MODERN PHYSICS

STRUCTURE OF AN ATOM

An atom consists of 3 particles namely -:

- Proton
- Neutrons
- Electrons

It is made up of the central part called nucleus around which electrodes rotate in orbit. The protons and neutrons lie within the nucleus and these particles are sometimes referred to as nuclei particles or nuclide

Name	Symbol	Sign of change
Protons	$^{1}_{1}H$	Positive
Neutrons	$^{1}_{0}n$	No change
Electrons	$^{0}_{-1}e$	Negative

The nucleus is positively charged

ISOTOPES

These are atoms of the same element having the same atomic numbers but different mass numbers

ATOMIC NUMBER

This is the number of protons in the nucleus of an atom.

MASS NUMBER

This is the sum of protons and neutrons in a nucleus of an atom. It is some times called atomic mass. It is expressed as

$^{Z}_{A}X$ Where A- atomic number and Z – mass number

e.g. Given that $^{35}_{17}Cl$ determine:

a) Number of protons = 17

b) Number of neutrons = 18

RADIOCTIVITY

This is the spontaneous disintegration of heavy unstable nuclei to form stable nuclei accompanied by release of energy particles like beta, gamma, alpha and energy.

ALPHA PARTICLES

An alpha particle is a helium atom which has lost 2 electrons an alpha particle has mass 4 and atomic number 2 which is positively charged.

PROPERTIES OF ALPHA PARTICLES

Ionized gases have a high ionizing power compared to gamma rays

They are deflected by both magnetic and electric fields

They are positively charged

They penetrate matter

Have a low penetrating power compared to alpha and beta particles.

When un stable nuclei emits an alpha particle , the mass reduces by 4 and atomic number by 2 e.g. a radioactive substance $^{238}_{92}X$ Undergoes decay and emits an alpha particle to form Y .

Write an equation for the process

$$^{238}_{92}X \longrightarrow {}^{x}_{y}Y + {}^{4}_{2}He$$

238 =x + 4 ⇔ x =234

92 = y + 2 ⇔ y = 90

$$^{238}_{92}X \longrightarrow {}^{234}_{92}Y + {}^{4}_{2}He$$

BETA PARTICLES $B(^{0}_{-1}e)$

These are high energy radiation when radioactive nuclei decays by emitting a beta particles. Mass number isn't affected but the atomic number increases by one.

PROPERTIES OF BETA PARTICLES

They carry negative charge

They cause ionization of gases

They are deflected by both electric and magnetic fields

They can penetrate matter which isn't too thick

E.g. unstable nuclei $^{226}_{88}X$ decays to form a stable nuclei Y

By emitting a beta particle

$$^{226}_{88}X \longrightarrow {}^{n}_{m}Y + {}^{0}_{-1}e$$

226 = n + 0 ⇔ n =226

88 = m + $^{-}$1 ⇔ m= 89

$$^{226}_{88}X \longrightarrow {}^{226}_{89}Y + {}^{0}_{-1}e$$

Write down an equation for the process

$$^{226}_{88}X \longrightarrow ^{226}_{89}Y + ^{0}_{-1}e$$

$$^{246}_{107}X \longrightarrow ^{x}_{y}Y + ^{0}_{-1}e$$

GAMMA RAYS

These are electromagnetic radiation with the shortest wave length when unstable nuclei decays by emitting gamma rays, the mass and atomic number are not affected

PROPATIES OF GAMMA RAYS

They have no charge.

They ionize gases although they have the least ionizing power compared to beta and alpha particles.

They are not deflected by both electric and magnetic fields for they penetrate matter, they have the greatest power compared to other particles.

SIMILARITIES BETWEEN ALPHA AND BETA PATICLES

Both ionize gases

They both penetrate matter

They are both deflected by electric magnetic fields

DIFFERENCES BETWEEN ALPHA AND BETA PARTICLES

Alpha particles carry positive charges while beta particles carry negative charges.

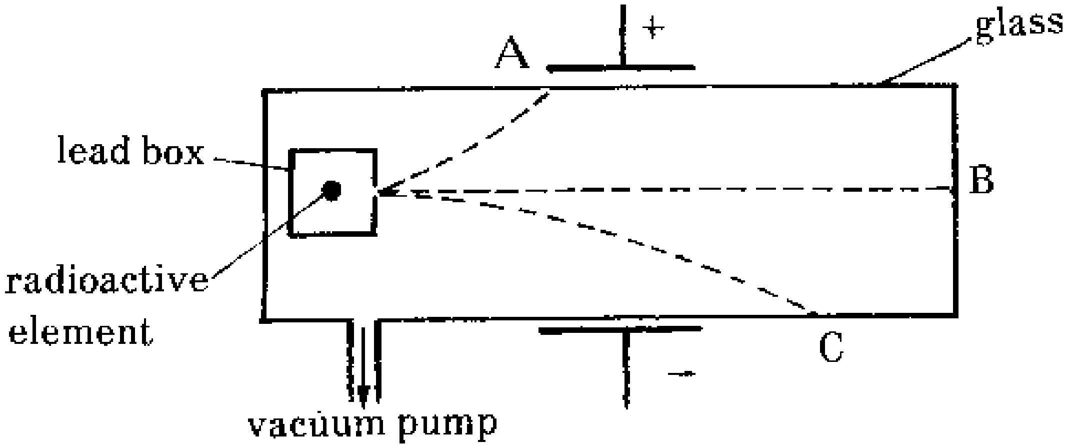
Alpha particles have low penetrative power compared to beta particle.

Other particles have a high ionizing power compared to beta particles.

Deflection for beta particles in an electric fields is towards the positive while that of the alpha particles is towards the negative plate.

Alpha particles are helium particles which have lost the electrons while beta particle are high energy electrons.

