
PRAYAS
JEE 2025
ATDB.uno
Lecture - 4
Physics
Capacitor
By- Saleem Ahmed Sir
Physics Wall

Topics *to be covered*

1. Circuit Analysis & heat loss
2.
3.
4.

30 W →
31 T → Holliday
1 F → Holliday =
2 S → capacitor (Last)
3 S
4 M
5 T
6 W
7 T → Try = Holliday
8 F
9 S →
10 S →
11 M →

Semi Cond → Logic Gate (2 hour)
Bohr model (next) ✓
modern = Nuclear physics ✓
X-ray → दो
waveoptics - 05 ✓
EMW → (3 hour) = (Next day No class)
(1:30 hour, 1:30 hour)
(2 hour 15 mint) + (45 mint)

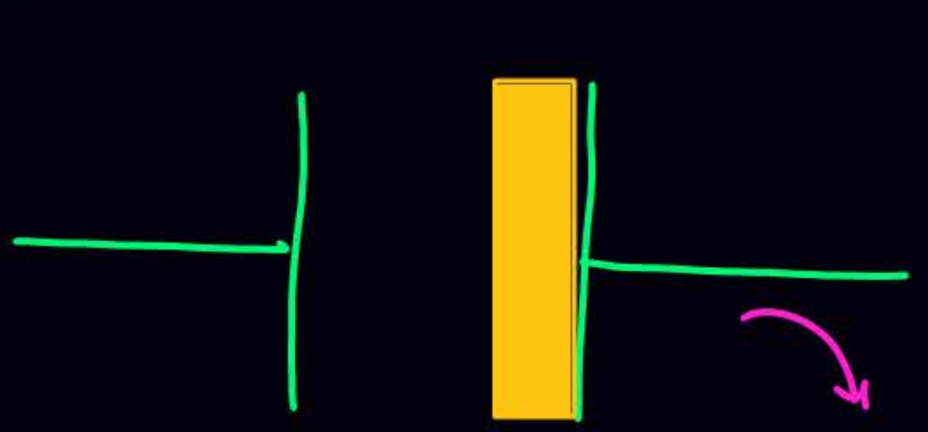
Diwali H.W

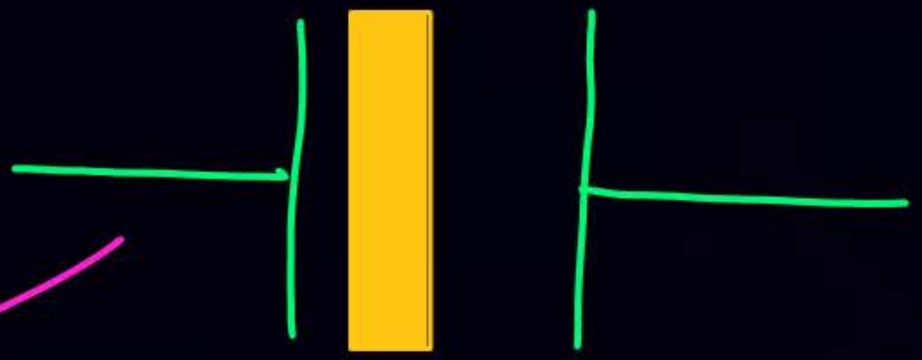
- KTG & thermo
- heat & elasticity
- fluid all formula
- wave (formula oriented)
- Electrost — 1 day.

mechanics
- → circular
- → WPE → collision) priority
- → COM → location of COM) priority
- → Rotation: MOI, Rolling on inclined, $\tau = I\alpha$, Equil.

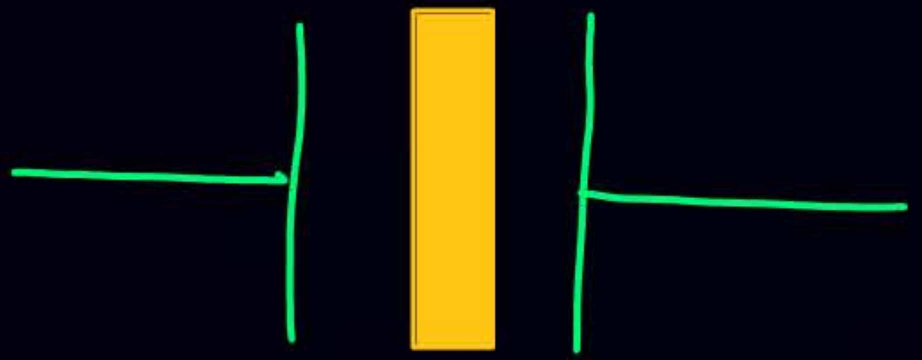
$L_i = L_f$

$$C = \frac{A\epsilon_0}{d - t\left(1 - \frac{1}{k}\right)}$$

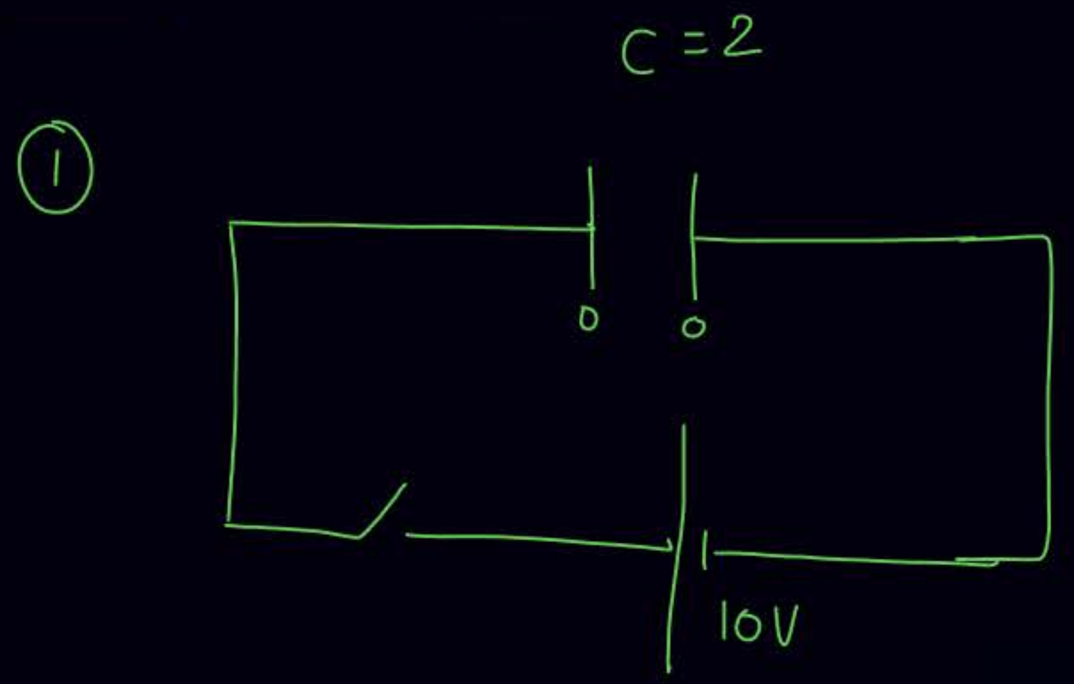


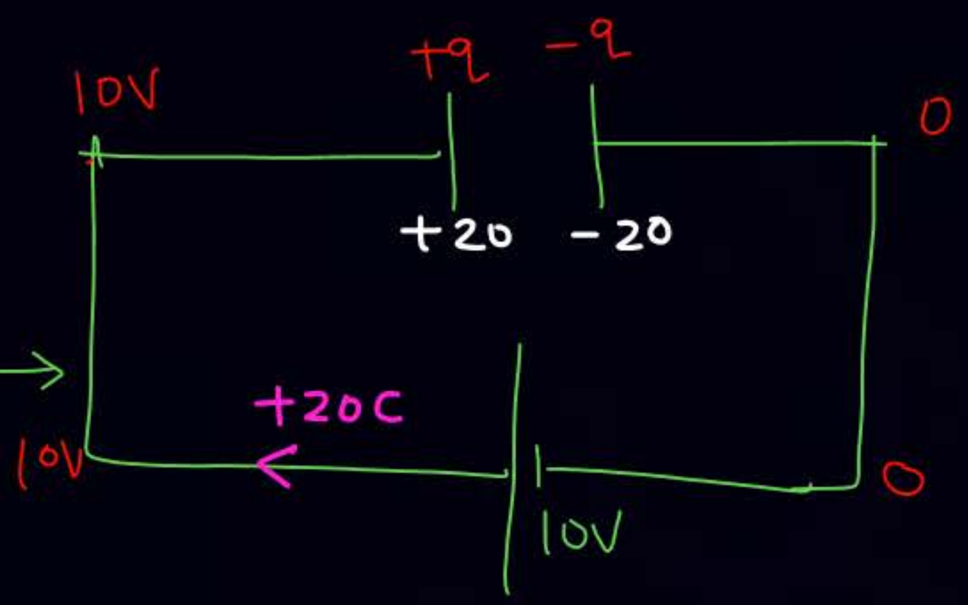


$$C = \frac{A\epsilon_0}{d - t\left(1 - \frac{1}{k}\right)}$$



$q = 2 \times 10 = 20$





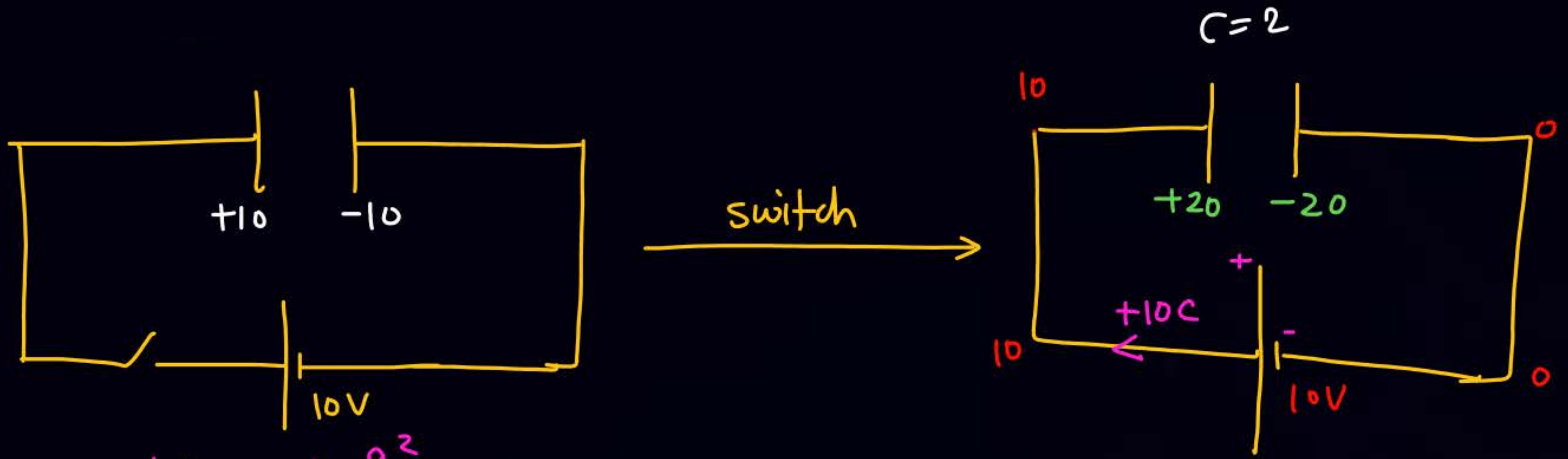
$$(WD)_{battery} = 20 \times 10 = 200$$

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

$$\text{Heat loss} = 200 - 100 = 100$$

50 %

Q



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

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

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

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

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

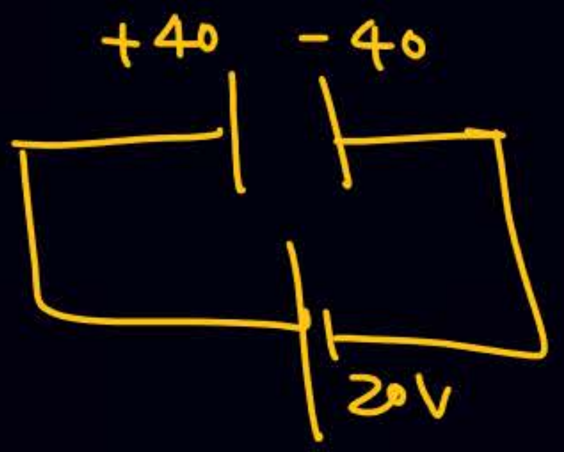
$$U_f = \frac{1}{2}CV^2 = \frac{1}{2}\times 2\times 10^2 = 100$$

