Lecture-7

Application of Heisenberg's Uncertainty Principle:

i. The non-existence of free electron in the nucleus.

The diameter of nucleus of any atom is of the order of 10^{-14}m. If any electron is confined within the nucleus then the uncertainty in its position (Δx) must not be greater than 10^{-14}m.

According to Heisenberg's uncertainty principle,

$\Delta x\ \Delta p \geq h / 2\pi$

The uncertainty in momentum is

$\Delta p \geq h / 2\pi\Delta x$, where $\Delta x = 10^{-14}$ m

$\Delta p \geq (6.63 X 10^{-34}) / (2 X 3.14 X 10^{-14})$

i.e. $\Delta p \geq 1.055 X 10^{-20}$ kg-m /s

This is the uncertainty in the momentum of electron and then the momentum of the electron must be in the same order of magnitude.

ii. Width of spectral lines (Natural Broadening)

Whenever a photon interacts with matter the atoms get excited and the excited atom gives up its excess energy by emitting a photon of certain frequency which leads to the spectrum. The broadening in the spectral lines is observed due to the indeterminateness in the atomic energies. According to Heisenberg's uncertainty relation

$$\Delta E = \frac{h}{2\pi\ \Delta t}$$

where ΔE is the uncertainty in the measurement of energies and Δt is the mean life time of the level is finite (10^{-8} secs). Therefore ΔE must have a finite energy spread that means the energy levels are not sharp and hence the broadening of the spectral lines.