Use the following data wherever necessary :

Charge of electron	$e = 1.6 \times 10^{-19}$ C

The following list of formulae may be found useful :

Law of radioactive decay	$N = N_0 e^{-kt}$
Half-life and decay constant	$t_{\frac{1}{2}} = \frac{\ln 2}{k}$
Activity and the number of undecayed nuclei	$A = kN$

Part A : HKCE examination questions

1. **< HKCE 1980 Paper II - 37 >**

In a β decay, element X, having a half-life of 3 days, decays into a stable element Y. If the initial mass of X is 4 g, what will be the masses of X and Y after 6 days ?

	Mass of X	Mass of Y
A.	0 g	4 g
B.	1 g	3 g
C.	2 g	2 g
D.	3 g	1 g

2. **< HKCE 1981 Paper II - 36 >**

If the three kinds of radiations α, β and γ are arranged in ascending order of their ionization power, their order is
A. α, β, γ
B. α, γ, β
C. β, α, γ
D. γ, β, α

3. **< HKCE 1982 Paper II - 38 >**

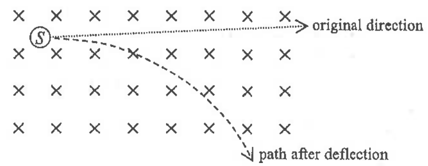
A radioactive substance has a half-life of 10 minutes. Which of the following statements is/are correct ?
(1) All the atoms of the radioactive substance will split into 4 equal parts in 5 minutes.
(2) All the atoms of the radioactive substance will decay completely in 20 minutes.
(3) All the atoms of the radioactive substance will decay within 10 minutes.
A. (1) only
B. (2) only
C. (3) only
D. None of them

4. **< HKCE 1983 Paper II - 36 >**

The half-life of a radioactive substance is 8 hours. Its initial mass is 3 g. Find the amount of the radioactive substance remaining unchanged after 24 hours.
A. 0.375 g
B. 0.75 g
C. 1 g
D. 2 g

5. **< HKCE 1984 Paper II - 36 >**

S is a radioactive source which emits radiation as it decays. If all the radiation emitted is bent by a magnetic field in the direction shown, then the radiation consists of



A. α and γ only
B. β and γ only
C. α only
D. β only

6. **< HKCE 1985 Paper II - 45 >**

The corrected count rate of a sample of radioactive material was measured on the first day of each month. The readings on July 1 and September 1 are 0.8 and 0.2 counts per second respectively. What is the half-life of the radioactive material ?
A. 7 days
B. 16 days
C. 31 days
D. 46 days

7. **< HKCE 1986 Paper II - 35 >**

The speeds of X-rays, γ rays and β rays in air are denoted by v_X, v_γ and v_β respectively. Which of the following is true ?
A. $v_X > v_\gamma > v_\beta$
B. $v_X < v_\gamma < v_\beta$
C. $v_X = v_\gamma = v_\beta$
D. $v_X = v_\gamma > v_\beta$

8. **< HKCE 1987 Paper II - 39 >**

Which of the following about α radiation is/are correct ?
(1) The mass of an α particle is about four times that of a proton.
(2) It has a stronger ionizing power than β radiation.
(3) It has a greater penetration power than γ radiation.
A. (1) only
B. (2) only
C. (1) & (2) only
D. (2) & (3) only

9. **< HKCE 1987 Paper II - 38 >**

Which of the following descriptions of the half-life of a sample of radioactive isotope is/are correct ? The half life is
(1) the time taken for the mass of the sample to fall to half of its initial value.
(2) the time taken for the activity of the sample to fall to half of its initial value.
(3) half of the time taken for the sample to decay completely.
A. (1) only
B. (2) only
C. (3) only
D. (1) & (2) only

10. **< HKCE 1988 Paper II - 39 >**

The activity of a radioactive source falls to $\frac{1}{8}$ of its original value in 24 minutes. The half-life of the source is
A. 3 min.
B. 6 min.
C. 8 min.
D. 72 min.

11. **< HKCE 1989 Paper II - 40 >**

A radioactive source has a half-life of 22 years. After 66 years, what fraction of the source remains undecayed ?

A. $\frac{1}{3}$

B. $\frac{1}{6}$

C. $\frac{1}{8}$

D. $\frac{1}{9}$

12. **< HKCE 1990 Paper II - 40 >**

In an experiment to measure the half-life of a radioactive isotope in a place where the background count rate is 20 counts per minute, the following results are recorded :

Time / minute	0	2	4	6	8	10	12
Total count rate / counts per minute	116	96	80	69	58	50	44

The half-life is about

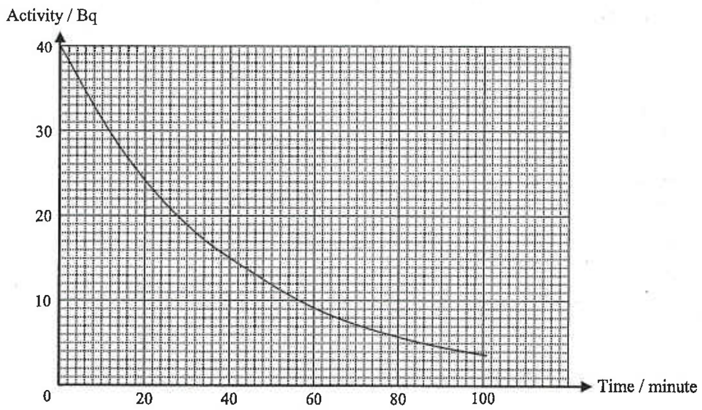
A. 4 min.

B. 6 min.

C. 8 min.

D. 10 min.

13. **< HKCE 1991 Paper II - 41 >**



The activity of a radioactive source is recorded on a graph as shown above. What is the half-life of the source ?

A. 20 min.

B. 24 min.

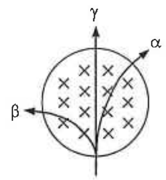
C. 28 min.

D. 32 min.

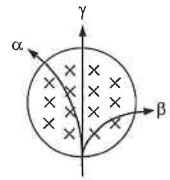
14. **< HKCE 1992 Paper II - 40 >**

Which of the following diagrams correctly shows the deflections of α, β and γ rays in a uniform magnetic field pointing into the paper ?

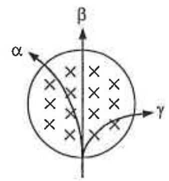
A.



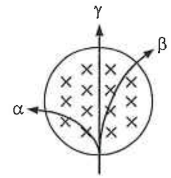
B.



C.



D.



15. **< HKCE 1993 Paper II - 39 >**

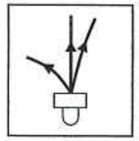
Which of the following signs is used to indicate radioactive material ?

A.

B.

C.

D.



16. **< HKCE 1994 Paper II - 38 >**

Arrange α, β and γ radiation in ascending order of their ionizing powers :

A. α , β , γ

B. β , γ , α

C. γ , α , β

D. γ , β , α

17. **< HKCE 1994 Paper II - 41 >**

The activity of a radioactive source drops from 640 Bq to 40 Bq in 2 hours. Find the half-life of the source.

A. 7.5 min.

B. 15 min.

C. 24 min.

D. 30 min.

18. **< HKCE 1995 Paper II - 26 >**

Which of the following cannot travel through a vacuum ?

A. β particles

B. Infra-red

C. Microwaves

D. Ultrasonics

19. < HKCE 1995 Paper II - 39 >

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

(1) X-rays consist of fast moving electrons.
(2) X-rays can blacken photographic films.
(3) X-rays can be used to detect weapons hidden in luggage.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

20. < HKCE 1996 Paper II - 39 >

Which of the following can be deflected by both an electric field and a magnetic field ?

(1) α particles
(2) β particles
(3) γ rays

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

21. < HKCE 1996 Paper II - 41 >

The activity of a radioactive isotope falls to $\frac{1}{16}$ of its initial value in one hour. Find the half-life of the isotope.

A. 3.75 minutes
B. 7.5 minutes
C. 10 minutes
D. 15 minutes

22. < HKCE 1997 Paper II - 39 >

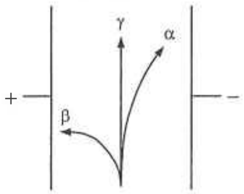
Which of the following statements about β particles is **incorrect** ?

A. β particles can be stopped by a piece of paper.
B. β particles can be deflected by a magnetic field.
C. β particles can blacken photographic films.
D. β particles can travel through a vacuum.

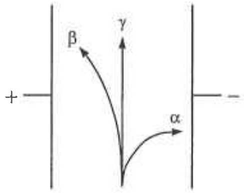
23. < HKCE 1998 Paper II - 40 >

Which of the following diagrams correctly shows the directions in which α, β and γ radiations are deflected in a uniform electric field produced by two charged metal plates ?

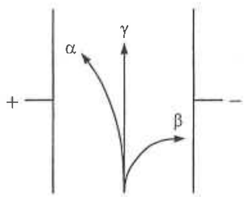
A.



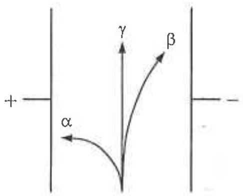
B.



C.



D.



24. < HKCE 1999 Paper II - 38 >

Which of the following statements about α particles is **incorrect** ?

A. α particles can be stopped by a piece of paper.
B. α particles can blacken photographic films.
C. α particles have a range of several centimetres in air.
D. α particles cannot travel through a vacuum.

25. < HKCE 1999 Paper II - 26 >

An insulated metal sphere carries positive charges. Which of the following will discharge the sphere ?

(1) bringing an alpha source near the sphere
(2) touching the sphere momentarily with a finger
(3) bringing a negatively charged metal rod near the sphere (but without touching it)

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

26. < HKCE 1999 Paper II - 37 >

The background count rate recorded by a Geiger-Muller counter is 80 counts per minute. When a radioactive source is placed closely in front of the Geiger-Muller tube, the count rate recorded is 560 counts per minute. After 6 hours, the count rate drops to 140 counts per minute. Find the half-life of the source.

A. 45 minutes
B. 1 hour
C. 1 hour 30 minutes
D. 2 hours

27. < HKCE 2000 Paper II - 40 >

Which of the following statements about α particles and γ rays is correct ?

A. Both of them are transverse waves.
B. Both of them can be deflected by a magnetic field.
C. Both of them have strong ionizing power.
D. Both of them can travel through a vacuum.

28. < HKCE 2000 Paper II - 41 >

Which one of the following is **not** a safety precautions for handling radioactive sources ?

A. Users should not eat or drink when handling radioactive sources.
B. Users should wear gloves for handling radioactive sources.
C. Radioactive sources should not be held close to the eye for visual examination.
D. Radioactive sources should be stored in wooden boxes after use.

29. < HKCE 2001 Paper II - 40 >

The initial activity of a radioactive isotope is 2000 Bq. After 4 hours, the activity of the isotope drops to 125 Bq. Find the half-life of the isotope.

A. 15 minutes
B. 30 minutes
C. 48 minutes
D. 60 minutes

30. < HKCE 2002 Paper II - 41 >

Which of the following particles **cannot** be deflected by a magnetic field ?

A. α-particles
B. β-particles
C. neutrons
D. protons

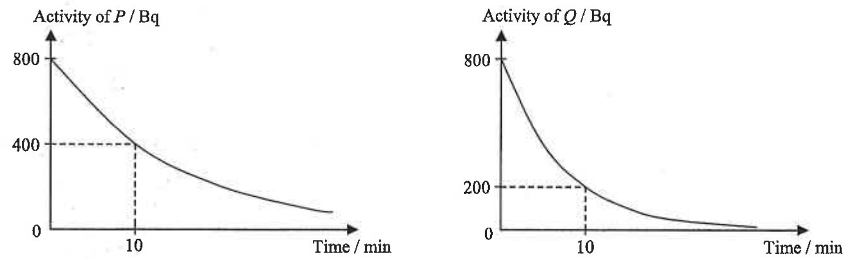
31. **< HKCE 2003 Paper II - 40 >**

Which of the following statements about α particles and γ rays is/are correct ?

(1) They can both be deflected by a magnetic field.
(2) α particles have a stronger ionizing power than γ rays.
(3) They are emitted with almost the same speed in radioactive decay.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

32. **< HKCE 2003 Paper II - 41 >**



The figures above show the variation of the activities of two radioactive sources P and Q with time. Find the ratio of the half-life of P to that of Q.

A. 1 : 1
B. 1 : 2
C. 2 : 1
D. 4 : 1

33. **< HKCE 2004 Paper II - 41 >**

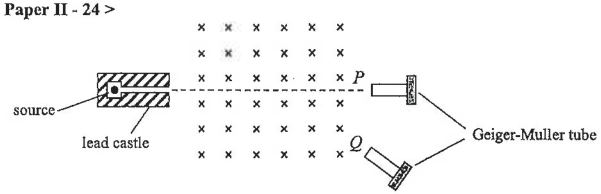
Different absorbers are placed in turn between a radioactive source and a Geiger-Muller tube. Three readings are taken for each absorber. The following data are obtained :

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

34. **< HKCE 2005 Paper II - 24 >**



A radioactive source is placed in front of a uniform magnetic field pointing into the paper as shown above. If a high count rate is recorded at positions P and Q, what kinds of radiation have been detected ?

