学生手册 2026–2028

CIE IGCSE Physics 全基础题型

0625 · Core & Extended · 核物理

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[5] 专题 5 核物理

5.1.1 原子

题型 1：看位置与电子数判原子状态（考频★★★★☆）

知识点 原子由位于中央的原子核和在核外运动的电子组成。

原子核带_____电，电子带_____电；原子核内的中子不带电。

原子核内还含带正电的_____；质子数等于电子数时，原子整体不带电。

答案：正；负；质子

怎么认 题目出现原子结构图或询问核内、核外粒子的电荷时，先看粒子位于原子核内还是核外。

一. 按位置辨电荷粒子

例题 1

(a) Fig. 10.1 represents an atom of carbon.

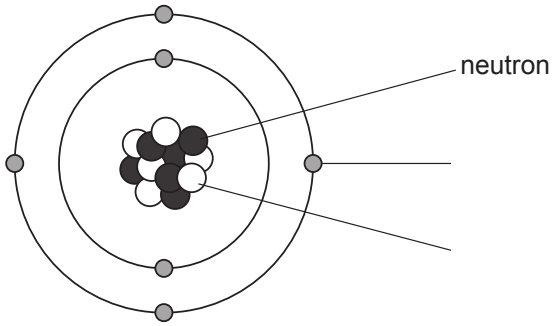


Fig. 10.1 (not to scale)

Complete the labels for the particles in Fig. 10.1.
On each dotted line, write the name of the particle.

（2024 春季 0625/32 第10题(a)）

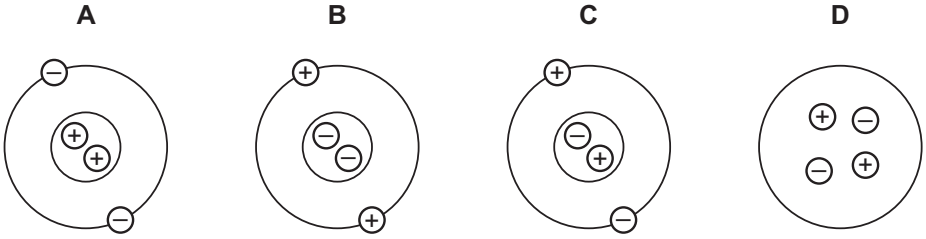
解：中间点线指向原子核外的粒子，核外运动的带负电粒子是电子。

下方点线指向原子核内与已标出的中子不同的一类粒子，该粒子是质子。

答：电子；质子。

针对练习

1. Which diagram represents the positions of the charged particles of an atom?



（2023 夏季 0625/12 第34题）

2. Which description of the structure of an atom is correct?

A a negatively charged nucleus with negatively charged electrons around it

B a negatively charged nucleus with positively charged electrons around it

C a positively charged nucleus with negatively charged electrons around it

D a positively charged nucleus with positively charged electrons around it

（2025 冬季 0625/13 第35题）

3. A simple model of the atom consists of small particles orbiting a central nucleus.

Which row is correct?

	charge on nucleus	charge on orbiting particles
A	negative	negative
B	negative	positive
C	positive	negative
D	positive	positive

（2024 夏季 0625/11 第32题）

4. Which description of the structure of an atom is correct?

A negatively charged electrons surrounding an uncharged nucleus

B negatively charged electrons surrounding a positively charged nucleus

C positively charged electrons surrounding an uncharged nucleus

D positively charged electrons surrounding a negatively charged nucleus

（2025 冬季 0625/11 第33题）

二. 数质子电子判电性

知识点 原子由带正电的原子核和绕核运动的带负电电子组成；原子核内的质子带正电，中子不带电。设质子数和电子数分别为 N_p、N_e，则总电荷量 $Q=(N_p-N_e)e$，其中 e 为元电荷量，单位为库仑（C）。质子数与电子数_____时为中性原子；电子数较多时为_____，电子数较少时为_____。

答案：相等；负离子；正离子

怎么认 题目出现质子数、电子数或粒子结构图时，先比较质子数与电子数。

例题 2 Which statement about an atom is correct?

A An atom has positive charge because there are only positive charges in the nucleus.

B An atom has negative charge because there are only negative charges in the nucleus.

C An atom has neutral charge because the positive charge in the nucleus equals the total negative charge of the electrons.

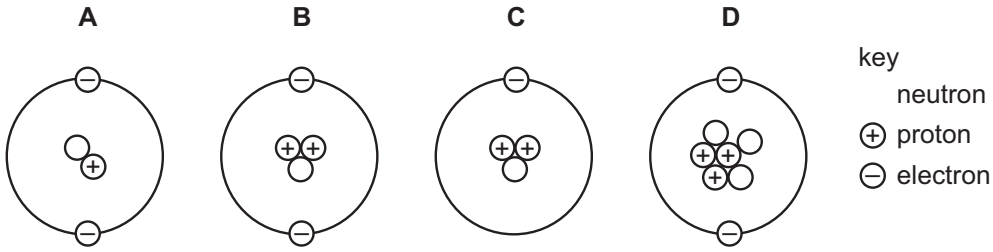
D An atom has neutral charge because the negative charge in the nucleus equals the total positive charge of the electrons.

（2024 春季 0625/12 第30题）

解：原子核内的质子带正电，核外电子带负电，二者所带电荷量大小相等。
由原子中质子数等于电子数，得 $Q=(N_p-N_e)e=0$，原子呈电中性。故选 C。

针对练习

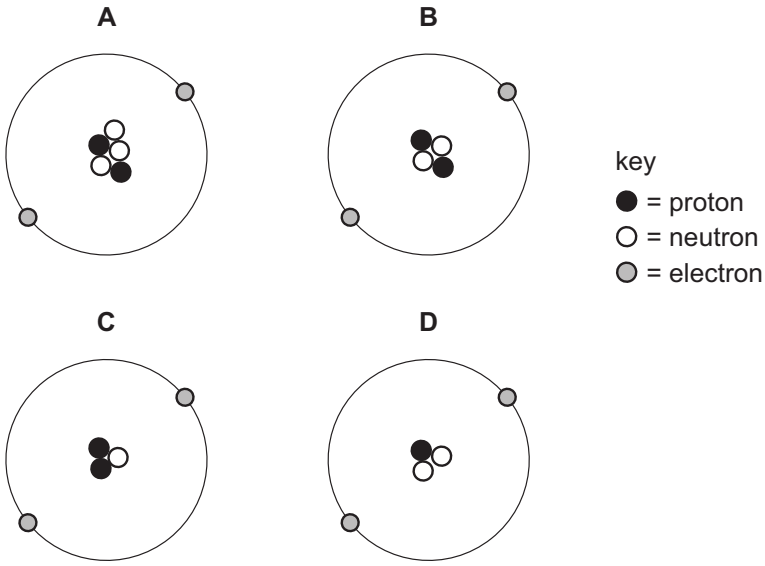
5. Which diagram represents the structure of a neutral atom?



（2024 冬季 0625/11 第34题）

6. The diagrams represent the protons, neutrons and electrons in different atoms and ions.

Which diagram shows a negatively charged ion?



（2023 冬季 0625/12 第34题）

三. 按电子得失判离子

知识点 原子由带正电的原子核和带负电的核外电子组成；中性原子的正、负电荷总量相等。

原子失去电子时，负电荷减少，形成_____；原子得到电子时，负电荷增加，形成_____。

这一判断以原子核不变为条件，离子形成时原子核内的正电荷_____；电荷量的单位是库仑（C）。

答案：正离子；负离子；不变

怎么认 题目出现正、负离子及电子得失时，先追踪核外电子数的增减。

例题 3 How are positive and negative ions formed from atoms?

	positive ion	negative ion
A	add positive charge to the nucleus	add an electron to the atom
B	add positive charge to the nucleus	remove positive charge from the nucleus
C	remove an electron from the atom	add an electron to the atom
D	remove an electron from the atom	remove positive charge from the nucleus

（2023 夏季 0625/11 第34题）

解：原子失去电子，负电荷减少，形成正离子；原子得到电子，负电荷增加，形成负离子。
表中符合这两种变化的是 C。
故选 C。

针对练习

7. An ion of the element oxygen is negatively charged.

Which change causes the ion to become a neutral oxygen atom?

A gain of electrons

B gain of protons

C loss of electrons

D loss of protons

（2025 夏季 0625/12 第33题）

8. A rechargeable battery contains lithium.

The lithium exists as positive lithium ions.

How does an ion of lithium differ from an atom of lithium?

A The ion has fewer electrons orbiting the nucleus.

B The ion has more electrons orbiting the nucleus.

C The nucleus of the ion has less charge.

D The nucleus of the ion is more positively charged.

（2023 春季 0625/12 第34题）

9. A magnesium ion has a double positive charge and a chloride ion has a single negative charge.

Which statement is correct?

A A chlorine atom gains an electron to form the chloride ion.

B A chlorine atom loses a proton to form the chloride ion.

C A magnesium atom loses an electron to form the magnesium ion.

D A magnesium atom gains two electrons to form the magnesium ion.

（2023 冬季 0625/22 第34题）

10. **(a)** **(i)** State how a neutral atom becomes a positive ion.

(ii) State the type of nuclear emission which is the most ionising.

（2024 冬季 0625/33 第10题(a)）

题型 2：把散射现象对应原子结构（考频★★★★☆）

知识点 原子由带正电的原子核和核外带负电的电子组成，原子内部大部分为_____。
用 α 粒子轰击很薄的金属箔时，绝大多数粒子直穿，少数发生偏转，极少数发生大角度偏转或反弹。
直穿现象表明原子核很小；大角度偏转表明原子核带_____，并集中了原子的大部分_____。
这些结论描述原子的结构、电性和质量分布，不含物理量单位。

答案：空的空间；正电；质量

怎么认 题目出现 α 粒子、薄金属箔和散射现象时，先写绝大多数直穿、少数偏转、极少数大角度偏转。

一. 先认装置与典型现象

例题 1

A scientist fires alpha-particles at a very thin sheet of gold and detects the particles that pass through.

Which statement about the results of the scattering experiment is correct?

A Alpha-particles are attracted to the nucleus of the atoms in the metal sheet.

B Half the mass of the atom is concentrated in the nucleus.

C Most of the alpha-particles are deflected, showing that the nucleus is very dense.

D Only a small number of alpha-particles are deflected, but some of these are deflected through large angles.

