Topicwise Questions

CAPACITANCE

Finding Capacitance, Parallel, Spherical, Cylindrical

1. Eight drops of mercury of equal radii possessing equal charges combine to form a big drop. Then the capacitance of bigger drop compared to each individual small drop is

(*a*) 8 times (*b*) 4 times

(*c*) 2 times (*d*) 32 times

2. The capacity of parallel plate condenser depends on

(*a*) The type of metal used

(*b*) The thickness of plates

(*c*) The potential applied across the plates

(*d*) The separation between the plates

3. Eight small drops, each of radius r and having same charge q are combined to form a big drop. The ratio between the potentials of the bigger drop and the smaller drop is

(*a*) 8 : 1 (*b*) 4 : 1

(*c*) 2 : 1 (*d*) 1 : 8

4. N identical spherical drops charged to the same potential V are combined to form a big drop. The potential of the new drop will be

(*a*) V (*b*) V/N

(*c*) V × N (*d*) $V \times N^{2/3}$

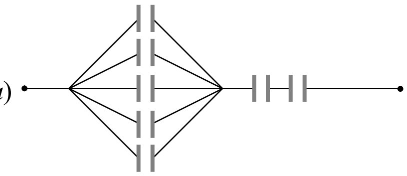
Equivalent Capacitance (Series & Parallel Combination)

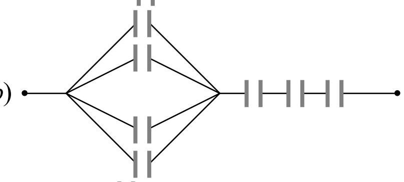
5. The condensers of capacity C_1 and C_2 are connected in parallel, then the equivalent capacitance is

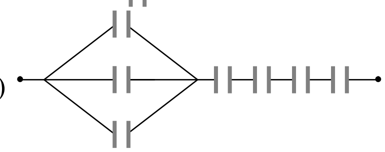
(*a*) $C_1 + C_2$ (*b*) $\dfrac{C_1C_2}{C_1 + C_2}$

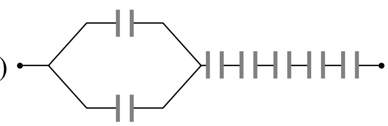
(*c*) $\dfrac{C_1}{C_2}$ (*d*) $\dfrac{C_2}{C_1}$

6. Seven capacitors each of capacity $2\mu F$ are to be so connected to have a total capacity $\dfrac{10}{11}\mu F$. Which will be the necessary figure as shown

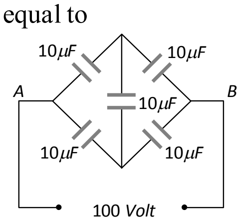
(*a*) 

(*b*) 

(*c*) 

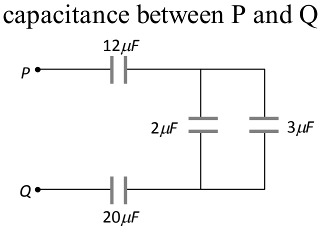
(*d*) 

7. Five capacitors of 10 μF capacity each are connected to a d.c. potential of 100 volts as shown in the adjoining figure. The equivalent capacitance between the points A and B will be equal to



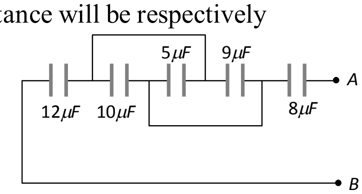
(*a*) 40 μF (*b*) 20 μF
(*c*) 30 μF (*d*) 10 μF

8. In the circuit diagram shown in the adjoining figure, the resultant capacitance between P and Q is



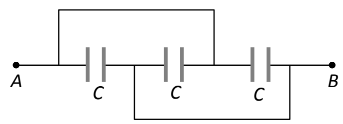
(*a*) 47 μF (*b*) 3 μF
(*c*) 60 μF (*d*) 10 μF

9. The capacities and connection of five capacitors are shown in the adjoining figure. The potential difference between the points A and B is 60 volts. Then the equivalent capacity between A and B and the charge on 5 μF capacitance will be respectively



(*a*) 44 μF; 300 μC (*b*) 16 μF; 150 μC
(*c*) 15 μF; 200 μC (*d*) 4 μF; 50 μC

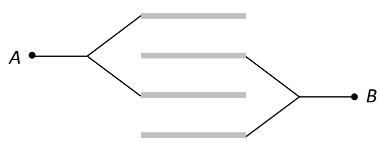
10. Three equal capacitors, each with capacitance C are connected as shown in figure. Then the equivalent capacitance between A and B is



(*a*) C (*b*) 3C

(*c*) $\frac{C}{3}$ (*d*) $\frac{3C}{2}$

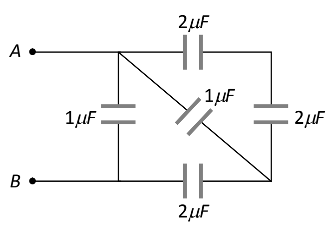
11. Four plates of the same area of cross-section are joined as shown in the figure. The distance between each plate is d. The equivalent capacity across A and B will be



(*a*) $\frac{2\varepsilon_0 A}{d}$ (*b*) $\frac{3\varepsilon_0 A}{d}$

(*c*) $\frac{3\varepsilon_0 A}{2d}$ (*d*) $\frac{\varepsilon_0 A}{d}$

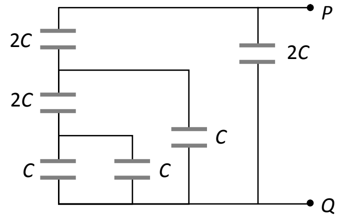
12. The total capacity of the system of capacitors shown in the adjoining figure between the points A and B is



(*a*) 1 μF (*b*) 2 μF
(*c*) 3 μF (*d*) 4 μF

13. Three capacitors each of 6μF are available. The minimum and maximum capacitances which may be obtained are
(*a*) 6 μF, 18 μF (*b*) 3 μF, 12 μF
(*c*) 2 μF, 12 μF (*d*) 2 μF, 18 μF

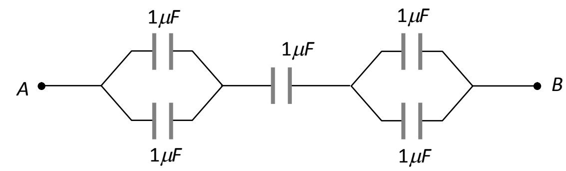
14. The resultant capacitance of given circuit is



(*a*) 3C (*b*) 2C

(*c*) C (*d*) $\frac{C}{3}$

15. The equivalent capacitance between A and B is



(*a*) 2 μF (*b*) 3 μF
(*c*) 5 μF (*d*) 0.5 μF

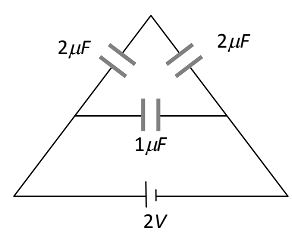
Circuit Analysis

16. A capacitor having capacitance C is charged to a voltage V. It is then removed and connected in parallel with another identical capacitor which is uncharged. The new charge on each capacitor is now
(*a*) CV (*b*) CV/2
(*c*) 2CV (*d*) CV/4

17. Two capacitors of 3pF and 6pF are connected in series and a potential difference of 5000 V is applied across the combination. They are then disconnected and reconnected in parallel. The potential between the plates is
(*a*) 2250 V (*b*) 2222 V
(*c*) 2.25×10^6 V (*d*) 1.1×10^6 V

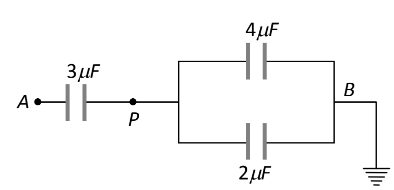
18. Three capacitors of capacitance 3 μF, 10 μF and 15 μF are connected in series to a voltage source of 100V. The charge on 15 μF is
(*a*) 50 μC (*b*) 100 μC
(*c*) 200 μC (*d*) 280 μC

19. The charge on any one of the 2 μF capacitors and 1 μF capacitor will be given respectively (in μC) as



(*a*) 1, 2 (*b*) 2, 1
(*c*) 1, 1 (*d*) 2, 2

20. In the figure a potential of + 1200 V is given to point A and point B is earthed, what is the potential at the point P



(*a*) 100 V (*b*) 200 V
(*c*) 400 V (*d*) 600 V

ENERGY AND HEAT DISSIPATED

21. A condenser has a capacity 2 μF and is charged to a voltage of 50 V. The energy stored is

(*a*) 25×10^5 Joule (*b*) $\frac{1}{2} \times 2 \times 50^2$ J

(*c*) 25×10 erg (*d*) 2500×10^{-6}J

22. A capacitor of capacitance 6μF is charged upto 100 volt. The energy stored in the capacitor is

(*a*) $\frac{1}{2} \times 6 \times 100^2$ Joule (*b*) 0.06 Joule

(*c*) 3×10 Joule (*d*) 0.03 Joule

23. A 40 μF capacitor in a defibrillator is charged to 3000 V. The energy stored in the capacitor is sent through the patient during a pulse of duration 2ms. The power delivered to the patient is

(*a*) 45 kW (*b*) 90 kW

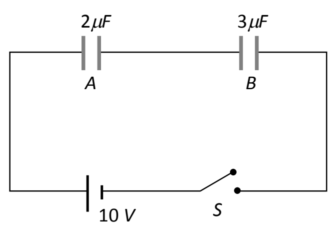
(*c*) 180 kW (*d*) 360 kW

24. The energy stored in a condenser is in the form of

(*a*) Kinetic energy (*b*) Potential energy

(*c*) energy (*d*) Magnetic energy

25. Two capacitors A and B are connected in series with a battery as shown in the figure. When the switch S is closed and the two capacitors get charged fully, then



(*a*) The potential difference across the plates of A is 4V and across the plates of B is 6V

(*b*) The potential difference across the plates of A is 6V and across the plates of B is 4V

(*c*) The ratio of electrical energies stored in A and B is 2 : 3

(*d*) The ratio of charges on A and B is 3 : 2

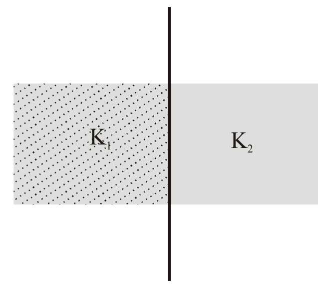
Dielectrics

26. An air filled parallel plate capacitor has capacity C. If distance between plates is doubled and it is immersed in a liquid then capacity becomes twice. Dielectric constant of the liquid is

(*a*) 1 (*b*) 2

(*c*) 3 (*d*) 4

27. A parallel plate capacitor with air as medium between the plates has a capacitance of 10 μF. The area of capacitor is divided into two equal halves and filled with two media as shown in the figure having dielectric constant $k_1 = 2$ and $k_2 = 4$. The capacitance of the system will now be

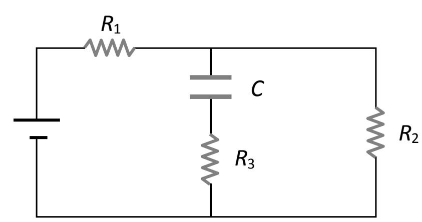


(*a*) 10 μF (*b*) 20 μF

(*c*) 30 μF (*d*) 40 μF

RC Circuit

28. In the circuit here, the steady state voltage across capacitor C is a fraction of the battery e.m.f. The fraction is decided by



(*a*) R_1 only (*b*) R_1 and R_2 only

(*c*) R_1 and R_3 only (*d*) R_1, R_2 and R_3

Learning Plus

1. The radii of two metallic spheres are 5 cm and 10 cm and both carry equal charge of 75μC. If the two spheres are shorted then charge transferred is.