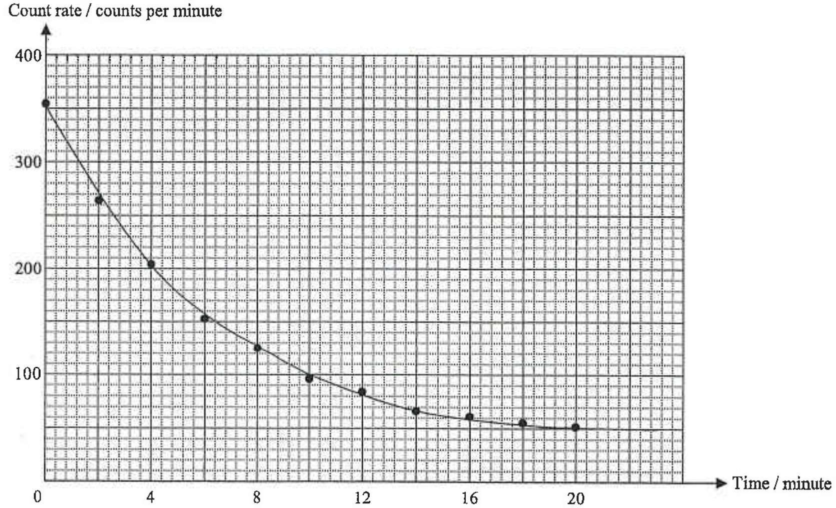
	P	***Q***
A.	γ	α
B.	γ	β
C.	β	α
D.	β	γ

35. **< HKCE 2006 Paper II - 42 >**

A radioisotope X has a half-life of 2 days while another radioisotope Y has a half-life of 1 day. Initially there are N undecayed atoms of X and 8 N undecayed atoms of Y. After how many days will X and Y have the same number of undecayed atoms ?

A. 3 days
B. 4 days
C. 6 days
D. 8 days

36. **< HKCE 2007 Paper II - 24 >**



Susan performs an experiment in which a radioactive source is placed closely in front of a GM counter. The graph shows the variation of count rate with time. What is the half-life of the radioactive substance ?

A. 4 minutes
B. 5 minutes
C. 8 minutes
D. 10 minutes

37. < HKCE 2007 Paper II - 26 >

Some dangerous substances are stored in a metal container inside a wooden box as shown in the figure. What metal should be used for the container and what type of substance is stored ?

	Metal used	Type of substance stored
A.	Iron	Radioactive
B.	Iron	Flammable
C.	Lead	Radioactive
D.	Lead	Flammable

38. < HKCE 2008 Paper II - 24 >

Which of the following descriptions about the half-life of a radioactive substance in a sample is correct ?
A. It is equal to half of the time for all the radioactive nuclei of the substance to decay.
B. It is equal to half of the time for a radioactive nucleus of the substance to decay.
C. It is equal to the time for the sample to reduce its mass by half.
D. It is equal to the time for half of the radioactive nuclei of the substance to decay.

39. < HKCE 2008 Paper II - 25 >

Which of the following actions will maximise a person's exposure to radiation ?
A. Using a GM tube and counter to measure the background radiation in laboratory.
B. Eating food that has been sterilised by exposure to gamma radiation.
C. Listening to radio.
D. Going for a flight to a distant place in a high-flying aeroplane.

40. < HKCE 2008 Paper II - 27 >

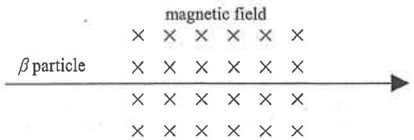
Which of the following statements about β particles is correct ?
A. β particles carry positive charge.
B. β particles can be deflected by a magnetic field.
C. β particles cannot be deflected by an electric field.
D. β particles can be stopped by a sheet of paper.

41. < HKCE 2009 Paper II - 26 >

The half-life of a radioactive sample is 15 hours. The initial count rate recorded is 1000 counts per minute. After 15 hours, the count rate recorded becomes 528 counts per minute. What is the background count rate ? (Measured in counts per minute.)
A. 25
B. 28
C. 50
D. 56

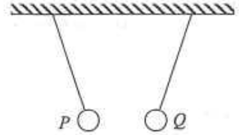
42. < HKCE 2010 Paper II - 45 >

In the figure, a β particle enters a region with a magnetic field pointing into paper and an electric field of unknown direction. The β particle has no deflection. What is the direction of the electric field ?



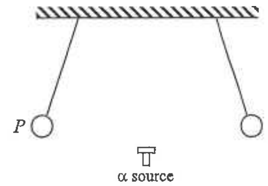
A. ←
B. →
C. ↑
D. ↓

43. < HKCE 2010 Paper II - 24 >

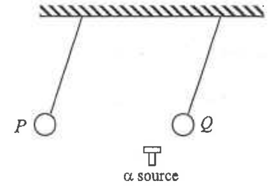


In the figure above, two charged metal balls P and Q are hung by insulating threads. P is positively charged while Q is negatively charged. An α source is put near the balls without touching them. Which of the following figures shows the situation after a period of time ?

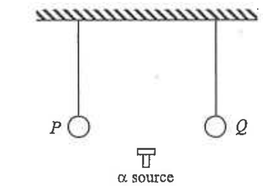
A.



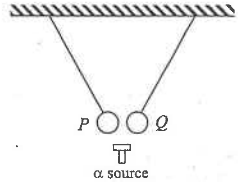
B.



C.



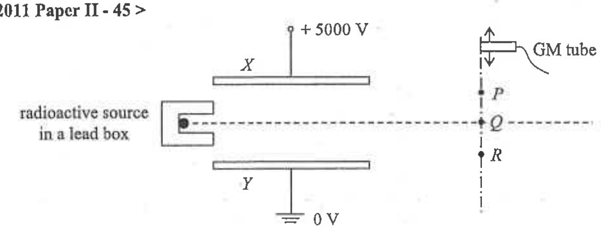
D.



44. < HKCE 2010 Paper II - 23 >

The initial activity of a sample of radioisotope is 960 Bq. Its activity drops to 240 Bq in 2 minutes. How much more time would be required for its activity to become 30 Bq ?
A. 2 minutes
B. 3 minutes
C. 4 minutes
D. 5 minutes

45. < HKCE 2011 Paper II - 45 >



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.

46. < HKCE 2011 Paper II - 22 >

Which of the following statements about α, β and γ radiations is **incorrect** ?

A. Only γ radiation can travel through a vacuum.
B. α radiation can be stopped by an aluminium plate of 5 mm thick.
C. β particles are fast moving electrons.
D. γ radiation can blacken a photographic film.

47. < HKCE 2011 Paper II - 23 >

A radioactive source is put in front of a GM tube. The initial count rate is 1050 counts per minute. It is known that the half-life of the source is 4 hours and the background count rate is 50 counts per minute. What is the most likely count rate after 8 hours ?

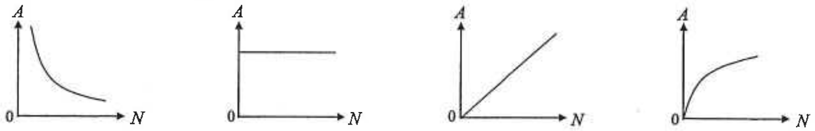
A. 50 counts per minute
B. 125 counts per minute
C. 250 counts per minute
D. 300 counts per minute

Part B : HKAL examination questions

48. < HKAL 1980 Paper I - 32 >

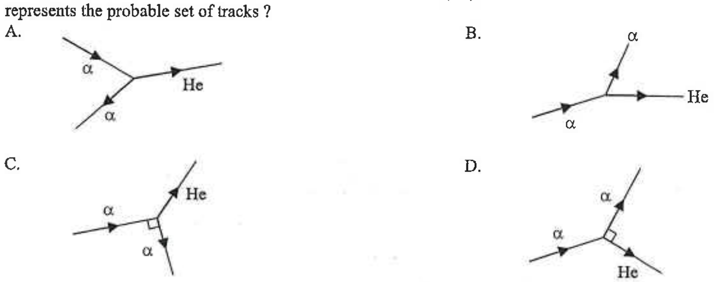
Which of the graphs below correctly shows the variation of the activity A of a radioactive sample with the number N of the undecayed nuclei in the sample ?

A. B. C. D.



49. < HKAL 1984 Paper I - 33 >

An alpha particle (α) makes a collision with a helium nucleus (He) in a cloud chamber. Which of the following diagrams best represents the probable set of tracks ?

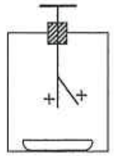


50. < HKAL 1985 Paper I - 31 >

Proactinium decays with a half-life of 72 s. The value of the decay constant is

A. 9.6×10^{-3} s.
B. 9.6×10^{-3} s^{-1}.
C. 0.014 s^{-1}.
D. 49.9 s.

51. < HKAL 1985 Paper I - 34 >



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 in divergence.
B. It will increase in divergence and then decrease.
C. It will collapse.
D. It will collapse and then re-diverge.

52. < HKAL 1988 Paper I - 44 >

An alpha-source originally consisted entirely of the element polonium. After the emission of an α-particle, each polonium nucleus becomes a lead nucleus. At the end of two years, the source was found to contain 98% lead and 2% polonium. What is the composition of the sample at the end of one year ?

A. 25% lead, 75% polonium.
B. 50% lead, 50% polonium.
C. 75% lead, 25% polonium.
D. 86% lead, 14% polonium.

53. < HKAL 1990 Paper I - 48 >

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

Absorber	Counts per minute
no absorber	712
a sheet of paper	504
5 mm thick aluminium sheet	496
25 mm thick lead block	218

From the above result, the radiation(s) emitted by the source is/are

A. α and γ rays only
B. β and γ rays only
C. α rays only
D. β rays only

54. < HKAL 1992 Paper I - 45 >

A radioactive source consists of a mixture of two radioisotopes P and Q. The half-life of P is 1 hour and that of Q is 2 hours. Both P and Q have stable daughter nuclei. The initial corrected count rate due to the mixture is 600 counts per minute. After 4 hours, the corrected count rate drops to 60 counts per minute. What was the initial count rate due to P only ?

A. 200 counts per minute.
B. 360 counts per minute.
C. 400 counts per minute.
D. 480 counts per minute.

55. < HKAL 1994 Paper IIA - 44 >

A GM counter is placed in front of an α-source and a count rate of 120 counts per minute is recorded. After a time equal to the half-life of the α-source, the count rate drops to 64 counts per minute. If a 5 mm thick lead sheet is inserted between the α-source and the detector, the count rate would probably be

A. 0 counts per minute.
B. 4 counts per minute.
C. 8 counts per minute.
D. 16 counts per minute.

56. **< HKAL 1996 Paper IIA - 44 >**

A counter is placed near a radioactive source that has a half-life of 1 hour. The counter registers 100 counts per minute at noon and 80 counts per min at 1 p.m. The expected count rate at 3 p.m. on the same day should be

A. 50 c.p.m.
B. 55 c.p.m.
C. 60 c.p.m.
D. 65 c.p.m.

57. **< HKAL 1998 Paper IIA - 41 >**

The activity of a sample of radioisotopes decreases to $\frac{1}{3}$ of its initial value in 12 s. How much more time is needed for the activity to decrease to $\frac{1}{9}$ of its initial value ?

A. 4 s
B. 8 s
C. 12 s
D. 16 s

58. **< HKAL 2000 Paper IIA - 44 >**

A radioactive source emits both α and γ radiation. A GM counter placing close to and in front of the source records a count rate of 500 counts per minute. 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	Recorded count rate / counts per minute
(Nil)	500
Cardboard	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 ?

	x	y	z
A.	350	350	150
B.	350	150	50
C.	350	150	0
D.	150	150	50

59. **< HKAL 2001 Paper IIA - 45 >**

The table gives the corrected count rate (in counts per minute) from three samples of radioisotopes at three different times.

Isotopes	0 min	20 min	40 min
X	480	243	119
Y	135	32	9
Z	168	118	93

From the above result, it can be concluded that

(1) X produces the most penetrating radiation.
(2) Y has the largest decay constant.
(3) Z has the longest half-life.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

60. **< HKAL 2001 Paper IIA - 42 >**

The activity of a radioactive sample was 70 Bq at time t = 5 minutes and 49 Bq at t = 10 minutes. What is its activity at time t = 0 ?

A. 112 Bq
B. 100 Bq
C. 95 Bq
D. 91 Bq

61. **< HKAL 2003 Paper IIA - 44 >**

A nuclide in a radioactive sample has a probability of 10^{-6} to decay in one second. What is the approximate half-life of the sample ?

A. 1 day
B. 1 week
C. 1 month
D. 1 year

62. **< HKAL 2004 Paper IIA - 42 >**

The activity of a radioactive sample is 1.0×10^6 Bq. The half-life of the sample is 5.3 years. Estimate the number of nuclei in the sample that decay in the first day.

A. 5.2×10^2
B. 3.2×10^8
C. 8.6×10^{10}
D. It cannot be estimated as the initial number of nuclei in the sample is not given.

63. **< HKAL 2005 Paper IIA - 24 >**

The activity of a radioactive source depends on

(1) the number of active nuclei in the source
(2) the half-life of the source
(3) the nature of the nuclear radiation emitted by the source

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

64. **< HKAL 2006 Paper IIA - 24 >**

Some typical radiation doses are given as follows :

	Radiation dose
Watching television	0.005 mSv / hr for watching every day in a year
Flying in an aircraft	0.001 mSv / hr
X-ray check	0.020 mSv each time

Arrange the following in ascending order of total radiation dose in one year.

(1) Watching television for 4 hours every day
(2) Travelling on an aircraft for 10 hours every month
(3) Taking X-ray check every 6 months

A. (1), (2), (3)
B. (2), (1), (3)
C. (1), (3), (2)
D. (3), (1), (2)

65. **< HKAL 2006 Paper IIA - 23 >**

Which of the following gives the correct interpretation of the decay constant of a radioactive substance ?
A. It is the rate of disintegrations of the substance.
B. It is the number of disintegrations of the substance occurring on one half-life of the substance.
C. It is the fraction of the active nuclei that undergoing decay in one second.
D. It is equal to the reciprocal of the half-life of the substance.

