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SECOND TERM E-LEARNING NOTE

SUBJECT: PHYSICS **CLASS: SS3**

WEEK 1 Date: ……………..

Topic

Electromagnetic induction

Content

Induced current

Laws of electromagnetic Induction

Induction Coil

A/C and DC Generator

Transformer and Power Transmission

Electromagnetic induction is the production of electric current or voltage in a conductor whenever there is a relative motion between the conductor and a magnetic field or a magnet.

The induced e.m.f. or current depends on

a. the speed of motion of the magnet. The faster the speed of motion, the larger the induced current
b. the number of turns of the coil
c. the presence of a soft-iron core inside the coil

The direction of the induced current reverses when the direction of motion of the magnet or coil is reversed.

The coil A and C are wound on a steel ring R. When the switch S is close, a deflection will be obtained on the galvanometer G, and when S is open G will show a deflection in the opposite direction.

Current will flow in the galvanometer whenever there is relative motion between the coil and the magnet. There is such a relative motion when the magnet moves towards the coil or away from the coil and when the magnet is stationary but the coil is moved. Such a current is called induced current and the phenomenon is called electromagnetic induction.

EVALUATION

1. Explain the term electro magnetic induction.
2. Describe how induced current are produced.

Law of Electromagnetic Induction.

There are two laws of electromagnetic induction

1. Faraday's law
2, Lenz's law

Faraday's law of electromagnetic induction states that whenever there is a change in the magnetic lines of force (e.m.f) is induced, the strength of which is proportional to the rateof change of the flux linked with the circuit.

The magnetic flux or field lines linking a coil depends on

i. the magnetic field strength
ii. the number of turns of the coil
iii. the area of each turn

To obtain a large induced e.m.f. move at a high speed across a strong magnetic field. Faraday's law gives the magnitude of the induced e.m.f.

Lenz law of electromagnetic induction states that the induced e.m.f is in such a direction as two oppose the motion or change producing it.

Lenz law gives the direction of the induced e.m.f or induced currents.

EVALUATION

1. State Faraday's law of electromagnetic induction
2. State Lenz law

3. What are the benefits of these law to modern day engineering/

Induction Coil

This is an electrical device that is capable of producing a very high intermittent e.m.f .by electromagnetic induction from a low voltage d.c.

Source e.g battery

It consist of:

i. a primary coil, made up of a few turns f thick copper wire, wound on a laminated soft iron core. The lamination of the core is to reduce loss of energy due to eddy currents.
ii. Secondary coil overlapping the primary coil. It is made up of a large number of turns of insulated thin copper wire. The ends of this coil are connected to an adjustable spark gap created by two adjustable brass rods.
iii. In front of the soft iron core of the primary coil is a make-and-break-device consisting of soft iron armature carried on a light brass spring to which is attached a platinum contact with adjustable screw. The primary circuit is completed from this contact through a key and the battery which provide the current.

The induction coil is commonly used in motorcar ignition system and in the operation of x-ray tubes.

EVALUATION

1. Draw a labeled diagram of the induction coil
2. Describe the principle of operation of the induction coil.

A.C and D.C Generator.

A machine that converts mechanical energy into electrical energy or electrical energy into mechanical energy is called a dynamo. When it changes mechanical energy into electrical energy it is called a generator, but when it changes electrical energy into mechanical energy, it is called a motor.

There are two classes of generators, the alternating current (A.C) generator and the direct current (D.C) generator.

The A.C. generator consists of:

a. an armature – a rectangular coil consisting of a large number of turns of insulated wire wound on a laminated soft iron core.
b. a magnetic field created by the curved poles of a horse-shoe magnet or an electromagnet.
c. two copper slip rings to which the ends of the rectangular coil are connected and which rotate with the armature.
d. two stationary carbon brushes which are made to pres lightly against the slip rings

EVALUATION

1. Draw a labeled diagram of A.C generator
2. Describe the principle of operation of A.C generator.

Direct Current (D.C) Generator

An a.c. generator can be made to produce a d.c by replacing the two slip rings with a single split ring or commutator. A split ring commutator is a slip ring that has been split into two segments which are insulated from each other. The ends of the coil are connected one to each split ring or commutator segment .

