

PRAYAS

JEE 2025

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Lecture - 4

Physics

Capacitor

By- Saleem Ahmed Sir





Topics *to be covered*

1 Circuit Analysis & heat loss

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2

3

4

30w

31T

1F

2S

3S

4M

5T

6w

7T

8F

9S

10S

11M

→

→

→

→

→

→

→

→

Holiday

Holiday =

capacitor (Last)

Try = Holiday

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Semi Cond

moden

Logic Gate

Bohr model (next)

Nuclear physics

X-ray

2 hour

45

wave optics - 05

EMW

(3 hour)

(1:30 hour, 1:30 hour)

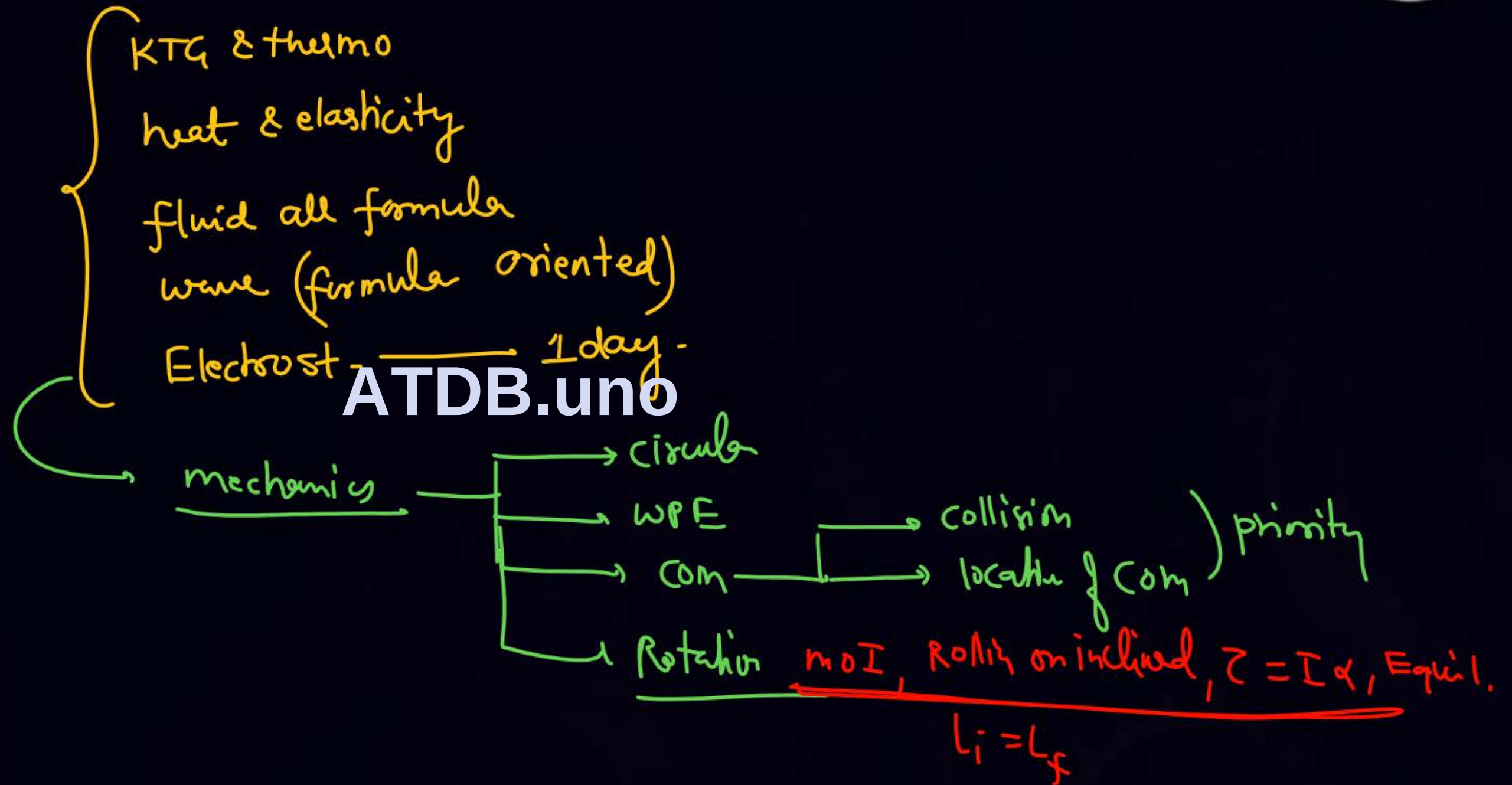
(2 hour 15 mint) + 45 mint

Next day No class

PW



Diwali H.w



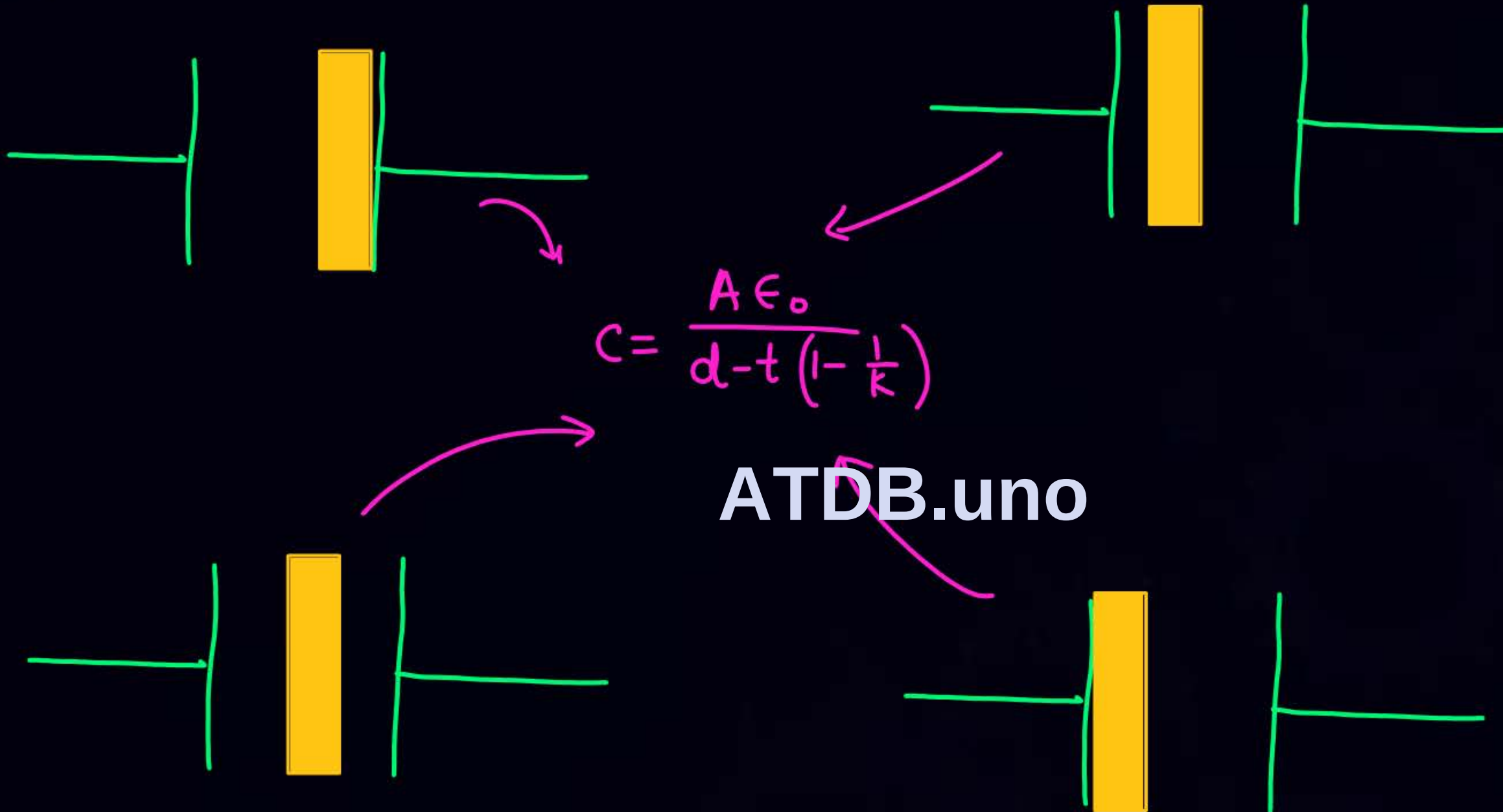


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$$C = \frac{AE_0}{d - t \left(1 - \frac{1}{k}\right)}$$



QUESTION

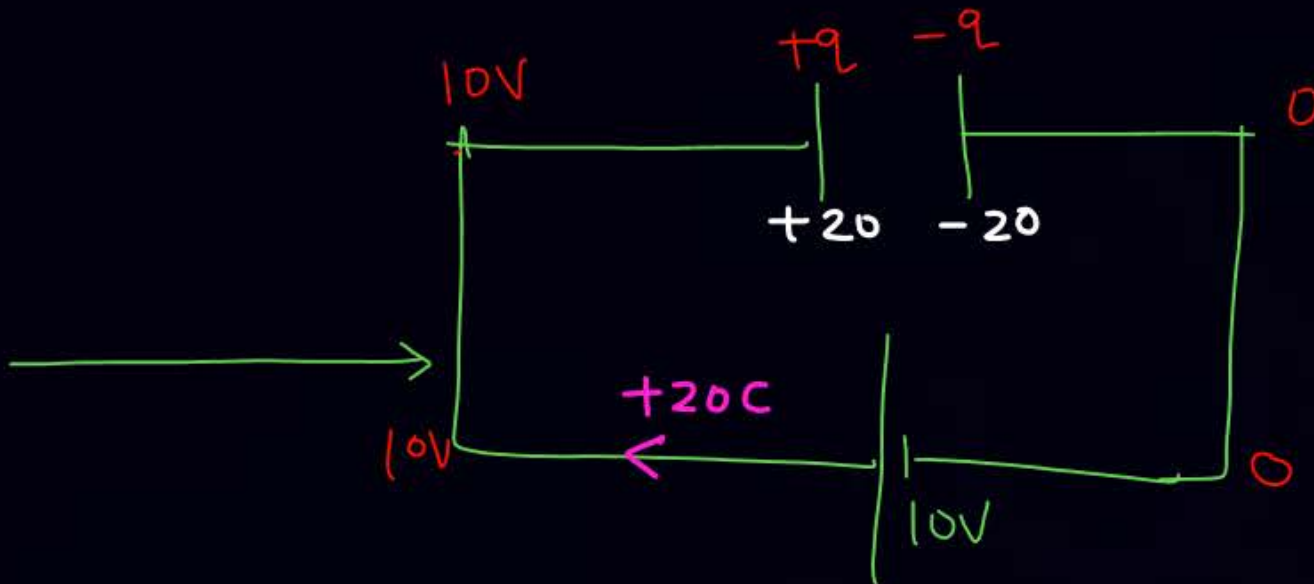
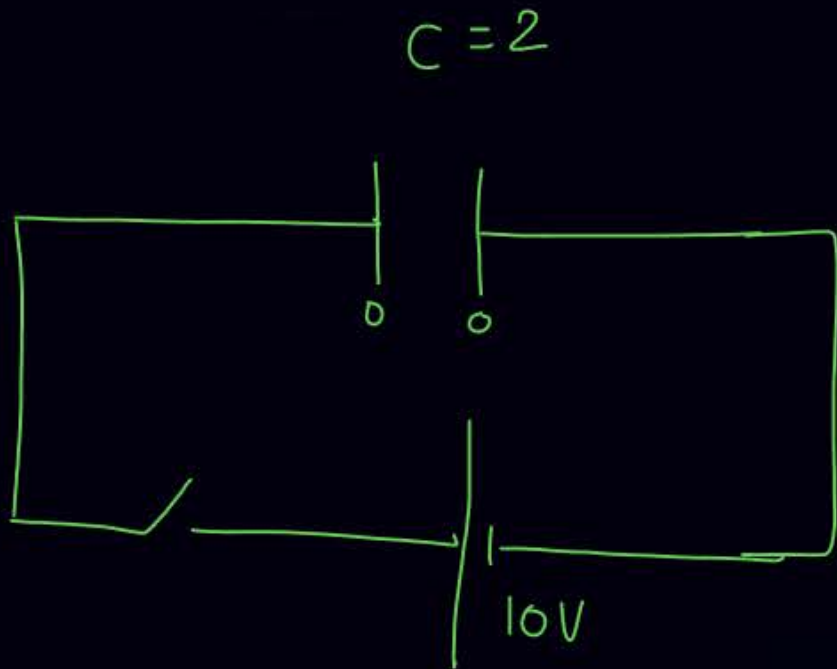


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Ques 1

(1)



