PHYSICS

Q. 1 **Assertion :** The capacity of conductor, under given circumstances remains constant irrespective of the charge present on it.

Reason : Capacity depends on size, shape of conductor and also on the memdium between the plates. **[A]**

Q.2 **Assertion** : Dielectric breakdown occurs under the influence of an intense light beam.

Reason : Electromagnetic radiations exert pressure. **[B]**

Q.3 **Assertion** : Work done in moving a charge between any two points in an electric field is independent of the path followed by the charge, between these points.

Reason : Electrostatic forces are non conservative. **[C]**

Q.4 **Assertion** : Farad is too big a unit of capacity.

Reason : Capacity of earth-which is the largest sphere is in microfarad. **[A]**

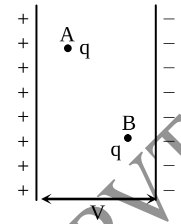
Q.5 **Assertion** : Capacity of a parallel plate condenser increases on introducing a conducting or insulating slab between the plates.

Reason : In both the cases, electric field intensity between the plates reduces. **[A]**

Q.6 **Assertion** : When charges are shared between any two bodies, no charge is really lost, but some lost of energy does occur.

Reason : Some energy disappears in the form of heat, sparking etc. **[A]**

Q.7 **Statement – 1/Assertion :** Two charges of magnitude q are placed at points A and B, between the two plates of parallel plate capacitor charged to a potential difference V as shown in the figure. The force on the two charge is same.



and

Statement-2/Reason :

The electric field inside the parallel plate capacitor is uniform. **[D]**

Q.8 **Assertion :** When charges are shared between two bodies, there occurs no loss of charge, but there does occur a loss of energy.

Reason : In case of sharing of charges energy of conservation fails. **[C]**

Q.5 **Statement I :** Farad is too big a unit of capacity.

Statement II : Capacity of earth- which is the largest sphere is in microfarad. **[A]**

Q.6 **Statement I :** Capacity of a parallel plate condenser increases on introducing a conducting or insulating slab between the plates.

Statement II : In both the cases, electric field intensity between the plates reduces. **[A]**

Q.7 **Statement I :** When charges are shared between any two bodies, some charge is lost, and some loss of energy does occur.

Statement II : Some energy disappears in the form of heat, sparking etc. **[D]**

Q.8 **Statement I :** The whole charge of a body can be transferred to another body.

Statement II : Charge can not be transferred partially. **[C]**

Q.9 **Statement I :** In a series combination of capacitors, charge on each capacitor is same.

Statement II : In such a combination, charge can move only along one route. **[A]**

Q.10 **Statement-I :** When a dielectric slab is gradually inserted between the plates of an isolated parallel-plate capacitor, the energy of the system decreases.

Statement-II : The force between the plates decreases. **[C]**

Q.11 **Statement-I :** A parallel plate capacitor is connected across battery through a key. A dielectric slab of dielectric constant k is introduced between the plates. The energy stored becomes k times.

Statement-II : The surface density of charge on the plate remain constant. **[C]**

Q.12 **Statement - 1 :** Presence of an uncharged conductor B in the neighbourhood of a charged conductor A decreases the potential of charged conductor A.

and

Statement - 2 : By induction negative charge is produced on face of the conductor B facing conductor A. The other face of the uncharged conductor B developes positive charge. The negative charge on the conductor B is closer to the conductor A in comparison to positive charge. Hence negative charge will have more dominating effect than positive charge. Therefore, as a whole potential of the system decreases.

[B]

Q.13 **Statement-I:** In case of two concentric conducting spherical shells having radii a and b (b > a), the capacitance of the system is always $\frac{4\pi\varepsilon_0 ab}{b-a}$.

Statement-II: The capacitance of two concentric conducting spherical shells depends upon the earthing of inner or outer shell.

Sol.[D] Statement-I is wrong but Statement-II is correct .

Q.14 **Statement-I**: By increasing temperature the surface tension will decrease.

Statement-II : By increasing temperature the intermolecular force will decreased so surface tension decrease.

Sol.[A] Both statement are true & correct explanation.

Q.15 **Statement-I**: A parallel plate capacitor is connected across battery through a key. A dielectric slab of dielectric constant K is introduced between the plates. The energy which is stored becomes K times

Statement-II : The surface density of charge on the plate remains constant or unchanged.

Sol.[C] Statement (I) correct Statement (II) false.

Q.16 **Statement-I**: When charges are shared between two bodies, there occurs no loss of charge but there does occur a loss of energy.

Statement-II : In case of sharing of charges, conservation of energy fails.

Sol.[C] Statement (I) correct Statement (II) false.

Q.17 **Statement-I**: A parallel plate capacitor is connected across battery through a key. A dielectric slab of dielectric constant K is introduced between the plates. The energy which is stored becomes K times

Statement-II : The surface density of charge on the plate remains constant or unchanged.

Sol.[C] Statement (I) correct Statement (II) false.

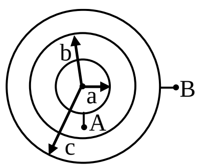
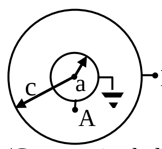
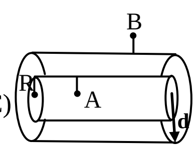
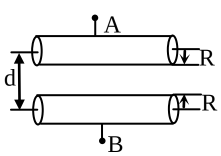
Q.18 **Statement-I**: When charges are shared between two bodies, there occurs no loss of charge but there does occur a loss of energy.

Statement-II : In case of sharing of charges, conservation of energy fails.

Sol.[C] Statement (I) correct Statement (II) false.

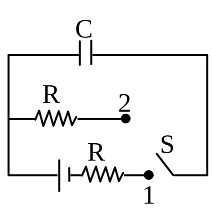
PHYSICS

Q.1 Match the columns for the capacitance of systems in column-I to their respective values of capacitance in column-II

Column-I	**Column-II**
(A)  (concentric shells) Capacitance C_{AB}	(P) $\frac{4\pi\varepsilon_0 c^2}{c-a}$
(B)  (Concentric shells) Capacitance C_{AB}	(Q) $\frac{4\pi\varepsilon_0 ac}{c-a}$
(C)  (concentric cylinders) Capacitance C_{AB} per unit length	(R) $\frac{2\pi\varepsilon_0}{\log_e(d/R)}$
(D)  (parallel wires of radius R at separation d) Capacitance C_{AB} per unit length	(S) $\frac{\pi\varepsilon_0}{\log_e(d/R)}$

[A → Q ; B → P ; C → R ; D → S]

Q.2 In the circuit shown in figure, the capacitor is initially uncharged. At t = 0, the switch is closed at position (1) and remain closed for long time. Then at t =t′, switch is shifted to position (2).



Column I	**Column II**
(A) As the capacitor charges from t = 0 to t = t′	(P) Current in the circuit falls exponentially
(B) As the capacitor discharge i.e. for t > t′	(Q) Current in the circuit grows exponentially
(C) Maximum current in the circuit depends on	(R) R, C
(D) Time to achieve 50% charging of the capacitor depends on	(S) R

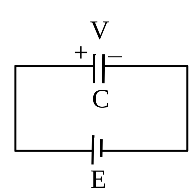
[A → P ; B → P ; C → S ; D → R]

Q.3

Column-I	**Column-II**
(A) When a dielectric slab is gradually inserted between the plates of an isolated parallel plate charged capacitor	(P) The electric potential energy of the system decreases
(B) When a dielectric slab is gradually inserted between the plates of a parallel plate capacitor & its potential is kept constant by connecting battery	(Q) Work done by external agent is positive
(C) When the plates of a parallel capacitor are pulled apart, keeping its potential constant by connecting battery	(R) Work done by battery is positive
(D) When the plates of a parallel plate capacitor are pulled apart, keeping its charge constant by disconnecting battery	(S) Work done by external agent is negative

[A → P,S ; B → R,S ; C → P,Q ; D → Q]

Q.4 A capacitor of capacitance C is charged to a potential V. Now it is connected to a battery of e.m.f E as shown in the figure :



Column-I	Column-II
(A) If V = E, then	(P) non-zero charge is supplied by the +ve terminal of battery to +ve plate of capacitor
(B) If V > E	(Q) Zero charge is supplied by + ve terminal of battery to +ve plate of capacitor
(C) If V < E, then	(R) non-zero thermal energy will be dissipated in the circuit
(D) If V ≠ E, then	(S) outer surfaces of the plates of capacitor have zero charge

Sol. **A → Q,S ; B → R,S ; C → P,R,S ; D → P,R,S**

For A : As potential difference across the capacitor is same as that of e.m.f of battery, no charge will be supplied by battery and hence work done by battery = 0 .

$U_i = U_f$ so $\Delta H = 0$

In all cases, zero charge appears on outer surfaces of the plates of capacitor.

For B : As V > E, so capacitor charges the battery and hence thermal energy will be developed in circuit.

For C : As V < E so battery performs some work on the capacitor.

For D : Combination of B and C.

Q.5 Match the entries of column I with the entries of column II.

Column-I	Column-II
(A) When a dielectric slab is gradually inserted between the plates of an isolated parallel plate capacitor	(P) The electric potential energy of the system decreases
(B) When a dielectric gradually inserted between the plates of a parallel plate capacitor and its potential is kept constant	(Q) Work done by external agent is positive
(C) When the plates of a parallel plate capacitor are pulled apart and its potential constant	(R) Work done by battery is positive
(D) When the plates of a parallel plate capacitor are pulled apart, keeping its charge constant	(S) Work done by external agent is negative

Sol. **A → PS, B → RS, C → PQ, D → Q**

For A :

Charge is constant , C increases, so energy stored decreases. System is isolated , so $W_{ext.} + W_{el.} = 0$

$\therefore W_{ext.} + W_{el.} + W_{battery} = 0$

For B :

Potential is constant, C increases, so energgy stored increases.

i.e., $dU > 0$ and $W_{el} < 0$

charged of capacitor increase, it means work done by battery is greater then zero.

From $W_{ext.} + W_{el.} + W_{battery}y = 0$

$W_{ext.} = -W(W_{battery} + W_{el.}) = 0$

but $W_{battery} = 2dU$

For C :

Potential is constant,C decreases, Q decreases and U also decreases.

So, $W_{battery} < 0$, $dU < 0$, $W_{el.} < 0$

For D :

Charge is constant, C decreases, U increases

So, $dU > 0$, $W_{el.} < 0$, so $W_{ext.} > 0$

Q.6 Match the following :

Column I	Column II
(A) σ^2/ε_0	(P) $C^2/J\text{-}m$
(B) ε_0	(Q) Farad
(C) $\dfrac{\text{ampere}-\text{second}}{\text{volt}}$	(R) J/m^3
(D) $\dfrac{V}{E}$	(S) metre

Sol. **A → R, B → P, C → Q, D → S**

$$A \rightarrow \frac{\sigma^2}{\varepsilon_0} = \varepsilon_0\left(\frac{\sigma}{\varepsilon_0}\right)^2 = \varepsilon_0 E^2 = \text{energy/volume}$$

$$B \rightarrow F = \frac{1}{4\pi\varepsilon_0}\cdot\frac{q^2}{r^2},\ \varepsilon_0 = \frac{q^2}{(F.r.).r} = \frac{C^2}{J-m}$$

$$C \rightarrow C = \frac{q}{V} = \frac{It}{V} \text{ or Farad} = \frac{\text{ampere}-\text{second}}{\text{volt}}$$

$$D \rightarrow \frac{V}{E} = \frac{(kq/r)}{(kq/r^2)}r$$

or $\dfrac{V}{E}$ has the units of length i.e., metre.

Q.7

	Column-I		Column-II
(A)	When a dielectric slab is gradually inserted between the plates of an isolated parallel plate capacitor	(P)	The electric potential energy of the system decreases
(B)	When a dielectric slab is gradually inserted between the plates of a parallel plate capacitor & its potential is kept constant	(Q)	Work done by external agent is positive
(C)	When the plates of a parallel capacitor are pulled apart, keeping its potential constant	(R)	Work done by battery is positive
(D)	When the plates of a parallel plate capacitor are pulled apart, keeping its charge constant	(S)	Work done by external agent is negative

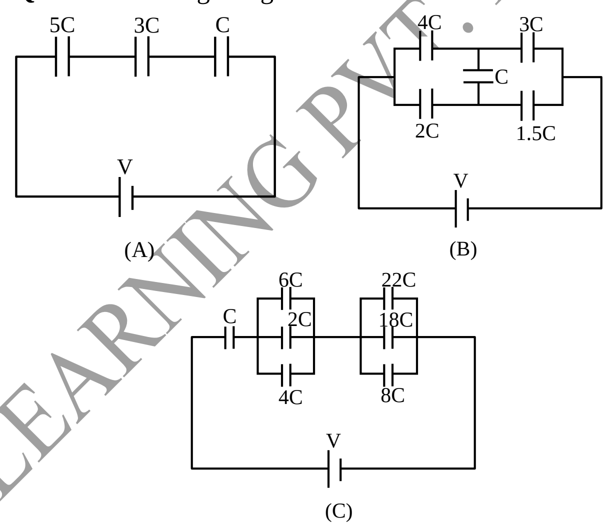
A $\rightarrow$ P, S B $\rightarrow$ R, S C $\rightarrow$ P, Q D $\rightarrow$ Q

Q.8 Match the following -

	Column I		Column II
(A)	Capacitance of parallel plate capacitor	(P)	Increase when separation between the plates of isolated capacitor increases
(B)	Potential difference across plates of parallel plate capacitor	(Q)	Independent of metal of plates
(C)	Charge on the plates of capacitor	(R)	Increase by insertion of dielectric slab between plates of isolated parallel plate capacitor
(D)	Electrostatic potential energy of capacitor	(S)	Remain constant if capacitor is connected to battery or power source

Ans. A $\rightarrow$ Q,R,S ; B $\rightarrow$ P,Q,S ; C $\rightarrow$ Q; D $\rightarrow$P,Q, S

Q.9 Referring to fig. match column-I with column II

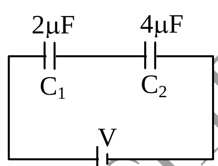


	Column I		Column II
(A)	Capacitor 5C in fig A	(P)	Potential difference across no other capacitor in the given figure is more than the potential difference across this capacitor
(B)	Capacitor 1.5 C in fig B	(Q)	Potential difference across no other capacitor in the given fig. is less than the potential difference across this

			capacitor
(C)	Capacitor 8C in fig C	(R)	No other capacitor in the given figure stores an amount of charge smaller than the stored in this capacitor
(D)	Capacitor 2C in fig C	(S)	Charge in this capacitor is more than the charge in any other capacitor in the given fig.