（2024 夏季 0625/21 第32题）

解：原子内部大部分为空的空间，故绝大多数 α 粒子穿过金箔；少数粒子靠近原子核而偏转，其中极少数发生大角度偏转。故选 D。

针对练习

1. The scattering of α-particles by a thin metal foil supports the nuclear model of an atom.

Why are α-particles used rather than neutrons?

A because they always travel more slowly

B because they are heavier

C because they are larger in diameter

D because they have a positive charge

（2023 春季 0625/22 第33题）

2. Which observation provides evidence for the nuclear atom?

A attraction of opposite charges

B emission of γ-rays during the decay of a radioactive nuclide

C scattering of α-particles by a thin metal foil

D scattering of γ-rays by a thin metal foil

（2025 夏季 0625/23 第34题）

3. The scattering of particles by a thin gold foil provided scientists with evidence for the nuclear atom.

Which particles were scattered by the gold nuclei in the thin foil?

A α-particles

B β-particles

C neutrons

D protons

（2024 夏季 0625/22 第33题）

二. 多数直穿推出大部为空

知识点 原子由带正电的原子核和带负电的核外电子组成；原子核很小，原子内部绝大部分是_____。

当带正电的 α 粒子射向很薄的金属箔时，绝大多数粒子几乎不偏转，说明原子内部绝大部分是空的；少数粒子发生大角度偏转或反弹，说明正电荷和大部分质量集中在很小的_____内。

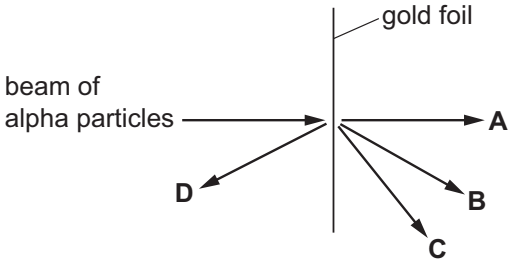
上述关系适用于薄金属箔的 α 粒子散射实验，各项结构结论均无单位。

答案：空的；原子核

怎么认 题目出现绝大多数 α 粒子几乎不偏转并穿过薄箔时，先判断原子内部绝大部分是空的。

例题 2 In an alpha particle scattering experiment, a beam of alpha particles is fired at a very thin piece of gold foil.

In which direction do most of the alpha particles travel after hitting the foil?



（2025 夏季 0625/21 第33题）

解： 原子内部绝大部分是空的，故绝大多数 α 粒子穿过金箔时几乎不偏转，仍沿入射方向运动。图中该方向为 A。故选 A。

针对练习

4. In α-particle scattering, α-particles are incident on a thin metal foil.

Which row describes results from the experiment and a conclusion that the results lead to?

	results	conclusion
A	most of the α-particles pass straight through the foil	most of the atom is empty space
B	most of the α-particles pass straight through the foil	the nucleus is very large
C	very few of the α-particles pass straight through the foil	most of the atom is empty space
D	very few of the α-particles pass straight through the foil	the nucleus is very large

（2023 冬季 0625/21 第34题）

5. **(a)** Alpha (α) particles are directed at a very thin sheet of gold foil.

The following observations provide evidence for the nuclear model of the atom.

State what conclusions may be made about the model of the atom from these observations.

(i) Observation: most of the particles pass straight through the foil.

(ii) Observation: a few particles bounce back or are deflected through large angles.

（2025 冬季 0625/43 第8题(a)）

三. 偏转反弹推出正小核

知识点 原子由中心体积很小的原子核和核外带负电的电子组成，原子内部大部分是空的。

原子核集中了原子的_____和全部_____；α 粒子带正电，靠近原子核时受到_____。

少数 α 粒子发生大角度偏转或反弹，说明原子核所占空间很小，并集中了原子的大部分质量。

答案：大部分质量；正电荷；斥力

怎么认 题目出现少数 α 粒子大角度偏转、反弹或近核轨迹图时，先由同号相斥判断正核及偏转方向。

例题 3 When a thin gold foil is bombarded with alpha particles, some alpha particles are deflected through large angles.

Which statement explains this deflection?

A Most of the atom consists of empty space.

B All of the positive charge and most of the mass of the gold atom are concentrated in a small volume.

C Positive charge in the gold atom is spread evenly throughout the atom.

D All of the negative charge is concentrated at its centre.

（2025 夏季 0625/22 第34题）

解：α 粒子带正电，由同号电荷相斥，金原子中能产生强斥力的正电荷集中在很小的区域。

该区域能使 α 粒子的运动方向显著改变，说明原子的大部分质量也集中在其中。

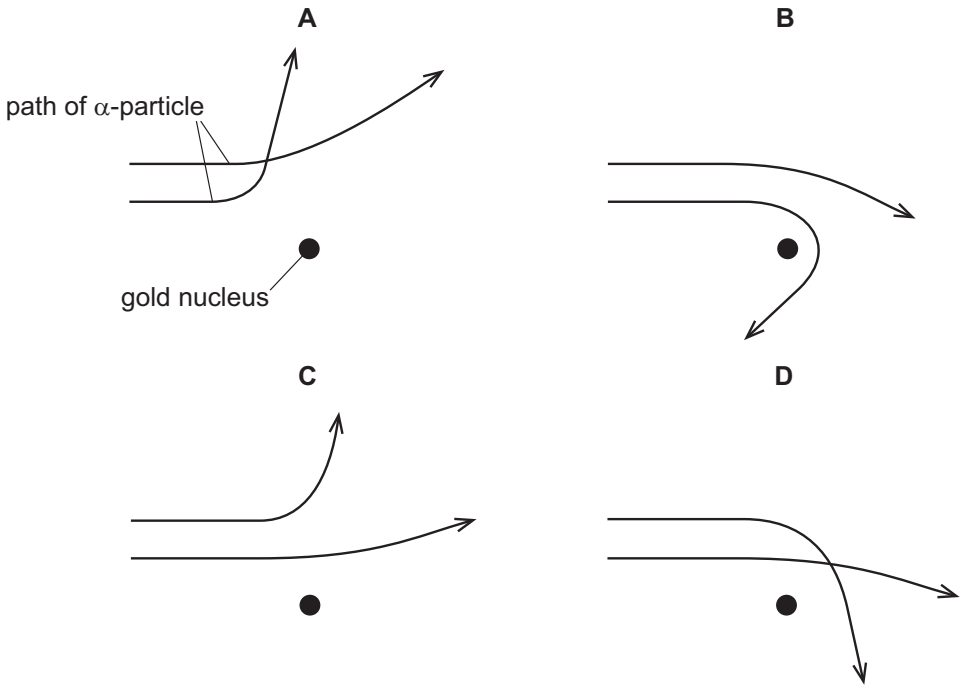
故选 B。

针对练习

6. The scattering of α-particles by a thin gold foil provides evidence for the nuclear model of the atom.

Two α-particles of the same energy are incident on a nucleus of gold.

Which diagram shows the correct paths followed by the α-particles as they pass close to the nucleus?



（2023 冬季 0625/23 第34题）

7. The arrow shows the path of an α-particle travelling towards the centre of a gold nucleus.



Which description of the path of the α-particle after striking the gold nucleus is correct?

A The α-particle is deflected through a very small angle towards the top of the page.

B The α-particle is deflected back along its initial path.

C The α-particle carries on in a straight line with **no** deflection.

D The α-particle is captured by the nucleus and goes into orbit around it.

（2025 冬季 0625/22 第33题）

四. 合并现象推出核式模型

知识点 α 粒子带正电；在很薄的金属箔散射实验中，粒子的运动方向变化反映原子内部结构。

多数 α 粒子沿直线穿过，说明原子内大部分区域是_____。

少数粒子偏转而极少数粒子反弹，说明原子核_____且带正电，并集中了原子的_____。

答案：空的；很小；大部分质量

怎么认 题目出现多数直穿、少数偏转和极少数反弹时，先分别对应空旷空间、小而带正电的原子核和核内大部分质量。

例题 4

(a) An experiment directs alpha particles at a very thin sheet of gold foil.

(i) Most of the alpha particles pass through the thin foil in a straight line.

State the conclusion about atoms from this observation.

(ii) Some of the alpha particles are deflected through angles less than 90° and a few are deflected through 180°.

State and explain **two** conclusions about the nuclei of atoms from this observation.

（2024 春季 0625/42 第9题(a)）

解：(i) 多数 α 粒子沿直线穿过金箔，说明原子内大部分区域是空的。

(ii) 只有少数 α 粒子发生偏转，说明能产生显著作用的原子核很小，只有少数粒子从原子核附近通过。

α 粒子带正电，偏转及反弹由它与原子核间的排斥力引起，说明原子核带正电。

答：(i) 原子内大部分区域是空的；(ii) 原子核很小且带正电。

针对练习

8. The scattering of alpha-particles from a thin gold foil produces the following observations.

- Most of the alpha-particles pass through the foil.
- Most of the alpha-particles are virtually undeflected.
- A small fraction of the alpha-particles are deflected through large angles.
- A very small fraction of the alpha-particles bounce back from the foil.

Which conclusion does **not** follow from these observations?

A Most of the mass of the gold atom is in its nucleus.

B Most of the atom is empty space.

C The nucleus consists of protons and neutrons.

D The nucleus must be charged.

（2023 夏季 0625/23 第33题）

9. α-particles are directed at a metal foil.

Most of the particles pass through the foil with little change in direction.

A small proportion of the particles are scattered back through large angles.

What does this evidence suggest about the structure of an atom?

A It consists of a charged centre much smaller than the size of the atom and with little of the mass of the atom.

B It consists of a negative charge the size of the atom containing small positive charges scattered through it.

C It consists of a charged centre much smaller than the size of the atom but with most of the mass of the atom.

D It consists of a positive charge the size of the atom containing small negative charges scattered through it.

（2024 冬季 0625/21 第34题）

5.1.2 原子核

题型 1：读写核素与粒子组成（考频★★★★☆）

知识点 原子核由质子和中子组成，电子分布在原子核外。

质子、中子、电子的相对电荷依次为 _____、_____、_____；相对电荷没有单位。

中性原子的总相对电荷为 0，因此质子数等于电子数。

答案：+1；0；−1

怎么认 题目出现原子结构图或粒子信息表时，先按位置辨粒子，再写相对电荷。

一. 按位置电荷辨三种粒子

例题 1

(a) Table 11.1 gives information about the particles in an atom.