DEFLECTION OF THE ABOVE RADIATION IN AN ELECTIC FIELD

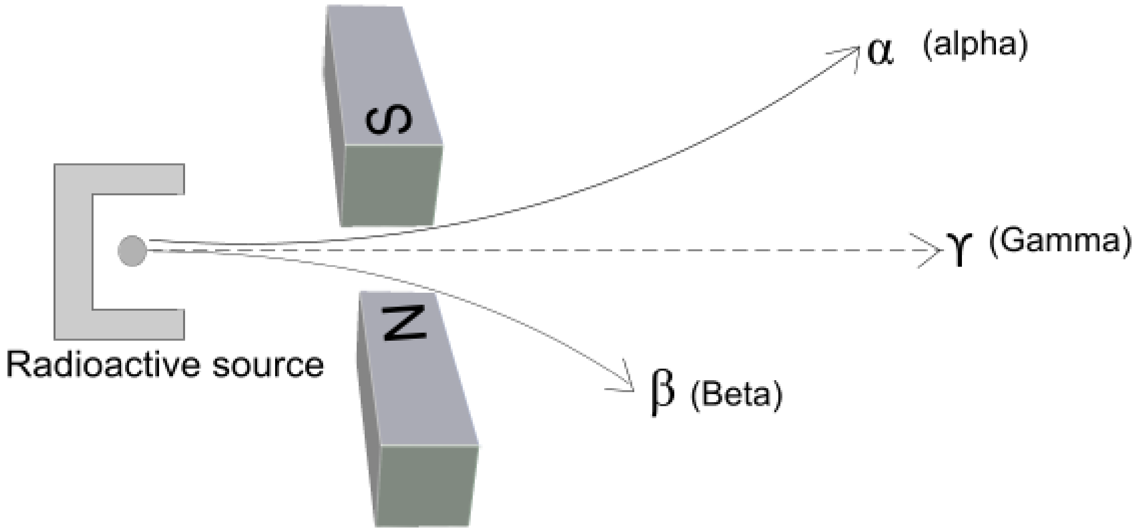


A RADIO ACTIVE ELEMENT

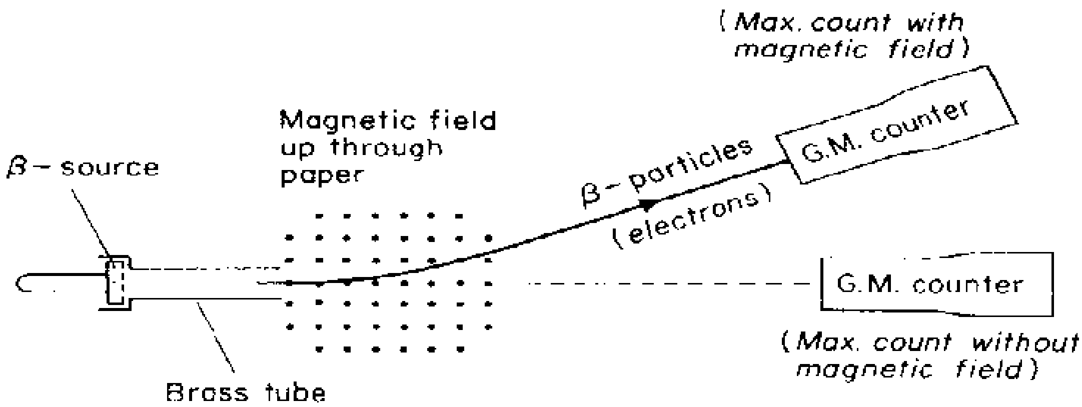
Is one whose nucleus disintegrates gradually and continuously emits powerful and invisible radiations.

- The alpha particles are deflected towards the negative plate indicating that they are positively charged.
- The beta particles are deflected towards plate indicating that they are negatively charged.
- While gamma rays go through the field under deflected showing that the carry on charge.

DEFLECTION BY A MAGNETIC FIELD



- The beta particle is deflected down wards (north pole) because they are negatively charged.
- While alpha particles are deflected upwards (South Pole) according to Flemings left hand rule.
- Gamma rays are not deflected because they possess no charge.



DANGER OF RADIATIONS

Beta and alpha particles cause skin burns and sores

Can cause cancer, leukemia and affect eye sight.

May damage body cells (reproductive organs and liver)

SAFETY PRECAUTIONS WHEN DEALING WITH RADIOACTIVE SOURCES

Radioactive sources should be held with forceps.

Avoid eating, drinking or smoking where radioactive sources are in use.

Radioactive sources must be kept in lead boxes

Wash hands thoroughly after exposing to radioactive materials

Any cut on the body should be covered before dealing with radioactive sources.

USES OF ALPHA, BETA, AND GAMMA RAYS

1. **Industrial uses**

   -used in tracer techniques to investigate the flow of liquids in chemical plants.

   - used in the automatic control of thickness of material in industries.

   - Study of wear and tear in machinery.

   - Gamma ray are used to detect faults in thickness of metals sheets in welded joints

2. **Medical uses**

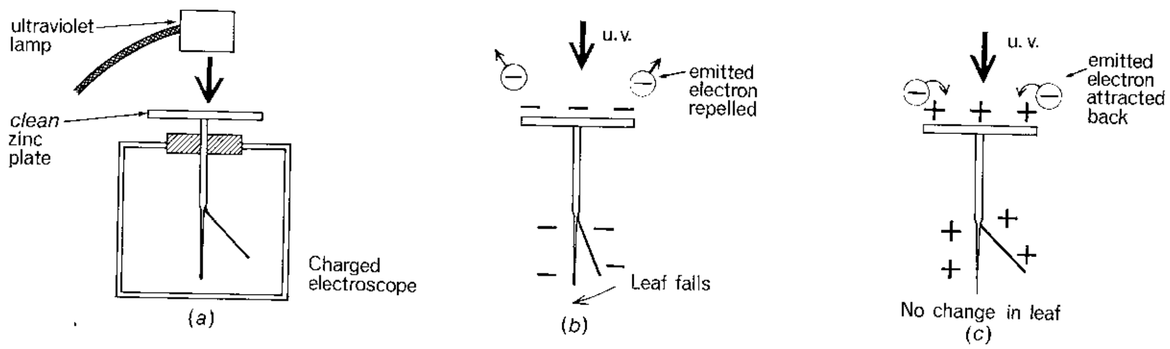
- Control amount in treatment of cancer
- They are used to kill bacteria in food (x- rays)
- Used to sterilize medical equipments like syringes

3. **Archeology**

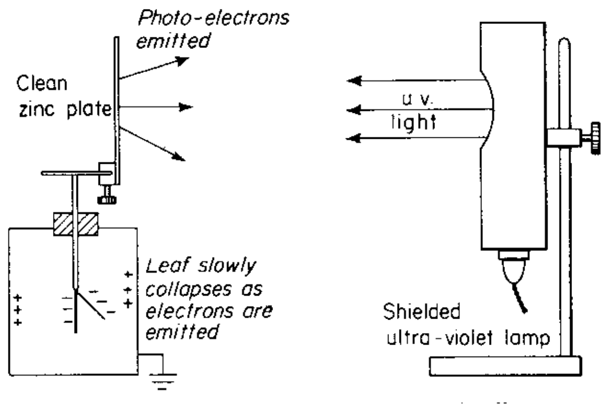
- Used to determine the time that has elapsed since death of organisms occurred , a process called **carbon dating.**
- **Geology**

  They are used to determine the age of rocks

IONISING EFFECTS OF RADIATIONS



- When a radioactive source is brought near the cap of a charge G.L.E , the leaf falls , this show that the G.L.E has been discharged as a of the ionization of air around the cap.
- If the G.L.E is positively charged negative ions or (electrons) from air attracted and the gold leaf falls and if is negatively charged, irons are attracted and leaf also falls.



Ultra violent radiation is incident on a clean zinc plate resting on the cap of a charged G.L.E as shown. Explain what is observed is

i) The G.L.E is positively charged

ii) Radio wave is used instead of ultra violent radiation.

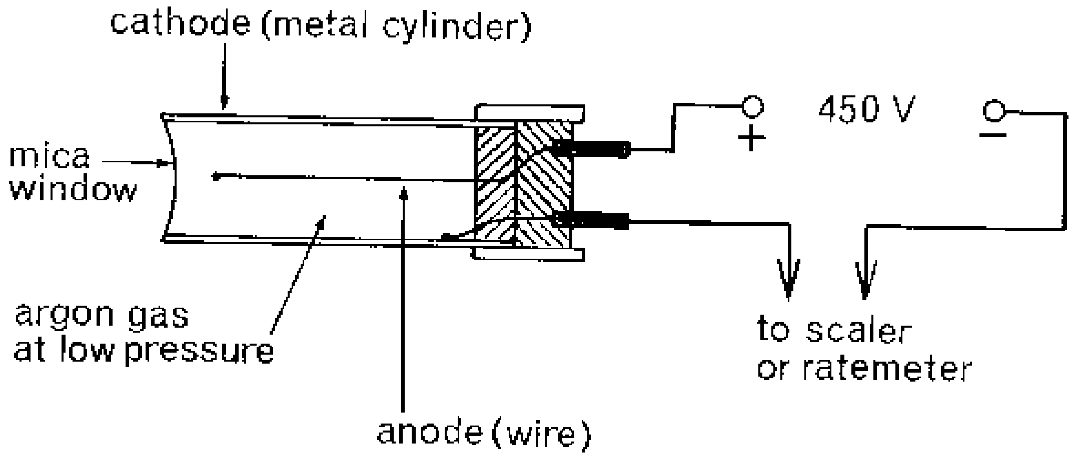
ANSWER

i) No further divergent of the leaf is observed because the ultra violent radiation eject electrons from the metal surface but the electrons are immediately attracted back hence no loss of charge.

