SET YOUR EYES ON THE PRIZE

Name____ Date_______________

SECOND TERM E-LEARNING NOTE

SUBJECT: PHYSICS **CLASS: SS 3**

SCHEME OF WORK

WEEK	TOPIC
1	Alternating Current (I)
2	Alternating Current (II)
3	Models of the Atom
4	Radioactivity (I)
5	Radioactivity (2)
6	Energy Quantization
7	Photo-Electricity (x-ray)
8	Conduction of Electricity in gases.
9	Wave- Particle Paradox
10	Rockets and Satellites; Component parts and functions Basic Electronics; Semiconductors.

REFERENCE TEXTBOOKS AND PAST QUESTIONS

- New School Physics by Prof. M.W Anyakoha.
- New System Physics by Dr. Chow.et.al
- WAEC past Questions pack
- UTME past Question pack
- MASTERS Physics Practical Manual.

WEEK ONE

TOPIC: ALTERNATING CURRENT(I)

CONTENT

- Alternating Current Circuit
- Graphical Representation
- Peak and R.M.S. Values

A.C circuits are circuits through which an alternating current flows. Such circuits are used extensively in power transmission, radio and television, computer technology, telecommunication and in medicine. It varies sinusoid ally or periodically, in such a way as to reverse its direction periodically. The commonest form of such a.c can be represented by;

$I = Io \sin 2\pi ft$………………………………………………………………… 1

$= Io \sin wt$

I is the instantaneous current at a time t, Io is the maximum (or peak) value of current or its amplitude; f is the frequency and w = (2π ft) us the angular velocity, (wt) is the phase angle of the current

Also,

$V = V_o \sin 2\pi ft$…………………………………………………………………………..2

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= V_o sin wt

Examples

If an a.c voltage is represented by 1f

V = 4 sin 900 πt, calculate the peak and instantaneous voltage

The peak voltage, Vo = 4v

2πft = 900πt

$f = \frac{900}{2}$

f = 450Hz

w = 2πf = 900π

Peak, and r.m.s. values of a.c

EVALUATION

1. Differentiate between peak and r.m.s voltage.
2. Calculate the peak and instantaneous voltage of an a.c source represented by; V = 5 sin 500∏t.

Variation of alternating current (or voltage) with time

An alternating current (or voltage) varies sinusoidally as shown in the diagram above. It is a sine waveform. The amplitude or peak value of the current Io is the maximum numerical value fo the current.

The root mean square (r.m.s) value of the current is the effective value of the the current . it is that steady current which will develop the same quantity of heat in the same time in the same resistance. The r.m.s. value for the current is given by:

$I_{r.m.s.} = \frac{I_o}{\sqrt{2}}$ ………………………………………………….. 3

The moving iron and hot wire meters measure the average value of the square of the current called the mean-square current. They are however calibrated in such a way as to indicate the r.m.s. current directly. This most a.c meters read the effective or r.m.s. values. The average value of an a.c voltage is zero.

GENERAL EVALUATION

1. Differentiate between heat and temperature.
2. Mention five effect of heat.

READING ASSIGNMENT

New School Physics p 447 -457

WEEKEND ASSIGNMENT

1. A 50Hz a.c circuit has a voltage of 220V and a current of 5.0A as its effective value. Determine the peak values of the voltage and its current. (a)311.0V and 1.71A (b) 331.0V and 7.10A (c) 311.00V and 7.10A(d)7.10V and 311.00A
2. Calculate the peak voltage of a mains supply of r.m.s value of 220V. (a)112V (b) 150V (c) 222V (d) 311V

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3. In an ac circuit the peak value of the potential difference is 180V. what is the instantaneous potential differences when the phase angle is 45^o. (a)45V (b) 90V (c) 90√2 V (d)180V
4. An ammeter connected to an a.c circuit records 5.5A. What is the peak value of the current? (a) 7.8 (b) 7.1 (c) 3.9 (d) 3.
5. When compared, the r.m.s value is .... the peak value.(a) greater than(b) same(c) lower than (d) inversely proportional to.

THEORY

1. Distinguish between alternating current (a.c) and direct current (d.c). Explainthe term peak value and r.m.s. value as they apply to a.c circuit
2. Draw a wave from diagram for an a.c and label the points at which the current is zero and maximum respectively. Determine the effective value of an a/c if its peak value is 15A.

SET YOUR EYES ON THE PRIZE

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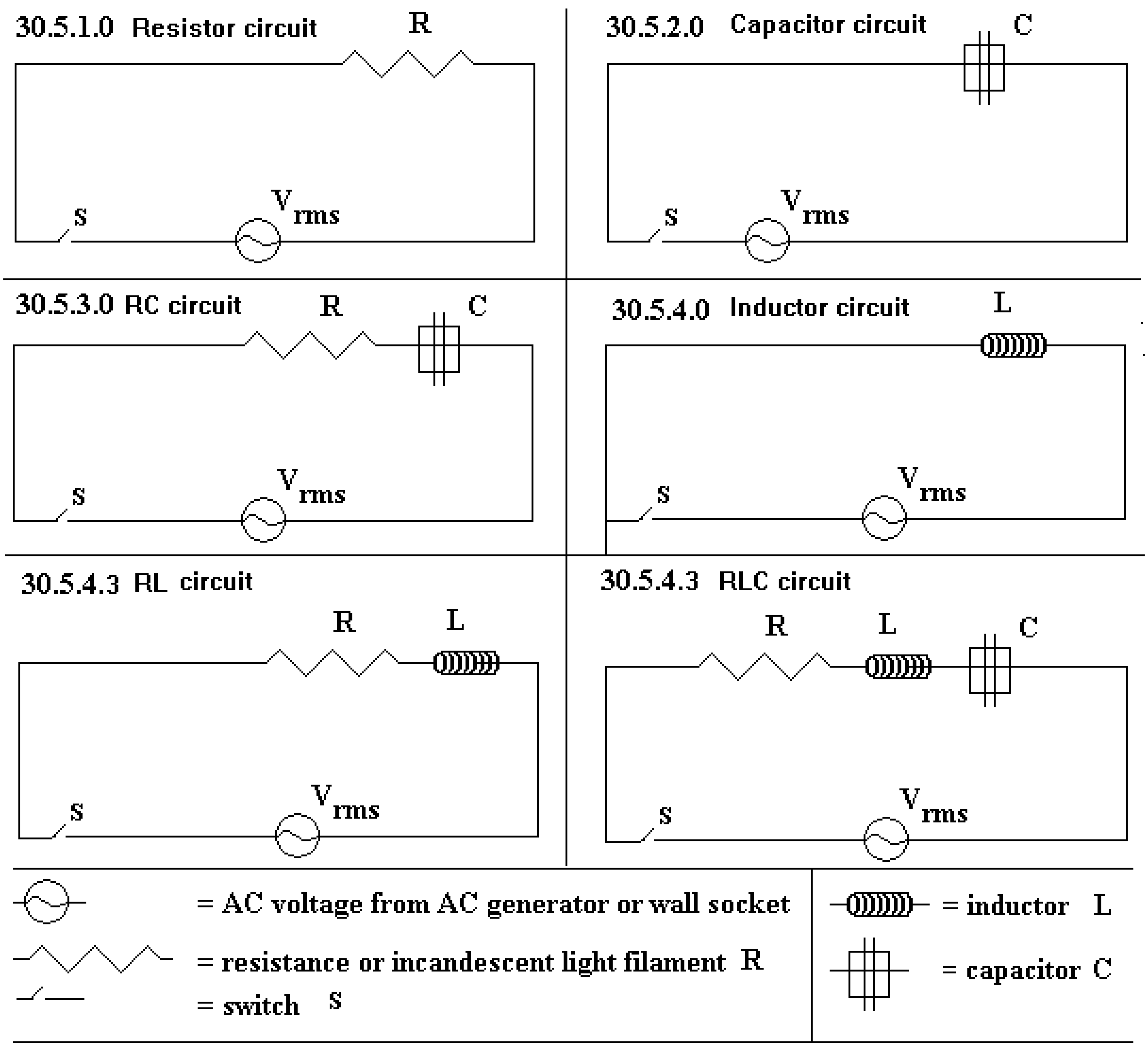
WEEK TWO

TOPIC: ALTERNATING CURRENT (II)

CONTENT

- A.C in Resistor, inductor and capacitor
- Energy in inductance, Reactance and impedance
- Vector Diagram
- Power in A/C
- Resonance and its applications



At any instant, the current through the resistor R, is I an the voltage across it is V

From ohm's law, $V = IR$

Thus the current is given by $I = \frac{V}{R.}$

But $V = Vo \sin wt$

$$I = \frac{V}{R} = \frac{V_0 \sin wt}{R}$$

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$I = I_o \sin wt$

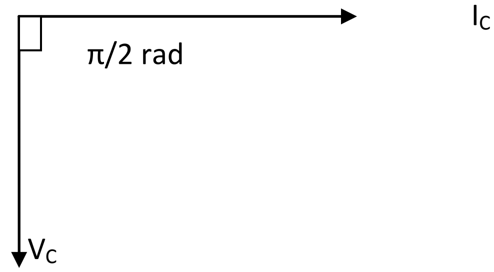
The voltmeter and ammeter connected in the circuit will read the r.m.s values of voltage and current

$$I_{r.m.s.} = \frac{V_{r.m.s}}{R.} \quad \ldots\ldots\ldots 4$$

The voltage and the current are said to be in phase or in step with each other . This means that both of them attain their maximum, zero and minimum values at the same instant in time.

Capacitance in an a.c circuit

In the circuit above, an a.c. voltage is connected in series with a capacitor.



