Delta Science Education

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HKDSE Physics

Core 5: Radioactivity and Nuclear Energy

Chapter 1: Radiation and Radioactivity

Part 1

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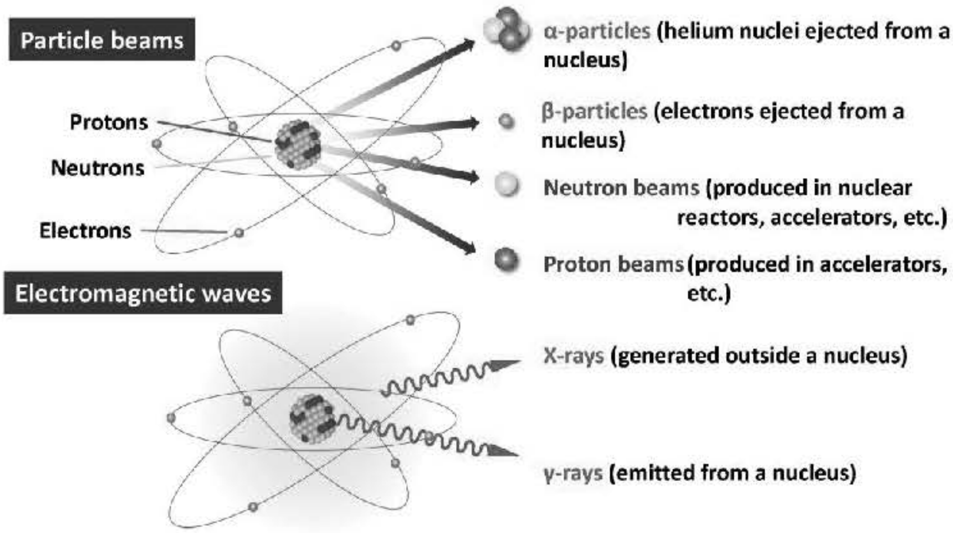
1. Radiation

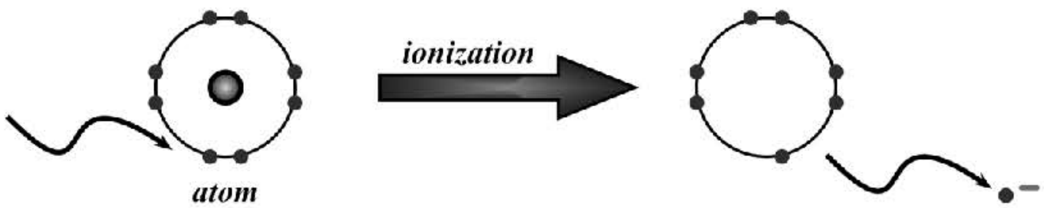
(1) What is radiation?



- Radiation is the emission or transmission of energy in the form of waves or particles.
- The forms of radiation can be **electromagnetic radiation / wave or particulate radiation** (including alpha particles, beta particles, and neutrons).
- **Nuclear radiation**: the radiation that is released in a ______ **process** (e.g. nuclear decay)

(2) What is ionizing radiation?

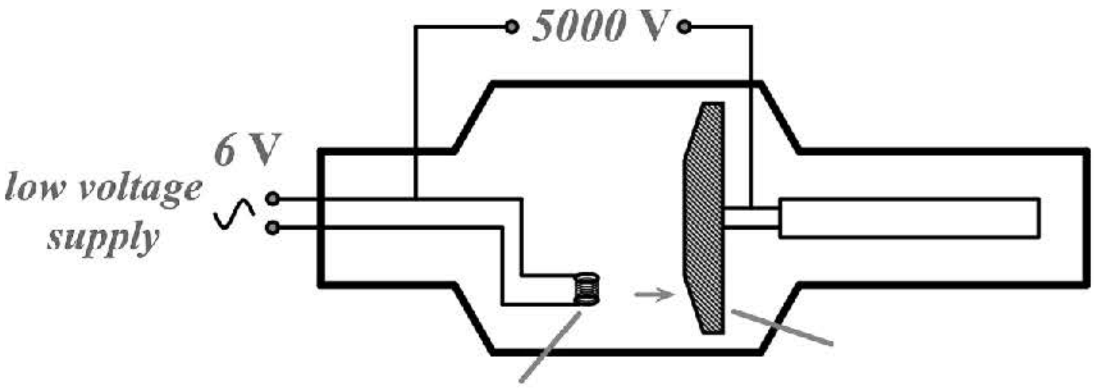
- **Ionizing radiation** has **high enough energy to kick out / remove electrons from an atom**, causing the atom to ______ and becomes an ___.



- When an atom is ionized, it becomes unstable and reactive, potentially leading to chemical reactions that may be harmful to living organisms. Thus they are very dangerous.
- **Common ionizing radiation:**
  - EM radiation: X-rays and gamma rays;
  - Particle radiation: alpha particles and beta particles
- Note: UV is not an ionizing radiation, but it is still harmful to human as it can cause skin cancer.

2. X-rays

(1) Production of X-rays



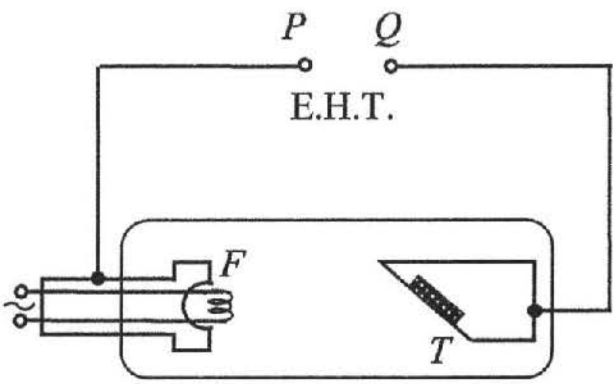
- X-ray was discovered by Rontgen in 1895. He won the Nobel Prize in 1901.
- X-ray was produced when **cathode ray** hits a **metal target**.

(2) Properties of X-rays

- X-ray is a type of **electromagnetic wave** with **wavelength about 10^{-10} m.**
  - X-ray is a **transverse** wave.
  - X-ray can travel in **vacuum** with the **speed of light**.
  - X-ray **does not carry charge**, thus it would not be deflected by electric field or magnetic field.
  - X-ray is an **ionizing** radiation, but **not a nuclear** radiation.
  - X-rays have **high penetrating power**.
  - X-rays can be **detected by a film**.
- Over exposure to x-rays is **dangerous** and can cause severe damage to body cells and can **leads to cancer**.

Examples that you must fully understand

1. The figure shows a schematic diagram of an X-ray tube in which the filament F and the metal target T are connected to terminals P and Q of an E.H.T. Which statement is correct?



A. ***P is the positive terminal and X-rays are emitted from T.***

B. ***P is the positive terminal and X-rays are emitted from F.***

C. ***Q is the positive terminal and X-rays are emitted from T.***

D. ***Q is the positive terminal and X-rays are emitted from F.***

2. Which of the following statements correctly describes the effect of over exposure to X-rays on human bodies?

(1) The body tissue may be damaged by the strong heating effect of X-rays.

(2) The skin may be damaged by the X-rays to cause skin cancer.

(3) The body tissue may be damaged by the X-rays due to their highly penetrating power.

(4) X-rays are dangerous as they are nuclear radiation.

3. Which of the following statements about X-rays is / are correct?

(1) X-rays consist of fast moving electrons.

(2) X-rays are produced when a heavy metal target is struck by fast moving electrons.

(3) In the production of X-rays, the speed of the X-rays depends on the speed of the electrons hitting the metal target.

(4) X-rays can blacken photographic films.

(3) Applications of X-rays

- **Medical use**
  - Low frequency X-rays are used. They can penetrate through ☐ but **not** ☐.
  - By taking X-ray pictures of the chest, doctors can diagnose lung disease. Or taking X-ray pictures of bones, doctor can diagnose bone fracture.
  - CT scanner (computerized tomography scanner) uses X-rays to take images of the interior of the human bodies.

- **Industry**
  - High frequency X-rays are used. They can penetrate through **metal**.
  - X-rays can also be used to inspect welded joints between metal plates.
  - X-rays are used to detect hidden weapons in luggage at airport.

Examples that you must fully understand

4. Which of the following is / are the application(s) of X-rays?

(1) To inspect the interior part of the teeth by dentist.

(2) To study the development of foetuses by using X-ray scanner.

(3) To detect the cracks in railway tracks.

(4) To sterilize food by killing bacteria.

