Capacitor

Question1

If a dielectric slab of dielectric constant 3 is introduced between the plates of a capacitor having electric field $15\pi NC^{-1}$, then the electric displacement is

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Options:

A.

$1250 \times 10^{-12} Cm^{-2}$

B.

$250 \times 10^{-12} Cm^{-2}$

C.

$125 \times 10^{-9} Cm^{-2}$

D.

$250 \times 10^{-9} Cm^{-2}$

Answer: A

Solution:

Given data

- Dielectric constant $K = 3$
- Electric field $E = 15\pi\, N/C$
- We are to find **electric displacement** D.

Step 1. Recall the relation

$D = \varepsilon_0 E + P = \varepsilon_0 K E$

(using $K = \frac{D}{\varepsilon_0 E}$).

So,

$D = \varepsilon_0 K E$

Step 2. Substitute values

$\varepsilon_0 = 8.854 \times 10^{-12}\,\mathrm{F/m}$

$D = (8.854 \times 10^{-12}) \times 3 \times (15\pi)$

Step 3. Compute

$D = 8.854 \times 10^{-12} \times 45\pi$

$45\pi \approx 141.37$

$D = 8.854 \times 10^{-12} \times 141.37$

$D \approx 1.252 \times 10^{-9}\,\mathrm{C/m^2}$

Step 4. Express in given unit format

$1.252 \times 10^{-9}\,\mathrm{C/m^2} = 1250 \times 10^{-12}\,\mathrm{C/m^2}$

✅ **Final Answer:**

$\boxed{D = 1250 \times 10^{-12}\,\mathrm{C/m^2}}$

Correct Option: A

Question2

A capacitor of capacitance 2μ F is charged with the help of a 60 V battery. After disconnecting the battery, if this capacitor is connected in parallel with another uncharged capacitor of capacitance $l\mu$ F, then the potential difference across the plates of 2μ F capacitor is

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Options:

A.

30 V

B.

60 V

C.

40 V

D.

20 V

Answer: C

Solution:

Step 1: Find the charge on the first capacitor.

The 2 μF capacitor is charged using the 60 V battery, so its charge is:
$q_1 = C \times V = 2 \times 10^{-6} \times 60 = 120 \times 10^{-6}$ C

Step 2: Find the charge on the second capacitor.

The 1 μF capacitor is not charged yet, so$q_2 = 0$ C

Step 3: Find total charge after connection.

The total charge when we join them is the sum of both charges: $q_{\text{total}} = 120 \times 10^{-6} + 0 = 120 \times 10^{-6}$ C

Step 4: Find total capacitance when connected in parallel.

When capacitors are connected in parallel, their capacitances add:
$C_{\text{total}} = 2\ \mu\text{F} + 1\ \mu\text{F} = 3\ \mu\text{F} = 3 \times 10^{-6}$ F

Step 5: Find the new (final) voltage across the capacitors.

The new voltage is the total charge divided by the total capacitance:$V_{\text{final}} = \frac{q_{\text{total}}}{C_{\text{total}}} = \frac{120 \times 10^{-6}}{3 \times 10^{-6}} = 40$ V

Question3

The energy stored in a capacitor of capacitance 10μ F when charged to a potential of 6 kV is

Options:

A.

100 J

B.

200 J

C.

180 J

D.

160 J

Answer: C

Solution:

Energy stored in a capacitor is,

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

$$\Rightarrow \quad U=\frac{1}{2}\times 10\times 10^{-6}\times\left(6\times 10^3\right)^2$$

$$=\frac{1}{2}\times 10\times 10^{-6}\times 36\times 10^6$$

$$=180\text{ J}$$

Question4

A parallel plate capacitor has plates of area $0.4\pi\ \mathrm{m}^2$ and spacing of 0.5 mm . If a slab of thickness 0.5 mm and dielectric constant 4.5 is introduced in between the plates of the capacitor, then the capacitance of the capacitor is

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Options:

A.

100 nF

B.

60 pF

C.

100 pF

D.

60 nF

Answer: A

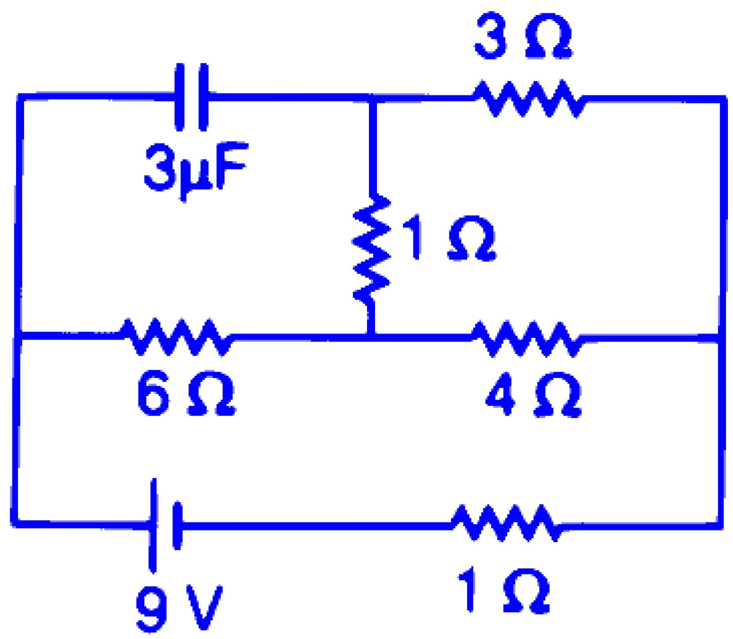
Solution:

Here dielectric fills the space between plates completely so,

$$\begin{aligned} C &= \frac{\varepsilon_0 K A}{d} \\ &= \frac{8.85 \times 10^{-12} \times 4.5 \times 0.4\pi}{0.5 \times 10^{-3}} \\ &\approx 100 \mathrm{nF} \end{aligned}$$

Question5

In the given circuit, the potential difference across the plates of the capacitor C in steady state is



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Options:

A.

6.5 V

B.

6 V

C.

9 V

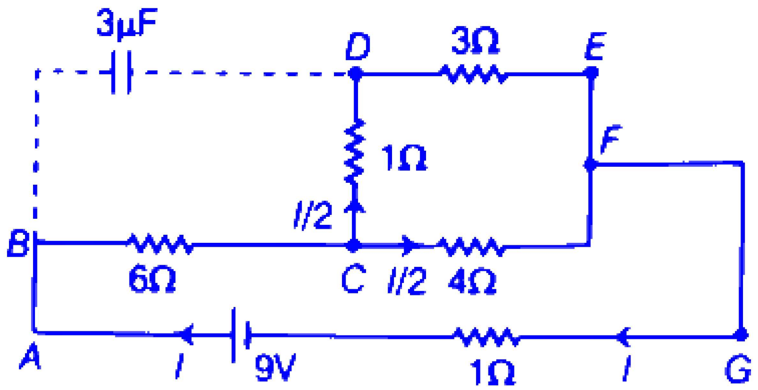
D.

7.5 V

Answer: A

Solution:

In given circuit capacitor does not conducts once it is charged. So in steady state we have following circuit.



$\Rightarrow$ Now, let $I=$ current drawn from cell. Then we have above current distribution.