Table 11.1

name of particle	relative charge	location in the atom
proton	+1	in the nucleus
neutron		
electron		orbiting the nucleus

Complete the table by writing the correct information in the three empty spaces.

（2025 春季 0625/32 第11题(a)）

解：由中子位于原子核内且不带电，得其相对电荷为 0，位置填原子核内。
由电子在原子核外运动且带负电，得其相对电荷为 −1。
答：中子一行填 0、原子核内；电子一行填 −1。

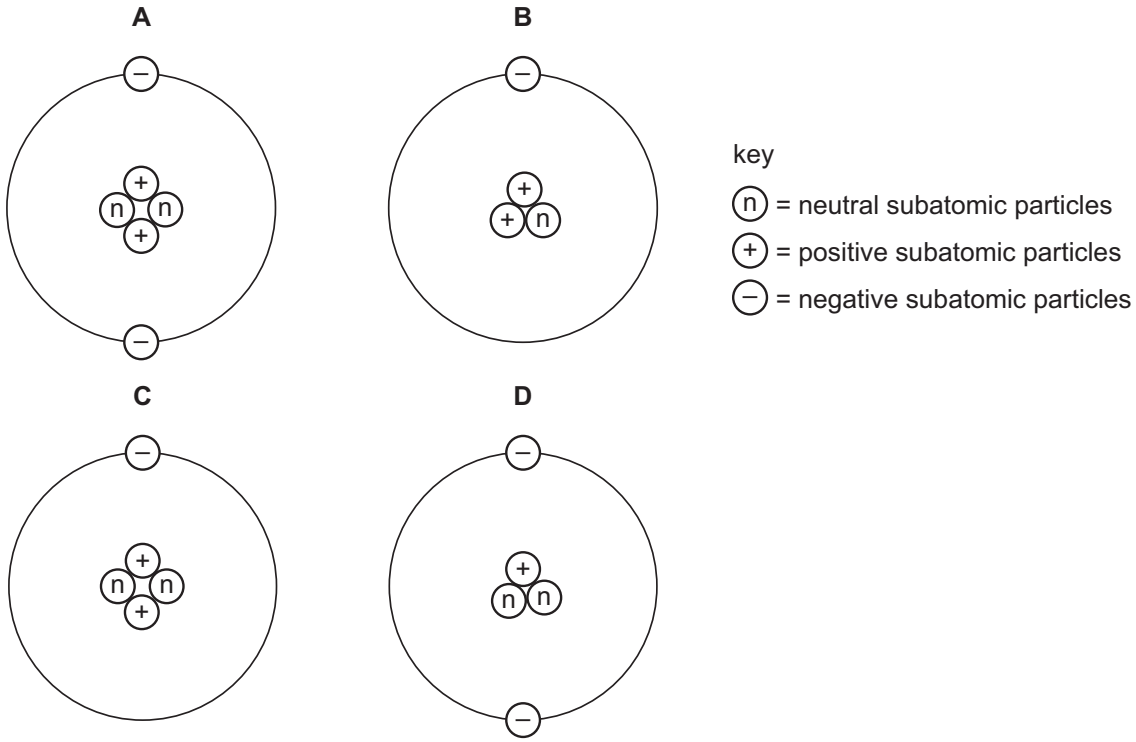
针对练习

1. What are the relative charges on a proton, a neutron and an electron?

	proton	neutron	electron
A	0	–1	+1
B	0	–1	–1
C	+1	0	–1
D	+1	0	+1

（2023 冬季 0625/13 第34题）

2. Which diagram shows the structure of a neutral atom?



（2024 夏季 0625/23 第33题）

3. Fig. 11.1 represents all the particles in an atom which is a radioactive isotope of carbon.

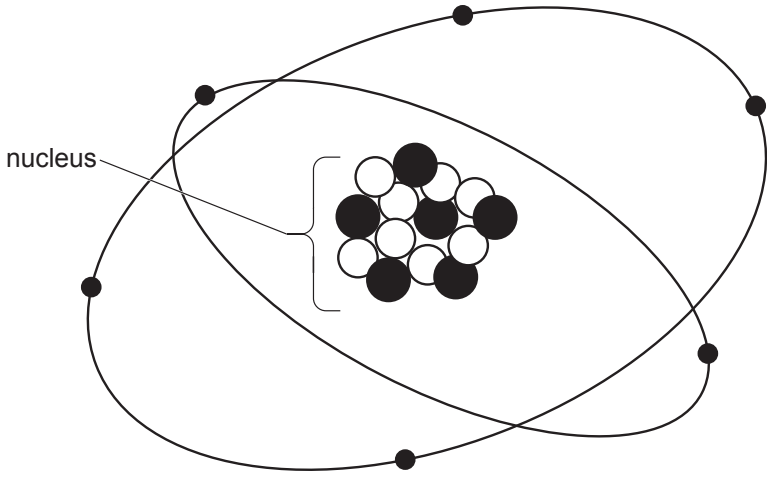


Fig. 11.1 (not to scale)

(a) Table 11.1 gives information about the particles shown in Fig. 11.1.

Using the information in Fig. 11.1, write in the empty boxes to complete Table 11.1.

Table 11.1

name of particle	number of particles	position of particle	relative charge of particle
electron			
neutron		in the nucleus	
	6		+1 (plus one)

（2023 夏季 0625/31 第11题(a)）

4. Fig. 9.1 represents an atom of beryllium. The labels A, B and C indicate three types of particle.

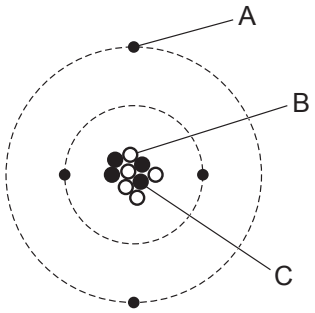


Fig. 9.1

(a) (i) Complete Table 9.1.

Name each type of particle and state the sign of its charge.

One row is done for you.

Table 9.1

type of particle	name	sign of charge
A		
B		
C	proton	positive (+)

(ii) There are several different isotopes of beryllium.

State what is meant by the term isotope.

（2023 夏季 0625/33 第9题(a)）

二. 读 A 和 Z 算核内粒子

知识点 核素符号的左上角表示核子数 A，左下角表示质子数 Z。

核子数 A 是核内质子数与中子数之和，质子数 Z 是核内质子数。

中子数等于_____；质子的相对电荷为 $+1$，中子的相对电荷为 0，核的相对电荷等于_____。

粒子数均为计数值；相对电荷以质子电荷大小为 1，均无单位。

答案：$A-Z$；$+Z$

怎么认 题目出现核素符号或同时给出核子数、质子数时，先读 A 和 Z，再算 $A-Z$。

例题 2 An iron nuclide is represented by the symbol shown.

$$^{56}_{26}\mathrm{Fe}$$

Which statements about a nucleus of this iron nuclide are correct?

1 The nucleus contains 56 neutrons.

2 The nucleon number is 30.

3 The proton number is 26.

A 1 and 2 **B** 1 and 3 **C** 2 and 3 **D** 3 only

（2023 春季 0625/12 第35题）

解： 由核素符号得

$A=56$

$Z=26$

中子数为

$N=A-Z=56-26=30$

故 1 错，2 错，3 对。故选 D。

针对练习

5. Radium is a radioactive element with the chemical symbol Ra. The proton number for radium is 88. Radium-223 is an isotope of radium that has a nucleon number of 223.

(b) Determine the number of neutrons in one nucleus of radium-223.

（2025 冬季 0625/31 第10题(b)）

6. An isotope of hydrogen has the nuclide notation $^{2}_{1}\mathrm{H}$.

How many neutrons are in the nucleus of this isotope and what is the relative charge on the nucleus?

	number of neutrons	relative charge
A	1	+1
B	1	+2
C	2	+1
D	2	+2

（2024 夏季 0625/21 第34题）

三. 由粒子数写符号或结构

知识点 原子核由质子和中子组成，电子分布在原子核外。

质子、中子和电子的相对电荷分别为_____，相对电荷没有单位。

质子数（原子序数）Z 等于原子核内的_____，由 Z 确定元素种类。

核子数（质量数）A 等于质子数与中子数之和，故中子数 $n=$ _____；A、Z 均没有单位。

核素符号写作 $^{A}_{Z}\mathrm{X}$；中性原子的电子数等于 Z，原子失去电子后形成正离子。

答案：$+1, 0, -1$；质子数；$A-Z$

怎么认 题目出现质子数、中子数并要求写核素符号或画原子结构时，先由质子数确定 Z 和元素。

例题 3

(b) An atom of lithium has the nuclide notation:

$$^{7}_{3}\mathrm{Li}$$

Draw a clearly labelled diagram to represent one atom of lithium.

（2024 春季 0625/32 第10题(b)）

解： 由核素符号 $^{7}_{3}\mathrm{Li}$ 得

$Z = 3$

$A = 7$

$n = A - Z = 7 - 3 = 4$

中性锂原子的电子数为 3。在原子核内画 3 个质子和 4 个中子，核外画两层电子轨道，内层画 2 个电子，外层画 1 个电子，并标明质子、中子、原子核和电子轨道。

答：原子核含 3 个质子和 4 个中子，核外含 3 个电子。

针对练习

7. Radium is a radioactive element with the chemical symbol Ra. The proton number for radium is 88. Radium-223 is an isotope of radium that has a nucleon number of 223.

(a) Write the nuclide notation for radium-223.

（2025 冬季 0625/31 第10题(a)）

8. A nucleus X has 17 protons and 18 neutrons.

Which notation is correct for this nucleus?

A $^{17}_{18}\mathrm{X}$ **B** $^{17}_{35}\mathrm{X}$ **C** $^{18}_{17}\mathrm{X}$ **D** $^{35}_{17}\mathrm{X}$

（2024 夏季 0625/22 第34题）

9. **(a)** Fig. 10.1 represents all the particles in a lithium atom.

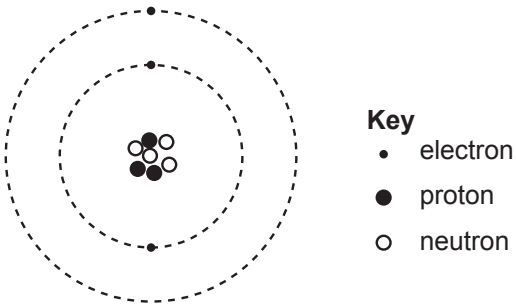


Fig. 10.1 (not to scale)

(i) State the proton number (atomic number) of the lithium atom in Fig. 10.1.

