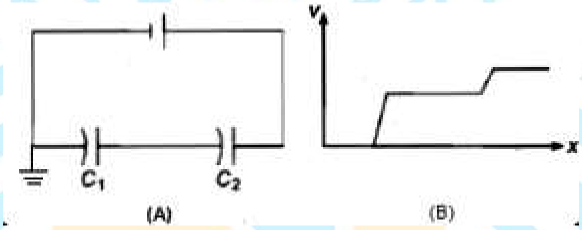
PHYSICS

DPP **CAPACITORS**

Shows two capacitors connected in series and joined to battery.

1. The graph shows the variation in potential as one moves from left to right on the branch containing the capacitors.



A) $C_1 > C_2$ B) $C_1 = C_2$ C) $C_1 < C_2$
D) The information is not sufficient to decide

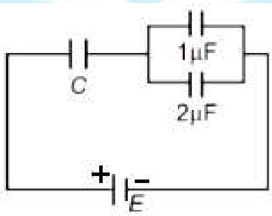
2. Two metal spheres of capacitance C_1 *and* C_2 carry some charges. They are put in contact and then separated. The final charges Q_1 *and* Q_2 on them will satisfy.

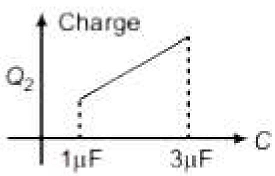
A) $\frac{Q_1}{Q_2} < \frac{C_1}{C_2}$ B) $\frac{Q_1}{Q_2} = \frac{C_1}{C_2}$ C) $\frac{Q_1}{Q_2} > \frac{C_1}{C_2}$ D) $\frac{Q_1}{Q_2} = \frac{C_2}{C_1}$

3. Two capacitors C_1 *and* C_2 are charged to $120V$ and $200V$ respectively. It is found that by connecting them together the potential on each one can be made zero. Then,

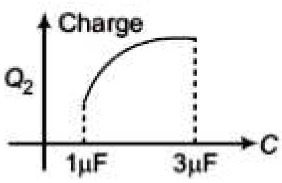
A) $3C_1 = 5C_2$ B) $3C_1 = 5C_2 = 0$ C) $9C_1 = 4C_2$ D) $5C_1 = 3C_2$

4. In the given circuit, charge Q_2 on the $2\mu F$ capacitor charges as C is varied from $1\mu F$ to $3\mu F$. Q_2 as a function of 'C' is given properly by:





A)



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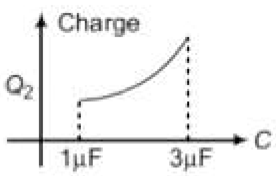
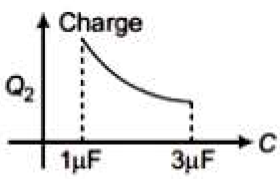


C)

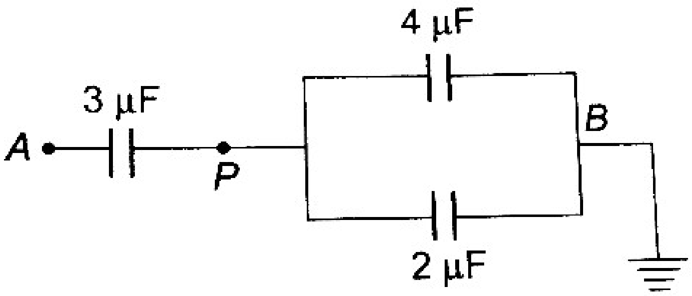


D)

5. A capacitance of $2\mu F$ is required in an electric circuit across a potential difference of $1.0KV$. A large number of $1\mu F$ capacitors are available which can withstand a potential difference of not more than $300V$. The minimum number of capacitors required to achieve this is

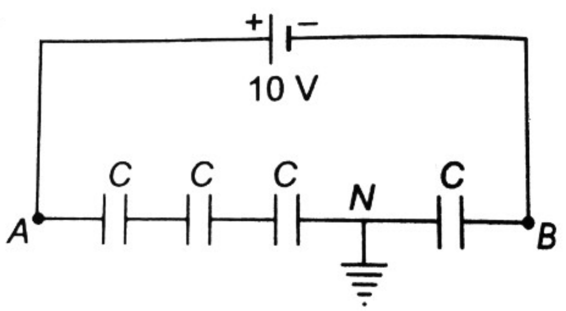
A) 24 B) 32 C) 2 D) 16

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



A) 100 V B) 200 V C) 400 V D) 800 V

7. Four identical capacitors are connected in series with a 10 V battery as shown in the figure. The point N is earthed. The potential of points A and B are



A) 10 V, 0 V B) 7.5 V, -2.5 V C) 5 V, -5 V D) 7.5 V, 2.5 V

8. A capacitor of capacity $2\mu F$ is charged to 100 V. What is the heat generated when this capacitor is connected in parallel to an another capacitor of same capacity?