The commutator is a current reverser. When the armature coil is rotated, the commutator automatically switches each end of the coil from one brush to the other each time the coil completes one-half of a revolution. As the current reverses in the coil after each half revolution, the connection between the coil and the brushes are reversed through the action of the commutator.

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

$$\therefore \frac{ES}{Ep} = \frac{Ns}{Np}$$

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.

$$\therefore \frac{Es}{Ep} = \frac{Ip}{Is}$$

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.

Example

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

$$\text{turns ration} = \frac{Ns}{Np} = \frac{120}{60} = 2$$

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 ?

$$\frac{Es}{Ep} = \frac{Ns}{Np}$$

$$\frac{Es}{} = \frac{300}{}$$

220 500

$$E_s = \frac{220 \times 300}{500.}$$

$E_s = 132$ 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 = I_pV_p

= 0.7 x 220 = 154w

secondary (output power) = I_sV_s = (I_s x 15)w

p = iv

$\frac{p}{V}$ =

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

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

:. Output power = 8 x 15 = 120 W

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

$$= \frac{120}{154} \times 100 = 78\%$$

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

Total power consumed in 24 hrs

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

Cost at 30k per kwh

$$= \left(\frac{0.7 \times 220}{1000} \times 24 \times \frac{30}{100} \right.$$

= N1

EVALUATION

1. Draw a labeled diagram to explain the working of a transformer which can produce 24v from a 240v supply.
2. 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

WEEKEND ASSIGNMENT

1, Induced current depends on the
i. number of turns in the coil
ii. strength of the magnet
iv. 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.

Theory

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 TWO ………………

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

$I = Io \sin 2\pi ft$
$= Io \sin wt$

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,

$V = Vo \sin 2\pi ft$
$= Vo \sin wt$

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

$2\pi ft = 900\pi t$

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

$f = 450Hz$

$w = 2\pi f = 900\pi$

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

Variation of alternating current (or voltage) with time.
An alternating current (or voltage) varies sinusoidally as shown in the diagram above. It is asine 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. $= \frac{I_o}{\sqrt{2}} = 0.707\%$.

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.

Reading Assignment

New School Physics p 447 -457

Theory.

1. Distinguish between alternating current (a.c) and direct current (d.c). Explainthe term peak valueand 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.

WEEK 3 Date:…………

Alternating Current
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 ®is I an the voltage across it is V

From ohm’s law,we have that

$V = iR$

Thus the current is given by

I = ’s law,we have that

$V = iR$

Thus the current is given by

$I = \frac{V}{R.}$

But $V = Vo \sin wt$

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

$I = Io \sin wt$

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

$I\ r.m.s. = \frac{Vr.m.s}{R.}$

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^o 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

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

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

$V = iX_c$

In other words, an ohm's law relation applies 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 2 UF 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 = 1xc

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

$$= 0.113A.$$

Peak current, $I_o = \sqrt{2}\ I_{r.m.s.} = 0.160A$

Inductance in A.C Circuit

V_L leads I_L by $\pi/2$ radians or 90o. 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 $\pi/2$ radian or 90o or by ¼ cycle. I and V have a phase difference of 90o ($\pi/2$)

$V = V_o \sin wt$

$I = I_o \sin (wt - \pi/2)$. 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 = 1 x L

The unit of XL is in ohms

$X_L = 2\pi fl$

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 o.2H inductance when an a.c voltage of 60HX is applied across it, if the voltage is given by V = 150 sin 120 πt.Calcualte the r.m.s and peak values of the current.

$X_L = 2\pi fl$

$= 2\pi \times 60 \; XL$

$= 120\pi l$

$= 120 \times \pi \times 0.2$

$= 75.40\Omega$

$V = 150 \sin 120 \pi t$

$V_o = 150V$

$F = 60Hz$

$V_{rms} = 0.76 = 0.7 \times 150 = 105V$

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

$= 1.39A$

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

$= 1.99A$

Series Circuit Containing Resistance ®
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

$I_o = \frac{V_o}{(R^2 + (X_L - X_c)^2)^{1/2}}$

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

$X = X_L - X_C.$

Let $Z = (R^2 + (X_L - X_C)^2)^{1/2}$

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

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

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.