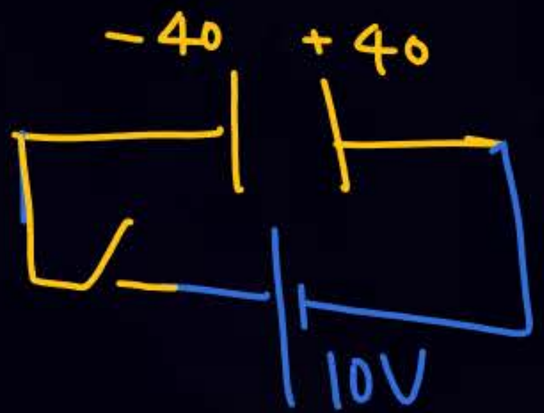
SSSM →

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

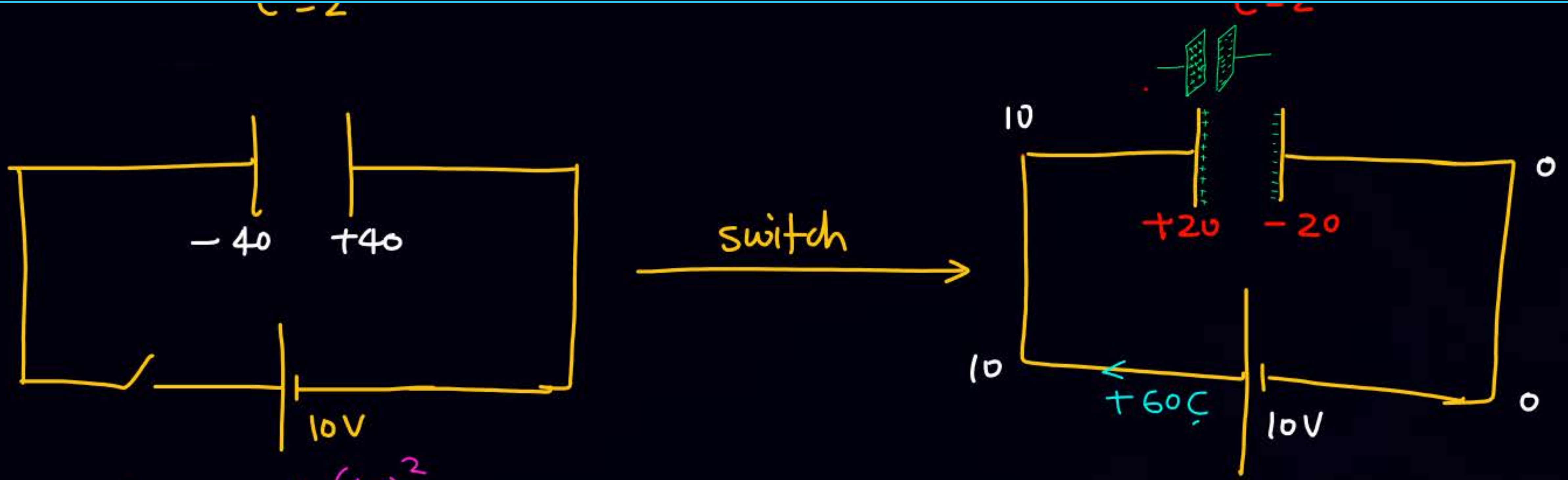
Q Language

A capacitor of capacitance 2F is fully charge by a battery of EMF 20 Volt.
Now battery is connected & another battery of emf 10V is connected such that negative plate of capacitor is connected to positive terminal of 10V battery. Find ① U_f ② (WD) by 10V battery ③ heat loss in second event





Q



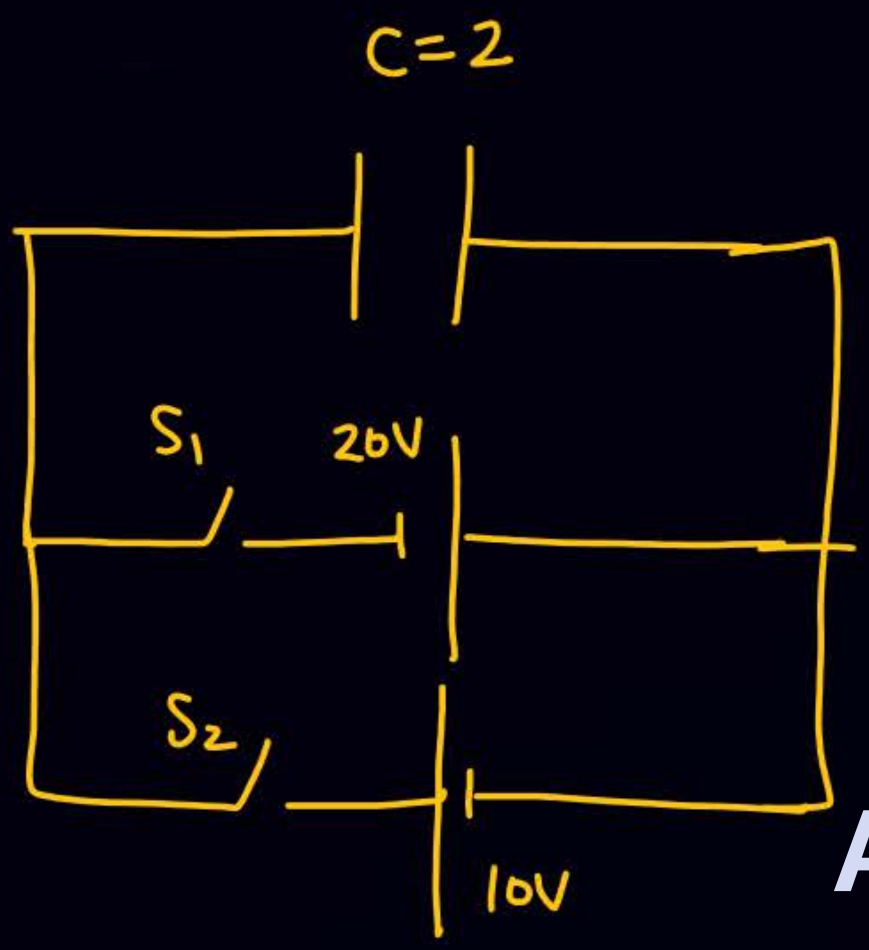
$U_i = \frac{1}{2}\frac{(40)^2}{2} = 400$

$q_f = 2 \times 10 = 20$

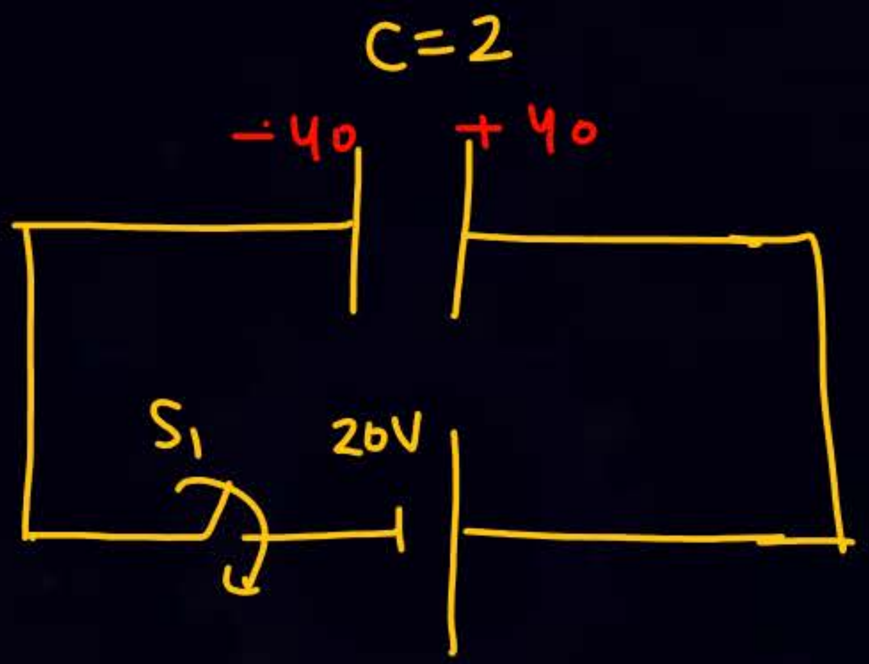
$(WD)_{battery} = +60 \times 10 = +600$

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

heat loss = 400 + 600 − 100

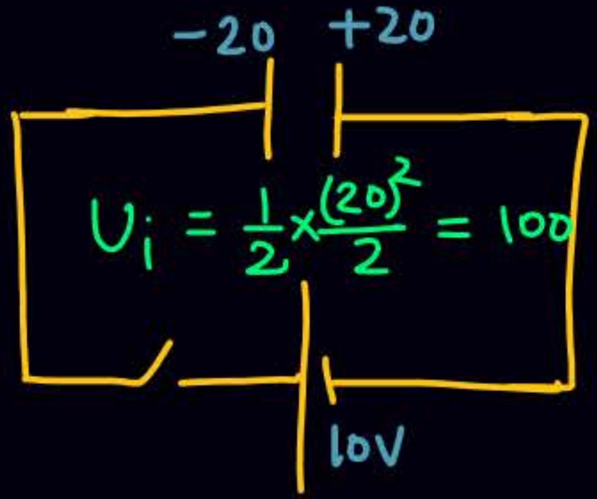


Initially S_1 is close & S_2 is open
& then $S_1 \longrightarrow$ open $S_2 \longrightarrow$ close