Using KVL in loop $ABCDEFGA$; we have;

$$-6I-1\frac{I}{2}-\frac{3I}{2}-I+9=0$$
$$\Rightarrow \quad 9I=9 \text{ or } I=1 \text{ A}$$

Now, potential difference between B and D (using KVL);

$$V_B-6\times1-1\times\frac{1}{2}=V_D$$
$$\Rightarrow V_B-V_D=6+\frac{1}{2}=\frac{13}{2}=6.5 \text{ V.}$$

Question6

One of the two identical capacitors having the same capacitance C, is charged to a potential V_1 and the other is charged to a potential V_2. If they are connected with their like plates together, then the decrease in the electrostatic potential energy of the combined system is

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Options:

A.

$\frac{C}{4}\left(V_1^2-V_2^2\right)$

B.

$\frac{C}{4}\left(V_1^2+V_2^2\right)$

C.

$\frac{C}{4}(V_1 - V_2)^2$

D.

$\frac{C}{4}(V_1 + V_2)^2$

Answer: C

Solution:

$$
\begin{aligned}
U_i &= \frac{1}{2}CV_1^2 + \frac{1}{2}CV_2^2 \\
&= \frac{1}{2}C\left(V_1^2 + V_2^2\right)
\end{aligned}
$$

Common potential,

$$
\begin{aligned}
V &= \frac{Q_1 + Q_2}{C_1 + C_2} = \frac{CV_1 + CV_2}{C + C} \\
&= \frac{V_1 + V_2}{2} \\
\Rightarrow \quad V &= \frac{V_1 + V_2}{2} \\
\therefore \quad U_f &= \frac{1}{2}C^1V^2 \\
&= \frac{1}{2}(2C)\left(\frac{V_1 + V_2}{2}\right)^2 = C\left(\frac{V_1 + V_2}{2}\right)^2 \\
\therefore \quad \Delta U &= U_i - U_f \\
&= \frac{1}{2}C\left(V_1^2 + V_2^2\right) - C\left(\frac{V_1 + V_2}{2}\right)^2 \\
&= \frac{C}{2}\left(V_1^2 + V_2^2\right) - \frac{C}{4}\left(V_1^2 + V_2^2 + 2V_1V_2\right) \\
&= \frac{C}{4}\left[2V_1^2 + 2V_2^2 - V_1^2 - V_2^2 - 2V_1V_2\right] \\
&= \frac{C}{4}\left[V_1^2 + V_2^2 - 2V_1V_2\right] = \frac{C}{4}(V_1 - V_2)^2
\end{aligned}
$$

Question7

If 27 indentical charged conducting spheres each of capacitance 10μ F combine to form a big sphere, then the capacitance of the big sphere is

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Options:

A.

$30 \mu \mathrm{~F}$

B.

$270 \mu \mathrm{~F}$

C.

$90 \mu \mathrm{~F}$

D.

$10 \mu \mathrm{~F}$

Answer: A

Solution:

Capacitance of small conducting sphere

$C=4 \pi \varepsilon_0 r=10 \mu \mathrm{~F}$

Since, $27 \times \frac{4}{3} \pi r^3=\frac{4}{3} \pi R^3 \Rightarrow R=3 r$

$\therefore$ Capacitance of big sphere

$$\begin{aligned} C^{\prime} & =4 \pi \varepsilon_0 R=4 \pi \varepsilon_0(3 r) \\ & =3\left(4 \pi \varepsilon_0 r\right)=3 \times 10=30 \mu \mathrm{~F} \end{aligned}$$

Question8

The capacitance of a spherical capacitor is 100 pF . If the spacing between the two spheres is 1 cm , then the radius of the inner sphere of the capacitor is

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Options:

A.

9 cm

B.

10 cm

C.

19 cm

D.

20 cm

Answer: A

Solution:

$$
\begin{aligned}
b-a=1\text{ cm}=1\times10^{-2}\text{ m},\\
b=\left(a+1\times10^{-2}\right)\text{m}\\
C=4\pi\varepsilon_0\left(\frac{ab}{b-a}\right)\\
\Rightarrow 100\times10^{-12}=\frac{1}{9\times10^9}\times\frac{a\left(a+1\times10^{-2}\right)}{1\times10^{-2}}\\
9\times10^{-3}=a^2+10^{-2}a\\
\Rightarrow 0.9=100a^2+a\\
\Rightarrow 100a^2+a-0.9=0\\
\Rightarrow a=\frac{-1\pm\sqrt{1^2-4\times100(-0.9)}}{2\times100}\\
=-1\pm\frac{\sqrt{361}}{200}=\frac{-1\pm19}{200}\\
=\frac{-1+19}{200}=\frac{18}{200}\text{ m}\\
=0.09\text{ m}=9\text{ cm}
\end{aligned}
$$

Question9

The energy stored in a capacitor is W. To double the charge on the plates of the capacitor, the additional work to be done is

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Options:

A.

W

B.

$4W$

C.

$\frac{4}{3}W$

D.

$3W$

Answer: D

Solution:

$$W = \frac{Q^2}{2C}$$
$$W' = \frac{(2Q)^2}{2C} = 4\left(\frac{Q^2}{2C}\right) = 4W$$

$\therefore$ Additional work done,

$W' - W = 4W - W = 3W$

Question10

A wire of length 10 m carrying current of 1 A is bent in to a circular loop. If a magnetic field of $2\pi \times 10^{-4}$ T is applied on the loop, then the maximum torque acting on it is

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Options:

A.

$100 \times 10^{-4}\ \mathrm{N-m}$

B.

$50 \times 10^{-4}\ \mathrm{N-m}$

C.

$25 \times 10^{-4}\ \mathrm{N-m}$

D.

$75 \times 10^{-4}\ \mathrm{N-M}$

Answer: B

Solution:

$\tau_{\max} = MB$
$\tau_{\max} = IAB$

Since, $2\pi r = 10$

$\Rightarrow \quad r = \frac{10}{2\pi}$

$\therefore$ Area of the loop

$$A = \pi r^2 = \pi\left(\frac{10}{2\pi}\right)^2$$
$$= \frac{100}{4\pi} = \frac{25}{\pi}\ \mathrm{m}^2$$
$$\therefore \tau_{\max} = LAB = 1 \times \frac{25}{\pi} \times 2\pi \times 10^{-4}$$
$$= 50 \times 10^{-4}\ \mathrm{N-m}$$

Question11

The radii of the inner and outer spheres of a spherical capacitor are 8 cm and 9 cm respectively. The outer sphere is earthed and the inner sphere is charged. If the space between the concentric spheres is filled with a liquid of dielectric constant 5 , the capacitance of the capacitor is

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Options:

A.

400 PF

B.

40 PF

C.

400μ F

D.

40μ F

Answer: A

Solution:

$$C=4\pi\varepsilon_0 k\frac{r_1 r_2}{r_2-r_1}$$

$$=4\pi\left(8.85\times10^{-12}\right)\times5\times\frac{(0.08)(0.09)}{0.09-0.08}$$

$$\simeq 400\times10^{-12}\text{ F}$$

$$\simeq 400\text{pF}$$

Question12

A capacitor of capacitance 2μ F is charged to 50 V and then disconected from the source. Later the gap between the plates of the capacitor is filled with a dielectric material. If the energy stored in the capacitor is decreased by 25% of its initial value, then the dielectric constant of the dielectric material is

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Options:

A.

