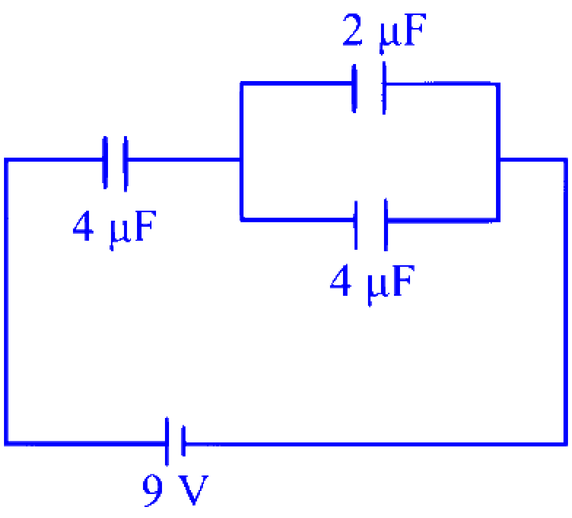
Capacitor

Question1

The potential difference across the 4 capacitor in the following circuit is



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Options:

A.

3.4 V

B.

4.6 V

C.

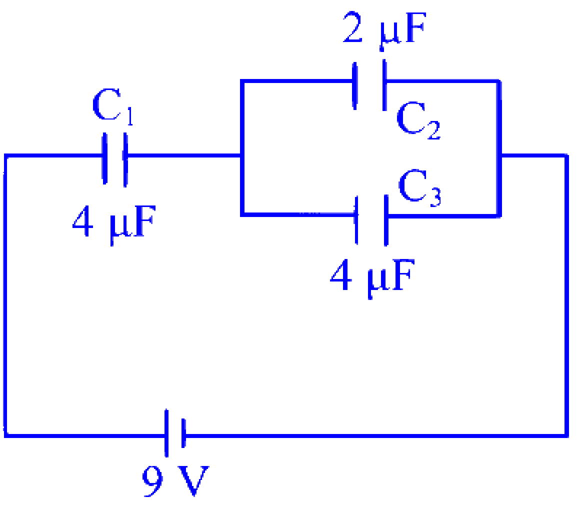
5.4 V

D.

6.2 V

Answer: C

Solution:



C_2 and C_3 capacitors are in parallel. Their equivalent capacitance is given by

$C_p = C_2 + C_3 = 2 + 4 = 6\mu F$

C_p is in series with C_1

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

As for series combination, the charge on the capacitors is same, therefore, potential across them is inversely proportional to their capacitances.

$V_1 : V_p = C_p : C_1$

$\therefore \quad V_1 = \frac{C_p}{C_p + C_1} V = \frac{6}{10} \times 9 = 5.4V$

Similarly, voltage across C_2 and C_3 will be

$\therefore \quad V_p = 9 - 5.4 \text{ V} = 3.6 \text{ V}$

The question asks for the voltage across a 4μ F capacitor. However, the circuit contains two 4μ F capacitors. Among the given options, 5.4 V is listed, but 3.6 V is not. Therefore, it is presumed that the voltage across the first 4μ F capacitor (C_1) is intended.

Question2

A capacitor of unknown capacity is connected across a battery of V volt. The charge stored in it is Q coulomb. When potential across the capacitor is reduced by V_1 volt, the charge stored in it becomes Q_1 coulomb. The potential V is

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Options:

A.

$\frac{QV_1}{Q-Q_1}$

B.

$\frac{Q_1V_1}{Q+Q_1}$

C.

$\frac{Q_1}{Q}$

D.

$\frac{Q}{Q_1}$

Answer: A

Solution:

Step 1: Formula for charge stored

The charge stored in a capacitor is given by the formula: $Q = CV$ where Q is the charge, C is the capacitance, and V is the voltage.

Step 2: Charge after voltage decreases

When the voltage is reduced by V_1, the new voltage becomes $V - V_1$. The new charge stored is: $Q_1 = C(V - V_1)$

Step 3: Isolate C (capacitance) from the second equation

We can find C from the second equation: $C = \frac{Q_1}{V-V_1}$

Step 4: Substitute C back into the first equation

Now, substitute C into the first equation: $Q = \left(\frac{Q_1}{V - V_1}\right)V$

Step 5: Rearranging to solve for V

Multiply both sides by $(V - V_1)$: $Q(V - V_1) = Q_1 V$

Expand and bring terms involving V to one side: $QV - QV_1 = Q_1 V$

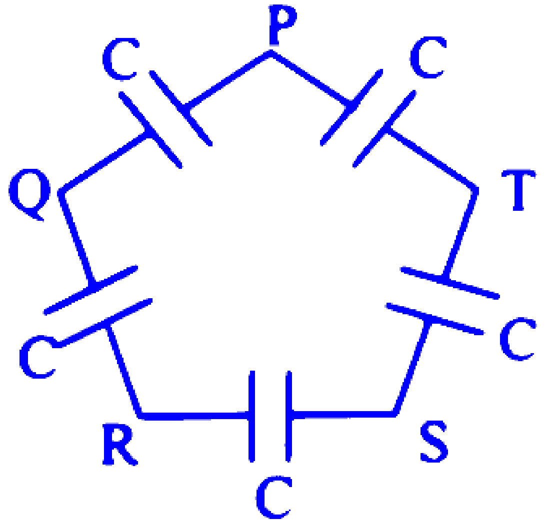
Now, get all V terms together: $QV - Q_1 V = QV_1$

Factor V on the left: $V(Q - Q_1) = QV_1$

Now, solve for V: $V = \frac{QV_1}{Q - Q_1}$

Question3

Five capacitors, each of capacitance ' C ' are connected as shown in the figure. The ratio of equivalent capacitance between P and R and the equivalent capacitance between P and Q is



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Options:

A.

1 : 4

B.

2 : 3

C.

3 : 1

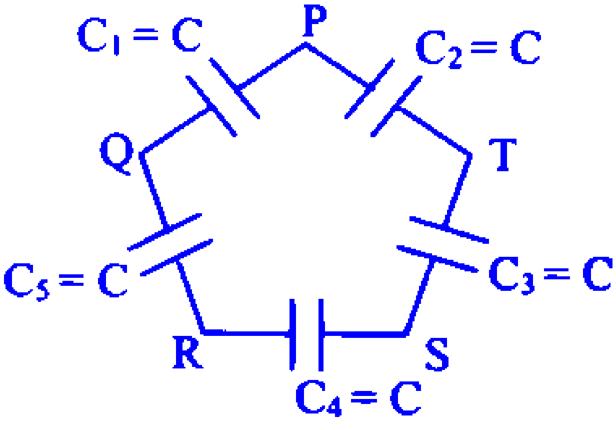
D.

5 : 2

Answer: B

Solution:

Let the capacitors be C_1, C_2, C_3, C_4 and C_5



Between P and Q- C_2, C_3, C_4 and C_5 are connected in series and C_1 is connected in parallel with them.

For the series combination

$$\frac{1}{C_{\text{series}}} = \frac{1}{C} + \frac{1}{C} + \frac{1}{C} + \frac{1}{C} = \frac{4}{C}$$

Equivalent capacitance,

$$C_{PQ} = C_{\text{series}} + C = \frac{C}{4} + C = \frac{5C}{4} \qquad \ldots (i)$$

Between points P and R – C_2, C_3 and C_4 are connected in series and C_1 and C_5 connected in series are connected in parallel with them

Between points P and R , capacitors C_2, C_3, and C_4 are connected in series, and this series combination is in parallel with another series combination of capacitors C_1 and C_5

$$\frac{1}{C_{\text{series}}} = \frac{1}{C} + \frac{1}{C} + \frac{1}{C} = \frac{3}{C} \Rightarrow C_{\text{series} \quad 1} = \frac{C}{3}$$
$$\frac{1}{C_{\text{series} \quad 2}} = \frac{1}{C} + \frac{1}{C} = \frac{2}{C} \Rightarrow C_{\text{series} \quad 2} = \frac{C}{2}$$

$$C_{PR} = C_{\text{series} \quad 1} + C_{\text{series} \quad 2} = \frac{C}{3} + \frac{C}{2} = \frac{5C}{6} \qquad \ldots (ii)$$

From (i) and (ii),

$$\frac{C_{PR}}{C_{PQ}} = \frac{5C/6}{5C/4} = \frac{2}{3}$$

Question4

The function of a dielectric in a capacitor is

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Options:

A.

to reduce the effective potential on plates,

B.

to increase the effective potential on plates.

C.

to decrease the capacity of capacitance.

D.

to reduce the plate area of the capacitor.

Answer: A

Solution:

The correct answer is:

Option A: to reduce the effective potential on plates.

Explanation:

- A dielectric is an insulating material placed between the plates of a capacitor.
- When a dielectric is inserted, the electric field inside the capacitor decreases because the dielectric becomes polarized.
- For the same charge stored on the plates, a lower effective potential difference exists across them.

- This leads to **increased capacitance** according to

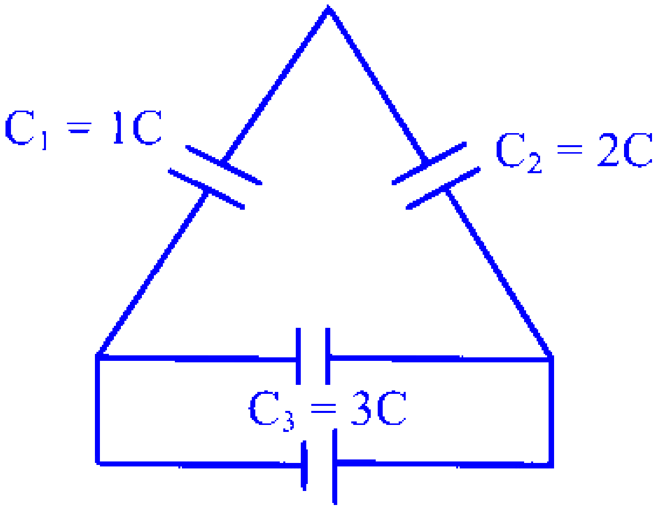
$C = \kappa \cdot C_0$

where κ is the dielectric constant, C_0 is the capacitance without the dielectric.

Hence, the dielectric's role is essentially to **reduce the effective potential** on the plates, thereby increasing capacitance. ✅

Question5

Three capacitors are connected to a battery as shown in figure. The ratio of charge on capacitors C_3 and C_1 is



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Options:

A. 1.5

B. 2.5

C. 3.5

D. 4.5

Answer: D

Solution:

Here, C_1 and C_2 are in series

$C_{12}=\frac{C_1 C_2}{C_1+C_2}=\frac{2 C^2}{3 C}=\frac{2}{3} C$

Also, C_3 is parallel to C_1 and C_2

$\therefore C_{eq}=C_{12}+C_3=\frac{2}{3} C+3 C=\frac{11}{3} C$

Charge on capacitor C_3

$Q_3=C_3 \cdot V=3 C V$

Charge on capacitor C_1

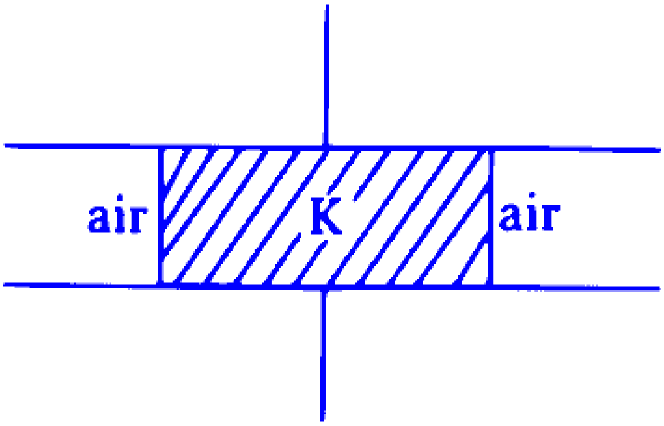
In series, charge on $C_1=Q_1=Q_{12}$

$$Q_{12}=C_{12} V=\frac{2}{3} CV$$

$$\therefore \quad \frac{\text{Charge on } C_3}{\text{Charge on } C_1}=\frac{3 CV}{\frac{2}{3} CV}=\frac{9}{2}=4.5$$

Question6

The capacity of air filled parallel plate capacitor is C_0. One-half of the space between the plates is filled with a dielectric constant ' K ' as shown in figure. The new capacity becomes C_n. The ratio C_n to C_0 is



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Options:

A. $\left(\frac{K+1}{2}\right)$

B. $\left(\frac{\mathrm{K}+1}{3}\right)$

C. $\left(\frac{\mathrm{K}+1}{4}\right)$

D. $4(\mathrm{~K}+1)$

Answer: A

Solution:

Original capacitor (air-filled): C_0

After adding dielectric (K) to half the plate area new capacitance $=\mathrm{C}$

$C_0=\frac{\varepsilon_0 A}{d}$

The plate is split in to two halves in parallel:

One half with air: A/2, dielectric constant = 1

One half with dielectric K : $\mathrm{A}/2$, dielectric constant $=K$

$$\therefore \quad C_{\text{air}} =\frac{E_0(A/2)}{d}=\frac{1}{2} \cdot \frac{\varepsilon_0 A}{d}=\frac{C_0}{2}$$
$$\therefore \quad C_{\text{dielectric}} =\frac{K \varepsilon_0(A/2)}{d}=\frac{K}{2} \cdot \frac{\varepsilon_0 A}{d}=\frac{K C_0}{2}$$

Total Capacitance (Parallel Combination)

$$C=C_{air}+C_{dielectric}=\frac{C_0}{2}+\frac{K C_0}{2}=\frac{C_0(1+K)}{2}$$

$$\therefore \frac{C_0}{C_0}=\left(\frac{K+1}{2}\right)$$

Question7

Seven capacitors each of capacitance 2μ F are to be connected in a configuration to obtain an effective capacitance $\left(\frac{10}{11}\right)\mu\mathrm{F}$. The combination is

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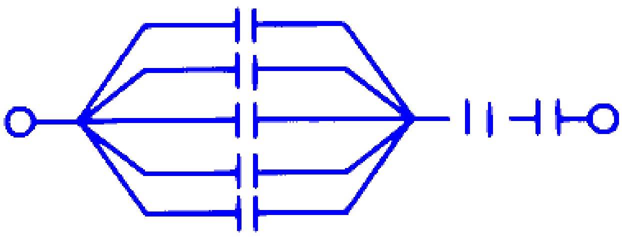
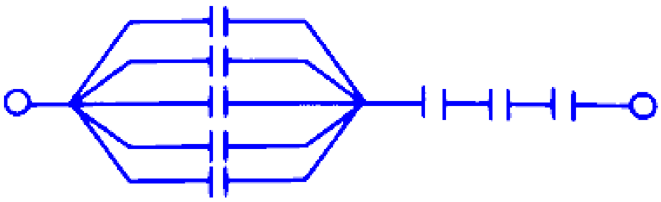
Options:

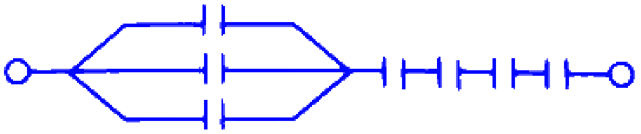
A.



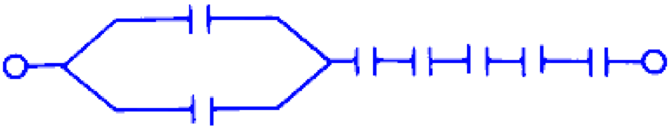
B.



C.



D.



Answer: A

Solution:

As required, equivalent capacitance should be,

$C_{eq} = \frac{10}{11} \mu \mathrm{F}$

For combination of the five capacitors in parallel and two in series,

$$\therefore \quad \frac{1}{C_{\text{eq}}} = \frac{1}{5C} + \left[\frac{1}{C} + \frac{1}{C}\right] = \frac{C + 10C}{5C^2}$$

$$\therefore \quad C_{\text{eq}} = \frac{5C}{11}$$

$$= \frac{5 \times 2}{11}$$

$$= \frac{10}{11} \mu\text{Fs}$$

$\therefore$ The required combination is 5 capacitors in parallel and 2 in series

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Question8

Two identical metal plates are given charges q_1 and q_2 $(q_2 < q_1)$ respectively. If they are now brought close together to form a parallel plate capacitor with capacitance ' C ', the potential difference ' V ' between the plates is

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Options:

A. $\frac{q_1 - q_2}{c}$

B. $\frac{q_1 + q_2}{C}$

C. $\frac{q_1 - q_2}{2C}$

D. $\frac{q_1 + q_2}{2C}$

Answer: C

Solution:

The effective charge on the capacitor is:

$Q = \frac{q_1 - q_2}{2}$

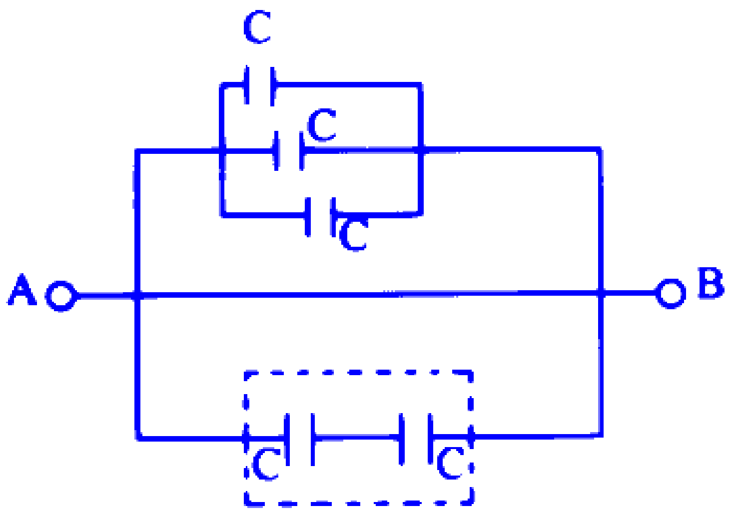
From formula for capacitance,

$$V = \frac{q}{C} = \frac{q_1 - q_2}{2C}$$
$$\therefore V = \frac{q_1 - q_2}{2C}$$

Question9

Five capacitors, each of capacity ' C ' are connected as shown in the figure. The resultant capacity between A and B is 14μ F. The

capacity of each capacitor is



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Options:

A. 2μ F

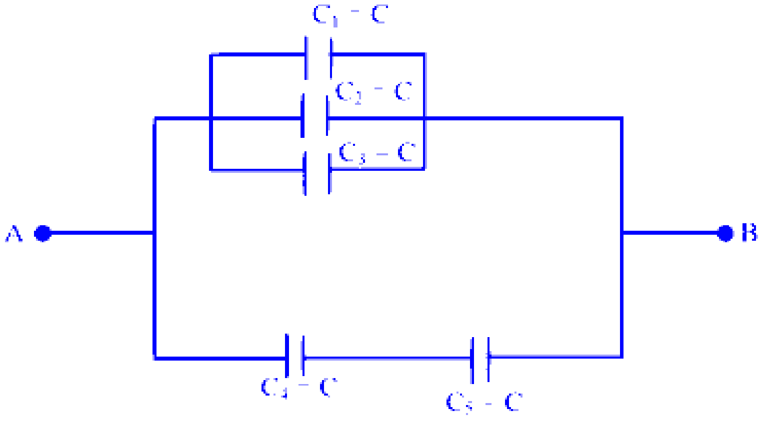
B. 3.5μ F

C. 4μ F

D. 2.8μ F

Answer: C

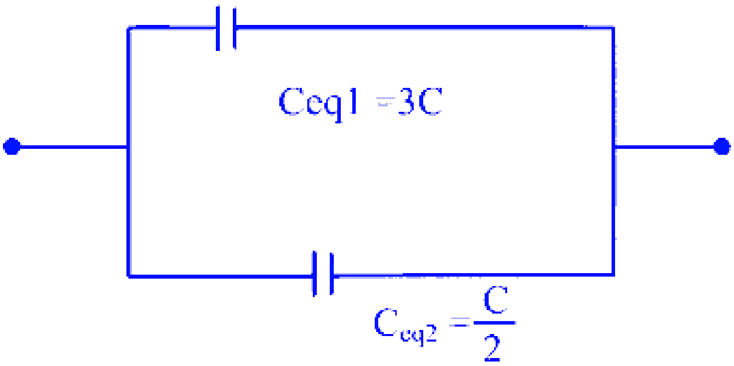
Solution:



$C_1, C_2 \& C_3$ are in parallel, whereas C_4 and C_5 are in series.

$\therefore \quad C_{eq1} = C_1 + C_2 + C_3 = 3C$

$\therefore \quad C_{eq2} = \frac{1}{C_4} + \frac{1}{C_5} = \frac{C}{2}$



C_{eq} is in parallel with $C_{eq\ 2}$

$$\therefore \quad C_{eq} = C_{eq1} + C_{eq2}$$

$$C_{eq} = \frac{7}{2}C$$

Now we know,

$$C_{eq} = 14\mu\text{ F}$$

$$\therefore \frac{7}{2}C = 14\mu\text{ F}$$

$$\therefore C = 4\mu\text{ F}$$

Question10

Two capacitors of 100μ F and 50μ F are connected in parallel. If the potential difference across 100μ F is 20 V and across 50μ F is 40 V , then the common potential of the parallel combination will be (same polarities of the capacitor connected together)

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Options:

A. 20 V

B. 60 V

C. $\frac{3}{80}$

D. $\frac{80}{3}$ V

Answer: D

Solution:

Step 1: Find the total charge before connecting.

Total charge before connecting = charge on C_1 + charge on C_2: $Q_{\text{total}} = C_1V_1 + C_2V_2$

Step 2: After connecting, both capacitors reach a common voltage V.

Total charge = $(C_1 + C_2)V$

Step 3: Set the total charges equal (since charge is conserved):

$(C_1 + C_2)V = C_1V_1 + C_2V_2 \text{So}, V = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}$

Step 4: Plug in the values.