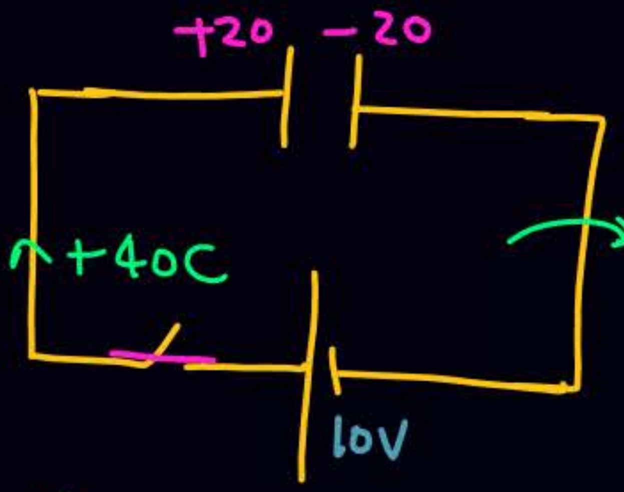


$C = 2$

Q



$U_i = \frac{1}{2} \times \frac{(20)^2}{2} = 100$



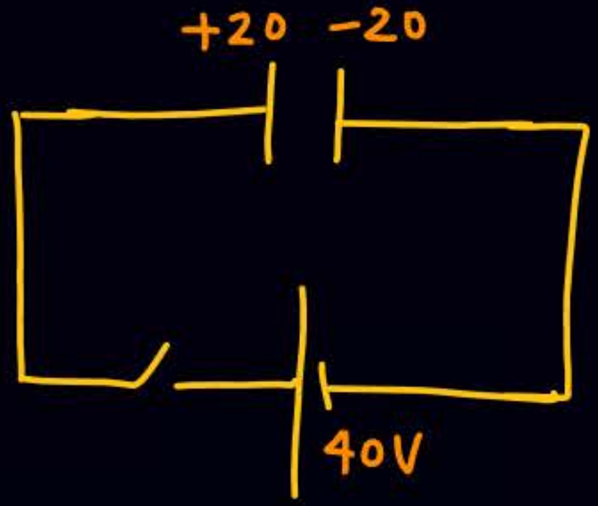
$U_f = \frac{1}{2}\frac{(20)^2}{2}$

$= 100$

$(W_D)_{batt} = +400$

heat loss = 400

$C = 2$



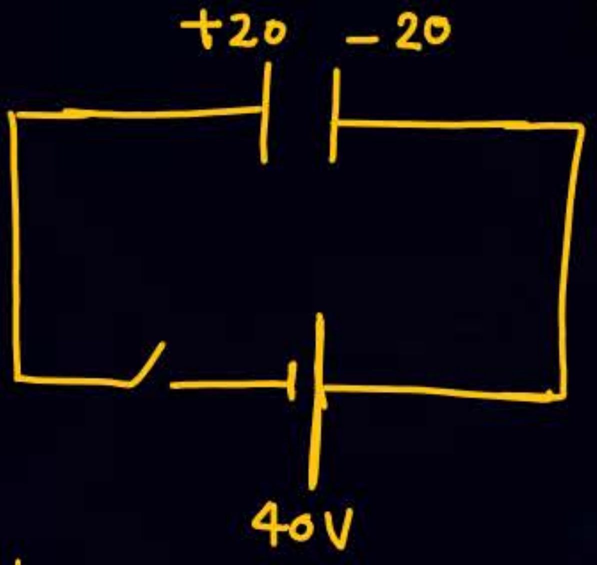
$q_f = 80$

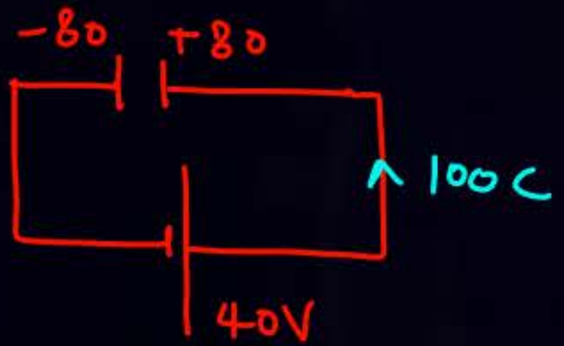
$(W_D)_{batt} = 60 \times 40 = 2400$

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

$= 900$

$C = 2$





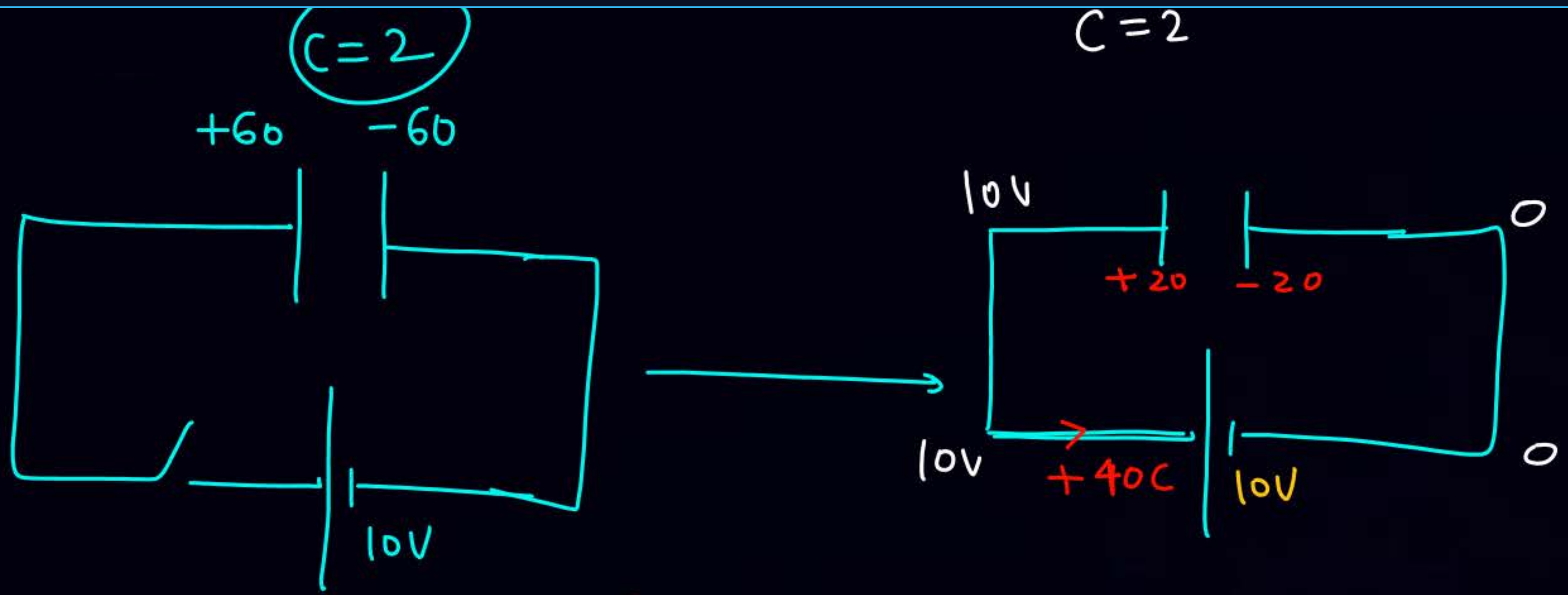
$(W_D) = 4000$

$U_i = 100$

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

heat $= 2500$

Q



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

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

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

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

heat loss $= 900 - 400 - 100 = 400$

heat loss (→ magnitude) $= U_i + (WD)_{battery} - U_f$

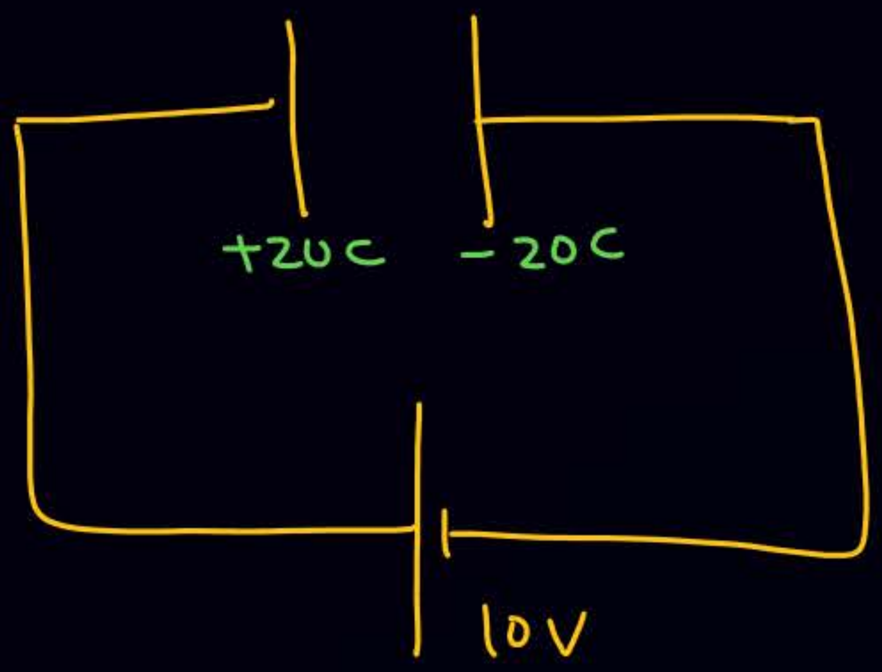
$= (WD)_{batter} - (U_f - U_i)$

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

heat loss $= (-400) - (100 - 900)$

$= -400 + 800 = \boxed{400}$

$C = 2F$



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

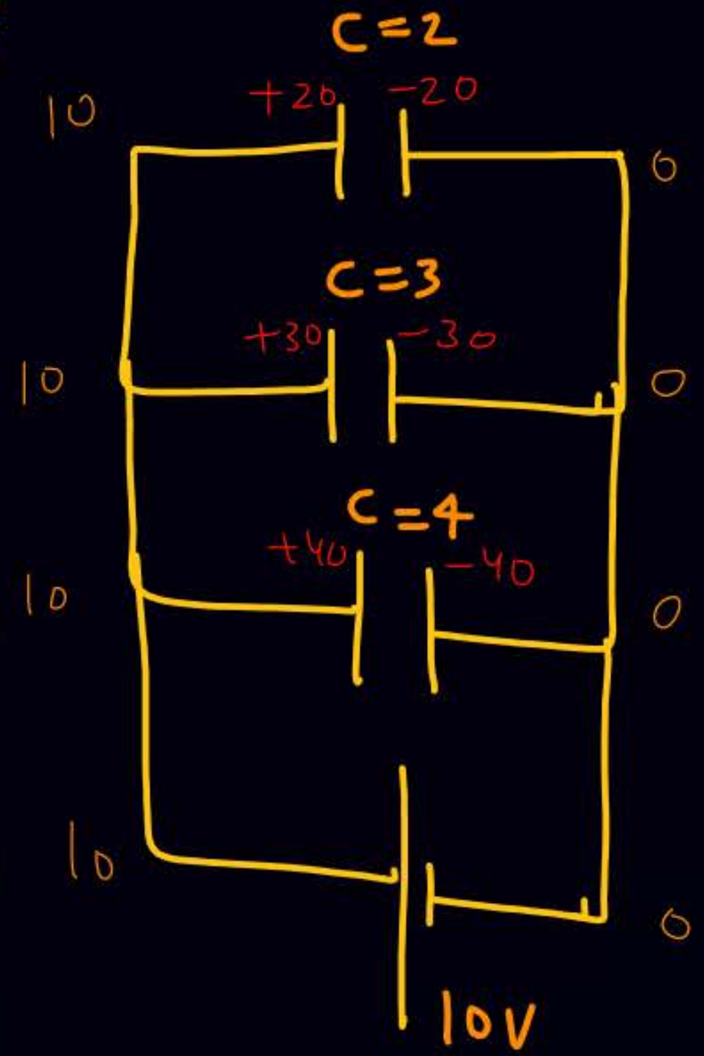
$C = 2\mu F = 2 \times 10^{-6} F$

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

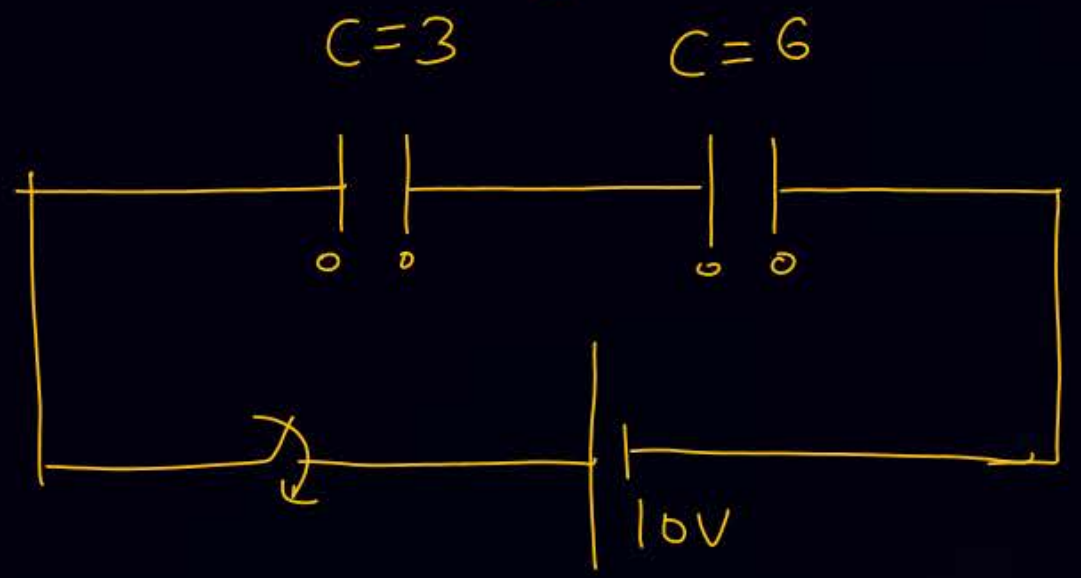
$= 20 \mu C$

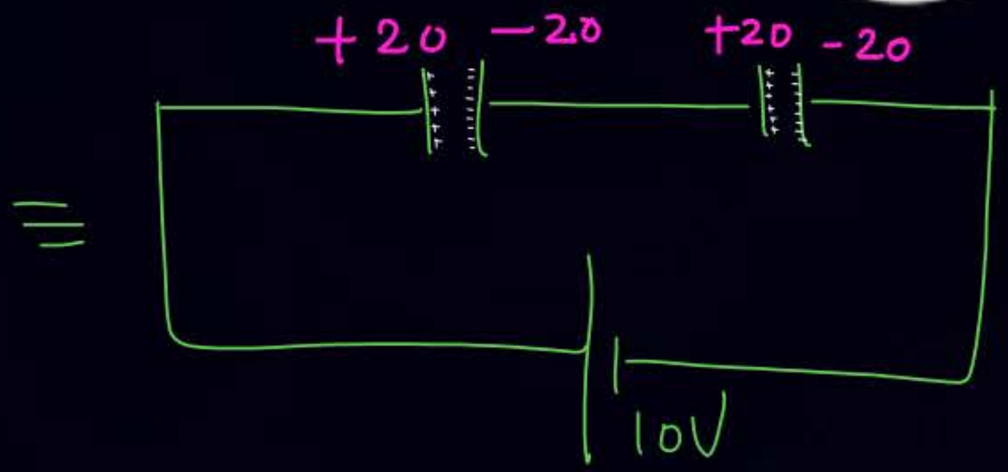
(Series ≡ Q ⟶ same)

