SUBJECT:

PHYSICS

CLASS:

SENIOR SECONDARY SCHOOL 3

TERM:

SECOND

SCHEME OF WORK

WEEK	TOPIC
1	Model of the atom – Concept of the atom - Rutherford, Bohr, Electron-cloud, Limitations of physical models
2	Nucleus – Radioactivity, Nuclear reaction, Nuclear power and atomic bomb, Nigeria's nuclear energy programme
3	Energy quantization – Energy levels in atom, Photo-electric effect, Einstein Photo Electric Equation and its explanation, thermionic emission, X-ray, Duality of matter – wave particle duality
4	Battery – construction of battery; Electroplating – electroplate a suitable electrode
5	Uses of machines – Need for the use of machines in doing work, Instances of use of machines, Dams and energy Production – Location of dams for producing electricity in Nigeria, Principle of Electricity from dam
6	Rockets and Satellites – Component part of rockets and satellites, functions of rockets and satellites and uses. Niger-SAT 1- Features, Operation and Uses; NICOM-SAT 1 - Features, Operation and Uses
7	Revision
8	Mock Examination

WEEK ONE

MODEL OF THE ATOM

- Model of the atom
- Concept of the atom Rutherford
- Bohr
- Electron-cloud
- Limitations of physical models

Model of the atom

J. J. THOMSON MODEL

J.J. Thomson proposed an atomic model which visualized the atom as a homogeneous sphere of positive charge inside of which are embedded negatively charged electrons.

He also determined the ratio of the charge to mass, $\frac{e}{m}$ of electrons, and found $\frac{e}{m}$ to be identical for all cathode rays particles, irrespective of the kind of gas in the tube or the metal the electrons are made of.

ERNEST RUTHERFORD MODEL

He proposed a planetary model for the atom which suggested that the atom consists of positively charged heavy core called the nucleus where most of the mass of the atom was concentrated .Around this nucleus, negatively charged electrons circle in orbits much as planets move around the sun. Each nucleus must be surrounded by a number of electrons necessary to produce an electrically neutral atom

LIMITATION OF RUTHERFORD MODEL

- It predicts that light of a continuous range of frequencies will be emitted whereas experiment shows line spectra instead of continuous spectra.
- It predicts that atoms are unstable-electrons quickly spiral into the nucleus but we know that atoms in general are stable, since the matter around us is stable.

Clearly Rutherford's model was not sufficient to explain experimental observations. Some sort of modification was needed and this was provided by Neils Bohr.

THE NIELS BOHR MODEL

He suggested a model of hydrogen atom in which:

i. The orbit at which an electron will move without radiating energy such that its angular momentum is quantized. He called the possible orbits stationary states. Only orbits of particular radii were possible. This orbit is given by the equation:

$$L = n(\frac{h}{2\pi})$$

$$mvr = \frac{nh}{2\pi}$$

Where: $mvr = angular\ momentum$

$m = mass\ of\ the\ electron$

$v = speed\ of\ the\ electron\ round\ the\ nucleus$

$r = radius\ of\ the\ orbit\ where\ the\ electron\ ids\ moving$

$n = pricipal\ quantum\ number\ which\ determines\ the\ orbit\ allowed\ (n = 1,2,3\ ...)$

ii. An electron will radiate energy if it jumps from higher orbital or energy to a lower orbital or energy. A photon of light emitted has the energy given by:

$$E_f - E_i = hf$$

Where:

$E_f - E_i = \Delta E$

$E_f = final\ energy\ level$

$E_i = initial\ energy\ level$

$h = Planck'sconstant = 6.67 \times 10^{-34} Js$

$f = frequency\ of\ emitted\ light$

Bohr was able to account for the appearance of line spectrum rather than continuous spectrum.

Bohr model is also known as the Bohr – Rutherford model since it was an extension of Rutherford planetary model. The great success of Bohr Theory is that;

- It gives a model for why atoms emit line spectra and accurately predicts, for hydrogen, the wave lengths of emitted lights or the frequencies of the lines in the hydrogen spectrum.
- It offers an explanation for absorption spectra; photons of just the right wavelength can knock an electron from one energy level to a higher one. To conserve energy, the photon must have just the right energy. This explains why a continuous spectrum passing through a gas will have dark (absorption) lines at the same frequencies as the emission line.
- It ensures the stability of atoms by stating that the ground state is the lowest state for an electron and there is no lower energy level to which it can go and emit more energy.
- It accurately predicts the ionization energy of 13.6eV for hydrogen.

THE 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 visualized as being in rapid motion within a relatively large region around the nucleus, but spending most of its time in certain high probability regions. 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. The electron is visualized as spread out around the nucleus in a sort of electron – cloud.

The probability of finding the electron inside the spherical boundary is high. The probability then decreases rapidly as the distance of the thin shell from the nucleus increases.

ATOMIC STRUCTURE AND CHEMICAL BEHAVIOUR

Today we consider the atom as made up of tiny but massive nucleus at the centre and outside the nucleus is a cloud of electrons which move in wave-like orbits or shells around the massive nucleus. The nucleus consists of protons which carry positive changes and neutrons which carry no charge. The neutron and proton together constitute the nucleon. All the mass of an atom is concentrated in the central nucleus. The protons, neutrons and electrons are the fundamental sub atomic particles of the atom.

The electron is the lightest particle of an atom, with a mass (M_e) of 9.10^{-31}kg and an electronic charge $e^- = 1.6 \times 10^{-19}$C.

The proton has a mass of 1.67×10^{-27}kg which is over 1836 times heavier than the mass of an electron. It carries a positive charge, $e^+ = 1.67 \times 10^{-29}$ c (i.e. $e^+ = e^- = 1.6 \times 10^{-19}$C). There is the same number of protons in the atoms of different elements. In a neutral atom, the number of protons equals the number of electrons.

Given an element X represented as

$$^{A}_{Z}X$$

$$A = mass\ (nucleon)\ number$$

$$Z = atomic\ (proton) number$$

The atomic number or proton number (Z) is the number of protons in the nucleus of an element. The mass number or nucleon number (A) is the total number of protons and neutrons in an atom of an element

ISOTOPES

Isotopes are atoms of the same element which have the same atomic number (Z) but different mass number (A). Isotopes are thus atoms with the same number of protons, but different number of neutrons. Isotopes have similar chemical properties because they have the same number of electrons round the nucleus. Chemical combinations is due to an exchange of outer or valence electrons between elements.

EXAMPLES OF ISOTOPES

i. chlorine

$^{35}_{17}Cl$ (17 protons, 17 electrons, 18 neutrons)
$^{37}_{17}Cl$ (17 protons, 17 electrons, 20 neutrons)

ii. carbon

$^{12}_{6}C$ (6 protons, 6 electrons, 6 neutrons)

$^{13}_{6}C$ (6 protons, 6 electrons, 7 neutrons)

iii. Oxygen

$^{16}_{8}O$ (8 protons, 8 electron 8 neutrons)

$^{17}_{8}O$ (8 protons, 8 electrons, 9 neutrons)

$^{18}_{8}O$ (8 protons, 8 electrons, 10 neutrons)

iv. Uranium

$^{238}_{92}U$ (92 protons, 92 electrons, 146 neutrons)
$^{235}_{92}U$ (92 protons, 92 electrons, 143 neutrons)

$^{234}_{92}U$ (92 protons, 92 electrons, 142 neutrons)

CLASSWORK 1

1. What is an atom?
2. Define the following terms (a) atomic number (b)mass number (c) valence electron

ASSIGNMENT 1

SECTION A

1. An element and its isotopes only differ in the number of (a) protons (c) electrons (c) ions (d) x – particles (e) neutrons
2. Bohr theory provides evidence for the (a) structure of the atom (b) positive charge of an electron (c) existence of energy levels in the atom (d) positive charge on a proton (e) none of the above
3. When an atom is in the ground state, it is said to be (a) grounded(b) excited (c) stable (d) ionized (e) radiating
4. Which of the following representation is correct form of an atom X with 28 electrons and 30 neutrons (a) $^{30}{}_{28}X$ (b) $^{28}{}_{30}X$ (c) $^{58}{}_{30}X$ (d) $^{58}{}_{28}X$ (e) $^{30}{}_{2}X$
5. Which of the following particles determine the mass of an atom? (a) protons and neutrons (b) Neutrons only (c) protons and electrons (d) Neutrons and electrons (e) Protons only

SECTION B

1. Write short note on the postulates of Rutherford's model of the atom and highlight the limitation of the model
2. Briefly explain the phenomenon called "isotope"
3. What are the essential features of the Electron –Cloud Model of the atom? Illustrate with a diagram

WEEK TWO

RADIOACTIVITY

- Radioactivity
- Nuclear reaction
- Nuclear power and atomic bomb
- Nigeria's nuclear energy programme

Radioactivity

Radioactivity is the spontaneous decay or disintegration of the nucleus of the atom of an element during which it emits α, β or γ rays or a combination of any or all the three and energy (or heat). Examples of radioactive elements are uranium, radium, radon, thorium, polonium, etc. These all have high atomic number (>82)

