inside the plates in such a way that it fills half the space between the plates. The work done by external agent to remove the dielectric material slowly from the space between the plates would be (the separation between the plates is d)



(A) $\frac{\varepsilon_0 a^2 (k-1) v_0^2}{2d}$ (B) $\frac{\varepsilon_0 a^2 (k-1) v_0^2}{4d}$ (C) $\frac{k\varepsilon_0 a^2 v_0^2}{2d}$ (D) none of these

Q.9 The figure shows a spherical capacitor with inner sphere earthed and outer shell is given some charge. The capacitance of the system is



(A) $\frac{4\pi\varepsilon_0 ab}{b-a}$ (B) $\frac{4\pi\varepsilon_0 b^2}{b-a}$ (C) $4\pi\varepsilon_0(b+a)$ (D) none of these

Q.10 A capacitor of capacitance C is initially charged to a potential difference of V volt. Now it is connected to a battery of 2V with opposite polarity. The ratio of heat generated to the final energy stored in the capacitor will be

(A) 1.75 (B) 2.25 (C) 2.5 (D) 1/2

[REASONING TYPE]

Q.11 **Statement-1:** In comparing two parallel plate capacitors each of capacitance $1\mu F$ filled with air but they differ significantly in size. The larger of the two can probably be charged up to a higher potential difference than the smaller one. It will thus be able to hold more energy than the smaller one.

Statemen-2: Breakdown strength, i.e. the electric field at which dielectric (air) breaks down, governs the charge holding capacity of the capacitor.

(A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

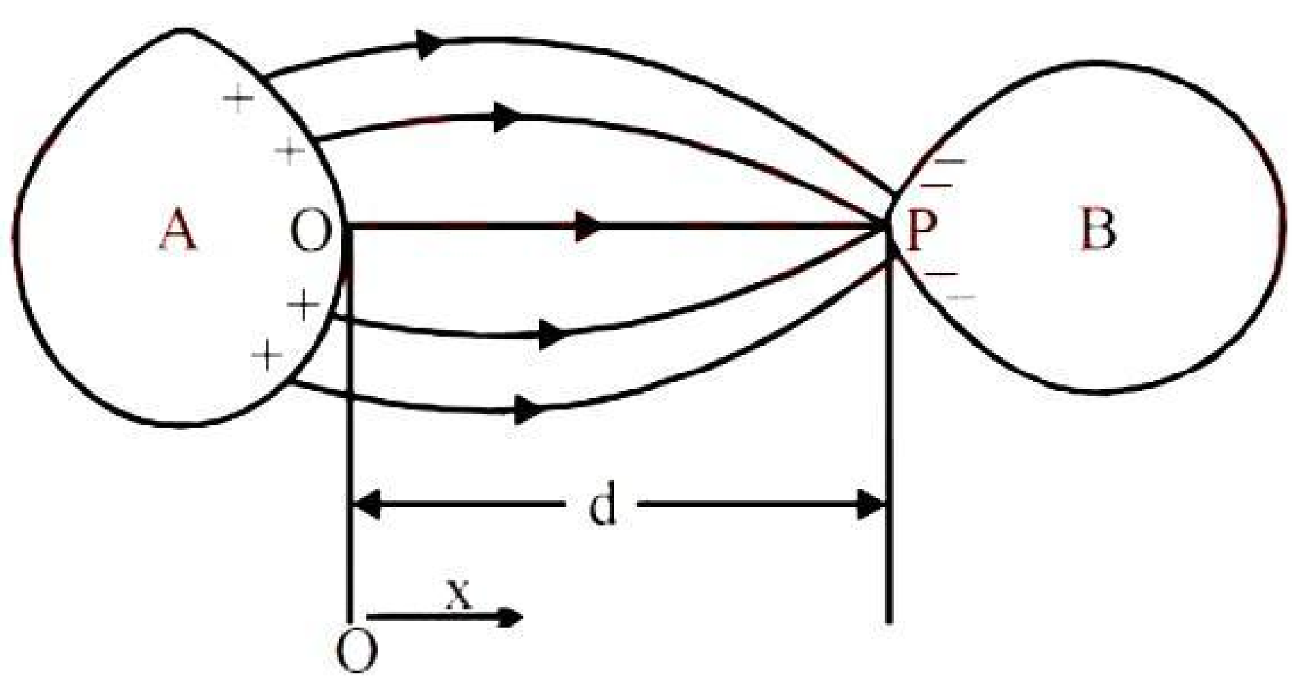
(C) Statement-1 is true, statement-2 is false.