Q



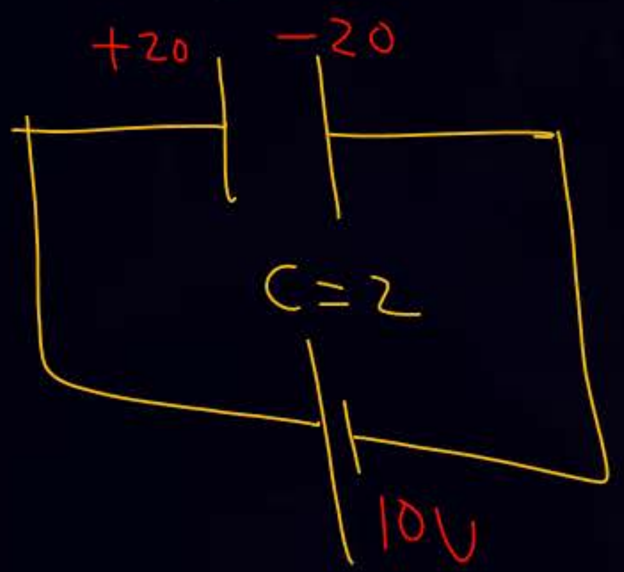
Q





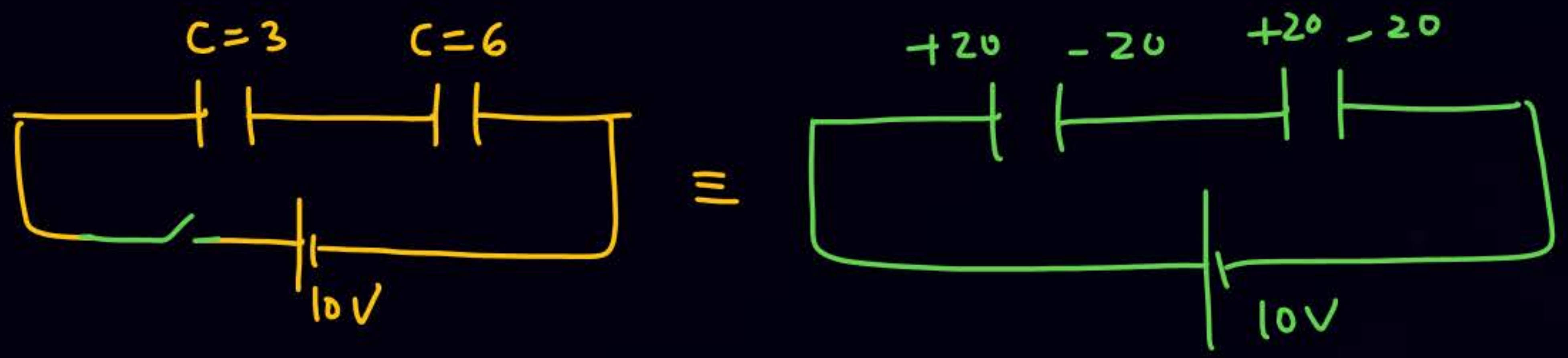
$$C_{eq} = \frac{3\times 6}{3+6} = 2$$

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



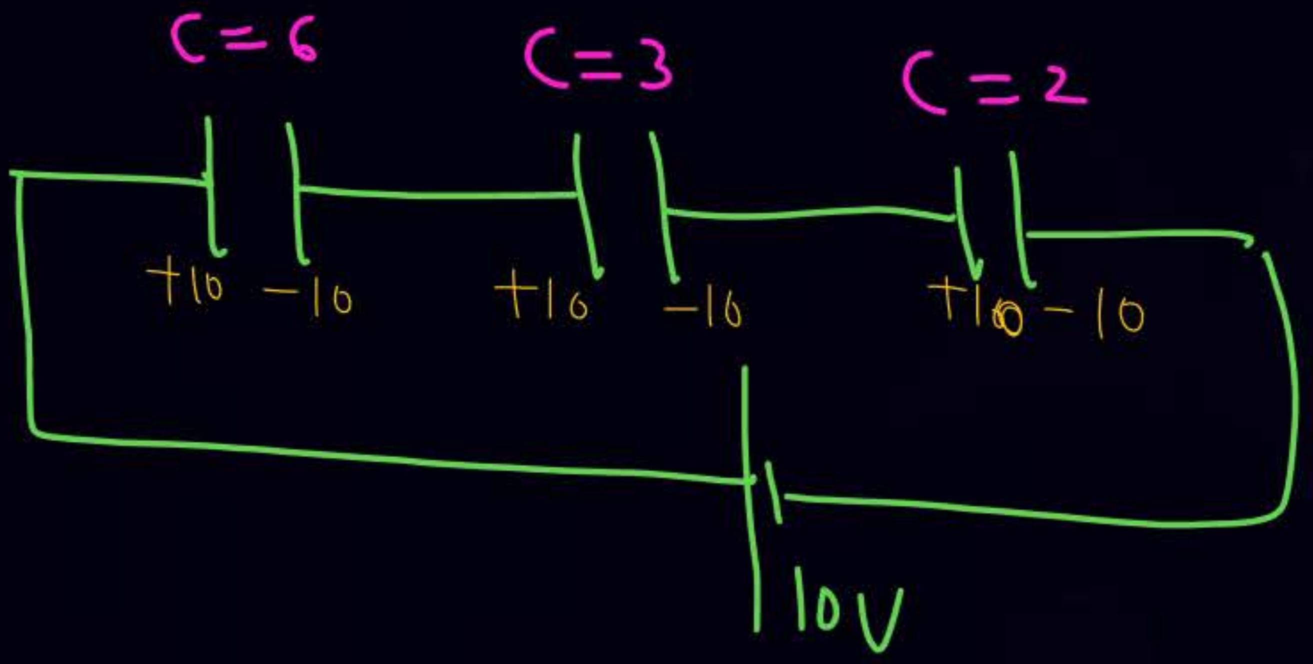
Q Initial Charge on each cap. is zero

(1)



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

(2)



