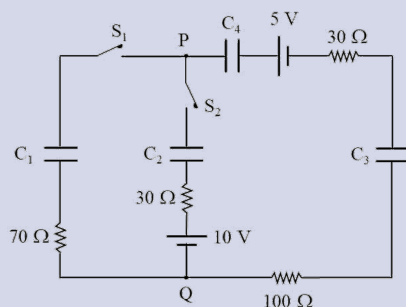


## JEE Advanced 2019 - Paper 1 - Physics 07

Senan

**Problem [ Multiple Choice Multiple Correct ]**

In the circuit shown, initially there is no charge on capacitors and keys  $S_1$  and  $S_2$  are open. The values of the capacitors are  $C_1 = 10\ \mu\text{F}$ ,  $C_2 = 30\ \mu\text{F}$  and  $C_3 = C_4 = 80\ \mu\text{F}$ . Which of the statement(s) is/are correct.



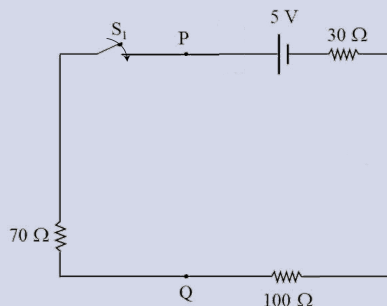
- (A) At time  $t = 0$ , the key  $S_1$  is closed, the instantaneous current in the closed circuit will be 25 mA.  
 (B) If key  $S_1$  is kept closed for long time such that capacitors are fully charged, the voltage across the capacitor  $C_1$  will be 4 V.  
 (C) The key  $S_1$  is kept closed for long time such that capacitors are fully charged. Now key  $S_2$  is closed, at this time, the instantaneous current across  $30\ \Omega$  resistor (between points  $P$  and  $Q$ ) will be 0.2 A (round off to 1<sup>st</sup> decimal place).  
 (D) If key  $S_1$  is kept closed for long time such that capacitors are fully charged, the voltage difference between point  $P$  and  $Q$  will be 10 V.

**What to Observe:**

- Initially, all capacitors are uncharged.
- Switches  $S_1$  and  $S_2$  are both open at the start.
- Capacitor values:
  - $C_1 = 10\ \mu\text{F}$
  - $C_2 = 30\ \mu\text{F}$
  - $C_3 = 80\ \mu\text{F}$
  - $C_4 = 80\ \mu\text{F}$

**My Approach:****Dissecting Option A****Thought**

Since the capacitors are initially uncharged, closing switch  $S_1$  allows current to flow without hindrance. The current can be calculated using Ohm's Law.

**Figure 1.** Circuit Diagram for Option A

Given:

- Voltage source:  $V = 5\ \text{V}$

- Resistors in series:  $R_{\text{eq}} = 30\ \Omega + 70\ \Omega + 100\ \Omega = 200\ \Omega$

Using Ohm's Law:

$$I = \frac{V}{R_{\text{eq}}} = \frac{5\text{ V}}{200\ \Omega} = 0.025\text{ A} = 25\text{ mA}$$

Therefore, **Option A is correct.**

### Dissecting Option B and D

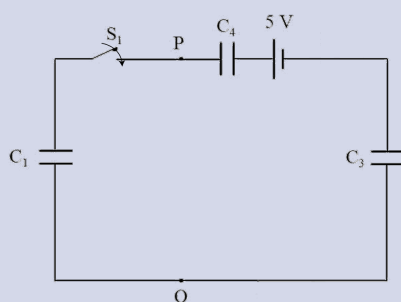
#### Thought

After closing switch  $S_1$  and waiting a long time, the capacitors reach a steady state where no current flows through them. In this state, the capacitor acts as an open circuit.

Capacitors  $C_1$ ,  $C_3$ , and  $C_4$  are connected in series, so they will all hold the same charge. We can replace them with an equivalent series capacitor.

The equivalent capacitance for capacitors in series is given by:

$$\frac{1}{C_{\text{eq}}} = \frac{1}{C_1} + \frac{1}{C_3} + \frac{1}{C_4}$$



**Figure 2.** Circuit Diagram for Option B and D

Given:

- $C_1 = 10\ \mu\text{F}$ ,  $C_3 = 80\ \mu\text{F}$ ,  $C_4 = 80\ \mu\text{F}$
- Voltage source:  $V = 5\text{ V}$

Calculating equivalent capacitance:

$$\begin{aligned} \frac{1}{C_{\text{eq}}} &= \frac{1}{10} + \frac{1}{80} + \frac{1}{80} = \frac{1}{10} + \frac{2}{80} = \frac{1}{10} + \frac{1}{40} = \frac{4+1}{40} = \frac{5}{40} \\ C_{\text{eq}} &= \frac{40}{5} = 8\ \mu\text{F} \end{aligned}$$

Charge on the equivalent capacitor:

$$Q = C_{\text{eq}} \cdot V = 8\ \mu\text{F} \cdot 5\text{ V} = 40\ \mu\text{C}$$

Since capacitors in series share the same charge,  $Q_{C_1} = 40\ \mu\text{C}$ .