(D) Statement-1 is false, statement-2 is true.

[PARAGRAPH TYPE]

Paragraph for question nos. 12 to 14

To find the capacitance between two arbitrary shaped conductors A and B carrying equal and opposite charges Q and –Q say, we use the formulae $C = \frac{Q}{V}$, where $V_{AB} = V = -\int E.d\ell$. If $E = \frac{aQ}{\varepsilon_0}\left(1 + \frac{x^2}{d^2}\right)$, where a = constant and d = least distance between the conductors, answer the following questions :



Q.12 The potential difference between the conductors is

(A) $\frac{aQd}{3\varepsilon_0}$ (B) $\frac{3aQd}{2\varepsilon_0}$ (C) $\frac{4aQd^2}{3\varepsilon_0}$ (D) $\frac{4aQd}{3\varepsilon_0}$

Q.13 The capacitance of the system is

(A) $\frac{\varepsilon_0}{4ad}$ (B) $\frac{\varepsilon_0 a}{3d}$ (C) $\frac{3\varepsilon_0}{4ad}$ (D) None of these

Q.14 The ratio of electrostatic field energy densities at O and P is

(A) 1 : 1 (B) 1 : 2 (C) 1 : 4 (D) None of these

[MULTIPLE CORRECT CHOICE TYPE]

Q.15 A parallel plate capacitor is charged and then disconnected from the source of steady E.M.F. The plates are then drawn apart farther. Again it is connected to the same source. Then

(A) the potential difference across the plate increases, while the plates are being drawn apart.

(B) the charge from the capacitor flows into the source, when the capacitor is reconnected.

(C) more charge is drawn to the capacitor from the source, during the reconnection.

(D) the electric intensity between the plates remains constant during the drawing apart of plates.

Q.16 Following operations can be performed on a capacitor :

X – connect the capacitor to a battery of emf E. Y – disconnect the battery

Z – reconnect the battery with polarity reversed. W – insert a dielectric slab in the capacitor

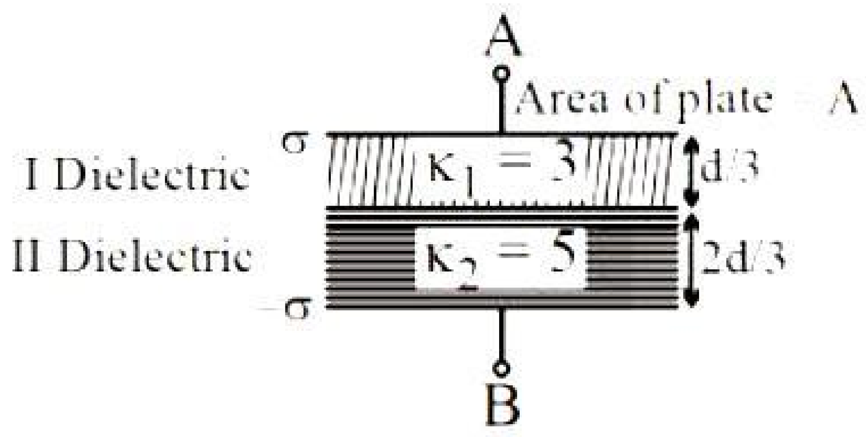
(A) In XYZ (perform X, then Y, then Z) the stored electric energy remains unchanged and no thermal energy is developed.

(B) The charge appearing on the capacitor is greater after the action XWY than after the action XYW.

(C) The electric energy stored in the capacitor is greater after the action WXY than after the action XYW.

(D) The electric field in the capacitor after the action XW is the same as that after WX.