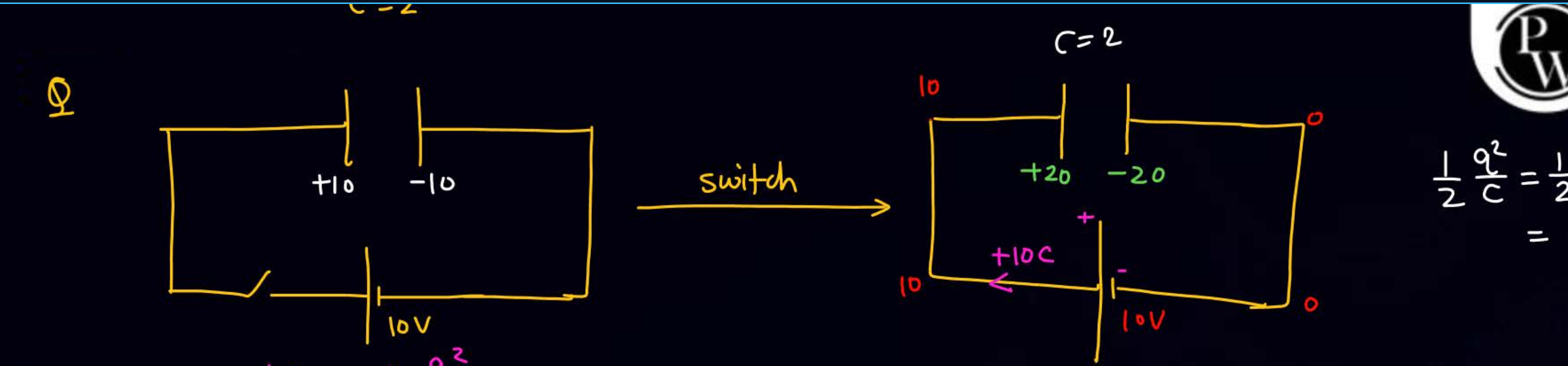
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(WD) $W_{\text{battery}} = 20 \times 10 = 200$

$U_f = \frac{1}{2} CV^2 = \frac{1}{2} \times 2 \times 10^2 = 100$

Heat loss = $200 - 100 = 100$

50%



$$U_i = \frac{1}{2} \frac{q_i^2}{C}$$

$$U_i = \frac{1}{2} \times \frac{(10)^2}{2} = 25$$

SSM

$$25 + 100 - 100 = \text{heat loss}$$

$$U_f = CV = 2 \times 10 = 20$$

(WD) by battery = $+10 \times 10 = +100$

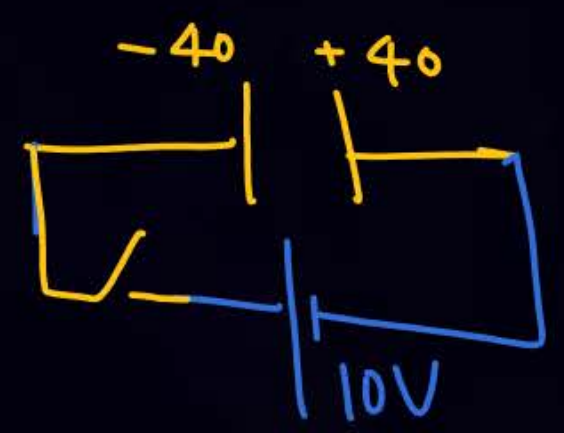
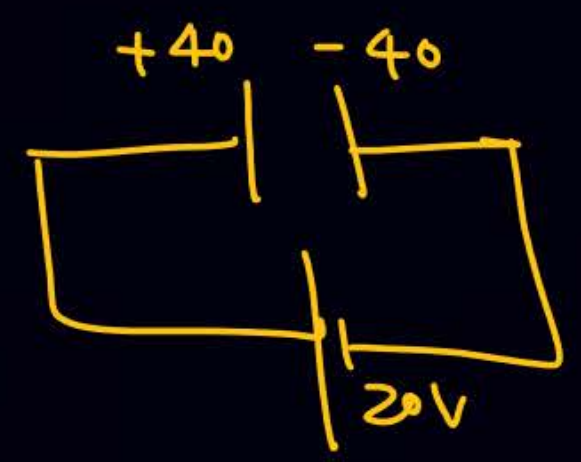
$$U_f = \frac{1}{2} CV^2 = \frac{1}{2} \times 2 \times 10^2 = 100$$

$$\frac{1}{2} \frac{q^2}{C} = \frac{1}{2} \times \frac{400}{2} = 100$$

Q Language

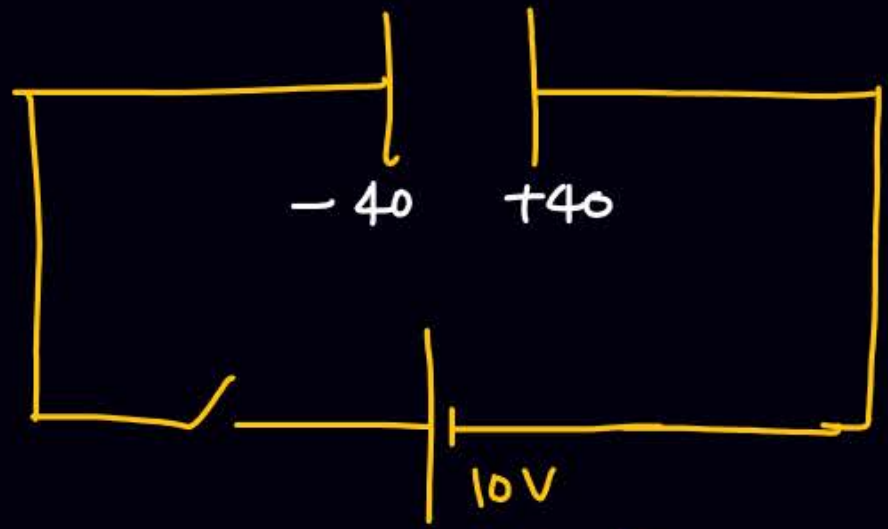


A capacitor of capacitance 2F is fully charge by a batter, of Emf 20 Volt .
Now battery is connected & another battery of $\text{emf } 10\text{V}$ is connected
such that negative plate of capacitor is connected to positive
terminal of 10V battery, find ① V_f ② WD by 10V batter
③ heat loss in second event

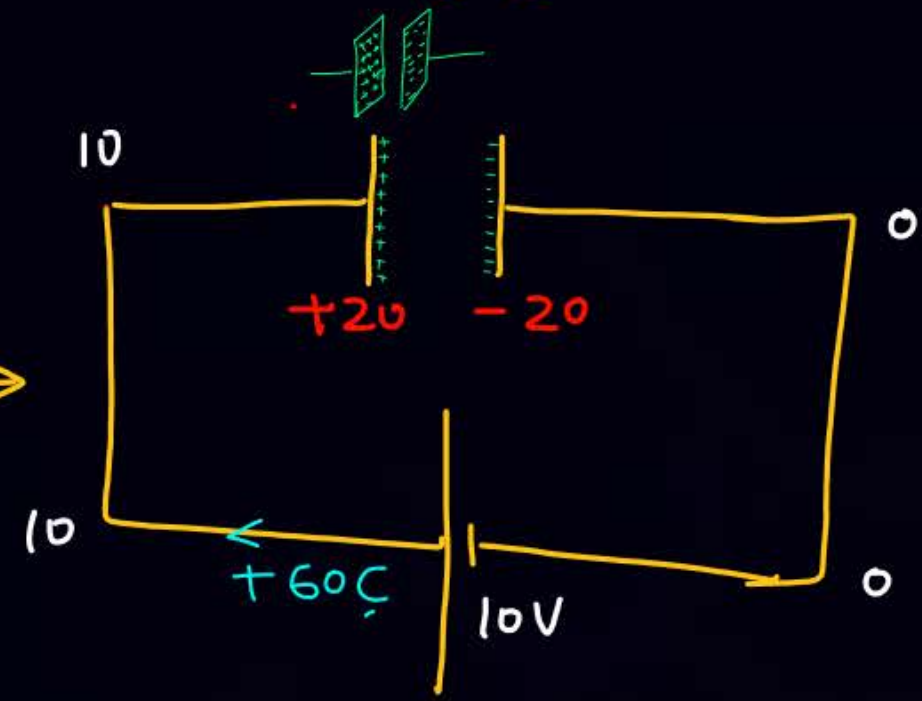




Q



switch



$$U_i = \frac{1}{2} \frac{(40)^2}{2} = 400$$

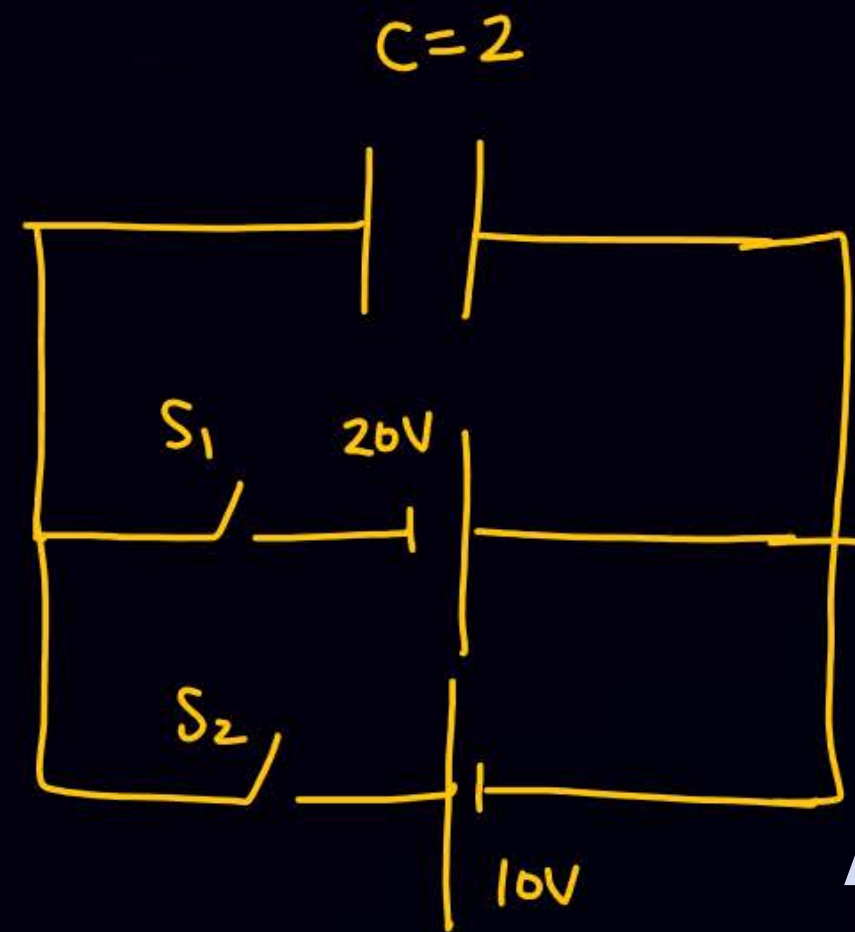
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$$q_f = 2 \times 10 = 20$$

(work) battery = + 60 \times 10 = + 600

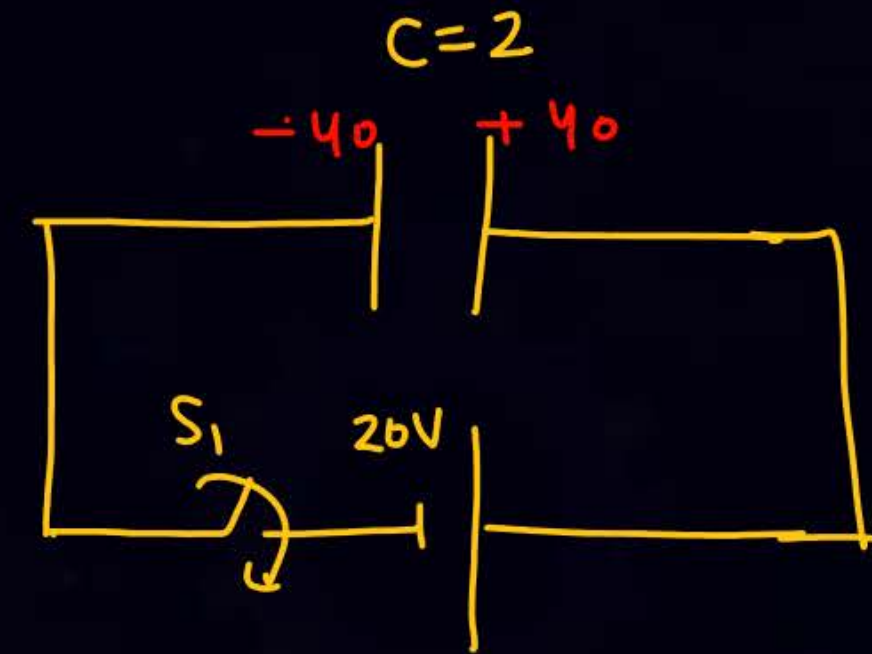
$$U_f = \frac{1}{2} C V^2 = \frac{1}{2} \times 2 \times 10^2 = 100$$

$$\text{heat loss} = 400 + 600 - 100$$



Initially S_1 is close & S_2 is open
& then $S_1 \rightarrow$ open $S_2 \rightarrow$ close

