EXERCISE-1

*** MARK IS MORE THAN ONE CORRECT QUESTIONS.**

SECTION A : DEFINITION OF CAPACITANCE

A 1. When 30μC charge is given to an isolated conductor of capacitance 5μF. Find out following
- (i) Potential of the conductor
- (ii) Energy stored in the electric field of conductor
- (iii) If this conductor is now connected to other isolated conductor of total charge 50 μC and capacity 10 μF then find out common potential of both the conductors.
- (iv) Find out heat dissipated during the process of charge distribution.
- (v) Find out ratio of final charges on conductors.
- (vi) Find out final charges on each conductor.

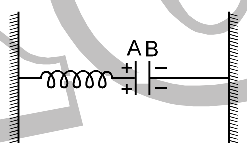
A 2. A and B are two spherical isolated conductors placed at large distance having radius ratio $\frac{r_A}{r_B} = \frac{1}{2}$ and charge ratio $\frac{Q_A}{Q_B} = \frac{2}{1}$. Find out following if they are joined by a conducting wire.

(i) Ratio of final charges $\frac{Q'_A}{Q'_B}$. (ii) Ratio of final charge densities $\frac{\sigma_A}{\sigma_B}$.

A 3. (i) Calculate the capacitance of a parallel plate capacitor having 20 cm × 20 cm square metal plates which are separated by a distance 8.85 mm.
(ii) If the plates contain equal but opposite charge of magnitude 20μC. then find out energy stored between the plates of capacitor.

A 4. An air-filled parallel-plate capacitor is to be constructed which can store 12 μC of charge when operated at 1200 V. What can be the minimum plate area of the capacitor? The dielectric strength of air is 3×10^6 V/m.

A 5. Plate A of a parallel air filled capacitor is connected to a spring having force constant k and plate B is fixed. If a charge + q is placed on plate A and charge – q on plate B then find out extension in the spring in equilibrium. Assume area of plate is 'A'.



A 6. The capacity of an isolated conducting sphere of radius R is proportional to :
(A) R^2 (B) $(1/R^2)$ (C) 1/R (D) R

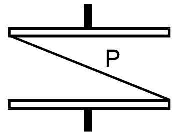
A 7. Work done in placing a charge of 8×10^{-18} C on a condenser of capacity 100 microfarad is-
(A) 16×10^{-32} J (B) 3.1×10^{-26} J (C) 4×10^{-10} J (D) 32×10^{-32} J

A 8. If two conducting spheres are separately charged and then brought in contact:
(A) The total energy of the two spheres is conserved
(B) The total charge of the two spheres is conserved
(C) Both the total energy and charge are conserved
(D) The final potential is always the mean of the original potential of the two spheres

A 9. 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 will be transferred–
(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

A 10. 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 energy of the system
(B) An increase in the energy of the system
(C) Always a decrease in the energy of the system
(D) A decrease in energy of the system until $q_1 R_2 = q_2 R_1$

A 11. A thin metal plate P is inserted between the plates of a parallel plate capacitor of capacity C in such a way that its edges touch the two plates [Fig.]. The capacity now becomes:



(A) C/2 (B) 2C (C) Zero (D) ∞

A 12. Two parallel metal plates carry charges +Q and –Q. A test charge placed between the plates experiences a force F. The plates are then moved apart so that the separation between them is doubled. The force on the test charge will now be
(A) F/2 (B) F (C) F/4 (D) 2F

A 13. 64 identical mercury drops combine to form one bigger drop. The capacitance of bigger drop, as compared to that of smaller drop will be-
(A) 8 times (B) 64 times (C) 4 times (D) 16 times

A 14. The force of attraction between the plates of a charged condenser is–
(A) $q^2/2\varepsilon_0 A$ (B) $q/2\varepsilon_0 A^2$ (C) $q^2A/2\varepsilon_0 A^2$ (D) None of the above

A 15. On increasing the plate separation of a charged condenser (battery is not connected), its energy
(A) increases (B) decreases (C) remains unchanged (D) None of the above

A 16. A parallel plate capacitor is charged and then isolated. On increasing the plate separation–

	Charge	Potential	Capacity
(A)	remains constant	remains constant	decreases
(B)	remains constant	increases	decreases
(C)	remains constant	decreases	increases
(D)	increases	increases	decreases

A 17. Two isolated metallic solid spheres of radii R and 2R are charged such that both of these have same charge density σ. The spheres are located far away from each other, and connected by a thin conducting wire. Then the new charge density on the bigger sphere is.
(A) $\frac{5\sigma}{6}$ (B) $\frac{5\sigma}{3}$ (C) $\frac{7\sigma}{6}$ (D) $\frac{7\sigma}{3}$

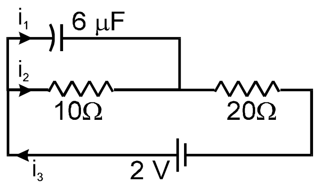
SECTION B : CIRCUITS WITH CAPACITOR AND USE OF KCL AND KVL

B 1. A capacitance C, a resistance R and an emf ε are connected in series at t = 0. What is the maximum value of
(a) the potential difference across the resistor, (b) the current in the circuit,
(c) the potential difference across the capacitor, (d) the energy stored in the capacitors.
(e) the power delivered by the battery and (f) the power converted into heat.

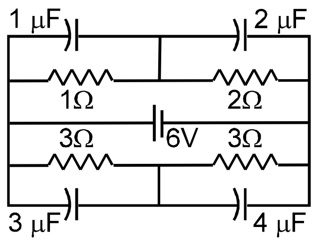
B 2. A parallel-plate capacitor with the plate area 100 cm^2 and the separation between the plates 1.0 cm is connected across a battery of emf 24 volts. Find the force of attraction between the plates.

B 3. (i) Find the charge on the capacitor shown in figure.

(ii) Find out values of i_1, i_2 and i_3 in steady state.

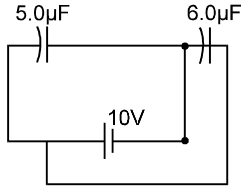


B 4. Find the final charges on the four capacitor of capacitance 1μF, 2μF, 3μF and 4μF shown in figure. (Assuming initially they are uncharged).

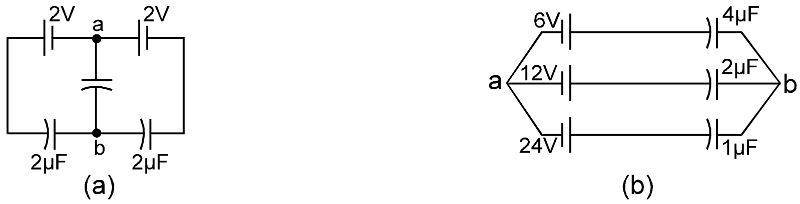


B 5. (i) Find the charge supplied by the battery in the arrangement shown in figure.

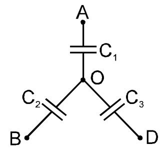
(ii) Find out charge on each capacitor.



B 6. Find the potential difference $V_a - V_b$ between the points a and b shown in each part of the figure.



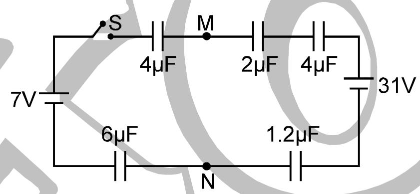
B 7. Three uncharged capacitors of capacitance $C_1 = 1\mu F$, $C_2 = 2\mu F$ and $C_3 = 3\mu F$ are connected as shown in figure to one another and to points A, B and D potentials $\phi_A = 10$ V, $\phi_B = 25$ V and $\phi_D = 20$ V. Determine the potential (ϕ_0) at point O.



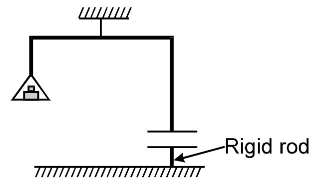
B 8. A capacitor with stored energy 4.0 J is connected with and identical capacitor with no electric field in between. Find the total energy stored in the two capacitors finally.

B 9. A 5.0 μF capacitor is charged to 12 V. The positive plate of this capacitor is now connected to the negative terminal of a 12 V battery and vice versa. Calculate the heat developed in the connecting wires.