Ans. **A → Q, R ; B → P, R ; C → Q, R ; D → Q, R**

Q. 10 In the given figure, the separation between the plates of C_1 is slowly increased to double of its initial value, then match the following –



Column - I		Column II	
(A)	The potential difference across C_1	(P)	increases
(B)	The potential difference across C_2	(Q)	decreases
(C)	The energy stored in C_1	(R)	increases by a factor of $\frac{6}{5}$
(D)	The energy stored in C_2	(S)	decreases by a factor of $\frac{18}{25}$

Sol. **A → P,R ; B → Q ; C → Q ; D → Q**

Q.11

Column - I		Column - II	
(A)	If distance between plates of capacitor (isolated) decrease	(P)	Potential difference across plate is decreased
(B)	If dielectric is inserted between plates of capacitor whose plates are connected with battery	(Q)	capacitance of the capacitor will increase
(C)	If area of plates of (isolated) capacitor is increased	(R)	Energy of capacitor will increase
(D)	If distance between plates of capacitor is decreased when plate of capacitor are connected with battery	(S)	Force between the plates will decrease

Ans. **A→ P,Q ; B → R,Q ; C→ P,Q,S ; D→ R,Q**

(A) For an isolated capacitor

Q = constant

∴ If distance between plate decrease, then capacitance will increase.

Q = CV

$\therefore \quad V \propto \frac{1}{C}$

[∴ as C increases V decreases]

Energy = $\frac{Q^2}{2C}$

[as C increase energy decreases]

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

[as Q = constant, F = constant]

(B) As battery is connected V = constant

as slab is inserted C increases

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

[∴ as C increases U increases]

$F = \frac{\text{Energy}}{\text{Separation}}$

[∴ as U increases F also increases]

(C) If area of plates of capacitor increases C increases.
as capacitor is isolated
Q = constant

$$V = \frac{Q}{C}$$

[$\therefore$ as C increases V decreases]

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

[$\therefore$ as C increases U decreases]

$$F = \frac{U}{d}$$

[$\therefore$ as U decreases F decreases]

(D) Capacitor is connected with battery
V = constant
as d decreases C increases

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

[$\therefore$ as C increases U increases]

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

Q = CV
[$\therefore$ as C increases Q increases
$\therefore$ F increases]

Q.12 Two singly ionized isotopes of an element are accelerated from rest through the same potential difference and they enter perpendicular into a uniform magnetic field.

Column - I	**Column - II**
(A) Their respective KE before entering into magnetic field	(P) Remains constant
(B) Their respective KE during motion in magnetic field	(Q) Are equal
(C) In the magnetic field path traced is	(R) Straight line
(D) In the magnetic field they cannot trace a path in	(S) Circular arc

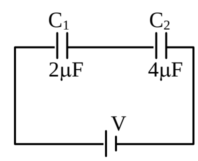
Ans. **A$\rightarrow$ Q ; B $\rightarrow$ P ; C$\rightarrow$ S; D$\rightarrow$ R**

Q. 13

Column - I	**Column II**
(A) When a dielectric slab is gradually inserted between the plates of an isolated parallel plate capacitor	(P) The electric potential energy of the system decreases
(B) When a dielectric slab is gradually inserted between the plates of a parallel plate capacitor and its potential is kept constant	(Q) Work done by external agent is positive
(C) When the plates of a parallel capacitor are pulled apart, keeping its potential constant	(R) Work done by battery is positive
(D) When the plates of a parallel plate capacitor are pulled apart, keeping its charge constant	(S) Work done by external agent is negative

Ans. **A $\rightarrow$ P,S ; B $\rightarrow$ R,S ; C $\rightarrow$ P,Q ; D $\rightarrow$ Q**

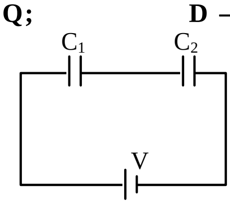
Q.14 In the given figure, the separation between the plates of C_1 is slowly increased to double of its initial value, then match the following :



Column -I	**Column-II**
(A) The potential difference across C_1	(P) increases
(B) The potential difference across C_2	(Q) decreases
(C) The energy stored in C_1	(R) increases by a factor of $\frac{6}{5}$
(D) The energy stored in C_2	(S) decreases by a factor of $\frac{18}{25}$

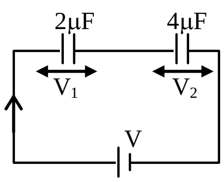
Sol. **A $\rightarrow$ P, R; B $\rightarrow$ Q;**

C → S, Q;　　　　　**D → Q;**



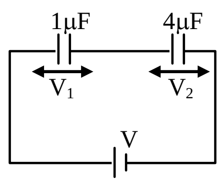
$C = \frac{\varepsilon_0 A}{d}$

As d is double $\therefore$ C becomes $\frac{2}{2} = 1\mu F$



$V_1 = \frac{4}{6} \times V = \frac{4}{6} V = \frac{2}{3} V = 0.6\ V$

$V_2 = \frac{2}{6} \times V = \frac{V}{3} = 0.3V$



$V_1 = \frac{4V}{5} = 0.8\ V$

$V_2 = \frac{1V}{5} = 0.2V$

Potential difference across C_1 increases, C_2 decreases.

Energy stored :

U_i in $C_1 = \frac{1}{2} C_1 V_1^2 = \frac{1}{2} \times 2 \times \frac{16}{36} V^2 = \frac{16}{36} V^2$

U_i in $C_2 = \frac{1}{2} C_2 V_2^2 = \frac{1}{2} \times 4 \times \frac{V^2}{9} = \frac{8}{9} V^2$

U_f in $C_1 = \frac{1}{2} \times 1 \times \frac{16}{25} V^2 = \frac{8}{25} V^2$

U_f in $C_2 = \frac{1}{2} \times 4 \times \frac{V^2}{25} = \frac{2}{25} V^2$

Potential energy of C_1 decreases by $\frac{18}{25}$ factor.

Potential energy of C_2 decreases.

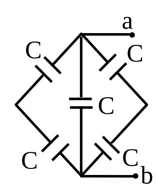
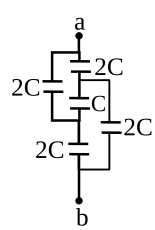
Q.15 A parallel plate capacitor with air between its plates is charged using a battery and then disconnected from the battery.

Match Column – I with Column – II :

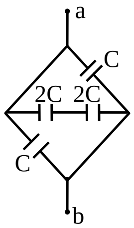
Column – I	**Column – II**
(A) Potential difference between the plates will decrease if	(P) Separation between the plates is increased to $\frac{K}{2}$ times the the initial value and space between the plates after the separation has increased, is completely filled with a dielectric (here K is the dielectric constant)
(B) Electric field strength between the plates will reduce if	(Q) Separation between the plates is increased
(C) Electric energy stored in the capacitor will decrease if	(R) A dielectric with K > 1 is filled between the plates of capacitor
(D) Electric energy density will decrease if	(S) Separation the plates is reduced

Sol. **A → P,R,S; B → P,R; C → P,R,S ; D → P,R**

Q.16 Match the column -

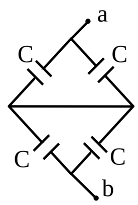
Column I	**Column II**
(a) 	(p) C_{eq} between a & b is 2C
(b) 	(q) C_{eq} between a & b is C

(c)



(r) C_{eq} between a & b is 3C

(d)



(A) (a) → p, (b) → p, (c) → q, (d) → r

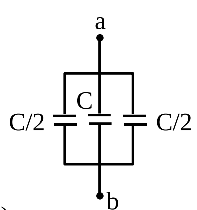
(B) (a) → p, (b) → p, (c) → r, (d) → q

(C) (a) → r, (b) → p, (c) → q, (d) → p

(D) (a) → p, (b) → r, (c) → q, (d) → r **[B]**

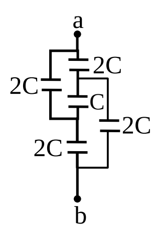
Sol. (a) → p, (b) → p, (c) → r, (d) → q

(a)



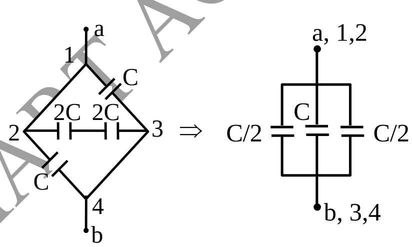
$C_{eq} = 2C \rightarrow p$

(b)



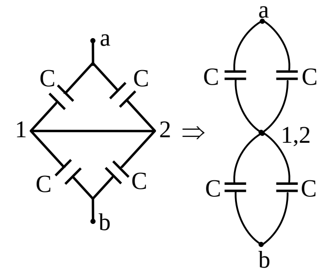
$C_{eq} = 2C \rightarrow p$

(c)



$C_{eq} = 3C \rightarrow r$

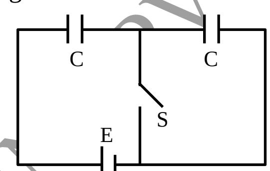
(d)



$C_{eq} = C \rightarrow q$

Q.17 **Match the Column :**

Consider the situation shown. The switch s is open for a long time and then closed. Then:



Column I

Column II

(A) Charge flow through battery when S is Closed

(P) $\frac{CE^2}{2}$

(B) Work done by battery

(Q) $\frac{CE}{2}$

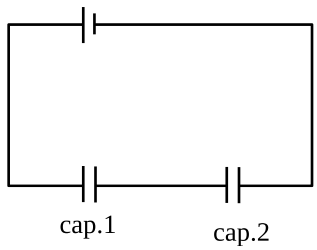
(C) Change in energy stored in capacitor

(R) $\frac{CE^2}{4}$

(D) Heat developed in the system

Sol. (A) → (Q); (B) → (R); (C) → (R); (D) →(S)

Q.18 Two identical parallel plate capacitor are connected in series and the combination is connected with a battery as shown. Some changes in capacitor 1 are now made independently after the steady state is achived listed in column I. Some effects which may occur in new steady state due to these changes on the capacitor 2 are listed in column II. Match the changes on capacitor 1 in column I with corresponding effect on capacitor 2 in column II.



Column -I	Column -II
(A) A dielectric slab is inserted	(P) charge on capacitor increases
(B) separation between plates is increased	(Q) charge on capacitor decreases
(C) A metal plate is inserted connecting both plate	(R) Energy stored in capacitor increases
(D) Separation between between is plate decreased capacitor	(S) Electric field the plates of increase
	(T) Potential difference across the plate of capacitor will increase

Sol. A → Q; B → P,R,S,T ; C → P,R,S,T ; D → Q

Q.19

Column-I	Column-II
(A) When a dielectric slab is gradually inserted between the plates of an isolated parallel plate capacitor	(P) The electric potential energy of the system decreases
(B) When a dielectric slab is gradually inserted between the plates of a parallel plate capacitor & its potential is kept constant	(Q) Work done by external agent is positive
(C) When the plates of a parallel capacitor are pulled apart, keeping its potential constant	(R) Work done by battery is positive
(D) When the plates of a parallel plate capacitor are pulled apart, keeping its charge constant	(S) Work done by external agent is negative

Sol. **A → P, S; B → R, S; C → P, Q; D → Q**

Q.1 A parallel plate air capacitor is connected to a battery. If plates of the capacitor are pulled further apart, then which of the following statements are correct ?

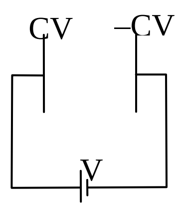
(A) Strength of electric field inside the capacitor remain unchanged, if battery is disconnected before pulling the plate.

(B) During the process, work is done by an external force applied to pull the plates whether battery is disconnected or it remain connected.

(C) Potential energy in the capacitor decreases if the battery remains connected during pulling plates apart.

(D) None of the above **[A,B,C]**

Sol.

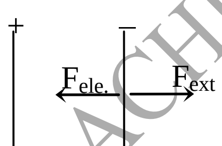


If battery is disconnected and plate are pulled apart, then charge will remain constant

$E = \frac{Q}{2A \in_0} \times 2 = \frac{Q}{A \in_0}$

$\therefore$ E remain same (A) is correct

work is done against attractive force by F_{ext}



(B) is correct

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

V = constant [as battery is connected]

$C = \frac{\in_0 A}{d}$ as d increase, C decrease

$\therefore$ U decrease, option (C) is correct.