Ic leads Vc by $\frac{\pi}{2}$ radians or 90° or by ¼ cycle

The voltage (v) and current (I) are out of place (not in step) . the current is said to lead on the voltage and the voltage is said to lad on the current. The phase difference between the current and the voltage is 90o or (π/2) radian

$V = V_o \sin wt$

$I = I_o \sin (wt + \pi/2)$

The capacitor opposes the flow of current. This opposition to the flow of a.c. offered by the capacitor is known as capacitive reactance, Xc. This is given by the relation

$$X_c = \frac{1}{2\pi fC} \quad \ldots\ldots\ldots 5$$

when an a.c.. voltage of frequency f is applied to a capacitance, c, then

$$V = IX_c \quad \ldots\ldots\ldots 6$$

In other words, from ohm's law relation, when applied to a capacitor.

In it, R is replaced by:

$X_c = \frac{1}{2\pi fC}$ Hence the unit of Xc is in ohms

Example

A 2µF capacitor is connected directly across a 150Vrms, 60Hz a.c source. Find

a) the r.m.s value of the current

b) the peak value of current.

$$X_c = \frac{1}{2\pi fC}$$

$$= \frac{1}{2\pi \times 60 \times (2 \times 10^{-6})\Omega}$$

$$= 1324.4\,\Omega$$

From V = IXc

$$I_{r.m.s.} = \frac{V_{rms}}{X_c} = \frac{150}{1324.4}$$

= 0.113A.

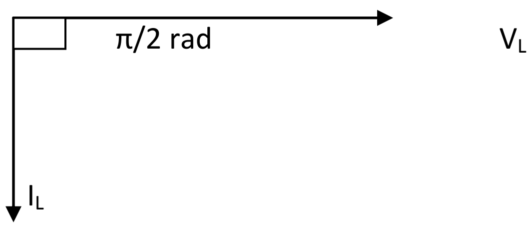
Peak current, Io = √2 Ir.m.s. = 0.160A

EVALUATION

Determine the r.m.s. value of the current in an a.c circuit with a 5.5μF capacitor across a $220V_{r.m.s}$, 50Hz.

Inductance in A.C Circuit

V_L leads I_L by π/2 radians or 90^o. The induced e.m.f. in the inductor L opposes the change in the current.As a result the current is delayed behing the voltage in the circuit. **The current lads behind V by π/2 radian or 90o or by ¼ cycle**. I and V have a phase difference of 90^o (π/2)



V = Vo sin wt

I = Io sin (wt – π/2).

Like R and C, an inductor L opposed the flow of current; i.e it has an impedance effect known as inductive reactance, X_L.

$V = I X_L$ ……………………………………………………………… 7

The unit of XL is in ohms

XL = 2πfL ………………………………………………….. 8

The unit of L is Henry (H), f is in hertz (Hz) and XL is in ohms.

Reactance is the opposition to the flow of a.c offered by a capacitor or an inductor or both.

Find the impedance across an inductor of 0.2H inductance when an a.c voltage of 60Hz is applied across it, if the voltage is given by V = 150 sin 120πt. Calculate the r.m.s and peak values of the current.

$XL = 2 \pi fL = 2\pi \times 60$ $X_L = 120\pi L = 120 \times \pi \times 0.2 = 75.40Ω$

V= 150 sin 120 π t

Vo = 150V F = 60Hz

Vrms = 0.76 = 0.7 x 150 = 105V

$$I_{rms} = \frac{V_{rms}}{X_L} = \frac{105}{75.4}$$

= 1.39A

$$I_o = \frac{V_o}{X_L} = \frac{150}{75.4}$$

= 1.99A

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EVALUATION

Determine the r.m.s. value of the current in an a.c circuit with a 5H capacitor across a $220V_{r.m.s}$, 50Hz.

Series Circuit Containing Resistance (R)Inductance (L) and Capacitance (C)

If an alternating voltage V = Vo sing 2πft is put across the circuit, it is observed that a steady state current given by I = Iosin2πft will flow along the circuit . The maximum or peak value of the current is given by

$$I_o = \frac{V_o}{\sqrt{(R^2 + (X_L - X_c)^2)}} \quad \ldots\ldots 9$$

$$= \frac{V_o}{\sqrt{R^2 + X^2}}$$

$X = X_L - X_{C.}$

Let $Z = \sqrt{(R^2 + (X_L - X_C)^2)}$

$\therefore I_o = \frac{V_o}{Z}$

$I_{r.m.s.} = \frac{V_{r.m.s}}{Z}$

Z is known as the impedance of the circuit.

Impedance (Z) is the overall opposition of a mixed circuit containing a resistor, an inductor and or a capacitor. It is measured in ohms.

$$X_c = \frac{1}{WC}$$

$$= \frac{1}{2\pi fC}$$

$X_L = WL = 2\pi fL$

$$= Z = \sqrt{R^2 + (wL - \frac{1}{wc})^2)}$$

$$Z = \sqrt{R^2 + (2\pi fL - \frac{1}{2\pi fC})^2}$$

in summary

$V = IR$

$V_L = I X_L$

$V_c = I X_C$

$V = IZ$

$V = I\sqrt{(R^2 + (X_L - X_c)^2)}$ ……………………………………………………………… 10

Example

(1) Find the r.m.s. value of an alternating current whose peak value is 5A.

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

= 0.707Io = 0.707 X 5 = 3.53A.

(2) in a.c circuit the peak value of the potential difference is 180v. What is the instantaneous p.d when it has reached $1/8^{th}$ of a cycle/

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1 cycle = 360^o

1/8 of a cycle = 360/8 = 45^o

E = Eo sin wt = Eo sin 45

= 180sin 45

= 180/√2

= 90√2V.

3. A circuit consist of a resistor 500 ohms and a capacitor 5uF connected in series . if an alternating voltage of 10v and frequency 50Hz is applied across the series circuit. Calculate:

i. the reactance of the capacitor

ii. the current flowing in the circuit

iii. the voltage across the capacitor

(b) If the capacitor is replaced with an inductor of 150mH, calculate the impedance and voltage across the inductor.

$$X_c = \frac{1}{2\pi fc}$$

$$= \frac{1}{2\pi \times 50 \times 5 \times 10^{-6}}$$

$$= 636.62 \text{ ohms}$$

II. $Z = \sqrt{R^2 + Xc^2}$

$= \sqrt{500^2 + 636.62^2}$

$= 809.5\ \Omega$

$I = \frac{V}{Z} = \frac{10}{809.5}$

$= 12.35 \times 10^{-3}$ A

12.35 mA.

iii. Vc =I X c = $12.35 \times 10^{-3} \times 636.62 = 7.86$ V

(b)$X_L = WL = 2\pi \times 50 \times 150 \times 10^{-3} = 47.12\ \Omega$

$Z = \sqrt{R^2 + X_L^{\ 2}} = \sqrt{500^2 - (47.12)^2} = 497.7\ \Omega$

$I = \frac{10}{497.7}$

= 0.02A

$V_L = 1 \times L = 0.02 \times 47.12$

= 942.4mA.

EVALUATION

An a.c circuit consist of a resistor 100Ω, an inductor 20H and a capacitor 5.0µF connected in series. If the source has $220V_{r.m.s}$, 50Hz across it, calculate; (i). the impedance, (ii). the current flowing in the circuit.

VECTOR DIAGRAM

When an alternating voltage is placed across a R.L.C series circuit, the resulting alternating current I. has the same frequency as the voltage (v_0 but the two differing phase or are said to be out of phase.

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Phase is the state of vibration of a periodically varying sytems at a particular time, wt = phase angle
Two vibrating systems with the same frequency are said to be inphase if their maximum, minimum and zero values occur at the same time; otherwise they re said to be out of phase.

The phase difference between the voltage and the current through an RLC series circuit is given by

$$\tan\theta = \frac{X}{R}$$

X = reactance $= X_L - X_c$ and R is the resistance .

For a circuit containing only a resistance R, the a.c voltage vibrates in phase or in step with the alternating current.

Thus Ǿ = O

For a circuit containing only a capacitance C, Vc and Ic are out phase by 90^0 or (π/2) radian. This means that the angle by which a particular phase Ic is in advance of a similar phase of Vc is 90^0 or π/2 radian or ¼ cycle

If Vc = Vo sin wt

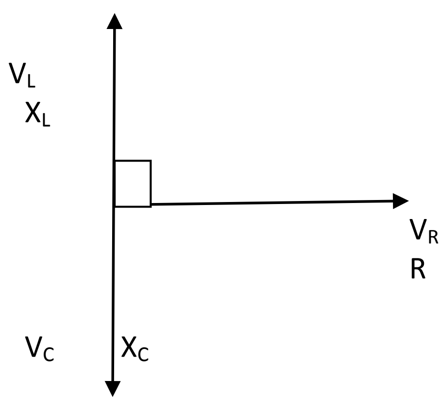
Then Ic = Io sin (wt - π/2).

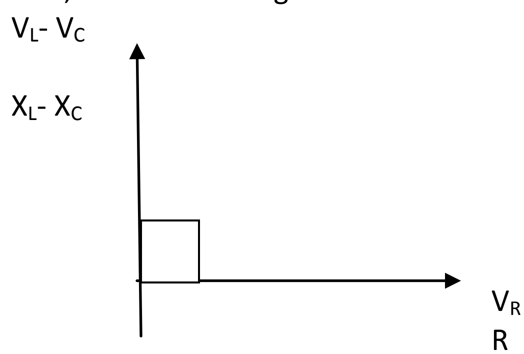
iii. If only an inductor L is connected to the a.c voltage, the current IL, lags on the voltage vL by π2 radians

V_L = Vo sin wt

I_L = Io sin (wt – π/2)

In a circuit containing RLC the current is the same for all the components of the circuit, and is in phase with the voltage across R. let V_R be the reference vector, the other voltage vectors acts as shown





The effective voltage V is given by

$$V^2 = V^2R + (V_L - V_C)^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 11$$

$$\tan Ǿ = \frac{V_L - V_C}{V_R}$$

$$= \frac{X_L - X_C}{R.}$$

If $X_L > X_C$, Ǿ is positive and I lags.