B 10. Five capacitors are connected as shown in figure below. 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.



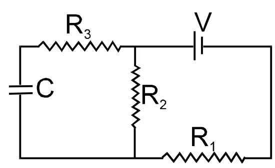
B 11. The lower plate of a parallel plate capacitor supported on a rigid rod. The upper plate is suspended from one end of a balance. The two plates are joined together by a thin wire and subsequently disconnected. The balance is then counterpoised. Now a voltage V = 5000 volt is applied between the plates. The distance between the plates is d = 5 mm and the area of each plate is A = 100 cm^2. Then find out the additional mass placed to maintain balance. [All the elements other than plates are massless and nonconducting]



B 12. The final potential difference between the plates of condenser C in the given figure will be–

(A) $\frac{V(R_1+R_2)}{R_1+R_2+R_3}$ (B) $\frac{V(R_1+R_2)}{R_2}$

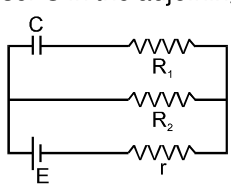
(C) $\frac{VR_2}{R_1+R_2}$ (D) $\frac{3(K+2)}{V}$



B 13. The magnitude of charge on either of the plates of condenser C in the adjoining circuit is-

(A) CE (B) $\frac{CER_2}{(R_1+r)}$

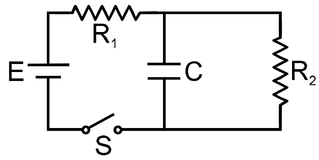
(C) $\frac{CER_2}{(R_2+r)}$ (D) $\frac{CER_1}{(R_2+r)}$



B 14*. In the circuit shown in figure the switch 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 $\frac{E}{R_1 + R_2}$



(C) energy stores in the capacitor is $\frac{1}{2}C\left(\frac{R_2 E}{R_1 + R_2}\right)^2$

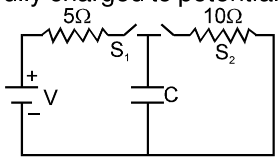
(D) current through the capacitor becomes zero

B 15 The plate separation in a parallel plate condenser is d and plate area is A. If it is charged to V volt then the work done in increasing the plate separation to 2d will be –

(A) $\frac{3}{2}\frac{\varepsilon_0 AV^2}{d}$ (B) $\frac{\varepsilon_0 AV^2}{d}$ (C) $\frac{2\varepsilon_0 AV^2}{d}$ (D) $\frac{\varepsilon_0 AV^2}{2d}$

B 16. In the adjoining diagram, the condenser C will be fully charged to potential V if -

(A) S_1 and S_2 both are open
(B) S_1 and S_2 both are closed
(C) S_1 is closed and S_2 is open
(D) S_1 is open and S_2 is closed.



B 17. Two condensers of capacitances C_1 and C_2 are charged to potentials V_1 and V_2 respectively. Energy will not be exchanged between them when these are connected in parallel, if (plates of same polarity connected together)

(A) $C_1V_1 /= C_2V_2$ (B) $V_1 = V_2$ (C) $C_1 = C_2$ (D) $\frac{C_1}{V_1} = \frac{C_2}{V_2}$

B 18. A 10μF condenser is charged to a potential of 100 volt. It is now connected to another uncharged condenser. The common potential reached is 40 volt. The capacitance of second condenser is -

(A) 2μF (B) 15μF (C) 10μF (D) 22μF

B 19. 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 parallel 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) $\frac{9CV^2}{2}$

B 20. Two parallel plate condensers of capacity of 20mF and 30mF are charged to the potentials of 30V and 20V respectively. If likely charged plates are connected together then the common potential difference will be-

(A) 100 V (B) 50 V (C) 24 V (D) 10 V

B 21. A capacitor of capacitance C_0 is charged to a potential V_0 and then isolated. A capacitor C is then charged from C_0, discharged and charged again ; the process being repeated n times. Due to this, potential of the larger capacitor is decreased to V value of C is :

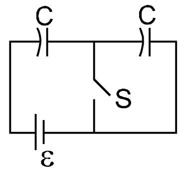
(A) $C_0 [V_0/V]^{1/n}$ (B) $C_0[(V_0/V)^{1/n} - 1]$ (C) $C_0 [(V_0/V) - 1]$ (D) $C_0 [(V/V_0)^n + 1]$

SECTION C : COMBINATION OF CAPACITORS

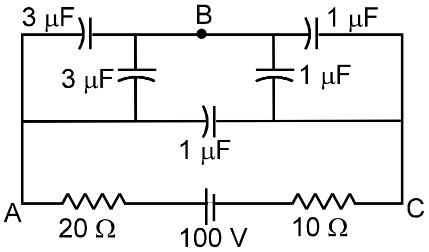
C 1. Three capacitors having capacitances 20μF, 30μF and 40μF are connected in series with a 12 V battery.
(i) Find the charge on each of the capacitors.
(ii) How much work has been done by the battery in charging the capacitors?

C 2. Consider the situation shown in the figure. The switch S is open for a long time and then closed.

(a) Find the charge flown through the battery when the switch S is closed.
(b) Find the work done by the battery.
(c) Find the change in energy stored in the capacitors.
(d) Find the heat developed in the system.



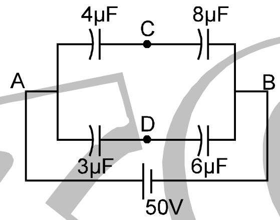
C 3. Find the potential difference between the points A and B and between the points B and C of figure in steady state.



C 4. If you have several 2.0 μF capacitors, each capable of withstanding 200 volts without breakdown, how would you assemble a combination having an equivalent capacitance of;
(a) 0.40 μF or of
(b) 1.2 μF, capable of withstanding 1000 volts.

C 5. A capacitor of capacitance C_1 = 1.0 μF charged upto a voltage V = 110 V is connected in a parallel to the terminals of a circuit consisting of two uncharged capacitor connected in series and possessing the capacitance C_2 = 2.0 μF and C_3 = 3.0 μF. What charge will flow through the connecting wires?

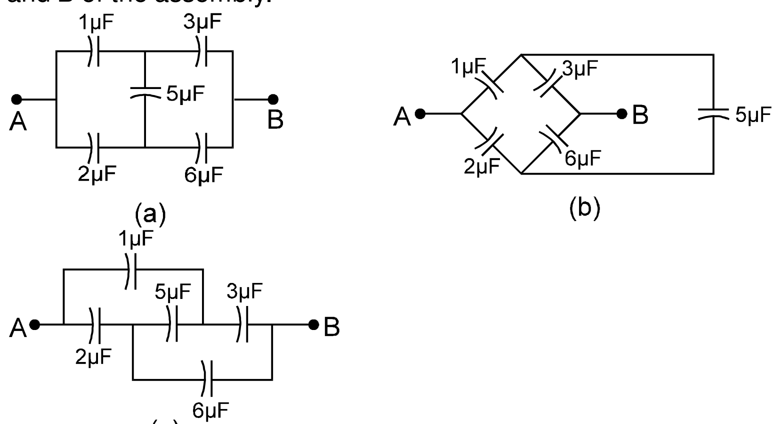
C 6. Take the potential of the point B as shown in figure to be zero.
(a) Find the potentials at the point C and D.
(b) If an uncharged capacitor is connected between C and D, what charge will appear in this capacitor?



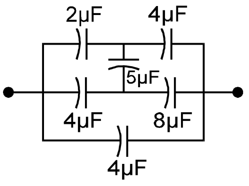
C 7. Find the potential difference $V_a - V_b$ between the points a and b shown in each part of the figure.

(a) (b)

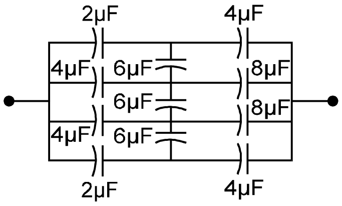
C 8. Convince yourself that parts (a), (b) and (c) of figure are identical. Find the capacitance between the point A and B of the assembly.



C 9. Find the equivalent capacitances of the combinations shown in the figure between the indicated points.