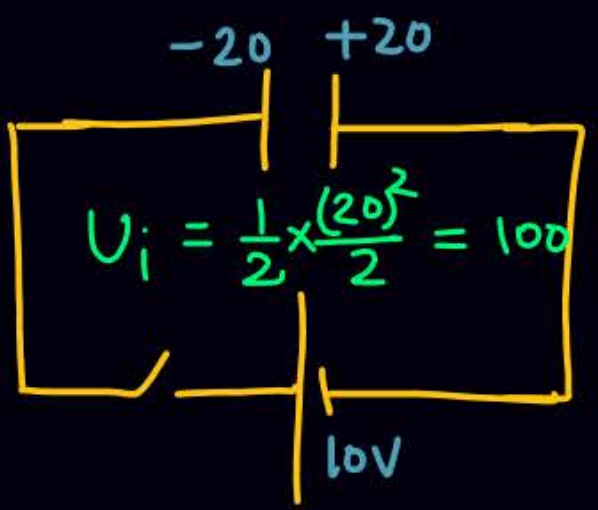
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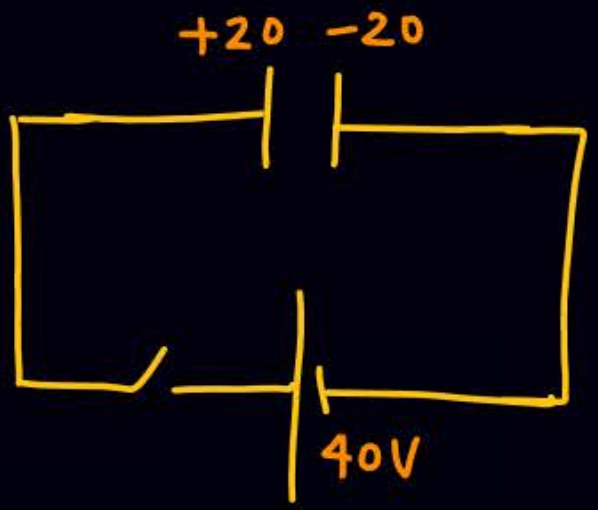


Q

C = 2



C = 2

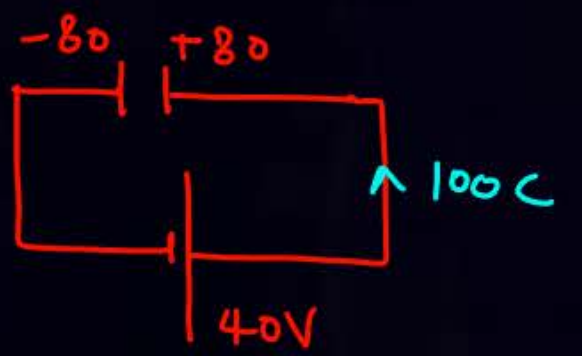
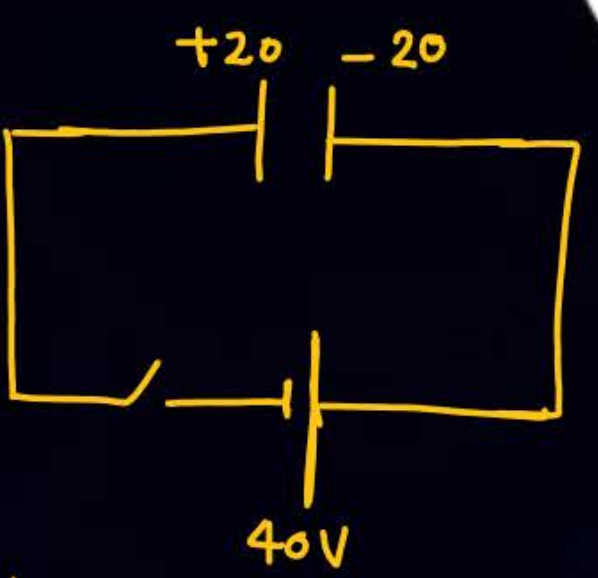


q_f = 80

(w)_{batt} = 60 \times 40 = 2400

heat loss = 100 + 2400 - \frac{1}{2} \frac{(80)^2}{2} = 900

C = 2

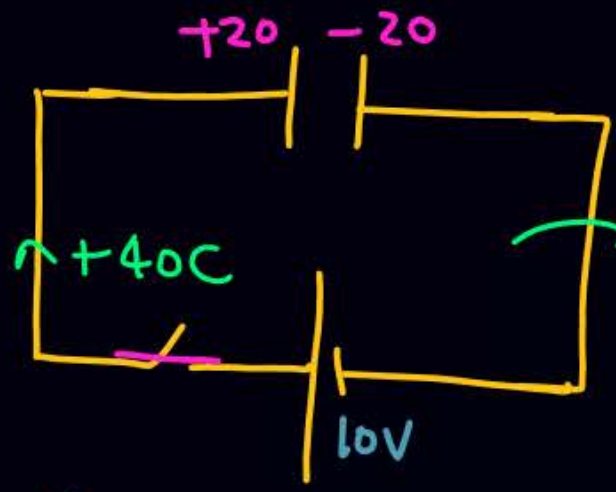


(w) = 4000

U_i = 100

U_f = \frac{1}{2} \times 2 \times (40)^2 = 1600

heat = 2500



U_f = \frac{1}{2} \frac{(20)^2}{2} = 100

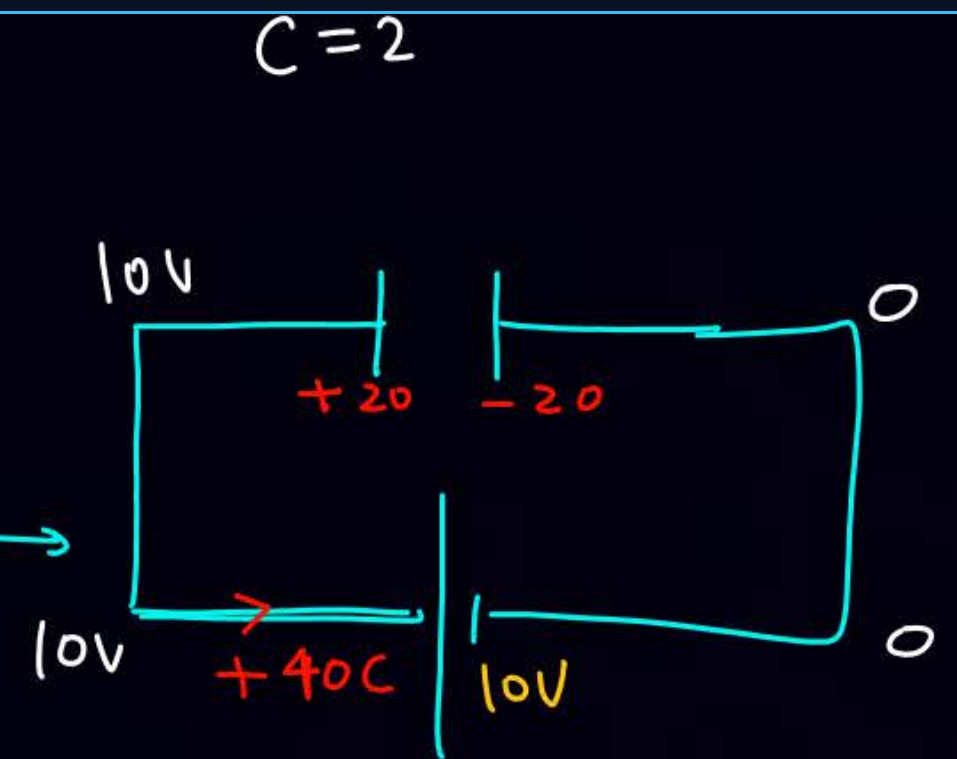
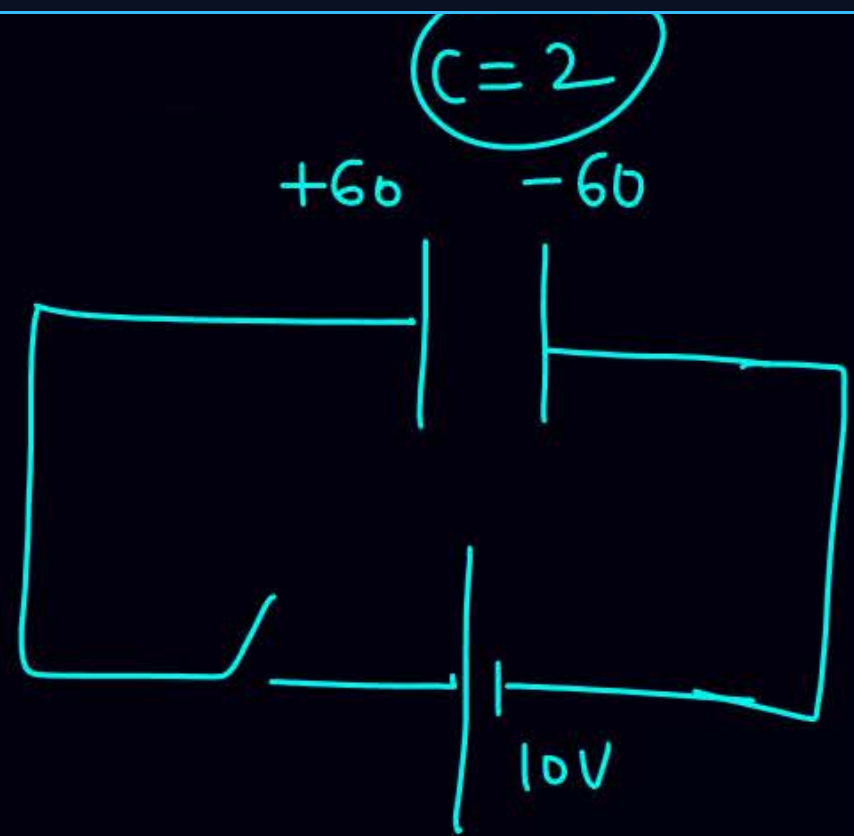
(w)_{batt} = +400

heat loss = 400



Ques

Q



$$q = CV$$
$$= 2 \times 10$$
$$= 20$$

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$$U_i = \frac{1}{2} \frac{(60)^2}{2} = 900$$

$$(wD)_{batt} = -40 \times 10 = -400$$

$$U_f = \frac{1}{2} \times 2 \times 10^2 = 100$$

$$\text{heat loss} = 900 - 400 - 100$$
$$= 400$$



heat loss $\rightarrow$ magnitude

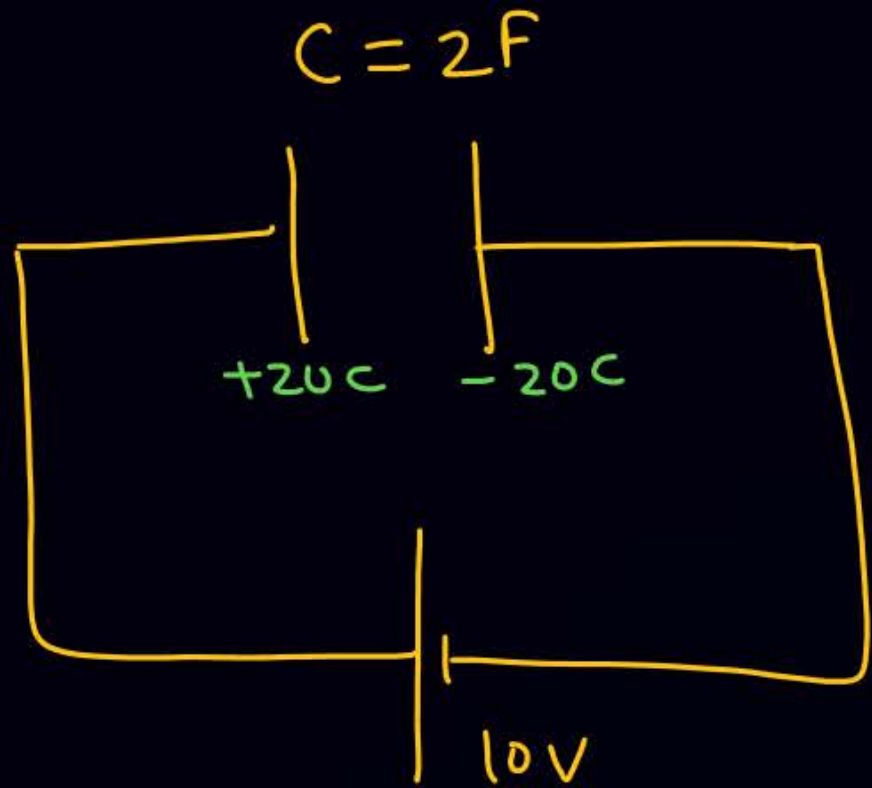
$$\text{heat loss} = U_i + (WD)_{\text{battery}} - U_f$$

$$= (WD)_{\text{battery}} - (U_f - U_i)$$

$$= (WD)_{\text{battery}} - \Delta U$$

$$\begin{aligned}\text{heat loss} &= (-400) - (100 - 900) \\ &= -400 + 800 = \boxed{400}\end{aligned}$$