Radiation	Alpha(α)particles	Beta(β) Particles	Gamma (γ)rays
Nature	Helium nuclei $^{4}_{2}He$	High Energy electrons	Electromagnetic wave of short wavelength
Velocity	5 – 7% speed of light	Travel at approximate speed of light	Travel at speed of light
Nature of charge	Positively charged	Negatively charged	Neutral
Effects of magnetic field	Slightly deflected towards the negative plate	Strongly deflected towards the positive plate	No effects
Ionizing power	High	low	None

Penetrating power	Little penetrating power e.g. thin sheets of paper	Good penetrating power e.g. aluminum	High penetrating power e.g. leads
Mass	Massive particle	Small particle	No mass

RADIOACTIVE DECAY

Radioactivity is a spontaneous process. It goes on independent of external control, it is not affected by temperature, or pressure or by chemical treatment. It is a random process as no one can predict which atom will disintegrate at a given time

Half-Life - The half- life of a radioactive element is the time taken for half of the atoms initially present in the element to decay. The rate of decay of radioactive elements is found to be proportional to the number of atoms of the material present. If there are N atoms of a radioactive element present at a time, t_i, then the probable number of disintegration per unit time or activity

$$-\frac{dN}{dt} \propto N \qquad \text{---1}$$

The minus sign arises from the fact that N is decreasing with time

$$\frac{dN}{dt} = -\lambda N \qquad \text{---2}$$

λ is a constant of proportionality called the decay constant.

$$\lambda = -\frac{1}{N}\left(\frac{dN}{dt}\right) \qquad \text{---3}$$

Hence **Decay Constant** – this is defined as the instantaneous rate of decay per unit of a substance

$$\lambda = \frac{number\ of\ atoms\ disintegrating\ per\ second}{no\ of\ atoms\ in\ the\ source\ at\ that\ time} \qquad \text{---4}$$

By integrating equation 2

$$N = N_0 e^{-\lambda t} \qquad \text{---5}$$

$$N_0 = Number\ of\ atoms\ present\ at\ time\ t = 0$$

$N = Number\ of\ atoms\ present\ at\ time\ t$

The time required for half of the atoms to disintegrate to half of the initial mass (half-life) is calculated thus:

$N = \frac{1}{2} N_0$ ---6

Substituting equation 6 into equation 5, gives

$\frac{N_0}{2} = N_0 e^{-\lambda t}$ ---7

$\frac{1}{2} = e^{-\lambda t}$ ---8

Taking the natural log of both sides

$\log_e \frac{1}{2} = -\lambda t$ ---9

But $\log_e \frac{1}{2} = \log_e 1 - \log_e 2 = 0 - \log_e 2 = -0.693$

Hence $-0.693 = -\lambda t$ ---10

$t = \frac{0.693}{\lambda}$ ---11

EXAMPLES

A certain radioactive element has a half-life of 10years.

1. How long will take to lose 7/8 of its atoms originally present?

2. How long will it take until only ¼ of the atoms originally present remain unchanged?

Solution

If 7/8 of its atoms have been lost, 1/8 remains

Half-life = 10years

1.

$\frac{N}{2}$ Atoms remain after 10years

$\frac{N}{4}$ Atoms remain after 20 years

$\frac{N}{8}$ Atoms remain after 30 years

:. It takes 30 years to lose 7/8 of its atoms.

2.

$\frac{N}{2}$ Atoms remain after 10years

$\frac{N}{4}$ Atoms remain after 20 years

Answer = 20years

TRANSFORMATION OF ELEMENTS

There are two types of radioactivity nature and artificial radioactivity.

NATURAL RADIOACTIVITY

Natural radioactivity is the spontaneous disintegration of the nucleus of an atom during which α particles, β particles or γ rays and heat (or energy) are released. When a radioactive element undergoes radioactive decay, it may emit either α, *B*, or γ rays. This changes the atomic number of the element; hence a new element is formed.

$^{226}_{88}Ra \rightarrow ^{4}_{2}He + ^{222}_{86}Ra + energy$ (Radium emits α particle)

$^{222}_{86}Rn \rightarrow 2\,^{0}_{-1}e + ^{222}_{88}Ra + energy$ (Radon emits two β particles)

$^{238}_{92}U \rightarrow 2\,^{4}_{2}He + 2\,^{0}_{-1}e + ^{230}_{90}Th + energy$ (Uranium emits two β and two α particles)

$^{234}_{90}Th \rightarrow \,^{0}_{-1}e + ^{234}_{91}Pa + energy$ (Thorium emits two β particles)

Generally we represent alpha (α) decay by

$$^{A}_{Z}X \rightarrow ^{4}_{2}He + ^{(A-4)}_{(Z-2)}Y$$

And Beta (β) decay by

$${}_{Z}^{A}X \rightarrow {}_{-1}^{0}e + {}_{(Z+1)}^{A}Y$$

Gamma radiation (γ) is a form of light, emitted as photons of energy *hf,* and has zero mass number and zero charge (A=0, Z=0)

ARTIFICIAL RADIOACTIVITY

If the radioactivity is induced in an element by irradiation with, for example, neutrons, the process is known as artificial radioactivity. By irradiation, it means exposure to radiation either by accident or by intent.

$${}_{2}^{4}He + {}_{7}^{14}N \rightarrow {}_{9}^{18}F \rightarrow {}_{8}^{17}O + {}_{1}^{1}H + energy$$

In artificial radioactivity an ordinary material, not normally radioactive is made radioactive by bombarding it with radioactive particles.

$${}_{2}^{4}He + {}_{13}^{27}Al \rightarrow {}_{15}^{30}P + {}_{0}^{1}n \rightarrow {}_{14}^{30}Si + {}_{1}^{0}e + energy$$

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

$${}_{0}^{1}n + {}_{11}^{24}Mg \rightarrow {}_{11}^{24}Na + {}_{1}^{1}P + energy$$

$${}_{2}^{4}He + {}_{4}^{9}Be \rightarrow {}_{6}^{12}C + {}_{0}^{1}n + energy$$

$${}_{0}^{1}n + {}_{27}^{59}Co \rightarrow {}_{27}^{60}Co + energy$$

Isotopes can also be made artificially by bombarding neutrons, or protons or deuterons at elements e.g.

$${}_{10}^{34}S + {}_{0}^{1}n \rightarrow {}_{10}^{35}S + energy$$

$${}_{35}^{79}Br + {}_{0}^{1}n \rightarrow {}_{35}^{80}Br + energy$$

Such artificially produced isotopes are unstable and decay with the emission of α – particles, β –particles and γ – rays. They are called radioisotopes. Radioisotopes are isotopes that are made artificially by bombarding neutrons or protons or deuterons at elements

Nuclear Energy

The protons and neutrons (nucleons) in the nucleus of each atom are held together by very powerful nuclear forces. An enormous amount of energy is required to tear the nucleon apart. Enrico Fermi (1934) discovered that the nucleus can be split by bombarding it with a slow neutron.

$$^{1}_{0}n + ^{235}_{92}U \rightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + 3^{1}_{0}n + energy$$

He discovered that the total mass of the component products is less than the mass of the original materials. The difference in mass (mass defect) is a measured of the nuclear energy released. According to Albert Einstein

$$E = \Delta mc^2$$

$$E = nuclear\ energy$$

$$\Delta m = mass\ defect$$

$$c = velocity\ of\ light\ (3.0 \times 10^8 ms^{-1})$$

NUCLEAR FISSION

This is the splitting up of the nucleus of a heavy element into two approximate equal parts with the release of a huge amount of energy and neutrons.

Fission can occur with most of the massive nuclei. When the heavy nucleus is bombarded by slow neutron, several neutrons are produced as by –products.

These neutrons may cause the splitting of other nuclei, which in turn yield more neutrons which may further split other nuclei and so on. Thus a chain reaction is set in motion

A chain reaction is a multiplying and self-maintaining reaction. When the size of the nuclei exceeds a certain critical mass, there is a rapid production of neutron accompanied by a release of tremendous amount of energy in a nuclear explosion. This is the principle of the atomic and nuclear fission bombs. Fission is also the process used in the present day nuclear power stations.

NUCLEAR FUSION

This is a nuclear process in which two or more light nuclei combine or fuse to form a heavier nucleus with the release of a large amount of energy e.g.

$$^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}n + energy$$

To bring the two lights nuclei together in a fusion process, very high temperature of the order $10^6 - 10^8$ degrees are required to overcome the coulomb repulsive forces between the two nuclei

ADVANTAGES OF FUSION OVER FISSION

1. Fusion is more easily achieved with lightest element e.g. hydrogen.
2. The raw materials required from fusion are more readily and cheaply available
3. Fusion process produces less dangerous (non-radioactive) by-products.