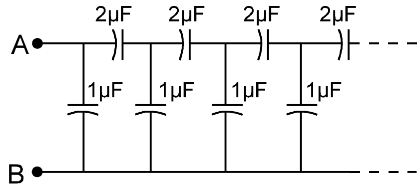
(a)



(b)

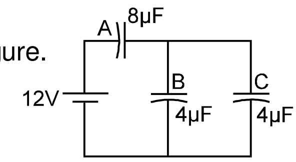
C 10. (i) Find the equivalent capacitance of the infinite ladder shown in the figure between the points A and B.

(ii) If now each capacitor is replaced by a capacitor which is double in capacitance then repeat the question.

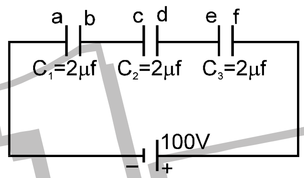


C 11. (i) Find the charge appearing on each of the three capacitors shown in figure.

(ii) Find out total work done by the battery during charging process.



C 12. Three condensers C_1, C_2 and C_3 are connected to a 100 Volt D.C. source as shown in the figure. If the charges stored on the plates of C_1, C_2. and C_3 are q_a, q_b and q_c, q_d and q_e, q_f respectively, then



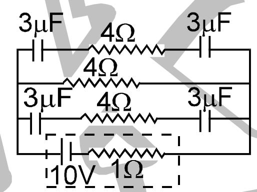
(A) $q_b + q_d + q_f = \dfrac{100}{9}$ Coulomb

(B) $q_b + q_d + q_f = 0$

(C) $q_b = q_d = q_f$

(D) $q_a + q_c + q_e = 50$ Coulomb

C 13.. In the following figure, the charge on each condenser in the steady state will be–



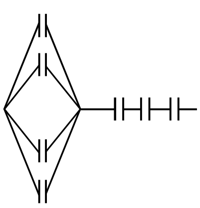
(A) 3μC (B) 6μC

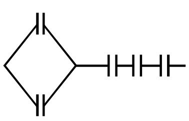
(C) 9μC (D) 12μC

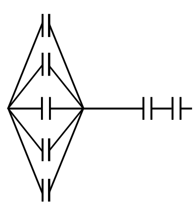
C 14. The minimum number of condensers each of capacitance of 2μF, in order to obtain resultant capacitance of 5μF will be-

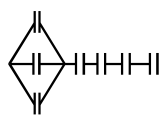
(A) 4 (B) 5 (C) 6 (D) 10

C 15. How the seven condensers, each of capacity 2μF, should be connected in order to obtain a resultant capacity of $\frac{10}{11}$ μF?

(A) 

(B) 

(C) 

(D) 

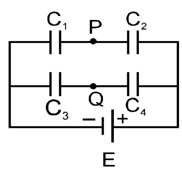
C 16. The potential difference between the points P and Q in the adjoining circuit will be-

(A) $\dfrac{(C_1C_4 - C_2C_3)E}{(C_1 + C_3)(C_2 + C_4)}$

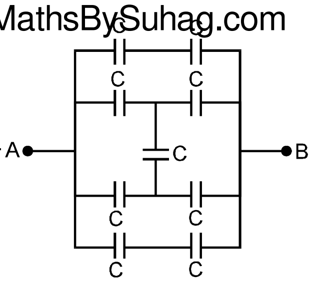
(B) $\dfrac{C_2C_3\,E}{C_1C_2\,(C_3 + C_4)}$

(C) $\dfrac{(C_2C_3 - C_1C_4)E}{(C_1 + C_2)(C_3 + C_4)}$

(D) $\dfrac{(C_2C_3 - C_1C_4)E}{(C_1 + C_2 + C_3 + C_4)}$

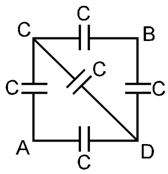


C 17. The resultant capacity between the points A and B in the following circuit will be-



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

C 18. The equivalent capacity between the points A and B in the adjoining circuit will be-

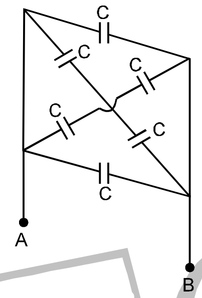


(A) C (B) 2C
(C) 3C (D) 4C

C 19. In the above problem the equivalent capacity between the points C and D will be-
(A) C (B) 2C (C) 3C (D) 4C

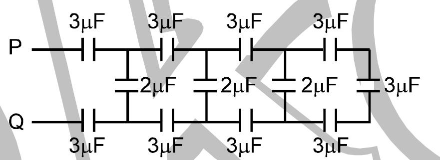
C 20. In the above problem the equivalent capacity between the points A and D will be-
(A) C (B) 2C (C) 8C/5 (D) 5C/8

C 21. The resultant capacity between the points A and B in the adjoining circuit will be-



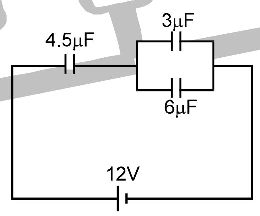
(A) C (B) 2C
(C) 3C (D) 4C

C 22. The effective capacity in the following figure between the point P and Q will be–



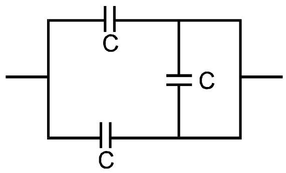
(A) 3μF (B) 5μF
(C) 2μF (D) 1μF

C 23. The potential difference between the plates of 4.5 μF capacitor in the following circuit will be-



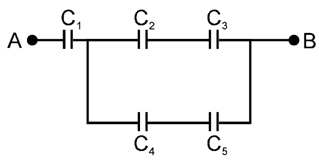
(A) $\frac{8}{3}$ (B) 4 volt
(C) 6 volt (D) 8 volt

C 24. The equivalent capacitance of the combination shown in Figure is.



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

C 25. In the given circuit, the P.D. between the points A and B is 10 V. Also $C_1 = C_2 = C_3 = C_4 = C_5 = 2\mu F$.



(i) Charge on C_1 :
(A) 10 μC (B) 20 μC (C) 50 μC (D) 5 μC

(ii) Charge on C_5 :
(A) 10 μC (B) 20 μC (C) 50 μC (D) 5 μC

(iii) P.D. across C_2 :
(A) 5 V (B) 2.5 V (C) 7.5 V (D) 10 V

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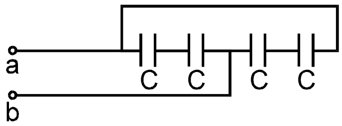
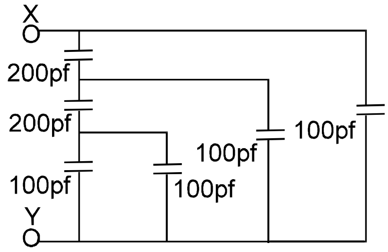
C 26. The capacitance of the combination between 'a' and 'b' is



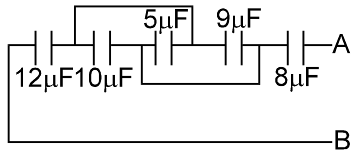
(A) $\frac{C}{3}$ (B) $\frac{4C}{3}$
(C) $\frac{3C}{4}$ (D) C

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



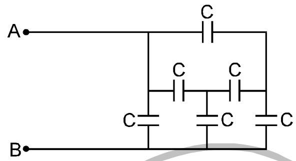
(A) 100 pF (B) 200 pF
(C) 300 pF (D) 400 pF

C 28. Five capacitors together with their capacitances are shown in the adjoining figure. The potential difference between the points A and B is 60 volt. The equivalent capacitance between the point A and B and charge on capacitor 5μF will be respectively –



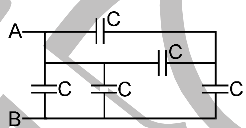
(A) 44 μF, 30 μC (B) 16 μF, 150 μC
(C) 15 μF, 200 μC (D) 4 μF, 50 μC

C 29. The equivalent capacitance between point A and B is



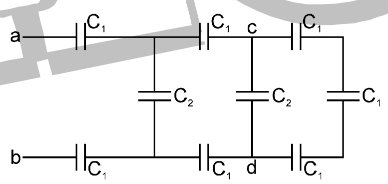
(A) C/4 (B) C/2
(C) C (D) 2C

C 30. In the battery of capacitors shown, all the capacitors have equal capacitances. Then the equivalent capacitance of the system across the terminals A and B :