(Ii) Radio waves have low energy thus are unable to release electrons so there will be no effect on the leaf divergence of the electroscope.

RADIATION DETECTORS

Geiger Muller counter.

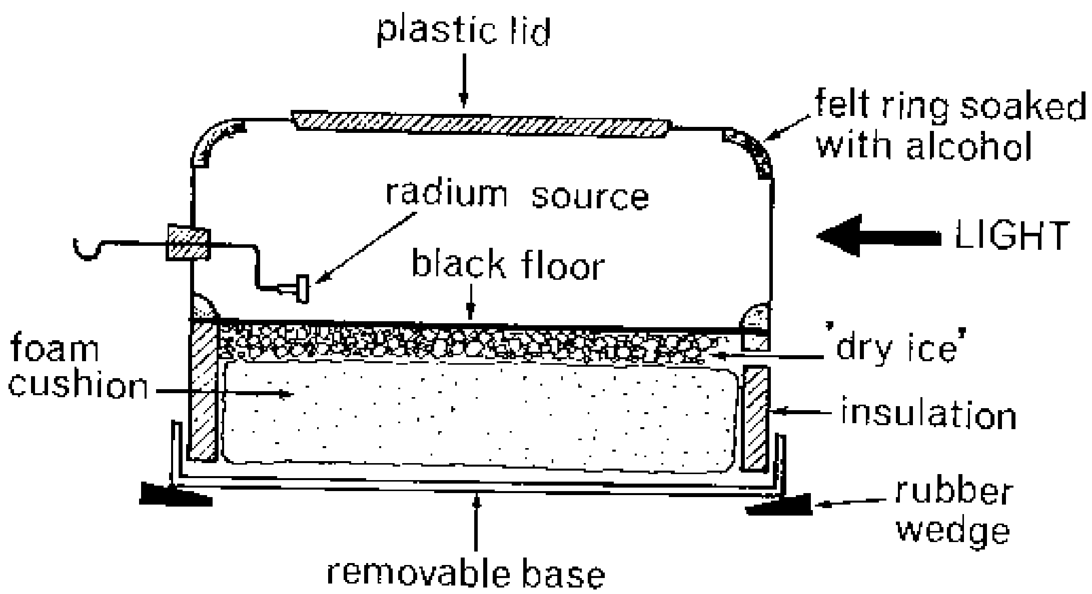


1. The radiation enters the tube thru the mica window and ionizes the Argon ions and electrons

Argon → $Ar^{+}{}_{(g)}$ + e-

The irons are accelerated towards the cathode and electrons towards the anode which cause more ionization by collision with argon atoms at the electrodes. The irons and the electrons cause accident pulse which is amplified and fed into the rate meter

2. **Diffusion cloud chamber.**

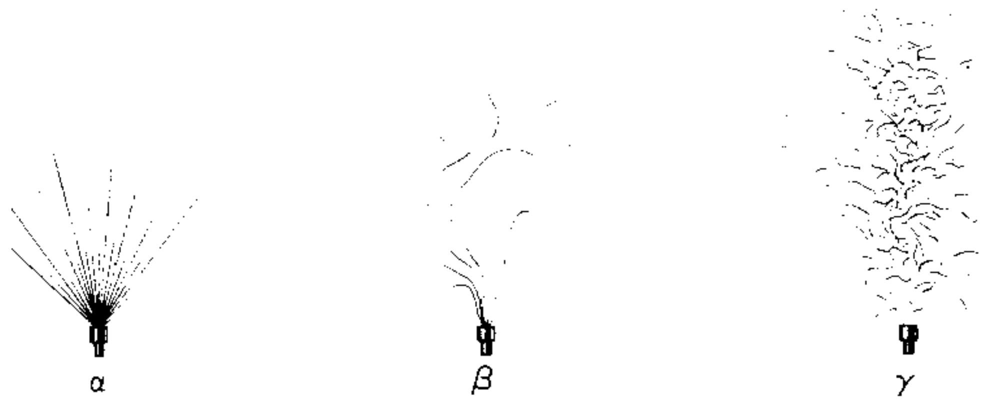


Radiation from the source leave trails of positive gaseous ions along each stroke.

The water/ alcohol vapour molecules are released. They condense as the ions and form small water or alcohol droplets. The droplets are then seen as a track when white light is reflected on them.

GAMMA RAYS

Gamma rays don't leave on actual track because they don't ionize gas if gamma rays are presnt whisky or wavy tracks are formed as shown below.



ALPHA PARTICLES

Are short straight and bold tracks, this is because they are good ionization of gas. A large number of ions observed which have different length due to difference in energy

The tracks obtained are as shown above.

BETA PARTICLES

Tracks made by beta particles are longer and fainter

They wonder as they are deflected by air molecules because they are light the tracks are as above.

Back ground radiation

These are radiations which naturally exist even in the absence of radioactive source. They are caused by natural tracks of radioactive materials in rocks. Cosmic rays from outer space.

These cosmic rays are very high energetic radio active particles which come from deep in space.

So the correct count = actual rate - back ground count rate.

e.g.

Given that the back ground rate is 2 counts , per minute and the Geiger Muller count rate determine the approximate number of radiations present.

Count rate = 25 - 2 = 23c/min

NUCLEAR FISSION

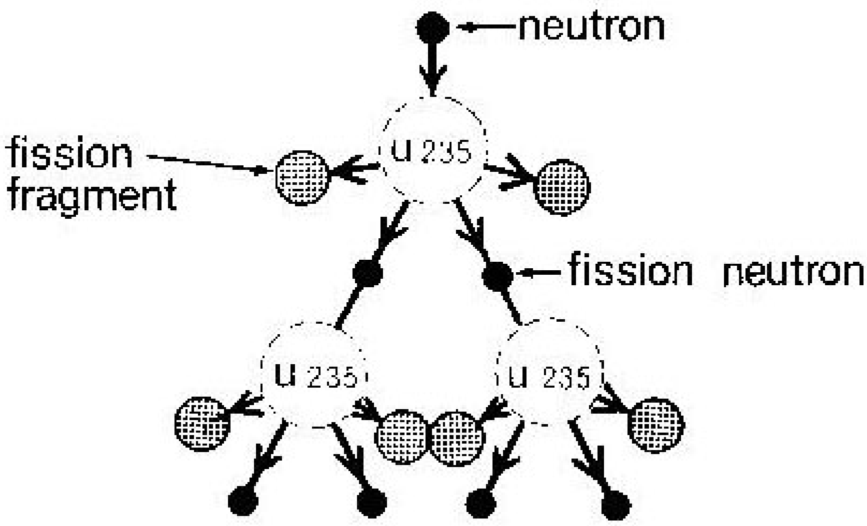
This is the splitting of nucleus of heavy atoms into 2 roughly nuclei. This process can be started bombardment of a clearly nuclei with a neutron. The products of the process are two light atom and more neutrons which can make a process continue.

The products of the reaction are two light atoms and have less mass than the correct value. The difference in the mass is due to energy loss which is given by the Einstein equation.

$E = mc^2$ where c is the speed of light and m is the mass difference (or defect)

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{144}_{56}Ba + ^{90}_{36}Kr + 2^{1}_{0}n$$

neutron — fission fragments — neutrons



APPLICATION OF NUELEAR FUSSION

Used in making atomic bombs

Used to generate electricity

Used to generate heat energy on large scale

CONDITIONS FOR NUCLEAR FISSION TO OCCUR

The Newton's should be moving at a high speed when meeting the heavy nuclei

There should be already nuclei splitting into light nucleus which isotopes which decay to produce isotopes like high speed neutrons.

