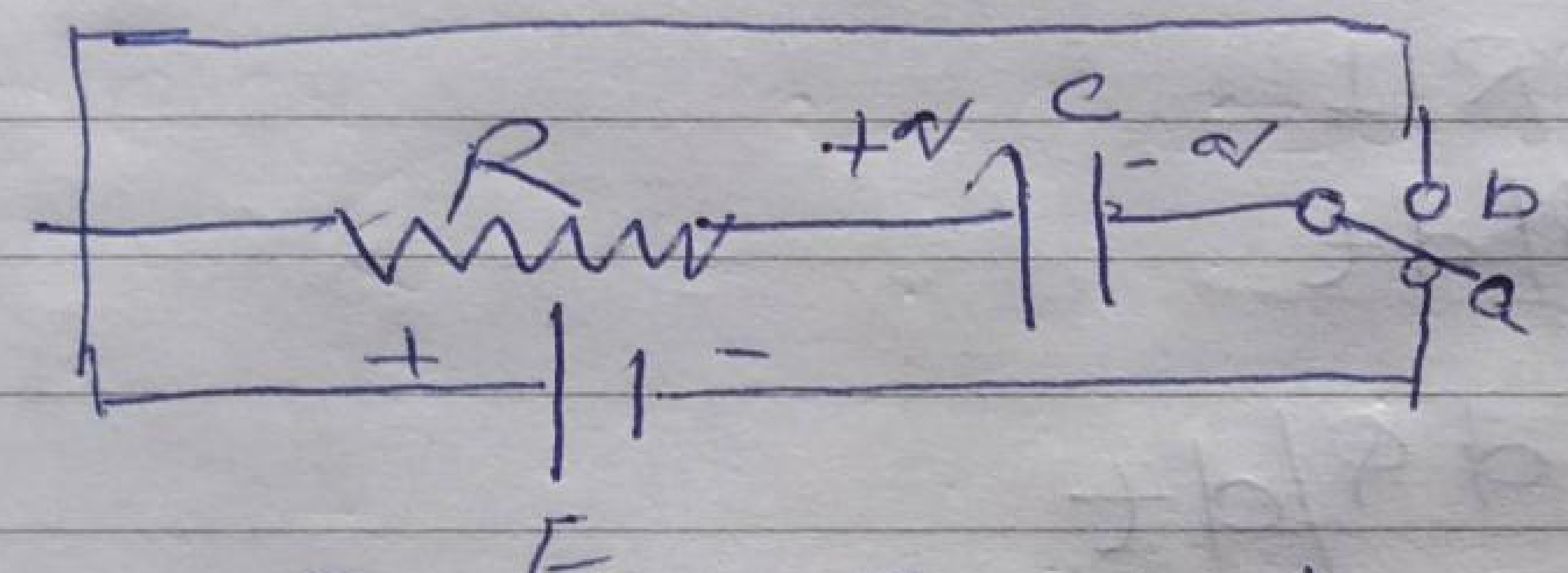
Que → Charging and discharging of capacitor (condenser) through a Resistance

or

Growth and decay of charge of a condenser (capacitor) through a Resistance.

Ans →



R = Resistance
C = Capacitor
E = Constant e.m.f of battery

Resistance (R) capacitor of capacitance (C) are connected with a battery of constant e.m.f E in series of circuit, when circuit is closed the current flowing in the circuit. The charging current ceases when the p.d between the plates of the capacitor becomes equal to the applied e.m.f E. Thus the charging of a capacitor involves the flow of varying current which is max^m at start and reduces to zero when the capacitor is fully charged.

At any instant t during charging if q is the charge on the capacitor plates.

the pot diff between them is Q/C. this acts opposite to the applied e.m.f E. The effective e.m.f at the instant t is $(E - Q/C)$

I — current flowing through R at any instant of time.

