An atom consists of 3 particles namely;

- Protons
- Neutrons
- Electrons

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

<table>
<thead>
<tr>
<th>Name</th>
<th>Symbol</th>
<th>Sign of charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protons</td>
<td>(_1^1\text{H})</td>
<td>Positive.</td>
</tr>
<tr>
<td>Neutrons</td>
<td>(_0^1\text{n})</td>
<td>No charge.</td>
</tr>
<tr>
<td>Electrons</td>
<td>(_-1^0\text{e})</td>
<td>Negative.</td>
</tr>
</tbody>
</table>

The nucleus is positively charged.
These are atoms of the same element having the same atomic numbers but different mass numbers.

Examples:
Hydrogen, carbon, chlorine, oxygen, $\frac{20}{10} Ne, \frac{22}{10} Ne$

**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 sometimes called atomic mass.

It is expressed as

\[ ^{A}_{Z}X \]

Where $A$ - atomic number and $Z$ – mass number

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

a) Mass number = .....35
(b) Number of protons =......17
c) Number of neutrons = ....18

Example

1. Given that \( ^{\text{238}}_{\text{92}} \text{X} \) state
   
   (a) The mass number
   
   (b) Number of protons
   
   (c) Number of neutrons

RADIOACTIVITY.

( ) VIDEO CLIP.

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

Or Radioactivity is the spontaneous disintegration of unstable radioactive elements with emission of radiations and energy.

Types of radiations.

There are three types of radiations, namely:

Alpha particle

Beta particle

Gamma ray
ALPHA PARTICLES.

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

\[ ^{4}_{2}\text{He} \]

**PROPERTIES OF ALPHA PARTICLES**

- Ionize gases i.e. 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 gamma and beta particles.

When unstable nuclei emits an alpha particle, the mass reduces by 4 and atomic number by 2

E.g. a radioactive substance \( ^{238}_{92}\text{X} \) Undergoes decay and emits an alpha particle to form \( \text{Y} \).

Write an equation for the process.

\[
^{238}_{92}\text{X} \rightarrow ^{x}_{y}\text{Y} + ^{4}_{2}\text{He}
\]

\[ 238 = x + 4 \]
These are high energy radiations. When radioactive nuclei decay by emitting beta particles, Mass number is not 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 is not too thick.

E.g. unstable nuclei $^{226}_{88}X$ decays to form a stable nuclei Y by emitting a beta particle. Write the equation to show the process.
226 = n + 0

n = 226

88 = m + 1

m = 89.

Write down an equation for the process.

GAMMA RAYS.

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

PROPERTIES 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
- They penetrate matter; they have the greatest power compared to other particles.

SIMILARITIES BETWEEN ALPHA AND BETA PARTICLES.

Both ionize gases.
They both penetrate matter.
They are both deflected by electric and magnetic fields.

DIFFERENCES BETWEEN ALPHA AND BETA PARTICLES.

<table>
<thead>
<tr>
<th>Alpha (α-particle)</th>
<th>Beta(β-particle)</th>
</tr>
</thead>
<tbody>
<tr>
<td>positively charged</td>
<td>negatively charged</td>
</tr>
<tr>
<td>have low penetrative power</td>
<td>have higher penetrative power</td>
</tr>
<tr>
<td>have higher ionizing power</td>
<td>have lower ionizing power</td>
</tr>
<tr>
<td>Deflected towards</td>
<td>deflected towards</td>
</tr>
</tbody>
</table>
DEFLECTION OF THE ABOVE RADIATION IN AN ELECTRIC FIELD.

A- Beta particles
B- Gamma rays
C- Alpha particles.

S.3 BLUE, 28/9/2016.

- The alpha particles are deflected towards the negative plate indicating that they are positively charged.
- The beta particles are deflected towards positive plate indicating that they are negatively charged.
- While gamma rays go through the field undeviated showing that they carry no charge.

**DEFLECTION BY A MAGNETIC FIELD.**

- The beta particle is deflected towards North Pole because they are negatively charged.
- While alpha particles are deflected towards the South Pole, according to Fleming’s left hand rule.
- Gamma rays are not deflected because they possess no charge.

