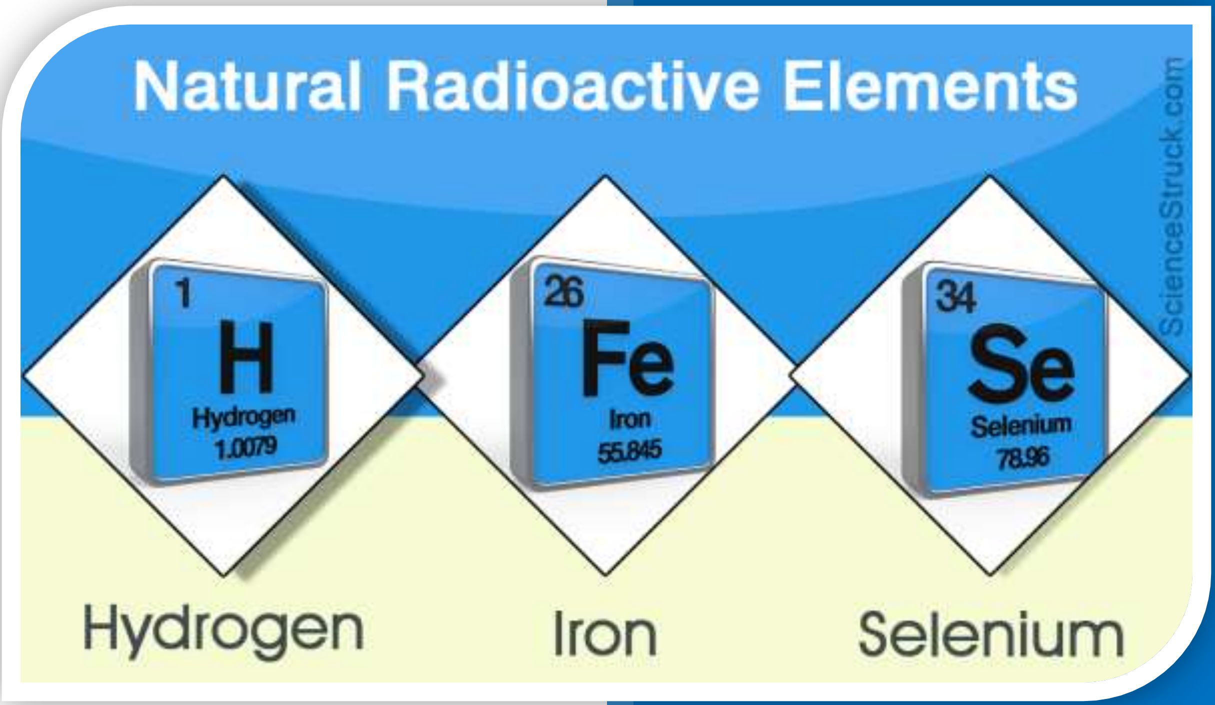
2020

RADIOACTIVITY



TEACHERS OF PHYSICS

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7/31/2020

1. Define Radio-activity. (2mks)

- ✓ Spontaneous random emission of particles from the nucleus of an unstable nuclide
- ✓ Spontaneous disintegration of the nucleus of an atom.
- ✓ Spontaneous disintegration of the unstable atoms.

2. What is meant by the following terms:

(i) Radioactive decay

- ✓ Radioactive decay is the process by which an element changes into another element by emitting a particle or radiation from the nucleus.

(ii) Isotope.

- ✓ Isotope is the atom of the same element with the same atomic number but different mass number.

3. **What** is meant by a radioactive substance? (1mk)

- ✓ Are stray radiation present in the atmosphere.

4. What is meant by Unstable nuclide (1mk)

- ✓ It is a nucleus in which neutrons to protons ratio greater than 1:3 or
- ✓ Nucleus in which ratio of protons to neutrons is not equal.

5. State one precaution that has to be observed when using a radioactive substance

- ✓ They should be kept in thick lead boxes.
- ✓ Should never be held with bare hands.

6. State one use of radioactivity in each of the following;

i) Medicine

- ✓ In medicine to sterilize medical equipment and control cancerous body growths.

ii) Agriculture.

- ✓ In agriculture to study the plant uptake of fertilizers and other chemicals.

7. Give one application of radioactivity. (1mk)

- ✓ In industries to detect bursting of pipes.
- ✓ In industries to detect flaws in metal casting and welded joints.
- ✓ In industries to determine the thickness of metal foils, paper and plastics.
- ✓ Source of nuclear energy
- ✓ Making of atomic bombs

8. **State one** use and **one** source of gamma rays. (2mk)

Use: To control the cancerous body growths.

Source: **Radioactive materials**

9. Give two uses of cobalt - 60 as a Radioactive source.

- ✓ To detect cracks in welded joints .
- ✓ To detect airspaces in welded joints.

10. One of the applications of **βeta** emission (β) is controlling thickness gauge. **Explain** how they are used for this purpose. (2mk)

- ✓ Used as detector by placing the source on one side of the gauge of material and detector on the other side to monitor how the radiation gets through.

11. State one application of radio isotopes in medicine and one in industry. (2 mks)

- ✓ In medicine to sterilize medical equipment.
- ✓ In industries to detect flaws in metal casting and welded joints.