(A) $\frac{8C}{3}$ (B) 2C
(C) $\frac{C}{2}$ (D) None of these

C 31. In the arrangement of the capacitors shown in the figure, each C_1 capacitor has capacitance of 3μF and each C_2 capacitor has capacitance of 2μF then,



(i) Equivalent capacitance of the network between the points a and b is :

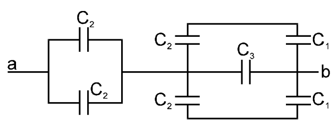
(A) 1μF (B)2μF (C) 4μC (D) $\frac{3}{2}$ μF

(ii) If V_{ab} = 900 V, the charge on each capacitor nearest to points 'a' and 'b' is :

(A) 300 μC (B) 600 μC (C) 450 μC (D) 900 μC

(iii) If V_{ab} = 900 V, then potential difference across points c and d is :
(A) 60 V (B) 100 V (C) 120 V (D) 200 V

C 32. A combination arrangement of the capacitors is shown in the figure



(i) C_1 = 3 μF, C_2 = 6 μF and C_3 = 2 μF then equivalent capacitance between 'a' and 'b' is :
(A) 4 μF (B) 6 μF (C) 1 μF (D) 2 μF

(ii) If a potential difference of 48 V is applied across points a and b, then charge on the capacitor C_3 at steady state condition will be :
(A) 8 μF (B) 16 μC (C) 32 μC (D) 64 μC

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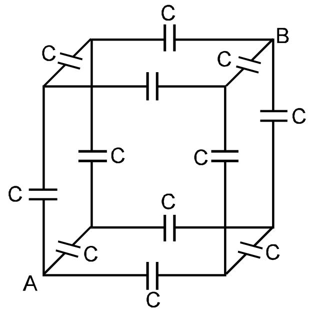
C 33. Each edge of the cube contains a capacitance C. The equivalent capacitance between the points A and B will be –



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

(C) $\frac{12C}{7}$ (D) $\frac{7C}{12}$

SECTION D : EQUATION OF CHARGING AND DISCHARGING

D 1. By evaluating $\int i^2R\,dt$, show that when a capacitor is charged by connecting it to a battery through a resistor the energy dissipated as heat equals the energy stored in the capacitor.

D 2. How many time constants will elapse before the current in a charging RC circuit drops to half of its initial value ? Answer the same question for a discharging RC circuit.

D 3. A capacitor of capacitance 100 μF is connected across a battery of emf 6.0 V through a resistance of 20 kΩ for 4.0 s. The battery is then replaced by a thick wire. What will be the charge on the capacitor 4.0 s after the battery is disconnected ?

D 4. The electric field between the plates of a parallel–plate capacitance 2.0 μF drops to one third of its initial value in 4.4 μs when the plates are connected by a thin wire. Find the resistance of the wire.

D 5. A capacitor charged to 50 V is discharged by connecting the two plates at t = 0. If the potential difference across the plates drops to 1.0 V at t = 10 ms, what will be the potential difference at t = 20 ms ?

D 6. A 5.0 μF capacitor having a charge of 20 μC is discharge through a wire of resistance 5.0 Ω. Find the that dissipated in the wire between 25 to 50 μs after the connections are made.

D 7. A capacitor of capacity 1 μF is connected in closed series circuit with a resistance of 10^7 ohms, an open key and a cell of 2 V with negligible internal resistance:
(i) When the key is switched on at time t = 0, find;
(a) The time constant for the circuit.
(b) The charge on the capacitor at steady state.
(c) Time taken to deposit charge equal to half that at steady state.
(ii) If after fully charging the capacitor, the cell is shorted by zero resistance at time t = 0, find the charge on the capacitor at t = 50 s.

D 8. A 100 μF capacitor is charged to 200 volt. It is discharged through a 2 ohm resistance. The amount of heat generated will be-
(A) 2 Joule (B) 4 Joule (C) 0.2 Joule (D) 0.4 Joule

D 9. A 3 mega ohm resistor and 1 μF capacitor are connected in a single loop circuit with a constant source of 4 volt. At one second after the connection is made what are the rates at which;
(i) the charge on the capacitor is increasing.

(A) $4(1-e^{-1/3})\ \mu$ C/s (B) $4e^{-1/3}\ \mu$ C/s

(C) $\frac{4}{3}e^{-1/3}\ \mu$ C/s (D) $\frac{4}{3}(1-e^{-1/3})$ J/s

(ii) energy is being stored in the capacitor.

(A) $\frac{16}{3}(1-e^{-1/3})e^{-1/3}\ \mu$J/s (B) $\frac{16}{3}(1-e^{-2/3})\ \mu$J/s

(C) $\frac{16}{3}e^{-2/3}\ \mu$J/s (D) None of these

(iii) joule heat is appearing in the resistor.

(A) $\frac{16}{3}e^{-1/3}\mu$ J/s (B) $\frac{1}{2}e^{-1/3}\mu$ J/s

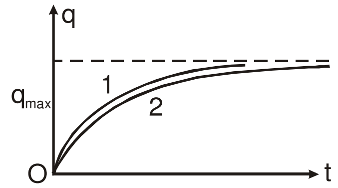
(C) $\frac{16}{3}(1-e^{-2/3})\,\mu$ J/s (D) $\frac{16}{3}(1-e^{-1/3})^2\,\mu$ J/s

(iv) energy is being delivered by the source.

(A) $16(1-e^{-1/3})$ μ C/s (B) 16μ C/s

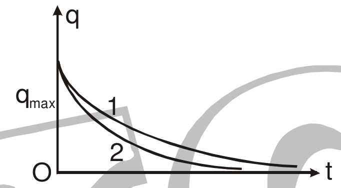
(C) $\frac{16}{3}e^{-1/3}$ μ C/s (D) $\frac{16}{3}(1-e^{-1/3})$ J/s

D 10*. The charge on the 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

D 11*. The instantaneous charge on a 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 emf of two DC sources in two different charging circuits).



(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 $E_1 = E_2$

D 12. A parallel-plate capacitor with plate area 20 cm^2 and plate separation 1.0 mm is connected to a battery. The resistance of the circuit is 10 kΩ, then the time constant of the circuit is :

(A) 0.18 μs (B) 0.36 μs (C) 1 μs (D) None of these

D 13. A 20 μF capacitor is joined to a battery of emf 6.0 V through a resistance of 100 Ω, then the charge on the capacitor 2.0 ms after the connections are made is :

(A) 120 μC (B) 66 μC (C) 76 μC (D) 146 μC

D 14. The plates of a capacitor of capacitance 10 μF, charged to 60 μC, are joined together by a wire of resistance 10 Ω at t = 0, then

(i) the charge on the capacitor in the circuit at t = 0 is :

(A) 120 μC (B) 60 μC (C) 30 μC (D) 44 μC

(ii) the charge on the capacitor in the circuit at t = 100 μs is :

(A) 120 μC (B) 60 μC (C) 22 μC (D) 18 μC

(iii) the charge on the capacitor in the circuit at t = 1.0 ms is :

(A) 0.003 μC (B) 60 μC (C) 44 μC (D) 18 μC

D 15. A capacitor of capacitance C is connected to a battery of emf ε at t = 0 through a resistance R, then

(i) the maximum rate at which energy is stored in the capacitor is :

(A) $\frac{\varepsilon^2}{4R}$ (B) $\frac{\varepsilon^2}{2R}$ (C) $\frac{\varepsilon^2}{R}$ (D) $\frac{2\varepsilon^2}{R}$

(ii) time at which the rate has this maximum value is

(A) 2CR ln2 (B) $\frac{1}{2}$ CR ln2 (C) CR ln2 (D) 3CR ln2

D 16. An uncharged capacitor of capacitances 12.0 μF is connected to a battery of emf 6.00 V and internal resistance 1.00 Ω through resistanceless leads. At 12.0 μs after the connections are made :