(*a*) 25 μC from smaller to bigger

(*b*) 25 μC from bigger to smaller

(*c*) 50 μC from smaller to bigger

(*d*) 50 μC from bigger to smaller

2. Two isolated charged metallic spheres of radii R_1 and R_2 having charges Q_1 and Q_2 respectively are connected to each other, then there is:

(*a*) No change in the electrical energy of the system

(*b*) An increase in the electrical energy of the system

(*c*) Always a decrease in the electrical energy of the system

(*d*) A decrease in electrical energy of the system until $Q_1 R_2 = Q_2 R_1$

3. No current flows between two charged bodies connected together when they have the same

(*a*) capacitance or Q/V ratio

(*b*) charge

(*c*) resistance

(*d*) potential or Q/C ratio

4. The capacitance of a parallel plate condenser does not depend upon

(*a*) the distance between the plates

(*b*) area of the plates

(*c*) medium between the plates

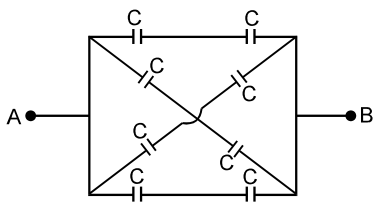
(*d*) metal of the plates

5. Two spherical conductors of capacitance 3.0 μF and 5.0 μF are charged to potentials of 300Volt and 500Volt. The two are connected resulting in redistribution of charges. Then the final potential is -

(*a*) 300 volt (*b*) 500 volt

(*c*) 425 volt (*d*) 400 volt

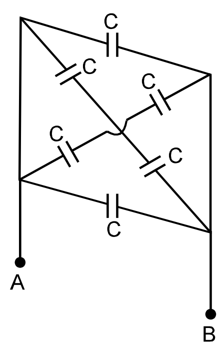
6. In the adjoining circuit, the capacity between the points A and B will be -



(*a*) C (*b*) 2C

(*c*) 3C (*d*) 4C

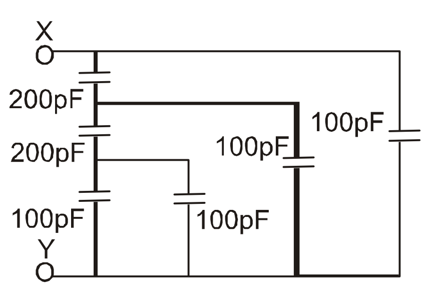
7. The resultant capacity between the points A and B in the adjoining circuit will be -



(*a*) C (*b*) 2C

(*c*) 3C (*d*) 4C

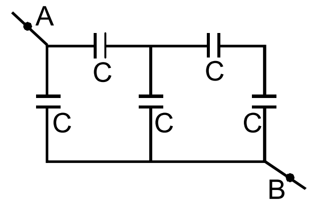
8. The equivalent capacitance between the terminals X and Y in the figure shown will be–



(*a*) 100 pF (*b*) 200 pF

(*c*) 300 pF (*d*) 400 pF

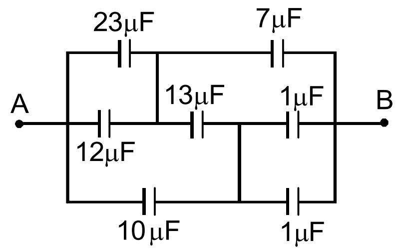
9. What is the equivalent capacitance of the system of capacitors between A & B



(*a*) $\frac{7}{6}$ C (*b*) 1.6C

(*c*) C (*d*) None

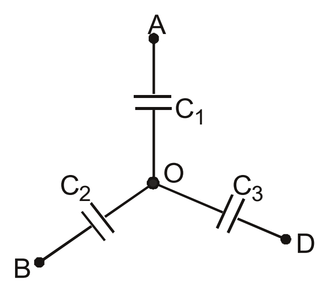
10. Find the equivalent capacitance across A & B



(*a*) $\frac{28}{3}$ μF (*b*) $\frac{15}{2}$ μF

(*c*) 15 μF (*d*) None

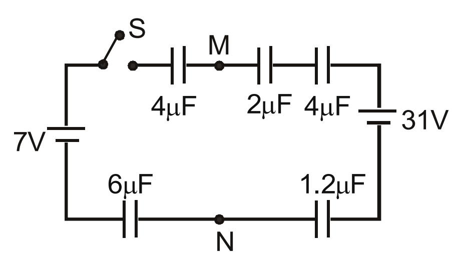
11. Three uncharged capacitors of capacitane $C_1 = 1\mu F$, $C_2 = 2\mu F$ and $C_3 = 3\mu F$ are connected as shown in figure to one another and to points A, B and D potential $\phi_A = 10V$, $\phi_B = 25V$ and $\phi_D = 20$ V, Determine the potential (ϕ_0) at point O.



(*a*) 20V (*b*) 30V

(*c*) 40V (*d*) 10V

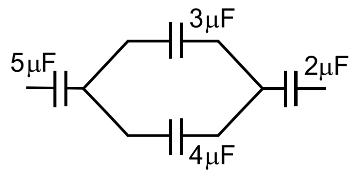
12. Five capacitors are connected as shown in the figure. Initially S is opened and all capacitors are uncharged. When S is closed, steady state is obtained. Then find out potential difference between the points M and N.



(*a*) 14 (*b*) 12

(*c*) 10 (*d*) 15

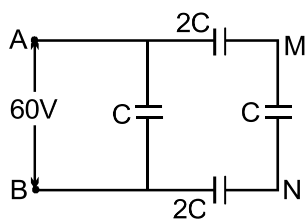
13. If charge on left plate of the 5 μ F capacitor in the circuit segment shown in the figure is-20 μ C, the charge on the right plate of 3 μ F capacitor is :-



(*a*) +8.57 μ C (*b*) –8.57 μ C
(*c*) + 11.42 μ C (*d*) –11.42 μ C

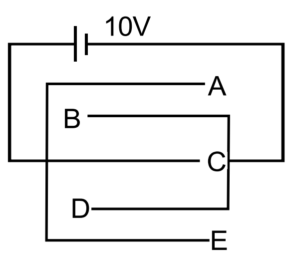
14. A capacitor C_1 = 4μF is connected in series with another capacitor C_2 = 1μF. The combination is connected across a d.c. source of voltage 200V. The ratio of potential across C_1 and C_2 is -
(*a*) 1 : 4 (*b*) 4 : 1
(*c*) 1 : 2 (*d*) 2 : 1

15. In the circuit shown, a potential difference of 60V is applied across AB. The potential difference between the points M and N is



(*a*) 10 V (*b*) 15 V
(*c*) 20 V (*d*) 30 V

16. Five identical capacitor plates are arranged such that they make capacitors each of 2 μ F. The plates are connected to a source of emf 10 V. The charge on plate C is



(*a*) +20 μ C (*b*) +40 μ C
(*c*) +60 μ C (*d*) +80 μ C

17. A capacitor of capacitance 1 μ F withstands the maximum voltage 6 kV while a capacitor of 2 μ F withstands the maximum voltage 4 kV. What maximum voltage will the system of these two capacitor withstands if they are connected in series?
(*a*) 10 kV (*b*) 12 kV
(*c*) 8 kV (*d*) 9 kV

18. Three capacitors 2 μ F, 3 μ F and 5 μ F can withstand voltages to 3 V, 2V and 1V respectively. Their series combination can withstand a maximum voltage equal to
(*a*) 5 Volts (*b*) (31/6) Volts
(*c*) (26/5) Volts (*d*) None

19. A capacitor is connected to a battery. The force of attraction between the plates when the separation between them is halved
(*a*) remains the same (*b*) becomes eight times
(*c*) becomes four times (*d*) becomes two times

20. A_1 is a spherical conductor of radius (r) placed concentrically inside a thin spherical hollow conductor A_2 of radius (R). A_1 is earthed and A_2 is given a charge +Q then the charge on A_1 is-
(*a*) –Q (*b*) Qr/R
(*c*) –rQ/R (*d*) –Q (R–r)/R

21. The energy of a charged capacitor resides in
(*a*) the electric field only
(*b*) the magnetic field only
(*c*) both the electric and magnetic field
(*d*) neither in electric nor magnetic field

22. The work done against electric forces in increasing the potential difference of a condenser from 20V to 40V is W. The work done in increasing its potential difference from 40V to 50V will be (consider capacitance of capacitor remain constant)
(*a*) 4W (*b*) $\frac{3W}{4}$
(*c*) 2W (*d*) $\frac{W}{2}$

23. A conductor of capacitance 0.5μF has been charged to 100volts. It is now connected to uncharged conductor of capacitance 0.2μF. The loss in potential energy is nearly-
(*a*) 7×10^{-4} J (*b*) 3.5×10^{-4} J
(*c*) 14×10^{-4} J (*d*) 7×10^{-3} J

24. A parallel plate condenser of capacity C is connected to a battery and is charged to potential V. Another condenser of capacity 2C is connected to another battery and is charged to potential 2V. The charging batteries are removed and now the condensers are connected in such a way that the positive plate of one is connected to negative plate of another. The final energy of this system is–
(*a*) zero (*b*) $\frac{25CV^2}{6}$
(*c*) $\frac{3CV^2}{2}$ (*d*) $\frac{9CV^2}{2}$

25. A 2 μ F capacitor is charged to a potential = 10 V. Another 4 μ F capacitor is charged to a potential = 20V. The two capacitors are then connected in a single loop, with the positive plate of one connected with negative plate of the other. What heat is evolved in the circuit?
(*a*) 300 μ J (*b*) 600 μ J
(*c*) 900 μ J (*d*) 450 μ J

26. The distance between the plates of a parallel plate condenser is d. If a copper plate of same area but thickness $\frac{d}{2}$ is placed between the plates then the new capacitance will become-

(*a*) half (*b*) double
(*c*) one fourth (*d*) unchanged

27. A parallel plate condenser is connected to a battery of e.m.f. 4 volt. If a plate of dielectric constant 8 is inserted into it, then the potential difference on the condenser will be-

(*a*) 1/2 V (*b*) 2V
(*c*) 4V (*d*) 32V

28. In the above problem if the battery is disconnected before inserting the dielectric, then potential difference will be-

(*a*) 1/2 V (*b*) 2V
(*c*) 4V (*d*) 32V

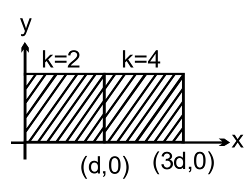
29. A parallel plate condenser with plate separation d is charged with the help of a battery so that U_0 energy is stored in the system. A plate of dielectric constant K and thickness d is placed between the plates of condenser while battery remains connected. The new energy of the system will be-

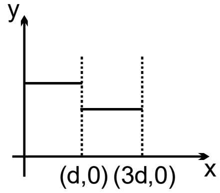
(*a*) KU_0 (*b*) K^2U_0
(*c*) $\frac{U_0}{K}$ (*d*) $\frac{U_0}{K^2}$

30. A metallic plate of thickness (t) and face area of one side (*a*) is inserted between the plates of a parallel plate air capacitor with a separation (d) and face are (*a*). Then the equivalent capacitance is :

(*a*) $\frac{\epsilon_0 A}{d}$ (*b*) $\frac{\epsilon_0 A}{(d \times t)}$
(*c*) $\frac{\epsilon_0 A}{(d - t)}$ (*d*) $\frac{\epsilon_0 A}{(d + t)}$

31. A parallel plate capacitor has two layers of dielectric as shown in figure. This capacitor is connected across a battery. The graph which shows the variation of electric field (E) and distance (x) from left plate.