**A VIDEO CLIP SHOWING THE ABOVE MOTION.**

**TUTOR VISTA IN DOCUMENT.**

**A RADIOACTIVE ELEMENT.**
- Is the element whose nucleus disintegrates gradually and continuously emitting powerful and invisible radiations.

**DANGERS 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 rays are used to detect faults in thickness of metal sheets in welded joints

2. **Medical uses**
- Controlled amount in treatment of cancer.
- They are used to kill bacteria in food.
- Used to sterilize medical equipment 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.
- When a radioactive source is brought near the cap of a charged G.L.E, the leaf falls, this shows that the G.L.E has been discharged because of the ionization of air around the cap.

- If the G.L.E is positively charged, negative ions or (electrons) from air are attracted and the gold leaf falls and if it is negatively charged, ions are attracted and leaf also falls.
radiation is incident on a clean zinc plate resting on the cap of a charged G.L.E as shown.

Explain what is observed if

i) The G.L.E is positively charged

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

**ANSWER**

i) No further divergence of the leaf is observed because the ultra violet 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 counters.
1. The radiation enters the tube through the mica window and ionizes the Argon ions and electrons

\[
\text{Argon} \rightarrow \text{Ar}^+ (g) + e^-
\]

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

2. **Diffusion cloud chamber.**
Radiation from the source leaves trails of positive gaseous ions along each stroke.

The water/ alcohol vapor 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 do not leave an actual track because they do not ionize gas. If gamma rays are present whisky or wavy tracks are formed as shown below.
ALPHA PARTICLES.

Are short straight and thick tracks.
This is because they are good ionization of gas.
They are massive.
A large number of ions observed which have different length due to difference in energy.
The tracks obtained are as shown below.

BETA PARTICLES.

Tracks made by beta particles are longer and fainter.
They wander 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 radioactive particles which come from deep in space.

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

**Example**

Given that the back ground rate is 2 counts per minute and the Geiger Muller count rate is 25 counts per minute. Determine the approximate number of radiations present.

Count rate = 25 - 2 = 23 counts per minute.

**NUCLEAR FISSION.**

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

\[
\frac{235}{92} \text{U} + \frac{1}{0} \text{n} \rightarrow \frac{144}{56} \text{Ba} + \frac{90}{36} \text{Kr} + 2 \frac{1}{0} \text{n}
\]

+ ENERGY.

The energy released in the nuclear fission of Uranium is about 200 meV.

APPLICATION OF NUCLEAR FISSION.

Used in making atomic bombs.

Used to generate electricity.

Used to generate heat energy on large scale.

CONDITIONS FOR NUCLEAR FISSION TO OCCUR.
- It occurs at a low temperature in presence of slow moving neutrons.
- There should be already splitting nuclei into light nucleus with 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.

\[
\begin{align*}
\text{\textit{Conditions for Nuclear Fusion to Occur.}} \\
\text{- Temperature should be very high (10^8k).} \\
\text{- The light nuclei should be at very high speed to overcome nuclear division.} \\
\text{Uses of Nuclear Fusion.}
\end{align*}
\]

An example of fusion of two deuterium nuclei to produce helium 3 and a neutron with release of energy.

\[
\begin{align*}
\nu^2\text{H} + \nu^2\text{H} &\rightarrow \nu^4\text{He} + \text{energy} \\
\nu^2\text{H} + \nu^2\text{H} &\rightarrow \nu^4\text{He} + \nu^2\text{n} + \text{energy}
\end{align*}
\]

\[
\begin{align*}
\nu^2\text{H} + \nu^2\text{H} &\rightarrow \nu^3\text{H} + \nu^1\text{n} + \text{Energy.}
\end{align*}
\]
- Used to produce hydrogen.
- Used to produce electricity.
- Used to produce heat energy on large scale.