$X_c = \underline{1}$

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

$$XL = WL = 2\pi fL$$

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

$$:. Z = \sqrt{R^2 + (2\pi fl - \frac{1}{2\pi fc})^2}$$

in summary

$V = IR$

$VL = I X L$

$Vc = I x C$

$V = 1Z$

$= 1 (R^2 + (XL – Xc)^2) ½$

Example

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

$$Irms = \frac{Io}{\sqrt{2}}$$

$= 0.707Io$

$= 0.707 = 3.53A.$

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

1 cycle = 360^o

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

$E = Eo \sin wt = Eo \sin 45$

$= 180\sin 45$

$= 180/\sqrt{2}$

$= 90\sqrt{2}$ volts.

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.

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

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

$= 636.62$ ohms

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

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

$= 809.5$ohms

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

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

12.35 MA.

iii. Vc =1 X c
= 12.35 x 10^{-3} x 636.62
= 7.86 volts

(b)XL = WL = 2π x 50 x 150 x 10^{-3}
= 47.12 OHMS
Z = √ r^2 +XL 2
=√500^2 = $(47.12)^2$
= 502.2OHMS
I $\frac{10}{502.2}$
= 19.9 X 10-3 A = 19.9Ma
V = 1 x L = 10.9 x 10^{-3} x 47.12
= 938 x 10^{-3} V = 938,MA.

VECTOR DIAGRAM

When an alternating voltage is placed across a R.V.C series circuit, the resulting alternating current i. has the same frequency as the voltage (v0 but the two differing phase or are said to be out of phase

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

$$\text{Tan } \theta = \frac{X}{R}$$

X = reactance =Xl – Xc 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 90o (π/2) radian. This means that the angle by which a particular phase Ic is in advance of a similar phase of Vc is 90o or π/2 radian or ¼ cycle
If Vc = Vo sin wt
Then Ic = Io sn (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
VL = Vo sin wt
IL = 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 Vr be the reference vector, the other voltage vectors acts as shown

The effective voltage V is given by

$V^2 = V^2R + (VL – VC)^2$

Tan Ǿ = $\frac{VL – VC}{VR}$

= $\frac{VL - XC}{R.}$

If XL > XC, Ǿ is positive and I lags.
If XL < Xc,Ǿ is negative and I leads V
For R and L series, we have

$V^2 = V^2R + V^2L.$

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

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

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

Tan Ǿ $\frac{VL}{VR}$

= $\frac{XL}{R}$

I lags V or V leads I
For R and C in series
V2 = V^2R + V2C

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

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

Tan Ǿ $\frac{Vc}{VR}$ = $\frac{Xc}{R}$

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 Ǿ

I, V are the effective (r.m.s) values of the current and voltage respectively and Ǿ is the angle of lag or lead between them . The quantity cos Ǿ is known as the power factor of the device. The power factor can have any value between zero and unity for Ǿ varying from 90^o to 0^o. For Ǿ = 90^o or cos Ǿ = 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

$P = I^2R$

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

P =IV (instantaneous value)

Power factor

$\cos Ø = \frac{\text{Resistance}}{\text{Impedance}}$

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.

$XL = 2\pi fl = 2\pi x\ 50 \times 5 = 500\pi$ohms
$Z = \sqrt{R=Xl} = \sqrt{(600)^2 + (500\pi)^2}$
$= 1.69 \times 10^3$ ohms

$I_{r.m.s} = \frac{V_{rms}}{Z} = \frac{15}{1.69 \times 10^3} = 8.88 \times 10^{-3}$ 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. $\tan Ø = \frac{XL}{R} = \frac{500\pi}{600} = 2.62.$

Ø = tan-1 (2.62) = 69.10

iv. Power supplied

$P = I^2R$
= (8.88 x 10-2)2 x600
= 4.73 x 10-2 w

v.p,d across R.

VR =IR
= 8.88 x 10-3 x 600
= 5.53ohms.

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 XL = 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 Xl = Xc

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

$$4\pi 2foLC = 1$$

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

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

since $w = 2\pi f$

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

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.

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

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

$= \frac{1}{2\pi\sqrt{x\ 10-11}}$

= 1299. 545Hz

13khz

At resonance X = R since XL =XC

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

$= \frac{2}{5}$

= 0.4A

Reading Assignment

New School physics pag 458-463

WEEKEND ASSIGNMENT

If the frequency of the a.c current above is $\frac{500}{\Pi}$Hz, what will be the reactance in the circuit .