Q.2 You have a parallel plate capacitor, a spherical capacitor and cylindrical capacitor. Each capacitor is charged by and then removed from the same battery. Consider the following situations

(i) separation between the plates of parallel plate capacitor is reduced

(ii) radius of the outer spherical shell of the spherical capacitor is increased

(iii) radius of the outer cylinder of cylindrical capacitor is increased

Which of the following is correct ?

(A) In each of these situations (i), (ii) and (iii), charge on the given capacitor remains the same and potential difference across it also remains the same

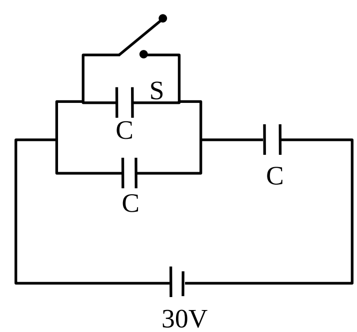
(B) In each of these situations (i), (ii) and (iii), charge on the given capacitor remains the same but potential difference, in situations (i) and (iii), decreases, and in situation (ii), increases

(C) In each of these situations (i), (ii) and (iii), charge on the given capacitor remains the same but potential difference, in situations (i), decreases, and in situations (ii) and (iii), increases

(D) Charge on the capacitor in each situation changes. It increases in all these situations but potential difference remains the same

[C]

Q. 3 Three capacitor each having capacitance C = 2 μF are connected with a battery of e.m.f 30 V as shown in the figure. When the switch S is closed, then –



(A) the amount of charge flown through the battery is 20 μ C

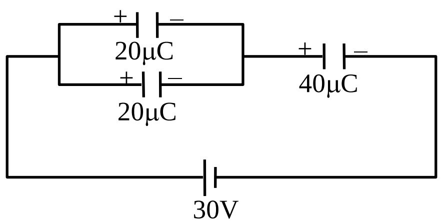
(B) the heat generated in the circuit is 0.6 mJ

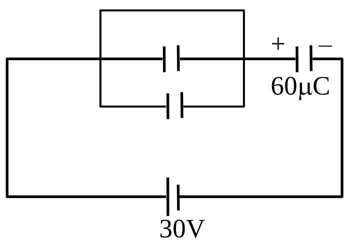
(C) the energy supplied by the battery is 0.6 mJ

(D) the amount of charge flown through the switch S is 60 μC

Sol. **[A,C,D]**

The charges stored in different capacitors before and after closing the switch S are :





The amount of charge flown through the battery is $q = 20\ \mu C$

$\therefore$ Energy supplied by the battery is :

$U = qV = (20 \times 10^{-6}) \times (30)$ J

$= 0.6$ mJ

Energy stored in all the capacitors before closing the switch S is :

$$U_i = \frac{1}{2} C_{net} V^2 = \frac{1}{2}\left(\frac{4}{3}\times 10^{-6}\right)(30)^2 = 0.6 \text{ mJ}$$

and after closing the switch,

$$U_f = \frac{1}{2} C_{net} V^2 = \frac{1}{2}(2 \times 10^{-6})(30)^2 = 0.9 \text{ mJ}$$

$\therefore$ Heat generated,

$H = \Delta U = (U_f - U_i) = 0.3$ mJ

and charge flown through the switch is 60 μC.

Q.4 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 :

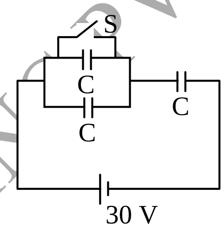
(A) the potential difference across the plates increases, while the plates are being drawn apart

(B) the potential difference across the plates decreases during the drawing apart of the plates

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

(D) the electric intensity between the plates remains constant during the drawing apart of the plates **[A,C,D]**

Q. 5 Three capacitors each having capacitance $C = 2\mu F$ are connected with a battery of emf 30 V as shown in figure. When the switch S is closed :



(A) the amount of charge flown through the battery is 20 μC

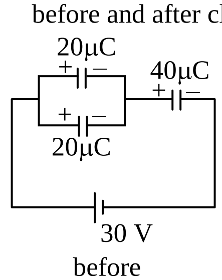
(B) the heat generated in the circuit is 0.6 mJ

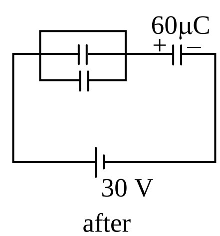
(C) the energy supplied by the battery is 0.6 mJ

(D) the amount of charge flown through the switch S is 60μC

Sol. **[A,C,D]**

The charges stored in different capacitors before and after closing the switch S are





The amount of charge flown through the battery is $q = 20\ \mu C$

$\therefore$ Energy supplied by the battery is

$U = qV = (20 \times 10^{-6})(30)$ J

$U = 0.6$ mJ

Energy stored in all the capacitors before closing the switch S is

$$U_i = \frac{1}{2} C_{net} V^2 = \frac{1}{2}\left(\frac{4}{3}\times 10^{-6}\right)(30)^2$$

$= 0.6$ mJ

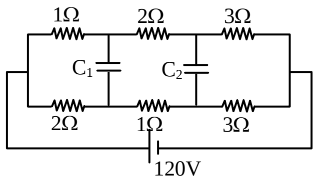
and after closing the switch

$$U_f = \frac{1}{2} C_{net} V^2 = \frac{1}{2}(2 \times 10^{-6})(30)^2$$

$= 0.9$ mJ

$\therefore$ Heat generated $H = U - (U_f - U_i) = 0.3$ mJ and charge flown through the switch is 60 μC.

Q.6 In the circuit shown in figure.



$C_1 = C_2 = 2\mu$F. Then charge stored in :

(A) capacitor C_1 is zero

(B) capacitor C_2 is zero

(C) both capacitors is zero

(D) capacitor C_1 is 40 μC

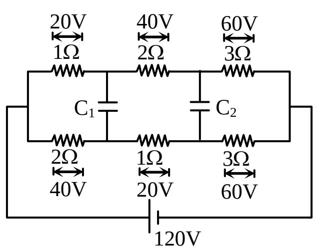
Sol. **[B,D]**

Potential difference across $C_1 = 20$ V

Potential difference across $C_2 = 0$ V

$\therefore$ Charge stored on $C_1 = 40\mu$C

and Charge stored on $C_2 = 0\ \mu$C



Q.7 A parallel plate air capacitor is connected to a battery. If plates of the capacitor are pulled further apart, then which of the following statements are correct -

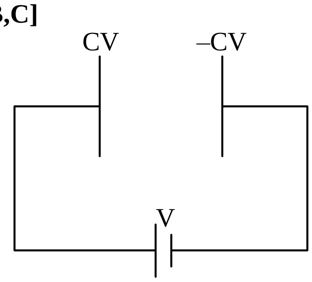
(A) Strength of electric field inside the capacitor remain unchanged, if battery is disconnected before pulling the plate.

(B) During the process, work is done by an external force applied to pull the plates whether battery is disconnected or it remain connected.

(C) Potential energy in the capacitor decreases if the battery remains connected during pulling plates apart.

(D) None of the above

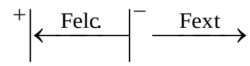
Sol. **[A,B,C]**



If battery is disconnected and plate are pulled apart, then charge will remain constant

$$E = \frac{Q}{2A \in_0} \times 2 = \frac{Q}{A \in_0}$$

$\therefore$ E remain same (A) is correct work is done against attractive force



by Fext. (B) is correct.

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

V = constant [as battery is connected]

$$C = \frac{\in_0 A}{d}$$

as d increase

C decrease $\therefore$ U decrease

option (C) is correct.

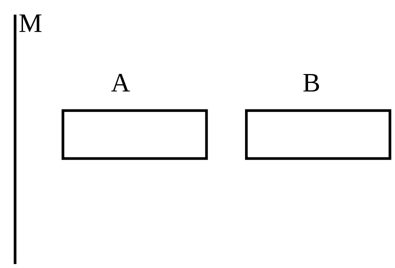
Q.8 A parallel plate capacitor of plate area A and plate separation d is charged to potential difference V and then the battery is disconnected A slab of dielectric constant K is then inserted between the plates of the capacitor so as to fill the space between the plates. If Q, E and W denote respectively, the magnitude of charge on each plate, the electric field between the plates (after the slab is inserted), and work done on the system, in question, in the process of inserting the slab, then - **[IIT-91]**

(A) $Q = \frac{\varepsilon_0 AV}{d}$ (B) $Q = \frac{\varepsilon_0 KAV}{d}$

(C) $E = \frac{V}{Kd}$ (D) $W = \frac{\varepsilon_0 AV^2}{2d}\left[1 - \frac{1}{K}\right]$

[A,C,D]

Q.9 A large non-conducting sheet M is given a uniform charge density. Two uncharged small metal rods A and B are placed near the sheet as shown in figure-



(A) M attracts A (B) M attracts B

(C) A attracts B (D) B attracts A

[A,B,C,D]

Q.10 Each plate of a parallel plate capacitor has a charge q on it. The capacitor is now connected to a battery. Now -

(A) The facing surfaces of the capacitor have equal and opposite charges

(B) The two plates of the capacitor have equal and opposite charges

(C) The battery supplies equal and opposite charges to the two plates

(D) The outer surfaces of the plates have equal charges **[A,C,D]**

Q.11 The separation between the plates of a charged parallel plate capacitor is increased. Which of the following quantities will change ?

(A) Charge on the capacitor

(B) Potential difference across the capacitor

(C) Energy of the capacitor

(D) Energy density between the plates

[B,C]

Q.12 Following operations can be performed on a neutran capacitor -

X –connect the capacitor to a battery of emf ε.

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

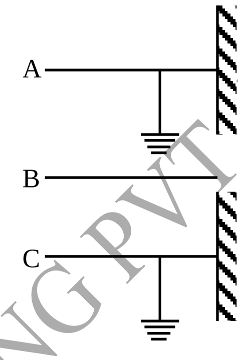
(B) The charge appearing on the capacitor is greater after the action XWY than after the action XYW

(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

[B,C,D]

Q.13 A, B & C are three large, parallel conducting plates horizontally. A & C are rigidly fixed and earthed. B is given some charge. Under electrostatics and gravitation forces B may be



(A) in equilibrium if it closer to A than to C

(B) in equilibrium midway between A and C

(C) in equilibrium if it is closer to C than to A

(D) B can never be in stable equilibrium

[A,D]

Q.14 A charge Q is imparted to two identical capacitors in parallel. Separation of the plates in each capacitor is d_0. Suddenly, the first plate of the first capacitor and the second plate of the second capacitor starts moving to the left with speed v, then –

(A) Charge on the two capacitor as a function of time are $\frac{Q(d_0 - vt)}{2d_0}$, $\frac{Q(d_0 + vt)}{2d_0}$

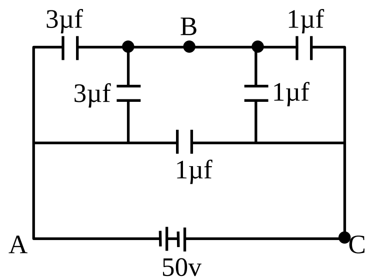
(B) Charge on the two capacitors as a function of time are $\frac{Qd_0}{2(d_0 - vt)}$, $\frac{Qd_0}{2(d_0 + vt)}$

(C) Current in the circuit will increase as time passes

(D) Current in the circuit will be constant

[A,D]

Q.15 In the circuit diagram shown below :



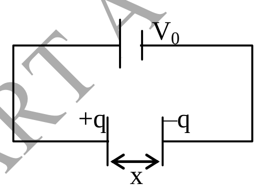
(A) The effective capacity between A and C is $\frac{3}{2}$ μf

(B) The effective capacity between A and C is $\frac{5}{2}$ μf

(C) The potential difference between A and B in steady state is $\frac{75}{2}$ volt

(D) The potential difference between B and C in steady state is $\frac{75}{2}$ volt **[B,D]**

Q.16 Two plates of a parallel plate capacitors carry charges q and –q and are separated by a distance x from each other. The capacitor is connected to a constant voltage source V_0. The distance between the plates is changed to x + dx. Then in steady state :



(A) Change in electrostatic energy stored in the capacitor is $\frac{-Udx}{x}$

(B) Change in electrostatic energy stored in the capacitor is $\frac{-Ux}{dx}$

(C) Attraction force between the plates is 1/2 qE

(D) Attraction force between the plates is qE
(where E is electric field between the plates)

[A,C]

Q.17 A dielectric slab of thickness d is inserted in a parallel plate capacitor whose negative plate is at x = 0 and positive pate is at x = 3d. The slab is equidistant from the plates. The capacitor is given some charge. As x goes from 0 to 3d - **[IIT -JEE 98]**

(A) the magnitude of the electric field remains the same

(B) the direction of the electric field remains the same

(C) the electric potential increases continuously

(D) the electric potential increases at first, then decreases and again increases

[Ans. B,C]

Q.18 A parallel plate condenser is charged by a battery. The battery is removed and a thick glass slab is placed between the plates. Now- **[REE-98]**

(A) the capacity of the condenser is increased

(B) the electrical energy stored in the condenser is decreased

(C) the potential across the plates is decreased

(D) the electric field between the plates is decreased

[Ans. A,B,C,D]

Q.19 A metallic sheet is inserted between plates parallel to the plates of a parallel plate capacitor. The capacitance of the capacitor - **[REE-2000]**

(A) increases

(B) is independent of the position of the sheet

(C) is maximum when the metal sheet is in the middle

(D) is maximum when the metal sheet touches one of the capacitor plates **[Ans. A,B]**

Q.20 A parallel plate air capacitor is connected to a battery. If plates of the capacitor are pulled further apart, then which of the following statements are correct ?