(*a*)


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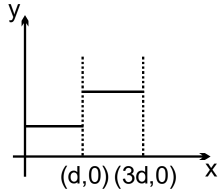

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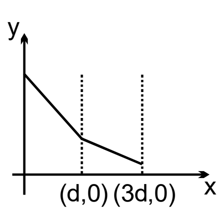

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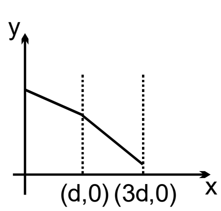


32. A parallel plate isolated condenser consists of two metal plates of area A and separation 'd'. A slab of thickness 't' and dielectric constant K is inserted between the plates with its faces parallel to the plates and having the same surface area as that of the plates. If K = 2, for what value of t/d will the capacitance of the system be 3/2 times that of the condenser with air filling the full space ?

(*a*) $\frac{1}{3}$ (*b*) $\frac{2}{3}$
(*c*) $\frac{3}{2}$ (*d*) 3

33. Hard rubber has a dielectric constant of 2.8 and a dielectric strength of 18×10^8 volts/meter. If it is used as the dielectric material filling the full space in a parallel plate capacitor. What minimum area may the plates of the capacitor have in order that the capacitance be 7.0×10^{-2} μf and that the capacitor be able to withstand a potential difference of 4000 volts.

(*a*) 0.62 m^{-2} (*b*) 0.32 m^{-2}
(*c*) 0.42 m^{-2} (*d*) 0.52 m^{-2}

34. The area of the plates of a parallel plate capacitor is A and the gap between them is d. The gap is filled with a non homogeneneous dielectric whose dielectric constant varies with the distance 'y' from one plate as: $K = \lambda \sec(\pi y/2d)$, where λ is a dimensionless constant. The capacitance of this capacitor is

(*a*) $\pi\varepsilon_0\lambda$ A/2d (*b*) $\pi\varepsilon_0\lambda$ A/d
(*c*) $2\pi\varepsilon_0\lambda$ A/d (*d*) None

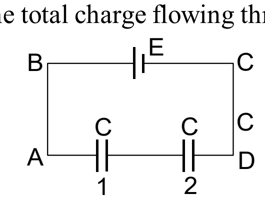
35. A capacitor stores 60 μ C Charge when connected across a battery. When the gap between the plates is filled with a dielectric, a charge of 120 μ C flows through the battery. The dielectric constant of the material inserted is

(*a*) 1 (*b*) 2
(*c*) 3 (*d*) None

36. Condenser A has a capacity of 15 μ F when it is filled with a medium of dielectric constant 15. Another condenser B has a capacity 1 μ F with air between the plates. Both are charged separately by a battery of 100 V. After charging, both are connected in parallel without the battery and the dielectric material being removed. The common potential now is

(*a*) 400 V (*b*) 800 V
(*c*) 1200 V (*d*) 1600 V

37. In the adjoining figure, capacitor (*a*) and (*b*) have a capacitance 'C' each. When the dielectric of dielectric constant K is inserted between the plates of one of the capacitor, the total charge flowing through battery is



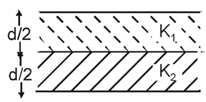
(*a*) $\frac{KCE}{K+1}$ from B to C

(*b*) $\frac{KCE}{K+1}$ from C to B

(*c*) $\frac{(K-1)CE}{2(K+1)}$ from B to C

(*d*) $\frac{(K-1)CE}{2(K+1)}$ from C to B

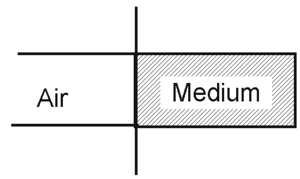
38. Two dielectric slabs of constant K_1 and K_2 have been filled in between the plates of a capacitor as shown below. What will be the capacitance of the capacitor



(*a*) $\frac{2\varepsilon_0 A}{d}(K_1+K_2)$ (*b*) $\frac{2\varepsilon_0 A}{d}\left(\frac{K_1+K_2}{K_1\times K_2}\right)$

(*c*) $\frac{d}{2\varepsilon_0 A}$ (*d*) $\frac{2\varepsilon_0 A}{d}\left(\frac{K_1\times K_2}{K_1+K_2}\right)$

39. The capacitance of a parallel plate capacitor is 2.5μF. When it is half filled with a dielectric as shown in the figure, Its capacitance becomes 5μF, the dielectric constant of the dielectric is



(*a*) 7.5 (*b*) 3.0

(*c*) 0.33 (*d*) 4.0

Advanced Level Multiconcept Questions

MCQ/COMPREHENSION/MATCHING/ NUMERICAL

1. When a charged capacitor is connected with an uncharged capacitor, then which of the following is/are correct option/ options.

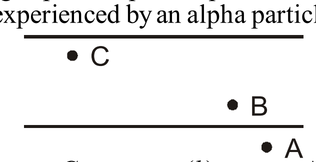
(*a*) the magnitude of charge on the charged capacitor decreases.

(*b*) a steady state is obtained after which no further flow of charge occurs.

(*c*) the total potential energy stored in the capacitors remains conserved.

(*d*) the charge conservation is always true.

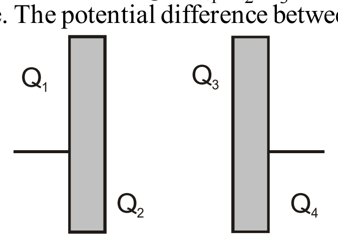
2. For a charged parallel plate capacitor shown in the figure, the force experienced by an alpha particle will be :



(*a*) maximum at C (*b*) zero at A

(*c*) same at B and C (*d*) zero at C

3. In an isolated parallel plate capacitor of capacitance C the four surfaces have charges Q_1,Q_2,Q_3 and Q_4 as shown in the figure. The potential difference between the plates is :



(*a*) $\frac{Q_1+Q_2}{C}$

(*b*) $\left|\frac{Q_2}{C}\right|$

(*c*) $\left|\frac{Q_3}{C}\right|$

(*d*) $\frac{1}{C}[(Q_1+Q_2)-(Q_3-Q_4)]$

4. Each plate of a parallel plate capacitor has a charge q on it. The capacitor is now connected to a battery. Now,

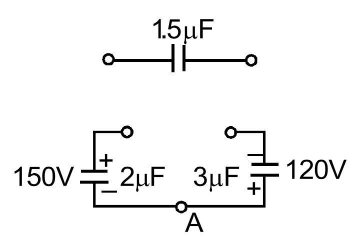
(*a*) the facing surfaces of the capacitor have equal and opposite charges

(*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

5. Two capacitors of 2μF and 3μF are charged to 150 volt and 120 volt respectively. The plates of capacitor are connected as shown in the figure. A discharged capacitor of capacity 1.5 μF falls on the free ends of the wire. Then



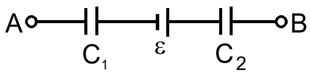
(*a*) charge on the 1.5 μF capacitor is 180 μC

(*b*) charge on the 2 μF capacitor is 120 μC

(*c*) charge flows through A from right to left

(*d*) charge flows through A from left to right

6. A circuit shown in the figure consists of a battery of emf 10V and two capacitors C_1 and C_2 of capacitances 1.0μF and 2.0μF respectively. The potential difference $V_A - V_B$ is 5V

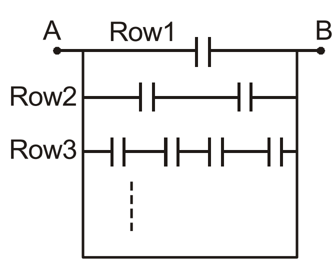


(*a*) charge on capacitor C_1 is equal to charge on capacitor C_2
(*b*) Voltage across capacitor C_1 is 5V
(*c*) Voltage across capacitor C_2 is 10 V
(*d*) Energy stored in capacitor C_1 is two times the energy stored in capacitor C_2

7. A parallel-plate capacitor is connected to a cell. Its positive plate A and its negative plate B have charges +Q and –Q respectively. A third plate C, identical to A and B, with charge +Q, is now introduced midway between A and B, parallel to them. Which of the following are correct?
(*a*) The charge on the inner face of B is now $-\frac{3Q}{2}$
(*b*) There is no change in the potential difference between A and B
(*c*) The potential difference between A and C is one-third of the potential difference between B and C
(*d*) The charge on the inner face of A is now Q/2

8. The separation between the plates of a isolated 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

9. Rows of capacitors containing 1, 2, 4, 8, ...∞ capacitors, each of capacitance 2F, are connected in parallel as shown in figure. The potential difference across AB = 10 volt, then :

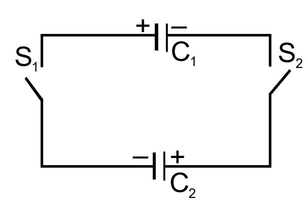


(*a*) Total capacitance across AB is 4F
(*b*) Charge of each capacitor will be same
(*c*) Charge on the capacitor in the first row is more than on any other capacitor
(*d*) Energy of all the capacitors is 50 J

10. The two plates X and Y of a parallel plate capacitor of capacitance C are given a charge of amount Q each. X is now joined to the positive terminal and Y to the negative terminal of a cell of emf E = Q/C.
(*a*) Charge of amount Q will flow from the negative terminal to the positive terminal of the cell inside it.
(*b*) The total charge on the plate X will be 2Q
(*c*) The total charge on the plate Y will be zero
(*d*) The cell will supply CE^2 amount of energy

11. When two identical capacitors are charged individually to different potentials and connected parallel to each other, after disconnecting them from the source :
(*a*) net charge on connected plates is less than the sum of initial individual charges.
(*b*) net charge on connected plates equals the sum of initial charges.
(*c*) the net potential difference across them is different from the sum of the individual initial potential differences.
(*d*) the net energy stored in the two capacitors is less than the sum of the initial individual energies.

12. Two capacitors C_1 = 4μF and C_2 = 2μF are charged to same potential V = 500 Volt, but with opposite polarity as shown in the figure. The switches S_1 and S_2 are closed.



(*a*) The potential difference across the two capacitors are same and is given by 500/3V
(*b*) The potential difference across the two capacitors are same and is given by 1000/3V
(*c*) The ratio of final energy to initial energy of the system is 1/9
(*d*) The ratio of final energy to initial energy of the system is 4/9

13. The terminals of a battery of emf V are connected to the two plates of a parallel plate capacitor. If the space between the plates of the capacitor is filled with an insulator of dielectric constant K, then :
(*a*) the electric field in the space between the plates does not change
(*b*) the capacitance of the capacitor increases
(*c*) the charge stored in the capacitor increases
(*d*) the electrostatic energy stored in the capacitor decreases

14. The plates of a parallel plate capacitor with no dielectric are connected to a voltage source. Now a dielectric of dielectric constant K is inserted to fill the whole space between the plates with voltage source remaining connected to the capacitor.
(*a*) the energy stored in the capacitor will become K–times
(*b*) the electric field inside the capacitor will decrease to K-times
(*c*) the force of attraction between the plates will increase to K^2 – times
(*d*) the charge on the capacitor will increase to K-times

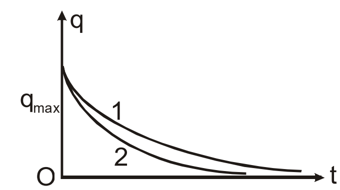
15. A parallel plate air capacitor is connected to a battery. The quantities charge, electric field and energy associated with this capacitor are given by Q_0, V_0, E_0 and U_0 respectively. A dielectric slab is now introduced to fill the space between the plates with the battery still in connection. The corresponding quantities now given by Q, V, E and U are related to the previous one as :
(*a*) $Q > Q_0$ (*b*) $V > V_0$
(*c*) $E > E_0$ (*d*) $U > U_0$

16. A parallel plate capacitor A is filled with a dielectric whose dielectric constant varies with applied voltage as K = V. An identical capacitor B of capacitance C_0 with air as dielectric is connected to voltage source V_0 = 30 V and then connected to the first capacitor after disconnecting the voltage source. The charge and voltage on capacitor.
(*a*) A are 25 C_0 and 25 V (*b*) A are 25 C_0 and 5 V
(*c*) B are 5c_0 and 5V (*d*) B are 5C_0 and 25 V

17. A parallel plate air-core capacitor is connected across a source of constant potential difference. When a dielectric plate is introduced between the two plates then :
(*a*) some charge from the capacitor will flow back into the source
(*b*) some extra charge from the source will flow back into the capacitor
(*c*) the electric field intensity between the two plate does not change
(*d*) the electric field intensity between the two plates will decrease

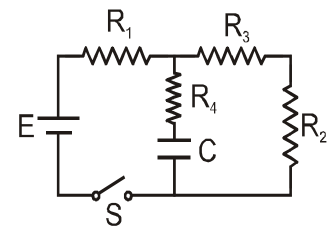
18. Following operations can be performed on a capacitor X – connect the capacitor to a battery of emf E Y – disconnect the battery Z – reconnect the battery with polarity reversed W – insert a dielectric slab in the capacitor
(*a*) In XYZ (perform X, then Y, then Z) the stored electric energy remains unchanged and no thermal energy is developed
(*b*) The charge appearing on the capacitor is greater after the action XWY than after the action XYW.
(*c*) The electric energy stored in the capacitor is greater after the action WXY than after the action XYW.
(*d*) The electric field in the capacitor after the action XW is the same as that after WX

19. The instantaneous charge on capacitor in two discharging RC circuits is plotted with respect to time in figure. Choose the correct statement(s) (where E_1 and E_2 are emfs of two DC sources in two different charging circuits and capacitors are fully charged).