Q.17 In the figure shown, if σ is the surface charge density on the upper metallic plate, then



(A) The ratio of energy density in I dielectric to second dielectric is 5/3

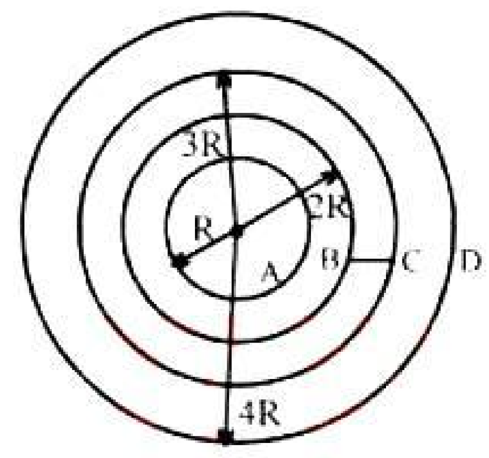
(B) The ratio of energy density in I dielectric to second dielectric is 3/5

(C) Total induced surface charge density on the interface of the two dielectric is $-3\sigma/15$

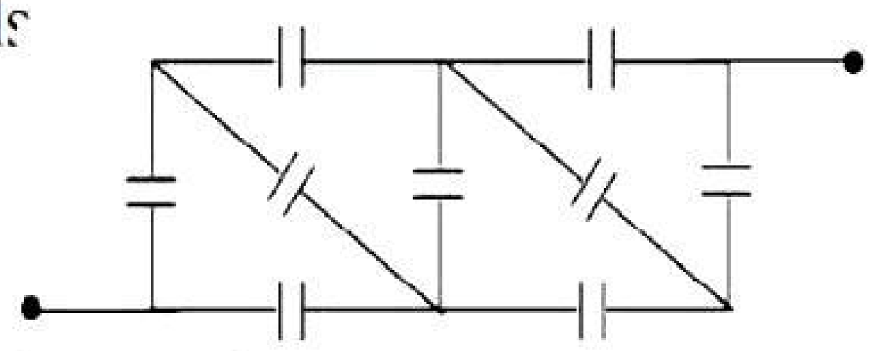
(D) Total induced surface charge density on the interface of the two dielectric is $-2\sigma/15$

[SUBJECTIVE TYPE]

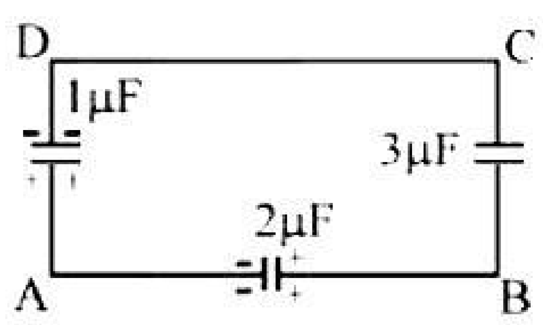
Q.18 Four concentric conducting spherical shell A, B, C & D having radius R, 2R, 3R & 4R respectively are shown in figure. Shell B & C are connected by thin conducting wire. Then calculate the capacitance of this system between shell A & shell D.



Q.19 Find the equivalent capacitance of the combination between the terminals as shown in the figure.
Each capacitor is of capacitance C.



Q.20 Three capacitors of capacitance 1 μF, 2 μF & 3 μF are given initial charges 3 μC, 1 μC and zero, respectively. They are connected together at a certain instant as shown, with the + & – signs indicating the charges on their plates at the time of connection. After the charge redistribution has taken place, find the charge on the 1 μF capacitor and the heat generated?