If $X_L < Xc$,Ǿ is negative and I leads V

For R and L series, we have

$$V^2 = V^2_R + V^2_L.$$

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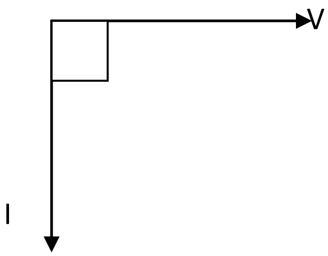
$I = \frac{V}{\sqrt{R^2 + X^2_L}}$

$Z = \sqrt{R^2 + X^2_L}$

Current I, lags on the applied voltage by Ø given by

$\tan Ø = \frac{V_L}{V_R}$

$= \frac{X_L}{R}$



I lags V or V leads I

For R and C in series

$V2 = V^2_R + V^2_C$

$I = \frac{V}{\sqrt{R^2 + X c^2}}$

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

$\tan Ø = \frac{Vc}{V_R} = \frac{Xc}{R}$

V lags I or I leads V.

POWER IN AN A.C CIRCUIT

The average power in an a.c circuit is given by;

$P = IV \cos Ø$

I, V are the effective (r.m.s) values of the current and voltage respectively and Ø is the angle of lag or lead between them . The quantity cos Ø is known as the power factor of the device. The power factor can have any value between zero and unity for Ø varying from 90^o to 0^o. For Ø = 90^o or cos Ø = 0, average power P is zero. A power factor of zero means the device is either a pure reactance, inductance or capacitance. Thus no power is dissipated in an inductance or capacitance.

However, if I is the r.m.s value of the current in a circuit containing a resistance R, the power absorbed in the reactance is given by

$P = I^2R$ ……………………………………………………………… 12

For an a.c circuit, the instantaneous power is given by

P =IV (instantaneous value)

Power factor

$\cos Ø = \frac{\text{Resistance}}{\text{Impedance}}$ ……………………………………………………………. 13

Example

A series circuit consist of a resistance 600 ohms and an inductance 5 henry's .An a.c voltage of 15v(rms) and frequency 50hz is applied across the circuit, calculate

i the current flowing through the circuit

ii. the voltage across the inductor
iii. the phase angle between I and the applied voltage
iv. the average power supplied
v. the p.d across the resistance.

$XL = 2\pi fl = 2\pi \times 50 \times 5 = 500\pi ohms$
$Z = \sqrt{R=Xl} = \sqrt{(600)^2 + (500\pi)} = 1.69 \times 10^3\ \Omega$
$Ir.m.s = \frac{Vrms}{Z} = \frac{15}{1.69 \times 10^3} = 8.88 \times 10^{-3}\ A = 8.88mA$

ii. voltage across the inductor

$VL = I\ XL = 8.88 \times 10^{-3} \times 500\pi = 4.44\pi volts = 14.95\ volts$

iii. $\tan \acute{\varnothing} = \frac{XL}{R} = \frac{500\pi}{600} = 2.62.$

$\acute{\varnothing} = \tan-1\ (2.62) = 69.10$

iv. Power supplied

$P = I^2R$
$= (8.88 \times 10^{-3})2 \times 600$
$= 4.73 \times 10-2\ w$

v.p,d across R.

$V = IR$
$= 8.88 \times 10^{-3} \times 600$
$= 5.53ohms.$

EVALUATION

1. An a.c circuit consist of a resistor 100Ω, an inductor 20H and a capacitor 5.0μF connected in series. If the source has $220V_{r.m.s}$, 50Hz across it, calculate the; (i) voltage across the inductor, (ii) voltage across the capacitor.
2. In the circuit in (1) above, determine the; (a)average power in the circuit, (b) power developed in (i)the inductor, and (ii)the capacitor.

RESONANCE IN RLC

Series Circuit

The current in RLC series circuit is given by:

$$I = \frac{V}{Z} = \frac{V}{\sqrt{R^2 + (XL - Xc)^2}}.$$

The maximum current is obtained in the circuit when the impedance is minimum. This happens when $X_L = Xc$

$$2\pi fL = \frac{1}{2\pi fC}.$$

Resonance is said to occur in an a.c series circuit when the maximum current is obtained from such a circuit. The frequency at which this resonance occur is called the resonance frequency (fo). this is the frequency at **which $X_L = Xc$**

$$2\pi foL = \frac{1}{2\pi foC}.$$

$4\pi^2 fo^2 LC = 1$

$fo^2 = \frac{1}{4\pi^2 LC}$

$fo = \frac{1}{2\pi \sqrt{LC}}$ ………………………………………………………… 14

since $w = 2\pi f$

$wo = \frac{1}{\sqrt{LC}}$

NOTE: At **f = fo, the current is maximum**.

APPLICATION OF RESONANCE

It is used to tune radios and tvs. Its great advantage is hat it responds strongly to one particular frequency.

Examples

An a.c voltage of amplitude 2.0 volts is connected to an RlC series circuit. If the resistance in the circuit is 5 ohms, and the inductance and capacitance are 3mh and 0.05 uf respectively. Calculate:

i. the resonance frequency,fo
ii. the maximum a.c. current at resonance.

$Fo = \frac{1}{2\pi\sqrt{LC}}$

$= \frac{1}{2\pi\sqrt{3 \times 10^{-3} \times 0.05 \times 10^{-6}}}$

$= \frac{1}{2\pi\sqrt{3 \times 10^{-11}}}$

$= 1299.545Hz$

$1.3KHz$

At resonance X = R since $X_L = X_C$

$I = \frac{Vo}{R}$

$= \frac{2}{5}$

$= 0.4A$

READING ASSIGNMENT

New School physics pag 458-463

GENERAL EVALUATION

1. Why is water not used as a thermometric substance.
2. Differentiate between evaporation and boiling.

WEEKEND ASSIGNMENT

1. A voltage supply of 12V r.m.s anf frequency of 90Hz is connected to a 4Ω resistor. Calculate the

peak value of the current . (a) 48.8A (b) 30.0A (c) 27.5A (d)4.2A

2. A 2µF capacitor is in series with a resistor of 5000Ω. A voltage of 5V r.m.s and frequency, I= 100Hzis connected to them. What is the capacitive reactance?
   (a) 795.5Ω (b) 895.5 Ω (c)1795Ω (d) 2005.0Ω
3. At what frequency will 20uf capacitor have a reactance of 500 ohms?
   (a) $\frac{100Hz}{\pi}$ (b) $\frac{50Hz}{\pi}$ (c) $150\frac{Hz}{\pi}$ (d) $100\pi \frac{Hz}{\pi}$ (e) $\frac{30Hz}{\pi}$
4. In an RLC series a,c circuit power is dissipated in (a) Resistance only (b) Reactance only (c) Resistance and reactance (d) Resistance, inductance and capacitance
5. In a series L-C circuit, the inductance and the capacitance are 0.5H and 20µF respectively. Calculate the resonance frequency of the circuit (a) 24.2Hz (b) 36.7Hz (c) 50.3Hz (d) 60.5Hz

THEORY

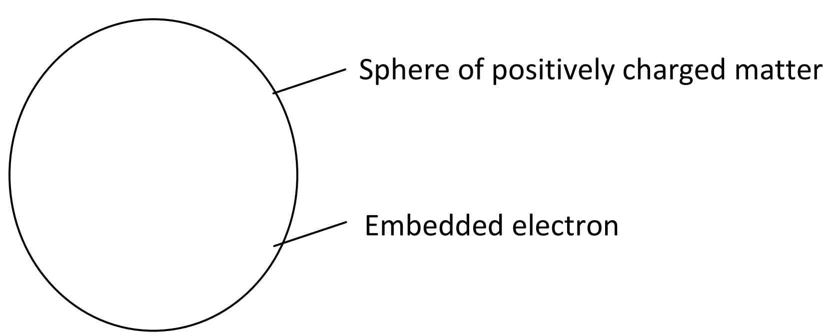
1. Explain what is meant by the terms impedance, phase angle and reactance as applied to an a.c. circuit. Calculate the impedance and phase angle for an a.c. circuit having a 100ohms resistance, 5*u*f capacitor in series if an a.c voltage of frequency 100Hz is applied across the circuit.
2. Draw a vector diagram of the relationship of I and V for an a.c. circuit containing
   (a) a pure inductor (b) a pure capacitor (c) a pure resistor

WEEK THREE
MODELS OF ATOMS
CONTENT

- Thompson, Rutherford, Bohr Models and Limitations
- Assumption of Bohr theory
- Electron Cloud Model
- Structure of Nucleus, Protons, Isotopes

THOMPSON MODEL

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



He also determined the ratio of the charged to mass, e/m , of electrons, and found 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.

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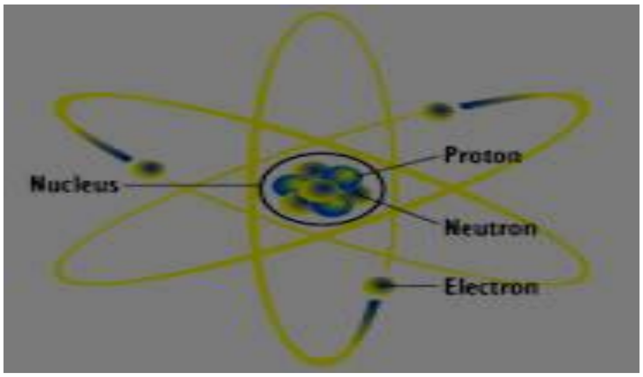
RUTHERFORD MODEL

He proposed a planetary model of the atom which suggested that the atom consists of positively charged heave 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



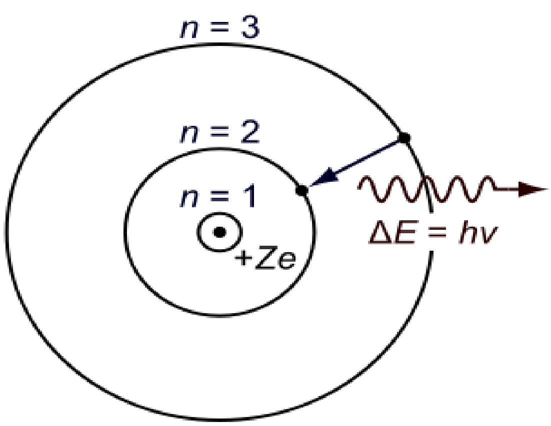
LIMITATION OF RUTHERFORD MODEL

1. It predicts that light of a continuous range of frequencies will be emitted whereas experiment show line spectra instead of continuous spectra.
2. It predict 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 sot of modification was needed and this was provided by Neils Bohr.