66. **< HKAL 2007 Paper IIA - 24 >**

Radioactive source P consists of 64×10^{12} active nuclei. Another source Q consists of 8×10^{12} active nuclei. The half-lives of P and Q are 2 days and 3 days respectively. After how long will the number of active nuclei in the two sources be equal ? (Assume that the daughter nuclides of both P and Q are stable.)
A. 6 days
B. 9 days
C. 12 days
D. 18 days

67. **< HKAL 2011 Paper IIA - 43 >**

Radioactive nuclides X and Y have half-lives 2 hours and 4 hours respectively. The decay of both nuclides gives stable daughter nuclides. Initially samples P and Q contain equal number of atoms of nuclide X and nuclide Y respectively. Which of the following statements are correct ?
(1) The initial activity of sample P is higher than that of sample Q.
(2) After 8 hours, sample P contains more active nuclei than sample Q.
(3) After 8 hours, the chance of a nucleus of X in sample P decaying in the next second is greater than that of a nucleus of Y in sample Q.
A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

68. **< HKAL 2012 Paper IIA - 44 >**

The activity of a radioisotope is 250 Bq at time $t = 0$ and 54 Bq at $t = 30$ min. What is its activity at $t = 10$ min ?
A. 130 Bq
B. 150 Bq
C. 185 Bq
D. It cannot be found as its half-life is not given.

69. **< HKAL 2013 Paper IIA - 45 >**

Arrange the following lengths in ascending order of magnitudes.
(1) range of α-particles in air
(2) grating spacing of a typical diffraction grating used in a school laboratory
(3) wavelength of ultra-violet radiation
A. (1), (2), (3)
B. (1), (3), (2)
C. (3), (1), (2)
D. (3), (2), (1)

70. **< HKAL 2013 Paper IIA - 43 >**

The initial activity of two radioactive sources, X and Y, are the same. Both X and Y decay to give stable daughter nuclei. The ratio of the activity of X to that of Y after 12 hours is 4 : 1. If the half-life of X is 6 hours, what is the half-life of Y ?
A. 1.5 hours
B. 2 hours
C. 3 hours
D. 12 hours

Part C : HKDSE examination questions

71. **< HKDSE Sample Paper IA - 35 >**

On which of the following does the activity of a radioactive source depend ?
(1) the nature of the nuclear radiation emitted by the source
(2) the half-life of the source
(3) the number of active nuclei in the source
A. (1) only
B. (2) only
C. (1) & (2) only
D. (2) & (3) only

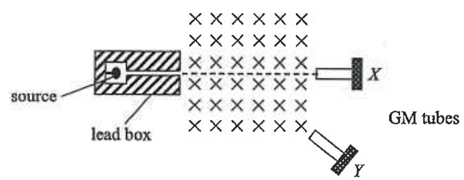
72. **< HKDSE Sample Paper IA - 36 >**

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

73. **< HKDSE Practice Paper IA - 35 >**



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 α radiations.
B. The source emits β radiations.
C. The source emits γ radiations.
D. The background count rate is about 100 counts per minute.

74. **< HKDSE Practice Paper IA - 34 >**

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) An α source can discharge a positively charged metal sphere nearby.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

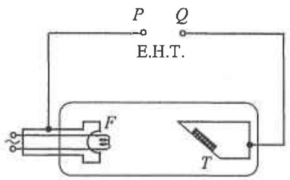
75. **< HKDSE 2012 Paper IA - 35 >**

A certain radioactive isotope X has a half-life of 20 hours. After a time interval of 10 hours, what is the approximate fraction (f) of a sample of the radioactive isotope X remaining ?

A. $\frac{1}{4} \leq f \leq \frac{1}{2}$
B. $f = \frac{1}{2}$
C. $\frac{3}{4} > f > \frac{1}{2}$
D. $f > \frac{3}{4}$

76. **< HKDSE 2012 Paper IA - 34 >**

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.

77. **< HKDSE 2013 Paper IA - 35 >**

Polonium-210 is a pure α-emitter with a half-life of 140 days and it will decay into lead, which is stable. Initially there is a sample containing 420 mg of pure polonium-210. Estimate the mass of polonium-210 left after 70 days.

A. 315 mg
B. 297 mg
C. 210 mg
D. 105 mg

78. **< HKDSE 2014 Paper IA - 32 >**

A GM counter is placed close to and in front of a radioactive source which emits both α and γ radiations. The count rate recorded is 450 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	Recorded count rate / counts per minute
(Nil)	450
cardboard	x
1 mm of aluminium	y
2 mm of lead	z

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

	x	y	z
A.	300	300	100
B.	300	100	50
C.	100	100	0
D.	100	50	50

79. **< HKDSE 2015 Paper IA - 32 >**

Some factories make use of radioactive source for manufacturing. Workers are required to wear clothes with film badges to measure the dosage of radiation received over a period of time. Which type of radiation below CANNOT be monitored by the film badges ?

A. α-radiation
B. β-radiation
C. γ-radiation
D. X-rays

80. **< HKDSE 2016 Paper IA - 32 >**

Which of the following statements about ionizing radiations is/are correct ?
(1) The ionizing power of α-particles is much stronger than that of β-particles.
(2) γ-radiation can be completely shielded by a 10 cm thick concrete wall.
(3) Ionizing radiations α, β and γ all undergo deflection in an electric field.

A. (1) only
B. (1) & (2) only
C. (1) & (3) only
D. (2) & (3) only

81. **< HKDSE 2016 Paper IA - 33 >**

Two radionuclides X and Y are of half-lives 3 hours and 4 hours respectively and initially there are N_X and N_Y undecayed nuclei respectively. After 24 hours, the number of undecayed nuclei of both nuclides becomes the same. Find $N_X : N_Y$.

A. 8 : 1
B. 4 : 3
C. 4 : 1
D. 2 : 1

82. **< HKDSE 2017 Paper IA - 32 >**

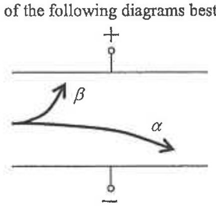
Which of the following statements about particles β and γ rays is correct ?

A. Only β particles can ionize air particles.
B. Only γ rays can travel through vacuum.
C. Both of them can be detected by a photographic film.
D. Both of them carry charge.

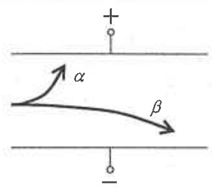
83. **< HKDSE 2017 Paper IA - 31 >**

Which of the following diagrams best shows the deflection of α and β particles in an uniform electric field in vacuum ?

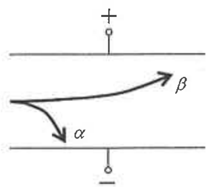
A.



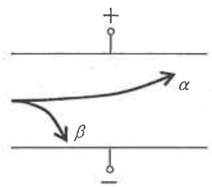
B.



C.



D.

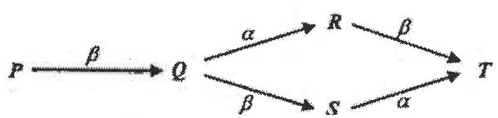


84. <HKDSE 2019 Paper IA-31>

85. <HKDSE 2020 Paper IA-30>

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



HKBAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

M.C. Answers

1. B	11. C	21. D	31. B	41. D
2. D	12. B	22. A	32. C	42. D
3. D	13. C	23. A	33. C	43. C
4. A	14. B	24. D	34. B	44. B
5. D	15. B	25. C	35. C	45. A
6. C	16. D	26. D	36. A	46. A
7. D	17. D	27. D	37. C	47. D
8. C	18. D	28. D	38. D	48. C
9. B	19. D	29. D	39. D	49. D
10. C	20. C	30. C	40. B	50. B

51. C	61. B	71. D	81. C
52. D	62. C	72. C	82. C
53. A	63. C	73. B	83. A
54. D	64. C	74. C	84. D
55. C	65. C	75. C	85. D
56. D	66. D	76. C	
57. C	67. B	77. B	
58. A	68. B	78. A	
59. D	69. D	79. A	
60. B	70. C	80. A	

M.C. Solution

1. B

Mass of X: $4\text{ g} \xrightarrow{3\text{ days}} 2\text{ g} \xrightarrow{3\text{ days}} 1\text{ g}$

Mass of Y: $4 - 1 = 3\text{ g}$

2. D

Ionization power : $\alpha > \beta > \gamma$

In ascending order : γ , β , α

3. D

× (1) Decay does not mean splitting of the atoms.

× (2) In 20 minutes, that is, 2 half-lives, there is still 25% of radioactive atoms left.

× (3) Half-life is the time taken for half of the number of radioactive atoms to decay.

4. A

$3 \xrightarrow{8\text{ hours}} 1.5 \xrightarrow{8\text{ hours}} 0.75 \xrightarrow{8\text{ hours}} 0.375$

After 24 hours, the mass remaining unchanged is 0.375 g

5. D

By using Left-hand rule :

Direction of magnetic field is into paper and direction of magnetic force is downward $\Rightarrow$ Direction of I is towards the left

As direction of I is opposite to velocity $\Rightarrow$ the radiation carries (–) charge $\Rightarrow$ β radiation

6. C

Corrected count rate : $0.8 \longrightarrow 0.4 \longrightarrow 0.2$

As in between July 1 and September 1, there is 62 days. $\therefore$ Half-life $= \frac{62}{2} = 31$ days

7. D

X-ray and γ-ray are both electromagnetic waves $\therefore$ they travel with the speed of light

β-particles are fast moving electrons, but not electromagnetic waves.

β-particles travel with a speed less than that of light.

8. C

✓ (1) An α-particle consists of 2 protons and 2 neutrons, and mass of proton and neutron is nearly the same.

✓ (2) ionizing power : $\alpha > \beta > \gamma$

× (3) α-particles have shortest range in air $\Rightarrow$ weakest penetrating power

9. B

× (1) The product of decay also carries mass, thus the total mass of the sample should remain unchanged.

✓ (2) Half-life is the time taken for the activity to drop to half of the initial value.

× (3) It takes 1 half-life for half of the number of **undecayed** nuclei to decay, but it does not mean another half is to be decayed in the next half-life.

10. C

$1 \longrightarrow \frac{1}{2} \longrightarrow \frac{1}{4} \longrightarrow \frac{1}{8}$

$\therefore$ Half-life $= \frac{24}{3} = 8$ min.

11. C

$1 \xrightarrow{22\text{ years}} \frac{1}{2} \xrightarrow{22\text{ years}} \frac{1}{4} \xrightarrow{22\text{ years}} \frac{1}{8}$

After 66 years, the fraction of the source remains undecayed is $\frac{1}{8}$

12. B

Time / minute	0	2	4	6	8	10	12
Corrected count rate / cpm	96	76	60	49	38	30	24

As the initial corrected count rate (96 cpm) reduces to about half (48 cpm) in 6 minutes

∴ half-life is about 6 minutes.

13. C

As activity drops from 40 Bq to 20 Bq in 28 minutes ∴ half-life = 28 min

14. B

By using Left-hand rule :

① magnetic force on α which is positive is towards the left

② magnetic force on β which is negative is towards the right

Thus, α is deflected to the left while β is deflected to the right.

As α is much heavier, the degree of deflection of α is much smaller than that of β.

15. B

It is a symbol for all types of radioactive substances.

16. D

Ionizing power : $\gamma < \beta < \alpha$

17. D

$640 \xrightarrow{\times\frac{1}{2}} 320 \xrightarrow{\times\frac{1}{2}} 160 \xrightarrow{\times\frac{1}{2}} 80 \xrightarrow{\times\frac{1}{2}} 40$

∴ Half-life $= \frac{2\text{ hours}}{4} = 0.5$ hours $= 30$ min.

18. D

✓ A. β-particles are particles that can travel in vacuum

✓ B. Infra-red is a type of electromagnetic waves that can travel in vacuum

✓ C. Microwave is a type of electromagnetic waves that can travel in vacuum

× D. Ultrasonics are sound waves with frequency > 20000 Hz, sound waves cannot travel in vacuum.

19. D

× (1) X-rays is a transverse wave, they do not consist of any particles.

✓ (2) X-rays can affect films, and be detected by films.

✓ (3) X-rays are used in airport to detect weapons in luggage.

20. C

Charged particles can be deflected by both a magnetic field and an electric field.

α is (+)-charged and β is (–)-charged, they can be deflected; γ is neutral, it cannot be deflected.

21. D

$1 \xrightarrow{\times\frac{1}{2}} \frac{1}{2} \xrightarrow{\times\frac{1}{2}} \frac{1}{4} \xrightarrow{\times\frac{1}{2}} \frac{1}{8} \xrightarrow{\times\frac{1}{2}} \frac{1}{16}$

∴ Half-life $= \frac{60}{4} = 15$ min.

22. A

× A. β particles can penetrate through paper but stopped by a thin sheet of aluminium.

✓ B. β particles are (–)-charged particles ⇒ deflected by B-field

✓ C. β particles are radiation, they can blacken films and be detected.

✓ D. β are particles, thus they can travel in vacuum.

23. A

α is (+) charged, it is attracted towards the negative plates and thus deflected towards the right

β is (–) charged, it is attracted towards the positive plate and thus deflected towards the left

Since β is lighter than α, thus the deflection of β is greater.

24. D

✓ A. α-particles have a very low penetrating power in matter, they are stopped by a piece of paper.

