SOLVED EXAMPLES

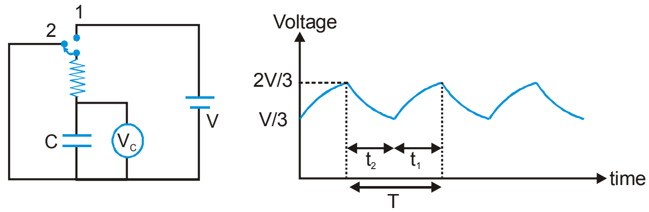
Ex. 1 Seven capacitors, each of capacitance 2μF are to be connected to obtain a capacitance of 10/11 μF. Which of the following combinations is possible ?

(A) 5 in parallel 2 in series **(B)** 4 in parallel 3 in series

(C) 3 in parallel 4 in series **(D)** 2 in parallel 5 in series

Sol. 5(2μF) in series with $\left(\frac{2\mu F}{2}\right)$, 10μF in series with 1μF, $C_{eq} = \frac{10\times 1}{10+1} = \frac{10}{11}\mu F$

Ex. 2 The switch in circuit shifts from 1 to 2 when $V_C > 2V/3$ and goes back to 1 from 2 when $V_C < V/3$. The voltmeter reads voltage as plotted. What is the period T of the wave form in terms of R and C?



(A) RC ℓn3 **(B)** 2RC ℓn 2 **(C)** $\frac{RC}{2}\ell n3$ **(D)** $\frac{RC}{3}\ell n3$

Sol. During time 't_2' capacitor is discharging with the help of resistor 'R' $\therefore$ $q = q_0 e^{-t/RC}$

$V = V_0\, e^{-t/RC}$ [∵Q=CV]

As $V_0 = \frac{2V}{3}$; $V = \frac{V}{3}$; $t_2 = RC\ \ell n2$

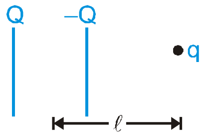
During time 't_1' capacitor is charging with the help of battery.

$\therefore$ $q = q_0\,(1-e^{-t/RC})$ or $V = V_0\,(1-e^{-t/RC})$

as $V_0 = \frac{2V}{3}$; $V = \frac{V}{3}$; $t_1 = RC\ \ell n2$

$T = t_1 + t_2 = 2RC\ \ell n2$

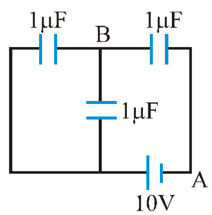
Ex. 3 The plates of very small size of a parallel plate capacitor are charged as shown .The force on the charged particle of charge 'q' at a distance 'ℓ' from the capacitor is : (Assume that the distance between the plates is d<< ℓ)



(A) Zero **(B)** $\frac{Qqd}{2\pi \epsilon_0 \ell^3}$ **(C)** $\frac{Qqd}{\pi \epsilon_0 \ell^3}$ **(D)** $\frac{Qqd}{4\pi \epsilon_0 \ell^3}$

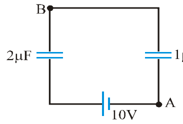
Sol. Assume capacitor as dipole and use $F = qE$, $E = \frac{2kp}{r^3}$,$p = Qd$

Ex. 4 In the circuit shown, if potential of A is 10V, then potential of B is -



(A) 25/3 V **(B)** 50/3 V **(C)** 100/3 V **(D)** 50 V

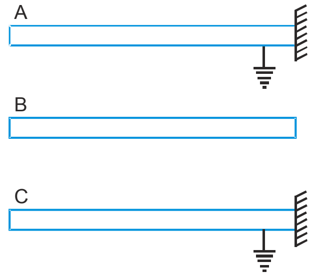
Sol. Given circuit can be reduced as



Charge on capacitors $=\left(\frac{2}{3}\right)(10)\mu C$

Now $V_B - V_A = \left(\frac{20}{3}\right)(1) = \frac{20}{3}$ $\Rightarrow$ $V_B = V_A + \frac{20}{3} = 10 + \frac{20}{3} = \frac{50}{3}V$

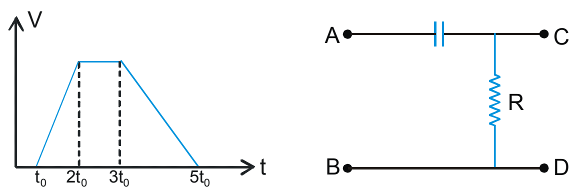
Ex. 5 A, B and C are three large, parallel conducting plates, placed horizontally. A and C are rigidly fixed and earthed. B is given some charge. Under electrostatic and gravitational forces, B may be–



(A) in equilibrium midway between A and C.
(B) in equilibrium if it is closer to A than to C.
(C) in equilibrium if it is closer to C than to A.
(D) B can never be in stable equilibrium.

Sol. As A and C are earthed, they are connected to each other. Hence, 'A + B' and 'B + C' are two capacitors with the same potential difference. If B is closer to A than to C then the capacitance C_{AB} is > C_{BC}. The upper surface of B will have greater charge than the lower surface. As the force of attraction between the plates of a capacitor is proportional to Q^2, there will be a net upwards force on B. This can balance its weight.

Ex. 6 A varying voltage is applied between the terminals A, B so that the voltage across the capacitor varies as shown in the figure Then.

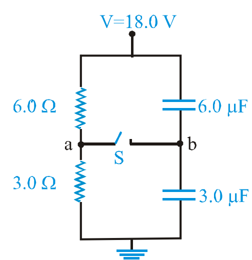


(A) The voltage between the terminals C and D is constant between $2t_0$ and $3t_0$
(B) The current in the resistor is 0 between $2t_0$ and $3t_0$
(C) The current in the resistor between t_0 and $2t_0$ is twice the current between $3t_0$ and $5t_0$
(D) None of these

Sol. When the capacitor voltage is constant its charge is constant. No current in the resistor.

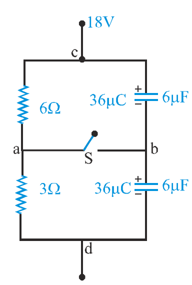
Also $C\frac{dV}{dt} = \frac{dq}{dt}$ is double between t_0 and $2t_0$ compared to $3t_0$ and $5t_0$

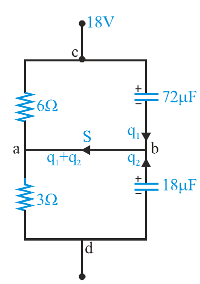
Ex. 7 Study the following circuit diagram in figure and mark the correct option**(S)**



(A) The potential of point a with respect to point b when switch S is open is –6V.
(B) The points a and b, are at the same potential, when S is opened.
(C) The charge flows through switch S when it is closed is 54 μC
(D) The final potential of b with respect to ground when switch S is closed is 8V

Sol. **(AC)**





When S is opened : $V_c - V_a = \frac{18 \times 6}{6+3} = 12V$

$V_c - V_b = \frac{18 \times 2}{6} = 6V \Rightarrow V_b - V_a = 12 - 6 = 6V$

Charges flown after S is closed :

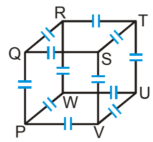
$q_1 = 72 - 36 = 36\mu C$, $q_2 = 36 - 18 = 18\mu C$

Charges flown through S after it is closed :

$36 + 18 = 54\ \mu C$

Final potential of b is 6V

Ex. 8 Twelve indentical capacitors each of capacitance C are connected as shown in figure.

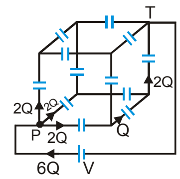


(A) The effective capacitance between P and T is $\frac{6C}{5}$

(B) The effective capacitance between P and U is $\frac{4C}{3}$

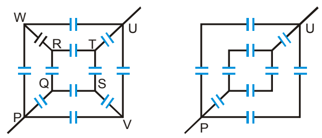
(C) The effective capacitance between P and V is $\frac{12C}{7}$

(D) All of the above statements are incorrect



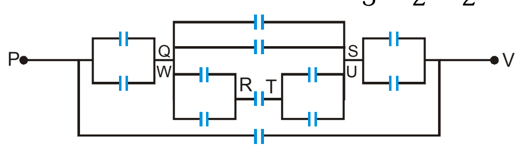
Sol. **For (A) :** $V = \frac{2Q}{C} + \frac{Q}{C} + \frac{2Q}{C} = \frac{5Q}{C}$, $C_{eff} = \frac{6Q}{V} = \frac{6C}{5}$

For (B) : Given circuit can be drawn as



Equalvent capacitance between P and $U = \frac{C}{3} + \frac{C}{2} + \frac{C}{2} = \frac{4C}{3}$

For (C) :

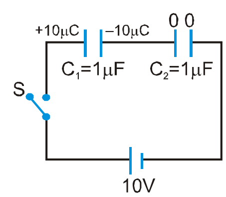


If a battery be connected across the terminals P and V, from symmetry $V_Q = V_W$ and $V_S = V_u$

$$\Rightarrow \quad \text{Equivalent capacitance} = \frac{\left(\frac{5}{2}C\right)(C)}{\frac{5}{2}C + C} + C = \frac{12C}{7}$$

Ex. 9 to 11

Following figure shows the initial charges on the capacitor. After the switch S is closed, find -



9. Charge on capacitor C_1

(A) 0 μC **(B)** 5 μC **(C)** 10 μC **(D)** None of these

10. Charge on capacitor C_2

(A) 0 μC **(B)** 5 μC **(C)** 10 μC **(D)** None of these

11. Work done by battery

(A) 50 μJ **(B)** 100 μJ **(C)** 150 μJ **(D)** None of these

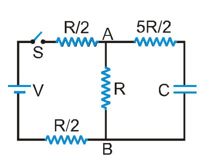
Sol.

9,10, 11 $10 - 2q + 10 = 0 \Rightarrow q=10$

$w_b = q_b(10) = 0$ charge flown through the battery is zero

Ex. 12 to 14

In the circuit shown in figure, the battery is an ideal one with emf V. The capacitor is initially uncharged. The switch S is closed at time t = 0.



12. The charge Q on the capacitor at time t is-

(A) $\frac{CV}{2}\left(1 - e^{-\frac{t}{RC}}\right)$ **(B)** $\frac{CV}{2}\left(1 - e^{-\frac{t}{3RC}}\right)$ **(C)** $\frac{CV}{2}\left(1 - e^{-\frac{2t}{5RC}}\right)$ **(D)** $\frac{CV}{2}\left(1 - e^{-\frac{2t}{9RC}}\right)$

13. The current in AB at time t is-

(A) $\frac{V}{2R}\left(1-e^{-\frac{t}{3RC}}\right)$ **(B)** $\frac{2V}{R}\left(1-e^{-\frac{t}{3RC}}\right)$ **(C)** $\frac{2V}{R}\left(1-\frac{e^{-\frac{t}{3RC}}}{6}\right)$ **(D)** $\frac{V}{2R}\left(1-\frac{e^{-\frac{t}{3RC}}}{6}\right)$

14. What is its limiting value at $t \to \infty$?

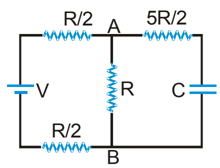
(A) $\frac{V}{2R}$ **(B)** $\frac{V}{R}$ **(C)** $\frac{2V}{R}$ **(D)** $\frac{V}{3R}$

Sol.

12. In steady state $V_C = V_{AB}$ = capacitor voltage = V/2

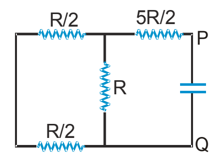
Calculation of time constant (τ_C)

effective resistance across C = 3R



$$q = q_0\left(1-e^{-\frac{t}{\tau_c}}\right),\ q_0 = C\,\frac{V}{2} \Rightarrow q = \frac{CV}{2}\left(1-e^{-\frac{t}{3RC}}\right)$$

13. $V_{AB} = \frac{5}{2}Ri + \frac{q}{C}$

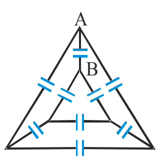
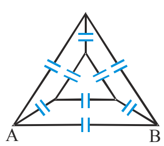
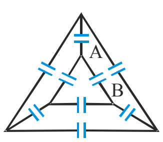
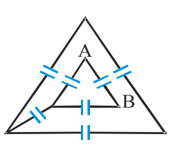


where $i = \frac{dq}{dt} = \frac{dv}{2\times 3RC}e^{-\frac{t}{3RC}},\ i = \frac{V}{6R}e^{-\frac{t}{3RC}}$

$$V_{AB} = \frac{5V}{12}e^{-\frac{t}{3RC}} + \frac{V}{2}\left(1-e^{-\frac{t}{3RC}}\right) \Rightarrow i_{AB} = \frac{V_{AB}}{R}$$

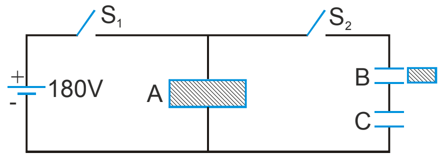
14. At $t \to \infty$ $V_{AB} = \frac{V}{2},\ i_{AB} = \frac{V}{2R}$

Exa. 15 All capacitors given in column-I have capacitance of 1μF.

Column-I (Circuit)	Column-II (Capacitance)
(A) 	**(P)** $\frac{4}{3}\mu F$
(B) 	**(Q)** $\frac{3}{2}\mu F$
(C) 	**(R)** $\frac{15}{8}\mu F$
(D) 	**(S)** $\frac{5}{3}\mu F$
	(T) None of these

Sol. **Ex. 16 to 18**

In the circuit shown, capacitor A has capacitance C_1=2μF when filled with dielectric slab (k = 2). Capacitor B and C are air capacitors and have capacitances C_2=3μF and C_3=6μF respectively.



16. Calculate the energy supplied by battery during process of charging when switch S_1 is closed alone.
(A) 0.0324 J **(B)** 0.0648 J **(C)** 0.015 J **(D)** 0.030 J

17. Switch S_1 is opened and S_2 is closed . The charge on capacitor B is
(A) 240 μC **(B)** 280 μC **(C)** 180 μC **(D)** 200 μC

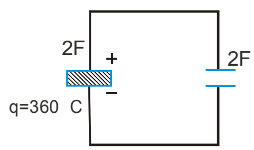
18. Now switch S_2 is opened, slab of A is removed. Another di–electric slab k = 2 which can just fill the space in B, is inserted into it and then switch S_2 is closed. The charge on capacitor B is
(A) 90 μC **(B)** 240 μC **(C)** 180 μC **(D)** 270 μC

Sol.

16. $q = CV = 2 \times 10^{-6} \times 180 = 360\ \mu C$

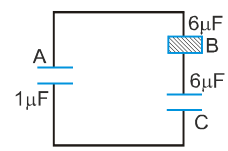
Energy supplied by battery = qV = 0.0648 J.

17. Equivalent of B & C = 2μF



Common potential $V = \dfrac{360\mu C}{4\mu F} = 90$ volt

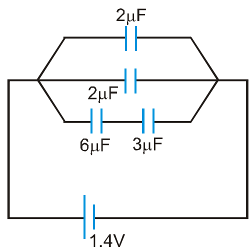
$\therefore$ q on B = $90 \times 2 \times 10^{-6} = 180\ \mu C$.



18. Common potential attained after S_2 is closed is $= \dfrac{360\mu C}{4\mu F} = 90$ volt.

$\therefore q_A = 90\ \mu C \ \therefore q_B = 360\ \mu C - 90\ \mu C = 270\ \mu C$

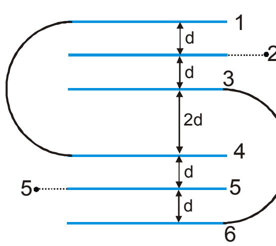
Ex. 19 In the given circuit find energy stored in capacitors in mJ.



Sol. $C_{eq} = 2 + 2 + 2 = 6\ \mu F$

Energy stored $= \dfrac{1}{2} C_{eq} V^2 = \dfrac{1}{2}(6 \times 10^{-3})(1.4)^2 = (3 \times 10^{-3})(2) = 6$ mJ

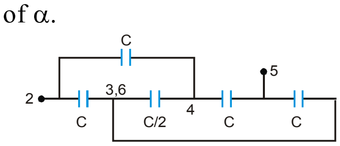
Ex . 20 There are six plates of equal area A and separation between the plates is d (d<<A) are arranged as shown in figure.



The equivalent capacitance between points 2 and 5, is $\alpha \dfrac{\epsilon_0 A}{d}$.