Voltage across  $C_1$ :

$$V_{C_1} = \frac{Q}{C_1} = \frac{40\ \mu\text{C}}{10\ \mu\text{F}} = 4\text{ V}$$

Therefore, **Option B is correct.**

It is evident that the potential difference across points  $P$  and  $Q$  is equal to the voltage across capacitor  $C_1$  in Option D.

Therefore, **Option D is incorrect.**

### Dissecting Option C

#### Thought

Since switch  $S_1$  has been closed for a long time, the capacitors connected to it are fully charged. In this steady state, the capacitors behave like voltage sources, similar to the analysis in Option B.

Additionally, capacitor  $C_2$  is initially uncharged, and immediately after closing switch  $S_2$ , it does not affect the circuit. Therefore, it can be ignored in the initial analysis.

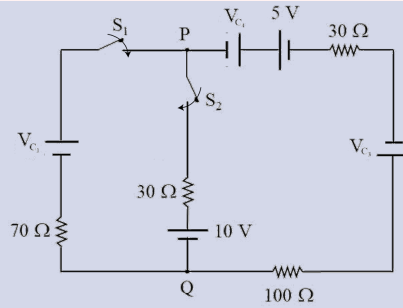


Figure 3. Circuit Diagram for Option C

We are given:

- $C_1 = 10 \mu\text{F}$ ,  $C_3 = 80 \mu\text{F}$ ,  $C_4 = 80 \mu\text{F}$
- Charge on each capacitor:  $Q = 40 \mu\text{C}$  (as calculated previously)

Using the formula  $V = \frac{Q}{C}$ , we compute:

$$V_{C_1} = \frac{40 \mu\text{C}}{10 \mu\text{F}} = 4 \text{ V}$$

$$V_{C_3} = \frac{40 \mu\text{C}}{80 \mu\text{F}} = 0.5 \text{ V}$$

$$V_{C_4} = \frac{40 \mu\text{C}}{80 \mu\text{F}} = 0.5 \text{ V}$$

Proceed by applying Kirchhoff's Voltage Law (KVL) to analyze the left and right loops:

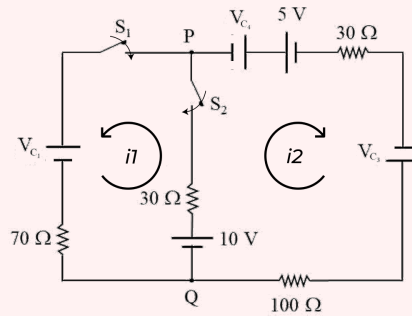


Figure 4. Circuit Diagram for KVL

Let the total current be (passing through  $30 \Omega$  resistor):

$$i = i_1 + i_2$$

**Applying KVL in the left loop (starting and ending at point Q):**

$$\Rightarrow 10 - 30(i_1 + i_2) - V_{C_1} - 70i_1 = 0$$

$$\Rightarrow 10 - 30(i_1 + i_2) - 4 - 70i_1 = 0$$

$$\Rightarrow 6 - 30(i_1 + i_2) - 70i_1 = 0$$

$$\Rightarrow 6 - 30i_1 - 30i_2 - 70i_1 = 0$$

$$\Rightarrow 6 - 100i_1 - 30i_2 = 0$$

(1)

**Applying KVL in the right loop (starting and ending at point Q):**

$$\Rightarrow 10 - 30(i_1 + i_2) + V_{C_4} - 5 + V_{C_3} - 100i_2 = 0$$

$$\Rightarrow 10 - 30(i_1 + i_2) + 0.5 - 5 + 0.5 - 100i_2 = 0$$

$$\Rightarrow 6 - 30(i_1 + i_2) - 100i_2 = 0$$

$$\Rightarrow 6 - 30i_1 - 30i_2 - 100i_2 = 0$$

$$\Rightarrow 6 - 30i_1 - 130i_2 = 0$$

(2)

Now solve equations (1) and (2) simultaneously:

$$(1) : 100i_1 + 30i_2 = 6$$

$$(2) : 30i_1 + 130i_2 = 6$$

We get:

$$i_1 = 0.04959 \text{ A}, \quad i_2 = 0.03471 \text{ A}$$

Therefore, the total current is:

$$i = i_1 + i_2 = 0.04959 + 0.03471 = 0.0843 \text{ A} = 84.3 \text{ mA}$$

Therefore, **Option C is incorrect.**

### Conclusion

Based on the detailed circuit analysis and calculated values:

Options A and B are correct.

Options C and D are incorrect, as their circuit behavior and resulting current or voltage values do not match the expected outcomes based on the given configurations.

### Support the Channel:

If you found this explanation helpful and it helped you think like a JEE Advanced ranker, consider supporting the channel!

- **Subscribe** to *The Bored IITian* for more such high-quality JEE problem breakdowns.
- **Share it with 3 friends** who have **never heard of the channel**. Help them level up too!
- Drop a comment or suggestion — your feedback helps improve future content.

*Note from Senan:* The way I solve and explain problems in this PDF is simply how I personally approach and think through JEE questions. This is **not** the only way to solve them. What I'm sharing here is my mindset and thought process — use it as inspiration, not as a prescription. Develop your own flow, but always stay curious and logical!

**YouTube Channel:** [youtube.com/@bored\\_iitian](https://youtube.com/@bored_iitian)