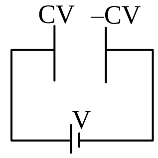
(A) Strength of electric field inside the capacitor remain unchanged, if battery is disconnected before pulling the plate

(B) During the process, work is done by an external force applied to pull the plates whether battery is disconnected or it remains connected

(C) Potential energy in the capacitor decreases if the battery remains connected during pulling plates apart

(D) None of the above **[A,B,C]**

Sol. If battery is disconnected and plate are pulled apart, then charge will remain constant

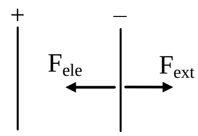


$$E = \frac{Q}{2A\varepsilon_0} \times 2 = \frac{Q}{A\varepsilon_0}$$

$\therefore$ E remain same

(A) is correct

Work is done against attractive force by F_{ext}



(B) is correct.

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

V = constant [as battery is connected]

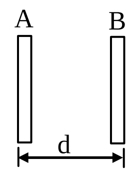
$$C = \frac{\varepsilon_0 A}{d}$$

as d increase

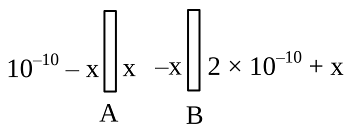
C decrease $\therefore$ U decrease

Option (C) is correct.

Q.1 Each plate of a parallel capacitor has area $S = 5 \times 10^{-3}$ m^2 and are d = 8.85 mm apart. Plate A has a positive charge $q_1 = 10^{-10}$ Cb and plate B has charge $q_2 = + 2 \times 10^{-10}$ Cb. Energy supplied by a battery of emf E = 10 volt when its positive terminal is connected with plate A and negative terminal with plate B is ….. 10^{-9} Joule. **[0001]**



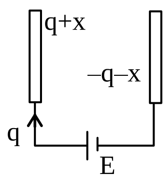
Sol.



$10^{-10} - x = 2 \times 10^{-10} + x$

$2x = -10^{-10}$

$x = -5 \times 10^{-11}$ Cb



Kirchoff law

$q + x = CE$

$q = CE - x$

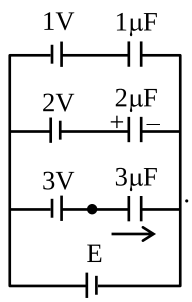
$= \frac{\varepsilon_0 S}{d}.E - (-5 \times 10^{-11})$

$= 10 \times 5 \times 10^{-12} + 5 \times 10^{-11} = 10^{-10}$ Cb

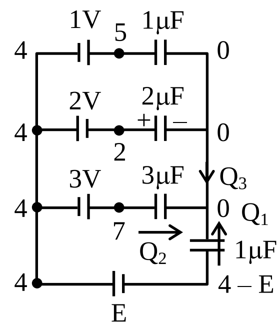
Energy supplied

$= qE = 10^{-10} \times 10 = 10^{-9}$ Joule

Q.2 In the figure shown, the emf E for which charge on 2μF capacitor is 4 μC is .... × 17 volt.



Sol.[2]



Potential across 2μF = $\frac{4}{2}$ = 2 volt

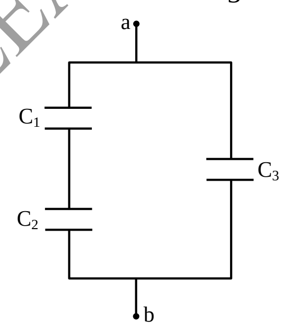
$Q_1 + Q_2 + Q_3 = 0$

$(4 - E) \times 1 + 7 \times 3 + [2 \times 2 + 5 \times 1] = 0$

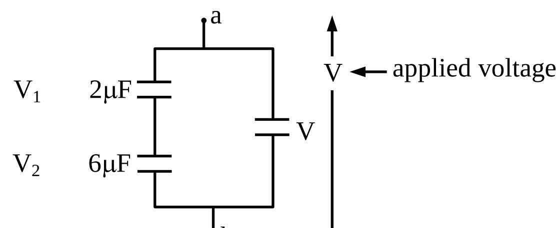
$4 - E + 21 + 9 = 0$

E = 34 volt

Q.3 In figure C_1 = 2μF C_2 = 6μF & C_3 = 3.5 μF. If break down voltages of the individual capacitors are V_1 = 100 V, V_2 = 50V & V_3 = 400 V. Maximum voltage can be placed across points a & b is ----× $\frac{100}{3}$ volt.



Sol. [4]



$V_1 = \frac{6}{8} \times V = \frac{3}{4} V$

$V_2 = \frac{1}{4} V$

Now $\frac{3}{4} V < 100 \Rightarrow V < \frac{400}{3}$

$\frac{V}{4} < 50 \Rightarrow V < 200$ V

$V < 400 \Rightarrow V < 400$

Common solution $V < \frac{400}{3}$

Q.4 A capacitor of capacity $2\mu F$ is charged to a potential difference of 12V. It is then connected across an inductor of inductance 0.6mH. The current in the circuit at a time when the potential difference across the capacitor is 6.0 volt is ……$\times 10^{-1}$Amp.

Sol. [6] In case of oscillatory discharge of capacitor through an inductor

$q = q_0 \cos \omega t$ with $\omega = \frac{1}{\sqrt{LC}}$

$q = CV$

$\cos \omega t = \frac{q}{q_0} = \frac{V}{V_0} = \frac{6}{12} = \frac{1}{2}$

$\omega t = \frac{\pi}{3}$ rad

$\omega = \frac{1}{\sqrt{LC}} = \frac{10^5}{\sqrt{12}}$ rad/sec

$I = \frac{dq}{dt} = -q_0\omega \sin \omega t$

$|I| = CV_0\omega \sin \omega t$

$= 2 \times 10^{-6} \times 12 \times \frac{10^5}{\sqrt{12}} \times \frac{\sqrt{3}}{2} = 0.6$ Amp

Q.5 A parallel plate capacitor is maintained at a certain potential difference. When a 3mm thick slab is introduced between the plates, in order to maintain the same potential difference the distance between the plates is increased by 2.4 mm. Find the dielectric constant of slab.

Sol. [5]

$q = q'$

$C_0V_0 = CV$

$C_0 = C$ as $V = V_0$ given

$C_0 = \frac{\epsilon_0 A}{d}$

$C_1 = \frac{\epsilon_0 A}{d - t + \frac{t}{K}}$

But by increasing d to d + 0.24 cm then

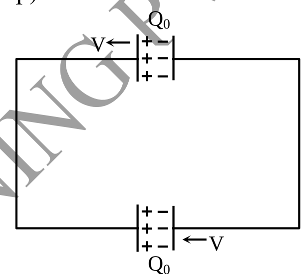
C_1 becomes $C = \frac{\epsilon_0 A}{(d + 0.24 - t) + \frac{t}{K}}$

$d = d + 0.24 - t + \frac{t}{K}$

$K = \frac{t}{t - 0.24} = 5$

Q.6 Two identical capacitors are connected as shown and having initial charge Q_0. Separation between plates of each capacitor is d_0. Suddenly the left plate of upper capacitor and right plate of lower capacitor start moving with speed v towards left while other plate of each capacitor remains fixed.

(given $\frac{Q_0 V}{2d_0} = 10$ amp). The value of current (in amp) in the circuit is………. × 4 ampere.



Sol. **[5]**

$\frac{q_1}{C_1} = \frac{q_2}{C_2}$

$q_1 + q_2 = 2Q_0$

$C_1 = \frac{\epsilon_0 A}{d_0 + Vt}$, $C_2 = \frac{\epsilon_0 A}{d_0 - Vt}$

$\frac{q_1}{q_2} = \frac{d_0 - Vt}{d_0 + Vt} \Rightarrow q_2 + q_2\left(\frac{d_0 - Vt}{d_0 + Vt}\right) = 2Q_0$

$\Rightarrow q_2\left(\frac{2d_0}{d_0 + Vt}\right) = 2Q_0$

$\Rightarrow q_2 = \frac{2Q_0}{2d_0}(d_0 + Vt)$

$I = \frac{dq_2}{dt} = \frac{Q_0 V}{d_0} = 20$ amp

Q.7 A leaky parallel plate capacitor is filled completely with a material having dielectric constant K = 5 and electric conductivity $\sigma = 7.4 \times 10^{-12}\ \Omega^{-1}\ m^{-1}$. If the charge on the plate at the instant t = 0 is **q** = 8.85 μC, then the leakage current at the instant t = 12 sec is………$\times 10^{-1}$ μA.

Sol. **[2]**

As in case of discharging of a capacitor through a resistance

$q = q_0\, e^{-t/CR}$

$i = -\dfrac{dq}{dt} = \dfrac{q_0}{CR} e^{-t/CR}$

Here, $CR = \left(\dfrac{\epsilon_0 KA}{d}\right)\left(\rho \dfrac{d}{A}\right) = \dfrac{\epsilon_0 K}{\sigma}$ [as ρ = $1/\sigma$]

i.e., $CR = \dfrac{8.846 \times 10^{-12} \times 5}{7.4 \times 10^{-12}} = 6$

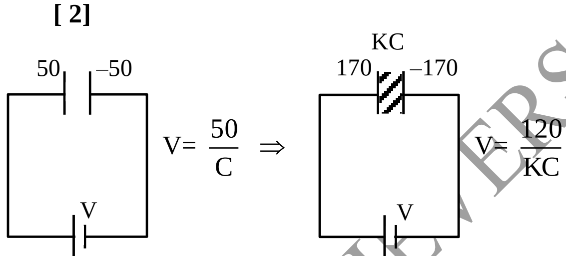
So, $i = \dfrac{8.85 \times 10^{-6}}{6} e^{-12/6}$

$= \dfrac{8.85 \times 10^{-6}}{6 \times 7.39}$ [As e = 2.718, e^2 = 7.39]

= 0.20 μ A

Q.8 A capacitor has charge 50μC. When the gap between the plates is filled with glass wool, then 120μC charge flows through the battery to capacitor. The dielectric constant of glass wool is……………

Sol. [2]



$\dfrac{50}{C} = \dfrac{120}{KC} \Rightarrow K = \dfrac{120}{50} = 2.4$

Q.9 An isolated parallel plate capacitor is maintained at a certain potential difference. When a 3 mm thick slab is introduced between the plates, in order to maintain the same potential difference the distance between the plates is increased by 2.4 mm. Find the dielectric constant of slab.

Sol. [5]

$q = q'$, $C_0V_0 = CV$, $C_0 = C$

as $V = V_0$ given

$C_0 = \dfrac{\epsilon_0 A}{d}$, $C_1 = \dfrac{\epsilon_0 A}{d - t + \dfrac{t}{K}}$

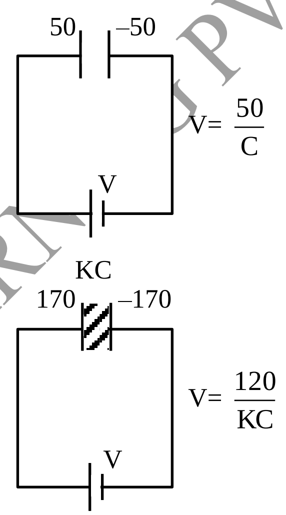
But by increasing d to d + 0.24 cm then

C_1 becomes $C = \dfrac{\epsilon_0 A}{(d + 0.24 - t) + \dfrac{t}{K}}$

$d = d + 0.24 - t + \dfrac{t}{K}$, $K = \dfrac{t}{t - 0.24} = 5$

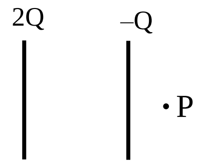
Q.10 A capacitor has charge 50μC. When the gap between the plate is filled with glass wool, then 120μC charge flows through the battery to capacitor. The dielectric constant of glass wool is……………

Sol.[0002]



$\dfrac{50}{C} = \dfrac{120}{KC} \Rightarrow K = \dfrac{120}{50} = 2.4$

Q.1 In the figure shown the plates of a parallel plate capacitor have unequal charges. Its capacitance is 'C' P is a point outside the capacitor and close to the plate of charge –Q. The distance between the plates is 'd' select incorrect alternative



(A) A point charge at point 'P' will experience electric force due to capacitor

(B) The potencial difference between the plates will be 3Q/2C

(C) The energy stored in the electric field in the region between the plates is $\frac{9Q^2}{8C}$

(D) The force on one plate due to the other plate is $\frac{Q^2}{2\pi\in_0 d^2}$ **[D]**

Sol. $E = \frac{2Q}{2A\varepsilon_0} + \frac{Q}{2A\varepsilon_0} \Rightarrow E = \frac{3Q}{2A\varepsilon_0}$

$E = \frac{3}{2}\frac{Q}{Cd} \Rightarrow Ed = \frac{3Q}{2C} = V$

(ii) F = EQ/2

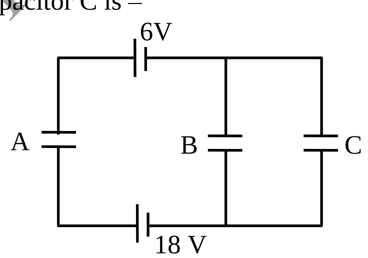
$F = \left(\frac{2Q}{2A\varepsilon_0}\right) \times \frac{(-Q)}{1} = \frac{-Q^2}{A\varepsilon_0}$

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

(iii) Energy = $\frac{1}{2}\varepsilon_0 E^2 Ad$

$= \frac{1}{2}\varepsilon_0\left(\frac{3Q}{2cd}\right)^2 Ad = \frac{9}{8}\frac{Q^2}{C}$

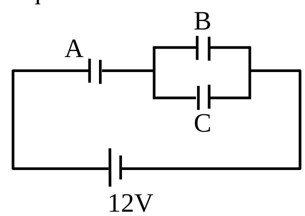
Q.2 Three capacitors A,B and C each of capacitance 1μF are connected as shown. The charge on capacitor C is –



(A) 4 μC (B) 6 μC

(C) 8 μC (D) 2 μC **[A]**

Sol. Equivalent circuit



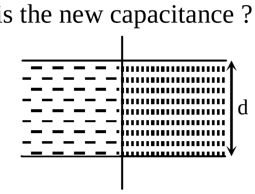
Q.3 A parallel plate capacitor is made by stacking 10 identical metallic plates equally spaced from one another and having the same dielectric between the plates. The alternate plates are then connected. If capacitor formed by two neighbouring plates has a capacitance C, the total capacitance of combination will be -

(A) $\frac{C}{10}$ (B) $\frac{C}{9}$

(C) 9C (D) 10C **[C]**

Sol. C_{eq} = (n – 1) C = 9C

Q. 4 A capacitor of capacitance 1 μF is filled with two dielectrics of dielectric constants 4 and 6. What is the new capacitance ?