NUCLEAR FUSION

This is the union of two light atomic nuclei to form a heavy atom. it involves the release of energy e.g

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

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

CONDITIONS FOR A NUCLEAR FUSION TO OCCUR

- Temperature should be very high
- The light nuclei should be at very high speed to over come nuclear division.

USES OF NUCLEAR FUSSION

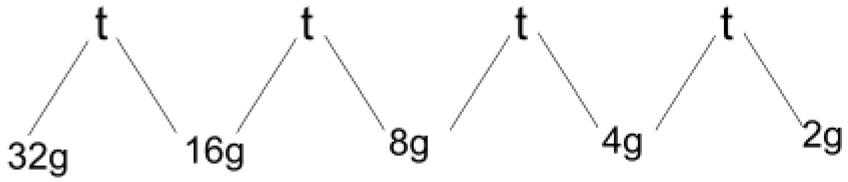
- Used to produce hydrogen.

- Used to produce electricity.
- Used to produce heat energy on large scale.

HALF LIFE

It is the time taken for radioactive substance to decay to half of its original mass e.g

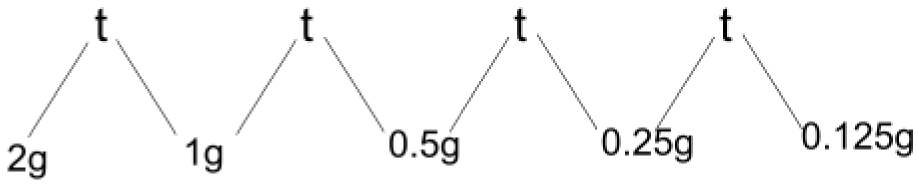
1. If a radioactive element of mass 32 decays to 2g in 96days . calculate the half life.



$4t = 96 \Leftrightarrow t = 24$ days

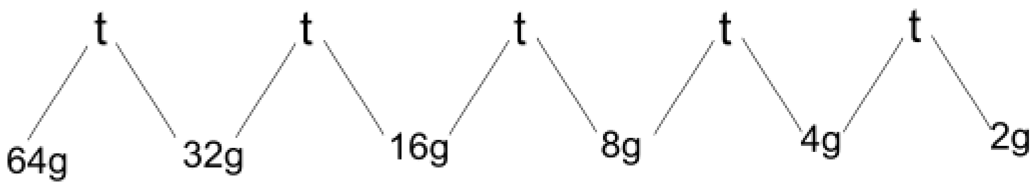
2. A certain radioactive substance takes 120years to decay from 2g to 0.125g . find the half life

Let it be t



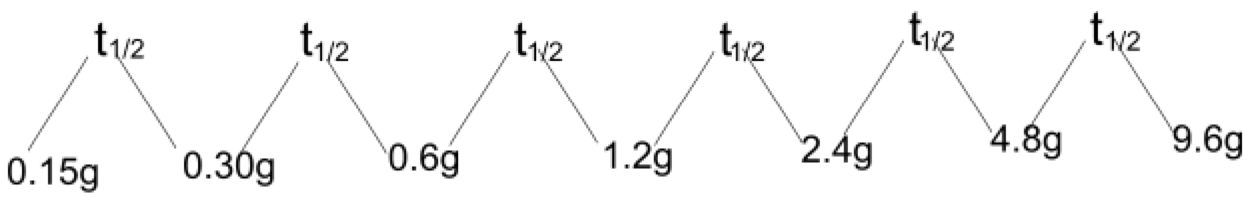
$4t = 120 \Leftrightarrow t = 30$ years

3. The half life of substance is 5days . find how long it takes for its mass to disintegrate from 64g to 2g



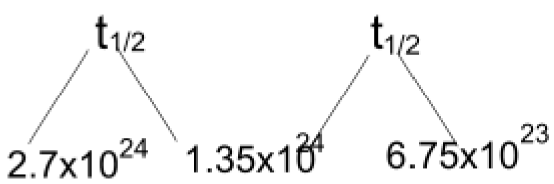
5 x 5 =25 days

A radioactive element has a half life of 4years . if after 24hours 0.15g remains calculate the initial mass of the radioactive material



$M_o =$ 9.6 days

A certain mass of a radioactive material contains 2.7×10^{24} atoms , how many atoms decayed after 3200years if the half life of material is 1600years



Mass remaining $= 6.75 \times 10^{23}$ atom

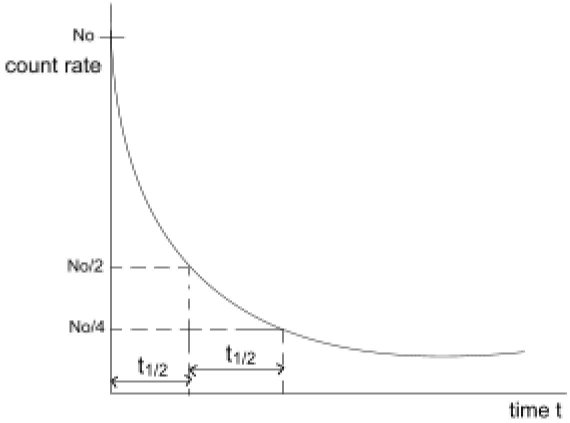
Mass decays = original mass - mass remaining

$= (2.7 \times 10^{24} - 6.75 \times 10^{23})$

$= 2.025 \times 10^{24}$ atoms

GRAPHICAL METHOD OF DETERMINING HALF LIFE

When a graph of account rate against time or radioactive nuclei is drawn, the half life of the radioactive nuclei can be determined as below.



Example 1

The following values obtained from the readings of a rate meter from a radioactive isotope of iodine

Time \min	0	5	10	15	20
Count rate Min -1	295	158	86	47	25

Plot a suitable graph and find the half life of the radioactive iodine.