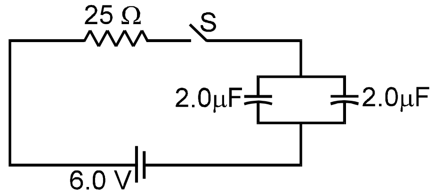
(i) the current in the circuit is :
(A) 4.42 A (B) 6 A (C) 2.21 A (D) 0 A

(ii) the power delivered by the battery is :
(A) 26.4 W (B) 13.2 W (C) 4.87 W (D) 0

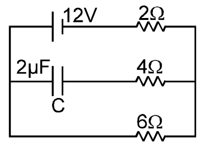
(iii) the power dissipated in heat is :
(A) 26.4 W (B) 13.2 W (C) 4.87 W (D) 0

(iv) the rate at which energy stored in the capacitor is increasing is :
(A) 26.4 W (B) 13.2 W (C) 4.87 W (D) 8.37 W

D 17. The charge on each of the capacitors 0.20 ms after the switch S is closed in figure is :
(A) 24 μC (B) 16.8 μC
(C) 10.37 μC (D) 4.5 μC



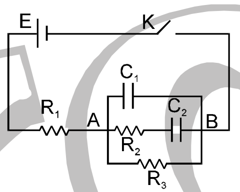
D 18. Charge on the capacitor in the given circuit in steady state condition is:
(A) 12 μC (B) 15 μC
(C) 18 μC (D) 6 μC



D 19. A network of capacitors and resistances is shown. Current in the circuit immediately after key K is closed and after a long time interval is :

(A) $\frac{E}{R_1}$, $\frac{E}{R_1+R_3}$ (B) $\frac{E}{R_1+R_3}$, $\frac{E}{R_1+\frac{R_2R_3}{R_2+R_3}}$

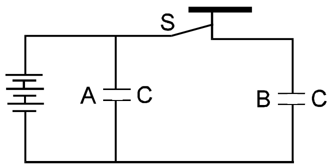
(C) Zero , $\frac{E}{R_1}$ (D) $\frac{E}{R_1+\frac{R_2R_3}{R_2+R_3}}$, $\frac{E}{R_1}$



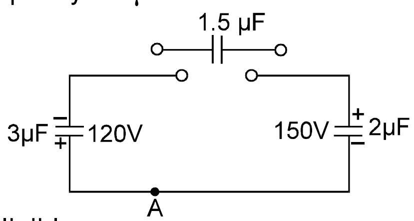
D 20. Fig. shows two identical parallel plate capacitors connected to a battery with switch S closed. The switch is now opened and the free space between the plates of the capacitors is filled with a dielectric of dielectric constant (or relative permittivity) 3. Then the ratio of the total electrostatic energy stored in both capacitors before and after the introduction of the dielectric.

(A) 1 (B) $\frac{2}{5}$

(C) $\frac{3}{5}$ (D) $\frac{5}{3}$



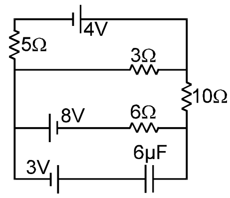
D 21*. Two capacitors of 2 μF & 3 μF are charged to 150 volt & 120 volt respectively. The plates of a capacitor are connected as shown in the fig. A discharged capacitor of capacity 1.5 μF falls to the free ends of the wire. Then:
(A) Charge on the 1.5 μF capacitor will become is 180 μC.
(B) Charge on the 2 μF capacitor will become 120 μC.
(C) +Ve charge flows through A from left to right.
(D) +Ve charge flows through A from right to left.



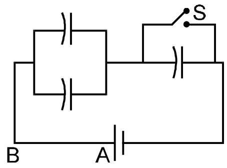
D 22. An electric circuit is as shown in the figure. The cells are of negligible internal resistances. Find : (in steady state)

(i) The currents in 3 Ω resistance and the cell of 8 volt.

(ii) The charge on the capacitor.



D 23. Each capacitor shown in figure has a capacitance of 5.0 μF. The emf of the battery is 50V. How much charge will flow through AB after the switch S is closed?



SECTION E : CAPACITOR WITH DIELECTRIC

E 1. The two parallel plates of a capacitor have equal and opposite charges Q. The dielectric has a dielectric constant K and resistivity ρ. Show that the "leakage" current carried by the dielectric is given by the relationship $i = \frac{Q}{K \epsilon_0 \rho}$.

E 2. 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 filling the full space. Compute: ($\epsilon_0 = 9 \times 10^{-12}$ S. I. units)
(i) Original capacitance C_0.
(ii) The charge Q on each plate.
(iii) Capacitance C after insertion of the dielectric.
(iv) Dielectric constant K.
(v) Permittivity ϵ of the dielectric.
(vi) The original field E_0 between the plates.
(vii) The electric field E after insertion of the dielectric.

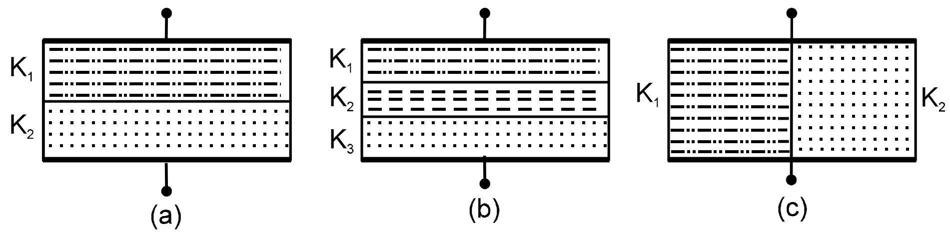
E 3. A parallel plate isolated condenser consists of two metal plates of area A and separation 'd'. A slab of thickness 't' and dielectric constant K is inserted between the plates with its faces parallel to the plates and having the same surface area as that of the plates. Find the capacitance of the system. 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? Calculate the ratio of the energy in the two cases and account for the energy change.

E 4. Hard rubber has a dielectric constant of 2.8 and a dielectric strength of 18 x 10^6 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 x 10^{-2} μf and that the capacitor be able to withstand a potential difference of 4000 volts.

E 5. Two parallel plate air capacitors filling the full space C were connected in series to a battery with e.m.f. ε. Then one of the capacitors was filled up with uniform dielectric with relative permittivity k. How many times did the electric field strength in that capacitor decrease? What amount of charge flows through the battery?

E 6. A parallel-plate capacitor of capacitance 5 μF is connected to a battery of emf 6 V. The separation between the plates is 2 mm. (a) find the electric field between the plates. (b) Find the electric field between the plates. (c) A dielectric slab of thickness 1 mm and dielectric constant 5 is inserted into the gap to occupy the lower half of it. Find the capacitance of the new combination. (d) How much charge has flown through the battery after the slab is inserted ?

E 7. Find the capacitances of the capacitors shown in figure. The plates area is A and the separation between the plates is d. Different dielectric slabs in a particular part of the figure are of the same thickness and the entire gap between the plates is field with the dielectric slabs.



E 8. The distance between the plates of a parallel plate condenser is d. If a copper plate of same 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

E 9. The capacitance of a condenser A is 1μF. It is filled with a medium of dielectric constant 15. The capacitance of another condenser B is 1μF. Both are separately charged by a battery of 100V. After charging the two condenser are connected in parallel without battery and without dielectric. The common potential will be-

(A) 400 V (B) 800 V (C) 1200 V (D) 1600 V

E 10. Two metal plates form a parallel plate condenser. The distance between the plates is d. A metal plate of thickness d/2 and of the same area is inserted completely between the plates. The ratio of capacitances in the two cases (later to initial) is :

(A) 2 : 1 (B) 1 : 2 (C) 1 : 1 (D) 1 : 4

E 11. On placing a dielectric slab between the plates of an isolated charged condenser its–

	Capacity	**Charge**	**Potential Difference**	**Energy stored**	**Electric field**
(A)	decreases	remains unchanged	decreases	increases	increases
(B)	increases	remains unchanged	increases	increases	decreases
(C)	increased	remains unchanged	decreases	decreases	decreases
(D)	decreases	remains unchanged	decreases	increases	remains unchanged

E 12*. 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.