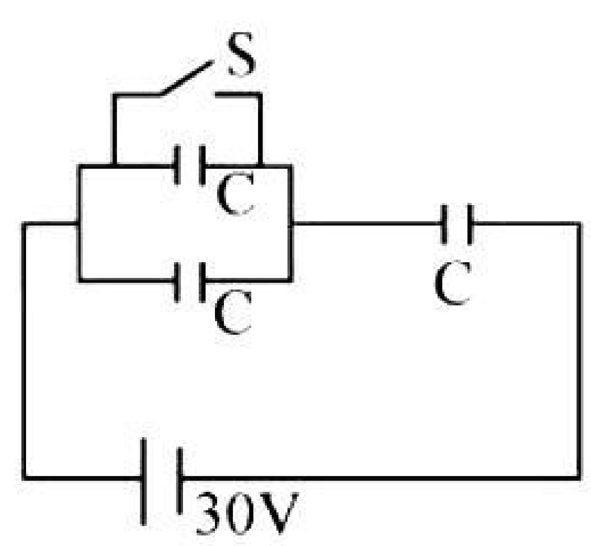
Q.21 The capacitors, each having capacitance C = 2μF are connected with a battery of emf 30 V as shown in figure. When the switch S is closed. Find

(a) the amount of charge flown through the battery

(b) the heat generated in the circuit

(c) the energy supplied by the battery

(d) the amount of charge flown through the switch S



ANSWER KEY

Q.1	C	Q.2	A	Q.3	C	Q.4	A	Q.5	B	Q.6	B	Q.7	D
Q.8	B	Q.9	B	Q.10	B	Q.11	A	Q.12	D	Q.13	C	Q.14	C

Q.15 ABD Q.16 BCD Q.17 AD Q.18 $C_{AD} = \frac{48}{7}\pi \in_0 R$ Q.19 $\frac{11C}{15}$

Q.20 $\frac{12}{11}$ μC, 3.34 μJ Q.21 (a) 20 μC, (b) 0.3 mJ, (c) 0.6 mJ. (d) 60 μC

HINTS AND SOLUTIONS

Q.1 C
Q.2 A
Q.3 C
Q.4 A
Q.5 B
Q.6 B
Q.7 D
Q.8 B
Q.9 B
Q.10 B

Sol. Initially, charge $q = CV$

and energy stored in capacitor $= \frac{1}{2}CV^2$

Finally, charge $q_2 = C \times 2V = 2CV$

Charge flown through the battery is

$q' = q_2 - (-q) = 3CV$

$\therefore$ Energy drawn from battery

$E_b = q' \times V' = 3CV \times 2V = 6CV^2$

Energy stored in capacitor $= \frac{1}{2}C(2V)^2$

$E_2 = 2CV^2$

Change in potential energy of capacitor $= 2CV^2 - \frac{1}{2}CV^2$

$\Delta E_C = \frac{3}{2}CV^2$

Energy lost in heat $= E_H = 6CV^2 - \frac{3}{2}CV^2 = \frac{9}{2}CV^2$

The ratio of $\frac{E_H}{E_2} = \frac{9}{4} = 2.25$

Q.11 A

Sol. $E = \frac{V}{d}$ $\qquad C = \frac{\epsilon_0 A}{d}$

$V = Ed \Rightarrow$ d is more $\Rightarrow$ V is more

$U = \frac{1}{2}CV^2 \Rightarrow$ V is more & U is more

Q.12 D

Sol. $V = -\int_0^d \frac{aQ}{\in_0}\ 1 + \frac{x^2}{d^2} dx$

$= -\frac{aQ}{\in_0}\left[d + \frac{d}{3}\right] = \frac{4aQd}{3\in_0}$

Q.13 C

Sol. $C = \frac{Q}{V} = \frac{3\in_0}{4a\,d}$

Q.14 C

Sol. $\frac{\frac{1}{2}\in_0 E_0^2}{\frac{1}{2}\in_0 E_P^2} = \frac{E_0^2}{E_{P^2}} = \frac{\left(\frac{aQ}{\in_0}\right)^2}{\left(\frac{aQ}{\in_0}\right)^2} = (1+1)^2 = \frac{1}{4}$

Q.15 ABD

Q.16 BCD

Q.17 AD

Q.18 [Ans. $C_{AD} = \frac{48}{7}\pi \in_0 R$]

Q.19 [Ans: $\frac{11C}{15}$]

Q.20 [Ans. $\frac{12}{11}\mu C$, 3.34 μJ]

Q.21 Ans (a) 20 μC, (b) 0.3 mJ, (c) 0.6 mJ. (d) 60 μC