(ii) Determine the nucleon number (mass number) of the lithium atom in Fig. 10.1.

(iii) Describe how a lithium atom changes to form a positive ion.

（2023 冬季 0625/33 第10题(a)）

10. A nuclide of strontium is represented by $^{90}_{38}\mathrm{Sr}$.

Which row gives the number and location of the electrons in an atom of $^{90}_{38}\mathrm{Sr}$?

	number of electrons	location of electrons
A	38	in the nucleus
B	38	surrounding the nucleus
C	52	in the nucleus
D	52	surrounding the nucleus

（2024 夏季 0625/13 第33题）

题型 2：用质子数识别同位素（考频★★★☆☆）

知识点 同位素是同一种元素的不同原子，其原子核的质子数相同而中子数不同。

质子数 Z 决定元素种类，核子数 A 等于质子数与中子数 N 之和，$A = Z + N$。

判断两个原子核是否为同位素，质子数必须_____，中子数必须_____。

质子数、核子数和中子数均为粒子个数，不带单位。

答案：相同；不同

怎么认 题目出现多个原子核的质子数与核子数或中子数时，先找质子数相同的，再确认中子数不同。

一. 同质子异中子判同位素

例题 1 The table gives information about four nuclei.

nucleus	proton number	nucleon number
1	26	59
2	27	59
3	27	60
4	28	60

Which nuclei are isotopes of the same element?

A 1 and 2 **B** 1 and 4 **C** 2 and 3 **D** 3 and 4

（2024 春季 0625/12 第31题）

解： 由同位素的定义，先比较质子数。

原子核 2 与 3 的质子数均为 27。

由 $N = A - Z$ 得

$N_2 = 59 - 27 = 32$

$N_3 = 60 - 27 = 33$

质子数相同而中子数不同，原子核 2 与 3 是同一种元素的同位素。故选 C。

针对练习

1. A nucleus of element X is represented as $^{56}_{26}X$.

Which is an isotope of element X?

A $^{26}_{56}X$ **B** $^{54}_{26}X$ **C** $^{56}_{24}X$ **D** $^{54}_{28}X$

（2023 夏季 0625/11 第35题）

2. The table shows the composition of three different nuclei.

nucleus	number of protons	number of neutrons
X	3	3
Y	3	4
Z	4	3

Which nuclei are isotopes of the same element?

A X, Y and Z **B** X and Y only **C** X and Z only **D** Y and Z only

（2023 夏季 0625/22 第34题）

3. **(b)** Isotopes of copper (Cu) include: Cu - 63 and Cu - 65.
Explain what is meant by 'isotopes of copper'.

（2024 冬季 0625/33 第10题(b)）

二. 列粒子数比较同位素

知识点 同位素是质子数相同、中子数不同的同一元素的原子。

核子数 A 等于质子数 Z 与中子数之和，因此中子数为 _____；粒子数没有单位。

原子核的电荷由 _____ 决定，所以同位素的核电荷相同。

同位素的中子数不同，因此原子核的质量 _____。

答案：$A-Z$；质子数；不同

怎么认 题目出现同位素、核素记号或粒子图并要求比较时，先分别列出质子数 Z 和中子数 $A-Z$。

例题 2 An element has two isotopes.

Which row compares the nucleus of one atom of each isotope?

	the charge on each nucleus	the mass of each nucleus
A	different	different
B	different	the same
C	the same	different
D	the same	the same

（2025 春季 0625/12 第36题）

解： 同位素属于同一元素，两个原子核的质子数相同。
原子核的电荷取决于质子数，故核电荷相同。
同位素的中子数不同，故原子核的质量不同。
故选 C。

针对练习

4. Carbon-14 ($^{14}_{6}C$) is a radioactive isotope of carbon. Carbon-12 ($^{12}_{6}C$) is not radioactive.

(a) Explain how an atom of carbon-14 ($^{14}_{6}C$) differs from an atom of carbon-12 ($^{12}_{6}C$).

（2024 冬季 0625/42 第10题(a)）

5. Many household smoke alarms contain a sample of the radioactive isotope americium-241 (Am).

(a) Americium-241 is the isotope of the element americium that has the nucleon number (mass number) 241.

(i) State how the composition of a nucleus of americium-241 differs from that of a nucleus of americium-242.

(ii) An atom of a different element has a nucleon number of 241.

State **two** differences between the composition of a nucleus of this atom and a nucleus of americium-241.

（2023 冬季 0625/41 第9题(a)）

6. **(a)** U-235 and U-238 are isotopes of uranium.

Fig. 10.1 shows the nuclide notation for U-235 and for U-238.

$^{235}_{92}U$ $^{238}_{92}U$

Fig. 10.1

(i) Compare the number of **protons** in one nucleus of U-235 with the number of protons in one nucleus of U-238.

(ii) Compare the number of **neutrons** in one nucleus of U-235 with the number of neutrons in one nucleus of U-238.

（2024 夏季 0625/32 第10题(a)）

7. Fig. 11.1 represents all the particles in a beryllium atom.

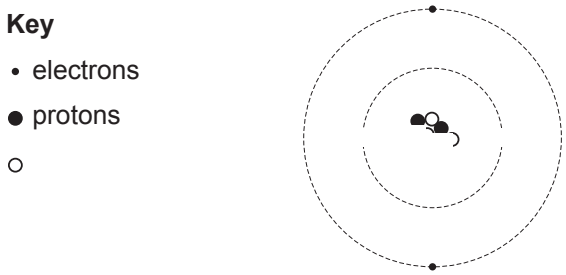


Fig. 11.1 (not to scale)

(ii) The key for Fig. 11.1 gives the names of two types of particle. One label is missing.

Complete the key by adding the name of the third type of particle shown in Fig. 11.1. [1]

(b) Fig. 11.2 shows four different particle diagrams, A, B, C and D.

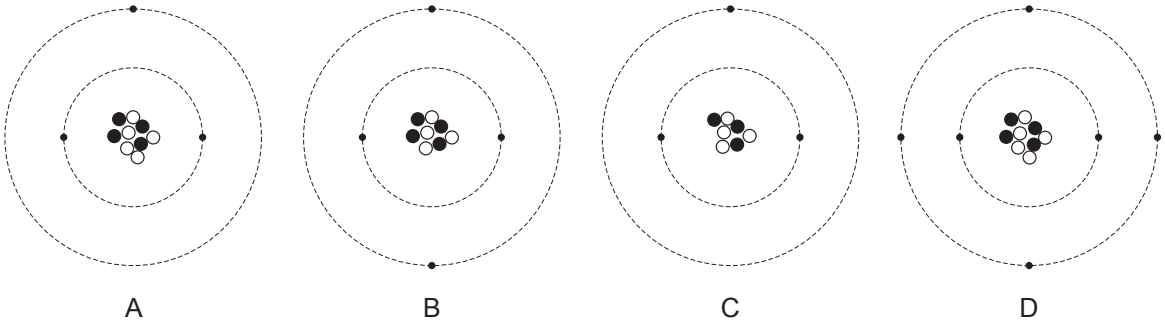


Fig. 11.2

(i) State which diagrams show an isotope of beryllium.

(ii) State which diagram shows a positive ion.

（2023 冬季 0625/32 第11题(b)）

题型 3：守恒处理裂变与聚变（考频★★★★☆）

知识点 一个重原子核分裂成两个较轻原子核的过程称为_____，过程释放能量；这种裂变可由原子核吸收_____引发。

两个轻原子核结合成一个较重原子核的过程称为_____，过程释放能量。

判断反应类型时，反应前一个重核分开的是裂变，两个轻核结合的是聚变。

答案：裂变；中子；聚变

怎么认 题目出现原子核分裂或结合的描述时，先看反应前后核的个数和大小。

一. 看核的分合判反应

例题 1 What occurs during nuclear fusion?

A Two light atomic nuclei join together and emit energy.

B Two light atomic nuclei join together and absorb energy.

C A heavy atomic nucleus splits and emits energy.

D A heavy atomic nucleus splits and absorbs energy.

（2024 春季 0625/22 第32题）

解：核聚变是两个轻原子核结合成较重原子核并释放能量的过程。
故选 A。

针对练习

1. Which particle is absorbed by a nucleus to cause nuclear fission?

A a neutron

B a proton

C an α-particle

D a β-particle

（2023 冬季 0625/21 第37题）

2. What happens in the process of nuclear fission?

A Electrons are added to a nucleus.

B Electrons are removed from a nucleus.

C The nucleus of an atom splits.

D Two atomic nuclei join together.

（2023 冬季 0625/22 第37题）

3. Which statement describes how nuclear energy is released by fission in a nuclear power station?

A Atoms join together to make molecules.

B Heavy nuclei split into lighter nuclei.

C Light nuclei join together to form heavier nuclei.

D Molecules break down into atoms.

（2023 冬季 0625/23 第37题）

4. What is nuclear fission?

A the merging of two nuclei to create a heavier nucleus

B the process by which electrons are removed from an atom

C the process by which stars generate energy

D the splitting of a nucleus to create two smaller nuclei

（2024 夏季 0625/23 第34题）

二. 由能量释放判断质量亏损

知识点 核裂变是一个较大的不稳定原子核分裂成两个较小原子核的过程，通常伴随中子放出和_____。

核聚变是两个较轻原子核结合成较重原子核的过程，也可释放能量。

裂变或聚变释放能量时，产物总质量_____反应物总质量；减少的质量转化为能量，质量单位为 kg，能量单位为 J。

答案：能量释放；小于

怎么认 题目出现裂变、聚变并比较反应前后总质量时，先判断反应是否释放能量。

例题 2

(a) A nuclear power station has a reactor where controlled nuclear fission of uranium-235 takes place.

(i) Explain what is meant by nuclear fission.

(ii) State **one** advantage and **one** disadvantage of generating electrical power in nuclear power stations compared with electrical power generated using wind turbines.