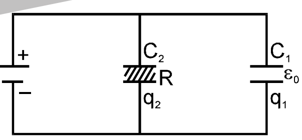
(A) the energy stored in the capacitor will become K–fold

(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

E 13. In the adjoining diagram the capacitors C_1 and C_2 are connected to a 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

E 14. A battery of 100 V is connected to a series combination of two similar parallel plate condensers. If dielectric of constant 4 is slipped between the plates of second condenser, then the potential differences on the condensers will respectively become-

(A) 75 V, 25 V (B) 50 V, 80 V (C) 80 V, 20 V (D) 20 V, 80 V.

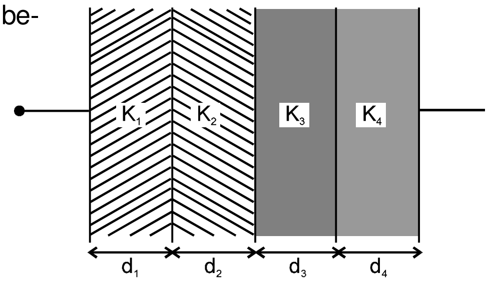
E 15. In the above problem if the battery is disconnected before inserting the dielectric, then potential difference will be-

(A) $\frac{1}{2}$V (B) 2V (C) 4V (D) 32V

E 16. 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) $\frac{U_0}{K^2}$

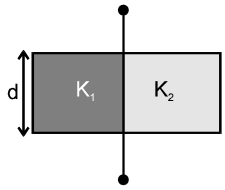
E 17. The effective capacitance of the system in adjoining figure will be-



(A) $C = \dfrac{\varepsilon_0 A}{\left[\dfrac{d_1}{K_1}+\dfrac{d_2}{K_2}+\dfrac{d_3}{K_3}+\dfrac{d_4}{K_4}\right]}$ (B) $C = \dfrac{\varepsilon_0 A}{4d}$

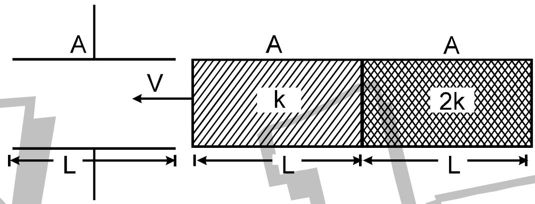
(C) $C = \dfrac{4d}{\varepsilon_0 A}$ (D) $C = \dfrac{K_1K_2K_4K_3}{4d}$

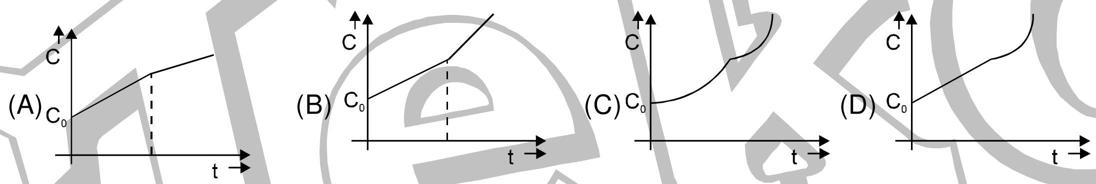
E 18. The capacitance of a parallel plate air condenser to 10μF. Two dielectric media of equal size are filled of relative permittivity 2 and 4 are filled in it. The effective capacity of the system will be -



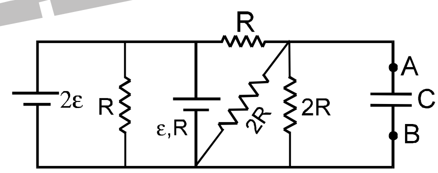
(A) 20 μF (B) 10 μF
(C) 40 μF (D) 30 μF

E 19. A parallel plate capacitor without any dielectric has capacitance C_0. A dielectric slab is made up of two dielectric slabs of dielectric constants K and 2K and is of same dimensions as that of capacitor plates and both the parts are of equal dimensions arranged serially as shown. If this dielectric slab is introduced (dielectric K enters first) in between the plates at constant speed, then variation of capacitance with time will be best represented by:





E 20. The time constant of the circuit shown is :



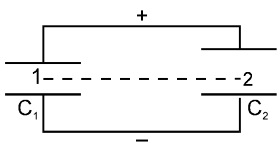
(A) $\dfrac{RC}{2}$ (B) $\dfrac{3RC}{5}$

(C) $\dfrac{RC}{3}$ (D) $\dfrac{RC}{4}$

SECTION F : MISCELLANEOUS

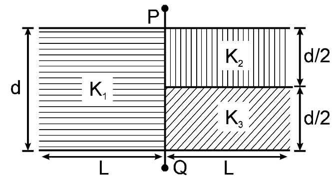
F 1. A variable air capacitor is made of 13 semicircular aluminium plates 4 cm in diameter. Find its maximum capacitance in μμF, if alternate plates are connected together for positive polarity and the remaining plates for the negative polarity. Assume the air gap between the plates to be 0.3 mm.

F 2. Two parallel plate capacitors with different distances between the plates are connected in parallel to a voltage source. A point positive charge Q is moved from a point 1 that is exactly in the middle between the plates of a capacitor C_1 to a point 2 (or a capacitor C_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? If yes, calculate the work done by the field if potential at 1 and 2 are V_1 and V_2.

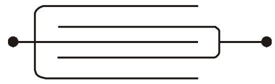


F 3. A spherical condenser has 10 cm and 12 cm as the radii of inner and outer spheres. The space between the two spherical is filled with a dielectric of dielectric constant 5. Find the capacity when;
(i) the outer sphere is earthed.
(ii) the inner sphere is earthed.

F 4. Parallel plate capacitor is constructed using three different dielectric materials as shown in the figure. The parallel plates, across which a potential difference is applied are of area A and are separated by a distance d, find the capacitance across P and Q.



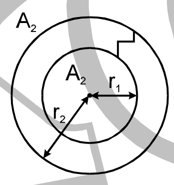
F 5. In the following figure the effective area of each plate of a mica condenser is A and distance between two consecutive plates is d. If the dielectric constant of mica is k, then the capacity of condenser will be-



(A) $\frac{\varepsilon_0 KA}{4d}$ (B) $\frac{4\varepsilon_0 KA}{d}$ (C) $\frac{\varepsilon_0 KA}{2d}$ (D) $\frac{2\varepsilon_0 KA}{d}$

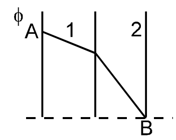
F 6. Two square metallic plates of 1 m side are kept 0.01 m apart, like a parallel plate capacitor, in air in such a way that one of their edges is perpendicular, to an oil surface in a tank filled with an insulating oil. The plates are connected to a battery of e.m.f. 500 volt. The plates are then lowered vertically into the oil at a speed of 0.001 m/s. Then the current drawn from the battery during the process is :
[dielectric constant of oil = 11, $\in_0 = 8.85 \times 10^{-12}\ C^2/N^2 m^2$]
(A) 4.43×10^{-8} A (B) 8.85×10^{-9} A
(C) 2.212×10^{-5} A (D) 4.425×10^{-9} A

F 7. Two spherical conductors A_1 and A_2 of radii r_1 and r_2 are placed concentrically in air. The two are connected by a copper wire as shown in figure. Then the equivalent capacitance of the system is



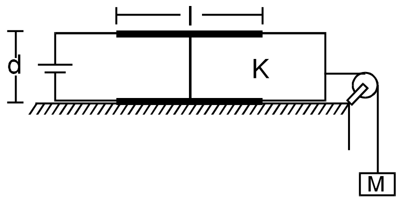
(A) $\frac{4\pi\varepsilon_0 k\, r_1.r_2}{r_2 - r_1}$ (B) $4\pi\in_0 (r_1 + r_2)$
(C) $4\pi\in_0 r_2$ (D) $4\pi\in_0 r_1$

F 8. A parallel plate capacitor is filled with a dielectric up to one half of the distance between the plates. The manner in which the potential between the plates varies with distance is illustrated in the figure. Which half (1 or 2) of the space between the plates is filled with the dielectric and what will be the distribution of the potential after the dielectric is taken out of the capacitor provided that;

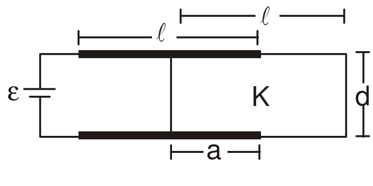


(a) The charges on the plates are conserved or
(b) The potential difference across the capacitor is conserved.