2. The following figures were obtained from Geiger Muller counter due to ignition if the sample of radon gas

Time\min	0	102	155	…….	300
Rate \min-1	1600		200	100	50

a) i) plot a graph of count rate against time

ii) Determine the half life

iii) Find the missing values

b) i) what is the count rate after 200 minutes

ii) after how many minutes is the count rate 1000 minutes

3. The following figures were obtained from Geiger miler counter due to ignition of the sample of radon gas

Time \min	0	102	155	208	300
Rate\min-1	1600	1400	200	100	50

a) Plot a graph of count rate against time

b) Determine the half life

c) Find the missing values

d) What is the count rate after 200minuts

e) After how many minutes is the count rate 1000 minutes

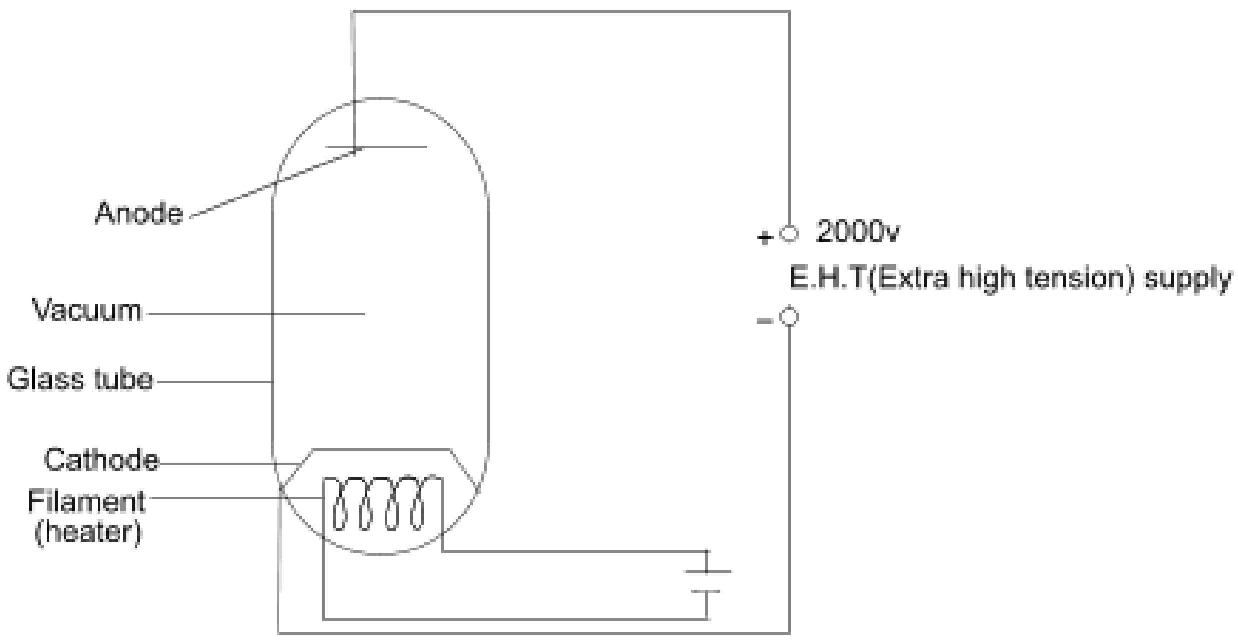
THERMONIC EMISSION

This is the process by which electrons are emitted from metal surface by heating. The steam of electrons is transmitted or travels in a straight line and these steams are called cathode rays.

Cathode rays these are steams of moving electrons are negatively charged particles orbiting around of an atom.

PRODUCTION OF CATHODE RAYS

The circuit is connected as shown



The metal cathode is heated by a filament. the filament is heated by passed of electric current thru it and electrons are emitted from the cathode .

The large p.d across the anode accelerates the electrons to move from cathode to the anode . the vacuum ensures that electrons move freely so that they don't collide with molecules.

PROPERTIES OF CATHODE RAYS

They carry a negative charge

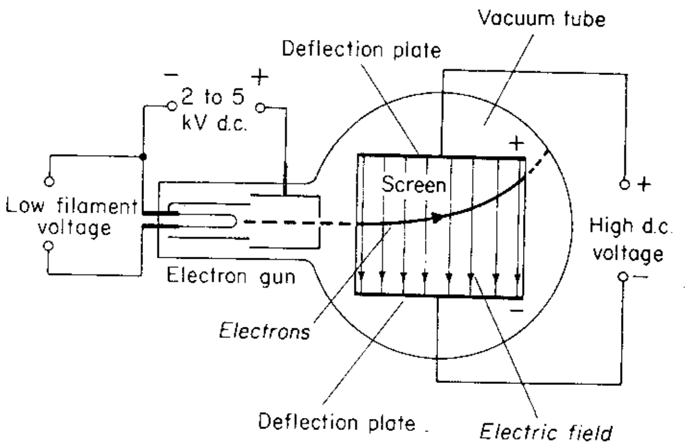
They are deflected by both electric and magnetic field

They ionize gases

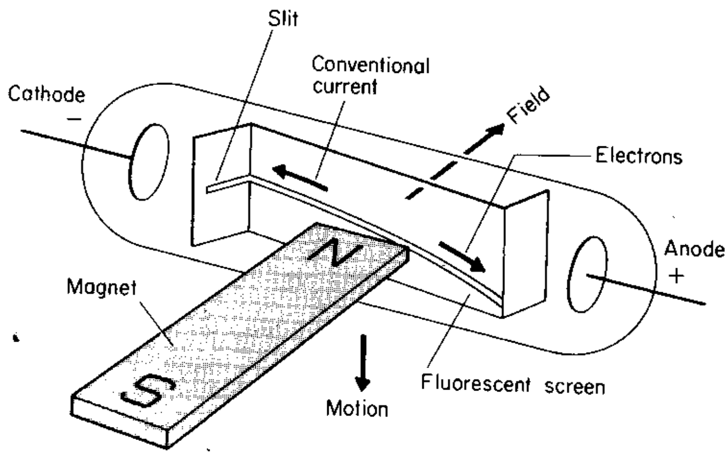
They cause fluorescence to some substance e.g. zinc sulphide

In an electric field, cathode rays are deflected towards the positive plate and in the magnetic field , the direction of deflection is determine using Flemings left hand rule

Electric field

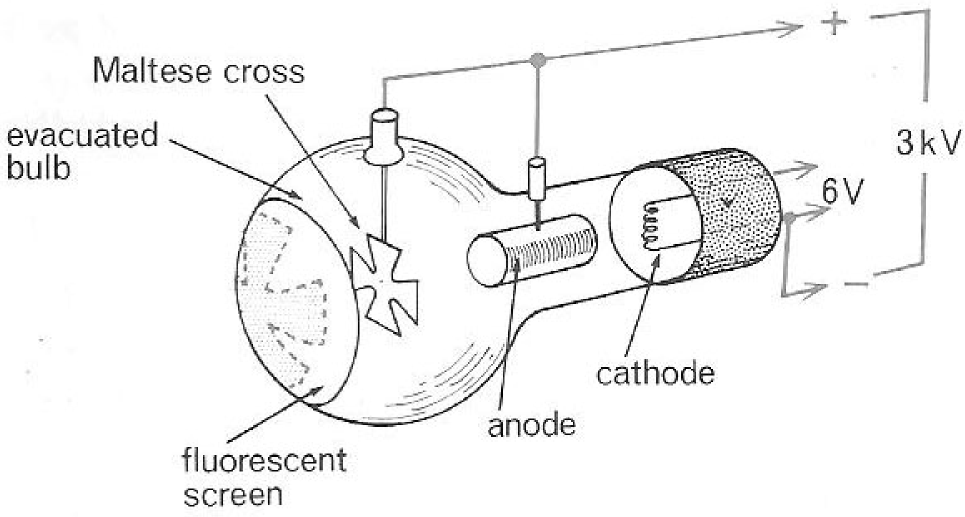


Magnetic field



EXPERIMENT TO SHOW THAT CATHODE RAYS TRAVEL IN STRAIGHT LINE

(THERMIONIC TUBE)



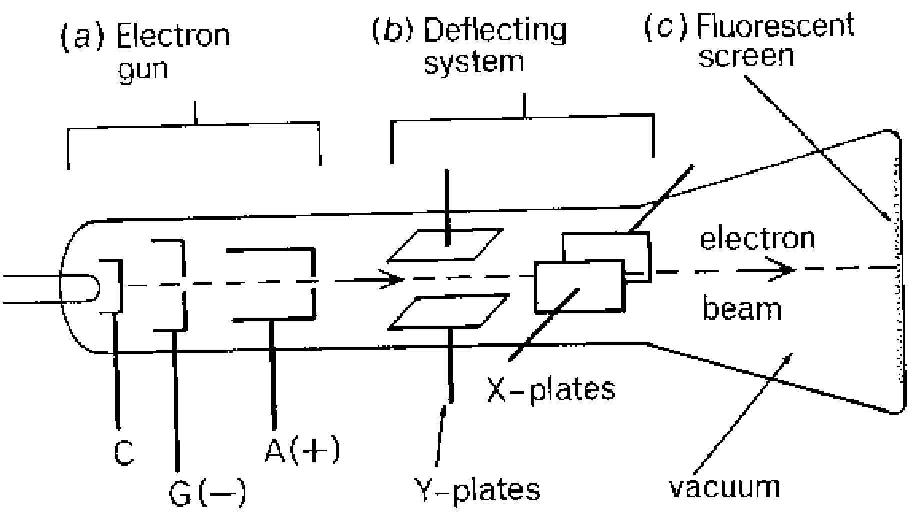
Cathode rays re incident towards the maltase cross.