（2023 春季 0625/42 第9题(a)）

解：由核裂变的定义，较大的不稳定铀-235 原子核分裂成两个较小原子核，并放出中子和大量能量。

核电站的供能不依赖风力，因而能连续供能；核反应会产生危险的放射性废料，需要长期储存。

答：(i) 较大的不稳定原子核分裂成两个较小原子核，并放出中子和大量能量；(ii) 优点是能连续供能，缺点是会产生需要长期储存的危险放射性废料。

针对练习

5. Fission and fusion are two types of nuclear process.

How does the total mass of the nuclides produced compare with the total mass of the original nuclide or nuclides in these nuclear processes?

	total mass of fission products compared to original nuclide	total mass of fusion products compared to original nuclides
A	same	same
B	more	less
C	less	more
D	less	less

（2023 夏季 0625/22 第33题）

6. The isotope uranium-235 is represented by

$$^{235}_{92}\mathrm{U}.$$

(b) Uranium-235 is a fuel used in nuclear reactors.

(i) State the process by which energy is released from uranium-235 in a nuclear reactor.

(ii) A nuclide equation for this process is

$$^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \longrightarrow {}^{140}_{54}\mathrm{Xe} + {}^{94}_{38}\mathrm{Sr} + 2\ {}^{1}_{0}\mathrm{n}.$$

Describe the mass and energy changes that take place during this process in a nuclear reactor.

（2023 冬季 0625/42 第8题(b)）

三. 守恒 A 与 Z 配核方程

知识点 核素记号 ${}^{A}_{Z}\mathrm{X}$ 中，A 是核子数，Z 是质子数，中子数为_____；A、Z 均无单位。

质子、中子和 α 粒子可分别写作 ${}^{1}_{1}\mathrm{p}$、${}^{1}_{0}\mathrm{n}$ 和 ${}^{4}_{2}\alpha$。

核反应方程成立时，方程两边的_____总和与_____总和分别相等。

核裂变是一个原子核分裂成两个或多个较小原子核的过程；核聚变是两个较小原子核结合成较大原子核的过程。

答案：$A-Z$；核子数 A；质子数 Z

怎么认 题目出现核反应方程缺项或未知核素时，先令两边的 A 总和、Z 总和分别相等。

例题 3

(b) Deuterium is an isotope of hydrogen (H) with 1 proton and 1 neutron. Nuclear fusion occurs when two nuclei of deuterium combine. An isotope of helium (He) and a neutron are formed.

Use nuclide notation to write down the nuclide equation for this reaction.

（2023 春季 0625/42 第9题(b)）

解：氘核有 1 个质子和 1 个中子，故其核子数为 2，质子数为 1。

由核子数守恒，氦核的核子数为

$2+2-1=3$

由质子数守恒，氦核的质子数为

$1+1-0=2$

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

答：${}^{2}_{1}\mathrm{H}+{}^{2}_{1}\mathrm{H}\rightarrow{}^{3}_{2}\mathrm{He}+{}^{1}_{0}\mathrm{n}$。

针对练习

7. A teacher writes the nuclide equation for a fusion reaction.

$$^{2}_{1}H + {}^{X}_{1}H \rightarrow {}^{4}_{2}Q + {}^{1}_{0}n$$

What is the missing number X and the missing element Q?

	X	Q
A	2	H
B	2	He
C	3	H
D	3	He

（2025 冬季 0625/22 第34题）

8. The nucleus of an isotope of nitrogen, N, absorbs a neutron. It then decays into an isotope of carbon, C, and emits x.

$$^{1}_{0}n + {}^{14}_{7}N \rightarrow {}^{14}_{6}C + x$$

What is x?

A α-particle

B β-particle

C γ-radiation

D proton

（2025 春季 0625/22 第38题）

9. $^{239}_{94}Pu$ is an isotope of plutonium.

The nucleus can absorb a neutron and then split to form two other nuclei.

Two nuclei that form are gold, $^{207}_{79}Au$, and phosphorus, $^{31}_{15}P$.

In this reaction, neutrons are also produced.

What is the number of neutrons produced when the nucleus splits?

A 1 **B** 2 **C** 4 **D** 5

（2025 冬季 0625/21 第33题）

10. An isotope of boron is used in the treatment of cancer in the brain.

Boron sticks to cancer cells in the brain.

(a) The isotope of boron is bombarded with neutrons then undergoes fission to form lithium and alpha-particles.

(i) Describe **one** difference between fission and fusion.

(ii) A nucleus of boron (B) contains 5 protons and 5 neutrons. Complete the nuclide equation for this fission reaction.

..... $B + {}^{1}_{0}n$

（2024 冬季 0625/43 第8题(a)）

5.2.1 放射性的探测

题型 1：认出本底与探测读数（考频★★★☆☆）

知识点 本底辐射是环境中一直存在的_____，待测放射源移走后仍能被测得。

电离核辐射用探测器测量，探测器与_____相连；计数率用 counts/s 或 counts/min 表示。

测量待测放射源时，修正计数率 = 总计数率 − 本底计数率。

氡气、岩石和建筑物、食物和饮料以及_____都是本底辐射的重要来源。

答案：电离核辐射；计数器；宇宙射线

怎么认 题目出现待测放射源移走后仍有计数，或要求扣除本底时，先用探测器连接计数器测本底计数率。

一. 无待测源仍计数判本底

例题 1 Which apparatus is used to measure background radiation?

A a counter, a detector and a source

B a counter and a detector only

C a counter and a source only

D a detector and a source only

（2024 春季 0625/12 第32题）

解：本底辐射是无待测放射源时环境中仍存在的电离核辐射。

测量电离核辐射需用探测器连接计数器，不需放射源。

故选 B。

针对练习

1. Which type of radiation is measured using a detector connected to a counter?

A visible light

B ionising nuclear

C microwave

D thermal

（2025 冬季 0625/11 第35题）

2. **(a)** **(i)** State what is meant by background radiation.

(ii) State **one** source that makes a significant contribution to background radiation.

（2025 夏季 0625/42 第9题(a)）

3. When measuring the emissions from a radioactive rock brought into the laboratory, a teacher mentions that background radiation must be taken into account.

What is this background radiation?

A ionising radiation in the laboratory when the radioactive rock is not present

B ionising radiation from the radioactive rock brought into the laboratory

C infrared radiation from the Sun

D infrared radiation from warm objects in the laboratory

（2024 冬季 0625/13 第34题）

4. Leaks in underground water pipes are detected using radioactive tracers. Fig. 10.1 shows a radiation detector above a water pipe.

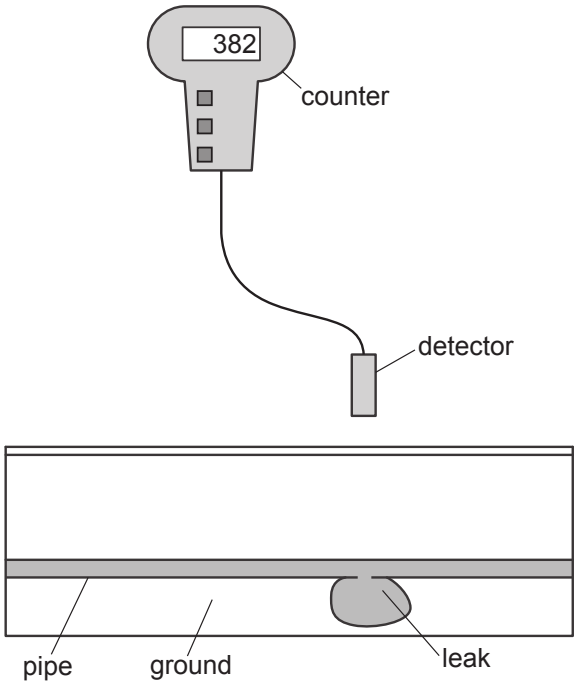


Fig. 10.1

(a) Before the radioactive tracer is added to the water, the detector measures the background radiation above the pipe. The average background radiation is 26 counts / minute.

(i) Define background radiation.

(ii) Suggest **one** source of radiation that may make a significant contribution to the background count rate.

(iii) A radioactive tracer is added to the water. The counter in Fig. 10.1 shows the count rate in counts / minute above the leak in the water pipe.

Determine the count rate due to the tracer.

（2024 夏季 0625/43 第10题(a)）

二. 对照清单识别本底来源

知识点 本底辐射是周围环境中始终存在的电离核辐射；附近没有待测放射源时，探测器仍可能记录计数。

主要自然来源包括_____、_____、食物和饮料、宇宙射线；医用 X 射线属于人造来源。

电离核辐射可用连接计数器的探测器测量，计数率单位为 counts/s 或 counts/minute。

答案：空气中的氡气；岩石和建筑物

怎么认 题目出现本底辐射来源或比例时，先对照四类主要来源，再判断是否为人造源。

例题 2 What is an artificial source of background radiation?

A X-ray machines in hospitals

B radon gas from rocks

C cosmic rays from the Sun

D plants and other living things

（2023 春季 0625/12 第36题）

解：医院中的 X 射线机由人工制造和使用，属于人造辐射源；岩石中的氡气、来自太阳的宇宙射线及生物体内的天然放射性物质均来自自然环境。
故选 A。

针对练习

5. **(c)** Radon gas is one source of background radiation.

Name **two** other sources that make a significant contribution to background radiation.

（2025 夏季 0625/32 第10题(c)）

6. **(c)** State **two** different sources of background radiation.

（2023 冬季 0625/43 第9题(c)）

7. A student suggests three sources of naturally occurring background radiation.

1 cosmic rays

2 medical X-rays

3 radioactive emissions from radon gas from the ground

Which suggestions are correct?

A 1 and 3 **B** 1 only **C** 2 and 3 **D** 2 only

（2024 冬季 0625/12 第34题）

8. The table shows the contribution to background radiation from the four most common sources.

source	percentage of total background radiation / %
radon gas (in the air)	48
rocks and buildings	13
food and drink	10
cosmic rays	11

Which percentage of background radiation comes from all other sources?

A 14% **B** 18% **C** 21% **D** 82%

（2025 夏季 0625/11 第34题）

题型 2：从总计数扣除本底（考频★★★☆☆）

知识点 本底辐射是没有待测放射源时，探测器仍能测得的核辐射。 计数率等于测得的计数除以_____，单位为 counts/s 或 counts/minute。待测放射源的修正计数率满足：修正计数率 = 总计数率 − _____。 相减时各计数率的_____必须相同；若测量时间相同，也可将总计数减去本底计数。

答案：测量时间；本底计数率；单位

怎么认 题目出现总计数或总计数率及本底计数率时，先统一单位并求各计数率，再相减。

一. 统一单位后直接相减

例题 1 A student is investigating the count rate of a radioactive substance.