✓ B. α-particles are radiation that can blacken films.

✓ C. α-particles have a very short range in air, about several centimeters.

× D. α are particles, they can travel in vacuum.

25. C

✓ (1) α-source emits α-particles that can ionize air molecules to give ion-pairs.
The ion-pairs can discharge sphere.

✓ (2) Touching the sphere with a finger is an Earthing process that can discharge the sphere.

× (3) Since the rod does not touch the sphere,
there is no flow of charge and does the charge in the sphere remains the same

26. D

Corrected count rate initially = 560 − 80 = 480 counts per minute

Corrected count rate after 6 hours = 140 − 80 = 60 counts per minute

Change of corrected count rate after each half-life : 480 ⟶ 240 ⟶ 120 ⟶ 60

∴ Half-life = $\frac{6}{3}$ = 2 hours

27. D

× A. α : not a wave

× B. γ : do not have charge ⇒ cannot be deflected by B-field

× C. γ : weak ionization power

✓ D. α : particles can travel in vacuum ; γ : electromagnetic waves can also travel in vacuum.

28. D

Radioactive sources should be stored in **lead** castles but not a wooden box only since lead is the most effective material to stop the radiations

29. D

Activity : 2000 ⟶ 1000 ⟶ 500 ⟶ 250 ⟶ 125

Number of half-lives = 4

Half-life = 4 hours × $\frac{1}{4}$ = 1 hour = 60 minutes

30. C

Neutrons are neutral particles. They would not be deflected by magnetic field or electric field.

31. B

× (1) α particles carry positive charges, they can be deflected by a magnetic field.
γ rays are neutral, they cannot be deflected by a magnetic field.

✓ (2) The ionizing power in descending order is α > β > γ

× (3) The speed of α particles is less than the speed of light in air but γ rays have the same speed as light in air

32. C

The half-life of P is 10 minutes.

The half-life of Q is 5 minutes, thus after 10 minutes, the activity of Q drops to one quarter.

Ratio of the half-life of P to that of Q = 10 : 5 = 2 : 1

33. C

After inserting the paper, the count rate is approximately unchanged, thus the source does not emit α.

After inserting the 5 mm Al, the count rate drops significantly, thus the source emits β.

After inserting the lead, the count rate drops significantly, thus the source emits γ.

34. B

P detects γ radiation since γ does not deflect in magnetic field

Q detects β radiation since magnetic force acts downwards on negative charged particles by using Left hand rule.

35. C

X: $N \xrightarrow{\text{2 days}} \frac{1}{2}N \xrightarrow{\text{2 days}} \frac{1}{4}N \xrightarrow{\text{2 days}} \frac{1}{8}N$

Y: $8N \xrightarrow{\text{1 days}} 4N \xrightarrow{\text{1 days}} 2N \xrightarrow{\text{1 days}} N \xrightarrow{\text{1 days}} \frac{1}{2}N \xrightarrow{\text{1 days}} \frac{1}{4}N \xrightarrow{\text{1 days}} \frac{1}{8}N$

After 6 days, both X and Y have the same number of undecayed atoms of $\frac{1}{8}N$

36. A

From the graph, the background radiation is 50.

The initial total count rate is 350, thus the initial corrected count rate is 350 − 50 = 300.

After one half-life, the corrected count rate should drop to 150, thus the total count rate is 150 + 50 = 200.

The total count rate drops to 200 after 4 minutes, thus the half-life is 4 minutes.

37. C

Lead is the suitable metal to be used in the container since most radiation can be blocked by lead.

The symbol represents RADIOACTIVE substance.

38. D

× A. Time for all the radioactive nuclei to decay is infinite, half of this time is also infinite.

× B. Time for a radioactive nucleus to decay is random.

× C. Mass of the sample remains unchanged since the sample includes the mother nuclei and daughter nuclei..

✓ D. Time for half of the radioactive nuclei to decay is the definition of half-life.

39. D

× A. The person still receives the background radiation only, no extra radiation is received.

× B. Food that has been sterilized by exposure to gamma radiation does not have radiation remain.

× C. Listening to radio does not receive any radiation.

✓ D. Passengers in high-flying aeroplane receive greater amount of cosmic radiation.

40. B

× A. β particles carry negative charge since they are electrons.

✓ B. β particles can be deflected by a magnetic field, direction of deflection is found by Left hand rule.

× C. β particles can be deflected by an electric field, towards the positive plate.

× D. β particles can penetrate through sheets of paper, they can be stopped by aluminium.

41. D

Assume that the background count rate is b counts per minute.

After one half-life, the corrected count rate is reduced to half.

∴ $(1000 - b) \times \frac{1}{2} = (528 - b)$ ∴ $b = 56$

42. D

By Left hand rule, the magnetic force is pointing downwards.

In order to balance the magnetic force, the electric force should be pointing upwards.

Since the electric force is opposite to the electric field for a negative charge, the β particle,

thus the electric field is pointing downwards.

43. C

After a period of time, both the balls P and Q are discharged by the ions produced by the α particles.

Thus, the two neutral balls would not exert forces on each other.

44. B

① $(240) = (960)\,(\frac{1}{2})^{2/t_{1/2}}$ $\therefore\ t_{1/2} = 1$ min.

② $(30) = (240)\,(\frac{1}{2})^{t/1}$ $\therefore\ t = 3$ min.

OR

① $(240) = (960)\,e^{-k(2)}$ $\therefore\ k = 0.693\ \text{min}^{-1}$

② $(30) = (240)\,e^{-0.693\,t}$ $\therefore\ t = 3$ min

45. A

At P, the radiation is β since it is attracted upwards towards the positive side of the electric field.

At Q, the radiation is γ since it is not deflected by the electric field.

After applying the magnetic field, the magnetic force acting on β is upwards, thus the count rate at P decreases.

As the radiation at Q is γ which is not affected by magnetic field, the count rate at Q is the same.

46. A

× A. All the three types of nuclear radiations can travel through a vacuum.

✓ B. α radiation can be stopped by a piece of paper, and also by a thicker piece of aluminium.

✓ C. β particles are electrons moving with high speed.

✓ D. All the three types of nuclear radiations, including γ, can blacken a photographic film.

47. D

Initial corrected count rate = 1050 − 50 = 1000 counts per minute

Number of half-life period = 8 / 4 = 2

Corrected count rate after 8 hours = $1000 \times (\frac{1}{2})^2$ = 250 counts per minute

Count rate after 8 hours = 250 + 50 = 300 counts per minute

48. C

By $A = kN$ $\therefore$ $A \propto N$, activity is directly proportional to the number of undecayed nuclei.

The graph is a straight line passing through the origin.

49. D

After colliding with a helium nucleus, it must be a right-angled fork track.

Option B is not correct since the angle of separation is not 90°.

50. B

$$k = \frac{\ln 2}{t_{\frac{1}{2}}} = \frac{\ln 2}{(72)} = 9.6\times10^{-3}\ \text{s}^{-1}$$

51. C

As the alpha particles would ionize the air, the ions then discharge the gold-leaf,

thus the gold-leaf would collapse.

52. D

At the end of 2 years, there is 2% Polonium remaining, thus

$(2\%) = (100\%)\,e^{-k(2)}$ $\therefore\ k = 1.96\ \text{year}^{-1}$

At the end of 1 year : $N = N_o\,e^{-(1.96)(1)} = 0.14\,N_o$

$\therefore$ There is 14% of Polonium and 86% of Lead.

53. A

Presence of paper : shows a significant drop in counts per minute ⇒ the source emits α-rays

Presence of Al : shows a slight change in counts per minute ⇒ the source does not emit β-rays

Presence of Pb block : shows a significant drop in counts per minute ⇒ the source emits γ-rays

54. D

Let x be the initial count rate of P, then $(600 - x)$ is the initial count rate of Q.

$$P:\ x \xrightarrow{1\text{ hour}} \frac{x}{2} \xrightarrow{1\text{ hour}} \frac{x}{4} \xrightarrow{1\text{ hour}} \frac{x}{8} \xrightarrow{1\text{ hour}} \frac{x}{16}$$

$$Q:\ (600 - x) \xrightarrow{2\text{ hours}} \frac{600-x}{2} \xrightarrow{2\text{ hours}} \frac{600-x}{4}$$

After 4 hours : $\frac{x}{16} + \frac{600-x}{4} = 60$ $\therefore\ x = 480$ cpm

55. C

Let b be the background radiation.

After one half-life, the corrected count rate is reduced to half.

$(120 - b) \times \frac{1}{2} = (64 - b)$

$\therefore\ b = 8$

After inserting the lead sheet, all the α particles would be absorbed.

Thus, the detector can then only measure the background radiation, which is 8 counts per minute.

56. D

Let b be the background radiation.

$(100 - b) \times \frac{1}{2} = (80 - b)$ $\quad\therefore\; b = 60$ cpm

$\therefore$ Activity of the source at noon = 100 – 60 = 40 cpm

After 3 hours, activity : $40 \xrightarrow{1\text{ hour}} 20 \xrightarrow{1\text{ hour}} 10 \xrightarrow{1\text{ hour}} 5$

$\therefore$ Expected count rate = 60 + 5 = 65 cpm

57. C

When the activity drops to $\frac{1}{3}$ of its initial value : $\left(\frac{1}{3}A\right) = A \cdot e^{-k(12)}$ $\quad\therefore\; k = 0.0916\ \text{s}^{-1}$

When the activity drops to $\frac{1}{9}$ of its initial value : $\left(\frac{1}{9}A\right) = A \cdot e^{-(0.0916)(t+12)}$ $\quad\therefore\; t = 12$ s

58. A

Cardboard : Due to the absorption of α-radiation, the count rate should drop.

1 mm of Al : Since there is no β-radiation, the count rate should remain the same as x.

5 mm of Pb : The count rate should drop due to the partial absorption of γ-radiation.
However, the lead would not absorb all the γ-radiation, thus the count rate cannot drop to 50 cpm.
Thus, the value of z should be 150.

59. D

× (1) Type of radiation cannot be known from the count rate at different times

✓ (2) Y has the shortest half-life since after 20 minutes it drops to about $\frac{1}{4}$
By decay constant $k = \frac{\ln 2}{t_{1/2}}$ $\quad\therefore$ Y has the largest decay constant

✓ (3) Z has the longest half-life since after 20 minutes it drops only to about 70 %

60. B

By $A = A_o\, e^{-kt}$

① $(70) = A_o\, e^{-k(5)}$

② $(49) = A_o\, e^{-k(10)}$

$\therefore\; \frac{70}{49} = e^{5k}$ $\quad\therefore\; k = 0.0713$ $\quad\therefore\; A_o = 100$ Bq

61. B

The decay constant k is the chance of decay per unit time.

$\therefore\; k = 10^{-6}\ \text{s}^{-1}$

Half-life $= \frac{\ln 2}{k} = \frac{\ln 2}{10^{-6}} = 6.93\times10^{5}\ \text{s} = 8\ \text{days} \approx 1\ \text{week}$

62. C

Since the time of 1 day is much less than the half-life of 5.3 years, activity remains constant in 1 day.

$\Delta N = A\,\Delta t = (1.0 \times 10^{6}) \times (1 \times 24 \times 3600) = 8.6 \times 10^{10}$

OR

$k = \frac{\ln 2}{5.3\times365\times24\times3600} = 4.147\times10^{-9}\ \text{s}^{-1}$

By $A_o = kN_o$ $\quad\therefore\; (1.0 \times 10^{6}) = (4.147 \times 10^{-9})\, N_o$ $\quad\therefore\; N_o = 2.41138 \times 10^{14}$

By $N = N_o \cdot e^{-k\cdot t}$ $\quad\therefore\; N = (2.41138\times10^{14}) \cdot e^{-(4.147\times10^{-9})\cdot(1\times24\times3600)} = 2.41052\times10^{14}$

$\Delta N = 2.41138 \times 10^{14} - 2.41052 \times 10^{14} = 8.6 \times 10^{10}$

63. C

By $A = kN$ $\quad\therefore$ Activity A depends on

① decay constant k or half-life $t_{1/2}$

② number of undecayed nuclei N in the source

By $t_{\frac{1}{2}} = \frac{\ln 2}{k}$, decay constant k is related to the half-life.

64. C

(1) Radiation dose of watching television for 4 hours every day = 0.005 mSv/hr × 4 hr = 0.02 mSv

(2) Radiation dose of flying in an aircraft = 0.001 mSv/hr × 10 h/month × 12 months = 0.12 mSv

(3) Radiation dose of X-ray check = 0.020 mSv × 2 = 0.04 mSv

Ascending order of total radiation dose : (1), (3), (2)

65. C

Decay constant is the probability of decay per unit time,

it means the fraction of the active nuclei present that decay in one second.

66. D

For nuclide P : $64 \to 32 \to 16 \to 8 \to 4 \to 2 \to 1 \to \frac{1}{2} \to \frac{1}{4} \to \frac{1}{8}$: time taken = 2 × 9 = 18 days

For nuclide Q : $8 \to 4 \to 2 \to 1 \to \frac{1}{2} \to \frac{1}{4} \to \frac{1}{8}$: time taken = 3 × 6 = 18 days

OR

By $(64 \times 10^{12}) \times \left(\frac{1}{2}\right)^{t/2} = (8 \times 10^{12}) \times \left(\frac{1}{2}\right)^{t/3}$

$\therefore\; 8 \times \left(\frac{1}{2}\right)^{t/2} = \left(\frac{1}{2}\right)^{t/3}$

$\therefore\; 2^{3} \times 2^{-t/2} = 2^{-t/3}$

$\therefore\; 3 - t/2 = -t/3$

$\therefore\; t = 18$ days

67. B

✓ (1) By $k = \ln 2 / t_{1/2}$, X has shorter half-life, thus X has greater decay constant k.
By $A = kN$, X has greater decay constant k, thus the activity of X in sample P is higher.