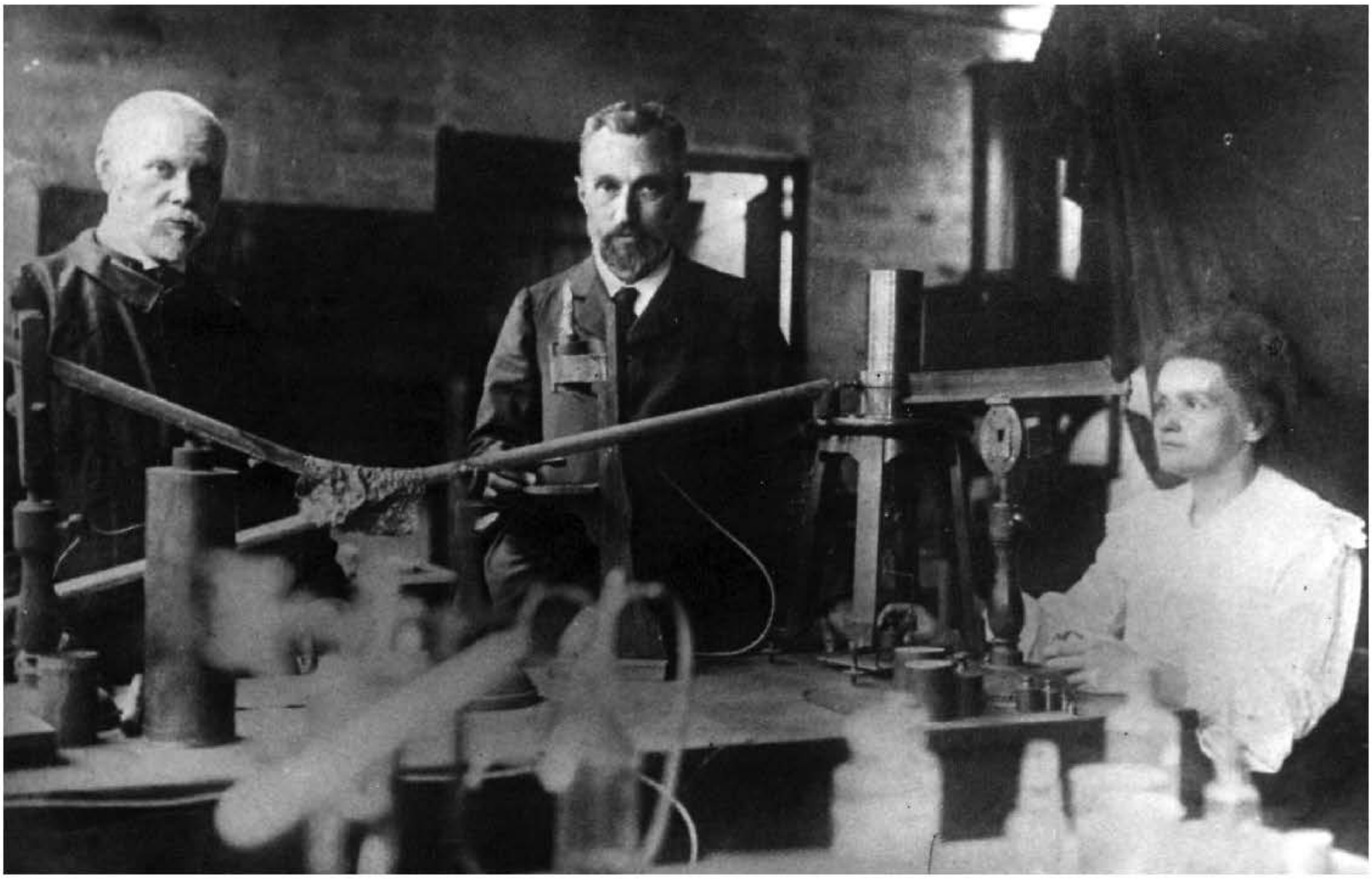
3. Discovery of Radioactivity and Nuclear Radiation

(1) Becquerel's experiment

- Nuclear radiation was discovered by Becquerel. He won the Nobel Prize in 1903.
- Becquerel once found that a wrapped radioactive source can blacken a photographic film and thus confirmed the existence of radiation.

(2) The Curies

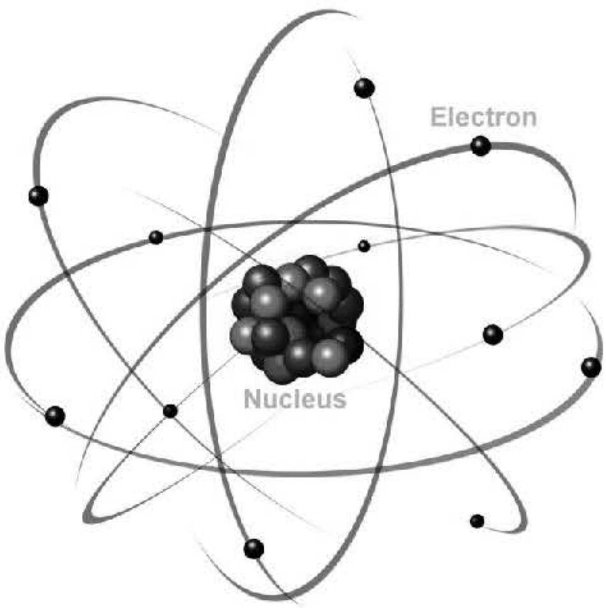
- Mr. and Mrs. Curie discovered two highly radioactive elements, radium and polonium.
- They succeeded in extracting 0.1 g pure radium from 800 kg of mineral.
- Mrs. Curie conducted many experiments to study the properties of nuclear radiation. She won the Nobel Prize twice, in 1903 and 1911.
- Mrs. Curie died of cancer due to prolong period of experiments dealing with radioactive substances.



4. Properties of Nuclear Radiation

(1) Types of nuclear radiation

- **Nuclear radiation:** the radiation that is released in a **nuclear process** (e.g. nuclear decay).
- All nuclear radiations come from the **nucleus** and **carry large amount of energy.**
- Nuclear radiations consist of:
  - **Alpha radiation** (α particles)
  - **Beta radiation** (β particles)
  - **Gamma radiation** (γ rays)



(2) Sources of radiation

- All nuclear radiation is emitted from ______________________.
- In school laboratory, there are 4 types of radioactive sources:
  - **Americium** emitting α radiation
  - **Strontium** emitting β radiation
  - **Cobalt** emitting γ radiation
  - **Radium** emitting α, β, γ radiation

(3) Nature of the 3 types of radiation

	Alpha particle	Beta particle	Gamma rays
Nature			
Symbol			
Mass			
Charge			
Speed			

- Mass in descending order:
- Speed in descending order:

Examples that you must fully understand

5. .

(a) Which of the following is / are nuclear radiation(s)?

(1) X-rays
(2) Gamma radiation
(3) Alpha particles
(4) Cathode rays

(b) Which of the following statements concerning X-ray is / are correct?

(1) X-rays consist of a beam of electrons.
(2) X-rays travel with a greater speed than beta particles.

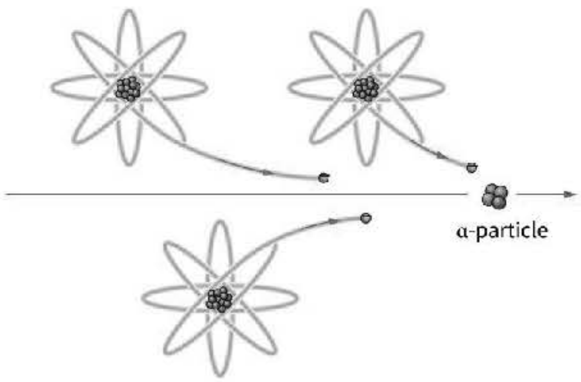
(c) State two similarities and two differences between X-ray and gamma ray.

Similarities: 1. They are both ______.
2. They both travel at the ______ of ______ in vacuum.
Differences: 1. X-ray and gamma ray have ______.
2. Gamma ray comes from the ______ of ______ but X-ray does not.

(d) State one similarity and one difference between cathode ray and beta radiation.

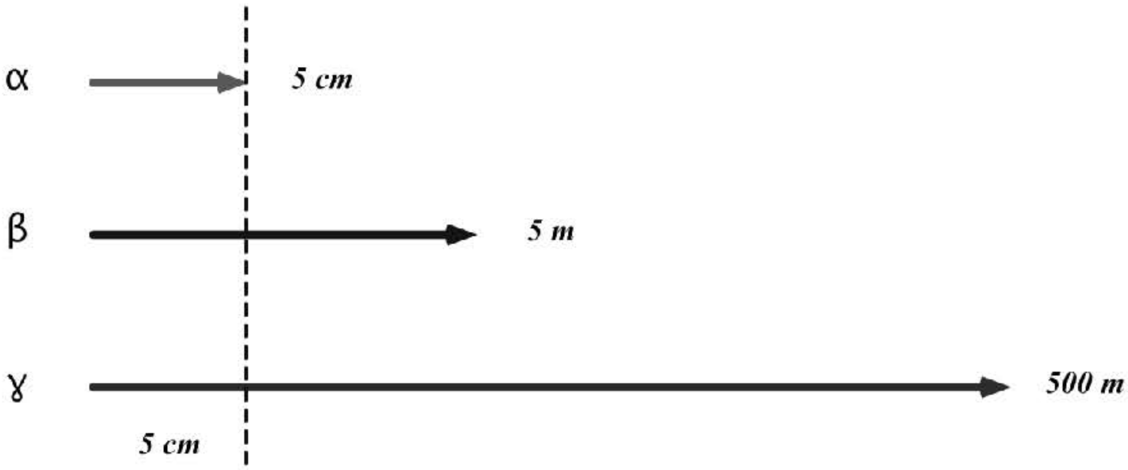
Similarity: They both consist of ______.
Difference: Beta comes from nucleus of atom by cathode ray comes from ______.

(4) Ionizing power



- When ionizing radiation passes through atoms or molecules, the radiation would collide with the atoms or molecules and **knock out or drag electrons away from the atoms or molecules to produce ion-pairs**.
- In the process, **the radiation loses some of its** ______ ______. After many ionizations, the radiation loses all of its energy and no longer has any ionizing effect.
- **Ionizing power** of radiation in descending order:
- ______ have ______ ionizing power since: (1) it has the greatest amount of ______ ______; and (2) it travels the ______

(5) Range in air



- <u>**Alpha particles**</u>
  - very short range in air
  - typical range: **a few centimeters (~5 cm)**
- <u>**Beta particles**</u>
  - medium range in air
  - typical range: **a few meters (~5 m)**
- <u>**Gamma radiation**</u>
  - very long range in air
  - typical range: **hundreds of meters (~500 m)**

(6) Penetrating power

■ **Alpha particles**

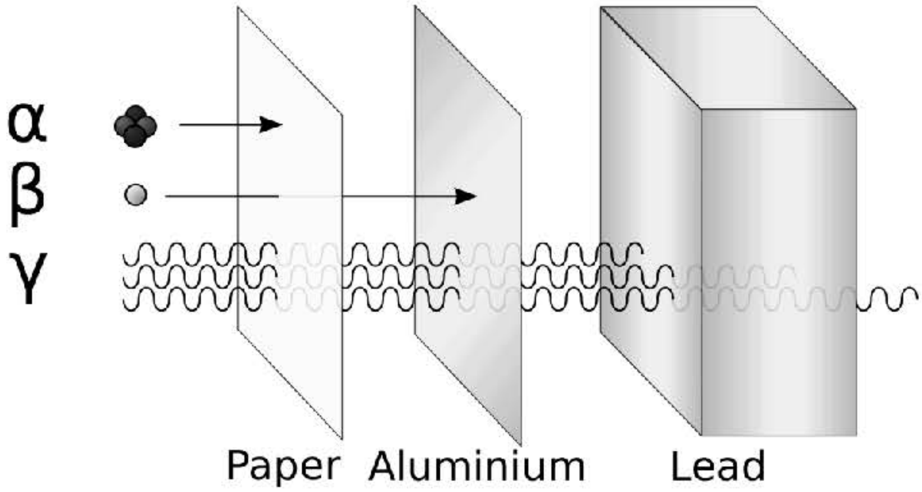
- stopped and absorbed by a sheet of ______
- stopped and absorbed by **human** ______

■ **Beta particles**

- ______ **absorbed by 1 mm aluminum** and ______ **stopped and absorbed by 5 mm aluminum**
- stopped and absorbed by human muscle

■ **Gamma radiation**

- can only be ______ **absorbed by a** ______ **block**
- **intensity of the gamma radiation decreases as the thickness of the lead increases**
- note that gamma radiation can never be totally absorbed
- can penetrate through the human body



Examples that you must fully understand

6. Arrange the following properties of the radiation in ascending order:

(a) Mass:

(b) Speed:

(c) Charge amount:

(d) Ionizing power:

(e) Range in air:

(f) Penetrating power:

Examples that you must fully understand

7. A dish containing an alpha-source is placed inside a gold leaf electroscope. If the gold-leaf is originally positively charged, what will happen to it after a few minutes?

