WEEK	TOPIC	CONTENT
1	SIMPLE A.C CIRCUITS	-Nomenclature in A.C circuits -Peak and r.m.s value -Resistance in an A.C circuit - Capacitance in an A.C circuit - Inductance in an A.C circuit
2	SIMLE A.C CIRCUIT CONT”D	-Resistance and impedance -Series circuit containing resistance, inductance and capacitance -Power in a.c circuit
3	MODELS OF AN ATOM	-Concept of the atom -The various model of the atom: Thomson, Rutherford, Bohr, Election Cloud models -Limitation of physical models
4	NUCLEUS	-Radioactivity-natural and artificial: i) Isotopes ii) Radioactive elements iii) Radioactive emission iv) Half-Life and decay constant
5	NUCLEUS CONT”D	-Transformation of electrons -Nuclear reaction: i) Fission ii) Fusion iii) Nuclear energy -Application of radioactivity -Nigeria nuclear energy programme
6	ENERGY QUANTIZATION	-Energy level in atoms i) Ground state ii) Excited state iii) Emission of light energy on return to ground state π atomic spectra)
7	ENERGY QUANTIZATION CONT”D	-Photo-electric effect - Einstein photo-electric equation and its explanation - X-ray: i) Production ii) Characteristics properties iii) Uses
8	DUALITY OF MATTER	-Wave nature of matter: i) Electron diffraction -particle nature of matter i) photo –electric effect ii) Compton effect -The uncertainty principle
9	PHYSICS TECHNOLOGY	-Constructing a battery -electroplating -Application of electromagnetic field i) construction of a galvanometer, an electric motor and generators
10	PHYSICS IN THE REAL WORLD	Construction of a model transmission system using a transformer -Need for use of machines in doing work i) Easier ii) Quicker II) more conveniently

		-instances of the use of machines i) At home ii) In offices iii) In industry iv) in agriculture v) in transportation etc. - Repairs and maintenance of machines i) Need for repairs of machines ii) Need for regular maintenance of machines iii) Maintenance schedule of machines
11	ENERGY AND SOCIETY	-Dams and Energy Production i) location of dams for producing electricity in Nigeria principle of production of electricity from a dam
12	ROCKETS AND SATELLITES	-Component parts of rockets and satellites -Functions of rockets and satellites -uses of rockets and satellites NIGERIAN SATELLITE -Nigeria Sat-1 I) Features of Niger Sat ii) Its operation and uses -NICOM SAT 1 i) Features of NICOM-SAT 1 ii) It operation and uses

WEEK 1/2

Ac CIRCUIT AND POWER IN AC CIRUIT

INTRODUCTION

A.c circuit is a circuit in which the current changes periodically or in which alternating current flows. Without alternating current, power transmission, radio, television and computer technology may have been impossible.

Nomenclature in alternating current circuit

The commonest form of alternating current circuit can be represented by

$I = I_o Sin(2\pi ft)$ or $I = I_o Sin\omega t$

$V = V_o Sin(2\pi ft)$ or $V = V_o Sin\omega t$

I is the instantaneous current

Io is the maximum or peak value of current or its amplitudes

V is the instantaneous voltage or its amplitude

F is the frequency

$\omega = 2\pi f$ is the angular velocity

$\omega t = 2\pi ft$ is the phase angle of the current

Root – mean – square value (r.m.s) is the effective current or voltage that will develop the same quantity of heat at the same time in the same resistance. Or r.m.s is the effective (average) value of current or voltage

Relationship between peak values and R.m.s

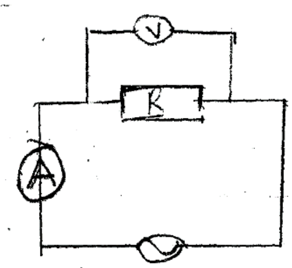
$I_{rms} = I_o/\sqrt{2}$

$V_{rms} = V_o/\sqrt{2}$

Resistance, capacitance and inductance in an A.C circuit

From ohm's law, I = V/R, but $V = V_o sin\omega t$

:. $I = \underline{Vosin\omega t} = V/R$



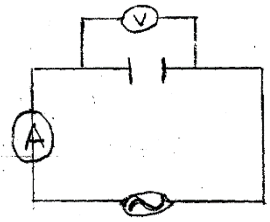
Resistor in an a.c circuit.

The voltage and current are said to be in phase or step with each other.

A voltmeter and an ammeter connected in the circuit will read r.m.s values of the voltage and current.

i.e. $I_{rms} = \frac{V_{rms}}{R}$

in a resistance in an a.c circuit

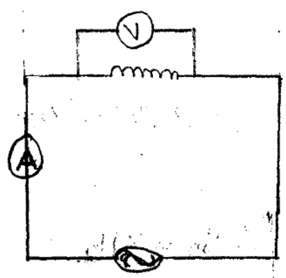


Capacitance in an a.c circuit

Considering another simple circuit with capacitor connected in series to the a.c voltage. The voltage and current are out of phase, i.e. they are not in step.

The current (I_c) leads the voltage (V_c) by 90^o or ($^\wedge/_2$) radians or by ¼ cycle.

