MODERN PHYSICS

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STRUCTURE OF AN ATOM

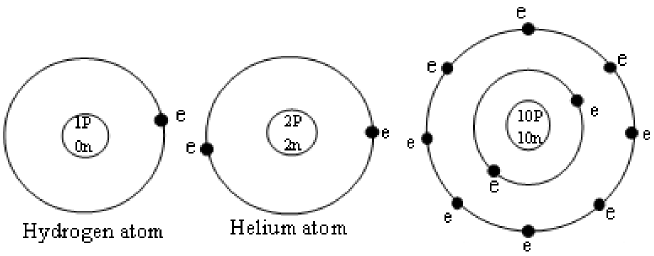
(a) The atom

An atom is defined as the smallest electrically neutral particle of an element that can take part in a chemical reaction.

An atom consists of 3sub atomic particles namely -:

- Proton
- Neutrons
- Electrons

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

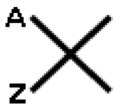


Hydrogen atom   Helium atom   Neon atom

Name of p'cle	Symbol	change	Location
Protons	1_H	$+1$	In the nucleus
Neutrons	0_n	0	In the nucleus
Electrons	-1_e	-1	Outside nucleus

The nucleus is positively charged

The atom of an element is represented in a chemical equation using a chemical symbol as shown below.



Where, X is the chemical symbol of the element, A is the mass number and Z is the atomic number.

An atom with specified number of protons and neutrons (or specified A and Z) is called a **nuclide**.

(b) Atomic number and mass number

(i) Atomic number (Z)

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

(ii) Atomic mass (A)

This is the sum of protons and neutrons in a nucleus of an atom. It is sometimes called **Mass number or nucleon number.**

The atomic number, **Z**, mass number, **A** and the number of neutrons, **n** are related by the expression:

$$\textbf{Atomic mass} = \textbf{Atomic number} + \textbf{No. of nucleons}$$

$$\mathbf{A = Z + n}$$

(c) Isotopes

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

Thus Isotopes of an element have;

(i) The same number of protons and electrons.

Carbon	-Carbon-12 ($^{12}_{6}\mathbf{C}$); Carbon-13 ($^{13}_{6}\mathbf{C}$); Carbon-14 ($^{14}_{6}\mathbf{C}$)
Chlorine	-Chlorine-35 ($^{35}_{17}\mathbf{Cl}$); Chlorine-35 ($^{37}_{17}\mathbf{Cl}$);
Uranium	-Uranium-35 ($^{236}_{92}\mathbf{U}$); Uranium-35 ($^{232}_{92}\mathbf{U}$)

Isotropy is the existence of atoms of the same element with the same atomic number, but different mass number.

Question:

Describe the composition of the following nuclides.

(i) $^{228}_{88}\mathbf{Ra}$ **(ii)** $^{210}_{82}\mathbf{Pb}$ **(iii)** $^{335}_{92}\mathbf{U}$

Exercise:

1. (1991 Qn. 18): $^{120}_{80}\mathbf{X}$ is a symbol for a nuclide whose number of neutrons is
   A. 40 B. 80 C. 120 D. 200
2. (1990 Qn. 7): The table below shows the numbers of the respective particles constituting atoms of elements P,Q, R and S.

Element	Neutrons	Protons	Electrons
P	0	1	1
Q	2	1	1
R	2	2	2
S	2	3	3

The isotopes are
   A. P and Q C. Q and R
   B. C. R and S D. Q and S

3. (1990 Qn. 11): The copper atom $^{63}_{29}\mathbf{Cu}$ has

	electrons	protons	Neutrons
A	29	29	34
B	34	34	29
C	34	29	29
D	34	39	34

4. (1991 Qn. 8): If X is an isotope of Y, then the
   A. Atomic mass of X is equal to that of Y
   B. Atomic mass is equal to the atomic number of Y
   C. Atomic number of X is equal to that of Y
   D. Atomic number of X is equal to the atomic mass of Y
5. (1994 Qn. 9): An atom has mass number 88 neutrons and atomic number 38. Which of the following statements are correct about the atom;
   (i) It has 38 protons and 50 neutrons
   (ii) It has 38 protons and 38 electrons
   (iii) It has 50 protons and 38 neutrons
   A. (i) and (ii) C. (ii) and (iii)
   B. C. (i) and (iii) D. (i), (ii) and (iii)
6. (1995 Qn. 18): Isotopes are nuclides with the same number of;
   A. Protons but different but different number of electrons
   B. Protons but different number of neutrons
   C. Neutrons but different number of protons
   D. Electrons but the same number of protons

7. (2004 Qn. 22): The table below shows the structure of four atoms P,Q, R and S

Elements	Neutrons	Protons	Electrons
P	6	6	6
Q	8	6	6
R	2	2	2
S	2	3	3

A. P and Q C. Q and R
B. P and S D. P and R

8. (2004 Qn. 32): An atom contains 3 electrons, 3 protons and 4 neutrons. Its' nucleon number is?
A. 3 B. 4 C. 6 D. 7

9. (2006 Qn. 21): A Nickel nuclide, ${}^{60}_{28}\mathbf{Ni}$ contains
A. 28 protons and 28 neutrons
B. 32 electrons and 28 neutrons
C. 28 protons and 32 neutrons
D. 28 electrons and 32 protons

10. ${}^{236}_{92}\mathbf{X}$ and ${}^{232}_{92}\mathbf{X}$ are isotopes of an element. Find the number of neutrons in the nucleus of ${}^{232}_{Z}\mathbf{X}$.
A. 144 B. 140 C. 92 D. 4

11. An isotope of nuclide, ${}^{35}_{17}\mathbf{X}$, has
A. 18 protons and 17 neutrons
B. 17 electrons and 18 neutrons
C. 17 protons and 20 neutrons
D. 18 protons and 18 neutrons

12. (a) What is the difference between atomic number and mass number?
(b) What is meant by;
(i) Mass number?
(ii) Atomic number?

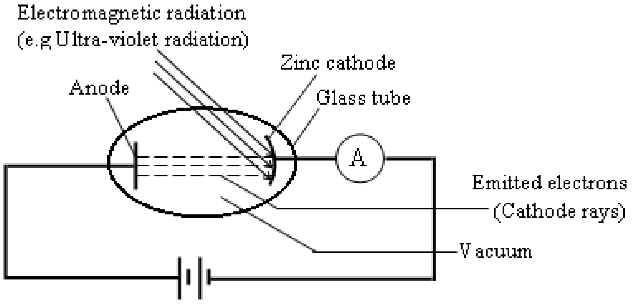
PHOTOELECTRIC AND THERMIONIC EMISSIONS

(a) Photoelectric Emission:

Photo electric emission is the ejection of electrons from a certain metal surface e.g zinc plate, when electromagnetic radiation of sufficient frequency falls on it.
It normally occurs in phototubes or photoelectric cells.

Phototube or Photoelectric cell

- ✓ A photoelectric cell consists of a cathode coated with a photo sensitive material and an anode. These are enclosed in a vacuum glass tube.
- ✓ The glass tube is evacuated in order to avoid collision of the ejected electrons with the air or gas molecules. This would otherwise lead to low currents.



Electromagnetic radiations (eg Ultra violet radiation) are directed onto the cathode and supplies sufficient energy that causes the liberation of electrons.
The electrons are then attracted by the anode. and produce current in the circuit hence the ammeter deflects.
Note: The flow of electrons to the anode completes the circuit and hence an electric current flows which causes the ammeter to deflect.

- ❖ The magnitude of the current produced is proportional to the intensity of the incident radiation.
- ❖ If gas is introduced into the tube, current decreases slowly because gas particles collide with electrons hence reducing the number of electrons reaching the anode.

Conditions for photoelectric effect to take place.

- ❖ Nature of the metal.
- ❖ Frequency of the incident electromagnetic radiation. It should be noted that electrons are not emitted until a certain frequency called Threshold frequency is reached.

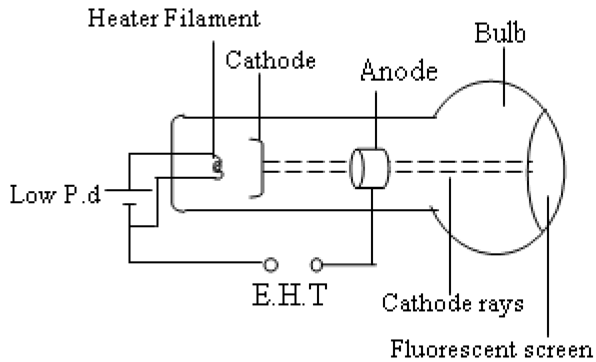
(b) Thermionic Emission:

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

CATHODE RAYS:

Cathode rays are steams of fast moving electrons.

Production of Cathode rays:



The cathode is heated by a low P.d applied across the filament.
The cathode then emits electrons by thermionic emission. The emitted electrons are then accelerated by a high p.d (E.H.T) applied between the filament and the anode so that they move with a very high speed to constitute the cathode rays.

Other methods by which cathode rays are produced are;

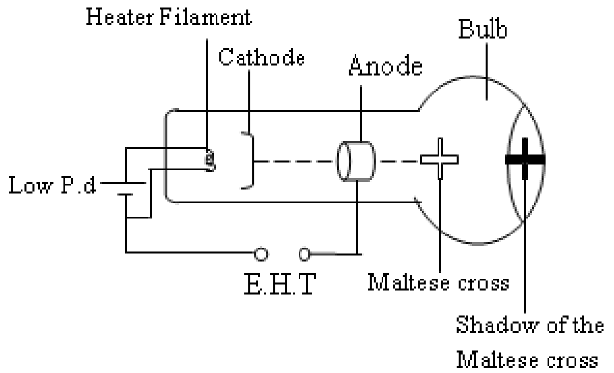
- Photoelectric emission
- Applying a high p.d
- By natural radioactive nucleus which emit beta particles.

Properties of cathode rays

- ❖ They travel in a straight line
- ❖ They carry a negative charge.
- ❖ They are deflected by an electric field. They are deflected towards the positive plate, since they are negatively charged.

- They are deflected by a magnetic field. 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. But remember, the direction of flow of current is opposite to that of electrons.
- They ionize air and gas molecules.
- They cause fluorescence to some substance e.g zinc sulphide.
- They darken photographic film.
- They posses kinetic energy and momentum
- They produce X-rays when stopped by matter.

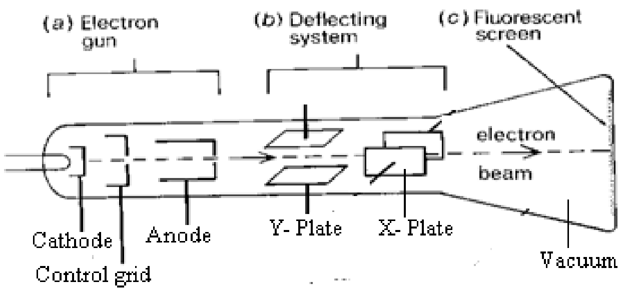
Experiment to show that cathode rays travel in straight line (Thermionic tube).



Cathode rays are incident towards the Maltese 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.

Applications of Cathode rays
The thermionic emission and cathode rays are utilized in cathode ray oscilloscope (C.R.O), X – ray tube, Image tube of a Tv, Electron microscope, etc.

THE CATHODE RAY OSCILLOSCOPE (C.R.O)
The C.R.O consists of three main components.



(a) The electron gun:
This consists of the following parts
(i) The cathode: It is used to emit electrons.
(ii) The control grid: It 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.