A) $2.5mJ$ B) $5mJ$ C) $10mJ$ D) $4mJ$

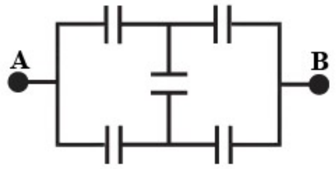
9. Consider two conductors. One of them has a capacity of 2 units and the capacity of the other is unknown. They are charged until their potentials are 4 and 5 units, respectively. The two conductors are now connected by a wire when their common potential is found to be 4.6 units. Then, the unknown capacity has the value (in the same units as above)

A) 6 B) 5 C) 4 D) 3

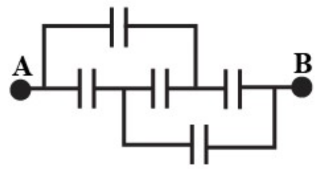
10. Consider three capacitors of capacitance C_1, C_2 and C_3. If C_1, C_2 and C_3 are in parallel, equivalent capacitance is 6 unit. When C_2 and C_3 are in parallel, the equivalent capacitance is 5 unit. If $C_1C_2C_3 = 6$, then the capacitances are

A) 1, 2, 3 B) 2, 4, 6 C) 1, 5, 7 D) 2, 5, 6

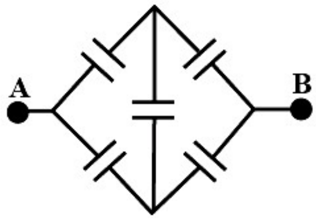
11. Four ways of making a network of five capacitors of the same value are shown in four choices. Three out of four are identical. The one which is different is



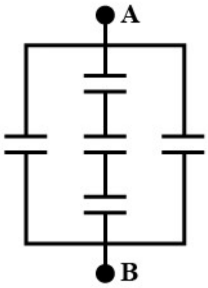
A)



B)

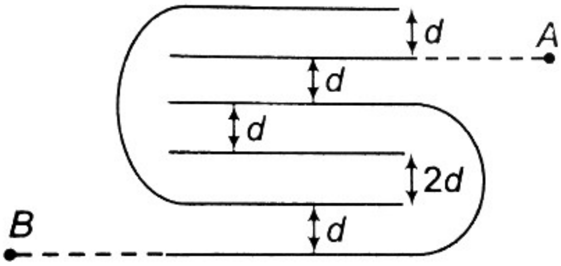


C)



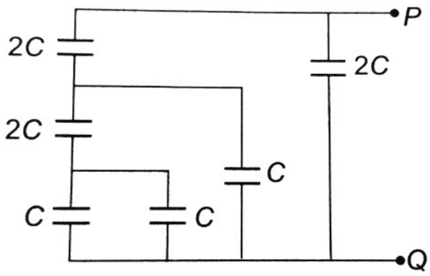
D)

12. Find equivalent capacitance between points $A\,and\,B$. [Assume each conducting plate is having same dimensions and neglect the thickness of the plate, $\frac{\varepsilon_0 A}{d} = 7\mu F$, where A is area of plates]



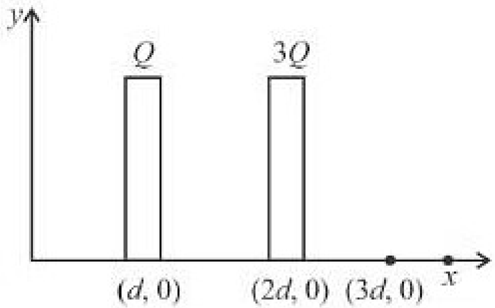
A) $7\mu F$ B) $11\mu F$ C) $12\mu F$ D) $15\mu F$