According to ohm's law

$$E - Q/C = RI$$

or $$I = dQ/dt$$

$$E - Q/C = R\,dQ/dt$$

$$dt = \frac{R\,dQ}{E - Q/C} = \frac{CR\,dQ}{EC - Q}$$

∴ Integrating it

$$\int dt = \int \frac{RC}{EC - Q}\,dQ$$

$$\therefore t = -CR \log_e (EC - Q) + A$$

where A is a constant of integration

At $t = 0$ $Q = 0$

$$\therefore A = CR \log_e CE$$

$$t = -CR \log_e (EC - Q) - \log_e (EC)$$

or $$\frac{-t}{CR} = \log_e \left(\frac{EC - Q}{EC}\right)$$

$$e^{-t/CR} = \frac{CE - Q}{CE} = 1 - \frac{Q}{CE}$$

$\therefore q = CE \left[1 - e^{-t/CR}\right]$

$\frac{Q-q}{Q_0} = e^{-t/cR}$ $\therefore$ $\boxed{Q = q_0 \left[1 - e^{-t/cR}\right]}$

$Q = CE$ The final steady charge

the rate of flow of charge

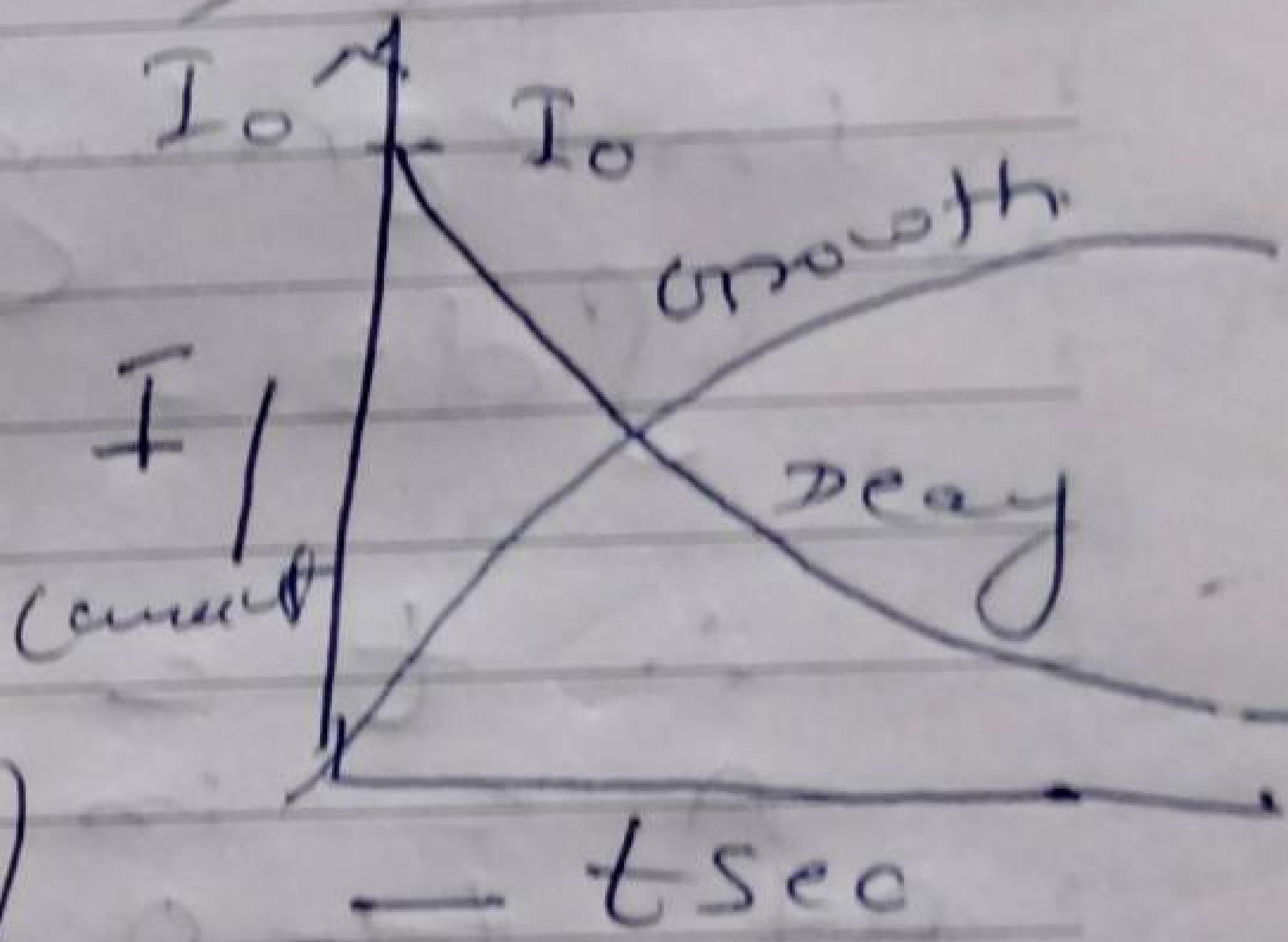
$dq/dt = \frac{Q_0}{cR} e^{-t/cR}$

$\therefore dq/dt = \frac{1}{cR} (Q_0 - q)$

$I = dq/dt$

$I_0 = \frac{Q}{cR}$

$\boxed{I = I_0 e^{-t/cR}}$



~~Charging~~. Growth of current in R-C circuit

at $t = CR$

$Q = Q_0(1 - e^{-1}) = 0.632\, Q_0$

The time taken by the charge to rise 2/3rd of its maxm steady value

Decay (Dischage) of capacitor) →

~~Charge~~ The capacitor is fully charged then circuit is open then the flow of charge or current and the capacitor is gradually charged

The discharging current ceases when the potential difference between the plates of the capacitor is reduced to zero. $E = 0$

$$E - q/C = R\,dq/dt$$

$$E = 0$$