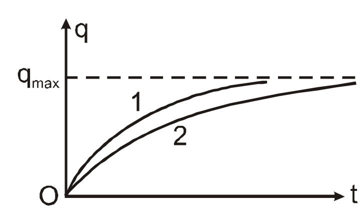
(*a*) $R_1C_1 > R_2C_2$ (*b*) $\frac{R_1}{R_2} < \frac{C_2}{C_1}$
(*c*) $R_1 > R_2$ if $E_1 = E_2$ (*d*) $C_2 > C_1$ if $E_1 = E_2$

20. In the circuit shown in figure the switch S is closed at t = 0.



A long time after closing the switch
(*a*) voltage drop across the capacitor is E
(*b*) current through the battery is $\frac{E}{R_1 + R_2 + R_3}$
(*c*) energy stored in the capacitor is
$$\frac{1}{2}C\left(\frac{(R_2 + R_3)E}{R_1 + R_2 + R_3}\right)^2$$
(*d*) current through the resistance R_4 becomes zero

21. The charge on capacitor in two different RC circuits 1 and 2 are plotted as shown in figure.



Choose the correct statement(s) related to the two circuits.
(*a*) Both the capacitors are charged to the same magnitude of charge
(*b*) The emf's of cells in both the circuits are equal.
(*c*) The emf's of the cells may be different
(*d*) The emf E_1 is more than E_2

22. Capacitor C_1 of the capacitance 1 microfarad and capacitor C_2 of capacitance 2 microfarad are separately charged fully by a common battery. The two capacitors are then separately allowed to discharge through equal resistors at time t = 0.

(*a*) the current in each of the two discharging circuits is zero at t = 0.

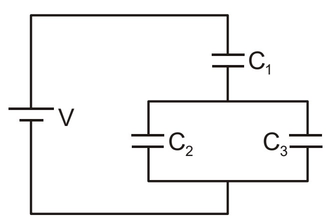
(*b*) the current in the two discharging circuits at t = 0 are equal but non zero.

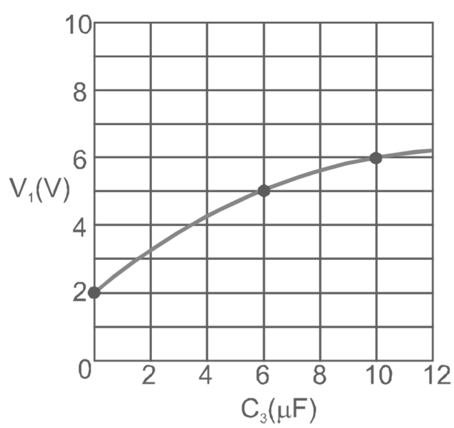
(*c*) the current in the two discharging circuits at t = 0 are unequal

(*d*) capacitor C_1 loses 50% of its initial charge sooner than C_2 loses 50% of its initial charge

Comprehension Type Questions – 1 (No. 23 to 25)

Capacitor C_3 in the circuit is a variable capacitor (its capacitance can be varied). Graph is plotted between potential difference V_1 (across capacitor C_1) versus C_3. Electric potential V_1 approaches on asymptote of 10 V as $C_3 \to \infty$.





23. EMF of the battery is equal to:

(*a*) 10 V (*b*) 12 V

(*c*) 16 V (*d*) 20 V

24. The capacitance of the capacitor C_1 has value:

(*a*) 2 μF (*b*) 6 μF

(*c*) 8 μF (*d*) 12 μF

25. The capacitance of C_2 is equal to:

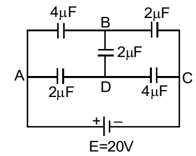
(*a*) 2 μF (*b*) 6 μF

(*c*) 8 μF (*d*) 12 μF

Comprehension Type Questions – 2 (No. 26 to 29)

The figure shows a diagonal symmetric arrangement of capacitors and a battery

26. Identify the correct statements.



(*a*) Both the 4μF capacitors carry equal charges in opposite sense

(*b*) Both the 4μF capacitors carry equal charges in same sense

(*c*) $V_B - V_D > 0$

(*d*) $V_D - V_B > 0$

27. If the potential of C is zero, then

(*a*) $V_A = +20V$

(*b*) $4(V_A - V_B) + 2(V_D - V_B) = 2V_B$

(*c*) $2(V_A - V_D) + 2(V_B - V_D) = 4V_D$

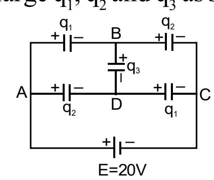
(*d*) $V_A = V_B + V_D$

28. The potential of the point B and D are

(*a*) $V_B = 8V$ (*b*) $V_B = 12V$

(*c*) $V_D = 8V$ (*d*) $V_D = 12V$

29. The value of charge q_1, q_2 and q_3 as shown in the figure are



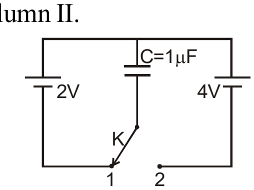
(*a*) $q_1 = 32\ \mu C$; $q_2 = 24\ \mu C$; $q_3 = -8\ \mu C$

(*b*) $q_1 = 48\ \mu C$; $q_2 = 16\ \mu C$; $q_3 = +8\ \mu C$

(*c*) $q_1 = 32\ \mu C$; $q_2 = 24\ \mu C$; $q_3 = +8\ \mu C$

(*d*) $q_1 = 3\ \mu C$; $q_2 = 4\ \mu C$; $q_3 = +2\ \mu C$

30. The circuit involves two ideal cells connected to a 1 μF capacitor via a key K. Initially the key K is in position 1 and the capacitor is charged fully by 2V cell. The key is then pushed to position 2. Column I gives physical quantities involving the circuit after the key is pushed from position 1. Column II gives corresponding results. Match the statements in Column I with the corresponding values in Column II.

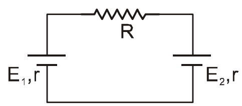


Column I	Column II
(*a*) The net charge crossing the 4 volt cell in μC is	(p) 2
(*b*) The magnitude of work done by 4 Volt cell in μJ is	(q) 6
(*c*) The gain in potential energy of capacitor in μJ is	(r) 8
(*d*) The net heat produced in circuit in μJ is	(s) 16

31. In each situation of column-I, a circuit involving two non-ideal cells of unequal emf E_1 and E_2 ($E_1 > E_2$) and equal internal resistance r are given. A resistor of resistance R is connected in all four situations and a capacitor of capacitance C is connected in last two situations as shown. Assume battery can supply infinity charge to the circuit ($r, R \neq 0, E_1, E_2 \neq 0$). Four statements are given in column-II. Match the situation of column-I with statements in column-II.

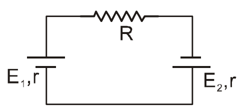
Column-I | **Column -II**

(*a*)



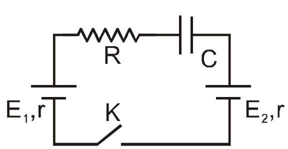
(p) magnitude of potential difference across both cells can never be same.

(*b*)



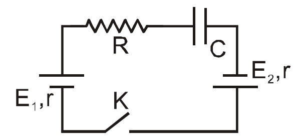
(q) cell of lower emf absorbs energy, that is, it gets charged up as long as current flows in circuit

(*c*) The capacitor is initially uncharged.



(r) potential difference across cell of After the key K is closed lower emf may be zero.

(*d*) The capacitor is initially uncharged.



(s) current in the circuit can never be zero After the key K is closed. (even after steady state is reached).

NUMERICAL VALUE BASED

32. A parallel plate capacitor contains a mica sheet (thickness 10^{-3} m) and a sheet of fibre (thickness 0.5×10^{-3} m). The dielectric constant of mica is 8 and that of the fibre is 2.5. Assuming that the fibre breaks down when subjected to an electric field of 6.4×10^{6} V/m, find the maximum safe voltage in k.V that can be applied to the capacitor.

33. A 4 μF and a 9 μF capacitor are connected in series across a 26 V battery. What is voltage of the battery required to charge a parallel combination of the two capacitors to the same total energy?

34. A 10 μF capacitor is fully charged across a 12 volt battery. The capacitor is then disconnected from the battery and connected across an initially uncharged capacitor, C. The voltage across each capacitor is now 3 volts. What is the unknown capacitance C (in μF)?

35. What is the force of attraction (in μN) between the plates of a flat plate air capacitor of area 17.7 cm^2, if the voltage on the plates is 500 V and the distance between them is 8.85 mm?

36. 2 conducting objects one with charge of +Q and another with –Q are kept on x-axis at x = –3 and x = + 4 respectively.

The electric field on the x-axis is given by $3Q\left(x^2 + \frac{4}{3}\right)$.

What is the capacitance C of this configuration of objects. Fill $\frac{1}{C}$ (in F^{-1}) in OMR sheet.