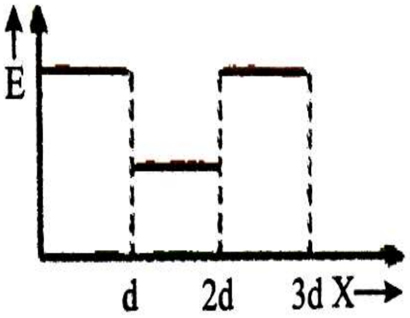
13. The resultant capacitance of given circuit between points $P\;and\;Q$ is

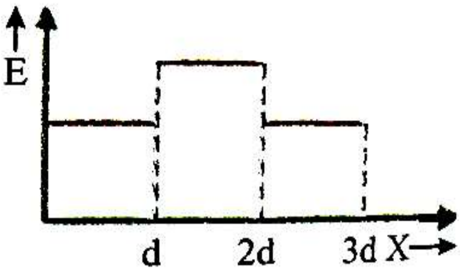


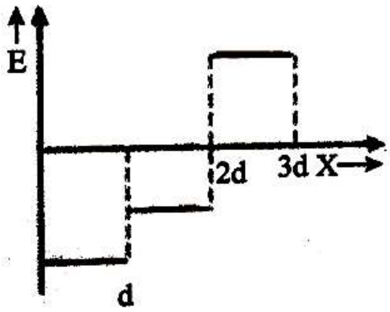
A) $3C$ B) $2C$ C) C D) $\frac{C}{3}$

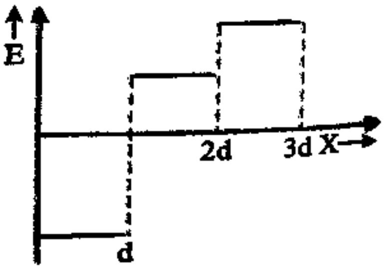
14. Two very large thin conducting plates having same cross-sectional area are placed as shown in figure. They are carrying charges $Q\;and\;3Q$, respectively. The variation of electric field as a function at x (for $x = 0$ to $x = 3d$) will be best represented by



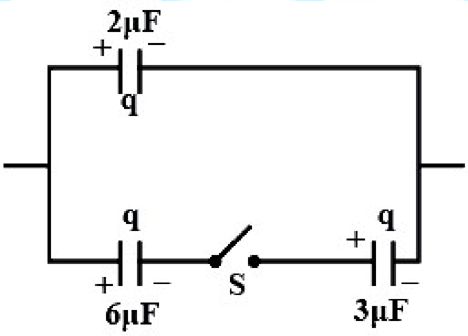
A) 

B) 

C) 

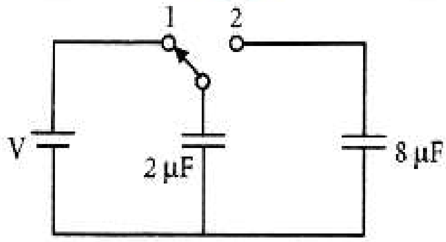
D) 

15. The flow of charge through switch S if it is closed is



A) Zero B) $\frac{q}{4}$ C) $\frac{2q}{3}$ D) $\frac{q}{3}$

16. $2\mu F$ capacitor is charged as shown in figure. The percentage of its stored energy dissipated after the switch S is turned to position 2 is



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

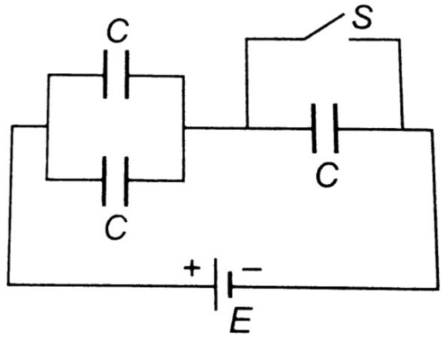
17. A capacitor of capacitance C is charged to a potential difference V from a cell and then disconnected from it. A charge $+Q$ is now given to its positive plate. The potential difference across the capacitor is now

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

18. The plates of a parallel plate capacitor are pulled apart with a velocity v. If at any instant their mutual distance of separation is x, then magnitude of rate of change of capacitance with respect to time varies as