$\frac{2}{3}$

B.

$\frac{4}{3}$

C.

$\frac{3}{4}$

D.

$\frac{3}{2}$

Answer: B

Solution:

Initial stored energy

$E_i = \frac{1}{2} C V^2$

Final stored energy,

$$\begin{aligned} E_f &= E_i - 0.25 E_i \\ E_f &= 0.75 E_i \qquad \ldots (i) \\ \therefore \quad E_f &= \frac{1}{2} C' V'^2 \\ &= \frac{1}{2}(KC)\left(\frac{V}{k}\right)^2 \\ E_f &= \frac{E_i}{K} \\ \Rightarrow 0.75 E_i &= \frac{E_i}{K} \quad \text{[from eq. (i)]} \\ \Rightarrow \quad \frac{1}{K} &= 0.75 \\ \Rightarrow \quad K &= \frac{1}{0.75} = \frac{4}{3} \end{aligned}$$

Question13

The space between the plates of a parallel plate capacitor is halved and a dielectric medium of relative permittivity 10 is introduced between the plates. The ratio of the final and initial capacitances of the capacitor is

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Options:

A. 20

B. 10

C. $1/10$

D. $1/20$

Answer: A

Solution:

The capacitance of a parallel plate capacitor is given by the formula:

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

where:

A is the area of the plates,

ε_0 is the permittivity of free space,

d is the distance between the plates.

In this scenario, the distance between the plates is halved, and a dielectric material with a relative permittivity (k) of 10 is introduced. The new capacitance (C') can be calculated as follows:

$C' = \frac{kA\varepsilon_0}{d'} = \frac{10 \cdot A\varepsilon_0}{d/2}$

Simplifying gives:

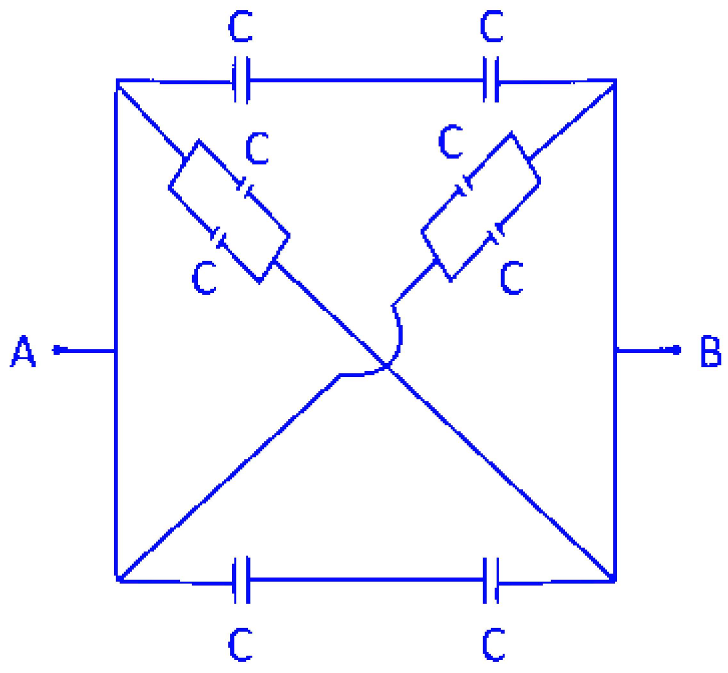
$C' = \frac{10 \cdot A\varepsilon_0}{d/2} = \frac{20 \cdot A\varepsilon_0}{d} = 20C$

Thus, the ratio of the final capacitance to the initial capacitance is:

$\frac{C'}{C} = 20$

Question14

Eight capacitors each of capacity 2μ F are arranged as shown in figure. The effective capacitance between A and B is



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Options:

A. 10μ F

B. 12μ F

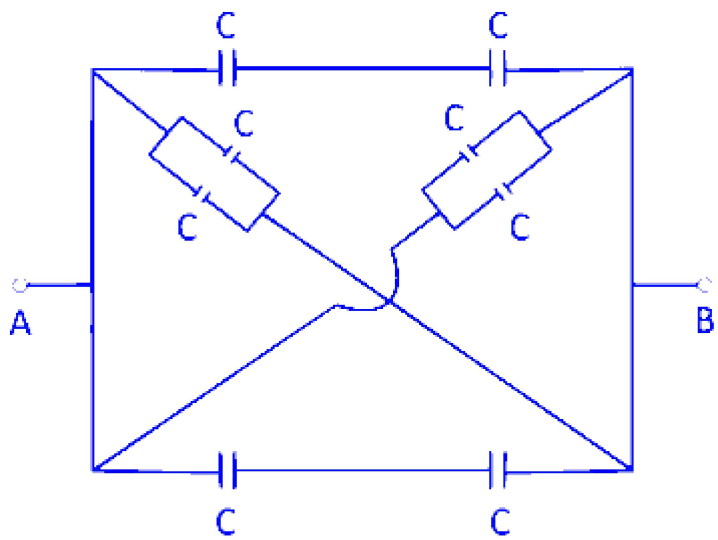
C. 16μ F

D. 4μ F

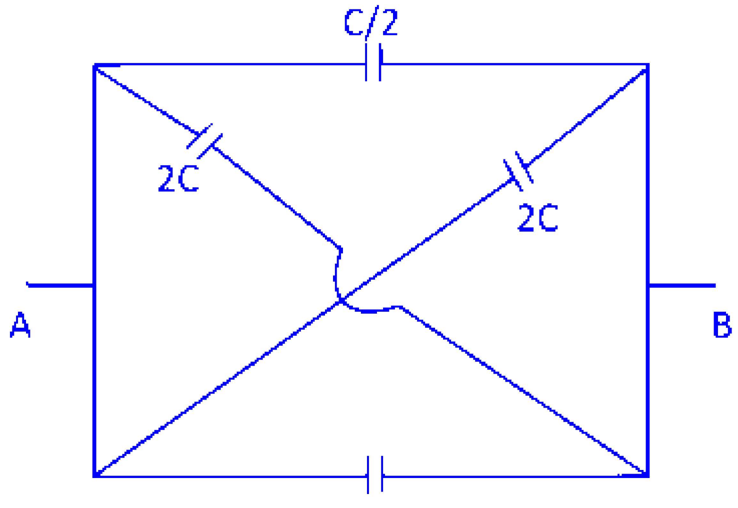
Answer: A

Solution:

Given capacitance, $C = 2\mu$ F



Equivalent circuit, Thus, $C_{\text{eq}} = \frac{C}{2} + \frac{C}{2} + 2C + 2C$



$$= C + 4C$$
$$C_{\text{eq}} = 5C$$
$$\therefore C_{\text{eq}} = 5 \times 2 = 10\mu \text{ F}$$

Question15

When a parallel plate capacitor is charged up to 95 V , its capacitance is C. If a dielectrtic slab of thickness 2 mm is inserted between plates and distance between the plates is increased by 1.6 mm such that the same potential difference is maintained. The dielectric constant of the material (slab) is

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Options:

A. 2.4

B. 4.5

C. 5.0

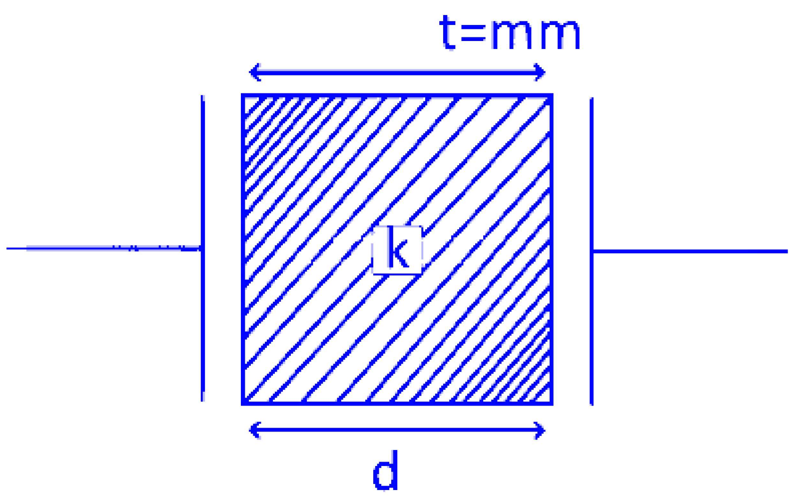
D. 9.0

Answer: C

Solution:

Let initial thickness $= d$

Thickness of dielectrics $= 2$ mm



It is given that final potential is same.

Let initial capacitance $= C_1$

Final capacitance $= C_2$

$\therefore \quad C_1 = C_2 \quad \ldots(i)$

$C_1 = \frac{A\varepsilon_0}{d}$ and $C_2 = \frac{A\varepsilon_0}{d'-t+\frac{t}{k}}$

where, $d' = d + 1.6$ mm

$$\Rightarrow \quad \frac{A\varepsilon_0}{d} = \frac{A\varepsilon_0}{(d+1.6) - t\left(1-\frac{1}{k}\right)}$$

$$\Rightarrow \quad \frac{1}{d} = \frac{1}{(d+1.6) - 2\left(1-\frac{1}{k}\right)}$$

$$\Rightarrow \quad d + 1.6 - 2 + \frac{2}{k} = d$$

$$\Rightarrow \quad k = 5$$

Question16

The capacitance of an isolated sphere of radius r_1 is increased by 5 times, when it is enclosed by an earthed concentric sphere of radius r_2. The ratio of their radii is

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Options:

A. $\frac{4}{5}$

B. $\frac{5}{4}$

C. $\frac{5}{1}$

D. $\frac{3}{5}$

Answer: A

Solution:

Given,

Radius of isolated sphere $= r_1$

Radius of earthed sphere $= r_2$

Capacitance of isolated sphere,

$C_1 = 4\pi\varepsilon_0 r_1 \qquad \ldots(i)$

Capacitance of isolated sphere enclosed in earthed sphere,

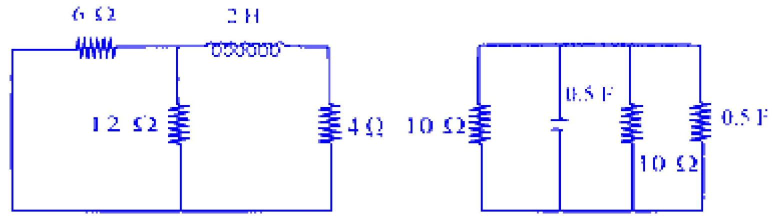
$C_2 = \frac{4\pi\varepsilon_0 r_1 r_2}{r_2 - r_1} \qquad \ldots(ii)$

Now, capacitance is 5 times

$$\Rightarrow \quad 5C_1 = C_2$$
$$\Rightarrow 5(4\pi\varepsilon_0 r_1) = \frac{4\pi\varepsilon_0 r_1 r_2}{r_2 - r_1} \Rightarrow 5 = \frac{r_2}{r_2 - r_1}$$
$$\Rightarrow 5r_2 - 5r_1 = r_2 \Rightarrow -5r_1 = -4r_2$$
$$\Rightarrow \quad \frac{r_1}{r_2} = \frac{4}{5}$$

Question17

Two figures are shown as Fig. A and Fig. B. The time constant of Fig. A is τ_A and time constant of Fig. B is τ_B. Then



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Options:

A. $\tau_A=\frac{1}{4}$ s and $\tau_B=5$ s

B. $\tau_A=\frac{1}{2}$ s and $\tau_B=\frac{1}{5}$ s

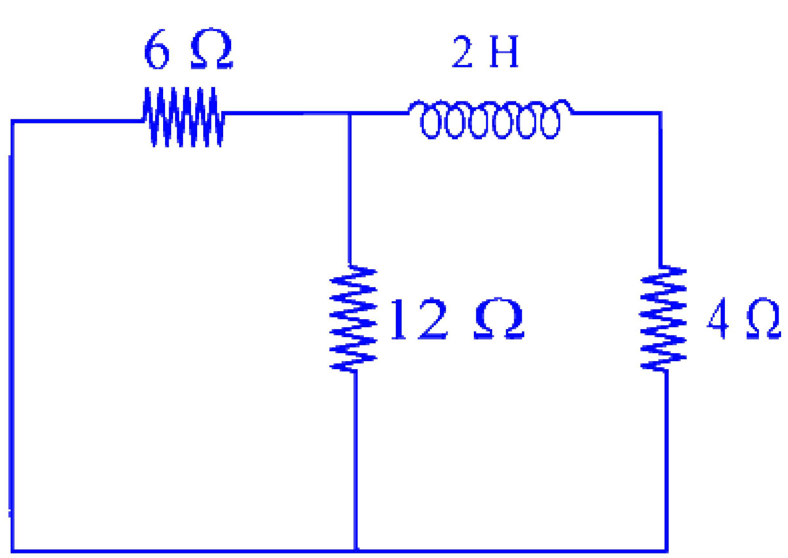
C. $\tau_A=4$ s and $\tau_B=5$ s

D. $\tau_A=\frac{1}{3}$ s and $\tau_B=10$ s

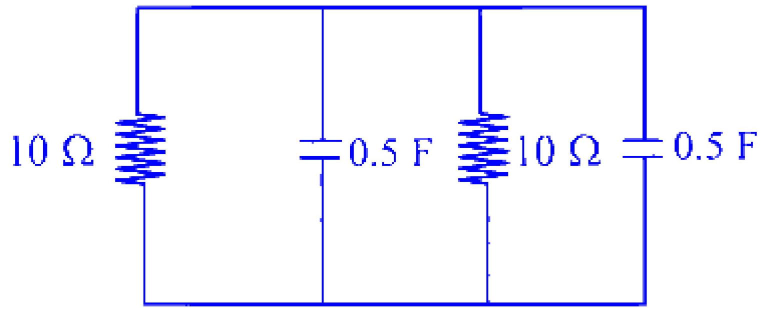
Answer: A

Solution:

For fig (A),



$R' = \frac{6 \times 12}{6+12} + 4 = 4 + 4$
$R' = 8$
$\therefore$ Time constant for circuit (A)
$\tau_A = \frac{L}{R'} = \frac{2}{8} = \frac{1}{4}$ s



Similar for figure (B)