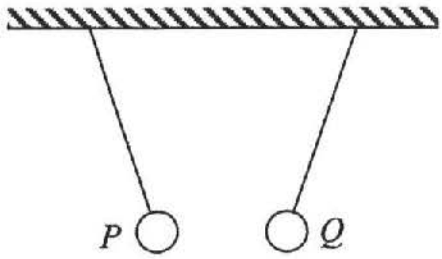
A. *It will increase divergence.*

B. *It will increase divergence and then decrease.*

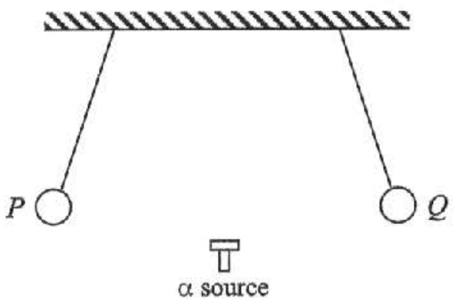
C. *It will collapse.*

D. *It will collapse and then re-diverge.*

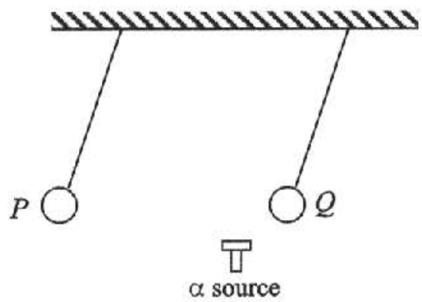
8. In the figure below, two charged metal balls P and Q are hung by insulating threads. P is positively charged while Q is negatively charged. An alpha-source is put near the balls without touching them. Which of the following figures shows the situation after a period of time?



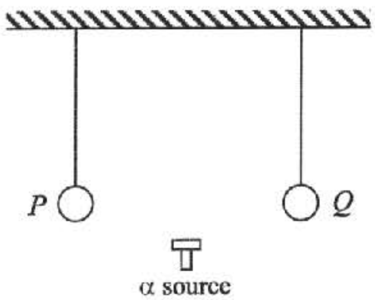
A.



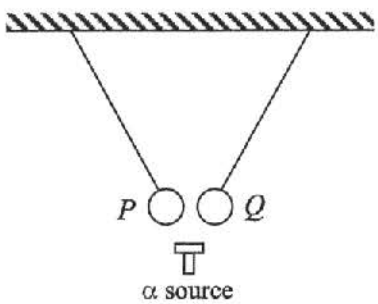
B.



C.



D.



Examples that you must fully understand

9. Which of the following statements about α and β particles is / are correct?

(1) The mass of an α particle is greater than that of a β particle.

(2) α particles have a stronger penetrating power than β particles.

(3) α particles have a shorter range in vacuum than β particles.

(4) An aluminium plate of 5 mm thick can stop β particles but not α particles.

(5) An α source can discharge a positively charged metal sphere nearby while a β source cannot.

10. Which of the following about α radiation is / are correct?

(1) The mass of an α particle is about four times that of a hydrogen atom.

(2) It travels with the same speed as γ radiation.

(3) It has a greater penetration power than β radiation.

(4) It can be stopped by a piece of paper.

(5) It cannot travel through vacuum.

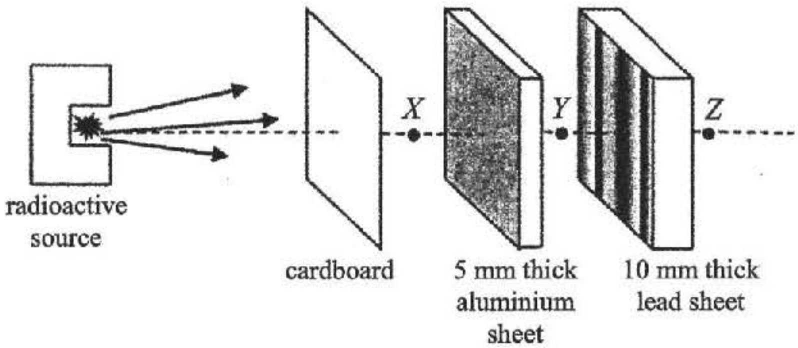
11. Which of the following about β radiation is / are correct?

(1) β particles can be stopped by a piece of paper.

(2) β particles can travel through vacuum.

(3) β particles are fast moving electrons.

12. A radioactive source emits α, β and γ radiations. Which statement about the radiation(s) detected at positions X, Y, Z indicated in the figure is correct?



(1) No radiation from the radioactive source is detected at Z.

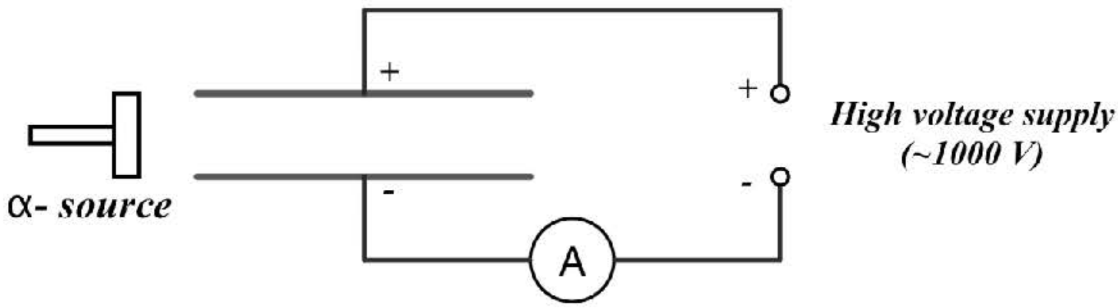
(2) Both β and γ radiations can be detected at Y.

(3) α radiation can only be detected at X but not at Y and Z.

(4) β radiation can only be detected at X but not at Y and Z.

Examples that you must fully understand

13. Two parallel plates connected to an EHT power supply with a sensitive ammeter in series are placed as shown.



(a) When an α-source is placed near the two parallel plates, the ammeter records a current. Explain briefly.

The α-particles emitted from the source ______ the air. The ions then ______ to the two parallel plates to give the current.

(b) If the α-source is placed at 20 cm from the parallel plates, what happens to the ammeter reading? Explain briefly.

The ammeter reading would ______, since the range of α in air is ______ ______.

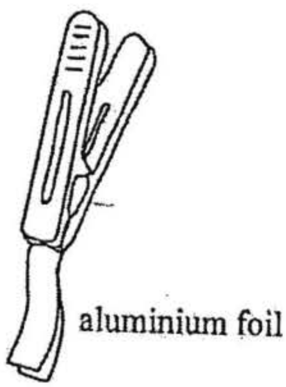
(c) If a β-source is used instead, what is the effect on the ammeter reading? Explain briefly.

The ammeter reading would ______, since the ionizing power of β is ______.

(d) What would be reading of the ammeter if the β-source in (c) is replaced by a γ-source? Explain briefly.

The ammeter reading would ______ or would become ______, since the ionizing power of γ is ______.

14. Two negatively charged aluminum foils clamped separately. They repel each other as shown.



(a) When the aluminum foils are placed near a radioactive source emitting β particle, what happens to the foils? Explain briefly.

The foils ______ since the β particles ______ the air and the ions then ______ the aluminium foils.

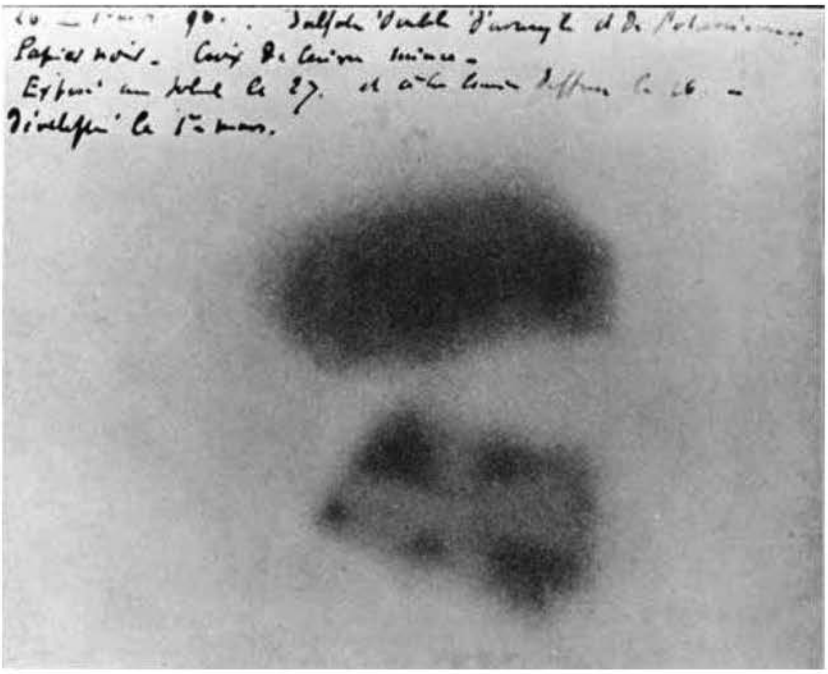
(b) What would happen if the source is replaced by another source emitting α particles or γ ray? Explain briefly.