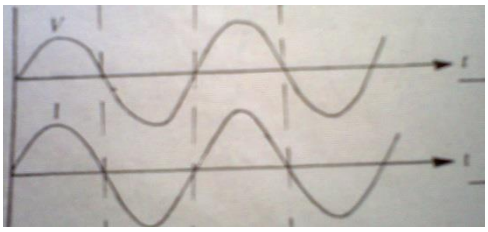
Thus, $V = V_o sin\omega t$, then $I = I_o sin(\omega t + ^\wedge/_2)$



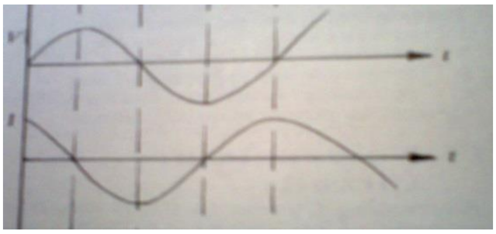
Inductance in an a.c circuit

When an inductor is connected in series in an a.c voltage circuit, the voltage (V_L) leads the current (I_L) by 90°
Thus, $V = V_o \sin\omega t$, then $I = I_o \sin(\omega t - ^\pi/_2)$

Wave form of Resistor, capacitor in an A.C circuit



Wave form of Resistor in an A.C circuit



Wave form of capacitor in an A.C circuit

REACTANCE

Inductive Reactance and Capacitive Reactance

The opposition offers by capacitor and inductor to the flow of current are known as capacitance reactance (x_c) and inducative reactance (x_L) respectively.

$Xc = \frac{1}{2\pi FC}$, $V = IX_c$
$X_L = 2\pi FL$, $V = IX_L$
Not also that
$X_c = V_o/I_o$ $X_L = V_o/I_o$
The units of Xc and X_L is the same as that of resistance, i.e. ohm's (Ω)

Calculation
1. The PHCN quoted that the power voltage supplied is 220V, what is the peak voltage

Solution

$V = Vo/\sqrt{2}$
or $Vo = \sqrt{2}V$
V = 220V
:. $Vo = 220 \times \sqrt{2}$
:. Vo = 311v

2. A supply of 240 r.m.s, F = 50Hz is connected to an inductor of 2H. calculate (a) the reactance of the inductor (b) the r.m.s value of current.

Solution

(a) $X_L = 2\pi FL$
F = 50Hz
L = 2H
$X_L = 2 \times \pi \times 50 \times 2$
$V = IX_L$
V = 240v
$X_L = 628\Omega$
(b) 240 = 628 x I
I = 240/628 = 0.4A r.m.s

3. In a radio circuit, a current of 4mA r.m.s, F = 1000Hz flows through a capacitor of 2μF in a circuit. Calculate π a) the reactance of the capacitor π b) the voltage across it.

SOLUTION

F = 100Hz
$C = 2\mu F = 2\times10^{-6}F$
$Xc = {}^1/_{2\pi FC}$
$Xc = {}^1/_{2\pi \times 1000 \times 2 \times 10^{-6}}$
= 79.56Ω

$V = I X_c$

I = 4mA

$X_c = 79.56\Omega$

V = 0.004 x 79.56 = 0.318v r.m.s

V = 0.318v r.m.s

Resonance Frequency

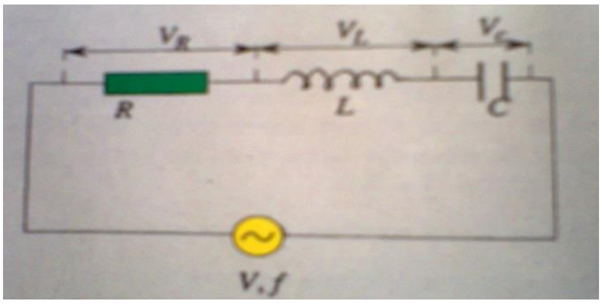
The frequency at which the inductive reactance (X_L) is equal to the capacitive reactance (X_c) is called resonance frequency.
At resonance
$Xc = X_L$
$1/2\pi FC = 2\pi FL$
$$F^2 = \frac{1}{4\pi^2 CL}$$

F = $\sqrt{\frac{1}{4\pi^2 CL}}$

:. F = ½π $\sqrt{1/_{CL}}$

IMPEDANCE

A practical a.c circuit normally contains all the three elements: the resistor (R), the capacitor (C) and indicator (L). let us consider the simplest case when the three elements are connected in series.



The overall resistance of circuit containing any two or three elements is called impedance. Impedance is therefore defined as the resistance offered by two or more elements, i.e. (resistor, inductor and capacitor).

Its unit is ohm (Ω). If V_{rms} is the effective voltage across the circuit carrying an effective current, I_{rms}, then

$$Z = {}^{Vrms}/_{Irms} = {}^{V}/_{I}$$

"Z" is the symbol for impedance

For two elements

Z = $\sqrt{R^2 + x_L^2}$ or Z = $\sqrt{R^2 + x_c^2}$

For phase angle, tan $\theta = \frac{X_L}{R}$ $or\ tan\ \theta = \frac{X_c}{R}$

Three Elements

Z = $\sqrt{R^2 + \pi\, x_L - X_c)^2}$

Phase angle, tan$\theta = \frac{V_L - V_c}{R} = \frac{X_L - X_c}{R}$

If X_L > Xc, ϕ is positive and the voltage leads the current

If X_L < Xc, ϕ is negative and the voltage lags the current

Calculation

A voltage of 40 rms, F = 100Hz is connected to a coil of inductance of 2H and negligible resistance in series with resistor R of 1000**Ω**. Calculate the (a) impedance (b) current flowing (c) voltage across L and R (d) phase angle.

Solution

Z = $\sqrt{R^2 + X_l^2}$

R = 1000Ω

X_L = 2πFL

= 2π x 100 x 2 = 1256Ω

:. Z = $\sqrt{1000^2 + 1256^2}$

= 1605Ω

$I_{rms} = V_{rms}$ $\frac{40}{X}$ = $\frac{0.025A}{1605}$

$V_L = IX_L$ = 0.025 x 1256 = 31.4v

V_R = IR = 0.025 x 1000 = 25v

tanθ = X_L/R = 1256/1000

= 1.256

θ = $\tan^{-1}$ (1.256) = 51.47°

In an a.c circuit a current of 2mA(rms), F = 1000Hz, flows in a series arrangement of an inductor 0.01H, a capacitor 60μF and a resistor of 10Ω. Calculate the voltage across the (a) whole circuit (b) inductor (c) phase angle.