A shadow of the cross is formed on the fluorescent screen.

The formation of the shadow verifies that cathode rays travels in a straight line.

The thermionic emission is utilized in cathode ray oscilloscope (C.R.O) X –ray tube, TV etc

THE C.R.O



The C.R.O consists of three main components.

1. The electron gun , this consists of the following parts

I) The cathode – used to emit electrons

II) The control grid – this is connected to low voltage supply and is used to control the number of electrons passing through it towards the anode.

III) The anode – the anode is used to accelerate the electrons and also focus the electrons into a fine beam.

N.B

Since the grid control the number of electrons moving towards the anode. It consequently controls the brightness of the spot on the screen.

2. **Deflecting system**

This consists of the x and y plates . they are used to deflect the electron beam horizontally and vertically.

3. **Fluorescent**

This is where the electrons beam is focused to form a bright spot

Time base switch – this is connected to the X – plate and is used to move the bright spot on the screen horizontally .

It is coating converts kinetic energy in light and produce a bright spot when the electrons beam is focused on it.

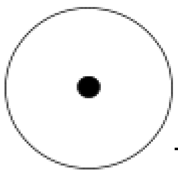
ACTION OF A C.R.O

When alternating current (a.c) is applied to the y- plate and time base (x –plate) is off , the spot is deflected vertically . The vertical line observed.

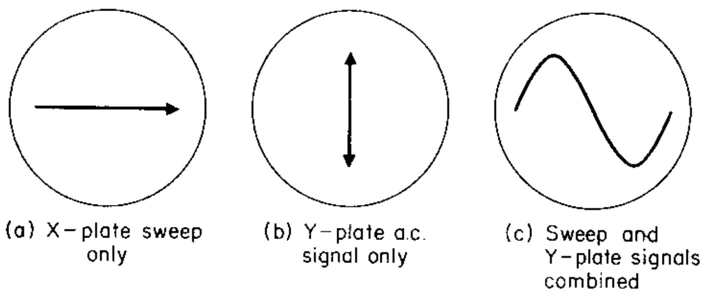
When time base (x- plate) is switched on and there is no signal on the y-plate , the spot is deflected horizontally . The horizontal line is observed.

When a.c is applied on the y-plate and x- plate is on ,a wave form is observed on the screen .

When time base is switched off and no signal to the y- plate, a spot is only observed.



Time base off and no signal on y- plate



USES OF A C.R O

1. **Frequency measurements**

This is achieved by comparing a wave form of known frequency with unknown frequency

Method

Adjust the time base of a C.R.O until one complete wave is obtained without altering the control grid of the C.R.O; apply a signal of known frequency.

Then compare the frequency by counting the number of complete waves .

2. **Measurement of p.d**

A C.R.O can be used as voltmeter because the distance spot is deflected depends on the p.d between the plates

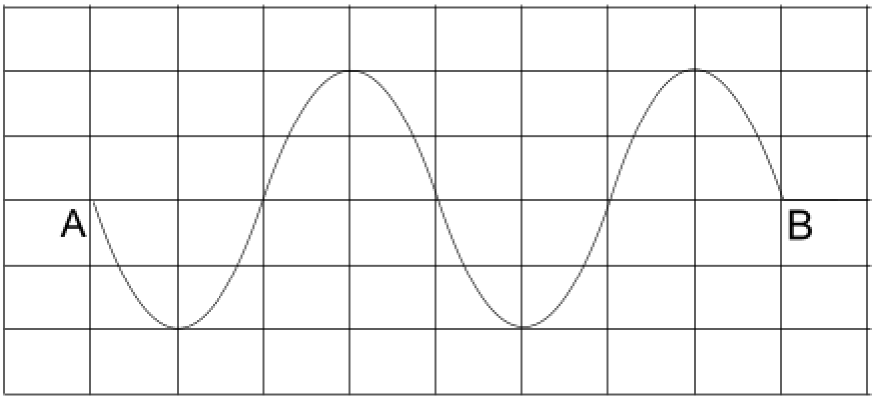
Method

Connect a cell 1.5V to the y-plate and adjust the grid control until the trace indicating the p.d is 1cm above 0 so that every 1cm deflection represents a p.d of 1.5V

Get unknown p.d and connect it to y-plate and then compare the deflection by counting the number of of cm deflected. This means that we can measure unknown p.d.

Example

1. A C.R.O with time base switch on is connected across a power supply; the wave form shown below is obtained.



Distance between each line is 1cm

i) identify the type of voltage generated from the power source alternating currents

ii) find the amplitude of voltage generated if voltage gain is 5V per cm

Amplitude = 2cm, 1cm = 5V

2cm is equivalent = (5 x2) v

= 10v

(iii) Calculate the frequency of power source is the time base setting on the C.R.O IS 5.0 X 10-3S\cm

Time for 2cycles = $8 \times 5.0 \times 10^{-3}$

$$\text{Time for 1 cycle} = \frac{8 \times 5.0 \times 10\text{-}3}{2}$$

= 0.02s

$$\text{Frequency} = \frac{1}{T} = \frac{1}{0.02} = 50HZ$$

3. Used to study wave forms of current and voltage

4. Used in manufacture of T.V.

X – RAYS

These are electromagnetic radiations produced when fast moving electrons are stopped by a metal target.

TYPES OF X – RAYS

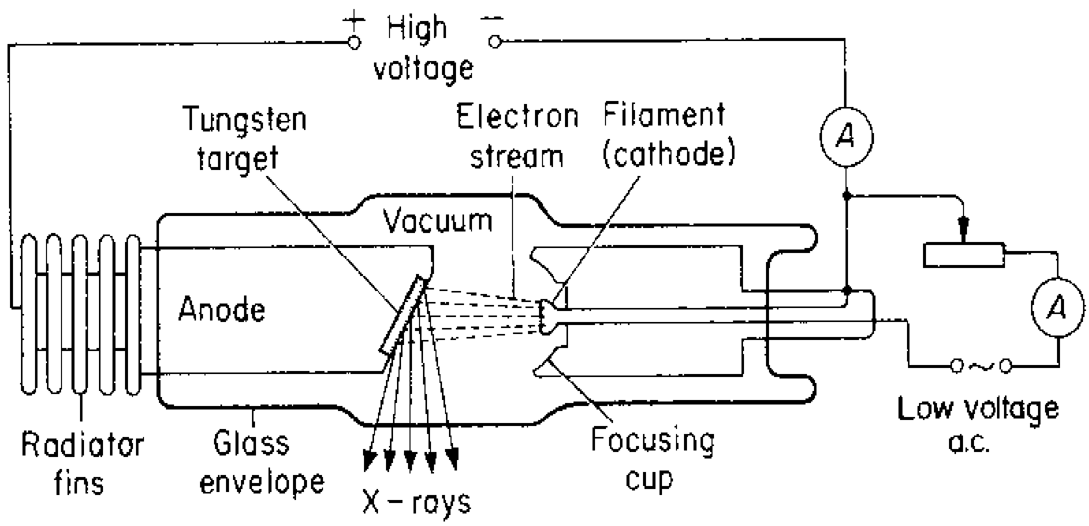
i) Soft x- rays

ii) Hard x – rays

Soft x –rays are produced at a low potential. They have a low penetrating power i.e low frequency and long wave length

Hard x –rays are produced at a high potential. They have a high penetrating power i.e very high frequency and short wave length.

