Q1

$$-\frac{\hbar^2}{2m}\frac{d^2}{dx^2}A\left(\frac{x}{x_0}\right)e^{-x/x_0}+V(x)\frac{Ax}{x_0}e^{-x/x_0}=E\frac{x}{x_0}e^{-}$$

$$-\frac{\hbar^2 A}{2m}\frac{d}{dx}\left[\frac{1}{x_0}e^{-x/x_0}-\frac{x}{x_0^2}e^{-x/x_0}\right]+V(x)\frac{Ax}{x_0}e^{-x/x_0}=E\frac{x}{x_0}e^{-x/}$$

$$-\frac{\hbar^2}{2m}A\left[-\frac{1}{x_0^2}e^{-x/x_0}-\frac{1}{x_0^2}e^{-x/x_0}+\frac{x}{x_0^3}e^{-x/x_0}\right]+V(x)\frac{Ax}{x_0}e^{-x/x_0}=$$

$$E\,x/x_0\,e^{-x/}$$

$\div A\frac{x}{x_0}e^{-x/x_0}$ on both side

$$-\frac{\hbar^2}{2m}\left[-\frac{2}{x x_0}+\frac{1}{x_0^2}\right]+V(x)=E \longrightarrow (1)$$

at $x=\infty$ $V(x)=0$

$$\therefore -\frac{\hbar^2}{2m x_0^2}=E \rightarrow \text{use this in eqn (1)}$$

$$\therefore V(x)=\frac{-2\hbar^2}{2m x x_0}=\frac{-\hbar^2}{2x x_0}$$

$$-\frac{\hbar^2}{2m}\frac{d^2}{dx^2} A e^{-\frac{\sqrt{km}\,x^2}{2\hbar}} + 0.5\,k x^2 A e^{-\frac{\sqrt{km}\,x^2}{2\hbar}} = EAe^{\ldots}$$

$$-\frac{\hbar^2 A}{2m}\frac{d}{dx}\left[-\frac{\cancel{2}x\sqrt{km}}{\cancel{2}\hbar}\, e^{-\frac{\sqrt{km}\,x^2}{2\hbar}}\right] + \frac{1}{2}kx^2 A e^{-\frac{\sqrt{km}\,x^2}{2\hbar}} = EA e^{-\frac{\sqrt{km}\,x^2}{2\hbar}}$$

$$-\frac{\hbar^2}{2m} A \frac{\sqrt{km}}{\hbar}\left[-e^{-\frac{\sqrt{km}\,x^2}{2\hbar}} + \frac{\cancel{2}x^2\sqrt{km}}{\cancel{2}\hbar}\, e^{-\frac{\sqrt{km}\,x^2}{2\hbar}}\right. + \frac{1}{2}kx^2 A e^{-\frac{\sqrt{km}\,x^2}{2\hbar}} = EA e^{-\frac{\sqrt{km}\,x^2}{2\hbar}}$$

$$+\frac{\hbar^2}{2m} A \frac{\sqrt{km}}{\hbar}\, e^{-\frac{\sqrt{km}\,x^2}{2\hbar}} - \frac{\hbar^2}{2m}\frac{km\,x^2}{\hbar^2} A e^{-\frac{\sqrt{km}\,x^2}{2\hbar}} + \frac{1}{2}kx^2 A e^{-\frac{\sqrt{km}\,x^2}{2\hbar}} = EA e^{-\frac{\sqrt{km}\,x^2}{2\hbar}}$$

$$+\frac{\cancel{\hbar^2}}{\frac{2\cancel{m}}{\sqrt{m}}} A \frac{\sqrt{k\cancel{m}}}{\cancel{\hbar}}\, e^{-\frac{\sqrt{km}\,x^2}{2\hbar}} - \frac{1}{2}kx^2 A e^{-\frac{\sqrt{km}\,x^2}{2\hbar}} + \frac{1}{2}kx^2 A e^{-\frac{\sqrt{km}\,x^2}{2\hbar}} = EA e^{-\frac{\sqrt{km}\,x^2}{2\hbar}}$$

0 0

$$+\frac{\hbar}{2}\sqrt{\frac{k}{m}}\, A e^{-\frac{\sqrt{km}\,x^2}{2\hbar}} = EA e^{-\frac{\sqrt{km}\,x^2}{2\hbar}}$$

$$\therefore \boxed{E = \frac{1}{2}\hbar\sqrt{\frac{k}{m}}}$$

$$T = e^{-2k_2 L}$$

$$\ln T = -2k_2 L$$

Width of the barrier

$$L = -\frac{\ln T}{2k_2}$$

$$k_2 = \frac{\sqrt{2m(U_0 - E)}}{\hbar}$$

$$= \frac{-2.303 \log T}{2k_2}$$

$$L = \frac{-2.303 \times \hbar \times \log T}{\sqrt{2m(U_0 - E)}}$$

$$= \frac{-2.303 \times \hbar \times \log_{10} 10^{-3}}{\sqrt{2 \times 9.1 \times 10^{-31} \times (2-1) \times 1.602 \times 10^{-19}}}$$

$$= \frac{-2.303 \times 6.626 \times 10^{-34} \times -3 \times 1}{\sqrt{2 \times 9.1 \times 10^{-31} \times 1 \times 1.602 \times 10^{-19}}}$$

