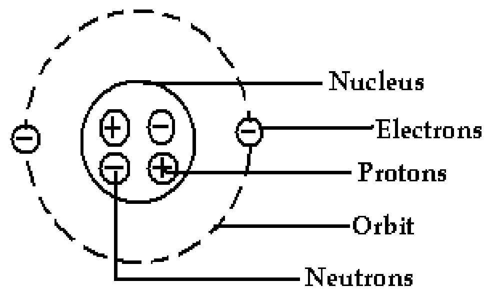
CHAPTER TWELVE

# MODERN PHYSICS
# ELECTRONS

## Atomic structure




An atom consists of a nucleus at its centre where its mass is concentrated. The nucleus consists of neutrons and protons and is surrounded by electrons which move around it in circular paths called orbits or shells.
In an atom, there are equal numbers of electrons and protons. Electrons carry a negative charge and protons and electrons in an atom form an electrically neutral combination.

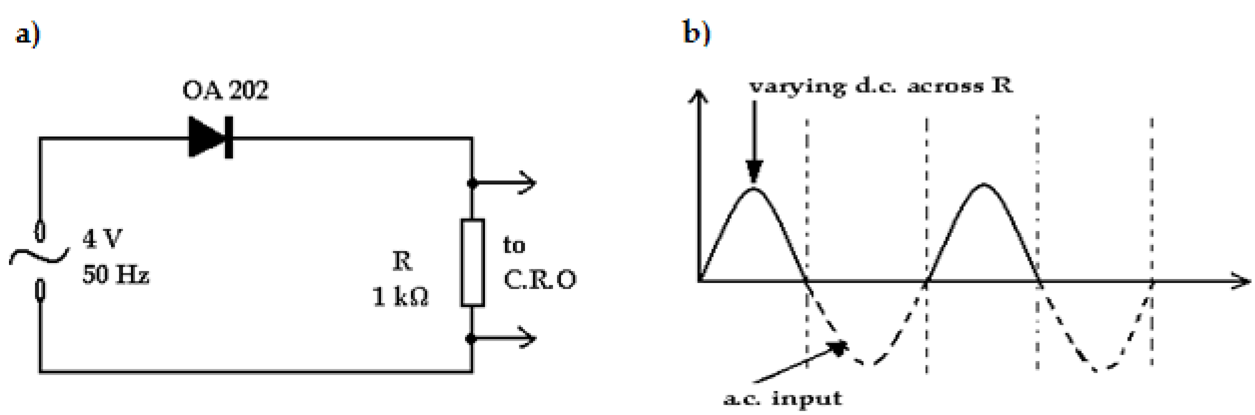
## Thermionic emission

When a metal is heated, the free electrons in it gain an extra energy which enables them to break through the surface of the metal and become free electrons.
The process by which electrons are emitted from hot metal surface is called **thermionic emission.**

## Rectification

A semiconductor diode rectifies, i.e. converts a.c. to d.c.

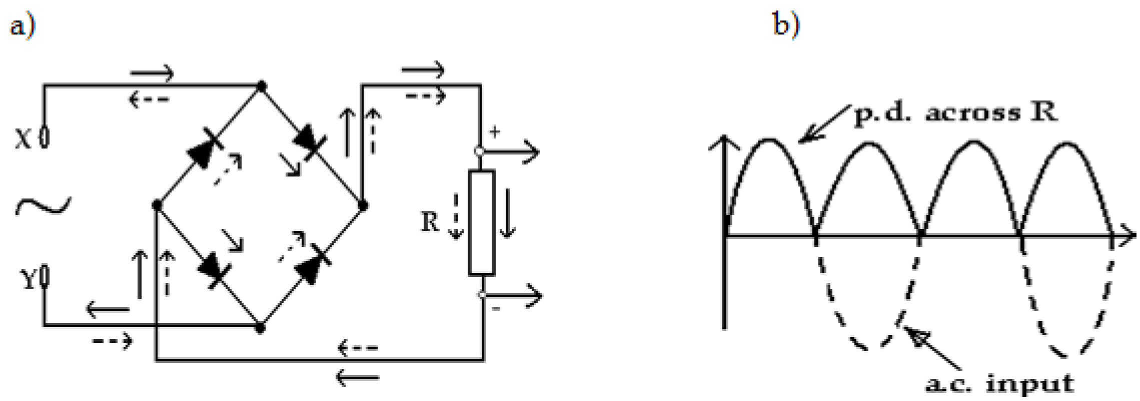
## a) Half wave rectification



The diode removes the negative half-cycles of a.c. to give a varying but one-way (direct) p.d. across R, the 'load' requiring a d.c. supply, Figure b above.

## Full wave rectification

Both the half-cycles of the a.c to be rectified are used. In the bridge circuit of fig. a, the current flows the solid arrows when X is positive and Y negative and the broken arrows on the negative half-cycles when the positive of X and Y are reversed. During both half-cycles, current flows in R and in the same direction giving a p.d. as shown below,



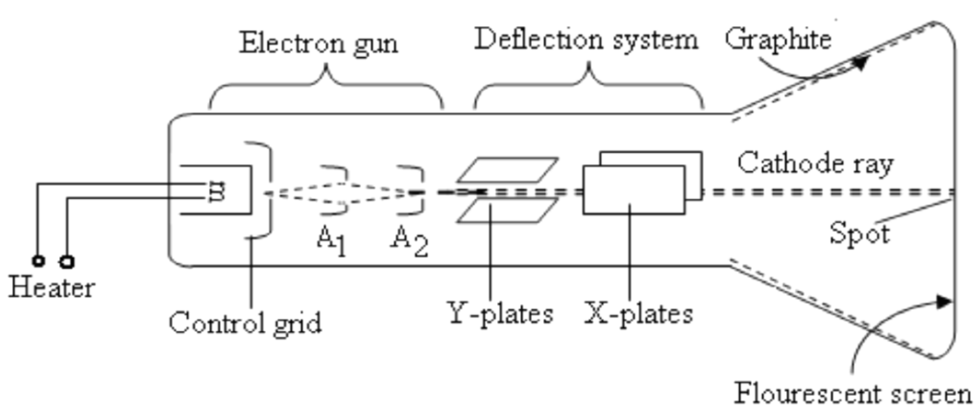

## Cathode rays

Streams of electrons moving at high speed are called cathode rays.

## CATHODE RAY OSCILLOSCOPE (C.R.O)

The C.R.O is one of the most important scientific instruments ever to be developed. It consists, like a television set.

A cathode ray tube has three main parts, as in figure below.




## a) Electron gun

This consists of a heater, a cathode **C**, another electrode called the grid **G**, and two or three anodes **$A_1$**, **$A_2$**. G is at negative potential with respect to C and controls the number of electrons passing through its central hole from C to A; it's the brightness control. The anodes are at high positive potential relative to C; they accelerate the electrons along the highly evacuated tube and also focus them into a narrow beam.

## b) Deflecting system

Beyond anode are two pairs of deflecting plates to which p.d.s can be applied. The Y-plates are horizontal but create a vertical electric field which deflects the beam vertically. The X-plates are vertical and deflect the beam horizontally.

## c) Fluorescent screen

A bright spot of light is produced on the screen where the beam hits it. The C.R.O. is of often used as a graph-plotter to display a wave form showing how a p.d. changes with time. The p.d is applied to the Y-plates and a circuit is switched on in the C.R.O., called the ***time base,*** which generates a p.d. across the X-plates. This sweeps the spot steadily and horizontally across the screen until it *flies back* very rapidly to the left of the screen and repeats the motion.