EVALUATION

What are the limitations of Rutherford's model?

THE BOHR'S MODEL



He suggested a model of hydrogen atom in which

i. the electron moves around the nucleus in certain specific circular orbits called energy level and that the centrifugal force due to this motion counter balances the electrostatic attraction between the electron and the nucleus. The electrons can move without losing or radiating energy in such orbits. He called the possible orbits stationary states. Only orbits of particular radii were possible. In general, the higher the energy of the electron, the farther its orbits from the nucleus.

ii. the energy of an electron in an atom cannot vary continuously to a limited number of discrete or individual values. The energy of the electron is said to be quantized (i.e can have only discrete values). He thus postulated that electrons in an atom cannot lose energy continuously but mist do so in quantum 'jumps'. He postulated that light is emitted only when an electron jumps from one stationary state to another of lower energy.

When such a jump occurs, a single photon of light would be emitted whose energy is given by

$hf = E_u - E_l$

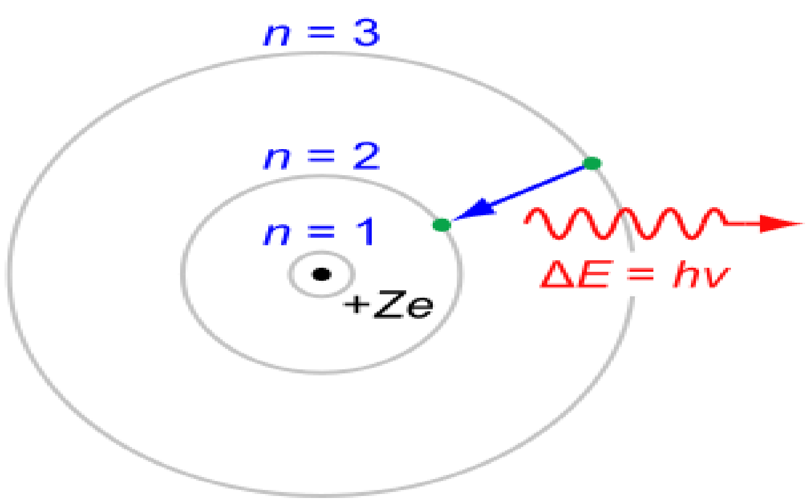
E_u = Energy of upper state

E_l = energy of lower state

h = planck constant ($h = 6.67 \times 10^{-34}$ Js)

f = frequency of emitted light

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



An electron absorbs energy when it transfers to higher energy level (excitation) Photon An electron emits a photon when it moves to a lower energy level.

iii. The third postulate of Bohr's model was that angular momentum values of the electron in an atom are quantized, that is, they are restricted to a limited number of discrete values that are integral 9n0 multiples of a constant, planck's constant (h) divided by 2 π. That angular momentum

$$L = n\frac{h}{2\pi} \quad n = 1,2,3,4\ldots$$

The integral n is called a quantum number

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;

i. it gives a model for why atoms emits, line spectra and accurately predicts, for hydrogen, the wave lengths of emitted lights or the frequencies of the lines in the hydrogen spectrum.

ii. 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.
iii. 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.
iv. It accurately predicts the ionization energy of 13.6ev for hydrogen.

EVALUATION
What are the successes of Bohr's model?

THE ELECTRON CLOUD MODEL
This model visualizes the atom as consisting of a tiny nucleus of radius of the order of 10^{-10} - 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.

Chemists prefer to consider the electron in terms of a cloud of negative charges (electron cloud), with a cloud being dense in regions of high electron probability and more diffuse in region of low probability.

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 (Me) of 9.10^{-31}kg and an electronic charge e- = 1.6×10^{-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 x 10-29 c (i.e e+ = e- = 1.6 x 10 -10). There are the same number of protons in the atoms of different elements.in a neutral atom, the number of protons equals the number of electrons.
We denote the atom of an element X by ${}^{A}_{z}X$
A = mass number
Z = atomic number

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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 (X) but different mass number. **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

a) i. $^{35}{}_{17}Cl$ (17 protons , 17 electrons, 18 neutrons)
   ii. $^{37}{}_{17}Cl$ (17 protons, 17 electrons, 20 neutrons)
b) $^{12}{}_{6}Cl$ (6 protons, 6 electrons, 6 neutrons)
   $^{13}{}_{6}Cl$ (6 protons, 6 electrons, 7 neutrons)
c) $^{16}{}_{8}O$ (8 protons, 8 electron 8 neutrons)
   $^{17}{}_{8}O$ (8 protons, 8 electrons, 9 neutrons)
   $^{18}{}_{8}O$ (8 protons, 8 electrons, 10 neutrons)
d) $^{238}{}_{92}U$ (92 protons, 92 electrons, 146 neutrons)
   $^{238\backslash 5}{}_{92}U$ (92 protons,92 electrons, 143 neutrons)
   $^{234}{}_{92}U$ (92 protons, 92 electrons, 142 neutrons)

GENERAL EVALUATION

1. Mention four effect of thermal expansion of solid
2. Mention four the advantages and disadvantages of thermal expansion of solid

READING ASSIGNMENT

New School Physics pgs 464-471

WEEKEND ASSIGNMENT

1. Which of the following statement is not true of the isotope of an element? They A. Are atoms of the same element B. Have the same chemical properties C. Have the same atomic mass D. Have the same mass number
2. Which of the following representation is correct from 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. $^{30}{}_{2}X$
3. Bohr theory provides evidence for the A structure of the atom B. positive charge of an electron C existence of energy level in the atom D. positive charge on a proton
4. 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
5. Which of the following names is not associated with the models of the atom. A. Isaac Newton B. Neils Bohr C. J.J. Thompson D. Ernest Rutherford E. John Dalton

THEORY

1. Describe the essential feature of the Bohr- Rutherford Model of the atom. What are its

successes and its failures. How does it account for line spectra.

2. What are the essential features of the Electron –Cloud Model of the atom. Illustrate with a diagram.

WEEK FOUR
TOPIC: RADIOACTIVITY (1)
CONTENTS

- Emission of Alpha and Beta particles and Gamma rays
- Properties and peaceful uses of radioactivity
- Radioactive hazards and safety precautions
- Binding energy

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).

If a small sample of radium is placed at the bottom of a small hole drilled in a block of lead. The radiation emitted from this radium emerged from the hole in a narrow beam. if the rays were subjected to a strong magnetic field placed at the side of a beam. A photographic plate situated at appropriate sides to receive the rays showed that the paths of some rays were bent to the right, some to the left and some went straight on, unbent.

Electrically charged plates placed at the side of the beam gave the same effect. The radiations that was bent towards the negative electric plate or the south pole of the magnetic field are called the Alpha particles (α –particles)

The radiations deflected towards the positive electric plate or the North pole of the magnetic field is called Beta particles (β – particles). The radiation that was neither affected by the electric or magnetic field is called gamma rays (γ). They are actually electromagnetic radiations.

Radiation	Alpha-particles	Beta Particles	Gamma - rays
Nature	Helium nuclei $^{4}_{2}He$	High Energy electrons	Electromagnetic wave of short wavelength
Velocity	5 – 7% speed of light	Travel at approx. speed of light	Travel at speed of light
Effects of magnetic field	Slightly deflected in a magnetic field (+ve)	Strongly deflected in a magnetic field (-ve)	No effects
Ionizing magnetic field	Large, cause heavy ionization	Medium	Small
Penetrating power	Little penetrating power e.g thin sheet	Good penetrating power e.g aluminium	High penetrating power e.g leads

Radioactive Decay; Half-life, Decay Constant

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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.

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, ti, then the probable number of disintegration per unit time or activity.

$$N \alpha \; - \frac{dN}{Dt}$$

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

$$\frac{dN}{dt} = -\lambda N$$

λ is a constant of proportionality called the decay constant.

$$:. \; \lambda = -\frac{1}{N}\left(\frac{dN}{dt}\right)$$

Hence, decay constant is defined as the instantaneous rate of decay per unit atom of a substance

$$\Lambda = \frac{\text{No of atoms disintegrating per second}}{\text{Np pf atoms in the source at that time}}$$

By integration

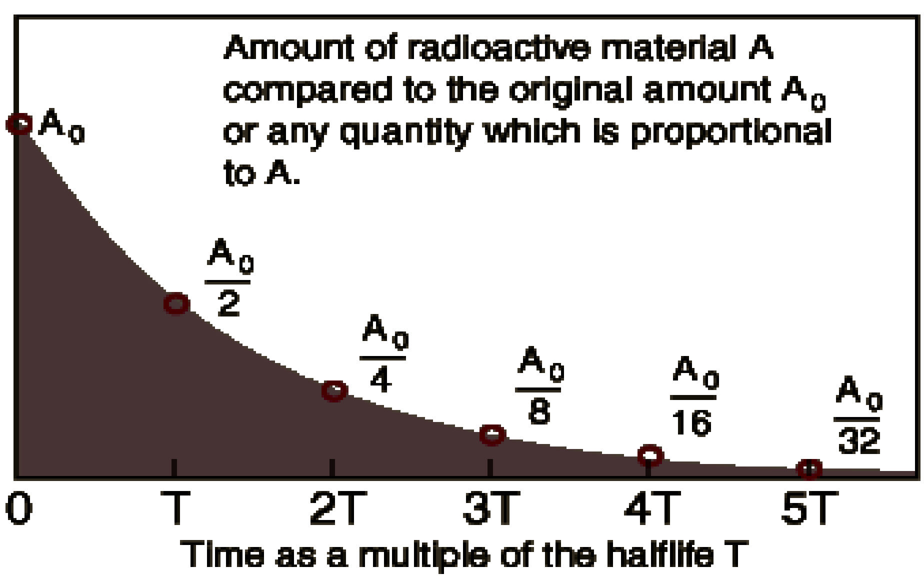
$$N = Noe^{-\lambda t}$$

No = Number of atoms present at time t = o

N = Number of atoms present at time t

$$T = \frac{0.693}{\Lambda}$$

$$A = A_0 2^{\frac{-t}{T_{1/2}}} = A_0 e^{\frac{-.693\, t}{T_{1/2}}}$$



Example

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.