$C_1 = 100 \times 10^{-6}$ F, $V_1 = 20$ V $C_2 = 50 \times 10^{-6}$ F, $V_2 = 40$ V

$V = \frac{100\times10^{-6}\times20+50\times10^{-6}\times40}{100\times10^{-6}+50\times10^{-6}}$

Step 5: Calculate:

$100 \times 10^{-6} \times 20 = 2 \times 10^{-3}$ $50 \times 10^{-6} \times 40 = 2 \times 10^{-3}$ Total numerator $= 4 \times 10^{-3}$

$100 \times 10^{-6} + 50 \times 10^{-6} = 150 \times 10^{-6} = 1.5 \times 10^{-4}$

$V = \frac{4\times10^{-3}}{1.5\times10^{-4}} = \frac{400}{15} = \frac{80}{3}$

Question11

A 4μ F capacitor is charged to 10 V . The battery is then disconnected and a pure 10 mH coil is connected across the capacitor so that LC oscillations are set up. The maximum current in the coil is

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Options:

A. 0.2 A

B. 0.1 A

C. 0.4 A

D. 0.25 A

Answer: A

Solution:

We have an LC oscillation setup:

- Capacitance $C = 4\mu F = 4 \times 10^{-6} F$
- Initial capacitor voltage $V = 10$ V
- Inductance $L = 10$ mH $= 10 \times 10^{-3} H = 0.01\ H$

Step 1: Initial energy stored in the capacitor

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

$E_C = \frac{1}{2} \cdot 4 \times 10^{-6} \cdot (10^2)$

$E_C = 2 \times 10^{-6} \cdot 100 = 2 \times 10^{-4}$ J

Step 2: Maximum energy in the inductor

At peak current, **all energy resides in the inductor**:

$E_L = \frac{1}{2} L I_{\max}^2$

Equating:

$\frac{1}{2} L I_{\max}^2 = E_C$

$\frac{1}{2} \cdot 0.01 \cdot I_{\max}^2 = 2 \times 10^{-4}$

$0.005\, I_{\max}^2 = 2 \times 10^{-4}$

$I_{\max}^2 = \frac{2 \times 10^{-4}}{0.005} = \frac{2 \times 10^{-4}}{5 \times 10^{-3}} = 0.04$

$I_{\max} = 0.2$ A

✅ **Final Answer:**

$I_{\max} = 0.2$ A

Correct Option: A (0.2 A)

Question12

A parallel plate air capacitor has capacity ' C ' and distance of separation between plates is ' d '. If a conducting sheet of thickness $\frac{2d}{3}$ is inserted in between the plates, the capacitance becomes C_1. The ratio of $\frac{C_1}{C}$ is

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Options:

A. 2 : 1

B. 4 : 1

C. 3 : 1

D. 5 : 1

Answer: C

Solution:

Before inserting conductor,

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

After inserting conductor of thickness $\frac{2 \mathrm{~d}}{3}$,

$$
\begin{aligned}
& d^{\prime}=d-\frac{2 d}{3}=\frac{d}{3} \\
& C_1=\frac{\varepsilon_0 A}{d^{\prime}}=\frac{3 \varepsilon_0 A}{d}
\end{aligned}
$$

The required ratio,

$\therefore \quad \frac{C_1}{C}=\frac{\frac{3 \varepsilon_0 A}{d}}{\frac{\varepsilon_0 A}{d}}=\frac{3}{1}$

Question13

Initially n identical capacitors are joined in parallel and are charged to potential V. Now they are separated and joined in series. Then

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Options:

A. potential difference and total energy of the combination remain the same.

B. potential difference remains the same and energy increases n times.

C. potential difference becomes nV and energy remains the same.

D. potential difference is nV and energy increases n times.

Answer: C

Solution:

Energy will remain the same due to conservation of energy

In case 1 , each capacitor is charged to p.d. V So, when they are connected in series, the p.d. will be nV

Question14

A series combination of 10 capacitors, each of value ' C_1 ' is charged by a source of potential difference ' 4 V '. When another parallel combination of 8 capacitors, each of value ' C_2 ' is charged by a source of potential difference ' V ', it has the same total energy stored in it as in the first combination. The value of ' C_2 ' is

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Options:

A. $\frac{C_1}{5}$

B. $\frac{8}{5} C_1$

C. $\frac{64}{5} C_1$

D. $\frac{C_1}{40}$

Answer: A

Solution:

Case 1: Series combination of 10 capacitors, each C_1.

- Equivalent capacitance of capacitors in **series**:

$$\frac{1}{C_{\text{eq1}}} = \frac{1}{C_1} + \frac{1}{C_1} + \ldots \text{ (10 terms)} = \frac{10}{C_1}$$

$$C_{\text{eq1}} = \frac{C_1}{10}.$$

- Energy stored when connected across $4\,\text{V}$:

$$U_1 = \frac{1}{2} C_{\text{eq1}} V^2 = \frac{1}{2} \cdot \frac{C_1}{10} \cdot (4)^2 = \frac{1}{2} \cdot \frac{C_1}{10} \cdot 16 = \frac{8}{10} C_1 = 0.8\, C_1.$$

Case 2: Parallel combination of 8 capacitors, each of capacitance C_2.

- Equivalent capacitance of capacitors in **parallel**:

$$C_{\text{eq2}} = 8C_2.$$

- Energy stored when connected across V:

$$U_2 = \frac{1}{2} C_{\text{eq2}} V^2 = \frac{1}{2} (8C_2) V^2 = 4C_2V^2.$$

Condition: Energy equal

$$U_1 = U_2$$

$$0.8C_1 = 4C_2V^2$$

$$C_2 = \frac{0.8}{4V^2} C_1 = \frac{0.2}{V^2} C_1 = \frac{C_1}{5V^2}.$$

Check the problem statement

The second system ("parallel combination… charged by a source of potential difference V") uses the **same total energy** as the first.

So the relation indeed gives:

$$C_2 = \frac{C_1}{5V^2}.$$

Now, **look at the given options**:

- A. $\frac{C_1}{5}$
- B. $\frac{8}{5} C_1$

- C. $\frac{64}{5} C_1$
- D. $\frac{C_1}{40}$

This suggests in the problem, V may actually equal **1 V** (i.e., the wording "charged by source potential difference 'V'" intends $V = 1$ volt).

If $V = 1$:

$C_2 = \frac{C_1}{5}$.

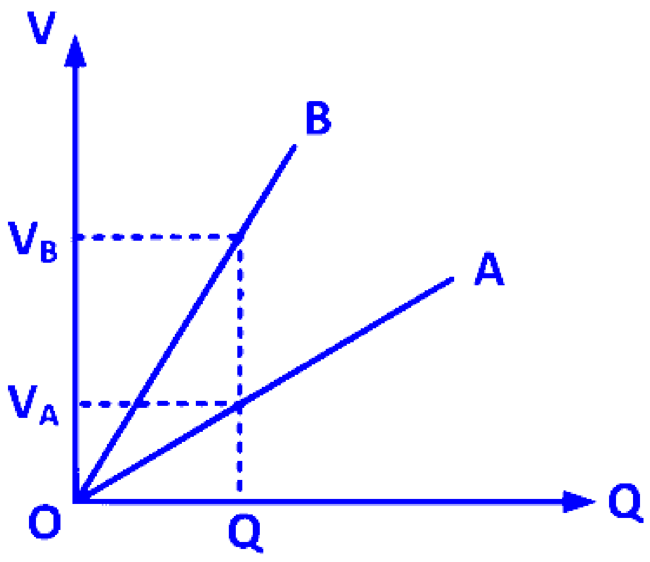
✅ **Final Answer:**

$\boxed{\frac{C_1}{5}}$

So the correct option is **A**.

Question15

The graph shows the variation of voltage (v) across the plates of two parallel plate capacitos A and B versus increase of charge Q stored in them. Then



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Options:

A. capacity of both capacitors is same.

B. capacity of A is higher than B.

C. capacity of B is higher than A.

D. capacity of both is zero.

Answer: B

Solution:

In the graph, $\mathrm{V_A}$ and $\mathrm{V_B}$ are the voltages across parallel plate capacitors A and B corresponding to charge Q on each of the capacitors.

$\mathrm{V_A = Q/C_A}$ and $\mathrm{V_B = Q/C_B}$

or $\frac{V_B}{V_A} = \frac{\frac{Q}{C_B}}{\frac{Q}{C_A}} = \frac{C_A}{C_B}$

Since, $V_B > V_A, \frac{V_B}{V_A} = \frac{C_A}{C_B} > 1$

$\therefore \quad C_A > C_B$, i.e. capacitor A has the higher capacitance.

Question16

Three capacitors each of capacitance ' C ' and breakdown voltage ' V ' are connected in series. The capacitance and breakdown voltage of the series combination will be respectively

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Options:

A. 3C, 3 V

B. $\frac{\mathrm{C}}{3}, \frac{\mathrm{V}}{3}$

C. 3C, $\frac{\mathrm{V}}{3}$

D. $\frac{\mathrm{C}}{3}$, 3 V

Answer: D

Solution:

Step 1: Equivalent capacitance (for series)

For capacitors in series:

$$\frac{1}{C_{\text{eq}}} = \frac{1}{C} + \frac{1}{C} + \frac{1}{C} = \frac{3}{C}$$

So,

$$C_{\text{eq}} = \frac{C}{3}.$$

Step 2: Breakdown voltage

Each capacitor can withstand a maximum voltage of V before breakdown.

When three are in **series**, the total applied voltage is divided (equally, since they have the same capacitance). Thus, each capacitor gets $\frac{V_{\text{total}}}{3}$.

For safe operation, none should exceed V.

So the maximum total breakdown voltage is:

$$V_{\text{eq}} = 3V$$

Final Answer:

$$C_{\text{eq}} = \frac{C}{3}, \quad V_{\text{eq}} = 3V$$

✅ Correct option: **D**

Question17

If the charge on the capacitor is increased by 3C, the energy stored in it increases by 21%. The original charge on the capacitor is

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Options:

A. 6 C

B. 3 C

C. 30 C

D. 90 C

Answer: C

Solution:

Step 1. Recall capacitor energy formula

The energy in a capacitor in terms of charge Q and capacitance C is:

$U = \frac{Q^2}{2C}$.

Step 2. Let original charge = Q

Original energy:

$U = \frac{Q^2}{2C}$.

New charge = $Q + 3$.

New energy:

$U' = \frac{(Q+3)^2}{2C}$.

Step 3. Relating energies

We are told:

$U' = U(1 + 0.21) = 1.21U$.

So:

$\frac{(Q+3)^2}{2C} = 1.21 \cdot \frac{Q^2}{2C}$.

Cancel $\frac{1}{2C}$:

$(Q + 3)^2 = 1.21Q^2$.

Step 4. Expand

$Q^2 + 6Q + 9 = 1.21Q^2$.

$6Q + 9 = 1.21Q^2 - Q^2 = 0.21Q^2$.

$0.21Q^2 - 6Q - 9 = 0$.

Step 5. Solve quadratic

Multiply through by 100 to eliminate decimals:

$21Q^2 - 600Q - 900 = 0$.

Divide by 3:

$7Q^2 - 200Q - 300 = 0$.

Quadratic:

$Q = \frac{200 \pm \sqrt{200^2 + 4 \cdot 7 \cdot 300}}{14}$.

$= \frac{200 \pm \sqrt{40000 + 8400}}{14} = \frac{200 \pm \sqrt{48400}}{14}$.

$\sqrt{48400} = 220$.

So:

$Q = \frac{200 \pm 220}{14}$.

Case 1: $Q = \frac{200+220}{14} = \frac{420}{14} = 30$.

Case 2: $Q = \frac{200-220}{14} = \frac{-20}{14} = -\frac{10}{7}$ (not possible).

Final Answer:

$\boxed{30\ \mathrm{C}}$

So the correct option is **C (30 C)**.

Question18

A parallel plate capacitor having plate area ' A ' and separation ' d ' is charged to a potential difference ' V '. The charging battery is disconnected and the plates are pulled apart to four times the initial separation. The work required to increase the distance between the plates is ($\varepsilon_0 =$ permittivity of free space)

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Options:

A. $\frac{\varepsilon_0 A V^2}{3d}$

B. $\frac{\varepsilon_0 A V^2}{4d}$

C. $\frac{2\varepsilon_0 A V^2}{d}$

D. $\frac{3\varepsilon_0 A V^2}{2d}$

Answer: D

Solution:

Step 1: Work Done Formula

The work done to separate the plates is the change in energy of the capacitor:
$W = U_{\text{final}} - U_{\text{initial}}$

Step 2: Initial Energy

When the plates are at the original distance, the energy stored is:
$U_{\text{initial}} = \frac{1}{2} C V_0^2$Here, C is the initial capacitance, and V_0 is the voltage across the plates.

Step 3: What Happens When the Plates Are Separated

After disconnecting the battery, the charge Q on the plates stays the same, but the distance is increased to $4d$.

The new capacitance is:$C' = \frac{\varepsilon_0 A}{4d} = \frac{C}{4}$

The voltage changes because Q is the same:$V' = \frac{Q}{C'} = \frac{Q}{C/4} = 4V_0$

Step 4: Final Energy

The new stored energy is:$U_{\text{final}} = \frac{1}{2} C' V'^2 = \frac{1}{2}\left(\frac{C}{4}\right)(4V_0)^2 = \frac{1}{2} \times \frac{C}{4} \times 16V_0^2 = 2CV_0^2$

Step 5: Calculate the Work Done

Plugging values into the work formula:$W = U_{\text{final}} - U_{\text{initial}} = 2CV_0^2 - \frac{1}{2}CV_0^2 = \frac{3}{2}CV_0^2$

Step 6: Substitute Capacitance

The capacitance formula is $C = \frac{\varepsilon_0 A}{d}$. So,$W = \frac{3}{2} \cdot \frac{\varepsilon_0 A}{d} V_0^2 = \frac{3\varepsilon_0 A V_0^2}{2d}$

Question19

A parallel plate capacitor has plate area $50 \mathrm{~cm}^2$ and plate separation 3 mm . The space between the plates is filled with a dielectric medium of thickness 1 mm and dielectric constant 4 . The capacitance becomes ($\varepsilon_0 =$ permittivity of free space)

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Options:

A. $\frac{18\varepsilon_0}{7}$

B. $\frac{20\varepsilon_0}{9}$

C. $\frac{16\varepsilon_0}{7}$

D. $\frac{14\varepsilon_0}{5}$

Answer: B

Solution:

Step 1: Recall concept

If a parallel-plate capacitor has partial dielectric filling in the direction of separation (i.e. layered dielectrics along thickness), then it is equivalent to capacitors **in series**.

- Plate area: $A = 50\,\text{cm}^2 = 50 \times 10^{-4}\,\text{m}^2 = 5 \times 10^{-3}\,\text{m}^2$.
- Separation: $d = 3\,\text{mm} = 3 \times 10^{-3}\,\text{m}$.
- Thickness of dielectric: $t_d = 1 \times 10^{-3}\,\text{m}$. Relative permittivity: $\varepsilon_r = 4$.
- Remaining thickness (air): $t_a = d - t_d = (3 - 1)\,\text{mm} = 2 \times 10^{-3}\,\text{m}$.

So effectively we have:

1. A capacitor with dielectric slab: $t_d = 1 \times 10^{-3}\,\text{m},\ \varepsilon = \varepsilon_0 \cdot 4$.
2. Another capacitor with air gap: $t_a = 2 \times 10^{-3}\,\text{m},\ \varepsilon = \varepsilon_0$.

Both share same area A and are in series.

Step 2: Capacitance of each section

- Dielectric part:

$C_1 = \frac{\varepsilon_0 \varepsilon_r A}{t_d} = \frac{4\varepsilon_0 \cdot 5 \times 10^{-3}}{1 \times 10^{-3}} = \frac{20\varepsilon_0}{1}$.

So, $C_1 = 20\varepsilon_0$.

- Air part:

$C_2 = \frac{\varepsilon_0 A}{t_a} = \frac{\varepsilon_0 \cdot 5 \times 10^{-3}}{2 \times 10^{-3}} = \frac{5}{2}\varepsilon_0 = 2.5\varepsilon_0$.

Step 3: Equivalent capacitance (series combination)

$\frac{1}{C_{\text{eq}}} = \frac{1}{C_1} + \frac{1}{C_2}$.

Substitute numbers:

$\frac{1}{C_{\text{eq}}} = \frac{1}{20\varepsilon_0} + \frac{1}{2.5\varepsilon_0}$.

$= \frac{1}{20\varepsilon_0} + \frac{1}{(5/2)\varepsilon_0} = \frac{1}{20\varepsilon_0} + \frac{2}{5\varepsilon_0}$.

$= \frac{1}{20\varepsilon_0} + \frac{8}{20\varepsilon_0} = \frac{9}{20\varepsilon_0}$.

Hence,

$C_{\mathrm{eq}} = \frac{20}{9}\varepsilon_0$.

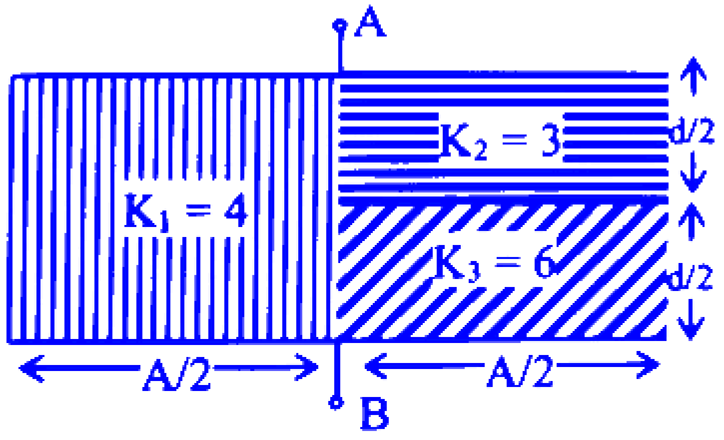
Final Answer:

$\boxed{\frac{20\varepsilon_0}{9}}$

That corresponds to **Option B**.

Question20

The equivalent capacitance between plates ' A ' and ' B ' (A -area of each plate, d-separation between plates) (ε_0 - permittivity of free space) is



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Options:

A. $\frac{A\varepsilon_0}{d}$

B. $\frac{2\ A\varepsilon_0}{d}$

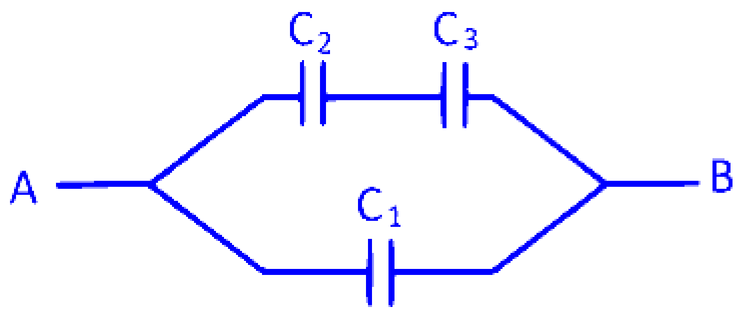
C. $\frac{4\ A\varepsilon_0}{d}$

D. $\frac{8\ A\varepsilon_0}{d}$

Answer: C

Solution:

The equivalent circuit is given below



C_2 and C_3 are connected in series, and this combination is then connected in parallel with C_1.

$$C_1=\frac{K_1\left(\frac{A}{2}\right)\varepsilon_0}{d}=\frac{2A\varepsilon_0}{d}=2C$$
$$C_2=\frac{K_2\left(\frac{A}{2}\right)\varepsilon_0}{\left(\frac{d}{2}\right)}=\frac{3A\varepsilon_0}{d}=3C$$
$$C_3=\frac{K_3\left(\frac{A}{2}\right)\varepsilon_0}{\left(\frac{d}{2}\right)}=\frac{6A\varepsilon_0}{d}=6C$$
$$C_s=\frac{C_2C_3}{C_2+C_3}=\frac{3C\times 6C}{3C+6C}=2C$$
$$C_{eq}=C_1+C_s=2C+2C=4C=\frac{4A\varepsilon_0}{d}$$

Question21

The voltage between the plates of a parallel plate capacitor of capacity 1μ F is changing at the rate of $4\ \mathrm{V/s}$. the displacement current in the capacitor is

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Options:

A. 4μ A

B. 3μ A

C. 1μ A

D. 6μ A

Answer: A

Solution:

Given:

- Capacitance, $C = 1\ \mu\text{F} = 1 \times 10^{-6}$ F
- Rate of change of voltage, $\frac{dV}{dt} = 4$ V/s

Displacement current (I_d) in a capacitor is given by:

$$I_d = C\frac{dV}{dt}$$

Substitute the given values:

$$I_d = 1 \times 10^{-6}\ \text{F} \times 4\ \text{V/s}$$

$$I_d = 4 \times 10^{-6}\ \text{A}$$

$$I_d = 4\ \mu\text{A}$$

Answer:

Option A: $4\ \mu$A

Question22

A parallel plate air capacitor has capacitance C_P. It is equally filled with parallel layers of materials of dielectric constants K_1 and K_2. Now its capacity becomes C_K. The ratio C_P to C_K is

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Options:

A. $\mathrm{K}_1 + \mathrm{K}_2$

B. $\frac{K_1+K_2}{K_1K_2}$

C. $\frac{K_1+K_2}{2K_1K_2}$

D. $\frac{2K_1K_2}{K_1+K_2}$

Answer: C

Solution:

When dielectrics are placed in series, the equivalent dielectric constant is:

$$\frac{1}{\mathrm{K}_{\mathrm{eq}}}=\frac{1}{2\,\mathrm{K}_1}+\frac{1}{2\,\mathrm{K}_2}$$
$$\frac{1}{\mathrm{K}_{\mathrm{eq}}}=\left(\frac{\mathrm{K}_1+\mathrm{K}_2}{2\,\mathrm{K}_1\,\mathrm{K}_2}\right)$$
$$\mathrm{K}_{\mathrm{eq}}=\left(\frac{2\,\mathrm{K}_1\,\mathrm{K}_2}{\mathrm{K}_1+\mathrm{K}_2}\right)$$

So, new capacitance:

$$C_K=K_{eq}\cdot C_P=\left(\frac{2K_1K_2}{K_1+K_2}\right)C_P$$
$$\frac{C_P}{C_K}=\frac{K_1+K_2}{2K_1K_2}$$

Question23

A parallel plate capacitor with plate area A and plate separation d is charged by constant current I. A plane surface of area $\frac{\mathrm{A}}{2}$, parallel to the plates is drawn simultaneously between the plates. The displacement current through this area is

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Options:

A. I

B. $\frac{\mathrm{I}}{2}$

C. $\frac{\mathrm{I}}{4}$

D. $\frac{1}{8}$

Answer: B

Solution:

Displacement current between the plates is equal to the conduction (charging) current I for the full area. The electric field and flux are uniform between the plates, so the displacement current through any surface is proportional to the area of that surface .