A. $\frac{0.009}{\Pi}$ ohms (b) 400 ohms

c. 1030 ohms (d) 1400 ohms (e) 2500 ohms

2. At what frequency will 20uf capacitor have a reactance of 500 ohms?

(a) $\frac{100}{\pi}$ (b) $\frac{50}{\pi}$ 150 (d) 100π (e) $\frac{30}{\pi}$

3. What is the peak value of a voltage whose r.m.s value is 100v

(a) 140v (b) 70V (c) 141.4V (d) 50V (e) 80.60V.

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. The resonance frequency (fo) in an RLC series circuit is given by
(a) $f_o = 2\pi\sqrt{LC}$ (b) $f_o = \frac{2\pi}{\sqrt{LC}}$
(c) $f_o = \frac{1}{2\pi\sqrt{LC}}$ (d) $f_o = \frac{1}{\sqrt{LC}}$

Theory

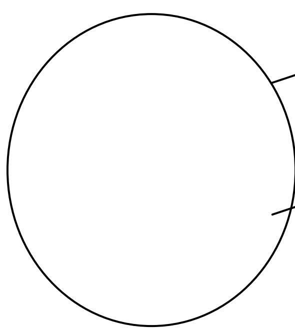
1. Explain what is meant by the terms impedance, phase angle and reactance as applied to an a.c. circuit. Calculate the impedance and phase angle for an a.c. circuit having a 100ohms resistance, 5*u*f capacitor in series if an a.c voltage of frequency 100Hz is applied across the circuit .
2. Draw a vector 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 4 Date:………..

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

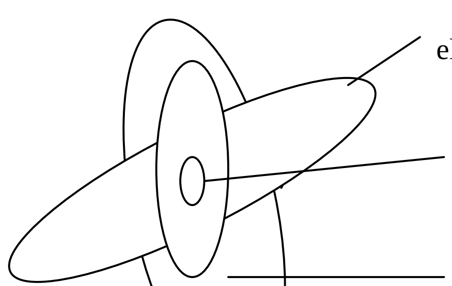
Thompson proposed an atomic model which visualized the atom as a homogenous sphere of positive charge inside of which are embedded negatively charged electrons.



He also determined the ratio of the chated 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.

Rutherford Model

He proposed a planetary model fo the atom which suggested that athe 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



nucleus

orbit

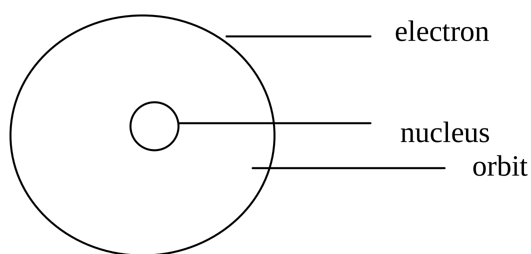
LIMITATION OF RUTHERFORD MODEL

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.

The Borh 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 = Eu – El

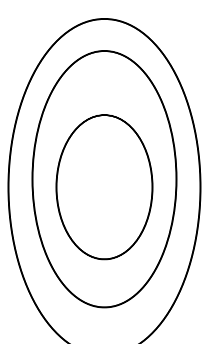
Eu = Energy of upper state

El = energy of lower state

H = planck constant (h = 6.67 x 10^{-34} Js)

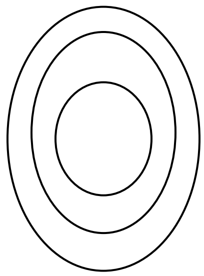
F = frequency of emitted light

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

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

The integral n is called a quantum number

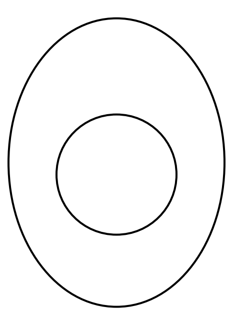
Bohr model is also known as the Bohr – Rutherford model since it was an extension of Rutherford planetary model. The great success of Bohr theory is that;

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.

The Electron Cloud model

This model visualizes the atom as consisting of a tiny nucleus of radius of the order of 10-15m. 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 (Mc) of 9.10-31kg and an electronic charge e-= 1.6 x 10-19 c.