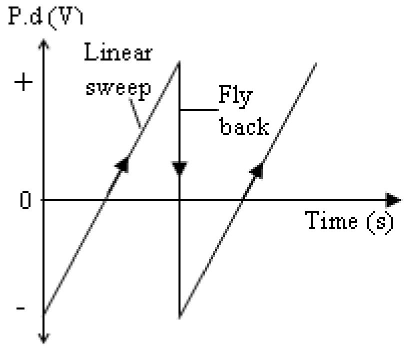
Note: Since the grid controls the number of electrons moving towards the anode. It consequently controls the brightness of the spot on the screen.

(b) Deflecting system:
This consists of the X- and Y- plates. They are used to deflect the electron beam horizontally and vertically respectively.

The X- plates are connected with the C.R.O to a special type of circuit called the time base circuit.

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 or sweep generator
This is a special electrical circuit which generates a "saw tooth" voltage (i.e. a voltage p.d that rises steadily to a certain value and falls rapidly to zero.)
This p.d (time base) is connected to X-plates and causes the spot of electron beam to move across the screen from left to right, This is called a **linear sweep**.
The spot returns to the left before it starts the next sweep. This is called **fly-back.** The time for the fly back is negligible.



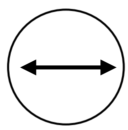
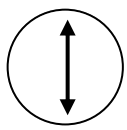
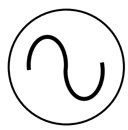
Note: During the fly back, the control grid is automatically made more negative thereby suppressing the brightness of the spot.

(c) Fluorescent Screen:
This is where the electron beam is focused to form a bright spot.
The coating on the screen converts kinetic energy into light energy and produce a bright spot when the electron beam is focused on it.

The graphite coating on the inner wall of the cathode ray tube traps stray electrons emitted from the screen and makes the potential in that region uniform.

Action of a C.R.O

(a) A.C out put on the screen of a C.R.O
Connecting a signal in form of alternating current (a.c) voltage across the plates has the following traces on the screen of a C.R.O.

(i) Time base off. X-plate a.c signal only.	(ii) Time base off. Y-plate a.c signal only	(iii) Time base on,. X and Y-plate a.c signals combined
		
Horizontal line at the centre	Vertical line at the centre	Sinusoidal wave

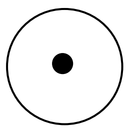
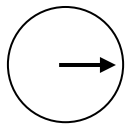
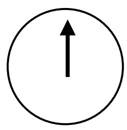
(i) When time base (x- plate) is switched on and there is no signal on the y-plate , the spot is deflected horizontally . The horizontal line is observed at the centre of the C.R.O...

(ii) 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 at the centre of the C.R.O..

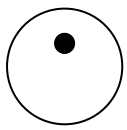
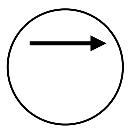
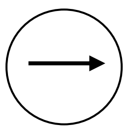
(iii) When a.c is applied on the y-plate and x- plate is on ,a wave form is observed on the screen.

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

(b) D.C out put on the screen of a C.R.O
Connecting a signal in form of direct current (d.c) voltage across the plates has the following traces on the screen of a C.R.O.

(i) Time base off. No signal on the plates	(ii) Time base off. X-plate signal only	(iii) Time base off. Y-plate signal only
		
Spot at the centre	One direction horizontal line from the centre	One direction vertical line from the centre

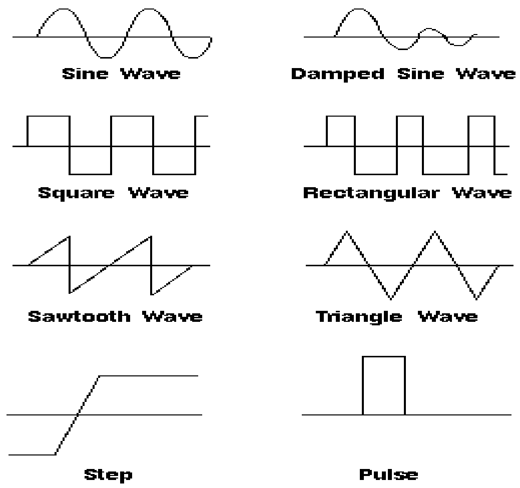
Note:

(i) Time base off. d.c signal on the Y-plates	(ii) Time base on, d.c signal on the Y-plates	(iii) Time base on. d.c signal on the X-plates
		
Spot	One direction horizontal line	One direction vertical line

Uses of a C.R O

(i) Measurement of a.c and d,c voltage
(ii) Measurement of frequency
(iii) Measurement of phase difference
(iv) Displaying pictures in TV sets.
(v) Displaying wave forms

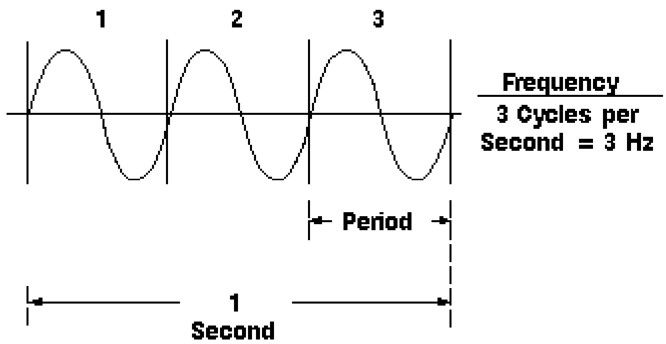
Displaying wave forms:



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 (input to the Y-plate) of known frequency.
A steady waveform of the input will be displayed on the c.r.o.
Then compare the frequency by counting the number of complete waves

If a signal repeats, it has a **frequency**. The frequency is measured in Hertz (Hz) and equals the number of times the signal repeats itself in one second.



Measurement of p.d
A C.R.O can be used as voltmeter because the spot is deflected depending 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.

Measuring d.c. Potential Difference

- switch off the time-base.
- a spot will be seen on the c.r.o. screen. Adjust the grid control (Y- gain control) until the trace indicating the

p.d is 1cm above 0 so that every 1cm deflection represents a p.d of 1.5V

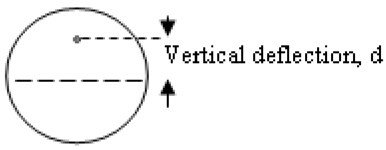
- d.c. to be measured is applied to the Y-plates.
- spot will either be deflected upwards or downwards.
- Deflection of the spot is proportional to the d.c. voltage applied. Then compare the deflection by counting the number of cm deflected. This means that we can measure unknown p.d.

Measuring d.c. Potential Difference

In this case, the voltage gain or the Y-sensitivity is set at a suitable value. Then the p.d to be measured is connected to the Y-plates and the time base is switched off.

The vertical deflection is measured and the direct voltage is got from:

$$\boldsymbol{V_{dc}} = \left[\begin{matrix}\boldsymbol{Voltage\ gain} \\ (\boldsymbol{or\ Y - sensitivity})\end{matrix}\right] \times \boldsymbol{Vertical\ deflection}$$



If the Y-gain control is set at 2 volts/division And the vertical deflection, y, is 1.5 divisions

Then d.c. voltage

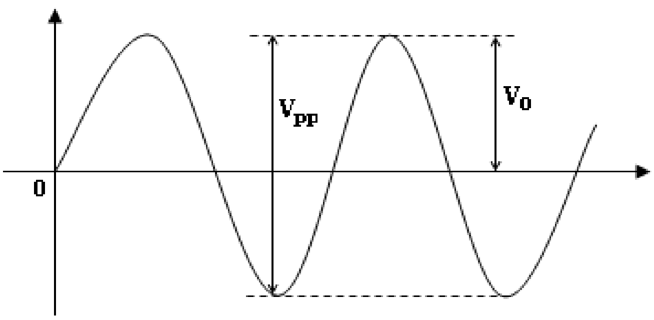
$$= 1.5 \times 2$$
$$= 3.0\ V$$

Measuring a.c. voltage

- switch off the time-base
- a spot will be seen on the c.r.o. screen.
- a.c. to be measured is applied to the Y-plates.
- spot will move up and down along the vertical axis at the same frequency as the alternating voltage.
- The spot moves to the top when the voltage increases to its maximum (positive)
- The spot moves to the bottom when the voltage decreases to its lowest (negative) .

When the frequency is high.

- The spot will move so fast that a vertical line is seen on the screen.
- Length of the vertical line gives the peak-to-peak voltage (Vpp) applied to the Y-plate.
- The peak voltage (Vp) = Vpp/2



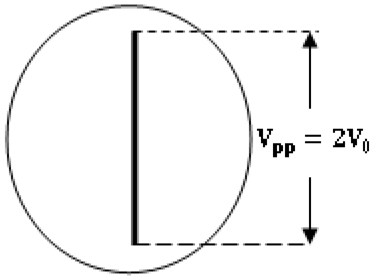
For a.c voltage

The length $\boldsymbol{l}$ of the vertical trace is measured and

$$\mathrm{V_{pp}} = \left[\begin{matrix}\text{Voltage gain} \\ (\text{ or Y} - \text{sensitivity})\end{matrix}\right] \times \text{Vertical deflection}$$

Where $\mathbf{V_{pp}}$ is the peak to peak voltage. The maximum voltage (amplitude, V_0) is given by $\mathbf{V_0} = \frac{\mathbf{V_{pp}}}{\mathbf{2}}$ and the actual voltage at root mean square (r.m.s) is given by

$$\mathbf{V_{r.m.s}} = \frac{\mathbf{V_0}}{\sqrt{\mathbf{2}}}$$



Example: 1

A CRO with Y-sensitivity (voltage gain) of 8Vcm[-1] has its Y-plates connected (with the time base turned off) to:

(a) A d.c accumulator delivering 16 V,

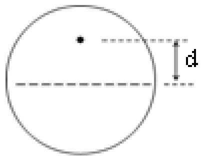
(b) An a.c voltage delivering 16 V at root mean square.

(i) Determine the deflection of the spot in (a) above and the length of a vertical line in (b) above.

(ii) Explain with a diagram what will happen if the plates are connected with time base on to a voltage in (b) above.

Solution

(a)



Given:

$\mathrm{V_{dc}} = 16\ \mathrm{V}$

$$\left[\begin{matrix}\text{Voltage gain} \\ (\text{ or Y sensitivity})\end{matrix}\right] = 8\mathrm{V\ cm^{-1}}$$

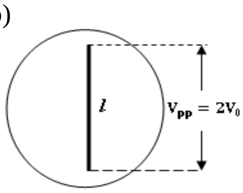
Then from;

$$V_{dc} = \left[\begin{matrix}Voltage\ gain \\ (\ or\ Y - sensitivity)\end{matrix}\right] \times Vertical\ deflection$$

$$16 = 8 \times d$$
$$d = 2\ \text{cm}$$

The spot will be deflected by 2 cm from the zero line.