Displacement current $I_d = \frac{A/2}{A} \times I = \frac{1}{2} I$

$\therefore \quad I_D = \frac{I}{2}$

Question24

Two parallel plate air c apacitors of same capacity ' C ' are connected in parallel to a battery of e.m.f. ' E '. Then one of the capacitors is completely filled with dielectric mnaterial of constant ' K '. The change in the effective capacity of the parallel combination is

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Options:

A. $\frac{\mathrm{C}}{(\mathrm{K}-1)}$

B. $\frac{\mathrm{KC}}{\mathrm{K}-1}$

C. $\mathrm{KC}+1$

D. $\mathrm{C}(\mathrm{K}-1)$

Answer: D

Solution:

Let the capacitance of each air capacitor be C.

Step 1: Initial effective capacitance (before inserting dielectric)

Since both capacitors are identical and connected in parallel:

$C_{\text{initial}} \quad = C + C = 2C$

Step 2: Insert dielectric of constant K in one capacitor

The capacitance of the capacitor with dielectric becomes:

$C' = KC$

So the effective capacitance of the parallel combination is:

$C_{\text{final}} = C + KC = (1 + K)C$

Step 3: Change in effective capacitance

Change in effective capacitance is:

$\Delta C = C_{\text{final}} - C_{\text{initial}}$

Substitute the values:

$\Delta C = (1 + K)C - 2C = (K - 1)C$

Step 4: Match with the options

So, the correct answer is

$\boxed{\mathrm{C(K-1)}}$

Option D is correct.

Question25

The plates of a parallel plate capacitor are separated by a distance 'd' with air as the medium between them. A dielectric slab of dielectric constant 3 is introduced between the plates so as to increase the capacity by 50%. The thickness of the dielectric slab is

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Options:

A. $\frac{\mathrm{d}}{2}$

B. $\frac{\mathrm{d}}{3}$

C. $\frac{\mathrm{d}}{5}$

D. $\frac{5\mathrm{~d}}{6}$

Answer: A

Solution:

Step 1: Calculate the initial capacitance of the parallel plate capacitor.

When the medium between the plates is air (or vacuum), the capacitance (C_0) is given by:

$C_0 = \frac{\epsilon_0 A}{d}$

where:

- ϵ_0 is the permittivity of free space.
- A is the area of each plate.
- d is the separation between the plates.

Step 2: Calculate the capacitance after introducing the dielectric slab.

When a dielectric slab of thickness t and dielectric constant K is introduced between the plates of a parallel plate capacitor, the new capacitance (C_f) is given by the formula:

$C_f = \frac{\epsilon_0 A}{d-t+\frac{t}{K}}$

In this problem, the dielectric constant $K = 3$. So, substituting this value:

$C_f = \frac{\epsilon_0 A}{d-t+\frac{t}{3}}$

To simplify the denominator:

$C_f = \frac{\epsilon_0 A}{d-\frac{3t}{3}+\frac{t}{3}}$

$C_f = \frac{\epsilon_0 A}{d-\frac{2t}{3}}$

Step 3: Use the given condition about the increase in capacity.

The problem states that the capacity increases by 50%. This means the final capacitance C_f is 150% of the initial capacitance C_0.

$C_f = C_0 + 50\% \text{ of } C_0$

$C_f = C_0 + 0.5C_0$

$C_f = 1.5C_0$

Step 4: Equate the expressions for C_f and solve for the thickness t.

Now, substitute the expressions for C_f and C_0 into the equation from Step 3:

$\frac{\epsilon_0 A}{d-\frac{2t}{3}} = 1.5\left(\frac{\epsilon_0 A}{d}\right)$

We can cancel out $\epsilon_0 A$ from both sides of the equation:

$\frac{1}{d-\frac{2t}{3}} = \frac{1.5}{d}$

Now, cross-multiply to solve for t:

$d = 1.5\left(d - \frac{2t}{3}\right)$

$d = 1.5d - 1.5 \times \frac{2t}{3}$

$d = 1.5d - \frac{3}{2} \times \frac{2t}{3}$

$d = 1.5d - t$

Rearrange the equation to isolate t:

$t = 1.5d - d$

$t = 0.5d$

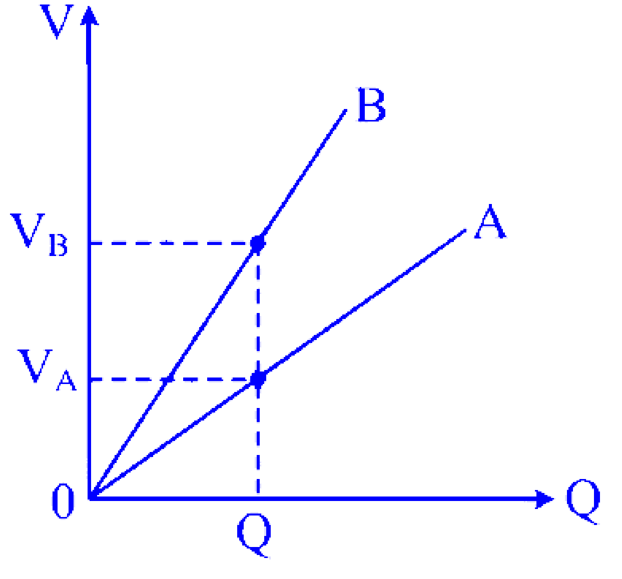
$t = \frac{d}{2}$

Thus, the thickness of the dielectric slab is $\frac{d}{2}$.

The final answer is $\boxed{\frac{\mathrm{d}}{2}}$.

Question26

The graph shows the variation of voltage ' V ' across the plates of two capacitors A and B versus increase in charge ' Q ' stored in them. Then



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Options:

A. capacitance A has high capacity.

B. capacitance B has high capacity.

C. both have same capacity.

D. capacity of $A = 2$ times capacity of B.

Answer: A

Solution:

The relationship between charge Q and voltage V for a capacitor is given by:

$Q = CV$

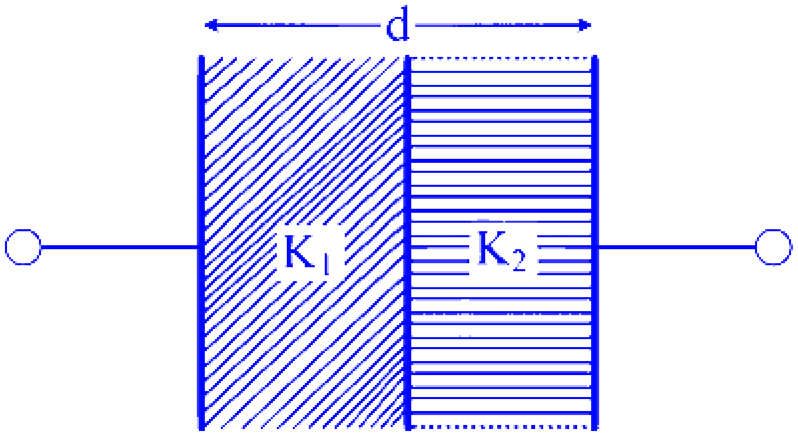
This equation is analogous to $y = mx$, where C is the capacitance, equivalent to the inverse of the slope of the line on the graph. Therefore, we can express capacitance C as:

$C = \frac{Q}{V} = \frac{1}{\text{slope of the line}}$

Since the line representing capacitor A has a smaller slope compared to that of capacitor B, the capacitance of A is greater than that of B.

Question27

Air capacitor has capacitance ' C_1 '. The space between two plates of capacitor is filled with two dielectrics as shown in figure. The new capacitance of the capacitor is ' C_2 '. The ratio $\frac{C_1}{C_2}$ is ($d =$ distance between two plates of capacitor, K_1 and K_2 are dielectric constants of two dielectrics respectively)



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Options:

A. $\mathrm{K}_1+\mathrm{K}_2$

B. $\frac{\mathrm{K}_1+\mathrm{K}_2}{\mathrm{~K}_1-\mathrm{K}_2}$

C. $\frac{2 \mathrm{~K}_1 \mathrm{~K}_2}{\mathrm{~K}_1+\mathrm{K}_2}$

D. $\frac{\mathrm{K}_1+\mathrm{K}_2}{2 \mathrm{~K}_1 \mathrm{~K}_2}$

Answer: D

Solution:

When an air capacitor has a capacitance of C_1, it is represented as:

$C_1=\frac{A \varepsilon_0}{d}$

where A is the area of the plates, ε_0 is the permittivity of free space, and d is the distance between the plates.

When the space between the plates of this capacitor is filled with two different dielectric materials, it affects the overall capacitance. The two dielectrics are inserted as shown, and this setup functions as capacitors in series. To find the new capacitance C_2 with dielectrics, we calculate as follows:

First, the capacitance with each dielectric in place is calculated:

For the first dielectric with constant K_1:

$C_{K 1}=\frac{A \varepsilon_0 K_1}{\frac{d}{2}}$

For the second dielectric with constant K_2:

$C_{K 2}=\frac{A \varepsilon_0 K_2}{\frac{d}{2}}$

The capacitance of the configuration can then be represented as capacitors in series:

$\frac{1}{C_2}=\frac{1}{C_{K 1}}+\frac{1}{C_{K 2}}$

Substitute the expressions for $C_{K 1}$ and $C_{K 2}$:

$\frac{1}{C_2}=\frac{1}{\frac{A \varepsilon_0 K_1}{d / 2}}+\frac{1}{\frac{A \varepsilon_0 K_2}{d / 2}}$

$\frac{1}{C_2}=\frac{\frac{d}{2}}{A \varepsilon_0 K_1}+\frac{\frac{d}{2}}{A \varepsilon_0 K_2}$

Simplify to:

$\frac{1}{C_2} = \frac{d}{2\varepsilon_0 A}\left(\frac{1}{K_1} + \frac{1}{K_2}\right)$

$C_2 = \frac{2\varepsilon_0 A}{d}\left(\frac{K_1 K_2}{K_1+K_2}\right)$

Therefore, the ratio of the original capacitance C_1 to the new capacitance C_2 is:

$\frac{C_1}{C_2} = \frac{K_1+K_2}{2K_1K_2}$

Question28

Two identical capacitors A and B are connected in series to a battery of E.M.F., 'E'. Capacitor B contains a slab of dielectric constant K. Q_{A} and Q_{B} are the charges stored in A and B . When the dielectric slab is removed, the corresponding charges are $\mathrm{Q}_{\mathrm{A}}^{\prime}$ and $\mathrm{Q}_{\mathrm{B}}^{\prime}$. Then

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Options:

A. $\frac{\mathrm{Q}_{\mathrm{A}}^{\prime}}{\mathrm{Q}_{\mathrm{A}}} = \frac{\mathrm{K}}{2}$

B. $\frac{\mathrm{Q}_{\mathrm{B}}^{\prime}}{\mathrm{Q}_{\mathrm{B}}} = \frac{\mathrm{K}+1}{2}$

C. $\frac{\mathrm{Q}_{\mathrm{A}}^{\prime}}{\mathrm{Q}_{\mathrm{A}}} = \frac{\mathrm{K}+1}{\mathrm{K}}$

D. $\frac{\mathrm{Q}_{\mathrm{B}}^{\prime}}{\mathrm{Q}_{\mathrm{B}}} = \frac{\mathrm{K}+1}{2\ \mathrm{K}}$

Answer: D

Solution:

When two capacitors, A and B, are connected in series, they will have the same charge initially due to the series configuration. Consider the capacitors connected to a battery of voltage E.

Initial Configuration with Dielectric in Capacitor B:

The capacitance of capacitor B with a dielectric is $C'_B = KC$, where C is the capacitance of capacitor A, and K is the dielectric constant.

For capacitors in series,

$$\frac{1}{C_{\text{eq}}} = \frac{1}{C} + \frac{1}{KC} = \frac{K+1}{KC}.$$

$$C_{\text{eq}} = \frac{KC}{K+1}.$$

The charge on the capacitors in series is given by:

$$Q = C_{\text{eq}} \cdot E = \frac{KC}{K+1} \cdot E.$$

Charges on Each Capacitor:

Since $Q_A = Q_B = Q$ (initially when the dielectric is present in B),

$$Q_A = Q_B = \frac{KC}{K+1} \cdot E.$$

After Removing the Dielectric from Capacitor B:

Without the dielectric, the capacitance of B becomes C. The equivalent capacitance is now:

$$\frac{1}{C'_{\text{eq}}} = \frac{1}{C} + \frac{1}{C} = \frac{2}{C}.$$

$$C'_{\text{eq}} = \frac{C}{2}.$$

The charge on the new configuration is:

$$Q' = C'_{\text{eq}} \cdot E = \frac{C}{2} \cdot E.$$

Since the capacitors are still in series, the charges on A and B are equal:

$$Q'_A = Q'_B = Q'.$$

Comparing the Charges:

For capacitor A:

$$\frac{Q'_A}{Q_A} = \frac{Q'}{Q_A} = \frac{\frac{C}{2} \cdot E}{\frac{KC}{K+1} \cdot E} = \frac{K+1}{2K}.$$

For capacitor B:

$$\frac{Q'_B}{Q_B} = \frac{\frac{C}{2} \cdot E}{\frac{KC}{K+1} \cdot E} = \frac{K+1}{2K}.$$

The correct option in this context would be:

Option D:

$$\frac{Q'_B}{Q_B} = \frac{K+1}{2K}$$

Question29

A series combination of n_1 capacitors, each of value C_1 is charged by a source of potential difference 6 V . Another parallel combination of n_2 capacitors, each of value C_2 is charged by a source of potential difference 2 V . Total energy of both the combinations is same. The value of C_2 in terms of C_1 is

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Options:

A. $\frac{3C_1}{n_1 n_2}$

B. $\frac{9\mathrm{n}_2}{\mathrm{n}_1}\mathrm{C}_1$

C. $\frac{3\mathrm{n}_2}{\mathrm{n}_1}\mathrm{C}_1$

D. $\frac{9C_1}{n_1 n_2}$

Answer: D

Solution:

When capacitors are connected in series, the equivalent capacitance is given by:

$(C_{\text{eq}})_1 = \frac{C_1}{n_1}$

The potential difference across this series is:

$V_1 = 6 \text{ V}$

For the capacitors connected in parallel, the equivalent capacitance is:

$(C_{\text{eq}})_2 = n_2 C_2$

The potential difference across this combination is:

$V_2 = 2 \text{ V}$

Given that the total energy for both combinations is the same, we have:

$U_1 = U_2$

The energy stored in a capacitor is given by the formula:

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

Therefore, equating the energies, we get:

$\frac{1}{2}\left(\frac{C_1}{n_1}\right)(6^2) = \frac{1}{2}(n_2C_2)(2^2)$

Simplifying the above equation:

$\frac{1}{2} \cdot C_1 \cdot 36 = \frac{1}{2} \cdot n_2 \cdot C_2 \cdot 4$

Further simplifying:

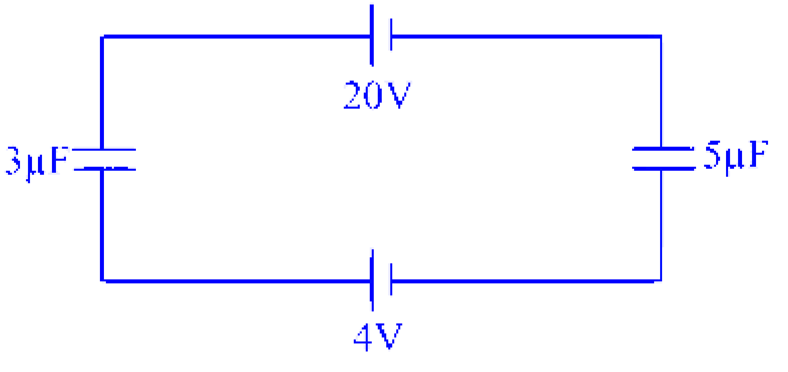
$18C_1 = 2n_2C_2$

Solving for C_2:

$C_2 = \frac{9C_1}{n_1n_2}$

Question30

In the circuit shown in the following figure, the potential difference cross 3μ F capacitor is



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Options:

A. 4 V

B. 6 V

C. 10 V

D. 16 V

Answer: C

Solution:

To find the potential difference across the $3\,\mu\text{F}$ capacitor, we start by determining the equivalent voltage and equivalent capacitance in the circuit.

First, calculate the equivalent voltage (V_{eq}):

$V_{eq} = 20 - 4 = 16\,\text{V}$

Next, determine the equivalent capacitance (C_{eq}) for the parallel combination of the $3\,\mu\text{F}$ and $5\,\mu\text{F}$ capacitors:

$C_{eq} = \frac{3\times5}{3+5} = \frac{15}{8}\,\mu\text{F}$

Then, calculate the total charge (Q) using the equivalent capacitance and voltage:

$Q = C_{eq} \times V_{eq} = \frac{15}{8} \times 16 = 30\,\mu\text{C}$

Finally, find the voltage across the $3\,\mu\text{F}$ capacitor (V_3) using the formula for charge (Q):

$V_3 = \frac{Q}{C} = \frac{30}{3} = 10\,\text{V}$

The potential difference across the $3\,\mu\text{F}$ capacitor is $10\,\text{V}$.

Question31

Three condensers of capacities ' C_1 ', ' C_2 ', ' C_3 ' are connected in series with a source of e.m.f. ' V '. The potentials across the three condensers are in the ratio

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Options:

A. $1:1:1$

B. $C_1 : C_2 : C_3$

C. $C_1^2 : C_2^2 : C_3^2$

D. $\frac{1}{C_1} : \frac{1}{C_2} : \frac{1}{C_3}$

Answer: D

Solution:

When capacitors are connected in series, they all carry the same charge. This is because the charge that is stored on one plate of a capacitor must equal the charge on the adjacent plate of the next capacitor. Therefore, if you consider the voltage across each individual capacitor, the relation can be described as follows:

For capacitors C_1, C_2, and C_3 with potentials V_1, V_2, and V_3 respectively, we have:

$$Q = C_1V_1 = C_2V_2 = C_3V_3$$

Solving for the voltage, we get:

$$V_1 = \frac{Q}{C_1}, \quad V_2 = \frac{Q}{C_2}, \quad V_3 = \frac{Q}{C_3}$$

Therefore, the potential (voltage) ratios will be inversely proportional to the capacitances:

$$V_1 : V_2 : V_3 = \frac{1}{C_1} : \frac{1}{C_2} : \frac{1}{C_3}$$

This relationship illustrates that the capacitor with the smallest capacitance will have the largest voltage across it, and vice versa. Hence, the potentials across the capacitors are in the ratio $\frac{1}{C_1} : \frac{1}{C_2} : \frac{1}{C_3}$.

Question32

When three capacitors of equal capacities are connected in parallel and one of the same capacity, capacitor is connected in series with the combination. The resultant capacity is 4.5μ F. The capacity of each capacitor is

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Options:

A. 5μ F

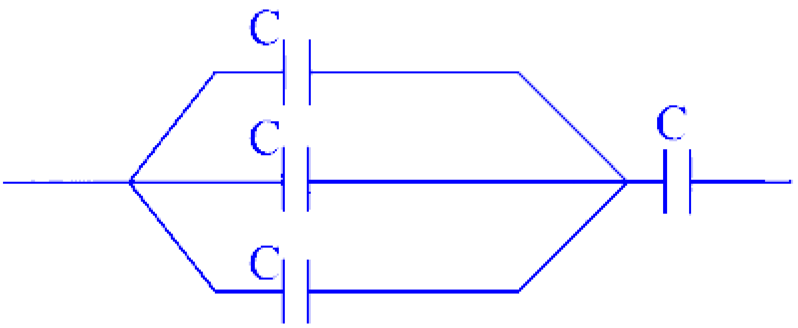
B. 7μ F

C. 6μ F

D. 8μ F

Answer: C

Solution:



$$C_{eq} = \frac{3C \times C}{3C + C} = \frac{3C^2}{4C}$$
$$C_{eq} = \frac{3C}{4}$$
$$\therefore \quad C = \frac{4C_{eq}}{3} = \frac{4 \times 4.5}{3} = 6\mu\ \mathrm{F}$$

Question33

Two parallel plate air capacitors of same capacity ' C ' are connected in series to a battery of emf ' E '. Then one of the capacitors is completely filled with dielectric material of constant ' K '. The change in the effective capacity of the series combination is

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Options:

A. $\frac{C}{2}\left[\frac{K+1}{K-1}\right]$

B. $\frac{2}{C}\left[\frac{K-1}{K+1}\right]$

C. $\frac{C}{2}\left[\frac{K-1}{K+1}\right]$

D. $\frac{C}{2}\left[\frac{K-1}{K+1}\right]^2$

Answer: C

Solution:

Let's break down the problem step by step.