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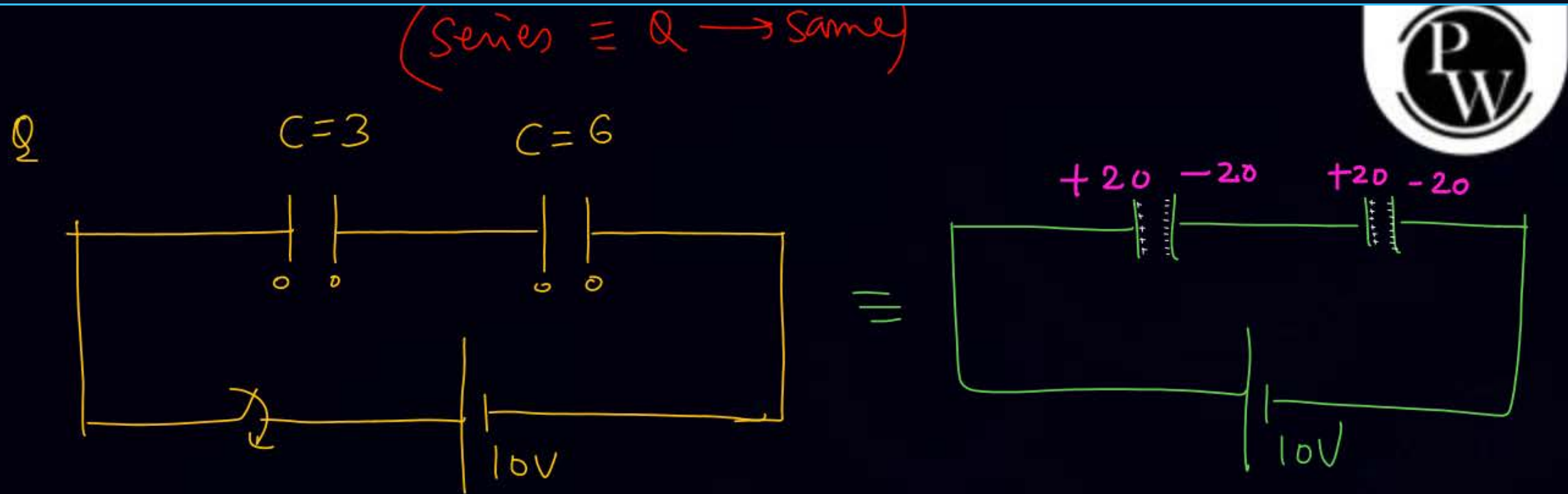
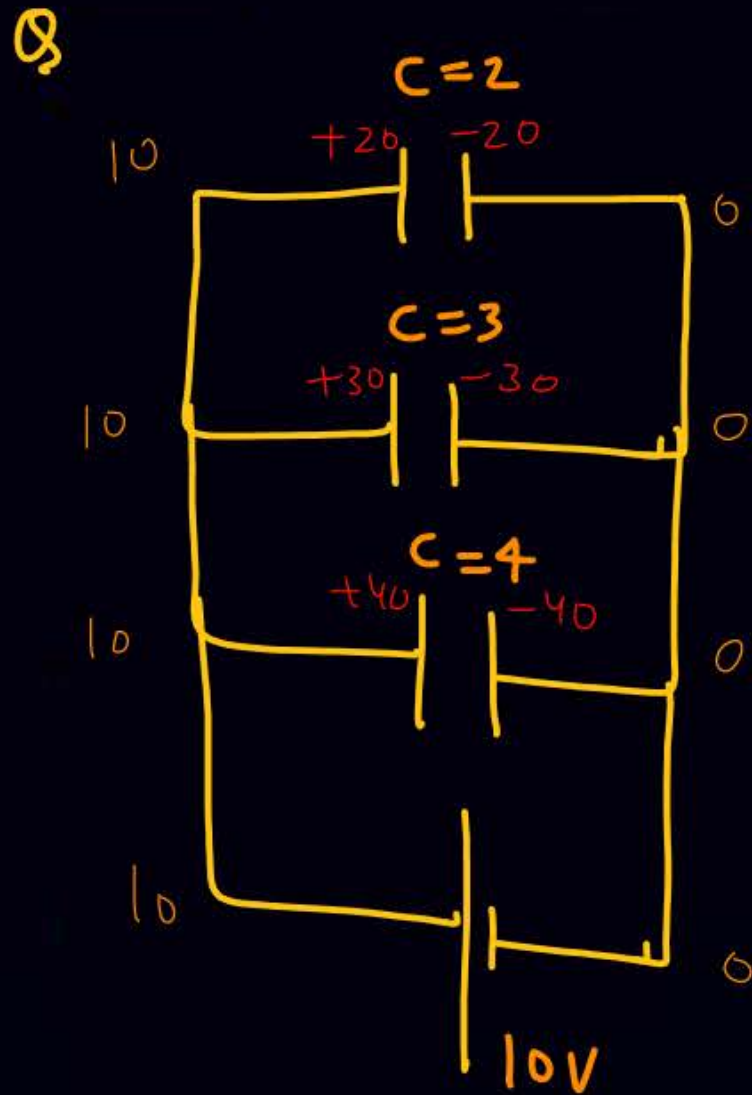
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$$Q = CV = 2 \times 10 = 20C$$

$$C = 2\mu F = 2 \times 10^{-6} F$$

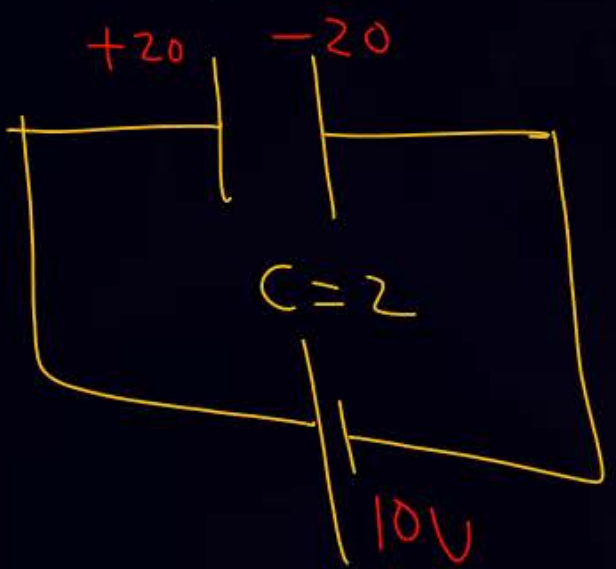


$$q = 2 \times 10^{-6} \times 10 = 20 \times 10^{-6} C$$
$$= 20\mu C$$



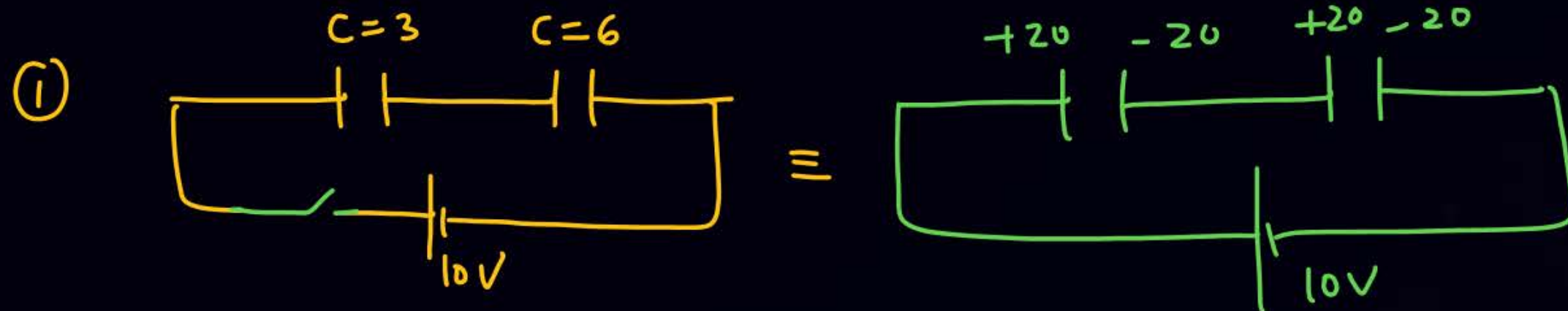
$C_{eq} = \frac{3 \times 6}{3 + 6} = 2$

$Q = C_{eq} V = 2 \times 10 = 20$



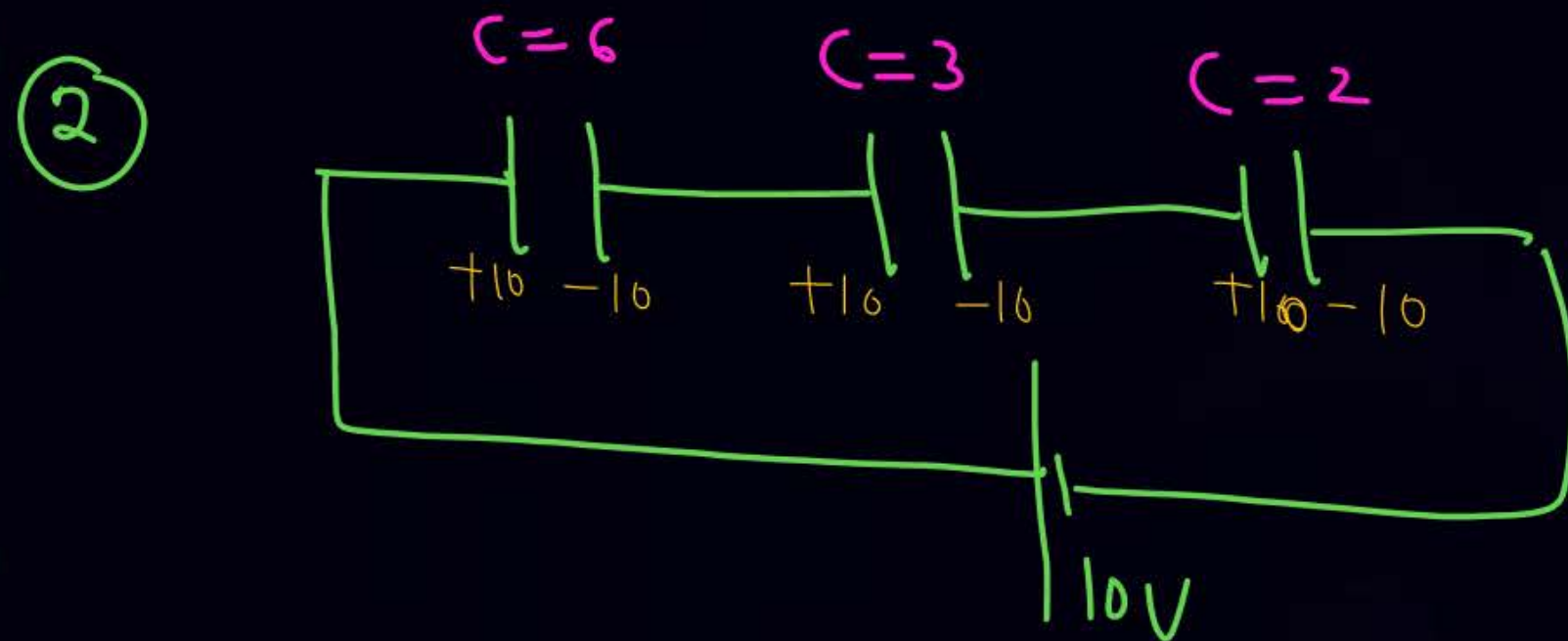


Q Initial charge on each cap. is zero



$$Q = C_{eq} V = 2 \times 10 = 20$$

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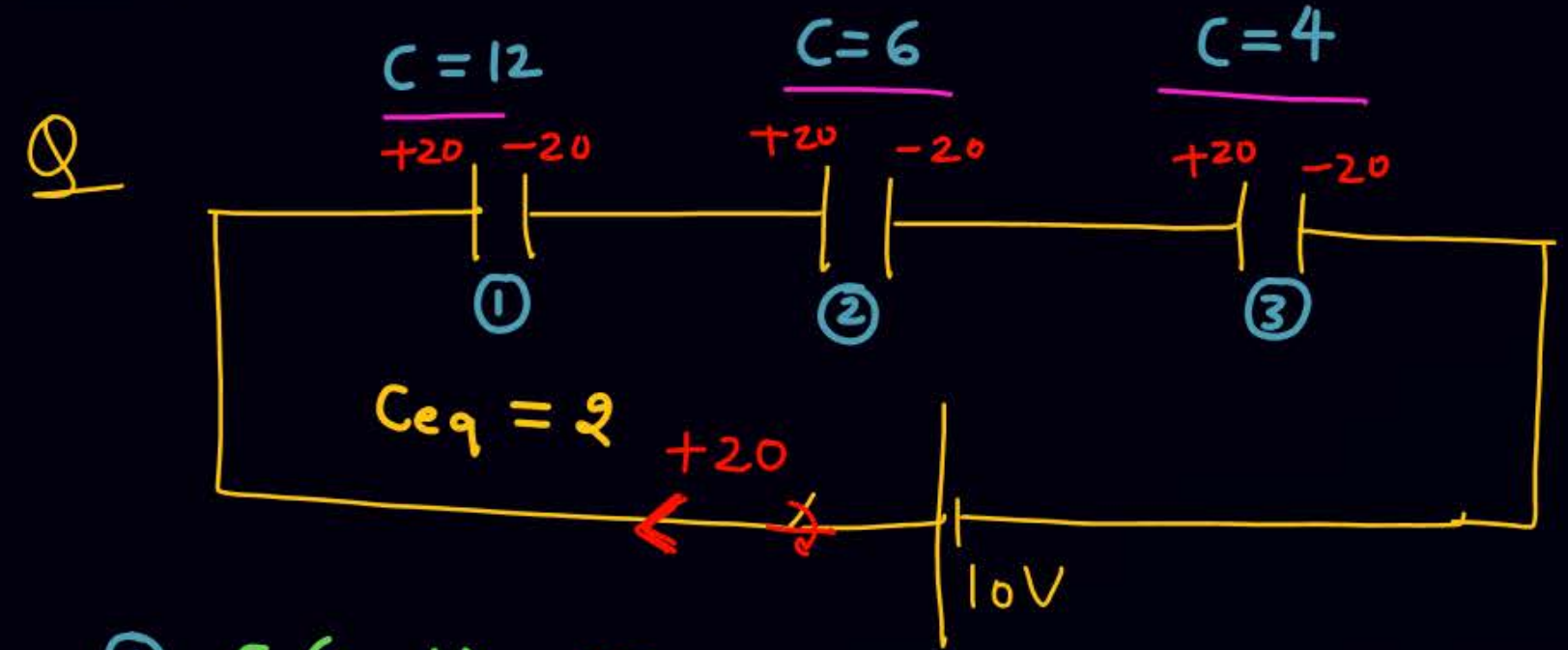


$$C_{eq} = 1$$

$$Q_{net} = C_{eq} V = 1 \times 10 = 10$$

Initially all cap. were uncharged

$$\frac{1}{C_{eq}} = \frac{1}{12} + \frac{1}{6} + \frac{1}{4} = \frac{1}{12} + \frac{2}{12} + \frac{3}{12} = \frac{6}{12} = \frac{1}{2}$$
$$C_{eq} = 2$$