(A) 10 μF (B) 5 μF

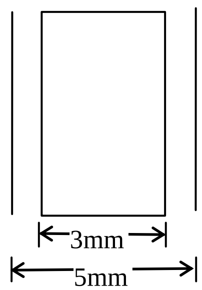
(C) 4 μF (D) None of these **[A]**

Sol. $C_{eq} = \left(\frac{\in r_1 + \in r_2}{2}\right)C$

$= \left(\frac{4+6}{2}\right)$ (1μF) = 5μF

Q. 5 Separation between the plates of a parallel plate capacitor is 5 mm. This capacitor, having air as the dielectric medium between the plates, is charged to a potential difference 25 V using a battery. The battery is then disconnected and a dielectric slab of thickness 3 mm and dielectric constant K = 10 is placed between the plates, as shown.

Potential difference between the plates after the dielectric slab has been introduced is -



(A) 18.5 V (B) 13.5 V

(C) 11.5 V (D) 6.5 V

Sol. **[C]**

The capacitor is charged by a battery of 25 V. Let the magnitude of surface charge density on each plate be σ. Before inserting the dielectric slab, electric field strength between the plates,

$$E = \frac{\sigma}{\varepsilon_0} = \frac{V}{d}$$

or $$E = \frac{\sigma}{\varepsilon_0} = \frac{25}{5\times10^{-3}} = 5000 \text{ N/C}$$

The capacitor is disconnected from the battery but charge on it will not change so that σ has the same value. When a dielectric slab of thickness 3mm is placed between the plates, the thickness of air between the plates will be 5 – 3 = 2 mm. Electric field strength in air will have the same value (5000 N/C) but inside the dielectric, it will be $\frac{5000}{K} = \frac{5000}{10}$

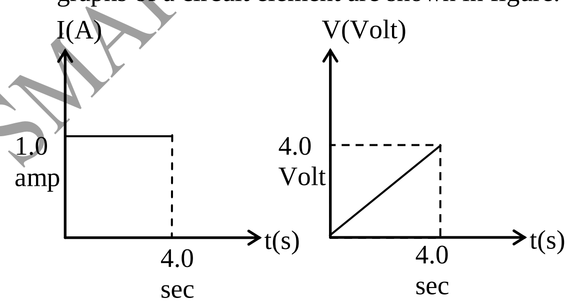
= 500 N/C

so potential difference = $E_{air}\, d_{air} + E_{med}\, d_{med}$

$= 5000 \times (2 \times 10^{-3}) + 500 \times (3 \times 10^{-3})$

= 11.5 V

Q.6 Current versus time and voltage versus time graphs of a circuit element are shown in figure.



The type of the circuit element is :

(A) capacitance of 2 F

(B) resistance of 2Ω

(C) capacitance of 1 F

(D) a voltage source of e.m.f 1 V

Sol. **[C]**

In case of a capacitor

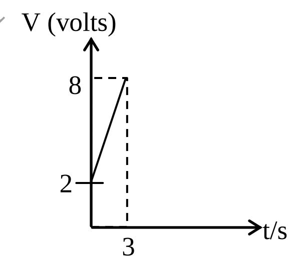
$$q = CV$$

$$\therefore \quad i = \frac{dq}{dt} = C\left(\frac{dV}{dt}\right)$$

$$\frac{dV}{dt} = \frac{4.0}{4.0} \text{ V/s} = 1.0 \text{ V/s}$$

Therefore, if C = 1 F then i = 1×1 = 1A (constant)

Q. 7 A circuit element is placed in a closed box. At time t = 0, a constant current generator supplying a current of I amp is connected across the box. Potential difference across the box varies according to graph shown in the figure. The element in the box is :



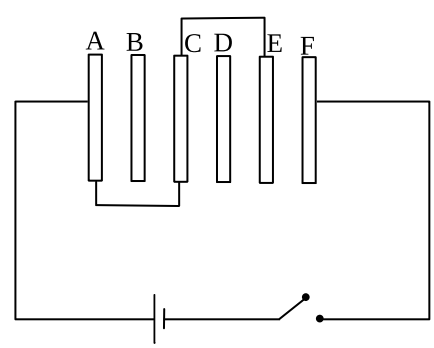
(A) a resistance of 2 ohm

(B) a battery of e.m.f 6 V

(C) an inductance of 2 H

(D) a capacitance of 0.5 F **[D]**

Q.8 A,B,C,D,E,F are conducting plates each of area A and any two consecutive plates separated by a distance d. The net energy stored in the system after the switch S is closed is :



(A) $\frac{3\varepsilon_0 A}{2d} V^2$ (B) $\frac{5\varepsilon_0 A}{12d} V^2$

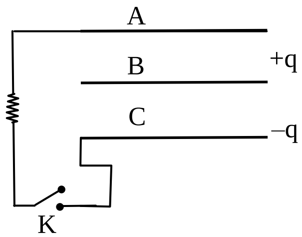
(C) $\frac{\varepsilon_0 A}{2d} V^2$ (D) $\frac{\varepsilon_0 A}{d} V^2$

Sol. **[C]**

$C_{eff} = \frac{\varepsilon_0 A}{d}$ since effective capacitance between plates A and E is zero

$\therefore U = \frac{1}{2} CV^2 = \frac{\varepsilon_0 A}{2d} V^2$

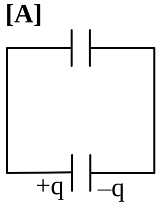
Q.9 Three identical metal plates of area 'A' are at distance d_1 & d_2 from each other. Metal plate A is uncharged, while plate B & C have respective charges +q & – q. If metal plates A &C are connected by switch K through a consumer of unknown resistance, what energy does the consumer give out to its surrounding ?
Assume $d_1 = d_2 = d$



(A) $\frac{q^2 d}{4\varepsilon_0 A}$ (B) $\frac{q^2 d}{\varepsilon_0 A}$

(C) $\frac{q^2 d}{2\varepsilon_0 A}$ (D) $\frac{2q^2 d}{\varepsilon_0 A}$

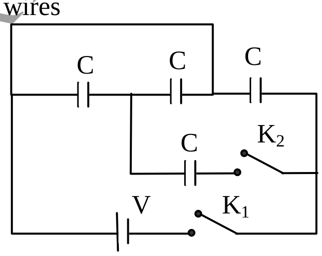
Sol. **[A]**



Energy loss = $\frac{1}{2}\frac{C^2}{C+C} \times V^2 = \frac{1}{2}\frac{C}{2} \times \frac{q^2}{C^2}$

$= \frac{q^2}{4C} = \frac{q^2 d}{4\varepsilon_0 A}$

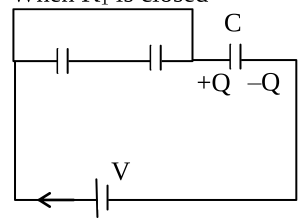
Q.10 Initially K_1 is closed, now if K_2 is also closed, find the heat dissipated in the resistances of connecting wires



(A) $\frac{1}{2} CV^2$ (B) $\frac{2}{3} CV^2$

(C) $\frac{1}{3} CV^2$ (D) $\frac{1}{4} CV^2$

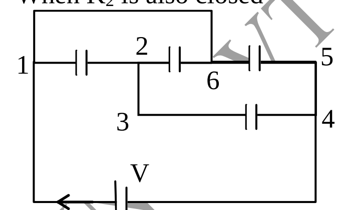
Sol. **[C]**
When K_1 is closed



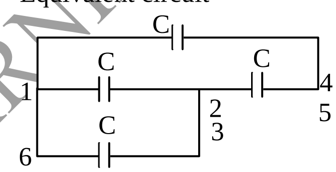
Q = CV

energy $U_i = \frac{1}{2} CV^2$

When K_2 is also closed



Equivalent circuit



$C_{eq} = C + \frac{2C}{3} = \frac{5C}{3}$

Energy $U_f = \frac{1}{2} \times \frac{5C}{3} V^2 = \frac{5}{6} CV^2$

Charge supplied by battery after closing K_2

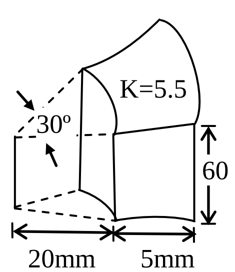
$= \frac{5}{3} CV - CV = \frac{2}{3} CV$

Energy supplied by battery = $U_f - U_i + \Delta H$

$\frac{2}{3} CV^2 = \frac{5}{6} CV^2 - \frac{1}{2} CV^2 + \Delta H$

$\therefore \Delta H = \frac{1}{3} CV^2$

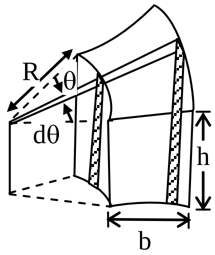
Q. 11 Find the capacitance between the inner & outer curved conductor surface as shown in figure



(A) 6.86 PF (B) 1.86 PF

(C) 3.26 PF (D) 12.63 PF

Sol. **[A]**



$$dc = \frac{\epsilon_0 KRd\theta \times h}{b}$$

all small discs are in parallel

$$\therefore C_{eq} = \sum dc = \int_{\theta=0}^{\frac{\pi}{6}} dc$$

$$= \frac{6Kh}{b} R \int_{\theta=0}^{\frac{\pi}{6}} d\theta$$

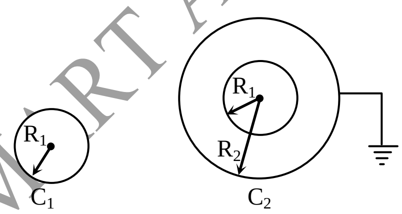
$$= \frac{\pi}{6} \times \frac{\epsilon_0 khR}{b}$$

Q.12 Capacity of an isolated sphere is increased n times when it is enclosed by an earthed concentric sphere. The ratio of their radii is –

(A) $\frac{n^2}{n-1}$ (B) $\frac{n}{n-1}$

(C) $\frac{2n}{n+1}$ (D) $\frac{2n+1}{n+1}$

Sol. **[B]**



$C_1 = 4\pi\varepsilon_0 R_1$

and $C_2 = 4\pi\varepsilon_0 \left(\frac{R_1 R_2}{R_2 - R_1}\right)$

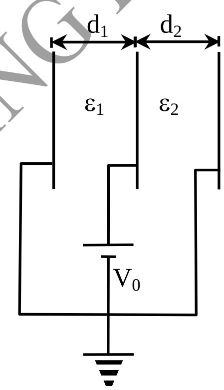
Given that $C_2 = nC_1$

or $\frac{R_2 R_1}{R_2 - R_1} = nR_1$

or $\frac{R_2/R_1}{R_2/R_1 - 1} = n$

or $\frac{R_2}{R_1} = \frac{n}{n-1}$

Q. 13 A capacitor is composed of three parallel conducting plates. All three plates are of same area A. The first pair of plates are kept a distance d_1 apart and the space between them is filled with a medium of a dielectric ε_1. The corresponding data for the second pair are d_2 & ε_2 respectively. What is the surface charge density on the middle plate ?