PEACEFUL USES OF NUCLEAR ENERGY

1. Many nuclear power plants are now being used to generate electricity
2. Several fission products obtained in nuclear reaction are used for radiotherapy
3. Radio isotopes from nuclear plants are used in agriculture as tracers and preservatives.
4. Some space crafts, ships and submarines are powered by nuclear energy.

CLASSWORK 2

1. What is radioactivity?
2. Differentiate between nuclear fission and fusion
3. The count rate of radioactive substances diminishes from 600 to 150 in 60 seconds. Determine the half-life of the substance

ASSIGNMENT 2

SECTION A

1. The number of neutrons contained in the nucleus of $^{238}_{92}U$ is (a) 92 (b) 146 (c) 238 (d) 330 (e) 230
2. A radioactive element has a decay constant of $0.077s^{-1}$, calculate its half-life (a) 12.5s (b) 9.0s (c) 5.1s (d) 0.5s (e) 1.25s
3. A substance has a half-life 3 minutes after 6 minutes the count rate was observed to be 400. What was its count rate at zero time? (a) 200 (b) 1200 (c) 1600 (d) 2400 (e) 3000

4. How many alpha particles are emitted in the radioactive decay of? ${}^{238}_{92}U \rightarrow {}^{230}_{90}Th + {}^{4}_{2}He + {}^{0}_{-1}\beta + \Delta E$ (a) 2 (b) 3 (c) 6 (d) 12 (e) 10
5. What is the decay constant of a radioactive element whose half-life is 3 seconds(a) 0.132s^{-1} (b) 0.231 s^{-1} (c) 0.347 s^{-1} (d) 0.693 s^{-1} (e) 0.924 s^{-1}

SECTION B

1. In 90 minutes, the activity of a certain radioactive substance falls to one – sixteenth of its original value. Calculate its half life
2. Write short note on Nigeria nuclear energy programme
3. Compare and contrast, alpha and beta radiation

WEEK THREE

ENERGY QUANTIZATION

- Energy quantization
- Energy levels in atom
- Photo-electric effect
- Einstein Photo Electric Equation and its explanation
- Thermionic emission
- X-ray
- Duality of matter – wave particle duality

Energy quantization

Bohr suggested that the electron in the atom exist in discrete energy known as quantization which can be removed from one level to the other. Energy in such bodies is emitted in separate or discrete energy packet called energy quanta (E_0)

$$E = hf \qquad \text{---1}$$

$h = Planck's\ constant.$

Energy levels in atom

Electrons in atoms are arranged around their nuclei in position known as energy level or electron shell. It requires more energy to remove electrons from the first energy level than to remove electrons from any of the other higher levels. The energy of an electron is given by the relation:

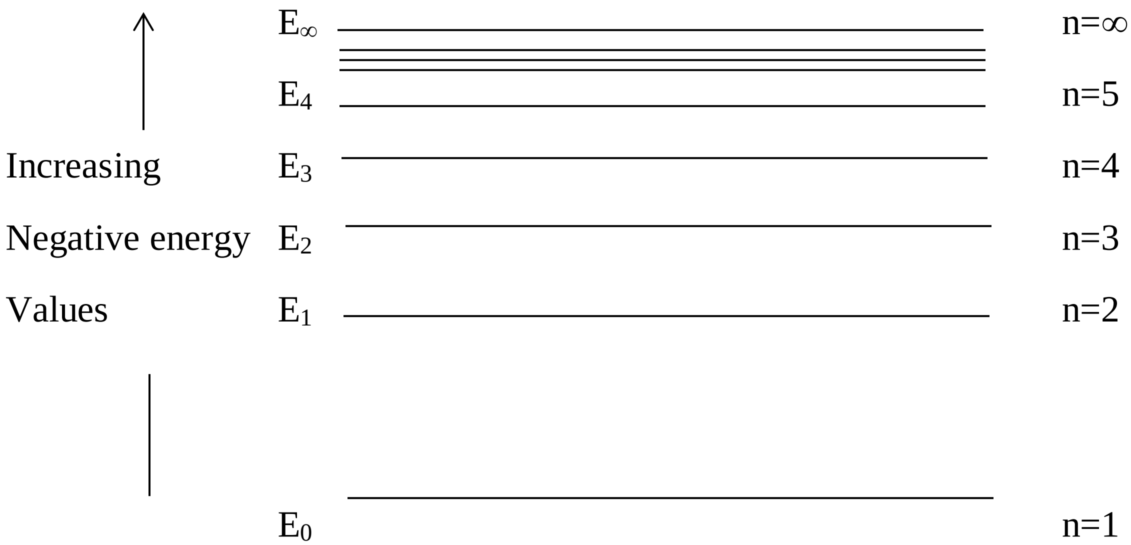
$$E = -\frac{1}{n^2}R \qquad \text{---2}$$

$n = electron\ quantum\ number$

$R = a\ constant$

The minus sign signifies that work must be done on the electron to remove it from the atom.

ENERGY LEVEL DIAGRAM



(Ground state -atom most stable state)

The ground state is the stable state or an atom corresponding to its minimum energy. When an atom is bombarded with an energetic particle, the atom is excited. An excited state is an allowed state of higher energy when the atom is unstable. One electron volt (1eV) is the energy acquired by an electron in falling freely through a potential difference of 1v

$1eV = 1.6\,x\,10^{-19}J$

During the excitation from lower energy level, the potential energy is converted into Kinetic energy so that the electrons eventually acquire a velocity given by:

$K.E = {}^{1}\!/_{2}\,mv^2 = eV$

The energy gained by electron = charge x p.d = eV

Therefore, the electron moves from one level to the other according to the relation.

$$E_n - E_0 = hf = \frac{hc}{\lambda} = eV$$

WORKED EXAMPLES

1. The change in energy level of an electron in an atom is 6.2×10^{-21}J. Calculate: (a) the frequency of the photon (b) the wavelength ($C = 3.0 \times 10^{8}$ ms^{-1}, $h = 6.625 \times 10^{-34}$Js)

Solution

$\Delta E = E_n - E_0$

$\Delta E = 6.2 \times 10^{-21}$

$\Delta E = hf$

$$f = \frac{\Delta E}{h}$$

$$f = \frac{6.2 \times 10^{-21}}{6.625 \times 10^{-34}}$$

$f = 9.358 \times 10^{2} Hz$

But

$C = f\lambda$

$$\lambda = \frac{C}{f}$$

$$\lambda = \frac{3.0 \times 10^{8}}{9.4 \times 10^{12}}$$

$\lambda =$

2. An atom excited to an energy level $E_2 = -12.42 \times 10^{-19}$J falls to a ground level of energy $E_0 = -30.3 \times 10^{-19}$J. Calculate the frequency and the wavelength of the emitted photon ($C = 3.0 \times 10^{8}$ ms^{-1}, $h = 6.625 \times 10^{-34}$Js).

Solution

$\Delta E = E_2 - E_0$

$\Delta E = -12.42 \times 10^{-19} - (-30.3 \times 10^{-19})$

$\Delta E = 17.88 \times 10^{-19}$

$$\Delta E = hf$$

$$f = \frac{\Delta E}{h}$$

$$f = \frac{1.788 \times 10^{-18}}{6.625 \times 10^{-34}}$$

$$f = 2.698 \times 10^{15} Hz$$

$$C = f \lambda$$

$$\lambda = \frac{C}{f}$$

$$\lambda = \frac{3.0 \times 10^{8}}{2.698 \times 10^{15}}$$

$$\lambda =$$

3. The ground state of hydrogen is -26.3eV and the second state is -10.3eV. Calculate the wavelength of the radiation if the electron returns to the ground state.

Solution

$$\Delta \mathrm{E} = E_2 - E_0$$

$$\Delta \mathrm{E} = -10.3\mathrm{eV} - (-26.3\mathrm{ev})$$

$$\Delta \mathrm{E} = 16\mathrm{eV}$$

1ev = $1.6x10^{-19}$J

16ev = 16 x $1.6x10^{-19}$J

$$\Delta E = hf = \frac{hc}{\lambda}$$

$$\lambda = \frac{hc}{\Delta E}$$

$$\lambda = \frac{6.625 \times 10^{34} \times 3.0 \times 10^{8}}{16 \times 16 \times 10^{-19}}$$

$$\lambda = 7.76 \times 10^{-19}\, m$$

4. If the p.d. by which an electron moves is 1.5kv. Calculate (a) the velocity with which the electron moves if the ratio of its charge to mass is 1.9 x 10^{11}c kg^{-1} (b) the kinetic energy

Solution

$K.E = {}^{1}/_{2}\, mv^2 = eV$

$2eV = mv^2$

$v^2 = \frac{2eV}{m}$

But ${}^{e}/_{m} = 1.8 \times 10^{11}$

$v = \sqrt{(2 \times 1.5 \times 10^3 \times 1.8 \times 10^{11})}$

$v = 2.3 \times 10^7 m/s$

$K.E = eV$

$K.E = 1.6 \times 10^{-19} \times 1.5 \times 10^3$

$$K.E = 2.4 \times 10^{-16} J$$

Photo-electric effect

When light falls on metal surface, electrons are emitted, this process is called photo electric effect emission, the emitted electrons are known as photo electrons.