(b)



$\mathrm{V_{r.m.s}} = 16\mathrm{V}$

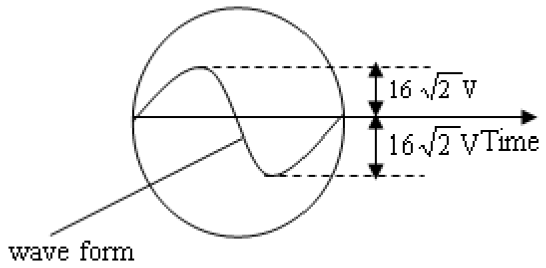
$$\left[\begin{matrix}\text{Voltage gain} \\ (\text{ or Y sensitivity})\end{matrix}\right] = 8\mathrm{V\ cm^{-1}}$$

$$\mathrm{V_{r.m.s}} = \frac{\mathrm{V_0}}{\sqrt{2}} \Rightarrow 16 = \frac{\mathrm{V_0}}{\sqrt{2}} \Rightarrow \mathrm{V_0} = 16\sqrt{2}\ \mathrm{V}$$

$$V_{pp} = \left[\begin{matrix}Voltage\ gain \\ (\ or\ Y - sensitivity)\end{matrix}\right] \times Vertical\ deflection$$

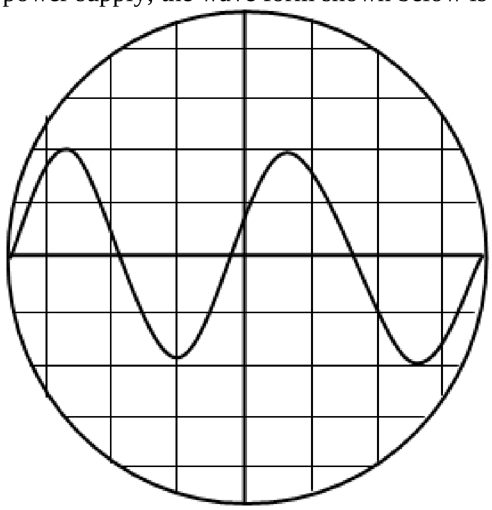
$$2 \times 16\sqrt{2} = 8 \times l$$
$$\boldsymbol{l} = 4\sqrt{2}\ \text{cm}$$

(ii) If the time base is on and Y-plates connected then we shall obtain the wave from below with a peak value $V_o = 16\sqrt{2}$ V



Example: 2

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 current voltage.**

(ii) Find the amplitude of voltage generated if voltage gain is 5V per cm.

Solution:

$$\begin{bmatrix} \text{Voltage gain} \\ (\text{ or Y} - \text{sensitivity}) \end{bmatrix} = 5\text{V cm}^{-1}$$

From the graph, Amplidude = 2 cm

$$V_0 = \begin{bmatrix} \text{Voltage gain} \\ (\text{ or Y} - \text{sensitivity}) \end{bmatrix} \times \text{Amplitude}$$

$$V_0 = 5 \times 2$$

$$V_0 = 10 \text{ V}$$

(iii) Calculate the frequency of power source if the time base setting on the C.R.O is 5 X 10^{-3}scm^{-1}.

Solution:

$$\begin{bmatrix} \text{Time sensitivity,} \\ (\text{Time base setting}) \end{bmatrix} = 5.0 \times 10^{-3} \text{ scm}^{-1}$$

From the graph, Length for 2 cycles = 8cm

Time, t for 2 cycles =?

Time, t for 2 cycles

$$\text{Time, t} = \begin{bmatrix} \text{Time sensitivity,} \\ (\text{Time base setting}) \end{bmatrix} \times \text{Legnth on time axis}$$

$$\text{Time, t} = (5.0 \times 10^{-3}) \times 8$$

$$\text{Time, t} = 0.04 \text{ s}$$

Time, T for 1 cycles (Period time, T)

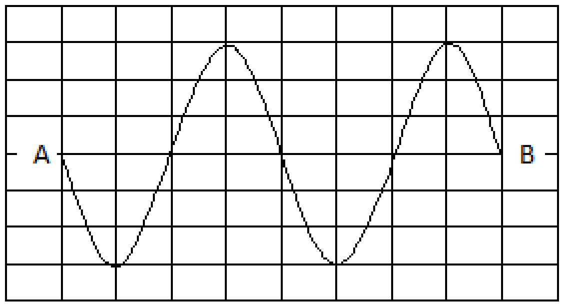
$$\text{Time, T} = \frac{\text{t}}{\text{No. of cycles}} = \frac{0.04 \text{ s}}{2} = 0.02 \text{ s}$$

Frequency;

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

Trial Question:

A cathode oscilloscope CRO with time base switched on is connected across a power supply. The wave form shown in figure below is obtained.



The distance between each line as 1cm.

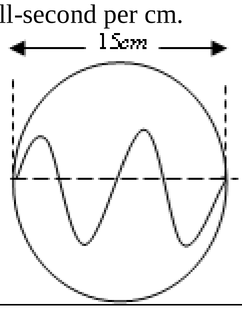
(i) Identify the type of voltage generated by the power supply.

(ii) Find the amplitude of the voltage generated if the voltage gain is 5Vcm^{-1}.

(iii) Calculate the frequency of the power source, l the time base setting on the C.R.O is 5 X 10^{-3}scm^{-1}.

Example: 3

Determine the frequency of the signal below, if the time base is set at 10 mill-second per cm.



2 cycles occupy	= 15 cm
1 cycle occupies	= 15/2 = 7.5 cm

$$\text{Period time, T} = \begin{pmatrix} \text{Legnth} \\ \text{for 1 cycle} \end{pmatrix} \times (\text{Time base setting})$$

$$\text{Period time, T} = 7.5 \times 10 \text{ ms cm}^{-1}$$

$$\text{Period time, T} = 75 \text{ ms}$$

$$\text{Period time, T} = 75 \times 10^{-3}\text{s}$$

Frequency;

$$\text{Frequency, f} = \frac{1}{\text{T}} = \frac{1}{75 \times 10^{-3}} = 13.33 \text{ Hz}$$

Note

If the CRO has no calibrated time base setting, when the unknown frequency f_2 of the signal is determined from the relation

$$\text{Since, } f \propto \frac{1}{d} \Rightarrow \mathbf{f_1 d_1 = f_2 d_2}$$

Where

d_1 – horizontal distance occupied by signal 1 for one cycle

d_2 – horizontal distance occupied by signal 2 for one cycle

f_1 – known frequency of signal at same time base setting.

Advantages of a C.R.O over an ammeter and voltmeter

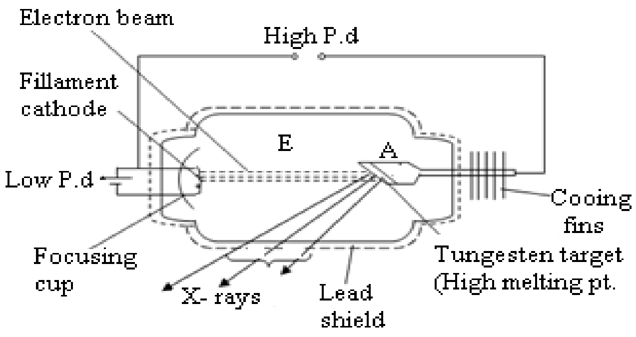
(i) It has infinite resistance and therefore draws very little current from the circuit.
(ii) It can be used to measure both **a.c** and **d.c** voltages.
(iii) It has instantaneous response.
(iv) It has no coil that can burn out.

X – RAYS

These are electromagnetic radiations of short wave length. They are produced when fast moving electrons are suddenly stopped by a metal target.
The process involved in the production of X-rays is the inverse of Photoelectric emission.

Production of X-Rays

X-rays are produced in an X-ray tube.



E = Evacuated tube (or Vacuum),
A = Copper anode

The cathode is heated to emit electrons by thermionic emission .using a low voltage supply.
A high p.d is applied across the anode to accelerate the electrons towards the anode.
When the cathode rays strike the metal target, about 99% of their kinetic energy is converted to heat energy and 1% is converted to X- rays.

Energy Changes in the X-ray tube.

$$\begin{matrix}\text{Electrical} \\ \text{energy}\end{matrix} \rightarrow \begin{matrix}\text{Heat enegy in} \\ \text{the filament}\end{matrix} \rightarrow \begin{matrix}\text{K.E of} \\ \text{electrons}\end{matrix} \rightarrow \begin{matrix}\text{E/m} \\ \text{energy}\end{matrix}$$

Note:

(i) The x – ray tube is evacuated to prevent fast moving electrons from being hindered by friction due to air resistance.
(ii) The heat generated is conducted away thru the copper anode to the cooling fins, or by use of a circulating liquid, oil or water through the hollow anode.
(iii) The curvature of the cathode helps to focus the electrons onto the anode.
(iv) The target is made of tungsten because tungsten has a very high melting point (33800).
(v) The lead shied is used to absorb stray X-rays hence preventing exposure of X-rays to un wanted regions.

Intensity of X-rays:

Intensity of X-rays refers to the number of X-rays produced.

- The intensity of X-rays increases when the filament current or heating current (the low P.d) is increased. This is because when the filament current is increased, the number of electrons hitting the target increases.
- The intensity also increases with the applied voltage across the tube since the applied voltage increases the energy with which the electrons hit the target hence increasing energy for X-ray photons.

Penetrating Power (Strength or Quality) of X-rays:

- The penetrating quality of X-Rays increases with the applied voltage across the tube
- X-rays of low frequency or low penetrating power are called **soft X-rays** and are produced when a low voltage is applied across the tube.
- If the applied voltage is high, X-rays (**hard X-rays**) of high frequency are produced.
- The penetrating power of X-rays is independent of the filament current.

Types of x – rays

(i) **Soft x –rays** are X-rays of low penetrating power i.e low frequency and long wave length produced when a low accelerating p.d is applied across the x-ray tube.

(ii) **Hard x –rays** are X-rays of high penetrating power i.e high frequency and short wave length produced when a high accelerating p.d is applied across the x-ray tube.

Properties of x- rays

- They can penetrate matter (the penetration increases with the frequency and its minimum in materials of high density e.g. lead.).
- They travel in straight lines at the speed of light.
- They are not deflected by both electric and magnetic fields since they are not charged.
- They can ionise a gas increasing its conductivity.
- They affect a photographic plate or film.
- They cause some substances to fluoresce e.g. Zinc sulphide.
- They are electromagnetic radiations of short wave length.
- They can produce photo electric emission.
- They undergo refraction, reflection and diffraction.

Health hazards of X-rays

Frequent exposure to X-rays can lead to dangers like;

- They destroy cells especially hard x- rays.
- Cause gene mutation or genetic change.
- Cause damage of eye sight and blood.
- Cause cancer eg Leukemia (cancer of the blood)
- Produce deep seated skin burns.

Safety Precautions

- 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.

- Soft X-rays should 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.

Uses of X-rays

a) **Medicine (Hospital Use)**

- Used to investigate bone fractures.
- Detecting lung tuberculosis..
- Used to locate swallowed metal objects.
- Used to detect internal ulcers along a digestive track
- 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.

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 of the photograph the bone that is studied to locate the broken part.

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. This done by using X-ray diffraction.

d) **Security:**

- X-rays are used to check luggage for potentially dangerous weapons and smuggled items at airports and custom security check point.

Differences between cathode rays and x-rays

Cathode rays	**X-rays**
Negatively charged	Have no charge
Travel at low speed	Travel at high speed
Low penetrating power	High penetrating power
Deflected by both Magnetic and electric fields	Not deflected since they have no charge.