SOLUTION

Z = $\sqrt{R^2 + \pi\, x_L - X_c)^2}$

X_L = 2πFL

= 2π x 1000 x 0.01 = 62.8Ω

Xc = $\frac{1}{2\pi f_c}$

Xc = $\frac{1}{2\pi\ x\ 1000\ x\ 610^{-6}}$ = 26.5Ω

:. Z = $\sqrt{10^2 + \pi\, 62.8 - 26.5^2}$)

= 37.6Ω

V = IZ

= 0.002 x 37.6 = 0.075v (r.m.s)

$$tan\theta = \frac{X_L - X_c}{R} = \frac{628 - 265}{10} = \frac{36.3}{10}$$

tan θ = 3.63

θ = $\tan^{-1}$ (3.63) = 74.6

Power in an A.C circuit containing resistor(R), inductor (L) and capacitor (C) i.e. (R-L-C circuit)

power is only developed at the resistor.

Power = IV = I^2R

For a.c, the instantaneous power dissipated is given by

P = $L^2{}_0R \sin^2\omega t$

Since L = Lo sinωt

i.e. P = I^2R ……… equ (1) or $L^2{}_oR$ $\sin^2\omega t$……… equ. (2)

A circuit consists of a capacitor of 2μf and a resistor of 1000Ω. An alternating emf of 12v rms and frequency 50Hz is applied. Find the

i. Current flowing
ii. Voltage across the capacitor
iii. Phase angle between the emf and current
iv. Average power supplied

Solution

Xc = 1/2πFC $\frac{1}{2\pi\ x\ 50\ x\ 2\ x\ 10^{-6}} = 1590\Omega$

Z = $\sqrt{1000^2 + 1600^2}$ = 1880Ω

i) I= V/Z = 12/1880 = 64 x 10^{-3}A

ii) Vc = IXc = 6.4 x 10^{-3} x 1590 = 10.2v

iii) Tan θ = **Xc/R =**$1590\Omega/1000$=1.59

or θ = $\tan^{-1}$ (1.59) = 58°

iv) power 1^2R = (6.4 x $10^{-3})^2$ x 1000 = 0.04w

:. Power = 0.04w

WEEK 3

ATOMIC MODEL

INTRODUCTION

Atomic theory gives moderately satisfactory explanation of the properties of matter, the mechanism of chemical change and the interaction of matter and energy.

John Dalton: John Dalton is generally credited as the father of atomic theory. Dalton viewed atom as:

i) being indestructible or indivisible
ii) being tiny hard spheres
iii) being the smallest component of matter

DISCREDIT OF DALTON'S ATOMIC THEORY

i) the discovery of radioactivity by Henry Becquerel showed that atoms are not indivisible or indestructible but can disintegrate forming atoms of different elements.

ii) The discovery of cathode rays in electric discharge tube by William Crookes showed that negatively charged electron are also component of the atom, hence it is not the smallest particles of matter.

By 1900, it was known that atoms contain electrons but on the whole, the atom was electrically neutral. Since atoms were electrically neutral, it means that there must exist within the atom positive charge to balance the negatively charge electrons.

Sir J.J Thomson an English Physicist to propose atomic theory

Sir J.J Thomson Atomic Models

i) He viewed atom as a homogeneous sphere of positive charge inside of which one embedded negatively charge electrons.

ii) He also established that the ratio of charge to mass (e/m) of electron to be same for all cathode-ray particles, irrespective of the gas type in the tube or the metal the electrodes are model of.

Ruther Ford Model (Planetary or nuclear model) – 1911

i) He viewed atom as consisting of a positively charged heavy core called the nucleus.

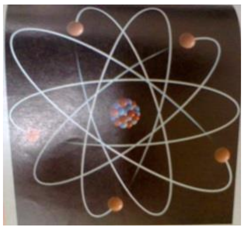
ii) Electron move in circle around the nucleus in orbit such as planet move around the sun

This model was a major step toward how we view atom today, it however, had two failures or problems or limitation.

LIMITATIONS OF RUTHERFOLD MODEL

i) It predicts that light of a continuous range of frequencies will be emitted from atoms, whereas experiment shows line spectra instead of continuous spectra.

ii) It predicts that atoms are unstable that electrons quickly spiral into the nucleus – but we know that atoms are generally stable.



Rutherford Planetary Model of atom

NEILS BOHR MODEL (The idea of energy quantization)

Neil's Bohr a Danish scientist suggested his own model in 1913 using hydrogen atom:

i) The electrons move around the nucleus in certain specific circular orbit (called energy levels), for which the angular momentum is quantized (i.e. have only discrete values). These possible orbits are called stationary states.

ii) The electrons in such stationary states can emit no radiation or less energy but can move about, but

iii) If an electron jumps from one energy level to a lower level, it emits a photon of light whose energy equals the difference in energy between the two states, i.e. $hf = E_1 - E_2$

Where h = Planck's constant, f = frequency of light emitted, E_1 and E_2 are upper and lower energy level respectively.

iv) The angular momentum L; of the atomic electron is quantized π i.e. they are restricted to a number of limited number of discrete values) by the rules L = nπ h/2π) where n = 1,2,3 … The integral n is called quantum number.

Bohr's model successfully predicts the frequencies of the lines in hydrogen spectrum, it introduced the idea of quantum number π n) and fixed energy levels. It could not however not explain the spectra from multi electron atoms.