DECAY

1. State the number of neutrons in the nucleus $^{107}_{32}\mathbf{X}$

N= 75

2. The following is part of a radioactive decay series.

$$^{234}_{83}Bi \xrightarrow{\beta} {}^{a}_{84}X \xrightarrow{\propto} {}^{230}_{b}Y$$

Determine the values of a and b

a=234, b=82

3. Radium $^{226}_{86}\mathbf{R}$ disintegrates into a new stable element lead $^{206}_{84}\mathbf{Pb}$ **how many** alpha and Beta particles are emitted (2mks)

226=206+4x

4x=226-206

4x=20

X=5

86=84+2x-y

86=84+10-y

y=94-86

y=8

5-alpha particles and 8- beta particles are emitted

4. Uranium 235 was bombarded with a neutron and fission took place in the following manner.

$$^{235}_{92}\mathbf{U} + {}^{1}_{0}\mathbf{n} \longrightarrow {}^{90}_{38}\mathbf{Rn} + {}^{a}_{b}\mathbf{X} + 10\,{}^{1}_{0}\mathbf{n}$$

Determine the values of **a** and **b** (2mk)

a =136 b = 54

5. $^{233}_{90}\mathbf{Th}$ disintegrates into radium (Ra) by emission of two alpha and two beta Particles **State**:

(i) the atomic number of the daughter nuclide (2mks)

A =87

(ii) The mass number of the daughter nuclide (2mks)

Z =225

6. Uranium $^{238}_{92}\mathbf{U}$ emits an alpha particle to become another element X, as shown in the equation below.

$$^{238}_{92}\mathbf{U} \longrightarrow {}^{A}_{Z}\mathbf{X} + \mathbf{alpha}$$

Determine the value of **A** and **Z** (1 mk)

A=234   z=90

7. The following is a part of a radio-active series.

$${}^{210}_{83}X \xrightarrow{r} {}^{210}_{84}Y \xrightarrow{Alpha} {}^{c}_{d}Z$$

Identify the radiation r, and find the values of c and d. (3mks)

✓ Beta radiation. C= 206 d=82

8. A typical nuclear fission reaction in a nuclear reactor is given below.

$${}^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \longrightarrow {}^{148}_{57}\mathrm{La} + {}^{85}_{35}\mathrm{Br} + x\,{}^{1}_{0}\mathrm{n}$$

(i) What is meant by nuclear fussion? (1mk)

✓ Process where energy is released when two lighter nuclei are fused together to form a heavier nucleus

(ii) Find the value of x. (1mk)

X=3

(iii) How are the neutrons produced used in the reactor? (1mk)

✓ Each of the neutrons produced at each collison casues further collisons with uranium atom causing chain reaction

9. The expression below is an equation for a radioactiveelement **P.** Elements **Q** and **R** are the daughter nuclides. **P, Q,** and R are not the actual symbols of any of the elements.

$${}^{235}_{92}P \longrightarrow {}^{231}_{90}Q \longrightarrow {}^{x}_{y}R$$

Identify the element R and state **two** of its characteristics.

R is Helium.

✓ Are positively charged electron in nature.

✓ Have high ionization energy due to its low speed.

10. Equation below shows a decay series of a radioactive isotope

$${}^{319}_{73}P_O \xrightarrow{X} {}^{315}_{71}T \xrightarrow{Y} {}^{315}_{72}K$$

Identify X and Y (2mks)

X= Alpha

Y= Beta

11. An isotope of uranium ${}^{238}_{92}\mathrm{U}$ decays by emitting an alpha particle and a beta particle. forming a new element M. Write down an equation for the reaction.

$${}^{238}_{92}U \longrightarrow {}^{234}_{91}M + {}^{4}_{2}\propto + {}^{0}_{-1}e$$

12. Find the value of a and b up the following equation (2mks)

$$^{234}_{92}U \longrightarrow ^{a}_{b}X + 2\alpha$$

a =226
b = 90

13. Complete the nuclear equation below (2 mks)

$$^{214}_{82}Pb \rightarrow ^{214}_{84}Pb + x\left(^{0}_{-1}e\right)$$

82=84-x
X=84-82
X=2

14. Complete the following nuclear reaction by identifying the values of x and y.

$$^{234}_{91}Pa \xrightarrow{\beta} ^{x}_{92}U \xrightarrow{\alpha} ^{230}_{y}Th$$

X= 234
Y= 90

15. What are the values of **m** and **a** in the nuclear equation given below:- (1mk)

$$^{a}_{m}X \rightarrow ^{230}_{90}Y + 2\propto$$

a = 238
m= 94

16. A radioactive nuclide $^{228}_{90}X$ decays by emitting an alpha particle and a neutron to become a nuclide $^{a}_{b}M$. Write a decay equation for the process giving the actual values of a and b.

$$^{228}_{90}X \longrightarrow ^{223}_{88}M + ^{4}_{2}\propto + ^{1}_{0}n$$

a = 223
b= 88

17. $^{220}_{86}Rn$ emits α - particles

(i) What is an α - particle? (1mk)

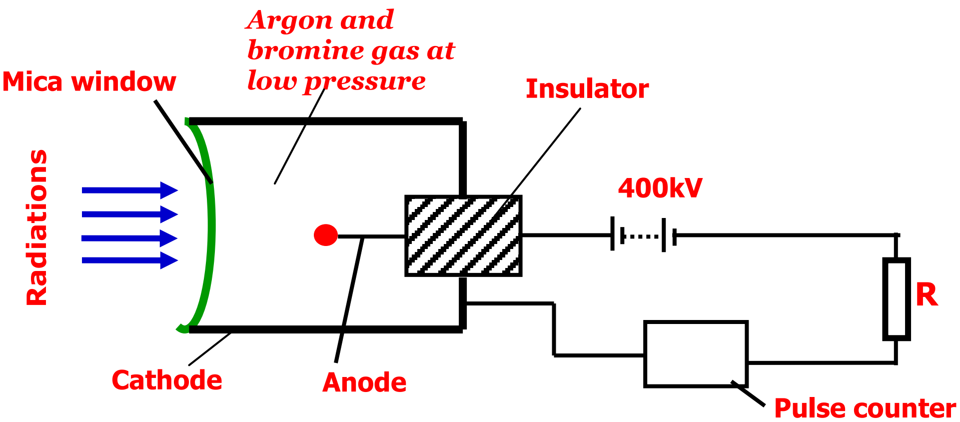
Are positively charged electron in nature.