Exercise:

1. Thermionic emission may occur when
A. Fast moving electrons hit a metal
B. A metal is given heat energy
C. Metal receives light energy.
D. A substance undergoes radioactive decay

2. Which one of the following will affect the number of electrons emitted in a thermionic tube?
(i) The p.d between anode and cathode
(ii) The pressure of the filament
(iii) The current flowing in the filament circuit
A. (i) and (ii) only C. (i) and (iii) only
B. (ii0 and (iii) only D. (iii) only

3. What is the process by which electrons are emitted from a hot filament?
A. Radioactivity
B. Nuclear reaction
C. Thermionic emission
D. Thermo-electric effect

4. Which one of the following are properties of cathode rays?
(i) They travel in straight lines
(ii) They can penetrate a thick sheet of paper
(iii) They darken a photographic plate
(iv) They are deflected by a magnetic field

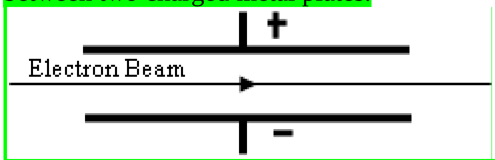
A. (i), (iii) and (iv) only C. (i), (ii) and (iv) only
B. (i), (ii) and (iii) only D. (iv) only

5. The phenomenon by which electrons are released from a metal surface when radiation falls on it is known as
A. Radioactivity C. Photoelectric effect
B. Thermionic emission D. Reflection

6. Streams of electrons moving at high speed are called?
A. X-rays C. Gamma rays
B. Cathode rays D. Alpha particles

7. The process by which electrons are emitted from the surface of a metal by application of heat is known as
A. Photoelectric emission
B. Electromagnetic emission
C. Thermionic emission
D. Heat emission

8. Fig below shows a beam of electrons incident mid way between two charged metal plates.

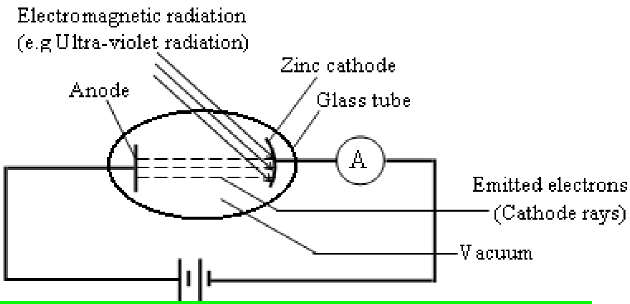


Which one of the following is correct? The beam
A. Is deflected towards the positive plate
B. Is deflected towards the negative plate
C. Moves perpendicular to the plates
D. Passes through the plates undetected.

9. The particles that are emitted from a hot metal surface are called
A. Electrons C. Neutrons
B. Protons D. Alpha

10. Cathode rays are;
A. Electromagnetic waves
B. Streams of X-rays
C. Protons emitted by a hot cathode
D. Streams of electrons moving at high speed

11. A Zinc cathode was enclosed in an evacuated glass tube as shown in fig below.



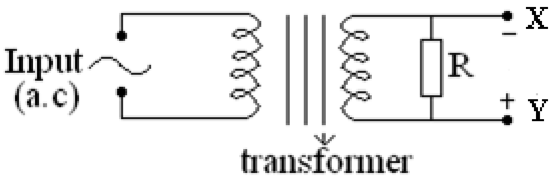
When the cathode was irradiated with ultra violet radiation, the ammeter gave a reading
(i) Explain why the ammeter gave a reading.
(ii) A gas was gradually introduced into the glass tube. Explain what happened.

12. (a) What is meant by the following?
(i) Thermionic emission.
(ii) Photoelectric effect

(b) State the conditions necessary for photoelectric effect to occur.

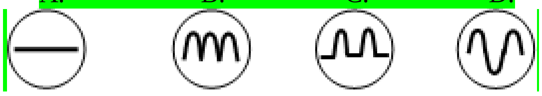
(c) With the aid of a diagram, describe how cathode rays are produced by thermionic emission.

13.



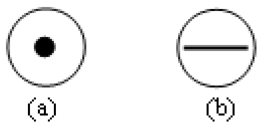
The wave form obtained when X and Y are connected to a cathode ray oscilloscope is:

A. B. C. D.



14. A sinusoidal wave is observed on a cathode ray oscilloscope, when;
A. A cell is connected to the Y- plates with time base off.
B. A low frequency alternating voltage is connected to the Y-plates with time base on.
C. A high frequency alternating voltage is connected to the Y-plates with time base on.
D. A cell is connected to the Y- plates with the time base on.

15. The figure below, (a) shows a spot of light on the screen of a C.R.O.

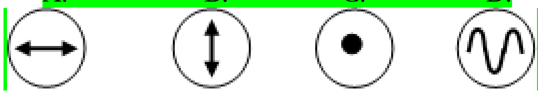


The spot can be turned into a horizontal straight line shown in (b), by;
A. Switching off the time base.
B. Switching on the time base.
C. Making one of the plates positive.
D. Connecting the a.c voltage to the Y- plates

16. The cathode ray oscilloscope may be used to;
(i) Measure energy.
(ii) Measure potential difference.
(iii) Display wave forms.
A. (i) only. C. (ii) and (iii) only.
B. (i) and (ii) only. D. (i), (ii) and (iii).

17. Which of the following represent the appearance on the screen of a cathode ray oscilloscope when a d.c voltage is connected across the Y- plates with the time base switched on?

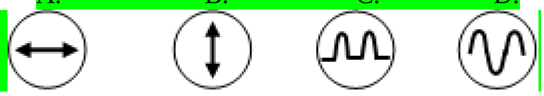
A. B. C. D.



18. The brightness on the screen of a T.V is determined by;
A. Darkness in the room.
B. Size of the screen.
C. Number of electrons reaching the screen.
D. Direction of the aerial.

19. Which one of the following sketches represents the appearance the wave form observed in a C.R.O connected across an a.c supply when the time base of the C.R.O is on?

A. B. C. D.

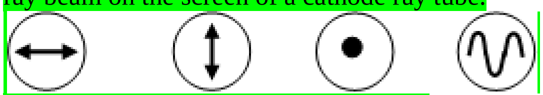


20. The brightness of the spot on a C.R.O screen is controlled by;
A. X – Plates. C. Grid.
B. Anode. D. Cathode.

21. The X and Y – plates in a cathode ray oscilloscope make up the:
A. Electron gun. C. Deflection system
B. Focusing system. D. Accelerating system.

22. (a) (i) Draw a well labeled diagram of a cathode ray oscilloscope. (C.R.O).
(ii) State one function of each part you have labeled in (i) above.

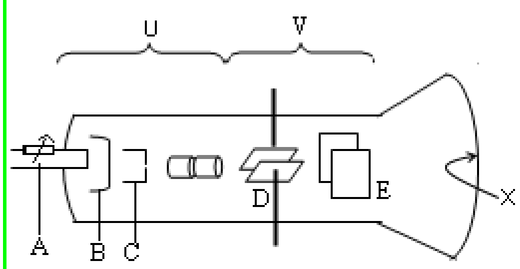
(b) The diagrams below show the traces of a cathode ray beam on the screen of a cathode ray tube.



Explain how each one may be obtained.

(c) Give two uses of a C.R.O.

23. The diagram below shows the main parts of a cathode ray oscilloscope (C.R.O).



(a) Name the parts labeled; A, B, C, D, E, U, V and X.
(i) Explain why the C.R.O is evacuated.

(ii) Describe briefly the principle of operation of a C.R.O.

(iii) Describe how a bright spot is formed on the screen.

(b) Using diagrams, show what is observed when on the screen of the C.R.O when;

(i) The CRO is switched on and no signal is applied to the Y - plates.

(ii) The time base is switched on and no signal is applied to the Y - plates.

(iii) An alternating signal is applied to the Y- plates while the time- box is switched off.

(c) Give two applications of a cathode ray oscilloscope.

24. Which of the following is the correct sequence of the energy conversions in an X – ray tube?

A. Electrical energy → Heat energy → K. E → Electro magnrtic energy

B. Heat energy → Electrical energy → K. E → Electro magnrtic energy

C. Electrical energy → Heat energy → Electro magnrtic energy → K. E

D. K. E energy → Electrical energy → Heat energy → Electro magnrtic energy

25. Which of the following is true about X – rays?

(i) Cause photographic emissions.

(ii) Deflected by an electric field.

(iii) Ionize matter

(iv) Not deflected by a magnetic field.

A. (i), (ii) and (iii).
C. (ii) and (iv).
B. (i) and (ii).
D. (i), (iii) and (iv).

26. The following are some of the uses of X – rays except;

A. Detection of flaws in a material.
B. Detection of affected tissues in living organisms.
C. Destruction of cancer cells.
D. Preservation of cereals.

27. The difference between X – rays and ultra – violet rays is that X – rays have;

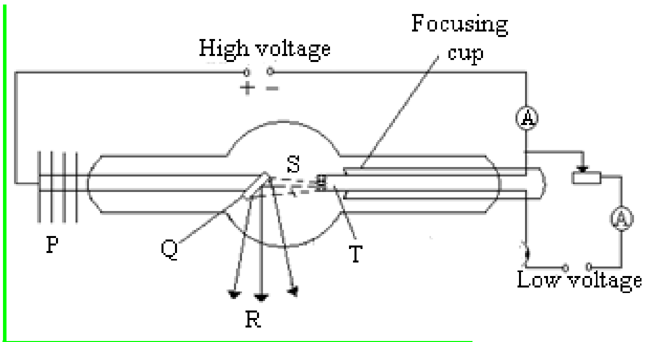
(i) Greater velocity.
(iii) Lower frequency.
(ii) Shorter wavelength.
(iv) More energy.

A. (i), (ii) and (iii).
C. (i) and (ii).
B. (ii) and (iv).
D. (i), (iii) and (iv).

28. The difference between soft and hard X – rays is that;

A. Hard X- rays travel faster than soft X – rays.
B. Hard X – rays penetrate more than the soft X–rays.
C. Hard X – rays less dangerous than the soft X–rays.
D. Soft X – rays are produced at high potential differences.

29. The diagram below shows a hot cathode X – ray tube.



(a) Name the parts labeled P, Q, R, S and T.

(b) What is the purpose of the;

(i) Low voltage.

(ii) High voltage

(c) State two applications of X – rays .

(d) Explain why part Q must be cooled.

30. (a) What are X – rays?

(b) With the aid of a labeled diagram, describe the structure and mode of operation of an X – ray tube.

(c) Explain how each of the following can be increased in an X – ray tube:

(i) Intensity of the X – rays.

(ii) Penetrating power of the X – rays.

(d) Give two biological uses of X – rays.

(e) State any four ways in which X – rays are similar to gamma rays.

RADIOCTIVITY

Radioactivity is the spontaneous disintegration of heavy unstable nucleus to form stable nucleus accompanied by release of radiations.

Activity is the number of disintegrations (or break down emissions) per second.

The radiations emitted are:

Alpha particles (α), beta particle (β) or gamma radiations (γ). Elements that emit radiations spontaneously are said to be radioactive elements.

Radioactivity is considered as a random process because you can not tell which atoms of a molecule will disintegrate at a particular instant.

Properties of Radiations emitted

(a) Alpha particle

An alpha particle is a helium nucleus which is positively charged i.e.$^{4}_{2}\mathbf{H}$.

Properties

- It is positively charged with a charge of +2.
- It has a low penetrating power because of its relatively large mass and due to this; it can be stopped or absorbed by a thin sheet of paper.
- It can be deflected by both electric and magnetic fields because of its charge and it is deflected towards a negative plate.
- It has a high ionising power due to its high charge or great charge.
- It has a low range in air.