A) $\frac{1}{x}$ B) $\frac{1}{x^2}$ C) x^2 D) x

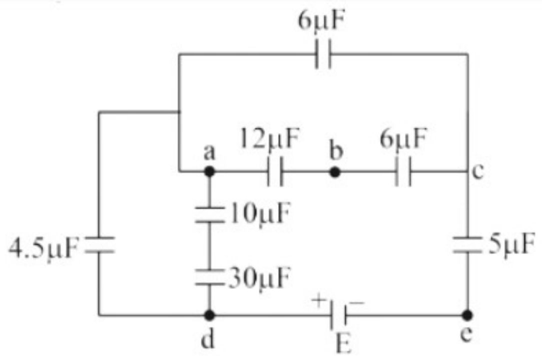
19. In the circuit shown, each capacitor has a capacitance C. The emf of the cell is E. If the switch S is closed, then



A) Positive charge will flow out of the positive terminal of the cell
B) Positive charge will enter the positive terminal of the cell
C) The amount of the charge flowing through the cell will be $\frac{1}{3}CE$
D) The amount of charge flowing through the cell is $\left(\frac{4}{3}\right)CE$

PASSAGE:

A combination of capacitors given is charged by a cell emf E as shown:



If it is given that V_{ab} i.e. potential difference between points $a\ and\ b$ is $4V$, then answer the given questions.

20

(A). Potential difference between points $a\ and\ c$ will be

A) 4 V B) 12 V C) 10 V D) 8 V

(B). Potential difference between points $d\ and\ a$ will be

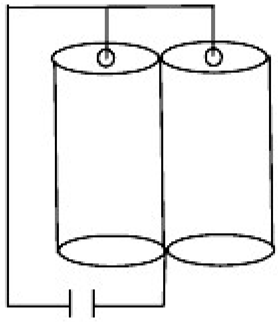
A) 4 V B) 12 V C) 10 V D) 8 V

(C). EMF E of the charging battery is

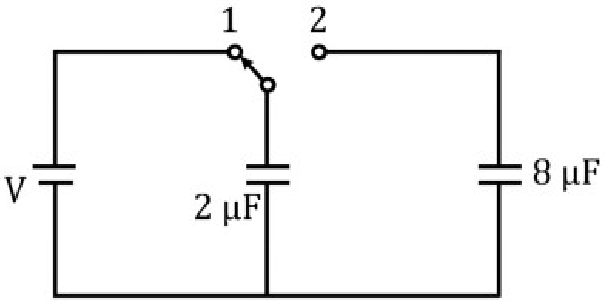
A) 46 V B) 12 V C) 20 V D) 18 V

21. Calculate the capacitance of a parallel-plate capacitor having $20\,cm \times 20\,cm$ square plates separated by a distance of $1.0\,mm$ _________.

22. The outer cylinders of two cylindrical capacitors of capacitance $2.2\mu F$ each are kept in contact and the inner cylinders are connected through wire. A battery of emf 10 V is connected as shown in the figure. Find the total charge supplied by the battery to the inner cylinders._____ μF

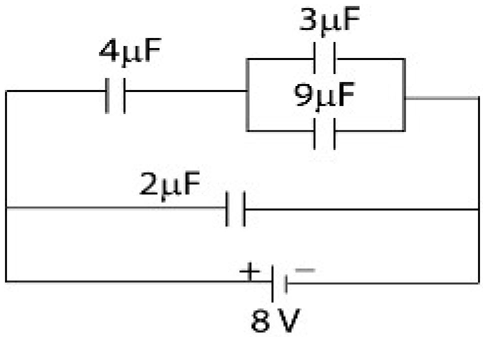


23. A capacitor of $2\mu F$ is charged as shown in figure. When the switch 'S' is turned to position 2, the percentage of its stored energy dissipated is _________%.



24. If the potential of a capacitor having capacity $6\mu F$ is increased from 10 V to 20 V, then increase in its energy will be _____$\times 10^{-4} J$.

25. 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 $4\mu F$ and $9\mu F$ capacitors) at a point distant 30 m from it, would equal



26. 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 $3\times 10^4 v/m$, the charge density of the positive plate will be close to_____.

27. 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 $\frac{d}{3}$ while the other one has dielectric constant $K_2 = 6$ and thickness $\frac{2d}{3}$, capacitance of the capacitor _______PF.

28. A capacitor stores $50\,\mu c$ charge when connected across a battery. When the gap between the plates is filled with a dielectric, a charge of $100\,\mu c$ flows through the battery. Find dielectric constant of the material inserted ______.

29. A capacitor has a capacitance of $7.28\,\mu F$. What amount of charge must be placed on each of its plate to make the potential difference between its plates equal to 25 V _______c

30. The 1000 small droplets of water each of radius r and charge Q make a big drop of spherical of big drop is how many times the potential of one small droplet _______ V.