Two identical air capacitors, each of capacitance C, are connected in series. The effective capacitance in series is given by

$$\frac{1}{C_{\text{series}}} = \frac{1}{C} + \frac{1}{C} = \frac{2}{C},$$

so

$$C_{\text{series}} = \frac{C}{2}.$$

Now, one capacitor is completely filled with a dielectric of constant K. When a capacitor is fully filled with a dielectric, its capacitance increases by a factor of K, so its new capacitance becomes KC. The other capacitor remains at C.

For two capacitors in series (one with capacitance KC and the other with C), the effective capacitance becomes:

$$C' = \frac{(KC) \cdot C}{KC + C} = \frac{KC^2}{C(K+1)} = \frac{KC}{K+1}.$$

The change in effective capacitance is the difference between the new effective capacitance and the original:

$$\Delta C = C' - \frac{C}{2} = \frac{KC}{K+1} - \frac{C}{2}.$$

To combine the terms, find a common denominator:

$$\Delta C = \frac{2KC - C(K+1)}{2(K+1)} = \frac{2KC - CK - C}{2(K+1)} = \frac{C(K-1)}{2(K+1)}.$$

Thus, the change in the effective capacitance is

$$\frac{C}{2}\left(\frac{K-1}{K+1}\right),$$

which corresponds to Option C.

Question34

Seven capacitors each of capacitance 2μ F are connected in a configuration to obtain an effective capacitance $\frac{6}{13}\mu$ F. The combination which will achieve this will have

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Options:

A. 5 capacitors in parallel and then 2 capacitors series.

B. 4 capacitors in parallel and then 3 capacitors series.

C. 3 capacitors in parallel and then 4 capacitors in series.

D. 2 capacitors in parallel and then 5 capacitors in series.

Answer: C

Solution:

To achieve an effective capacitance of $\frac{6}{13}\,\mu\mathrm{F}$ using seven capacitors, each with a capacitance of $2\,\mu\mathrm{F}$, you should arrange them with 3 capacitors in parallel and 4 capacitors in series.

Here's how the calculation works:

Parallel Connection: When capacitors are connected in parallel, their capacitances add up. So for 3 capacitors in parallel:

$$C_{\text{parallel}} = 3 \times C = 3 \times 2\,\mu\mathrm{F} = 6\,\mu\mathrm{F}$$

Series Connection: When capacitors are connected in series, the reciprocal of the total capacitance is the sum of the reciprocals of individual capacitances. For 4 capacitors, each of capacitance C, in series, the total capacitance is:

$$\frac{1}{C_{\text{series}}} = \frac{1}{C} + \frac{1}{C} + \frac{1}{C} + \frac{1}{C} = \frac{4}{C}$$

Therefore:

$$C_{\text{series}} = \frac{C}{4} = \frac{2\,\mu\mathrm{F}}{4} = 0.5\,\mu\mathrm{F}$$

Combining Series and Parallel: For combining the parallel and series connections, where C_{total} is the effective capacitance:

$$\frac{1}{C_{\text{total}}} = \frac{1}{C_{\text{parallel}}} + \frac{1}{C_{\text{series}}} = \frac{1}{6} + \frac{1}{0.5} = \frac{1+12}{6} = \frac{13}{6}$$

Consequently:

$$C_{\text{total}} = \frac{6}{13}\,\mu\mathrm{F}$$

Therefore, the required configuration is 3 capacitors in parallel followed by 4 capacitors in series to yield an overall capacitance of $\frac{6}{13}\,\mu\mathrm{F}$.

Question35

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

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Options:

A. $\frac{1}{4}\mathrm{C}\left(\mathrm{V}_1^2+\mathrm{V}_2^2\right)$

B. $\frac{1}{4}\mathrm{C}\left(\mathrm{V}_1^2-\mathrm{V}_2^2\right)$

C. $\frac{1}{4}C(V_1+V_2)^2$

D. $\frac{1}{4}\mathrm{C}(\mathrm{V}_1-\mathrm{V}_2)^2$

Answer: D

Solution:

To determine the decrease in energy when two identical capacitors are connected, we start by calculating the initial energy of the system. Each capacitor has capacitance C, with one charged to a potential V_1 and the other to V_2.

Initial Energy:

The initial energy U_i of the system is the sum of the energies stored in both capacitors:

$U_i=\frac{1}{2}CV_1^2+\frac{1}{2}CV_2^2=\frac{1}{2}C(V_1^2+V_2^2)$

When Capacitors are Joined:

When the capacitors are connected, they share charge to reach a common potential V. The formula for this common potential is:

$V=\frac{CV_1+CV_2}{2C}=\frac{V_1+V_2}{2}$

Final Energy:

The final energy U_f of the system is given by:

$U_f=\frac{1}{2}(2C)V^2=\frac{1}{2}2C\left(\frac{V_1+V_2}{2}\right)^2=\frac{1}{4}C(V_1+V_2)^2$

Decrease in Energy:

The decrease in energy is the difference between the initial and final energies:

Decrease in energy $=U_i-U_f=\frac{1}{2}C(V_1^2+V_2^2)-\frac{1}{4}C(V_1+V_2)^2$

Through simplification, this can be expressed as:

Decrease in energy $=\frac{1}{4}C(V_1-V_2)^2$

Question36

The potential difference that must be applied across the series and parallel combination of 4 identical capacitors is such that the energy stored in them becomes the same. The ratio of potential difference in series to parallel combination is

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Options:

A. 1 : 2

B. 1 : 4

C. 4 : 1

D. 2 : 1

Answer: C

Solution:

To find the ratio of the potential difference required for equal energy storage in both series and parallel combinations of four identical capacitors, let's analyze the equivalent capacitance for each configuration.

Series Combination

The equivalent capacitance for capacitors in series is given by:

$C_1 = \frac{C}{4}$

The potential energy stored in this series configuration is:

$U_1 = \frac{1}{2} C_1 V_1^2$

Parallel Combination

The equivalent capacitance for capacitors in parallel is:

$C_2 = 4C$

The potential energy stored in the parallel configuration is:

$U_2 = \frac{1}{2} C_2 V_2^2$

Equating Energy

Since the energy stored in both configurations is equal, we have:

$U_1 = U_2$

This implies:

$C_1 V_1^2 = C_2 V_2^2$

Substituting the expressions for C_1 and C_2, we get:

$\frac{C}{4} V_1^2 = 4 C V_2^2$

To find the ratio of the potential differences, solve for:

$\frac{V_1^2}{V_2^2} = \frac{4C \times 16}{C}$

Simplifying:

$\frac{V_1^2}{V_2^2} = \frac{16}{1}$

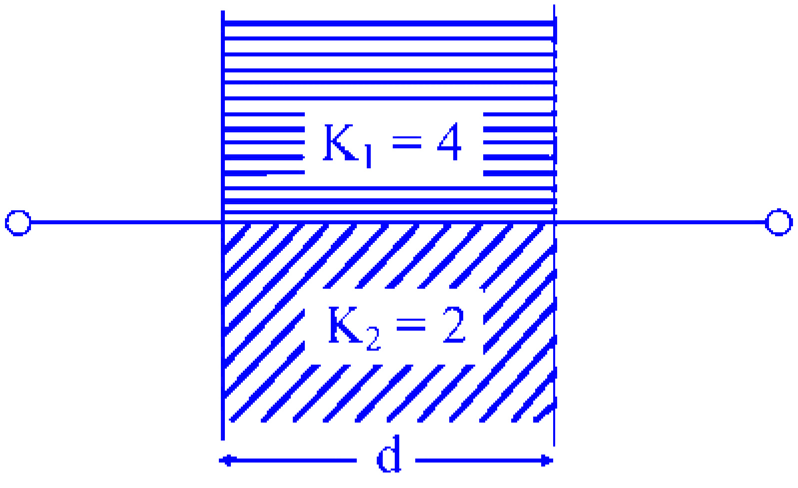
So, the ratio of the potential differences is:

$\frac{V_1}{V_2} = \sqrt{\frac{16}{1}} = \frac{4}{1}$

Thus, the ratio of potential difference in series to parallel combination is 4:1.

Question37

Air capacitor has capacitance of 1μ F. Now the space between two plates of capacitor is filled with two dielectrics as shown in figure. The capacitance of the capacitor is [$\mathrm{d}=$ distance between two plates of capacitor, K_1 and K_2 are dielectric constants of first dielectric and second dielectric respectively]



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Options:

A. 3μ F

B. 6μ F

C. 8μ F

D. 12μ F

Answer: A

Solution:

To determine the capacitance of the capacitor after inserting dielectrics, we start with the original capacitance of the air-filled parallel plate capacitor, given by:

$C=\frac{\varepsilon_0 A}{d}=1 \mu \mathrm{F}$

Once the space between the plates is filled with two dielectrics, the scenario changes. The dielectrics divide the space between the plates into two sections, each with its own capacitance.

For the first dielectric with dielectric constant $K_1=4$, the capacitance becomes:

$C_1=K_1 \cdot \frac{\varepsilon_0 A}{2 d}=4 \cdot \frac{1}{2}=2 \mu \mathrm{F}$

Similarly, for the second dielectric with dielectric constant $K_2=2$, the capacitance is:

$C_2=K_2 \cdot \frac{\varepsilon_0 A}{2 d}=2 \cdot \frac{1}{2}=1 \mu \mathrm{F}$

Given that both sections are in parallel, the effective capacitance $C_{\text {eff }}$ of the capacitor is the sum of the two individual capacitances:

$C_{\text {eff }}=C_1+C_2=2 \mu \mathrm{F}+1 \mu \mathrm{F}=3 \mu \mathrm{F}$

Question38

The function of dielectric in a capacitor is

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Options:

A. to reduce the effective potential on plates.

B. to increase the effective potential on plates.

C. to decrease the capacitance.

D. to reduce the plate area of capacitor.

Answer: A

Solution:

The correct answer is Option A.

Here's why:

When a dielectric is inserted between the plates of a capacitor, the dielectric material becomes polarized. This polarization creates an electric field that opposes the field due to the charges on the plates.

As a result, the effective electric field inside the capacitor is reduced. Since the potential difference (voltage) across the capacitor is related to the electric field by:

$V = E \cdot d$

(where d is the separation between the plates), reducing the electric field E also reduces the effective potential difference V between the plates.

With a lower effective potential difference for the same amount of charge, the capacitance, defined by

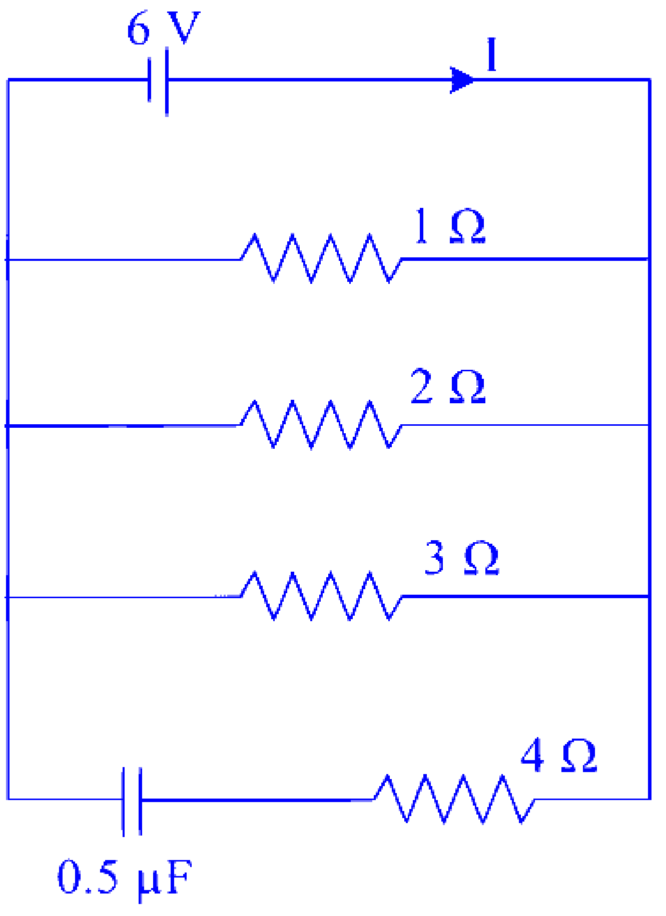
$C = \frac{Q}{V}$,

increases. This explains why the dielectric increases the capacitance rather than decreasing it.

So, Option A, "to reduce the effective potential on plates," correctly describes the role of a dielectric in a capacitor.

Question39

In the given circuit diagram, in the steady state the current through the battery and the charge on the capacitor respectively are



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Options:

A. 2 A and $3 \mu C$

B. $\frac{6}{11}$ A and $\frac{12}{7} \mu C$

C. 11 A and $3 \mu C$

D. zero ampere and $3 \mu C$

Answer: C

Solution:

In the steady state of the given circuit, the current through the capacitor is zero. This implies that there is no current flowing through the 4 Ω resistor.

To find the effective resistance (R_eq) for the parallel combination of the other resistors (1 Ω, 2 Ω, and 3 Ω), we use:

$$\frac{1}{R_{\text{eq}}}=\frac{1}{1}+\frac{1}{2}+\frac{1}{3}=\frac{6+3+2}{6}=\frac{11}{6}$$

The total current (I) flowing through the circuit is given by:

$$I=\frac{V}{R_{\text{eq}}}=\frac{6\text{ V}\times 11}{6}=11\text{ A}$$

For the charge on the capacitor, we use the formula $Q=CV$, where C is the capacitance and V is the voltage across the capacitor:

$$Q_C=0.5\ \mu\text{F}\times 6\text{ V}=3\ \mu\text{C}$$

Question40

A parallel plate capacitor of capacitance ' C ' is connected to a battery and charged to a potential difference ' V '. Another capacitor of capacitance 3 C is similarly charged to a potential difference 3 V . The charging battery is then disconnected and capacitors are connected in parallel to each other in such a way that positive terminal of one is connected to the negative terminal of the other. The final energy of the configuration is

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Options:

A. $\frac{3}{2}$ CV^2

B. 8 CV^2

C. $\frac{13}{2}$ CV^2

D. 18 CV^2

Answer: B

Solution:

When two parallel plate capacitors are connected in parallel, their combined capacitance is the sum of their individual capacitances. Here’s a simplified breakdown:

Capacitance in Parallel:

Capacitor 1 has a capacitance C and is charged to a potential difference V.

Capacitor 2 has a capacitance $3C$ and is charged to a potential difference $3V$.

Combined Capacitance:

$C_{\text{eq}} = C + 3C = 4C$

Net Potential Difference:

The capacitors are connected such that the positive terminal of one is connected to the negative terminal of the other. This results in the net potential difference being the difference between the two:

$V_{\text{net}} = 3V - V = 2V$

Final Energy Calculation:

The energy stored in a capacitor is given by the formula:

$\text{Energy} = \frac{1}{2} C_{\text{eq}} V_{\text{net}}^2$

Substituting the calculated values:

$\text{Energy} = \frac{1}{2} \times 4C \times (2V)^2 = 8CV^2$

Therefore, the final energy of the configuration is $8CV^2$.

Question41

A parallel plate air capacitor, with plate separation ' d ' has a capacitance of 9 pF . The space between the plates is now filled with two dielectrics, the first having $\mathrm{K}_1 = 3$ and thickness $\mathrm{d}_1 = \mathrm{d}/3$, while the 2^{nd} has $\mathrm{K}_2 = 6$ and thickness $d_2 = 2\,\mathrm{d}/3$. The capacitance of the new capacitor is :

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Options:

A. 3.8 pF

B. 20.25 pF

C. 40.5 pF

D. 45 pF

Answer: C

Solution:

For a parallel plate capacitor with a dielectric material, the capacitance is described by the formula:

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

where,

C is the capacitance,

A is the area of one of the plates,

ε_0 is the permittivity of free space,

k is the dielectric constant of the material,

d is the separation between the plates.

Calculating Individual Capacitances

For each section with a different dielectric:

First Dielectric:

Dielectric constant $k_1 = 3$

Thickness $d_1 = \frac{d}{3}$

The capacitance C_1 is:

$C_1 = \frac{A\varepsilon_0 k_1}{d_1} = \frac{A\varepsilon_0 \times 3}{d/3} = 9\frac{A\varepsilon_0}{d} = 9C$

Second Dielectric:

Dielectric constant $k_2 = 6$

Thickness $d_2 = \frac{2d}{3}$

The capacitance C_2 is:

$C_2 = \frac{A\varepsilon_0 k_2}{d_2} = \frac{A\varepsilon_0 \times 6}{2d/3} = 9\frac{A\varepsilon_0}{d} = 9C$

Calculating Total Capacitance

Since these two sections are in series, the total capacitance C_{total} is given by:

$C_{\text{total}} = \frac{C_1 \times C_2}{C_1 + C_2} = \frac{9C \times 9C}{9C + 9C} = \frac{81C^2}{18C} = \frac{9}{2}C$

Given that the original capacitor had a capacitance of $9\,\text{pF}$, substitute this into the total capacitance equation:

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

Thus,

$C_{\text{total}} = 40.5\,\text{pF}$

Therefore, the capacitance of the new capacitor is $40.5\,\text{pF}$.

Question42

A parallel plate capacitor has plate area $40\ \text{cm}^2$ and plate separation 2 mm . The space between the plates is filled with a dielectric medium of thickness 1 mm and dielectric constant 5 . The capacitance of the system is ($\varepsilon_0 =$ permittivity of vacuum)

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Options:

A. $24\varepsilon_0$ F

B. $\frac{3}{10}\varepsilon_0$ F

C. $\frac{10}{3}\varepsilon_0$ F

D. $10\varepsilon_0$ F

Answer: C

Solution:

For a parallel plate capacitor composed of two capacitors in series, the equivalent capacitance can be calculated using the formula:

$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$

The capacitance C_1 of the portion with the dielectric is given by:

$C_1 = \frac{A\varepsilon_0 k}{t}$

And the capacitance C_2 of the portion without the dielectric is:

$C_2 = \frac{A\varepsilon_0}{d-t}$

where:

A is the plate area,

ε_0 is the permittivity of vacuum,

k is the dielectric constant,

t is the thickness of the dielectric,

d is the total separation between the plates.

Substituting the given values:

$\frac{1}{C_{eq}} = \frac{1}{\frac{40\times10^{-4}\varepsilon_0\times5}{1\times10^{-3}}} + \frac{1}{\frac{40\times10^{-4}\varepsilon_0}{2\times10^{-3}-1\times10^{-3}}}$

Simplifying, we calculate:

$\frac{1}{C_{eq}} = \frac{1}{20\varepsilon_0} + \frac{1}{4\varepsilon_0}$

Therefore, the equivalent capacitance C_{eq} is:

$C_{eq} = \frac{10}{3}\varepsilon_0\,\mathrm{F}$

Question43

A parallel plate capacitor is charged and then isolated. If the separation between the plates is increased, which one of the following statement is NOT correct?

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Options:

A. Charge remains constant after it is isolated.

B. Potential difference across the plates decreases.

C. Potential difference across the plates increases.

D. Capacitance of capacitor decreases.

Answer: B

Solution:

Option B is NOT correct.

In a parallel plate capacitor, the charge Q remains constant after it is isolated, as stated in Option A. When the separation d between the plates is increased, the capacitance C of the capacitor is given by the formula:

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

where ε is the permittivity of the dielectric material between the plates, and A is the area of the plates. Since C is inversely proportional to d, increasing the separation decreases the capacitance, as described in Option D.

The potential difference V across the plates is related to charge and capacitance by

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

Since the charge Q remains constant and the capacitance C decreases when the separation is increased, the potential difference V must increase, which aligns with Option C. Therefore, the statement that the potential difference decreases (Option B) is incorrect.

Question44

Two circular metal plates each of radius ' r ' are kept parallel to each other distance ' d ' apart. The capacitance of the capacitor formed is ' C_1 '. If the radius of each of the plates is increased to $\sqrt{2}$ times the earlier radius and their distance of separation decreased to half the initial value, the capacitance now becomes ' C_2 '. The ratio of the capacitances $\mathrm{C}_1 : \mathrm{C}_2$ is

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Options:

A. 1 : 1

B. 1 : 2

C. 1 : 4

D. 4 : 1

Answer: C

Solution:

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

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

where ε_0 is the permittivity of free space, A is the area of the plates, and d is the distance between the plates.

Initial Capacitance C_1:

The area of each plate, A_1, is:

$A_1 = \pi r^2$

So, the initial capacitance C_1 is:

$C_1 = \frac{\varepsilon_0 \pi r^2}{d}$

Changed Capacitance C_2:

The radius of each plate is increased to $\sqrt{2} \times r$, so the new area A_2 is:

$A_2 = \pi(\sqrt{2}r)^2 = 2\pi r^2$

The distance between the plates is decreased to $\frac{1}{2}d$.

The new capacitance C_2 is:

$C_2 = \frac{\varepsilon_0 \cdot 2\pi r^2}{\frac{1}{2}d} = \frac{2 \cdot \varepsilon_0 \pi r^2}{\frac{1}{2}d} = \frac{4\varepsilon_0 \pi r^2}{d}$

Ratio $C_1 : C_2$:

$\frac{C_1}{C_2} = \frac{\frac{\varepsilon_0 \pi r^2}{d}}{\frac{4\varepsilon_0 \pi r^2}{d}} = \frac{1}{4}$

Therefore, the ratio of the capacitances $C_1 : C_2$ is:

Option C: $1 : 4$

Question45

The amount of work done in increasing the voltage across the plates of a capacitor form 5 V to 10 V is ' W '. The work done in increasing it from 10 V to 15 V will be (nearly)

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Options:

A. 0.6 W

B. W

C. 1.25 W

D. 1.67 W

Answer: D

Solution:

To calculate the work done in increasing the voltage across the plates of a capacitor from 5 V to 10 V and then from 10 V to 15 V, we use the formula for the work done on a capacitor:

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

For a constant capacitance C, the work done, W, is proportional to the square of the voltage, V, so $W \propto V^2$.