NB: The Bohr's model is also known as Bohr-Rutherford model since it was an extension of Rutherford planetary model

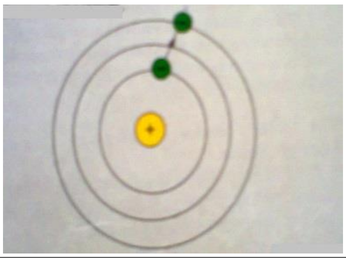


Fig a: An electron absorbs energy when it is transfer to a higher energy level(excitation)

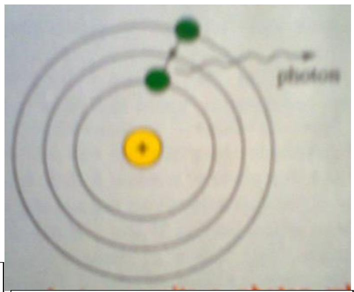
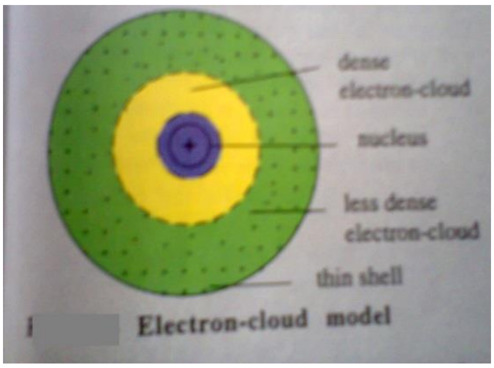


Fig: b An electron emits a photon when it moves to a lower energy level

Electron – cloud model

This model visualizes the atom as consisting of a tiny nucleus of radius of the order of 10^{-15}m. the electron is visualize as being in rapid motion within a relatively large region around the nucleus but spending most of its time in certain high probability regime. Thus, the electron is not considered as a ball revolving around the nucleus but as a particle or wave with a specified energy having only a certain probability of being in a given region in the space outside the nucleus. This nucleus is a sort of electron-cloud.



ATOMIC STRUCTURE

Atom is known to be made up of a tiny but massive nucleus at the centre and outside the nucleus is a cloud of electrons which move in a wave-like orbits around the massive nucleus.

The nucleus consists of positively charge protons and neutron which has no charge. The proton and neutron together constitute the nucleon. The protons, neutrons and electrons are the fundamental subatomic particles of the atom.

Electron (e) has a mass of $9.1x10^{-31}$kg and it is the highest particle with an electronic charge of i.e. e^- $-1.6x10^{-19}$C

Proton has a mass of $1.67x10^{-27}$kg which is about 1836 times heavier than the mass of an electron. It has a charge of i.e. e^+ = e- = $1.6x10^{-9}$C. The neutron has the same mass as proton but has no charge.

The atomic number or proton number π z) is the number of protons in the nucleus of an element.

The mass number or nucleon number π A) is the total number of protons and neutrons in an atom of an element.

The number of neutron is given by A – Z

We denote the atom of an element x by ${}^{A}_{Z}X$

E.g. if carbon is denoted by 12_cC, what is the neutron number

A = 12

Z = 6

Neutron number = A – Z

12 – 6

WEEK 4/5

RADIOACTIVITY AND NUCLEAR REACTION

INTRODUCTION

In 1896, Henry Becquerel of French physicist discovered that a uranium compound placed on a photographic plate which was covered with light proof paper caused the plate to be fogged or exposed.

He traced this effect to some unknown radiation coming from the uranium compound. This phenomenon was called radioactivity. Substances that give rise to radioactivity are called radioactive substances or elements.

Radioactivity is the spontaneous emission of radiation from substance. Radioactive elements are those elements that spontaneously emit radiation from their nucleus, e.g. radium, thorium, radan, ionium, polonium, etc.

PROPERTIES OF THE EMITTED PARTICLES

Radiation	Alpha (α) – particles	Beta (β) – particles	Gamma (γ) rays
Nature	Helium nuclei 42H	High energy electrons	Electromagnetic waves of very short wave length
Velocity	5-7% speed of light	Travel at approx. speed of light	Travel at speed of light
Charge	+2e (+3.2x10^{-19}C)	-e (-1.6x10^{-19})	Electrically neutral
Mass	Relatively massive	Relatively light	Negligible
Effect of magnetic field	Slightly deflected in a field in a direction expected for a positive charge	Strongly defected in a magnetic field in a direction expected for a negative charge	Small or no effect
Ionizing	Large, cause heavy ionization	Medium about 0.1% of that of α-particles	Small
Penetrating power	Little penetrating power e.g. stop by thin sheets of paper	Good penetrating power in air. Stop by several mm of aluminum	High penetrating in air and in solid e.g. many cm of lead
Fluorescence	Cause fluorescence in ZnS	No fluorescence in ZnS	

RADIOACTIVE DECAY, HALF LIFE AND DECAY CONSTANT

Radioactive decay is the disintegration of unstable nuclides to form stable ones. Alpha (α) and beta (β) particles are in fact the pieces of the nucleus which have been thrown out, while γ-rays are electromagnetic radiations which often accompanies the ejection of α-and β particles

HALF-LIFE

The time taken for half of the atoms initially present in an element to decay is known as half-life of the radioactive elements.

DECAY CONSTANT

Let us suppose that these are Q atoms in a radioactive element at a time, t, the disintegration per unit time can be exposed by ${dQ}/{dt}$.

The rate of disintegration is proportional to the number of atoms available at a time t.

$$\frac{dQ}{dt} \propto Q \qquad \text{-------- (1)}$$

i.e. $$\frac{dQ}{dt} = \lambda Q \qquad \text{-------(2)}$$

Where λ is the constant of the proportionality called decay constant of the element

$\lambda = -1/N(dN/dt)$ ----(3) by integrating equation (3), we have

$N = N_o e^{-\lambda t}$ -----(4)

At half-life, $N = \frac{1}{2}N_o$ ----- (5)

Substituting (5) into (4)

$\frac{N_o}{2}$ = $N_0 e^{-\lambda t}$

½ = $e^{-\lambda t}$

taking natural logarithm of both sides and simplifying, we have

-0.693 = - λt

t = $\frac{0.693}{\lambda}$

Natural radioactivity is the spontaneous disintegration of the nucleus of an atom during which α and β particles, or gamma rays or a combination of any or all the three and heat are released.

e.g.