The time- base is an electrical circuit which generates a saw-tooth type of voltage shown below:

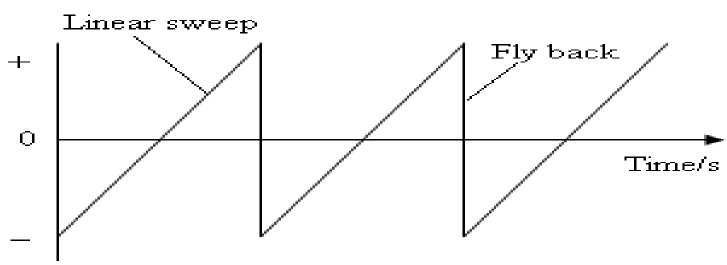
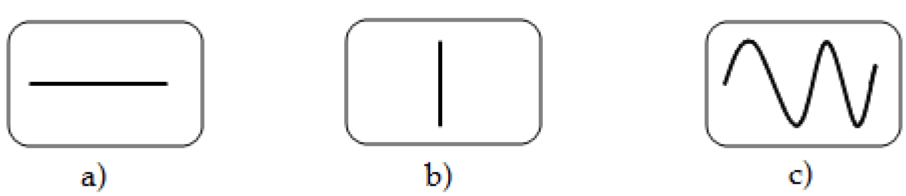



Figure below shows traces for
(a) Time base on X only,
(b) a.c. on Y only and
(c) a.c. on Y and time base on X.




The time- base is an electrical circuit which generates a saw-tooth type of voltage shown below:

## Properties of cathode rays

1. They heat objects onto which they fall. This shows that they have considerable energy.

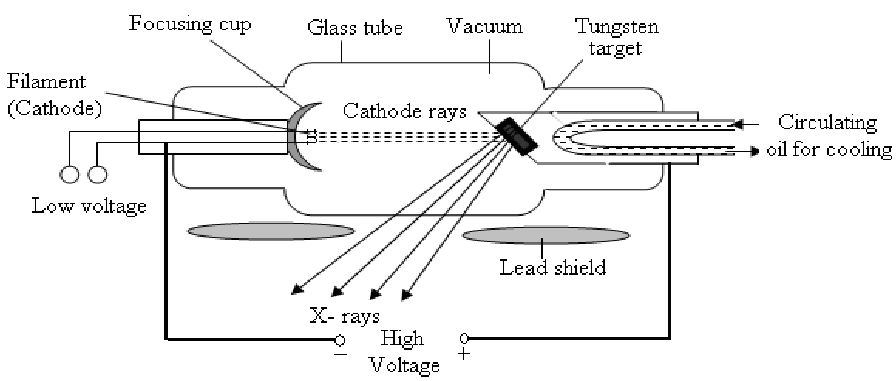
2. They have momentum and therefore have mass.
3. They are deflected by magnetic fields according to Fleming's left hand rule.
4. They are negatively charged.
5. They are deflected by electric field.
6. They cause glass and other materials to fluorescent.
7. They travel in straight lines.

### Uses of C.R.O

1. Measure voltage.
2. Measure frequency.
3. Measure phase difference.
4. Measure small time interval.
5. Measure drawing pictures on TV set.

## X-RAYS

An X-ray tube consists of a cathode filament focusing cup, a metal target which is usually made of tungsten which has a high melting point all enclosed in an evacuated tube, cooling fins (circulating oil for cooling), a low voltage supply and a high voltage supply.




The cathode filament is heated by a low voltage supply (p.d.) and the electrons are emitted by thermionic emission. These electrons are directed onto a metal target by the focusing cup. When a high voltage (20000V) is applied across the anode and the cathode, the electrons are accelerated to a very high speed towards the target. On striking the target, the electrons are instantly brought to rest. Because of this, they give up all their energy to the target. About 99% of the energy appears as heat and about less than 1% of the energy appears as electromagnetic radiations called ***X-rays.***

The heat produced in the target is removed by means of cooling fins.

***There are two types of X-rays; soft and Hard.***

*a) Soft X-rays are produced at low voltage and they have low penetrating power, energy and long wave lengths.*

*b) Hard X-rays are produced at high voltage and they have a high penetrating power, high energy and short wave length.*

## Properties of X-rays:

They are electromagnetic radiations. I.e. they van pass through flesh but not bones.

1. They really penetrate matter up to 1mm of lead.
2. They ionize gas.
3. They give interference and diffraction effects.
4. They are not deflected in an electric or magnetic field.
5. They carry no electric charge.
6. They travel in straight lines.
7. They cause florescence.
8. They affect a photographic film.

## Uses of X-rays

In hospitals, X-rays are used to:

1. Investigate the Lungs to detect tuberculosis.
2. Investigate the broken bones in x-ray photography.
3. Treat cancerous diseases and other malignant growth in human body.

## Industrial uses of X-rays

1. They are used to detect defects in motor tyres.
2. Study the structure of crystals.
3. To detect cracks which are invisible to the eye, in metal casting and welding joints.

## Health hazards of X-rays

1. They damage blood and eye sight.
2. They can cause serious diseases which may appear sometimes many years after the time of irradiation.
3. They destroy living cells in our bodies.
4. They can produce genetic changes which appear in subsequent generation.

## Safety precautions of X-rays

1. Unnecessary exposure to X-ray must be avoided.
2. If exposure is necessary, it should be for a very short time.
3. Repeated exposure of X-rays to a patient must be avoided.
4. There should be no X-ray exposure for babies, born or unborn.
5. The technicians in X-ray laboratories should wear lead coated overcoats.
6. Exposure should be for the part affected only.

7. If necessary at all, the other parts of the body must be covered with layer of lead material.

# RADIOACITIVITY

## Introduction:
Some naturally occurring elements are unstable. They slowly and spontaneously decompose to gain stability by throwing away sub-atomic particles (portions of their nuclei).
Such elements are called radioactive elements.

*Examples* of radioactive elements are:
Uranium (U), radium (Ra), polonium (Po), protactinium (Pa).
The emission of the sub-atomic particles to gain stability is called radioactivity.

## Definition:
*Radioactivity is the spontaneous disintegration of unstable radioactive element with emission of radiations (sub-atomic particles) and energy.*

Examples of radiation detectors are;
(i) The spark counter
(ii) The Geiger- muller (G-M) tube.

Types of radiations:
There are three types of radiations, namely:
(i) Alpha particle (α).
(ii) Beta particle (β)
(iii) Gamma ray (γ).

### Radiations and their properties

## a) Alpha particles (α)
***Alpha particles** are high speed helium nuclei.* The symbol for an alpha particle is ${}^{4}_{2}He$. Where the superscript (4) is the nucleon (mass) number and the subscript (2) is the proton number. They are called particles as a result of their appreciable mass.

**Properties:**
(i) They are positively charged and the magnitude of the charge is double that of an electron.
(ii) They cause intense ionization in gas.
(iii) They have very short range in air of a few cm (5-8cm).

(iv) They are stopped by a thick sheet of paper.
(v) They have a speed less than that of light.
(vi) They are deflected by electric and strong magnetic fields.
(vii) They affect photographic films.
(viii) They produce flashes when incident on fluorescent substances.

## Note:

When a nuclide undergoes alpha decay:
It loses two protons and neutrons hence its nucleon (mass) number reduces by four.
Its atomic number reduces by two and
The daughter nuclide (new element formed) is two steps to the left in the periodic table.
A nuclide is an atomic species of an element which emits radiations, particles and energy spontaneously from its nucleus

**General Nuclear Reaction Equation for a- particle decay**

$$\underset{\text{Parent Nuclide}}{{}^{y}_{x}A} \longrightarrow \underset{\text{daughter Nuclide}}{{}^{y-4}_{x-2}V} + \underset{\text{Alpha particle}}{{}^{4}_{2}\alpha} + \text{energy}$$

**E.g.** Uranium decays by emitting alpha particles to become thorium.

$${}^{238}_{92}U \longrightarrow {}^{234}_{90}Th + {}^{4}_{2}He$$

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

The thorium and the lead formed are stable.
This change of one element to another is called transmutation.