PHYSICS
KEY

1-10	C	B	A	B	B	C	B	B	D	A
11-20	D	A	A	C	A	B	C	B	A,D	B,C,D
21-30	350	44	80	9×10^{-4}	420	6×10^{-7}	40.5	3	182×10^{-6}	100

SOLUTIONS

1. ACCORDING TO THE GRAPH WE CAN SAY THAT THE POTENTIAL DIFFERENCE ACROSS THE CAPACITOR C1 IS MORE THAN THAT ACROSS C2

Since charge Q is same i.e,

Q=C1V1=C2V2

⇒C2C1=V1V2

⇒C1<C2 (V1>V2)

2. Let the charge on two sphere initially are q1 & q2. Now when these two capacitors (spheres) are kept in contact with each other and separated. Then charges on the two spheres are,

Let Q1 & Q2 are the final charges on spheres. So, final charge will be conserved.

Q1+Q2=q1+q2

Q2Q1=C2V2C1V1

The charge will flow until the potential of both the spheres becomes the same.

Q2Q1=C2VC1V

Q2Q1=C2C1

3. Potential can be made zero only if they have same charge.

⟹120C1=200C2

∴ 6C1=10C2

3C1=5C2

4. Let the charge on the capacitor C be Q.
Charge on the combination of 1 and 2μF is also Q.
Q2=1+22Q=32Q
But, Q=E(3+C3C)
∴Q2=32E(3+C3C)=3+C2EC
As we can see, since C is between 1 and 3, Q2 will increase until C=3.
Options(A) and (D) are eliminated.
slope of curve, dCdQ2=(3+C)2(3+C)2E−2EC=(3+C)26E
Thus, slope decreases as C increases

5. ***m×300>1000***

m>310

or m=4

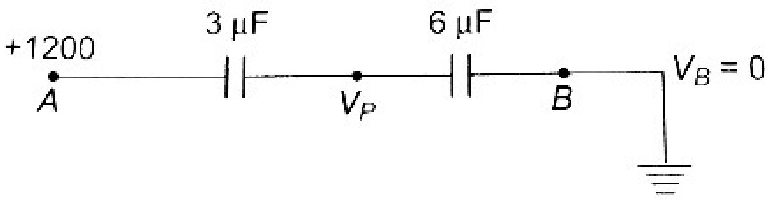
For m=4, capacitance of 1 branch is 41μF=0.25μF

For overall capacitance of 2μF, 8 such branches or equivalent

is Ceq=8×0.25=2μF

Total capacitors required= 8×4=32

6. Given circuit can be reduced as



Let potential at P is V_P and potential at B is V_B. As capacitors $3\,\mu F$ and $6\,\mu F$ are in series, they have same charge.

∴ Charge on $3\,\mu F$ = Charge on $6\,\mu F$

∴ $C_1V_1 = C_2V_2$

Or $3\left(1200 - V_p\right) = 6\left(V_p - V_B\right)$

As B point is earthed.

So, $V_B = 0$

So, $1200 - V_P = 2V_P$

∴ $V_P = 400\,volt$

7. All capacitors have equal capacitance. Hence, equal potential drop ($= 2.5V$) will take place across all capacitors.

$V_N - V_B = 2.5V$

$0 - V_B = 2.5V$

$\therefore V_B = -2.5V$

Further, $V_A - V_N = 3(2.5)V$

$= 7.5V$

$V_A = +7.5V$

8. $q = CV = 200\,\mu C$

In parallel, the common potential is given by

$$V = \frac{Total\ charge}{Total\ capacity}$$

$$= \frac{200\ \mu C}{(2+2)\mu F} = 5V$$

Heat loss = $U_i - U_f$

$$= \frac{1}{2}(2\times10^{-6})(100)^2 - \frac{1}{2}(4\times10^{-6})(50)^2$$

$$= 5\times10^{-3} J$$

$$= 5 mJ$$

9. $\because q_i = q_f$

$$C_1V_1 + C_2V_2 = (C_1 + C_2)V$$

$\therefore (2)(4) + (C)5 = (2+C)4.6$

$$0.4C = 1.2$$

$\therefore$ C = 3 units.