Radium 226 decay be emitting alpha particles and the nuclear reactions is

$$^{226}_{88}Ra \rightarrow \, ^{222}_{86}Rn + \, ^{4}_{2}H + Energy$$

Radon decays to Radium by emitting 2β-particles (i.e. on electron)

$$^{222}_{86}Rn \rightarrow \, ^{222}_{88}Ra + 2^{0}_{=1}e + Energy$$

Uranium – 238 decays by emitting - 2α-particles and 2β-particles to thorium 230

$$^{238}_{92}U \rightarrow \, ^{230}_{90}Th + 2^{4}_{2}H + 2_{-1}^{\,0}e + Energy$$

NB: When an element decays by emitting alpha particles, the atomic number and mass number are altered by decreasing when it emits β-particle, its atomic number increases but its mass number remains unaltered.

Atoms of material which are not normally radioactivity can be made radioactive by bombarding it with radioactive particles. when this happened, it is called artificial radioactivity. The particles of bombardment of the nuclei are neutron ($^{1}_{o}n$), proton ($^{1}_{1}p$), and alpha ($^{4}_{2}H$)

$$^{6}_{3}Li + \, ^{1}_{0}n \rightarrow \, ^{3}_{1}H + \, ^{4}_{2}H + Energy$$

$$^{9}_{4}Be + \, ^{1}_{o}n \rightarrow \, ^{12}_{6}Ca + \, ^{1}_{0}n + Energy$$

Artificial radioactivity decays in a way similar to natural radioactivity.

Radioisotopes or radioactive isotopes are isotopes that are made artificially by bombarding neutrons or protons or deuterons at elements.

$e.g \; ^{34}_{10}S + \, ^{1}_{o}n \rightarrow \, ^{35}_{10}S$

$e.g \; ^{59}_{10}C_a + \, ^{1}_{o}n \rightarrow \, ^{60}C_a$

Uses of Radioisotopes

i. It is used in medicine as radiotherapy
ii. it is used in industry to study defects in metal and welded joints
iii. It is used in agriculture as radioactive tracers and preservatives
iv. It is used in geological research for radio-dating

Application of Radioactivity

i) It is used in agricultural and scientific research
ii) It is used in medical field and
iii) it is used in industrial field

Health Hazard

Bodies that are exposed to radiation are subjected to genetic mutations π changes), causing cancer and undesired hereditary effects. The ionizing properties of α-particles can damage the skin. It kills, causes sterility and blood abnormalities.

Workers in radioactive laboratory are shielded with thick blocks of lead iron or concrete and they also monitor their radiation exposure.

Nuclear Energy

Nuclear energy is the energy released when radioactive decay occurs.

Nuclear Fission: This is a process in which a nuclear bombardment of the nucleus of a heavy element like uranium is split into two parts of roughly the same mass. The mass of the two parts together is less than the mass of the original uranium nucleus. The difference in mass is measure of the nuclear energy released. According to Albert Einstein, the energy release E= mc^2

Where m is the mass defect (difference in mass) and c is the velocity of light (i.e. 3.0 x 10^{-8}mls)

$$^{235}_{92}U + \, ^{i}_{o}n \rightarrow \, ^{141}_{56}B_a + \, ^{92}_{36}K_r + \, ^{1}_{o}n + \, ^{1}_{o}n + \, ^{1}_{o}n + energy$$

The neutrons produced are used to bombard more uranium – 235 and make more nuclides decay, in what is called a chain reaction

Nuclear fusion: this is the process in which two or more light nuclei combine to form a heavier nucleus with the release of a large amount of energy

$$ {}_{1}^{2}H + {}_{1}^{3}H \rightarrow {}_{2}^{4}H_e + {}_{o}^{1}n + energy $$

Advantages of fusion over fission

1. Fusion is easily achieved with the lightest elements so that nuclear repulsion is easily overcome as nuclei approach each other.
2. The by-products of nuclear fusion are less dangerous, they are non-radioactive.
3. hydrogen can be obtained by electrolysis of sea water which is cheaper and plentiful. Thus, the raw materials for fusion are cheaply available.
4. There is no upper limit to the mass of hydrogen that can be exploded, so very large energies can be obtained.

Peaceful use of nuclear energy includes the following

1. Electric power station: it is use in the generation of power
2. medicine: It is used in radiotherapy
3. Agriculture: It is used in radioactive tracers and preservatives
4. In transportation: some space craft ships and submarines are powered by nuclear energy

Nigeria Nuclear Energy Programme

Nigeria National Atomic Energy Commission π NAEC) is the agency that is saddled with the responsibility of nuclear energy programme in Nigeria. The body was set up to see how power problems can be overcome by use of nuclear energy when energy demand will increase expectedly as from year 2017.

The challenges facing the agency are:

i) There is concern about safety and security of radioactive source
ii) there is lacked of dedicated storage facilities and
iii) detection capacity at point of entry
iv) inadequately trained staff and inadequate tracking of sources

WEEK 6/7

TOPIC: ENERGY QUANTIZATION

Introduction: Bohrs suggested that electrons exist in an atom only in quantum or discrete energy level. This is known as quantization.

Energy Level in An Atom

Every electron within an atom is situated at a particular orbit known as energy level or electron orbit.

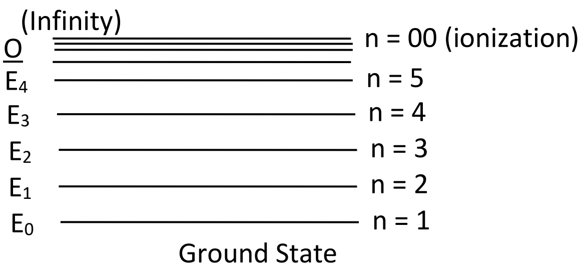
Every energy level or electron orbit has a discrete value or definite value or is quantized.