Thus, the ratio of work done in two different voltage intervals is given by:

$\frac{W_1}{W_2}=\frac{V_2^2-V_1^2}{V_3^2-V_2^2}$

Where:

$V_1=5 \mathrm{~V}$

$V_2=10 \mathrm{~V}$

$V_3=15 \mathrm{~V}$

Using these values, we find:

$\frac{W}{W_2}=\frac{10^2-5^2}{15^2-10^2}=\frac{100-25}{225-100}=\frac{75}{125}=\frac{3}{5}$

Solving for W_2, we have:

$W_2=\frac{5}{3} W=1.67 W$

Hence, the work done in increasing the voltage from 10 V to 15 V is approximately 1.67 W.

Question46

Charge on a parallel plate capacitor of capacity C is Q , the electric field intensity between its two plates separated by a distance of t is

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Options:

A. $\frac{Qt}{C}$

B. $\frac{Q}{Ct}$

C. $\frac{C}{Qt}$

D. $\frac{Ct}{Q}$

Answer: B

Solution:

The electric field intensity (E) between the plates of a parallel plate capacitor is given by the formula:

$\mathrm{E}=\frac{\mathrm{Q}}{\mathrm{A}\varepsilon}$ ... (i)

Where:

Q is the charge on the capacitor.

A is the area of the plates.

ε is the permittivity of the dielectric material between the plates.

The capacitance (C) of a parallel plate capacitor is expressed as:

$\mathrm{C}=\frac{\mathrm{A}\varepsilon}{\mathrm{t}}$

Solving for $A\varepsilon$ gives:

$A\varepsilon=\mathrm{Ct}$ ... (ii)

Substituting equation (ii) into equation (i):

$\mathrm{E}=\frac{\mathrm{Q}}{\mathrm{Ct}}$

Thus, the electric field intensity between the plates is $\frac{\mathrm{Q}}{\mathrm{Ct}}$.

Question47

A circuit having a self inductance of 1 henry carries a current of 1 A . To prevent the sparking when the circuit is broken, a capacitor which can withstand 500 V is connected across the switch. What is the minimum value of the capacitance of the capacitor?

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Options:

A. 2μ F

B. 4μ F

C. 6μ F

D. 8μ F

Answer: B

Solution:

The energy stored in an inductor is given by the expression:

$E=\frac{1}{2} L I^2$

where L is the inductance and I is the current. In this case, the energy is stored in a self-inductance $L=1$ henry with a current $I=1$ ampere. Substituting these values into the expression:

$E=\frac{1}{2} \times 1 \times 1^2=\frac{1}{2}$ joule

To prevent sparking, the energy from the inductor is transferred to a capacitor when the circuit is broken. The energy stored in a capacitor is given by:

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

where C is the capacitance and V is the voltage across the capacitor. The maximum voltage the capacitor can withstand is $V=500$ volts. Equating the two expressions for energy:

$\frac{1}{2} L I^2=\frac{1}{2} C V^2$

Simplifying, we find:

$L I^2=C V^2$

Solving for C, the minimum capacitance, we have:

$C=\frac{L I^2}{V^2}$

Substitute the given values $L=1$ henry, $I=1$ ampere, and $V=500$ volts:

$C=\frac{1 \times 1^2}{500^2}=\frac{1}{250000}$

Converting to microfarads:

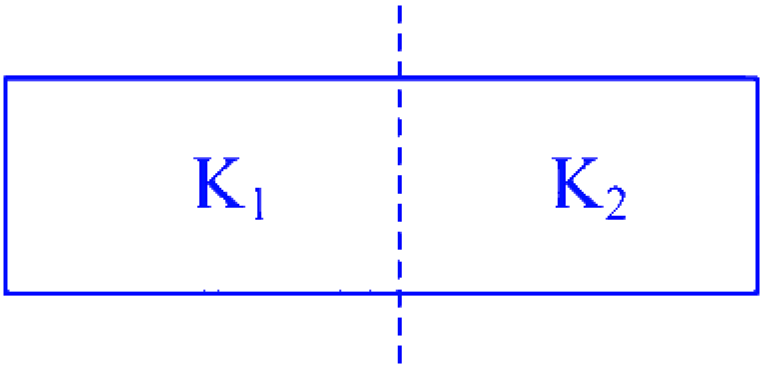
$C=4 \times 10^{-6}$ farads $=4 \mu\mathrm{F}$

Thus, the minimum value of the capacitance of the capacitor is:

Option B: 4 μF

Question48

A parallel plate capacitor with air medium between the plates has a capacitance of 10μF. The area of capacitor is divided into two equal halves and filled with two media (as shown in figure) having dielectric constant $K_1 = 2$ and $K_2 = 4$. The capacitance of the system will be



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Options:

A. 10 μF

B. 20 μF

C. 30 μF

D. 40 μF

Answer: C

Solution:

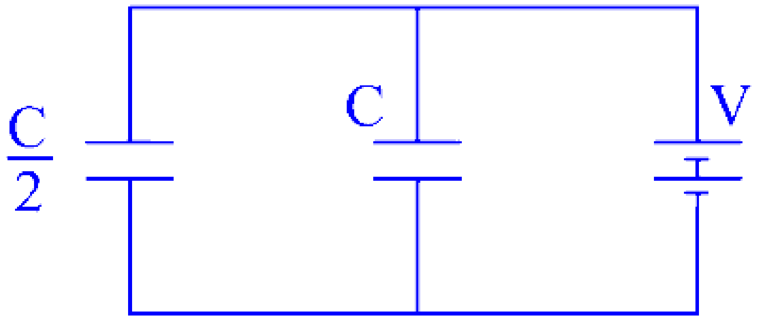
$C = \frac{\varepsilon_0 A}{d} = 10\mu F$

After dividing the area into two equal halves, the resultant capacitance is calculated as,

$$C_{eq} = C_1 + C_2$$
$$= \frac{K_1 \varepsilon_0 A_1}{d} + \frac{K_1 \varepsilon_0 A_1}{d} = \frac{\frac{2\varepsilon_0 A}{2}}{d} + \frac{\frac{4\varepsilon_0 A}{2}}{d}$$
$$\therefore \quad C_{eq} = \frac{\varepsilon_0 A}{d} + \frac{2\varepsilon_0 A}{d} = \frac{3\varepsilon_0 A}{d} = 3 \times 10 = 30\mu F$$

Question49

Two condensers one of capacity $\frac{C}{2}$ and other capacity C are connected to a battery of voltage V as shown. The work done in charging fully both the condensers is



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Options:

A. $\frac{1}{2} CV^2$

B. $\frac{3}{4} CV^2$

C. $\frac{3}{2} CV^2$

D. $2 CV^2$

Answer: B

Solution:

The two condensers are in parallel. Their equivalent capacitance is $C_c = C + \frac{C}{2} = \frac{3C}{2}$

The formula for work done is

$$W = \frac{1}{2}C_eV^2$$
$$W = \frac{1}{2}\left(\frac{3C}{2}\right)V^2$$
$$W = \frac{3}{4}CV^2$$

Question50

Which of the following combination of 7 identical capacitors each of $2\mu F$ gives a capacitance of $\frac{10}{11}\mu F$?

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Options:

A. 5 in parallel and 2 in series

B. 4 in parallel and 3 in series

C. 3 in parallel and 4 in series

D. 2 in parallel and 5 in series

Answer: A

Solution:

For n identical capacitors connected in series, the equivalent capacitance is, $C_s = \frac{C}{n}$

Similarly, for m identical capacitors connected parallel to each other, the equivalent capacitance is, $C_p = mC$

Assuming the two combinations are connected in series, the net capacitance,

$$\frac{1}{C_{net}} = \frac{1}{mC} + \frac{n}{C} = \frac{11}{10}\mu F \quad \ldots.\left(\because C_{net} = \frac{10}{11}\mu F\right)$$
$$\therefore \text{ for } C = 2\mu F,$$
$$\frac{11 \times 2}{10} = \frac{1}{m} + n$$
$$\therefore \quad \frac{1}{m} + n = \frac{11}{5} \quad \text{..... (i)}$$

Substituting the values for m and n in equation (i) from each option, the correct answer can be found to be (A).

Question51

In a parallel plate capacitor with air between the plates, the distance d between the plates is changed and the space is filled with dielectric constant 8. The capacity of the capacitor is increased 16 times, the distance between the plates is

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Options:

A. 2d

B. 4d

C. d/2

D. d/4

Answer: C

Solution:

Capacitance of a parallel plate capacitor is given by, $C = \frac{\varepsilon_0 A}{d}$

When capacitor is completely filled with dielectric K then, $C' = \frac{\varepsilon_0 K A}{d'}$

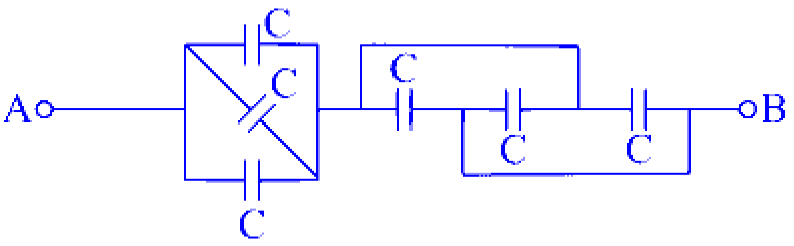
According to question, $\frac{C'}{C} = \frac{16}{1} = \frac{\frac{\varepsilon_0 \times 8 \times A}{d'}}{\frac{\varepsilon_0 \times A}{d}}$

$$\Rightarrow \quad \frac{16}{1} = \frac{8d}{d'}$$

$$\Rightarrow \quad d' = \frac{d}{2}$$

Question52

In the given figure, the equivalent capacitance between points A and B is



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Options:

A. 1.5 C

B. 2 C

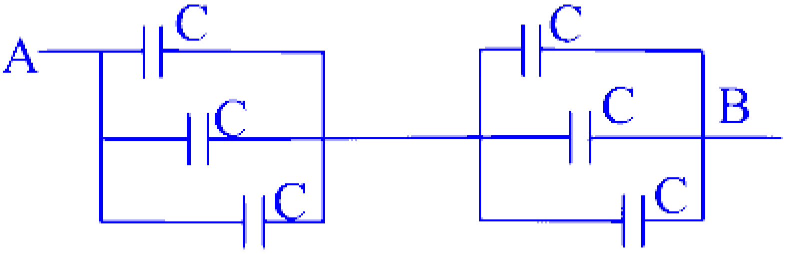
C. 3 C

D. 6 C

Answer: A

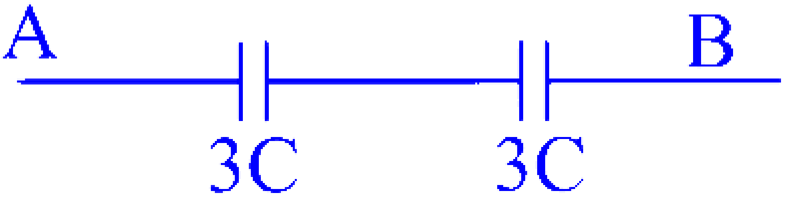
Solution:

The given circuit can also be redrawn as,



Thus, the parallel capacitors are calculated as $C_p = C + C + C = 3C$

Hence,



The equivalent capacitance between A and B is

$$\frac{1}{C_{\text{eq}}} = \frac{1}{3C} + \frac{1}{3C}$$
$$\Rightarrow \frac{1}{C_{\text{eq}}} = \frac{2}{3C}$$
$$\Rightarrow C_{\text{eq}} = \frac{3}{2}C$$
$$\Rightarrow C_{\text{eq}} = 1.5C$$

Question53

If the charge on the capacitor is increased by 3 coulombs, the energy stored in it increases by 44%. The original charge on the capacitor is

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Options:

A. 10 C

B. 15 C

C. 20 C

D. 25 C

Answer: B

Solution:

Energy stored in a charged capacitor is

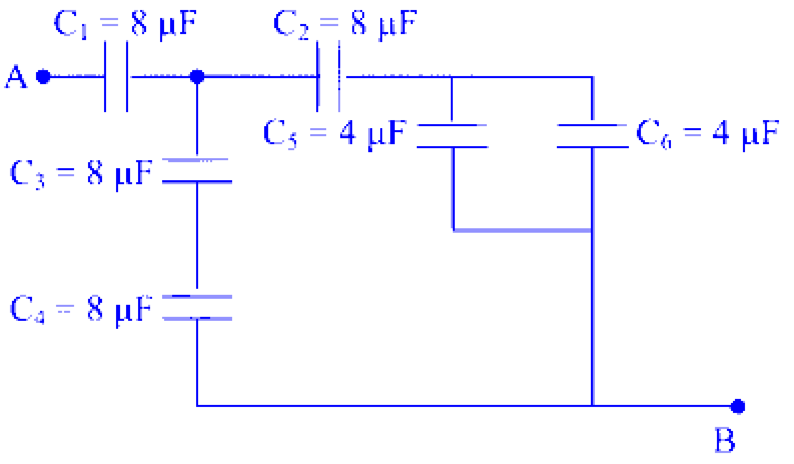
$\mathrm{U} = \frac{\mathrm{Q}^2}{2\mathrm{C}} \quad \Rightarrow \mathrm{U} \propto \mathrm{Q}^2$

As per given condition, when, $\mathrm{Q}_2 = (\mathrm{Q}_1 + 3)$,

$\therefore \quad \mathrm{U}_2 = 44\% \text{ of } \mathrm{U}_1 = \frac{144}{100}\mathrm{U}_1$
$\therefore \quad \frac{\mathrm{Q}_2^2}{2\mathrm{C}} = \frac{144}{100} \times \frac{\mathrm{Q}_1^2}{2\mathrm{C}}$
$\therefore \quad \mathrm{Q}_1 = \frac{10}{12}\mathrm{Q}_2$
$\therefore \quad \mathrm{Q}_1 = \frac{5}{6}(\mathrm{Q}_1 + 3)$
$\therefore \quad 6\mathrm{Q}_1 = 5\mathrm{Q}_1 + 15$
$\therefore \quad \mathrm{Q}_1 = 15\mathrm{C}$

Question54

In the given capacitive network the resultant capacitance between point A and B is



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Options:

A. 8 μF

B. 4 μF

C. 2 μF

D. 16 μF

Answer: B

Solution:

In the given circuit, C_3 and C_4 are in series and $\mathrm{C}_3 = \mathrm{C}_4 = 8\mu\mathrm{F}$

$\therefore \quad \frac{1}{\mathrm{C}_S} = \frac{1}{\mathrm{C}_3} + \frac{1}{\mathrm{C}_4}$

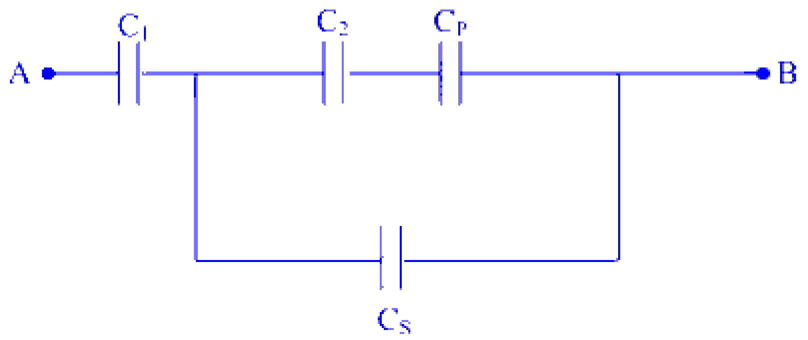
$$\begin{aligned} \therefore \quad \mathrm{C}_S &= \frac{\mathrm{C}_3^2}{2\mathrm{C}_3} \\ \mathrm{C}_S &= \frac{\mathrm{C}_3}{2} \\ \therefore \quad \mathrm{C}_S &= 4\mu\mathrm{F} \quad \text{.... (i)} \end{aligned}$$

C_5 and C_6 are in parallel and $\mathrm{C}_5 = \mathrm{C}_6 = 4\ \mu\mathrm{F}$

$C_P = C_5 + C_6$

$\therefore \quad C_P = 8\mu F$

$\therefore$ Equivalent circuit is as shown in figure.



Now, C_2 and C_P are in series and their combination in parallel with C_S

$$\therefore \quad C_E = \frac{C_2 C_p}{C_2 C_p} + C_s$$

$$C_E = \frac{(8)(8)}{16} + 4$$

$$\therefore \quad C_E = 8\mu F$$

Now, C_1 and C_E are in series,

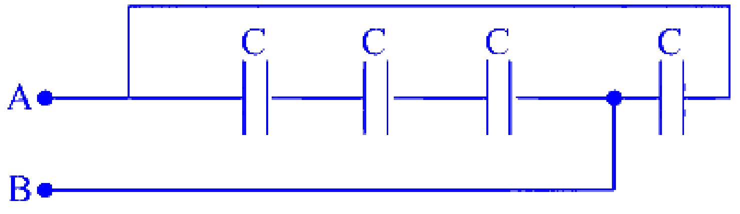
$$\therefore \quad C = \frac{C_1 C_E}{C_1 + C_E}$$

$$\therefore \quad C = \frac{(8)(8)}{16}$$

$$\therefore \quad C = 4\mu F$$

Question55

The equivalent capacity between terminal A and B is



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Options:

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

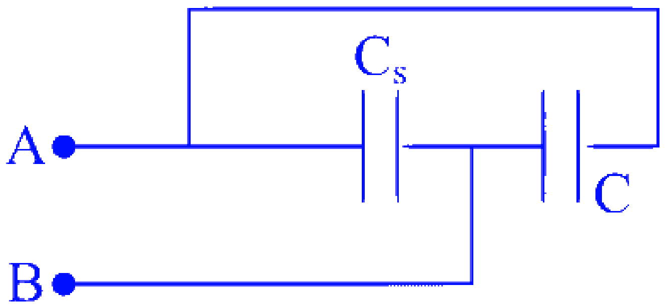
B. $\frac{3C}{4}$

C. $\frac{C}{3}$

D. $\frac{4C}{3}$

Answer: D

Solution:



$$\frac{1}{C_s} = \frac{1}{C} + \frac{1}{C} + \frac{1}{C}$$

$$\therefore \quad C_s = \frac{C}{3}$$

Now, C_s and C are connected in parallel,

$\therefore \quad C_{net} = C_s + C = \frac{C}{3} + C = \frac{4C}{3}$

Question56

The potential on the plates of capacitor are $+20$ V and -20 V. The charge on the plate is 40C. The capacitance of the capacitor is

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Options:

A. 2 F

B. 1 F

C. 4 F

D. 0.5 F

Answer: B

Solution:

$$
\begin{aligned}
& V=20-(-20)=40 \text { volt } \\
& Q=40 C \\
& C=\frac{Q}{V} \\
\therefore \quad & C=\frac{40}{40} \\
\therefore \quad & C=1 F
\end{aligned}
$$

Question57

Two spherical conductors of capacities $3 \mu \mathrm{F}$ and $2 \mu \mathrm{F}$ are charged to same potential having radii $3 \mathrm{~cm}$ and $2 \mathrm{~cm}$ respectively. If 'σ_1' and 'σ_2' represent surface density of charge on respective conductors then $\frac{\sigma_1}{\sigma_2}$ is

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Options:

A. $\frac{1}{3}$

B. $\frac{1}{2}$

C. $\frac{2}{3}$

D. $\frac{3}{4}$

Answer: C

Solution:

We know, $C = \frac{Q}{V}$

As both the charged spheres are at the same potential, the charge on both spheres is

$Q_1 = C_1 V$
$Q_2 = C_2 V$

The charge densities of both spheres are

$\sigma_1 = \frac{Q_1}{A_1} = \frac{C_1 V}{4\pi r_1^2}$

Similiarly,

$\sigma_2 = \frac{Q_2}{A_2} = \frac{C_2 V}{4\pi r_2^2}$

Taking the ratios,

$$\begin{aligned} & \frac{\sigma_2}{\sigma_1}=\frac{C_2 r_1^2}{C_1 r_2^2} \\ & \frac{\sigma_2}{\sigma_1}=\frac{2 \times 10^{-6} \times(0.03)^2}{3 \times 10^{-6} \times(0.02)^2}=\frac{3}{2} \\ \therefore \quad & \frac{\sigma_1}{\sigma_2}=\frac{2}{3} \end{aligned}$$

Question58

Three identical capacitors of capacitance 'C' each are connected in series and this connection is connected in parallel with one more such identical capacitor. Then the capacitance of whole combination is

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Options:

A. 3C

B. 2C

C. $\frac{4}{3}$C

D. $\frac{3}{4}$C

Answer: C

Solution:

The equivalent capacitance of three capacitances connected in series is

$$\frac{1}{C_{eq}} = \frac{1}{C} + \frac{1}{C} + \frac{1}{C}$$
$$\frac{1}{C_{eq}} = \frac{3}{C}$$
$$C_{eq} = \frac{C}{3}$$

This capacitance is connected in parallel with another capacitance.

$$\Rightarrow C_{\text{total}} = \frac{C}{3} + C$$
$$C_{\text{total}} = \frac{4C}{3}$$

Question59

A parallel plate capacitor is charged by a battery and battery remains connected. The dielectric slab of constant 'K' is inserted between the plates and then taken out. Then electric field between the plates

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Options:

A. remains the same

B. increases

C. decreases

D. becomes zero

Answer: A

Solution:

✅ Correct Answer: A. remains the same

✔ **Explanation**

A parallel-plate capacitor is connected to a **battery**, and the battery **remains connected.**

This means:

👉 **The voltage V across the capacitor remains constant.**

Electric field between the plates is:

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

Where:

- V = voltage (constant because battery is connected)
- d = plate separation (unchanged)

So **electric field remains constant**, no matter what dielectric you insert or remove.