④ pot. diff across $C_1 = \frac{q}{C_1} = \frac{20}{12}$

" " $C_2 = \frac{20}{6}$

" " $C_3 = \frac{20}{4}$

① $q(\text{each}) = 20$

② (wr) battery = $20 \times 10 = +200$

③ $U_1 = \frac{1}{2} \frac{(20)^2}{12}$

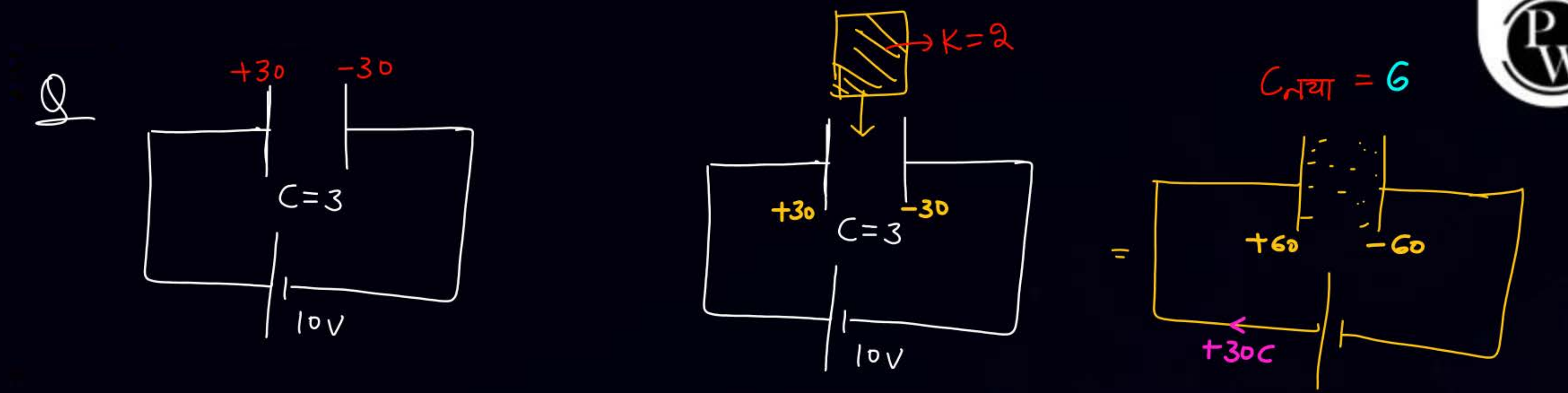
$U_2 = \frac{1}{2} \frac{(20)^2}{6}$

$U_3 = \frac{1}{2} \frac{(20)^2}{4}$

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⑤ heat loss = $(0 + 200) - (U_1 + U_2 + U_3)$

$U_f = \frac{1}{2} \frac{q^2}{C_{eq}} = \frac{1}{2} \times \frac{(20)^2}{2} = 100$

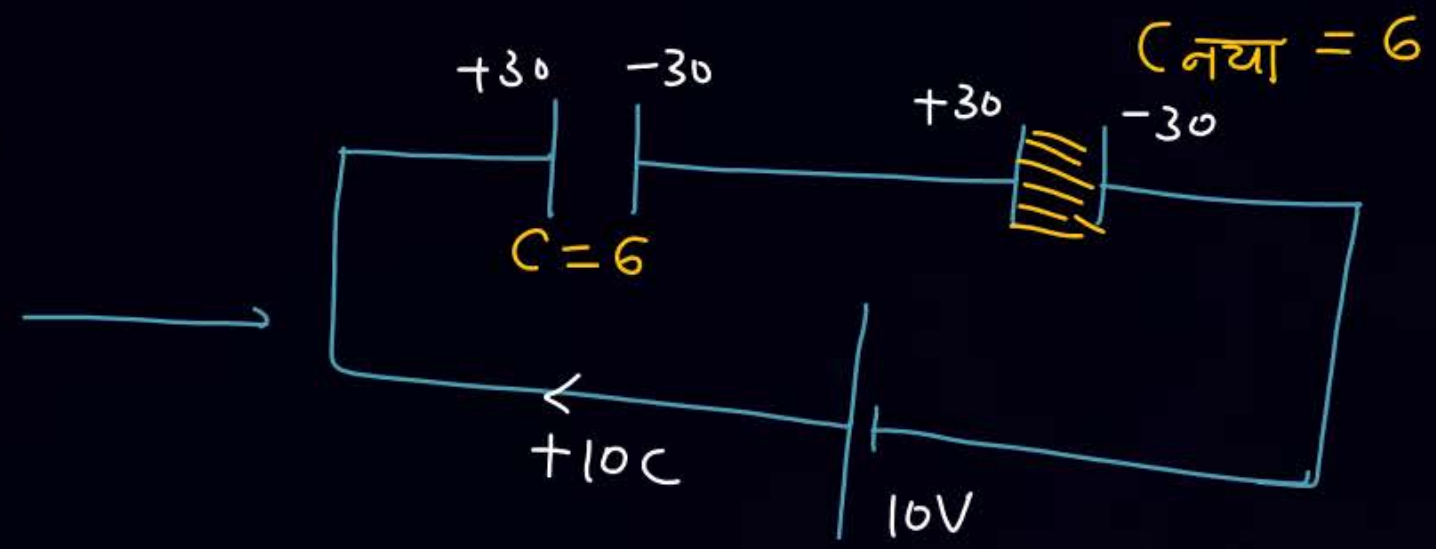
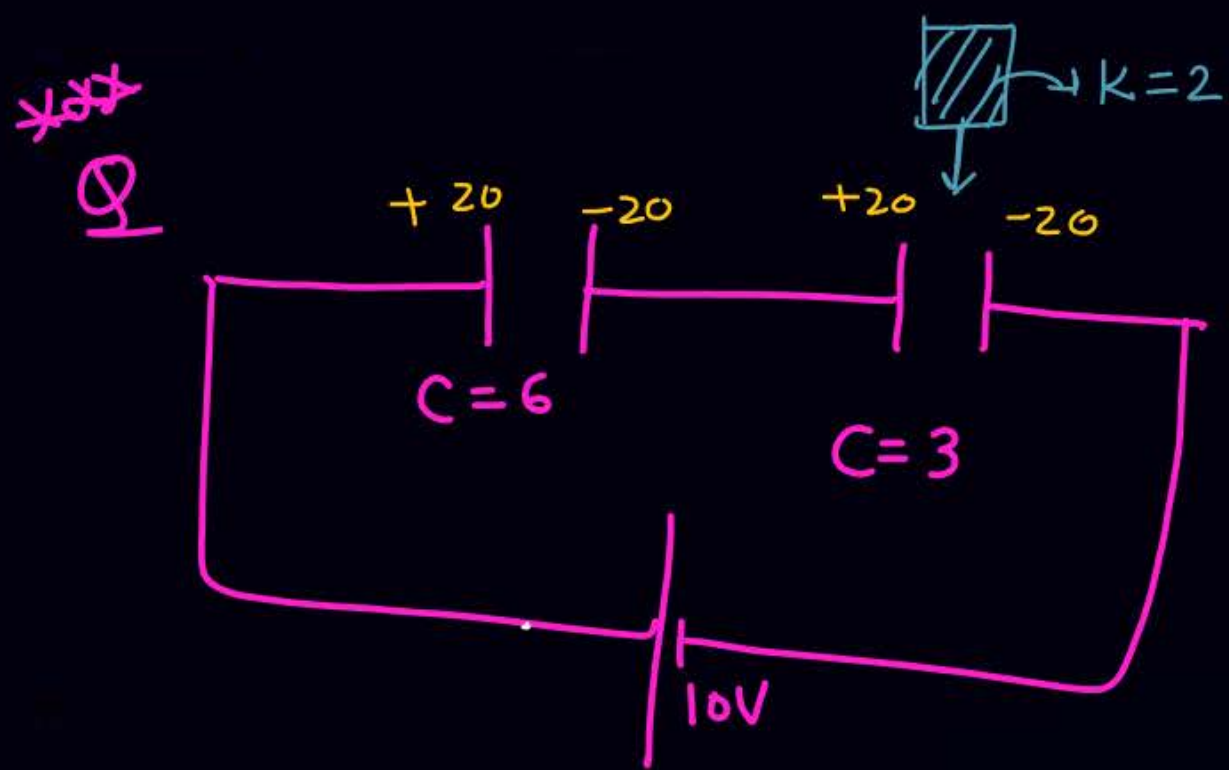


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$$C_{\text{नया}} = \frac{A\epsilon_0 K}{d} = KC$$

