Heisenberg's Uncertainity Principle:-

This Principle was discovered by Heisenberg in 1927. It states that we can measure either position or momentum of a particle with any desired degree of accuracy (within limit of experimental Equipment). OR

It is impossible to measure both position and momentum simultaneously with accuracy.

$$\Delta x \cdot \Delta P_x \geq \frac{h}{4\pi}$$

Δx → Uncertainity in position.
ΔP → Uncertainity in momentum.

Physical significance!

I) Uncertainity principle Explain why it is possible for Radiation and Matter to have dual (wave-particle) character.

II) It also make it clear that we can predict only the probable behaviour of quantum mechanical system not the Exact behaviour.

III) It helps in understanding many phenomenon like absence of electron within Nuclei, natural broadening of spectral lines etc.

Energy Momentum Uncertainity:-

The uncertainity relation for simultaneous measurement of Energy E & time t expressed as.

$$\Delta E \cdot \Delta t \geq \frac{\hbar}{2} \qquad \left(\hbar = \frac{h}{2\pi}\right)$$

Derivation: let us consider a microparticle moving with velocity v, Its kinetic Energy willbe.

$$E = \frac{1}{2} m v^2$$

$$\Delta E = \Delta\left(\frac{1}{2} m v^2\right)$$

$$= m v \Delta v = v \Delta P$$

$$\left(v = \frac{\Delta x}{\Delta t}\right)$$

$$\Rightarrow \Delta E = \frac{\Delta x}{\Delta t} \Delta P$$

$$\Delta E \cdot \Delta t = \Delta x \cdot \Delta P$$

$$\boxed{\Delta E \cdot \Delta t \geq \frac{\hbar}{2}}$$

or $\boxed{\Delta x \cdot \Delta P \geq \frac{\hbar}{2}}$