× (2) After 8 hours, the number of X in P drops to 1/16 and the number of Y in Q drops to 1/4.
Thus the number of X in sample P is less.

✓ (3) The chance of decay in unit time is the decay constant.
As the decay constant of X is greater, the chance is also greater.

68. B

By $A = A_o e^{-kt}$

$\therefore$ $(54) = (250)\, e^{-k(30)}$

$\therefore$ $k = 0.0511$ min^{-1}

At $t = 10$ min. : $A = (250)\, e^{-(0.0511)(10)} = 150$ Bq

69. D

(3) wavelength of ultra-violet radiation is of the order of 10^{-8} m

(2) grating spacing is of the order of 10^{-6} m

(1) range of α in air is of the order of 10^{-2} m (a few cm)

70. C

For X: 12 hours is two half-lives $\therefore$ $A_X = A_o \times (\frac{1}{2})^2 = \frac{1}{4} A_o$

After 12 hours,

$A_X : A_Y = 4 : 1$

$\therefore$ $A_Y = \frac{1}{4} A_X = \frac{1}{4} \times (\frac{1}{4} A_o) = \frac{1}{16} A_o$

For Y: $A = A_o (\frac{1}{2})^{t/t_{1/2}}$

$\therefore$ $(\frac{1}{16} A_o) = A_o (\frac{1}{2})^{(12)/t_{1/2}}$ $\therefore$ $t_{1/2} = 3$

$\therefore$ half-life of Y = 3 hours

71. D

× (1) The nature or type of radiation (α, β, γ) emitted would not affect or relate to the activity of the source.

✓ (2) The activity A is proportional to the decay constant k, which is related by the half-life.

✓ (3) The activity A is proportional to the number of active (undecayed) nuclei N.

72. C

After inserting the paper, the count rate is approximately unchanged, thus the source does not emit α.

After inserting the 5 mm Al, the count rate drops significantly, thus the source emits β.

After inserting the lead, the count rate drops significantly, thus the source emits γ.

73. B

× A. Since there is no count rate recorded at positions above X, the source may or may not emit α radiations.

✓ B. Since the count rate at Y is greater than X, there must be some radiation deflected downwards to reach Y.
By Left hand rule, the downward magnetic force should act on negative particles, that is, β radiations.

× C. The source may or may not emit γ radiation,
as the count rate at X may consist of γ and background or background only

× D. The source may emit γ radiation, thus the count rate of 101 cpm at X may be due to γ and background.

74. C

✓ (1) The mass of an α particle is the mass of a helium nucleus but the mass of a β particle is nearly zero.

× (2) The penetrating power of α is weaker than β.

✓ (3) α particles can ionize the air, the ions then discharge the charged metal sphere.

75. C

By $N = N_o (\frac{1}{2})^{10/20} = 0.707\, N_o$

$\therefore$ $f = \dfrac{N}{N_o} = 0.707$

$\therefore$ $0.75 > f > 0.5$

76. C

Cathode rays (beam of electrons) is emitted from F which is the negative terminal, thus Q is the positive terminal.

When electrons hit the metal target at T, X-rays are emitted from T.

77. B

$M = M_o (\frac{1}{2})^{t/t_{1/2}}$

$= (420) (\frac{1}{2})^{70/140}$

$= 297$ mg

78. A

Note that γ radiation can never be totally absorbed.

Thus, z must be greater than the background radiation of 50 counts per minute.

The only option is A that z is 100 counts per minute.

79. A

α-radiation cannot pass through the plastic bag to reach the film, thus α-radiation cannot be detected by film badge.

The other 3 types of radiation can pass the plastic bag to reach the film inside the badge to be detected.

80. A

✓ (1) Ionizing power of ionizing radiation in descending order is $\alpha > \beta > \gamma >$ X-ray

× (2) γ-radiation can never be completely shielded by concrete wall, no matter how thick it is.

× (3) Only α and β will be deflected in an electric field as they carry charges.
γ radiation is an electromagnetic wave, it cannot be deflected in an electric field.

81. C

By $N = N_o (\frac{1}{2})^{t/t_{1/2}}$

$\therefore N_X (\frac{1}{2})^{24/3} = N_Y (\frac{1}{2})^{24/4}$

$\therefore N_X (\frac{1}{2})^{8} = N_Y (\frac{1}{2})^{6}$

$\therefore \frac{N_X}{N_Y} = \frac{4}{1}$

82. C

× A. Both β and γ can ionize air particles.

× B. Both β and γ can travel through vacuum.

✓ C. Both of them can be detected by a film.

× D. Only β carries charge, γ is neutral.

83. A

In an electric field, β that carries negative charge will deflect towards the (+) plate, thus it deflects upwards.

α that carries positive charge will deflect towards the (–) plate, thus it deflects downwards.

As mass of β is much smaller than that of α, the deflection of β should be much greater than that of α.

The following list of formulae may be found useful :

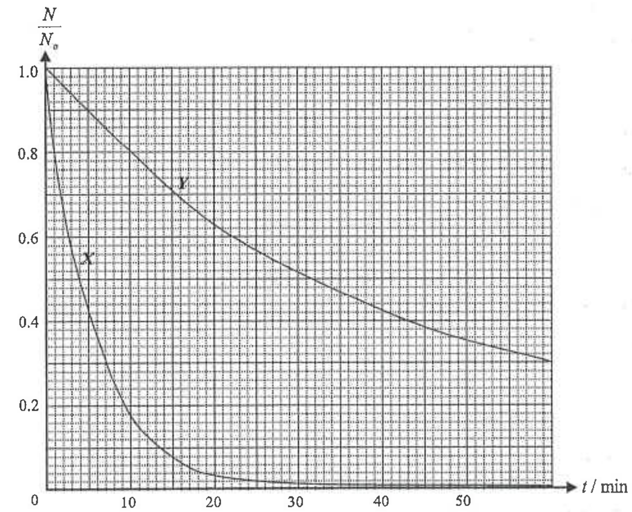
Law of radioactive decay $N = N_0 e^{-kt}$

Half-life and decay constant $t_{\frac{1}{2}} = \frac{\ln 2}{k}$

Activity and the number of undecayed nuclei $A = kN$

Part A : HKCE examination questions

1. **< HKCE 1982 Paper I - 8 >**



The above figure show the decay curves of two radioactive elements X and Y both emitting β-particles. N_o is the number of radioactive atoms present at time $t = 0$ and N is the number at the end of t minutes.

(a) What are the half-lives of X and Y ? (2 marks)

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(b) A mixture of X and Y is placed in front of a Geiger counter. Initially, they have the same number of radioactive atoms. Which of the two, X or Y, will be mainly responsible for the reading shown on the Geiger counter during the first four minutes ? Estimate the fraction of the total number of counts due to that element. (5 marks)

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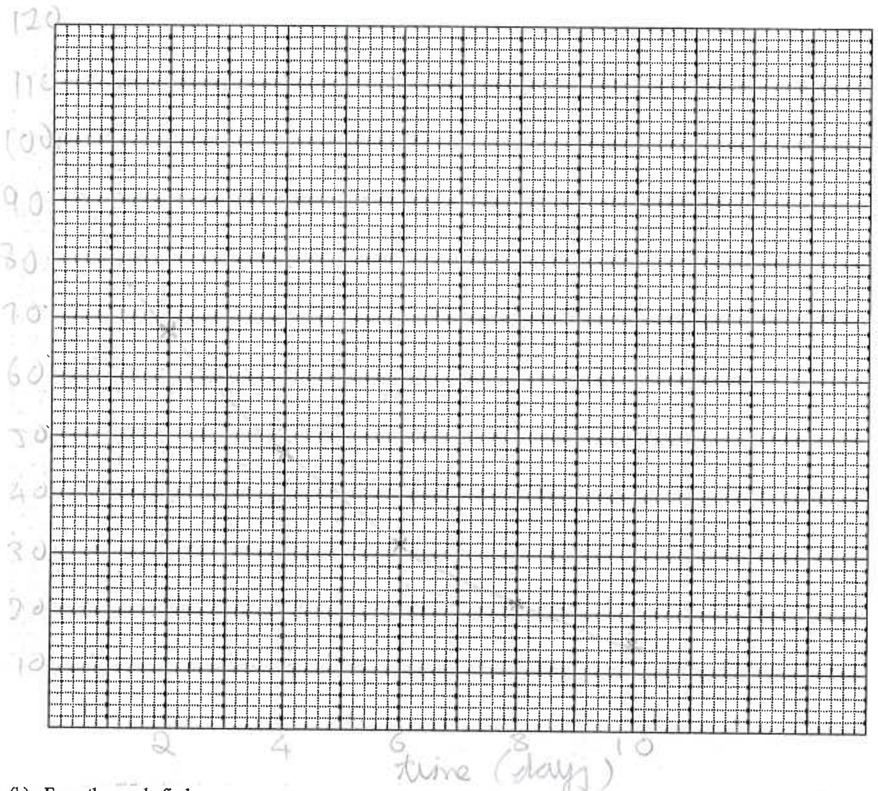
2. < HKCE 1983 Paper I - 9 >

The activity from a sample of Radium is measured at two-day intervals. The readings are tabulated below :

Time / days	0	2	4	6	8	10
Activity / Bq	100	68	47	32	22	15

(a) Plot the decay graph below to show the activity against time. (4 marks)



(b) From the graph, find (2 marks)

(i) the activity of the sample after 5 days, and

(ii) the half-life of the sample.

3. < HKCE 1983 Paper I - 9 >

A Geiger-Muller counter is placed on a bench.

(a) Explain why the counter registers a reading even when no radioactive source is placed nearby. (1 mark)

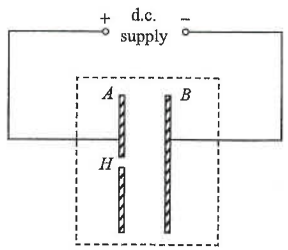
(b) When a radioactive source is placed near the counter, the counter registers 520, 510 and 514 counts per minute in the first three consecutive minutes. Explain why the three readings differ from each other ? (2 marks)

(c) When a piece of paper is placed between the source and the counter, the counter registers 540, 510 and 512 counts per minute in the first three consecutive minutes. However, when the paper is replaced by an aluminium sheet, the counter gives reading of 7, 9 and 8 counts per minute in three consecutive minutes.

What type(s) of radiation (α, β or γ) is/are being emitted by the source ? Give a reason for your answer. (4 marks)

4. < HKCE 1984 Paper I - 9 >

Two parallel metal plates A and B are placed in a vacuum chamber as shown in the figure below. They are connected to a d.c. supply. A hole H is drilled in plate A. A particle P passes through hole H and accelerates towards plate B.

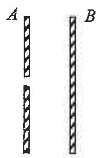


(a) What is the sign of the charge carried by P ? (1 mark)

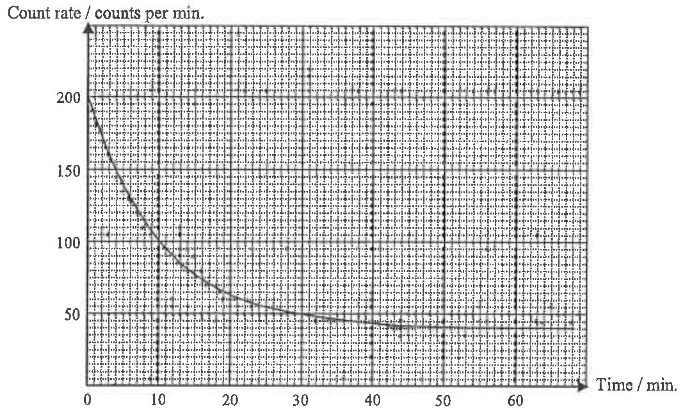
(b) The particle P is emitted from a radioactive source which undergoes α-, β- and γ-decay simultaneously.

(i) What kind of particle (α, β or γ) should P be ? (1 mark)

(ii) Draw a diagram to show how to prevent the other two kinds of particles from reaching H. Show the tracks of the particles in your diagram. (4 marks)



5. **< HKCE 1986 Paper I - 9 >**



The figure above shows the variation of count rate of a radioactive source measured by a GM counter with time.

(a) Find from the figure, the background count rate of the room. (2 marks)

(b) Find the count rate due only to the radioactive source at time 0. (2 marks)

(c) Determine the half-life of the radioactive source. (2 marks)

6. **< HKCE 1987 Paper I - 9 >**

The below figure shows a pair of positively charged aluminium foils.