$$(w) = 10 \times 30$$

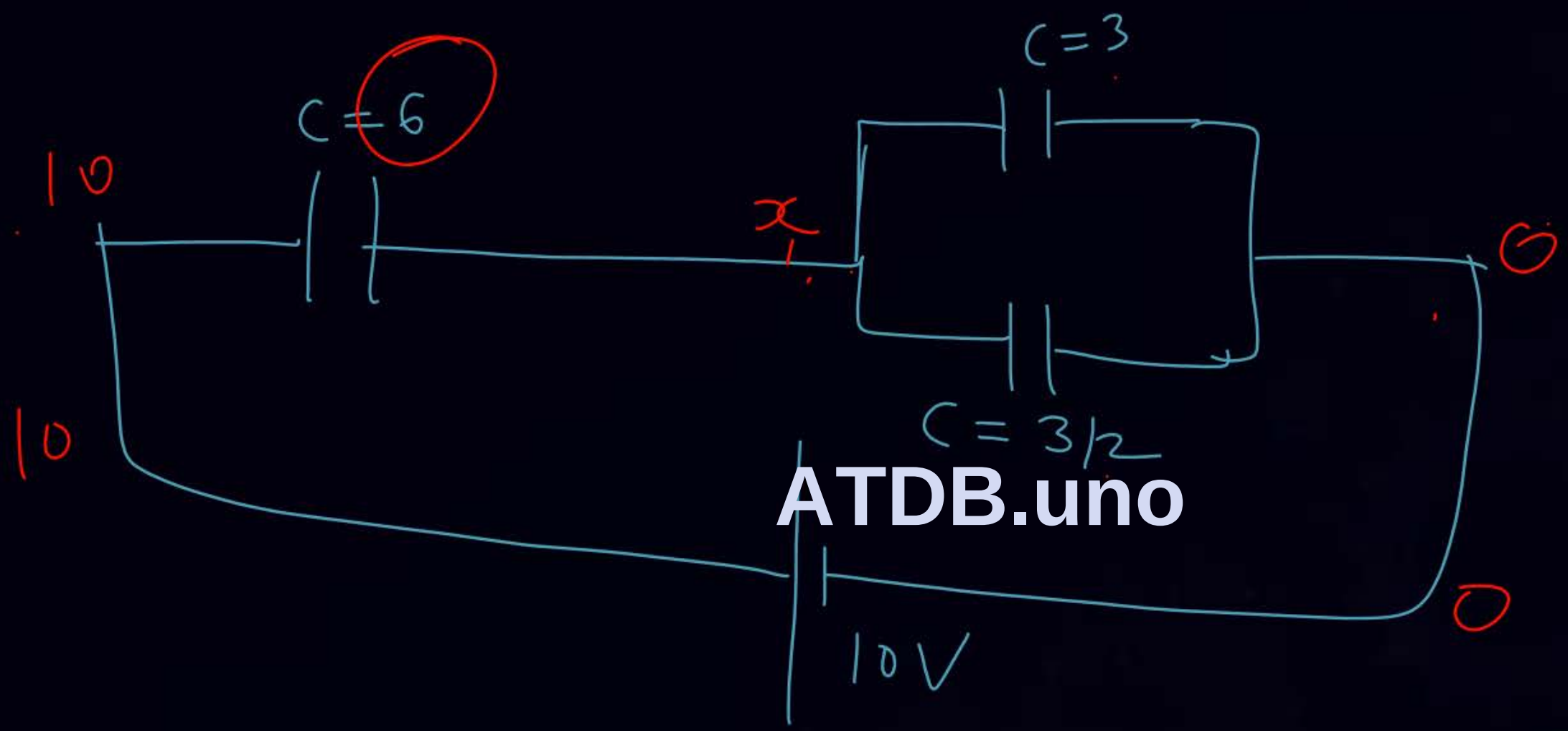
$$\text{battery} = 300$$



ATDB.uno $(C_{\text{new}})_{\text{new}} = 3$

$$q_{\text{नया}} = 3 \times 10 = +30$$

$$(wD)_{\text{battery}} = 10 \times 10 = +100$$



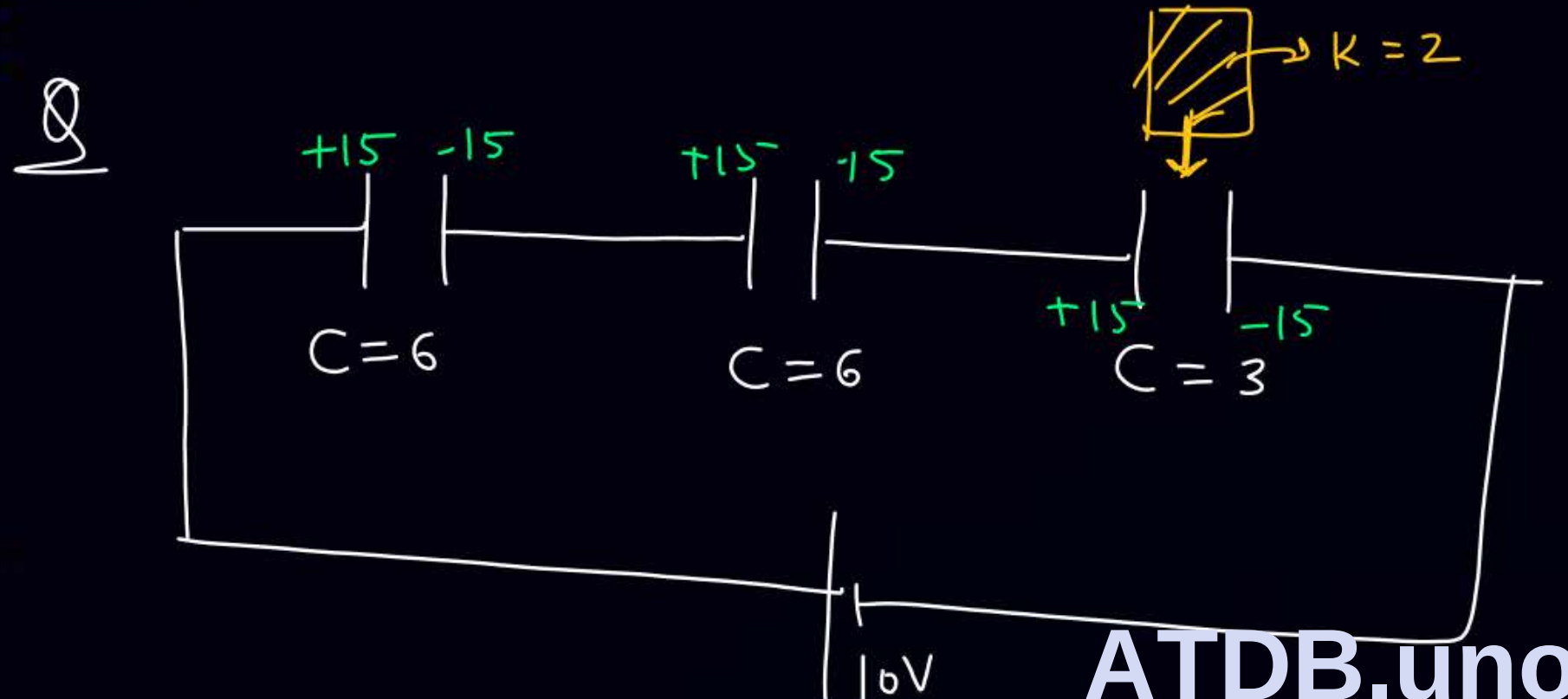
$$C_{3\pi L} = \frac{A/2 \cdot \epsilon_0 K}{d}$$
$$= \left(\frac{A \epsilon_0}{d} \right) \frac{K}{2}$$
$$= 3 \times \frac{2}{2} = 3$$

$$\frac{\frac{A}{2} \epsilon_0}{d}$$



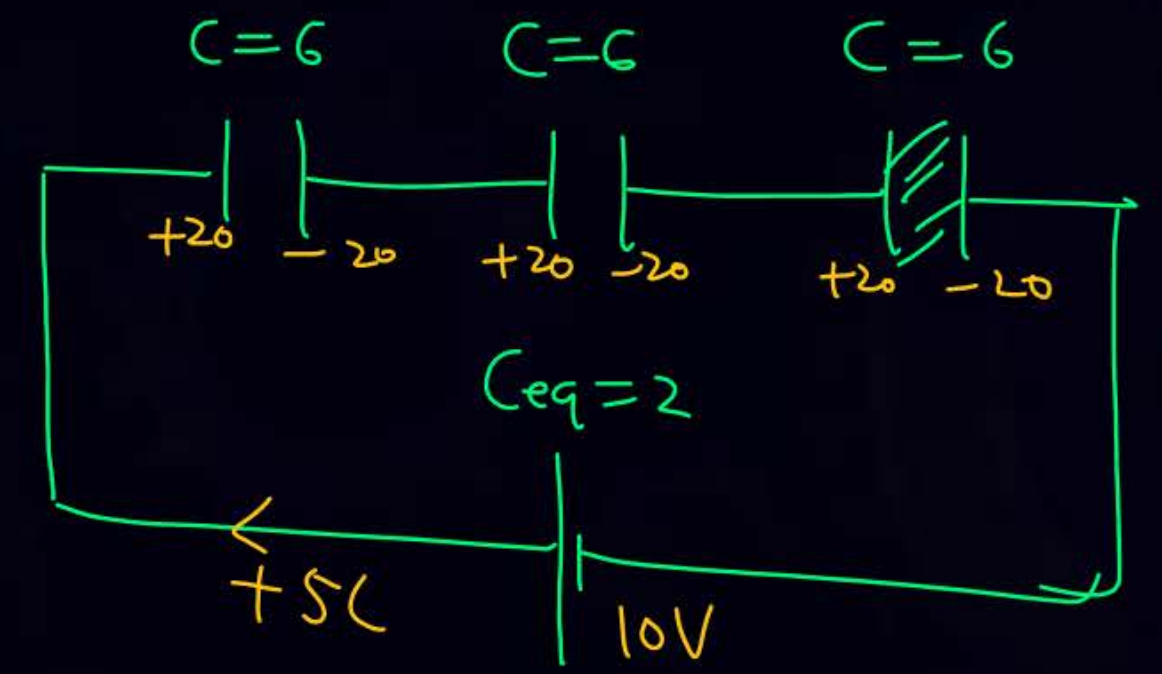
$$K = K_1 + K_2$$



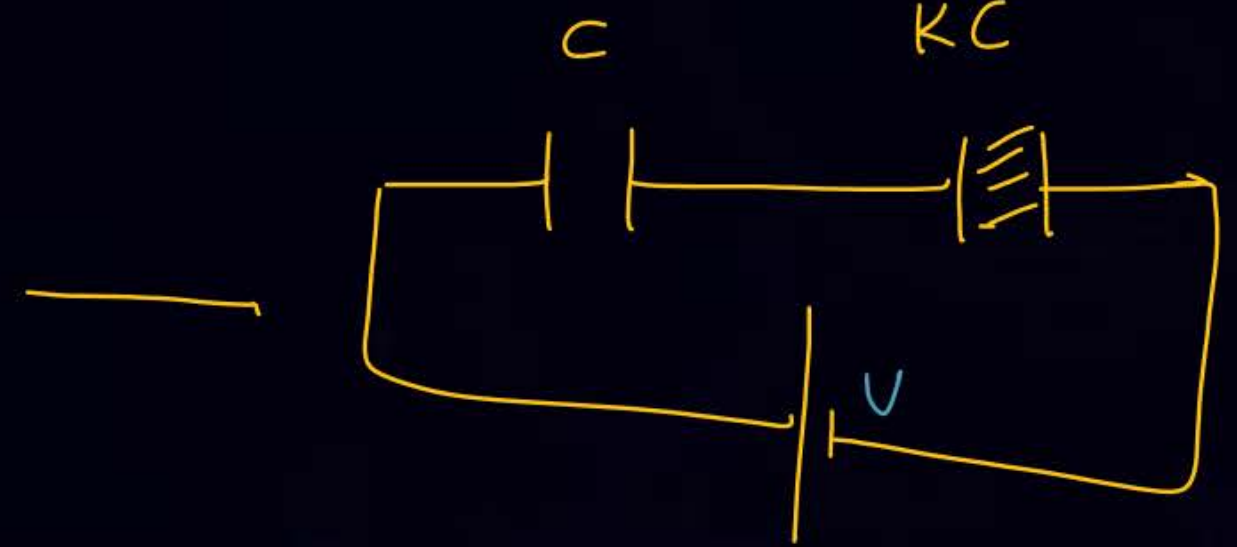
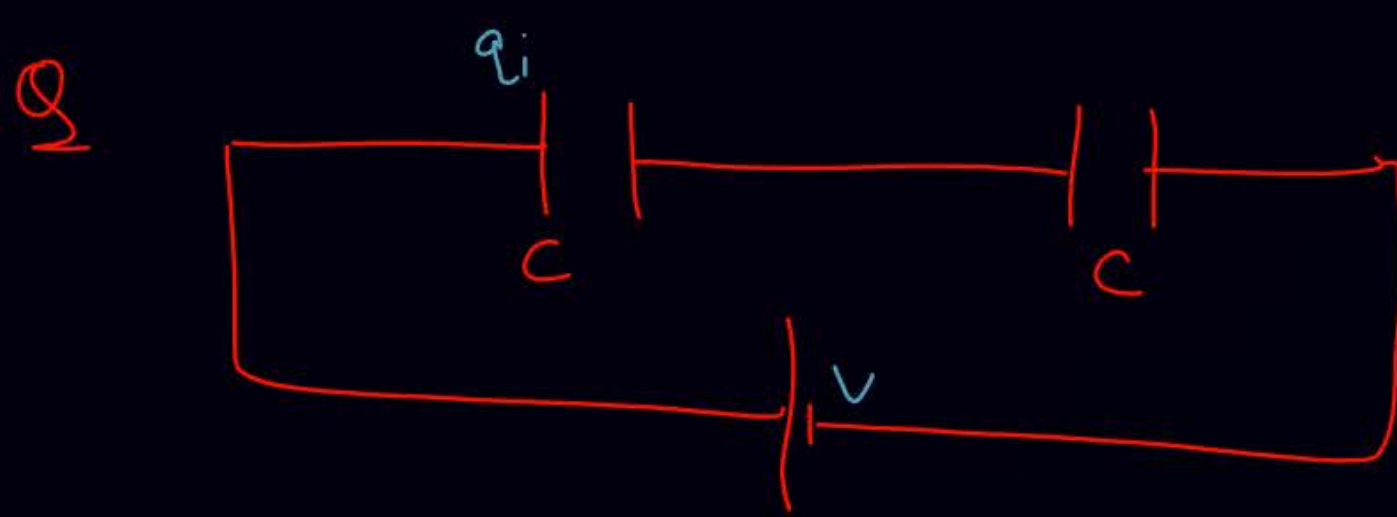


- ① $(WD)_{\text{by battery}} = +5 \times 10 = 50$
- ② $\text{Charg flow thru battery} = +5C$

$$C_{eq} = \frac{3}{2}$$
$$q = \frac{3}{2} \times 10 = 15$$



home
Sheet



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

$$q_i = \frac{CV}{2}$$

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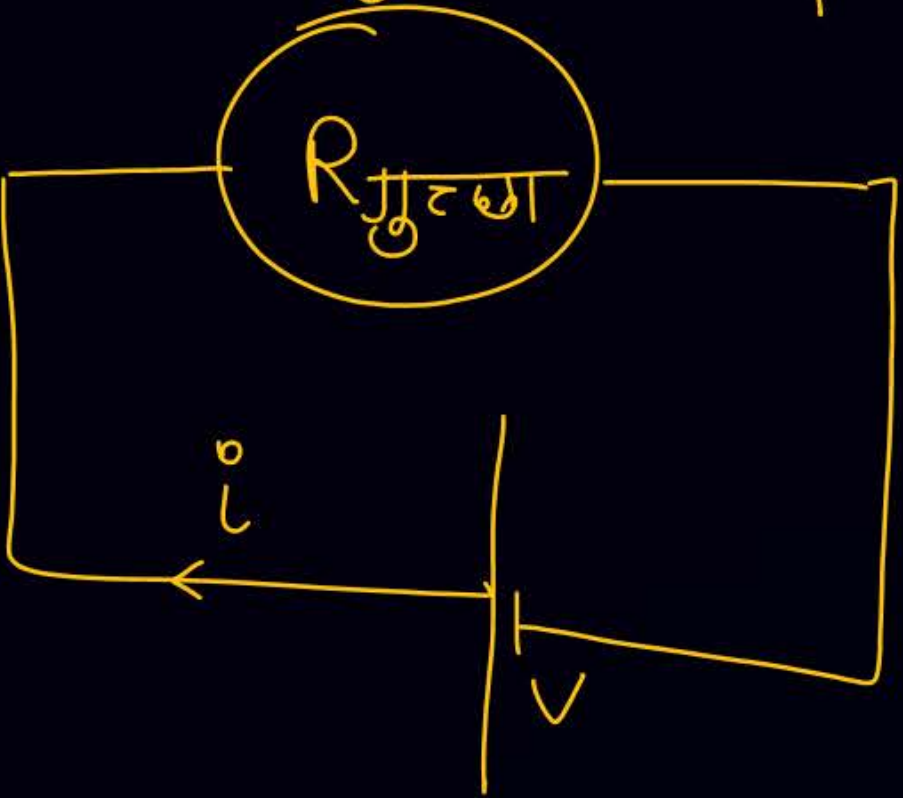
$$C_{eq} = \frac{C \cdot (KC)}{C + KC} = \left(\frac{K}{K+1} \right) C$$