Neil's Bohr from experimental result of radiation obtained from energetic atoms assumed that

i. Electron in a given atom possesses a specified amount of energy or a discrete value of energy.

   Hence, electrons are restricted to energy level that has the same discrete value as to itself.

ii. The energy of the electron could only change from one level to another but not to any value between those levels.



The diagram above is an illustration of energy level.

The energy level closet to the nucleus has the lowest energy and it is called the ground state of the electron.

Eo is assigned to the ground state and it represents the energy of the ground state

The energy of an electron is given by $E = -E_o/n^2$

Where n is the electron quantum number and E_n is a constant. The negative sign is an indication that work must be done to remove the electron from the atom.

It is possible for an electron to move from a lower energy level to a higher energy level if they have enough energy and this is known as excitation. This is made possible by heating or bombarding the atom with energetic particles and its energy is increase.

Excitation: This is defined as the movement of an electron from a lower energy level to a higher energy level as a result of discrete energy value impacted to the electron. When the excited electron losses energy, it goes back to a lower energy level. It does this (It loses energy) by emitting a photon or quantum of light with characteristic frequency, f, (or wavelength, λ) in the process, according to the relation;

$E= E_n- E_o = hf_n= hc/\lambda_n$

[Recall $c = f\lambda \therefore f = c/\lambda$]

Where E is the energy change

E_n is the energy in the excited state in joules or eV.

F_n is the frequency of the emitted photon in hertz

λ_n is the wavelength in metre

h is Planck's constant π $h = 6.6 \times 10^{-34}$ JS).

The increase in quantum number makes the corresponding E_n closer to zero, in the limit of $n = \infty$; $E\infty = O$ and the electron is no longer bounded to the nucleus to form an atom. At that stage, ionization has occurred.

<u>Atomic Spectrum π Line Spectrum), Continuous spectrum and Absorption Spectrum</u>

When gas atoms are excited, they give off light which when analyzed is seen to consist of a large number of spectral lines. Each line consists of light of one wave length or colour. This type of spectrum is called a **line spectrum or atomic spectrum**: It is a spectrum that consists of a number of well defined lines each having a particular frequency or wavelength or colour.

A continuous spectrum consists of light of all colours or wave length.

If a continuous spectrum is passed through a gas, dark lines are observed. These dark lines correspond to lines normally emitted by the gas. This is called an **absorption spectrum**. Gases absorbs light at the same frequencies at which they emit.

Every atom has its own characteristic atomic spectrum i.e no two different atoms have the same atomic spectrum.

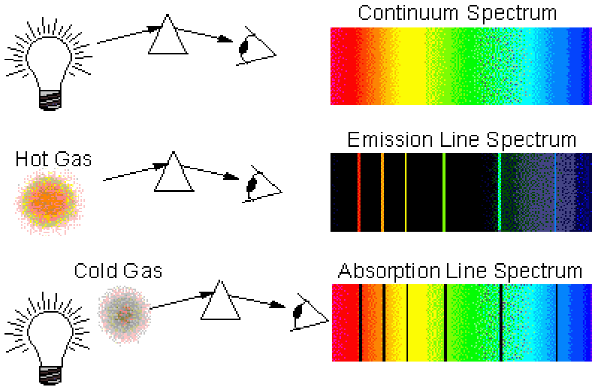


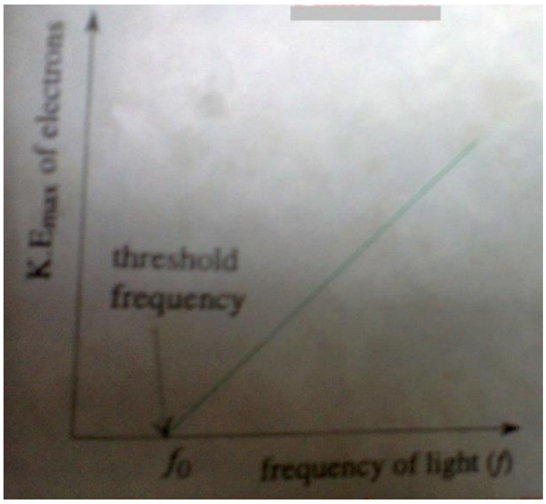
PHOTO – ELECTRIC EFFECT

In1902, Lenard discovered that electrons were emitted whenever light radiation falls upon metal surface. The mitted electrons are called photo-electrons.

Therefore, photo-electric effect or photoelectricity is the process of light falling on a metal surface leading to the liberation of electrons inform of photons or quanta of energy. Lenard found that maximum kinetic energy of the emitted electrons depended only on the frequency or wave length of the incident light and not on the intensity π power) of the light beams. Increasing the intensity of the light only increases the number of photo-electrons, but not their velocity or kinetic energy.

Also, below a certain frequency π or corresponding higher wave length called the threshold wave length) called the threshold frequency π f_o), no electrons were emitted even through the incident light beam was very strong.

When light with frequency less than threshold frequency is incident on metal surface, complete absorption of light energy takes place. The absorbed energy is used to raise the energy level of the surface electrons.



Threshold frequency: This is the frequency of incident light falling on metal surface must possess to liberate electrons without giving them any additional kinetic energy.

Work function π W_o): The minimum energy needed to pull out an electron from a metal surface.

NB: Wave theory of light could not explain photo electricity but particle nature of light does.