10. $C_1 + C_2 + C_3 = 6$

$$C_2 + C_3 = 5$$

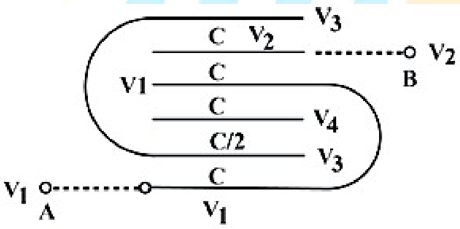
$$C_1 \times C_2 \times C_3 = 6$$

Solving these three equations, we get

$C_1 = 1$ unit, $C_2 = 2$ unit and $C_3 = 3$ unit

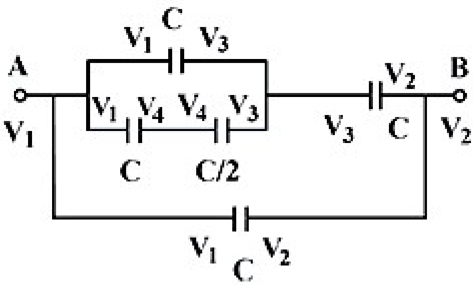
11. First three circuits are balanced Wheatstone bridge circuits.

12.



$$C = \frac{\varepsilon_0 A}{d} = 7\mu F$$

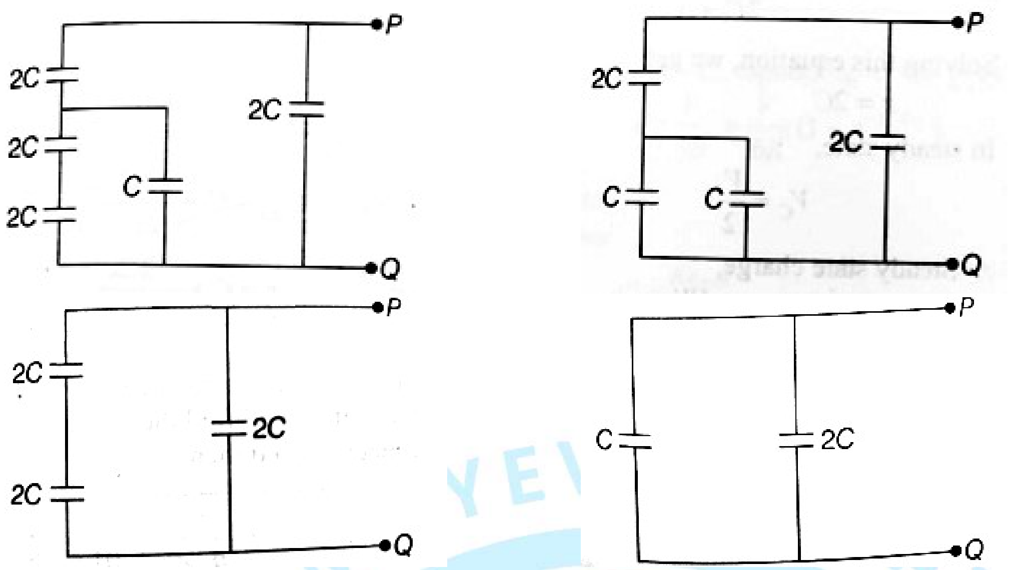
The equivalent circuit is as shown in figure.



$$C_{AB} = \frac{11}{7}C = \frac{11}{7}(7\ \mu F)$$

$$= 11\mu F$$

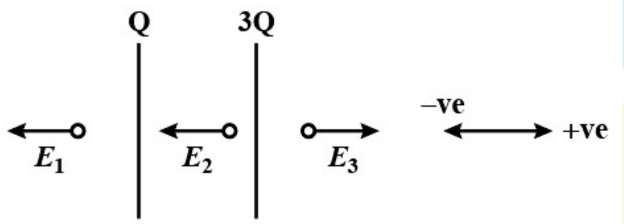
13. The given circuit can be simplified in the following way.



So, capacity between P *and* Q

$C_{PQ} = 2C + C = 3C$

14.



$$E_1 = \frac{Q}{2\varepsilon_0} + \frac{3Q}{2\varepsilon_0} = \frac{2Q}{\varepsilon_0} = E_3$$

$$E_2 = \frac{2Q}{2\varepsilon_0} - \frac{Q}{2\varepsilon_0} = \frac{Q}{\varepsilon_0}$$

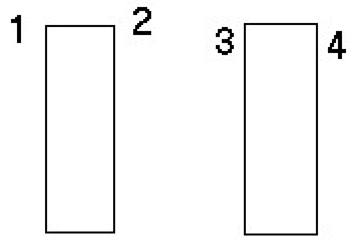
E_1 *and* E_2 are in the negative direction and E_3 in positive direction.