How must he adjust his reading for the background count?

A Add the background count to his reading.

B Ignore the background count as it will not affect his reading.

C Subtract the background count from his reading.

D Take repeat readings to eliminate the background count.

（2024 春季 0625/22 第31题）

解：探测器读数包含待测放射源产生的计数和本底计数，
修正读数 = 探测器读数 − 本底计数
故应从读数中减去本底计数。故选 C。

针对练习

1. A detector near a radioactive source shows a reading of 2000 counts / minute.

How is the corrected count rate determined?

A by moving the detector closer to the source

B by placing an absorber between the detector and the source

C by repeating and averaging the measurements

D by taking away the background radiation count rate

（2025 夏季 0625/22 第35题）

2. A radioactive source is placed near a detector connected to a counter.

210 counts are recorded by the counter in 3 minutes.

The background count rate is 20 counts per minute (cpm).

What is the corrected count rate for the radioactive source?

A 50 cpm **B** 70 cpm **C** 190 cpm **D** 270 cpm

（2023 夏季 0625/21 第35题）

二. 先平均或读平台再相减

知识点 本底辐射是周围环境中始终存在的电离辐射，探测器记录的总计数率包含放射源计数率和本底计数率。

修正计数率等于_____。

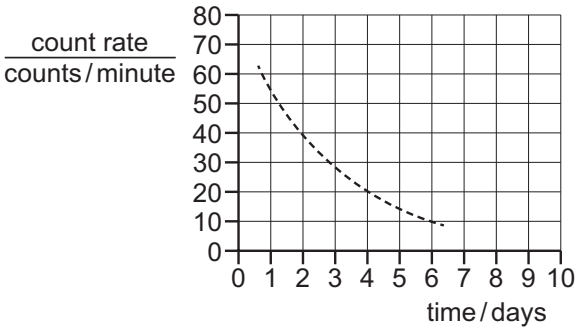
多次测量时间相同时，先求本底计数的平均值，再除以每次测量时间；衰变曲线的长期平台值可读作本底计数率。

计数率的单位为_____或_____。

答案：总计数率减本底计数率；counts/s；counts/minute

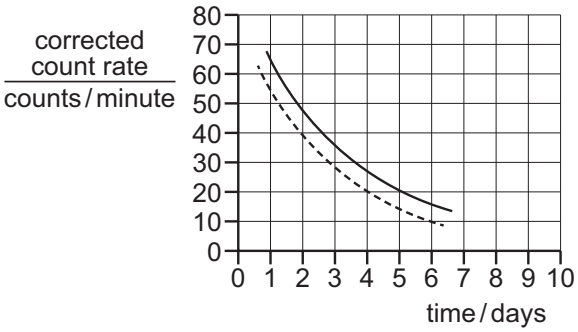
怎么认 题目出现含本底的总计数率、重复本底测量或衰变曲线平台时，先求本底计数率并相减。

例题 2 The dashed line on the graph shows the decay curve recorded from a sample of a particular radioactive isotope. The count rate includes background radiation.

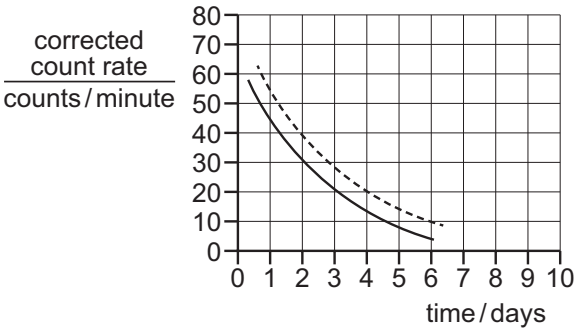


Which curve shows the corrected count rate for the decay?

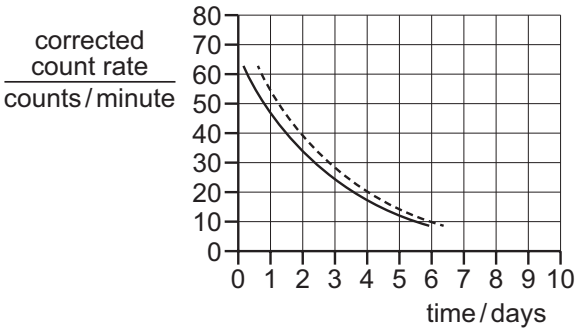
A



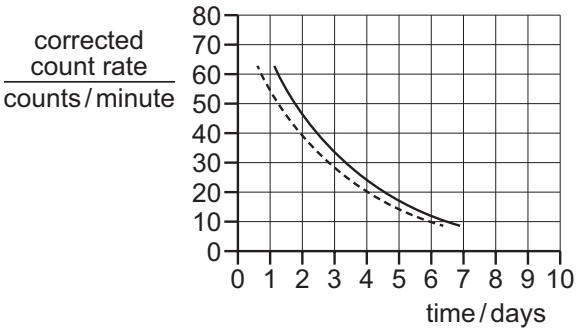
B



C



D



（2024 夏季 0625/22 第35题）

解：本底计数率的平均值在测量期间视为不变，修正后各时刻均有

$$R_{\text{修正}} = R_{\text{总}} - R_{\text{本底}}$$

故修正曲线应始终位于虚线下方，且与虚线的竖直差保持不变；样品衰变后，修正计数率趋近于 0。图 B

符合。
故选 B。

针对练习

3. Some students set up an experiment to measure the count rate for a radioactive source.

First, they measure the radioactive background count rate in the laboratory by taking three measurements. Each measurement is taken over a 10-minute period.

The table shows their results.

number of counts in 10 minutes		
first measurement	second measurement	third measurement
170	164	185

Next, the students measure the counts near the radioactive source. This count rate is measured as 949 counts per minute.

What is the corrected count rate for the source?

A 932 counts per minute

B 776 counts per minute

C 430 counts per minute

D 78 counts per minute

（2025 冬季 0625/23 第33题）

4. A student is carrying out an experiment to measure the radiation from a radioactive source.

He uses a radiation detector and records the total counts in 5-minute intervals. He does this three times with the source present and three times with the source absent. Here are his results.

total counts in 5 minutes with source present	total counts in 5 minutes with source absent
68	25
73	28
69	22

What is the average corrected count rate for the source?

A 5 counts / minute

B 9 counts / minute

C 25 counts / minute

D 45 counts / minute

（2024 冬季 0625/22 第36题）

5.2.2 三种核辐射

题型 1：按本质与屏蔽辨三种辐射（考频★★★★☆）

知识点 不稳定原子核衰变时会自发发出核辐射，发射方向随机；电荷量的单位是 C。

基本电荷量 $e = 1.6 \times 10^{-19}$ C。

α 粒子是_____，带 $+2e$ 电荷，薄纸便能将其阻挡。

β^- 粒子是_____，带 $-e$ 电荷，可用薄铝片阻挡。

γ 辐射是_____，不带电，需用厚混凝土或厚铅阻挡。

答案：氦核；高速电子；电磁波

怎么认 题目出现 α、β、γ 与粒子种类、电荷或屏蔽物的对应关系时，先写三者的组成和电荷。

一. 先写本质与电荷

例题 1 Which row correctly identifies the nature of each radioactive emission?

	alpha (α)	beta (β)	gamma (γ)
A	helium nucleus	electromagnetic wave	electron
B	electron	helium nucleus	electromagnetic wave
C	helium nucleus	electron	electromagnetic wave
D	electromagnetic wave	electron	helium nucleus

（2024 春季 0625/12 第33题）

解：α 粒子是带 $+2e$ 电荷的氦核，β^- 粒子是带 $-e$ 电荷的高速电子，γ 辐射是不带电的电磁波。

三项对应相符的是 C 行。

故选 C。

针对练习

1. A nucleus of strontium-90 is represented using nuclide notation as shown.

$$^{90}_{38}\mathrm{Sr}$$

(b) Strontium-90 decays by emitting β-particles (beta-particles).

Describe the nature of β-particles.

（2024 夏季 0625/31 第10题(b)）

2. Unstable nuclei emit ionising radiation when they decay.

(a) Draw **one** line from each type of ionising radiation to its nature.

type of ionising radiation	nature
alpha (α)	electromagnetic wave
beta (β)	helium nucleus
gamma (γ)	electron

（2025 冬季 0625/32 第9题(a)）

3. **(a)** Table 9.1 shows some properties and values for α-particles, β-particles and γ-radiation.

Complete Table 9.1.

Table 9.1

type of radiation	number of protons	number of neutrons	charge / C	stopped by
α	2		$+ 3.2 \times 10^{-19}$	thin sheet of paper
β		0		thin sheet of aluminium
γ	0			

（2023 夏季 0625/42 第9题(a)）

4. Strontium-89 is a radioactive beta-emitter used to treat bone cancers.

A solution of strontium chloride is injected into patients and accumulates in their bones.

Which statement about this treatment is **not** correct?

A Beta radiation is a form of electromagnetic radiation.

B Beta-particles are a form of ionising radiation.

C The strontium-89 atoms change to atoms of another element when they decay.

D Beta-particles are negatively charged.

（2025 冬季 0625/12 第36题）

二. 排电离与穿透强弱

知识点 不稳定原子核会自发发出方向随机的核辐射；α 粒子是氦原子核，β^- 粒子是高速电子，γ 射线是电磁波。

三种核辐射的电离能力由强到弱为 _____、β、γ，穿透能力由强到弱为 _____、β、α；相对强弱没有单位。

纸或几厘米空气能阻挡 α 粒子，铝片能阻挡 β 粒子，厚铅或混凝土能减弱 γ 射线。

α、β 粒子带电，在电场和磁场中会偏转；β 粒子质量较小，偏转较大，γ 射线不带电，不发生偏转。

答案：α；γ

怎么认 题目出现三种辐射、射程、吸收材料或穿透比较时，先写电离 $\alpha > \beta > \gamma$，穿透 $\gamma > \beta > \alpha$。

例题 2 Which statement about alpha, beta and gamma emissions is correct?

A Alpha-particles are lighter than beta-particles.

B Beta-particles are **not** deflected by magnetic fields.

C Gamma rays are more penetrating than alpha-particles and beta-particles.