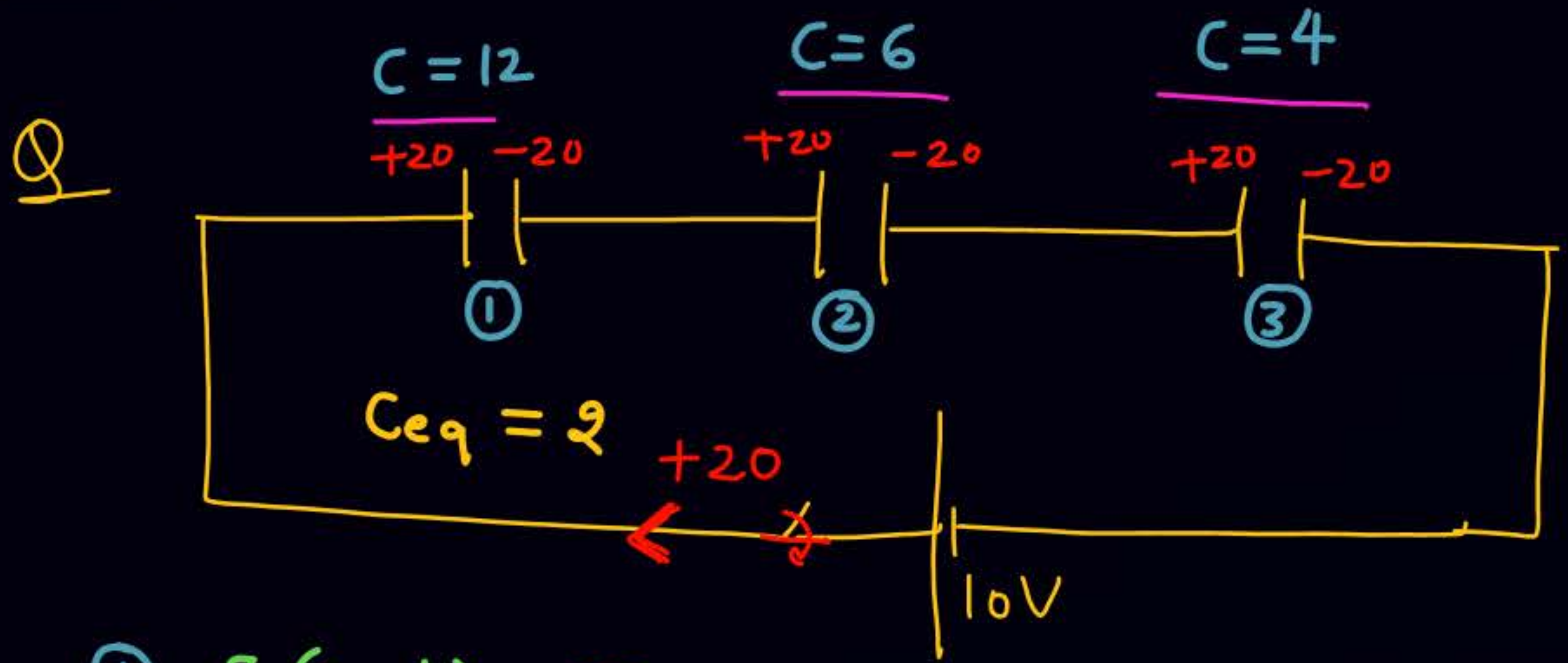
$C_{eq} = 1$

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

Initially all cap. was uncharged

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

$C_{eq} = 2$



(1) $q(\text{each}) = 20$

(2) $(WD)_{\text{battery}} = 20 \times 10 = +200$

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

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

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

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

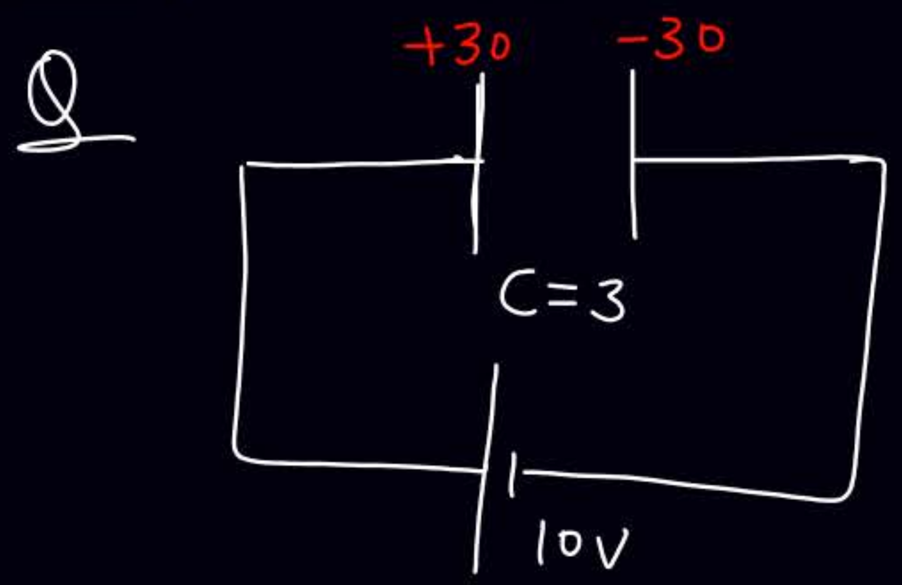
" " $C_2 = \frac{20}{6}$

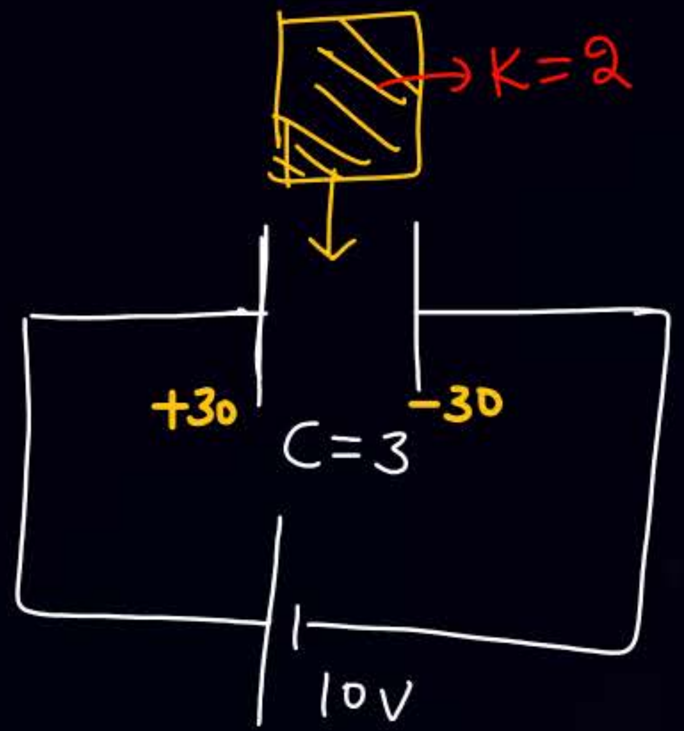
" " $C_3 = \frac{20}{4}$

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

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

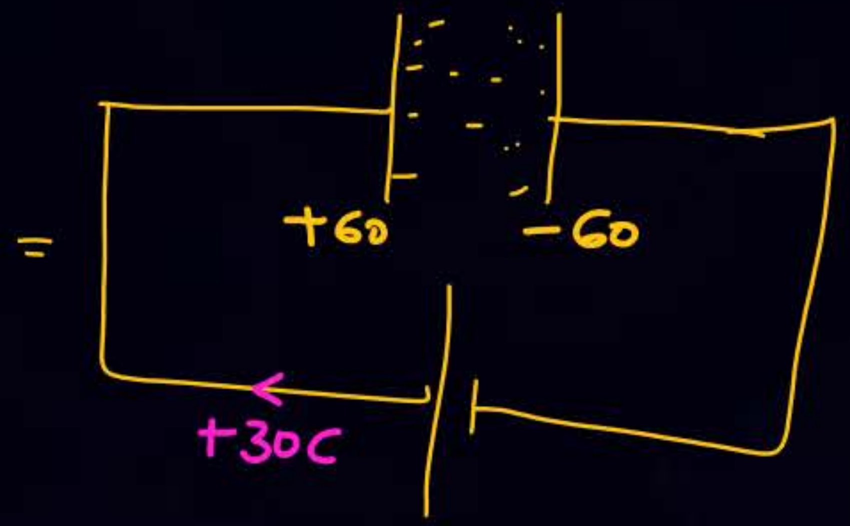
Q





$C_{नया} = 6$

=

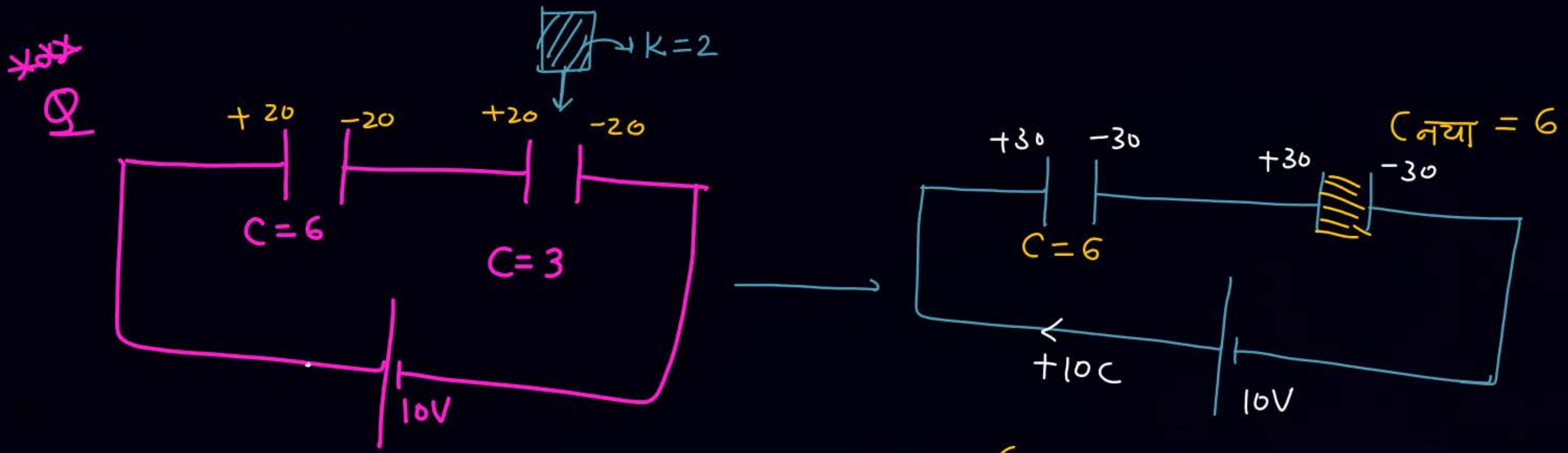


$C = \frac{A\epsilon_0}{d}$

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

$(WD)_{battery} = 10 \times 30$

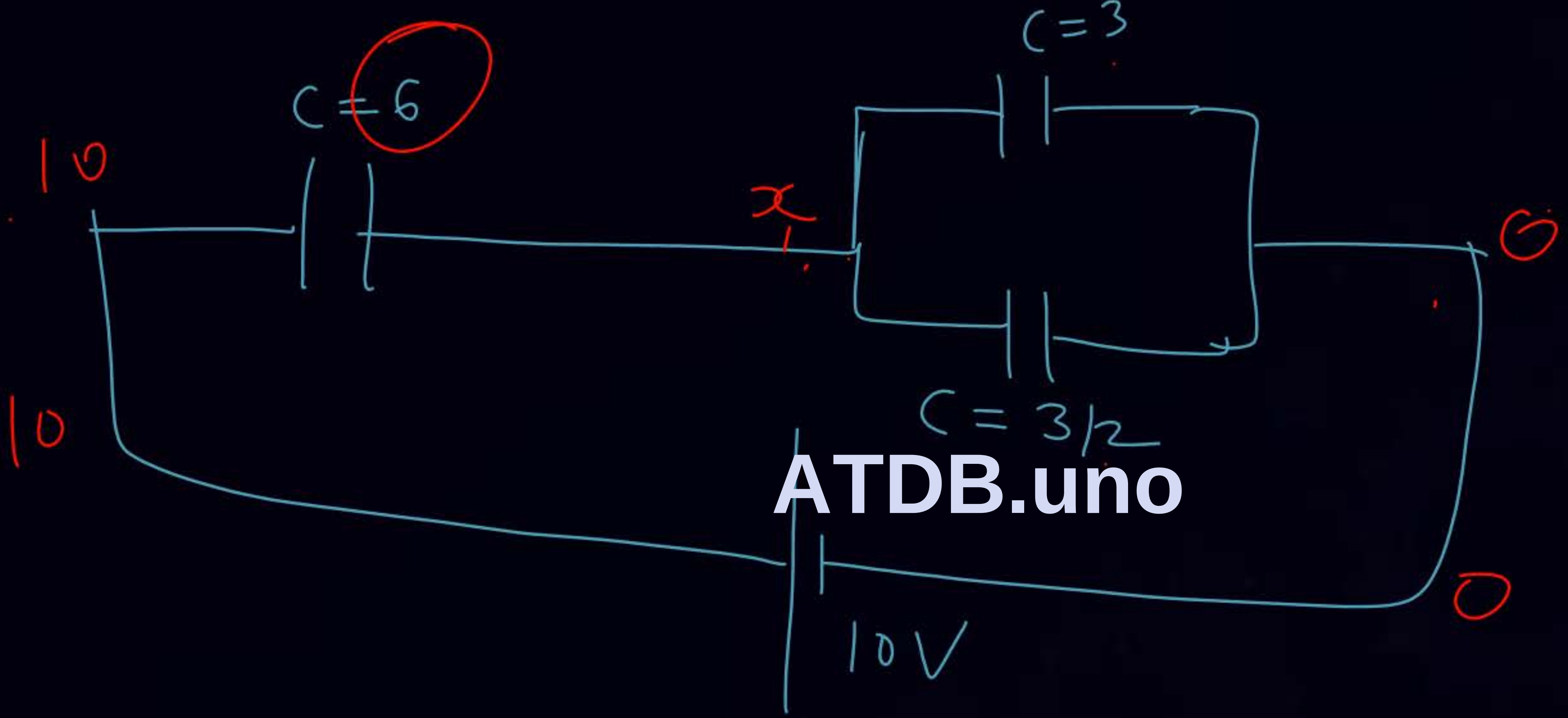
$= 300$



$$(C_{eq})_{new} = 3$$

$$q_{नया} = 3 \times 10 = +30$$

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



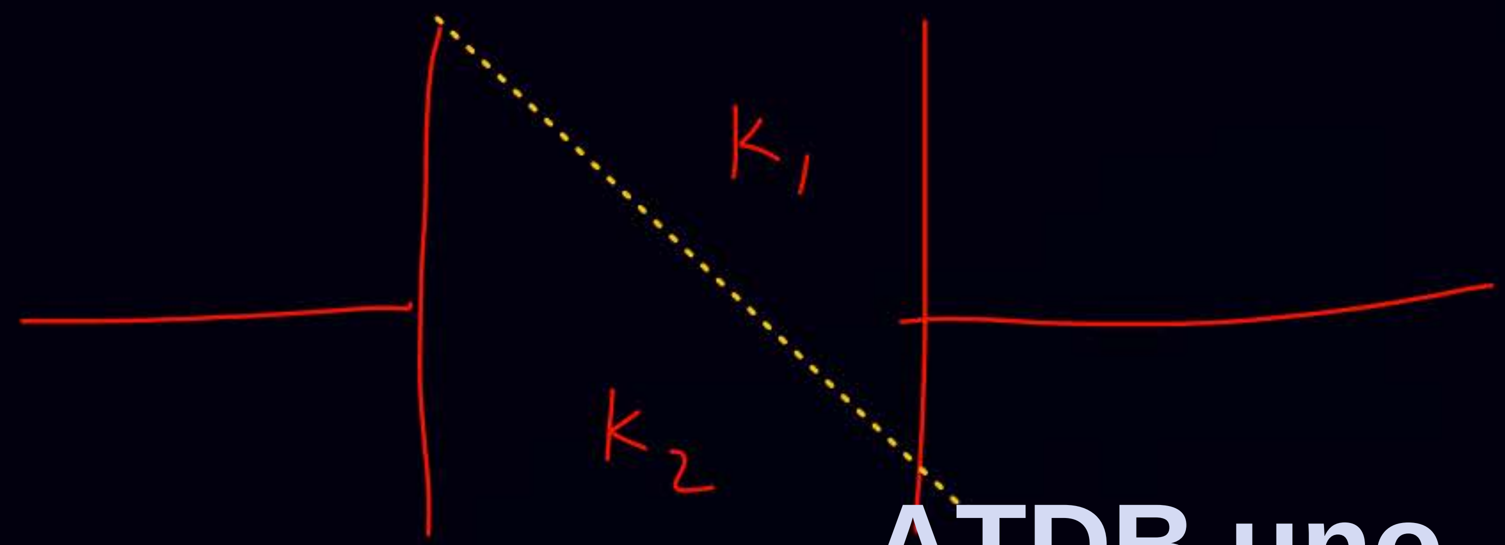
$$C_{\text{उपर}} = \frac{A/2 \cdot \epsilon_0 K}{d}$$

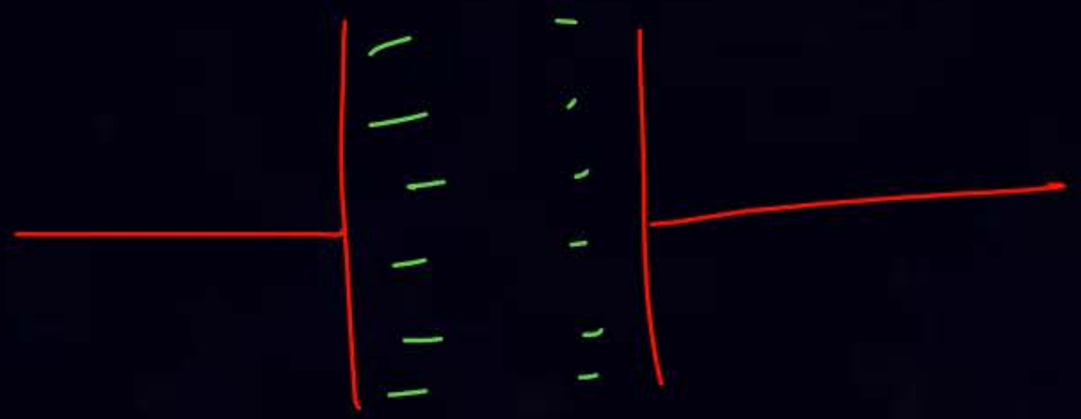
$$= \frac{A\epsilon_0}{d}\,\frac{K}{2}$$