(ii) When $^{220}_{86}Rn$ emits an α - particle, it becomes an isotope of the element polonium (Po). Write a decay equation to represent this change(1mk)

$$^{220}_{86}Rn \longrightarrow ^{216}_{84}Po + ^{4}_{2}\propto$$

RADIATION

1. Draw a labeled diagram of a Geiger- Muller tube.



2. Explain how Geiger- Muller tube detects radioactive particles/rays.

- ✓ Radiations ionize the gas. Negative ions moves towards the anode while positive ions move towards the cathode. Ions accelerate and collide with more gas particles causing further ionization which results into an avalanche of electrons. The avalanche of electrons causes an electric pulse.

3. State two factors that determine the extent of the damage to the body cell caused by the radiation from radioactive substances.

- ✓ Mass of the radiation
- ✓ Penetrating power.
- ✓ Speed of the electron.

4. State what is meant by background radiation as used in radioactivity(1mk)

- ✓ Counts registered in the absence of a radioactive source.

5. A Geiger – miller tube registers some effects even in the absence of a radioactive source. Explain this observation and state one cause. (2mk)

- ✓ **Due to background radiations which is from cosmic rays.**

6. Alpha particles(∝) are more ionizing than Beta(β) particles. Give **two** reasons for this.

- ✓ Alpha particles are heavier than beta particles due to large mass.
- ✓ Alpha particles have higher charge than beta particles due their low speed.

7. Three radioactive substances have to be stored safely. Details of the substances are given below.

Substance	**Half life**	**Type of radiation given out**
A	**5000 years**	**Alpha (∝)**
B	**4 years**	**Beta (β)**
C	**156 years**	**Gamma (γ)** **Alpha (∝)**

Which of the following containers would you use for each substance.

(i) Aluminium (ii) Thin plastic (iii) lead lined (3mks)

A: Thin plstic

B: Aluminium

C: Lead lined

Give a **reason** to your answer to part (iii) (1mk)

- ✓ Gamma radiations have highest penetrating power hence can only be stopped by lead shield.

8. When carrying out experiments with radioactive substances the source should never be held with bare hands but with forceps. Explain? (1mk)

- ✓ To prevent radiations from penetrating into the body since they destroy body cells.

9. When carrying out experiments with radioactive sources, students are instructed that;

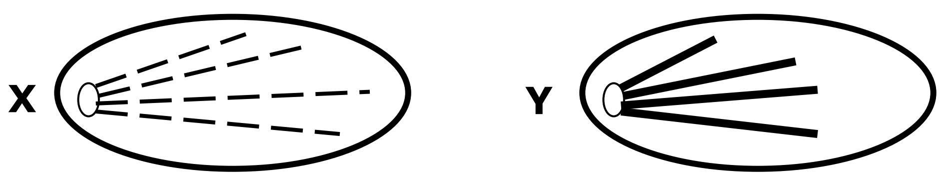
(i) The source should never be held close to the human body;

- ✓ To avoid penetration of radiations into the body which destroys body cells.

(ii) No eating or drinking is allowed in the laboratory.
Why is it important to follow these instructions? (3mk)

- ✓ To avoid radiations from penetrating into the body in case of any leakage.
- ✓ To reduce the chances of pressure leakage out of the laboratory area.

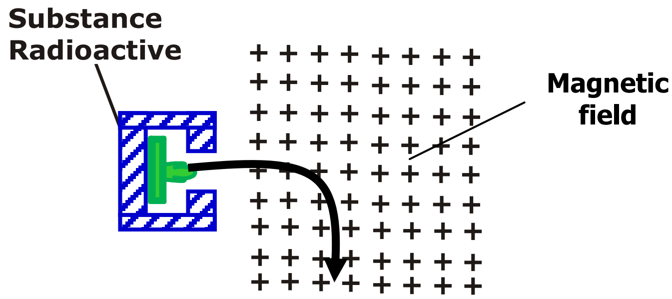
10. **Identify** the type of emissions that formed the tracks in each case below. (2mk)



X: Beta particles

Y: Alpha particles

11. Fig shows the path of radiation from a radioactive source after entering a magnetic field. The magnetic field is directed into the paper and is perpendicular to the place of the paper shown in the figure.



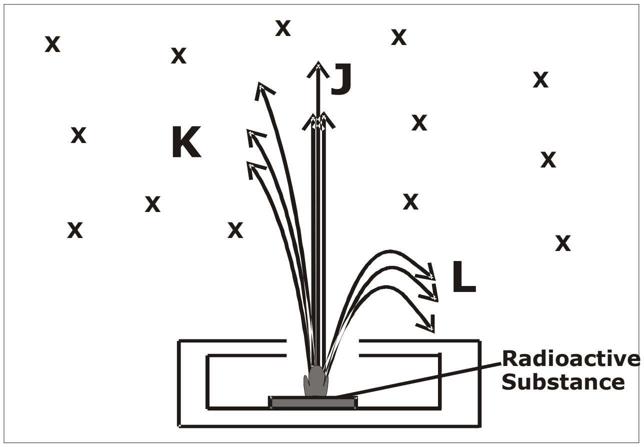
a) Identify the radiation.

- ✓ Beta radiation

b) Give a reason for your answer.

- ✓ The are readily deflected owing to their little mass.

12. Radiations from a radioactive isotope were subjected to a strong magnetic field .The results are represented in the figure below.