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

Half-life = 10years

N/4 remains after 20 years

N/8 remains after 30 years:. it takes 30 years to lose 7/8 of its atoms

N/2 remain unchanged after 10 years

N/4 remains unchanged after 20 years

Ans = 20years

EVALUATION

If the half life of a radioactive substance is 2.45 X 10^8s, determine is decay constant.

TRANSFORMATION OF ELEMENTS

There are two types of radioactivity

1. Natural radioactivity
2. Artificial 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 elements 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.

$${}^{226}_{88}X \xrightarrow{\alpha} {}^{4}_{2}He + {}^{222}_{86}Rn + \text{energy}$$

$${}^{222}_{88} \xrightarrow{2B} 2\,{}^{0}_{-1}e + {}^{222}_{90}Ra + \text{energy}$$

$${}^{238}_{92}U \xrightarrow{2\alpha,\ 2\beta} 2\,({}^{4}_{2}He) + 2\,{}^{o}_{-1}e + {}^{230}_{91}Th + \text{energy}$$

$${}^{234}_{90}U \xrightarrow{\beta} {}^{0}_{-1}e + {}^{234}_{91}Pa + \text{energy}$$

Generally we represent alpha (α) decay by

$${}^{A}_{Z}X \longrightarrow {}^{4}_{2}He + {}^{A-4}_{Z-2}y + \text{energy}$$

And *B* decay by

$${}^{A}_{Z}X \longrightarrow {}^{0}_{-1}e + {}^{A}_{(z+1)}y$$

ARTIFICIAL RADIOACTIVITY

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

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

in artificial radioactivity, an ordinary materials is made radioactive by bombarding itwith radioactive particles.

$^{4}He + {}^{27}Al \longrightarrow {}^{30}P + {}^{1}n$

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

$^{1}{}_{0}n + {}^{24}{}_{12}Mg \longrightarrow {}^{24}{}_{11}Na + {}^{1}{}_{1}P$ + energy

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

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

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

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

$^{79}{}_{10}Br + {}^{1}{}_{0}n \longrightarrow {}^{35}{}_{10}Br$ + energy

such artificially produced isotope are unstable and decay with the emission of α – particles, β – particles and γ – rays. They are called radio isotopes.

GENERAL EVALUATION

1. With the aid of a diagram, explain the anomalous behaviour of water
2. Describe an experiment to determine the apparent cubic expansivity of a liquid

READING ASSIGNMENT

New School Physics pg 468-471

WEEKEND ASSIGNMENT

1. The phenomemon of radioactivity was first discovered by (A) Marie Curie (B) J.J. Thompson (C) Henri Becquerel (D) Nent Bohr (E) Enrico Fermi
2. A radioactive substance has a half-life of 3 days. If a mass of 1.55g of this substance is left after decaying for 15days,dertermine the original value of the mass (A) 49.6g (B) 37.2g (C) 24.8g (D) 12.4g
3. Which of the following is usually used to cause fission in an atomic reactor? (A) alpha particles (B) beta particles (C) electrons (D) neutrons
4. A substance has a half-life 30 mins after 6mins the count rate was observed to be 400. What was its count rate at zero time. (A) 200 (B) 1200 (C) 1600 (D) 2400
5. A nuclide $^{202}{}_{84}Y$ emits in succession an α-particle and β-particle. The atomic number of the resulting nuclide is (A) 198 (B) 83 (C) 82 (D) 80.

THEORY

1 (a) Define radioactivity; half-life and decay constant.
(b) Write down the relation between half-life and decay constant
(c) In 180 minutes, the activity of a certain radioactive substance falls to one –eight of its original value. Calculate its half-life.

2 (a)A nuclide X emits β-particle to form a daughter nuclide Y. write a nuclear equation to illustrate the charge conservation.
(b) the isotope of a nuclide has a half-life of $5.4X10^{3}$s.Calculate its decay constant.

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WEEK FIVE

TOPIC: RADIOACTIVITY (2)

CONTENTS

- Artificial Transformation
- Nuclear Fission
- Nuclear Fusion
- Nuclear Energy
- Chain reaction
- Peaceful uses of nuclear energy.

ARTIFICIAL TRANSFORMATION

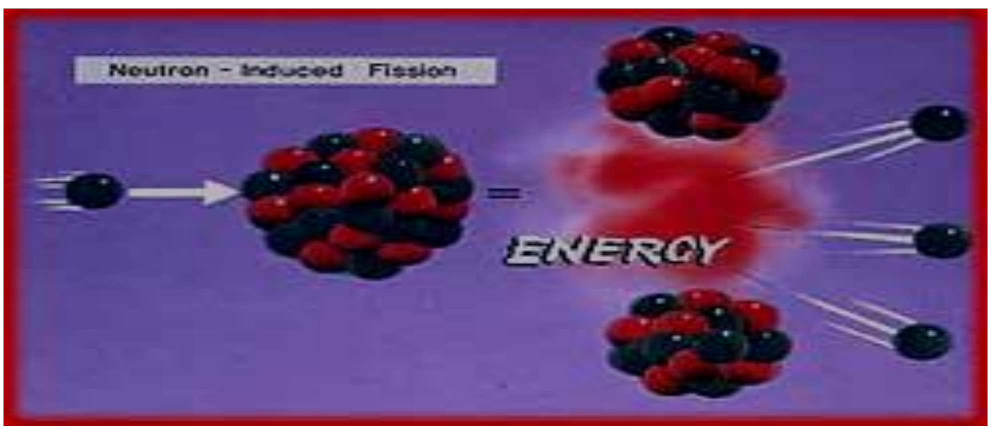
Artificial transformation is induced in an element by irradiation (exposure to radiation) either by accident or by intent) . It was first achieved by Rutherford. An ordinary material not normally radioactive is made radioactive by bombarding it with radioactive particles e.g

$$^{4}_{2}He + ^{27}_{13}Al \longrightarrow ^{30}_{15}P + ^{1}_{0}n$$

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.

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



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

$E = \Delta mc2$

E = nuclear energy

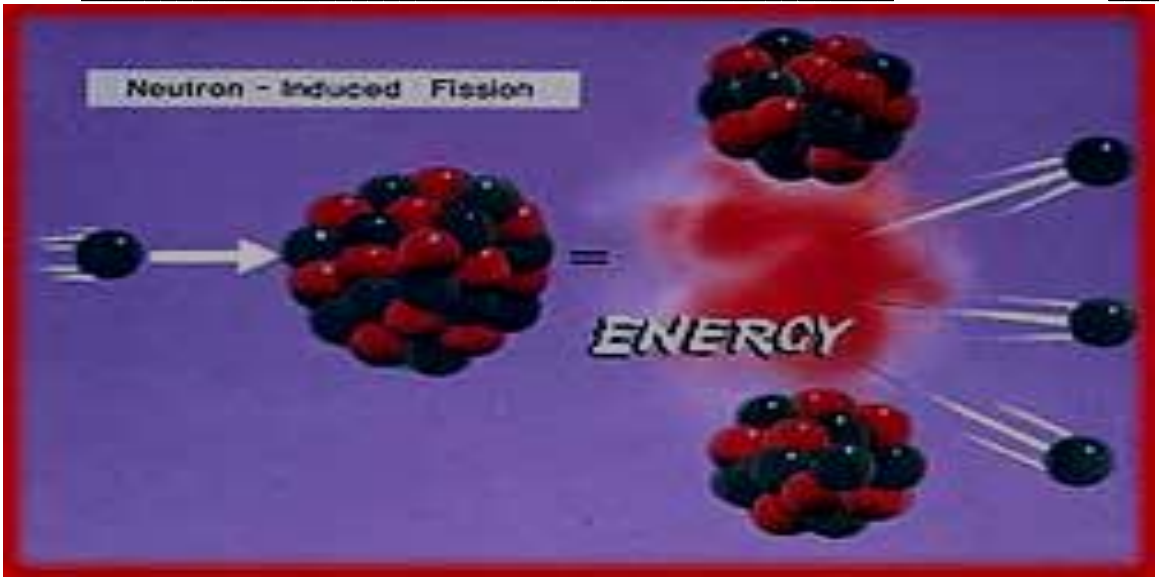
Δm = mass defect

c= velocity of light (3.0×10^{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 occurs with most of the massive nuclei. When the heavy nucleus is bombarded by slow neutron, several neutrons are produced as by –products.