**Differences between Nuclear fission and Nuclear fusion.**

<table>
<thead>
<tr>
<th>Nuclear fission.</th>
<th>Nuclear fusion.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the disintegration of a heavy nucleus into two lighter nuclei.</td>
<td>Is the combining of two light nuclei to form a heavy nucleus.</td>
</tr>
<tr>
<td>Requires low temperature</td>
<td>Requires high temperature.</td>
</tr>
<tr>
<td>Requires slow neutron for bombardment.</td>
<td>Neutron is not required but is a product of nuclear fusion.</td>
</tr>
<tr>
<td>Results into four products.</td>
<td>Results into three products.</td>
</tr>
<tr>
<td>Energy released is high.</td>
<td>Energy released is low.</td>
</tr>
</tbody>
</table>

**HALF-LIFE.**

The half-life period of a substance is defined as the time taken for half the atoms in any given sample of substance to decay.
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 kg decays to 2 kg in 96 days. Calculate the half-life.

\[ 4t = 96 \]
\[ t = 24 \text{ days} \]

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

Let it be \( t \)

\[ 4t = 120 \]
\[ t = 30 \text{ years} \]
3. The half-life of substance is 5 hours. Find how long it takes for its mass to disintegrate from 64 g to 2 g.

\[
\begin{array}{ccccccc}
64g & \rightarrow & 32g & \rightarrow & 16g & \rightarrow & 8g & \rightarrow & 4g & \rightarrow & 2g \\
\end{array}
\]

\[5 \times 5 = 25 \text{ hours.}\]

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

\[
\begin{array}{ccccccc}
0.15g & \rightarrow & 0.30g & \rightarrow & 0.6g & \rightarrow & 1.2g & \rightarrow & 2.4g & \rightarrow & 4.8g & \rightarrow & 9.6g \\
\end{array}
\]

\[M_0 = 9.6 \text{ g}\]

5. A certain mass of a radioactive material contains \(2.7 \times 10^{24}\) atoms, how many atoms decayed after 3200 years if the half-life of material is 1600 years.

\[
\begin{array}{ccccccc}
2.7\times10^{24} & \rightarrow & 1.35\times10^{24} & \rightarrow & 6.75\times10^{23} \\
\end{array}
\]

Mass remaining \[= 6.75 \times 10^{23} \text{ atom}\]

Mass decays \[= \text{original mass} - \text{mass remaining}\]

\[= (2.7 \times 10^{24} - 6.75 \times 10^{23})\]
= 2.025 \times 10^{24} \text{ atoms}

The half-life of radium is 1620 years, what fraction of radium would have decayed after 9720 years if we started with 1 g of radium?

**GRAPHICAL METHOD OF DETERMINING HALF LIFE**

When a graph of count 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 were obtained from the readings of a rate meter of a radioactive isotope of iodine.

<table>
<thead>
<tr>
<th>Time</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>No, count rate</td>
<td>1</td>
<td>1/2</td>
<td>1/4</td>
<td>1/8</td>
<td>1/16</td>
</tr>
</tbody>
</table>
Plot a suitable graph and find the half-life of the radioactive iodine.

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

<table>
<thead>
<tr>
<th>Time per min</th>
<th>0</th>
<th>102</th>
<th>155</th>
<th>...m...</th>
<th>300</th>
</tr>
</thead>
<tbody>
<tr>
<td>count Rate per min</td>
<td>1600</td>
<td>...t...</td>
<td>200</td>
<td>100</td>
<td>50</td>
</tr>
</tbody>
</table>

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 per minute?

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

<table>
<thead>
<tr>
<th>Time per min</th>
<th>0</th>
<th>10</th>
<th>155</th>
<th>208</th>
<th>300</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate per min</td>
<td>1600</td>
<td>1400</td>
<td>200</td>
<td>100</td>
<td>50</td>
</tr>
</tbody>
</table>

a) Plot a graph of count rate against time.
b) Determine the half-life.
c) What is the count rate after 200 minutes?
d) After how many minutes is the count rate 1000 per minute?
Qn(a) Define the following:

(i) Atomic number.

(ii) Mass number.