15. Equivalent capacitance of $6\mu F$ and $3\mu F$ is also $2\mu F$ and charge across it is also q or circuit is balanced. Hence, there is no flow of charge.

16. $q_i = C_i V = 2V = q$

This charge will remains constant after switch S is shifted

17.



$$q_1 = q_4 = \frac{q_{total}}{2} = \frac{CV - CV + Q}{2} = \frac{Q}{2}$$

$$q_2 = (Q + CV) - \frac{Q}{2} = \left(\frac{Q}{2} + CV\right)$$

$$q_3 = -q_2 = -\left(\frac{Q}{2} + CV\right)$$

Electric field between two plates and hence the potential difference is due to q_2 *and* q_3 only.

$$PD = \frac{q_2}{C} = V + \frac{Q}{2C}$$

18. $C = \frac{\varepsilon_0 4}{x}$

$$\frac{dC}{dt} = -\frac{\varepsilon_0 A}{x^2}\left(\frac{dx}{dt}\right) = -\frac{\varepsilon_0 A v}{x^2}$$

$$\left|\frac{dC}{dt}\right| \infty \frac{1}{x^2}$$

19. $C_i = \frac{(C)(2C)}{C + 2C} = \frac{2}{3}C$

$$q_i = C_i E = \frac{2}{3}EC$$

$$C_f = 2C$$

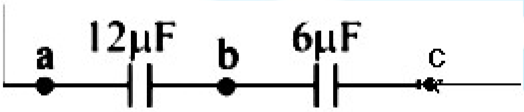
$\therefore$ $q_f = 2EC$

$$\Delta q = q_f - q_i$$

$$= \frac{3}{4}CE$$

20.

(A). Considering branch ac,



$V_{ab} = 4V$ (given)

$\Rightarrow$ $Q_{ab} = C_{ab}V_{ab} = 12\,\mu F \times 4V = 48\,\mu C$

As, $12\,\mu F$ and $6\,\mu F$ capacitors are in series

$\therefore$ Charge on both must be same.

$\Rightarrow$ $Q_{bc} = 48\mu C$

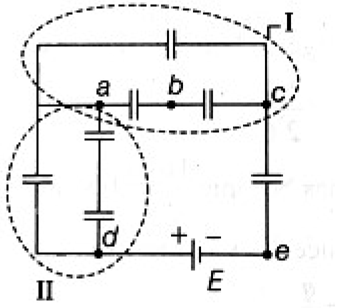
$V_{bc} = 6\mu F$

$V_{bc} = \frac{48}{6}V = 8V$

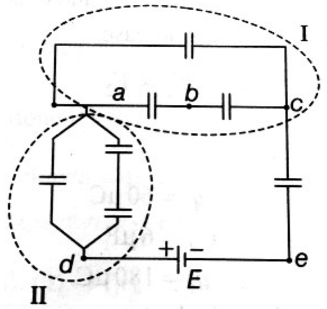
Hence $V_{ac} = V_a - V_c = V_a - V_b + V_b - V_c$

$= 4 + 8 = 12V$

(B). In given circuit, there are two portions marked I and II as shown



Now, considering circuit as given in figure.



Clearly I and II parts are in series, so charge on both portions must be same.

As, $C_{ac} = 12V$

And C_{eq} of portion marked $I = 10\mu F$

So charge on portion $I = V_{eq} \times C_{eq}$

$= 10 \times 12 = 120\mu C$

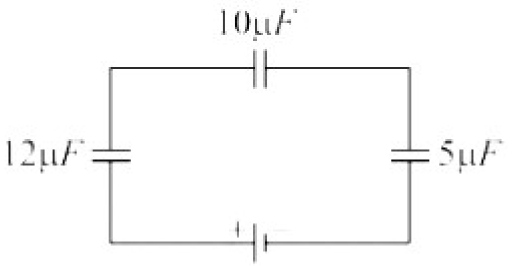
$\therefore$ Charge on portion II $= 120\mu C$

$\Rightarrow C_{ad} \times (V_d - V_a) = 120\,\mu C$

$\Rightarrow \quad 12 \times (V_d - V_a) = 120\,\mu C \quad \{\therefore C_{ad} = 12\mu F\}$

$\Rightarrow \quad (V_d - V_a) = 10V$

(C). we can consider the given circuit as



Charge on $5\,\mu F$ capacitor = $120\,\mu C$

$\therefore \quad V_c - V_e = \frac{120}{5} = 24V$

$\therefore \quad E = 120 + 10 + 24 = 46V$

21. Hint: $C = \frac{\varepsilon_0 A}{d}$

22. The capacitance of the outer sphere = $2.2\,\mu F$, $C = 2.2\,\mu F$, $V = 10V$

Let the charge given to individual cylinder = q

$q = CV = 2.2 \times 10 = 22\mu F$

$\therefore$ The total charge given to the inner cylinder = 22+22 = $44\mu F$.