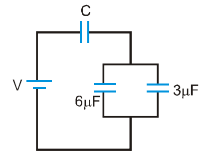
Then find the value of α.

Sol. Redraw the circuit



$C_{eq} = C = \dfrac{\epsilon_0 A}{d}$

Ex. 21 If charge on 3μF capacitor is 3μC. Find the charge on capacitor of capacitance C in μC.



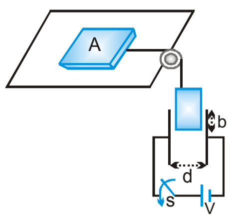
Sol. Potential difference across 3μF = P.D. across 6 μF = 1V

$\Rightarrow$ Charge on 6μF = 6μC

$\Rightarrow$ Total charge on combination of 6μF and 3μF = 9μC

Therefore charge on C = 9μC

Ex. 22 A block A of mass m kept on a rough horizontal surface is connected to a dielectric slab of mass m/6 and dielectric constant K by means of a light and inextensible string passing over a fixed pulley as shown in fig. The dielectric can completely fill the space between the parallel plate capacitor of plate are $\ell \times \ell$ and separation between the plates d kept in vertical position. Initially switch S is open and length of the dielectric inside the capacitor is b.



The coefficient of friction between the block A and the surface is $\frac{\mu}{4}$. Ignore any other friction.

(A) Find the minimum value of the emf V of the battery so that after closing the switch the block A will move

(B) If $V = 2V_{min}$ find the speed of the block A when the dielectric completely fills the space between the plates of the capacitor.

Sol. **(A)** The forces acting on the dielectric are electrostatic attractive force of field of capacitor and its weight.

The block will slip when $F_E + mg \geq \mu Mg$ $F_E \geq \frac{M}{4}g - \frac{M}{6}g$

$$\frac{1}{2}\frac{\varepsilon_0 \ell}{d}(K-1)V^2 \geq \frac{Mg}{12} \qquad \therefore V_{min} = \sqrt{\frac{Mg}{12} \times \frac{2d}{\varepsilon_0 \ell (K-1)}} = \sqrt{\frac{Mgd}{6\varepsilon_0 \ell (K-1)}}$$

(B) Now $V = 2V_{min}$. In this case the block will accelerate

Dielectric : $F_E + mg - T = ma$ ...(i) and Block : $T - \mu Mg = Ma$ ...(ii)

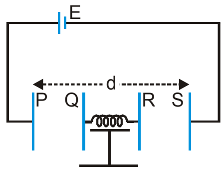
eq. (i) and (ii) give $a = \frac{F_E + (m - \mu M)g}{m + M}$

As $F_E = \frac{1}{2}\frac{\varepsilon_0 \ell}{d}(K-1)V^2 = \frac{1}{2}\frac{\varepsilon_0 \ell}{d}(K-1) \times 4 \times \frac{Mgd}{6\varepsilon_0 \ell (K-1)} = 2Mg$

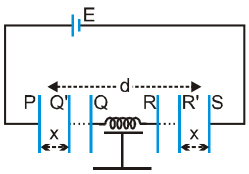
Thus $a = \dfrac{2Mg - \frac{M}{12}g}{\frac{7M}{6}} = \frac{23g \times 6}{7} = \frac{138}{7}g$

From equation of motion, $v^2 = 2as \Rightarrow v^2 = 2\left(\frac{138g}{7}\right) \times (\ell - b) \Rightarrow v = \sqrt{\frac{276}{7}g(\ell - b)}$

Ex. 23 Two parallel plate capacitors with area A are connected through a conducting spring of natural length ℓ in series as shown. Plates P and S have fixed positions at separation d. Now the plates are connected by a battery of emf E as shown. If the extension in the spring in equilibrium is equal to the separation between the plates, find the spring constant k.



Sol. Let charge on capacitors be q and separation between plates P and Q and R and S be x at any time distance between plates P and Q and R and S is same because force acting on them is same.



Capacitance of capacitor PQ, $C_1 = \frac{\varepsilon_0 A}{x}$

Capacitance of capacitor RS, $C_2 = \frac{\varepsilon_0 A}{x}$ From KVL $\frac{q}{C_1} + \frac{q}{C_2} = E \Rightarrow q = \frac{\varepsilon_0 AE}{2x}$

At this moment extension in spring, $y = d - 2x - \ell$.

Force on plate Q towards P, $F_1 = \frac{q^2}{2A\varepsilon_0} = \frac{\varepsilon_0^2 A^2 E^2}{8Ax^2\varepsilon_0} = \frac{A\varepsilon_0 E^2}{8x^2}$

Spring force on plate Q due to extension in spring, $F_2 = ky$

At equilibrium, separation between plates = extension in spring

Thus $x = y = d - 2x - \ell \Rightarrow x = \frac{d-\ell}{3}$ ...**(i)** and $F_1 = F_2$ ...**(ii)**

From eq. **(i)** and **(ii)**, $\frac{A\varepsilon_0 E^2}{8x^2} = ky = kx \Rightarrow x = \left(\frac{A\varepsilon_0 E^2}{8K}\right)^{1/3}$ ...**(iii)**

From eq. **(i)** and **(iii)**, $\left(\frac{d-\ell}{3}\right) = \frac{A\varepsilon_0 E^2}{8K} \Rightarrow k = \frac{A\varepsilon_0 E^2 27}{8(d-\ell)^3}$

Exercise # 1

[Single Correct Choice Type Questions]

1. A parallel plate capacitor of capacitance C is connected to a battery and is charged to a potential difference V. Another capacitor of capacitance 2C is connected to another battery and is charged to potential difference 2V. The charging batteries are now disconnected and the capacitors are connected in parallel to each other in such a way that the positive terminal of one is connected to the negative terminal of the other. The final energy of the configuration is–

(A) Zero **(B)** $\frac{25CV^2}{6}$ **(C)** $\frac{3CV^2}{2}$ **(D)** $\frac{9CV^2}{2}$

2. A 40 μF capacitor in a defibrillator is charged to 3000 V. The energy stored in the capacitor is sent through the patient

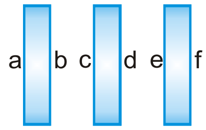
during a pulse of duration 2 ms. The power delivered to the patient is :–

(A) 45 kW **(B)** 90 kW **(C)** 180 kW **(D)** 360 kW

3. An automobile spring extends 0.2 m for 5000 N load. The ratio of potential energy stored in this spring when it has been compressed by 0.2 m to the potential energy stored in a 10 μF capacitor at a potential difference of 10000 V will be :–

(A) 1/4 **(B)** 1 **(C)** 1/2 **(D)** 2

4. Three parallel metallic plates, each of area A are kept as shown in the figure and charges Q_1, Q_2 and Q_3 are given to them. Edge effects are negligible. Calculate the charges on the two outermost surfaces 'a' and 'f'.



(A) $\frac{Q_1 + Q_2 + Q_3}{2}$ **(B)** $\frac{Q_1 + Q_2 + Q_3}{3}$ **(C)** $\frac{Q_1 - Q_2 + Q_3}{3}$ **(D)** $\frac{Q_1 - Q_2 + Q_3}{2}$

5. The distance between plates of a parallel plate capacitor is 'd'. Another thick metal plate of thickness d/2 and area same as that of plates is so placed between the plates, that it does not touch the plates. The capacity of the resultant capacitor :–

(A) remain same **(B)** becomes double **(C)** becomes half **(D)** becomes one fourth

6. Two conducting spheres of radii R_1 and R_2 are charged with charges Q_1 and Q_2 respectively. On bringing them in contact there is :–

(A) no change in the energy of the system

(B) an increase in the energy of the system if $Q_1R_2 \neq Q_2R_1$

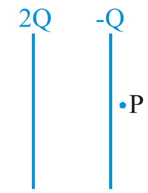
(C) always a decrease in energy of the system

(D) a decrease in energy of the system if $Q_1R_2 \neq Q_2R_1$

7. A capacitor of value 4 μF charged at 50V is connected with another capacitor of value 2μF charged at 100V, in such a way that plates of similar charges are connected together. Before joining and after joining the total energy in multiples 10^{-2} J will be :–

(A) 1.5 and 1.33 **(B)** 1.33 and 1.5 **(C)** 3.0 and 2.67 **(D)** 2.67 and 3.0

8. In the figure shown the plates of a parallel plate capacitor have unequal charges. Its capacitance is 'C'. P is a point outside the capacitor and close to the plate of charge–Q. The distance between the plates is 'd' then which statement is wrong



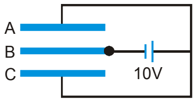
(A) A point charge at point 'P' will experience electric force due to capacitor

(B) The potential difference between the plates will be $\frac{3Q}{2C}$

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

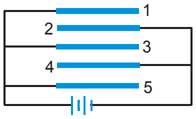
(D) The force on one plate due to the other plate is $\frac{Q^2}{2\pi \epsilon_0 d^2}$

9. Three plates A,B and C each of area 0.1 m^2 are separated by 0.885 mm from each other as shown in the figure. A 10V battery is used to charge the system. The energy stored in the system is:



(A) 1 μJ **(B)** 10^{-1} μJ **(C)** 10^{-2} μJ **(D)** 10^{-3} μJ

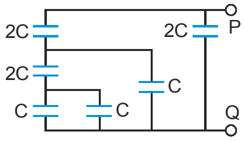
10. Five identical plates are connected across a battery as follows :



If the charge on plate 1 be +q, then the charges on the plates 2,3,4 and 5 are

(A) –q, +q,–q,+q **(B)** –2q, +2q,–2q,+q **(C)** –q, +2q,–2q,+q **(D)** None of the above

11. The value of equivalent capacitance of the combination shown in figure between the points P and Q is :–



(A) 3 C **(B)** 2 C **(C)** C **(D)** C/3

12. N identical capacitor are joined in parallel and the combination is charged to a potential V. Now if they are separated and then joined in series then energy of combination will :–

(A) remain same and potential difference will also remain same

(B) remain same and potential difference will become NV

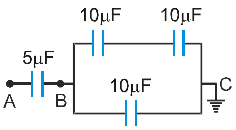
(C) increase N times and potential difference will become NV

(D) increase N time and potential difference will remains same

13. A parallel plate capacitor is made by stacking n equally spaced plates connected alternatively. If the capacitance between any two adjacent plates is C, then the resultant capacitance is–

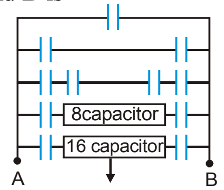
(A) (n – 1)C **(B)** (n + 1)C **(C)** C **(D)** nC

14. In the given circuit if point C is connected to the earth and a potential of +2000 V is given to point A, the potential at B is :–



(A) 1500 V **(B)** 1000 V **(C)** 500 V **(D)** 400 V

15. An infinite number of identical capacitors each of capacitance 1μ F are connected as in adjoining figure. Then the equivalent capacitance between A and B is



(A) 1μ F **(B)** 2μ F **(C)** 1/2 μF **(D)** ∞

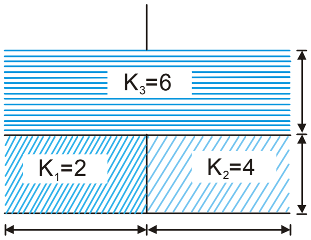
16. A parallel plate capacitor with air between the plates has a capacitance of 9 pF. The separation between its plates is 'd'. The space between the plates is now filled with two dielectrics. One of the dielectric has dielectric constant K_1 = 3 and thickness $\frac{d}{3}$ while the other one has dielectric constant K_2 = 6 and thickness $\frac{2d}{3}$. Capacitance of the capacitor is now

(A) 1.8 pF **(B)** 45 pF **(C)** 40.5 pF **(D)** 20.25 pF

17. Two parallel plate capacitors whose capacities are C and 2 C respectively, are joined in parallel. These are charged by V potential difference. If the battery is now removed and a dielectric of dielectric constant K is filled in between the plates of the capacitor C, then what will be the potential difference across each capacitor ?

(A) $\frac{V}{K+2}$ **(B)** $\frac{2V}{K+2}$ **(C)** $\frac{3V}{K+2}$ **(D)** $\frac{2+K}{3V}$

18. A parallel plate capacitor of capacitance C (without dielectrics) is filled by dielectric slabs as shown in figure. Then the new capacitance of the capacitor is

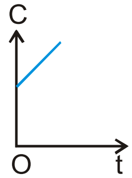


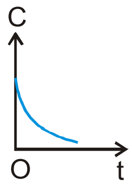
(A) 3.9 C **(B)** 4 C **(C)** 2.4 C **(D)** 3 C

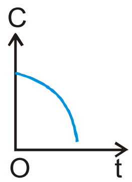
19. A fully charged capacitor has a capacitance C. It is discharged through a small coil of resistance wire embedded in a thermally insulated block of specific heat capacity s and mass m. If the temperature of the block is raised by ΔT, the potential difference V across the capacitance is–

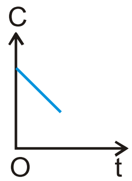
(A) $\sqrt{\frac{2mC\Delta T}{s}}$ **(B)** $\frac{mC\Delta T}{s}$ **(C)** $\frac{ms\Delta T}{C}$ **(D)** $\sqrt{\frac{2ms\Delta T}{C}}$

20. Dielectric sheet placed between the plates of parallel plate capacitor. Now capacitor is charged and battery is disconnected. Now t = 0 sheet is taken out very slowly then which of the following is correct for the variation of capacitance with time

(A)


(B)


(C)


(D)


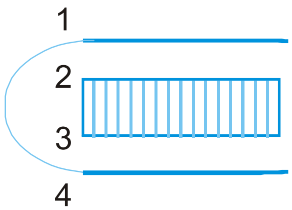
21. Two capacitor having capacitance 8 μF and 16μF have breaking voltage 20V & 80 V. They are combined in series. The maximum charge they can store individually in the combination is-

(A) 160 μC **(B)** 200 μC **(C)** 1280 μC **(D)** None of these

22. The capacitance (C) for an isolated conducting sphere of radius (A) is given by $4\pi\varepsilon_0 a$. This sphere is enclosed within an earthed concentric sphere. The ratio of the radii of the spheres being $\frac{n}{(n-1)}$ then the capacitance of such a sphere will be increased by a factor-

(A) n **(B)** $\frac{n}{(n-1)}$ **(C)** $\frac{(n-1)}{n}$ **(D)** a.n

23. Four identical plates 1,2,3 and 4 are placed parallel to each other at equal distance as shown in the figure. Plates 1 and 4 are joined together and the space between 2 and 3 is filled with a dielectric of dielectric constant k=2. The capacitance of the system between 1 and 3 & 2 and 4 are C_1 and C_2 respectively. The ratio $\frac{C_1}{C_2}$ is-

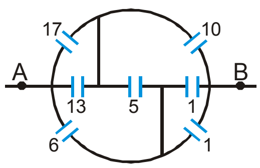


(A) $\frac{5}{3}$ **(B)** 1 **(C)** $\frac{3}{5}$ **(D)** $\frac{5}{7}$

24. A capacitor of capacitance 1 μF withstands the maximum voltage 6 kV while a capacitor of 2μF withstands the maximum voltage 4 kV. What maximum voltage will the system of these two capacitor withstands if they are connected in series ?