Topicwise Questions

1. (*c*) Volume of 8 small drops = Volume of big drop

$$8\times\frac{4}{3}\pi r^3=\frac{4}{3}\pi R^3 \Rightarrow R=2r$$

As capacity is r, hence capacity becomes 2 times

2. (*d*) $C=\dfrac{K\varepsilon_0 A}{d}$

3. (*b*) By using $V_{big}=n^{2/3}v_{small}$

$$\Rightarrow \frac{V_{big}}{v_{small}}=(8)^{2/3}=\frac{4}{1}$$

4. (*d*) If the drops are conducting, then

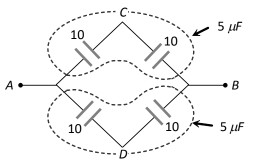
$$\frac{4}{3}\pi R^3=N\left(\frac{4}{3}\pi r^3\right)$$

$\Rightarrow R=N^{1/3}r$. Final charge $Q=Nq$

So final potential $V=\dfrac{Q}{R}=\dfrac{Nq}{N^{1/3}r}=V\times N^{2/3}$

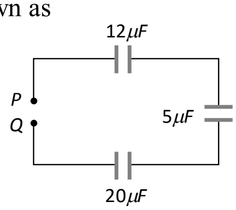
5. (*a*) **6.** (*a*)

7. (*d*) In the given system, no current will flow through the branch CD so it can be removed



Effective capacitance of the system = 5 + 5 = 10 μF

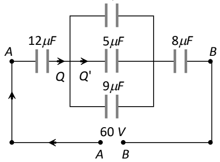
8. (*b*) The given circuit can be drawn as where $C=(3+2)\ \mu F=5\ \mu F$



$$\frac{1}{C_{PQ}}=\frac{1}{5}+\frac{1}{20}+\frac{1}{12}=\frac{20}{60}=\frac{1}{3}$$

$\Rightarrow C_{PQ}=3\ \mu F$

9. (*d*) The given circuit can be redrawn as follows



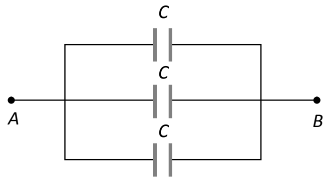
Equivalent capacitance of the circuit $C_{AB}=4\ \mu F$

Charge given by the battery $Q=C_{eq}V=4\times 60=240\ \mu C$

Charge in 5μF capacitor

$$Q'=\frac{5}{(10+5+9)}\times 240=50\ \mu C$$

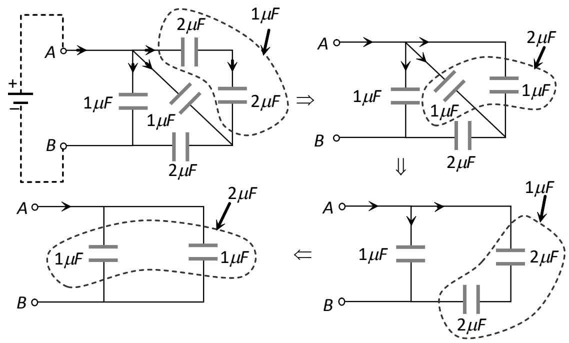
10. (*b*) The given circuit can be redrawn as follows



$\Rightarrow C_{AB}=3C$

11. (*b*) The given arrangement is equivalent to the parallel combination of three identical capacitors. Hence equivalent capacitance $=3C=\dfrac{3\varepsilon_0 A}{d}$

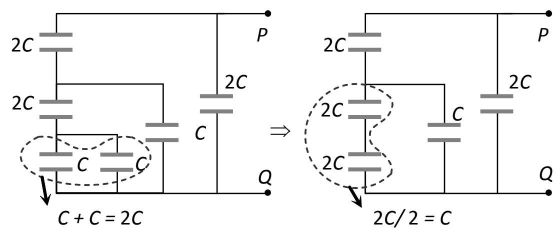
12. (*b*) The given circuit can be simplified as follows

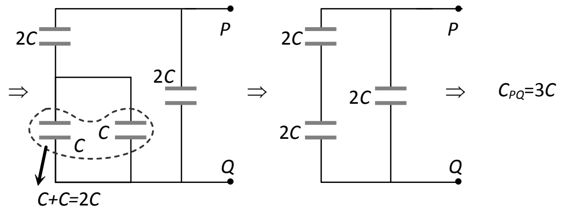


Hence equivalent capacitance between A and B is 2μF.

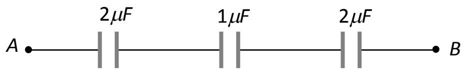
13. (*d*) Minimum when connected in series and maximum when connected in parallel

14. (*a*)





15. (*d*)



$$\frac{1}{C}=\frac{1}{2}+\frac{1}{1}+\frac{1}{2}=\frac{1+2+1}{2}=\frac{4}{2}=2$$

$\Rightarrow \quad C_{AB}=0.5\ \mu F$

16. (*b*) Charge flows to second capacitor until the potential is same i.e. V/2. So new charge = CV/ 2

17. (*b*) $\frac{1}{C}=\frac{1}{3}+\frac{1}{6} \Rightarrow C=2\ pF$

Total charge = $2\times10^{-12}\times5000=10^{-8}$ C

The new potential when the capacitors are connected in parallel is

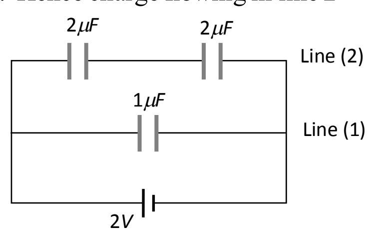
$$V=\frac{2\times10^{-8}}{(3+6)\times10^{-12}}=2222\ V$$

18. (*c*) $\frac{1}{C_{eq}}=\frac{1}{3}+\frac{1}{10}+\frac{1}{15} \Rightarrow C_{eq}=2\ \mu F$

Charge on each capacitor

$Q=C_{eq}\times V \Rightarrow 2\times100=200\ \mu C$

19. (*d*) Potential difference across both the lines is same i.e. 2 V. Hence charge flowing in line 2



$Q=\left(\frac{2}{2}\right)\times2=2\ \mu C$. So charge on each capacitor in line (2) is 2 μC

20. (*c*) Given circuit can be reduced as follows

In series combination charge on each capacitor remain same. So using Q = CV

$\Rightarrow C_1V_1=C_2V_2 \Rightarrow 3\,(1200-V_p)=6\,(V_P-V_B)$

$\Rightarrow 1200-V_p=2V_p \ (\because V_B=0)$

$\Rightarrow 3V_p=1200 \ \Rightarrow V_p=400$ volt

21. (*d*) $U=\frac{1}{2}CV^2=\frac{1}{2}\times2\times10^{-6}\times(50)^2=25\times10^{-4}$ J

$=25\times10^{3}$ erg

22. (*c*) $U=\frac{1}{2}CV^2=\frac{1}{2}\times6\times10^{-6}\times(100)^2=0.03$ J

23. (*b*) $\text{Power}=\frac{\frac{1}{2}CV^2}{t}=\frac{1\times40\times10^{-6}\times(3000)^2}{2\times2\times10^{-3}}=90$ kW

24. (*b*)

25. (*b*) In series combination of capacitors, voltage distributes on them, in the reverse ratio of their capacitance i.e.

$\frac{V_A}{V_B}=\frac{3}{2}$ ......(i)

Also $V_A+V_B=10$ ....(ii)

On solving (i) and (ii) $V_A=6V$, $V_B=4V$

26. (*d*) $C=\frac{\varepsilon_0A}{d}$ ......(i)

$C'=\frac{\varepsilon_0KA}{2d}$ ......(ii)

From equation (i) and (ii)

$\frac{C'}{C}=\frac{K}{2}$

$\Rightarrow \ 2=\frac{K}{2} \Rightarrow K=4$

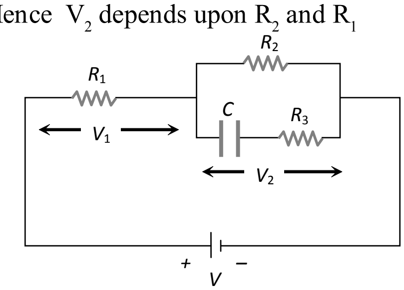
27. (*c*) $C_R=C_1+C_2=\frac{k_1\varepsilon_0A_1}{d}+\frac{k_2\varepsilon_0A_2}{d}$

$$=\frac{2\times\varepsilon_0\frac{A}{2}}{d}+\frac{4\times\varepsilon_0\frac{A}{2}}{d}=2\times\frac{10}{2}+4\times\frac{10}{2}=30\ \mu F$$

28. (*b*) In steady state potential difference across capacitor V_2= potential difference across resistance

$R_2=\left(\frac{R_2}{R_1+R_2}\right)V$

Hence V_2 depends upon R_2 and R_1



Learning Plus

1. (*a*) $Q_t=Q_1+Q_2=150\mu C$

$\frac{Q_1'}{Q_2'}=\frac{C_1}{C_2}=\frac{1}{2} \Rightarrow Q_1'=50\mu C$

$Q_2'=100\mu C$

25μC charge will flow from smaller to bigger sphere .

2. (*d*) Charge is flow until potential are equal and in charge flow energy is decrease

$\frac{Q_1}{C_1}=\frac{Q_2}{C_2} \Rightarrow Q_1R_2=Q_2R_1$.

3. (*d*) Charge / Current flows from higher to lower potential or Q/C ratio.

4. (*d*) $C = \dfrac{k \in_0 A}{d}$ where k = dielectric constant of medium between the plates

A = Area, d = distance between the plates

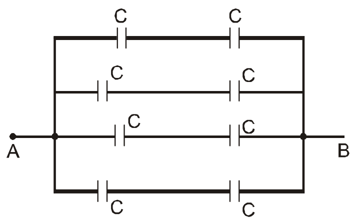
5. (*c*) $Q_1 = 900\mu C$ $\quad Q_2 = 2500\mu C$

When the two capacitors are connected together let the common potential is V.

$$900 + 2500 = (3+5)V$$

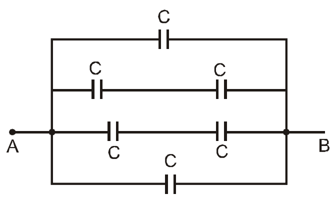
$$V = \frac{3400}{8} = 425V$$

6. (*b*)



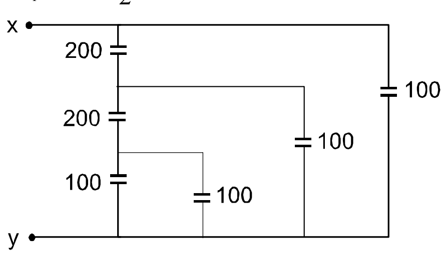
$C_{eq} = \dfrac{4C}{2} = 2C.$

7. (*c*)

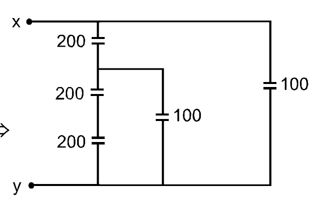


$C_{eq} = C + \dfrac{2C}{2} + C = 3C.$

8. (*b*)

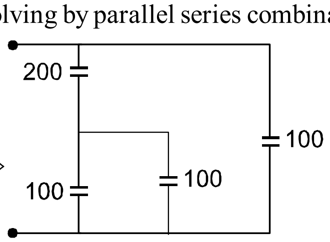


$\Rightarrow$

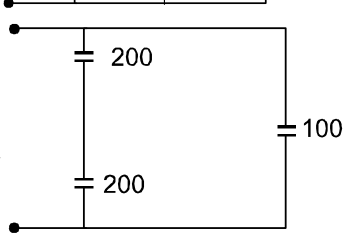


solving by parallel series combinations,

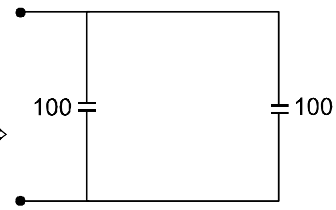
$\Rightarrow$



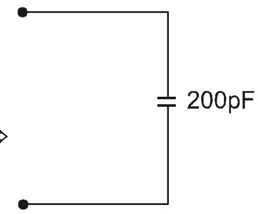
$\Rightarrow$



$\Rightarrow$

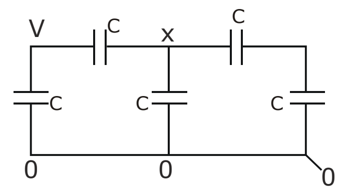


$\Rightarrow$

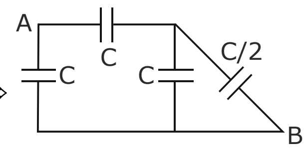


$C_{eq} = 200$ pF

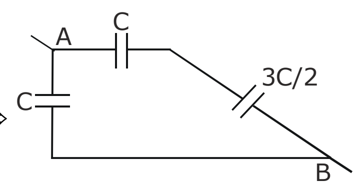
9. (*b*) Solving the circuit using following steps