## b) Beta (β) particles or rays ( ${}^{0}_{-1}e$)

***Beta particles*** *or rays are high speed electrons emitted from radioactive element.*
These electrons result from the decay of a neutron to a proton according to the equation:

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

**Properties:**

(i) They are negatively charged.
(ii) They are more penetrative than alpha particles. This is because of their high speed.
(iii) They are more easily deflected in both electric and magnetic fields.

(iv) Their ionizing power is much less than that of α- particles.
(v) They are stopped by a thin sheet of aluminium.
(vi) They have a range in air of several metres.
(vii) They produce flashes when incident on fluorescent substances.

**General Nuclear Reaction Equation for beta (β) decay**

$$ {}^{y}_{x}A \longrightarrow {}^{y}_{x+1}Q \quad + \quad {}^{0}_{-1}\beta \quad \text{Energy} $$

| Parent Nuclide | | Daughter Nuclide | Alpha particle |
|---|---|---|---|

**Note**: When a nuclide undergoes beta decay:
Its atomic number increases by one.
Its nucleon (mass) number remains the same and
The daughter nuclide (new element formed) is one step to the right in the periodic table.

## c) Gamma ray (γ).

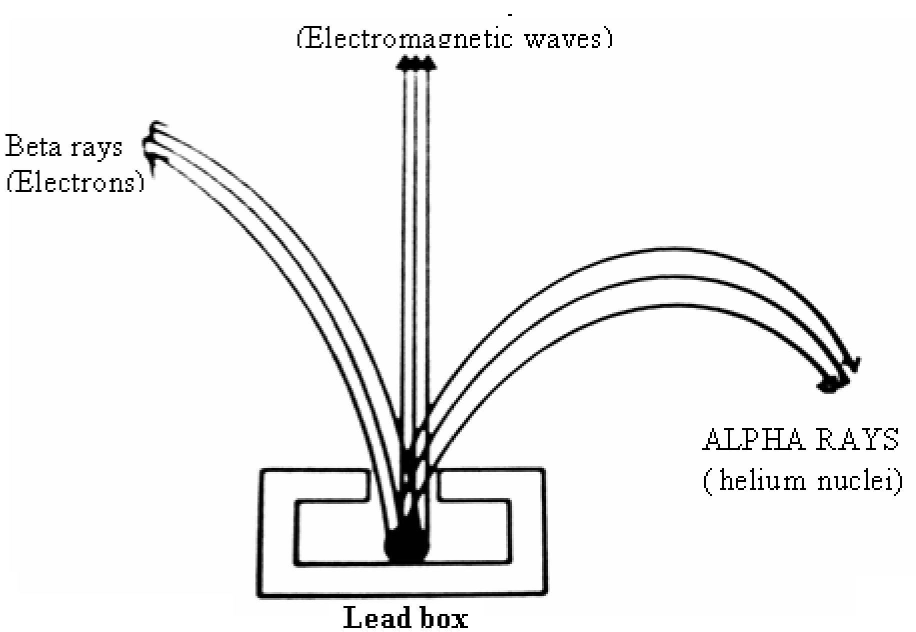
*A **gamma ray** is a very-high –energy form of electromagnetic radiation with very short wavelength.*
The wave lengths range from $10^{-10}$m below as such their wavelengths are shorter than those of X-rays.

**Properties**
They travel at speed of light ($3.0 \times 10^{8}ms^{-1}$) since they are electromagnetic radiations.
They have neither mass nor charge.
They are not deflected by both electric and magnetic fields.
Their have much more penetrating power than both α-particles.
They have ionization effect less than beta particles.
They have interference and diffraction effects.
They are absorbed by thick block of lead.
They cause fluorescence when incident on fluorescent substances.

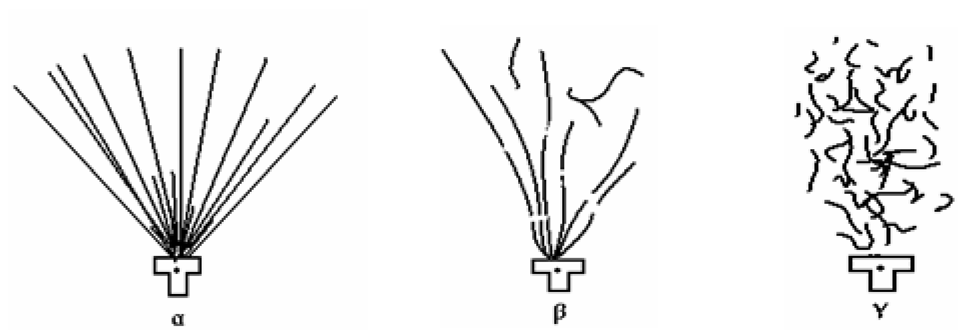
## Laws of radioactive decay

1. When an element disintegrates by the emission of an α-particle it turns into an element with chemical properties similar to those of an element two places earlier in the periodic table.
2. When an element disintegrates by the emission of a β -particle it turns into an element with properties similar to those of an element one place later in the periodic table.

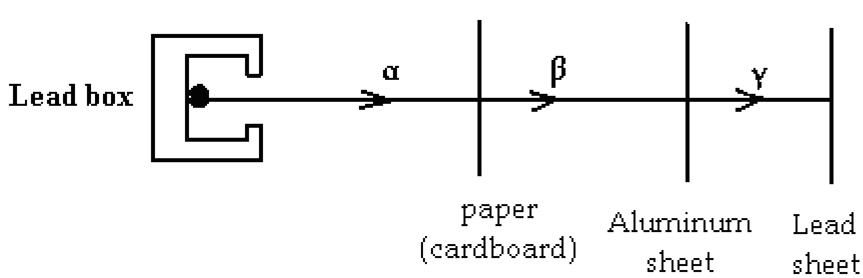
*The diagram of radioactivity showing the three radiations*



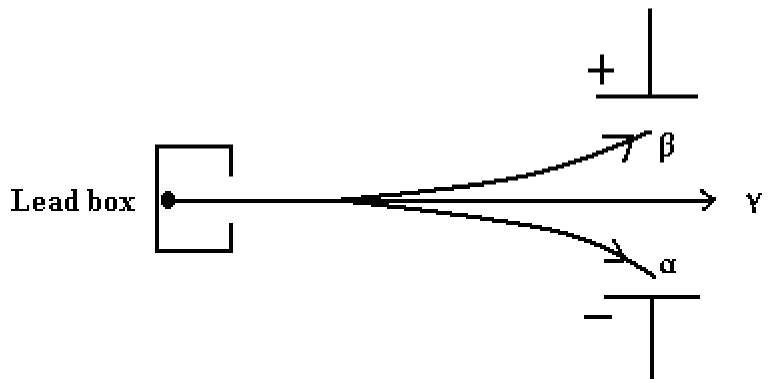

*The diagram showing the tracks of the three radiations*




*The diagram showing the three radiations passing through paper, aluminum Sheet and lead*




## *The diagram showing the three radiations passing through an electric field*




## Differences between α and β particles

An alpha particle (α) is a helium ion with a positive charge while a Beta particle is an electron with negative charge

An alpha particle can penetrate thin paper (low penetrating power) while a beta particle can penetrate thin metal foil (high penetrating power).

An alpha particle has mass of 4 units while a beta particle has negligible mass.

## Comparison between Gamma rays and X- rays

X-Rays differ from gamma rays in two ways.

Gamma rays have much shorter wavelength than X-rays.

Gamma rays originate from the nuclei of atoms while X-rays are as a result of orbital electron transitions or jumps.

## Health Hazards of Radioactive Radiations

Radioactive radiations are dangerous to life. This is because they damage body cells.