D Gamma rays are more ionising than alpha-particles and beta-particles.

（2025 春季 0625/12 第38题）

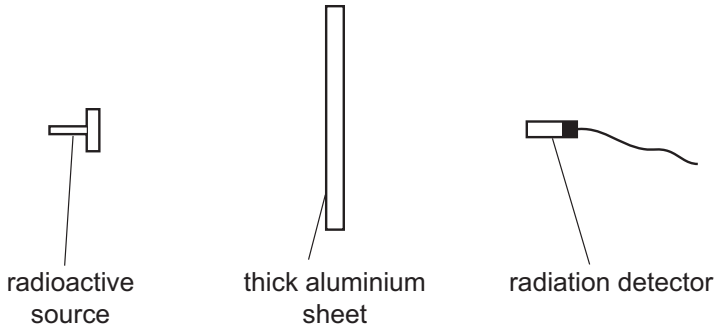
解：α 粒子是氦原子核，质量大于作为电子的 β 粒子，A 错。
β 粒子带电，会被磁场偏转，B 错。
穿透能力为 $\gamma > \beta > \alpha$，C 对。
电离能力为 $\alpha > \beta > \gamma$，D 错。
故选 C。

针对练习

5. **(c)** Compare the penetrating abilities of alpha particles, beta particles and gamma rays.

（2025 春季 0625/32 第11题(c)）

6. The diagram shows a radioactive source, a thick aluminium sheet and a radiation detector.



The radiation detector shows a reading greater than the background reading.

Which type of radiation is being emitted by the source and detected by the detector?

A α-radiation

B β-radiation

C γ-radiation

D infrared radiation

（2024 冬季 0625/11 第36题）

7. An isotope of boron is used in the treatment of cancer in the brain.

Boron sticks to cancer cells in the brain.

(b) The alpha-particles destroy the cancer cells. Suggest and explain **one** reason why alpha particles are more suitable than gamma radiation for use in this treatment of brain cancer.

（2024 冬季 0625/43 第8题(b)）

8. Which statement about alpha, beta and gamma radiation is **not** correct?

A Alpha particles are deflected most in an electric field.

B Beta particles are deflected most in a magnetic field.

C Gamma radiation is **not** deflected by a magnetic field.

D Gamma radiation is least ionising.

（2025 夏季 0625/22 第36题）

三. 逐层加屏蔽判成分

知识点 放射性原子核可自发地、随机地向各方向发出 α 粒子、β 粒子和 γ 射线。

α 粒子被_____挡住；β 粒子可穿过纸，但被几毫米厚的铝显著吸收；γ 射线需用_____显著削弱。

探测器读数可用计数表示，计数率的常用单位为 counts/min；比较屏蔽效果时，测量时间及源与探测器的距离应相同。

加入某种材料后计数明显减小，表明被该材料吸收的辐射原来存在；计数近似不变，表明没有相应成分。

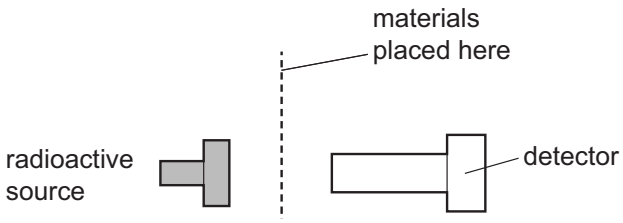
带电的 α 粒子和 β 粒子在电场中发生偏转，不带电的 γ 射线_____。

答案：一张纸；厚铅；不发生偏转

怎么认 题目出现纸、铝、铅逐层屏蔽及计数变化时，先比较每加一层材料后的计数变化。

例题 3 A radioactive source is placed near a detector.

The radiation arriving at the detector from the source is measured for 10 minutes with different materials placed between the source and the detector.



material between source and detector	radiation detected / counts
none	5626
sheet of paper	5629
thick sheet of aluminium	2226
thick sheet of lead	255

Which types of radiation are emitted by the source?

A α-particles and γ-rays

B α-particles only

C β-particles and γ-rays

D β-particles only

（2024 夏季 0625/21 第35题）

解：纸前后的计数 $5626 \approx 5629$，差异来自放射性衰变的随机起伏，说明源中无 α 成分。

厚铝使计数由 5629 降至 2226，说明源中有被铝吸收的 β 成分。

厚铅使计数由 2226 降至 255，说明源中有被铅显著削弱的 γ 成分。

故选 C。

9. The emissions from a radioactive source pass through a sheet of lead that is 10 mm thick.

Which type of radiation is emitted from the source and how is the radiation affected by an electric field?

	type of radiation	effect of electric field on radiation
A	α	radiation deflected
B	α	radiation **not** deflected
C	γ	radiation deflected
D	γ	radiation **not** deflected

（2024 夏季 0625/12 第35题）

10. A radioactive source is placed 20 mm in front of a detector.

The count rate from the source is 2000 counts / minute.

With a thin sheet of paper between the source and the detector, the count rate is 2000 counts / minute.

With a sheet of aluminium 5 mm thick between the source and the detector, the count rate is 1200 counts / minute.

Which radioactive emissions are coming from the source?

A alpha, beta and gamma

B alpha only

C beta and gamma only

D beta only

（2025 冬季 0625/11 第34题）

11. **(b)** Fig. 9.1 represents three types of emission P, Q and R from a radioactive nucleus. The diagram shows whether each emission can penetrate paper and aluminium.

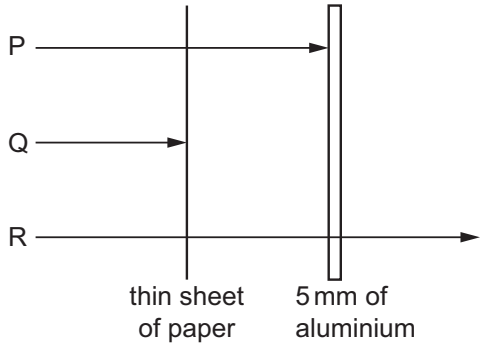


Fig. 9.1

Identify the types of emission labelled P, Q and R.

（2025 冬季 0625/33 第9题(b)）

题型 2：按带电与荷质比判偏转（考频★★★★☆）

知识点 电场中带电粒子受到电场力，正电荷的受力方向与电场方向_____，负电荷的受力方向与电场方向_____。

α 粒子带正电，β^- 粒子带负电，γ 射线不带电，因此前两者在电场中偏转，γ 射线不偏转。

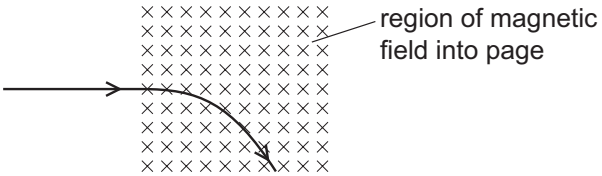
在同一电场中，粒子的质量越小，运动方向改变越明显；β^- 粒子的质量远小于 α 粒子，偏转通常更_____。

答案：相同；相反；明显

怎么认 题目出现带电粒子的电场偏转图时，先定电荷，再由受力方向反推电场方向。

一. 按电荷判电场偏向

例题 1 A beta-particle enters a uniform magnetic field directed into the page and deflects downwards, as shown.



Which direction of electric field would also deflect an electron downwards?

A into the page

B out of the page

C down the page

D up the page

（2024 春季 0625/22 第33题）

解：由 $\boldsymbol{F}=q\boldsymbol{E}$，∵电子带负电，∴电场力方向与电场方向相反。

电子向下偏转，故电场力向下，电场方向向上。

故选 D。

针对练习

1. α-particles, β-particles and γ-rays are emitted by radioactive nuclei when they decay.

Which emissions can be deflected by an electric field?

A α-particles, β-particles and γ-rays

B α-particles and β-particles only

C β-particles and γ-rays only

D γ-rays and α-particles only

（2023 冬季 0625/11 第35题）

2. Why are beta-particles deflected more strongly than alpha-particles when they enter an electric field?

A Beta-particles have less mass than alpha-particles.

B Beta-particles are negatively charged.

C Beta-particles have lower velocities than alpha-particles.

D Beta-particles have more ionising power than alpha-particles.

（2023 冬季 0625/23 第36题）

3. **(b)** Fig. 8.1 shows three beams of ionising radiation, alpha, beta and gamma, passing between two parallel plates. The plates are charged and there is a uniform electric field between them.

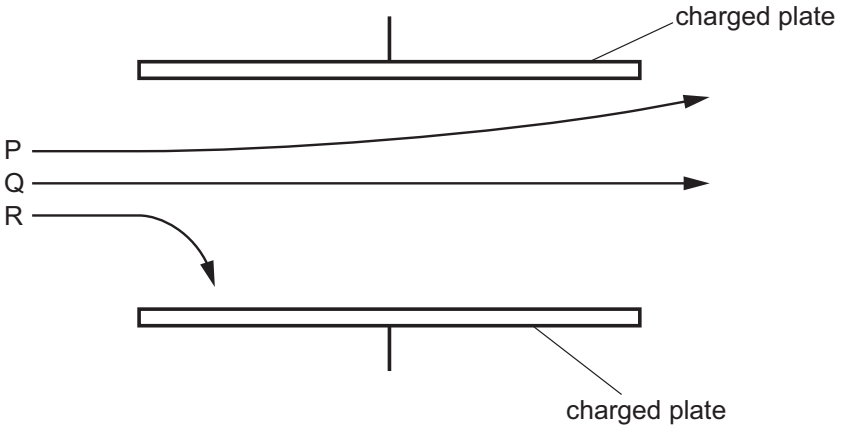


Fig. 8.1

(i) State and explain which path P, Q or R shows a beam of alpha particles.

(ii) State and explain the direction of the electric field between the plates.