Identify the radiations J and K giving a reason for your choice. (4mk)

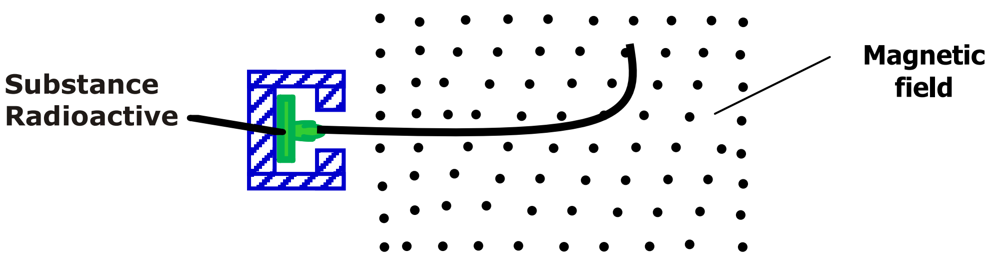
a) J Gamma radiation

Reason → They are not charged hence cannot be deflected by magnetic fields (1 mk)

b) K Alpha radiation

Reason → Are positively charged hence deflected to the left. (1 mk)

13. Figure below shows the path of radiation from a radioactive source . The filed is perpendicular to the paper an directed out of the paper.



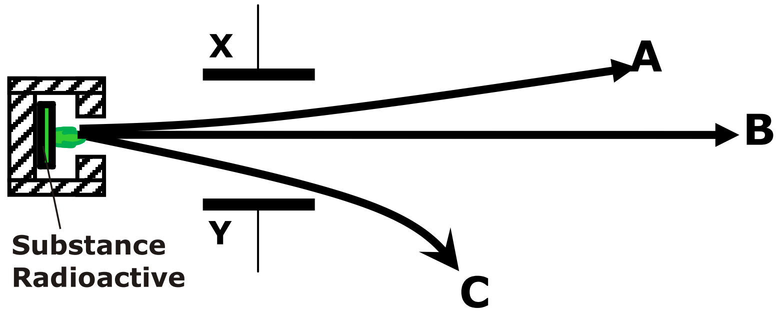
i) Identify the radiation. (1mk)

- ✓ Beta radiation

ii) State **two** properties of the radiation stated in a(i) above. (2mks)

- ✓ They are negatively charged electrons in nature.
- ✓ They have less ionizing power than alpha radiation.
- ✓ They carry charge.
- ✓ They posses kinetic energy.

14. The diagram in the figure below shows paths taken by three radiations **K, L** and **M** from a radioactive isotope through an electric field.



i) State the charge on plate **Y**. (1mk)

✓ Positive

ii) Identify the radiations **A** and **C**. (2mks)

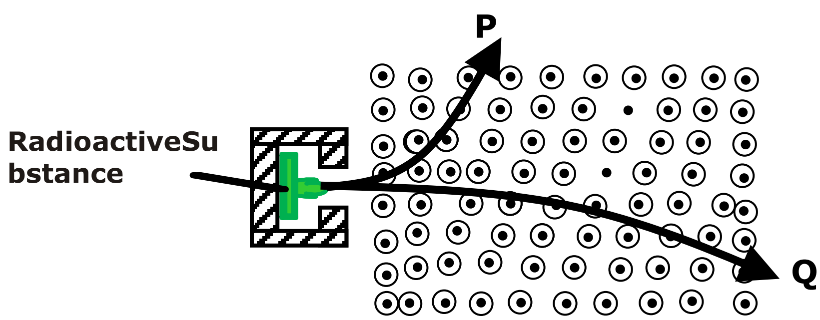
✓ A= Alpha particle

✓ C= Beta particle

iii) Give a reason why **C** deviates more than **A**. (1mk)

✓ A more massive than C

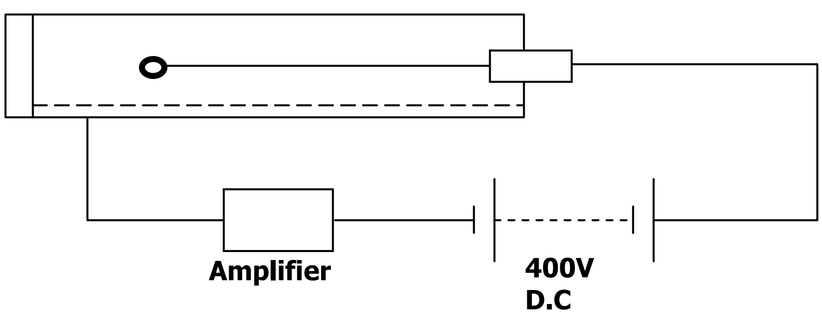
15. The figure below shows paths taken by radiations from a radioactive material through a Magnetic field. Identify radiation P and Q. (2mk)



P -Beta radiation

Q-Alpha radiation

16. The figure **below** shows a G.M tube.



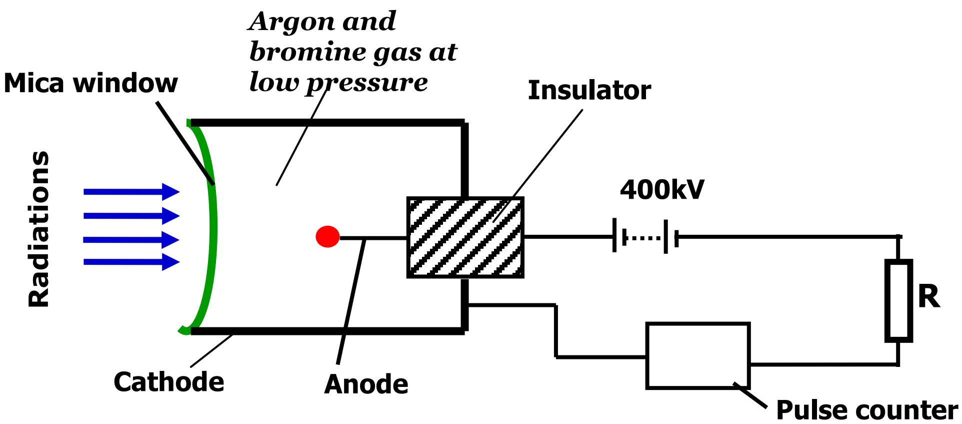
(i) Give the reason why the mica window is made thin. (1 mark)

✓ *-To allow radiation to <u>penetrate inside</u> the tube.*

(iii)What is the purpose of the halogen vapour. (1mk)

✓ To absorb the kinetic energy of the positive ions before they cause secondary electron emission.