**a) Alpha particles:**

The danger from alpha particles is small unless the source enters the body.

**b) Beta and gamma radiations**

They cause:

Radiation burns (i.e. redness and sore on the skin),

Leukemia, (blood cancer),

Sterility (inability to produce children),

Low body resistance to normal diseases as a result of damage to blood corpuscles.

Mutation, a genetic change, occurring during DNA replication and protein synthesis.

The effects appear in the subsequent generations. E.g. a child may be born with one arm both with one arm shorter than the other.

## Safety Precautions:

Radioactive sources should be handled with care.
They should always be handled with forceps and never be touched with bare hand.
No eating, drinking or smocking must be done where radioactive sources are in use.
Hands should be washed thoroughly after exposure to any radioactive material.
Any cuts in the body should be covered before using radioactive source.
During experiments the sources of radioactive elements should be arranged such that the radiation window point away from your body.
Radioactive sources should always be kept in lead boxes when not in use.

## Applications of Radioactivity

Despite the dangers associated with radioactivity, there are many useful applications as seen in the following fields.
Medical, Agriculture, Industry, and Archaeology.

**Uses of Radioactivity**

**(i) Medical**

In medical they are used

- as tracers in medicine.
- to treat cancerous cells (radiotherapy).

**(ii) Agriculture**

In agriculture they are used to produce varieties of plants with new characteristics e.g. Resistance to plant diseases.

**(iii) Industry**

Industrially, radioactivity is used

- to provide source of energy.
- to measure the thickness of metal sheets.
- in food preservation.

**(iv) Archaeology**

- Radioisotopes of carbon is used to date archaeological remains dead living organisms. This is referred to as carbon dating.

- Determining the age of fossils (remains of old plants and animals) every living thing (plant or animal) has a certain constant quantity of carbon -14 elements (isotope). When the plant or animal dies this isotope begins decaying and the rate of disintegration decreases with time. So when a fossil is obtained the rate of disintegration is determined, and this is used to calculate the age of the fossil. i.e. when the plant or animal died, which would show when that type of plant or animal existed.

## Definitions

***Atomic number*** *is the number of protons or electrons in an electrically neutral atom.*

***Mass number*** *is the total number of protons and neutrons in the nucleus of an atom.*

**N.B:** An atom of an element X of mass number A and atomic number Z and neutron number N is represented as:

$$A = N + Z$$

***Isotopes*** *are atoms of the same element with the same atomic number but different mass numbers.*

e.g: $^{35}_{17}Cl$ and $^{37}_{17}Cl$, $^{1}_{1}H$ and $^{2}_{1}H$.

***Radioisotope*** *is an isotope which undergoes spontaneous decay (radioactivity) with emission of radiations.*

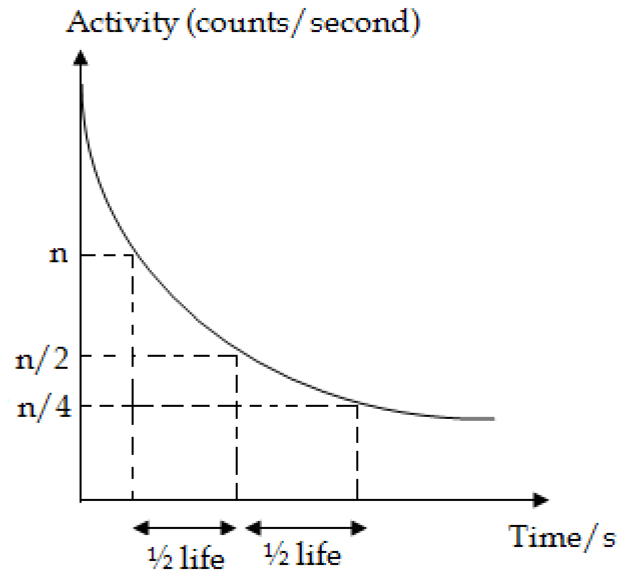
- ***Industrial application of radioisotope:*** sodium -24($^{24}_{11}Na$) is used as tracer in pipelines of water or sewage to study the progress of flow, so can detect blockage or leakage.

# HALF LIFE

***Half life*** *is the time taken for a radioactive substance to decay to half of its original mass*.

T- half life can be in seconds, minutes, hours, days, months and years.

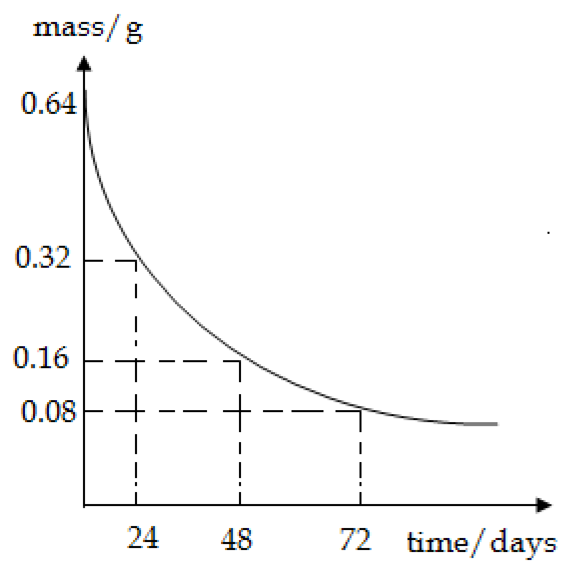
Figure below shows a typical decay curve for a radioisotope obtained by plotting the readings of a rate meter which is used to measure the activity over a period of about three half lives. From such a graph the half life may be found as follows.
If the count rate is n at some time $t_1$ and has fallen to n/2 at time $t_2$, then the half life is ($t_2$-$t_1$).
Similarly, if the count rate has fallen to n/4 at time $t_3$, the half life is ($t_3$-$t_2$).



Decay curve for a radioactive substance

**Example:** The half life of a radioactive substance is 24 days. Calculate the mass of the substance which decayed after 72 days if the original mass is 0.64g.

**Solution:** *Half Life T* = *24 days*
*Time of decay* = *72 days*
*Original mass* = *0.64g*




*Mass left after 72 days* = *0.08g*
*Mass that has decayed after 72 days* = *0.64 – 0.08*
= *0.56g*

**Example**: The half life of a sample is 14 days, starting with activity 32g, calculate how long it will take for the mass to drop to 2g.

**Solution :**

$$32g \xrightarrow[14days]{T} 16g \xrightarrow[14days]{T} 8g \xrightarrow[14days]{T} 4g \xrightarrow[14days]{T} 2g$$

The mass will drop to 2g after 4half lives

Now T =14 days

$$4T = x \quad \Rightarrow \quad x = \frac{14\,days\;x\;4T}{T} = 56\,days$$

**Example**: A 40g sample of a radioactive substance reduced to 2.5g in 96 days.

(i) What was its half life

(ii) How much will it remain after another 96 days

**Solution**

(i)

$$40g \xrightarrow{T} 20g \xrightarrow{T} 10g \xrightarrow{T} 5g \xrightarrow{T} 2.5g$$

The mass dropped from 40g to 2.5g after 4 half lives

Now $4T_{1/2} = 96 \Rightarrow \quad T_{1/2} = \mathbf{24days}$

(ii) $(1/2)^4 \times 2.5 = 1/16 \times 2.5 = \mathbf{0.15625g}$ *or*

$$2.5g \xrightarrow{T} 1.25g \xrightarrow{T} 0.625g \xrightarrow{T} 0.3125g \xrightarrow{T} 0.15625g$$

Example: The following figures were obtained from the reading of a counter source. Plot a graph of the count rate against time and deduce the half life of the source.

| Time s) | 0 | 20 | 40 | 60 | 80 | 100 | 120 |
|---|---|---|---|---|---|---|---|
| Corrected counts | 120 | 74 | 48 | 30 | 20 | 12 | 8 |

## NUCLEAR REACTIONS

There are two types of nuclear reactions;

(i) Nuclear fusion

(ii) Nuclear fission

(a) **Nuclear fission:**

It is the splitting of a nucleus into two or more nuclei releasing radioactive particles (α,β,γ) and energy.