(b) A radioactive nuclide $^{42}_{19}Y$ emits both beta and gamma radiations when it decays to nucleus $X$.

Write a balanced equation for the nuclear reaction.

Give three differences between beta and alpha particles.

(c) The table below shows the count rate of a certain radioactive material.

<table>
<thead>
<tr>
<th>Count rate ($s^{-1}$)</th>
<th>132</th>
<th>86</th>
<th>56</th>
<th>38</th>
<th>24</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time (days)</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Plot a suitable graph and use it to determine:

(i) The half-life of the radioactive sample.

(ii) The count rate after six days.

(d) State two conditions for each of the following to occur:

(i) Fission.

(ii) Fusion.
THERMIONIC EMISSION
This is the process by which electrons are emitted from metal surface by heating.

The stream of electrons travel in a straight line and these streams are called cathode rays.

**Cathode rays** these are streams of moving electrons and are negatively charged particles orbiting around an atom.

PRODUCTION OF CATHODE RAYS USING A THERMIONIC DIODE.

The circuit is connected as shown
• The metal cathode is heated by a filament using a low voltage.

• Electrons are emitted thermionically from the cathode.

• These electrons emitted are accelerated by EHT towards the anode which is at a negative potential difference.

• The fast moving stream of electrons at the cathode towards the anode is cathode rays.

The anode accelerates the electrons to move from cathode to the anode.

The vacuum ensures that electrons move freely so that they do not collide with air molecules.

**NB.** *Thermionic diode*/*vacuum diode* is an electric device with two electrodes in a vacuum. It consists of a hot filament called cathode surrounded by cylindrical anode which is enclosed in highly evacuated glass tube.

**S.3red 15/10/2015.**

**PROPERTIES OF CATHODE RAYS.**

- They carry a negative charge.
- They are deflected by both electric and magnetic fields.
- They ionize gases.
- They cause fluorescence to some substance e.g. zinc sulphide.
- They travel in a straight line.

**NB:** In an electric field, cathode rays are deflected towards the positive plate and in the magnetic field; the direction of deflection is determined using Fleming’s left hand rule.

(NEW Cathode Ray Experiment Animated.flv.mp4) VIDEO CLIP.

**Electric field.**

**Magnetic field.**
EXPERIMENT TO SHOW THAT CATHODE RAYS TRAVEL IN A STRAIGHT LINE (THERMIONIC TUBE)

Cathode rays are incident on the maltese cross.
A shadow of the cross is formed on the fluorescent screen.
The formation of the shadow verifies that cathode rays travel 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 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 controls the number of electrons moving towards the anode, it
consequently controls the brightness of the spot on the screen.

As the grid control is made more negative, it repels most of the electrons, allowing a few to reach the screen hence screen appears dark. When it is made more positive, it attracts the electrons hence brightening the screen.

2. Deflecting system.

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

X plates are vertical so they deflect the electron beam horizontally.

Y plates are horizontal so they deflect the electron beam vertically.

3. Fluorescent

This is where the electron 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.

The time base generates p.d across the X – plate in that as the time base is switched on, the bright
spot is formed on the screen. The bright spot sweeps steadily and horizontally, repeatedly from left to right and this leads to generation of an a.c voltage.

**Electrical energy-k.e-light energy (spot)**

**ACTION OF A C.R.O.**

When an 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 is 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 an a.c is applied on the y-plate and time base 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.


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 cm deflected. This means that we can measure unknown p.d.