The maximum kinetic energy of the emitted electrons is independent of the intensity of the incident light but proportional to the frequency (or wavelength) of the incident light.

Increasing the intensity of light increases the number of photo-electrons, but does not increase their energy or velocity. The absorbed energy is used to overcome the potential barrier of the photo-electrons.

APPLICATION

Photoelectric emissions are used in the following:

i. Burglary alarm
ii. Television camera

iii. Automatic devices for switching street light
iv. Sound production of film track
v. Industrial controls and counting operations.

Einstein Photo Electric Equation

Einstein photoelectric equation is given by

$$E = \frac{1}{2}mv^2$$

$$E = hf - w$$

$$w = hf_0$$

$$E = maximum\ kinetic\ energy\ that\ can\ be\ given\ to\ a\ photo\ electrons$$

$$W = work\ function$$

$$f_0 = Threshold\ frequency$$

$$hf = maximum\ energy\ of\ the\ liberated$$

THRESHOLD FREQUENCY (f_0)

This is the lowest frequency that can cause photo emission of electrons from a metallic surface. Below threshold frequency, emission will not occur.

WORK FUNCTION $(w = hf_0)$

This is the minimum energy required to liberate electrons from a metallic surface i.e. $(w = hf_0)$

$$E = hf - w$$

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

$$hf = hf_0 + E$$

$$E = hf - hf_0$$

Recall that

$$E = \frac{1}{2}mv^2 = eV$$

Thus,

$$E = hf - hf_0 = eV$$

EXAMPLE

Compute the frequency of the photon whose energy is required to eject a surface electron with a kinetic energy of 3.5 x 10^{-16}eV if the work function of the metal is 3.0 x 10^{-16}eV (h = 6.6 x 10^{-34}Js, 1eV = 1.6 x10^{-19}J)

$$E = hf - w$$

$$hf = E + w$$

hf=3.5 x 10^{-16}+3.0 x 10^{-16}=6.5 x 10^{-16}eV=6.5 x 10^{-16} x 1.6 x 10^{-19}

$$f = \frac{E + w}{h}$$

$$f = \frac{6.5 \times 10^{-16} \times 1.6 \times 10^{-19}}{6.6 \times 10^{-34}}$$

$$f = 0.157Hz$$

THRESHOLD WAVELENGTH

The threshold wavelength is the longest wavelength that will produce photo-electrons when the surface is illuminated.

$$w = hf_0$$

$$w = h\frac{c}{\lambda_0}$$

$$\lambda_0 = \frac{hc}{w}$$

Example

The work function of Lithium is 2.30eV; calculate (a) the maximum energy in Joules of photoelectrons liberated by light of wavelength 3.3 x 10-17m (b) the threshold wavelength of the metal.

Solution

$W = 2.3eV$

$E = hf - w$

$E = \frac{hc}{\lambda_0} - w$

$\lambda_0 = \frac{hc}{E + w}$

$\lambda_0 = 5.4 \times 10^{-7} m$

X-ray

X-ray was discovered in 1895 by Williams Rontgen. X – Rays are produced when thermally generated electrons from a hot filament are accelerated through a high potential difference and focused on to a tungsten target, where the electrons are suddenly stopped.

MODE OF PRODUCTION

In the X- ray tube, a high potential difference is applied between the hot cathode and the anode. Electrons are emitted from the cathode and are accelerated at an extremely high speed. They are abruptly decelerated when they strike the anode causing the emission of high energy radiation of short wavelength i.e. X-rays. The anode becomes very hot in the process and requires cooling fins on the outside of the tube.

ENERGY CONVERSION DURING X – RAY PRODUCTION

During X – ray production, electrical energy is converted to thermal energy. The thermal energy is converted into mechanical energy (kinetic energy) to accelerate the electron. The mechanical energy is converted into electromagnetic energy of the x-ray

TYEPS OF X – RAY

There are two types of x- rays

1. Hard x-rays – they have higher penetrating power and shorter wavelength
2. Soft x-rays - they have lower penetrating power and longer wavelength

HARDNESS

This is a measure of the strength or penetrating ability of the x – ray.

INTENSITY

This is the energy radiated per unit time per unit area by the x –ray. It depends on the current of the filament

PROPERTIES OF X- RAYS

1. They have high frequency
2. They have short wavelength (2×10^{-10}m)
3. They have high penetrating power
4. X ray have the velocity of light in space
5. X-rays travel in straight line
6. They are not deflected by electric or magnetic field.
7. They are diffracted by crystals.
8. They ionized gases
9. They cause zinc sulphide to fluorescence

APPLICATION OF X – RAYS

1. For examining body to locate broken bones
2. To detect metals and contraband in a baggage
3. They are used to detect cracks and flaws in metal castings and welded joints
4. For investigating crystal structure
5. Treatment of tumors and malignant growth
6. It is used in agriculture to kill germs
7. It is used in radiotherapy

HAZARDS OF X- RAYS

i. It causes genetic mutation
ii. It can destroy body cells
iii. It causes leukaemia, by damaging body tissues
iv. It causes skin burns and cancer.

PRECAUTIONS

Those who work with x-rays should put on lead coat and they should always go for regular medical checkup.

THERMIONIC EMISSION

Whenever a metal is heated to a sufficiently high temperature, electrons are emitted from the surface of the metal in a process known as thermionic emission

When the filament is heated to a high temperature, extra energy given to its free electrons at the surface of the metal enables them to break through the surface of the metal and exist outside it as an ‘electron cloud’. This is the process of thermionic emission.

The diode valve is a simple application of the principle of thermionic emission. It consists of an anode, usually in the form of a cylinder, a hot filament (heater) made of tungsten wire and components surrounding the filament. All these components parts are enclosed in a highly evacuated glass bulb.

Duality of matter – wave particle duality

The principle of wave-particle duality explains the dual nature of matter as a wave and as a particle.

DUALITY OF LIGHT

Light is an electromagnetic wave which radiates out from its source with a velocity of $3x10^8$m/s. This can be used to explain the concepts of reflection, refraction and interference. To explain other concepts like emission, absorption, photo electric effect and radiation of energy by heated bodies, it is assumed that light energy travels through space in the form of concentrated bundles of energy called photons. Each photon is assumed to have energy $E = hf$. According to Planck’s theory, h is called Planck constant.

Evidence of particle nature of light

i. Compton effect
ii. Photoelectric emission
iii. Radiation of light by hot objects

DUALITY OF MATTER

The wave-particle duality refers to the idea that light and matter (such as electrons) have both wave and particle properties. This means they can either behave as wave or as light but not as both simultaneously.

Louis de Broglie predicted the wavelength of the wave produced by a particle in motion as:

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

Where:

$\lambda = wavelength\ of\ the\ particle\ wave$

$p = mv = momentum\ of\ the\ particle\ in\ motion$

$h = Planck's\ universal\ constant$

The kinetic energy of such particle is related to its momentum by:

$$E_k = \frac{1}{2}mv^2 = \frac{1}{2}\frac{mv^2 \times m}{m} = \frac{P^2}{2m}$$

Recall that

$$E_k = \frac{1}{2}mv^2 = eV$$

Then, $\frac{P^2}{2m} = eV$

$$P = \sqrt{2meV}$$

Hence, the wavelength of the particle can be given as:

$$\lambda = \frac{h}{mv} = \frac{h}{p} = \frac{h}{\sqrt{2meV}}$$

UNCERTAINTY PRINCIPLE

Heisenberg has shown by this experiment in electron diffraction that it is impossible to make precise measurement of both the position(x), and momentum (p) of a particle simultaneously. He added that any such measurement has inbuilt uncertainties Δx in the position and Δp in the momentum.

Therefore, 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 approximately equals the Planck's constant, h.

He showed that:

$$\Delta x . \Delta P \geq h$$

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

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

ΔE is the uncertainty in the energy, ΔP is the uncertainty in the momentum, Δx is the uncertainty in the position and Δt, the uncertainty in time of the particle. Hence, this principle is saying that we cannot determine the exact values of these quantities.