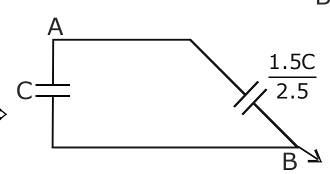
$\Rightarrow$



$\Rightarrow$

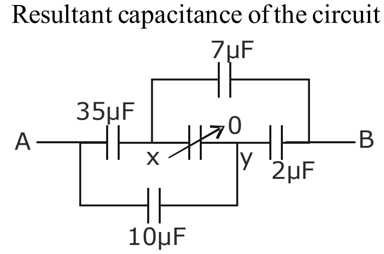


$\Rightarrow$

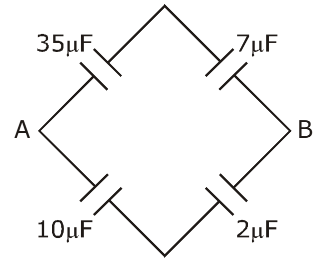


Resultant capacitance of the circuit = 1.6C

10. (*b*)



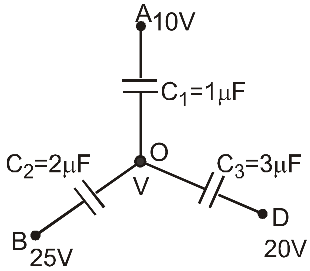
As the resulting circuit is a Wheat stone bridge hence current in 13μF capacitor is zero. Hence the circuit now reduces to



The resultant capacitance is $\frac{35}{6}+\frac{10}{6}=\frac{45}{6}$

$=\frac{15}{2}\ \mu F$

11. (*a*)



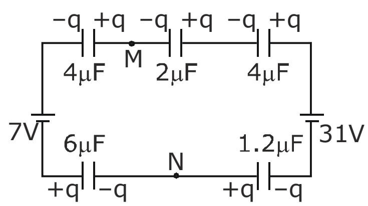
From junction law

$(V-10)1+(V-20)3+(V+25)2=0$

$6V=120$

$V=20$ Volt

12. (*b*) Let q be the charge on all the capacitor



Apply KVL

$$31-\frac{q}{4}-\frac{q}{2}-\frac{q}{4}-7-\frac{q}{6}-\frac{q}{12}=0$$

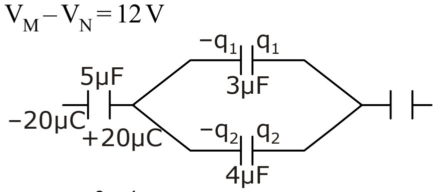
$$24=\left[\frac{3+6+3+2+10}{12}\right]q$$

$q=12\ \mu C$

$$\text{Now } V_N+\frac{q}{6}+7+\frac{q}{4}=V_M$$

$V_M-V_N=12\ V$

13. (*a*)



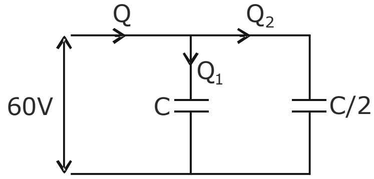
$q_1 : q_2 = 3 : 4$

$q_1=\frac{3}{7}\times 20\mu C$

14. (*a*) $V_1 : V_2=\frac{1}{C_1}:\frac{1}{C_2}=C_1{:}C_2$

$$\frac{V_1}{V_2}=\frac{C_1}{C_2}=\frac{1}{4}$$

15. (*d*)



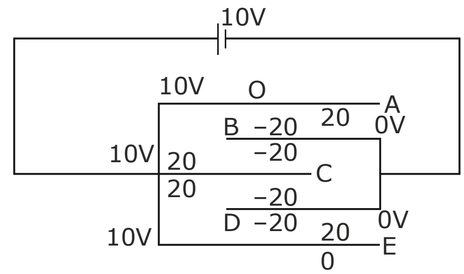
$Q=\frac{3}{2}C\times 60=90C$

Q : Q = C : C = 2 : 1

$Q_2=\frac{1}{3}\times 90=30\ C$

Potential difference across $C=\frac{30C}{C}=30\ V$

16. (*b*)

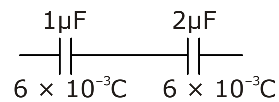


Total charge on plate C = 40 μC

17. (*d*) Maximum charge on 1st capacitor $=6\times10^{-3}$C.

Maximum charge on 2nd capacitor $=8\times10^{-3}$C.

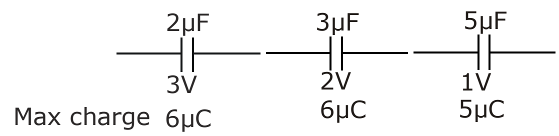
In series the maximum charge they can have is 6×10^{-3}C



Hence maximum voltage =

$$V=\frac{6\times10^{-3}}{1\times10^{-6}}+\frac{6\times10^{-3}}{2\times10^{-6}}=9KV$$

18. (*b*)



Hence maximum charge that the series can with stand is 5 μC. So break down voltage $=5\times\frac{31}{30}=\frac{31}{6}$ volt

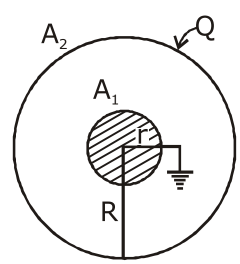
19. (*c*) We know that force between plates is

$$\frac{\sigma^2 A}{2\in_0}=\frac{Q^2}{2A\in_0}=\frac{C^2V^2}{2A\in_0}$$

$$=\frac{\in_0^2 A^2V^2}{2A\in_0 d^2}=\frac{\in_0 AV^2}{2d^2}$$

$$C_i=\frac{\in_0 Av^2}{2d^2}\quad C_f=\frac{\in_0 Av^2\times 4}{2d^2}$$

20. (*c*) Let us assume charge on A_1 is q and potential of A_1 is zero as it is earthed.



Potential of A_1 is due to charges Q & q. So we can write the equation as

$$V=\frac{KQ}{r}q+\frac{KQ}{R}=0$$

$$\frac{q}{r}=\frac{-Q}{R}\Rightarrow q=\frac{-Qr}{R}$$

21. (*a*) Charge carries electrical energy so capacitor stores electrical energy.

22. (*b*) $W = U_f - U_i = \frac{1}{2}CV_f^2 - \frac{1}{2}CV_i^2 = \frac{1}{2}\ C\,(40^2 - 20^2)$

$W = 600\,C$

$W_1 = \frac{1}{2}\ C\,(50^2 - 40^2) = \frac{900}{2}\ C$

$W_1 = \frac{900}{2} \cdot \frac{W}{600} = \frac{3}{4}\ W$

23. (*a*) Initially

$$U_i = \frac{1}{2}CV^2 = \frac{1}{2} \times 0.5 \times 10^{-6} \times 10^4 = 0.25 \times 10^{-2}\ J$$

When the 0.5 μF capacitor is connected to an uncharged capacitor let the common potential is V.

$0.5 \times 100 = 0.7\,V$

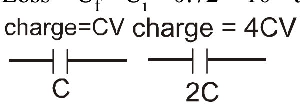
$$V = \frac{0.5 \times 100}{0.7} = \frac{500}{7}\ \text{Volt}$$

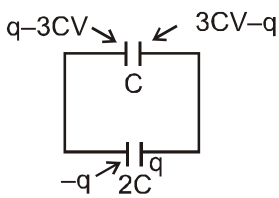
$U_f = \frac{1}{2} \times 0.7 \times 10^{-6} \times \frac{500}{7} \times \frac{500}{7}$

$= 1.78 \times 10^{-3}\ J$

Loss $= U_f - U_i = 0.72 \times 10^{-3}\ J$

24. (*c*)

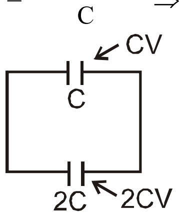




Total charge $= 4\,CV - CV = 3\,CV$

Now, let it is distributed as shown, potential across the capacitors is same

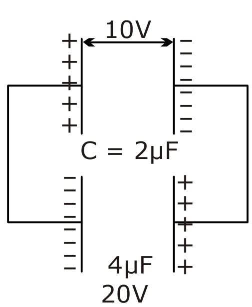
So, $\frac{q}{2C} = \frac{3CV - q}{C} \Rightarrow q = 2\,CV$



Total potential energy $= \frac{Q_1^2}{2C_1} + \frac{Q_2^2}{2C_2}$

$$= \frac{C^2V^2}{2C} + \frac{4C^2V^2}{2 \times 2C} = \frac{3CV^2}{2}$$

25. (*b*)



Before connection

$Q_1 = 2 \times 10 = 20,\ Q_2 = 4 \times 20 = 80$

$U_i = \frac{1}{2}\ 2(10)^2 + \frac{1}{2}\ 4\,(20)^2 = 900\ J$

Since connected as shown

After $Q_{net} = -20 + 80$

Connection $= 60$

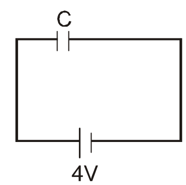
$V = \frac{60}{2+4} = 10$ Volt

$U_f = \frac{1}{2}\ 6(10)^2 = 300\ J$

Heat generated $= -U_f + U_i = 600\ J$

26. (*b*) $C' = \frac{\epsilon_0 A}{d/2} = \frac{2\epsilon_0 A}{d} = 2C.$

27. (*c*)



Here, Potential difference on the capacitor will depend on emf of battery i.e., 4V

28. (*a*) Charge or battery $= Q = CV = 4\,C$

Now charge remains same, as battery is disconnected

new capacitance $= C' = KC = 8C$

$C'V' = Q$

$V' = \frac{Q}{C'} = \frac{4C}{8C} = \frac{1}{2}\ V$

29. (*a*) $U_0 = \frac{1}{2}CV^2$ (given)

Now energy $= U' = \frac{1}{2}C'V^2$

$C' = CK$

$U' = \frac{1}{2}CV^2\,K = U_o K$

30. (*c*) For metal $k = \infty$

Hence from formula.

$C_{eq} = \frac{\epsilon_0 A}{d - t + t/k}$

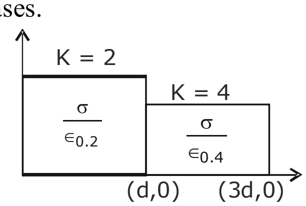
$C = \frac{\epsilon_0 A}{(d - t)}$

31. (*a*) Electric field between two plates of capacitor is given by $\frac{\sigma}{K\epsilon_0}$

When $K = 1$ then $E = \frac{\sigma}{\epsilon_0}$

then $K = K$ then $E = \frac{\sigma}{K\epsilon_0}$

On increasing dielectric constant electric field decreases.



32. (*b*) $C = \dfrac{\in_0 A}{d - t + \dfrac{t}{k}}$

Now $\dfrac{\in_0 A}{d - t + \dfrac{t}{k}} = \dfrac{3}{2}\dfrac{\in_0 A}{d}$

$\left(d - \dfrac{t}{2}\right) = \dfrac{2d}{3} \Rightarrow \dfrac{t}{d} = \dfrac{2}{3}$

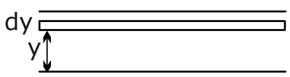
33. (*a*) $V_{max} = E_{max} d_{max} = 4000$

$d = \dfrac{4000}{18 \times 10^6}$

Now, $C = \dfrac{\in_0 KA_{min}}{d_{max}} = 7 \times 10^{-2}\,\mu f$

$A = \dfrac{7 \times 10^{-2} \times 10^{-6} \times 4000}{8.85 \times 10^{-12} \times 2.8 \times 18 \times 10^6} = 0.63\,m^2$

34. (*a*)



$dc = \dfrac{\varepsilon_0 A\lambda \sec(\pi y / 2d)}{dy}$

All the elements are in series

Hence $\dfrac{1}{C^n_{eq}} = \displaystyle\int_0^d \dfrac{dy}{\varepsilon_0 A\lambda} \cos\left(\dfrac{\pi y}{2d}\right)$

$= \dfrac{2d}{\varepsilon_0 A\lambda\pi}\left[\sin\left(\dfrac{\pi y}{2d}\right)\right]_0^d$

$C_{eq} = \dfrac{\varepsilon_0 A\lambda\pi}{2d}$

35. (*c*) As the potential difference is constant hence we can say that

$Q_1 = 60\,\mu C = V \times C$ ....(1)

Now there is already 60 μC on the capacitor.

