The time taken for the magnetic energy to reach 25% of its maximum value, when a solenoid of resistance R, inductance L is connected to a battery, is : (JEE MAIN 2021)

A infinite

B $\frac{L}{R}$ ln10

C $\frac{L}{R}$ ln2

D $\frac{L}{R}$ ln5

$i = i_0 e^{-t/\tau}$

2. Let ~~$i = i_0 \sin(\omega t)$~~ be the time varying current in the given L-R circuit (τ = time constant)

Max. magnetic energy = $\frac{1}{2} L i_0^2$

Here, magnetic energy = 25% (i.e. $\frac{1}{4}$) of max. value

$$\Rightarrow \frac{1}{2} L\left(i_0^2 e^{-2t/\tau}\right) = \frac{1}{4}\left(\frac{1}{2} L i_0^2\right)$$

$$\Rightarrow e^{-2t/\tau} = \frac{1}{4}$$

$$\Rightarrow 4 = e^{2t/\tau}$$

$$\Rightarrow \ln 4 = \ln_e e^{2t/\tau}$$

$$\Rightarrow 2\ln(2) = \frac{2t}{\tau} \quad \left(\text{where } \tau = \frac{L}{R}\right)$$

$$\Rightarrow \boxed{t = \frac{1}{R}\ln(2)} \longrightarrow \text{Option (c) is the answer}$$