Note: When un stable nuclei emits an alpha particle, the mass number reduces by 4 and atomic number reduces by 2. When a nuclide decays by release of an alpha particle, it loses two protons and two neutrons. This can be expressed as below:

$$^{A}_{Z}X \longrightarrow {}^{A-4}_{Z-2}Y + {}^{4}_{2}He$$

Parent nuclide — Daughter nuclide — alpha particle

Example

(i) Uranium decays by emitting alpha particles to become thorium;

$$^{238}_{92}U \longrightarrow {}^{206}_{82}Th + {}^{4}_{2}He$$

(ii) Polonium – 210 undergoes alpha decay to become lead – 206;

$$^{210}_{84}Po \longrightarrow {}^{206}_{82}Pb + {}^{4}_{2}He$$

Question:

1. A radioactive substance $^{238}_{92}\mathbf{X}$ undergoes decay and emits an alpha particle to form nuclide Y. Write an equation for the process.

2. A radioactive substance $^{238}_{92}\mathbf{X}$ undergoes decay and emits two alpha particles to form nuclide Y. Write a balanced equation for the process.

(b) A beta particle

A beta particle is a high energy electron i.e. $^{-1}_{0}\mathbf{e}$.

Properties

- It is negatively charged with a charge of -1.
- It has a low ionising power because of its low charge (-1).
- It has a higher penetrating power because of its low mass and due to this; it can be stopped or absorbed by an aluminium foil (a few cm).
- It can also be deflected by both electric and magnetic fields at a higher angle and it is deflected towards a positive plate.
- It has a high range in air.

Note:

When a radioactive nuclei decays by emitting a beta particles. Its mass number is not affected but the atomic number increases by one.

When an element decays by emitting a beta particle, it loses an electron. This results from the decay of a neutron to a proton:

$$^{1}_{0}n \longrightarrow {}^{1}_{1}P + {}^{0}_{-1}\beta$$

neutron — proton — beta particle

Beta decay can be expressed as:

$$^{A}_{Z}X \longrightarrow {}^{A}_{Z+1}Y + {}^{0}_{-1}e$$

parent nuclide — daughter nuclide — beta particle

Example

Radioactive sodium undergoes beta decay to become magnesium. This can be written as:

$$^{24}_{11}Na \longrightarrow {}^{24}_{12}Mg + {}^{0}_{-1}e$$

Note: When a nuclide undergoes beta decay:

(i) Its atomic number increases by one.
(ii) Its atomic mass remains the same.

Questions:

1. An unstable nuclide $^{226}_{88}\mathbf{X}$ decays to form a stable nuclei **Y** by emitting a beta particle.
   (i) Write down an equation for the process.
   (ii) How would nuclide X be affected if a beta particle was emitted instead of the alpha particle?
   (iii) Compare the nature and properties of an alpha particle with those of a beta particle,

2. A radioactive nucleus $^{226}_{88}\mathbf{Ra}$ undergoes decay and emits two alpha particles and two beta particles to form nuclide **S**. State the atomic number and mass number of nuclide S.

3. (a) Consider the equation below.

$$^{210}_{82}X \xrightarrow{(i)} {}^{206}_{80}Y \xrightarrow{(ii)} {}^{206}_{81}Z$$

Name the particle emitted at each of the stages (i) and (ii).

(c) Gamma Rays

These are neutral electromagnetic radiations with the shortest wave length.

Properties

They are neutral (not charged) and therefore can not be deflected by both electric and magnetic fields.
They have the highest penetrating power because of their light mass and due to this they can be stopped or absorbed by a lead metal or shield which has the highest density.
They can also cause ionisation of a gas by knocking off electrons from the neutral atoms but this is by small amounts.
They have the highest possible range in air.

Question:

1. (a) Describe the composition of the $^{23}_{11}\mathbf{Na}$ atom**.**

(b) $^{60}_{27}\mathbf{Co}$ is a radioisotope of Cobalt which emits a beta particle and very high energy gamma rays to form an element Y. Write a balanced equation for the nuclear reaction.

$$^{60}_{27}Co \longrightarrow {}^{60}_{28}Y + {}^{0}_{-1}e + \gamma$$

2. A radioactive nuclide $^{230}_{90}\mathbf{X}$ emits 4 alpha particles, 2 beta particles and gamma radiations to turn into another nuclide, Y. Find the mass number and atomic number of Y.

3. A radioactive nuclide ${}^{230}_{90}\mathbf{X}$ decays to nuclide Z according to the decay process below.

$${}^{232}_{90}X \xrightarrow{A} {}^{228}_{88}Y \xrightarrow{B} {}^{228}_{89}Z \xrightarrow{C} {}^{228}_{89}Z$$

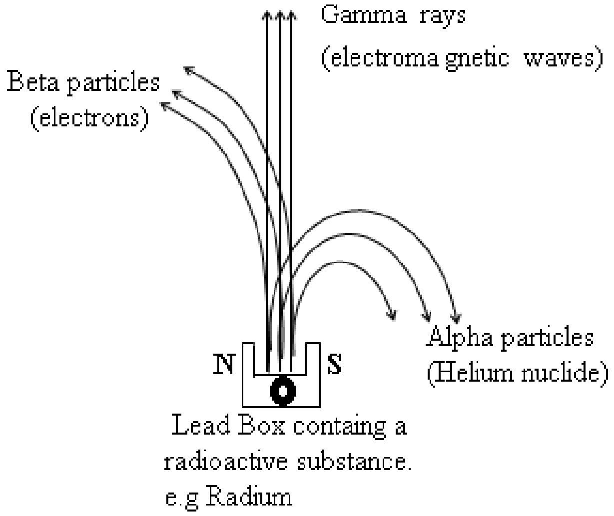
(a) Identify the particles or radiations A, B and C.
(b) State two differences between radiations A and B.

Note: In a chemical reaction or equation,

(i) The total mass number on the left must be equal to the total mass number on the right hand side.

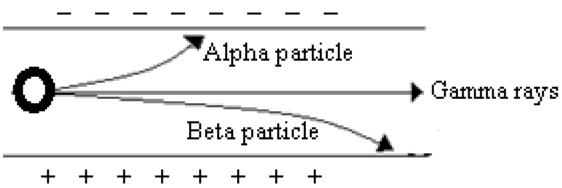
(ii) The total atomic number on the left must be equal to the total atomic number on the right hand side.

Deflection of Alpha, Beta and Gamma radiations in electric and magnetic fields



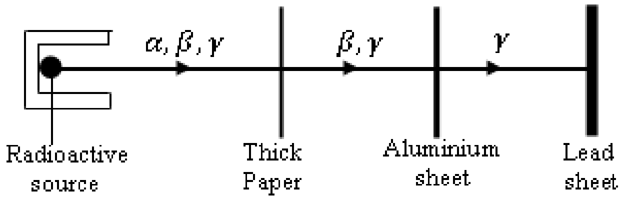
Alpha particles are deflected in a direction towards the South Pole while beta particles are deflected towards the North Pole.
Alpha particles are less deflected than beta particles implying that alpha articles are heavier than beta particles.
The gamma rays are not deflected in the magnetic field implying that they have no charge.

If the radiations are subjected to an electric field, the paths below are seen.



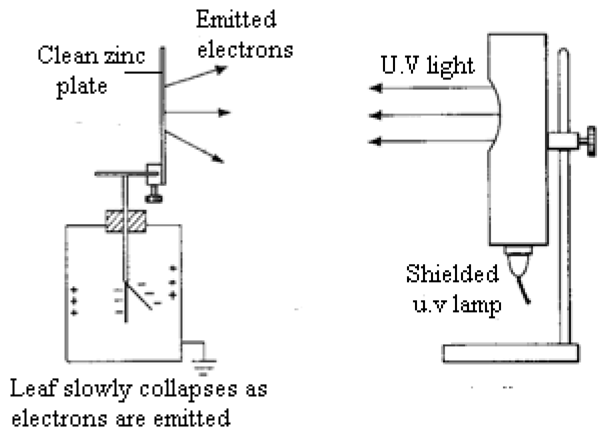
Alpha particles are deflected towards the negative plate since they are negatively charged, while beta particles are deflected towards the positive plate since they are negatively charge.
The gamma rays are not deflected in the electric field implying that they have no charge.

Penetration Power of Alpha, Beta and Gamma radiations



Ionising effects of the radiations

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



- 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.

Question:
Explain what is observed when;
(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.

Back ground radiation
These are radiations which are naturally existing 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 radiated particles which come from deep in space. So the correct count rate = actual rate plus back ground count rate.

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

$$\text{Count rate} = 25 - 2$$
$$= 23\ \text{C min}^{-1}$$

Comparisons of the Radiations

(a) Similarities between alpha and beta particles.

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

(b) Differences between alpha and beta particles.

Property	Radiation	
	Alpha particle	**Beta particle**
Charge	Positive	Negative
Nature	Helium particles which have lost the electrons	High energy electrons
Deflection in fields	Towards negative plate and south pole	Towards positive plate and north pole
Penetrating power	Low: Penetrate thin paper but stopped by thick ones.	High: Penetrate thick paper and thin alluminium foil but stopped by thick alluminium sheets.
Ionizing power	High (Most)	Moderate
Absorbed by	Thick sheets of paper	5mm of alluminium

(c) Differences between Gamma rays and X-rays

	Gamma rays	**X-rays**
(i) Wave Length	Shorter wave length than X-rays.	Longer wave length than gamma rays.
(ii) Origin	From nuclei of atoms as a result of radioactivity.	From cathode rays suddenly stopped by matter.

(d) Comparison of Alpha, Beta and Gamma radiations

Property	Radiation		
	Alpha particle	**Beta particle**	**Gamma rays**
Charge	Positive (+2)	Negative (-1)	No charge (0)
Nature	Helium particles which have lost the electrons	High energy electrons	High energy electromagnetic radiation.
Deflection in fields	Towards negative plate and south pole	Towards positive plate and north pole	Not deflected
Penetrating power	Least	Moderate	Most
Ionizing power	Most	Moderate	Least
Absorbed by	Thick sheets of paper	5mm of alluminium	Thick sheet of lead
Range in air (in m)	0.05	3	100

Note:

(iii) Range of radiation is the maximum distance covered by a radiation in air before it is totally absorbed.

(iv) Ionisation is the process of changing the neutral atoms of a gas into positive and negative ions.

Detectors of the radiations

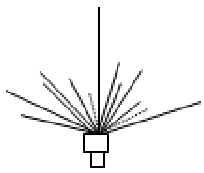
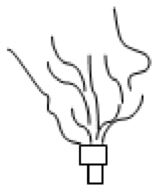
These include:

(i) Ionisation chamber
(ii) Geiger Muller Tube (G.M tube)
(iii) Cloud chamber (both expansion type and diffusion cloud chamber)
(iv) Scintillation counter

Cloud chamber tracks for the Alpha, Beta and Gamma radiations

When an ionising radiation from a radioactive source, enters the chamber the ions are produced.
Alcohol droplets in the cloud chamber will collect around these ions produced forming strings.
Using a strong illumination, the droplets can be photographed by using a camera.
The type of radiation depends on the thickness or length of the traces of ions formed.

Alpha particles produce, thick short, straight and continuous tracks, Beta particles produce longer but wavy tracks and Gamma rays have an irregular and faint tracks as shown below.

Alpha particle	Beta particle	Gamma rays
		
Short, straight and continuous tracks	Long and wavy tracks	Irregular and faint tracks

Dangers of radiations.

(i) Alpha particles;

Alpha particles are less dangerous unless the source enters the body.