(a) When the aluminium foils are placed near an α source, the foils are found to gradually collapse. Briefly explain why. (2 marks)

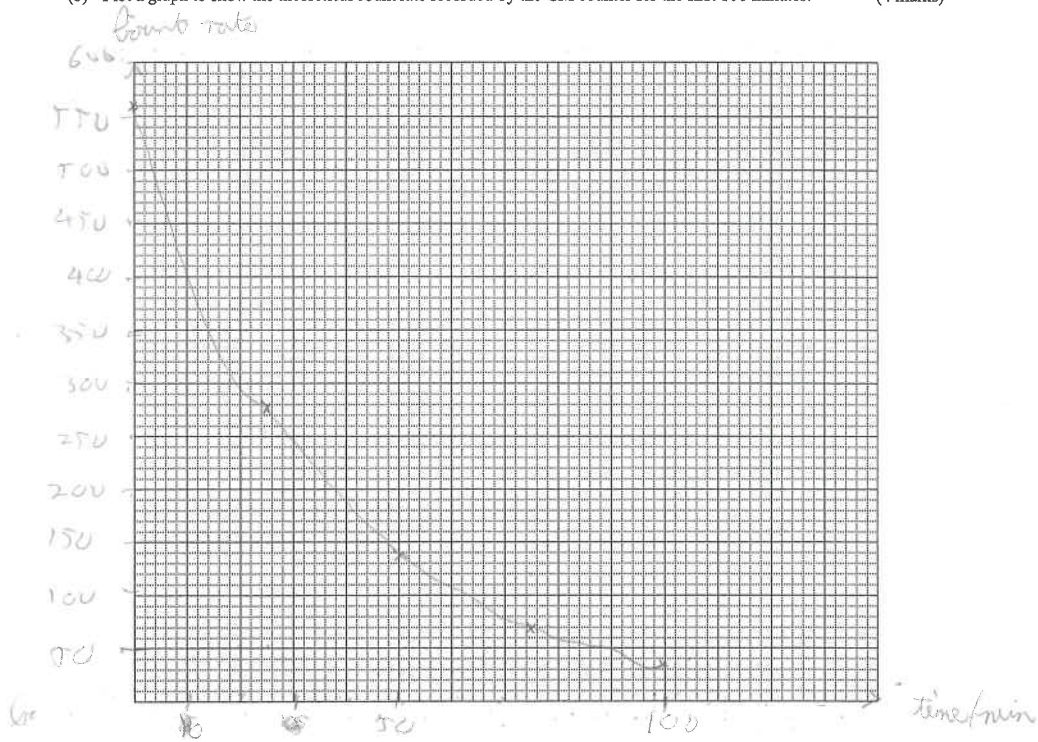
(b) Would the foils collapse faster or slower if the foils were placed near a γ source instead of an α source ? Explain briefly. (2 marks)

7. **< HKCE 1989 Paper I - 9 >**

A student measures the count rate of a source of half-life of 25 min using a GM counter in a room with very little background radiation. Initially the reading of the GM counter shows 560 counts per second.

(a) What should be the count rate of the source after 25 minutes ? (2 marks)

(b) Plot a graph to show the theoretical count rate recorded by the GM counter for the first 100 minutes. (4 marks)



(c) The actual readings of the GM counter are as follows:

Time / min.	0	50	75	100
Count rate / counts per second	560	154	70	31

Do you think that the GM counter is working properly ? Explain briefly. (3 marks)

8. < HKCE 1989 Paper I - 9 >

(a) What is the major source of background radiation

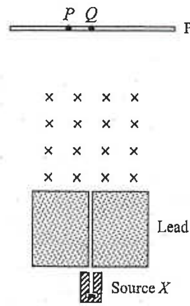
(i) at an altitude of 10000 m above sea-level ;

(ii) inside the Lion Rock Tunnel ;

(iii) in an underground coal mine ? (3 marks)

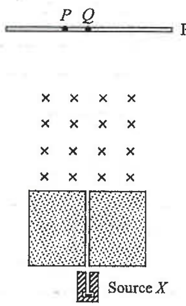
(b) It is reported that the background radiation in a concrete building is higher than that in a wooden hut. A person thus decides to move to a wooden hut. Do you think that his decision is wise ? Explain briefly. (3 marks)

9. < HKCE 1990 Paper I - 9 >



The above figure shows the set-up of an experiment carried out in an evacuated chamber to study the radiation from a radioactive source X. X emits α, β and γ radiation. 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 figure below, sketch and label the paths of the α, β and γ radiation emitted from the source X. (5 marks)



9. (b) Explain briefly

(i) why the experiment is carried out in an evacuated chamber ; (2 marks)

(ii) the use of the lead block in the set-up. (2 marks)

(c) If a piece of cardboard is placed between the source and the lead block, what type(s) of radiation would be recorded on the photographic film ? (2 marks)

(d) Suggest an alternative detector to replace the photographic film in the experiment. (2 marks)

10. < HKCE 1993 Paper I - 7 >

A cloud chamber is used to observe the tracks of α-particles.

(a) Describe the tracks of α-particles in the cloud chamber. (2 marks)

(b) An α-particle collides with a helium nucleus to form a fork track. What is the angle of the fork track and what does this angle indicate ? (2 marks)

11. **< HKCE 1995 Paper I - 7 >**

In a school laboratory, the background count rate recorded by a GM counter is 100 counts per minute.

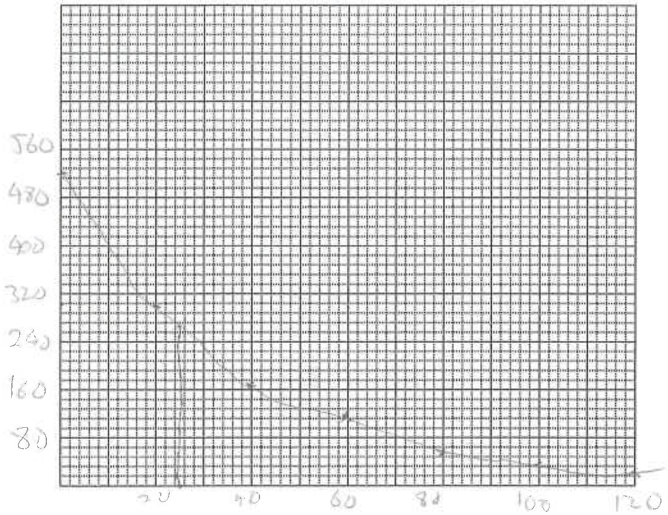
(a) The counter is placed close in front of a radioactive source P. The following results are obtained :

Time t / hour	0	20	40	60	80	100	120
Recorded count rate / counts per minute	620	400	270	199	157	133	118

520 300 170 99 57 33 18

(i) Find the corrected count rate at $t = 0$. (1 mark)

(ii) Plot the graph of the corrected count rate against time on the graph below. (5 marks)



(iii) Hence find the half-life of the source. (1 mark)

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

Material	Recorded count rate / counts per minute
–	620
Paper	623
5 mm Aluminium	98
5 mm Lead	101

Explain how the result shows that P emits β radiation only and it does not emit α or γ radiation. (3 marks)

11. (c) If the experiment in (b) 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 below table.

Material	Recorded count rate / counts per minute
–	750
Paper	x
5 mm Aluminium	y
5 mm Lead	z

From the following list, choose suitable values for x, y and z :

0, 100, 195, 540, 750

(Note : A reading may be used more than once.) (3 marks)

12. **< HKCE 1999 Paper I - 6 >**

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	Recorded count rate / counts per minute		
	1st reading	2nd reading	3rd reading
–	700	710	693
Paper	702	703	701
1 mm Aluminium	313	320	317
5 mm Lead	98	101	100

The background count rate recorded by the counter is 100 counts per minute.

(a) Explain why the three readings for each absorber are not identical. (1 mark)

(b) Explain how the above results show that the source emits β radiation only and it does not emit α and γ radiation. (4 marks)

13. **< HKCE 2001 Paper I - 11 >**

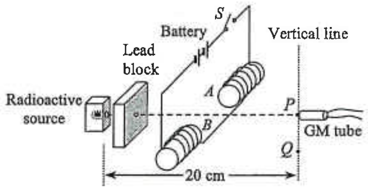


Figure 1

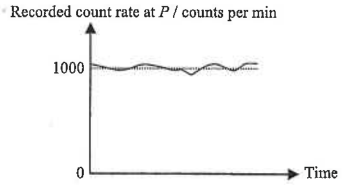


Figure 2

Figure 1 shows a set-up used to study the radiation from a radioactive source. A GM tube is placed at position *P*, which is at 20 cm from the source. Two coils *A* and *B* connected to a battery and a switch *S* are placed between the source and the GM tube as shown. Initially, *S* is open and the variation of the count rate recorded by the GM tube with time is shown in Figure 2.

(a) Explain why the count rate shown in Figure 2 is **not** due to α particles, no matter what kinds of radiation are emitted by the source. (2 marks)

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(b) Now switch *S* is closed. The GM tube is placed at positions *P* and *Q* in turn (see Figure 1) and the count rates recorded are shown in Figure 3 and 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.

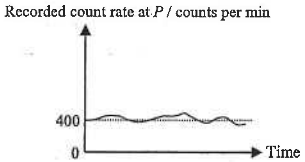

Figure 3

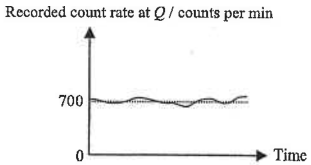

Figure 4

(i) State the direction of the magnetic field formed between coils *A* and *B*. (1 mark)

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(ii) What kind of radiation is recorded when the GM tube is held at any point vertically above *P* ? Explain your answer. (3 marks)

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

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

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(c) The above experiment **cannot** determine whether α particles are emitted by the source. Suggest a method for finding out the answer. (2 marks)

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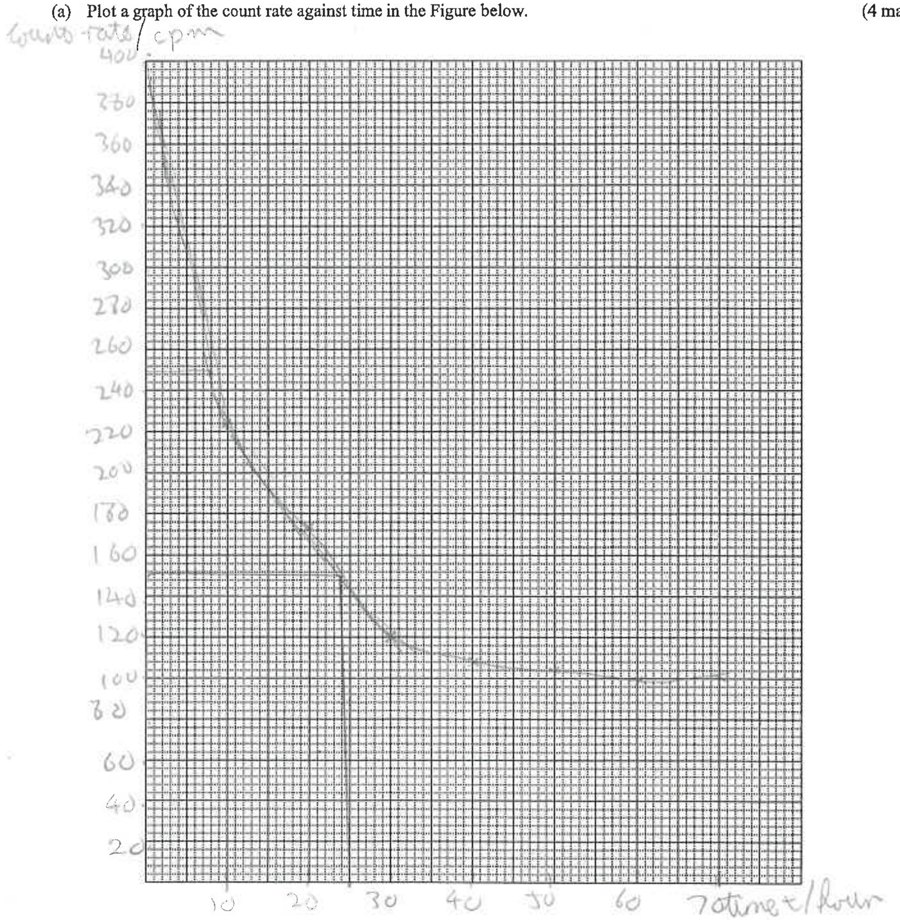
14. **< HKCE 2005 Paper I - 8 >**

Carol performs an experiment to measure the half-life of a radioactive source. She places a Geiger-Muller tube in front of the source and the following results are obtained :

Time *t* / hour	0	10	20	30	40	50	60	70
Count rate / counts per minute	400	225	154	119	107	105	100	102

(a) Plot a graph of the count rate against time in the Figure below. (4 marks)



(b) Estimate the background count rate. (1 mark)

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(c) Estimate the corrected count rate at $t = 0$. Hence, or otherwise, estimate the half-life of the source. (2 marks)

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15. **< HKCE 2006 Paper I - 8 >**

Workers of nuclear plants are required to wear film badges (see 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 (see Figure 2) so that the types of incoming radiation can be distinguished.