The proton has a mass of 1.67 x 10-27kg 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

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 he 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)
   $^{238\backslash5}_{92}U$(92 protons,92 electrons, 143 neutrons)
   $^{234}_{92}U$ (92 protons, 92 electrons, 142 neutrons)

Reading Assignment

New School Physics pg464-471.

WEEKEND ASSIGNMENT

1. which of the following statement is not correct?
   Isotopes of an element have
   A. the same number of electric charges on the nucleus
   B. the same chemical properties
   C. different nucleon numbers
   D. different proton numbers

E. different atomic masses.

2. Which of the following representation is correct fro 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. An element and its isotopes only differ in the number of
A protons B. electrons © ions D. x – particles E. Neutrons
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 5 Date:…………

Topic
Radioactivity
Contents
Emission of Alpha and Beta particles and Gamma rays.
Properties and Peaceful uses of radioactivity, radio active 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	High penetrating power e.g leads

		aluminium	

Radioactive Decay; Half life, Decay Constant

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 radio active 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

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

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

Transformation of Elements

There are two types of radioactivity nature and 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, hance a new element is formed.

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

${}^{222}_{88}$ 2*B* 2 -1e + ${}^{222}_{88}Ra$ + energy\

$\overset{238}{92} \xrightarrow{2\alpha,\ 2\beta}$ 2 (4He) 2-1°e + $\overset{230}{90}$ th of energy

$\overset{234}{90} \xrightarrow{\beta}$ -ie = ${}^{234}_{91}Pa$ + energy

Generally we represent alpha (α) decay by

$\overset{A}{Z}X \longrightarrow$ 42 He+ $\left(\overset{A\ -4}{Z\ -2}\right)y$ + energy

And *B* decay by

$\overset{A}{Z}X \longrightarrow$ -1e + $\overset{A}{(2+1)}y$

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.

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

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

4He + 27 Al $\rightarrow$ 30P ^{1}n $\rightarrow$ 30Si + ie + energy.

${}^{I}n + {}^{6}_{3}Li \rightarrow$ 3H + ${}^{4}_{2}He$ + energy
${}^{I}n$ + 24Mg $\rightarrow {}^{24}_{11}Na + {}^{1}P$ + energy
4He + 9Be $\rightarrow$ 12C + ^{1}n + energy
${}^{1}n + {}^{59}_{27}Co \rightarrow {}^{60}_{27}Co$ + energy

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

34S + ^{1}n $\rightarrow {}^{35}_{10}S$ + energy
79Br + ^{1}n $\rightarrow {}^{35}_{10}Br$ + 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.

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. What are Beta particles
(A) protons (B) Neutrons (C) Electrons (D) Helium nuclei
3. Alpha particles are
(A) not charged (B) highly penetrating (C) Helium nuclei (D) electromagnetic radiation
4. A substance has a half life 30 mins after 6 ins 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. The number of neutrons contained in the nucleus of $^{238}_{92}U$ is
(A) 92 (B) 146 (C) 238 (D) 330.

Theory

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

2. The half life of a radioactive iodine is measured to be 8.0 days. A solution containing 1.5mg of this iodine on a certain day. Write down on a table the mass of iodine remaining after 8, 16, 24, 32 days. Plot a graph of mass against time and from it deduce the mass of iodine that would remain at the end of 30 days.

Week 6 Date :…………….

Topic
Artificial Transformation
Nuclear Fission
Nuclear Fussion
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

$$He + {}^{27}_{13}Al \;\_\_\_\; {}^{30}_{15}P + {}^{1}n \longrightarrow Si + {}^{o}e + \text{energy.}$$

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.

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

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 (3.0×10^8ms-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 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. 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.

$$21H + 3H \longrightarrow He + {}^{1}n = energy$$

To bring the two lights nuclei together in a fusion process, very high temperature of the order 106 – 108 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 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.

Weekend Assignment

If a nucleus H decays, a nucleus of H3 is formed accompanied with the emission of

a) beta particles
b) gamma particle
c) alpha particle

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

3. When the nucleus of a uranium is split into two fragments or nearly equal masses, the sum of the masses of the fragments is less than the mass of the original nucleus. This difference is a measure of the

(a) change in the momentum of each fragment
(b) nuclear energy release
(c) kinetic energy lost

4. What is the peak value of the voltage whose r.m.s value is 100v.
   (A) 140v (B) 70V (C) 50V
5. An element and its isotopes only differ in the number of
   (A) proton (B) electrons (C) neutrons

Theory

1. Explain the terms nuclear fission and nuclear fusion
2. Explain chain reaction and state one condition necessary for chain reaction to occur.