CLASSWORK 1

1. What is ionization energy?
2. Explain photoelectric effect
3. An electron jumps from one energy level to another in an atom radiating 9.0 x 10^{-19}J. If h = 6.6 x 10^{-34}Js and C = 3.0 x 10^{8}m/s, what is the wavelength of the radiation?
4. Explain the term excitation
5. Define threshold wavelength
6. Determine the frequency of the photon whose energy is required to eject a surface electron with a kinetic energy of 1970x10^{-19}eV. If the work function of the metal is 1334 x 10^{-19}eV. (1eV = 1.6 x 10^{-19}J, h = 6.6 x 10^{-34}Js, C = 3.0x10^{8} ms^{-1})
7. The maximum kinetic of the photo electrons depend on (a) work function (b) frequency (c) intensity of the incident ray
8. The minimum energy required to liberate an electron from a metallic surface is (a) ionization energy (b) work function (c) kinetic energy,

ASSIGNMENT

SECTION A

1. Which of the following are not complimentary variables (a)Energy and time (b) energy and position (c) Energy and mass (d) Velocity and position .
2. Which of the following factors does not support the wave model of light? (a) Diffraction (b) Interference (c)Refraction (d) Photo emission

3. According to quantum theory, electromagnetic wave is transmitted in tiny bundles of energy called (a) phonons (b) electrons (c) photons (d) protons
4. Which of the following scientists proposed the uncertainty principle? (a) De Broglie (b) Heinsberg (c) Newton (d)Lenz
5. When a metal is heated to a high temperature and electrons are emitted from its surface, this is known as ……….(a) photoelectric emission (b) thermionic emission (c) field emission (d) secondary emission
6. The term electrical discharge means (a) voltage is a gas (b) current in a liquid (c) current in a gas (d) voltage in a liquid.
7. Which of the following is an application of glow discharge phenomena? (a) filament lamp (b) fluorescent lamp (c) cathode ray oscilloscope (d) electron microscope
8. Which of the following is an application of hot cathode emission? (a) filament lamp (b) cathode ray oscilloscope (c) electron telescope (d)Binoculars
9. Which of the following contributed to conduction in a gas?(i) molecules (ii) electrons (iii) ion (A) I only (b) II only (c) I and III only (d) II and III only.
10. The minimum frequency that can cause photo emission of electrons from metal surface is known as (a) wavelength (b) threshold frequency (c) frequency of the incident light (e) none of the above
11. The energy associated with the photon of a radio transmission at 3×10^{5}Hz ($h=6.60\times10^{-34}$Js) (a) 1.30×10^{-29}J (b) 2.00×10^{-29}J (c) 1.30×10^{-28}J (d) 2.00×10^{-28}J (e) 3.2×10^{-29}J
12. Production of x-rays in an x-ray tube begins with (a)photoelectric emission (b) collision of electrons (c) thermionic emission (d) field emission (e) no one of the above
13. The maximum kinetic energy of the photoelectrons emitted from a metal surface is 0.34eV. If the work function of the metal surface is 1.83eV, find the stopping potential (a) 0.34V (b) 2.17V (c) 1.49V (d) 1.09V (e) 3.0V
14. Two radioactive elements A and B half-lives of 100 and 50 years respectively. Samples A and B contain equal number atoms. What is the ratio of the remaining atoms of A to that of B after 200 years? (a) 4:1(b) 2:1 (c) 1:1 (d) 1:2 (e) 1:4

SECTION B

1. (a) Explain what is meant by the duality of matter, illustrating your answer with observable phenomenon

(b) The mass and wavelength of a moving electron are 9.1×10^{-31}Kg and 1.0×10^{-10}m respectively. Calculate the kinetic energy of the electron and hence its velocity

2. (a) What is the energy of a photon whose frequency is 50KHZ, given that Planck constant, h= 6.6×10^{-34}Js.
   (b) Describe briefly the production of x-ray
   (c) Highlight 5 uses of x-ray
3. (a) A bullet of mass 0.002kg is fired with a velocity of 1000m/s. What is its de Broglie wavelength?
   (b) Define half-life
4. A radioactive element X with atomic number 88 and mass number 226 emits in succession (i) an alpha particle (ii) a beta particle and; (iii) gamma radiation. Explain, using equations where necessary, the changes that take place in the atomic structure of the element at each stage.

WEEK FOUR

BATTERY

- ❖ Battery
- ❖ Construction of battery
- ❖ Electroplating – electroplate a suitable electrode

TOPIC: ELECTRIC CELLS

SUB-TOPIC-: ELECTRIC CIRCUIT

Electric current is simply electric charge in motion. In conductors such as cables or wire, the current consist of swam of moving electron. Electric cells are chemical devices, which are capable of causing an electric current to flow. This produces electric force, which pushes the current along. If there is a complete circuit of conductors by which current can leave from one end to terminal of the cell and travel round to the other terminal, a current will flow. This current will be the at any point round the circuit and of the line is broken, the current is stopped or switched off. The electrons flow from the negative terminal or cathode of the cell to the procedure terminal or anode

SUB-TOPIC-: TYPES OF ELECTRIC CELLS

Electric cells are divided into two namely: the primary cells and the secondary cells

PRIMARY CELLS: These are those cells in which current is produced as a result of an irreversible chemical charge.

SECONDARY CELLS: These cells are those which can be recharged when they run down by passing current backwards through them .

There are three component in a cell .Two of them are electrodes in the primary cell, the two electrodes are of different metals (graphics is often used) the third item is the container bearing the electrolyte. Examples of electrolyte are strips of aluminum, Carbons (graphite) copper, iron lead and zinc

SUB-TOPIC: THE SIMPLE PRIMARY CELL (VOLTAIC CELL) A simple cell can be made by placing two different electrodes (metals) in an electrolyte. Two wire are then used to connect these metals to a voltmeter, an instrument which measure the potential different between any two point in an electric circuit. If a deflection is noticed it mean that the cell creates a voltage. If the deflection is done to the right it mean that the electrode, or anode, which is connected to the positive terminal of the voltmeter is the positive electrode, or anode, while the one is connected to the negative terminal is the negative electrode or cathode. If the deflection is however done to the left, a reconnection should be done .

The two major deflects of a simple all are polarization and local action

POLARIZATION: The cell is characterized by the release of “hydrogen bubbles.” The bubbles collect at the positive electrode and insulate it. This show down and eventually stops the working of the cell. This defect is called polarization.

This defect can be corrected either by occasionally brushing the plates, which is highly inconvenient, or by using a depolarizer e.g. manganese oxide. This oxides hydrogen to form and so removes the hydrogen bubble.

LOCAL ACTION: This occurs when pure zinc is not in use. The impurities in the zinc results in the gradual wearing away of the zinc plates. This can be prevented by cleaning the zinc with H_2SO_4 and then rubbed with mercury. The mercury amalgamates the zinc by covering the impurities thereby preventing it from coming into contact with electrolyte.

SUB-TOPIC-: LECLANCHE CELL

Leclanche cells are of two types : the wet and the dried types. The wet leclanche cell consists of a zinc rod at the cathode in solution of ammonium chloride contained in a glass vessel. The anode is a carbon rod contained in a porous pot and is surrounded by manganese chloride as a depolarize

An e.m.f. Is set up by the zinc, the carbon and the electrolyte, which drives a current from zinc to carbon through the cell. This carbon is at a higher potential than the zinc. When an external circuit is connected to the cell, current flows from carbon to zinc out side. The e.m.f is set up because zinc reacts with the ammonium chloride to form zinc chloride, ammonia and hydrogen, and electrons are released. These electrons flow from the zinc plate to the carbon plate out side the cell.

Hydrogen reacts with the manganese dioxide and oxidizes it to form water. The e.m.f of a leclanche cell is 1.5 v.Its defect include

When the cell has worked for some time, the rate of hydrogen production becomes greater than rate at which it is oxidized by the manganese dioxide, hence the formation of polarization. Therefore the cell must be allowed to rest from time. This primary cells are restricted to intermittent current supply because they do not give continuous service.

They are too heavy to carry about without spilling the liquid

For the dry leclanche cell, the defect of heaviness is overcome

The ammonium chloride electrolyte is a jelly-like material and not aligned solution. The positive electrode is a carbon rod surrounded by a packed mixture of manganese dioxide and powered carbon, inside a zinc container, which is the negative electrode.

The dry can be carry about easily E.g. torch batteries, and transistor radio batteries. Due to local action, they deteriorate after sometime.

THE DANIEL CELL

This is also a primary cell invented to counter the problem of polarization. The zinc rod is the negative electrode while the positive electrode is the container. The electrolyte is dilute tetrasulphate (vi) acid contained in a porous pot around the zinc rod, and the depolarize is copper tetraoxosulphate (vi) in the surrounding copper container. The diaphoreses is mush more efficient than the leclanche cell. The e.m.f. is of a constant value of l..08V.

Fig: **THE DANIEL CELL**

Secondary cell are of two main type: lead acid accumulator, and the alkaline or Nife accumulation.

The lead-acid accumulator. This is the most common one. It consist of lead oxide as the positive electrode, lead as the negative electrode and tetra oxosulphate (vi) acid as the electrolyte. During the discharge, when the cell is given out current both plates gradually charge to lead tetraoxosulphate (vi) while the acid gradually becomes more dilute and the density decreases. When fully charge the relative density and e.m.f. of the cell are 1.25 and 2.2v respectively. But when discharge they are reduced to 1.5 and less than 2.0v respectively. The rod density of the cell should not be allowed to drop 1.15 before it is recharged. **MAINTENANCE OF LEAD ACID ACCUMULATORS**

1 The liquid level must be maintained by using distilled H_2^O

2. The cell should be charge if relative. Density of acid falls below 1.15. it is fully charged when relative.

density of acid is 1.25. it is tested with a special hydrometer.