X – RAY PRODUCTION



The cathode is heated to emit electrons by thermionic emission .using a low voltage supply. A large p.d is used on the anode to accelerate the electrons. On reaching the anode, the first moving electron is hit the metal target off a high melting point.

The kinetic energy of electrons is converted into heat and x- rays.

The x – ray tube is evacuated to prevent fast moving electrons from being hindered by friction due to air resistance. The heat generated is conducted away thru the copper anode to the cooling fins

The magnitude of x-rays produced is determined by the number of fast moving electrons heating the target.

PROPERTIES OF X- RAYS

Readily penetrate thru matter

They are not affected by electric and magnetic fields

They cause fluorescent and have no charge

They cause ionization

They travel in straight lines

HEALTH HARZARDS

They destroy cells especially hard x- rays

Cause gone mutation or genetic change

Cause damage of eye sight and blood.

Produce deep seated skin burns.

PRECAUTIONS FOR SAFETY

Avoid unnecessary exposure to x –rays

Keep exposure time as short as possible

The x- ray beam should only be restricted to parts of the body being investigated .

Workers dealing with x-rays should wear shielding jackets with a layer of lead.

Exposure should be avoided for unborn babies and very young children.

USES OF X- RAYS

(a) Medicine

Used to investigate born fractures

Detects lung tuberculosis

Used to treat cancer especially when it hasn't spread by radiotherapy i.e very hard x-rays are directed to the cancer cells so that the latter are destroyed

Used to detect internal ulcers along a digestive track

Used to locate swallowed metal objects

(b)Industrial use

Used to detect cracks in car engines and pipes

Used in inspection of car tyres

Used to locate internal imperfections in welded joints e.g pipes , boilers storage tanks e.t.c.

Used to detect cracks in building

(c) X-ray crystallography

Used to determine inter – atomic spacing in the crystal

HOW AN X-RAY IS USED TO LOCATE BROKEN PARTS OF A BONE .

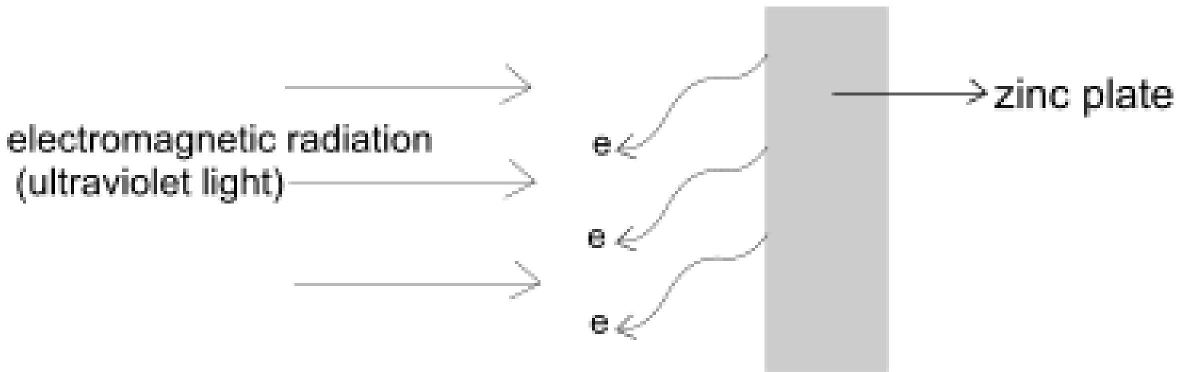
Bones are composed of much denser material than flesh hence if x- rays are passed thru the body , they are absorbed by the bones onto a photographic plate which produces a shadow photograph and bones

DIFFERENCES BETWEEN CATHODE RAYS AND X-RAYS

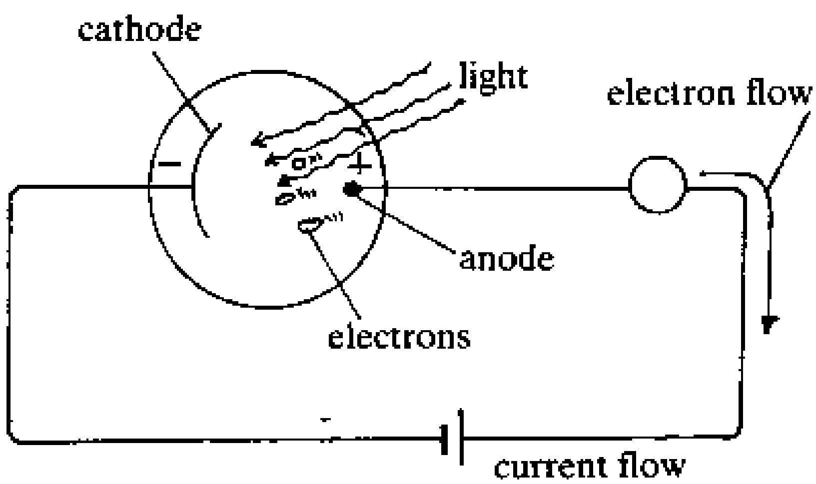
CATHODE RAYS	X- RAYS
Negatively charged	neutral
Low penetrating power	highly penetrating
Can be deflected by both	
Magnetic and electric field	cannot be deflected
Travel at low speed	travel at high speed .

PHOTO ELECTRIC EMISSION

This is the emission of electrons from a certain metal plate e.g zinc plate when electromagnetic radiation falls on it.



Consider a zinc plate and an anode closed in vacuum in which an ammeter and a cell are connected in series as shown below.



Electrons are produced by zinc atoms photo electrically thee electrons are attracted by the anode and produce current in the circuit hence the ammeter reflects.

If gas is introduced, current increases slowly because gas particles collide with electrons and hence this reduces the number of electrons reaching the anode.

CONDITIONS FOR PHOTOELECTRIC EFFECT TO TAKE PLACE

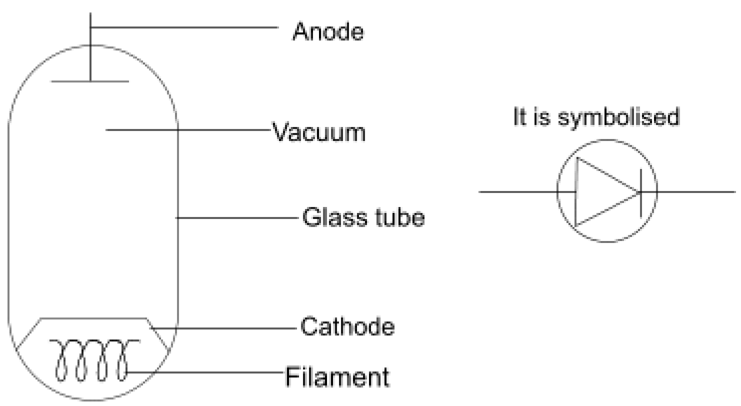
- Depends on the nature of the metal.

Light incident on the metal surface must have a certain minimum frequency known as threshold frequency.

THERMIONIC DIODE (diode valve)

A diode is an evacuated glass containing anode and cathode and restricts current in one direction and doesn't permit the reverse direction.