Figure 1

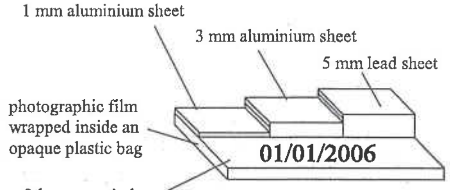


Figure 2

(a) What type(s) of radiation cannot be detected by the badge ? (1 mark)

(b) Why is an opaque plastic bag used to wrap the photographic film ? (1 mark)

(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 aluminium sheet	5	3	4
Beneath the 3 mm aluminium sheet	5	1	2
Beneath the 5 mm lead sheet	4	0	0

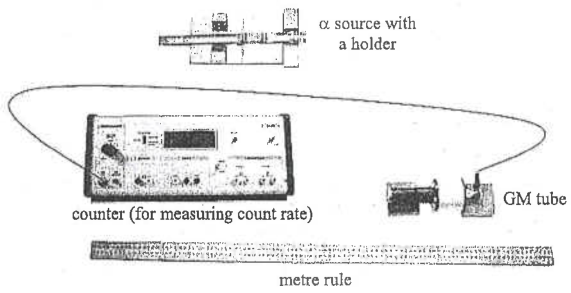
(i) Based on the results in the above Table, explain which type(s) of radiation John and Mary are definitely being exposed to respectively. (3 marks)

(ii) Give one reason why different degrees of blackening were recorded on the films of Mary and Ken. (1 mark)

(d) Suggest one hazard of exposure to ionizing radiations. (1 mark)

16. **< HKCE 2007 Paper I - 8 >**

In a physics lesson, a teacher uses the apparatus shown in Figure 13 to find the range of α particles in the air. Describe the procedures of the experiment. (4 marks)

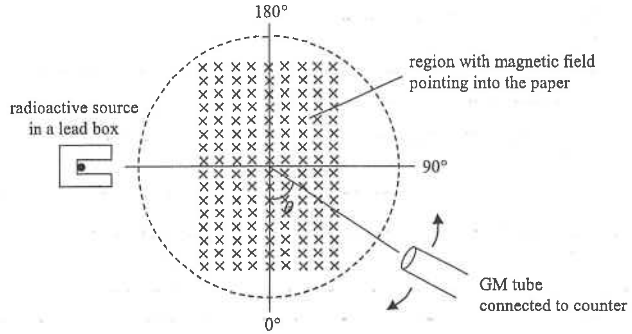


17. **< HKCE 2008 Paper I - 12 >**

(a) A teacher places a radioactive source 1 cm in front of a Geiger-Muller tube (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. (1 mark)

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



17.

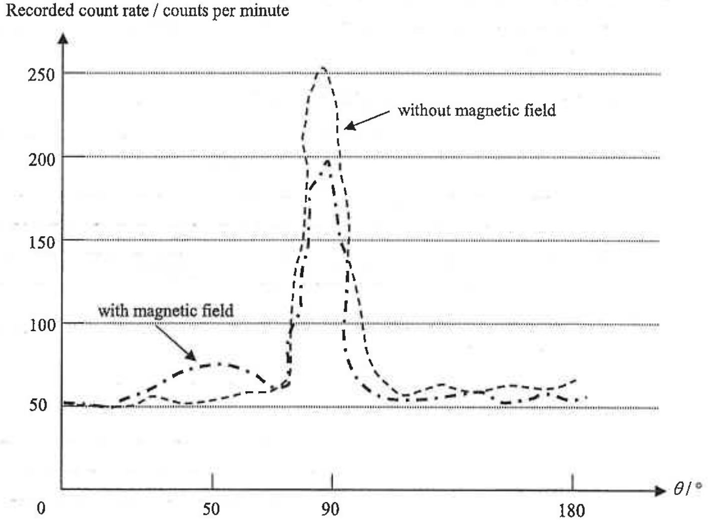


Figure 2

(b) Estimate the count rate due to the background radiation. (1 mark)

(c) Using the result in Figure 2, explain why it can be concluded that the radioactive source emits β and γ rays. (4 marks)

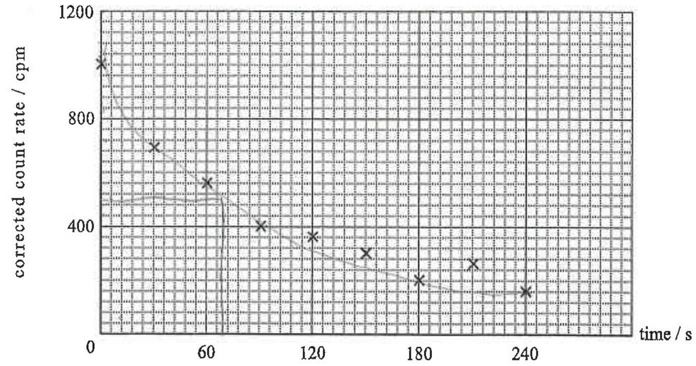
(d) Estimate the count rate due to each type of radiation at θ = 90° without the magnetic field. Write the answer in the Table below.

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

(2 marks)

Part B : HKAL examination questions

18. < HKAL 1983 Paper IIB - 6 >



A radioactive source emits β particles. The corrected count rates are recorded and plotted in the above figure.

(a) A student comments that the readings have been taken carelessly because the points plotted in the above Figure do not fall on a smooth curve. Do you agree ? Explain your reasoning. (1 mark)

(b) Use the above Figure to estimate the half life of the radioactive source. (1 mark)

(c) Estimate the decay constant of protactinium-234. (1 mark)

(d) Express in words the relationship between the decay constant and the probability of an atom decaying. (1 mark)

Part C : HKDSE examination questions

19. **< HKDSE Practice Paper IB - 11 >**

The decay of radioactive isotope protactinium-238 (^{238}Pa) has a half-life of approximately 136 s. A sample of ^{238}Pa is put in front of a GM tube and the initial count rate is 1000 counts per minute. The background count rate is 50 counts per minute.

(a) It is known that the decay of ^{238}Pa does not emit γ radiation. Suggest a simple test to verify the radiation from ^{238}Pa is β radiation but not α radiation. (3 marks)

(b) Estimate the decay constant of ^{238}Pa. (1 mark)

(c) Hence, or otherwise, estimate the time taken for the count rate to drop to 250 counts per minute. (3 marks)

20. **< HKDSE 2014 Paper IB - 10 >**

Voyager I is a space probe designed by NASA to operate for over ten years in space. It was equipped with a radioisotope thermoelectric generator (RTG) which can convert the energy released from the decay of a radioactive source into electrical power. *Voyage I* operates with a plutonium-238 radioactive source that undergoes α-decay.

(a) The plutonium-238 source is sealed inside a thin metallic casing of the RTG. The photo shows a NASA staff handling the RTG with his bare hands. Explain why it is fine for it to be handled by the staff in this way. (1 mark)

20. When *Voyager I* was launched, the number of plutonium-238 atoms in the source was 3.2×10^{25}.

Given : half-life of plutonium-238 = 87.74 years.

Take 1 year = 3.16×10^{7} s.

(b) (i) Find the activity, in Bq, of the plutonium source at the time of launch. (3 marks)

(ii) When a plutonium-238 atom decays, it releases 5.5 MeV of energy. Estimate the power, in kW, delivered by the source at the time of launch. (2 marks)

(iii) The RTG of *Voyage I* is still in operation as *Voyage I* just left the solar system in September 2013 after it was launched 36 years ago. Estimate the corresponding power delivered by the plutonium source, expressed in percentage of the power delivered at the time of launch. (2 marks)

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

Question Solution

1. (a) Half-life of X = 4 min [1]

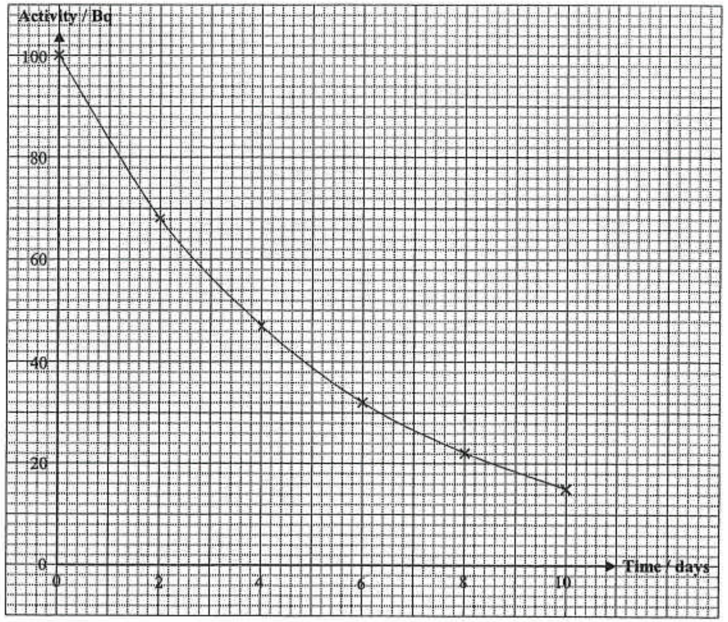
Half-life of Y = 32 min [1]

(b) X will be mainly be responsible for the reading [1]

Ratio of the number of counts due to X to that of Y = 0.5 : 0.08 [2]

Fraction of total number of counts due to X = $\frac{0.5}{0.5+0.08}$ = 0.862 [2]

2. (a)



< Two axes correctly labeled > [1]

< Scales properly marked > [1]

< Points correctly plotted > [1]

< Curve correctly drawn > [1]

(b) (i) activity after 5 days = 39 Bq < accept 38 Bq to 40 Bq > [1]

(ii) half-life = 3.7 days < accept 3.6 to 3.8 days > [1]

3. (a) There is background radiation. [1]

(b) It is due to the random nature of radiation. [2]

(c) β radiation only [1]

There is no α since α is stopped by paper. [1]

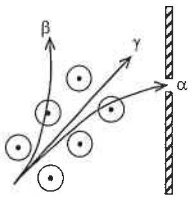
β is present since β is absorbed by aluminium and the count rate is reduced. [1]

There is no γ since the count rate left is very small which should be due to background radiation. [1]

4. (a) The charge is positive. [1]

(b) (i) α particle [1]

(ii) Use magnetic field [1]



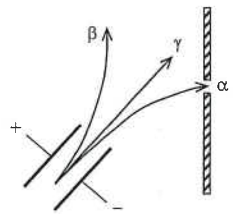
< correct deflection of α to the slit > [1]

< correct indication of the direction of the magnetic field > [1]

< β and γ correctly deflected > [1]

OR

Use electric field [1]



< correct deflection of α to the slit > [1]

< correct indication of the direction of the electric field or polarity > [1]

< β and γ correctly deflected > [1]

5. (a) Background count rate = 40 counts per minute [2]

(b) Count rate at time 0 = 200 – 40 [1]

= 160 counts per minute [1]

(c) Half-life = 7 minutes < accept 6.5 minutes to 7.5 minutes > [2]

6. (a) The α particles ionize air. [1]

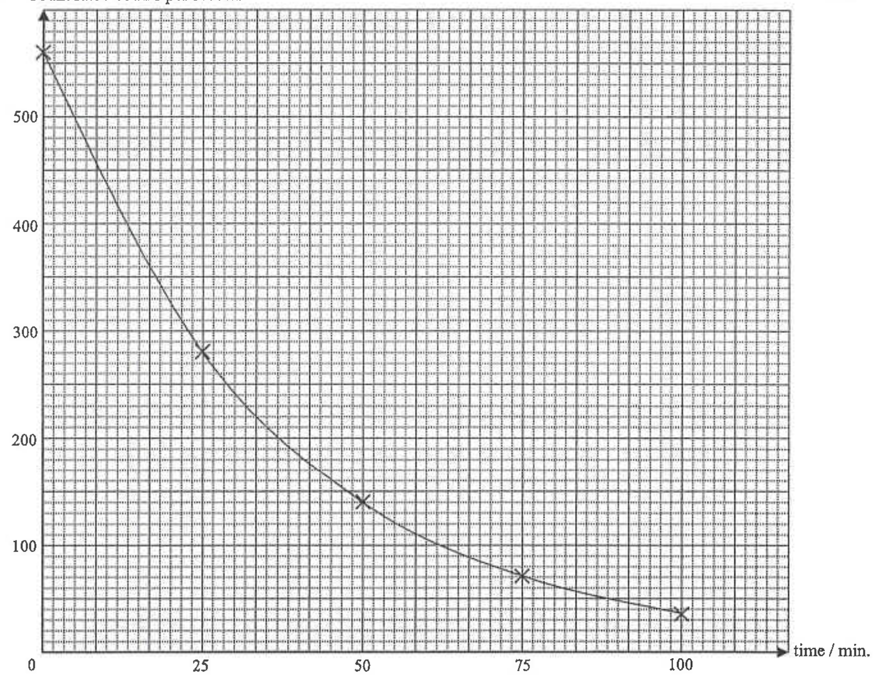
The ions then discharge the aluminium foils. [1]

(b) The foils would collapse slower [1]

since γ has weaker ionizing power [1]

7. (a) 280 counts per second [2]

(b) [4]



(c) Yes, the GM counter is working properly. [1]

The readings do not match the theoretical curve exactly due to the random nature of radiation. [2]

8. (a) (i) cosmic radiation from the outer space [1]

(ii) from the rock [1]

(iii) from the coal (or carbon) [1]

8. (b) Both Yes or No are acceptable but the reasons should be consistent. [1]

<u>Reason for Yes</u> : [2]

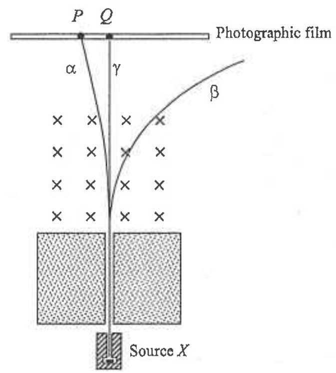
* The cumulative effect of radiation is harmful

<u>Reason for No</u> : (any **ONE**) [2]

* The background radiation in a concrete building is weak and not hazardous
* The chance of being harmed by other factors such as fire in a wooden hut is increased

< No mark is awarded if only answer Yes or No >

9. (a)



< 2 rays reaching P, Q > [1]

< α radiation – towards the left > [1]

< γ radiation – no deflection > [1]

< β radiation – towards the right > [1]

< β radiation not reaching the film > [1]

(b) (i) α-particles have short range in air. [2]

(ii) To produce a fine beam of radiation [2]

(c) γ radiation only [2]

(d) GM tube [2]

10. (a) The tracks are (ANY TWO) : [2]