F 9. Consider the situation shown in figure. The width of each plate is b. The capacitor plates are rigidly clamped in the laboratory and connected to a battery of emf ε. All surface are frictionless. Calculate the value of M for which the dielectric slab will stay in equilibrium.



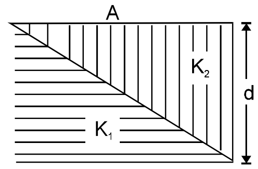
F 10. Consider the situation shown in figure. The plates of the capacitor have plate area A and are clamped in the laboratory. The dielectric slab is released from rest with length a inside the capacitor. Neglecting any effect of friction or gravity, show that the slab will execute periodic motion and find its time period.



EXERCISE-2

1. The magnitude of electric field E in the annular region of a charged cylindrical capacitor.
(A) Is same throughout
(B) Is higher near the outer cylinder than near the inner cylinder.
(C) Varies as 1/r, where r is the distance from the axis
(D) [illegible]^2 where r is the distance from the axis. **[JEE - 96,2]**

2. The capacitance of a parallel plate capacitor with plate area 'A' and separation d is C. The space between the plates is filled with two wedges of dielectric constant K_1 and K_2 respectively. Find the capacitance of the resulting capacitor.
[JEE - 96,2]



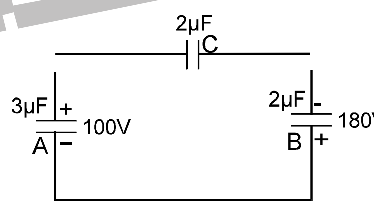
3. A battery of 10 volt is connected to a capacitor of capacity 0.1 F. The battery is now removed and this capacitor is connected to a second uncharged capacitor. If the charge distributes equally on these two capacitors, find the total energy stored in the two capacitors. Further, compare this energy with the initial energy stored in the first capacitor. **[REE - 96,5]**

4. A parallel combination of 0.1 MΩ resistor and a 10 μF capacitor is connected across a 1.5 volt source of negligible resistance. The time required for the capacitor to set charged upto 0.75 volt is approximately (in seconds):
(A) ∞ (B) $\log_e 2$ (C) $\log_{10} 2$ (D) zero **[JEE - 97,2]**

5. A leaky parallel plate capacitor is filled completely with a dielectric having dielectric constant k = 5 and electrical conductivity $\sigma = 7.4 \times 10^{-12}\ \Omega^{-1}\ m^{-1}$. If the charge on the plate at t = 0 is q = 8.8 μC, then calculate the leakage current at the instant t = 12 s. **[JEE - 97,5]**

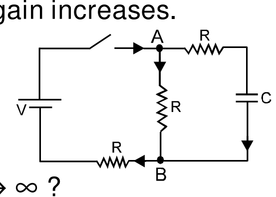
6. An electron enters the region between the plates of a parallel plate capacitor at a point equidistant from either plate. The capacitor plates are 2×10^{-2} m apart and 10^{-1} m long. A potential difference of 300 volt is kept across the plates. Assuming that the initial velocity of the electron is parallel to the capacitor plates, calculate the largest value of the velocity of the electron so that they do not fly out of the capacitor at the other end. **[JEE - 97,5]**

7. Two capacitors A and B with capacitors 3µF and 2µF are charged to a potential difference of 100 V and 180 V respectively. The plates of the capacitors are connected as shown in fig. with one wire from each capacitor free. The upper plate of A is positive and that of B is negative. An uncharged 2µF capacitor C with lead wires falls on the free ends to complete the circuit. Calculate.
(i) The final charge on the three capacitors and
(ii) The amount of electrostatic energy stored in the system before and after the completion of the circuit. **[JEE - 97,5]**



8. A dielectric slab of thickness d is inserted in a parallel plate capacitor whose negative plate is at x = 0 and positive plate is at x = 3d. The slab is equidistant from the plates. The capacitor is given some charge. As x goes from 0 to 3d. **[JEE - 98,2]**
(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.

9. In the circuit shown in the figure, the battery is an ideal one, with e.m.f. V. The capacitor is initially uncharged. The switch S is closed at time t = 0.
(a) Find the charge Q on the capacitor at time t.
(b) Find the current in AB at time t. What is its limiting value as $t \to \infty$?
[JEE - 98,8]



10. The circular plates A and B of a parallel plate air capacitor have a diameter of 0.1 m and are 2×10^{-3} m apart. The plates C and D of a similar capacitor have a diameter of 0.12 m and are 3×10^{-3} m apart. Plate A is earthed. Plates B and D are connected together. Plate C is connected to the positive pole of a 120 volt battery whose negative is earthed. Calculate

(i) The combined capacitance of the arrangement and

(ii) The energy stored in it. **[REE - 98,5]**

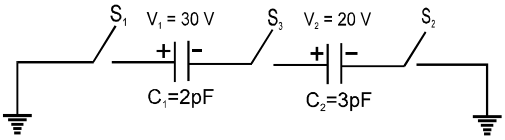
11. For the circuit shown, which of the following statements is true? **[JEE - 99,2]**

(A) With S_1 closed, $V_1 = 15$ V, $V_2 = 20$ V

(B) With S_3 closed, $V_1 = V_2 = 25$ V

(C) With S_1 and S_2 closed, $V_1 = V_2 = 0$

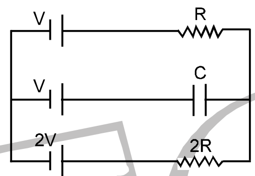
(D) With S_1 and S_2 closed, $V_1 = 30$ V, $V_2 = 20$ V



12. Calculate the capacitance of a parallel plate condenser, with plate area A and distance between plates d, when filled with a dielectric whose dielectric constant varies as; $\in(x) = \in_0 + \beta x \quad 0 < x < \frac{d}{2}$; $\in(x) = \in_0 + \beta(d - x) \ \frac{d}{2} < x < d$. For what value of β would the capacity of the condenser be twice that when it is without any dielectric? **[REE 2000,6]**

[Note : In this problem the examiner has used wrong notation of dielectric constant. Assume $\in(x)$ as the absolute permittivity of the medium at x.]

13. In the given circuit with steady current the potential drop across the capacitor must be:

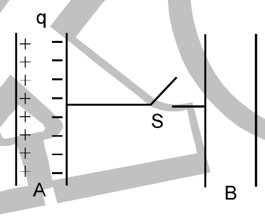


(A) V (B) V/2

(C) V/3 (D) 2V/3

[JEE - 2001,3]

14. Consider the situation shown in the figure. The capacitor A has a charge q on it whereas B is uncharged. The charge appearing on the capacitor B a long time after the switch is closed is



(A) zero

(B) q/2

(C) q

(D) 2q

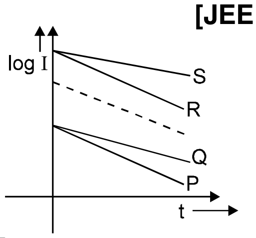
[JEE - 2001,3]

15. Two identical capacitors have the same capacitance C. One of them is charged to potential V_1 and the other to V_2. The negative ends of the capacitors are connected together. When the positive ends are also connected, the decrease in energy of the combined system is:

(A) $\frac{1}{4} C (V_1^2 - V_2^2)$ (B) $\frac{1}{4} C (V_1^2 + V_2^2)$

(C) $\frac{1}{4} C (V_1 - V_2)^2$ (D) $\frac{1}{4} C (V_1 + V_2)^2$ **[JEE 2002,3]**

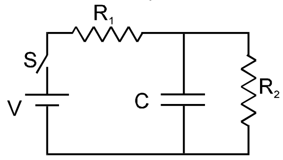
16. Dotted line represents the charging of a capacitor with resistance X. If resistance is made 2X then which will be the graph of charging



(A) P (B) Q

(C) R (D) S **[JEE Scr. 2004]**

17. In the given circuit the capacitor C is uncharged initially and switch 'S' is closed at t = 0. If charge on capacitor at time 't' is given by equation $Q = Q_0 (1 - e^{-\alpha t})$. Find value of Q_0 and α ? **[JEE Mains 2005, 4]**