## Conditions for nuclear fission

- Nuclear fission takes place in the presence of slow moving neutrons
- Low temperature

Example of Nuclear fission is the bombardment of $^{235}_{92}U$ by slow neutrons.

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{236}_{92}U \rightarrow ^{144}_{56}Ba + ^{90}_{36}Kr + 2^{1}_{0}n + \text{Energy}$$

- The energy released by nuclear fission of a single atom of uranium is about 200meV.
- Nuclear reactors make use of controlled fission to provide energy while nuclear the atom bomb makes use of uncontrolled fission reaction.

**(b)** **Nuclear fusion:**

It is the joining together of two or more nuclei to form one nucleus releasing energy and radioactive particles.

## Conditions for nuclear fusion

Nuclear fusion takes place at very high temperature about $10^8$K. The high temperature provides the nuclei which are fuse with the energy needed to overcome their mutual electrostatic repulsion.

**E.g.** The fusion of two deuterium nuclei to produce helium 3

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

Reactions of this type occur in the sun & stars and the source of the sun's/ stars` energy.

**Difference between**

| Nuclear fission | Nuclear fusion |
| --- | --- |
| Is the disintegration of a heavy nucleus into two lighter nuclei | Is the combining of two light nuclei to form a heavy nucleus |
| Requires low temperature/energy | Requires high temperature/energy |
| Requires low neutrons for bombardment | Neutron are not required but are a product of fusion |

| | |
|---|---|
| Result into four products | Results into three products |
| Energy released is high | Energy released is low |

- In both fission and fusion energy is released and this energy is called nuclear energy. This energy can be used to generate electricity or in atomic bombs.

Similarities

Both processes release energy

The energy provided per unit mass of reactant by the two processes are much the same.

# TEST 12

## SECTION A

1. The following equations represent the part of radioactivity series.

$$^{234}_{90}Th \rightarrow \quad X\text{-Radiation}$$

Substance x and the radiation in the equation above are

A. $^{234}_{91}Pa$ and gamma

B. $^{230}_{90}Th$ and beta

C. $^{230}_{90}Th$ and gamma

D. $^{234}_{91}Pa$ and beta

2.

| Element | Neutrons | Protons | Electrons |
|---|---|---|---|

| | | | |
|---|---|---|---|
| P | 6 | 6 | 6 |
| Q | 8 | 6 | 6 |
| R | 2 | 2 | 2 |
| S | 2 | 3 | 3 |

The table above shows the structure of four atoms P, Q, R, and S. Which ones are isotopes of the same elements?

A. P and Q B. Q and R

C. P and S D. P and S

3. Streams of electrons moving at a high speed are called

A. x-rays B. gamma rays

C. cathode rays D. alpha particles

4. An atom contains 3 electrons, 3 protons and 4 neutrons. Its nucleon number is

A.3 B. 4 C.6 D.7

5. 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

6. Radium nucleus ${}^{226}_{98}\mathrm{Ra}$ decays to Radon (Rn) by $a$-particle emission. What is the nuclear equation for this reaction?

a) ${}^{226}_{88}\mathrm{Ra} \rightarrow {}^{3}_{2}\mathrm{He} + {}^{223}_{86}\mathrm{Rn}$

b) ${}^{226}_{88}\mathrm{Ra} \rightarrow {}^{4}_{2}\mathrm{He} + {}^{222}_{86}\mathrm{Re}$

c) ${}^{4}_{2}\mathrm{He} + {}^{222}_{86}\mathrm{Rn} \rightarrow {}^{226}_{88}\mathrm{Ra}$

d) ${}^{226}_{88}\mathrm{Ra} \rightarrow {}^{225}_{88}\mathrm{Rn} + {}^{1}_{0}\mathrm{N}$

7. Which of the following are properties of X-rays? They

(i) carry no charge

(ii) are longitudinal waves

(iii) are not deflected by the magnetic and electric fields

(iv) travel in straight lines.

| | | | |
|---|---|---|---|
| (a) | (i), (ii) and (iv) only | (b) | (i), (ii) and (iii) only |
| (c) | (ii), (iii) and (iv) only | (d) | (i), (iii) and (iv) only. |

8. State the radiations that may be emitted by a radioactive substance

(a) Alpha, gamma and x-rays
(b) Cathode rays, x-rays and beta
(c) gamma, alpha and Beta
(d) Cathode rays, x-rays and alpha

9. When Uranium 235 is bombarded with a neutron, it splits according to the equation

$$^{235}_{92}U \quad + \quad ^{1}_{0}n \quad \rightarrow \quad ^{M}_{N}P \quad + \quad ^{92}_{36}Kr + 3^{1}_{0}n.$$

M and N on P represent

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

10. The brightness on the screen of a T.V is determined by

(a) darkness in the room
(b) the size of the screen
(c) the number of electrons reaching the screen
(d) direction of the aerial

11. Which one of the following relations is from the nucleus of an atom?

| | | | |
|---|---|---|---|
| A. | Cathode rays | B. | Gamma rays. |
| C. | Infra red rays. | D. | Ultra violet rays. |

12. In the atomic bomb, energy is produced by

| | | | |
|---|---|---|---|
| A. | fusion. | B. | fission. |
| C. | radioactivity. | D. | thermionic emission. |

13. Which of the following are attracted towards the negative plate in an electric field?

| | | | |
|---|---|---|---|
| A. | Beta particles. | B. | Alpha particles |
| C. | Gamma rays. | D. | Neutron. |

14. Which one of the following are properties of Cathode rays?

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

15. The cathode ray oscilloscope may be used to
(i) measure energy.
(ii) measure potential difference.
(iii) display wave forms.

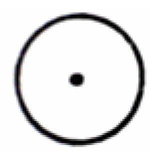
A. (i) only. B. (i) and (ii) only.
C. (ii) and (iii) only. D. (i), (ii) and (iii).

16. Which of the following represents an appearance on the screen of a cathode ray oscilloscope when a. d.c. voltage is connected across the Y-plates with the time-base switches on?


(a)


(b)


c)


d)

17. Which one of the following is a properties of X-rays?
A. They can deflected by magnetic field.
B. They can ionize matter.
C. They can cause photo-electric emission.
D. They can electrically charged particles.

18.


(a)


(b)

Fig. 3

The above figure shows a spot on the screen of a cathode ray oscilloscope. The spot can be turned in an horizontal straight line as 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 an a.c voltage to the Y-plates

19. A possible isotope of ${}^{3}_{3}Li$ has
A. two protons and three neutrons
B. two protons and four neutrons
C. three protons and four neutrons
D. four protons and three neutrons

20. ${}^{228}_{90}Th \rightarrow {}^{A}_{Z}X$ + alpha particle.
The above equation represents an activity in which thorium decays and emits an alpha particle. Find the value of Z.

A. 88 B. 89 C. 91 D.92

21. 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

22. Element X emits radiation R and forms element Y as given in the equation

$${}^{A}_{Z}X \rightarrow {}^{A}_{z-1}Y + r$$

While A and Z are mass and atomic members respectively radiation R is
a) alpha particles
b) beta particles
c) gamma rays
d) X-rays

23. The atomic number of an element is the number of

(a) protons in its atom
(b) neutrons in its atom
(c) electrons and protons in its atom
(d) neutrons and protons in its atom

24. Nuclear fission occurs when

(a) Uranium is heated to a very high temperature
(b) Two deuterium (heavy hydrogen) atoms come together
(c) A hydrogen molecule splits into two atoms
(d) Nuclei of Uranium atoms split into lighter nuclides.