$$= 3 \times \frac{2}{2} = 3$$

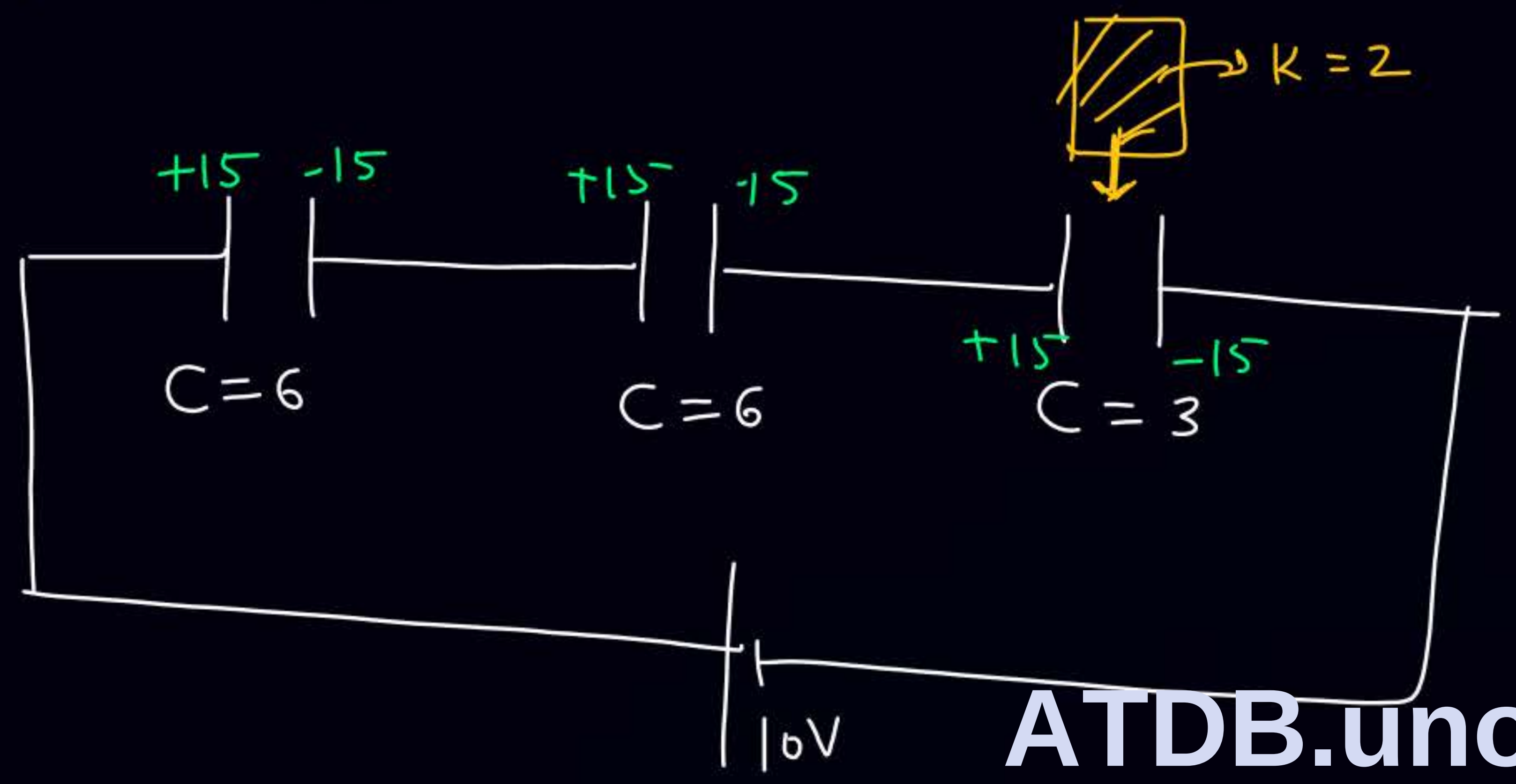
$$\frac{\frac{A}{2}\epsilon_0}{d}$$

$$K = K_1 + K_2 y$$





Q

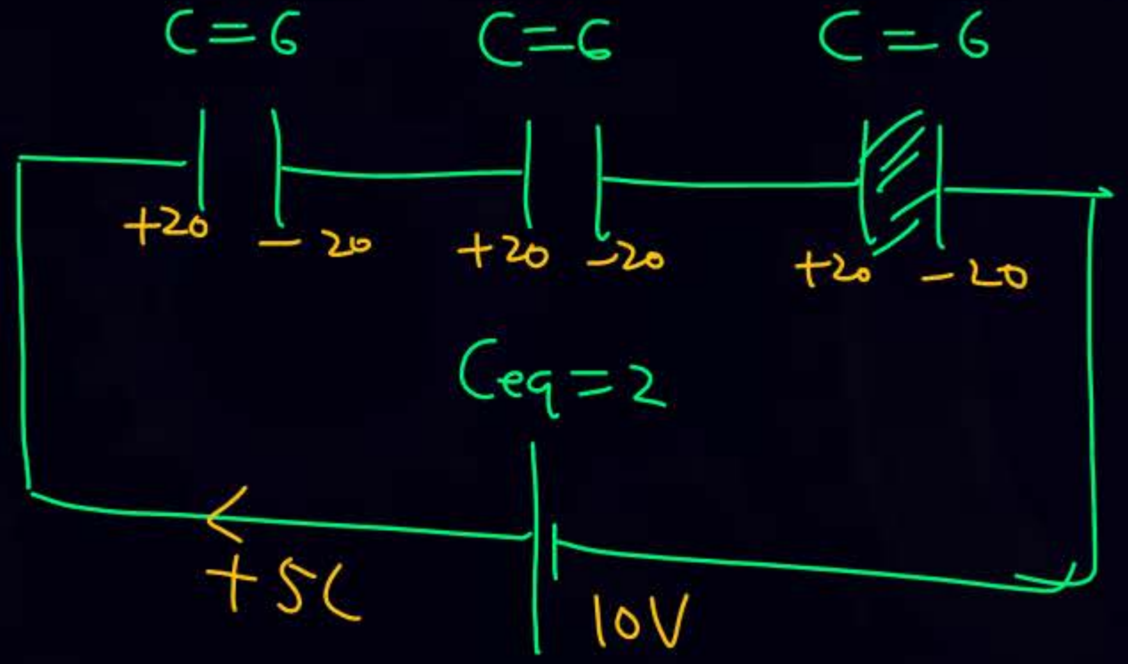


$C_{eq} = \frac{3}{2}$

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

① $(WD)_{\text{by battery}} = +5 \times 10 = 50$

② Charge flow through battery $= +5C$

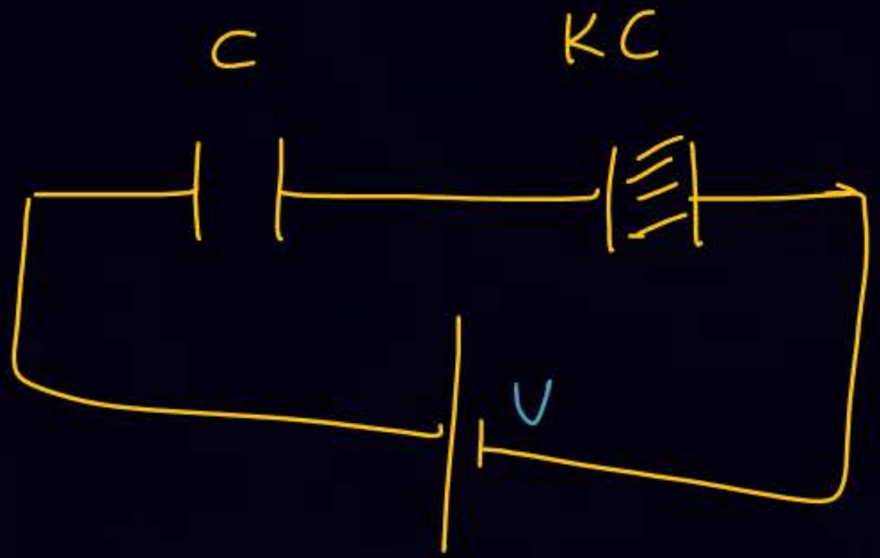


home

Sheet

Q

—



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

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

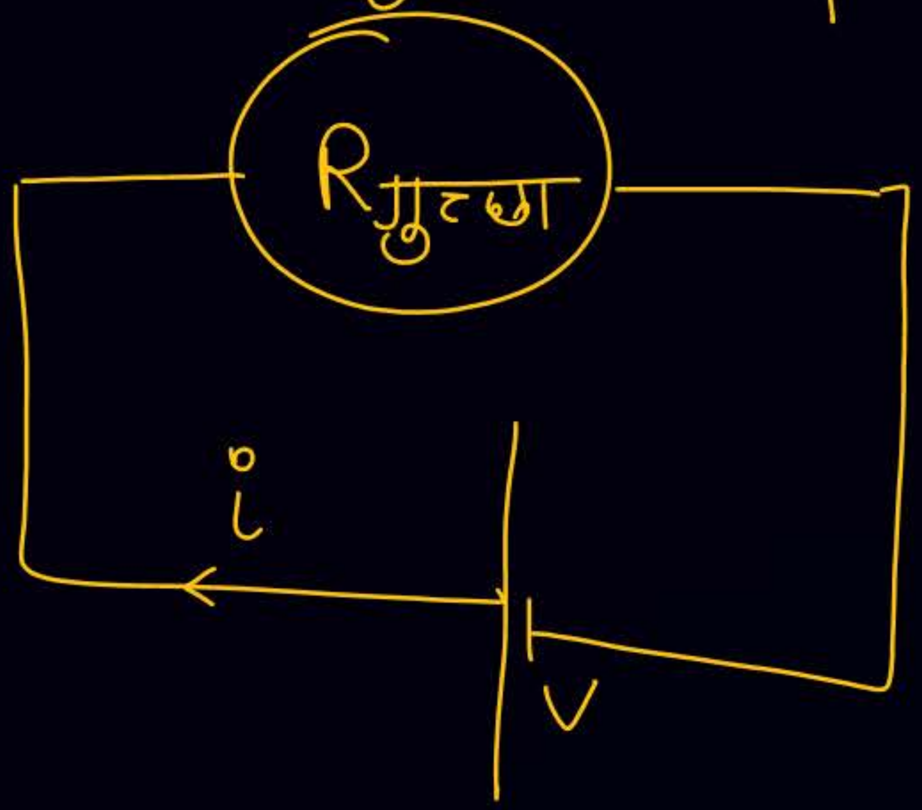
$$C_{eq} = \frac{C.(KC)}{C+KC} = \left(\frac{K}{K+1}\right) C$$

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

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

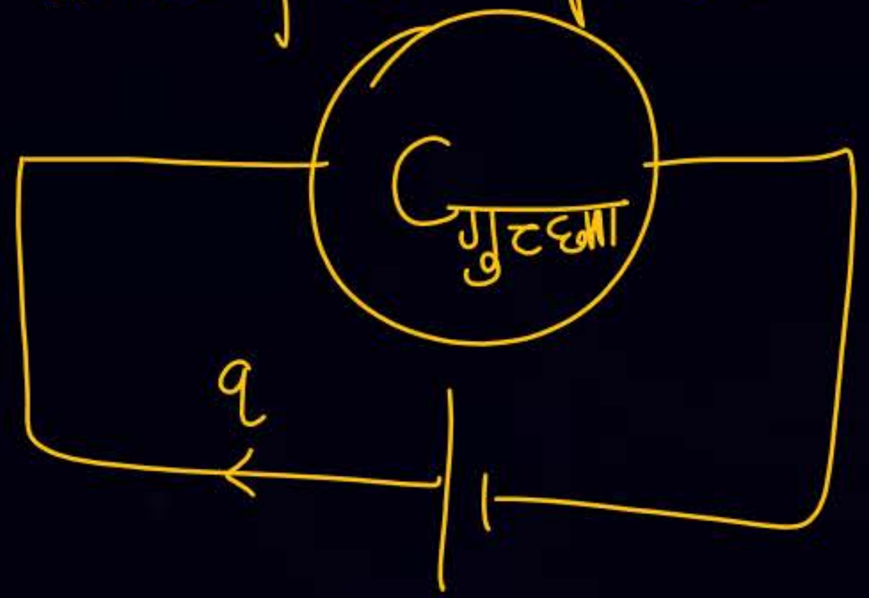
$$R_{\text{गुटखा}} = R_{eq.}$$

#



$$i = \frac{V}{R_{\text{गुटखा}}} \qquad V = i R_{\text{गुटखा}}$$

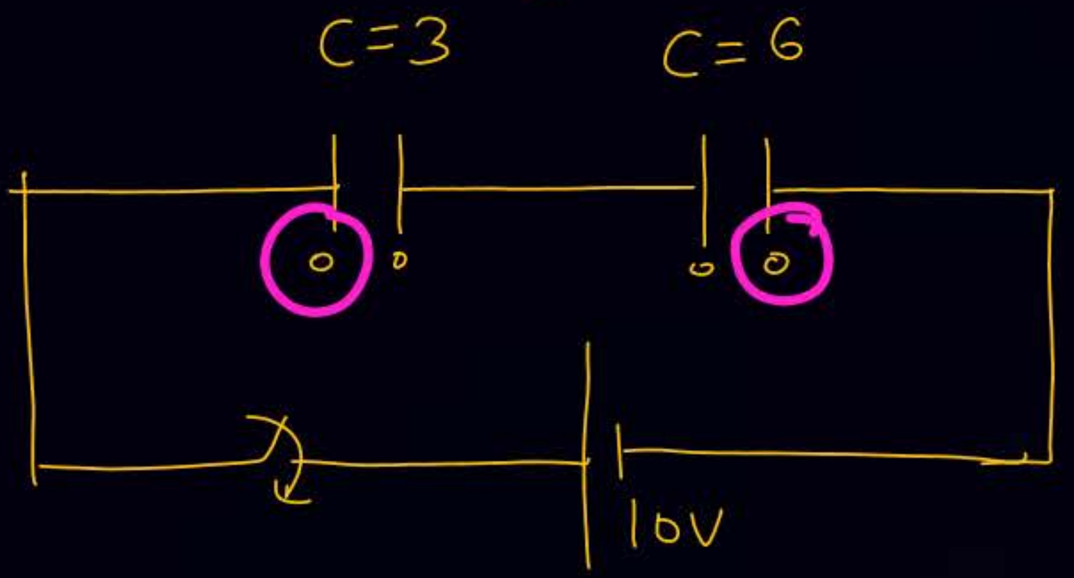
Initially all Cap. Uncharge



$$q = C_{eq} V = C_{\text{गुटखा}} V$$

(Series ≡ Q → same)