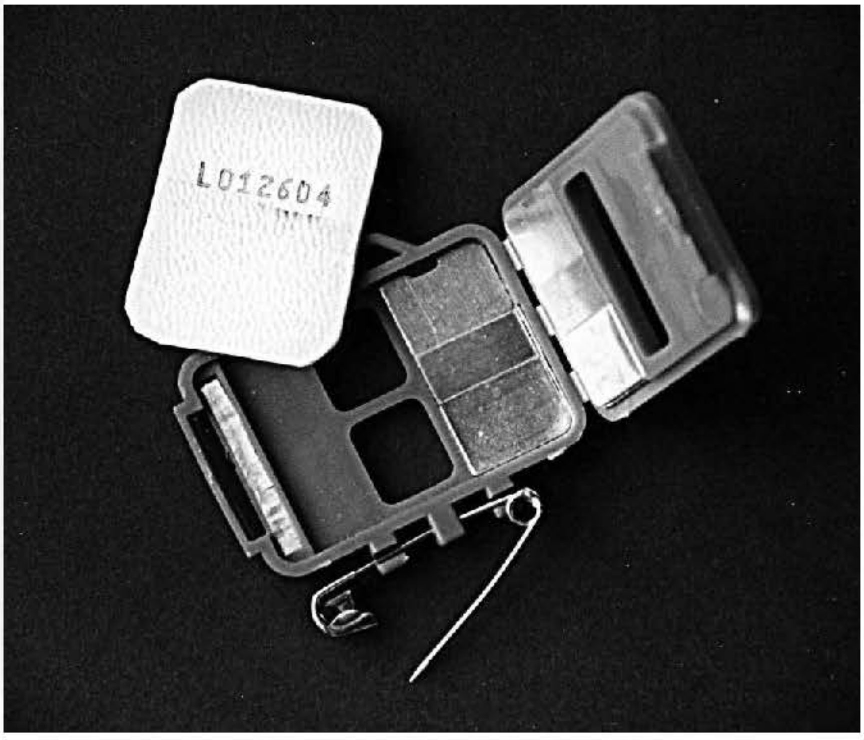
For α, the foils would ______ ______ since the ionizing power of α is ______. However, since the ______ power of γ is so ______ that the foils would ______ ______.

5. Detection of Radiation

(1) Photographic film

- All the 3 types of nuclear radiation **can be detected by a photographic film.**
- When the film is exposed to radiation, the film would be ______.





Examples that you must fully understand

15. Workers of nuclear plants are required to wear film badges (Figure 1) to monitor their exposure to radiation. Inside the film badge, an opaque plastic bag is wrapped around a sheet of photographic film. Aluminium and lead sheets are also placed inside the badge (Figure 2) so that the types of incoming radiation can be distinguished.

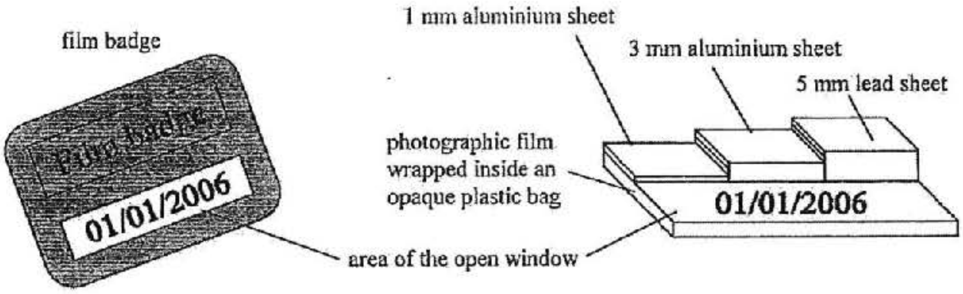


Figure 1 Figure 2

(a) What type(s) of radiation can be detected by the badge?

______ radiation and ______ radiation

(b) Why is an opaque plastic bag used to wrap the photographic film?

To prevent ______ ______ from ______ the bag and ______ the film.

(c) The films of three workers John, Mary and Ken were developed. The Table below shows the degrees of blackening on different regions of the films inside the badges which they wore.

Regions on the film	Degree of blackening (0-5) (0 = not blackened; 5 = most blackened)		
	John	**Mary**	**Ken**
Beneath the open window	**5**	**5**	**5**
Beneath the 1 mm Al sheet	**5**	**3**	**4**
Beneath the 3 mm Al sheet	**5**	**1**	**2**
Beneath the 5 mm Pb sheet	**4**	**0**	**0**

(i) **Based on the results in the above Table, explain which type(s) of radiation John and Mary are definitely being exposed to respectively.**

John is exposed to ______ radiation since ______ can pass through ______ ______ sheet and ______ the film. Mary is exposed to ______ radiation since the film under the ______ ______ is ______ but the film under the ______ ______ sheet is ______ blackened.

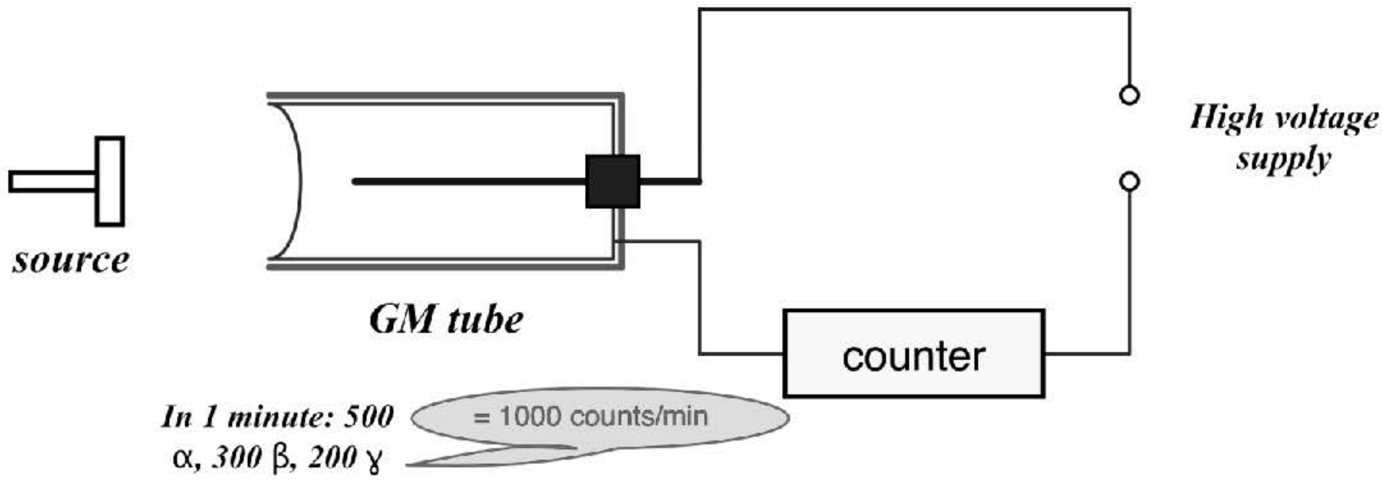
(ii) **Why different degrees of blackening were recorded on the films of Mary and Ken.**

The radiation dose received by Ken is ______ than that of Mary.

(d) Suggest one hazard of exposure of ionizing radiations.

It can ______ cells. It can cause ______. It can cause the genetic change.

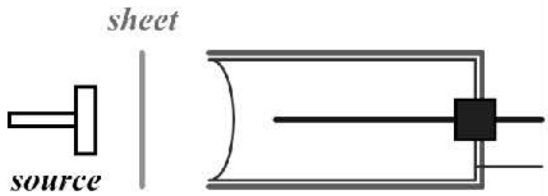
(2) GM tube (Geiger-Muller tube)



- A GM tube can be connected to a counter to form a GM counter which measures the **count rate**.
- The unit of the count rate is **counts per minute (c.p.m.) or counts per second**.
- All the 3 types of radioactive radiation can be detected by a GM counter.
- The count rate includes the total counts of α, β and γ, **irrespective of their ionizing power.**

Examples that you must fully understand

16. Suppose you are given the following apparatus: a GM counter, a sheet of paper, a 5 mm thick aluminum sheet and thick lead block. Describe how you can demonstrate that a radioactive source emits α particles and γ radiation but does not emit β particles.



(1) Place the source ______ the GM tube since α has very ______ in air.

(2) Insert the ______ between the GM tube and the source. The reading of the GM tube should ______, showing that the source emits α.

(3) Replace the paper sheet with the ______. The reading of the GM counter should be ______, showing that the source does not emit β.

(4) Replace the aluminum sheet with the ______. The reading of the GM counter should ______, showing that the source emits γ.

17. Different absorbers are placed in turn between a radioactive source and a Geiger-Muller tube. Three readings are taken for each absorber. The following data are obtained:

Absorber	Count rate / s^{-1}		
-	200	205	198
Paper	197	202	206
5 mm aluminium	112	108	111
25 mm lead	60	62	58
50 mm lead	34	36	34

What type(s) of radiation does the source emit?

A. β **only**

B. γ **only**

C. β **and** γ **only**

D. α, β **and** γ

Why are the readings in the three measurements not the same?

The slight fluctuation of the count rate is due to the ______ of radiation.

Examples that you must fully understand

18. This example is about using a GM tube.

(a) To find out the kind(s) of radiation emitted by a radioactive source P, sheets of different materials are placed in turn between P and a GM counter. The following results are obtained:

Material	Recorded count rate / counts per minute
--	**520**
Paper	**523**
5 mm Aluminium	**79**
25 mm Lead	**82**

(i) Explain how the above result shows that P emits β radiation only and it does not emit α or γ radiation.

When the paper is inserted, the count rate remains ______, showing that P does not emit α radiation.