$$-q/C = R\,dq/dt$$

$$dt = -\frac{RC}{q}\,dq = -RC\frac{dq}{q}$$

integrating it

$$\int dt = -RC\int dq/q$$

$$\therefore t = -RC\log_e q + A$$

A = integration const

At $t = 0$ $q = q_0$

$$A = +RC\log_e(q_0)$$

or $t = -(RC\log_e q + RC\log_e q_0)$

$$t = -RC\log_e(q/q_0)$$

$$\therefore q/q_0 = e^{-t/RC}$$

$$\boxed{Q = q_0 e^{-t/RC}}$$

$$I = \frac{dq}{dt} = \frac{Q}{RC}e^{-t/RC}$$

$$I = \frac{q}{RC} e^{-t/RC} = I_0 e^{-t/RC}$$

$$\boxed{I = I_0 e^{-t/RC}}$$

The charge and the discharge of a capacitor the current begins with its maxm value and decays exponentially to zero

Energy stored in the capacitor During charging

dq = An extra increase of charge on the capacitor.

The small amount of work done

$$dU = q/C \, dq.$$

total work done

$$U = \int dU = q/C \int dq.$$

$$U = \frac{1}{2} q^2/C = \frac{1}{2} C \, q^2/C^2$$

$$= \frac{1}{2} C E^2 \qquad \boxed{q/C = E}$$

$$\boxed{U = \frac{1}{2} C E^2}$$

The Energy dissipated during the charging of a capacitor →

$$q = q_0 [1 - e^{-t/RC}]$$

$$I = dq/dt = q_0/RC \, e^{-t/RC}$$

~~dq = [illegible]~~ = [illegible]

$d\omega$ = the energy dissipated in time dt

$$d\omega = I^2 R\, dt = \frac{Q_0^2 \cancel{R}}{C^2 R^{\cancel{2}}} e^{-2t/RC}\, dt$$

$$\therefore \omega = \frac{Q_0^2}{C^2 R} \int_0^\infty e^{-2t/RC}\, dt = \frac{1}{2}\frac{Q_0^2}{C}$$

$$\boxed{\omega = \frac{1}{2} Q_0 E}$$

which is independent of R