3. Used to study wave forms of current and voltage.

4. Used in the manufacture of T.V.

Example

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

```
<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```

Distance between each line is 1cm
i) Identify the type of voltage generated from the power source \textit{alternating currents}.

ii) Find the amplitude of voltage generated if voltage gain is 5 V\text{cm}^{-1}.

Amplitude = 2\text{cm}, \quad 1\text{cm} = 5 \text{ V}.

2\text{cm} \text{ is equivalent} = (5 \times 2) \text{ V} = 10 \text{ V}.

Calculate the frequency of power source if the time base setting on the C.R.O is $5.0 \times 10^{-3} \text{ scm}^{-1}$.

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

Time for 1 cycle = $\frac{8 \times 5.0 \times 10^{-3}}{2} = 0.02 \text{ s}$

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

S3B 26/10/2016.

2. (a) Give one reason why it is possible to use a wider screen in a television set than in a C.R.O.
In T.V, deflection of electron beam is by magnetic field which gives a wider deflection. In C.R.O, it is by electric field which gives a smaller deflection.

(b) State one advantage of using a C.R.O. as a voltmeter.
- Can measure both a.c and d.c voltages.
- Not damaged by over loading.
- Electrons act like a pointer of negligible inertia.
- Has definite resistance hence accurate.

UNEB 2015.

X – RAYS.

(VIDEO CLIP.

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.
That is; they have a low frequency and long wave length.

**Hard x–rays** are produced at a high potential.

They have a high penetrating power.

That is; they have a very high frequency and short wave length.

**X–RAYS 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 fast moving electrons hit the metal target of a high melting point.
• The kinetic energy of electrons is converted into heat and x-rays. (About 99% of kinetic energy is converted to heat and 1% is converted to 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 through 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.

Cooling in the x-ray tube.

It is achieved either by:
- Use of radiation fins or
- Circulating liquid, oil or water through hollow anode.

PROPERTIES OF X-RAYS.

- Readily penetrate through matter.
- They are not affected by electric and magnetic fields.
- They cause fluorescence and have no charge.
- They cause ionization.
- They travel in straight lines.
**HEALTH HARZARDS**

- They destroy cells especially hard x-rays.
- Cause gene mutation or genetic change.
- Cause damage of eye sight and blood.
- Produce deep skin burns.

**SAFETY PRECAUTIONS.**

Direct and frequent exposure should be avoided.

Soft x-rays should always be used on human tissues.

- 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.
- 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.

**USES OF X-RAYS.**

(a) In hospitals (Medicine.)
- Used to investigate bone fractures.
- Detects lung cancer.
Used to treat cancer especially when it has not spread; by radiotherapy.

That is very hard x-rays are directed to the cancer cells so that the latter are destroyed.

Used to detect internal ulcers along a digestive tract.

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 and storage tanks.
- Used to detect cracks in building.

3RED, 20/10/2015.

(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 through the body; they are absorbed by the bones onto a photographic
plate which produces a shadow photograph and bones.  3B/1\textsuperscript{st}/11/2016.

DIFFERENCES BETWEEN CATHODE RAYS AND X-RAYS.

<table>
<thead>
<tr>
<th>CATHODE RAYS</th>
<th>X- RAYS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negatively charged.</td>
<td>Neutral.</td>
</tr>
<tr>
<td>Low penetrating.</td>
<td>Highly penetrating.</td>
</tr>
<tr>
<td>Can be deflected by both magnetic and electric fields.</td>
<td>Cannot be deflected by both magnetic and electric fields.</td>
</tr>
<tr>
<td>Travel at low speed.</td>
<td>Travel at high speed.</td>
</tr>
</tbody>
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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 photoelectrically, the electrons are attracted by the anode and produce current in the circuit hence the ammeter deflects.

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 PHOTOCURRENT 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 does not 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 milliammeter connected to the anode.
By varying the anode potential for different heater currents a graph of anode current $I_a$ and $V_a$ is obtained as below.

![Graph showing anode current $I_a$ vs anode voltage $V_a$.]

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.

![Diagram of diode circuits](image)

In (a) it is a forward bias so the bulb lights
In (b) it is a reverse bias the bulb does not light.

PROCESS OF RECTIFICATION:
- With no diode, the voltage output across the load resistor, alternating current input voltage = p.d across the resistor

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

The source of a.c is connected in series with the diode; the output 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 input and
output voltages with time may be seen by connecting the input and output 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 below. 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 input, then the output 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 \( p \) and \( r \) will conduct.

During the next half cycle if \( a \) is negative and \( b \) is positive \( o \) and \( q \) conduct.

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