When the aluminum is inserted, the count rate ______ showing that P emits β radiation.

When the lead is inserted, the count rate remains ______, showing that P does not emit γ radiation.

(ii) Explain why the count rate increases slightly when a paper is inserted.

It is due to the ______ of radiation.

(b) If the experiment above is repeated with another source Q which emits both α and γ radiation, a different set of readings would be obtained, as shown in the following table.

Material	Recorded count rate / counts per minute
--	**850**
Paper	
5 mm Aluminium	
25 mm Lead	

Choose suitable values to fill up the above table from the following list: 0, 80, 165, 570, 850

(Note: A reading may be used more than once.)

Examples that you must fully understand

19. Different absorbers are placed in turn between a radioactive source and a Geiger-Muller tube. Three readings are taken for each absorber. The following data are obtained:

Absorber	**Count rate / s^{-1}**		
-	200	205	198
1 mm aluminium	162	168	171
25 mm lead	120	122	118

What type(s) of radiation may the source emit?

A. α **only**

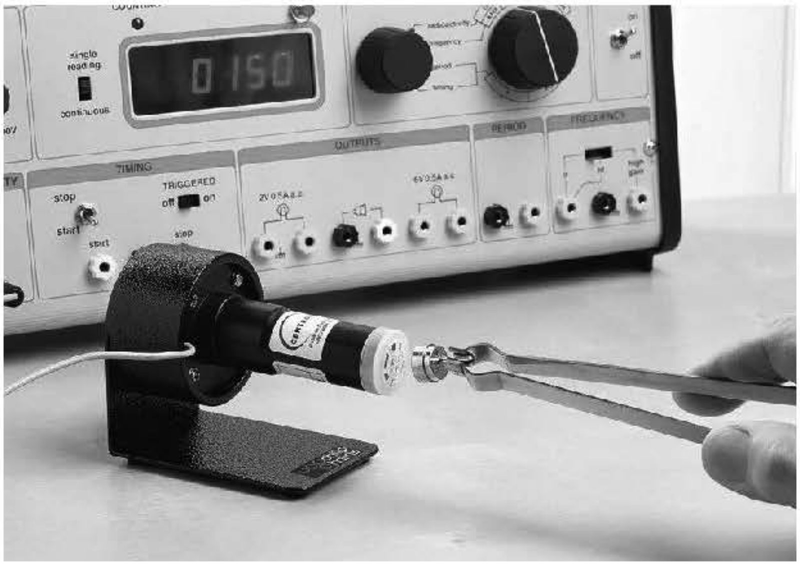
B. β **only**

C. α **and** β **only**

D. β **and** γ **only**

E. α, β **and** γ

20. In a physics lesson, a teacher uses the apparatus shown below to find the range of α particles in the air. Describe the procedures of the experiment.



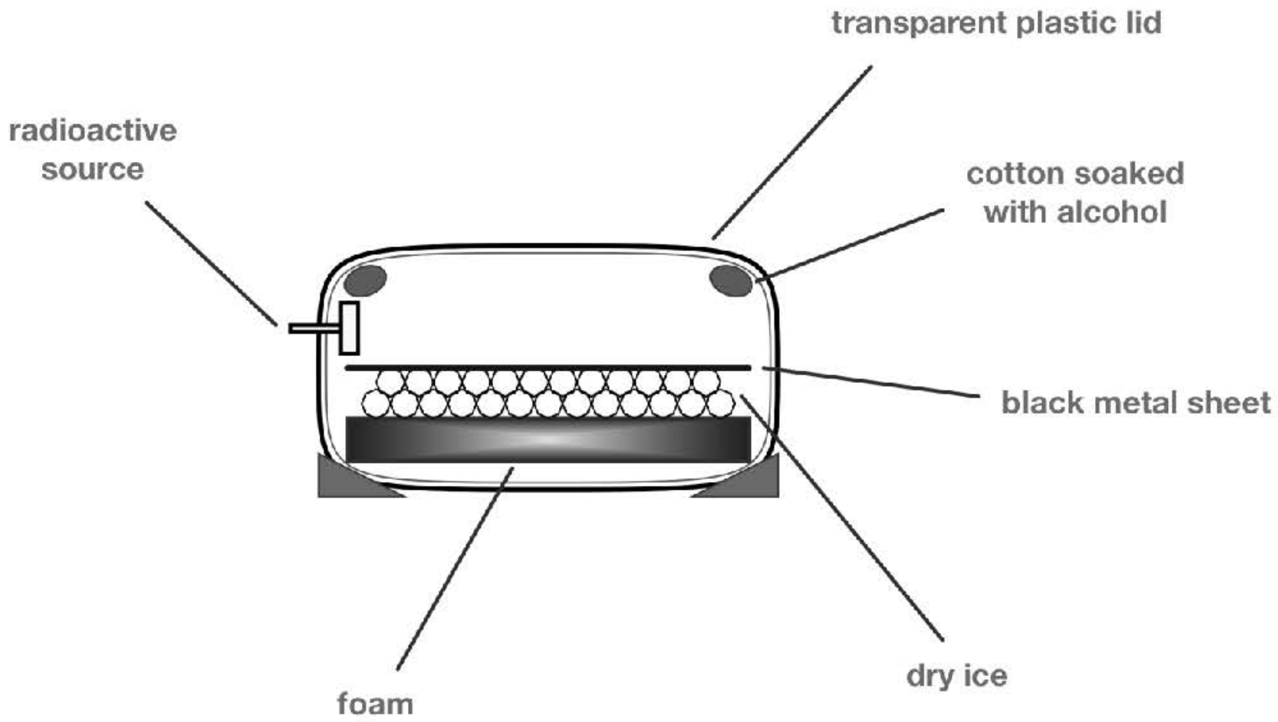
Place the alpha source [ ] and facing the GM tube.

[ ] gradually and observe the count rate reading.

Mark the point for the [ ] count rate.

Measure the distance between a source and the GM tube with the metre rule to give the range.

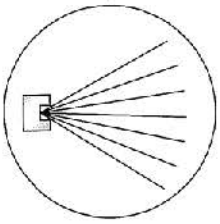
(3) Cloud Chamber



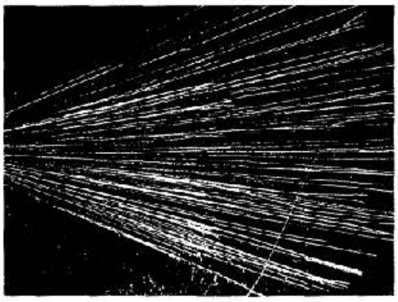
- **Cloud chamber** can detect the ______ **of the individual particle.**

- **All the 3 types of a radiation can be detected.**

1. Tracks of alpha particles



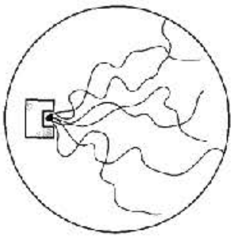
(a)



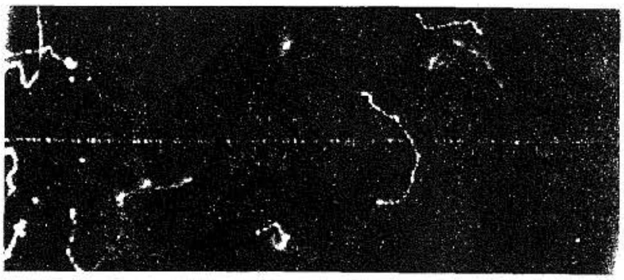
(b)

- Characteristics of the tracks produced by α
  - **Straight** – since they have ______
  - **Thick** – since they have ______
  - **Equal length** – since each α coming from the same source **carries** ______
  - **Short** – since α have ______

2. Tracks of beta particles



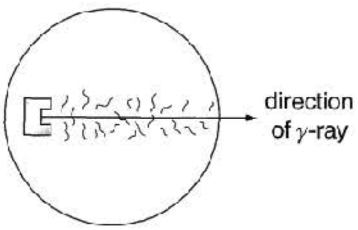
(a)



(b)

- The tracks are
  - **Thin** – since β has **weak ionizing power**
  - **Curved** – since β has **small mass**

3. Tracks of gamma ray

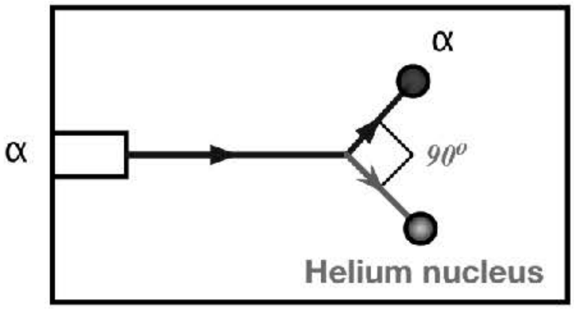


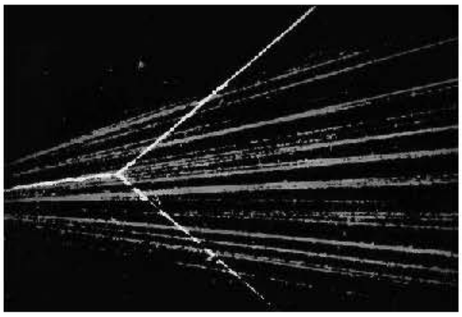
(a)

(b)

- The tracks are ______ since the **ionizing power** of γ is ______.

4. The right-angled fork track of α particle





- If a cloud chamber containing some helium gas is used to observe the tracks of alpha particles, then a **right-angled fork track** may be observed.
- The fork track shows that **an alpha particle and a helium nucleus have the same** ☐.