25. Background radiation is due to
(i) cosmic rays from the sun
(ii) microwaves
(iii) radioactive fall out
(iv) radiations from T.V set

(a) (i), (ii) and (iv) only (b) (i) , (ii) and (iii)
(c) (i),(iii) and (iv) only (d) (ii), (iii) and (iv) only

26. Two alpha particles are produced when an unknown particle $x$ is used to bombard lithium $^7{}_3Li$ as shown in the equation

$$^{7}_{3}Li \quad + \quad x \quad \rightarrow \quad ^{4}_{2}He \quad + \quad ^{4}_{2}He$$

What is $x$ ?

(a) A beta particle (b) An alpha particle
(c) A neutron (d) A proton

27. The difference between hard and soft X-rays is that

(a) hard X-rays travel faster than soft X-rays
(b) hard X-rays penetrate more than soft X-rays
(c) hard X-rays are less dangerous than soft X-rays
(d) soft X-rays are produced at high potential differences.

28. An atom has a mass number 88 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) (b) (i) and (iii)
(c) (ii) and (iii) (d) (i), (ii) and (iii)

29. If $^{a}_{b}$X and $^{c}_{d}$Y are isotopes, then

| | | | |
|---|---|---|---|
| (a) | a = c | (b) | a = d |
| (c) | b = c | (d) | b = d |

30. The process by which heavy nuclei split to form lighter nuclei is called

| | | | |
|---|---|---|---|
| a) | fusion | b. | fission |
| c). | Ionisation | d. | Radioactivity |

31. When the nucleus of a radioactive atom loses an alpha particle, the atomic number

| | | | |
|---|---|---|---|
| A. | remains the same | B. | increases by one |
| C. | decreases by two | D. | decreases by four |

32. Infrared radiation cannot detected by

A. A Geiger Muller tube
B. A photographic film
C. A fluorescent paint
D. A thermometer with a blackened bulb.

33. Which one of the following parts of the cathode ray tube form the electron gun?

a) Cathode, metal anode, heater, grid
b) Grid, metal anode, cathode, Y-plates
c) Cathode, grid, heater, X-plates
d) Cathode, metal anode, grid, heater, X-plates, Y-plates.

34. The brightness of the spot of the C.R.O. screen is controlled by
(a) X-plates (b) Anode (c) grid (d) cathode

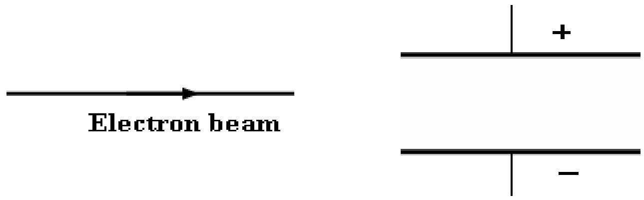
35. Which of the following are properties of cathode rays.
(i) they are electrically neutral.
(ii) they travel in straight lines.
(iii) they are deflected by magnetic fields

| | | | |
|---|---|---|---|
| (a) | (i) and (ii) only | (b) | (i) and (iii) only |
| (c) | (ii) and (iii) only | (d) | (i), (ii) and (iii) only |

36. Which of the following are attracted towards the negative plate in an electric field?

| | | | |
|---|---|---|---|
| A. | Beta particles. | B. | Alpha particles. |
| C. | Gamma rays. | D. | Neutron. |

37.




A beam of electrons is incident midway between two changed plates as shown above. The beam will

(a) deflect upwards
(b) deflect downwards
(c) move perpendicular to the plates
(d) pass through the plates un deflected.

38. Isotopes are nuclides with the same number of
(a) protons 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 neutrons

39.

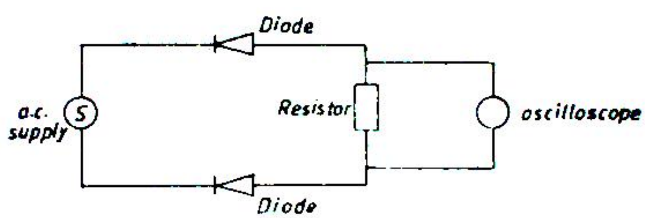
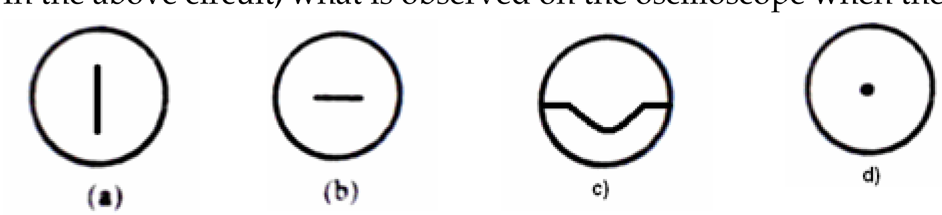



Fig.1

In the above circuit, what is observed on the oscilloscope when the time base is on ?




40. Which one of the following is the correct order in which some energy changes occur in the electron gun of the cathode ray tube?

| | | | | | |
|---|---|---|---|---|---|
| A. | light | → | heat | → | K.E |
| B. | electric | → | light | → | heat |
| C. | Electric | → | heat | → | K.E |
| D. | sound | → | electric | → | heat |

41. The phenomenon by which electrons are realesed from a metal surface when radiation falls on it is known as

(a) radio activity (b) photoelectric effect

(c) thermonic emission (d) reflection

42. A radioactive element may emit

1. alpha particles
2. gamma rays
3. beta particles
4. protons.

A. 1,2,3 only B. 1,3 only

C. 2,4 only D. 4 only

43. A sinusoidal wave is observed on a cathode ray oscilloscope when

(a) A cell is connected to the the Y plates with a time base off

(b) a low frequency alternating voltage is connected to the Y plates with the time base on

(c) a high frequency alternating voltage is connected to the Y plates with the time base on.

(d) a cell is connected to the Y plates with the time base on

.

SECTION B

1. (a) Describe a simple of the atom.

(b) What is meant by radioactivity?

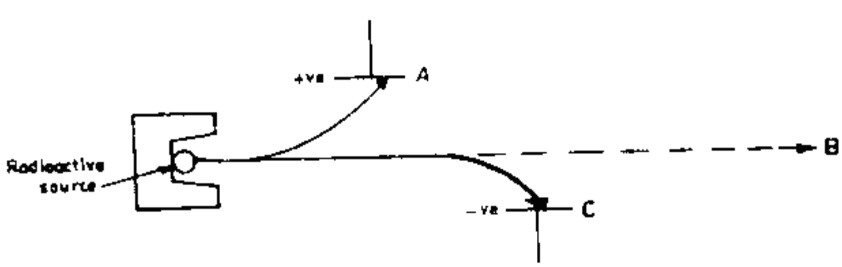
2. a) (i) What is meant by nuclear fission?

(ii) Give one method of starting the process in (a) (i).

(b) (i) Account for the energy released in nuclear fission?

(ii) State one use of nuclear energy.

3.



A radioactive source emits radiation, which are directed between two positively charged metal plates as shown in the figure above.

(a) Name the radiation labeled A, B and C.

(b) What happens when the radioactive source is completely covered with an ordinary sheet of paper.