(ii) Beta Particles and Gamma radiations:

These are very dangerous because they damage skin tissues and destroy body cells.
They cause:

(i) Radiation burns. (i.e. redness and sore on the skin).
(ii) Leukemia, (Blood cancer).
(iii) Sterility, (Inability to reproduce).
(iv) Blindness, (i.e. they damage the eye sight)
(v) Low body resistance to normal diseases, due to damage of blood corpuscles.
(vi) Mutation. (A harmful genetic change, that occurs during DNA replication and protein synthesis).
The effects of genetic mutations appear in the subsequent generations. E.g, a child may be born with one arm or both but when one is shorter than the other.

Safety precautions when dealing with radioactive sources

Radioactive sources should be handled with care. In that;

- They should be held with forceps or a pair of tongs and not with bare hands.

- ❖ Avoid eating, drinking or smoking where radioactive sources are in use.
- ❖ Radioactive sources must be kept in lead boxes when not in use.
- ❖ Wash hands thoroughly after exposing them to radioactive materials.
- ❖ Any cut on the body should be covered before dealing with radioactive sources.
- ❖ Operators should put on gloves and lead coats.
- ❖ During experiments with radioactive materials, the radiations should not be directed towards the people.

Applications of Radioactivity
(Uses of alpha , beta ,and gamma rays)
The uses in various fields are based on the following

❖ Gauge control and fault finding:
If a radioisotope is placed on one side of a moving sheet of material and a GM tube on the other, the count rate decreases if the thickness increases. Flows in a material can be detected in a similar way; the count-rate will increase where a flaw is present.

❖ Radioactive tracers:
A small amount of a weak radioisotope is injected into the system and traced by a GM tube or other detectors.

❖ Radiotherapy
Gamma rays are used in the treatment of cancer and detecting breakages in bones.

❖ Sterilization
Gamma rays are used to sterilize medical and industrial instruments and foods.

❖ Archaeology
Living plants and animals take in radioactive carbon. When a tree dies, no fresh carbon is taken and the carbon starts to decay. By measuring the residual activity of carbon containing material such as wood, charcoal the age of archaeological remains can be estimated.

(a) **Industrial uses:**
They are used;
- ✓ in tracer techniques to investigate the flow of liquids in chemical plants. (Identifying oil leakages in oil pipe lies).
- ✓ in the automatic control of thickness or uniformity of materials in industries. (e.g Cigarettes)
- ✓ In the study of wear and tear in machinery.
- ✓ To detect faults in thickness of metals sheets in welded joints. (gamma rays)
- ✓ in food preservations.
- ✓ to sterilize equipments in food industry
- ✓ to detect smoke
- ✓ in energy production: Nuclear reactors use radio isotopes to produce electricity.

(b) **Medical uses**
- ✓ Used to treat cancerous cells. (Radiotherapy).
- ✓ They are used to kill bacteria in food (x- rays).
- ✓ Used to sterilize medical surgical equipments.
- ✓ Locate broken bones
- ✓ Asses the amount of blood in a patient

(c) **Archeological uses**
- ✓ Used to determine the time that has elapsed since death of a certain organism occurred in a process called **carbon dating.**

(d) **Geology**
- ✓ They are used to determine the age of rocks.

(e) Biological uses
- ✓ Used to study the uptake of fertilizers by plants.
- ✓ Used to sterilize insects and hence eliminate pests that destroy crops.

(f) Defense
- ✓ Nuclear reactions of fusion and fission are used in manufacture of weapons of mass destruction like nuclear and atomic bombs.

Exercise:

1. Which one of the following radiations has the listed properties?
(i) Long range in air.
(ii) Not deflected by magnetic and electric fields.
(iii) Cause very little ionization of air molecules.
A. Alpha. C. Gamma
B. Beta. D. X - rays.

2. A radioactive source decays by emission of all the three radiation. The radiation enters normally into electric field as shown in figure 3.

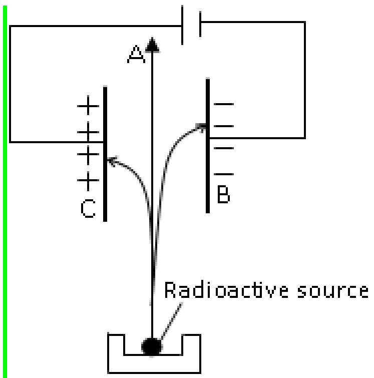
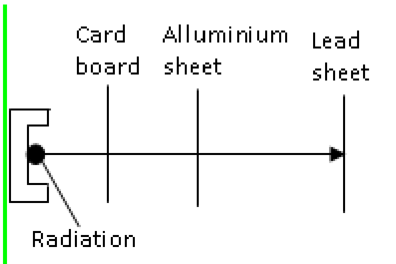


Fig. 3.

(a) Which radiation is most likely to detect at;
(i) Position A. (ii) Position B. (iii) Position C.

(b) (i) What can you deduce about the charges of the radiation?
(ii) State two differences between radiation A and B.
(iii) What happens when the radioactive source is completely covered with an ordinary sheet of paper.
(iv) Draw diagrams to show the paths of the particles named in (d) above.

(c) A radioactive source that emits all the three radiations is placed in front of the cardboard aluminum and lead sheets as shown in the figure above. Name the radiations likely to be between the card board.



(i) Cardboard and aluminum sheet.
(ii) Aluminum and the lead sheets

(d) (i) Name any three precautions which must be undertaken by one working with ionizing radiation.
(ii) Give 2 uses of radioactivity.
(iii) Name two health hazards of radioactivity.

(e) Name one;
(i) Industrial use;
(ii) Biological use of radio activity.

HALF LIFE

Half life is the time taken for a radioactive substance to decay to half of its original mass (or nuclei).

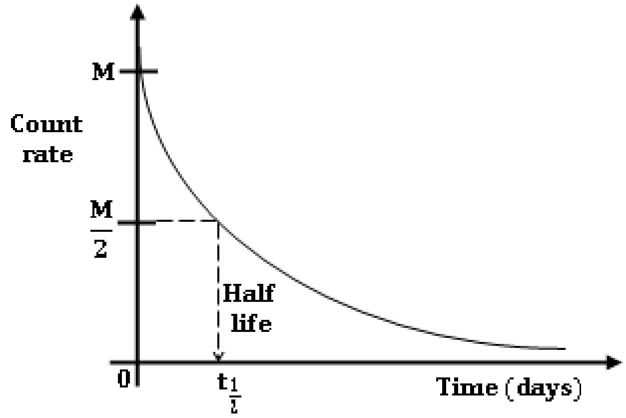
Half life can be measured in any unit of time, e.g seconds, minutes, hours, days, weeks, months and years.
It is not affected by physical factors like temperature and pressure.
It is different for different nuclides as shown for some nuclides in the table below.

Radioactive element	Symbol	Half life	Radiations
Polonium – 218	$^{218}_{84}Po$	3.05 minutes	α
Thorium – 234	$^{234}_{90}Th$	24.10 days	β, γ
Uranium – 234	$^{234}_{92}U$	2.47×10^5 years	α, γ
Uranium – 238	$^{238}_{92}U$	4.51×10^9 years	α, γ

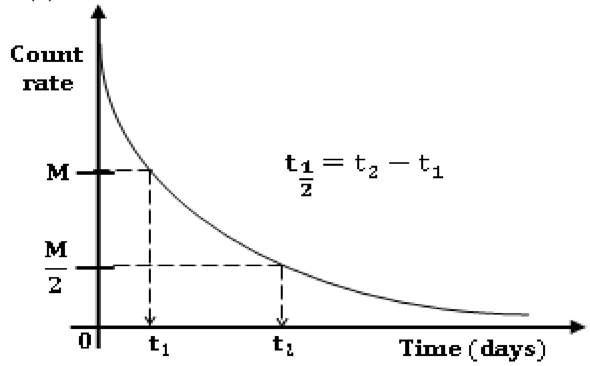
Note:
- These values are **not** to be memorized.
- The last two are called **Radioisotopes**. (Radioactive atoms of the same element with the same atomic number but different mass numbers).

Experiment to determine the half life of a radioactive nuclide.
- ✓ Place the source of the radioactive nuclide into the ionization chamber or Geiger Muller tube.
- ✓ Note and record the count rate (Change in the intensity of radiations from the source with time).
- ✓ Plot a graph of intensity or number of nuclei remaining against time.
- ✓ Read off the half life from the graph.

How to read half life from the graph:
- ✓ Draw a horizontal line from half of the original amount (or count rate or original number of nuclei) to meet the curve.
- ✓ Draw a vertical line from the point on the curve to meet the time axis.
- ✓ Read the value of half life from where the vertical line meets the time axis.



In some cases, the original mass may not coincide with the zero (0) time.



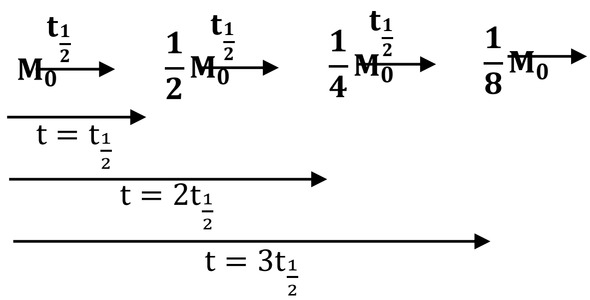
Calculations of Half life:

Method I: Using a table

Time Taken, t	Mass remaining, M_t	Mass Decayed $M_D = M_o - M_t$
0	M_0	0
$t_{\frac{1}{2}}$	$M_o\left(\frac{1}{2}\right)^1$	
$2t_{\frac{1}{2}}$	$M_o\left(\frac{1}{2}\right)^2$	
$3t_{\frac{1}{2}}$	$M_o\left(\frac{1}{2}\right)^3$	
-	-	
-	-	
$nt_{\frac{1}{2}}$	$M_o\left(\frac{1}{2}\right)^n$	

Where: $\mathbf{nt_{\frac{1}{2}} = t}$

Method II: Arrow Diagram (Crude method)



The total time taken for the required amount to decay, is given by; $\mathbf{t} = \mathbf{nt_{\frac{1}{2}}}$

Where, $\mathbf{n}$ is the number of half lives in a time, $\mathbf{t}$

Method III: Using the formula

The mass remaining after a time t, M_t, when an original sample of mass M_o decays with a half- life of $t_{\frac{1}{2}}$ is given by;

$$\mathbf{M_t = M_o\left(\frac{1}{2}\right)^n : Where,\ n = \frac{t}{t_{\frac{1}{2}}}}$$

Case I: Finding the half life when the final mass, M and time taken, t are given,.

- ❖ In this method, we continuously half the initial count rate or initial mass until the given count rate or final mass.
- ❖ Then we use the formula; $\mathbf{t = nt_{\frac{1}{2}}}$. Where, t is the time taken for the decal to half, $\mathbf{t_{\frac{1}{2}}}$ is the half life and n is the number of half lives.

Example 1:

(1994 Qn. 15): The count rate of a radioactive isotope falls from 600 counts per second to 75 counts per second in 75 minutes. Find the half life of the radio isotope.

Solution:

Method I: Using a table

$M_0 = 600\ Cs^{-1}$; $M_t = 75\ Cs^{-1}$; $t = 75s$

Count rate(Cs^{-1})	Number of half- lives, n
$M_0 = 600$	0
300	1
150	2
$M_t = 75$	3

Then from; $\mathbf{nt_{\frac{1}{2}} = t}$.