More 120 μC charge flows from battery. Hence net charge on capacitor is

$Q_2 = 180\,\mu C = V \times KC$ ....(2)

$(2)/(1) \Rightarrow 3 = K$

36. (*b*) Charge on 15 μF capacitor A = 1500 μC.

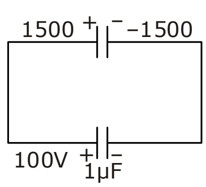
Charge on capacitor B = 100 μC.

When they are connected with dielectric removed from A the capacitor.

Capacitance of A now becomes 1 μF.

$C_i = \dfrac{\varepsilon_0 A.15}{d} = 15C = 15\mu F,$

$C_f = \dfrac{\varepsilon_0 A}{d}\ C = 1\mu F$



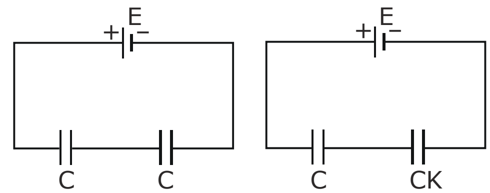
Q remains constant

$Q_{net} = C_{eq} \times V_{common}$

$1500 + 100 = 2V$

V = 800 Volt

37. (*d*) **Initially** **Finally**



$C^n_{eq} = \dfrac{C}{2} \quad C^n_{eq} = \dfrac{CK}{K+1}$

$q_i = \dfrac{CE}{2} \quad q_f = \dfrac{CEK}{K+1}$

$q_f - q_i = q_{flown} = \dfrac{CEK}{K+1} - \dfrac{CE}{2}$

$= \dfrac{CE(K-1)}{2(K+1)}$

$\dfrac{CE}{2} < \dfrac{CEK}{K+1}$

So charge flows from C to B.

38. (*d*) The two capacitance C_1 & C_2 behave as a series arrangment as both the capacitors have equal charge on them

$C_1 = \in_0 \dfrac{AK_1}{d/2}$

$C_2 = \in_0 \dfrac{AK_2}{d/2}$

$C_{eq} = \dfrac{C_1 C_2}{C_1 + C_2}$

$= \dfrac{\dfrac{\varepsilon_o AK_1}{d/2} \times \dfrac{\varepsilon_o AK_2}{d/2}}{\left(\dfrac{\varepsilon_o AK_1}{d/2}\right) + \left(\dfrac{\varepsilon_o AK_2}{d/2}\right)} = \dfrac{2\varepsilon_o A}{d}\left(\dfrac{K_1 K_2}{K_1 + K_2}\right)$

39. (*b*) Initially

$C = 2.5 = \dfrac{\varepsilon_o A}{d}$

The two capacitanes act as a parallel connection

$C' = \dfrac{\varepsilon_o A/2}{d} + \dfrac{K\varepsilon_o A/2}{d}$

$5\mu F = \dfrac{\varepsilon_o A}{2d} + \dfrac{K\varepsilon_o A}{2d}$

$5 = \dfrac{2.5}{2} + K\dfrac{2.5}{2}$

$\dfrac{10}{2.5} = K + 1 \Rightarrow K = 3$

Advanced Level Multiconcept Questions

MCQ/COMPREHENSION/MATCHING/ NUMERICAL

1. (*a*, *b*, *d*)

Magnitude of charge on the charged capacitor decreases and total charge is conserved.

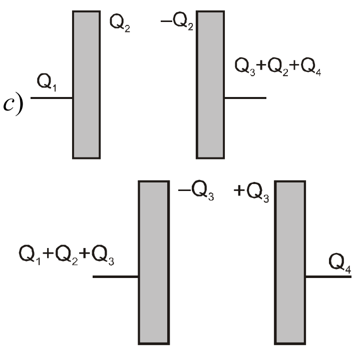
At $V_1 = V_2 \Rightarrow$ no further flow of charge occurs i.e. condition of steady state.

In charge flow energy is consumed in heat.

2. (*b*, *c*)

Electric field in the capacitor is same at every where which is equal to V/d. so that force at C and B point is same. Electric field out side the capacitor is zero so that force at A point is zero.

3. (*b*, *c*)



Charge on outer surfaces are equal so

$Q_1 = Q_3 + Q_2 + Q_4$ ....(i)

and $Q_1 + Q_2 + Q_3 = Q_4$ ....(ii)

$$V = \left|\frac{Q_2}{C}\right| \text{ or } V = \left|\frac{Q_1 - Q_3 - Q_4}{C}\right|$$

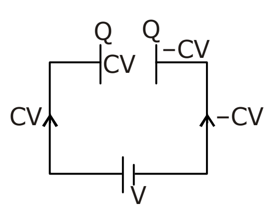
$$V = \left|\frac{Q_3}{C}\right| \text{ or } V = \left|\frac{Q_1 - Q_2 - Q_4}{C}\right|$$

Adding (i) and (ii)

$Q_1 = Q_4$ and $Q_2 = -Q_3$

4. (*a*, *c*, *d*)

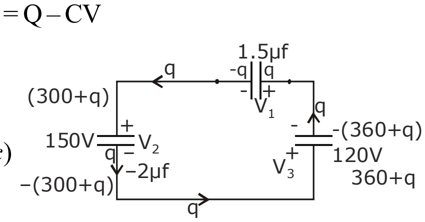
When two plates of capacitor are connected to a battery. The charges get distributed so that the charges on facing surface are equal & opposite. Also the battery does not create or destroy charges it distributes it.



$Q_1 = Q + CV$

$Q_2 = Q - CV$

5. (*a*, *b*, *c*)



$V_1 + V_2 + V_3 = 0$

$$\frac{Q_1}{C_1} + \frac{Q_2}{C_2} + \frac{Q_3}{C_3} = 0$$

$$\frac{300+q}{2} + \frac{q}{1.5} + \frac{360+q}{3} = 0$$

$$\frac{900 + 3q + 4q + 720 + 2q}{6} = 0$$

$9q = -1620$

$q = -180$

$Q_1 = 120\mu C$

$Q_2 = 180\mu C$

Flow of charge from right to left through A

6. (*a*, *d*)

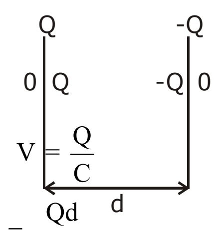
As the capactitance are in series hence charge on both of them will be same. $E = \frac{Q^2}{2C}$

$V_1 : V_2 = \frac{1}{1} : \frac{1}{2}$, $V_1 = \frac{2}{3} \times 15 = 10V$

$V_2 = 5V$

7. (*a*, *b*, *c*, *d*) Initially

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



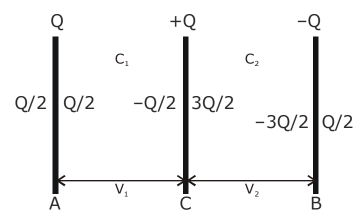
$V = \frac{Q}{C}$

$= \frac{Qd}{\in_0 A}$

Finally $C_1 = C_2 = \frac{2 \in_0 A}{d}$

$$V_1 = \frac{Q\,d}{2.2 \in_0 A}$$

$$V_2 = \frac{3Q\,d}{2.2 \in_0 A}$$



$$V = V_1 + V_2 = \frac{Q\ d}{\in_0 A}$$

$V_f = V_i$

8. (*b*, *c*) Isolated $\rightarrow$ Q = constant C $\downarrow$

Energy $= \frac{Q^2}{2C} \uparrow$, $E = \frac{\sigma}{\in_0}$ = constant

Energy density $= \frac{1}{2} \in_0 E^2$ = constant

9. (*a*, *c*) C = 2μF

$$C_{eq} = C + \frac{C}{2} + \frac{C}{4} + \frac{C}{8} + \frac{C}{16} + ...$$

$$C_{eq} = C\left(\frac{1}{1-1/2}\right) = 2\left(\frac{1}{1/2}\right) = 4\mu F \qquad \textbf{Ans}$$

Charge on first row capacitor is $q_1 = 2 \times 10\mu C = 20\mu C$
Charge on second row capacitor is $q_2 = 1 \times 10\mu C = 10\mu C$

Charge on third row capacitor is $q_3 = \frac{1}{2} \times 10\mu C = 5\mu C$

Therefore charge on the capacitor in the first row is more than on any other capacitor.

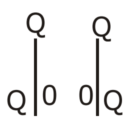
Energy stored in all capacitor is $= \frac{1}{2} C_{eq} V^2 = \frac{1}{2} \times 4 \times 10^{-6} \times (10)^2 = 0.2$ mJ **Ans**

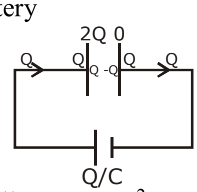
C = 2μF

$$C_{eq} = C + \frac{C}{2} + \frac{C}{4} + \frac{C}{8} + \frac{C}{16} + ...$$

$$C_{eq} = C\left(\frac{1}{1-1/2}\right) = 2\left(\frac{1}{1/2}\right) = 4\mu F \qquad \textbf{Ans}$$

10. (*a*, *b*, *c*, *d*) Initially
After connecting battery

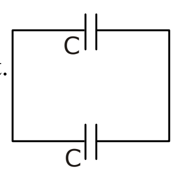




Energy supplied by cell = QE = CE^2

11. (*b*, *c*, *d*) $Q_1 = CV_1$
$Q_2 = CV_2$
Net charge = const.
[B correct]
$2CV = C(V_1 + V_2)$

$$V = \frac{V_1 + V_2}{2}$$



[C correct]

As charge flows energy will certainly be lost.
[D correct]
Net charge on the connected plates is equal sum of initial charges because charge is conserved.

12. (*a*, *c*) $4 \times 500 - 2 \times 500 = 6 \times V$

13. (*a*, *b*, *c*) $E = \frac{V}{d} \Rightarrow$ remains constant

$C' = KC \Rightarrow$ Increase
$Q' = KQ \Rightarrow$ Increase

$U = \frac{1}{2}KCV^2 = KU \Rightarrow$ Increase

14. (*a*, *c*, *d*) Battery connected V = constant

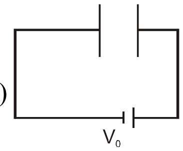
$U' = \frac{1}{2}KCV^2 = KU \Rightarrow$ Increase by K–times

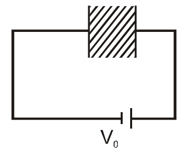
$E = \frac{V}{d}$ = constant

$$F = \frac{Q^2}{2\epsilon_0 A} \Rightarrow F = \frac{C^2V^2}{2\epsilon_0 A} \Rightarrow F' = \frac{K^2C^2V^2}{2\epsilon_0 A} = K^2F$$

$\Rightarrow$ Increase by K^2–times
$Q = C'V \Rightarrow Q' = KCV = KQ \Rightarrow$ Increase by K–times.

15. (*a*, *d*)





Potential difference = V_0 Potential difference = V_0
Capacitance = C
Capacitance = KC
[K is the dielectric constant of Slab K > 1]
$Q_0 = CV_0$
New charge = $KC\,V_0$

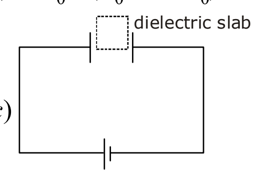
Potential Energy $= \frac{1}{2}CV_0^2$

New potential energy $= \frac{1}{2}KC\,V_0^2$

Correct options are (*a*), (*d*).