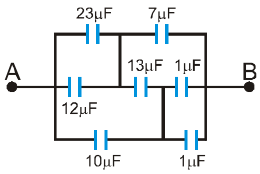
(A) 10 kV **(B)** 12 kV **(C)** 8 kV **(D)** 9 kV

25. The equivalent capacitance across AB (all capacitance in μF) is



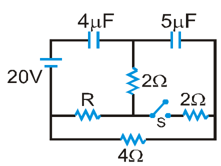
(A) $\frac{20}{3}$ μF **(B)** 9μF **(C)** 48μF **(D)** None of these

26. The equivalent capacitance across A & B is



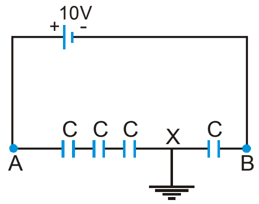
(A) $\frac{28}{3}$ μf **(B)** $\frac{15}{2}$ μF **(C)** 15 μF **(D)** None of these

27. The heat produced in the capacitors on closing the switch S is



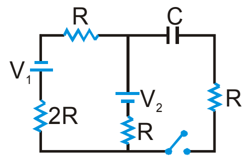
(A) 0.0002 J **(B)** 0.0005 J **(C)** 0.00075 **(D)** Zero

28. Four identical capacitors are connected in series with a battery of emf 10V. The point X is earthed. Than the potential of point A is–



(A) 10 V **(B)** 7.5 V **(C)** –7.5 V **(D)** 0 V

29. The time constant of the shown circuit for charging is



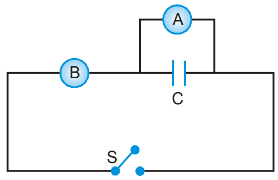
(A) $\frac{5}{3}RC$ **(B)** $\frac{5}{2}RC$ **(C)** $\frac{7}{4}RC$ **(D)** $\frac{7}{3}RC$

Exercise # 2 Part # I [Multiple Correct Choice Type Questions]

1. 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–homogeneous dielectric whose dielectric constant varies with the distance 'y' from one plate as : $K = \lambda \sec\left(\frac{\pi y}{2d}\right)$, where λ is a dimensionless constant. The capacitance of this capacitor is

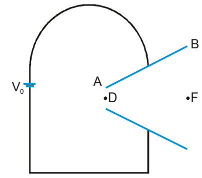
(A) $\frac{\pi\varepsilon_0\lambda A}{2d}$ **(B)** $\frac{\pi\varepsilon_0\lambda A}{d}$ **(C)** $\frac{2\pi\varepsilon_0\lambda A}{d}$ **(D)** None

2. A capacitor of capacitance C is connected to two voltmeters A and B. A is ideal, having infinite resistance, while B has resistance R. The capacitor is charged and then the switch S is closed. The readings of A and B will be equal



(A) At all times **(B)** After time RC **(C)** After time RC ℓn 2 **(D)** Only after a very long time

3. In the given figure, a capacitor of non–parallel plates is shown. The plates of capacitor are connected by a cell of emf V_0. If σ denotes surface charge density and E denotes electric field. Then



(A) $\sigma_A > \sigma_B$ **(B)** $E_F > E_D$ **(C)** $E_F = E_D$ **(D)** $\sigma_A = \sigma_B$

4. When a capacitor discharges through a resistance R, the time constant is τ and the maximum current in the circuit is i_0 –

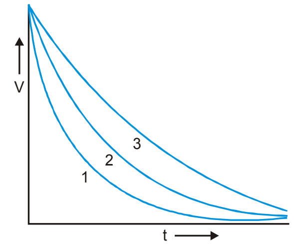
(A) The initial charge on the capacitor was $i_0\tau$

(B) The initial charge on the capacitor was $1/2\ i_0\tau$

(C) The initial energy stored in the capacitor was $i_0^2 R\tau$

(D) The initial energy stored in the capacitor was $1/2\ i_0^2 R\tau$

5. Three identical capacitors A, B and C are charged to the same potential and then made to discharge through three resistances R_A, R_B and R_C, where $R_A > R_B > R_C$. Their potential differences (V) are plotted against time t, giving the curves 1, 2 and 3. The relations between A, B, C and 1, 2, 3 is/are -



(A) $1 \rightarrow A$ **(B)** $2 \rightarrow B$ **(C)** $1 \rightarrow C$ **(D)** $3 \rightarrow A$

6. Capacitors $C_1 = 1\mu F$ and $C_2 = 2\mu F$ are separately charged from the same battery. They are then allowed to discharge separately through equal resistors–

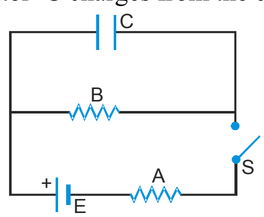
(A) The currents in the two discharging circuits at t = 0 is zero.

(B) The currents in the two discharging circuits at t = 0 are equal but not zero.

(C) The currents in the two discharging circuits at t = 0 are unequal.

(D) C_1 loses 50% of its initial charges sooner than C_2 loses 50% of its initial charge.

7. In the circuit shown, A and B are equal resistances. When S is closed, the capacitor C charges from the cell of emf E and reaches a steady state



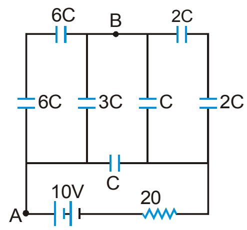
(A) During charging, more heat is produced in A than in B.

(B) In the steady state, heat is produced at the same rate in A and B.

(C) In the steady state, energy stored in C is $1/4\ CE^2$.

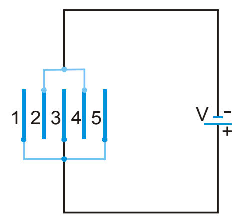
(D) In the steady state, energy stored in C is $1/8\ CE^2$

8. For the circuit shown here, the potential difference between points A and B is



(A) 2.5 V **(B)** 7.5 V **(C)** 10 V **(D)** Zero

9. Five identical capacitor plates, each of area A, are arranged such that adjacent plates are at distance d apart. The plates are connected to a source of emf V as shown in figure. Then the charges on plates 1 and 4 are, respectively

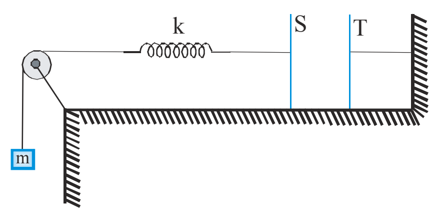


(A) $\frac{\varepsilon_0 AV}{d}, \frac{2\varepsilon_0 AV}{d}$ **(B)** $\frac{2\varepsilon_0 AV}{d}, \frac{-2\varepsilon_0 AV}{d}$ **(C)** $\frac{\varepsilon_0 AV}{d}, \frac{-2\varepsilon_0 AV}{d}$ **(D)** $\frac{\varepsilon_0 AV}{d}, \frac{-\varepsilon_0 AV}{d}$

10. A number of capacitors, each of capacitance 1 μF and each one of which gets punctured if a potential difference just exceeding 500 volt is applied are provided. Then an arrangement suitable for giving a capacitor of capacitance 3 μF across which 2000 volt may be applied requires at least :–

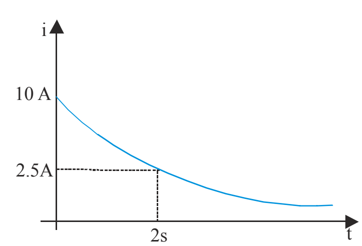
(A) 4 component capacitors **(B)** 12 component capacitors
(C) 48 component capacitors **(D)** 16 component capacitors

11. The plates S and T of an uncharged parallel plate capacitor are connected across a battery. The battery is then disconnected and the charged plates are now connected in a system as shown in the figure. The system shown is in equilibrium. All the strings and spring are insulating and massless. The magnitude of charge on one of the capacitor plates is : [Area of plates = A]



(A) $\sqrt{2mgA\varepsilon_0}$ **(B)** $\sqrt{\frac{4mgA\varepsilon_0}{k}}$ **(C)** $\sqrt{mgA\varepsilon_0}$ **(D)** $\sqrt{\frac{2mgA\varepsilon_0}{k}}$

12. The figure shows, a graph of the current a discharging circuit of a capacitor through a resistor of resistance 10 Ω:



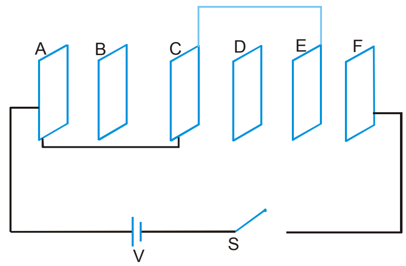
(A) The initial potential difference across the capacitor is 100 volt.

(B) The capacitance of the capacitor is $\frac{1}{10\ell n2}$ F.

(C) The total heat produced in the circuit will be $\frac{500}{\ell n2}$ joules

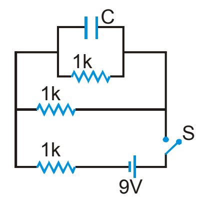
(D) The thermal power in the resistor will decreases with a time constant $\frac{1}{2\ell n2}$ second.

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



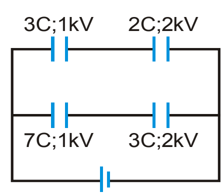
(A) $\frac{3\varepsilon_0 A}{2d}V^2$ **(B)** $\frac{5\varepsilon_0 A}{12d}V^2$ **(C)** $\frac{\varepsilon_0 A}{2d}V^2$ **(D)** $\frac{\varepsilon_0 A}{d}V^2$

14. A capacitor C = 100 μF is connected to three resistor each of resistance 1kΩ and a battery of emf 9V. The switch S has been closed for long time so as to charge the capacitor. When switch S is opened, the capacitor discharges with time constant–



(A) 33 ms **(B)** 5 ms **(C)** 3.3 ms **(D)** 50 ms

15. The diagram shows four capacitors with capacitance and break down voltages as mentioned. What should be the maximum value of the external emf source such that no capacitor breaks down?



(A) 2.5 kV **(B)** 10/3kV **(C)** 3 kV **(D)** 1 kV

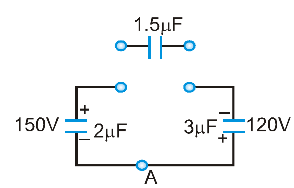
16. Two capacitors of 2μF and 3μF are charged to 150 volt and 120 volt respectively. The plates of capacitor are connected as shown in the figure. A discharged capacitor of capacity 1.5μF falls to the free ends of the wire. Then–

(A) charge on the 1.5μF capacitor is 180μC

(B) charge on the 2μF capacitor is 120 μF

(C) charge flows through A from right to left

(D) charge flows through A from left to right.



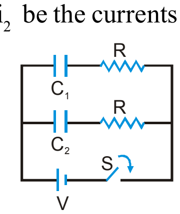
17. In the circuit shown in figure $C_1 = 2C_2$. Switch S is closed at time t=0. Let i_1 and i_2 be the currents flowing through C_1 and C_2 at any time , then the ratio i_1/i_2

(A) is constant

(B) increases with increase in time t

(C) decreases with increase in time t

(D) first increases then decreases



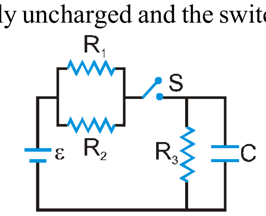
18. The circuit shown in the figure consists of a battery of emf ε=10 V; a capacitor of capacitance C=1.0 μF and three resistor of values $R_1 = 2\Omega$, $R_2 = 2\Omega$ and $R_3 = 1\Omega$. Initially the capacitor is completely uncharged and the switch S is open. The switch S is closed at t = 0.

(A) The current through resistor R_3 at the moment the switch closed is zero

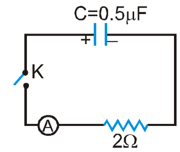
(B) The current through resistor R_3 a long time after the switch closed is 5A.

(C) The ratio of current through R_1 and R_2 is always constant

(D) The maximum charge on the capacitor during the operation is 5μC

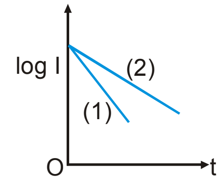


19. A charged capacitor is allowed to discharge through a resistor by closing the key at the instant t = 0. At the instant t = (ℓn4)μs, the reading of the ammeter falls half the initial value. The resistance of the ammeter is equal to–



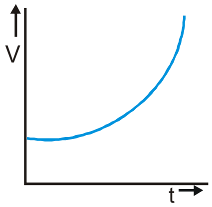
(A) 1MΩ **(B)** 1Ω **(C)** 2Ω **(D)** 2MΩ

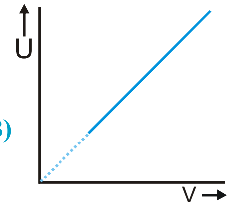
20. A capacitor of capacity C is charged to a steady potential difference V and connected in series with an open key and a pure resistor 'R'. At time t=0, the key is closed. If I = current at time t, a plot of log I against 't' is as shown in (1) in the graph. Later one of the parameters i.e. V,R or C is changed keeping the other two constant, and the graph (2) is recorded. Then–

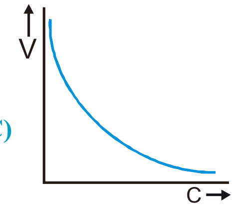


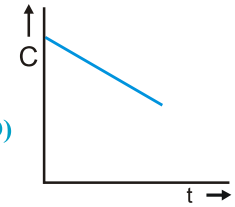
(A) C is reduced **(B)** C is increased **(C)** R is reduce **(D)** R is increased

21. A parallel plate capacitor has a dielectric slab in it. The slab just fills the space inside the capacitor. The capacitor is charged by a battery and then battery is disconnected. Now the slab is started to pull out slowly at t=0. If at time t, capacitance of the capacitor is C, potential difference across is V and energy stored in it is U, then which of the following graphs are correct?

(A) 

(B) 

(C) 

(D) 

22. 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 :

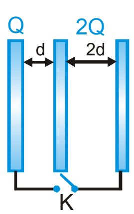
(A) Charge on the inner face of B is now $-\frac{3Q}{2}$

(B) There is no change in the potential difference between A and B

(C) Potential difference between A and C is one–third of the potential difference between B and C

(D) Charge on the inner face of A is now $\frac{Q}{2}$

23. Three large plates are arranged as shown. How much charge will flow through the key k if it is closed ?

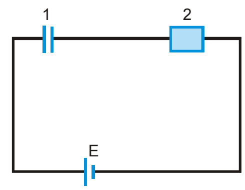


(A) $\frac{5Q}{6}$ **(B)** $\frac{4Q}{3}$ **(C)** $\frac{3Q}{2}$ **(D)** None of these

24. 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 = 30V and then connected to the first capacitor after disconnecting the voltage source. The charge and voltage on capacitor

(A) A are $25C_0$ and 25V **(B)** A are $25C_0$ and 5V **(C)** B are $5C_0$ and 5V **(D)** B are $5C_0$ and 25V

25. Two identical capacitors 1 and 2 are connected in series to a battery as shown in figure. Capacitor 2 contains a dielectric slab of dielectric constant k as shown. Q_1 and Q_2 are the charges stored in the capacitors. Now the dielectric slab is removed and the corresponding charges are Q'_1 and Q'_2. Then



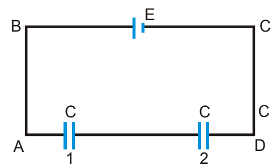
(A) $\frac{Q'_1}{Q_1} = \frac{k+1}{k}$ **(B)** $\frac{Q'_2}{Q_2} = \frac{k+1}{2}$

(C) $\frac{Q'_2}{Q_2} = \frac{k+1}{2k}$ **(D)** $\frac{Q'_1}{Q_1} = \frac{k}{2}$

26. A capacitor of capacitance C is charged to a potential difference V from a cell and then disconnected from it. A charge +Q is now given to its positive plate. The potential difference across the capacitor is-

(A) V **(B)** $V + \frac{Q}{C}$ **(C)** $V + \frac{Q}{2C}$ **(D)** $V - \frac{Q}{C}$, if $V < CV$

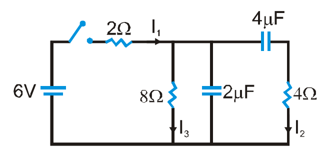
27. In the adjoining figure, capacitor (1) and (2) have a capacitance 'C' each.When the dielectric of dielectric constant K is inserted between the plates of one of the capacitor, the total charge flowing through battery is-



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

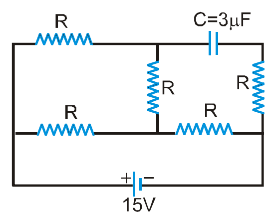
(C) $\frac{(K-1)CE}{2(K+1)}$ from B to C **(D)** $\frac{(K-1)CE}{2(K+1)}$ from C to B

28. In the circuit shown in the figure, the switch S is initially open and the capacitor is initially uncharged. I_1, I_2 and I_3 represent the current in the resistance 2Ω, 4Ω and 8Ω respectively.



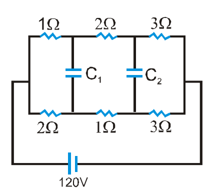
(A) Just after the switch S is closed, $I_1 = 3A$, $I_2 = 3A$ and $I_3 = 0$
(B) Just after the switch S is closed, $I_1 = 3A$, $I_2 = 0$ and $I_3 = 0$
(C) Long time after the switch S is closed, $I_1 = 0.6A$, $I_2 = 0$ and $I_3 = 0$
(D) Long time after the switch S is closed, $I_1 = I_2 = I_3 = 0.6A$.