Examples that you must fully understand

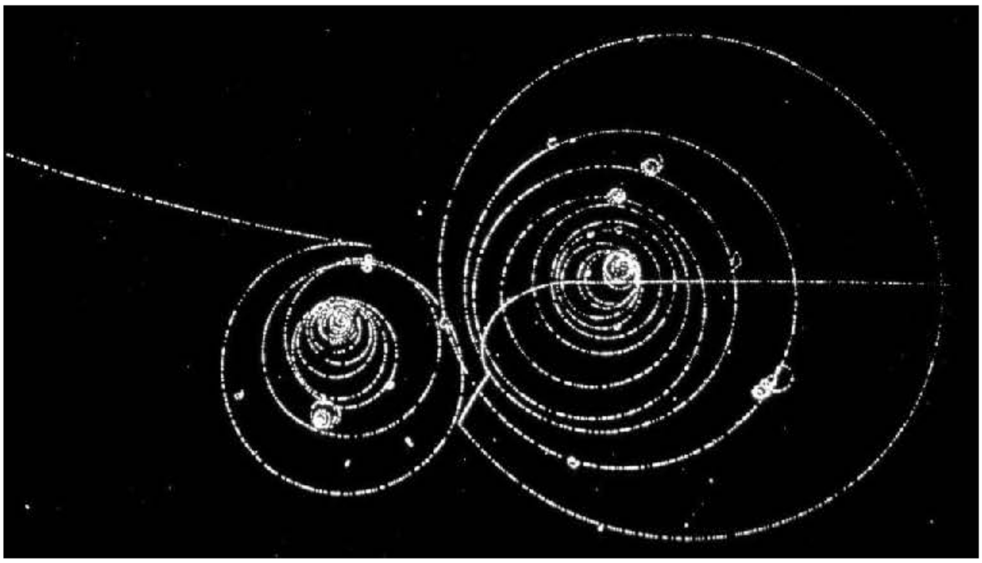
21. A cloud chamber is used to observe the tracks of alpha particles.

(a) Describe and explain the tracks of alpha particles in the cloud chamber. Give any three of them.

The tracks are ☐ since alpha has ☐ ☐.
The tracks are ☐ since alpha has ☐ ☐ ☐.
The tracks are ☐ since alpha has ☐ ☐ ☐ ☐.

(b) The chamber contains a small amount of helium gas. Sometimes a fork track can be observed. State the angle of the fork track and what conclusion can be drawn?

The angle is ☐. Alpha particle and helium nucleus have the ☐ ☐.



6. Background Radiation

(1) Count rate due to background radiation

- If no radioactive source is placed near the GM tube, the GM counter can still measure certain readings. The readings are due to **background radiation.**
- The count rate due to background radiation may vary at different locations and/or times.
- The count rate due to background radiation is approximately constant at a certain place and certain time.

Time/ hour	0	1	2	3	4
Count rate/ counts per minute	60	62	58	63	57

- The slight fluctuation is due to the ☐ **nature** of radiation.
- When the GM counter is used to measure the radiation of a radioactive sample, the count rate must include the count rates due to background radiation. Only the **corrected count rate** can represent the actual number of radioactive particles emitted by the radioactive source that can enter the GM tube.

> Corrected count rate = total / measured count rate – background count rate

(2) Sources of background radiation

- Background radiation is due to the ionizing radiation present in the environment. This can be due to:
  - **Cosmic radiation from space**
  - **Radiation from rock**
  - **Radiation in air**
  - **Radiation from food**
  - **Radiation from living things or dead living things**

Examples that you must fully understand

22. The background count rate in an experiment is determined using a GM counter. Four readings of the count rate in each minute are taken. Which set of readings below is the most probable?

	1st minute	2nd minute	3rd minute	4th minute
A.	5	62	8	69
B.	40	40	40	40
C.	60	50	30	20
D.	29	26	31	35

23. Different absorbers are placed in turn between a radioactive source and a Geiger-Muller tube. Three readings are taken for each absorber. The following data are obtained:

Absorber	Count rate / s^{-1}		
-	200	205	198
Paper	197	202	206
1 mm aluminium	112	108	111
25 mm lead	60	62	58
50 mm lead	58	64	60

What type(s) of radiation does the source emit?

A. β only

B. γ only

C. β and γ only

D. α, β and γ

Why are the readings in the three measurements not the same?

The slight fluctuation of the count rate is due to the ________ of radiation.

24. A radioactive source is placed in front of a GM tube connected to a counter. Various absorbers are placed between the source and the GM tube and the count-rate recorded. The following results were obtained. It can be deduced from these results that the radiation(s) emitted by the source is / are

A. α and γ only

B. β and γ only

C. α only

D. β only

Absorber	Counts per minute
no absorber	711
a sheet of paper	508
5 mm thick aluminium sheet	493
25 mm thick lead block	218

Examples that you must fully understand

25. A radioactive source is placed in front of a GM tube connected to a counter. Various absorbers are placed between the source and the GM tube and the count-rate recorded. The following results were obtained:

Absorber	Counts per minute
no absorber	711
a sheet of paper	508
5 mm thick aluminium sheet	493
25 mm thick lead block	218

It can be deduced from these results that the radiation(s) emitted by the source is / are

A. **α and γ only**

B. **β and γ only**

C. **α only**

D. **β only**

Can we conclude the counts "218" is solely due to the background radiation?

26. A GM counter is placed close to and in front of a radioactive source which emits both α and γ radiation. The count rate recorded is 500 counts per minute while the background count rate is 50 counts per minute. Three different materials are placed in turn between the source and the counter. The following results are obtained:

Material	Counts per minute
Nil	500
Carboard	x
1 mm of aluminium	y
5 mm of lead	z

Which of the following is a suitable set of values for x, y and z?

A. *x: 350; y: 350; z: 150*

B. *x:350; y: 150; z: 50*

C. *x: 350; y: 150; z: 0*

D. *x: 150; y: 150; z:50*

Examples that you must fully understand

27. A radioactive source is placed in front of a GM tube connected to a counter. Various absorbers are placed between the source and the GM tube and the count-rate recorded. The following results were obtained:

Absorber	Counts per minute
no absorber	700
a sheet of paper	300
2 mm thick aluminium sheet	290
25 mm thick lead block	100

Which of the following statements is / are correct?

(1) The count rate due to the alpha radiation is about 400 counts per minute.

(2) The count rate due to the gamma radiation is about 200 counts per minute.

(3) The background radiation is about 100 counts per minute.

28. To investigate the kind(s) of radiation emitted by a radioactive source, a Geiger-Muller counter is placed close in front of the source and sheets of different absorbers are placed in turn between the source and the counter. Three readings are taken at one-minute intervals for each absorber. The following results are obtained:

Absorber	Count rate / min^{-1}		
-	700	710	693
Paper	702	703	701
1 mm aluminium	313	320	317
5 mm lead	98	101	100

It is noted that the background count rate recorded by the same counter is around **100 counts per minute**. Explain how the above results show that the source emits beta radiation only and it does not emit alpha and gamma radiation.

Alpha radiation is stopped by a piece of ______ while beta radiation can only be ______ ______. Gamma radiation is ______.

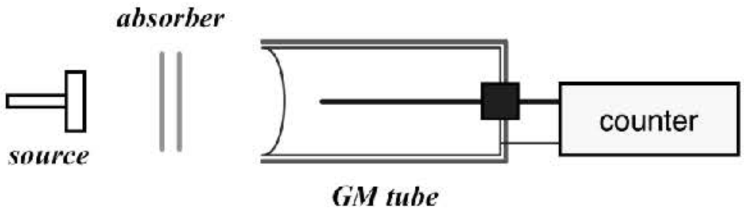
As the count rates ______ when a sheet of paper is inserted, the source ______ alpha radiation.

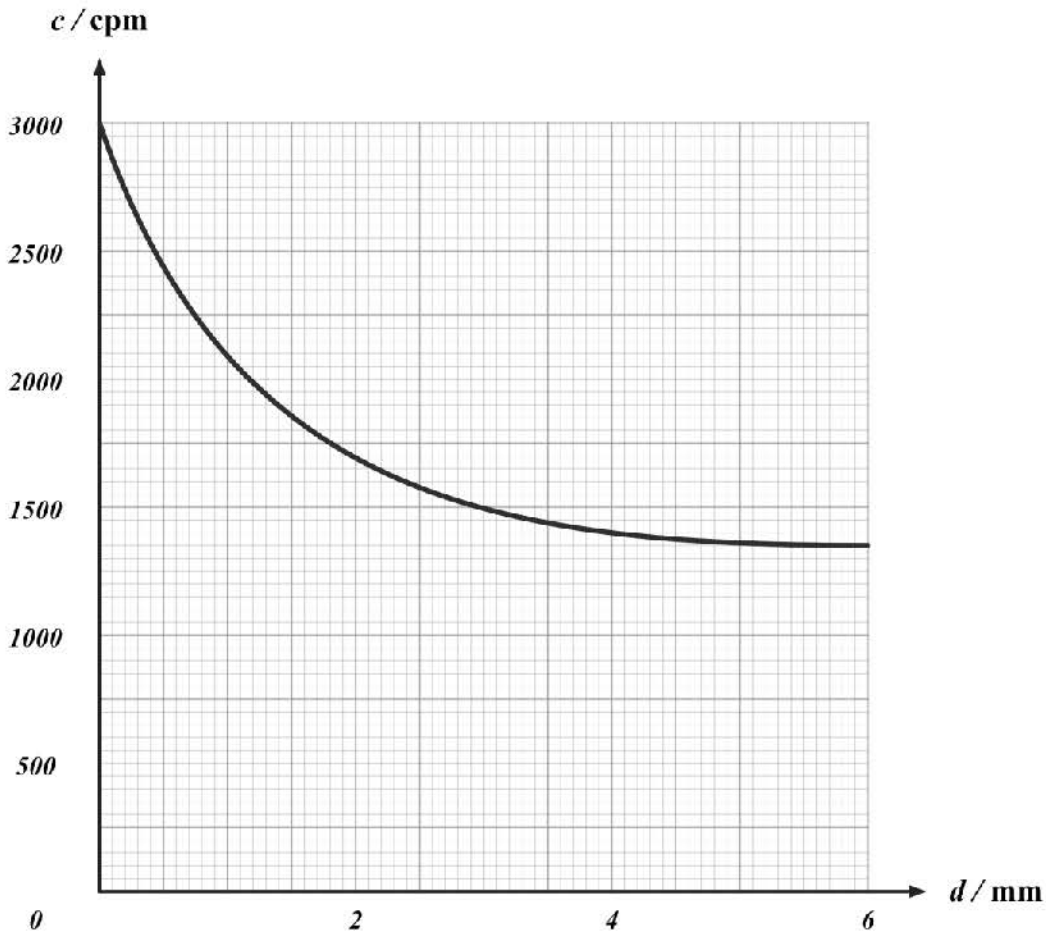
As the count rates ______ when 1 mm aluminium sheet is inserted, the source ______ beta radiation.