WEEK 7 Date: …………..

Topic:
Energy Quantization

Bohr suggested that the electron in the atom exist in discrete energy known as quantizaton which can be removed fom one level to the other. Energy in such bodies is emitted in separate or discrete energy packet called energy quanta (E0

$E = hf$

H = planck's constant.

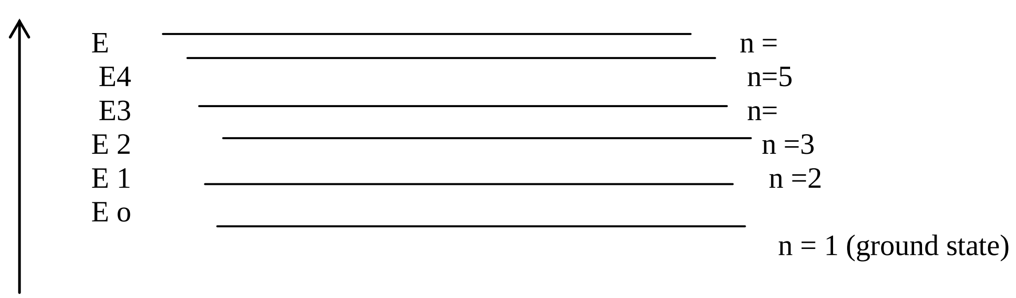
ENERGY LEVEL IN AN ATOM

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:

$$K.E = \frac{1}{2} MV2 = eV.$$

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

$$En - Eo = hf = eV$$
$$\lambda$$

Worked example

1. The change in energy level of an electron in an atom is 6.2 x 10 -21J. Calculate :
   (a) the frequency of the photon
   (b) the wavelength
   (C = 3.0 x 108 ms -1, h = 6.625 x 10 -34Js)

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

$\Delta E = hf$

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

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

But $C = f\lambda$

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

2. An atom excited to an energy level E2 = -12 .42 x 10-19J falls to a ground level of energy Eo = - 30.3 x 10-19J. Calculate the frequency and the wavelength of the emitted photon.

$\Delta E = E2 - Eo$

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

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

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

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

$\Delta E = E2 - EO = -10.3EV - (-26.3ev)$

$= 16ev$

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

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

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

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

$$= \underline{1.9875 \times 10^{-25}}$$

2.56×10^{-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 = ½ mv2 = ev

2ev =mv2

$v2 = \frac{2ev}{m}$

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 x 10-19 x 1.5x 103

= 2.4 x 10-16J.

LINE SPECTRA FROM HOT BODIES

If the light of excited gas is examined in a spectrometer, an emission spectrum is seen e.g Neon produces a line spectrum. The spectrum consist of a number of well defined lines, each having a particular wavelength and frequency .

ABSORPTION SPECTRA

Absorption spectra are dark lines in the emission spectrum of a heated substance due to absorption of radiation .Electrons absorb radiation if theyjump from lower energy level to higher energy level.

SPECTRA OF DISCHARGE LAMP

If a gas put into a discharge tube and if its pressure is progressively reduced using a power pump as shown below

When a high p.d is applied at low pressure, an electric discharge takes place in the tube and the gas glows. The gas glows because its atom is given energy by the flow of electricity through the tube. The colour of the gas depends on the nature of the gas used .

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.Which of the following have the greatest penetrating power?

(A)Beta ray (B) Gammar rays (C) X- rays.

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. Which of the following statement is correct about cathode rays. They are fast moving
   (A) atoms (B)ions (C) electrons

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.

Theory

1. Explain the term excitation

2. An electron jumps from one energy level to another in an atom radiating 9.0 x 10-19J. if h = 6.6 x 10 $^{-34}$jS and C = 3.0 x 10^{8}m/s, what is the wavelength of the radiation .

WEEK 8 Date :………….