29. In the circuit shown, the cell is ideal, with emf = 15V. Each resistance is of 3Ω. The potential difference across the capacitor is



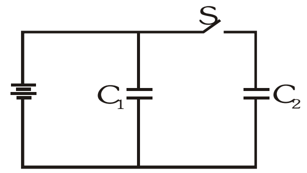
(A) zero **(B)** 9V **(C)** 12V **(D)** 15V

30. In the circuit shown in figure $C_1 = C_2 = 2\mu F$. Then charge stored in



(A) capacitor C_1 is zero
(B) capacitor C_2 is zero
(C) both capacitor is zero
(D) capacitor C_1 is 40 μC

31. Two capacitors of equal capacitance ($C_1=C_2$) are shown in the figure. Initially, while the switch S is open, one of the capacitors is uncharged and the other carries charge Q_0. The energy stored in the charged capacitor is U_0. Sometimes after the switch is closed, the capacitors C_1 and C_2 carry charges Q_1 and Q_2, respectively; the voltage across the capacitors are V_1 and V_2; and the energies stored in the capacitors are U_1 and U_2. Which of the following statements is incorrect ?

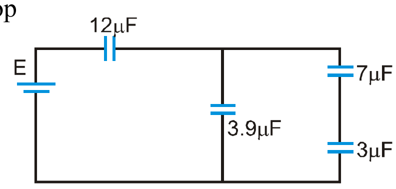


(A) $Q_0 = \frac{1}{2}(Q_1+Q_2)$ **(B)** $Q_1=Q_2$ **(C)** $V_1=V_2$ **(D)** $U_1=U_2$ **(E)** $U_0 = U_1+U_2$

32. A capacitor C is charged to a potential difference V and battery is disconnected. Now if the capacitor plates are brought close slowly by some distance

(A) Some +ve work is done by external agent
(B) Energy of capacitor will decrease
(C) Energy of capacitor will increase
(D) None of the above

33. Four capacitors and a battery are connected as shown. The potential drop across the 7μF capacitor is 6V. Then the



(A) potential difference across the 3μF capacitor is 10V
(B) charge on the 3μF capacitor is 42μC
(C) e.m.f. of the battery is 30V
(D) potential difference across the 12μF capacitor is 10V.

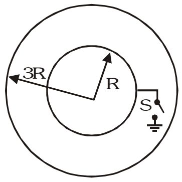
34. A parallel plate capacitor of plate area A and plate separation d is charged to potential difference V and then the battery is disconnected. A slab of dielectric constant K is then inserted between the plates of the capacitor so as to fill the space between the plates. If Q,E and W denote respectively,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

(A) $Q=\frac{\varepsilon_o AV}{d}$ **(B)** $Q=\frac{\varepsilon_o KAV}{d}$ **(C)** $E=\frac{V}{Kd}$ **(D)** $W=-\frac{\varepsilon_0 AV^2}{2d}\left(1-\frac{1}{K}\right)$

35. An uncharged capacitor having capacitance C is connected across a battery of emf V. Now the capacitor is disconnected and then reconnected across the same battery but with reversed polarity. Then which of the statement is incorrect

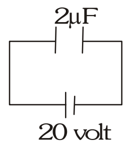
(A) After reconnecting, heat energy produced in the circuit will be equal to two–third of the total energy supplied by battery.
(B) After reconnecting, no energy is supplied by battery.
(C) After reconnecting, whole of the energy supplied by the battery is converted into heat.
(D) After reconnecting, thermal energy produced in the circuit will be equal to $2CV^2$.

36. Two thin conducting shells of radii R and 3R are shown in the figure. The outer shell carries a charge +Q and the inner shell is neutral. The inner shell is earthed with the help of a switch S.



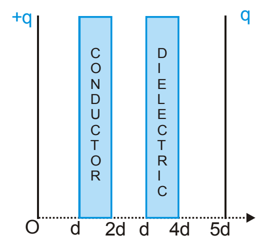
(A) With the switch S open, the potential of the inner sphere is equal to that of the outer
(B) When the switch S is closed, the potential of the inner sphere becomes zero
(C) With the switch S closed, the charge attained by the inner sphere is –Q/3
(D) By closing the switch the capacitance of the system increases

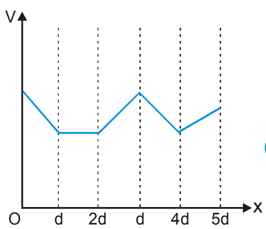
37. In the figure a capacitor of capacitance 2μF is connected to a cell of emf 20 volt. The plates of the capacitor are drawn apart slowly to double the distance between them, The work done by the external agent on the plates is :

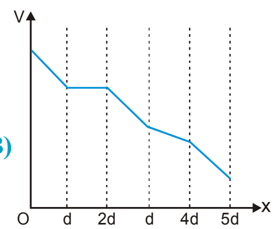


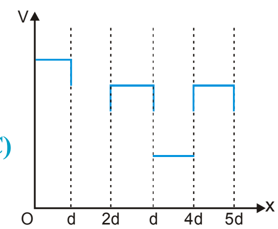
(A) – 200μJ **(B)** 200μJ **(C)** 400μJ **(D)** – 400μJ

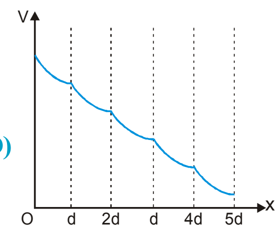
38. The distance between plates of a parallel plate capacitor is 5d. The positively charged plate is at x=0 and negatively charged plates is at x=5d. Two slabs one of conductor and the other of a dielectric of same thickness d are inserted between the plates as shown in figure. Potential (V) versus distance x graph will be



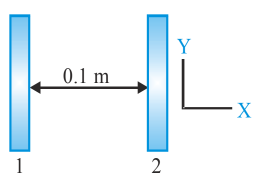
(A)


(B)


(C)


(D)


39. Two insulating plates are both uniformly charged in such a way that the potential difference between them is $V_2 - V_1 = 20$ V. (i.e., plate 2 is at a higher potential). The plates are separated by d = 0.1 m and can be treated as infinitely large. An electron is released from rest on the inner surface of plate 1. What is its speed when it hits plate 2 ? ($e = 1.6 \times 10^{-19}$ C, $m_e = 9.11 \times 10^{-31}$ kg)



(A) 2.65×10^6 m/s **(B)** 7.02×10^{12} m/s **(C)** 1.87×10^6 m/s **(D)** 32×10^{-19} m/s

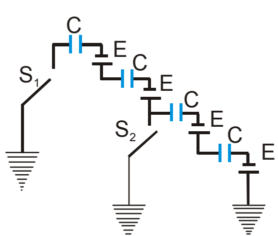
40. A capacitor of capacitance C is initially charged to a potential difference of V volt. Now it is connected to a battery of 2V with opposite polarity. The ratio of heat generated to the final energy stored in the capacitor will be

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

41. A conducting body 1 has some initial charge Q, and its capacitance is C. There are two other conducting bodies, 2 and 3, having capacitance : $C_2 = 2C$ and $C_3 \to \infty$. Bodies 2 and 3 are initially uncharged. Body 2 is touched with body 1. Then, body 2 is removed from body 1 and touched with body 3, and then removed. This process is repeated for N times. Then, the charge on body 1 at the end must be :

(A) $Q/3^N$ **(B)** $Q/3^{N-1}$ **(C)** Q/N^3 **(D)** None of these

42. In the given circuit, all the capacitors are initially uncharged. After closing the switch S_1 for a long time suddenly S_2 is also closed and kept closed for a long time. Total heat produced after closing S_2 will be:



(A) $4\,CE^2$ **(B)** $\frac{1}{2}CE^2$

(C) $2\,CE^2$ **(D)** 0

Part # II [Assertion & Reason Type Questions]

These questions contains, Statement 1 (assertion) and Statement 2 (reason).

(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1

(B) Statement–1 is True, Statement–2 is True ; Statement–2 is NOT a correct explanation for Statement–1

(C) Statement–1 is True, Statement–2 is False.

(D) Statement–1 is False, Statement–2 is True.

(E) Both Statement-1 and Statement-2 are false.

1. **Statement–I :** Increasing the charge on the plates of a capacitor means increasing the capacitance.

Statement–II : Because $Q = CV \Rightarrow Q \propto C$.

2. **Statement–I :** When dielectric is filled between plates of capacitor battery is disconnected then its potential energy increases.

Statement–II : Work is done on capacitor by external system when dielectric is inserted.

3. **Statement–I :** Capacitor is filled with, same thickness of dielectric ($t < d$) and conducting sheet one after another, then capacitance are C_1 and C_2 respectively then $C_1 < C_2$.

Statement–II : Capacitance is more in presence of metal sheet in compare to dielectric sheet as $K_{Conduct} > K_{dielectric}$.

4. **Statement–I :** A dielectric slab is inserted between the plates of an isolated charged capacitor. The charge on the capacitor will remain the same.

Statement–II : Charge on a isolated system is conserved.

5. **Statement–I :** If the distance between parallel plates of a capacitor is halved and dielectric constant is made three times, then the capacitance becomes 6 times.

Statement–II : Capacitance of the capacitor does not depend upon the nature of the material of the plates of the capacitor.

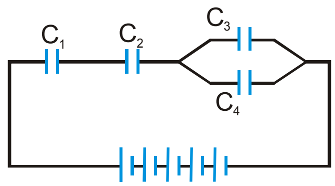
6. **Statement–I :** The capacitance of a capacitor depends on the shape, size and geometrical placing of the conductors and its medium between them.

Statement–II : When a charge q passes through a battery of emf E from the negative terminal to an positive terminal, an amount qE of work is done by the battery.

Exercise # 3

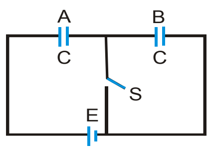
Part # I [Matrix Match Type Questions]

1. In the circuit shown in figure. $C_1=C$, $C_2=2C$, $C_3=3C$, $C_4=4C$.



Column I		Column II	
(A)	Maximum potential difference	**(P)**	across C_1
(B)	Minimum potential difference	**(Q)**	across C_2
(C)	Maximum potential energy	**(R)**	across C_3
(D)	Minimum potential energy	**(S)**	across C_4

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

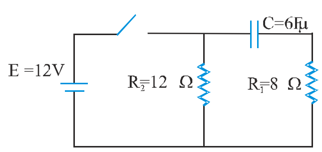


Column–I		Column–II	
(A)	Charge flown through battery when S is closed	**(P)**	$\frac{CE^2}{2}$
(B)	Work done by battery	**(Q)**	$\frac{CE}{2}$
(C)	Charge on capacitor A when switch S is closed	**(R)**	$\frac{CE^2}{4}$
(D)	Heat developed in the system	**(S)**	CE

Part # II [Comprehension Type Questions]

Comprehension # 1

The circuit contains ideal battery E and other elements arranged as shown. The capacitor is initially uncharged and switch S is closed at t = 0, (use $e^2 = 7.4$):



1. Time constant of the circuit is:

(A) 48 μs **(B)** 28.8 μs **(C)** 72 μs **(D)** 120 μs

2. The potential difference across the capacitor in volts, after two time constants, is :

(A) 2 **(B)** 7.6 **(C)** 10.4 **(D)** 12

3. The potential difference across resistor R_1 involtes after two time constants, is :

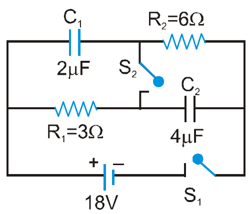
(A) 1.6 **(B)** 7.6 **(C)** 10 **(D)** 12

4. The potential difference across resistor R_2 involts after two time constants, is:

(A) 2 **(B)** 7.6 **(C)** 10 **(D)** 12

Comprehension # 2

In the circuit shown initially the switches are open and capacitors are uncharged. Switches S_1 and S_2 are closed simultaneously at $t = 0$.



1. Charge on capacitor C_2

(A) 12 μC **(B)** 24 μC **(C)** 48 μC **(D)** None of these

2. Now switch S_2 is opened after a long time interval then charge flow through the S_1 is

(A) 12 μC **(B)** 24 μC **(C)** 36 μC **(D)** 48 μC

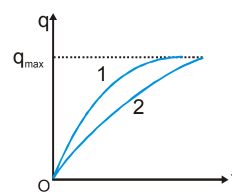
3. In above question the amount of heat dissipated in resistors

(A) 136 μJ **(B)** 272 μJ **(C)** 68 μJ **(D)** None of these

Comprehension # 3

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

1. Choose the correct statement (s) related to the two circuits.



(A) Both the capacitors are charged to the same charge.

(B) The emf's of cells in both the circuit are equal.

(C) The emf's of the cells may be different.

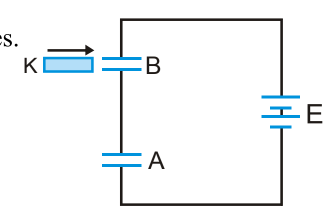
(D) The emf E_1 is more than E_2

2. Identify the correct statement(s) related to the R_1, R_2, C_1 and C_2 of the two RC circuits

(A) $R_1 > R_2$ if $E_1 = E_2$ **(B)** $C_1 < C_2$ if $E_1 = E_2$ **(C)** $R_1C_1 > R_2C_2$ **(D)** $\frac{R_1}{R_2} < \frac{C_2}{C_1}$

Comprehension # 4

Two identical capacitor A and B, each of capacitance 'C' are connected in series.



The combination connected to a battery of emf E. A dielectric slab of dielectric constant K is introduced between the plates of capacitor B to cover entire space between the plates.

1. After introduction of dielectric slab in B, the ratio of capacitance of A and B is

(A) 1:1 **(B)** 1:K **(C)** K:1 **(D)** 1: $\sqrt{K}$

2. After introduction of dielectric slab in B, the ratio of potential differences across A and B will be

(A) 1:1 **(B)** 1:K **(C)** K:1 **(D)** 1: $\sqrt{K}$

3. The ratio of potential differences across A before and after the introduction of dielectric slab in B will be

(A) 1:1 **(B)** 1:K **(C)** (K+1) :2 **(D)** K+1:2K

4. The ratio of potential difference across B before and after the introduction of dielectric slab in B will be

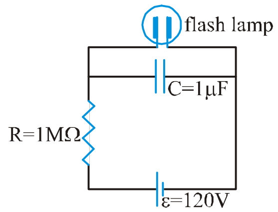
(A) 1:1 **(B)** K:1 **(C)** (K+1):2 **(D)** K+1:2K

5. The ratio of energy stored in capacitors A and B after the introduction of dielectric slab in B is

(A) 1:1 **(B)** 1:K **(C)** K:1 **(D)** $(K+1)^2:K^2$

Comprehension # 5

A highway emergency flasher uses a 120 volt battery, a 1 MΩ resistor, a 1 mF capacitor and a neon flash lamp in the circuit shown in the figure. The flash lamp has a resistance more than 10^{10} Ω when the voltage across it is less than 110V. Above 110 V, the neon gas ionizes, the lamp's resistance drops to 10 Ω, and the capacior discharges completely. Until the capacitor voltage reaches the breackdown voltage V_b = 110 V, the large resistance of the flash lamp ensures that it draws a negligible current.



The capacitor charges as if the lamp were absent. At V_b, however, the lamp resistance quickly becomes negligible, and the capacitor discharges through the lamp as if the battery and the series resistor were absent. The time between the flashes is the time for the capacitor to charge to V_b. The flash duration is roughly the time for the capacitor to discharge through the lamp, or about 3 time constant of the capacitor–lamp circuit. The flash energy is the stored energy in the capacitor at 110 volt.

1. The flash interval is found by solving for the time when the capacitor voltage is V_b = 110 V.
$V_b = \varepsilon(1 - e^{-t/CR})$, $\ell n\ 12 = 2.5$). Flash interval is

(A) 2 s **(B)** 2/5 s **(C)** 5/2 s **(D)** 1 s

2. Time constant (τ_c) of the capacitor–lamp circuit is-

(A) 20 μs **(B)** 15 μs **(C)** 30 μs **(D)** 10 μs

3. Flash duration is

(A) 10 μs **(B)** 20 μs **(C)** 30 μs **(D)** 5 μs

4. The energy in the flash is

(A) 6.1 mJ **(B)** 6.1 J **(C)** 3 mJ **(D)** 12.2 mJ

Exercise # 4

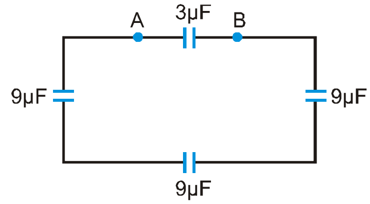
[Subjective Type Questions]

1. A 400 μF condenser is charged at the steady rate of 100 μC per second. Calculate the time required to establish a potential difference of 100 volt between its plates.