4. (a) Define the following;

(i) atomic number

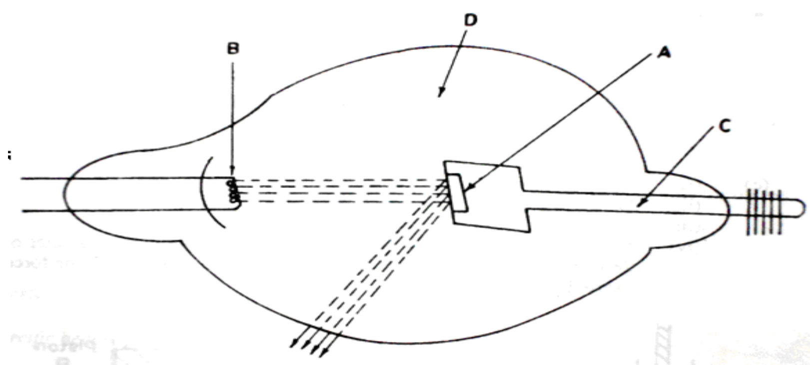
(ii) isotopes of an element

(b) State two differences between an α - and a β -particle

(c) (i) What is meant by nuclear fission and nuclear fusion.

(ii) Give one example where each one occurs

5. Figure below shows the main parts of an x-ray tube.




(a) Name the parts labelled A, B, C and D.

(b) List in order the energy changes, which occur in the x-ray tube.

(c) Describe one industrial use of x-rays.

6. Name the electromagnetic radiation which

(i) causes sensation of heat.

(ii) passes though a thin sheet of lead.

(iii) is used in satellite communication.

(iv) is used for remote control of a television receiver.

7. The symbol $^{235}_{92}U$ denotes a uranium nucleus.

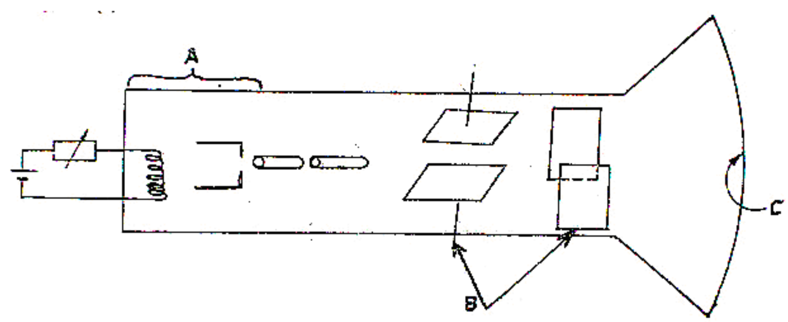
(a) What is the meaning of?

(i) 235?

(ii) 92?

(b) Write down a balanced nuclear equation showing the decay of $^{235}{}_{92}U$ to a nuclide X by emission of an alpha particle.

8. a)




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

(i) Name the parts labelled A,B and C

(ii) Why is the C.R.O evacuated?

(b) (i) Describe briefly the principals of operation of C.R.O

(ii) How is the bright spot formed on the screen?

(c) Use diagrams to show what is observed on the screen of a C.R.O when

(i) the C.R.O is switched on and no signal is applied on the Y-plates

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

(iii) an alternating signal is applied on the Y-plates while the time base is switched off

(d) Give two uses of the C.R.O

9. (a) What is meant by the atomic number of an element?

(b) One isotope of neon is denoted by $^{20}{}_{10}Ne$. how many neutrons does the isotope have?

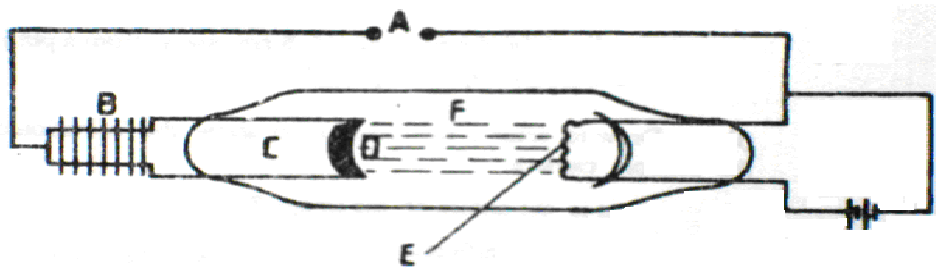
(c) $^{60}_{70}Co$ is a radioactive isotope of cobalt which emits a beta particle and very high energy gamma rays to form an element X. Write a balanced equation for the nuclear reaction.

10. (a) (i) What is meant by a radio isotope?

(ii) State one industrial application of radio isotopes.

(b) Describe what happens when a beam of radiation consisting of α-, β- and γ-rays is incident on a thin sheet of lead.

(c) The diagram above shows the essential parts of an X-ray tube.

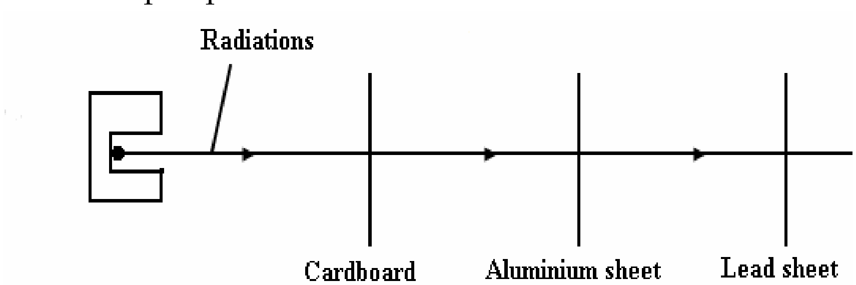



(i) Name the parts labelled A, B, C, D, E and F.
(ii) State the function of each part.
(iii) Describe how X-rays are produced.

(d) What safety precautions must be taken in an X-ray laboratory?

11. (a) What is a radioactive nuclide?
(b) A radioactive element X decays by emitting an alpha particle and gamma rays. Write a balanced equation for the decay.
(c) State what happens to a beta particle as it passes in between two oppositely charged plates.

12. a) What is an alpha particle?




(b) A radioactive source decays by emission of all the three radiations. The radiation centre normally into an electric field as shown in the figure above. Which radiations are most likely to be detected at
(i) position A
(ii) position B
(iii) position C

(c) A radioactive source which emits all the there radiations is placed in front of a cardboard, aluminium and lead sheets as shown in the figure above. Name the radiations likely to be between the:
(i) cardboard and the aluminium sheet,
(ii) aluminium and lead sheets

(d) Name any three precautions, which must be under taken by one working with ionising radiation.

(e) name one:
(i) industrial use,

(ii) biological use, of radioactivity.

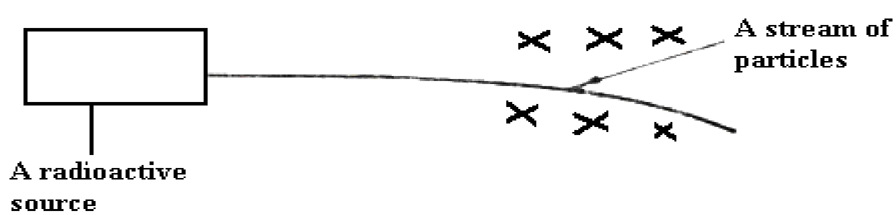
13. (a) What is meant by the terms
   (i) Isotopes
   (ii) Radioisotope
   (b) (i) Name and state the nature of the emissions from radioactive nuclides
   (ii) What effect does each of the emissions have on the parent nuclide?
   (c) Give two uses of radioactivity.

14. (a) Define the terms atomic number and mass number
   (b) When lithium is bombarded by neutrons, a nuclear reaction occurs which is represented by the following equation

$$ {}^{6}_{3}Li \quad + \quad {}^{1}_{0}n \quad \rightarrow \quad {}^{3}_{1}H \quad + \quad P $$

   Complete the equation and name P.
   (c) Describe the application of radioactivity in determining the age of fossils (remains of old plants and animals)
   (d) Give two harmful effects of radioactivity
   (e) State three differences between cathode rays and x-rays.