3 .If the cell is not in use for a long time, it should be discharge from time to time or the acid remove and the

cell dried.

4. The battery should be kept clean so that current dose not leaks away across the casing between the terminals. The alkaline or Nife accumulators.

The name is gotten from the chemical symbol nickel (Ni) and iron (Fe). The positive electrode is made of nickel hydrogen while the negative plate is either of iron or calcium. The electrolyte is potassium hydroxide dissolve in water. This cell last longer and lead acid cells, keep their charge longer and they require less maintenance. They are used for emergencies in factories and hospitals. They are expensive and bulky with a small e.m.f value, about 1.25v.

EVALUATION

- What is the advantage of dry leclanche. Cell over wet leclanchecell.?
- How can polarization and local action be prevented.?

Reading Assignment

New School Physics for Senior Secondary Schools (M.W. ANYAKOHA pgs 397 – 402).

WEEKEND ASSIGNMENT

- The energy transformation taking place when a cell supplies current to a bulb is from (a)light energy to heat energy (b) mechanical energy to light energy (c)solar energy to electrical energy (d) chemical energy to light energy
- which of the following devices convert sheet energy to electric current? (a)photo cell (b) battery (c) voltmeter (c) thermocouple

(3). during an activity, is coulombs of charge passed though an ammeter in 2second what is the reading of the ammeter ? (a) 2A (b) 5A (c) 8A (d)10A

(4). which of the following devices coverts mechanical energy to electric current (a) battery (b) photocell (c) thermopile (d)dynamo

(5). the rheostat could serve the following except. (a)as a variable resistor (b)as a potential divider (c)as a means of varying the current in a circuit .(d) as a converter of solar energy to electrical energy

THEORY

- Briefly differentiate between primary cell and secondary cells.
- list two defects of a simple cell

ELECTROLYSIS

DEFINITION OF SIMPLE TERMS

ELECTROLYSIS-: Is the process whereby a liquid conducts electricity by the movement of positive and negative ions within the liquid while undergoing chemical changes.

ELECTROLYTES -: Are liquid, which allows the electricity through them is called electrolytes. Such electricity is salt solutions, alkalis and dilute acids (acidulated water).

NON-ELECTROLYTES-: are liquids, which do not allow electricity to pass through them. Such liquids include distilled water, alcohol, liquid paraffin and sugar solution.

NOTE-: metals and hydrogen are deposited at the cathode, while non-metals and oxygen are deposited on the anode. The anode may dissolve in solution.

Electrolysis does not manufacture electric charges and it is the "splitting' of compounds by electricity. E.g. water decomposes into oxygen and hydrogen by electric current.

Electrolysis begins when the electric circuit is completed and ends abruptly when the electric circuit is broken

FARADAY'S LAWS OF ELECTROLYSIS

Faraday's first law states that the mass of a substance liberated during the process of electrolysis is proportional to the quantity of electricity passed through the electrolyte

Faraday's second law of electrolysis states that the relative masses of substances liberated by the same quantity of electricity are proportional t their chemical equivalents.

SIMPLE CALCULATIONS

If M is the mass of substance deposited when a current q flows for time t, then the quantity of electricity of electricity which flows is flows is It, and

$m = Z\,It.$

Where, Z = electrochemical equivalent (e.c.e) the substance.

$\ldots.\ Z = \frac{m}{It} =$

I = current in A

t = time in see

m = mass of substance in grammes.

APPLICATIONS OF ELECTROLYSIS

In industry, electrolysis is used in electroplating of metals, purification of metals and electrolytic production of metals from compounds.

(I) ELECTROPLATING

This process is used in coating cutlery and other articles with copper, silver, chromium, nickel or gold. The article to be plated is used as the cathode and the coating metal is used as the anode. The electrolyte is a solution of a salt of a salt of the plating metal. For example, in the silver –plating of a spoon is made the cathode, pure silver is the anode, and silver nitrate solution is the electrolyte (see figure below). Two anodes would be placed, one on each side of the spoon so that back and front would be plated at once.

The silver nitrate dissociates in solution into silver ion and nitrate ions.

$AgNoAg^{+} + No^{-}_{3}$

When electricity is passed through the solution, the Ag ions move towards the cathode where they are discharged and the spoon becomes coated with metallic silver. The NO remains in solution, combining with silver from the anodes to form more silver nitrate, thus staying at its original concentration.

(ii)THE PURIFICATION OF METALS

In the electrolysis of copper sulphate using copper electrodes, copper is deposited at the cathode while at the same time the copper from the anode goes into solution.

In purification of copper metal, the impure copper is made the anode while the pure copper is made the cathode. When current is passed, copper ions are dissolved from the anode and deposited at the cathode leaving the impurities behind. The pure copper is used in manufacture of electric cables because of its low

resistance.

(iii)THE ELECTROLYTIC PREPARATION OF METALS FROM COMPOUNDS

Metals such as aluminum, sodium and potassium are prepared from their molten chlorides or hydroxide by the process of electrolysis.

EVALUATION

1. Mention at least two uses of electrolysis

2. Explain how electrolysis can be used to calibrate an ammeter

EVALUATION

1. Which of the following statement about the defects of simply cells is not correct? (a) Polarization defect is minimized by use of manganese oxide as depolarizer (b) Polarization may also be reduced by brushing the plates occasionally (c) Local action occurs because zinc is not pure (d) local action also occurs because hydrogen bubbles accumulate at the plate.
2. Which of a-d below is correct? (1) Ordinary torch battery is an example of primary cell (ii) accumulations has very high interne resistance (a)(i) only (b) (ii) only (c)(iii) only (d) (i) and (ii) only
3. Which of the following statement is not true? (a) the chemical action in a primary cell is irreversible (b)lead-acid accumulation can be recharged (c)lead-acid accumulator has large internal resistance (d)a secondary cell can be recharged.
4. The defect in simple cell which result in a back e.m.f and increase in internal resistance is known as (a)local action (b) reduction (c)polarization (d) oxidation
5. Which of the following instrument is most accurate for comparing e.m.f of two cells? (a) Wheatstone bridge (b) galvanometer (c) potentiometer (d)meter bridge

ASSIGNMENT

1. What is electrolysis?

2. In an electrolysis of copper tetraxosulphate (vi) using copper electrodes, 1.53g of copper wire deposited in 30 minutes. Determine the average current used. ($z=3.29 \times 10^{-4}$)

ELECTROMAGNETIC FIELD

Fleming left hand rule

Application – D.C Motors, moving coil galvanometer.

ELECTROMAGNETIC FIELD: This is a field representing the joint interaction of electric and magnetic forces. It is exerted on a charged particles . The force on a charge q moving with a velocity v (less than the velocity of light is given by

$$F = q (E + v \times B)$$

A conductor carrying an electric current when placed in a magnetic field experiences a mechanical force. It can be demonstrated by using two metal rails fixed on each side of a powerful horse-shoe magnet. A copper rod is placed across the rails. When we pass current through this copper rod, it is observed that the copper rood rolls along the rails, towards the right. If by adjusting the rheostat, we cause more current to flow through the rod, we will observe that the rod moves faster . Thus the force on the rod increases when the current increase.

DIRECTION OF THE FOCE; The direction of force on a current carrying conductor placed perpendicular to the magnetic field is given by Fleming's left-hand rule which is stated as follows:

If the thumb, forefinger and middle finger are held mutually at right angles to one another with the fore-finger pointing in the direction of magnetic filed, and the second finger in the direction of Current, then the thumb will point in the direction of Motion for force producing motion .

Motion

Field

Current

EVALUATION.

1. What do you understand the term electromagnetic field?

2. State Fleming's left hand rule

Applications of Electro magnetic Field.

i.ELECTRIC MOTOR: The electric motor is a device for converting electrical energy into chemical energy. It consist:

(i) a rectangular coil of insulated wire, known as armature ,

(ii)a powerful magnetic field in which the armature turns is provided by two curve pole pieces of a powerful magnet

.(iii) a commutator consisting of a split copper ring, two halves of which are insulated from each other.

(iv) two carbon brushes which are made to press lightly against either side of the split-ring commutator

ii. **MOVING COIL GALVANOMETER**: This galvanometer is one of the most sensitive and accurate methods for detecting or measuring extremely small currents or potential differences.

Structure:

It consist essentially of

1. A light rectangular vertical coil ABCD pivoted in jeweled bearings such that it can move in a vertical

plane

2. two curved pole piece of a horse shoe magnet and a soft iron core or cylinder inserted between the pole pieces.

3. two spiral non-magnetic control springs of phosphor bronze, each of which is attached to the jeweled bearing or spindle. Current enters or leaves the rectangular coil through these spiral springs. The springs also provide the control couple .

EVALUATION

STUDENT PROJECT. Draw the structures of the electric motor and the moving coil galvanometer. Explain the working principle of both

WEEKEND ASSIGNMENT

1. The current produced by a simple dynamor is not steady because:

(a) a back e,m,f opposes the induced voltage

(b) eddy currents oppose the motion which induces them, and absorbs energy from the current

(c) the magnetic field produced by the magnet is not sufficiently uniform.