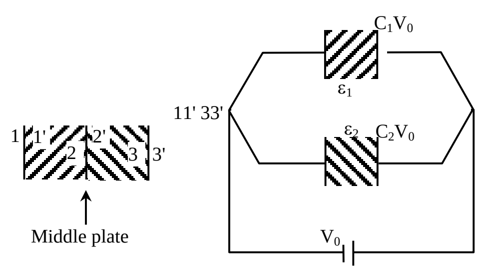


(A) $\varepsilon_0 V\left[\frac{\varepsilon_1}{d_1} + \frac{\varepsilon_2}{d_2}\right]$ (B) $-\varepsilon_0 V\left[\frac{\varepsilon_1}{d_1} + \frac{\varepsilon_2}{d_2}\right]$

(C) $2\varepsilon_0 V\left[\frac{\varepsilon_1}{d_1} + \frac{\varepsilon_2}{d_2}\right]$ (D) $-2\varepsilon_0 V\left[\frac{\varepsilon_1}{d_1} + \frac{\varepsilon_2}{d_2}\right]$

Sol. **[A]**

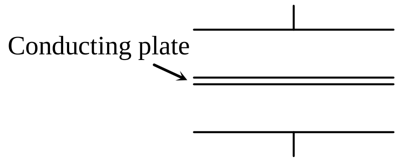
Equivalent circuit



Total charge on 2 & 2' plate = $\left[\frac{\varepsilon_1 \varepsilon_0 A}{d_1} + \frac{\varepsilon_2 \varepsilon_0 A}{d_2}\right]V$

$\sigma = \varepsilon_0 V \left[\frac{\varepsilon_1}{d_1} + \frac{\varepsilon_2}{d_2}\right]$

Q.14 A thin conducting plate is inserted in half way between the plates of a parallel plates capacitor of capacitance C.

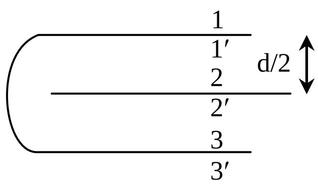


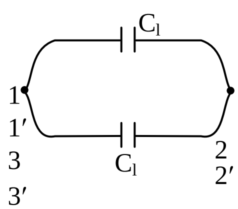
What does the value of capacitance, if both the plate of capacitor is shortened ?

(A) C (B) 2C

(C) 3C (D) 4C

Sol. **[D]**





$= 2 \times \frac{(\epsilon_0\ A)\times 2}{d} = 4 \cdot \frac{\epsilon_0\ A}{d} = 4C$

Q.15 An air parallel plate capacitor has capacity C. When the area and distance between the plates is doubled, the capacitance is C_1, then $\frac{C_1}{C}$ is –

(A) 1 (B) 2

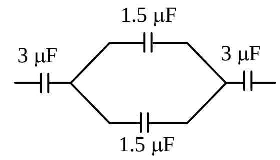
(C) 3 (D) 4 **[A]**

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

$C_1 = \frac{\epsilon_0(2A)}{2d} = C$

$\frac{C_1}{C} = 1$

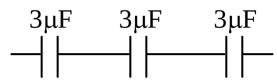
Q.16 Equivalent capacitance in the circuit is –



(A) 1.0 μF (B) 2.0 μF

(C) 1.5 μF (D) 3.0 μF **[A]**

Sol.



$\Rightarrow C_{eq} = 1\mu F$

Q.17 The two spherical shells are at large separation one of them has radius 10 cm and has 1.25 μC charge. The other is of 20 cm radius and has 0.75 μC charge. If they are connected by a conducting wire of negligible capacity, the charge on the shells are-

(A) 1 μC, 1μC (B) $\frac{2}{3}$ μC, $\frac{4}{3}$ μC

(C) $\frac{4}{3}$ μC, $\frac{2}{3}$ μC (D) 0.25 μC, 0.25 μC

[A]

Sol. Total charge = 1.25 μC + 0.75 μC = 2 μC

$q_1' : q_2' = R_1 : R_2 = 1 : 2$

$\therefore\ q_1' = \frac{1}{3}\times 2 = \frac{2}{3}\mu C$

$q_2' = \frac{2}{3}\times 2 = \frac{4}{3}\mu C$

Q.18 A capacitor of 10 μF is connected to a source of 50 V and then disconnected. When the space between the plates is filled with teflon of dielectric constant 2.5. The new potential difference is –

(A) 20 V (B) 20.8 V

(C) 23.8 V (D) 25 V **[A]**

Sol. Battery disconnected so Q = constant

C' = 2.5 C

$V = \frac{Q}{C} \propto \frac{1}{C}$

$\therefore\ V' = \frac{V}{2.5} = \frac{50}{2.5} = 20$ volt

Q.19 Two metal spheres of capacitances C_1 and C_2 carry some charges. They are put in contact and then separated. The final charges Q_1 and Q_2 on them will satisfy -

(A) $\frac{Q_1}{Q_2} < \frac{C_1}{C_2}$ (B) $\frac{Q_1}{Q_2} = \frac{C_1}{C_2}$

(C) $\frac{Q_1}{Q_2} > \frac{C_1}{C_2}$ (D) $\frac{Q_1}{Q_2} = \frac{C_2}{C_1}$ **[B]**

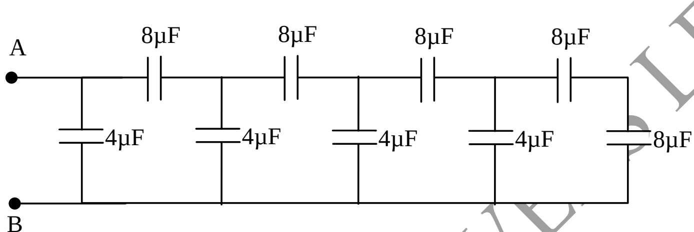
Q.20 How much positive charge should be given to the earth so that to have same potential that of a positively charged sphere of 1 μC and radius 1 cm. Radius of earth = 6400 km -

(A) 600 Coulomb (B) 640 Coulomb

(C) 340 Coulomb (D) 240 Coulomb

[B]

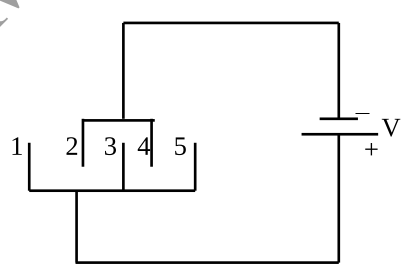
Q.21 Find the equivalent capacitance between A and B.



(A) 2 μF (B) 6 μF

(C) 8 μF (D) 12 μF **[C]**

Q.22 Five identical plates each of area A are joined as shown in the figure the distance between the plates is d. The plates are connected to a potential difference of V volts. The charges on plates 1 and 4 will be –



(A) $\frac{\varepsilon_0 AV}{d}, \frac{2\varepsilon_0 AV}{d}$

(B) $\frac{-\varepsilon_0 AV}{d}, \frac{2\varepsilon_0 AV}{d}$

(C) $\frac{\varepsilon_0 AV}{d}, \frac{-2\varepsilon_0 AV}{d}$

(D) $\frac{-\varepsilon_0 AV}{d}, \frac{-2\varepsilon_0 AV}{d}$ **[C]**

Q.23 A condenser of capacitance 10 μF has been charged to 100 V. It is now connected to another uncharged condenser in parallel. The common potential becomes 40 V. The capacitance of another condenser is -

(A) 15 μF (B) 5 μF

(C) 10 μF (D) 16 μF **[A]**

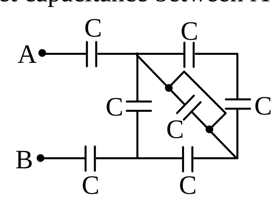
Sol. $C_1 = 10\mu F$ $C_2 = ?$

$V_1 = 100$ V $V_2 = 0$

$V_{common} = 40$ V

$$V_{common} = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}$$

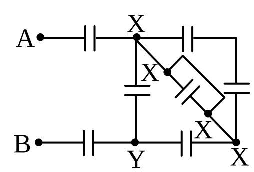
Q.24 The net capacitance between A and B is

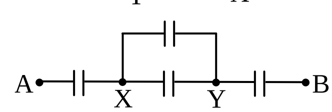


(A) 6 C (B) $\frac{2C}{5}$

(C) $\frac{2C}{3}$ (D) None of these **[B]**

Sol. Use Junction method

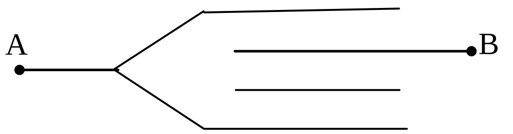




$$\frac{1}{C_{eq}} = \frac{1}{C} + \frac{1}{2C} + \frac{1}{C}$$

$$\therefore\ C_{eq} = \frac{2C}{5}$$

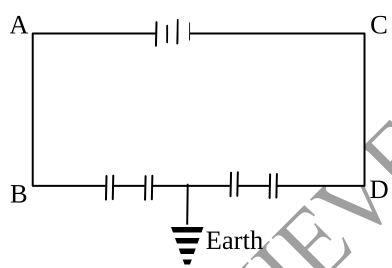
Q.25 If C_0 is the capacitance between two adjacent plates, find the capacitance of the combination between A and B –



(A) $\frac{C_0}{2}$ (B) $\frac{3C_0}{2}$

(B) $\frac{C_0}{4}$ (D) $2C_0$ **[B]**

Q.26 Four equal capacitors , each with a capacitance (C) are connected to a battery of E.M.F 10 volts as shown in the adjoining figure. The mid point of the capacitor system is connected to earth. Then the potentials of B and D are respectively –



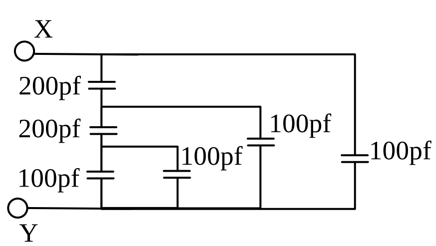
(A) + 10 volts, zero volts

(B) + 5 volts, – 5 volts

(C) – 5 volts, + 5volts

(D) zero volts, 10 volts **[B]**

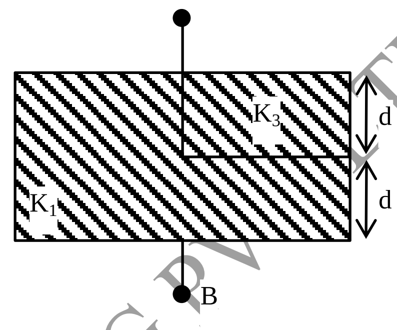
Q.27 The equivalent capacity between the terminals X and Y in the figure shown will be –



(A) 100 pF (B) 200 pF

(C) 300 pF (D) 400 pF **[B]**

Q.28 What is the capacitance of the capacitor of square plates of area A, Shown in figure –

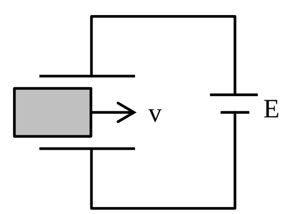


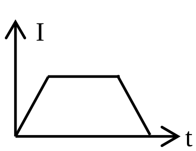
(A) $\frac{\epsilon_0 A}{4d}\frac{K_1K_2}{K_1+K_2}$ (B) $\frac{\epsilon_0 A}{d}\frac{K_1(K_1+K_2)}{3K_1+K_2}$

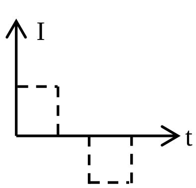
(C) $\frac{\epsilon_0 A}{4d}\frac{K_1(K_1+3K_2)}{K_1+K_2}$ (D) $\frac{\epsilon_0 A}{4d(K_1+3K_2)}$

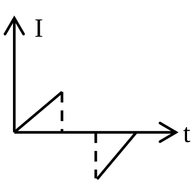
[C]

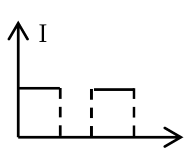
Q.29 A dielectric slab of area A and thickness d is inserted between the plates of a capacitor of area 2A and distance between plates d with a constant speed v as shown in the fig. The capacitor is connected to a battery of emf E. The current in the circuit varies with time as



(A) 

(B) 

(C) 

(D) 

[B]

Q.30 Find the capacitance of a system of three parallel plates each of area A separated by distance d_1 and d_2. The space between them is filled with dielectrics of relative dielectric constants ε_1 and ε_2. The dielectric constant of free space is ε_0 –

(A) $\frac{\varepsilon_1\varepsilon_2\varepsilon_0 A}{\varepsilon_1 d_2 + \varepsilon_2 d_1}$

(B) $\frac{\varepsilon_1\varepsilon_2\varepsilon_0 A}{\varepsilon_1 d_1 + \varepsilon_2 d_2}$

(C) $\frac{\varepsilon_1\varepsilon_2 A}{\varepsilon_0(\varepsilon_1 + \varepsilon_2) d_1 d_2}$

(D) $\frac{A}{\varepsilon_1\varepsilon_2\varepsilon_0(\varepsilon_1 d_1 + \varepsilon_2 d_2)}$ **[A]**

Q.31 For making a parallel plate capacitor , two plates of copper, a sheet of mica (thickness = 0.1 mm, K = 5.4), a sheet of glass (thickness = 0.2 mm, K = 7) and a slab of paraffin (thickness = 1.0 cm, K = 2) are available. To obtain the largest capacitance, which sheet should you place between the copper plates ?