$R'' = \frac{10 \times 10}{10+10} = 5\Omega$

and equivalent capacitance,

$C_{\text{eq}} = 0.5 + 0.5 = 1$ F

$\therefore$ Time constant, $\tau_B = RC$

$= 5 \times 1 = 5$ s

Question18

Three parallel plate capacitors of capacitances 4μ F, 6μ F and 12μ F are first connected in series and then in parallel. The ratio of the effective capacitances in the two cases is

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Options:

A. $1 : 11$

B. $5 : 8$

C. $3 : 7$

D. $4 : 9$

Answer: A

Solution:

Given the capacitances:

$C_1 = 4\,\mu\mathrm{F}$

$C_2 = 6\,\mu\mathrm{F}$

$C_3 = 12\,\mu\mathrm{F}$

When connected in series:

To find the equivalent capacitance for capacitors in series, we use the formula:

$C_{\text{eq}} = \frac{C_1C_2C_3}{C_1C_2+C_2C_3+C_3C_1}$

Substituting the given values:

$C_{\text{eq}} = \frac{4\times6\times12}{4\times6+6\times12+12\times4} = \frac{288}{144} = 2\,\mu\mathrm{F}$

When connected in parallel:

For capacitors in parallel, the equivalent capacitance is the sum of the capacitances:

$C_{\text{eq}} = C_1 + C_2 + C_3$

Substituting the given values:

$C_{\text{eq}} = 4 + 6 + 12 = 22\,\mu\mathrm{F}$

Calculating the ratio:

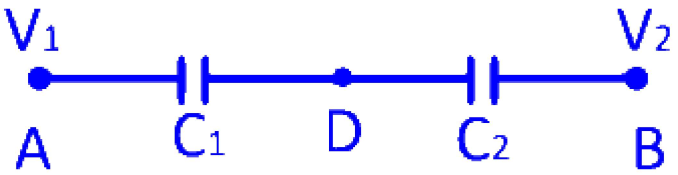
The ratio of the effective capacitances when connected in series to when connected in parallel is:

$\frac{2}{22} = \frac{1}{11}$

Thus, the ratio is 1 : 11.

Question19

Two condensers C_1 and C_2 in a circuit are joined as shown in the figure. The potential of point A is V_1 and that of point B is V_2. The potential at point D will be



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Options:

A. $\frac{1}{2}(V_1 + V_2)$

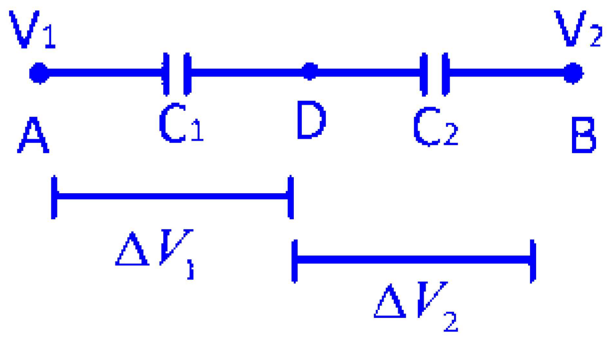
B. $\frac{C_2V_2+C_1V_2}{C_1+C_2}$

C. $\frac{C_1V_1+C_2V_2}{C_1+C_2}$

D. $\frac{C_2V_1-C_1V_2}{C_1+C_2}$

Answer: C

Solution:



Let the potential of point D be V.

In the above figure, capacitors C_1 and C_2 are in series combination.

Potential difference across both the capacitors are,

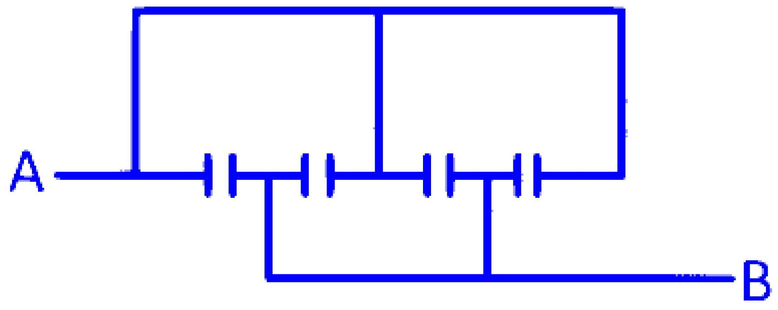
$$\Delta V_1 = V_1 - V$$
$$\Delta V_2 = V - V_2$$

We knows that in series arrangement, the charge on capacitor will be equal.

$$\Rightarrow \quad Q_1 = Q_2$$
$$C_1 (V_1 - V) = C_2 (V - V_2)$$
$$\Rightarrow \quad C_1V_1 - C_1V = C_2V - C_2V_2$$
$$\Rightarrow \quad C_1V + C_2V = C_2V_2 + C_1V_1$$
$$\Rightarrow \quad V (C_1 + C_2) = C_1V_1 + C_2V_2$$
$$\Rightarrow \quad V = \frac{C_1V_1+C_2V_2}{(C_1+C_2)}$$

Question20

Four condensers each of capacitance 8μ F are joined as shown in the figure. The equivalent capacitance between the points A and B will be



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Options:

A. 32μ F

B. 2μ F

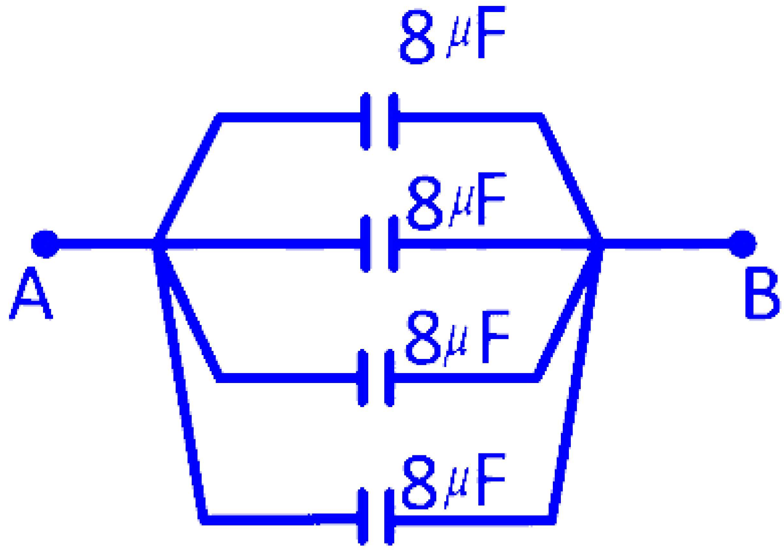
C. 8μ F

D. 16μ F

Answer: A

Solution:

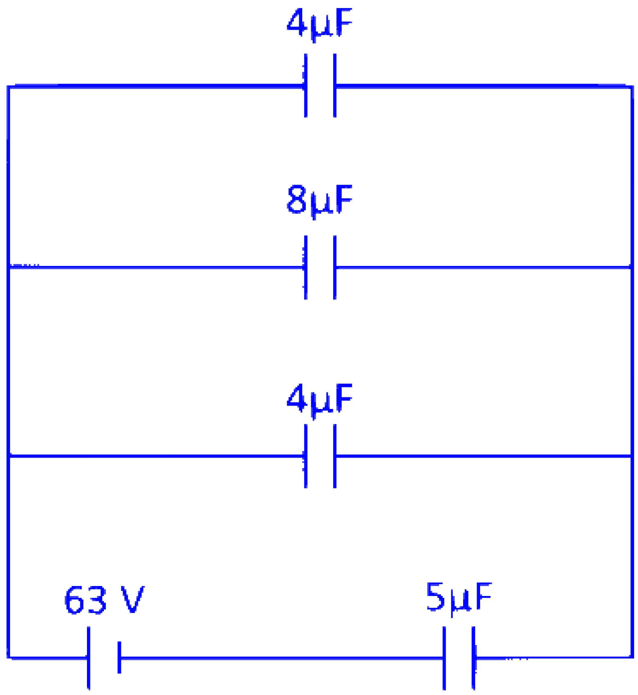
The given arrangement of capacitor are represented as