(d) the induced current opposes the motion which causes it, in accordance with Len's law.

2. Induced current depend on the

(a) Number of turns in the coil

(b) Strength of the magnet

© sped with which the magnet is plunged into the coil

3. To convert an alternating current dynamo into a direct current dynamo the

(a) number of turns in the coil is increased

(b) strength of the field magnet is increased

(c) slip rings are replaced with split ring commutator

(d) coils is wound on a soft iron armature

4. Which of the following operation will not lead to an increase in the induced e.m.f in a coil of wire rotating between the poles of a magnet? Increasing the :

(a) area

(b) strength of the magnet

© gap between the poles of the current

(d) number of turns in the coil

(e) speed of rotation in the coil

5. Which of the following statements about a generator is not correct?

(a) it can produce direct current

(b0 it can produce alternating current

© it requires an external supply of energy to rotate the coil

(d) it requires an external supply of current to the coil

THEORY

1. Explain the term ‘electromagnetic field

2. Name three powerful permanent magnet.

TRANSFORMER AND POWER TRANSMISSION

A transformer is an electrical device for changing the size of an a.c. voltage. It acts to increase or decrease the em.f of an alternating current. It consists of two separate sets of coil, the primary coil and the secondary coil. The primary coil is the input winding of turns of wire and the secondary coil is the output winding. The coils are wound round a soft-iron core. The soft-iron core acts to increase and concentrate the magnetic flux within the core. It is also laminated, i.e. it consists of sheets of soft-iron insulated from each other instead of a solid block of iron. This lamination reduces loss of energy in the form of heat due to eddy currents introduced in the core.

STEP DOWN TRANSFORMER

When an alternating e.m.f. or a.c voltage (EP) is applied at the terminals of the primary coil (p), an alternating magnetic flux is produced in the iron core which links or threads the secondary coil (s). An alternating e,m,f (Es) of the same frequency as that Ep is induced in the secondary coil by mutual inductance.

Mutual inductance is the flow of induced current or voltage in a coil due to an aternting or varying current in a neighbouring coil.

The total flux linking the two coils is proportional to their number of turns. The induced e.m.f in the secondary coil (Ep) depends on the e.m.f. in the primary coil and on the ratio of the number of turns in each

:. $\frac{ES}{Ep} = \frac{Ns}{Np}$

In an ideal transformer with a 100% efficiency, the power developed in the secondary coil is equal to the power developed in the primary coil.

:. $\frac{Es}{Ep} = \frac{Ip}{Is}$

Hence, $\frac{Es}{Ep} = \frac{Ns}{Np} = \frac{Ip}{Is}$.

To use a transformer to increase an applied voltage, i.e to make Es greater than Ep, Ns must be grater than Np . such a transformer which increases or steps up the applied or primary voltage is called a step-up transformer. In a step-up, the primary current is greater than the secondary current but the primary voltage is less than the secondary voltage.

ENERGY LOSSES IN PRACTICAL TRANSFORMER

There are energy losses in practical transformers due to:

i. Eddy currents ii. Hysteresis loss, iii. Heat loss iv. Leakage of magnetic flux

Eddy Current reduces efficiency because they consume power and this causes energy lost in the form of heat. Such loss can be reduced by laminating the core.

Hysteresis loss is wasted energy due to reversing the magnetization of the core. It is reduced by the use of special alloys in the core of the primary coil.

Heat loss: the primary and secondary coils have resistance, some energy is lost in the form of heat(I2R) in the coils. This can be reduced by using thick wires or low resistance coils.

Some energy is lost due to leakage of magnetic flux. This arises because not all the lines of inductin due to current in the primary coil pass entirely through the iron core. This loss is reduced by efficient core design.

EXAMPLES

1. Find the turns ration in a transformer which delivers a voltage of 12ov in the secondary coil from a primary voltage of 60v.

turns ration = Ns = 120 = 2

Np 60

2. A transformer has 500 turns in the primary coil and 300 turns in the secondary coil. If the primary coil is connected to a 220v mains, what voltage will be obtained from the secondary coil? What type of transformer is this ?

Es = Ns

EpNp

Es= 300

- 500

Es = 220 x 300

500.

Es= 132 v

It is a step-down transformer because secondary voltage is less than primary voltage (132 < 220)

3. A transformer supplies 15v from a 220v mains. If the transformer takes 0.7A from the mains when used to light three lamps connected in parallel and each rated 15v,40w, calculate:

i. the efficiency of the transformer

ii the cost of using it for 24hrs at 30k per kwh.

Primary or input power = IpVp

= 0.7 x 220 = 154w

secondary (output power) =IsVs = (Is x 15)w

p = iv

$\frac{p}{V}$ =

Is = $\frac{40}{15.}$ = 2.67A.

Total current taken by the 3 lamps in parallel = 3 x 2.67 =8A

:. Output power = 8 x 15 = 120 W

Efficiency = $\frac{\text{Output Power}}{\text{Input Power}}$ X 100

= 120 x 100

- = 78%

Power consumed = $\frac{0.7 \times 220}{1000}$ Kw

Total power consumed in 24 hrs

= $\frac{0.7 \times 220}{1000.}$ x 24kwh

Cost at 30k per kwh

= (0.7 x 220 X 24 X 30

- 100

= N1

EVALUATION

- Draw a labeled diagram to explain the working of a transformer which can produce 24v from a 240v supply.
- Give two reasons which explains why the efficiency of the transformer cannot be 100%.

POWER TRANSMISSION

Power generated at power stations are distributed over large distances to consumers through metal cables, Power can be transmitted either at low current and high voltage or at high current and low

voltage . Because the metal cables through \h which the power is transmitted have a certain amount of electrical resistance, transmitting power at high current will lead to loss of energy in the form of heat. To avoid, this power is transmitted at high voltage and low current. This is known as high tension transmission.

Low currents leads to low energy loss. It also requires thinner cables, cost of cable materials is considerably reduced if power is transmitted with low current and high voltages.

Step down transformers are used to reduce the high transmitted voltages to lower voltages required in home and factories .

READING ASSIGNMENT

New School Physics pg 447 – 457

EVALUATION

1, Induced current depends on the

i. number of turns in the coil

ii. strength of the magnet

- speed with which the magnet is plunged into the coil

Which of these is/are false

(a) I only (b) II only (c) II and III only (d) III only (e) None of the above.

2. To convert an alternating current dynamo into a direct current dynamo the ;

(a) number of turns in the coil is increased (b) strength of the field magnet is increased

(c) slip rings are replaced with split rings commutator (d) coil is wound on a soft iron armature

3. Which of the following devices would be used onts own in the working of a petro-driven motor car engine for obtaining a high voltage from a low one

(a) induction coil (b) A.C dynamo (c) D.C generator (d) the transformer (e) the electric motor.

4. A transformer with 5500turns in its primary is used between a 240v a.c supply and a 120v kettle. Calcualte the number of turns in the secondary

(a) 1100 (b) 2750 (c) 460 (d) 232 (e) 10.

5. If a current –carrying coil is mounted on a metal frame, the back e.m.f. induced in the coil causes

(a) inductance (b) Eddy current s (c) Electromagnetism (d) Dipole moment.

ASSIGNMENT

1. With the aid of a diagram, describe the principle of an induction coil. Mention two applications of this device.

1b, State the laws f electromagnetic induction

3.Distinguish between a step-up and a step down transformer. Give two reasons why it is preferred to transmit power over long distances using a high voltage and a low current.

WEEK FIVE

- Uses of machines
- Need for the use of machines in doing work
- Instances of use of machines
- Dams and energy Production
- Location of dams for producing electricity in Nigeria
- Principle of Electricity from dam

Uses of machines

A machine is a device that aids man in the performance of work and makes the work easier, quicker and more convenient. Machines use energy to multiply a force, change the direction of a force, transform or transfer energy or multiply speed.

A machine may also be used to change the direction of a force. A single pulley at the top of a flagpole enables one end of the rope to exert an upward force on the flag as a downward force is exerted on the other end

Another use of a machine is to transform energy. A generator transforms mechanical energy into electrical energy. A steam turbine transforms heat energy into mechanical energy.

Need for the use of machines in doing work

Machines are needed to make our work easier, quicker and more convenient. Machines are employed to save work and multiply our ability to do work. They increase the force we need, add some energy, do work we could not do before.

REPAIRS AND MAINTENANCE OF MACHINES

Machines especially those with moving parts should be checked routinely for regular maintenance and probably repairs. This should be done to ensure the normal operation of machines and to prevent any possible break down. Maintenance requires things like lubrication, cleaning and replacing minor parts to ensure smooth running of the machine.