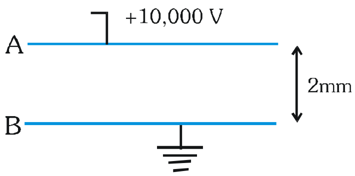
2. Four capacitors are connected as shown in fig. If a 4 volt battery is connected between A and B then calculate

(i) Total charge stored on the capacitors.

(ii) Total electrostatic energy stored in capacitors.

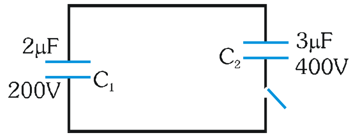


3. Two plates A and B are kept at a distance of 2 mm, as shown in figure. The plate A is at potential of 10,000 volt and the plate B is earthed. Determine the intensity of electric field between the plates.



4. An insulated conductor initially free from charge is charged by repeated contacts with a plate which after each contact has a charge Q due to some mechanism. If q is charge on the conductor after the first operation, prove that the maximum charge which can be given to the conductor is this way is $\frac{Qq}{Q-q}$.

5. Two capacitor of capacity C_1 and C_2 are connected according to figure. Now switch is closed. Calculate charge on each capacitor.



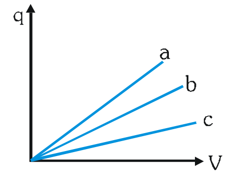
6. A battery of 10 V is connected to a capacitor of capacitance 0.1 μF. The battery is now removed and this capacitor is connected to a second uncharged capacitor. If the charge distributes equally on these two capacitors then find

(i) The total energy stored in two capacitors.

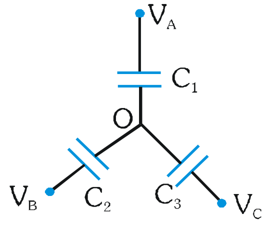
(ii) The ratio of this energy with the initial energy stored in the first capacitors.

7. Figure shows plots of charges versus potential difference for three parallel plate capacitors, which have the plate areas and separations given in the table. Which of the plots goes with which of the capacitors ?

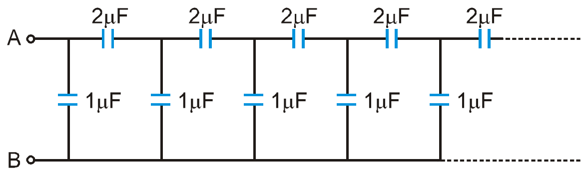
Capacitor	Area	Separation
1	A	d
2	2A	d
3	A	2d



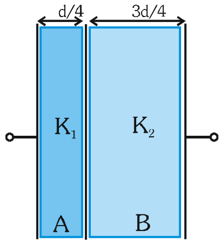
8. Calculate the potential of point O in terms of $C_1, C_2, C_3, V_A, V_B, \& V_C$ in the following circuit.



9. Find the equivalent capacitance of the infinite ladder shown in figure between the points A & B.

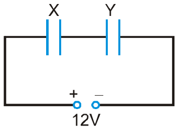


10. Two medium of dielectric constant K_1 and K_2 are introduced according to given figure. If $\frac{K_1}{K_2}=3$ then calculate ratio of capacity of part A and part B and net capacity of system. (Area of each plate is A)



11. A parallel plate capacitor is to be designed with a voltage rating 1 kV using a material of dielectric constant 10 and dielectric strength 10^6 Vm^{-1}. What minimum area of the plates is required to have a capacitance of 88.5 pF ?

12. X and Y are two parallel plate capacitors having the same area of plates and same separation between the plates. X has air between the plates and Y contains a dielectric medium $\varepsilon_r = 5$.

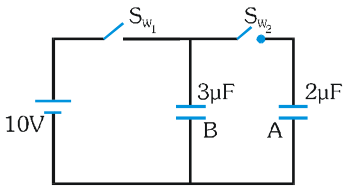


(i) Calculate the potential difference between the plates of X and Y.

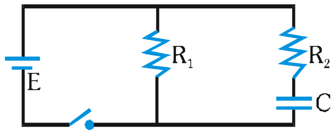
(ii) What is the ratio of electrostatic energy stored in X and Y ?

13. A potential difference of 300V is applied between the plates of a plane capacitor spaced 1 cm apart. A plane parallel glass plate with a thickness of 0.5 cm and a plane parallel paraffin plate with a thickness of 0.5 cm are placed in the space between the capacitor plates find **(i)** intensity of electric field in each layer **(ii)** the drop of potential in each layer **(iii)** the surface charge density of the charge on the plates. Given that : $K_{paraffin}=2$, $K_{glass}=6$.

14. In given circuit switch S_{W_1} is closed and S_{W_2} is open. After long time S_{W_1} is opened and S_{W_2} is closed. Calculate charge on each capacitor.



15. For the circuit shown in figure, find



(i) the initial current through each resistor

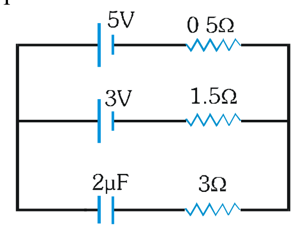
(ii) steady state current through each resistor

(iii) final energy stored in the capacitor

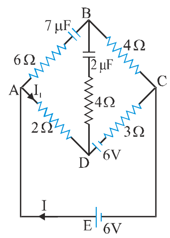
(iv) time constant of the circuit when switch is opened

(v) time constant of the circuit when switch is closed

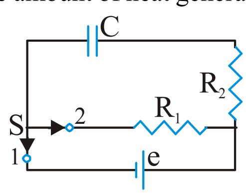
16. In given circuit find the charge on capacitor.



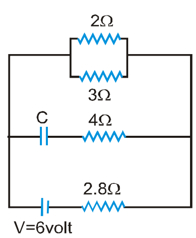
17. In the network shown in figure, find I, I_1 and the charge on the 7μF capacitor after equilibrium conditions have been reached.



18. A capacitor of capacitance C = 5 μF is connected to a source of constant emf e = 200 V. The switch S was thrown over from contact 1 to contact 2. Find the amount of heat generated in a resistance R_1 = 500Ω if R_2 = 330Ω.

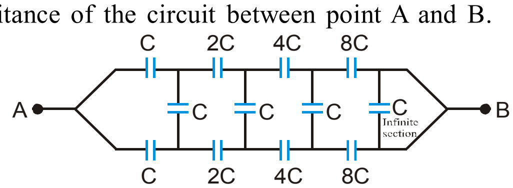


19. Calculate the steady state current in the 2Ω resistor shown in the circuit (see figure). The internal resistance of the battery is negligible and the capacitance of the condenser C is 0.2 μF.

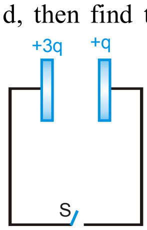


20. The plates of a parallel plate capacitor are given charges +4Q and -2Q. The capacitor is then connected across an uncharged capacitor of same capacitance as first one (=C). Find the final potential difference between the plates of the first capacitor.

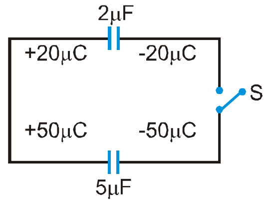
21. Find the equivalent capacitance of the circuit between point A and B.



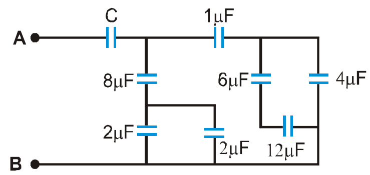
22. The two identical parallel plates are given charges as shown in figure. If the plate area of either face of each plate is A and separation between plate is d, then find the amount of heat liberate after closing the switch.



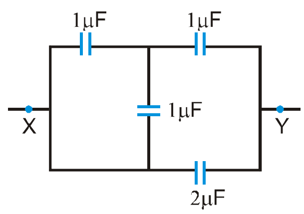
23. Find heat produced in the circuit shown in figure on closing the switch S.



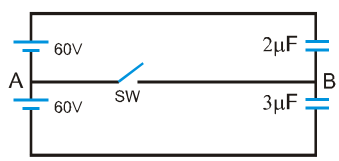
24. In the following circuit, the resultant capacitance between A and B is 1μF. Find the value of C.



25. The figure shows a circuit consisting of four capacitors. Find the effective capacitance between X and Y.

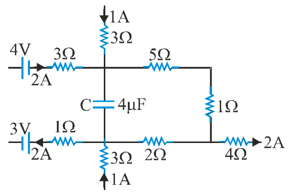


26. In the circuit shown in the figure, initially SW is open. When the switch is closed, the charge passing through the switch__ in the direction_ to....

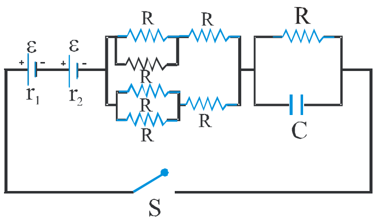


27. A leaky parallel plane capacitor is filled completely with a material having dielectric constant k = 5 and electrical conductivity s = $7.4 \times 10^{-12}\ \Omega^{-1}\ m^{-1}$. If the charge on the plane at instant t = 0 is q = 8.85 mC, then calculate the leakage current at the instant t = 12s.

28. A part of circuit in a steady state along with the currents flowing in the branches, the values of resistances etc. is shown in the figure. Calculate the energy stored in the capacitor C (4μF).

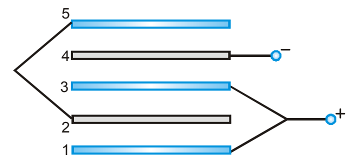


29. In the circuit shown in the figure initially switch S is open and capacitor is uncharged. Internal resistances of the cells are r_1 and r_2 their emf's are equal to ε. The potential difference across the cell of internal resistance r_1 becomes zero long time after closing the switch. Find the value of R in terms of other known physical quantities. All symbols have their usual meaning.

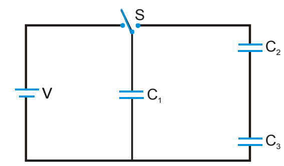


30. The gap between the plates of a plane capacitor is filled with an isotropic insulator whose di–electric constant varies in the direction perpendicular to the plates according to the law $K = K_1\left[1 + \sin\frac{\pi}{d}x\right]$, where d is the separation, between the plates and K_1 is a constant. The area of the plates is S. Determine the capacitance of the capacitor.

31. Five identical conducting plates 1, 2, 3, 4 and 5 are fixed parallel to and equidistant from each other (see figure). Plates 3 and 5 are connected by a conductor while 1 and 3 are joined by another conductor. The junction of 1 and 3 and the plate 4 are connected to a source of constant e.m.f. V_0. Find
(i) the effective capacity of the system between the terminals of the source
(ii) the charges on plates 3 and 5.
Given : d = distance between any 2 successive plates and A=area of either face of each plate.



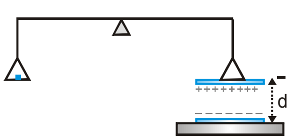
32. When the switch S in the figure is thrown to the left, the plates of capacitors C_1 acquire a potential difference V. Initially the capacitors C_2 and C_3 are uncharged. The switch is now thrown to the right. What are the final charges q_1, q_2 and q_3 on the corresponding capacitors.



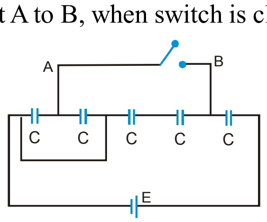
33. A parallel plate capacitor is filled by a dielectric whose relative permittivity varies with the applied voltage according to the law $\varepsilon_r = \alpha V$, where $\alpha = 1$ per volt. The same (but containing no dielectric) capacitor charged to a voltage V=156 volt is connected in parallel to the first "non–linear" uncharged capacitor. Determine the final voltage V_f across the capacitors.

34. A capacitor consists of two air spaced concentric cylinders. The outer radius b is fixed, and the inner is of radius a. If breakdown of air occurs at field strength greater than Eb show that the inner cylinder should have
(i) radius a= b/e if the potential of the inner cylinder is to be maximum
(ii) radius a=b/ $\sqrt{e}$ if the energy per unit length of the system is to be maximum.

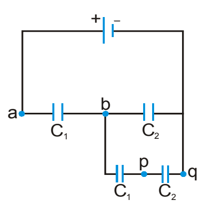
35. The lower plate of a parallel plate capacitor lies on an insulating plane. The upper plate is suspended from one end of a balance. The two plates are joined together by a thin wire and subsequently disconnected. The balance is achieved. A voltage 5000V is applied between the plates, what additional weight should be placed to maintain the balance? The separation between the plates d=5 mm and the area of each plate, A=100 cm^2.



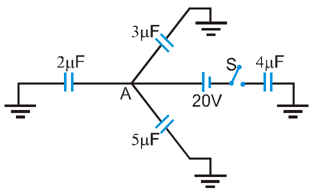
36. Find the charge which flows from point A to B, when switch is closed.



37. In the given network if potential difference between p and q is 2V and $C_2 = 3C_1$, then find the potential difference between a & b.



38. Three capacitors of 2μF, 3μF and 5μF are individually charged with batteries of emf's 5V, 20V and 10V respectively. After disconnecting from the voltage sources, these capacitors are connected as shown in figure with their positive polarity plates are connected to A and negative polarity is earthed. Now a battery of 20V and an uncharged capacitor of 4μF capacitance are connected to the junction A as shown with a switch S. When switch is closed, find



(i) the potential of the junction A.
(ii) final charges on all four capacitors.

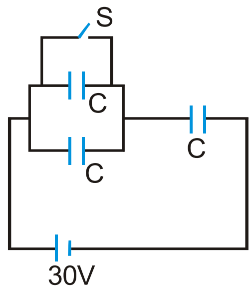
39. The plates of a parallel plate capacitor are separated by a distance d=1 cm. Two parallel sided dielectric slabs of thickness 0.7 cm and 0.3 cm fill the space between the plates. If the dielectric constants of the two slabs are 3 and 5 respectively and a potential difference of 440V is applied across the plates. Find :
(i) the electric field intensities in each of the slabs.
(ii) the ratio of electric energies stored in the first to that in the second dielectric slab.

40. Two parallel plate capacitors of capacitance C and 2C ae connected in parallel then following steps are performed.
(i) A battery of voltage V is connected across the capacitors.
(ii) A dielectric slab of relative permittivity k is slowly inserted in capacitor C.
(iii) Battery is disconnected.
(iv) Dielectric slab is slowly removed from capacitor.
Find the heat produced in **(i)** and work done by external agent in step **(ii)** & **(iv)**.

41. A charge 200 μC is imparted to each of the two identical parallel plate capacitors connected in parallel. At t=0, the plates of both the capacitors are 0.1 m apart. The plates of first capacitor move towards each other with velocity 0.001 m/s and plates of second capacitor move apart with the same velocity. Find the current in the circuit.