* straight
* thick
* short
* of about the same length

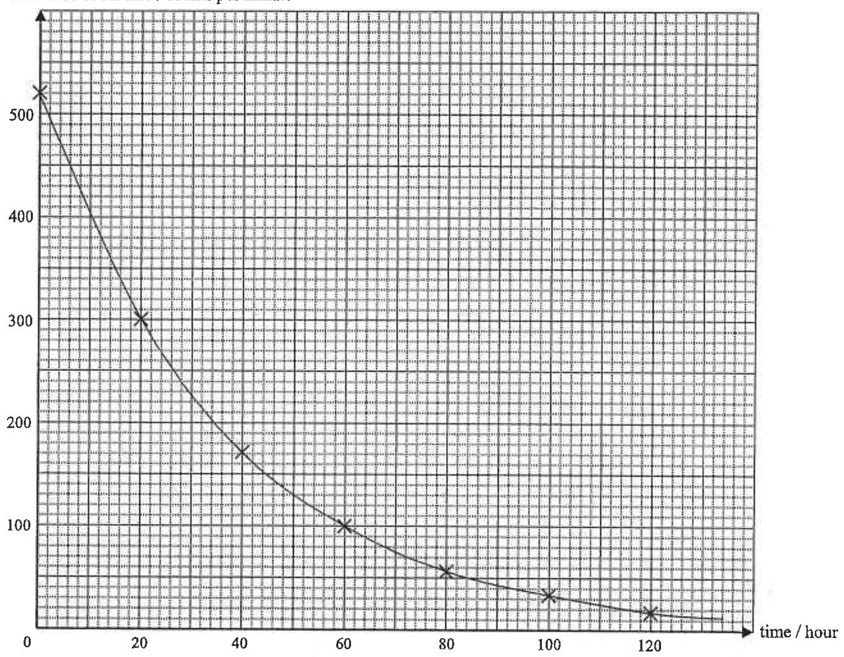
(b) The angle is 90° [1]

The masses of an α particle and a helium nucleus are the same. [1]

11. (a) (i) Corrected count rate = 520 counts per minute [1]

(ii) [1]

Time t / hour	0	20	40	60	80	100	120
Corrected count rate / counts per minute	520	300	170	99	57	33	18



< Correct label of the two axes with units > [1]

< An appropriate scale (not less than 1 cm to 50 c.p.m. and 1 cm to 10 hours) > [1]

< Correct points plotted > [1]

< Smooth curve drawn > [1]

(iii) From the graph, half-life = 25 hours < from 23 to 27 hours is acceptable > [1]

(b) The source does not emit α radiation
since the recorded count rate almost remains unchanged when a sheet of paper is inserted. [1]

The count rate drops significantly when aluminium is inserted, this illustrates that it emits β radiation. [1]

The source does not emit γ radiation
because the count rate is approximately unchanged when 5 mm lead is inserted. [1]

11. (b) **OR**

The source does not emit α radiation
since the recorded count rate almost remains unchanged when a sheet of paper is inserted. [1]

The count rate drops significantly when aluminium is inserted, this illustrates that it emits β radiation. [1]

The source does not emit γ radiation
because the count rate already drops to background rate when aluminium is inserted. [1]

(c) x = 540 [1]

y = 540 [1]

z = 195 [1]

12. (a) This is due to the random nature of radiation. [1]

(b) As the count rates remain unchanged when a sheet of paper is inserted,
the source does not emit α radiation. [1]

As the count rates drop significantly when 1 mm aluminium sheet is inserted,
the source emits β radiation. [1]

As the count rates drop to background radiation when 5 mm lead is inserted,
the source does not emit γ radiation. [1]

13. (a) The range of α particles in air [1]
is only a few centimeters. [1]

(b) (i) The magnetic field is directed from B to A. [1]

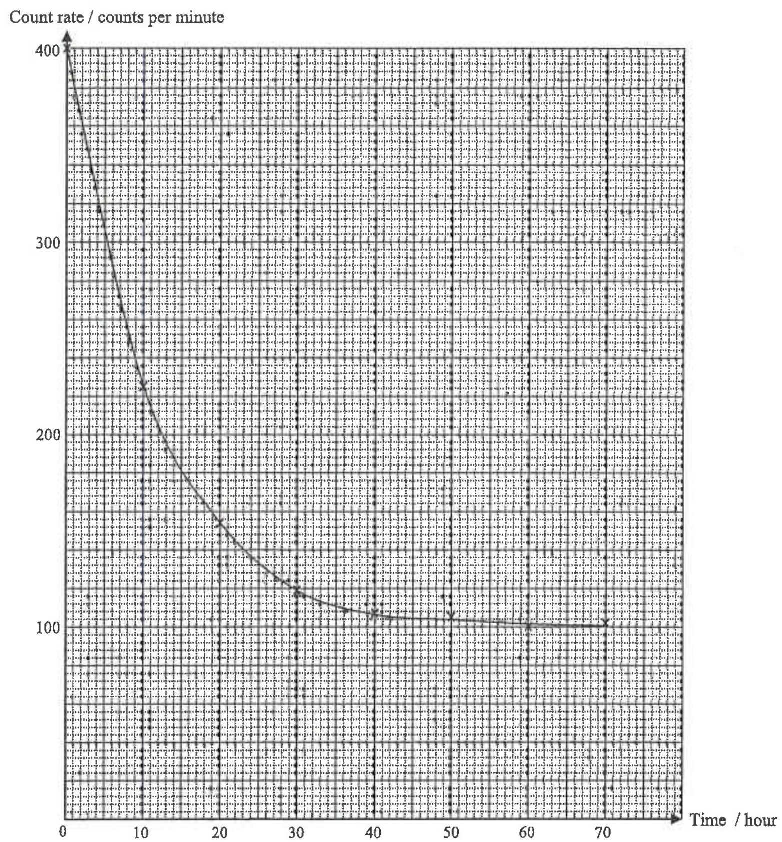
(ii) The count rate is due to background radiation only. [1]
β or γ cannot be deflected upward. [2]

(iii) As the count rate at P and Q are greater than the background radiation, some radiations are detected. [1]
As the radiation detected at P is not deflected by the magnetic field, it must be γ radiation. [1]
As the radiation detected at Q is deflected downwards by the magnetic field, it must be β radiation. [1]
So the source emits β and γ radiation. [1]

(iv) The background radiation is recorded at both Figure 3 and Figure 4, [1]
so the background radiation is counted twice and thus the sum is greater. [1]

(c) Place the GM tube close in front of the source. [1]
Insert a piece of paper in between.
If the count rate drops significantly, α particles are emitted. [1]

14. (a)



< Two axes correctly labelled with units > [1]

< An appropriate scale > [1]

< Correct points (at least 7 points correct) > [1]

< A curve through the points > [1]

(b) The background count rate is 100 counts per minute. < from 95 to 105 is acceptable > [1]

(c) The corrected count rate at $t = 0$ is 300 counts per minute. < from 295 to 305 is acceptable > [1]

The half-life is 8 hours. < from 7 to 9 hours is acceptable > [1]

15. (a) α radiation cannot be detected. [1]

(b) To prevent light rays from entering the bag and blackening the film. [1]

15. (c) (i) John is exposed to γ radiation [1]

since γ can pass through the 5 mm lead sheet and blacken the film. [1]

Mary is exposed to β radiation since the film under the aluminium sheets is blackened but the film under the 5 mm lead sheet is not blackened. [1]

(ii) The radiation dose received by Ken is higher than that of Mary. [1]

(d) Any **ONE** of the following : [1]

* It can destroy living cells.
* It can cause cancer.
* It can cause the genetic change.

16. Place the α source close to and facing the GM tube. [1]

Increase their separation gradually and observe the count rate reading. [1]

Mark the point for the rapid drop in count rate. [1]

Measure the distance between α source and the GM tube with the metre rule to give the range. [1]

17. (a) No α radiation from the source. [1]

(b) 50 counts per minute (50 cpm) < accept 50 to 60 cpm > [1]

(c) With magnetic field, a peak of count rate appears at 50°. [1]

As β-particles are negatively charged, they deflect inside the magnetic field. [1]

With magnetic field, a peak of current still exists at 90°. [1]

As γ-ray does not have charge, it does not deflect inside the magnetic field. [1]

(d) β : 50 < accept 50 to 60 > [1]

γ : 150 < accept 140 to 160 > [1]

18. (a) No! It is due to the random nature of radiation. [1]

(b) Half life = 72 s < from 60 to 84 s is acceptable > [1]

(c) $k = \dfrac{\ln 2}{72} = 0.00963\ s^{-1}$ < from $0.00825\ s^{-1}$ to $0.0116\ s^{-1}$ are acceptable > [1]

(d) The decay constant is equal to the probability of decay of an atom per unit time. [1]

OR

The decay constant is equal to the probability of decay of an atom in 1 s. [1]

19. (a) Insert a piece of paper between the sample and the GM tube.

The count rate will remain approximately unchanged, showing that no α radiation is emitted. [1]

Insert a 5 mm aluminium plate between the sample and the GM tube. [1]

The count rate will drop to the background count rate level, showing that β radiation is emitted. [1]

(b) $k = \dfrac{\ln 2}{136} = 5.10 \times 10^{-3}\ s^{-1}$ [1]

(c) Initial corrected count rate = 1000 – 50 = 950 cpm

Final corrected count rate = 250 – 50 = 200 cpm [1]

By $C = C_o e^{-kt}$ **OR** By $C = C_o \left(\dfrac{1}{2}\right)^{t/t_{1/2}}$ [1]

$\therefore\ (200) = (950)\ e^{-5.10\times10^{-3}\,t}$ $\quad\quad$ $\therefore\ (200) = (950)\left(\dfrac{1}{2}\right)^{t/136}$

$\therefore\ t = 306\ s$ $\quad\quad$ $\therefore\ t = 306\ s$ [1]

20. (a) The penetrating power of α is so weak that it cannot pass through the thin metallic casing of the RTG. [1]

(b) (i) $k = \dfrac{\ln 2}{t_{1/2}} = \dfrac{\ln 2}{(87.74\times3.16\times10^{7})} = 2.50 \times 10^{-10}\ s^{-1}$ [1]

$A_o = kN = (2.50 \times 10^{-10})\,(3.2 \times 10^{25})$ [1]

$= 8.00 \times 10^{15}$ Bq [1]

(ii) $P = EA$

$= (5.5 \times 10^{6} \times 1.6 \times 10^{-19})\,(8 \times 10^{15})$ [1]

= 7040 W = 7.04 kW [1]

(iii) By $P = EA \quad \therefore\ P \propto A$

$\dfrac{P}{P_o} = \dfrac{A}{A_o} = e^{-(2.50\times10^{-10})\times(36\times3.16\times10^{7})} \times 100\% = 75.2\%$ [2]

OR

$\dfrac{P}{P_o} = \dfrac{A}{A_o} = \left(\dfrac{1}{2}\right)^{t/t_{1/2}} = \left(\dfrac{1}{2}\right)^{36/87.74} \times 100\% = 75.2\%$ [2]

< accept using the ratio of number of nuclei N > < accept 75% >

Hong Kong Diploma of Secondary Education Examination

Physics – Compulsory part (必修部分)

Section A – Heat and Gases (熱和氣體)
1. Temperature, Heat and Internal energy (溫度、熱和內能)
2. Transfer Processes (熱轉移過程)
3. Change of State (形態的改變)
4. General Gas Law (普適氣體定律)
5. Kinetic Theory (分子運動論)

Section B – Force and Motion (力和運動)
1. Position and Movement (位置和移動)
2. Newton's Laws (牛頓定律)
3. Moment of Force (力矩)
4. Work, Energy and Power (作功、能量和功率)
5. Momentum (動量)
6. Projectile Motion (拋體運動)
7. Circular Motion (圓周運動)
8. Gravitation (引力)

Section C – Wave Motion (波動)
1. Wave Propagation (波的推進)
2. Wave Phenomena (波動現象)
3. Reflection and Refraction of Light (光的反射及折射)
4. Lenses (透鏡)
5. Wave Nature of Light (光的波動特性)
6. Sound (聲音)

Section D – Electricity and Magnetism (電和磁)
1. Electrostatics (靜電學)
2. Electric Circuits (電路)
3. Domestic Electricity (家居用電)
4. Magnetic Field (磁場)
5. Electromagnetic Induction (電磁感應)
6. Alternating Current (交流電)

Section E – Radioactivity and Nuclear Energy (放射現象和核能)
1. Radiation and Radioactivity (輻射和放射現象)
2. Atomic Model (原子模型)
3. Nuclear Energy (核能)

Physics – Elective part (選修部分)

Elective 1 – Astronomy and Space Science (天文學和航天科學)
1. The universe seen in different scales (不同空間標度下的宇宙面貌)
2. Astronomy through history (天文學的發展史)
3. Orbital motions under gravity (重力下的軌道運動)
4. Stars and the universe (恆星和宇宙)

Elective 2 – Atomic World (原子世界)
1. Rutherford's atomic model (盧瑟福原子模型)
2. Photoelectric effect (光電效應)
3. Bohr's atomic model of hydrogen (玻爾的氫原子模型)
4. Particles or waves (粒子或波)
5. Probing into nano scale (窺探納米世界)

Elective 3 – Energy and Use of Energy (能量和能源的使用)
1. Electricity at home (家居用電)
2. Energy efficiency in building (建築的能源效率)
3. Energy efficiency in transportation (運輸業的能源效率)
4. Non-renewable energy sources (不可再生能源)
5. Renewable energy sources (可再生能源)

Elective 4 – Medical Physics (醫學物理學)
1. Making sense of the eye (眼的感官)
2. Making sense of the ear (耳的感官)
3. Medical imaging using non-ionizing radiation (非電離輻射醫學影像學)
4. Medical imaging using ionizing radiation (電離輻射醫學影像學)