✔ What happens when dielectric is inserted?

- Capacitance increases:

$$C' = KC$$

- Charge increases because:

$$Q = CV \quad (\text{V constant})$$

- Electric field **does NOT** change, because $E = V/d$.

✔ What happens when the dielectric is removed?

- Capacitance returns to original.
- Charge returns to original (battery keeps V fixed).
- Electric field remains:

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

Question60

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

Options:

A. $\frac{1}{4}\mathrm{C}\left(\mathrm{V}_1^2-\mathrm{V}_2^2\right)$

B. $\frac{1}{4}\mathrm{C}\left(\mathrm{V}_1^2+\mathrm{V}_2^2\right)$

C. $\frac{1}{4}\mathrm{C}\left(\mathrm{V}_1-\mathrm{V}_2\right)^2$

D. $\frac{1}{4}\mathrm{C}\left(\mathrm{V}_1+\mathrm{V}_2\right)^2$

Answer: C

Solution:

Initial energy of the combined system

$\mathrm{U}_1=\frac{1}{2}\mathrm{CV}_1^2+\frac{1}{2}\mathrm{CV}_2^2=\frac{\mathrm{C}}{2}\left(\mathrm{V}_1^2+\mathrm{V}_2^2\right)$

On joining the two condensers in parallel, common potential,

$\mathrm{V}=\frac{\mathrm{V}_1+\mathrm{V}_2}{2}$

$\therefore$ Final energy of the combined system:

$\mathrm{U}_2=\frac{1}{2}(\mathrm{C}+\mathrm{C})\left(\frac{\mathrm{V}_1+\mathrm{V}_2}{2}\right)^2$

$\therefore$ Decrease in energy will be:

$$\begin{aligned}
\Delta \mathrm{U} &= \mathrm{U}_1-\mathrm{U}_2 \\
&= \frac{\mathrm{C}}{2}\left(\mathrm{V}_1^2+\mathrm{V}_2^2\right)-\frac{1}{2}(\mathrm{C}+\mathrm{C})\left(\frac{\mathrm{V}_1+\mathrm{V}_2}{2}\right)^2 \\
&= \frac{1}{4}\mathrm{C}\left(\mathrm{V}_{\mathrm{f}}-\mathrm{V}_2\right)^2
\end{aligned}$$

Question61

If a capacitor of capacity $900\ \mu\mathrm{F}$ is charged to $100\ \mathrm{V}$ and its total energy is transferred to a capacitor of capacity $100\ \mu\mathrm{F}$, then its potential will be

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Options:

A. 30 V

B. 200 V

C. 300 V

D. 400 V

Answer: C

Solution:

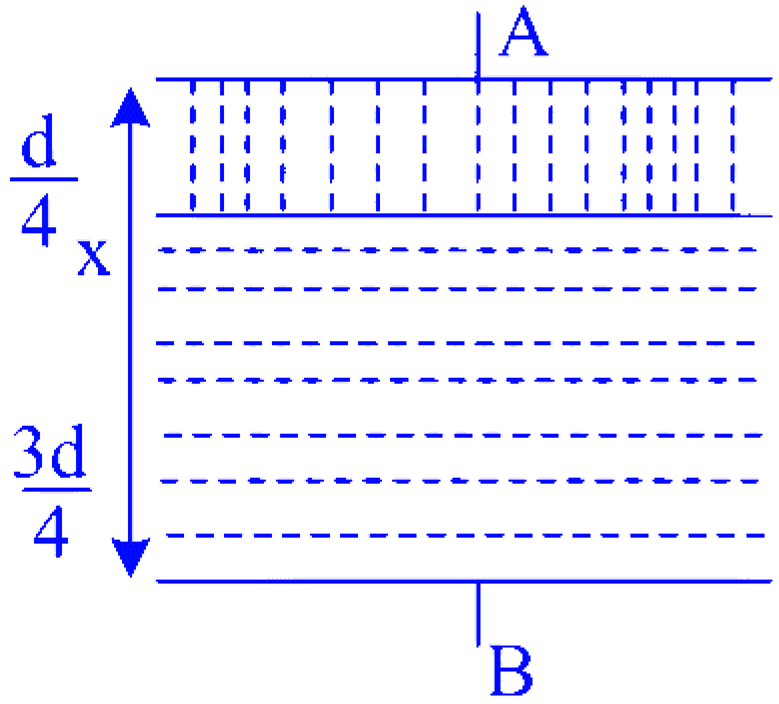
Let the unknown potential be $\mathrm{V_u}$

Energy of a capacitor $= \frac{1}{2}\mathrm{CV}^2$

$$\Rightarrow \frac{1}{2}C_1V_1^2 = \frac{1}{2}C_2(V_u)^2$$
$$\frac{1}{2} \times 900 \times 10^{-6} \times (100)^2 = \frac{1}{2} \times 100 \times 10^{-6} \times (V_u)^2$$
$$(V_u)^2 = 9 \times 100^2$$
$$\therefore \quad V_u = 300 \text{ V}$$

Question62

Two dielectric slabs having dielectric constant '$\mathrm{K_1}$' and '$\mathrm{K_2}$' of thickness $\frac{\mathrm{d}}{4}$ and $\frac{3\mathrm{~d}}{4}$ are inserted between the plates as shown in figure. The net capacitance between A and B is $[\varepsilon_0$ is permittivity of free space]



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Options:

A. $\frac{2\ A\varepsilon_0}{d}\left[\frac{K_1\ K_2}{3\ K_1+K_2}\right]$

B. $\frac{3\ A\varepsilon_0}{d}\left[\frac{K_1+K_2}{K_1\ K_2}\right]$

C. $\frac{3\ A_0}{2\ d}\left[\frac{K_1+K_2}{K_1\ K_2}\right]$

D. $\frac{4A\varepsilon_0}{d}\left[\frac{K_1K_2}{3K_1+K_2}\right]$

Answer: D

Solution:

Capacity of 1^{st} Capacitor,

$C_1=\frac{K_1\varepsilon_0A}{d/4}=\frac{4K_1\varepsilon_0A}{d}$

Capacity of 2^{nd} Capacitor,

$C_2=\frac{K_2\varepsilon_0\ A}{3\ d/4}=\frac{4\ K_2\varepsilon_0\ A}{3\ d}$

Equivalent capacitance $\frac{1}{C}=\frac{1}{C_1}+\frac{1}{C_2}$

$$\frac{1}{C_1}=\frac{d}{4 K_1 \varepsilon_0 A} ; \frac{1}{C_2}=\frac{3 d}{4 K_2 \varepsilon_0 A}$$
$$\frac{1}{C}=\frac{d}{4 K_1 \varepsilon_0 A}+\frac{3 d}{4 K_2 \varepsilon_0 A}$$
$$\frac{1}{C}=\frac{d}{4 \varepsilon_0 A}\left[\frac{1}{K_1}+\frac{3}{K_2}\right]$$
$$\frac{1}{C}=\frac{d}{4 \varepsilon_0 A}\left[\frac{K_2+3 K_1}{K_1 K_2}\right]$$
$$\therefore \quad C=\frac{4 \varepsilon_0 A}{d}\left[\frac{K_1 K_2}{3 K_1+K_2}\right]$$

Question63

A parallel plate capacitor has plate area 'A' and separation between plates is 'd'. It is charged to a potential difference of V_0 volt. The charging battery is then disconnected and plates are pulled apart three times the initial distance. The work done to increase the distance between the plates is ($\varepsilon_0=$ permittivity of free space)

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Options:

A. $\frac{3 \varepsilon_0 A V_0{ }^2}{d}$

B. $\frac{\varepsilon_0 A V_0^2}{2 d}$

C. $\frac{\varepsilon_0 A V_0{ }^2}{3 d}$

D. $\frac{\varepsilon_0 A V_0{ }^2}{d}$

Answer: D

Solution:

Let the initial capacitance be $C_0=\frac{\varepsilon_0 A}{d}$

Let the charge on the capacitor be $Q_{\text {initial }}=C_0 V_0$

Plate separation is increased by 3 times i.e., $d^{\prime}=3 d$

$\mathrm{C}_{\text{final}} = \frac{\varepsilon_0 \mathrm{~A}}{3 \mathrm{~d}} = \frac{1}{3}\left(\frac{\varepsilon_0 \mathrm{~A}}{\mathrm{~d}}\right) = \frac{\mathrm{C}_0}{3}$

Let $\mathrm{Q}_{\text{final}}$ be the final charge on the capacitor and V_{final} be the final potential on the capacitor.

$\therefore \quad \mathrm{Q}_{\text{final}} = \mathrm{C}_{\text{final}} \mathrm{~V}_{\text{final}} = \frac{1}{3} \mathrm{C}_0 \mathrm{~V}_{\text{final}}$

As the capacitor is isolated,

$$
\begin{aligned}
& \mathrm{Q}_{\text{final}} = \mathrm{Q}_{\text{initial}}, \\
& \mathrm{C}_0 \mathrm{~V}_0 = \frac{1}{3} \mathrm{C}_0 \mathrm{~V}_{\text{final}} \\
& \therefore \quad \mathrm{V}_{\text{final}} = 3 \mathrm{~V}_0 \\
& \text{Work done} = \text{Final P.E} - \text{Initial P.E} \\
& = \frac{1}{2} \mathrm{C}_{\text{final}} \left(\mathrm{V}_{\text{final}}\right)^2 - \frac{1}{2} \mathrm{C}_0 \left(\mathrm{~V}_0\right)^2 \\
& = \frac{1}{2} \frac{\mathrm{C}_0}{3} 9 \mathrm{~V}_0^2 - \frac{1}{2} \mathrm{C}_0 \mathrm{~V}_0^2 \\
& = \mathrm{C}_0 \mathrm{~V}_0^2 \left(\frac{3}{2} - \frac{1}{2}\right) \\
& = \mathrm{C}_0 \mathrm{~V}_0^2 \\
& = \frac{\varepsilon_0 \mathrm{AV}_0^2}{\mathrm{~d}} \quad \ldots\left(\because \mathrm{C}_0 = \frac{\varepsilon_0 \mathrm{~A}}{\mathrm{~d}}\right)
\end{aligned}
$$

Question64

Two capacitors $\mathrm{C}_1 = 3 \mu \mathrm{F}$ and $\mathrm{C}_2 = 2 \mu \mathrm{F}$ are connected in series across d.c. source of $100 \mathrm{~V}$. The ratio of the potential across C_2 to C_1 is

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Options:

A. 2 : 3

B. 3 : 2

C. 6 : 5

D. 5 : 6

Answer: B

Solution:

$$\begin{aligned} & \mathrm{C}_1=3 \mu \mathrm{F} \text { and } \mathrm{C}_2=2 \mu \mathrm{F} \\ \therefore \quad & \mathrm{C}_{\text {series }}=\frac{\mathrm{C}_1 \mathrm{C}_2}{\mathrm{C}_1+\mathrm{C}_2}=\frac{6}{5} \mu \mathrm{F} \\ & \text { Also, } \mathrm{Q}=\mathrm{CV} \\ & \mathrm{Q}=\mathrm{C}_{\text {series }} \times \mathrm{V} \\ & =\frac{6}{5} \times 100=120 \mu \mathrm{C} \end{aligned}$$

Q will be the same across both the capacitors as they are in series.

$\therefore$ Potential across capacitors,

$$\begin{aligned} & \mathrm{V}_1=\frac{\mathrm{Q}}{\mathrm{C}_1}=\frac{120}{3}=40 \mathrm{~V} \\ & \mathrm{~V}_2=\frac{\mathrm{Q}}{\mathrm{C}_2}=\frac{120}{2}=60 \mathrm{~V} \\ \therefore \quad & \mathrm{V}_2: \mathrm{V}_1=60: 40=3: 2 \end{aligned}$$

Question65

The mean electrical energy density between plates of a charged air capacitor is (where $\mathrm{q}=$ charge on capacitor, $\mathrm{A}=$ Area of capacitor plate)

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Options:

A. $\frac{q^2}{2 \varepsilon_0 A^2}$

B. $\frac{\mathrm{q}}{2 \varepsilon_0 \mathrm{~A}^2}$

C. $\frac{\mathrm{q}^2}{2 \varepsilon_0 \mathrm{~A}}$

D. $\frac{\varepsilon_0 \mathrm{~A}}{\mathrm{q}^2}$

Answer: A

Solution:

For a parallel plate capacitor, the energy density $= \frac{1}{2} E^2 \varepsilon_0$

But E $= \frac{\sigma}{\varepsilon_0}$

$$
\begin{aligned}
\therefore \quad \text{Energy density} & =\frac{1}{2} \frac{\sigma^2}{\varepsilon_0^2} \times \varepsilon_0 \\
& =\frac{\sigma^2}{2 \varepsilon_0} \\
& =\frac{\left(\frac{\mathrm{q}}{\mathrm{A}}\right)^2}{2 \varepsilon_0} \quad \ldots .(\because \sigma=\mathrm{q} / \mathrm{A}) \\
& =\frac{\mathrm{q}^2}{2 \mathrm{~A}^2 \cdot \varepsilon_0}
\end{aligned}
$$

Question66

A parallel combination of two capacitors of capacities '2 C' and 'C' is connected across $5 \mathrm{~V}$ battery. When they are fully charged, the charges and energies stored in them be 'Q_1', 'Q_2' and 'E_1', 'E_2' respectively. Then $\frac{E_1-E_2}{Q_1-Q_2}$ in J / C is (capacity is in Farad, charge in Coulomb and energy in J)

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Options:

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

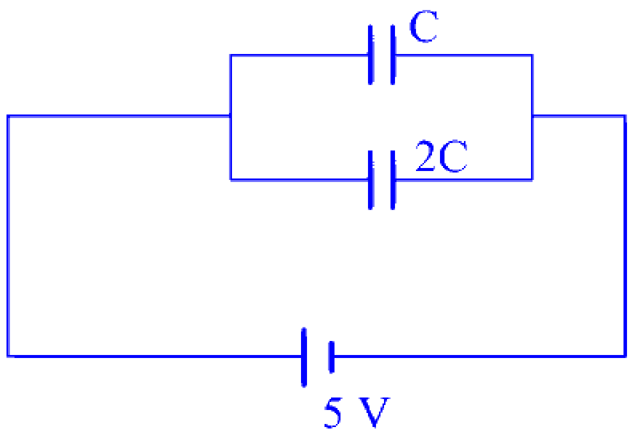
B. $\frac{4}{5}$

C. $\frac{5}{2}$

D. $\frac{2}{5}$

Answer: C

Solution:



We know, $Q = C.V$

$\therefore \quad Q_1 = 10C \text{ and } Q_2 = 5C$

Energy stored, $E = \frac{1}{2}CV^2$

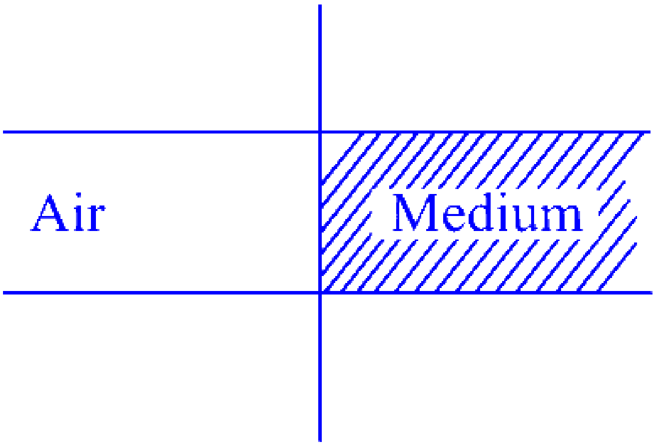
$\therefore \quad E_1 = \frac{1}{2}C_1 V^2 = \frac{1}{2} \times 2C \times 25 = 25 \text{ J}$

Similarly, $E_2 = \frac{1}{2}C_2 V^2 = \frac{1}{2} \times C \times 25 = 12.5 \text{ J}$

$\therefore \quad \frac{E_1 - E_2}{Q_1 - Q_2} = \frac{12.5}{5} = \frac{5}{2}$

Question67

The capacitance of a parallel plate capacitor is $2.5\ \mu$F. When it is half filled with a dielectric as shown in figure, its capacitance becomes $5\ \mu$F. The dielectric constant of the dielectric is



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Options:

A. 7.5

B. 3

C. 4

D. 5

Answer: B

Solution:

Given $C=\frac{\varepsilon_0 A}{d}=2.5\ \mu F$

When half filled with air,

$$\mathrm{C}_1=\frac{\varepsilon_0(\mathrm{~A}/2)}{\mathrm{d}}=\frac{\varepsilon_0\mathrm{~A}}{2\mathrm{~d}} \quad \ldots\ldots(\because \varepsilon_{\mathrm{r}}=1)$$

When half filled with a dielectric,

$$\mathrm{C}_2=\frac{\varepsilon_{\mathrm{r}}\varepsilon_0(\mathrm{~A}/2)}{\mathrm{d}}=\frac{\varepsilon_{\mathrm{r}}\varepsilon_0\mathrm{~A}}{2\mathrm{~d}}$$

From the figure, it can be seen that C_1 and C_2 are in parallel configuration.

$$\begin{aligned}
\therefore \quad & \mathrm{C}_{\mathrm{eq}}=\mathrm{C}_1+\mathrm{C}_2 \\
& \text{Given, } \mathrm{C}_{\mathrm{eq}}=5\mu\mathrm{F} \\
& \Rightarrow 5\mu\mathrm{F}=\frac{\varepsilon_0\mathrm{~A}}{2\mathrm{~d}}+\frac{\varepsilon_{\mathrm{r}}\varepsilon_0\mathrm{~A}}{2\mathrm{~d}} \\
& 5=\frac{2.5}{2}+\varepsilon_{\mathrm{r}}\frac{2.5}{2} \\
& \frac{3.75}{1.25}=\varepsilon_{\mathrm{r}} \\
\therefore \quad & \varepsilon_{\mathrm{r}}=3
\end{aligned}$$

Question68

The ratio of potential difference that must be applied across parallel and series combination of two capacitors C_1 and C_2 with their capacitance in the ratio $1:2$ so that energy stored in these two cases becomes same is

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Options:

A. $3 : \sqrt{2}$

B. $\sqrt{2} : 3$

C. $2 : 9$

D. $9 : 2$

Answer: B

Solution:

Given: $\mathrm{C}_1 : \mathrm{C}_2 = 1 : 2$

$$\begin{aligned} \therefore \quad & \mathrm{C}_2 = 2\mathrm{C}_1 \\ & \mathrm{C}_\mathrm{P} = \mathrm{C}_1 + \mathrm{C}_2 = \mathrm{C}_1 + 2\mathrm{C}_1 = 3\mathrm{C}_1 \\ & \mathrm{C}_\mathrm{S} = \frac{\mathrm{C}_1\mathrm{C}_2}{\mathrm{C}_1 + \mathrm{C}_2} = \frac{2\mathrm{C}_1^2}{3\mathrm{C}_1} = \frac{2}{3}\mathrm{C}_1 \end{aligned}$$

Let V_P and V_S be the potentials applied across the parallel and series combinations respectively, then using $\mathrm{E} = \frac{1}{2}\mathrm{CV}^2$ we can write,

$$\begin{aligned} & \tfrac{1}{2}C_P V_P^2 = \tfrac{1}{2}C_S V_S^2 \\ \therefore \quad & \tfrac{V_P^2}{V_S^2} = \tfrac{C_S}{C_P} \\ & \tfrac{V_P}{V_S} = \sqrt{\tfrac{\frac{2}{3}C_1}{3C_1}} = \tfrac{\sqrt{2}}{3} \end{aligned}$$

Question69

The potential energy of charged parallel plate capacitor is v_0. If a slab of dielectric constant K is inserted between the plates, then the new potential energy will be

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Options:

A. $\frac{v_0}{\mathrm{K}}$

B. v_0 K^2

C. $\frac{v_0}{\mathrm{K}^2}$

D. v_0^2

Answer: A

Solution:

We know, $v_0=\frac{Q^2}{2C}$

On inserting the slab of dielectric constant k, the new capacitance $\mathrm{C}'=\mathrm{KC}$

$\therefore$ New potential energy $v_0'=\frac{Q^2}{2C'}$

$v_0^1=\frac{\mathrm{Q}^2}{2\mathrm{KC}}=\frac{v_0}{\mathrm{K}}$

Question70

A parallel plate air capacitor has a uniform electric field 'E' in the space between the plates. Area of each plate is A and the distance between the plates is 'd'. The energy stored in the capacitor is $[\varepsilon_0=$ permittivity of free space)

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Options:

A. $2\varepsilon_0\mathrm{EAd}$

B. $\frac{1}{2}\varepsilon_0\mathrm{E}^2\mathrm{Ad}$

C. $\frac{\varepsilon_0\mathrm{E}^2}{2\mathrm{Ad}}$

D. $\frac{\mathrm{E}^2\mathrm{Ad}}{2\varepsilon_0}$

Answer: B

Solution:

The intensity of the electric field (E) between two plane parallel sheets of equal and opposite charges is given by $\mathrm{E}=\frac{\sigma}{\varepsilon_0}$

$\therefore \sigma=\mathrm{E} \varepsilon_0$ where $\sigma=$ surface density of charge $=\frac{\mathrm{Q}}{\mathrm{A}}$

$\therefore$ Charge on either plate of the capacitor is $\mathrm{Q}=\sigma \mathrm{A}=\varepsilon_0 \mathrm{EA}$ and $\mathrm{C}=\frac{\varepsilon_0 \mathrm{~A}}{\mathrm{~d}}$

$\therefore$ The energy stored in the capacitor is

$$\mathrm{U}=\frac{1}{2} \frac{\mathrm{Q}^2}{\mathrm{C}}=\frac{\left(\varepsilon_0 \mathrm{EA}\right)^2}{2 \cdot \frac{\varepsilon_0 \mathrm{~A}}{\mathrm{~d}}}=\frac{\varepsilon_0^2 \mathrm{~A}^2 \mathrm{E}^2 \times \mathrm{d}}{2 \varepsilon_0 \mathrm{~A}}$$

$$\therefore \mathbf{U}=\frac{\mathbf{1}}{\mathbf{2}} \varepsilon_0 \mathbf{E}^{\mathbf{2}} \mathbf{A d}$$

Question71

A parallel plate capacitor is charged and then disconnected from the charging battery. If the plates are now moved further apart by pulling them by means of insulating handles, then

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Options:

A. the capacitance of the capacitor increases

B. the charge on the capacitor decreases

C. the voltage across the capacitor increases

D. the energy stored in the capacitor decreases

Answer: C

Solution:

For a parallel plate capacitor, $\mathrm{C}=\frac{\varepsilon_0 \mathrm{~A}}{\mathrm{~d}}$

When the charging battery is disconnected and d is increased then

(a) Q remains constant

(b) $\mathrm{C} \propto \frac{1}{\mathrm{~d}}$ hence if d is increased, C is decreased.