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

43. The capacitor each having capacitance C=2μF are connected with a battery of emf 30V as shown in figure. When the switch S is closed. Find
(i) the amount of charge flown through the battery
(ii) the heat generated in the circuit
(iii) the energy supplied by the battery
(iv) the amount of charge flown through the switch S



Exercise # 5

Part # I [Previous Year Questions] [AIEEE/JEE-MAIN]

1. A ball whose kinetic energy is E, is projected at an angle of 45° to the horizontal. The kinetic energy of the ball at the highest point of its flight will be- **[AIEEE - 2002]**

(1) E (2) $E/\sqrt{2}$ (3) E/2 (4) zero

2. If there are n capacitors in parallel connected to V volt source, then the energy stored is equal to- **[AIEEE - 2002]**

(1) CV (2) $\frac{1}{2}nCV^2$ (3) CV^2 (4) $\frac{1}{2n}CV^2$

3. Capacitance (in F) of a spherical conductor having radius 1 m, is- **[AIEEE - 2002]**

(1) 1.1×10^{-10} (2) 10^{-6} (3) 9×10^{-9} (4) 10^{-3}

4. A sheet of aluminium foil of negligible thickness is introduced between the plates of a capacitor. The capacitance of the capacitor- **[AIEEE - 2003]**

(1) decreases (2) remains unchanged (3) becomes infinite (4) increases

5. The work done in placing a charge of 8×10^{-18} coulomb on a condenser of capacity 100 micro-farad is : **[AIEEE-2003]**

(1) 16×10^{-32} joule (2) 3.1×10^{-26} joule (3) 4×10^{-10} joule (4) 32×10^{-32} joule

6. A fully charged capacitor has a capacitance 'C'. It is discharged through a small coil of resistance wire embedded in a thermally insulated block of specific heat capacity 's' and mass 'm'. If the temperature of the block is raised by 'ΔT', the potential difference 'V' across the capacitance is : **[AIEEE-2005]**

(1) $\sqrt{\frac{2mC\Delta T}{s}}$ (2) $\frac{mC\Delta T}{s}$ (3) $\frac{ms\Delta T}{C}$ (4) $\sqrt{\frac{2ms\Delta T}{C}}$

7. A parallel plate capacitor is made by stacking n equally spaced plates connected alternatively. If the capacitance between any two adjacent plates is 'C', then the resultant capacitance is : **[AIEEE-2005]**

(1) (n – 1)C (2) (n + 1) C (3) C (4) nC

8. A battery is used to charge a parallel plate capacitor till the potential difference between the plates becomes equal to the electromotive force of the battery. The ratio of the energy stored in the capacitor and the work done by the battery will be **[AIEEE-2007]**

(1) 1 (2) 2 (3) 1/4 (4) 1/2

9. A parallel plate condenser with a dielectric of dielectric constant *K* between the plates has a capacity *C* and is charged to a potential *V* volts. The dielectric slab is slowly removed from between the plates and then reinserted. The net work done by the system in this process is **[AIEEE-2007]**

(1) $\frac{1}{2}(K-1)CV^2$ (2) $CV^2(K-1)/K$ (3) $(K-1)CV^2$ (4) zero

10. A parallel plate capacitor with air between the plates has a capacitance of 9 pF. The separation between its plates is 'd'. The space between the plates is now filled with two dielectrics. One of the dielectrics has dielectric constant $k_1 = 3$ and thickness d/3 while the other one has dielectric constant $k_2 = 6$ and thickness 2d/3. Capacitance of the capacitor is now: **[AIEEE-2008]**

(1) 45 pF (2) 40.5 pF (3) 20.25 pF (4) 1.8 pF

11. Let C be the capacitance of a capacitor discharging through a resistor R. Suppose t_1 is the time taken for the energy stored in the capacitor to reduce to half its initial value and t_2 is the time taken for the charge to reduce to one-fourth its initial value. Then the ratio t_1/t_2 will be **[AIEEE-2010]**

(1) 1 (2) $\frac{1}{2}$ (3) $\frac{1}{4}$ (4) 2

12. A resistor 'R' and 2μF capacitor in series is connected through a switch to 200 V direct supply. Across the capacitor is a neon bulb that lights up at 120 V. Calculate the value of R to make the bulb light up 5s after the switch has been closed. ($\log_{10}2.5 = 0.4$) **[AIEEE - 2011]**

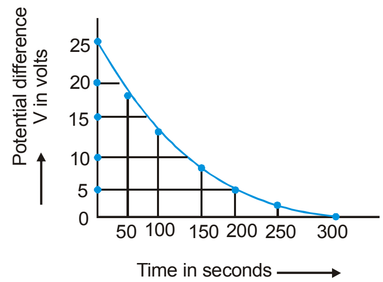
(1) $1.3 \times 10^4 \Omega$ **(2)** $1.7 \times 10^5 \Omega$ **(3)** $2.7 \times 10^6 \Omega$ **(4)** $3.3 \times 10^7 \Omega$

13. Combination of two identical capacitors, a resistor R and a dc voltage source of voltage 6V is used in an experiment on a (C – R) circuit. It is found that for a parallel combination of the capacitor the time in which the voltage of the fully charged combination reduces to half its original voltage is 10 second. For series combination the time needed for reducing the voltage of the fully charged series combination by half is : **[AIEEE -2011]**

(1) 10 second **(2)** 5 second **(3)** 2.5 second **(4)** 20 second

14. The figure shows an experimental plot discharging of a capacitor in an RC circuit. The time constant τ of this circuit lies between : **[AIEEE- 2012]**

(1) 150 sec and 200 sec
(2) 0 and 50 sec
(3) 50 sec and 100 sec
(4) 100 sec and 150 sec



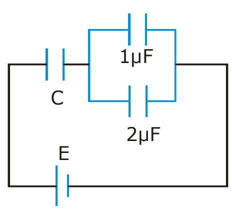
15. Two capacitors C_1 and C_2 are charged to 120 V and 200 V respectively. It is found that by connecting them together the potential on each one can be made zero. Then : **[JEE-Mains 2013]**

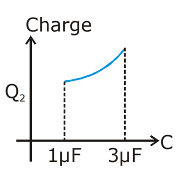
(1) $5C_1 = 3C_2$ **(2)** $3C_1 = 5C_2$ **(3)** $3C_1 + 5C_2 = 0$ **(4)** $9C_1 = 4C_2$

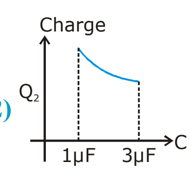
16. A parallel plate capacitor is made of two circular plates separated by a distance of 5 mm and with a dielectric of dielectric constant 2.2 between them. When the electric field in the dielectric is 3×10^4 V/m, the charge density of the positive plate will be close to : **[JEE-Mains 2014]**

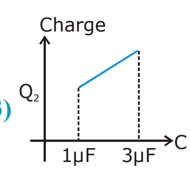
(1) 3×10^4 C/m^2 **(2)** 6×10^4 C/m^2 **(3)** 6×10^{-7} C/m^2 **(4)** 3×10^{-7} C/m^2

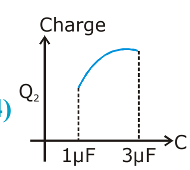
17. In the given circuit, charge Q_2 on the 2μF capacitor changes as C is varied from 1μF to 3μF. Q_2 as a function of 'C' is given properly by : (figure are drawn schematically and are not to scale) **[JEE-Mains 2015]**



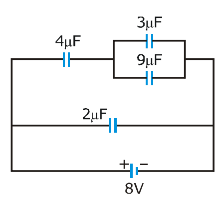
(1) 

(2) 

(3) 

(4) 

18. A combination of capacitors is set up as shown in the figure. The magnitude of the electric field, due to a point charge Q (having a charge equal to the sum of the charges on the 4μF and 9μF capacitors), at a point distant 30 m from it, would equal : **[JEE-Mains 2016]**

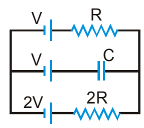


(1) 360 N/C **(2)** 420 N/C **(3)** 480 N/C **(4)** 240 N/C

Part # II [Previous Year Questions][IIT-JEE ADVANCED]

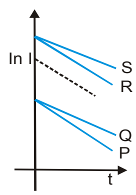
Straight Objective Type questions

1. In the given circuit, with steady current, the potential drop across the capacitor must be :– **[IIT-JEE 2002]**



(A) V **(B)** V/2 **(C)** V/3 **(D)** 2V/3

2. A capacitor is charged using an external battery with a resistance x in series. The dashed line shows the variation of ℓn I with respect to time. If the resistance is changed to 2x, the new graph will be : **[IIT-JEE 2004]**

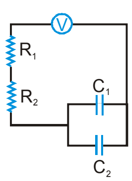


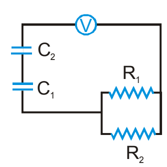
(A) P **(B)** Q **(C)** R **(D)** S

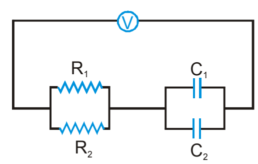
3. A 4μF capacitor, a resistance of 2.5 MΩ is in series with 12V battery. Find the time after which the potential difference across the capacitor is 3 times the potential difference across the resistor. [Given $\ell n2 = 0.693$]

(A) 13.86 s **(B)** 6.93 s **(C)** 7 s **(D)** 14 s **[IIT-JEE 2005]**

4. Find the time constant for the given RC circuits in correct order :R_1 = 1Ω, R_2 = 2Ω, C_1 = 4 μF and C_2 = 2μF



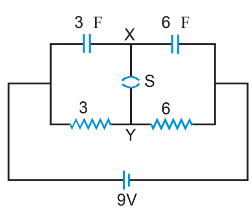




[IIT-JEE 2006]

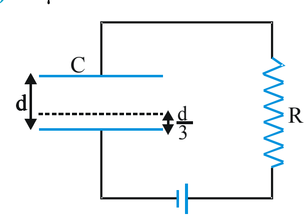
(A) 18, 4, 8/9 **(B)** 18, 8/9, 4 **(C)** 4, 18, 8/9 **(D)** 4, 8/9, 18

5. A circuit is connected as shown in the figure with the switch S is open. When the switch is closed, the total amount of charge that flows from Y to X is : **[IIT-JEE 2007]**



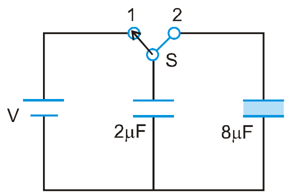
(A) zero **(B)** 54 μC **(C)** 27 μC **(D)** 81 μC

6. A parallel plate capacitor C with plates of unit area and separation d is filled with a liquid of dielectric constant K = 2. The level of liquid is $\frac{d}{3}$ initially. Suppose the liquid level decreases at a constant speed v, the time constant as a function of time t is : **[IIT-JEE 2008]**



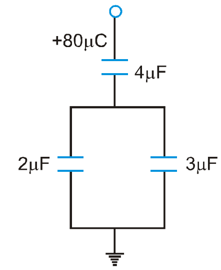
(A) $\frac{6\varepsilon_0 R}{5d + 3vt}$ **(B)** $\frac{(15d + 9vt)\varepsilon_0 R}{2d^2 - 3dvt - 9v^2t^2}$ **(C)** $\frac{6\varepsilon_0 R}{5d - 3vt}$ **(D)** $\frac{(15d - 9vt)\varepsilon_0 R}{2d^2 + 3dvt - 9v^2t^2}$

7. A 2μF capacitor is charged as shown in figure. The percentage of its stored energy dissipated after the switch S is turned to position 2 is **[JEE' 2010]**



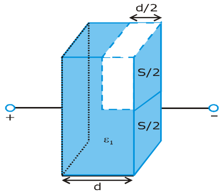
(A) 0% **(B)** 20%
(C) 75% **(D)** 80%

8. In the given circuit, a charge of +80 μC is given to the upper plate of the 4μF capacitor. Then in the steady state, the charge on the upper plate of the 3μF capacitor is : **[IIT-JEE-2012]**



(A) +32 μC **(B)** +40 μC **(C)** +48 μC **(D)** +80 μC

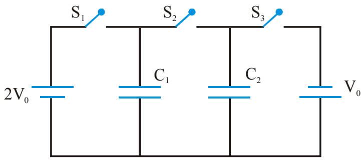
9. A parallel plate capacitor having plates of area S and plate separation d, has capacitance C_1 in air. When two dielectrics of different relative primitivities ($\varepsilon_1 = 2$ and $\varepsilon_2 = 4$) are introduced between the two plates as shown in the figure, the capacitance becomes C_2. The ratio $\frac{C_2}{C_1}$ is - **[IIT-JEE 2015]**



(A) 6/5 **(B)** 6/5 **(C)** 7/5 **(D)** 7/3

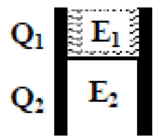
Multiple Correct type question

1. In the circuit shown in the figure, there are two parallel plate capacitors each of the capacitance C. The switch S_1 is pressed first to fully charge the capacitor C_1 and then released. The switch S_2 is then pressed to charge the capacitor C_2. After some time, S_2 is released and then S_3 is pressed, After some time, **[IIT-JEE 2013]**



(A) the charge on the upper plate of C_1 is $2CV_0$ **(B)** the charge on the upper plate of C_1 is CV_0
(C) the charge on the upper plate of C_2 is 0. **(D)** the charge on the upper plate of C_2 is $-CV_0$

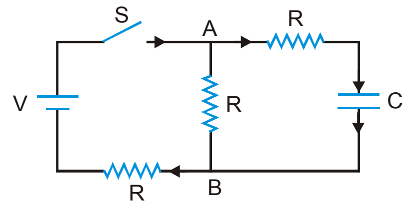
2. A parallel plate capacitor has a dielectric slab of dielectric constant K between its plates that covers 1/3 of the area of its plates, as shown in the figure. The total capacitance of the capacitor is C while that of the portion with dielectric in between is C_1. When the capacitor is charged, the plate area covered by the dielectric gets charge Q_1 and the rest of the area gets charge Q_2. The electric field in the dielectric is E_1 and that in the other portion is E_2. Choose the correct option/options, ignoring edge effects. **[IIT-JEE 2014]**



(A) $\frac{E_1}{E_2} = 1$ **(B)** $\frac{E_1}{E_2} = \frac{1}{K}$ **(C)** $\frac{Q_1}{Q_2} = \frac{3}{K}$ **(D)** $\frac{C}{C_1} = \frac{2+K}{K}$

Subjective Questions

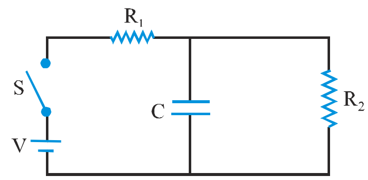
1. In the circuit shown in figure, the battery is an ideal one, with emf V. The capacitor is initially uncharged. The switch S is closed at time t= 0. **[IIT-JEE 1998]**



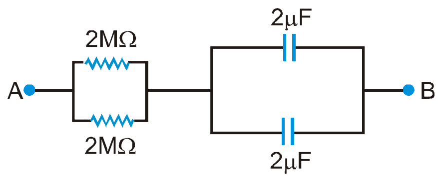
(i) Find the charge Q on the capacitor at time t.

(ii) Find the current in AB at time t. What is its limiting value as $t \to \infty$?

2. At t = 0, switch S is closed. The charge on the capacitor is varying with time $Q = Q_0(1 - e^{-\alpha t})$. Obtain the value of Q_0 and α in the given circuit parameters. **[IIT-JEE 2005]**



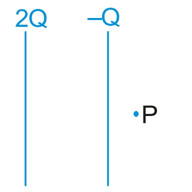
3. At time t=0, a battery of 10V is connected across points A and B in the given circuit. If the capacitors have no charge initially, at what time (in seconds) does the voltage across them become 4V? [Take : $\ell n\ 5 = 1.6$, $\ell n 3 = 1.1$] **[IIT-JEE 2010]**



MOCK TEST

SECTION - I : STRAIGHT OBJECTIVE TYPE

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



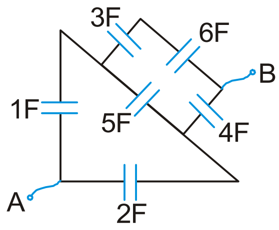
(A) A point charge at point 'P' will experience electric force due to capacitor

(B) The potential difference between the plates will be $\frac{3Q}{2C}$

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

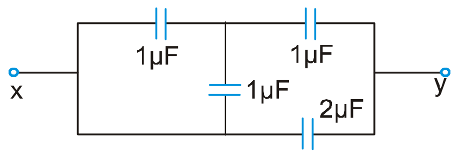
(D) The force on one plate due to the other plate is $\frac{Q^2}{2\pi \in_0 d^2}$

2. In the figure shown the equivalent capacitance between 'A' and 'B' is :



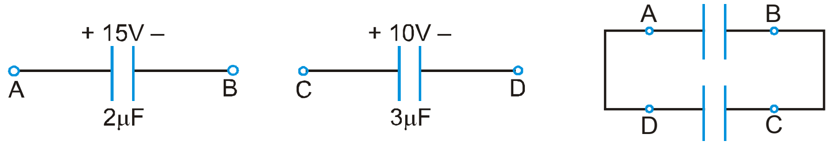
(A) 3.75 F **(B)** 2 F **(C)** 21 F **(D)** 16 F

3. The equivalent capacitance between x & y is:



(A) $\frac{5}{6}$ μF **(B)** $\frac{7}{6}$ μF **(C)** $\frac{8}{3}$ μF **(D)** 1 μF

4. In the figure initial status of capacitance and their connection is shown. Which of the following is incorrect about this circuit :



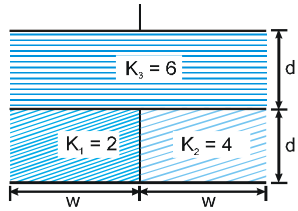
(A) Final charge on each capacitor will be zero

(B) Final total electrical energy of the capacitors will be zero

(C) Total charge flown from A to D is 30μC

(D) Total charge flown from A to D is – 30μC

5. A parallel plate capacitor of capacitance C (without dielectrics) is filled by dielectric slabs as shown in the figure. Then the new capacitance of the capacitor is:



(A) 3.9 C **(B)** 4 C **(C)** 2.4 C **(D)** 3 C

6. A capacitor (without dielectric) is discharging through a resistor. At some instant a dielectric is inserted between the plates, then

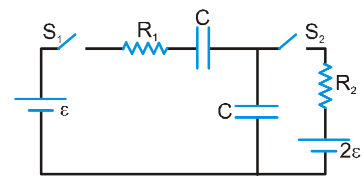
(A) Just after the insertion of the dielectric, current will increase.

