TDC Part I
Subsidiary
Inorganic Chemistry

Department of Chemistry

L.S COLLEGE MUZAFFARPUR
B. R. A. BIHAR UNIVERSITY
Dr. Priyanka

TOPIC:-de-Broglie equation

1.8 de-BROGLIE HYPOTHESIS

Einstein in 1905 suggested that light shows dual character, i.e. particle as well as wave nature. de-Broglie in 1923 extended Einstein's view and said that all the forms of matter like electrons, protons, neutrons, atoms, molecules, etc. also show dual character, he further said that wavelength (λ) of the moving particles of mass m and velocity vis given by

$$\lambda = \frac{h}{mv}$$

Where, h = Planck 's

constantm = mass

of electron

υ = velocity of electron

This equation is called as de-Broglie's wave equation and λ is called de-Broglie's wavelength.

Derivation of de-Broglie's equation:

We know that the energy (E) of a photon is given by E = hv............. (1)

$$\text{i.e } \upsilon = \frac{c}{\lambda}$$

Putting the value of υ in equation number (1)

$$E = h.\frac{c}{\lambda}\text{..............(2) (According to Planck's Quantum theory).}$$

According to Einstein's equation

$$E = mc^2 \text{ .... (3)}$$

Here, **c =** velocity of light

λ = wave length

m **=** mass of protonOn combining the above equation (2) and (3) we get

$$mc^2 = h\frac{c}{\lambda}$$

$$mc = \frac{h}{\lambda}$$

$$h = \lambda mc$$

$$\lambda = \frac{h}{m \times c} \text{.....................} (4)$$

Thus for another particle moving with a velocity **υ** then,

$$\lambda = \frac{h}{m \times v}$$

We know that m • v = ρ

$$\lambda = \frac{h}{\rho} \text{.............} (5)$$

Where ρ = momentum of the particles.

The equation (4) is known as de-Broglie's wave equation.

Experimental verification of de-Broglie's wave equation:

If an electron of charge**e** is accelerated by an applied potential, **v** (ES units), i.e. kinetic energy (KE) is given by:

$$KE = V_e \text{.........} (1),$$

Also the magnitude of KE of an electron moving with a velocity **υ** is also given by;

$$KE = \frac{1}{2} mv^2 \text{............} (2)$$

On combining these two relations we have,

$$KE = V_e = \frac{1}{2} mv^2$$

Or

$$\upsilon = \sqrt{ve/m}$$

Now on putting the value of **υ** obtained as above in de- Broglie's equation –

$$\lambda = \frac{h}{mv}$$

We get, $\lambda = \frac{h}{\sqrt{\frac{2ve}{m}}}$

On putting the value of h = $6.624 \bullet 10^{-34}$ Js, e = 1.602×10^{-31} kg, the above equation becomes

$$\lambda = \frac{12.26}{\sqrt{V\ volts}}\ A^0 \text{ (de- Broglie's equation)}$$

If a potential difference of 10 volts is applied the wavelength **λ** of the e^- wave emerging out would be equal to 3.877 A^0. Similarly if the potential difference is varied between 10 and 10000 volts, λ would vary between 3.877 A^0 and 0.1226 A^0. It is well-known that X- Rays have the wavelength in this range.

1.9 HEISENBERG'S UNCERTAINTY PRINCIPLES

According to this principle it is not possible to determine simultaneously and precisely both the position and momentum (or velocity) of a microscopic moving particle like electron, proton etc.Thus from the above discussion Heisenberg gives a mathematical treatment which can be expressed as:

$$\bullet x \text{ X} \bullet p \geq \frac{h}{4\pi} \text{ ....(1)}$$

Where •x = uncertainty position, •p = uncertainty momentum and h = Planck's constant, the sign≥ means that the product of •x and •p is equal and greater than $\frac{h}{4\pi}$ but never less than $\frac{h}{4\pi}$.

The above equation shows •x and•p are inversely proportional to each other which means that•x is very small,•p would be large.

Similarly if an attempt is made to measure the momentum (velocity) of the particle exactly, the uncertainty in the measurement of its position becomes large.

So the equation (1) can be written as:

$$\bullet x \text{ X} \bullet p = \frac{h}{4\pi} \text{ ....(2)}$$

We know that, $\Delta p = m \text{ X } \bullet v$;

Where m = mass of moving particle,

Δv = change in velocity

The equation (2) is also written as

$$\bullet x \text{ X } m \text{ X } \bullet v = \frac{h}{4\pi}$$

$$\bullet x \text{ X } \bullet v = \frac{h}{4\pi m}$$