16. (*b*, *c*) $30C_0 = (C_0 + KVC_0).V$

17. (*b*, *c*)

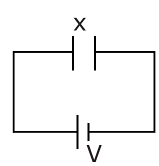


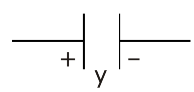
V = const.

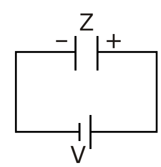
$$C = \frac{\varepsilon_0 kA}{d} \qquad C\uparrow,\ Q = CV\uparrow$$

$e = \frac{V}{d}$ = const.

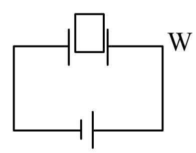
18. (*b*, *c*, *d*)



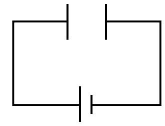


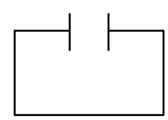


$\varepsilon = \frac{1}{2}CV^2 \qquad \varepsilon = \frac{1}{2}CV^2 \quad \varepsilon = \frac{1}{2}CV^2$

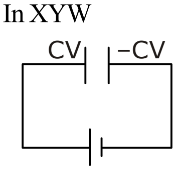


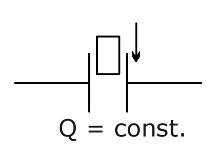
(*b*) In XWY charge increases



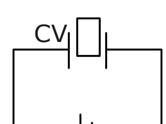


In XYW



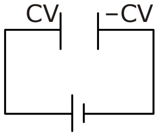


(*c*)



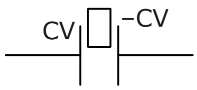
$$\varepsilon = \frac{Q^2}{2C}$$

$$\varepsilon = \frac{k^2C^2V^2}{2KC} = \frac{1}{2}KCV^2$$



$$\varepsilon = \frac{Q^2}{2C} = \frac{C^2V^2}{2KC} = \frac{1}{2}\frac{CV^2}{K}$$

Now insert dielectric



$$\text{W.D.} = U_f - U_i = -\frac{\varepsilon_0 A V^2}{2d}\left(1 - \frac{1}{k}\right)$$

19. (*a*, *c*) $t_1 > t_2$

$R_1C_1 > R_2C_2$ for same q_{max}

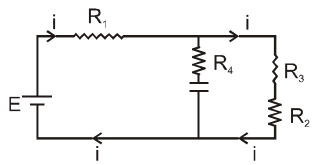
$q_{01} = q_{02} \Rightarrow E_1C_1 = E_2C_2$

If $E_1 = E_2 \Rightarrow C_1 = C_2 \Rightarrow R_1 = R_2$.

20. (*b*, *c*, *d*)

A long time after closing the switch, system comes in steady state and no current flow through capacitor..

Circuit : -



$$i = \frac{E}{R_1 + R_2 + R_3}$$

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

$$= \frac{1}{2}C\left(\frac{E(R_3 + R_2)}{R_1 + R_2 + R_3}\right)^2$$

21. (*a*, *c*)

$q_{max} = q_{01} = q_{02}$ = Both capacitors are charged up to the same magnitude of charge

$t_2 > t_1$

$R_2C_2 > R_1C_1$

$q_{01} = C_1V_1 = q_{02} = C_2V_2$

$C_1 \neq C_2$

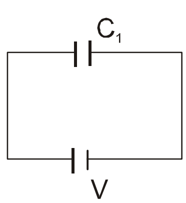
So $V_1 \neq V_2$.

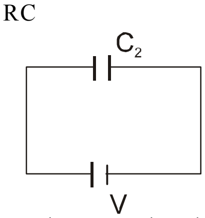
22. (*b*, *d*) During decay of charge in RC circuit

$I = I_0 e^{-t/RC}$

where $I_0 = \frac{q_0}{RC}$

when $t = 0, I = I_0 = \frac{q_0}{RC}$





Since potential difference between the plates is same initially therefore I same in both the cases at t = 0 and is equal to

$$I = \frac{q_0}{RC} = \frac{V}{R}$$

Also $q = q_0e^{-t/RC}$. When $q = \frac{q_0}{2}$ then $\frac{q_0}{2} = q_0\,e^{-t/RC}$

$\Rightarrow e^{+t/RC} = 2.$

$\frac{t}{RC} = \ell n2$

$\Rightarrow t = RC\log_e 2$

$\Rightarrow t \propto C$. Therefore time taken for the first capacitor ($1\mu F$) for discharging 50% of Initial charge will be less.

(*b*), (*d*) are the correct options.

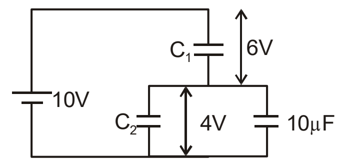
23. (*a*) **24.** (*c*) **25.** (*a*)

(23 to 25)

When $C_3 = \infty$, there will be no charge on C_2

As $V_1 = 10$ V therefore V = 10 V

From graph when $C_3 = 10\ \mu F, V_1 = 6\,V$

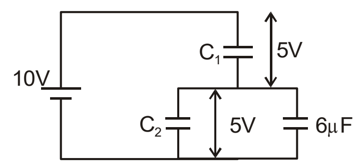


Charge on C_1 = Charge on C_2 + Charge on C_3

$6C_1 = 4C_2 + 40\ \mu C$ .... (1)

Also when $C_3 = 6\ \mu F, V_1 = 5V$

Again using charge equation



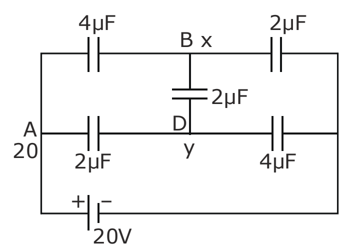
$5C_1 = 5C_2 + 30\ \mu C$ ....(2)

Solving (1) and (2)

$C_1 = 8\ \mu F$

$C_2 = 2\ \mu F$.

26. (*b*, *c*) Let us assume potential at B to be x & D to be y.



$(x - 20)4 + (x - y)2 + 2x = 0$

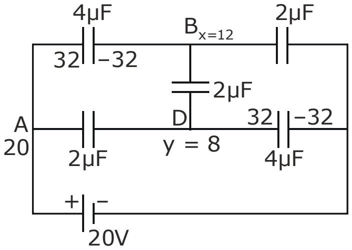
$4x - y = 40$ ....(1)

$2(y - x) + (y - 20)2 + y(4) = 0$

$\Rightarrow 4y - x = 20$ ....(2)

Solving (1) and (2)

$x = 12 ; y = 8$



$V_B - V_D = 12 - 8 = 4 > 0$

27. (*a*, *b*, *c*, *d*)

(*a*) As from figure $V_A = 20V$

(*b*) $4(V_A - V_B) + 2(V_D - V_B)$
$= 4(20 - 12) + 2(8 - 12)$
$= 32 - 8 = 24 = 2V_B$

(*c*) $2(V_A - V_D) + 2(V_B - V_D)$
$= 2(20 - 8) + 2(12 - 8)$
$= 24 + 8 = 32 = 4V_D$

(*d*) $V_B + V_D = 12 + 8 = 20 = V_A$

28. (*b*, *c*) $V_B = 12 \quad V_D = 8$

29. (*c*) $q_1 = 4(20 - 12) = 32\mu C$
$q_2 = 2(20 - 8) = 24\mu C$
$q_3 = 2(12 - 8) = 8\mu C$

30. (*a*) p (*b*) r (*c*) q (*d*) p

The initial charge on capacitor $= CV_i = 2 \times 1\mu C = 2\mu C$

The final charge on capacitor $= CV_f = 4 \times 1\ \mu C = 4\mu C$

$\therefore$ Net charge crossing the cell of emf 4V is

$q_f - q_i = 4 - 2 = 2\ \mu C$

The magnitude of work done by cell of emf 4V is $W = (q_f - q_i)\,4 = 8\ \mu J$

The gain in potential energy of capacitor is

$\Delta U = \frac{1}{2} C (V_f^2 - V_i^2) = \frac{1}{2}\ 1 \times [4^2 - 2^2]\ \mu J = 6\ \mu J$

Net heat produced in circuit is $\Delta H = W - \Delta U = 8 - 6 = 2\ \mu J$

31. (*a*) p, q, s (*b*) p, r, s (*c*) p, q (*d*) p, r

(*a*) For potential difference across each cell to be same

$$E_1 - ir = E_2 + ir \quad \text{or} \quad i = \frac{E_1 - E_2}{2r} \left(< \frac{E_1 - E_2}{2r + R} \right)$$

Hence potential difference across both cells cannot be same.

Cell of lower emf charges up.

For potential difference across cell of lower emf to be zero

$E_2 + ir = 0$ which is not possible.

Current in the circuit cannot be zero $\because E_1 \neq E_2$.

(*b*) For potential difference across each cell to be same

$E_1 - ir = E_2 - ir$ which is not possible

No cell charges up.

For potential difference across cell of lower emf to be zero

$E_2 - ir = 0$ and $E_1 - i(r + R) = 0$

or $\frac{E_1}{r + R} = \frac{E_2}{r}$ which is possible. $\because E_1 > E_2$.

Current in the circuit cannot be zero.

(*c*) Situation is same as in (*a*) except current decreases from $\frac{E_1 - E_2}{2r + R}$ to zero.

Hence the only option that shall changes is 'current shall finally be zero.'

(*d*) Situation is same as in (*b*) except current decreases from $\frac{E_1 + E_2}{2r + R}$ to zero.

Hence the only option that shall changes is 'current shall finally be zero.'

32. [5.2]

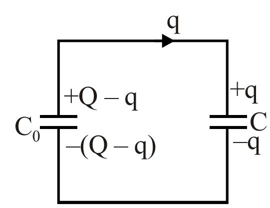
33. $C_1 = \frac{A\varepsilon_0 k_1}{d_1}\ \&\ C_2 = \frac{A\varepsilon_0 k_2}{d_2} \Rightarrow \frac{C_1}{C_2} = \frac{8}{5}$

Series $v = \frac{8}{13} V$

$$E = \frac{V}{1} = \frac{\frac{8}{13}V}{0.5 \times 10^{-3}} = 6.4 \times 10^6$$

V = 5200 Volt

34. [0030] $\frac{q}{C} = \frac{Q - q}{C_0} \Rightarrow q\left(\frac{C + C_0}{CC_0}\right) = \frac{Q}{C_0}$



$\therefore\ \frac{q}{C} = \frac{Q}{C + C_0} = \frac{C_0 V_0}{C + C_0}$

$\Rightarrow\ \frac{10}{C + 10} \times 12 = 3$

$\therefore\ C = 30$

35. [0025] $F = \frac{Q^2}{2A\epsilon_0} = \frac{c^2 v^2}{2A\epsilon_0} = \frac{\epsilon_0 A}{2d^2} v^2$

$$= \frac{8.85 \times 10^{-12} \times 17.7 \times 10^{-4} \times 500^2}{2 \times (8.85 \times 10^{-3})^2}$$

$$= \frac{10^{-16} \times 25 \times 10^4}{10^{-6}} = 25\mu N$$

36. [0119] $Q = CV$

$$V = -\int_{-3}^{4} E dx = -20 \int_{-3}^{4} \left(x^2 + \frac{4}{3}\right) dx$$

$$V = -2Q \left[\frac{x^3}{3} + \frac{4x}{3} \Big|_{-3}^{4} \right]$$

$$V = -2Q \left[\frac{1}{3}[64 + 27] + \frac{4}{3}[7] \right]$$

$$\frac{Q}{C} = 3Q \left[\frac{119}{3} \right]$$

$$\frac{1}{C} = 119\ F^{-1}$$