$$q_f = C_{eq}V = \left(\frac{KC}{K+1} \right) V$$

$$(WD)_{batt_y} = (q_f - q_i) \times V$$

#

$R_{\text{जुड़ता}} = R_{eq}$

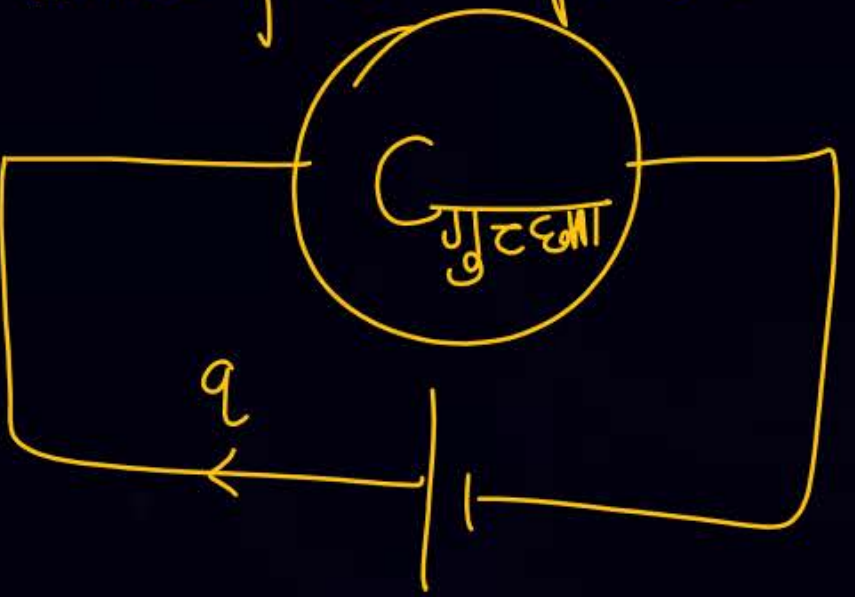


$i = \frac{V}{R_{\text{जुड़ता}}}$

$V = i R_{\text{जुड़ता}}$

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Initially all Cap. Uncharge



$q = C_{eq} V = C_{\text{जुड़ता}} V$

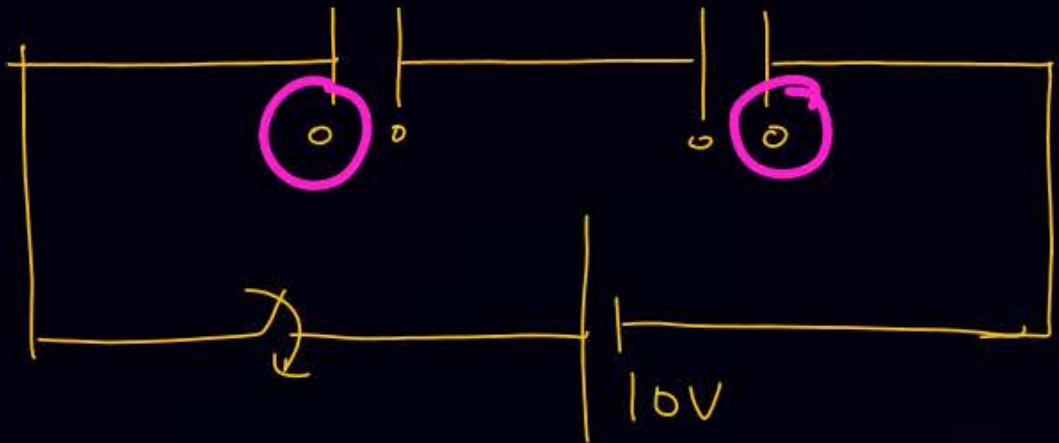
PW

Q

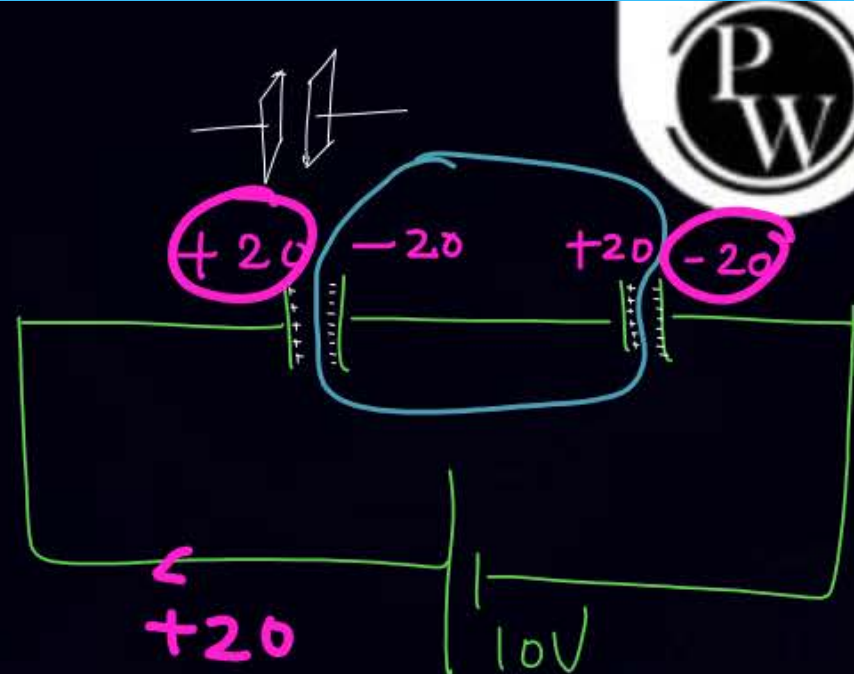
Q

C=3

C=6

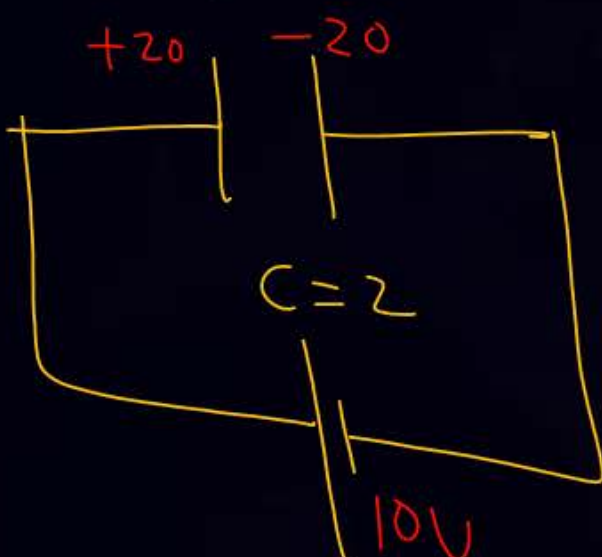


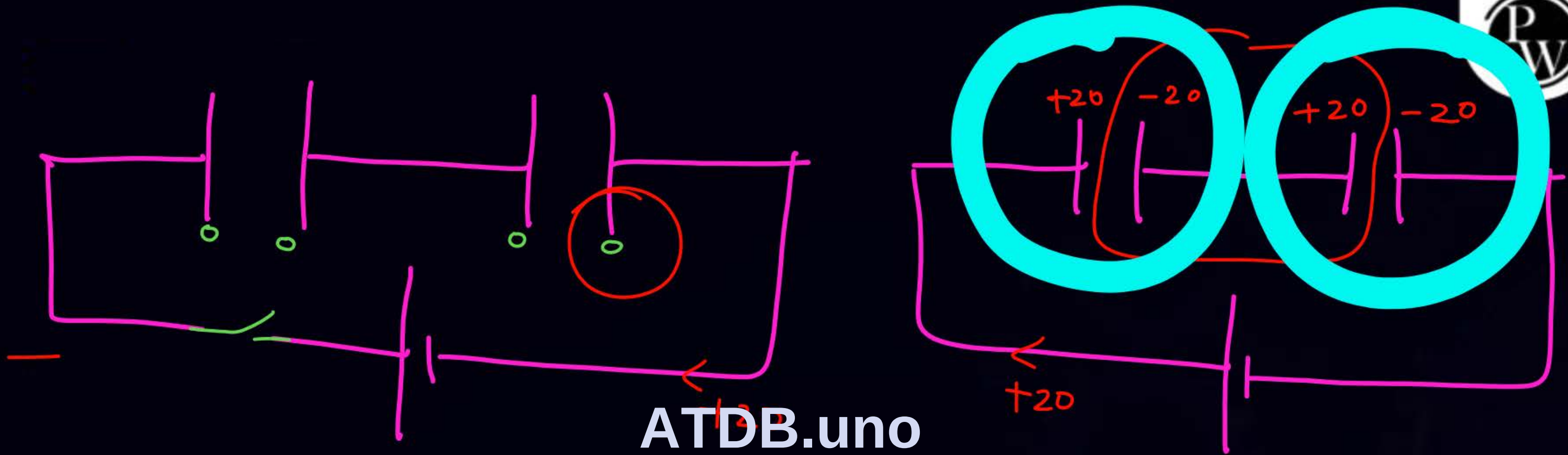
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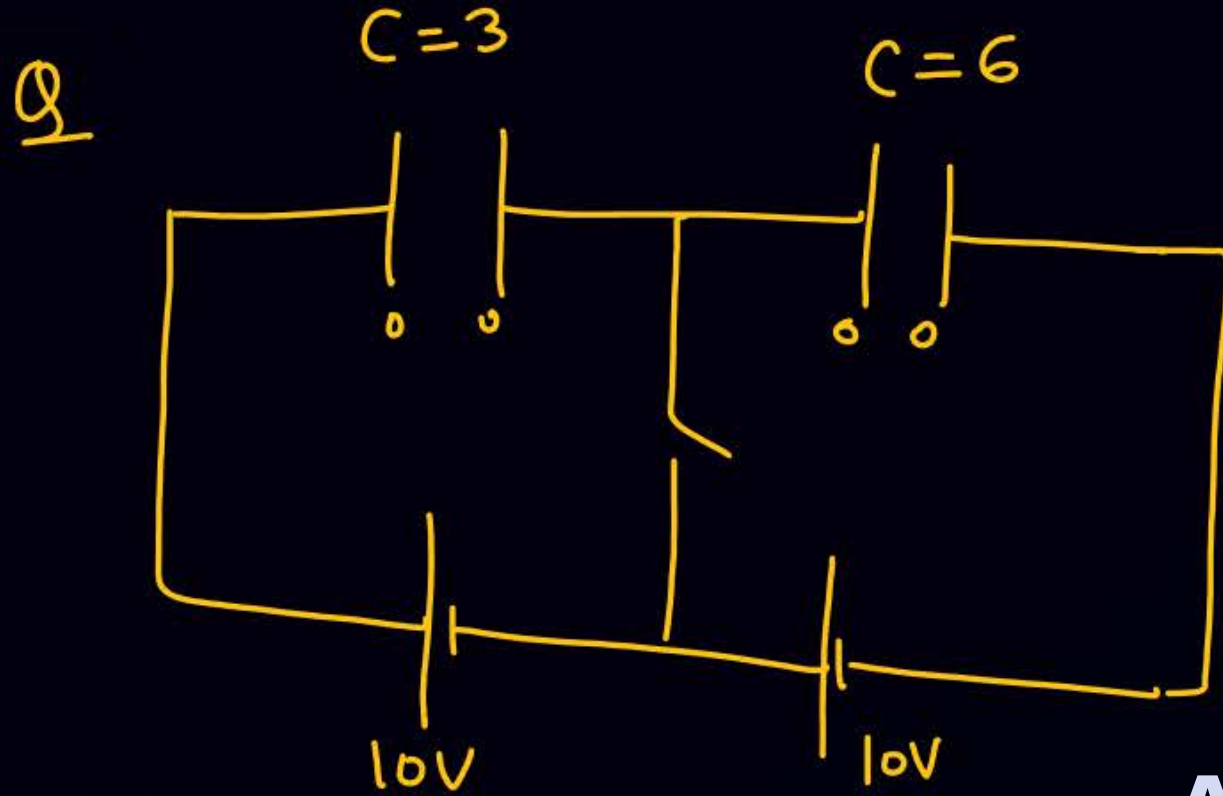


$$C_{eq} = \frac{3 \times 6}{3 + 6} = 2$$

$$Q = C_{eq} V$$







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- find
- ① charge flow through switch when switch is closed $\equiv 30 C$
 - ② (WD) by battery (both) & heat loss after switch close.



$$\text{heat loss} = \left[\frac{1}{2} \times \frac{(40)^2}{3} + \frac{1}{2} \times \frac{(40)^2}{6} \right] + 200 - 100$$

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$$- \left[\frac{1}{2} \times 3 \times 10^2 + \frac{1}{2} \times 6 \times 10^2 \right]$$



30. A charge of $+ 2.0 \times 10^{-8} \text{ C}$ is placed on the positive plate and a charge of $- 1.0 \times 10^{-8} \text{ C}$ on the negative plate of a parallel-plate capacitor of capacitance $1.2 \times 10^{-3} \mu\text{F}$. Calculate the potential difference developed between the plates.