17. **Figure** below shows the diagram of a Geiger – Muller tube connected to a power supply and a pulse counter.



(i) Why should the Argon gas be at low pressure? (1mk)

✓ To be easily ionized by the radiations.

(ii) Briefly explain how the Geiger – Muller tube detects the radiation emitted by a radioactive (4mks)

✓ *-When a radioactive substance is placed in front of the window, the emitted radiations enter the tube through the window ionizing the gas inside. The negative ions moves towards the central anode while positive ions moves to the cathode; thus a discharge is suddenly obtained between anode and cathode and registered as current by counter.*

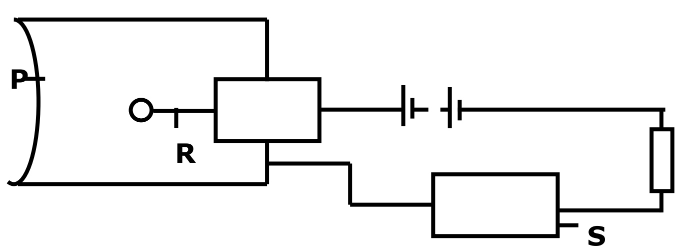
(iii) State the purpose of the bromine gas in the tube (1mk)

✓ It acts as a quenching agent.

(iv) Suggest one way of increasing the sensitivity of the tube (1mk)

✓ By using very high voltage at cathode and anode.
✓ By use of amplifier to amplify the small current.
✓ By marking the mica window as thin as possible.

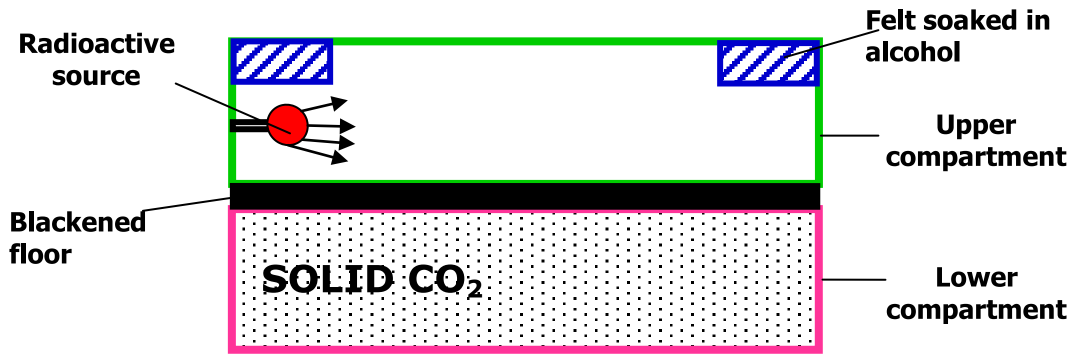
18. The figure below shows the Geiger-muller tube;



Name the parts labelled**P, R, S**: (3mks)

P- mica window
R-anode
S-pulse counter.

19. The figure below shows the cross section of a diffusion cloud chamber used to detect radiation from radioactive sources



(i) State one function of each f the following ; 2 mks

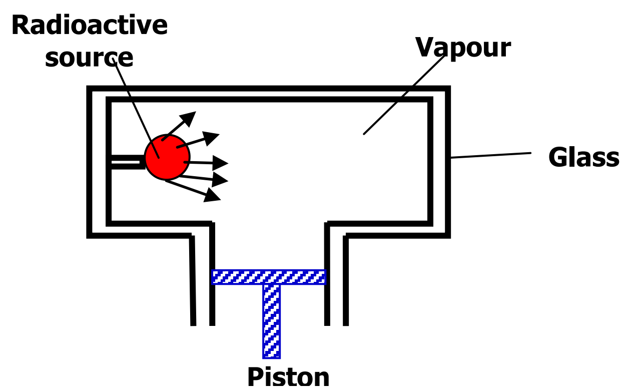
Alcohol; - To produce alcohol vapour.

Solid CO_2;- To cool alcohol vapour.

(ii) When radiation from the source enters the chamber, some white traces are observed. Explain how these traces are formed and state how the radiation is identified.

✓ The radiation from source ionizes air along its path. Alcohol condenses around these ions forming droplets or traces. The nature of these traces identifies the radiation.

20. Fig below shows an expansion cloud chamber.



(i) What is the purpose of the Vapour? (1mk)

✓ To produce alcohol vapour

(ii) Explain how the radiations emitted by the radioactive source in the chamber are detected . (4mks)

✓ When a radioactive element emits radiations into the chamber. The air inside is ionized.The piston moves down suddenly, air in the chamber expands and cooling occurs. Ions is formed which act as nuclei on which the saturated alcohol condenses, forming tracks.

ACTIVITY

1. Define the term half life. (1mk)

- ✓ The time taken for half the number of nuclides initially present in a radioactive sample to decay.
- ✓ Is the time taken for the activity to decrease to half of the initial value of radioactivity nuclei present to decay.

2. The half-life of a certain radioactive substance is 57 days. Explain the meaning of this statement.

- ✓ It takes 57 days for the radioactive substance to decay by half of its original amount.

3. Name the quantities, which must be measured so as to determine the half-life of a radioactive sample whose half-life is known to be a few hours.

- ✓ Original count rate
- ✓ Remaining count rate.
- ✓ Time of decay.

4. Explain what causes chain reaction in a nuclear reactor. (1mk)

- ✓ The neutrons produced during nuclear fission and fusion continually bombards more and more nuclides.