Topic

PHOTO ELECTRIC EFFECT

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 :

1.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 i.e 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 x 10-34JS, 1eV = 1.6 x 10-19J).

$$E = hf - w$$

$$E + w = hf$$

$$\frac{E + W}{H} = f$$

$$= \frac{(3.5 + 3.0) \times 10^{-16} \times 1.6\ 10^{-19}}{6.6 \times 10^{-34}}$$

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

$$= 1.58 \times 10^{-1}\ \text{Hz}$$

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 Lithum is 2.30 V, calculate

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

$W = 2.3$ ev

$E = hf - w$

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

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

$\lambda o = 5.4 \times 10^{-7}$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 OPERATION

In the X- ray tube, a high potential difference is applied between the hot cathode and the anode. Electronsare emitted from the cathode and are accelerated to an extremely high speed. They are abruptly decelerated whenthey strike the anode causing the emission of high energy radiatin 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

TYEPS OF X – RAY

There are two tupes of x- rays

1.Hard x – rays of x- rays

Characteristics of Hard x-rays

i. High penetrating power or ability

ii. Shorter wavelength

Characteristics of X –ray.

i. low penetrating power
ii. 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. 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. Treatement 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 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 check up.

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 (bn) 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. Define threshold wavelength
2. Determine the frequency of the photonwhose energy is required to eject a surface electron with a kinetic energy of 1970 x 10-19 eV. If the work function of the metal is 1334 x 10-19eV. (1eV = 1.6 x 10-19J, h = 6.6 x 10-34JS, C = 3 .0 x 108 ms-1)

WEEK 9 Date:…………..

Topic:
Conduction of Electricity in Gases
Contents
1. Condition for discharge
.ii Characteristics of cathode rays and application
iii Thermonic emission and application ‘
iv. Diode valve
v. 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
Draw a discharge tube and explain how electricity is conducted through it.
What are cathode rays?
Characteristics of Cathode rays
They consist of streams of fast moving electrons.
They cause glass and other materials to glow or fluoresce with a greenish colour.
They travel in straight lines
They are deflected by electric and magnetic field.
They can ionize a gas
They will turn a light paddle wheel in the tube because they have mass, momentum and energy.
They are highly energetic particles.
They can affect photographic plates
They can produce x-rays from high density metals when they are suddenly stopped by such metals.
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.