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Ans. 12.5 V



31. A charge of $20\text{ }\mu\text{C}$ is placed on the positive plate of an isolated parallel-plate capacitor of capacitance $10\text{ }\mu\text{F}$. Calculate the potential difference developed between the plates.

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Ans. 1 V



36. Two capacitors of capacitances 20.0 pF and 50.0 pF are connected in series with a 6.00 V battery. Find (a) the potential difference across each capacitor and (b) the energy stored in each capacitor.

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Ans. (a) 1.71 V , 4.29 V (b) 184 pJ , 73.5 pJ



37. Two capacitors of capacitances $4.0\ \mu\text{F}$ and $6.0\ \mu\text{F}$ are connected in series with a battery of $20\ \text{V}$. Find the energy supplied by the battery.

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Ans. $960\ \mu\text{J}$



46. Consider the situation shown in figure (31-E23). The switch S is open for a long time and then closed. (a) Find the charge flown through the battery when the switch S is closed. (b) Find the work done by the battery. (c) Find the change in energy stored in the capacitors. (d) Find the heat developed in the system.

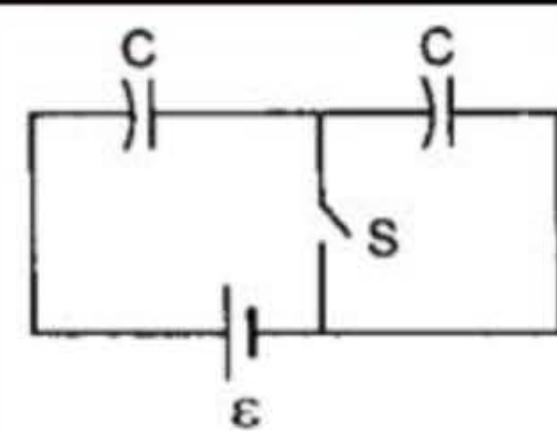


Figure 31-E23

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Ans. (a) $C\mathcal{E}/2$, (b) $C\mathcal{E}^2/2$ (c) $C\mathcal{E}^2/4$ (d) $C\mathcal{E}^2/4$



48. A $5.0 \mu\text{F}$ capacitor is charged to 12 V. The positive plate of this capacitor is now connected to the negative terminal of a 12 V battery and vice versa. Calculate the heat developed in the connecting wires.

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Ans. 1.44 mJ



49. The two square faces of a rectangular dielectric slab (dielectric constant 4.0) of dimensions $20\text{ cm} \times 20\text{ cm} \times 1.0\text{ mm}$ are metal-coated. Find the capacitance between the coated surfaces.

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Ans. 1.42 nF



50. If the above capacitor is connected across a 6.0 V battery, find (a) the charge supplied by the battery, (b) the induced charge on the dielectric and (c) the net charge appearing on one of the coated surfaces.

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Ans. (a) 8.5 nC (b) 6.4 nC (c) 2.1 nC



51. The separation between the plates of a parallel-plate capacitor is 0.500 cm and its plate area is 100 cm^2 . A 0.400 cm thick metal plate is inserted into the gap with its faces parallel to the plates. Show that the capacitance of the assembly is independent of the position of the metal plate within the gap and find its value.

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Ans. 88 pF



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

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Ans. 3



53. A parallel-plate capacitor of capacitance $5\ \mu\text{F}$ is connected to a battery of emf $6\ \text{V}$. The separation between the plates is $2\ \text{mm}$. (a) Find the charge on the positive plate. (b) Find the electric field between the plates. (c) A dielectric slab of thickness $1\ \text{mm}$ and dielectric constant 5 is inserted into the gap to occupy the lower half of it. Find the capacitance of the new combination. (d) How much charge has flown through the battery after the slab is inserted?

Ans. (a) $30\ \mu\text{C}$ (b) $3 \times 10^3\ \text{V m}^{-1}$ (c) $8.3\ \mu\text{F}$ (d) $20\ \mu\text{C}$



54. A parallel-plate capacitor has plate area 100 cm^2 and plate separation 1.0 cm . A glass plate (dielectric constant 6.0) of thickness 6.0 mm and an ebonite plate (dielectric constant 4.0) are inserted one over the other to fill the space between the plates of the capacitor. Find the new capacitance.

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Ans. 44 pF



56. Find the capacitances of the capacitors shown in figure (31-E24). The plate area is A and the separation between the plates is d . Different dielectric slabs in a particular part of the figure are of the same thickness and the entire gap between the plates is filled with the dielectric slabs.

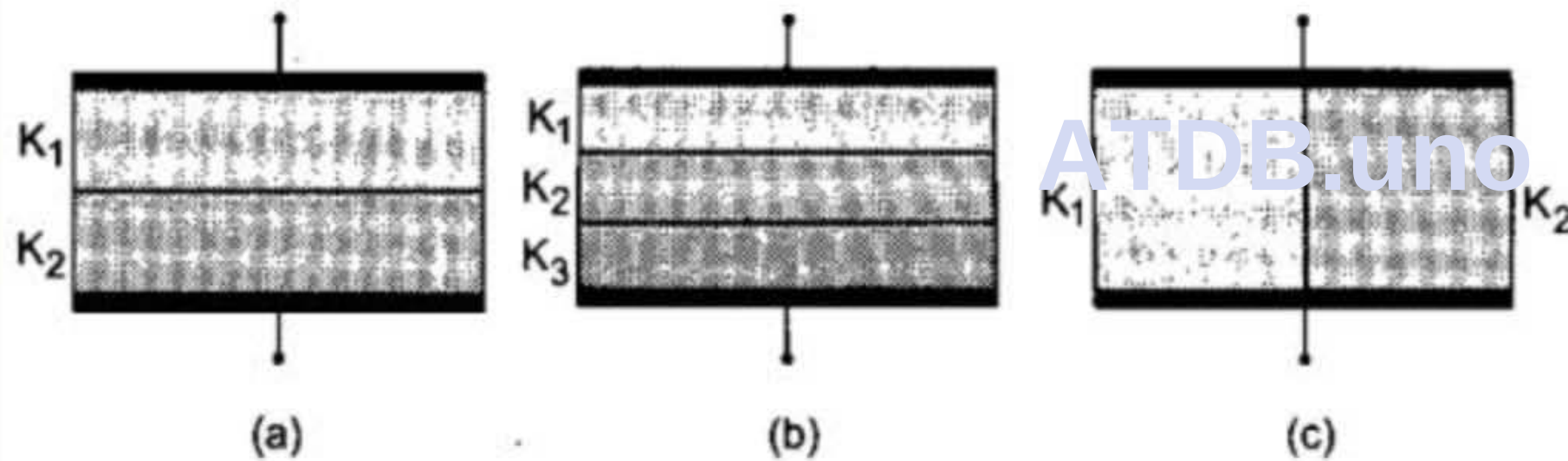
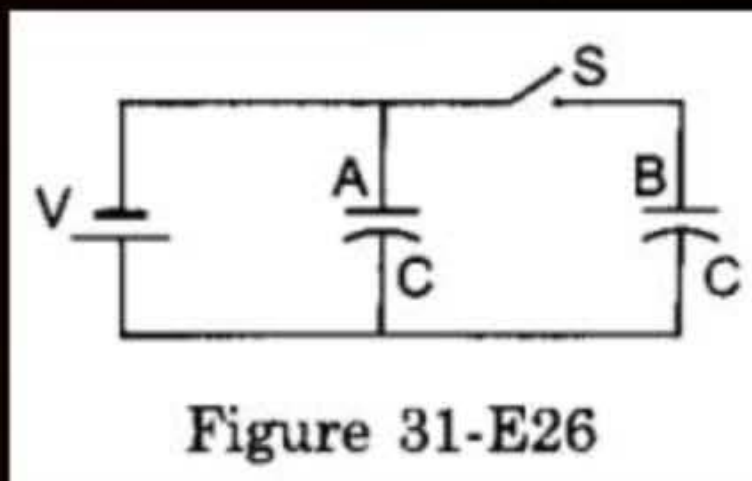


Figure 31-E24

Ans. (a) $\frac{2 K_1 K_2 \epsilon_0 A}{d(K_1 + K_2)}$ (b) $\frac{3 \epsilon_0 A K_1 K_2 K_3}{d(K_1 K_2 + K_2 K_3 + K_3 K_1)}$
(c) $\frac{\epsilon_0 A}{d(K_1 + K_2)}$



58. Figure (31-E26) shows two identical parallel plate capacitors connected to a battery through a switch S . Initially, the switch is closed so that the capacitors are completely charged. The switch is now opened and the free space between the plates of the capacitors is filled with a dielectric of dielectric constant 3. Find the ratio of the initial total energy stored in the capacitors to the final total energy stored.



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Ans. 3 : 5

QUESTION – 35

An electron with kinetic energy K_1 enters between parallel plates of a capacitor at an angle ' α ' with the plates. It leaves the plates at angle ' β ' with kinetic energy K_2 . Then the ratio of kinetic energies $K_1 : K_2$ will be:

[JEE Mains-2021]

1 $\frac{\sin^2 \beta}{\cos^2 \alpha}$

2 $\frac{\cos^2 \beta}{\cos^2 \alpha}$

3 $\frac{\cos \beta}{\cos \alpha}$

4 $\frac{\cos \beta}{\sin \alpha}$

ATDB.uno**Ans. (2)**

QUESTION – 41

Two capacitors of capacities $2C$ and C are joined in parallel and charged up to potential V . The battery is removed and the capacitor of capacity C is filled completely with a medium of dielectric constant K . The potential difference across the capacitors will now be:

[JEE Mains-2021]

1 $\frac{V}{K+2}$

2 $\frac{V}{K}$

3 $\frac{3V}{K+2}$

4 $\frac{3V}{K}$

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Ans. (3)

QUESTION – 52

A parallel plate capacitor is formed by two plates each of area $30 \pi \text{ cm}^2$ separated by 1 mm. A material of dielectric strength $3.6 \times 10^7 \text{ Vm}^{-1}$ is filled between the plates. If the maximum charge that can be stored on the capacitor without causing dielectric breakdown is $7 \times 10^{-6} \text{ C}$, the value of dielectric constant of the material is:

$$\left\{ \text{Use: } \frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ Nm}^2 \text{C}^{-2} \right\}$$

[JEE Mains-2022]**ATDB.uno****1** 1.66**2** 1.75**3** 2.25**4** 2.33**Ans. (4)**

QUESTION – 70

A parallel plate capacitor of capacitance 2 F is charged to a potential V. The energy stored in the capacitor is E_1 . The capacitor is now connected to another uncharged identical capacitor in parallel combination. The energy stored in the combination is E_2 .

The ratio $\frac{E_2}{E_1}$ is:

[11 April 2023 - Shift 1]

1 2 : 1

2 2 : 3

3 1 : 2

4 1 : 4

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Ans. (3)

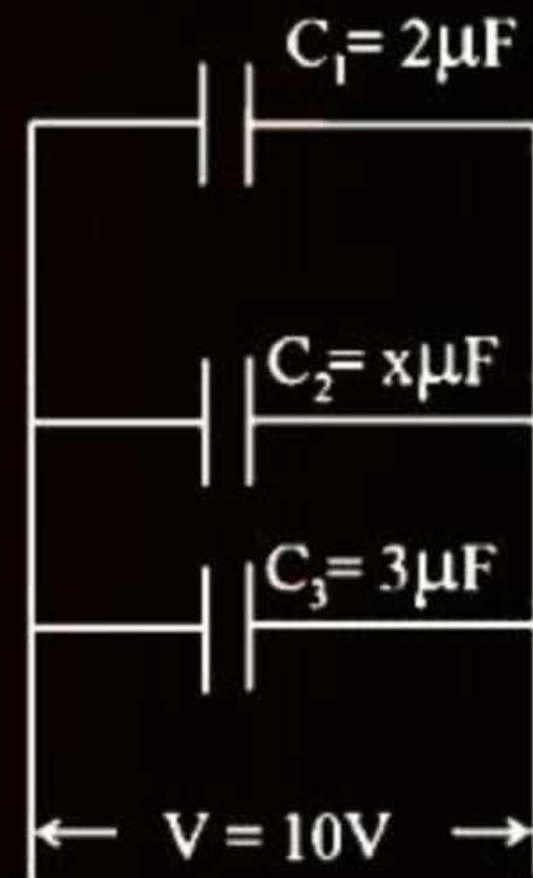


QUESTION – 73

In the given figure the total charge stored in the combination of capacitors is $100\mu\text{C}$.
The value of 'x' is _____.

[15 April 2023 - Shift 1]

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Ans. (5)

QUESTION – 81

A parallel plate capacitor with plate separation 5 mm is charged up by a battery. It is found that on introducing a dielectric sheet of thickness 2 mm, while keeping the battery connections intact, the capacitor draws 25% more charge from the battery than before. The dielectric constant of the sheet is _____. **[31 Jan. 2024 - Shift 1]**

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Ans (2)



Home work

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THANK YOU

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