Question 9. Relativistic corrections become necessary when the expression for the kinetic energy 1/2 mv^2 , becomes comparable with mc^2. where m is the mass of the particle. At what de-Broglie wavelength, will relativistic corrections become important for an electron?
(a) A=10nm (b) A =10^{-1} nm (c) A=10^{-4} nm (d) A=10^{-6} nm

Ans-(c),(d)

Key concept: De-Brogile or matter wave is independent of die charge on the material particle. It means, matter wave of de-Broglie wave is associated with every moving particle (whether charged or uncharged). The de-Broglie wavelength at which relativistic corrections become important that the phase velocity of the matter waves can be greater than the speed of the light (3×10^8 m/s).

The wavelength of de-Broglie wave is given by

$\lambda = h/p = h/mv$

Here, $h = 6.6 \times 10^{-34}$ Js

and for electron, $m = 9 \times \mathbf{10^{-31}}$ kg

To approach these types of problem we use hit and trial method by picking up each option one by one.

In option (a), $\lambda_1 = 10$ nm $= 10 \times 10^{-9}$ m $\simeq 10^{-8}$ m

$$\Rightarrow \quad v_1 = \frac{6.6 \times 10^{-34}}{(9 \times 10^{-31}) \times 10^{-8}}$$

$$= \frac{2.2}{3} \times 10^5 \approx 10^5 \text{ m/s}$$

In option (b), $\lambda_2 = 10^{-1}$ nm $= 10^{-1} \times 10^{-9}$ m $= 10^{-10}$ m

$$\Rightarrow \quad v_2 = \frac{6.6 \times 10^{-34}}{(9 \times 10^{-31}) \times 10^{-10}} \approx 10^7 \text{ m/s}$$

In option (c), $\lambda_3 = 10^{-4}$ nm $= 10^{-4} \times 10^{-9}$ m $= 10^{-13}$ m

$$\Rightarrow \quad v_3 = \frac{6.6 \times 10^{-34}}{(9 \times 10^{-31}) \times 10^{-13}} \approx 10^{10} \text{ m/s}$$

In option (d), $\lambda_4 = 10^{-6}$ nm $= 10^{-6} \times 10^{-9}$ m $= 10^{-15}$ m

$$\Rightarrow \quad v_4 = \frac{6.6 \times 10^{-34}}{(9 \times 10^{-31}) \times 10^{-15}} \approx 10^{12} \text{ m/s}$$

Thus, options (c) and (d) are correct as v_3 and v_4 is greater than 3×10^8 m/s.