CH107 Tutorial-3

Answers

1.

(a) $\psi(\theta) = \frac{1}{\sqrt{2\pi}} e^{\pm in\theta}$, where $n^2 = \frac{2I}{\hbar^2} E_n$.

(b) $E_n = \frac{\hbar^2 n^2}{2I}$

(c) $n = 0, \pm 1, \pm 2, \ldots\ldots$
(n is an integer)

2. $A = \sqrt{\frac{3}{4\pi}}$

3. Y_1^0 is an eigen function of operator $\hat{L}^2$;
Corresponding Eigen value $= 2\hbar^2$

4. (a) For hydrogen atom problem, Hamitonian can be expressed as a sum of Hamiltonian for centre of mass motion and relative motion between electron and neutron.

$$\hat{H}_{total} = \hat{H}_{CM} + \hat{H}_{rel}$$

$$\hat{H}_{rel} = \underbrace{-\frac{\hbar^2}{2\mu}\nabla_r^2}_{K.E} - \underbrace{\frac{Q Z e^2}{r}}_{P.E}$$

In potential energy operator there is a factor 'r' in the denominator.
$r = \sqrt{x^2+y^2+z^2}$

It is not possible to solve the Schrödinger equation by 'seperation of variable' method in x,y,z co-ordinate system, which lead to invoke spherical polar co-ordinates (r, θ, ϕ);

4.(b) For, rigid rotor, internuclear distance is constant. However in case of Hydrogen atom problem radius is not constant. In both cases there is contribution of angular part (θ, ϕ);

5. $$\hat{\nabla}^2 = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial}{\partial r}\right) - \frac{\hat{L}^2}{\hbar^2 r^2}$$

$\hat{L}^2 \rightarrow$ Total angular momentum operator.