(c) $C=\frac{Q}{V}$ or $V=\frac{Q}{C}$ if C is decreased, V will increase

(d) $E=\frac{1}{2} \frac{Q^2}{C}$ if C is decreased, then E will increase

Thus (a), (b) and (d) are wrong. Only (c) is correct.

Question72

The force between the plates of a parallel plate capacitor of capacitance 'C' and distance of separation of the plates 'd' with a potential difference 'V' between the plates is

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Options:

A. $\frac{V^2 d}{C}$

B. $\frac{C^2 V^2}{d^2}$

C. $\frac{CV^2}{2 d}$

D. $\frac{C^2 V^2}{2 d^2}$

Answer: C

Solution:

The force of attraction between the plates of a parallel plate capacitor is

$$\begin{aligned} F &= \frac{\sigma^2 A}{2\varepsilon_0}=\frac{Q^2}{A^2} \times \frac{A}{2\varepsilon_0}\left(\because \sigma=\frac{Q}{A}\right) \\ &= \frac{Q^2}{2\varepsilon_0 A}=\frac{C^2 V^2}{2\varepsilon_0 A}(\because Q=CV) \\ \therefore F &= C\left[\frac{CV^2}{2\varepsilon_0 A}\right]=\frac{\varepsilon_0 A}{d} \times \frac{CV^2}{2\varepsilon_0 A} \\ \therefore F &= \frac{1}{2} \frac{CV^2}{d} \end{aligned}$$

Question73

A battery is used to charge a parallel plate capacitor till the potential difference between the plates becomes equal to the e.m.f. of the battery. The ratio of the energy stored int he capacitor to the work done by the battery will be

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Options:

A. 2

B. $\frac{1}{2}$

C. 1

D. $\frac{1}{4}$

Answer: B

Solution:

Energy stored in the capacitor $\mathrm{U}=\frac{1}{2} q \mathrm{~V}$

Work done by the battery $\mathrm{W}=\mathrm{qV}$

$\therefore \frac{\mathrm{U}}{\mathrm{W}}=\frac{1}{2}$

Question74

Capacitors of capacities $\mathrm{C}_1, \mathrm{C}_2$ and C_3 are connected in series. If the combination is connected to a supply of 'V' volt, then potential difference across capacitor 'C_1' is

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Options:

A. $\frac{C_2C_3+C_1C_3+C_1C_2}{C_1C_2V}$

B. $\frac{C_2C_3+C_1C_3+C_1C_2}{C_1C_2C_3V}$

C. $\frac{C_2C_3V}{C_2C_3+C_1C_3+C_1C_2}$

D. $\frac{C_1C_2C_3V}{C_2C_3+C_1C_3+C_1C_2}$

Answer: C

Solution:

In series combination, the equivalent capacitance C is given by

$$\begin{aligned} \frac{1}{C} &= \frac{1}{C_1}+\frac{1}{C_2}+\frac{1}{C_3} \\ \therefore \quad \frac{1}{C} &= \frac{C_2C_3+C_1C_3+C_1C_2}{C_1C_2C_3} \\ \therefore \quad C &= \frac{C_1C_2C_3}{C_2C_3+C_1C_3+C_1C_2} \end{aligned}$$

Charge Q stored by the combinations is given by

$Q = CV = \frac{C_1C_2C_3V}{C_2C_3+C_1C_3+C_1C_2}$

Charge on each capacitor is same. Hence potential difference across C_1 is $V_1 = \frac{Q}{C_1}$

$\therefore \quad V_1 = \frac{C_2C_3V}{C_2C_3+C_1C_3+C_1C_2}$

Question75

The plates of a parallel plate capacitor of capacity 'C_1' are moved closer together until they ant half their original separation. The new capacitance 'C_2' is

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Options:

A. $C_2 = \frac{C_1}{2}$

B. $C_2 = C_1$

C. $C_2 = 2C_1$

D. $C_2 = 3C_1$

Answer: C

Solution:

✅ Correct Answer: $C_2 = 2C_1$

✔ Explanation

For a **parallel-plate capacitor**:

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

Where

- A = plate area
- d = separation between plates

✔ Given:

Plate separation is made **half** of its original value.

Initially:

$$C_1 = \frac{\varepsilon_0 A}{d}$$

After halving distance:

$$C_2 = \frac{\varepsilon_0 A}{d/2}$$

$$C_2 = 2 \cdot \frac{\varepsilon_0 A}{d} = 2C_1$$

Question76

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

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Options:

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

B. $\frac{1}{2}C\left(v_1^2 + v_2^2\right)$

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

D. $\frac{1}{2}C(V_1 + V_2)^2$

Answer: A

Solution:

$$
\begin{aligned}
& Q_1 = CV_1, Q_2 = CV_2, Q = Q_1 + Q_2 = 2CV \\
& \therefore CV_1 + CV_2 = 2CV \\
& \therefore \quad V = \frac{V_1 + V_2}{2}
\end{aligned}
$$

$$
\begin{aligned}
& \text{Decrease in energy } = \frac{1}{2}CV_1^2 + \frac{1}{2}CV_2^2 - \frac{1}{2}(2C)\left(\frac{V_1 + V_2}{2}\right)^2 \\
& = \frac{1}{2}C\left[V_1^2 + V_2^2 - 2\left(\frac{V_1 + V_2}{2}\right)^2\right] \\
& = \frac{1}{2}C\left[V_1^2 + V_2^2 - \frac{1}{2}(V_1 + V_2)^2\right] \\
& = \frac{1}{4}C\left[2V_1^2 + 2V_2^2 - (V_1 + V_2)^2\right] \\
& = \frac{1}{4}C(V_1 - V_2)^2
\end{aligned}
$$

Question77

If the potential difference across a capacitor is increased from 5 V to 15 V, then the ratio of final energy to initial energy stored in the capacitor is

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Options:

A. 1 : 3

B. 27 : 1

C. 3 : 1

D. 9 : 1

Answer: D

Solution:

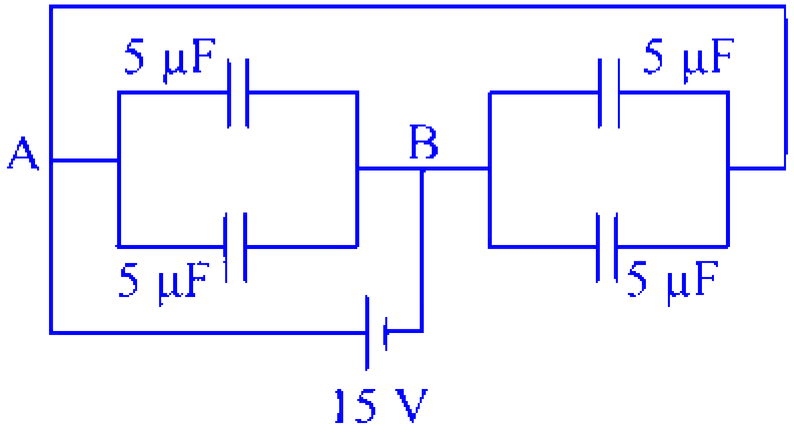
Initial energy $W_1 = \frac{1}{2}CV_1^2$

Final energy $W_2 = \frac{1}{2}CV_2^2$

$\therefore \quad \frac{W_2}{W_1} = \left(\frac{V_2}{V_1}\right)^2 = \left(\frac{15}{5}\right)^2 = (3)^2 = 9$

Question78

The charge on each capacitor when a voltage source os 15 V is connected in the circuit as shown, is



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Options:

A. 75 μC

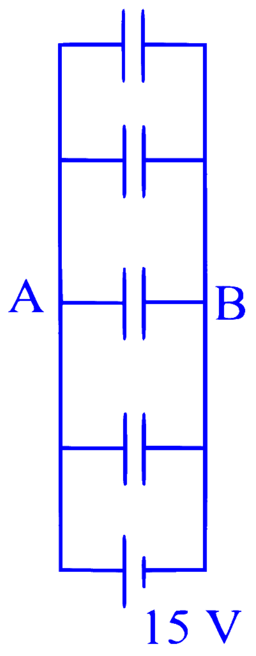
B. 150 μC

C. 30 μC

D. 60 μC

Answer: A

Solution:



The circuit can be drawn as shown

Each capacitor has capacitance of $5 \mu \mathrm{F}$.

The capacitors are in parallel. Hence equivalent capacitance$\mathrm{C}=20 \mu \mathrm{F}$

The charge stored by the combination

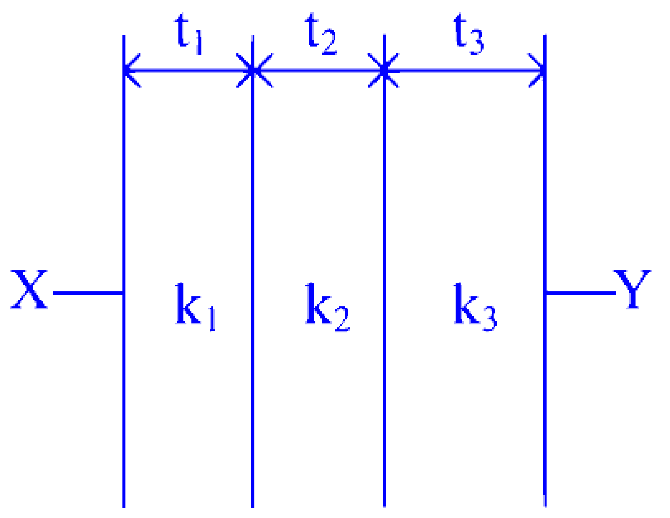
$\mathrm{Q}=\mathrm{CV}=20 \times 15=300 \mu \mathrm{C}$

$\therefore$ The charge on each capacitor is

$\frac{300}{4}=75 \mu \mathrm{C}$

Question79

Two parallel plates with dielectric placed between the plates are as shown in figure. The resultant capacity of capacitor will be [A = area of plate. t_1, t_2 and t_3 are thickness of dielectric slabs, $\mathrm{k}_1, \mathrm{k}_2$ and k_3 are dielectric constants.



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Options:

A. $\frac{A\varepsilon_0}{\left[\frac{t_1+t_2+t_3}{k_1+k_2+k_3}\right]}$

B. $\frac{A\varepsilon_0(k_1k_2k_3)}{t_1t_2t_3}$

C. $A\varepsilon_0\left[\frac{k_1}{t_1}+\frac{k_2}{t_2}+\frac{k_3}{t_3}\right]$

D. $\frac{A\varepsilon_0}{\left[\frac{t_1}{k_1}+\frac{t_2}{k_2}+\frac{t_3}{k_3}\right]}$

Answer: C

Solution:

✅ Correct Answer: C (the expression with $A\varepsilon_0\left[\frac{k_1}{t_1}+\frac{k_2}{t_2}+\frac{k_3}{t_3}\right]$)

✔ **Explanation**

In this setup, **three dielectric slabs** of dielectric constants

$$k_1,\ k_2,\ k_3$$

and thicknesses

$$t_1,\ t_2,\ t_3$$

are placed between parallel plates **side by side**, fully filling the area between plates.

📌 **Key idea:**
When dielectric slabs are placed *side-by-side*, each forms a **separate capacitor in parallel.**

So the effective capacitance is:

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

Each capacitor has capacitance:

$$C_i = \frac{\varepsilon_0 k_i A}{t_i}$$

Therefore:

$$C_{\text{eq}} = \frac{\varepsilon_0 k_1 A}{t_1} + \frac{\varepsilon_0 k_2 A}{t_2} + \frac{\varepsilon_0 k_3 A}{t_3}$$

Factor out $A\varepsilon_0$:

$$\boxed{C_{\text{eq}} = A\varepsilon_0\left(\frac{k_1}{t_1}+\frac{k_2}{t_2}+\frac{k_3}{t_3}\right)}$$

This matches **Option C.**

Question80

In parallel plate capacitor, electric field between the plates is 'E'. If the charge on the plates is 'Q' then the force on each plate is

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Options:

A. QE

B. $\frac{QE^2}{2}$

C. QE^2

D. $\frac{QE}{2}$

Answer: D

Solution:

The field produced by charge on each plate is $\frac{E}{2}$.

Hence force on each plate is given by

$F = Q\times$ (Field produced by the other plate)

$= \frac{QE}{2}$

Question81

If the charge on the capacitor is increased by 2 C the energy stored in it increased by 21%. Total original charge on the capacitor is

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Options:

A. 10 C

B. 5 C

C. 20 C

D. 15 C

Answer: C

Solution:

Let's start by recalling the formula for the energy stored in a capacitor. The energy U stored in a capacitor with capacitance C and charge Q is given by:

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

Since we do not know the capacitance C, we will manipulate the formula using given information. If the charge on the capacitor is increased by 2 C, the new charge Q' becomes $Q + 2$. Thus, the new energy U' becomes:

$U' = \frac{(Q+2)^2}{2C}$

We are given that this new energy is 21% greater than the original energy. Therefore, we can write:

$U' = 1.21U$

Substituting the expressions for U and U', we get:

$\frac{(Q+2)^2}{2C} = 1.21 \cdot \frac{Q^2}{2C}$

Since C is a common factor in the numerator and denominator, it cancels out. Hence, we can simplify to:

$(Q + 2)^2 = 1.21Q^2$

Expanding and rearranging the equation, we obtain:

$Q^2 + 4Q + 4 = 1.21Q^2$

$0.21Q^2 - 4Q - 4 = 0$

Solving this quadratic equation using the quadratic formula, where $a = 0.21$, $b = -4$, and $c = -4$, we get:

$Q = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Substitute the values of a, b, and c:

$Q = \frac{4 \pm \sqrt{(-4)^2 - 4 \cdot 0.21 \cdot (-4)}}{2 \cdot 0.21}$

$Q = \frac{4 \pm \sqrt{16 + 3.36}}{0.42}$

$Q = \frac{4 \pm \sqrt{19.36}}{0.42}$

$Q = \frac{4 \pm 4.4}{0.42}$

Therefore, we have two possible solutions for Q:

$Q = \frac{4+4.4}{0.42} = 20$

$Q = \frac{4-4.4}{0.42} = -0.95\ (not\ practical)$

Since a negative charge is not practical in this context, the original charge on the capacitor is:

Option C: 20 C

Question82

When the battery across the plates of a charged condenser is disconnected and a dielectric slab is introduced between its plates then the energy stored

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Options:

A. becomes infinity

B. does not change

C. increases

D. decreases

Answer: D

Solution:

To understand what happens to the energy stored in a charged capacitor when a dielectric slab is introduced between its plates (after disconnecting the battery), let's break down the concepts involved.

A capacitor stores energy in the electric field between its plates. The energy stored in a capacitor is given by the formula:

$U = \frac{1}{2} \frac{Q^2}{C}$

where:

- **U** is the energy stored.
- **Q** is the charge on the capacitor.
- **C** is the capacitance of the capacitor.

The capacitance of a capacitor is given by:

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

where:

- ε_0 is the permittivity of free space.
- **A** is the area of the plates.
- **d** is the distance between the plates.

When a dielectric slab with dielectric constant **κ** is introduced between the plates, the new capacitance **C'** becomes:

$C' = \kappa C$

Since the battery is disconnected, the charge **Q** on the capacitor remains constant. Let's understand the impact of the increased capacitance (due to the dielectric slab) on the stored energy.

The new energy stored **U'** can be expressed as:

$U' = \frac{1}{2}\frac{Q^2}{C'}$

Substituting $C' = \kappa C$, we get:

$U' = \frac{1}{2}\frac{Q^2}{\kappa C}$

This equation shows that:

$U' = \frac{U}{\kappa}$

We know that $\kappa > 1$, therefore:

$U' < U$

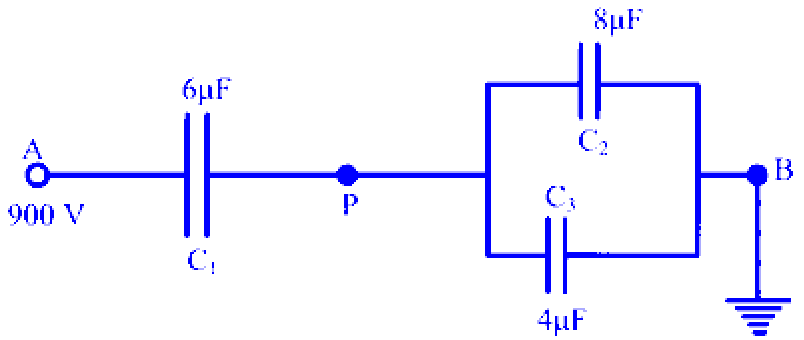
This indicates that the energy stored in the capacitor decreases when a dielectric slab is introduced between its plates (after disconnecting the battery).

So, the correct answer is:

Option D: decreases

Question83

In the given figure potential at point 'A' is 900 volt and point 'B' is earthed. What will be the potential at point 'P' ?



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Options:

A. 900 V

B. 100 V

C. 300 V

D. 600 V

Answer: C

Solution:

Capacitors C_2 and C_3 are in parallel. Hence their equivalent capacitance

$C_4 = C_2 + C_3 = 8 + 4 = 12\mu F$

C_4 and C_1 are in series.

Their equivalent capacitance $C = \frac{12 \times 6}{12+6} = \frac{72}{18} = 4\mu F$

Charge stored by the combination

$q = CV = 4 \times 900$

$= 3600\mu C$

In the series combination, change in same on each capacitor.

$\therefore$ Charge on $C_1 = 3600\mu C$

$P, D,$ across C_1 is $V_1 = \frac{q}{C_1} = \frac{3600}{6} = 600$ V

$\therefore V_A - V_P = 600 \quad \therefore 900 - V_P = 600$

$\therefore V_P = 300V$

Question84

Two identical parallel plate air capacitors are connected in series to a battery of emf 'V'. If one of the capacitor is inserted in liquid of dielectric constant 'K' then, potential difference of the other capacitor will become

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Options:

A. $\frac{\mathrm{K}-1}{\mathrm{KV}}$

B. $\frac{\mathrm{K}+1}{\mathrm{KV}}$

C. $\left(\frac{\mathrm{KV}}{\mathrm{K}+1}\right)$

D. $\frac{\mathrm{KV}}{\mathrm{K}-1}$

Answer: C

Solution:

Let the capacitance of capacitors are C initially.

So, afterward $\mathrm{C}_1=\mathrm{kC}$ and $\mathrm{C}_2=\mathrm{C}$

p.d. across capacitor C_2 is

$V_2=\frac{C_2 V}{C_1+C_2}=\frac{k C V}{C+k C}=\frac{k V}{k+1}$

Question85

A condenser of capacity 'C_1' is charged to potential 'V_1' and then disconnected. Uncharged capacitor of capacity 'C_2' is connected in parallel with 'C_1'. The resultant potential 'V_2' is

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Options:

A. $\frac{V_1 C_2}{C_1}$

B. $\frac{\mathrm{C}_2}{\mathrm{C}_1+\mathrm{C}_2}$

C. $\frac{C_1 V_1}{C_2}$

D. $\frac{C_1 V_1}{C_1+C_2}$

Answer: D

Solution:

The charge stored by the charged condenser is

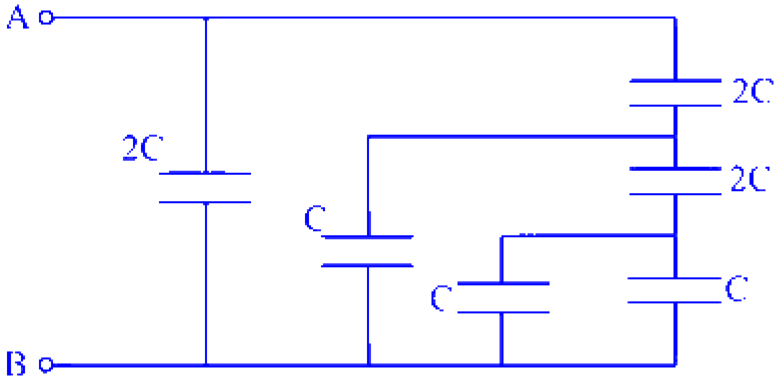
$\mathrm{Q}=\mathrm{C}_1 \mathrm{~V}_1$

When the uncharged condenser is connected in parallel, the effective capacitance becomes $\left(C_1+C_2\right)$

Hence the potential $V_2=\frac{Q}{C_1+C_2}=\frac{C_1 V_1}{C_1+C_2}$

Question86

The resultant capacity between points A and B in the given circuit is



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Options:

A. C

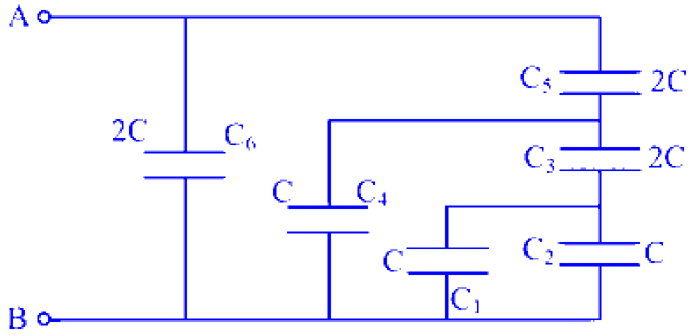
B. $\frac{C}{3}$

C. 3C

D. 2C

Answer: C

Solution:



C_1 and C_2 are in parallel

Their equivalent capacitance $\mathrm{C}_7=2\mathrm{C}$

C_7 and C_3 are in series

Their equivlanet capacitance is $\mathrm{C}_8=\mathrm{C}$

C_8 and C_4 are in parallel

Their equivalent capacitance is $\mathrm{C}_9=2\mathrm{C}$

C_9 and C_5 are in series. Their equivalent capacitance $\mathrm{C}_{10}=\mathrm{C}$

C_{10} and C_6 are in parallel. Their equivalent capacitance is 3C.