Q



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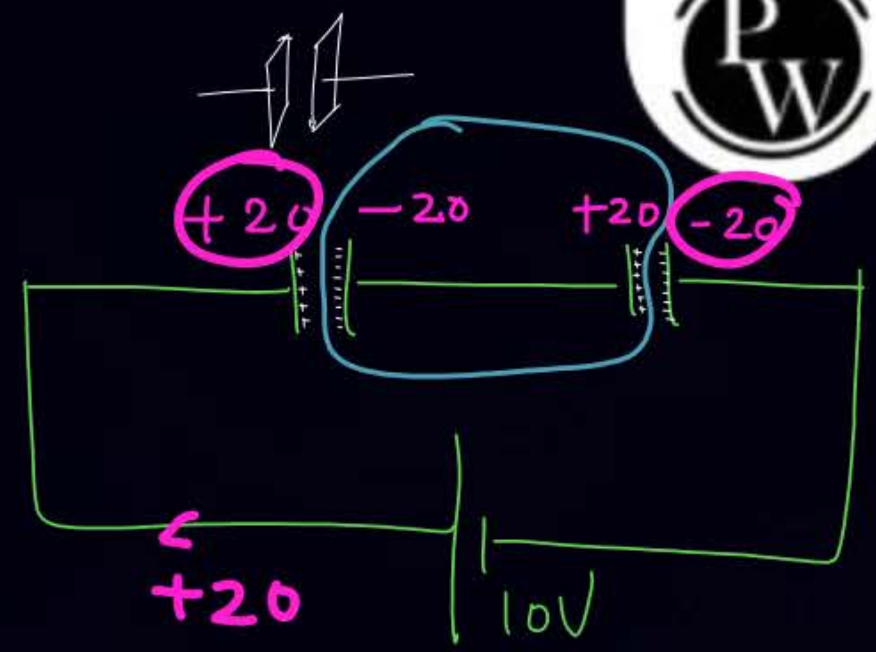
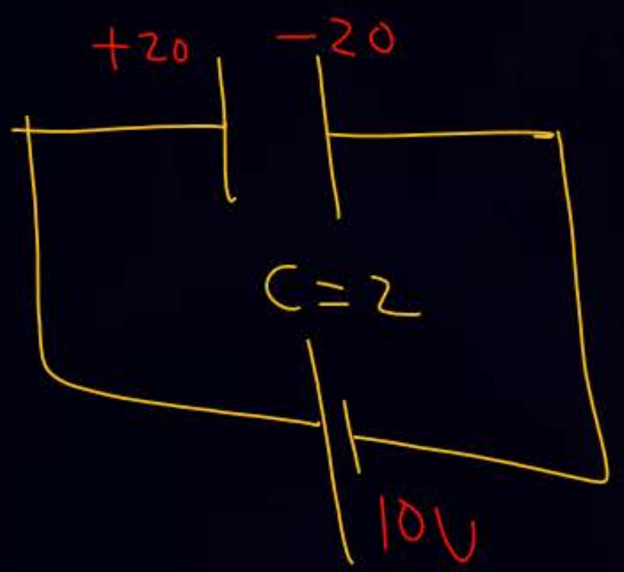
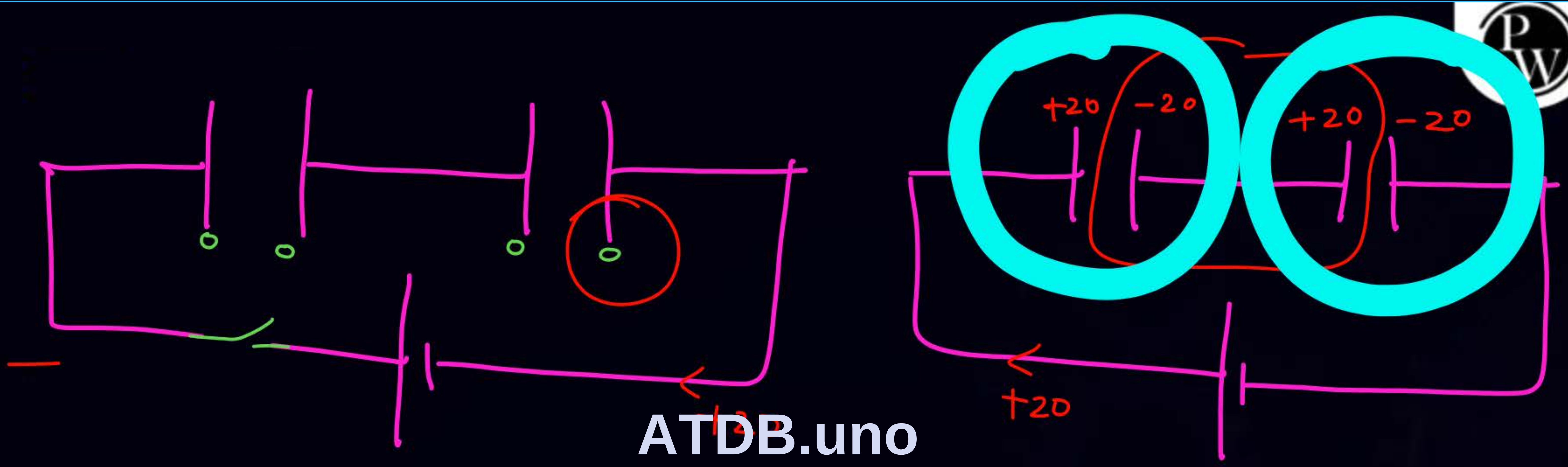


$Q = C_{eq} V$

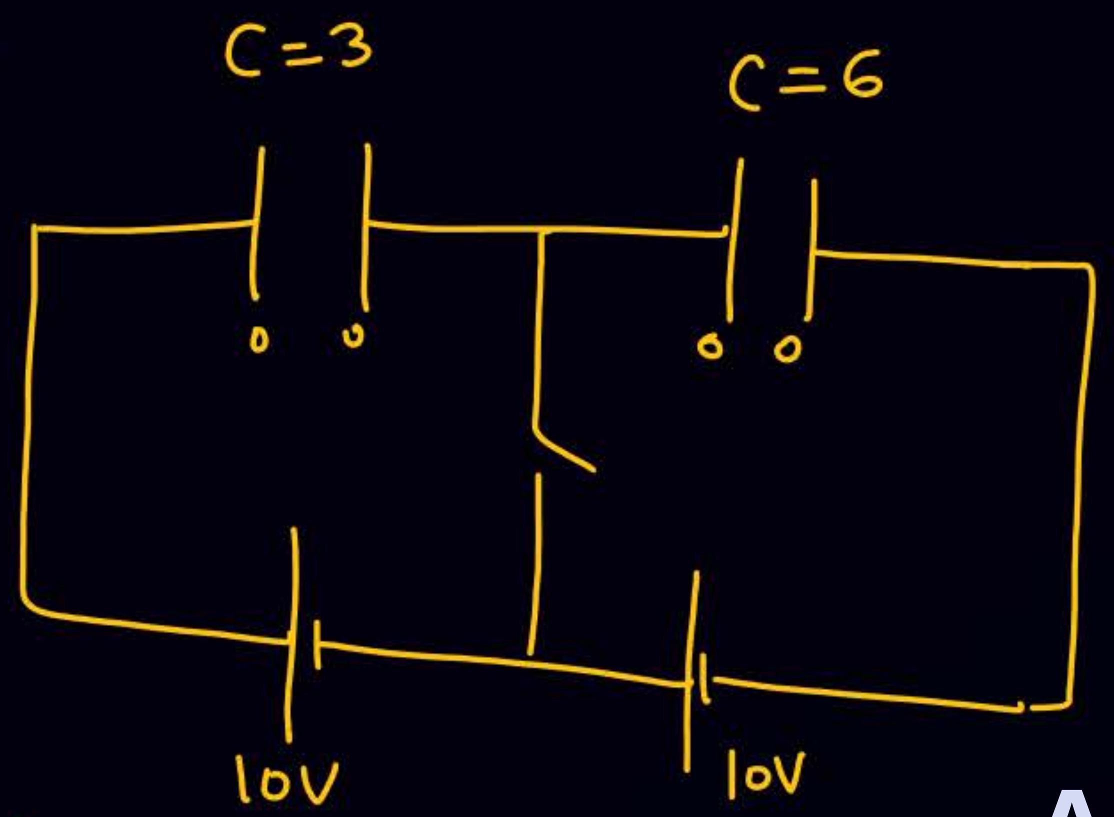
$C_{eq} = \frac{3 \times 6}{3+6} = 2$

10




+20
−20
+20
−20
+20

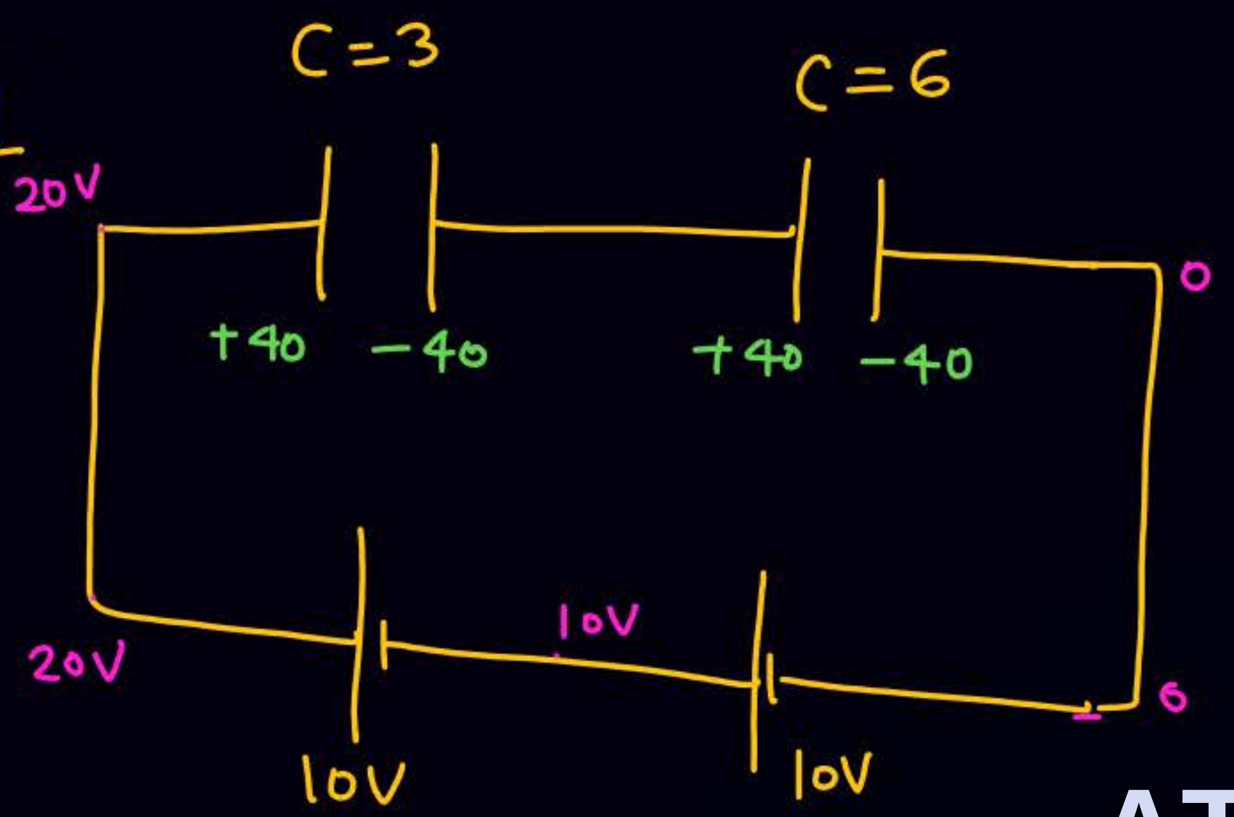
Q



find ① charge flow through switch when switch is closed = 30 C

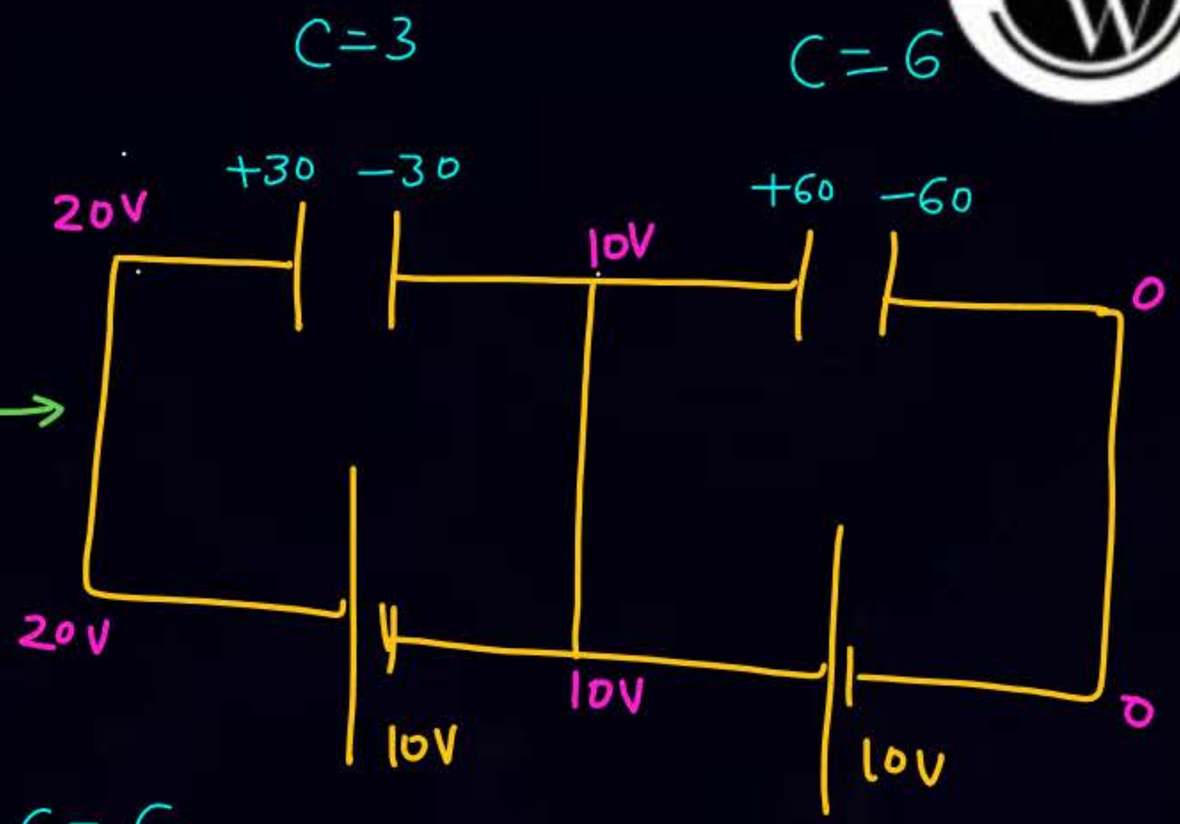
② (WD) by battery (both) & heat loss after switch close.