As the count rates ______ when 5 mm lead is inserted, the source ______ gamma radiation.

Examples that you must fully understand

29. In the below experiment, a source emitting α, β and γ radiations is placed at a distance of about 10 cm from a G-M tube. The count rates are measured for different thickness, d, of absorber plates made of aluminium. The results are shown in the graph below. The count rates due to background radiation have been deducted.





(a) Would the count rate include alpha radiation? Explain briefly.

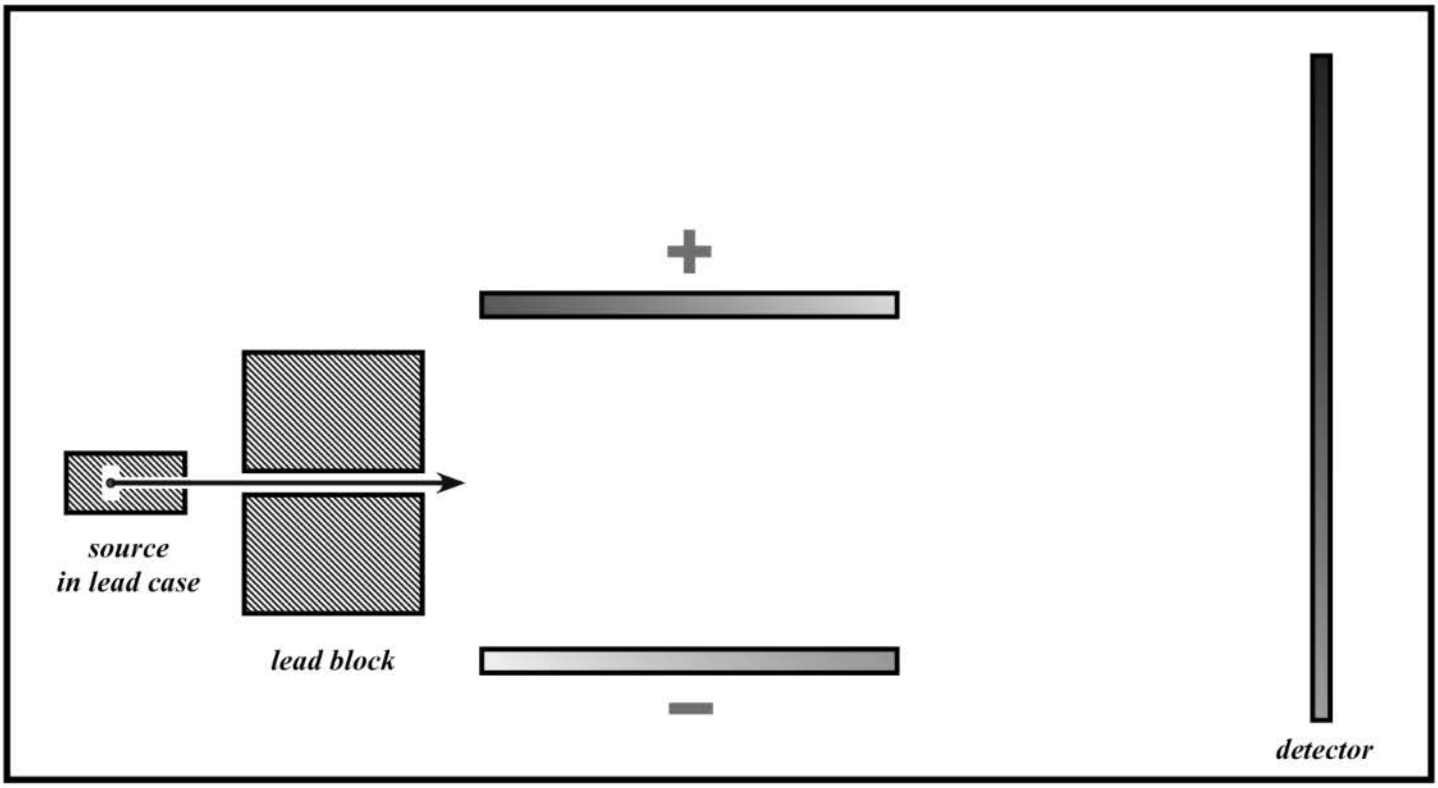
____! Since the range of alpha particles in ____ is about ________.

(b) Estimate the count rate due to the β and γ radiation.

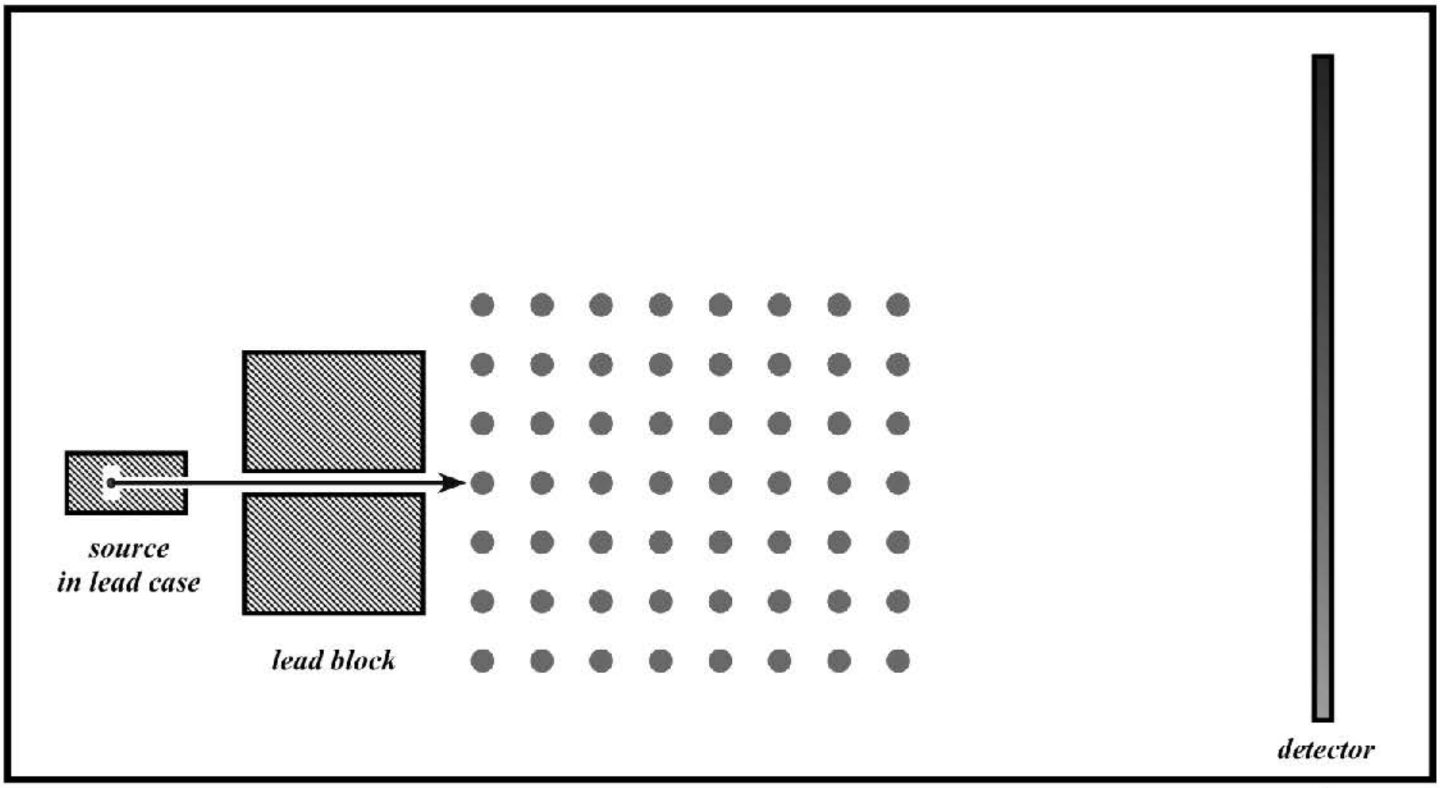
(c) What is the minimum thickness of aluminium needed to absorb all the β radiation?

7. Deflection of Radiation Particles

(1) Deflection of radiation in an Electric field



(2) Deflection of radiation in a Magnetic field



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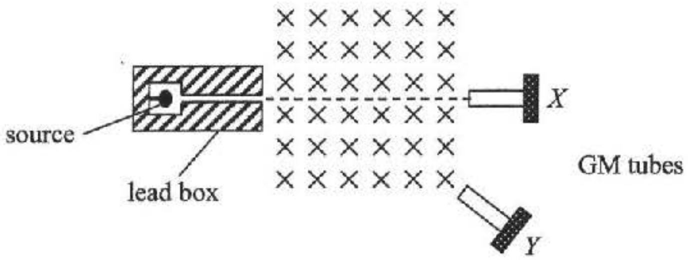
30. Which of the following statements about ionizing-radiations is/are correct?

A. *The ionizing power of α-particles is much stronger than that of β-particles.*

B. *γ-radiation can be completely shielded by a 10 cm thick concrete wall.*

C. *Ionizing radiations α, β and γ all undergo deflection in an electric field.*

31. A radioactive source is placed in front of a uniform magnetic field pointing into the paper as shown above. The count rates recorded by the GM tubes at X and Y are 101 counts per minute and 400 counts per minute respectively. Which of the following deductions must be correct?