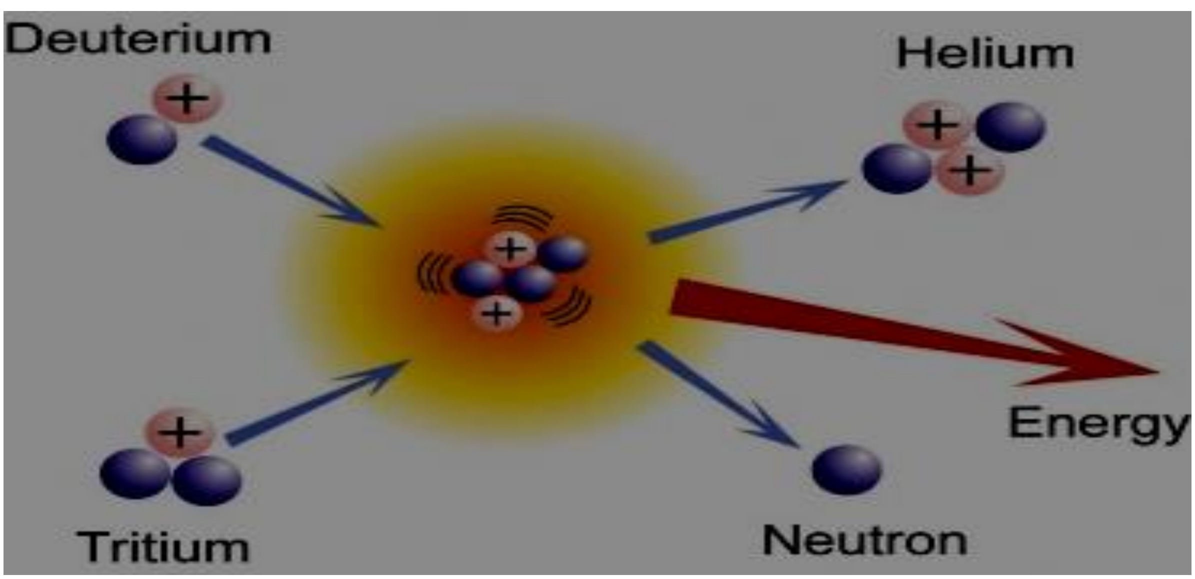
These neutrons may cause the splitting of other nuclei, which in turn yield more neutrons which may further split other nuclei and so on.Thus a chain reaction is set in motion
A chain reaction is a multiplying and self maintaining reaction . When the size of the nuclei exceeds a certain critical mass, 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. It is also the process used in the present day nuclear power station .

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.

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

To bring the two lights nuclei together in a fusion process, very high temperature of the order $10{,}600^{0}C$ are required to overcome the coulomb repulsive forces between the two nuclei.



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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 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.

GENERAL EVALUATION

1. Define the following terms (a) Conduction (b) Convection (c) Radiation
2. With the aid of a diagram, explain how the construction of a thermos flask minimizes heat exchange with the surrounding.

WEEKEND ASSIGNMENT

1. If a nucleus $^{3}_{1}H$ decays, a nucleus of $^{3}_{2}H$ is formed accompanied with the emission of (a) beta particles (b) gamma particle (c) alpha particle (d) x-rays.
2. The count rate of radioactive substances diminishes from 600 to 150 in 60 secs. Determine the half life of the substance (a) 15 secs (b) 30 secs (c) 45 secs (d) 60secs.
3. a radioactive substance half life of 20hrs. what fraction of the original radioactive nuclide will remain after 80hrs (a) 1/32 (b) 1/16 (c) 1/8 (d) 15/16
4. a material of mass $1.0X10^{-3}$kg undergoes fission process which decreases its mass by 0.02%. calculate the amount energy released in the process [$c=3X10^{8}$m/s]
   (A) $1.8X10^{20}$J (B) $1.8X10^{13}$J (C) $1.8X10^{11}$J (D) $1.8X10^{10}$J
5. In a nuclear reaction the mass defect is $2.0X10^{-6}$g. Calculate the energy released, given velocity of light is $3X10^{8}$m/s. (A) $9.0X10^{07}$J (B) $1.8X10^{08}$J (C) $1.8X10^{09}$J (D) $9.0X10^{-10}$J

THEORY

1. Explain the terms nuclear fission and nuclear fusion
2. Nuclear reaction is given by the equation $^{2}_{1}H + ^{3}_{1}H \longrightarrow ^{4}_{2}H + ^{1}_{0}n$ + energy
   (a) What type of nuclear reaction is it?
   (b) state two component in a nuclear reactor used to control chain reaction

WEEK SIX

TOPIC: ENERGY QUANTIZATION

CONTENT

- Energy Quanta
- Energy Level in Atoms
- Kinetic Energy of Emitted Photon

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

$E = hf$

h = Planck's constant.

f = frequency

ENERGY LEVEL IN AN 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 .

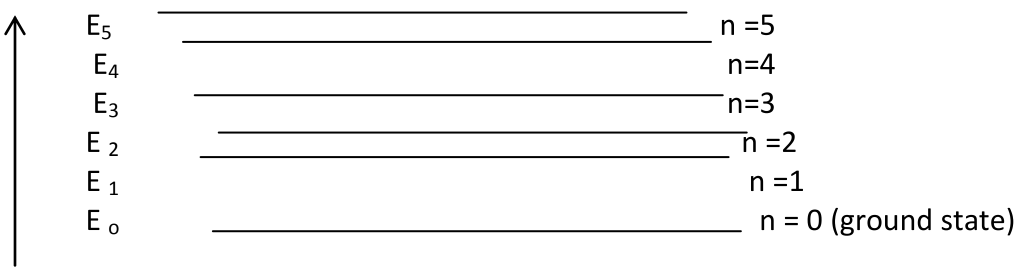
$$E = -\frac{1}{n^2}R$$

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



The ground state is the stable state or an atom corresponding to its minimum energy. When an atom is heated 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 (IeV) is the energy acquired by an electron in falling freely through a p.d of 1 Volt = 1.6 x 10 -19J.

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:

$$\mathbf{K.E = \tfrac{1}{2} MV^2 = eV.}$$

The energy gained by electron = charge x p.d = eV. Therefore, the electron moves from one level to the other according to the relation.

$$\mathbf{E_n - E_o = \frac{hf}{\lambda} = eV}$$

Worked example

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)

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

$\Delta E = hf$

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

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

But $C = f\lambda$

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

2. An atom excited to an energy level $E_2 = -12.42 \times 10^{-19}$J falls to a ground level of energy Eo = - 30.3 x 10-19J. Calculate the frequency and the wavelength of the emitted photon.

$\Delta E = E_2 - E_o$

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

$= 17.88 \times 10^{-19}J$

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

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

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.

$\Delta E = E_2 - E_O = -10.3EV - (-26.3ev)$

$= 16ev$

$1ev = 1.6 \times 10^{-19}$ J

$\therefore 16ev = 16 \times 1.6 \times 10^{-19}J$

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

$$\therefore \lambda = \frac{hc}{\Delta E} = \frac{6.625 \times 10^{34} \times 3.0 \times 10^{8}}{16 \times 1.6 \times 10^{-19}}$$

$$= \frac{1.9875 \times 10^{-25}}{25.6 \times 10^{-18}}$$

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

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

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

$2ev = mv^2$

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

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

Ke = eV

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

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

GENERAL EVALUATION

1. With the aid of a diagram, explain charge distribution
2. Name two devices that can store charge.

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READING ASSIGNMENT

New School physics pgs

WEEKEND ASSIGNMENT

1. When an atom is in ground state, it is said to be (A) excited (B) stable (C) ionized
2. In which of the following transitions is the largest quantum of energy liberated by an hydrogen atom, when the electron changes energy level? (A) n=2 to n=1 (B) n=2 to n=3 (C) n=3 to n=2 (D) n=1 to n=2
3. Which of the following give rise to the line spectra obtained from atoms. (A) change of electron from a higher to lower energy level (B) potential energy of the electron inside an atom (C) Excitement of an electron in the atom
4. A 50KV is applied across an x-ray tube. Calculate the maximum velocity of the electrons produced. [Me= $9.11X10^{-31}$Kg, e= $1.6X10^{-19}$C] (A) $4.2X10^{8}$m/s (B) $1.8X10^{8}$m/s (C) $4.2X10^{5}$m/s (D) $1.8X10^{5}$m/s
5. The nucleon number and the proton number of a neutral atom are 238 and 92 respectively. What is the number of neutrons in the atom? (A) 146 (B) 330 (C) 73 (D) 52.

THEORY

1. An electron of charge $1.6X10^{-19}$C is accelerated in a vacuum from rest at zero volt towards a plate 40KV. Calculate the kinetic energy of the electron
2. An electron jumps from one energy level to another in an atom radiating $9.0x10^{-19}$J. If h = 6.6×10^{-34}Js and C = 3.0×10^{8}m/s, what is the wavelength, and the frequency of the radiation.

WEEK SEVEN

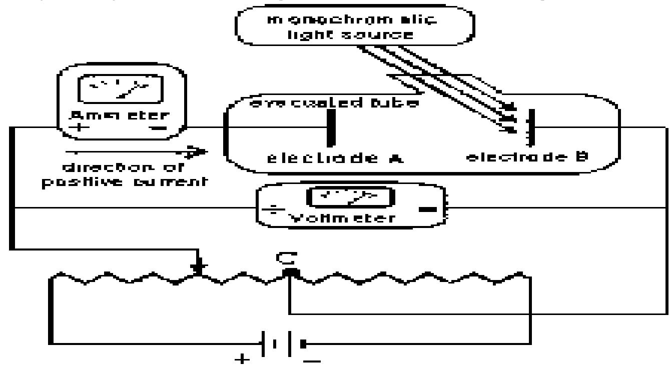
TOPIC: PHOTO ELECTRIC EFFECT

CONTENT

- Application
- Photoelectric Equation
- Threshold frequency
- Work funtion
- x-ray

When light falls on a 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 photo electrons are independent of the intensity of the incident light but depends on the frequency or wavelength of the incident light.



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

APPLICATION

Photoelectric emissions is used in the following :

I Burglary alarm
ii Television camera
iii Automatic devices for switching light at dusk e. street light.
iv. Sound production of film track
v. industrial controls and counting operations.

EINSTEN PHOTOELECTRIC EQUATION

Einstein photoelectric equation is given by

$E = hf - w$
$W = hfo$
E = maximum kinetic energy that can be given to a photo electrons
W = work function
fo = Threshold frequency
hf = W = maximum energy of the liberated. Photoelectrons.

THRESHOLD FREQUENCY (fo)

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 = hfo)

This is the minimum energy required to liberate electrons from a metallic surface.
W = hfo.