15. (a) (i) Name the particles emitted by radioactive nuclides.
   (ii) Give one property common to the particles named in (i).
   (b)




   A stream of particles from a radioactive source passes through a magnetic field directed into the plane of the paper as shown in the above figure.
   (i) Identify the particles in the stream.
   (ii) Sketch a diagram to show the path of the particles in an electric field.
   (c) Distinguish between the terms fusion and fission.
   State two conditions necessary for each to occur.

16. (a) What is meant by the following?
   photo-electric effect?
   (b) (i) State the conditions necessary for photo-electric effect to take place?

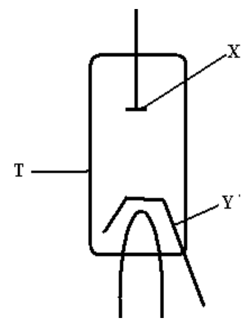
(ii) With aid of a labeled diagram, describe how an alternating current can be fully rectified.

(c) (i) State the function of the fluorescent screen in a cathode ray oscilloscope.

(ii) Give two applications of cathode ray oscilloscope.

17. (a) What is thermionic emission?

(b)




The diagram above shows a thermionic diode. Name the parts labelled X,Y.

(c) Describe briefly how electrons are made to move across the tube T.

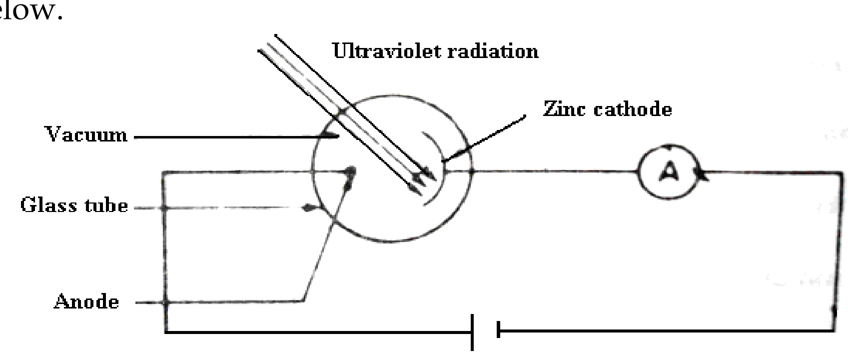
(d) State two differences between cathode rays and x-rays.

(e) In the production of x-rays tube, why must be target be cooled?

18. (a) (i) Name the particles emitted by the radioactive materials.

(ii) Draw diagrams to show the path of the particles named in (a) (i) and in a cloud chamber

(b) A Zinc cathode was enclosed in an evacuated glass tube as shown in the figure below.




When the cathode was irradiated with ultra violet radiations, 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?

# TEST 12.1

## SECTION A

**1.** The half life of a radioactive substance is 10s. How long will it take for a mass of 16g of that substance to reduce to 2g

(a) 40s (b) 30s
(c) 20s (d) 10s

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

A. 16.0 B. 17.25
C. 26 D. 42

**3.** Thorium has a half-life of 24days. How many days would it take 8 kg of thorium to disintegrate to 1g?

A. 3 B. 24
C. 72 D. 96

**4.** The half-life of a radioactive element is 4 hours. Find the mass of the element that decays after 24 hours if the initial mass is 9.6g

a) 0.15g b) 1.6g
c) 9.45g d) 4.8g

**5.** The half-life of a radioactive element is 10 days. Find the mass left after 40 days if the initial mass is 16g

(a) 1g (b) 2g
(c) 4g (d) 8g

**6.** A radioactive metal decays to $^1/_{16}$ of its original quantity in 2 hours. What is its half life?

(a) 15 min (b) 24min
(c) 30min (d) 40min

**7.** The count rate of a radioactive isotope falls from 600 counts per second to 75 counts per second in 75minutes. The half-life of the radioactive isotope is

(a) 8 min (b) 19 min
(c) 25 min (d) 75 min

**8.** The half life of a radioactive material is 20 days. Find the initial mass of the material if 2g of it remains after 80 days

a). 4g    b). 8g

c). 16g    d). 32g

## SECTION B

**1.** A radioactive material takes 50 hours for 93.75% of its mass to decay. Find its half-life.

**2.** 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.

**3.** (a) What is meant by the *half-life of a radioactive material*?

(b) 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?

**4.** A radioactive material of mass 8g has a half –life of 20 days. Find how much of it will decay after 60days?

**5.** A radioactive sample has a half-life of $3 \times 10^3$years

(a) What does the statement half-life of $3 \times 10^3$ years mean?

(b) How long does it take for three-quarters of the sample to decay?

**6.** The half-life of Uranium is 24days. Calculate the mass of Uranium, which remains after 120days if the initial mass is 64g

**7.** (a) Define half life.

(b) $x$ grams of a radioactive material of half life of 3 weeks, decays and 5.12g remains after 15 weeks. Determine the value of $x$.

**TEST ONE**
1.D 2.C 3.A 4.B 5.A 6.C 7.D 8.C 9.A 10.D 11.A 12.D 13.D 14.A
15.C

**TEST 2**
1.A 2.B 3.C 4.A 5.C 6.C 7.D 8.A 9.B 10.B 11.A 12.A 13.B
14.B 15.A

**TEST 3**
1. D 2. B 3.A 4.C 5. B 6.A 7.C 8. B 9.C 10.D

**TEST 4**
1. D 2. B 3.A 4.C 5. B 6.A 7.C 8. B 9.C 10.D

**TEST 5**
1.B 2.D 3. D 4.B 5.C 6.B 7.D 8.C 9.B 10.D 11.D

**TEST 6**
1.A 2.D 3.C 4.A 5.B 6.C 7.C 8.B 9.B 10.C 11.B 12.C 13.C 14.D
15.D 16.B 17.A 18.B

**TEST 7.1**
1.D 2.A 3.D 4.C 5.C 6.A 7.C 8.D 9.A 10.A 11.A 12.D 13.C 14.C
15.A 16.A

**TEST 7.2**
1. A 2.B 3.D 4.B 5.C 6.C 7.D

**TEST 8**
1.A 2.B 3.A 4.C 5.C 6.B 7.C 8.C 9.C 10.D 11.B 12.A 13.D 14.C
15.B 16.B 17.B 18.A 19.A 20.C 21.A 22.C 23.C 24.D

**TEST 9**
1.A 2.D 3.B 4.C 5.C 6.A 7.A 8.C 9.A 10.C 11.C 12.D 13.A 14.B15.C
16.B 17.B 18.D 19.D 20.B 21.C 22.A 23.B 24.C 25.D 26.D 27.B

**TEST 10**

1.A 2.B 3.D 4.B 5.C

**TEST 11.1**

1.A 2.C 3.A 4.C 5.D 6.C

**TEST 11.2**

1. D 2. D 3. C 4.B 5. C 6. B 7. D 8. D 9. A 10.B 11.C 12.B

**TEST 11.3**

1. C 2. C 3. A 4. C 5. C 6. C 7. B 8. A 9. A 10. B

**TEST 11.4**

1. C 2. C 3. A 4. C 5. C 6. C 7. B 8. A 9. A 10. B

**TEST 12**

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.D | 2.A | 3.C | 4.D | 5.C | 6.B | 7.C | 8.C | 9.B | 10.C | | | |
| 11.B | 12.C | 13.B | 14.B | 15.C | 16.A | 17.C | 18.B | 19.C | 20.A | | | |
| 21.C | 22.B | 23.A | 24.D | 25.C | 26.D | 27.B | 28.A | 39.D | 30.B | | | |
| 31.C | 32.A | 33A. | 34.C | 35.C | 36.B | 37.A | 38.B | 39.B | 40. C | 41.B | 42.A | 43.B |

**TEST 12.1 half life**

1.B 2.B 3.C 4.C 5.A 6.C 7.C 8.D