$3t_{\frac{1}{2}} = 75.$

$t_{\frac{1}{2}} = 25$ minutes

Method II: Arrow Diagram (Crude method)

$$600 \xrightarrow{1\mathbf{t_{\frac{1}{2}}}} 300 \xrightarrow{2\mathbf{t_{\frac{1}{2}}}} 150 \xrightarrow{3\mathbf{t_{\frac{1}{2}}}} 75$$

$$\mathbf{t = 75\ minutes}$$

Then from; $\mathbf{nt_{\frac{1}{2}} = t}$.

$3t_{\frac{1}{2}} = 75.$

$t_{\frac{1}{2}} = 25$ minutes

Method III: Using the formula

The mass remaining after a time t, M_t, when an original sample of mass M_o decays with a half- life of $t_{\frac{1}{2}}$ is given by;

$$\mathbf{M_t = M_o\left(\frac{1}{2}\right)^n : Where,\ n = \frac{t}{t_{\frac{1}{2}}}}$$

$M_t = M_o\left(\frac{1}{2}\right)^n$:

$75 = 600\left(\frac{1}{2}\right)^n$:

$75 = 600(2^{-1})^n$

$(2)^{-n} = \frac{75}{600}$

$2^{-n} = \frac{1}{8}$

$2^{-n} = 2^{-3}$

$-n = -3$

$n = 3$

Alternatively; At the stage of;

$2^{-n} = \frac{1}{8}$

Introducing logarithms to base 10 on both sides;

$\log 2^{-n} = \log 0.125$

$-n \log 2 = \log 0.125$

$-n = \frac{\log 0.125}{\log 2}$

$-n = -3$

$n = 3$

Then from; $\mathbf{nt_{\frac{1}{2}} = t}$.

$3t_{\frac{1}{2}} = 75.$

$t_{\frac{1}{2}} = 25$ minutes

Example 2:

(1987 Qn. 6): After 18 hours, a sixteenth of the original mass of a radioactive isotope remained. What is the half life of the isotope.

Solution:

Method I: Using a table

Let the initial amount be N;

$N = ?$; $N_t = \frac{N}{16}$; $t = 18$ Hours

Mass	Number of half- lives, n
$M_0 = N$	0
$\frac{N}{2}$	$1\mathbf{t_{\frac{1}{2}}}$
$\frac{N}{4}$	$2\mathbf{t_{\frac{1}{2}}}$
$\frac{N}{8}$	$\mathbf{3t_{\frac{1}{2}}}$
$M_t = \frac{N}{16}$	$4\mathbf{t_{\frac{1}{2}}}$

Then from; $\mathbf{nt_{\frac{1}{2}} = t}$.

$4t_{\frac{1}{2}} = 18.$

$t_{\frac{1}{2}} = 4.5$ hours

Method II: Arrow Diagram (Crude method)

$$N \xrightarrow{1\mathbf{t_{\frac{1}{2}}}} \frac{N}{2} \xrightarrow{2\mathbf{t_{\frac{1}{2}}}} \frac{N}{4} \xrightarrow{3\mathbf{t_{\frac{1}{2}}}} \frac{N}{8} \xrightarrow{4\mathbf{t_{\frac{1}{2}}}} \frac{N}{16}$$

$$\mathbf{t = 18\ Hours}$$

Then from; $\mathbf{nt_{\frac{1}{2}} = t}$.

$4t_{\frac{1}{2}} = 18.$

$t_{\frac{1}{2}} = 4.5$ hours

Method III: Using the formula

The mass remaining after a time t, M_t , when an original sample of mass M_o decays with a half- life of $t_{\frac{1}{2}}$ is given by;

$$\mathbf{M_t = M_o\left(\frac{1}{2}\right)^n : Where,\ n = \frac{t}{t_{\frac{1}{2}}}}$$

$N_t = N\left(\frac{1}{2}\right)^n$: $\frac{N}{16} = N\left(\frac{1}{2}\right)^n$: $\frac{1}{16} = \left(\frac{1}{2}\right)^n$ $2^{-n} = 2^{-4}$ $-n = -4$ $n = 4$	Alternatively; At the stage of; $2^{-n} = \frac{1}{16}$ Introducing logarithms to base 10 on both sides; $\log 2^{-n} = \log 0.0625$ $-n\log 2 = \log 0.0625$ $-n = \frac{\log 0.0625}{\log 2}$ $-n = -4$ $n = 4$

Then from; $\mathbf{nt_{\frac{1}{2}} = t}$.

$4t_{\frac{1}{2}} = 18.$

$t_{\frac{1}{2}} = 4.5$ hours

Case II: Finding the mass left when half life and time taken are given

- Half the original mass continuously until we reach the time given.
- The mass that corresponds to the time given is the mass left.

Example 3:

(1994 Qn. 6): The half life of a radioactive element is 2 minutes. What fraction of the initial mass is left after 8 minutes?

Solution:

Method I: Using a table

Let the initial amount be N;

N =? ; $N_t = \frac{N}{16}$; $t_{\frac{1}{2}} = 2$ minutes; $t = 8$ minutes;

Mass	Number of half- lives, n	Time taken, t (minutes)
$M_0 =\ N$	0	0
$\frac{1}{2}N$	$1\mathbf{t_{\frac{1}{2}}}$	2
$\frac{1}{4}N$	$2\mathbf{t_{\frac{1}{2}}}$	4
$\frac{1}{8}N$	$3\mathbf{t_{\frac{1}{2}}}$	6
$M_t = \mathbf{\frac{1}{16}}N$	$4\mathbf{t_{\frac{1}{2}}}$	**8**

From the table, the fraction left after 8 minutes $= \frac{1}{16}$

Method II: Arrow Diagram (Crude method)

$$N \xrightarrow{1\mathbf{t_{\frac{1}{2}}}} \frac{\mathbf{N}}{\mathbf{2}} \xrightarrow{2\mathbf{t_{\frac{1}{2}}}} \frac{\mathbf{N}}{\mathbf{4}} \xrightarrow{3\mathbf{t_{\frac{1}{2}}}} \frac{\mathbf{N}}{\mathbf{8}} \xrightarrow{4\mathbf{t_{\frac{1}{2}}}} \frac{\mathbf{N}}{\mathbf{16}}$$

$$\mathbf{t = 8\ minutes}$$

$$N \xrightarrow{\mathbf{2}} \frac{\mathbf{N}}{\mathbf{2}} \xrightarrow{\mathbf{4}} \frac{\mathbf{N}}{\mathbf{4}} \xrightarrow{\mathbf{6}} \frac{\mathbf{N}}{\mathbf{8}} \xrightarrow{\mathbf{8}} \frac{\mathbf{N}}{\mathbf{16}}$$

$$\mathbf{t = 8\ minutes}$$

From the above, the fraction left after 8 minutes $= \frac{1}{16}$

Method III: Using the formula

The mass remaining after a time t, M_t , when an original sample of mass M_o decays with a half- life of $t_{\frac{1}{2}}$ is given by;

$$\mathbf{M_t = M_o\left(\frac{1}{2}\right)^n : Where,\ n = \frac{t}{t_{\frac{1}{2}}}}$$

$$n = \frac{t}{t_{\frac{1}{2}}} = \frac{8}{2} = 4$$

$$N_t = N\left(\frac{1}{2}\right)^n:$$

$$N_t = N\left(\frac{1}{2}\right)^4:$$

$$\frac{N_t}{N} = \left(\frac{1}{2}\right)^4$$

$$\frac{N_t}{N} = \frac{1}{16}$$

Thus, the fraction left after 8 minutes $= \frac{1}{16}$

Example 4:

(1994 Qn. 6): The half life of Uranium is 24 days. Calculate the mass of Uranium that remains after 120 days if the initial mass is 64g.

Solution:

Method I: Using a table

Let the initial amount be N;

$M_0 = 64$ g ; M_t =? ; $t_{\frac{1}{2}} = 24$ days; $t = 120$ days;

Mass (g)	Number of half- lives, n	Time taken, t (days)
$M_0 = 64$	0	0
32	$1\mathbf{t_{\frac{1}{2}}}$	24
16	$2\mathbf{t_{\frac{1}{2}}}$	48
8	$3\mathbf{t_{\frac{1}{2}}}$	72
4	$4\mathbf{t_{\frac{1}{2}}}$	96
$M_t =$ **2**	$5\mathbf{t_{\frac{1}{2}}}$	**120**

From the table, the mass left after 120 days = **2 g**

Method II: Arrow Diagram (Crude method)

Try using the crude method, you will still get themass left after 120 days $= \mathbf{2\ g}$

Method III: Using the formula

The mass remaining after a time t, M_t, when an original sample of mass $M_o$decays with a half- life of $t_{\frac{1}{2}}$ is given by;

$$\mathbf{M_t = M_o \left(\frac{1}{2}\right)^n : Where,\ n = \frac{t}{t_{\frac{1}{2}}}}$$

$$n = \frac{t}{t_{\frac{1}{2}}} = \frac{120}{24} = 5$$

$$N_t = N\left(\frac{1}{2}\right)^n :$$
$$N_t = 64 \times \left(\frac{1}{2}\right)^5 :$$
$$N_t = 64 \times \frac{1}{32}$$
$$N_t = 2 :$$

Thus, the mass left after 120 days = 2 g

Case III: Finding the mass decayed when half life and time taken are given

- Half the original mass continuously until we reach the time given.
- The mass that corresponds to the time given is the mass left.
- Find the mass decayed from the expression:

$$\mathbf{Mass\ decayed = Original\ mass - Mass\ left}$$

Where**:** Original mass = mass at a time t = 0.
Mass left = mass corresponding to the given time

Example 5:
(2001 Qn. 4) (e) : The half life of a radioactive substance is 24 days. Calculate the mass of the substance which has decayed after 72 days, if the original mass is 0.64g.
Solution:

Method I: Using a table

Let the initial amount be N;
$M_0 = 0.64$ g ; $M_t = ?$; $t_{\frac{1}{2}} = 24$ days; $t = 72$ days;

Mass (g)	Number of half- lives, n	Time taken, t (days)
$M_0 = 0.64$	0	0
0.32	$1\mathbf{t_{\frac{1}{2}}}$	24
0.16	$2\mathbf{t_{\frac{1}{2}}}$	48
$M_t = 0.08$	$3\mathbf{t_{\frac{1}{2}}}$	72

From the table, the mass left after 72 days = 0.08 g

$$\mathbf{Mass\ decayed = Original\ mass - Mass\ left}$$
$$Mass\ decayed = 0.64 - 0.08$$
$$Mass\ decayed = \mathbf{0.56\ g}$$

Method II: Arrow Diagram (Crude method)

Try using the crude method, you will still get the mass left after 72 days $= \mathbf{0.08\ g}$ and Mass decayed $= \mathbf{0.56\ g}$

Method III: Using the formula

The mass remaining after a time t, M_t, when an original sample of mass $M_o$decays with a half- life of $t_{\frac{1}{2}}$ is given by;

$$\mathbf{M_t = M_o \left(\frac{1}{2}\right)^n : Where,\ n = \frac{t}{t_{\frac{1}{2}}}}$$

$$n = \frac{t}{t_{\frac{1}{2}}} = \frac{72}{24} = 3$$

$$N_t = N\left(\frac{1}{2}\right)^n :$$
$$N_t = 0.64 \times \left(\frac{1}{2}\right)^3 :$$
$$N_t = 0.64 \times \frac{1}{8}$$
$$N_t = 0.08 :$$

Thus, the mass left after 72 days = 0.08 g

$$\mathbf{Mass\ decayed = Original\ mass - Mass\ left}$$
$$Mass\ decayed = 0.64 - 0.08$$
$$Mass\ decayed = \mathbf{0.56\ g}$$

Example 6:
(2002 Qn. 23): The half life of a radio active substance is 10s. How long will it take for a mass of of 16g of the substance to reduce to 2g? **[Ans: t = 30s].**

Example 7:
(2008. Qn.8) (c): A radioactive element has a half life of 4 minutes. Given that the original count rate is 256 counts per minute,

(i) Find the time taken to reach a count rate of 16 counts per minute. **[Ans: t = 16 minutes]**
(ii) What fraction of the original number of atoms will be left by the time the count rate is 16 counts per minute? **[Ans: Fraction left $= \frac{1}{16}$]**

Example 8:
(a) The table below shows results obtained in an experiment to determine the half life of a radioactive substance.