(B) Just after the insertion of the dielectric, charge on capacitor will increase.

(C) Just after the insertion of the dielectric, energy stored in the capacitor will increase.

(D) after the insertion of the dielectric, time constant will increase

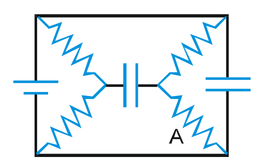
7. In the circuit shown, switch S_2 is closed first and is kept closed for a long time. Now S_1 is closed. Just after that instant the current through S_1 is:



(A) $\frac{\varepsilon}{R_1}$ towards right **(B)** $\frac{\varepsilon}{R_1}$ towards left

(C) zero **(D)** $\frac{2\varepsilon}{R_1}$

8. Each resistor in the following circuit has a resistance of 2MΩ and the capacitors have capacitances of 1μF. The battery voltage is 3V. The voltage across the resistor 'A' in the following circuit in steady state is :



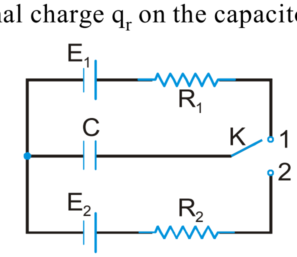
(A) 0 V **(B)** 0.5 V **(C)** 0.75 V **(D)** 1.5 V

9. An uncharged capacitor is connected in series with a resistor and a battery. The charging of the capacitor starts at t = 0. The rate at which energy in capacitor is stored :

(A) first increases then decreases **(B)** first decreases then increases

(C) remains constant **(D)** continuously decreases

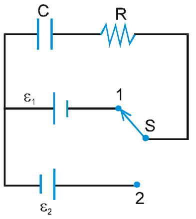
10. The key K (figure) is connected in turn to each of the contacts over short identical time intervals so that the change in the charge on the capacitor over each connection is small. The final charge q_r on the capacitor is :



(A) $\frac{(E_1R_2 + E_2R_1)C}{R_1 + R_2}$ **(B)** $\frac{(E_1 E_2) C}{E_1 + E_2}$

(C) $\frac{(E_1R_1 + E_2R_2) C}{R_1 + R_2}$ **(D)** none of these

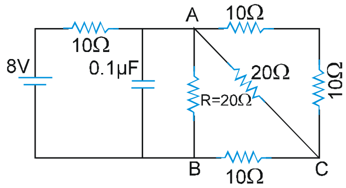
11. Initially switch S is connected to position 1 for a long time. The net amount of heat generated in the circuit after it is shifted to position 2 is



(A) $\frac{C}{2}(\varepsilon_1+\varepsilon_2)\varepsilon_2$ (B) $C(\varepsilon_1+\varepsilon_2)\varepsilon_2$

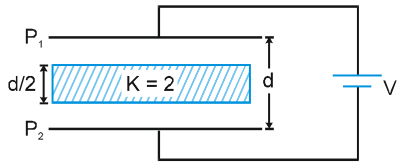
(C) $\frac{C}{2}(\varepsilon_1+\varepsilon_2)^2$ (D) $C(\varepsilon_1+\varepsilon_2)^2$

12. A capacitor of capacitance 0.1 μ F is connected to a battery of emf 8V as shown in the fig. Under steady state condition.



(A) Charge on the capacitor is 0.4 μ C.
(B) Charge on the capacitor is 0.2 μ C.
(C) Current in the resistor(R) between points A & B is 0.1 A.
(D) Current in the resistor(R) between point A & B is 0.4 A.

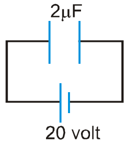
13. In the figure shown a parallel plate capacitor has a dielectric of width d/2 and dielectric constant K = 2. The other dimensions of the dielectric are same as that of the plates. The plates P_1 and P_2 of the capacitor have area 'A' each. The energy of the capacitor is :



(A) $\frac{\epsilon_0 AV^2}{3d}$ (B) $\frac{2\epsilon_0 AV^2}{d}$

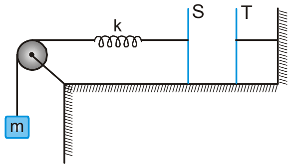
(C) $\frac{3}{2}\frac{\epsilon_0 AV^2}{d}$ (D) $\frac{2\epsilon_0 AV^2}{3d}$

14. In the figure a capacitor of capacitance 2μF is connected to a cell of emf 20 volt. The plates of the capacitor are drawn apart slowly to double the distance between them. The work done by the external agent on the plates is :



(A) – 200 μJ (B) 200 μJ
(C) 400 μJ (D) – 400 μJ

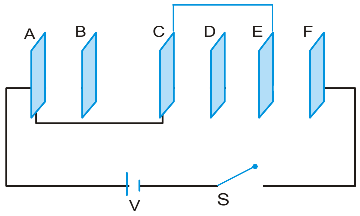
15. The plates S and T of an uncharged parallel plate capacitor are connected across a battery. The battery is then disconnected and the charged plates are now connected in a system as shown in the figure. The system shown is in equilibrium. All the strings and spring are insulating and massless. The magnitude of charge on one of the capacitor plates is: [Area of plates = A]



(A) $\sqrt{2mg\,A\epsilon_0}$ (B) $\sqrt{\frac{4mg\,A\epsilon_0}{k}}$

(C) $\sqrt{mg\,A\epsilon_0}$ (D) $\sqrt{\frac{2mg\,A\epsilon_0}{k}}$

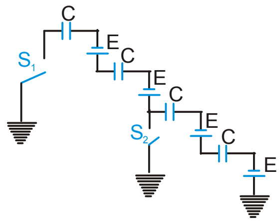
16. In the figure shown A, B, C, D, E, F are conducting plates each of area A and any two consecutive plates separated by a distance d. The net energy stored in the system after the switch S is closed is:



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

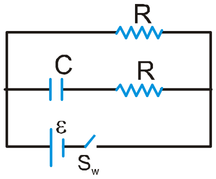
(C) $\frac{\varepsilon_0 A}{2d}V^2$ (D) $\frac{\varepsilon_0 A}{d}V^2$

17. In the given circuit, all the capacitors are initially uncharged. After closing the switch S_1 for a long time suddenly S_2 is also closed and kept closed for a long time. Total heat produced after closing S_2 will be:



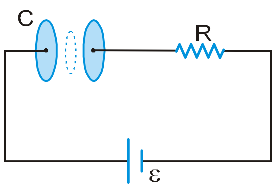
(A) $4C\varepsilon^2$ (B) $\frac{1}{2}C\varepsilon^2$ (C) $2C\varepsilon^2$ (D) 0

18. If at t = 0 the switch S_W is closed, then the charge on capacitor in the given circuit (initially uncharged) when the current through battery becomes 50% of its maxi mum value is (assume battery is ideal):



(A) $\frac{C\varepsilon}{3}$ (B) $\frac{C\varepsilon}{2}$ (C) $\frac{C\varepsilon}{4}$ (D) $C\varepsilon$

19. In the circuit shown the capacitor of capacitance C is initially uncharged. Now the capacitor is connected in the circuit as shown. The charge passed through an imaginary circular loop parallel to the plates (also circular) and having the area equal to half of the area of the plates, in one time constant is:

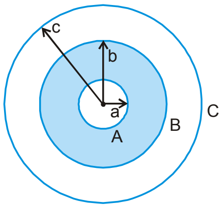


(A) $C\varepsilon\left(1-\frac{1}{e}\right)$ (B) $\frac{C\varepsilon}{2}\left(1-\frac{1}{e}\right)$ (C) $\frac{C\varepsilon}{4}$ (D) zero

20. A parallel plate capacitor (without dielectric) is charged by a battery and kept connected to the battery. A dielectric slab of dielectric constant 'k' is inserted between the plates fully occupying the space between the plates. The energy density of electric field between the plates will:

(A) increase k^2 times k^2 (B) decrease k^2 times
(C) increase k times (D) decrease k times

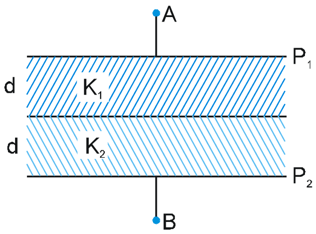
21. In the figure shown A and C are concentric conducting spherical shells of radius a and c respectively. A is surrounded by a concentric dielectric medium of inner radius a, outer radius b and dielectric constant k. If sphere A is given a charges Q, the potential at the outer surface of the dielectric is.



(A) $\frac{Q}{4\pi\epsilon_0 kb}$ (B) $\frac{Q}{4\pi\epsilon_0}\left(\frac{1}{a}+\frac{1}{k(b-a)}\right)$

(C) $\frac{Q}{4\pi\epsilon_0 b}$ (D) None of these

22. In the figure shown P_1 and P_2 are two conducting plates having charges of equal magnitude and opposite sign. Two dielectrics of dielectric constant K_1 and K_2 fill the space between the plates as shown in the figure. The ratio of electrical energy in 1st dielectric to that in the 2nd dielectric is



(A) 1 : 1 (B) $K_1 : K_2$ (C) $K_2 : K_1$ (D) $K_2^2 : K_1^2$

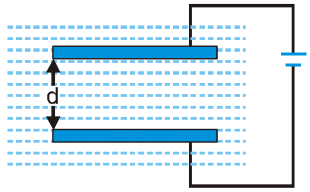
23. In the figure shown two long straight wires with the same cross-section are arranged in air, parallel to one another. The distance between the axis of the wire is η times larger then the radius of wire's cross-section. Capacitance of the wires per unit length would be (Take $\eta >> 1$)

Top view of the arrangement

(A) $\frac{2\pi\epsilon_0}{\ln\eta}$ (B) $\frac{\pi\epsilon_0}{2\ln\eta}$

(C) $\frac{\pi\epsilon_0}{\ln\eta}$ (D) Information insufficient

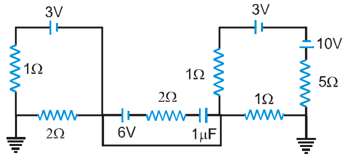
24. A parallel plate capacitor is immersed in a liquid dielectric having dielectric constant ε as shown in the figure. Find the force acting on a unit surface of the plate from the dielectric.



(A) $\frac{\varepsilon\varepsilon_0 V^2}{2d^2}$ (B) $\frac{\varepsilon_0(\varepsilon-1)V^2}{2d^2\times\varepsilon}$

(C) $\frac{\varepsilon V^2}{2d^2}$ (D) $\frac{\varepsilon(\varepsilon-1)\varepsilon_0 V^2}{2d^2}$

25. For the circuit shown in the figure, determine the charge of the capacitor in steady state.



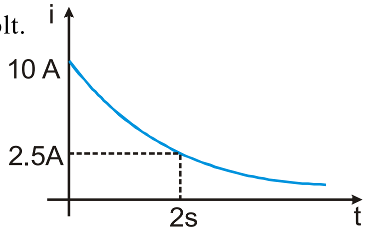
(A) 4μC (B) 6μC (C) 1μC (D) Zero

26. Two identical capacitors are charged to different potentials then they are connected to each other in such a way that the sum of charges of plates having positive polarity remains constant. Mark the correct statement.

(A) Sum of charges of plates having negative polarity remains constant.
(B) Mean of individual final potentials is different from mean of individual initial potentials.
(C) Total energy stored in two capacitors in final state may be equal to that in initial state.
(D) Heat dissipation in the circuit could be zero.

SECTION - II : MULTIPLE CORRECT ANSWER TYPE

27. The figure shows, a graph of the current in a discharging circuit of a capacitor through a resistor of resistance 10 Ω.



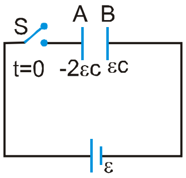
(A) The initial potential difference across the capacitor is 100 volt.

(B) The capacitance of the capacitor is $\frac{1}{10\,\ell n\,2}$ F.

(C) The total heat produced in the circuit will be $\frac{500}{\ell n 2}$ joules.

(D) The thermal power in the resistor will decrease with a time constant $\frac{1}{2\ell n 2}$ second.

28. A parallel plate capacitor of capacitance 'C' has charges on its plates initially as shown in the figure. Now at t = 0, the switch 'S' is closed.



Select the correct alternative(s) for this circuit diagram.

(A) In steady state the charges on the outer surfaces of plates 'A' and 'B' will be same in magnitude and sign.
(B) In steady state the charges on the outer surfaces of plates 'A' and 'B' will be same in magnitude and opposite in sign.
(C) In steady state the charges on the inner surfaces of the plates 'A' and 'B' will be same in magnitude and opposite in sign.
(D) The work done by the cell by the time steady state is reached is $\frac{5\varepsilon^2 C}{2}$.

29. 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 K-times

(C) the force of attraction between the plates will become K^2-times

(D) the charge on the capacitor will become K-times.

30. A parallel plate capacitor of capacitance 10 μF is connected to a cell of emf 10 Volt and fully charged. Now a dielectric slab (k = 3) of thickness equal to the gap between the plates, is very slowly inserted to completely fill in the gap, keeping the cell connected. During the filling process:

(A) the increase in charge on the capacitor is 200 μC.

(B) the heat produced is zero.

(C) energy supplied by the cell = increase in stored potential energy + work done on the person who is filling the dielectric slab.

(D) energy supplied by the cell = increase in stored potential energy + work done on the person who is filling the dielectric slab + heat produced.

31. 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

SECTION - III : ASSERTION AND REASON TYPE

32. **Statement-1 :** If the potential difference across a plane parallel plate capacitor is doubled then the potential energy of the capacitor becomes four times under all conditions.

Statement-2 : The potential energy U stored in the capacitor is $U = \frac{1}{2}CV^2$, where C and V have usual meaning.

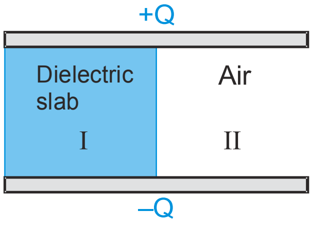
(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1

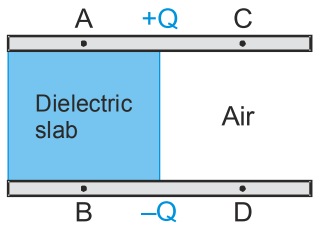
(C) Statement-1 is True, Statement-2 is False

(D) Statement-1 is False, Statement-2 is True

33. **Statement-1 :** A charged plane parallel plate capacitor has half interplanar region (I) filled with dielectric slab. The other half region II has air. Then the magnitude of net electric field in region I is less than that in region II.



Statement-1 : In a dielectric medium induced (or polarised) charges tend to reduce the electric field.



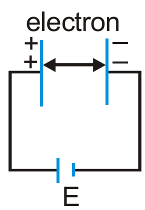
(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True.

34. **Statement-1 :** A dielectric is inserted between the plates of an isolated fully-charged capacitor. The dielectric completely fills the space between the plates. The magnitude of electrostatic force on either metal plate decreases, as it was before the insertion of dielectric medium.

Statement-2 : Due to insertion of dielectric slab in an isolated parallel plate capacitor (the dielectric completely fills the space between the plates), the electrostatic potential energy of the capacitor decreases.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True.

35. **Statement I :** During the charging of a capacitor using a battery, the electrons transferred from positive plate of capacitor to negative plate via dielectric medium in between the plates as shown.



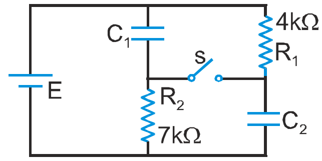
Statement II : The direction of electric field in between the capacitor plates is from positive plate to negative plate.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True.