Hence equivalent capacitance between A and B is 3C.

Question87

An air filled parallel plate capacitor has a capacity $2\ \mathrm{pF}$. The sepeartion of the plates is doubled and the interspace between the plates is filled with dielectric material, then the capacity is increased to $6\ \mathrm{pF}$. The dielectric constant of the material is

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Options:

A. 3

B. 6

C. 2

D. 4

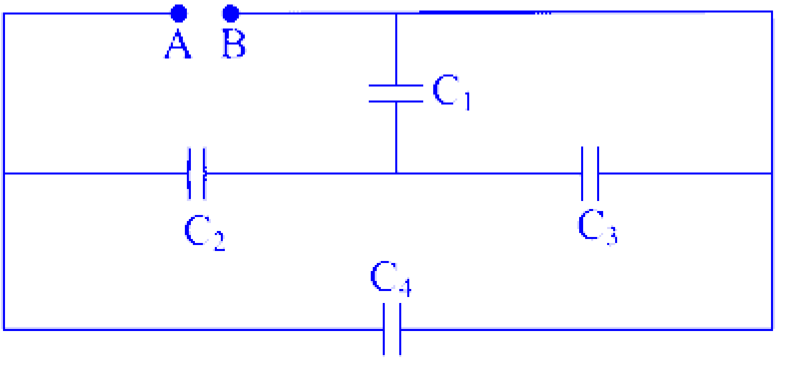
Answer: B

Solution:

$$C = \frac{KA\varepsilon_0}{d}$$
$$\therefore \frac{C_2}{C_1} = \frac{k_2}{k_1} \cdot \frac{d_1}{d_2}$$
$$\therefore \frac{6}{2} = \frac{k_2}{1} \cdot \frac{1}{2}$$
$$\therefore k_2 = 6$$

Question88

In the arrangement of the capacitors as shown in figure, each capacitor is of 6 μF, then equivalent capacity between points A and B is



Options:

A. 12 μF

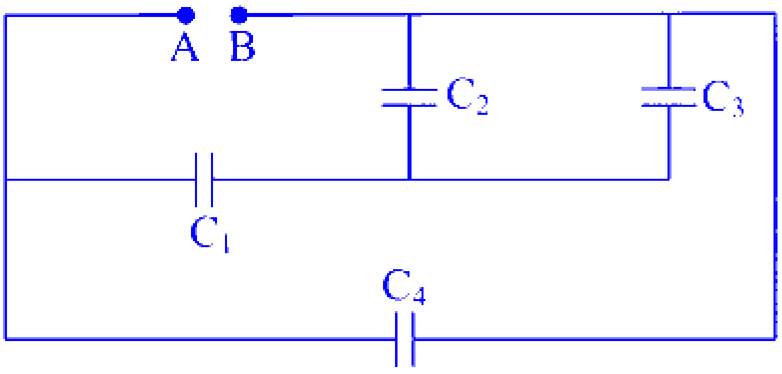
B. 6 μF

C. 4 μF

D. 10 μF

Answer: D

Solution:



$C_1 = C_2 = C_3 = C_4 = 6\ \mu F$

C_2 and C_3 are in parallel.

Hence their equivalent capacitance, $C_5 = 2 \times 6 = 12\ \mu F$

C_5 and C_1 in series.

Hence their equivalent capacitance C_6 is given by

$\frac{1}{C_6} = \frac{1}{12} + \frac{1}{6} = \frac{3}{12} = \frac{1}{4}$

$\therefore C_6 = 4\ \mu F$

C_6 and C_4 are in parallel.

Hence their equivalent capacitance is $C = 4 + 6 = 10\ \mu F$

Question89

A parallel plate air capacitor is charged upto 100 V. A plate 2 mm thick is inserted between the plates. Then to maintain the same potential difference, the distance between the plates is increased by 1.6 mm. The dielectric constant of the thick plate is

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Options:

A. 4

B. 5

C. 2

D. 3

Answer: B

Solution:

If d is the initial distance between the plates then capacitance is given by $\mathrm{C}=\frac{\mathrm{kA} \in_0}{\mathrm{~d}}$

When a plate of thickness t = 2 mm is inserted between the plates the capacitance,

$C_1=\frac{k A \in_0}{\left(d-t+\frac{t}{k}\right)}$

If distance between the plates is increased by $\mathrm{x}=1.6 \mathrm{~mm}$

Capacitance becomes, $C_2=\frac{\mathrm{kA} \in_0}{\left(d+x-t+\frac{t}{k}\right)}$ But $C_2=C$

$$\begin{aligned}
& \therefore \mathrm{d}+\mathrm{x}-\mathrm{t}+\frac{\mathrm{t}}{\mathrm{k}}=\mathrm{d} \\
& \therefore \mathrm{t}-\mathrm{x}=\frac{\mathrm{t}}{\mathrm{k}} \\
& \therefore 2-1.6=\frac{2}{\mathrm{k}} \\
& \therefore 0.4=\frac{2}{\mathrm{k}} \quad \therefore \mathrm{k}=5
\end{aligned}$$

Question90

A parallel plate capacitor filled with oil of a dielectric constant 3 between the plates has capacitance 'C'. If the oil is removed, then the capacitance of the capacitor will be

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Options:

A. $\frac{C}{\sqrt{3}}$

B. 3C

C. $\sqrt{3}C$

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

Answer: D

Solution:

✅ Correct Answer: D. $\frac{C}{3}$

✔ **Explanation**

A parallel-plate capacitor completely filled with a dielectric of dielectric constant $K = 3$ has capacitance:

$$C = KC_0$$

Where C_0 is the capacitance **without** dielectric.

Given:

$$C = 3C_0$$

We are asked to find the capacitance **after the oil (dielectric) is removed**, which means the capacitor returns to its original value:

$$C_0 = \frac{C}{3}$$

Hence:

✔ **New capacitance** = $\frac{C}{3}$

Question91

Two capacitors of capacities 2μ F and 4μ F are connected in parallel. A third capacitor of 6μ F capacity is connected in series with this combination. A battery of 12 V is connected across this combination. The charge on 2μ F capacitor is

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Options:

A. 12μC

B. 11μC

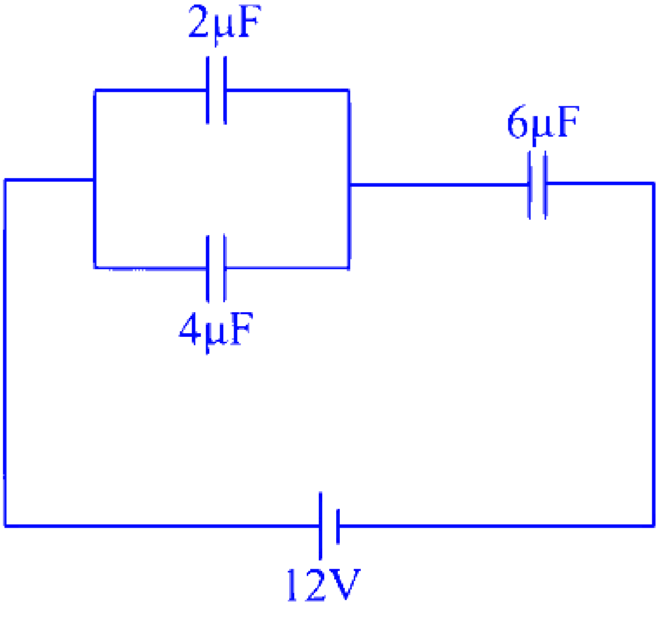
C. 14μC

D. 16μC

Answer: A

Solution:

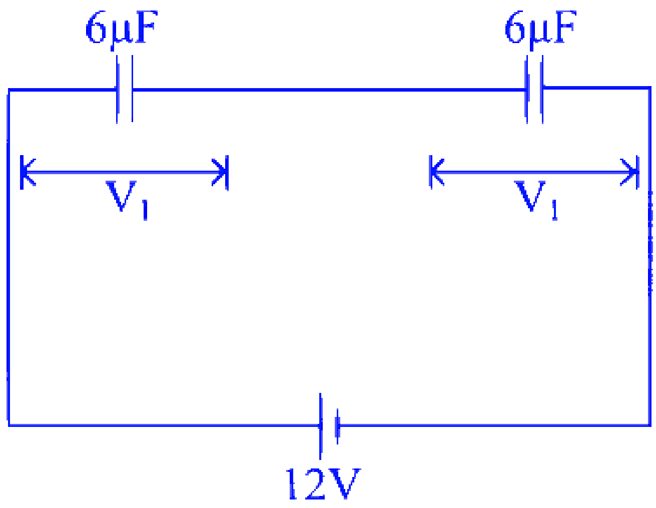
The circuit diagram of given situation is as shown below



The equivalent capacitance of 2μ F and 4μ F capacitors connected in parallel is

$C_{\text{eq}} \quad = 2+4=6 \mu \mathrm{~F}$

The circuit now becomes



As, both the capacitors are of same capacitance, so potential of 12 V is equally divided in themi.e.

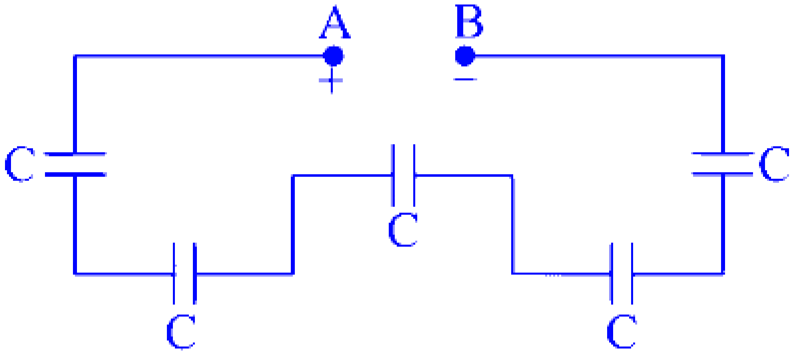
$V_1=V_2=6 \mathrm{~V}$

In parallel combination, potential remains same.

$\therefore$ Charge on $2 \mu \mathrm{~F}, Q=2 \times V_1=2 \times 6=12 \mu \mathrm{C}$

Question92

Five capacitors each of capacity C are connected as shown in figure. If their resultant capacity is $2 \mu \mathrm{F}$, then the capacity of each condenser is



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Options:

A. 5 μF

B. 2 μF

C. 2.5 μF

D. 10 μF

Answer: D

Solution:

Given that the resultant capacitance $C_{\text{eq}} = 2\,\mu\text{F}$:

The capacitors are connected in series. Therefore, the formula for the equivalent capacitance of capacitors in series is:

$\frac{1}{C_{\text{eq}}} = \frac{1}{C} + \frac{1}{C} + \frac{1}{C} + \frac{1}{C} + \frac{1}{C}$

This simplifies to:

$\frac{1}{C_{\text{eq}}} = \frac{5}{C}$

Substitute the given equivalent capacitance:

$\frac{1}{2\,\mu\text{F}} = \frac{5}{C}$

Solving for C:

$C = 10\,\mu\text{F}$

Therefore, each capacitor has a capacitance of $10\,\mu\text{F}$.

Question93

The capacitance of a parallel plate capacitor with air as medium is 3μF. With the introduction of a dielectric medium between the plates, the capacitance becomes 15μF. The permittivity of the medium in SI unit is $[\varepsilon_0 = 8.85 \times 10^{-12}$SI unit]

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Options:

A. 8.845×10^{-11}

B. 0.4425×10^{-10}

C. 15

D. 5

Answer: B

Solution:

The capacitance of a parallel plate capacitor with air is

$C = \frac{\varepsilon_0 A}{d}$ .... (i)

where, $\varepsilon_0 =$ permittivity of free space or air. The capacitance with a dielectric medium between the plates is

$C' = \frac{\varepsilon_m A}{d}$ .... (ii)

where, $\varepsilon_m =$ permittivity of medium.

Here, $C' = 15\mu\text{F}, C = 3\mu\text{F}$

and $\varepsilon_0 = 8.85 \times 10^{-12}$ SI unit

From Eqs. (i) and (ii), we get

$$\begin{aligned}
\frac{C'}{C} &= \frac{\varepsilon_m A}{d} \times \frac{d}{\varepsilon_0 A} = \frac{\varepsilon_m}{\varepsilon_0} \\
\varepsilon_m &= \frac{\varepsilon_0 C'}{C} = \frac{8.85 \times 10^{-12} \times 15 \times 10^{-6}}{3 \times 10^{-6}} \\
&= 44.25 \times 10^{-12} \text{ SI unit} \\
&= 0.4425 \times 10^{-10} \text{ SI unit}
\end{aligned}$$

Question94

In a parallel plate air capacitor the distance between plates is reduced to one fourth and the space between them is filled with a dielectric medium of constant 2 . If the initial capacity of the capacitor is 4μ F. then its new capacity is

Options:

A. 32μ F

B. 18μ F

C. 8μ F

D. 44μ F

Answer: A

Solution:

The capacitance of a parallel plate air capacitor is given by

$C_0=\frac{\varepsilon_0 A}{d}$ .... (i)

where, $\varepsilon_0=$ permittivity of the medium,

$A=$ area of plates

and $d=$ distance between the plates

When the distance between plates is reduced and a dielectric slab is introduced, then the capacitance becomes

$C=\frac{K \varepsilon_0 A}{d_1}$ .... (ii)

Where, $K=$ dielectric constant of medium.

Here, $K=2, d_1=\frac{d}{4}$ and $C_0=4 \mu \mathrm{~F}=4 \times 10^{-6} \mathrm{~F}$

From Eq. (ii), we get

$$
\begin{aligned}
C & =4\left(\frac{K \varepsilon_0 A}{d_1}\right)=4 K\left(\frac{\varepsilon_0 A}{d}\right) \\
& =4 K C_0 \quad \text{.... (iii) [from Eq. (i)]}
\end{aligned}
$$

Substituting given values in Eq. (iii), we get

$C=4 \times 2 \times 4=32 \mu \mathrm{~F}$

Question95

Which of the following combinations of 7 identical capacitors each of 2μ F gives a resultant capacitance of $10 / 11 \mu$ F ?

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Options:

A. 3 in parallel and 4 in series

B. 2 in parallel and 5 in series

C. 4 in parallel and 3 in series

D. 5 in parallel and 2 in series

Answer: D

Solution:

For n capacitors i.e., $C_4, C_2, \ldots\ldots\ldots\ldots C_n$ their equivalent capacitance, when connected in

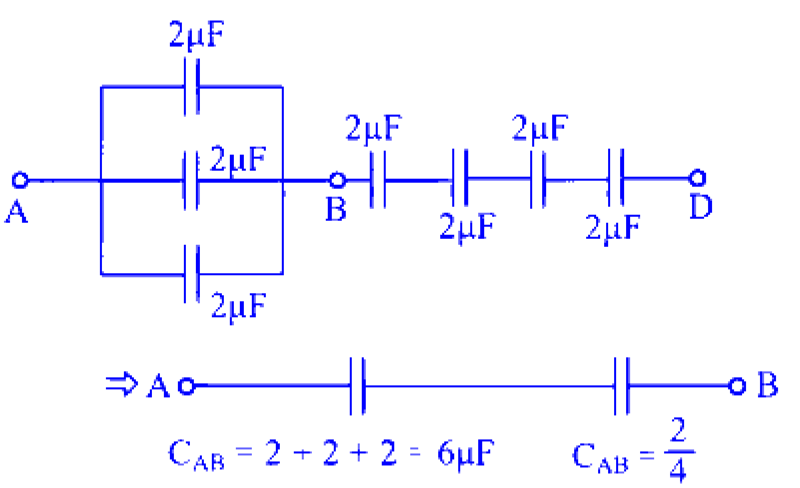
(a) series is given as, $\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots\ldots$

and

(b) parallel is given as, $C_p = C_1 + C_2 + \ldots\ldots\ldots$

In the given problem, we will check the net capacitance in each option and compare it with the desired capacitance mentioned in it.

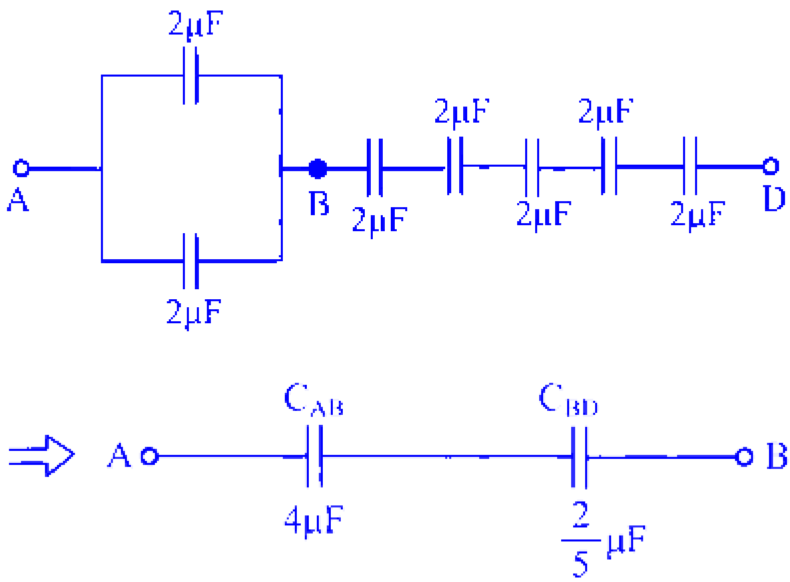
(a) 3 capacitors are in parallel and 4 capacitors are connect in series, i.e.,



where, C_{AB} is the equivalent capacitance of parallel branches between A and B and C_{BD} is equivalent capacitance of series capacitors between B and D. So, equivalent capacitance.

$$C_{\text{eq}} = \frac{C_{AB} \cdot C_{BD}}{C_{AB} + C_{BD}} = \frac{6 \times \frac{2}{4}}{6 + \frac{2}{4}} = \frac{6}{13} \mu \mathrm{~F}$$

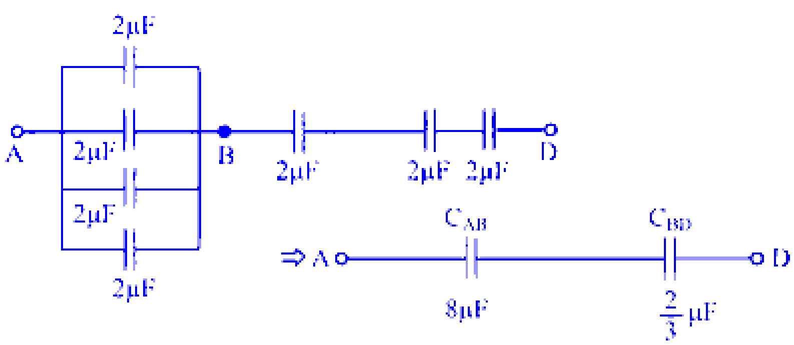
Similarly, (b) 2 capacitors are in parallel and 5 capacitors are connect in series i.e.,



So, equivalent capacitance,

$$C_{\text{eq}} = \frac{4 \times \frac{2}{5}}{4 + \frac{2}{5}} = \frac{4}{11} \mu \text{ F}$$

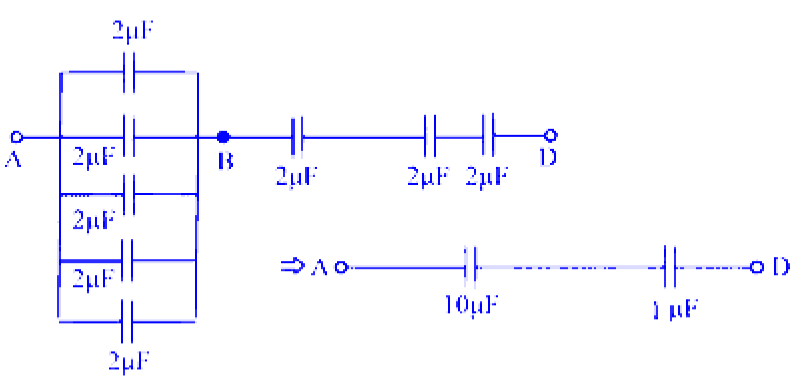
(c) 4 capacitors are in parallel and 3 capacitors are connect in series i.e.,



So, equivalent capacitance,

$$C_{\text{eq}} = \frac{8 \times \frac{2}{3}}{8 + \frac{2}{3}} = \frac{16}{26} = \frac{8}{13} \mu \text{ F}$$

(d) 5 capacitors are in parallel and 2 capacitors are connect in series i.e.,



So, equivalent capacitance,

$$C_{eq} = \frac{10 \times 1}{10 + 1} = \frac{10}{11} \mu \text{ F}$$

So, the correct option is (d).