(A) Mica (B) Glass
(C) Paraffin (D) None of these

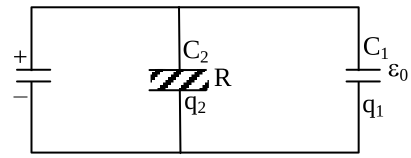
[A]

Q.32 The capacity of a parallel plate condenser is C_0. If a dielectric of relative permittivity ε_r and thickness equal to one fourth the plate separation is placed between the plates, then its capacity becomes C. Then value of $\frac{C}{C_0}$ will be-

(A) $\frac{5\varepsilon_r}{4\varepsilon_r + 1}$ (B) $\frac{4\varepsilon_r}{3\varepsilon_r + 1}$

(C) $\frac{3\varepsilon_r}{2\varepsilon_r + 1}$ (D) $\frac{2\varepsilon_r}{\varepsilon_r + 1}$ **[B]**

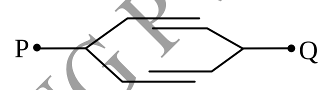
Q.33 In the adjoining diagram the capacitors C_1 and C_2 are connected to battery. Air is filled between the plates of C_1 and a dielectric is filled between the plates C_2, then -



(A) $q_1 < q_2$ (B) $q_1 > q_2$
(C) $q_1 + q_2$ (D) None of these

[A]

Q.34 Figure below shows four plates each of area A and separated from one another by a distance d. What is the capacitance between P and Q –

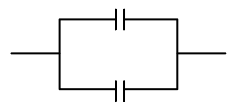


(A) $\frac{\varepsilon_0 A}{d}$ (B) $\frac{2\varepsilon_0 A}{d}$

(C) $\frac{3\varepsilon_0 A}{d}$ (D) $\frac{4\varepsilon_0 A}{d}$ **[B]**

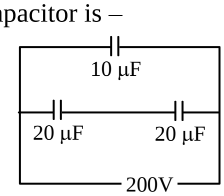
Sol. By using point potential method

equivalent circuit is



$\therefore$ $C_{eq} = \frac{2 \in_0 A}{d}$

Q.35 In the adjoining figure given below, charge on 10 μF capacitor is –

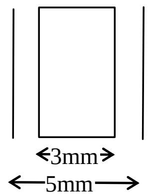


(A) 2×10^{-3} C (B) 16×10^{-4} C
(C) 4×10^{-3} C (D) 8×10^{-4} C **[A]**

Sol. $V_{10\mu F} = 200V$

$\therefore$ $Q = CV = (10 \times 10^{-6})(200) = 2 \times 10^{-3}$ C

Q.36 Separation between the plates of a parallel plate capacitor is 5 mm. This capacitor, having air as the dielectric medium between the plates, is charged to a potential difference 25 V using a battery. The battery is then disconnected and a dielectric slab of thickness 3 mm and dielectric constant K = 10 is placed between the plates, as shown. Potential difference between the plates after the dielectric slab has been introduced is –



(A) 18.5 V (B) 13.5 V
(C) 11.5 V (D) 6.5 V

Sol. **[C]**

The capacitor is charged by a battery 25 V. Let the magnitude of surface charge density on each plate be σ. Before inserting the dielectric slab, field strength between the plates,

$$E = \frac{\sigma}{\varepsilon_0} = \frac{V}{d}$$

or $E = \frac{\sigma}{\varepsilon_0} = \frac{25}{5\times10^{-3}} = 5000$ N/C

The capacitor is disconnected form the battery but charge on it will not change so that σ has the same value. When a dielectric slab of thickness 3 mm is placed between the plates, the air thickness between the plates will be 5 – 3 = 2 mm. Electric field strength in air will have the same value (5000 N/C) but inside the dielectric, it will be $\frac{5000}{K} = \frac{5000}{10} = 500$ N/C

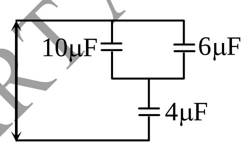
So potential difference

$= E_{air}\, d_{air} + E_{med}\, d_{med}$

$= 5000 \times (2\times10^{-3}) + 500 \times (3\times10^{-3})$

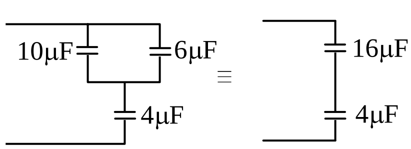
$= 11.5$V

Q.37 The equivalent capacitance of the combination of the capacitors is –



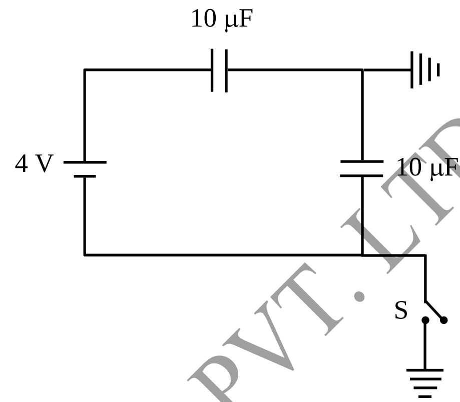
(A) 3.20 μF (B) 7.80 μF
(C) 3.90 μF (D) 2.16 μF **[A]**

Sol.



$$C_{eq} = \frac{16\times4}{16+4} = 3.20\ \mu F$$

Q.38 In the given fig. the work done by battery after the switch S is closed –



(A) 100 μJ (B) – 100 μJ
(C) 80 μJ (D) – 80 μJ **[C]**

Sol. Before the switch S is closed

$Q_i = C_{eq} V$

$= 5 \times 4 = 20\ \mu C$

When the switch S is closed

$Q_f = CV$

$= 10 \times 4 = 40\ \mu C$

$W(cell) = \Delta QE = (Q_f - Q_i) \times E$

$= 20 \times 4 = 80\ \mu J$

Q.39 A capacitor stores 50 μC charge when connected across a battery. When the gap between the plates is filled with a dielectric, a charge of 100 μC flows through the battery. The dielectric constant of the material is -

(A) 2.5 (B) 2
(C) 4 (D) 3 **[D]**

Sol. $Q_1 = C_1V$

$Q_2 = C_2V$

$$\frac{50}{150} = \frac{\varepsilon_0}{K\varepsilon_0}$$

K = 3

Q.40 Three identical, parallel conducting plates A, B and C are placed as shown. Switches S_1 and S_2 are open, and can connect A and C to earth when closed. +Q charge is given to B. Then:

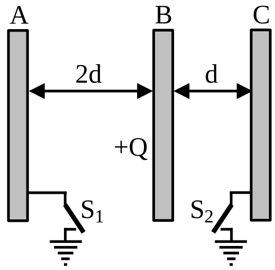


Fig.

(A) If S_1 is closed with S_2 open, a charge of amount Q will pass through S_1

(B) If S_2 is closed with S_1 open, a charge of amount Q will pass through S_2

(C) If S_1 and S_2 are closed together, a charge of amount Q/3 will pass through S_1 and a charge of amount 2Q/3 will pass through S_2

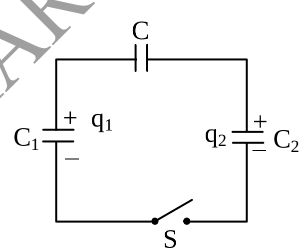
(D) All of the above statements are incorrect

[D]

Sol. When either A or C is earthed (but not both together), a parallel-plate capacitor is formed with B, with ±Q charges on the inner surfaces. [The other plate, which is not earthed, plays no role]. Hence, charge of amount +Q flows to earth.

When both are earthed together A and C effectively become connected. The plates now form two capacitors in parallel with capacitances in the ratio 1:2 and hence, share charges Q in the same ratio.

Q.41 Two capacitor C_1 & C_2, charged with q_1 & q_2 are connected in series with an uncharged capacitor C, as shown in figure. As the switch S is closed-



(A) C gets charged in any condition

(B) C gets charged only when $q_1C_2 > q_2C_1$

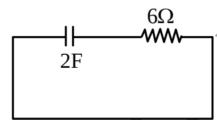
(C) C gets charged only when $q_1C_2 < q_2C_1$

(D) C gets charged when $q_1C_2 \neq q_2C_1$ **[D]**

Sol. Charge in the circuit flows only when potential difference across C_1 is either greater or less than that across C_2

ie. $\frac{q_1}{C_1} \neq \frac{q_2}{C_2}$ $\therefore$ $q_1C_2 \neq q_2C_1$

Q.42 In the condenser show in the circuit is charged to 5V and left in the circuit, in 12 s the charge on the condenser will become –



(A) $\frac{10}{e}$ C (B) $\frac{e}{10}$ C

(C) $\frac{10}{e^2}$ (D) $\frac{e^2}{10}$ C **[A]**

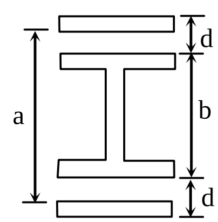
Sol. During discharge

$$q_c = CE\left(e^{\frac{-t}{RC}}\right)$$

$$= 2 \times 5\left(e^{-\frac{12}{12}}\right)$$

$$= \frac{10}{e}$$

Q.43 Two capacitors are joined in series as shown in figure. The area of each plate is A. The equivalent of the combination is –

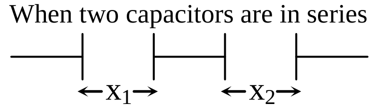


(A) $\frac{\varepsilon_0 A}{d_1 - d_2}$ (B) $\frac{\varepsilon_0 A}{a - b}$

(C) $\varepsilon_0 A\left(\frac{1}{a} - \frac{1}{b}\right)$ (D) $\varepsilon_0 A\left(\frac{1}{d_1} - \frac{1}{d_2}\right)$

[B]

Sol. When two capacitors are in series



$$\Rightarrow \frac{1}{C_{eq}} = \frac{x_1}{\epsilon_0 A} + \frac{x_2}{\epsilon_0 A} = \frac{x_1 + x_2}{\epsilon_0 A}$$

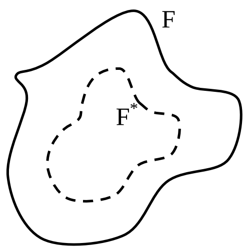
$\therefore C_{eq} = \dfrac{\in_0 A}{x_1 + x_2}$

$= \dfrac{\in_0 A}{\text{Sum of separations between plates}}$

Now in given arrangement
Capacitors are in series
& sum of separations = a – b

$\therefore C_{eq} = \dfrac{\in_0 A}{a - b}$

Q.44 A closed body, whose surface F is made of metal foil, has an electrical capacitance C with respect to an uniformly distant point. The foil is now dented in such a way that the new surface F^* is entirely inside or an the original surface as shown in the figure. Then –



(A) Capacitance of F^* > capacitance of F
(B) Capacitance of F^* < capacitance of F
(C) Capacitance of F^* = capacitance of F
(D) Nothing can be concluded from given **[B]**

Sol. $U_i = \dfrac{Q^2}{2C_i}$

$U_f = \dfrac{Q^2}{2C_f}$

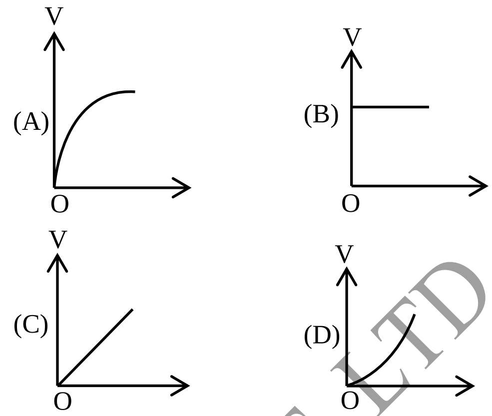
As surface was deformed in such a way that charge on original surface are coming closer or moving perpendicular to electric force acting on them total energy of foil get increase.

$U_f > U_i$

$\dfrac{Q^2}{2C_f} > \dfrac{Q^2}{2C_i}$

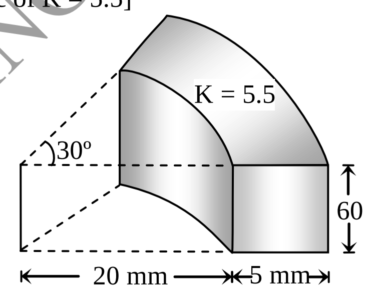
$C_i > C_f$

Q.45 If the current, charging a capacitor, is kept constant then the potential difference V across the capacitor varies with time t as –



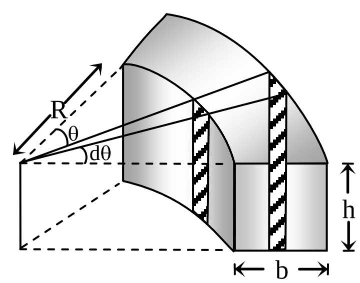
[C]

Q.46 Find the capacitance between the inner and outer curved cylindrical conductor surface as shown in figure :
[Space between conductor surface is filled with dielectric of K = 5.5]



(A) 6.86 PF (B) 1.86 PF
(C) 3.26 PF (D) 12.63 PF **[A]**

Sol.