18. An uncharged capacitor of capacitance 4μF, a battery of emf 12 volt and a resistor of 2.5 MΩ are connected in series. The time after which $v_c = 3v_R$ is (take $\ell n2 = 0.693$)

(A) 6.93 seconds (B) 13.86 seconds

(C) not available (D) not available **[JEE Scr. 2005]**

Answers

Exercise - 1

SECTION A :

A 1. (i) 6 V (ii) 90 μJ (iii) $\frac{16}{3}$ V (iv) $\frac{5}{3}$ μJ

(v) $\frac{Q_{5\mu F}}{Q_{10\mu F}} = \frac{1}{2}$ (vi) $Q_{5\mu F} = \frac{80}{3}\mu C$ $Q_{10\mu F} = \frac{160}{3}\mu C$

A 2. (i) $\frac{Q'_A}{Q'_B} = \frac{1}{2}$ (ii) $\frac{\sigma_A}{\sigma_B} = \frac{2}{1}$

A 3. (i) 40 pF (ii) 5 J

A 4. 0.45 m^2 **A 5.** $\frac{Q^2}{2k\in_0 A}$ **A 6.** D

A 7. D **A 8.** B **A 9.** A

A 10. D **A 11.** D **A 12.** B

A 13. C **A 14.** A **A 15.** A

A 16. B **A 17.** A

SECTION B :

B 1. (a) ε (b) $\frac{\varepsilon}{R}$ (c) ε (d) $\frac{1}{2}C\varepsilon^2$ (e) $\frac{\varepsilon^2}{R}$ (f) $\frac{\varepsilon^2}{R}$

B 2. 2.54×10^{-7} N

B 3. (i) 4 μC (ii) 0, 1/15 A, 1/15 A

B 4. 2 μC, 8 μC, 9 μC and 12 μC

B 5. (i) 110 μC (ii) $Q_{6\mu F}$ = 60 μC, $Q_{5\mu F}$ = 50 μC

B 6. (a) zero (b) – 10.3 V]

B 7. $\phi_0 = \frac{\phi_A C_1 + \phi_B C_2 + \phi_D C_3}{C_1 + C_2 + C_3} = 20$ V

B 8. 2.0 J **B 9.** 1.44 mJ **B 10.** 12

B 11. 4.5 g *B 12. B* *B 13. C*

B 14*. BCD **B 15.** D *B 16. C*

B 17. B **B 18.** B **B 19.** AC

B 20. C **B 21.** B

SECTION C : COMBINATION OF CAPACITORS

C 1. (i) 110 μC on each, (ii) 1.33×10^{-3} J

C 2. (a) Cε/2, (b) $C\varepsilon^2/2$ (c) $C\varepsilon^2/4$ (d) $C\varepsilon^2/4$

C 3. 25 V and 75 V.

C 4. (a) five 2 μC capacitors in series (b) 3 parallel rows; each consisting of five 2.0 μF capacitors in series

C 5. 60 μC

C 6. (a) 50/3 μV at each point (b) zero

C 7. (a) $\frac{12}{11}$ V (b) – 8 V **C 8.** 2.25 μF

C 9. (a) 8 μF (b) 8 μF

C 10. (i) 2 μF, (ii) 4 μF

C 11. (i) 48 μC on the 8 μF capacitor and 24 μC on each of the 4 μF capacitors (ii) 576 μJ

C 12. C **C 13.** D **C 14.** A

C 15. C **C 16.** C **C 17.** C

C 18. A **C 19.** B **C 20.** C

C 21. C **C 22.** D **C 23.** D

C 24. B **C 25.** (i) A (ii) D (iii) B

C 26. D **C 27.** B **C 28.** D

C 29. D **C 30.** A

C 31. (i) A (ii) D (iii) B **C 32.** (i) A (ii) D

C 33. A

SECTION D :

D 1. **D 2.** $\frac{1}{2}(1 - 1/e^2)CV^2$ **D 3.** 70 μC

D 4. 2.0 Ω. **D 5.** 0.02 V **D 6.** 4.7 μJ.

D 7. (i) (a) 10 s (b) 2 μC (c) 10 ln2 = 6.94 s
(ii) q = $(2\,e^{-5})$μC = 1.348×10^{-8} C

D 8. A **D 9.** (i) C (ii) A (iii) D (iv) D

D 10. AC **D 11.** AC *D 12. A*

D 13. C **D 14.** (i) A (ii) B (iii) C

D 15. (i) A (ii) C **D 16.** (i) C (ii) B (iii) C (iv) D

D 17. C **D 18.** C **D 19.** A

D 20. C *D 21. AC*

D 22. (i) $\frac{24}{143}$ = 0.17 A to the left, $\frac{76}{143}$ = 0.53 A to the left (ii) 46.92 μC

D 23. 3.3×10^{-4} C

SECTION E :

E 2. (i) 180 pF (ii) 5.4×10^{-7} C (iii) 540 pF
(iv) 3 (v) $27 \times 10^{-12}\ C^2 N^{-1} m^{-2}$ (vi) 3×10^5 v/m
(vii) 1×10^5 v/m

E 3. $\frac{t}{d} = \frac{2}{3}$, $\frac{w_i}{w_F} = \frac{3}{2}$ **E 4.** 0.62 m^2

E 5. $\frac{1}{2}(1+k)$, $\Delta q = \frac{1}{2}\,CE\,\frac{k-1}{k+1}$

E 6 (a) 30 μC (b) 3×10^3 V/m (c) $\frac{25}{3}$ μF (d) 20μC

E 7. (a) $\frac{2K_1K_2\varepsilon_0 A}{d(K_1+K_2)}$ (b) $\frac{3\varepsilon_0 A\,K_1\,K_2K_3}{d\,(K_1K_2+K_2K_3+K_3K_1)}$

(c) $\frac{\varepsilon_0 A}{2\,d}\,(K_1+K_2)$

E 8. B **E 9.** B **E 10.** A

E 11. C **E 12.** ACD **E 13.** A

E 14. C **E 15.** A **E 16.** A

E 17. A **E 18.** D **E 19.** B

E 20. A

SECTION F : MISCELLANEOUS

F 1. 222.8 pF

F 2. work done by the field = $Q(V_1 - V_2)$

F 3. (i) $\frac{10}{3} \times 10^{-10}$ F (ii) $\frac{104}{30} \times 10^{-10}$ F

F 4. $\frac{\varepsilon_0 A}{d}\left[\frac{k_1}{2} + \frac{k_2\,k_3}{k_2+k_3}\right]$ ***F 5.*** *B*

F 6. D ***F 7.*** *C*

F 8. 1st part has di-electric;
(a) extend graph of 2
(b) straight line joining points A and B

F 9. $\frac{\varepsilon_0 b\varepsilon^2(K-1)}{2dg}$ **F 10.** $8\sqrt{\frac{(\ell-a)\ell md}{\varepsilon_0 A\varepsilon^2(K-1)}}$

Exercise - 2

1. C **2.** $\frac{CK_1K_2}{(K_2-K_1)}\,\ell n\,\frac{K_2}{K_1}$

3. 2.5 J, $\frac{U_{initial}}{U_{final}} = \frac{5}{2.5} = 2$

4. D **5.** $i = \frac{q\sigma}{k\epsilon_0}\,e^{-1\sigma/\epsilon_0 K} \cong 0.2$ μA

6. $\frac{2}{\sqrt{30}} \times 10^8$ m/s **7.** (i) 210 μC (ii) 18 mJ

8. B, C

9. (a) $q = \frac{CV}{2}\,[1 - e^{-2t/3RC}]$

(b) $i = \frac{V}{2R}\left[1 - \frac{1}{3}e^{-2t/3RC}\right]$; $i = \frac{V}{2R}$ as $t \to \infty$

10. (i) 17 pF (ii) 122.4 nJ

11. D

12. $\beta d = \varepsilon_0 \ell n\left(1+\frac{\beta d}{2\varepsilon_0}\right)$, $C = \frac{A\beta}{2\ell n\left(1+\frac{\beta d}{2\varepsilon_0}\right)}$

13. C **14.** A **15.** C **16.** B

17. $Q_0 = \frac{R_2VC}{R_1+R_2}$ & $\alpha = \frac{(R_1+R_2)}{CR_1R_2}$ **18.** B