SECTION - IV : COMPREHENSION TYPE

Comprehension # 1

The switch s has been closed for long time and the electric circuit shown carries a steady current. Let $C_1 = 3.0\ \mu F$, $C_2 = 6.0\ \mu F$, $R_1 = 4.0\ k\Omega$, and $R_2 = 7.0\ k\Omega$. The power dissipated in R_2 is 2.8 W.



36. The power dissipated to the resistor R_1 is

(A) 2.8 W **(B)** 1.6 W **(C)** 4.9 W **(D)** 0

37. The charge on capacitors C_1 and C_2 are respectively.

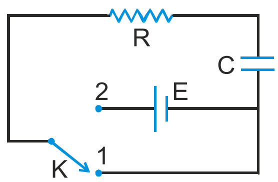
(A) 940 μC, 940 μC **(B)** 440 μC, 440 μC **(C)** 240 μC, 840 μC **(D)** 840 μC, 240 μC

38. Long time after switch is opened, the charge on C_1 is :

(A) Zero **(B)** 420 μC **(C)** 240 μC **(D)** 660 μC

Comprehension # 2

In the shown circuit involving a resistor of resistance R Ω, capacitor of capacitance C farad and an ideal cell of emf E volts, the capacitor is initially uncharged and the key is in position 1. At t = 0 second the key is pushed to position 2 for t_0 = RC seconds and then key is pushed back to position 1 for t_0 = RC seconds. This process is repeated again and again. Assume the time taken to push key from position 1 to 2 and vice versa to be negligible.



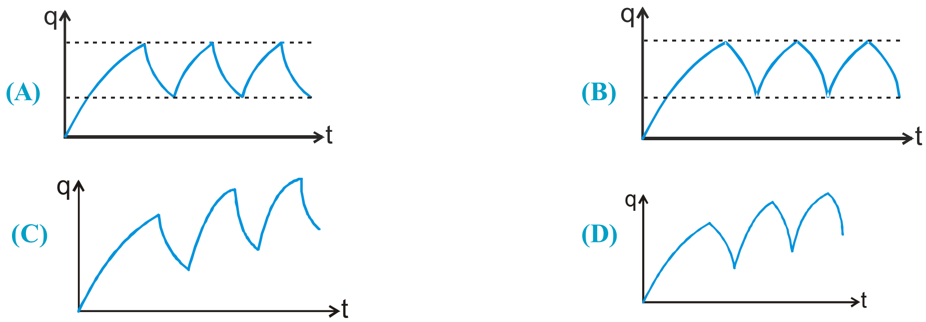
39. The charge on capacitor at t = 2RC second is

(A) CE **(B)** $CE\left(1-\frac{1}{e}\right)$ **(C)** $CE\left(\frac{1}{e}-\frac{1}{e^2}\right)$ **(D)** $CE\left(1-\frac{1}{e}+\frac{1}{e^2}\right)$

40. The current through the resistance at t = 1.5 RC seconds is

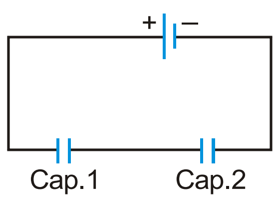
(A) $\frac{E}{e^2R}(1-\frac{1}{e})$ **(B)** $\frac{E}{eR}(1-\frac{1}{e})$ **(C)** $\frac{E}{R}(1-\frac{1}{e})$ **(D)** $\frac{E}{\sqrt{e}R}(1-\frac{1}{e})$

41. Then the variation of charge on capacitor with time is best represented by



SECTION - V : MATRIX - MATCH TYPE

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

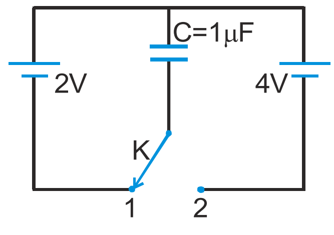


Column I	Column II
(A) A dielectric slab is inserted.	**(P)** Charge on the capacitor increases.
(B) Separation between plates increased.	**(Q)** Charge on the capacitor decreases.
(C) A metal plate is inserted connecting both plates	**(R)** Energy stored in the capacitor increases.
(D) The left plate is grounded.	**(S)** Energy stored in capacitor is decreased
	(T) No change is occurred.

43. In each situation of column-I some changes are made to a charged capacitor under conditions of constant potential difference or constant charge. Condition of constant potential difference means that a cell is connected across the capacitor and condition of constant charge means that the capacitor is isolated. Match the conditions in column-I with corresponding results in column-II.

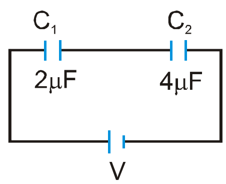
Column I	Column II
(A) For a capacitor maintained at constant potential difference, the separation between plates is increased.	**(P)** Then electric field inside the capacitor decreases in comparison to what it was before the change.
(B) For a capacitor maintained at constant charge, the separation between the plates is increased	**(Q)** Then electric field inside the capacitor remains same.
(C) For a capacitor maintained at constant potential difference, area of the both the plates is doubled.	**(R)** Then potential energy stored in the capacitor decreases in comparison to what it was before the change.
(D) For a capacitor maintained at constant charge, area of both plates is doubled	**(S)** The potential energy stored in the capacitor increases in comparison to what it was before the change.
	(T) Capacitance of capacitor decreases

44. 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 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

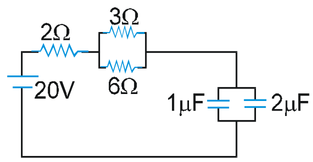
45. In the given figure, the separation between the plates of C_1 is slowly increased to double of its initial value then.



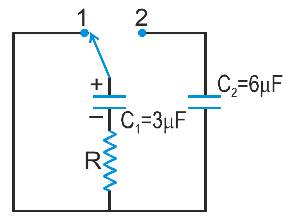
	Column-I		Column-II
(A)	the potential difference across C_1	**(P)**	increases
(B)	the potential difference across C_2	**(Q)**	decreases
(C)	the energy stored in C_1	**(R)**	increases by a factor of 6/5
(D)	the energy stored in C_2	**(S)**	decreases by a factor of 18/25
		(T)	decreases by a factor of 9/25

SECTION - VI : INTEGER TYPE

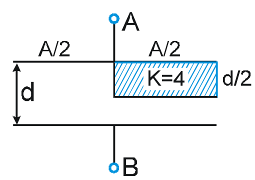
46. In the circuit shown the capacitors are initially uncharged. In a certain time the capacitor of capacitance 2μF gets a charge 20μC. In that time interval, find the heat produced in each resistor 6Ω in μ J



47. In the circuit shown a charged capacitor $C_1 = 3$ μF is discharged through R = 1 kΩ by putting the switch is position 1. When the current reaches $I_0 = 2$ A, the switch is thrown to position 2 to discharge through uncharged capacitor $C_2 = 6$ μF and steady state is allowed to reach. Find the heat dissipated (in Joules) in the resistor R after switch is thrown to position 2.



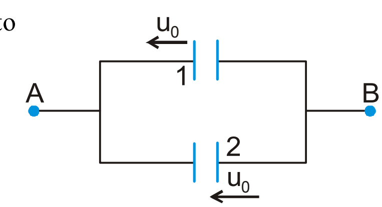
48. In the figure shown find the equivalent capacitance between terminals 'A' and 'B'. The letters have their usual meaning capacitance is $\dfrac{x\varepsilon_0 A}{10\,d}$ then x is.



49. A parallel plate capacitor is to be designed which is to be connected across 1 kV potential difference. The dielectric material which is to be filled between the plates has dielectric constant K = 6π and dielectric strength 10^7 V/m.
For safely the electric field is never to exceed 10% of the dielectric strength. With such specifications, if we want a capacitor of capacitance 50 pF, what minimum area (in mm^2) of plates is required for safe working?

(use $\varepsilon_0 = \dfrac{1}{36\pi} \times 10^{-9}$ in MKS)

50. Two identical capacitor having plate separation d_0 are connected parallel to each other across points A and B as shown in the figure. A charge Q is imparted to the system by connecting a battery across A and B and battery is removed. Now first plate of first capacitor and second plate of second capacitor starts moving with constant velocity u_0 towards left. Find the magnitude of current flowing in the loop during this process.



51. Given that $C_A = 1\ \mu F$, $C_B = 2\ \mu F$ and $C_C = 2\ \mu F$. Initially each capacitor was charged to potential differences of $V_A = 10V$, $V_B = 40\ V$ and $V_C = 60\ V$ separately and are kept as shown in figure (a). Now they are connected as shown in figure (b). The + and - sign shown in figure (b) represent initial polarities. Find total amount of heat produced in μJ by the time steady state is reached.

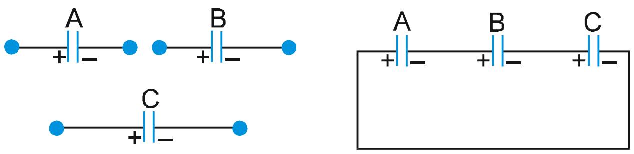
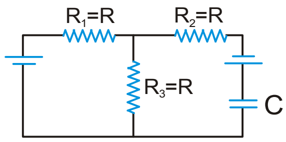


Fig. (a) Fig. (b)

52. In the figure shown the capacitor is initially uncharged. Find the current in R_3 (= R) at time 't'.



ANSWER KEY

EXERCISE - 1

1. C **2.** D **3.** B **4.** A **5.** B **6.** D **7.** A **8.** D **9.** B **10.** B **11.** A **12.** B **13.** A
14. C **15.** B **16.** C **17.** C **18.** A **19.** D **20.** D **21.** A **22.** A **23.** B **24.** D **25.** B **26.** B
27. D **28.** B **29.** C

EXERCISE - 2 : PART # I

1. A **2.** A **3.** A **4.** A, D **5.** B,C,D **6.** B,D **7.** A,B,D **8.** A **9.** C **10.** C **11.** A
12. A,B,C,D **13.** C **14.** D **15.** A **16.** A,B,C **17.** B **18.** ABCD **19.** C **20.** B
21. A,B,C,D **22.** A,B,C,D **23.** A **24.** B,C **25.** C **26.** C **27.** D **28.** B
29. C **30.** B,D **31.** E **32.** B **33.** B,C,D **34.** A,C,D **35.** B
36. A,B,C,D **37.** B **38.** B **39.** A **40.** B **41.** A **42.** D

PART # II

1. **(D)** **2.** **(C)** **3.** **(A)** **4.** **(A)** **5.** **(B)** **6.** **(B)**

EXERCISE - 3 : PART # I

1. $A \to P$; $B \to R,S$; $C \to P$; $D \to R$ **2.** $A \to Q$; $B \to P$; $C \to S$; $D \to R$

PART # II

Comp. #1 : 1. A 2. C 3. A 4. D **Comp. #2 :** 1. C 2. D 3. A
Comp. #3 : 1. A,C 2. D **Comp. #4 :** 1. B. 2. C 3. D 4. C 5. C
Comp. #5 : 1. C 2. D 3. C 4. A

EXERCISE - 4

1. (i) $24\mu C$ (ii) $48\mu J$ **2.** 400 s **3.** $5\times10^6\,\frac{V}{m}$ **4.** $Q_1 = 640\mu C, Q_2 = 960\mu C$ **6.** $\frac{C_1V_A + C_2V_B + C_3V_C}{C_1 + C_2 + C_3}$

7. a^{-2}, b^{-1}, c^{-3} **8.** **(i)** $2.5\mu J$ **(ii)** $\frac{1}{2}$ **9.** $2\mu F$ **10.** (i) 8V (ii) 5 **11.** 9, $\frac{1.2K_2 \epsilon_0 A}{d}$ **12.** $10^{-3}\ m^2$

13. $Q_A = 12\mu C$, $Q_B = 18\mu C$ **14.** **(i)** $1.55\times10^4\,\frac{V}{m}, 4.5\times10^4\,\frac{V}{m}$ **(ii)** 75V, 225 V **(iii)** $8\times10^{-7}\,\frac{C}{m^2}$ **15.** $9\times10^{-6}C$

16. **(i)** $i_1 = \frac{E}{R_1}, i_2 = \frac{E}{R_2}$ **(ii)** $i_1 = \frac{E}{R_1}, i_2 = 0$ **(iii)** $\frac{1}{2}CE^2$ **(iv)** $C(R_1+R_2)$ **(v)** R_2C **17.** $I = I_1 = 0, Q = 42\ \mu C$ **18.** 0.9 A

19. 60 mJ **20.** C **21.** 3Q/2C **22.** 0 **23.** $\frac{1}{2}\frac{q^2d}{\epsilon_0 A}$ **24.** $\frac{8}{3}\mu F$ **25.** $\frac{32}{23}\mu F$ **26.** $60\mu C$, A to B **27.** 0.8 mJ

28. $0.198\ \mu A$ **29.** $\frac{\epsilon s\pi K_1}{2d}$ **30.** $\frac{4}{7}(r_1-r_2)$ **31.** 12V **32.** **(i)** $\frac{5}{3}\frac{\epsilon_0 A}{d}$ **(ii)** $Q_3 = \frac{4}{3}\frac{\epsilon_0 AVa}{d}$, $Q_5 = \frac{2}{3}\frac{\epsilon_0 AVa}{d}$

33. $q_1 = \frac{C_1^2V(C_2+C_3)}{C_1C_2 + C_2C_3 + C_1C_3}$, $q_2 = q_3 = \frac{C_1C_2C_3V}{C_1C_2 + C_2C_3 + C_3C_1}$ **34.** 4.52×10^{-3} kg **36.** 30V **37.** $\frac{4}{7}CE$ from B to A

38. **(i)** 5×10^4 V/m, 3×10^4 V/m, **(ii)** 35/9 **39.** **(i)** $\frac{100}{7}$ volts, **(ii)** 28.56 μC, 42.84 μC, 71.4 μC, 22.88 μC **40.** $2\mu A$

41. **(i)** $\frac{3}{2}CV^2$

(ii) $W_{agent} = -W_{battery} + \left(U_f - U_i\right)_{stored\ energy} = -(K-1)CV_0^2 + \frac{1}{2}KCV_0^2 + \frac{1}{2}(2C)V_0^2 - \frac{1}{2}CV_0^2 - \frac{1}{2}(2C)V_0^2 = -\frac{1}{2}(K-1)CV_0^2$

(iii) $\frac{1}{6}(K+2)(K-1)CV^2$ **42.** (i) 20μC, (ii) 0.3 mJ, (iii) 0.6 mJ (iv) 60 μC **43.** 9J

EXERCISE - 5 : PART # I

1. 2 **2.** 1 **3.** 2 **4.** 4 **5.** 4 **6.** 1 **7.** 1 **8.** 4 **9.** 4 **10.** 3 **11.** 4 **12.** 1 **13.** 4
14. 1 **15.** 2 **16.** 3 **17.** 4 **18.** 2

PART # II

Straight Objective type question

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

Multiple Correct type question

1. B,D **2.** A,D

Subjective

1. **(i)** $Q = \frac{CV}{2}\left(1 - e^{-\frac{2t}{3RC}}\right)$, **(ii)** $i_2 = \frac{V}{2R} - \frac{V}{6R}e^{-\frac{2t}{3RC}}, \frac{V}{2R}$ **2.** $Q_0 = \frac{CVR_2}{R_1 + R_2}, \alpha = \frac{R_1 + R_2}{CR_1R_2}$ **3.** (2)

MOCK TEST

1. D **2.** B **3.** C **4.** D **5.** A **6.** D **7.** B **8.** D **9.** A **10.** A **11.** C **12.** A
13. D **14.** B **15.** A **16.** C **17.** D **18.** D **19.** D **20.** C **21.** C **22.** C **23.** C **24.** D
25. B **26.** A **27.** A,B,C,D **28.** A,C,D **29.** A,C,D **30.** A,B,C,D **31.** B D **32.** D
33. D **34.** D **35.** D **36.** B **37.** C **38.** D **39.** C **40.** D **41.** C
42. A → P, R ; B → Q, S ; C → P, R ; D → T **43.** A → P,R,T ; B → Q, S, T ; C → Q, S ; D → P, R
44. A → P ; B → R ; C → Q ; D → P **45.** A → P, R ; B → Q ; C → Q, S ; D → Q, T

46. 75 μJ **47.** 4 J **48.** $\frac{13}{10}\frac{\varepsilon_0 A}{d}$ **49.** 300 mm^2 **50.** $I = \frac{Qv_0}{2d_0}$ **51.** 3025 μJ

52. $i = \frac{\varepsilon}{2R}\left(1 - e^{-\frac{2t}{3RC}}\right)$