$dC = \dfrac{\varepsilon_0 KRd\theta \times h}{b}$

All small dC are in parallel

$\therefore C_{eq} = \Sigma dC = \int_{\theta=0}^{\frac{\pi}{6}} dC$

$= \dfrac{6KhR}{b} \int_{\theta=0}^{\frac{\pi}{6}} d\theta = \dfrac{\pi}{6} \times \dfrac{\varepsilon_0 KhR}{b}$

Q.47 A parallel plate capacitor is made by stacking n equally spaced plates connected alternately. If the capacitance between any two plates is C. Then the resultant capacitance is -

(A) C (B) nC

(C) (n – 1) C (D) (n +1) C **[C]**

Q.48 A capacitor of capacitance 160 μF is charged to a potential difference of 200V and then connected across a discharge tube which conducts until the potential deference across it has failed to 100 V. The energy dissipated in the tube is -

(A) 6.4 J (B) 4.8 J

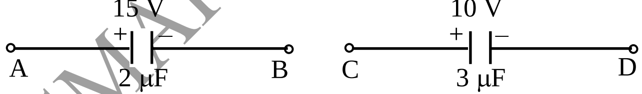
(C) 3.2 J (D) 2.4 J **[D]**

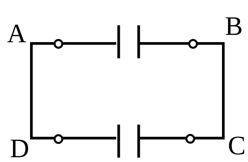
Q.49 A capacitor of capacitance C is charged to a potential difference V_0. The charging battery is disconnected and the capacitor is connected to a capacitor of unknown capacitance C_x. The P.D. across the combination is V. The value of C_x should be-

(A) $\frac{C(V_0 - V)}{V}$ (B) $\frac{C(V - V_0)}{V}$

(C) $\frac{CV}{V_0}$ (D) $\frac{CV_0}{V}$ **[A]**

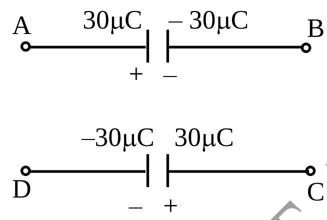
Q.50 In the figure initial status of capacitance and their connection is shown. Which of the following is incorrect about this circuit -

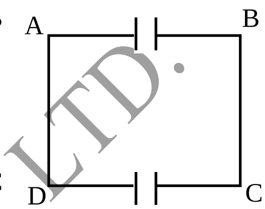




(A) Final charge on each capacitor will be zero
(B) Final total electrical energy of the capacitors will be zero
(C) Total charge flown from A to D is 30 μC
(D) Total charge flown from A to D is – 30 μC **[D]**

Sol. $V = \frac{Q_1 + Q_2}{C_1 + C_2} = 0$



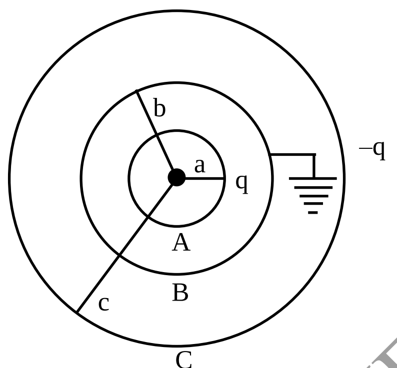


Final potential difference = zero
final charge = zero

Q.1 Two conducting spheres of radii 6 cm and 12 cm each having same charge of 3×10^{-8} C are kept very far apart. If the spheres are connected to each other by a conducting wire (a) find the direction and amount of charge transferred and (b) final potential of each sphere.

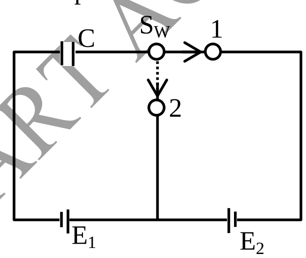
Ans. [(a) charge transferred = $(q_1 - q'_1) = (q_2 - q'_2) = 1 \times 10^{-8}$ C (b) $V'_1 = V'_2 = V = 3$ kV]

Q.2 Figure shows three concentric thin spherical shells A, B and C of radii a, b and c respectively. The shells A and C are given charges q and –q respectively and the shell B is earthed. Find the charges appearing on the outer surfaces of B and C.



Ans. $\left[\frac{bq}{c}, -q\left(1-\frac{b}{c}\right)\right]$

Q.3 What amount of heat will be generated in the circuit shown in the figure when the switch S is shifted from position 1 to 2 ?



Ans. [$Q = 1/2\, C\, E_2^2$]

Q.4 A parallel plate capacitor of plate area $A = 10^{-2}$ m^2 and plate separation $d = 10^{-2}$ m is charged to $V_0 = 100$ volt. Then after removing the charging battery, a slab of insulating material of thickness $b = 0.5 \times 10^{-2}$ metre and dielectric constant $K = 7$ is inserted between the plates. Calculate the free charge on the plates of the capacitor, electric field intensity in air, electric field intensity in the dielectric, potential difference between the plates and capacitance (with dielectric present).

Ans. [16×10^{-12} farad = 16 μμF]

Q.5 Three dielectric slabs A, B, C of thicknesses 5 mm, 3 mm, 2 mm and dielectric constants 2, 3 and 5 respectively fill the space between the plates of a parallel plate capacitor. The distance between the plates being 10 mm. If a potential difference of 351 V is applied to the plates. Find the electric field intensity in each of the dielectric.

Ans. [45K V/m, 30K V/m, 18K V/m]

Q.6 The parallel plates of a capacitor have an area 0.2 m^2 and are 10^{-2} m apart. The original potential difference between them is 3000 V, and it decreases to 1000 V when a sheet of dielectric is inserted between the plates. Compute:

(a) original capacitance C_0

(b) the charge Q on each plate

(c) capacitance C after insertion of the dielectric

(d) dielectric constant K

(e) permittivity ε of the dielectric

(f) the original field E_0 between the plates and

(g) the electric field E after insertion of the dielectric.

($\varepsilon_0 = 9 \times 10^{-12}$ S.I. unit)

Ans. (a) 180 pF (b) 54×10^{-8}C (c) 540 pF

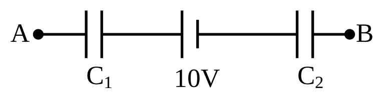
(d) 3 (e) 27×10^{-12} C^2 N^{-1} m^{-2} (f) 3×10^5 V/m

(g) 10^5 V/m]

Q.7 A charge of $+ 2.0 \times 10^{-8}$ C is placed on the positive plate and a charge of -1.0×10^{-8} C on the negative plate of a parallel-plate capacitor of capacitance 1.2×10^{-3} μF. Calculate the potential difference developed between the plates.

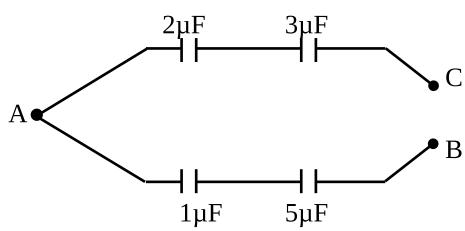
Ans. [12.5 V]

Q.8 A circuit has a section *AB* shown in fig. The emf of the source equals E = 10 V the capacitances are equal to C_1 = 1.0 μF, C_2 = 2μF and the potential difference $\phi_A - \phi_B$ = 5.0 V. Find the voltage across each capacitor.



Ans. [$V_1 = q/C_1 = 10/3$ V, $V_2 = q/C_2 = 5/3$ V, where $q = (\phi_A - \phi_B + \varepsilon)\, C_1C_2/(C_1 + C_2)$)

Q.9 Four perfect capacitors are connected as shown to the three terminals A, B and C. Now, terminals B and C are connected together, what capacitance would be measured across terminals A and B ?

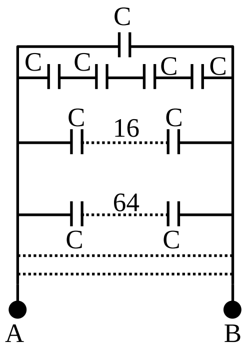


Ans. $\left[\frac{61}{30}\mu F\right]$

Q.10 Three capacitors of capacitances 0.002, 0.004 and 0.006 μF are connected in series. The puncture voltage of each capacitor is 4000V. The electric potential of 11000V is applied across the series combination of capacitors. Will the breakdown of capacitor having capacitance 0.006 μF take place ? Give answer analytically.

Ans. [No]

Q.11 An infinite number of identical capacitors, each of capacitance 1μF are connected as infinite number of rows having capacitors 1, 4, 16, 64, 256, ... respectively as indicated in the fig. If these rows are connected in parallel, evaluate the equivalent capacitance between points A and B.



Ans. [4/3 μF]

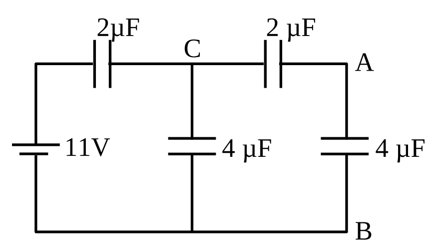
Q.12 A capacitor of capacity C_1 = 1.0 μF withstands are maximum voltage V_1 = 6 kV while another capacitor of capacitance C_2 = 2 μF withstands the maximum voltage V_2 = 4 kV. What maximum voltage will the system of these two capacitors withstand if they are connected in series ?

Ans. [9 kV]

Q.13 A particle of mass 9×10^{-31} kg and a negative charge of 1.6×10^{-19} coulomb projected horizontally with a velocity of 10^5 m/s into a region between two infinite horizontal parallel plate having 0.3 cm gap and the particles enters 0.1 cm below the top plate. The top and bottom plates are connected respectively to the positive and negative terminals of a 30 volt battery. Find the component of the velocity of the particle just before it hits on one of the plate.

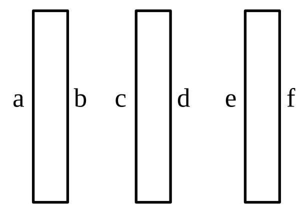
Ans. .[1.88×10^6 m/s]

Q.14 Find the potential difference between the points A and B in the fig. The values of capacitances are in μF.



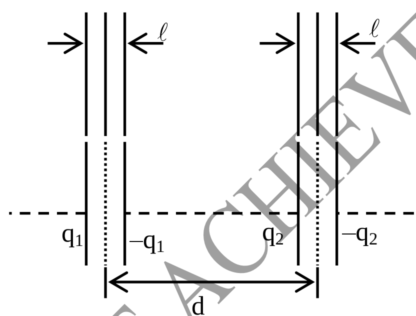
Ans. [1 V]

Q.15 Three parallel metallic plates, each of area A are kept as shown in the figure and charges Q_1, Q_2 and Q_3 are given to them. Edge effects are negligible. Calculate the charges on the two outermost surfaces 'a' and 'f'. Is there any relation between charge on 'a' and charge on f ?



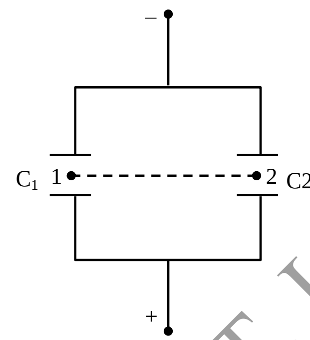
Ans. $\left[\left(\frac{Q_1+Q_2+Q_3}{2}\right)\text{on each}, Q_a = Q_f\right]$

Q.16 Two parallel-plate capacitors are arranged perpendicular to the common axis. The separation *d* between the capacitors is much larger than the separation *l* between their plates and than their size. The capacitors are charged to q_1 and q_2 respectively. Find the force *F* of interaction between the capacitors.



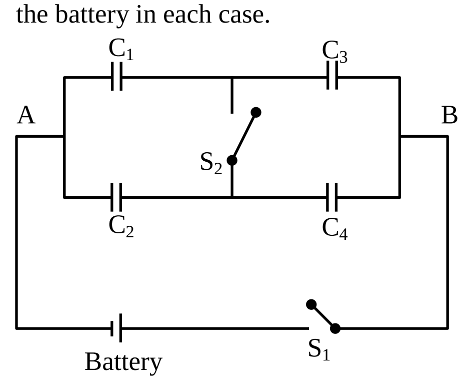
Ans. $\left[\frac{3}{2}\frac{q_1 q_2 l_2}{\pi\varepsilon_0 d^4}\right]$

Q.17 Two parallel plate capacitors with different distances between the plates are connected in parallel to a voltage source. A point positive charge is moved from point '1' i.e. exactly in the middle between the plates of a capacitor C_1 to a point '2' that lies at a distance from the negative plate of C_2 equal to half the distance between the plates of C_1. Is any work done in the process ? Explain clearly.



Ans. [Yes]

Q.18 Four capacitances C_1, C_2, C_3 and C_4 are connected to a battery of constant e.m.f. 12 volt as shown in the figure. Find the charge on each capacitor when
(a) the switch S_1 is closed and
(b) the switch S_2 is also closed.
Given C_1 = 1 μF, C_2 = 2 μF, C_3 = 3 μF and C_4 = 4 μF. Calculate the total charge drawn from the battery in each case.



Ans. $Q_1 = Q_3$ = 9 μC, $Q_2 = Q_4$ = 16 μC (ii) Q_1 = 8.4 μC, Q_2 = 16.8 μC, Q_3 = 10.8 μC, Q_4 = 14.4 μC

Q.19 The gap between the plates of a parallel-plate capacitor is filled with isotropic dielectric whose permittivity ε varies linearly from ε_1 to ε_2 ($\varepsilon_2 > \varepsilon_1$) in the direction perpendicular to the plates. The area of each plate equals *S*, the separation between the plates is equal to *d*. Find the capacitance of the capacitor;

Ans. $[C = \varepsilon_0 (\varepsilon_2 - \varepsilon_1) S/d \ln (\varepsilon_2/\varepsilon_1)]$

Q.20 A sheet of mica, 1 mm thick and of relative permittivity 6, is interposed between two parallel brass plates 3 mm apart. The remainder of the space between the plates is occupied by air. Calculate the area of each plate if the capacitance between them is 0.001 μF. Assuming that air can withstand a potential gradient of 3MV/m. Show that a p.d. of 5 KV between the plates will not cause a flashover.

Ans. [A = 0.2447 m^2, $E_{air} = 2.3 \times 10^6$ V/m]