Count rate	250	175	76	38	25
Time (min.)	0	5	10	15	20

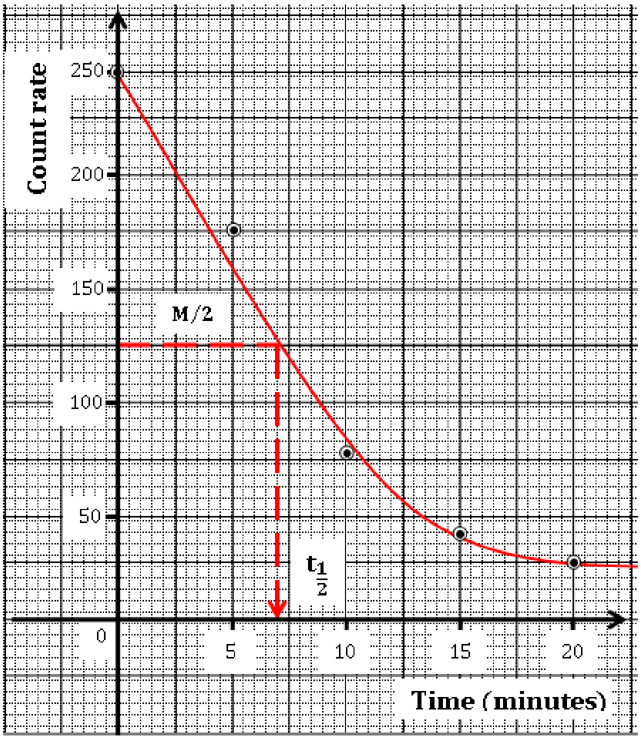
Draw a graph of count rate against time and use it to determine the half life of the radioactive substance.

(b) Explain why radioactive substances must be stored in thick lead containers.

(c) The nuclide $\mathbf{^{220}_{84}X}$ has a half life of 3000 years and decays to nuclide Y by emission of an alpha particle. and three beta particles

(i) State the meaning of the statement "Half- life of a nuclide is 3000 years."
(ii) Write a balanced equation for the decay process.
(iii) What percentage of the original sample of the nuclide, remains after three half lives.

Solution:
(a)



From the graph above, half life,

$$t_{\frac{1}{2}} = 5 + 4(0.5)$$
$$= \mathbf{7 minutes}$$

(b) Radioactive materials emit radiations, alpha, beta particles and gamma rays which are harmful to human life. Lead containers absorb these radiations and prevent them from coming into contact with people.

(c) (i) The element takes 3000 years to decay to half its original mass.

(ii)

$$^{220}_{84}X \longrightarrow {}^{216}_{85}Y + {}^{4}_{2}He + 3\,{}^{0}_{-1}e$$

(iii)

Method I: Using a table

%age mass	Number of half- lives
100	0
50	1
25	2
12.5	3

Therefore, 12.5% of the original mass will remain after 3 half lives.

Method II: Arrow Diagram (Crude method)

$$220 \xrightarrow{t_{\frac{1}{2}}} 110 \xrightarrow{t_{\frac{1}{2}}} 55 \xrightarrow{t_{\frac{1}{2}}} 27.5$$

Thus the percentage of the original sample that remains after 3 half lives is given by;

$$= \frac{\text{Mass left}}{\text{Original mass}} \times 100\%$$

$$= \frac{27.5}{220} \times 100\%$$

$$= 12.5\%$$

Method III: Using the formula

The mass remaining after a time t, M_t, when an original sample of mass M_o decays with a half- life of $t_{\frac{1}{2}}$ is given by;

$$\mathbf{M_t = M_o\left(\frac{1}{2}\right)^n : Where,\ n = \frac{t}{t_{\frac{1}{2}}}}$$

$$M_t = M_o\left(\frac{1}{2}\right)^n :$$
$$M_t = 220\left(\frac{1}{2}\right)^3 :$$
$$M_t = 220 \times \frac{1}{8} :$$
$$M_t = 27.5\text{ g}$$

Thus the percentage of the original sample that remains after 3 half lives is given by;

$$= \frac{\text{Mass left}}{\text{Original mass}} \times 100\%$$
$$= \frac{27.5}{220} \times 100\%$$
$$= 12.5\%$$

Exercise:

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

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

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

4. A radioactive sample has a half life of 3×10^3 years. Find how long it takes for three quarters of the sample to decay.

5. The activity of a radioactive element with a half life of 30 days is 2400 counts per second. Find the activity of the element after 120 days.

6. The count rate from a radioactive source is 138 counts per minute when the back ground rate is 10 counts per minute. If the half life of the source is 6 days, find the count rate after 18 days.

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

8. 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?
[**Ans:** 2.025×10^{24} atoms]

9. (a) The activity of a radioactive source decreases from 4000 counts per minute to 250 counts per minute in 40 minutes. What is the half life of the source?
(c) A carbon source initially contains 8×10^6 atoms. Calculate the time taken for 7.75×10^6 atoms to decay.

10. The table below shows the count rates of a certain radioactive material.

Count rate (s^{-1})	6400	5380	3810	2700	1910	1350
Time (min)	0	1	3	4	7	9

Plot a suitable graph and use it to find the half life of the material.

11. 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.

12. The following figures were obtained from Geiger miller 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

13. 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) What is the count rate after 200 minutes?
d) After how many minutes is the count rate 1000 minutes?

NUCLEAR REACTIONS:

A nuclear reaction is a process in which energy is produced by either splitting a heavy nucleus or combining two lighter nuclei at high temperatures.
A nuclear reaction takes place in a nuclear reactor.

Types of nuclear reactions:

(i) Nuclear fission

This is the splitting of a heavy unstable nucleus into two lighter nuclei with the release of energy.
This process can be started by bombardment of a heavy nucleus with a fast moving neutron. The products of the process are two light atom and more neutrons which can make the process continue.

Example:
When Uranium – 235 is bombarded with slow moving neutrons, Uranium – 236 is formed.
Uranium – 236 then under goes nuclear fission to form Barium, (Ba) and Krypton, (Kr) with the release of neutrons and energy according to the equation below.

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{236}_{92}U \rightarrow ^{144}_{56}Ba + ^{92}_{36}Kr + 2^{1}_{0}n + \text{Energy}$$

The energy released in a single nuclear fission reaction of a single Uranium atom is about **200 MeV.**

Conditions for nuclear fission to occur:
- Low temperatures.
- Fast moving neutrons

Application of nuclear fission:
- Used in making atomic bombs.
- Used to generate electricity.
- Used to generate heat energy on large scale.

Note: Nuclear reactors make use of controlled nuclear fission while **atomic bombs** make use of un controlled nuclear fission.

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(ii) Nuclear fusion:

This is the union (or combining) of two light nuclei at high temperatures to form a heavy nucleus with the release of energy.

Example:
When two Deuterium (Heavy hydrogen) nuclei combine at very high temperature (of about 10^8K), Helium – 3 and a neutron are produced accompanied by the release of energy according to the equation below.

$$^{2}_{1}H + ^{2}_{1}H \rightarrow ^{3}_{2}He + ^{1}_{0}n + \text{Energy}$$

Reactions of this type occur in the in the sun and stars and are the source of the sun's or star's energy.

Conditions for nuclear fission to occur:
- Very high temperatures.
- The light nuclei should be at very high speed to over nuclear division.

Application of nuclear fission:
- Used to produce hydrogen.
- Used in making atomic bombs.
- Used to generate electricity.
- Used to generate heat energy on large scale.

Similarities between nuclear fission and nuclear fusion.
- In both nuclear reactions, nuclear energy is released which can be used to generate electricity, heat or in atomic bombs.
- Energy changes in a nuclear reactor:

$$\begin{pmatrix}\text{Nuclear}\\ \text{energy}\end{pmatrix} \rightarrow \begin{pmatrix}\text{Chemical}\\ \text{energy}\end{pmatrix} \rightarrow \begin{pmatrix}\text{Kinetic}\\ \text{energy}\end{pmatrix} \rightarrow \begin{pmatrix}\text{Electrical}\\ \text{energy}\end{pmatrix}$$

Differences between nuclear fission and nuclear fusion.

Nuclear fission	Nuclear fusion
Is the disintegration of a heavy nucleus into two lighter nuclei..	Is the combining of two lighter nuclei to form a heavy nucleus.
Requires low temperature.	Requires high temperatures
Requires slow neutrons for bombardment	Neutrons are not required. For fusion to occur
High energy is released	Lower energy is released
Results into 4 products	Results into 3 products

Exercise:

1. (a) What is meant by radio activity?
(b) The equation below shows a reaction which takes place in a nuclear reactor.

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{236}_{92}U \rightarrow ^{141}_{x}Ba + ^{y}_{36}Kr + 3^{1}_{0}n + \text{Energy}$$

(i) Name the reaction represented by the equation
(ii) Find the values of x and y.

2. **(1991 Qn. 1).** The process whereby the nuclei of alight elements combine to form a heavy nuclei is called?
A. Fission B. Fusion
C. Ionisation D. Radioactivity

3. **(1993 Qn. 22).** The process by which a heavy nucleus split to form lighter nuclei is called?
A. Fission B. Fusion
C. Ionisation D. Radioactivity

4. **(1994 Qn. 18).** ${}^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{144}_{56}\mathrm{Ba} + {}^{92}_{36}\mathrm{Kr} + 2x$
The equation above represents a nuclear reaction. Identify ***x*.**
A. Proton B. Neutron
C. Alpha particle D. Beta particle

5. **(2000 Qn. 7).** In the atomic bomb, energy is produced by:
A. Fission B. Fusion
C. Thermionic emission D. Radioactivity

6. **(2001 Qn. 17).** When Uranium – 235 is bombarded with a neutron, it splits according to the equation;
$${}^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{M}_{N}\mathbf{P} + {}^{92}_{36}\mathrm{Kr} + 3{}^{1}_{0}\mathrm{n}$$
M and N on P represent;

	M	N
A	56	141
B	141	56
C	199	36
D	107	128

7. (a) (i) Distinguish between nuclear fission and nuclear fusion.
(ii) two conditions necessary for each to occur.

(b) State **one** example where nuclear fusion occurs naturally.
(c) State **one** use of nuclear fission.

(d) The following nuclear reaction takes place when a neutron bombards a sulphur atom.
$$\mathbf{{}^{34}_{6}S} \quad + \quad \mathbf{{}^{1}_{0}n} \quad \rightarrow \quad \mathbf{{}^{a}_{b}Y}$$
(i) Describe the composition of nuclide Y formed.
(ii) Nuclide Y decays by emission of an alpha particle and a gamma ray. Find the changes in mass and atomic number of the nuclide.