$$L = 1.4526 \times 10^{-8}\ m$$

$$\boxed{L = 14.526\ nm}$$

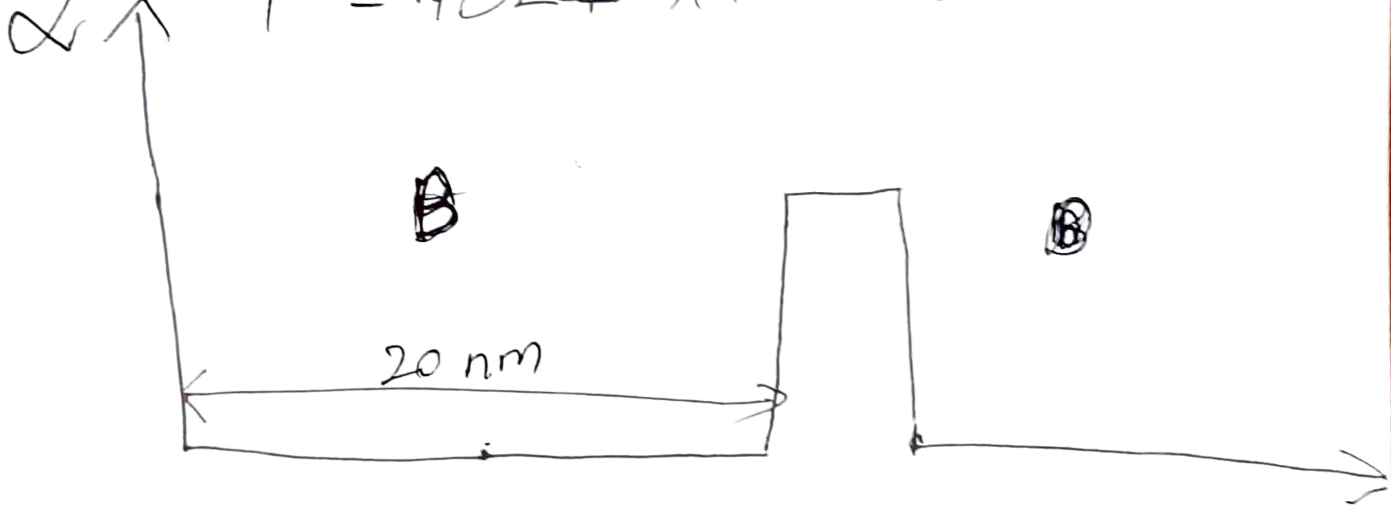
$$T = e^{-2k_2 L}$$

$$= e^{-2\frac{\sqrt{2m(U_0 - E)}}{\hbar} \times L}$$

$$= e^{-2\frac{\sqrt{2\times 9.1\times 10^{-31}\times(6-1)\times 1.602\times 10^{-19}}}{6.626\times 10^{-34}}\times 5\times 10^{-9}}$$

$$T = 1.8\times 10^{-50}$$

Q5



Q5) Transmission probability $T = e^{-2k_2 L}$

Here $L = 5 \times 10^{-9}$ m

$$k_2 = \frac{\sqrt{2m(V_0 - E)}}{\hbar}$$

to convert eV to J

$$= \frac{\sqrt{2 \times 9.1 \times 10^{-31} \times (6-1) \times 1.602 \times 10^{-19}}}{\frac{6.62 \times 10^{-34}}{2 \times 3.14}}$$

$$= \frac{2 \times 3.14 \times \sqrt{9.1 \times 10^{-30} \times 1.602 \times 10^{-19}}}{6.626 \times 10^{-34}}$$

$$k_2 = 1.145 \times 10^{10}$$

$$T = e^{-2 \times 1.145 \times 10^{10} \times 5 \times 10^{-9}}$$

$$= e^{-2 \times 5 \times 1.145 \times 10}$$

$$T = e^{-114.5}$$

$$\boxed{T = 1.876 \times 10^{-50}} \Rightarrow \frac{1}{T} = f = 5.[illegible] \times 10^{49}$$

~~So the particle has to hit the~~

So, $\frac{1}{T}$ gives the minimum frequency of hitting the barrier before it is escaping from the region B the particle is ~~a~~ having energy 1eV

velocity of the particle is given by

to convert eV-J

$$v = \sqrt{\frac{2E}{m}} = \sqrt{\frac{2 \times 1 \times 1.602 \times 10^{-19}}{9.1 \times 10^{-31}}}$$

$$\boxed{v = 5.93 \times 10^{5} \, m/s}$$

As given in the problem, the particle is at $x=0$ moving toward $-x$ direction at $t=0$.

$\therefore$ the particle has to travel (2×20nm) 40 nm before it hit the barrier 1 time.

~~So, it will be hitting the~~

To hit the barrier $5 \times 10^{49}$ times, it has to travell the distance of $\underbrace{5 \times 10^{49} \times 40 \times 10^{-9}}_{200 \times 10^{40}\,m}$ m

So, time taken by the particle to cover this distance is

$$t = \frac{d}{v} = \frac{200 \times 10^{40}}{5.93 \times 10^{5}} = 3.37 \times 10^{36}\, s$$

~~t~~