<u>Einstein's Photo – electric Equation and Its Explanation</u>

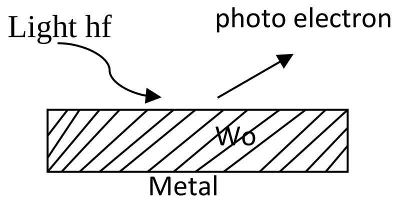
In 1905, Einstein used particle theory of light to explain the experimental result in photo electricity. He suggested that light could be considered as "Packets" of energy, like particles, and these are called photons. π This concept was put forward first by max Planck)

Einstein said that the unit or quantum of energy in a light beam was given by

$$E = hf$$

Where f is the frequency in Hertz

h is the Planck's constant, $6.6x10^{-34}$ JS.



$hf = Wo + E_k$

But $E_k = ½ mv^2$

$\therefore hf = Wo + E_k$.

but, $E_k= ½ mv^2$

Hence, $hf = Wo + ½ mv^2$

$E_k = hf – Wo$

Where

E_k is kinetic energy in joules

Wo is work function in joules

m is the mass of the electron in kg

v is the velocity of the electron in m/s

Note, $½ mv^2 = E_k = eV$

Where eV is called the electron –volt.

The electron-volt (eV) is the energy that is required to stop the motion of an ejected electron. It is equal to the energy of the ejected electron.

IeV = $1.6 x10^{-19}$ joules

$W_o = hf_o$

f_o is the threshold frequency

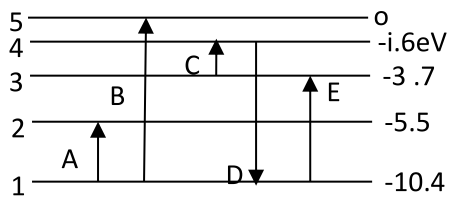
$$E_k = hf – hf_o$$

Calculations

1. A photon has a wave length $5.0x10^{-?}$ Calculate

   (i) Its frequency (ii) its energy in joules (iii) its energy in eV if IeV = $1.6 x 10^{-19}$ J. (take = $3.0x10^8$mls, h = $6.6x10^{-34}$ JS)

2.



The above diagram shows some energy level in the mercury atom, where level 1 is the ground state level.

i. Which energy change represents ionization of the atom?
ii. Calculate the energy change when an electron falls from level 4 to level 2
iii. As in (ii) calculate the wave length and frequency of the photon emitted (Take C = $3.0x10^8$ mls, h = $6.6x10^{-34}$ JS) l ev = $1.6x10^{-19}$ J.

3. Radiation of frequency $12.0x10^{15}$ Hz falls on a metal surface. If the maximum kinetic energy of the ejected electrons is $1.9 x10^{-21}$ J. Calculate.

i. The work function (ii) The threshold frequency

4. Calculate the frequency of a photon whose energy is required to eject a surface electron with kinetic energy of $1.97 x10^{-16}$ eV if the work function of the metal is $1.33x10^{-16}$ eV.

Soln

1i. $c = f\lambda$

$c = 3.0x10^8$ mls

$\lambda = 5.0 x10^{-7}$ m

f = ?

$f = c/\lambda \quad = \frac{3x10^8}{5x10^{-7}} = 6\ .0x10^{14}$ Hz

ii. Quantum of energy = hf

$= 6.6\ x10^{-34}\ x\ 6.0\ x10^{14}$

$= 39.6\ x10^{-20} = 3.96\ x0^{-19}$ J

iii. $3.96\ x10^{-19}/1.6x10^{-19} = 2.475$ eV

=2.5 eV

2

(i). Energy B shows the energy for ionization to occur.

(ii).$E_4 – E_2 = E = - 3.7- (-10.4)$

= - 3.7+10.4

= 6.7eV

(iii). E = hf

$6.7 = 6.6x10^{-34}\ x\ f$

But l eV = $1.6x10^{-19}$ J

$6.7\ x\ 1.6\ x10^{-19} = 6.6x10^{-34}$ f

$F = \frac{6.7x1.6x10^{-19}}{6.6\ x10^{-34}} = 1.62x10^{15}$ Hz

3i. $hf = Wo + E_k$ ………(1)

$Wo = hf – E_k$ …………...(2)

$f = 12x10^{15}$ Hz

$h = 6.6x10^{-34}$ JS

$E_k = 1.9x10^{-19}$ J

Substituting into (2)

$Wo = 6.6\ x10^{-34}\ x\ 12\ x\ 10^{15} – 1.9x10^{-19}$

$= 79.2\ x\ 10^{-19} – 1.9\ x\ 10^{-19}$

$= (79.2 – 1.9)\ x\ 10^{-19}$

$= 77.3x10^{-19}$ J

$\therefore$ Wo = $77.3\ x10^{-19}$ J

(ii). $W_o = hf_o$

$f_o = W_o/h = \quad 77.3\ x\ 10^{-19} / 6.6\ x10^{-34}$

$\therefore f_o = 11.7\ x\ 10^{15}$ Hz

$= 1.17\ x\ 10^{16}$ Hz

4. $hf = W_o + E_k$

$E_k = 1.97\ x\ 10^{16}\ eV = 1.97\ x\ 10^{-16}\ x\ 1.6x10^{-19}$J

$W_o = 1.33x10^{-16}eV=1.33x10^{-16}\ x\ 1.6x10^{-19}$J

$h = 6.6\ x10^{-34}$ JS

From the above equation, $f = \frac{W_{o+E_k}}{h}$ i.e.

$$f=\frac{1.33\times10^{-16}\times1.6\times10^{-19}+1.97\times10^{-16}\times1.6\times10^{-19}}{6.6\times10^{-34}}$$

f = 0.08Hz

X – Ray

X – ray was discovered accidentally by a German physicist called Wilhelm Konrad Rontgen while he was studying the conduction of electricity in a gas at low pressure