$\therefore C_{AB} = 8 + 8 + 8 + 8 = 32\mu$ F

Question21

In the given circuit, the potential difference across 5μ F capacitor is



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Options:

A. 48 V

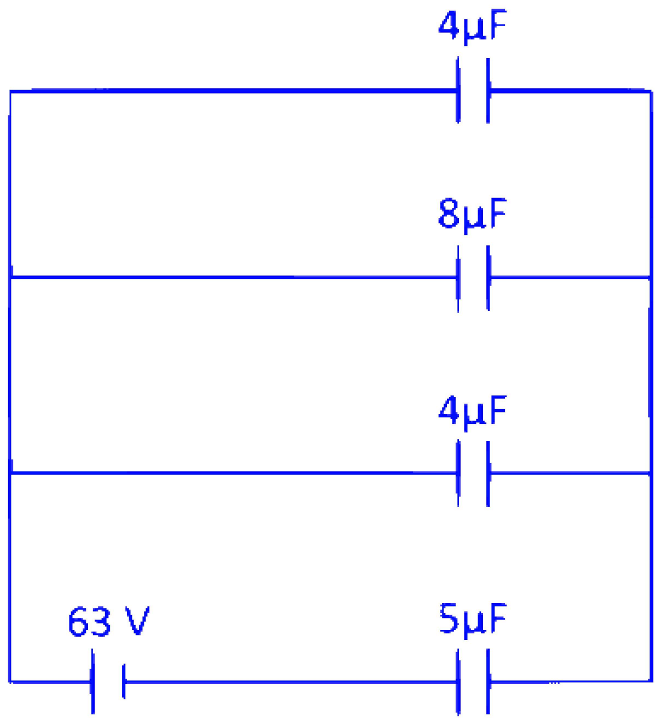
B. 24 V

C. 63 V

D. 21 V

Answer: A

Solution:



According to figure,

$4 \mu \mathrm{~F}, 8 \mu \mathrm{~F}, 4 \mu \mathrm{~F}$ are in parallel combination. So,

$C^{\prime}=4+8+4=16 \mu \mathrm{~F} \quad \ldots$ (i)

Now, $C^{\prime}$ and $5 \mu \mathrm{~F}$ are in series combination. So, total capacitance in the circuit is,

$\frac{1}{C_{\text {total }}}=\frac{1}{5}+\frac{1}{C^{\prime}}$

From Eq. (i), $C_{\text {total }} \quad=\frac{16 \times 5}{16+5}=\frac{80}{21} \mu \mathrm{~F}$

Total charge in the given circuit,

$$
\begin{aligned}
q_{\text{total}} & =C_{\text{total}} \cdot V \\
& =\frac{80}{21} \times 63=240 \mu \mathrm{C}
\end{aligned}
$$

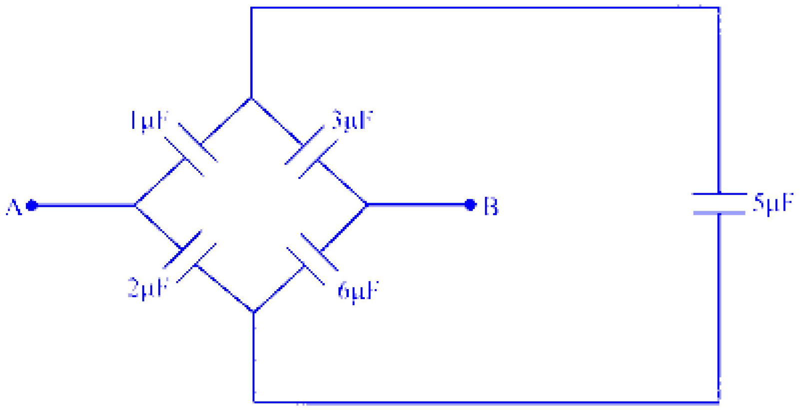
Charge remains same in series combination. So, 5μ F also have 240μC charge.

The potential difference across 5μ F capacitor is,

$$
\begin{aligned}
& V^{\prime}=\frac{Q}{C}=\frac{240}{5} \\
& V^{\prime}=48 \mathrm{~V}
\end{aligned}
$$

Question22

The capacitance between the points A and B in the following figure.



AP EAPCET 2022 - 5th July Morning Shift

Options:

A. $\frac{3}{8} \mu F$

B. $\frac{9}{4} \mu \mathrm{F}$

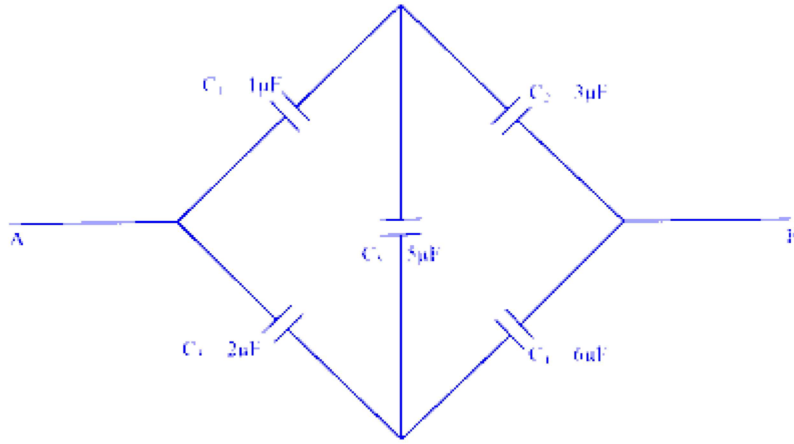
C. $\frac{4}{5} \mu \mathrm{F}$

D. $2 \mu \mathrm{F}$

Answer: B

Solution:

The given circuit diagram can be represented as

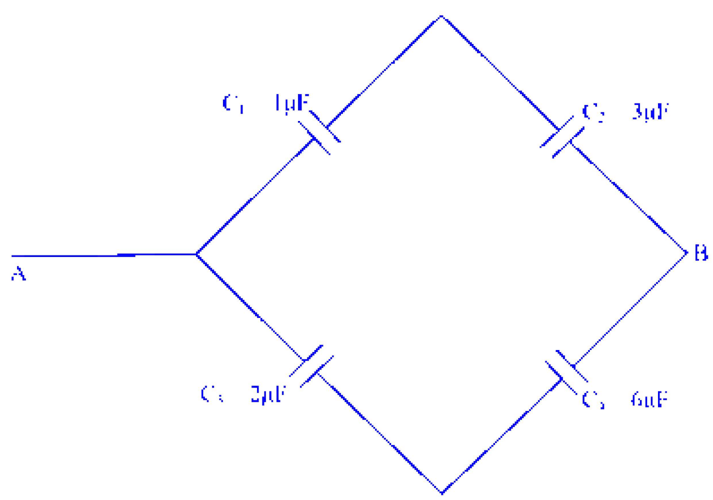


Since, $\frac{C_r}{C_2} = \frac{C_3}{C_4} = \frac{1}{3}$

Hence, given circuit follows the condition of balance wheatstone bridge.