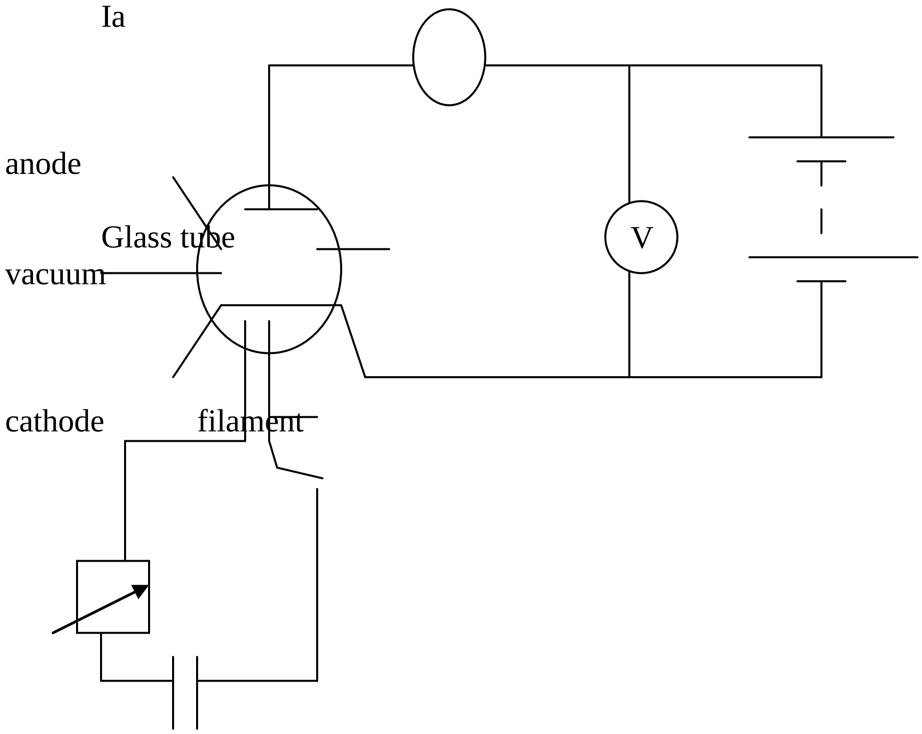
Thermionic Emission

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



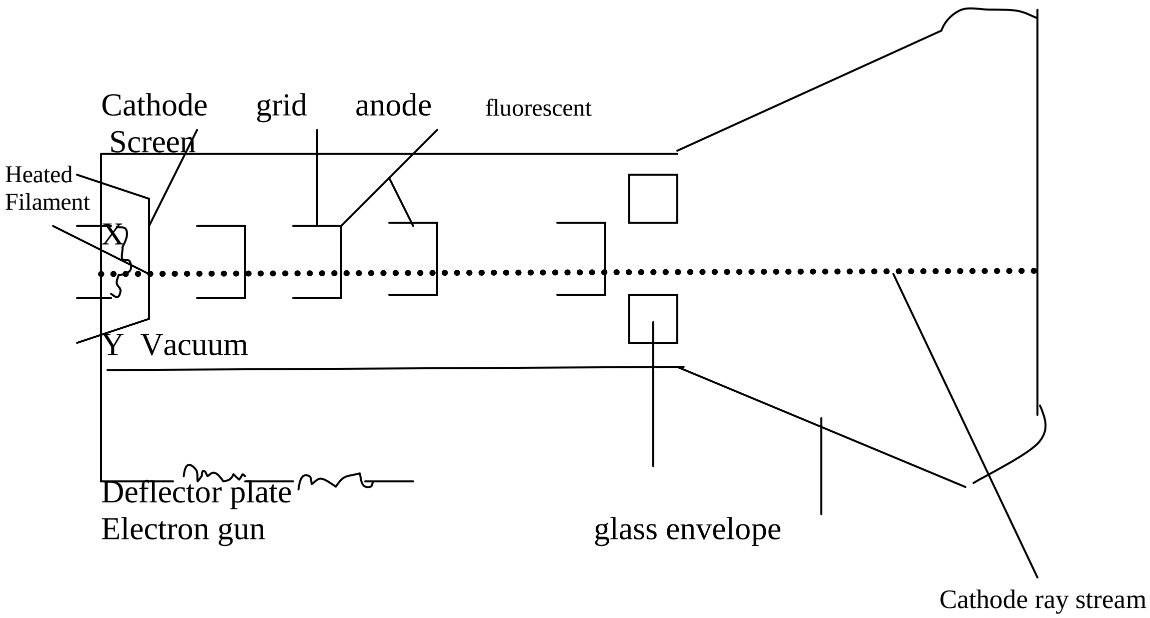
The filament supplies free electrons when heated by the current from the battery (E), when the anode is made positive in potential with respect to the cathode, electrons low towards the anode and constitute the anode current (Ia) which is registered by the milliameter.

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.



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.

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

1a. Draw a labeled diagram of a cathode ray oscilloscope showing the essential parts. What are the function of

i. the hot filament (b) the anode (iii) fluorescent screen (iv) deflector plates

1b. State one way in which cathode rays differ from electromagnetic waves

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

b. what is thermionic emission .

WEEK 10. Date:………

Topic
Wave – Particles Duality (Paradox)
Contents
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
Briefly explain the duality of light.
Explain three concepts that shows the behaviour of light as particle.
Duality of Matter
Newton's theories and laws considered matter and electrons as particles. De Broglie postulated that an electron mass 'm' moving with a velocity V radiates energy at a frequency $f = \frac{MV}{H}$ and wavelength $= \frac{h}{Mv}$ (h = Planck constant). This is true for electrons and
Other elementary particles like protons and neutrons.
EVALUATION
What is the energy of a photon whose frequency is 50KHZ, given that Planck constant, h= 6.6 x 10-34 Js.
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
Heinsberg has shown by this experiment in electron diffraction that it is impossible to know the exact position and velocity of a particle at any given time. In the experiment, an electron was assumed to be a bundle of waves which extends over a small region Δs. 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 Δs is the uncertainty in the position and Δv the uncertainty in the velocity of a particle, $\Delta s \, \Delta v \geq \frac{h}{m}$, m is the mass of the particle.

If P is the momentum, then $\Delta P = \Delta MDV$

:. $\Delta P \Delta X > h$; $\Delta E \Delta t > h$

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

EVALUATION

Explain Heinsberg uncertainty principle

State two phemomena 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. 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

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

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