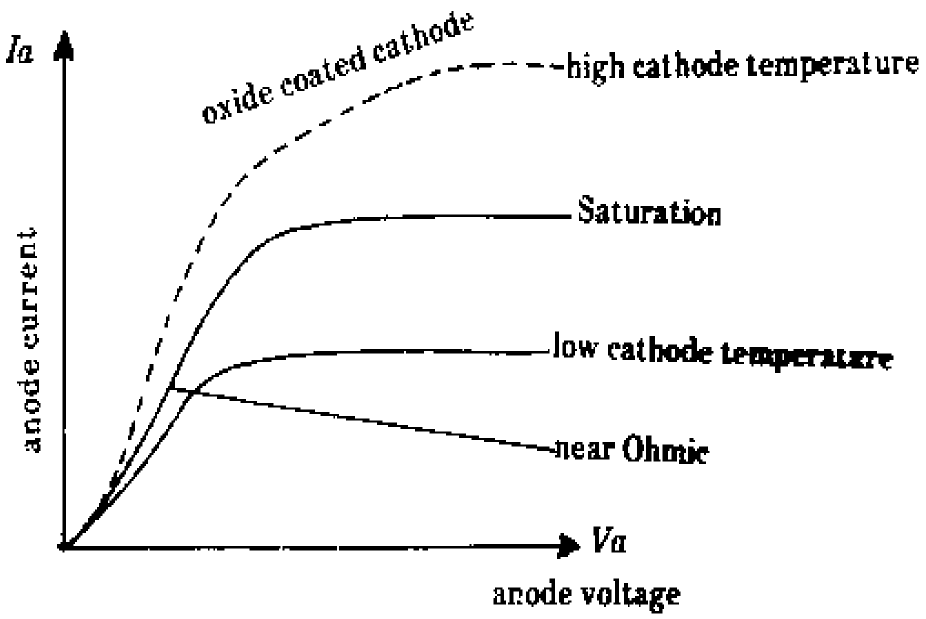
A cathode can be directly heated by passing current through it or can be indirectly heated by passing filament wire close to it.



ACTION

When the cathode gets heated, it emits electrons to form a space charge around it which is then attracted by the anode causing flow of electrons.

The electrons at the anode are detected by the milli ammeter connected to the anode by varying the anode potential for different heater currents a graph of anode current Ia and Va is obtained as below.



From the graph, it is observed that –

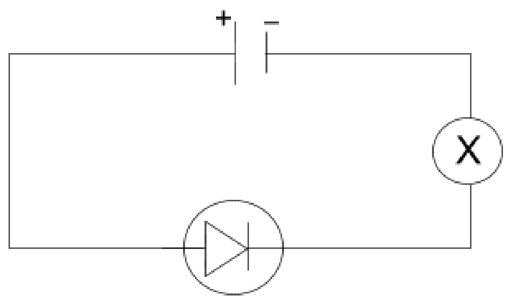
I) The higher the heater current, the higher number of attractions to the anode.

II) A certain value of anode potential, all electrons available at the cathode are being attracted to the anode ,this is known as saturated point and the corresponding current is known as saturation current.

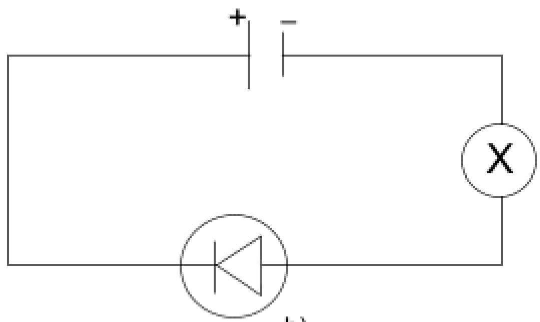
III) Saturation current is the maximum current flowing in a diode at a particular temperature.

The most important property of diode is that it conducts in one direction with low resistance and opposite direction; it has a very high resistance. Therefore it acts as a rectifier.

A rectifier allows current to flow in one direction rectification is the process of converting a.c to d.c.



a)



b)

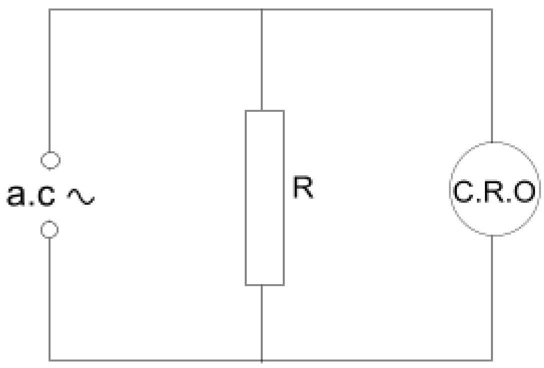
in (a) it is a forward bias so the bulb lights

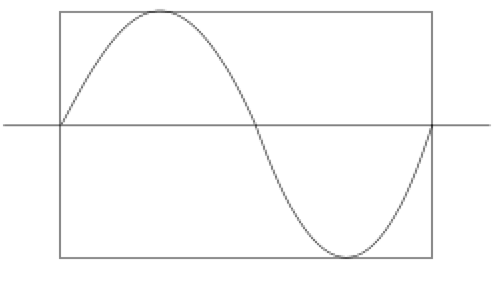
In (b) it is a reverse bias the bulb doesn't light.

PROCESS OF RECTIFICATION

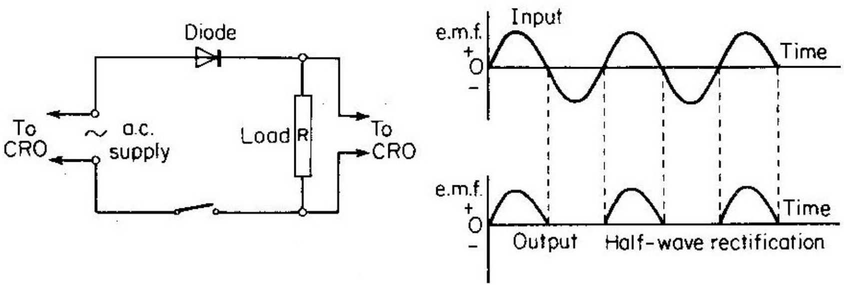
-With no diode, the voltage output across the load resistor,

Alternating current in put voltage = p.d across the resistor





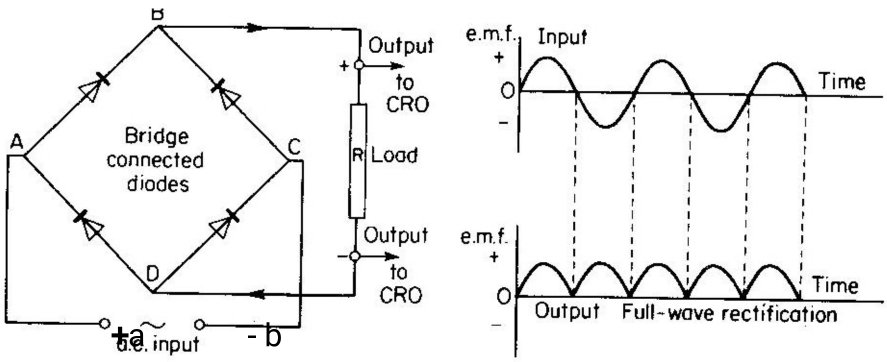
-With one diode, the out voltage is half way rectified on screen.



The source of a.c is connected in series with the diode, the out put from the circuit will flow in one direction in series of pulses as shown above. This is called half-wave rectification. The variation in the in put and out put voltages with time may be seen by connecting the in put and out put terminals, in turn, to a C.R.O as shown above.

-With four diode output voltage a full wave is rectified.

Both half cycles of a.c are rectified. The current follows the direction as indicated in the figure above. The diodes are all pointing round the sides of square towards B and away from D. if the current direction is traced through the diodes, as A and C become alternately positive and negative from the a.c in put, then the out put current will always flow out of B, through the load and back to D. Therefore in both half cycles, current flows in the same direction.



EXPLANATION

During half cycle, when a is positive and b is negative AB and DC will conduct.

During the next half cycle if A is negative and B is positive AD and BC conduct.

In both half cycles current flows through R in one direction of a to b.