E-NOTE FOR PHYSICS SS 3 WEEK 3 OF TERM 3 2020 SESSION

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TERM/ WEEK : THREE / WEEK 3

SUBJECT: PHYSICS

CLASS: SS 3

TOPIC: WAVE PARTICLE PARADOX

WAVE PARTICLE DUALITY OF MATTER

This statement implies that matter can exist as wave or as particle but not as the two simultaneously.

This means that matter can behave at one time as wave and at another time as particle.

There are various evidences and properties that show the behavior of matter in this manner;

The following properties of matter shows its behaviors as a particle, Particle nature such as

1 Photo-electricity/ photoelectric effect

2 Compton effect

3 momentum

3 radiation of energy from hot bodies

4 emission and absorption of light.

5 thermionic emission .

The following properties of matter shows its behavior as wave, these are:

1 reflection

2 refraction

3 diffraction

4 interference

5 polarization

The two aspects , waves and particle are linked through the two relations

$$E = hf$$

&

$$p = h/\lambda$$

$$\lambda = h/mv$$

Where; E = energy of the particle

P = momentum of the particle.

h = planck's constant = 6.63×10^{-34}Js

m = mass of the particle

v = velocity of the particle

THE UNCERTAINTY PRINCIPLE

In general, the process of making a measurement tends to alter the quantity being measured. This is very much pronounced in very small scales such as the atomic and the nuclear scales. From the uncertainty principle, it is very impossible to make a precise measurement of both the position (x) and the momentum (p) of a particle simultaneously.

In fact the more precisely the location of the particle has to be specified , the more uncertainty is introduced into the determination of its momentum and conversely too.Any such measurement have inbuilt uncertainties. Δx in the position and Δp in the momentum. Such measurements can only be expressed as probabilities.

Heisenberg showed that

$$\Delta x \,.\, \Delta p \geq h$$

$$\Delta x \,.\, \Delta v \geq h$$

$$\Delta E \,.\, \Delta t \geq h$$

Hence ΔE, Δt, Δp and Δx are the uncertainty in the energy, time, momentum and position measurements.

1 Momentum and position

2 Energy and time

3 position and velocity,

Are all known as **COMPLEMENTARY VARIABLES.**

HEISENBERG UNCERTAINTY PRINCIPLE

“ States that it is impossible to know accurately, the exact position and momentum of a particle simultaneously. The uncertainty in the momentum multiplied by the uncertainty in the position is approximately equals the Planck’s constant, h”

Note

Because of the extremely small value of h ($6.63X10^{-34}Js$) the uncertainty principle is of no consequence for objects above atomic sizes.

PHOTOELECTRIC EFFECT AND EINSTEIN EQUATION

Electrons are ejected from a metal surface when electromagnetic radiation of sufficient frequency falls on a metal. A metal emits electrons provided that the wavelength of the radiation is less than a certain value. If the wavelength is too long, the electrons will not be emitted no matter the intensity and duration of the radiation. For example, when ultraviolet radiation of a particular frequency and wavelength falls on zinc, electron are emitted by the zinc atom.

PHOTOELECTRICITY: can be defined as the emission of electrons from ametal plate when it is illuminated by light of appropriate wavelength and frequency.

The maximum kinetic energy of the emitted electrons depends only on the frequency or wavelength of the incident light and not the intensity of the light beam.

WORK FUNCTION (W_0)

This is the minimum energy needed to pull out an electron from the surface of a metal.

THRESHOLD FREQUENCY (f_0)

This is the minimum frequency that must be exceeded for an electron emission to occur

THRESHOLD WAVELENGHT (λ_0)

This is the minimum wavelength that must be exceeded before electron emission can occur.

When a photon or quantum of light energy , E of hf is incident on a metal, part of the energy known as the work function liberates the electro from the metal , The remaining energy gives the liberated electron a kinetic energy of $1/2mv^2$. This process is represented by Einstein equation.

Energy of Photon = Work function + Kinetic Energy

$$hf = hf_0 + \frac{1}{2} m_e v^2$$

$$hf = hf_0 + eV$$

$$hf = hc/\lambda_0 + eV$$

where $w_0 = hf_0 = hc/\lambda_0$ = work function

λ_0 = Threshold wavelength

f_0 = threshold frequency

$E_k = 1/2m_e v^2 = eV$ = maximum kinetic energy (J)

Check this link for a you tube video

https://www.khanacademy.org/partner-content/bjc/2018-challenge/2018-challenge-physics/v/the-wave-