5. Differentiate between nuclear fission and nuclear fusion (1mk)

- ✓ Nuclear fission is the splitting of heavy nucleus into lighter nuclei with the release of energy while fusion is the process where energy is released when two lighter nuclei are fused together to form a heavier nucleus.
- ✓ ***Fission is the process where uranium nucleus is bombarded with a neutrons then split into two but equal radioactive particle with more neutrons and a lot of energy while Fusion is where two light particles are fused together then split to release energy.***

6. One of the isotopes of Uranium has a half life of 576 hours.

i) Complete the table to show how the mass varies with time from an initial mass of 1280 mg.

Time (Hours)	**576**	**1152**	**1728**	**2304**
Mass (Mg) 1280	**640**	**320**	**160**	**80**

ii) Explain whether the mass of the isotope will eventually reduce to zero.

- ✓ It will reduce to zero. The number nuclides present in a radioactive sample undergo decay.

7. In a sample there are $\mathbf{5.12 \times 10^{20}}$ atoms of Krypton 92 initially. If the half-life of Krypton is 3.0s, determine the number of atoms that will have decayed after 6s

- $N = No(\frac{1}{2})^{I/t}$

$= 5.12X10^{20}(\frac{1}{2})^{6/3}$

$= 5.12X10^{20} \times {}^{1}/_{4}$

$= 1.28X10^{20}$ atom

8. Cobalt 60 is a radioisotope that has a half-life of 5.25 years. What fraction of the original atoms in a sample will remain after 21 years.

N= No(½) $^{T/t}$
=(½) $^{21/5.25}$
=$^{1}/_{16}$
=$\frac{1}{16}$

9. A nucleus of an element X of atomic mass 238 and atomic number 92 decays by emitting 8 alpha particles and 10 beta particles and finally forms a nucleus of an element y. Write the equation of the reaction.

$$^{228}_{90}X \longrightarrow {}^{206}_{86}Y + 8({}^{4}_{2}\propto) + 10{}^{0}_{-1}e$$

10. A certain nuclide P decays by emission of a beta-particle to form a daughter nuclide Q. The daughter nuclide Q subsequently decays by alpha emission to form a nuclide R. The half-life of P is 20 seconds

(i) How long would it take for three quarters of a sample of P to decay?(2mk)

N=1-$\frac{3}{4}$ = $\frac{1}{4}$

0.25=(½) $^{T/20}$

$\log 0.25 = \frac{T}{20}\mathrm{x}\log 0.5$

T=40 seconds

(ii) How does the atomic number of nuclide R compare with that of nuclide P? (1mk)

✓ Atomic number of R is less than that of P

(iii) What effect would an increase of temperature have on the rate of decay (1mk)

✓ No effect.

11. Given that 5g of cobalt-60 is kept in a laboratory and it has a half-life of 5 years. Calculate its mass after 15 years.

N= No(½) $^{T/t}$

=5(½) $^{15/5}$
=5x $^{1}/_{8}$
=0.625g

12. A radioactive substance has a mass of 0.2g and an activity of 1.0 x 10^3 disintegration per second at **t =0**. What would be the activity of a sample of mass 0.6g of the same substance at the time t = 0

N= No(½) $^{T/t}$
=1.0X10^3(½) $^{0.6/0.2}$
=1000x $^{1}/_{8}$
=125g/second.

13. Radon has a half-life of 4 days. A sample of radon has a mass of 40 g. What mass of the sample will have decayed after 16 days? (3mks)

N= No(½) $^{T/t}$

$=40(\frac{1}{2})^{16/4}$
$=40 \times \frac{1}{16}$
$=2.5g$
$=40g-2.5g$
$=37.5g$

14. A radioactive sample has a mass of 16g and a half-life of 10 days. How much of the original sample remains after 40 days. (2mk)

$N = N_o(\frac{1}{2})^{T/t}$
$=16(\frac{1}{2})^{40/10}$
$=16 \times \frac{1}{16}$
$=1g$

15. A sample of a radioactive substance has a mass and 2g and half-life of 7 days, what fraction of the original sample would be decayed after 21 days. (3mk)

$N = N_o(\frac{1}{2})^{T/t}$
$=(\frac{1}{2})^{21/7}$
$=\frac{1}{8}$
$=1 - \frac{1}{8}$
$=\frac{7}{8}$

16. A radioactive element A of half life 31 days decays to element B. A sample of A of mass 32g is kept in a container. Assuming B is stable; calculate the mass of B that will be in the container after 124 days. (3 mks)

$N = N_o(\frac{1}{2})^{T/t}$
$=32(\frac{1}{2})^{124/31}$
$=32 \times \frac{1}{16}$
$=2g\surd$
$B=32-2=30g\surd$

17. The graph in Fig shows the activity of a radioactive sample against time. From the graph, determine;

(i) The initial count rate at t = 0 minutes. (2 mks)

300

(ii) Half – life of the radioactive substance. (2 mks)

1.7 minutes

18. The graph below shows radioactive decay of iodine.

Use the graph to determine the:-

(i) Fraction of the amount remaining after 16.2 days. (2mks)

$\frac{184}{400}$

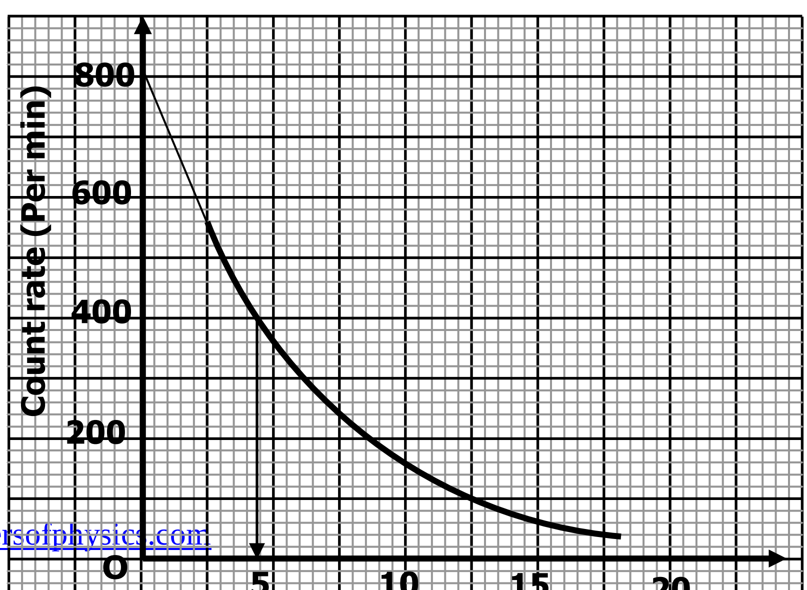
(ii) Determine the half – life of iodine. (2mks)

14.4 days

(iii) Mass remaining after 17 days. (1mk)

180g

19. The graph in Fig shows the activity of a radioactive sample against time. From the graph, determine;



(i) The initial count rate at **t = 0** minutes.