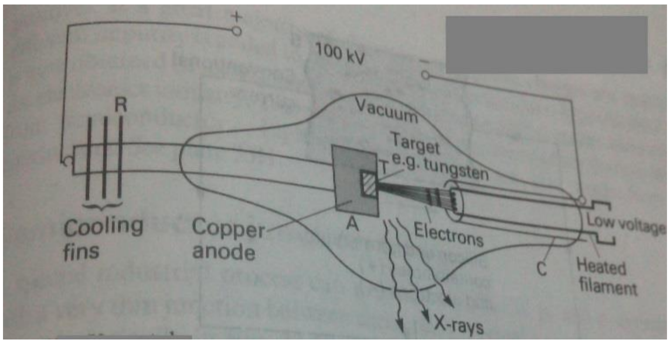
Production of X – Ray

A hot filament or cathode emit electrons: T is a metal “target”, made of copper or tungsten. The target is embedded in the copper block A at the end of a metal rod. A is the anode and it is kept at a high voltage, such as 100kv or higher depending on the use of tube. Electrons are produced by thermionic emission from the hot cathode which is a heated tungsten filament. The filament lies inside a curved metal cylinder which acts to focus the emitted electrons on to the tungsten target embedded in A. Electrons reach A with high energy since it is accelerated. A large fraction of the kinetic energy of the accelerated electrons is converted to heat when the electrons hit the target and the rest of the energy of the electrons is converted into X – rays which are radiated from the tungsten through a window. The heat so generated is conducted through the copper anode A of high conductivity and removed by cooling fins.

The energy conversion in the production of X – rays are as follows

Electric energy ⟶ Heat energy ⟶ Kinetic ⟶ Electromagnetic energy (X – ray)

Kinetic ⟶ Heat energy



<u>Characteristics and Properties of X – rays</u>

i. They have very short wave length, about 10^{-12} cm

ii.The have velocity of light of about 3×10^{8} mls

iii. They are not deflected by both electric and magnetic fields

iv. They undergo diffraction by crystals

v. X – rays ionizes gases which in turn become conducting

vi. They have high penetrating power. Hence, they can easily pass through most solid substances which are opaque to ordinary light.

vii. They affect photographic plates

viii. They travel in a straight line like light

ix. They cause the liberation of electrons when they fall on certain substances.

Application of X – rays

i. Hidden faults in metal castings, welded joints in construction industry and bullet in a patient's leg are easily identified using X – rays

ii. Alterations in the original arts and graphic works are easily recalled with X – rays

3. They are used in airports to detect metals and contraband in a baggage.

4. They are used in radio – therapy; radiography and in agriculture to kill germs

5. They are used in hospital to inspect internal organs such as lungs, heart, kidney, intestine and they are used in the treatment of tumors, skin diseases and cancerous cells.

Health Hazards of X – rays

i. X – rays are highly penetrating: It destroys living cells, causes skin burn, causes damage to blood and eye sight.

ii. X – rays can produce genetic changes which appear in subsequent generations π Genetic mutation)

iii. It does causes serious diseases such as cancer cells.

Precautionary Measures Against Radiation from X - rays

i. Workers in X – rays laboratories should always be shielded by wearing lead apron or coat

ii. Dosimeters are always kept in X– rays environment to monitor radiation levels

iii. Thick walls should also be erected in radiography rooms to control the spread of X- rays

iv. Workers in the X – rays laboratories should go for regular check

WEEK 8

TOPIC: DUALITY OF MATTER

Introduction:

The duality of matter or the wave – particle duality or wave paradox is a phenomenon that shows matter has dual or double nature. It has both the nature of waves and particles but not as both at the same time.

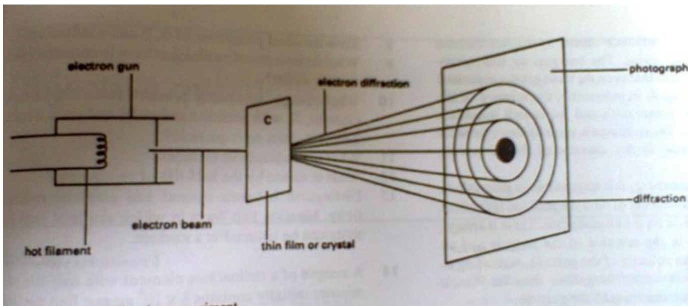
Depending on the experimental conditions, particles or Waves properties can be used to explain the result of the experiment.

Hence, we have the particle theory of matter and wave theory of matter.

Wave nature of matter

i. Electron diffraction

ii.



40.10 Electron diffraction experiment

Particle Nature of Matter

i. Photo-electric effect

ii. Campton effect.

Heisenberg Uncertainty Principle

If a train is moving, it momentum at a particular position, or their energy at a particular time, can both be measured with an accuracy which depends on the instruments used.

In the world of atomic particles such as electrons, however, Heisenberg recognized that there was always an uncertainty or inaccuracy in these measurements additional to those of instruments. Electrons, for example, behave as waves which spreads out, leading to uncertainty in measurement of their positions. If the electron position, x is measured to a high degree of accuracy, there is relatively low degree momentum, P, according to Heisenberg. We can never measure both x and P simultaneously to a high degree of accuracy.

Therefore, the Heisenberg uncertainty principle states that If Δx is the uncertain in measuring x, and Δp is the uncertainty in measuring P, then, their product is equal to or greater than h, the Planck's constant. So,

$$\Delta x \times \Delta p \geq h$$

The uncertainty principle also hold for energy and time, position and velocity.

WEEK 9-11

Topic: Physics in the real world

Construction of battery.

Electroplating.

Application of electromagnetic field.

Construction of a galvanometer, an electric motor and generator.

Construction of a model transmission system using a transformer.

WEEK 12

TOPIC: Physic in Technology

Need for the use of machine in doing work

Easier

Quicker

More conveniently

Instances of the use of machines

At home

In the offices

In industry

In agriculture

In transportation

Repairs and maintenance of machines

Need for repairs of machine

Need for regular maintenance of machines

Maintenance schedule of machines