NEED FOR REPAIR OF MACHINES

Machines are repaired so that we can put it into continuous use. The defective parts of the machine are replaced with new ones. Repair of machines is cost effective instead of purchasing and installing new ones

NEED FOR REGULAR MAINTENANCE OF MACHINES

Regular maintenance increases efficiency and speed of machines. It conserves the energy and life of machines, prevents the replacing of the parts of the equipment before the scheduled time. Regular maintenance of machines ensures safety of the operator since if the machine is not in good condition, it might lead to a major accident. Regular maintenance of machines also saves money and time.

Dams and energy Production

A dam is a barrier constructed across a stream or river to impound water and raise its level for various purposes such as generating electricity, irrigation and water supply systems, increase river depths for navigational purposes, to control water flow during times of flood and drought, create artificial lakes for fisheries and recreational use. In Nigeria, dams are used mainly for water supply systems, energy production (hydroelectricity) and for irrigation purposes. The following are some of the dams in Nigeria:

Location of dams for producing electricity in Nigeria

1. **KAINJI DAM**: It is dam across the Niger River in Kainji, Niger State, Nigeria. Construction of the dam began in 1964 and was completed in 1968.The dam is one of the longest dams in the world and the largest in Nigeria. The dam has a generating capacity of 800MW of electricity and generates electricity for all the large cities in Nigeria.
2. **SHIRORO HYDROELECTRIC POWER STATION**: It is a hydroelectric power plant of the Kaduna River, Shiroro, Niger State in Nigeria. It has a power generating capacity of 600MW of electricity enough to power over 404,000 homes. It was completed in 1990 and creates Lake Shiroro.
3. **ASEJIRE RESERVOIR**: It is located in Oyo State in the South West of Nigeria on the Osun River, about 30km East of Ibadan. The reservoir provides raw water to the Asejire and Osegere water treatment plants in Ibadan. The water supply project was completed in 1972, and has a capacity of about 80million litres per day of which 80% is used for domestic purpose.

4. **GUSAU DAM**: It holds a reservoir on the Sokoto River just upstream from Gusau, capital of Zamfara State of Nigeria. It supplies water to the city and neighboring communities.
5. **JEBBA HYDROELECTRIC POWER STATION**: It is a hydroelectric plant of the Niger River in Nigeria. It has a power generating capacity of 540MW enough to power over 364,000 homes. The power station is located in Jebba, Niger State, North Central, Nigeria. It was completed in 1985 and creates Lake Jebba.

Principle of Production of Electricity from dam

The power of falling water is unlocked by a hydroelectric dam in the form of electricity. Hydroelectric power produced by hydroelectric dams account for 20% of the world's total production of electrical energy.

A large quantity of water is stored in a reservoir or dam. The height or depth of the stored water determines how much electricity can be generated. As the depth increases, the generation of electricity also increases. A control gate is used for releasing/blocking water from the dam. Depending upon the electricity requirements, the gate is opened.

The released water from the dam reaches the turbine blade through the penstock. The proper slope and diameter of the penstock is important for the efficiency of the dam.

The turbine consists of a number of large fan blades and a spindle. The spindle rotates when the water strikes the blades. Thus, the power of flowing water is converted to the rotational power of the spindle. The spindle of the turbine is connected to the alternator where rotational power of spindle is converted into electrical power. The produced electricity is the distributed to the grid. The outflow of water from the turbine is released to a river.

EVALUATION

1. What is a dam?
2. Highlight State four uses of dams
3. What do you understand by the term “machine”?

ASSIGNMENT

1. List 10 international DAMS, stating its location, function and capacity

2. Mention four factors for siting a dam location
3. How is electricity produced from dams?
4. Mention five ways of maintaining dam

WEEK SIX

ROCKETS AND SATELLITES

- Rockets and Satellites
- Component part of rockets and satellites
- Functions of rockets and satellites and uses
- Niger-SAT 1- Features, Operation and Uses
- NICOM-SAT 1 - Features, Operation and Uses

Rockets and Satellites

A rocket or rocket vehicle is a missile, spacecraft, aircraft or other vehicle which obtains thrust from a rocket engine.

A satellite is an object that goes around or orbits a larger object such as a planet. While there are natural satellites like the moon, hundreds of man-made satellites also orbit the earth.

In all rockets, the exhaust is formed entirely from propellants carried within the rockets before use. Rocket engine works forward simply by throwing their exhaust backwards extremely fast. Rocket engine employs the principle of jet propulsion.

Rocket vehicles are often constructed in the archetypal tall thin rucked shape that takes off vertically but there are usually many different types of rockets including:

a. Tiny models such as balloon rockets, water rockets, sky rockets or small solid rockets

b. Space rocket such as the enormous Saturn V used for the Apollo program

c. Missile rockets

d. Rocket cars

e. Rocket bike

f. Rocket powered aircraft

g. Rocket sleds

h. Rocket trains

I. Rocket torpedoes

j. Rocket powered jet packs

k. Space probes, etc.

Rockets work by accelerating gas to very high speeds inside and then letting the gas escape from the back of the rocket.

Satellites are celestial bodies orbiting round a planet or star. Artificial satellites are used for many different things including scientific studies of the solar system, worldwide telecommunications, military intelligence, television and earth monitoring for weather or climate studies.

Component part of rockets and satellites

Rockets consist of a propellant, a place to put propellant (such as a propellant tank) and a nozzle. They may also have one or more rocket engines, directional stabilization devices such as fins, vernier engines or engines gimbals for thrust vectoring, gyroscopes and a structure (typically monologue) to hold these components together. Rockets intended for high speed atmospheric use also have an aerodynamic fairing such as nose cone which usually holds the payload.

As well as these components, rockets can have any number of other components such as beings (rocket planes), parachutes, wheels (rocket cars) etc. Vehicles frequently possess navigation systems and guidance systems which typically use satellite navigation and inertial navigation systems.

The main components of satellite (human-made satellite) are communication capabilities with earth, a power source and a control system to accomplish its mission.

Functions of rockets and satellites and uses

1. **MILITARY:** Some military weapons use rockets to propel warheads to their targets. A rocket and its payload together are referred to as a missile when the weapon has a guidance system (not all missiles use rocket engines, some use other engines such as jets) or as a rocket if it is unguided.
2. **SCIENCE AND RESEARCH:** Sounding rockets are commonly used to carry instruments that take readings from 50km to1500km above the surface

of the earth, the altitudes between those reachable by weather balloons and satellites.

3. **SPACEFLIGHT**: Larger rockets are normally launched from launch pad which serves as a stable support until a few seconds after ignition. They are used to rapidly accelerate spacecraft when they change orbits or de-orbit for landing. Also, a rocket may be used tons often hard parachutes landing immediately before touchdown
4. **RESCUE:** Rockets were used to propel a line to a stricken ship so that a breeches buoy can be used to rescue those on board. Rockets are also used to launch emergency flares
5. **HOBBY, SPORT AND ENTERTAINMENT:** Hobbyists build and fly model rockets of various types and rockets are used to launch both commercially available fireworks and professional fireworks display. Satellites are used in communications, navigation, weather forecasting, environmental monitoring, manned platforms etc.
6. **COMMUNICATIONS SATELLITES**: They have a quiet, yet profound effect on our daily lives. They link remote areas of the earth with telephone and television. Modern financial business is conducted at high speed via satellite

Niger-SAT 1- Features, Operation and Uses

Nigeria made its debut in satellite space technology on September 27, 2003 when it launched Sat-1 aboard a Russian rocket. The Niger-sat1 carries an imaging payload that provides satellite images of 32m resolution with a swath width of 600km using push broom scanning in three spectral bands (Red, Green and Near infra-red) and 3-5 days revisit and a daily revisit when in constellation with four other satellites.

FEATURES OF NIGER SAT-1

These are the patch antennas, QFH antennas, camera banks, module stack which consists of SSD4, OBC386, GPS/SA1100, OBC186, ADCS power, yam wheel, propulsion tank and propulsion controller

OPERATION AND USES OF NIGERSAT-1

It is in space and is being operated from the ground station (mission control ground station) in Abuja, Nigeria for telemetry, tele-control and command of the spacecraft.

It is used for monitoring of boundaries and oil pipelines, ground water investigation, oil theft and smuggling activities band environmental observations. It is used for better planning and effective disaster management.

NICOM-SAT 1 - Features, Operation and Uses

It is Nigerian communications satellite. It is also called NIGCOM-SAT 1.It was launched in May, 2007by along March 3-B rocket in China.

FEATURES OF NICOM-SAT 1

It is a superb hybrid geostationary satellite with a launch mass of 5150kg, a service life of at least 15 years and reliability more than 0.70 at the end of its lifetime. Located 42.5E, with forty transponders (30 active andb10 redundant)

OPERATION AND USES OF NICOM-SAT 1

Nigcomsat Limited Incorporated operates and manages Nicom-Sat 1. Nicom-Sat 1 is useful in broadcasting, telecommunications, internet and multimedia services for Africa.

CLASSSWORK 6

1. (a) What is satellite? (a) State four features of a satellite
2. Enumerate four functions of satellites

ASSIGNMENT 6

1. Give a brief account of the first satellite launched

WEEK SEVEN

Revision

WEEK EIGHT

Mock Examination