800 counts

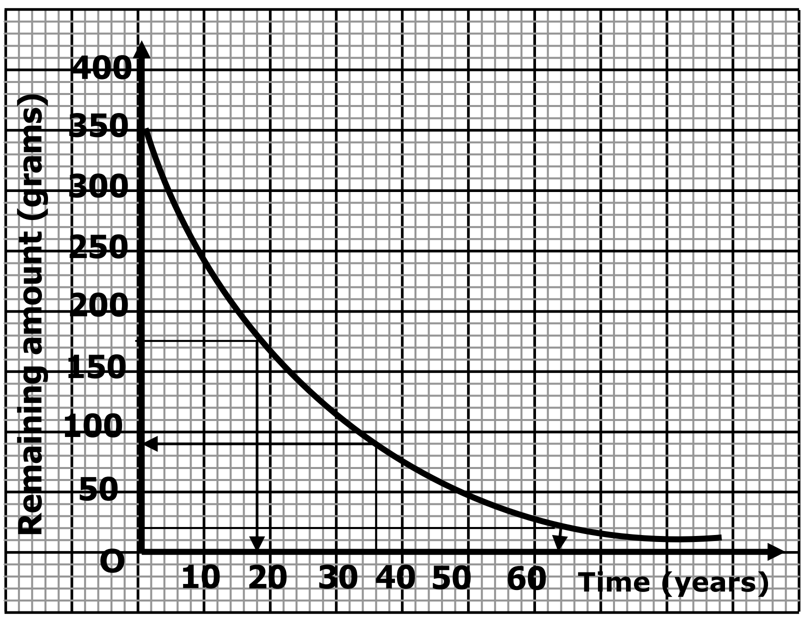
(ii) Half – life of the radioactive substance.

4.5 minutes

(iii) The count rate when time is **12minutes**.

100 counts

20. The graph below shows radioactive decay of a radioactive substance.



Use the graph to determine the:-

(i) The half – life of the substance.

18 years

(ii) Mass remaining after **36** years days.

90g

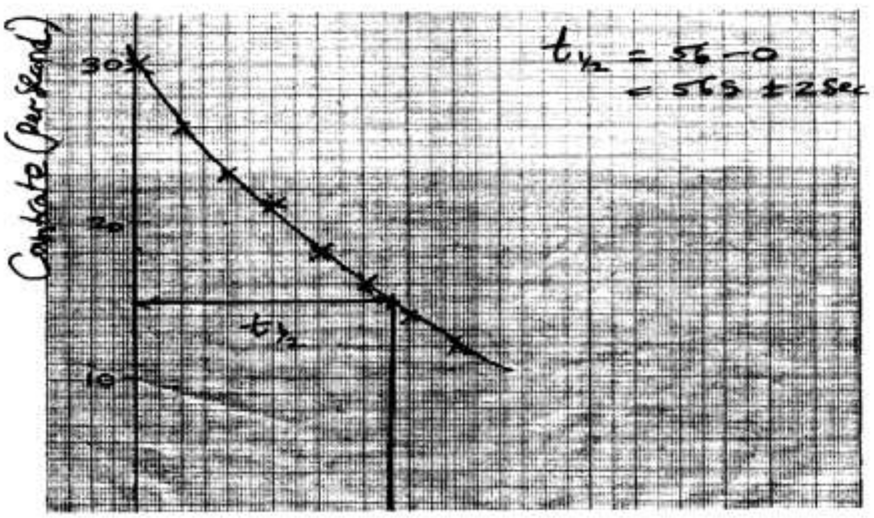
(iii) The time taken for the mass to fall to **20g**

64 years

21. The following results were obtained as shown in table I.

Time (Seconds)	**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**

Count rate (per seconds)	**30**	**26**	**23**	**21**	**18**	**16**	**14**	**12**



i) Plot on the graph paper provided the graph of the count rate (y-axis) against time.