23. When the switch S is connected to point1, then initial energy stored in the capacitor can be given as = $\frac{1}{2}(2\mu F)\times V^2$

When the switch 'S' is connected to point 2 energy dissipated on connection across $8\mu F$ will be = $\frac{1}{2}\left(\frac{C_1C_2}{C_1+C_2}\right)V^2$

$$=\frac{1}{2}\times\frac{2\mu F\times 8\mu F}{10\,\mu F}\times V^2$$

$$=\frac{1}{2}\times(1.6\mu F)\times V^2$$

Therefore % loss of energy = $=\frac{1.6}{2}\times 100=80\%$

24. Energy stored in the capacitor is given by $U=\frac{1}{2}CV^2$

If initial potential V_1 and final potential is V_2, then increase in energy

$$\Delta U=\frac{1}{2}C\left(V_2^2-V_1^2\right)$$

$$=\frac{1}{2}\times 6\times 10^{-6}\left[(20)^2-(10)^2\right]$$

$$=\frac{1}{2}\times 6\times 10^{-6}\left[(20+10)(20-10)\right]$$

$$=\left(3\times 10^{-6}\right)\times 300$$

$$\Delta U=9\times 10^{-4}\,J$$

25. Equivalent capacitance in the above branch will be 4+9+34(9+3)μF=3μF.

Total charge in above branch will be Q=CV=24μC. This charge resides on the 4μF capacitor

and 12μF (combination of 3 μF and 9μF) capacitor.

Now, voltage across 12μF combination of capacitors is given by V=Q/C=24/12=2V. This is the same as the voltage across 9μF capacitor.

Hence, charge on 9μF capacitor is Q=CV=9×2=18μC

From above total charge on 4μF and 9μF capacitors is 24+18=42μC

Now, by coulomb's law,

E=r2kQ

E=3029×109×42×10−6=420N/C

26. By formula of electric field between the plates of a capacitor E=Kε0σ

σ=EKε0=3×104×2.2×8.85×

=6.6×8.85×

=5.841×

≅6× C/m2

27. $C = \frac{\varepsilon_0 A}{d} = 9 \times 10^{-12} F$

With dielectric $C = \frac{\varepsilon_0 k A}{d}$

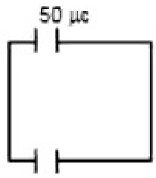
$C_1 = \frac{\varepsilon_0 A 3}{d/3} = 9c$, $C_2 = \frac{\varepsilon_0 A}{2d/3} = 9c$

$C_{total} = \frac{9}{2} \times 10^{-12} F \Rightarrow C_{total} = 40.5 pF$

28. Initial charged stored = $50\,\mu C$

Let the dielectric constant of the material induced be 'k'

Now, when the extra charge flown through battery is 100



Now

$C_1 = \frac{\varepsilon_0 A}{d} or \frac{q_1}{V} = \frac{\varepsilon_0 A}{d} \to (1)$

$C_2 = \frac{\varepsilon_0 A k}{d} or \frac{q_2}{V} = \frac{\varepsilon_0 A k}{d} \to (2)$

Dividing (1) & (2) we get $\frac{q_1}{q_2} = \frac{1}{k}$

$\Rightarrow \frac{50}{150} = \frac{1}{k} \Rightarrow k = 3$

29. Hint $q = CV$

$182 \times 10^{-6} C$

30. $\frac{4}{3}\pi R^3 = 1000 \times \frac{4}{3}\pi r^3 \Rightarrow R = 10r$

$V = \frac{kq}{r}$ & $V^1 = \frac{kq}{R} \times 100$

Total charge on one small droplets in q and on the big drop in $1000q$

$\frac{V^1}{V} = \frac{1000r}{R} = \frac{1000}{10} = 100V$.