(ii) *Binding energy of an electron in atom*

The uncertainty in position Δx of the electron is of the order of $2R$ where R is the radius of the electron orbit. The corresponding uncertainty in momentum component Δpx is given by

$$\Delta px \geq \frac{h}{2\pi\, 2R}$$

$$|\vec{p}| \sim px \sim \Delta px \sim \frac{h}{2\pi 2R} \sim 0.527 \times 10^{-24} \text{ kg ms}^{-1}.$$

This is non-relativistic momentum for an electron. The kinetic energy K is given by

$$K = \frac{p^2}{2m_0} = \left(\frac{h}{4\pi R}\right)^2 \frac{1}{2m_0} = \frac{h^2}{32\pi^2 m_0 R^2}.$$

The potential energy of an electron in the field of nucleus $V = -\dfrac{Ze^2}{4\pi \in_0 R}$ where Z is the atomic number. The total energy of the electron in its orbit can be given by

$$E = K + V = \frac{h^2}{32\pi^2 m_0 R^2} - \frac{Ze^2}{4\pi \in_0 R}$$

$$E = \frac{10^{-20}}{R^2} - \frac{15\times 10^{-10} Z}{R} \text{ eV}.$$

Taking $R = 10^{-10}$ m, $E = (1\text{–}15\ z)$ eV $= (-15\ Z)$ eV.

The binding energy of outermost electrons in H and He are –13.6 and –24.6 eV respectively which is comparable to the binding energy derived from uncertainty principle.