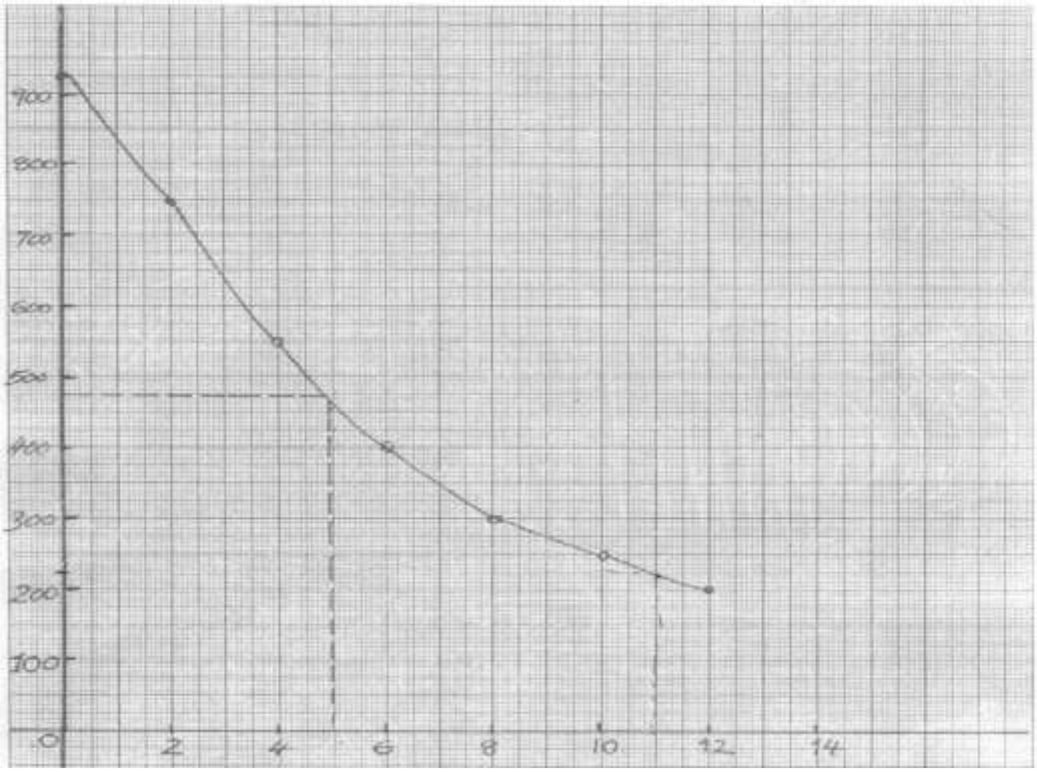
ii) From the graph, determine the half-life of Radon – 220. (1mk)

56 seconds

22. Geiger Muller tube without a radio active substance near it recorded a count rate of 50 counts per minute. When a radio active substance was held near it the following data was obtained.

Count rate /min	**950**	**750**	**550**	**400**	**300**	**230**	**170**	**130**
Time in days	**0**	**2**	**4**	**6**	**8**	**10**	**12**	**14**

In the graph provided, plot a suitable graph of count rate per min (y-axis) against timein days. (4mks)



Use your graph to determine the following questions

(i) Half life of the substance used. (1mk)

4.95 days = 5 days

(ii) Approximate count rate on the 11th day. (1mk)

220 disintegrations / min.

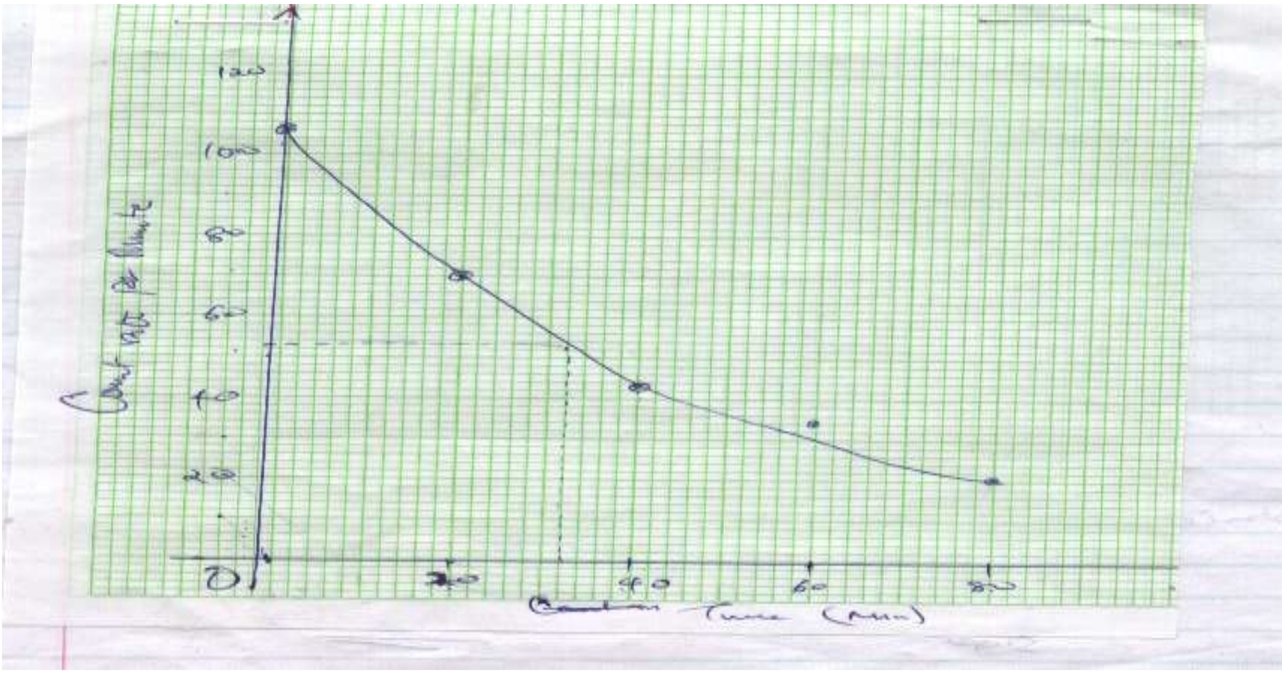
23. A G.M tube indicated a constant count rate of 5 counts per minute when a radioactive source was placed at a distance of about 10cm from it. When the source was moved close to about 4 cm the count rate varied as follows.

Time (min)	**0**	**20**	**40**	**60**	**80**
Count rate per minute.	**106**	**70**	**43**	**34**	**20**

(i) The count rate was constant at a distance of 10 cm away. Explain (1mk)

- ✓ Because of background radiation
- ✓ ***This is the range of alpha particle in air***
- ✓

(ii) Plot a graph of count rate against time. (5mk)



(iii) Use your graph to estimate the half life of the source. (2mks)

32 minutes

24. Sketch a graph of count rate against time for a sample of a radio isotope whose initial count rate is R_0 counts per hour. Indicate on the sketch the half-life, $T_{1/2}$ of the radioisotope (3mks)