Hence, capacitor C_5 is ineffective.

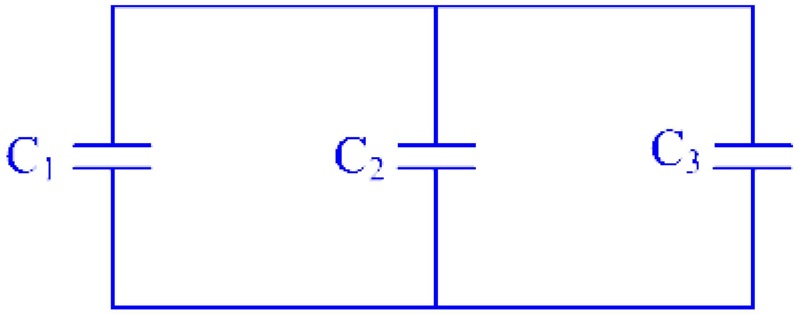
Now, the circuit diagram is redrawn as



$$C_{AB} = \frac{C_1 C_2}{C_1 + C_2} + \frac{C_3 C_4}{C_3 + C_4} = \frac{1 \times 3}{1+3} + \frac{2 \times 6}{2+6}$$
$$= \frac{3}{4} + \frac{12}{8} = \frac{9}{4} \mu\text{F}$$

Question23

A capacitor of capacitance $C_1 = 1\mu\text{F}$ is charged using a 9 V battery. C_1 is, then removed from the battery and connected to capacitors C_2 and C_3 of $2\mu\text{F}$ and $3\mu\text{F}$, respectively as shown in the figure. Find the charge on C_3 after equilibrium has reached is



AP EAPCET 2022 - 4th July Morning Shift

Options:

A. 4.5×10^{-6}C

B. 3.5×10^{-6}C

C. 2.5×10^{-6}C

D. 1.5×10^{-5}C

Answer: A

Solution:

Given, $C_1 = 1\mu\text{F}, V = 9$ V,

$C_2 = 2\mu\text{F}, C_3 = 3\mu\text{F}$

Equivalent capacitance of C_2 and C_3

$C' = C_2 + C_3 = 2 + 3 = 5\mu\text{F}$

Common potential difference when C_1 and C' are combined, is given as

$$V' = \frac{\text{total charge } (Q)}{\text{total copacitance } (C_1 + C')}$$
$$V' = \frac{Q}{C_1 + C'}$$

But $Q = C_1 V$
$$\therefore V' = \frac{C_1 V}{C_1 + C'} = \frac{1 \times 9}{1 + 5} = \frac{9}{6} = 1.5 \text{ V}$$

Charge on capacitor C_3 is given as

$$Q_3 = C_3 V'$$
$$= 3 \times 10^{-6} \times 1.5 = 4.5 \times 10^{-6}\text{C}$$

Question24

A 60 μF parallel plate capacitor whose platesare separated by 6 mm is charged to 250 V,and then the charging source is removed.When a slab of dielectric constant 5 andthickness 3 mm is placed between the plates,find the change in the potential differenceacross the capacitor.

AP EAPCET 2021 - 20th August Morning Shift

Options:

A. 250 V

B. 100 V

C. 150 V

D. 75 V

Answer: B

Solution:

Given,

Capacitance of parallel plate capacitor, $C_0 = 60 \propto \mathrm{F}$

$= 60 \times 10^{-6}\ \mathrm{F}$

Separation between plates, $d = 6\ \mathrm{mm}$

$= 6 \times 10^{-3}\ \mathrm{m}$

Electric potential, $V_0 = 250\ \mathrm{V}$

Dielectic constant of slab, $K = 5$

and thickness of slab, $t = 3\ \mathrm{mm}$

$= 3 \times 10^{-3}\ \mathrm{m}$

Since, $C = \frac{q}{V} = \frac{\varepsilon_0 A}{d} = \frac{\varepsilon_0 A}{d - t\left(1 - \frac{1}{K}\right)}$

where, q is charge stored, V is potential,ε_0 is free space permittivity $= 8.854 \times 10^{-12} \mathrm{Nm}^2 \mathrm{C}^{-2}$ and A is plate area

$$\begin{aligned} \therefore \quad q_0 &= C_0 V_0 \\ &= 60 \times 10^{-6} \times 250 = 15 \times 10^{-3} \mathrm{C} \end{aligned}$$

and new capacitance, $C' = \frac{\varepsilon_0 A}{\left[6-3\left(1-\frac{1}{5}\right)\right] \times 10^{-3}} \ldots \text{(i)}$

and $\varepsilon_0 A = C_0 d$

$$\begin{aligned} \Rightarrow \quad \varepsilon_0 A &= 60 \times 10^{-6} \times 6 \times 10^{-3} \\ &= 360 \times 10^{-9} \end{aligned}$$

Put this value in Eq. (i), we get

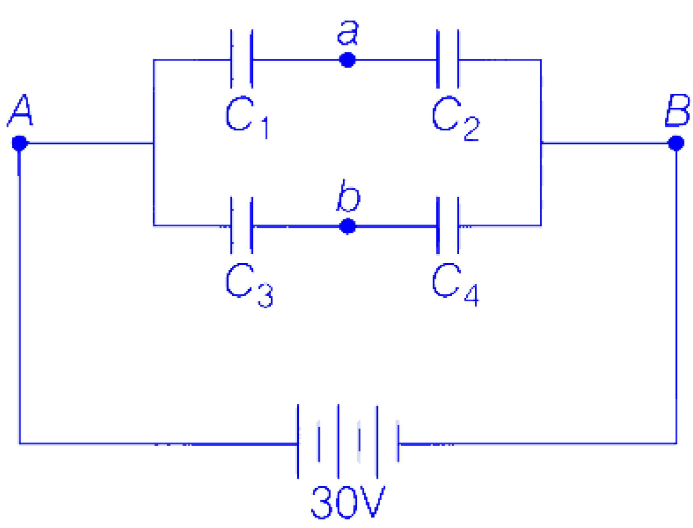
$C' = \frac{360 \times 10^{-9}}{3.6 \times 10^{-3}} = 10^{-4}$ F

Final potential stored in capacitor $= \frac{q_0}{C'} = \frac{15 \times 10^{-3}}{10^{-4}} = 150$ V

Hence, voltage difference $= 250 - 150 = 100$ V

Question25

Four capacitors with capacitances $C_1 = l \propto \mathrm{F}, C_2 = 1.5 \propto \mathrm{F}, C_3 = 2.5 \propto \mathrm{F}$ and $C_4 = 0.5 \propto \mathrm{F}$ are connected as shown and are connected to a 30 V source. The potential difference between points a and b is



AP EAPCET 2021 - 19th August Evening Shift

Options:

A. 5 V

B. 9 V

C. 10 V

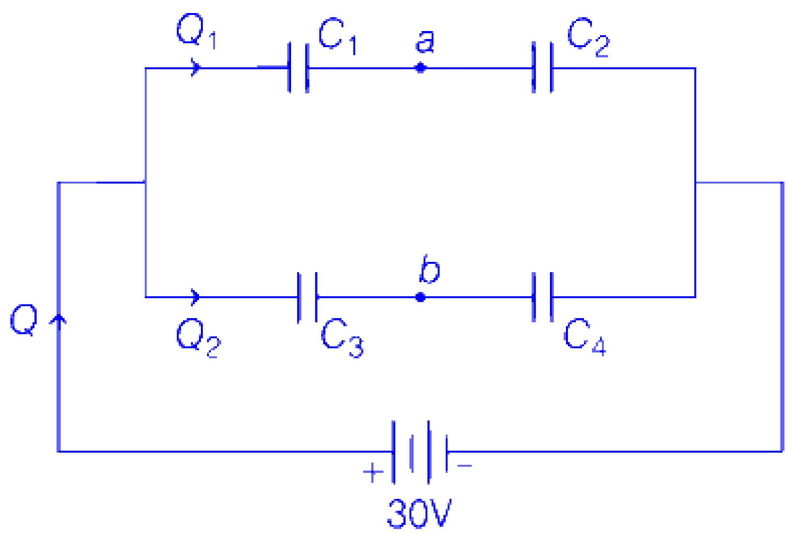
D. 13 V

Answer: D

Solution:

Given, C_1, C_2, C_3 and C_4 are 1 μF, 1.5 μF, 2.5 μF and 0.5 μF.

Supply voltage = 30 V



Let V_{ab} is potential across a and b,

Q is charge in circuit and Q_1, Q_2 are branch charges.

Since, series equivalent capacitance $\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2}$

$\Rightarrow \quad C_s = \frac{C_1 C_2}{C_1 + C_2}$

and in parallel connection voltages remain same

$$\therefore \quad Q_1 = \frac{C_1 C_2}{C_1 + C_2} V \Rightarrow Q_1 = \frac{1 \times 1.5}{1 + 1.5} \times 30$$

$$= \frac{1.5}{2.5} \times 30 = 18 \mu\text{C}$$

Similarly, $\quad Q_2 = \frac{2.5 \times 0.5}{2.5 + 0.5} \times 30 = 12.5 \mu\text{C}$

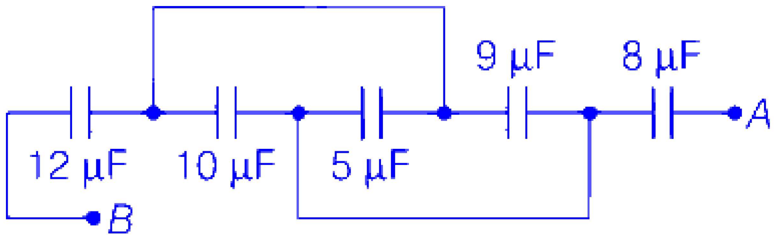
$$\therefore \quad V_{ab} = V_a - V_b = (V - V_b) - (V - V_a)$$

$$= \frac{Q_2}{C_3} - \frac{Q_1}{C_1} = \frac{12.5}{2.5} - \frac{18}{1} = -13 \text{ V}$$

$$\therefore \quad V_{ba} = 13 \text{ V}$$

Question26

In the given circuit, if the potentialdifference between A and B is 80 V, then theequivalent capacitance between A and B andthe charge on 10 $\propto$ F capacitor respectively,are



AP EAPCET 2021 - 19th August Morning Shift

Options:

A. 4 $\propto$ F and 133 $\propto$ C

B. 164 $\propto$ F and 150 $\propto$ C

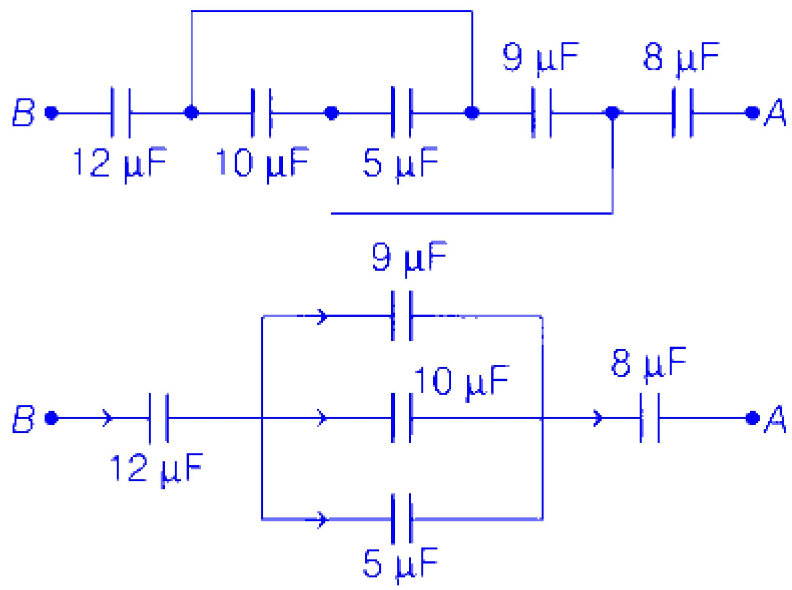
C. 15 $\propto$ F and 50 $\propto$ C

D. 4 $\propto$ F and 50 $\propto$ C

Answer: A

Solution:

According to given circuit diagram,



Voltage across A and $B, V_{AB} = 80$ V

Let charge in $9 \propto$ F, $10 \propto$ F and $5 \propto$ F be Q_1, Q_2 and Q_3.

Net charge, $Q = Q_{9 \propto \mathrm{F}} + Q_{10 \propto \mathrm{F}} + Q_{5 \propto \mathrm{F}}$

As we know that,

Parallel equivalent capacitance,

$$C'_{\mathrm{eq}} = C_1 + C_2 + C_2$$
$$\therefore C'_{\mathrm{eq}} = 9 + 10 + 5 = 24 \propto \mathrm{F}$$

and series equivalent capacitance,

$$\frac{1}{C_{\mathrm{eq}}} = \frac{1}{C_a} + \frac{1}{C_b} + \frac{1}{C_c}$$
$$\Rightarrow \frac{1}{C_{\mathrm{eq}}} = \frac{1}{12} + \frac{1}{24} + \frac{1}{8} \Rightarrow \frac{1}{C_{\mathrm{eq}}} = \frac{2+1+3}{24}$$
$$\Rightarrow C_{\mathrm{eq}} = \frac{24}{6} \propto \mathrm{F} = 4 \propto \mathrm{F}$$

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

$$\therefore \quad Q = CV$$
$$= 4 \times 10^{-6} \times 80 = 320 \propto \mathrm{C}$$

Since, in series connection,

$$V = V_{12 \propto \mathrm{F}} + V_{10 \propto \mathrm{F}} + V_{8 \propto \mathrm{F}}$$
$$\Rightarrow \quad 80 = \frac{320}{12} + V_{10 \propto \mathrm{F}} + \frac{320}{8}$$

$\Rightarrow V_{10 \propto F} = 13.33\, V$

$\therefore Q_{10 \propto F} = V_{10 \propto F} \times 10$

$\simeq 133 \propto C$