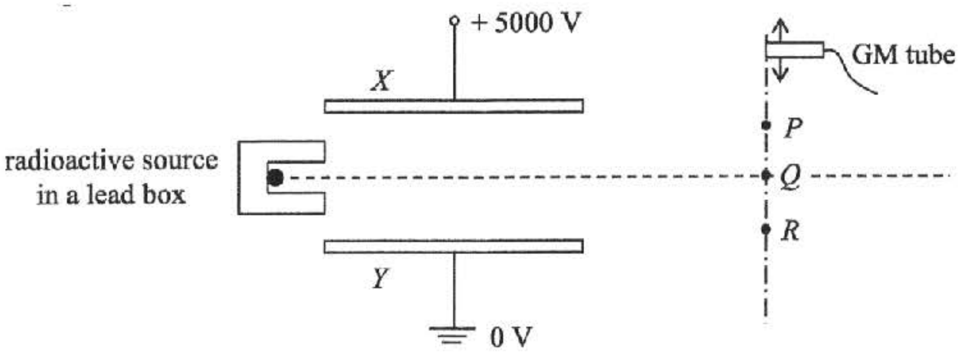
A. *The source does not emit alpha radiations.*

B. *The source emits betta radiations.*

C. *The source emits gamma radiations.*

D. *The background count rate is about 100 counts per minute.*

32. The figure shows a radioactive source placed near two parallel metal plates X and Y that are connected to a power supply. When a GM tube is moved along the dotted line, the count rate shows a significant increase at P and Q respectively. Which of the following statements is correct when a magnetic field pointing out of paper is applied between X and Y?



A. *The count rate at P decreases and the count rate at Q remains the same.*

B. *The count rates at P and Q remain the same.*

C. *The count rate at P decreases and the count rates at Q and R increase.*

D. *The count rates at P, Q and R are equal.*

Examples that you must fully understand

33. The figure below shows the set-up of an experiment carried out in an evacuated chamber to study the radiation from a radioactive source. The source emits α, β and γ radiation. A lead block of length 5 cm is used to ensure the radiations travel in a straight line. A magnetic field (pointing into the paper) is applied. The photographic film is developed and marks in the positions *P* and *Q* are observed.

(a) In the above figure, sketch and label the paths of α, β and γ radiations.

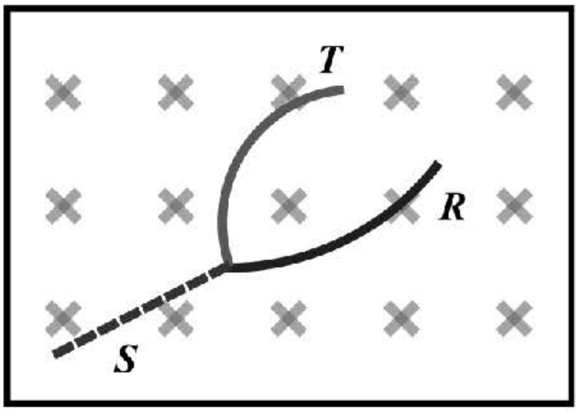
(b) What type(s) of radiation would be recorded on the photographic film if the experiment is conducted in air?

[ ]

(c) Suggest another suitable device for detection of the radiations in the above experiment.

[ ]

34. A neutron decays in a very short time into a proton and a negative particle. The below figure shows the initial and the subsequent paths of the particles in a magnetic field.



(a) Identify the paths R, S and T for the three particles.

[ ] is the proton; [ ] is the neutral particle; [ ] is the negative particle.

(b) Explain briefly the paths R and T are curved.

There is a [ ] acting [ ] to their motion.

Examples that you must fully understand

35. A radioactive source emits α , β and γ radiations in air.

(a) A GM counter is placed at point P as shown in the above figure. What type of radiations cannot be detected by the counter? Explain briefly. Hence, suggest how to detect that radiation at P.

[ ] cannot be detected since the range [ ] is only a [ ].
To detect [ ] radiation at P, the experiment should be carried out in an [ ] [ ].

(b) In the figure below, A is connected to the (+)-terminal and B is connected to the (-)-terminal of a voltage supply.

(i) **What type of radiation is detected at point Q?**
It is due to the [ ] radiation.

(ii) **Describe and explain what happens to the count rate detected at point P.**
The count rate would [ ] since [ ] is [ ] towards [ ].

(c) What should be done so that the count rate is unchanged at P even when the electric field is applied?

Apply a [ ] perpendicular [ ] the paper so that the [ ] force is balanced by the [ ] force.

(d) Explain briefly the use of the lead block in the set-up.

To produce a [ ] of radiation.

(e) Suggest what can be used to detect the radiation in the experiment.

Examples that you must fully understand

36. Figure 1 shows a set-up used to study he radiation from a radioactive source in air. Initially *S* is open and the variation of the count rate recorded by the GM tube with time is shown in Figure 2.

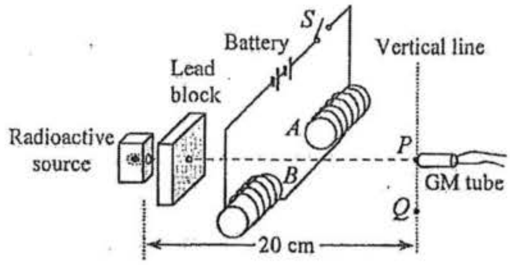


Figure 1

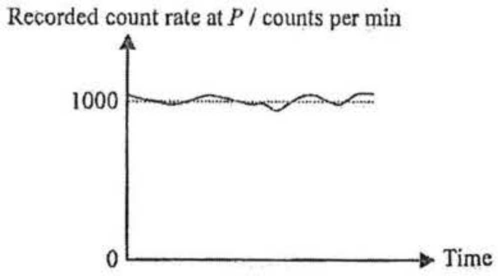


Figure 2

(a) Explain why the count rate shown in Figure 2 has slight fluctuation.

The fluctuation is due to the ______ of radiation.

(b) Now switch S is closed. The GM tube is placed at positions P and Q in turn and the count rates recorded are shown in the Figure 3 and Figure 4 respectively. When the GM tube is placed at any point vertically above P, an average count rate of 100 counts per minute is recorded at each point.

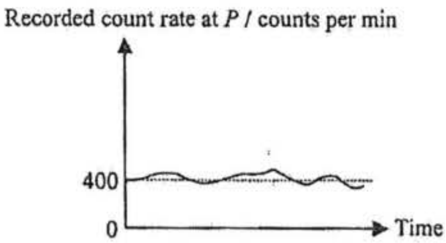


Figure 3

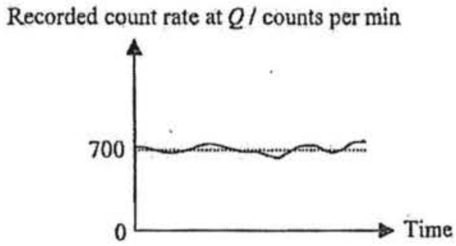


Figure 4

(i) **State the direction of the magnetic field formed between coils A and B.**

The direction is from ☐ to ☐.

(ii) **What conclusion about the radiation emitted by the source can you draw from Figure 3 and 4? Explain your answer.**

As the count rates are greater than the background radiation, some ______ are detected. The radiation at P is ______ by the magnetic field, it must be ______ radiation. The radiation at Q is deflected ______ by the magnetic field, it must be ______ radiation. So the source emits ______ and ______ radiation.

(iii) **Explain why the sum of the average count rates recorded in Figure 3 and Figure 4 is greater than that recorded in Figure 2.**

The ______ is recorded at both Figure 3 and Figure 4, so the background radiation is counted ______ and thus the sum is greater.

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37.

(a) A teacher places a radioactive source 1 cm in front of a GM tube and measures the count rate. When he inserts a piece of paper between the radioactive source and the GM tube, he finds that there is no significant change in the measured count rate. State the conclusion about the type of radiation emitted from the radioactive source.

There is ☐ from the source.

The teacher then conducts another experiment to investigate the deflection of radiations inside a magnetic field as shown in Figure 1. The GM tube can be rotated from 0° to 180° around the magnetic field. Figure 2 shows the count rate recorded at different angles with or without the magnetic field.

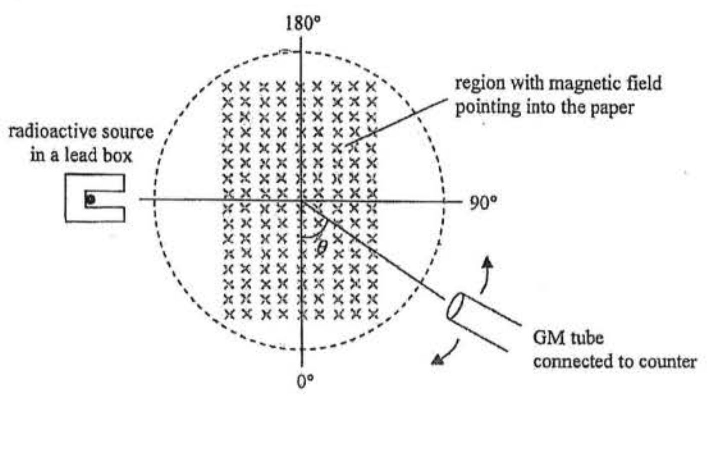

Figure 1

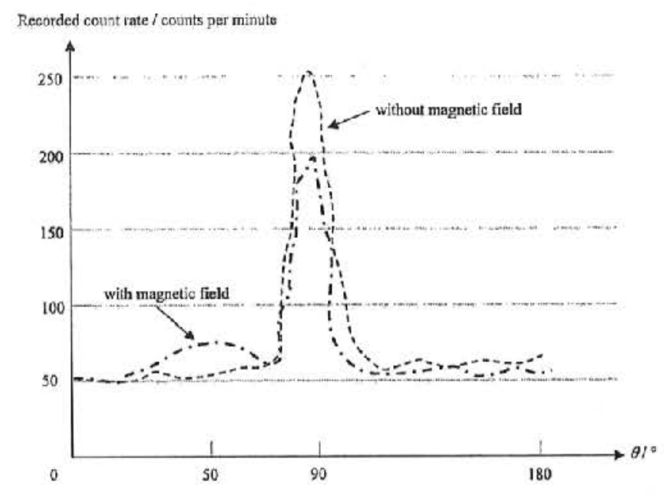

Figure 2

(b) Estimate the count rate due to the background radiation.

Background count rate = ☐

(c) Estimate the count rate due to each type of radiation at θ = 90° without the magnetic field.

Type of radiation	Count rate / counts per minute
α	0
β	
γ	