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
($h = 6.6 \times 10^{-34}$JS, $1eV = 1.6 \times 10^{-19}$J).

$$E = hf - w$$
$$E + w = hf$$
$$\frac{E + W}{H} = f$$
$$= \frac{(3.5 + 3.0) \times 10^{-16} \times 1.6 \times 10^{-19}}{6.6 \times 10^{-34}}$$
$$= \frac{6.5 \times 1.6 \times 10^{-16 -19+ 34}}{6.6}$$
$$= 1.58 \times 10^{-1} \text{ Hz}$$

THRESHOLD WAVELENGTH

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

$$W = hf_o$$

$$W = \frac{hc}{\lambda_o}$$

$$\lambda_o = \frac{hc}{W}$$

The work frequency of Lithium is 2.30eV, calculate

i. the maximum energy in Joules of photoelectrons liberated by light of wavelength 3.3×10^{-17}m
ii. the threshold wavelength of the metal.

i. $W = 2.3$ ev

$$E = hf - w$$

$$= \frac{hc}{\lambda} - w$$

$$= \frac{6.6 \times 10^{-34} \times 3.0 \times 10^{8}}{3.3 \times 10^{-17}} - (2.3 \times 1.6 \times 10^{-19})$$

$$= 2.208 \times 10^{-27}\text{J}$$

ii.

$$W = \frac{hc}{\lambda_o}$$

$$\lambda_o = \frac{hc}{W.}$$

$$\lambda_o = \frac{6.6 \times 10^{-34} \times 3.0 \times 10^{8}}{2.3 \times 1.6 \times 10^{-19}}$$

$$\lambda_o = 8.61 \times 10^{-7}\text{m}$$

EVALUATION

1. If photon of wave length $2.0 \text{ X } 10^{17}$m is incident on a metal and the kinetic energy of the emitted electrons is 23.5eV . Calculate the work function of the metal. ($h = 6.6 \times 10^{-34}$JS, 1eV = 1.6×10^{-19}J, $c = 3.0 \times 10^{8}$).
2. Determine the threshold frequency of the metal in (1) above, hence explain what will happen if a light of frequency 9.1×10^{22}*Hz* is illuminated on the metal.

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.

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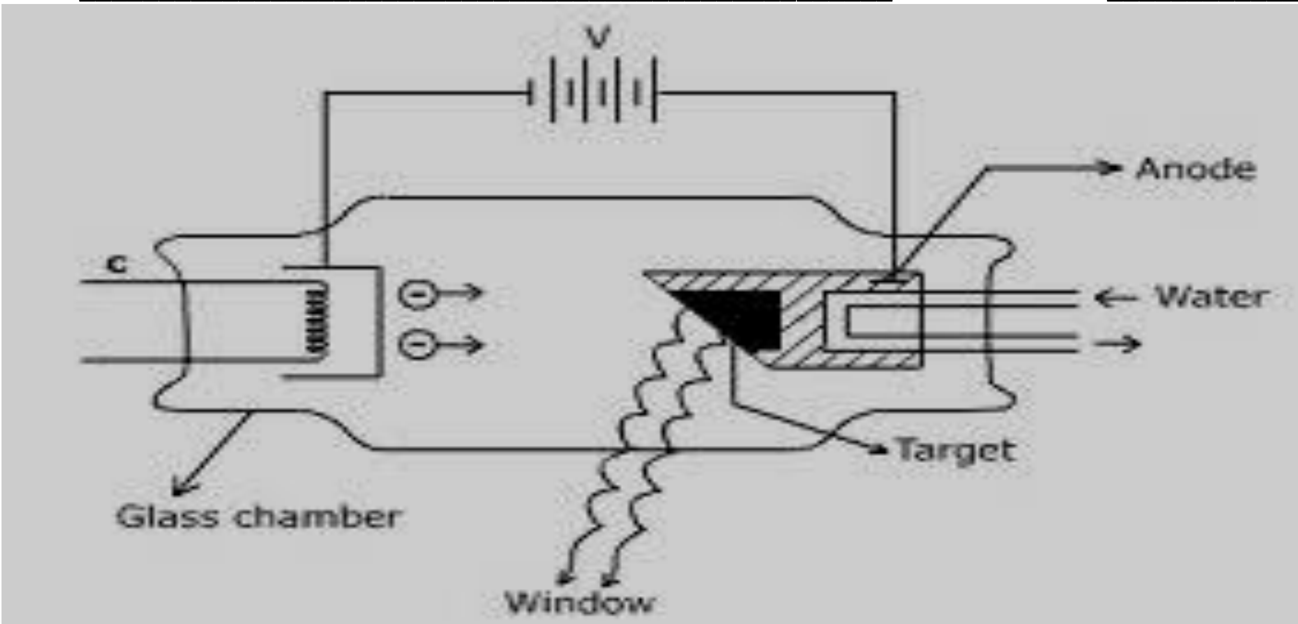


MODE OF OPERATION

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 to 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 gins 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

TYPES OF X – RAY

There are two types of x- rays

1. Hard x – rays and
2. Soft x- rays

Characteristics of Hard x-rays

i. High penetrating power or ability
ii. Shorter wavelength

Characteristics of soft x –ray.

i. low penetrating power
ii. longer wavelength

EVALUATION

1. state the energy conversions in an x-ray tube.
2. Differentiate between soft and hard x-ray.

Name____ Date________________

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. X – rays are electromagnetic waves of high frequency
2. X – rays have short wavelength (2 x 10-10m)
3. X – rays have high penetrating power
4. X-rays travels in straight line
5. They are not diffracted by electric or magnetic field.
6. They are not diffracted by crystals.
7. They ionized gases
8. They cause zinc sulphide to fluoresce.

Application of X – ray

i. For examining body to locate broken bones
ii. To detect metals and contra band in a baggage
iii. They are used to detect cracks n welded joints
iv. For investigating crystal structure
v. Treatment of tumors and malignant growth
vi. It is used in agriculture to kill germs.

Hazards of x- rays

i. It causes genetic mutation
ii. It can destroy body cells
iii. it causes leukemia, 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 check-up.

GENERAL EVALUATION

1. What is the function of lighting conductors
2. Explain lighting

WEEKEND ASSIGNMENT

1. Which of the following give rise to the line spectra observed in atoms? (a) excitation of electrons in the atom (b) change of an electron from a higher to a lower energy level (c) Distributed photo in the nucleus
2. Which of the following is called photo electric effect. (a) two electrons are created from a quantum of light (b) metals absorbs quanta of light and then emits electrons (c) a high energy

emits photon as it is slowed down

3. 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
4. The maximum kinetic of the photo electrons depend on (a) work function (b) frequency (c) intensity of the incident ray
5. The minimum energy required to liberate an electron from a metallic surface is (a) ionization energy (b) work function (c) kinetic energy,

THEORY

1. (a) explain the terms “ hardness” and “ intensity” as applied to x-ray tube.
   (b) State three uses of x-rays
2. Determine the frequency of the photon whose energy is required to eject a surface electron with a kinetic energy of 1.970×10^{-19} eV. If the work function of the metal is 1.334×10^{-19}eV.(1eV = 1.6×10^{-19}J, h = 6.6×10^{-34}Js, C = $3.0 \times 10^{8}ms^{-1}$)

WEEK EIGHT
TOPIC: CONDUCTION OF ELECTRICITY IN GASES
CONTENT

- Condition for discharge
- Characteristics of cathode rays and application
- Thermionic emission and application
- Diode valve/Cathode rays Oscilloscope

Condition for Discharge

Experiments with discharge tube show that gases conduct electricity under low pressure and high potential difference. At very low pressure and high voltage, the gas in the discharge tube breaks into ions. The positive ions move towards the cathode, the negative ions and free electrons move towards the anode. The positive ions knocks off electrons from the metal plate of the cathode. The electrons produced at cathode are called cathode rays.

EVALUATION

1. Draw a discharge tube and explain how electricity is conducted through it.
2. What are cathode rays?

Characteristics of Cathode rays

1. They consist of streams of fast moving electrons.
2. They cause glass and other materials to glow or fluoresce with a greenish colour.
3. They travel in straight lines
4. They are deflected by electric and magnetic field.
5. They can ionize a gas
6. They will turn a light paddle wheel in the tube because they have mass, momentum and energy.
7. They are highly energetic particles.
8. They can affect photographic plates

Name____ Date________________

9. They can produce x-rays from high density metals when they are suddenly stopped by such metals.
10. They are highly penetrating and can penetrate through metals such as aluminium, steel and gold foil.

Application of Cathode rays

One application of cathode rays is in fluorescent tubes used commercially for lighting and display signs. The tube contain mercury vapour, which at low pressure glow or fluoresce at the passage of cathode rays.

EVALUATION

1. Mention at least five characteristics of cathode rays
2. Describe how cathode rays are used in fluorescent lamp and in the production of neon sign.

Thermionic Emission

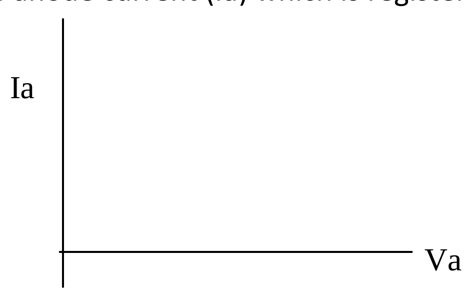
Whenever a metal is heated to a sufficiently high temperature, electrons are emitted from the surface of the metal in a process known as thermionic emission

When the filament is heated to a high temperature, extra energy given to its free electrosn 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 tehrmionic 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.

Action of a diode, diode characteristics

The filament supplies free electrons when heated by the current from the battery (E), when the anode is made positive in potential with respect to the cathode, electrons flow towards the anode and constitute the anode current (Ia) which is registered by the milli-ammeter.



Diode Characteristics

Diode characteristics curve shows that diode valve does not obey Ohm's law . That is why it is called non-Ohmic conductor . Because the action of diode allows current to flow only in one direction, the valve is used as rectifier to produce d.c. voltage from an a.c supply.