Q



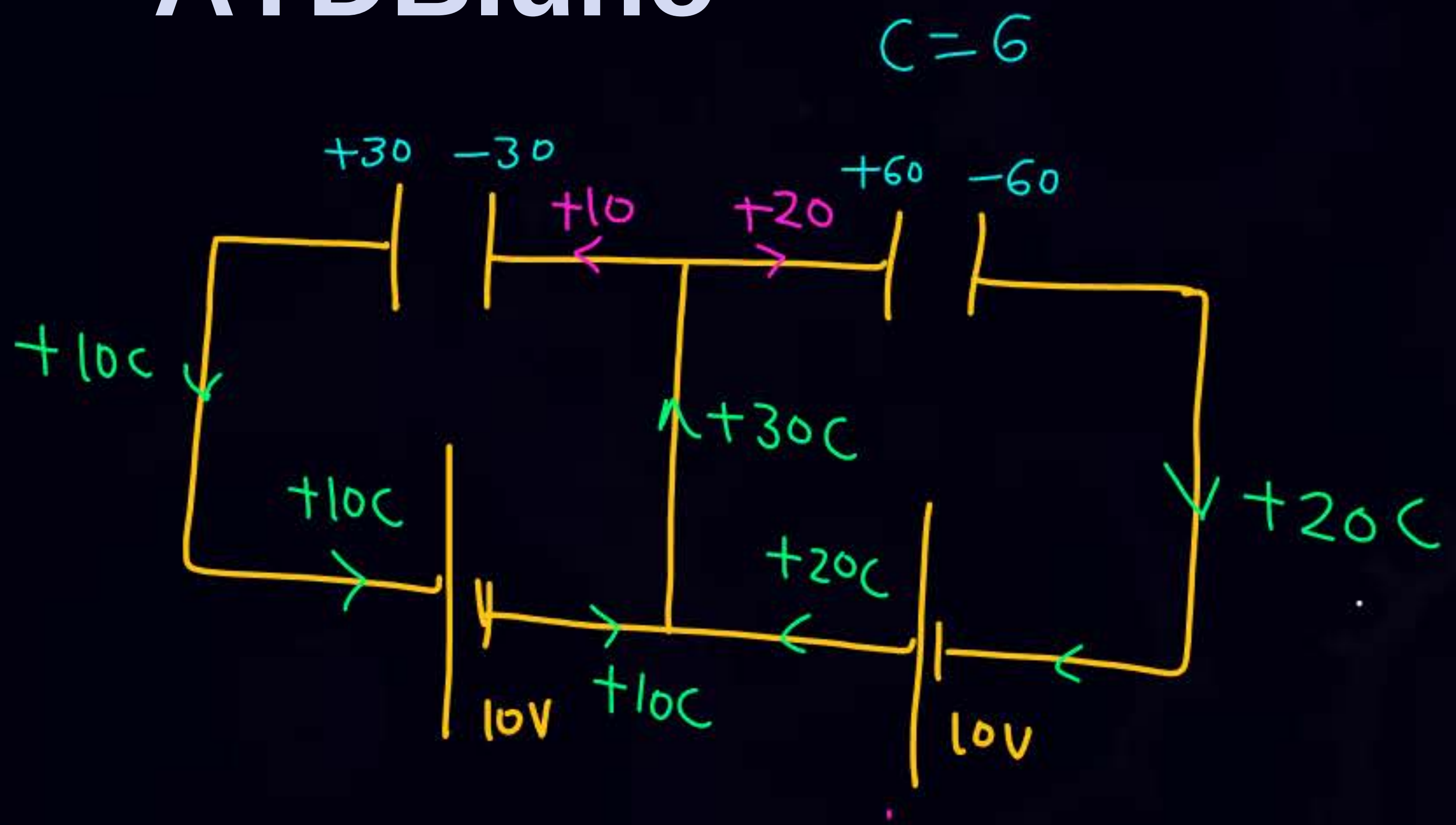
Solⁿ

switch close



$$(WD)_{left} = -10 \times 10 = -100$$

$$(WD)_{right} = +20 \times 10 = +200$$



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

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

30. A charge of $+2 \cdot 0 \times 10^{-8}$ C is placed on the positive plate and a charge of $-1 \cdot 0 \times 10^{-8}$ C on the negative plate of a parallel-plate capacitor of capacitance $1 \cdot 2 \times 10^{-3}$ μF.

Calculate the potential difference developed between the plates.

Ans. 12.5 V

31. A charge of 20 μC is placed on the positive plate of an isolated parallel-plate capacitor of capacitance 10 μF. Calculate the potential difference developed between the plates.

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.

Ans. (a) 1·71 V, 4·29 V (b) 184 pJ, 73·5 pJ

37. Two capacitors of capacitances $4{\cdot}0\,\mu F$ and $6{\cdot}0\,\mu F$ are connected in series with a battery of 20 V. Find the energy supplied by the battery.

Ans. 960 μJ

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.

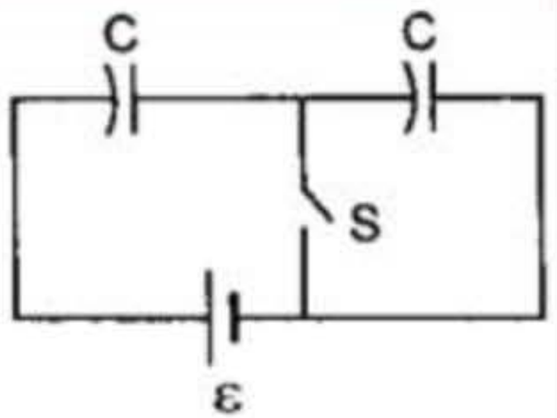


Figure 31-E23

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 μF 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.

Ans. 1.44 mJ

49. The two square faces of a rectangular dielectric slab (dielectric constant 4·0) of dimensions $20\ \text{cm} \times 20\ \text{cm} \times 1{\cdot}0\ \text{mm}$ are metal-coated. Find the capacitance between the coated surfaces.

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.

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.

Ans. 88 pF

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

Ans. 3

53. A parallel-plate capacitor of capacitance $5\,\mu F$ is connected to a battery of emf 6 V. The separation between the plates is 2 mm. (a) Find the charge on the positive plate. (b) Find the electric field between the plates. (c) A dielectric slab of thickness 1 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) $30\,\mu C$ (b) $3 \times 10^3\,V\,m^{-1}$ (c) $8{\cdot}3\,\mu F$ (d) $20\,\mu C$

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.

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.

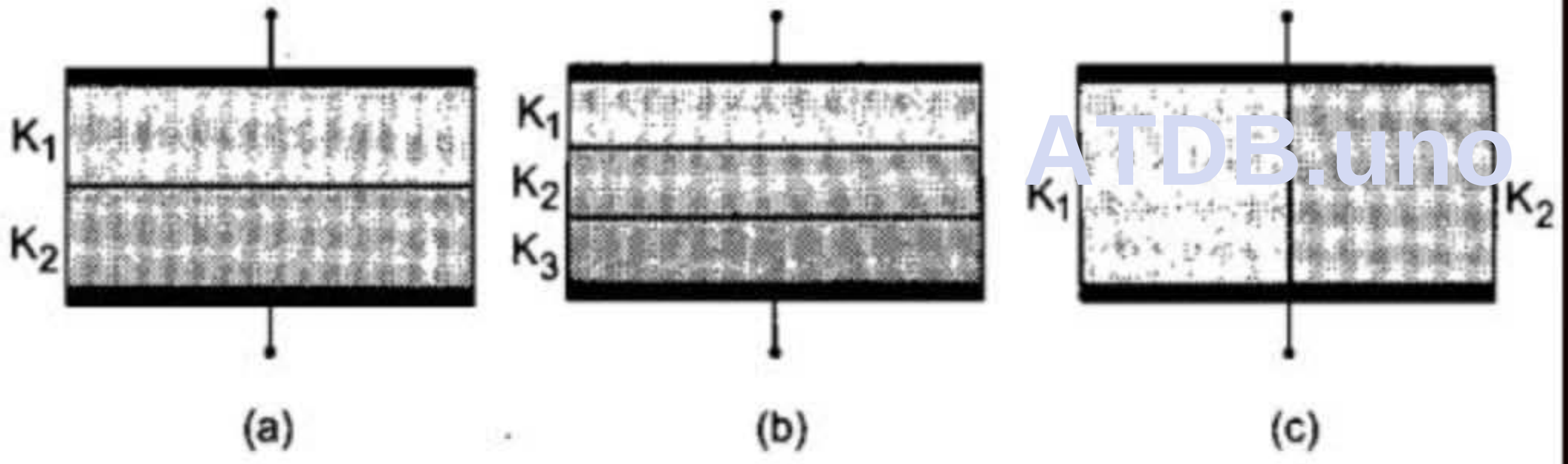


Figure 31-E24

Ans. (a) $\frac{2K_1K_2\varepsilon_0 A}{d(K_1+K_2)}$ (b) $\frac{3\varepsilon_0 A K_1K_2K_3}{d(K_1K_2+K_2K_3+K_3K_1)}$

(c) $\frac{\varepsilon_0 A}{[illegible]}(K_1+K_2)$

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.

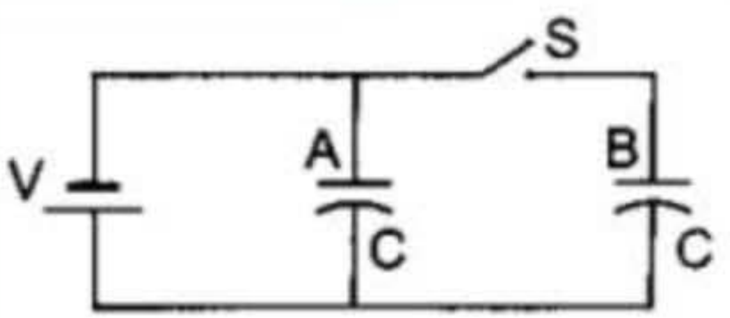


Figure 31-E26

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

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

Ans. (3)

QUESTION - 52

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

$\left\{\text{Use: } \frac{1}{4\pi\varepsilon_0} - 9 \times 10^9 \text{Nm}^2\text{c}^{-2}\right\}$ [JEE Mains-2022]

(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

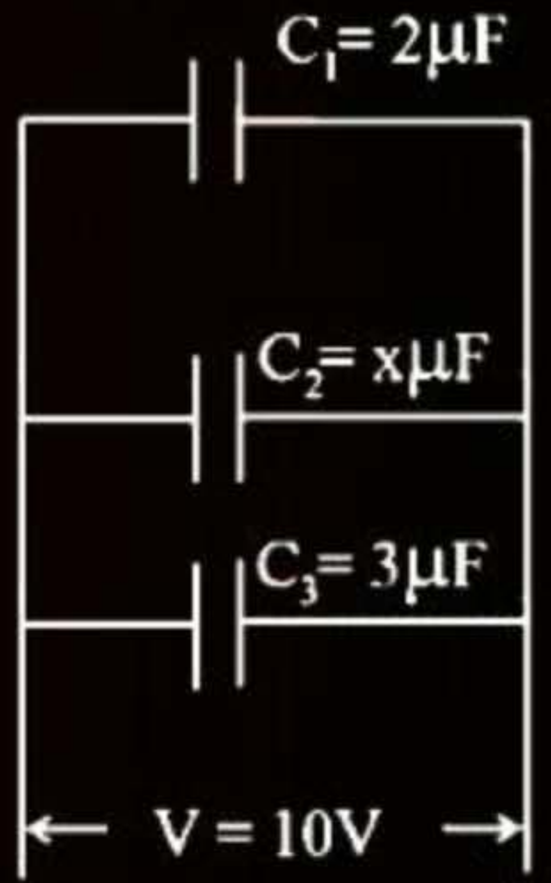
(4) 1 : 4

Ans. (3)

QUESTION - 73

In the given figure the total charge stored in the combination of capacitors is 100μC. The value of 'x' is ______.

[15 April 2023 - Shift 1]



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]

Ans (2)

Home Work

- DPP
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THANK
YOU