Question 13. A particle moves in a closed orbit around the origin, due to a force which is directed towards the origin. The de-BrOglie wavelength of the particle varies cyclically between two values λ_1, λ_2 with $\lambda_1 >$ λ_2 Which of the following statements are true?

(a) The particle could be moving in a circular orbit with origin as centre

(b) The particle could be moving in an elliptic orbit with origin as its focus

(c) When the de-Broglie wavetength is λ_1 the particle is nearer the origin than when its value is λ_2

(d) When the de-Broglie wavelength is λ_2 the particle is nearer the origin than when its value is λ_1

Solution:

(b, d) According to the question, here given that the de-Broglie wavelength of the particle can be varying cyclically between two values λ_1 and λ_2, it is possible if particle is moving in an elliptical orbit with origin as its one focus.
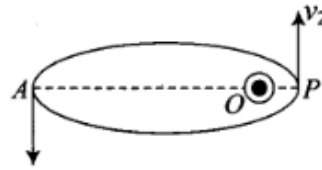
As shown in the figure given alongside,

Let v_1 and v_2 be the speed of particle at A and B respectively and origin is at focus O. If λ_1 and λ_2 are the de-Broglie wavelengths associated with particle while moving at A and B respectively, then

$$\lambda_1 = \frac{h}{mv_1}$$

and
$$\lambda_2 = \frac{h}{mv_2}$$

$$\therefore \quad \frac{\lambda_1}{\lambda_2} = \frac{v_2}{v_1}$$

Since $\quad \lambda_1 > \lambda_2$

$\therefore \qquad v_2 > v_1$

By law of conservation of angular momentum, the particle moves faster when it is closer to focus.

From figure, we note that origin O is closed to P than A.