Cathode Ray Oscilloscope

The cathode rays oscilloscope is an instrument used for the investigation of currents voltages in electronic circuits. It is a vacuum tube containing an electron gun at one end, and a fluorescent screen at the other end. Between these are to pairs of deflector plates near the middle of the tube. The electron gun consists of (i) the heated filament, to supply electrons by thermionic emission, (ii) the anode (iii0 the cathode. The anode acts as focusing lens t o accelerate and focus the electron on to a spot in the fluorescent screen.

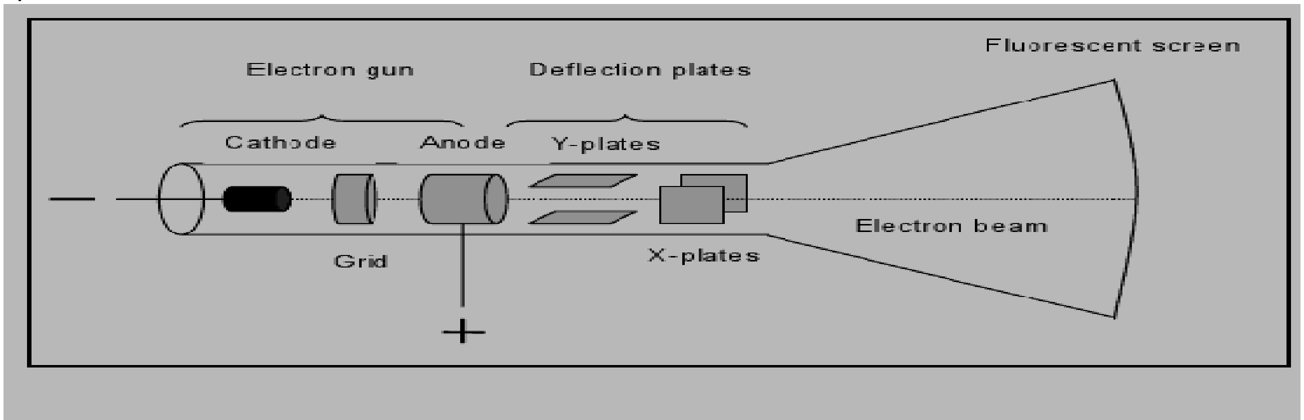


Figure 1: The basic structure of a *CRO*

The cathode rays oscillope is used for studying all types of wave forms especially the alternating current wave forms and to measure frequencies and amplitude of voltage of electronic devices.

GENERAL EVALUATION

1. Define gravitational potential
2. Define gravitational field

READING ASSIGNMENT

New School Physics for SSS page 481-483.

WEEKEND ASSIGNMENT

1. 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
2. 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.
3. Which of the following is an application of glow discharge phenomena? (a) filament lamp (b) fluorescent lamp (c) cathode ray oscilloscope (d) electron microscope .
4. Which of the following is an application of hot cathode emission. (a) filament lamp (b) cathode ray oscilloscope (c) electron telescope (d) Binoculars
5. Which of the following contributed to conduction in a gas? (i) molecules (ii) electrons (iii) ions (A) I only (b) II only (c) I and III only (d) II and III only.

THEORY

1 (a) Draw a labeled diagram of a cathode ray oscilloscope showing the essential parts
(b) What are the functions of: (i) the hot filament (ii) the anode (iii) fluorescent screen (iv) deflector plates
(c) State one way in which cathode rays differ from electromagnetic waves

2 (a) Describe briefly how electrons can be liberated from i. a cold cathode ii. A hot cathode

(b) What is thermionic emission.

WEEK NINE
TOPIC: WAVE – PARTICLES DUALITY (PARADOX)
CONTENT

- Duality of Light
- Duality of Matter
- Uncertainty Principle.

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 3 x 108m/s. This can be use 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. Thus, the particle nature of light is highlighted.

EVALUATION

1. Briefly explain the duality of light.
2. Explain three concepts that show the behavior of light as particle.

DUALITY OF MATTER
Newton's theories and laws considered matter and electrons as particles. De Broglie postulated that an electron of mass 'm' moving with a velocity v radiates energy and has a wavelength, $\lambda = \frac{h}{mv}$ (h = Planck constant).
This is true for electrons and other elementary particles like protons and neutrons.

EVALUATION

1. What is the energy of a photon whose frequency is 50KHz, given that Planck constant, h= 6.6 x 10-34 Js.
2. A bullet of mass 0.002kg is fired with a velocity of 1000m/s. what is its de Broglie wavelength? Will the wave nature of this mass be observable?

UNCERTAINTY PRINCIPLE
Heisenberg has shown by this experiment in electron diffraction that **it is impossible to know the exact position and velocity of a particle simultaneously.** In the experiment, an electron was assumed to be a bundle of waves which extends over a small region Δx. The exact position of the atom in this bundle and within space Δs is difficult to know. This uncertainty is called, the uncertainty of indeterminacy. He therefore says that if Δx is the uncertainty in the position and Δv the uncertainty in the velocity of a particle,

$\Delta V \Delta x \geq h$

If P is the momentum, then P =△m V △

:. △ P△X ≥ $\frac{h}{2\pi}$

△E △ ≥ $\frac{h}{2\pi}$

E is the uncertainty in the energy of the particle and t, the uncertainty in time. Hence, this principle is saying that we cannot determine the exact values of these quantities.

GENERAL EVALUATION

1. Explain Heisenberg uncertainty principle
2. State two phenomena that can be satisfactorily explained by assuming that matter behaves like (a) waves (b) particles.

WEEKEND ASSIGNMENT

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. The duality of matter implies that matter? (a) Exist as particle of dual composition (b) has momentum and energy (c) has both wave and particle property (d) is made up of dual materials
3. According to quantum theory, electromagnetic wave is transmitted in tiny bundles of energy called (a) photons (b) electrons (c) photons (d) protons
4. Which of the following scientists proposed the uncertainty principle? (a) De Broglie (b) Heisenberg (c) Newton (d) Lenz
5. The uncertainty in the measurement of two complementary variables is ____ $\frac{h}{2\pi}$ (a) ≥ (b) ≥ (c) ≈ (d) =

THEORY

1. With what fundamental accuracy can the position of a 60g piece of stone be located, if the stone has a speed of 240m/s, accurate to 0.1%.
2. (a) State Heisenberg uncertain principle.
   (b) Mention two phenomena that can be explained in terms of the particulate nature of light.

WEEK TEN
TOPIC: ROCKETS AND SATELLITES (BASIC ELECTRONICS)
CONTENT

- Satellite and their functions
- Components of a satellite
- Semiconductors.

SATELLITES AND THEIR FUNCTIONS

The word satellite refers to a body orbiting a larger one. There are natural satellites (e.g the Earth and other planets orbiting the Sun), and artificial satellites such as; Communication Satellites (that transmit telecommunication signals), Global Positioning Satellites (that allow for the identification of locations on the Earth) and Meteorological Satellites (that monitor weather and climate patterns). Examples of

Nigeria satellite includes; Niger-SAT 1 (a disaster-monitoring microsatellite), NICOM-SAT 1 (for mobile phone and internet services. However due to the failure of its solar cells system, the satellite has ceased to function).

COMPONENTS OF A SATELLITE

All satellites have some common basic components that work together to form the following systems;

a) Power generation and distribution system
b) Command and data handling system
c) Payload
d) Protective shielding
e) Rocket thruster system.

Other components include; solar cells, batteries, command antenna, communication antenna, radio receivers and transmitters, rocket fuel, rocket motor, rocket thrusters, cameras.

BASIC ELECTRONICS; SEMICONDUCTORS

Semiconductors are crystalline or amorphous solids with distinct electrical characteristics.
They are of higher of higher resistance than the typical conductors but of lower of lower resistance than the insulators. Their resistance decreases with temperature - a behavior opposite to that of metals.

Their conducting properties can be altered in useful ways by the deliberate introduction (‘’doping’’) of impurities into the crystal structure.
Doping greatly increases the number of charge carriers (holes and electrons) within the crystal.
There are two major types of impurities; the donor and the acceptor. Antimony, Arsenic and Phosphorus are typical donor elements while Aluminum, Boron and Gallium are good acceptors.
Addition of donor element produces the n–type semiconductor while the addition of acceptor element results in the p–type semiconductor.

The n-type semiconductor contains mostly free electrons, it has excess electrons (i.e its charge carriers are the excess electron), and a p-type semiconductor contains mostly free holes, it has a shortage of electron (i.e its charge carriers are the excess holes).

A single semiconductor can have many p- and n- type regions when doped under precise conditions. The junction between these regions are referred to as the p-n junction.

Doping lowers the resistance of a semiconductor but also permits the creation of semi-conduction junction. The behavior of charge carriers at this junction is responsible for its usefulness in diodes, transistors and all modern electronics.

The most widely used semiconductors are Silicon, Germallium and compounds of Gallium. Elements located where the metalloids are on the periodic table are usually used as semiconductors.

GENERAL EVALUATION

1. With the aid of a diagram, describe how continuous current can be generated from mechanical energy

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2. With the aid of a diagram, describe how continuous current can be generated from chemical energy.

WEEKEND ASSIGNMENT

1. Most satellite depend on ….. for the generation of their electrical energy supply. (a) d.c generators (b) Leclanche cells (c) solar cells (d) hydroelectricity.
2. The following are components parts of a rocket except (a) fins (b) nozzle (c) propellant tank (d) turbine.
3. One of the following is a component of a satellite (a) camera (b) fins (c) command antenna (d) solar cells.
4. The function of the fins in a rocket is to (a) beautify it (b) make it fly (c) stabilize it and maintain its direction of motion (d) increase its mass.
5. What is the function of the power generation and distribution system in a satellite?
(a) capturing solar energy and converting it to the electrical energy needed (b) increase the weight of the engine (c) receiving and transmitting of data (d) to beautify the satellite.

THEORY

1. Draw a satellite and a rocket, labeling at least five parts on each.
2. What are satellites used for?