（2025 冬季 0625/43 第8题(b)）

二. 用方向曲率判磁场路径

知识点 γ辐射不带电，在磁场中_____；α粒子带正电，β粒子带负电，二者的偏转方向相反。

在粒子速率相当、运动方向与磁场方向垂直且处于同一磁场时，荷质比越大，轨迹半径越_____；荷质比的单位为$\mathrm{C\ kg^{-1}}$。

β粒子的荷质比远大于α粒子，故偏转更明显；三者的电离作用由强到弱为α、β、γ。

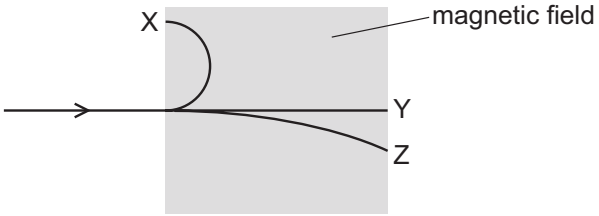
判定弯向时，正电荷的运动方向作为电流方向按左手定则判断；β粒子的受力方向与同向运动的正电荷相反。

答案：不偏转；小

怎么认 题目出现三种核辐射的磁场路径图时，先判直线为γ，再以弯向和轨迹半径区分α、β。

例题 2 The diagram represents the paths of three types of ionising radiation, X, Y and Z, through a magnetic field.

The three types of radiation are alpha, beta and gamma.



Which statement about the ionising radiation is correct?

A X is positively charged.

B Y is negatively charged.

C Z is the most strongly ionising.

D X has a smaller mass than Y.

（2024 夏季 0625/23 第35题）

解：Y沿直线前进，故Y为γ辐射。
X与Z弯向相反，且X的轨迹半径较小，故X为β粒子，Z为α粒子。
α粒子的电离作用最强，故选 C。

针对练习

4. The isotope thallium-208 ($^{208}_{81}Tl$) is radioactive. It decays by β-decay.

(b) A sample of thallium-208 is placed in a thick lead container. Fig. 8.1 shows a narrow beam of β-particles and γ-radiation emerging from a small hole in one side of the container.

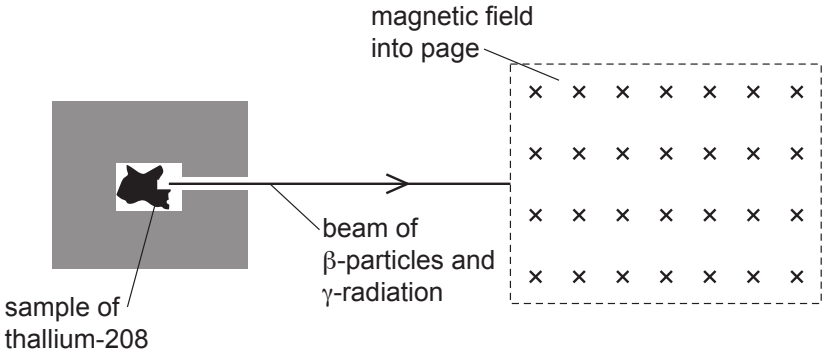


Fig. 8.1

The narrow beam enters a region where there is a magnetic field that is directed into the page.

On Fig. 8.1:

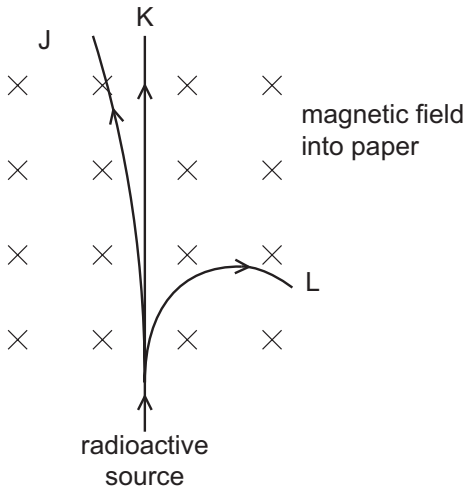
- draw a line **labelled β** to indicate the path of the β-particles in the magnetic field
- draw a line **labelled γ** to indicate the path of the γ-radiation in the magnetic field.

（2024 夏季 0625/41 第8题(b)）

5. A radioactive source emits α-particles, β-particles and γ-rays into a vacuum where there is a magnetic field.

The magnetic field acts perpendicularly into the plane of the paper.

The paths J, K and L of the three types of radiation through the magnetic field are shown.



Which radiation follows path J, path K and path L?

	J	K	L
A	α-particles	β-particles	γ-rays
B	α-particles	γ-rays	β-particles
C	β-particles	α-particles	γ-rays
D	β-particles	γ-rays	α-particles

（2025 冬季 0625/23 第34题）

6. **(a)** Fig. 9.1 shows a beam of radiation in a vacuum. The beam contains α-particles, β-particles and γ-radiation.

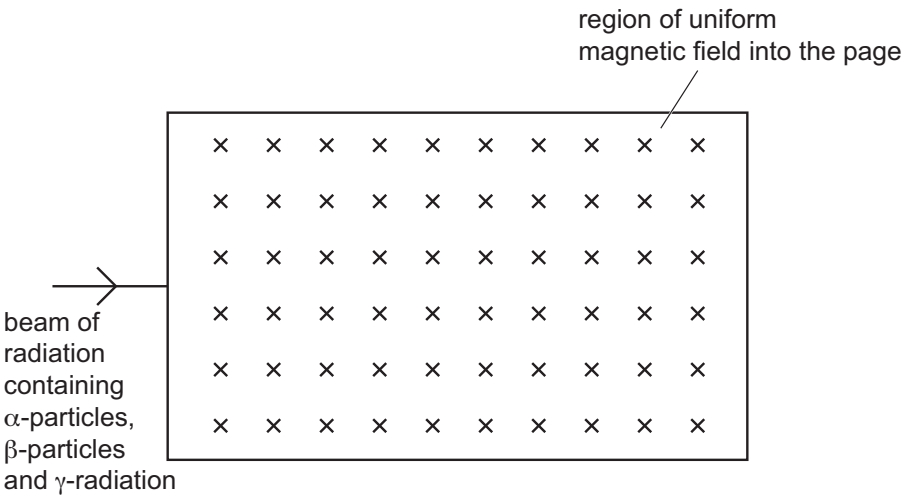


Fig. 9.1

The beam enters a region where there is a strong, uniform magnetic field. The direction of the magnetic field is into the page.

On Fig. 9.1 draw and label the paths within the magnetic field of:

(i) α-particles (label this path α)

(ii) β-particles (label this path β)

(iii) γ-radiation (label this path γ)

（2025 冬季 0625/42 第9题(a)）

三. 用电荷动能解释电离

知识点 α 粒子是带 $+2e$ 电荷的氦核，β 粒子是带 $-e$ 电荷的高速电子；α 粒子的质量远大于 β 粒子。粒子的动能为 $E_k = \frac{1}{2}mv^2$，单位为焦耳（J）；比较动能时，质量与速率必须同时考虑。
在同一介质中，带电荷量越_____、可传递的动能越_____，电离作用通常越强；强电离使能量沿较短路程损失，因而穿透能力较_____。

答案：大；大；弱

怎么认 题目出现 α、β 粒子的质量、速率、电荷或动能比较时，先由 $E_k = \frac{1}{2}mv^2$ 比较动能，再判断电离作用。

例题 3 A beta particle has less mass than an alpha particle, but the speed of a beta particle emitted during radioactive decay is approximately 20 times greater than the speed of an alpha particle.

Which statement correctly compares properties of these two particles?

A Alpha particles are less penetrating because they have less kinetic energy than beta particles.

B Alpha particles are more penetrating because they have less kinetic energy than beta particles.

C Alpha particles are less ionising because they have more kinetic energy than beta particles.

D Alpha particles are more ionising because they have more kinetic energy than beta particles.

（2025 夏季 0625/23 第33题）

解：α 粒子的质量约为 β 粒子的 7300 倍，且 $v_\beta = 20v_\alpha$。
由 $E_k = \frac{1}{2}mv^2$ 得
$\frac{E_{k\alpha}}{E_{k\beta}} = \frac{m_\alpha v_\alpha^2}{m_\beta v_\beta^2}$
$= \frac{7300}{20^2} \approx 18$
故 α 粒子的动能较大。α 粒子的电荷量大小为 $2e$，比 β 粒子的 e 大，因而电离作用较强，穿透能力较弱。
故选 D。

针对练习

7. **(c)** A different element decays by the emission of an alpha particle (α-particle).

Give **two** reasons why α-particles are more strongly ionising than β-particles.

（2025 夏季 0625/43 第11题(c)）

8. An α-particle and a β-particle have the same kinetic energy.

Why does the α-particle have a larger ionising effect than the β-particle as it passes through air?

A The α-particle has a larger charge and a larger velocity so is closer to an air particle for a shorter time.

B The α-particle has a larger charge and a smaller velocity so is closer to an air particle for a longer time.

C The α-particle has a smaller charge and a larger velocity so is closer to an air particle for a shorter time.

D The α-particle has a smaller charge and a smaller velocity so is closer to an air particle for a longer time.

（2024 冬季 0625/22 第35题）

9. Three statements about alpha (α) particles and beta (β) particles are listed.

1 The magnitude of the charge on an α-particle is twice the charge on a β-particle.

2 The mass of an α-particle is large compared with the mass of a β-particle.

3 The kinetic energy of an α-particle is small compared to the kinetic energy of a β-particle.

Which statements help to explain the different ionising effects of α-particles and β-particles?

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

（2025 冬季 0625/21 第34题）

题型 3：按穿透与寿命选择放射源（考频★★☆☆☆）

知识点 半衰期是放射性样品中未衰变原子核数减至初始值_____所需的时间，单位可用 s、min、h、d 或 a。
三种核辐射中，α 的穿透能力最弱，β 的穿透能力_____，γ 的穿透能力_____。
用于测厚时，辐射应能穿过被测材料并被部分吸收；材料越厚，探测器的计数率越低。
放射源的半衰期应能覆盖使用期，使使用期间的活度变化较小，同时避免过长时间的辐射。

答案：一半；中等；最强

怎么认 题目出现材料厚度、探测器或使用期时，先按材料选择穿透能力，再按使用期选择半衰期。

例题 1 Which type of radioactive source is suitable for use in measuring and controlling the thickness of paper in a paper-manufacturing factory?

	type of emission	half-life
A	alpha	long
B	alpha	short
C	beta	long
D	beta	short

（2024 夏季 0625/22 第36题）

解： 测量纸张厚度时，辐射应穿过纸张，并随纸张厚度增加而有更多辐射被吸收。
α 粒子会被纸张吸收，β 粒子的穿透能力适合测量纸张厚度。
工厂需长期使用，半衰期应较长，使放射源在使用期内的活度变化较小。
故选 C。

针对练习

1. Leaks in underground water pipes are detected using radioactive tracers. Fig. 10.1 shows a radiation detector above a water pipe.

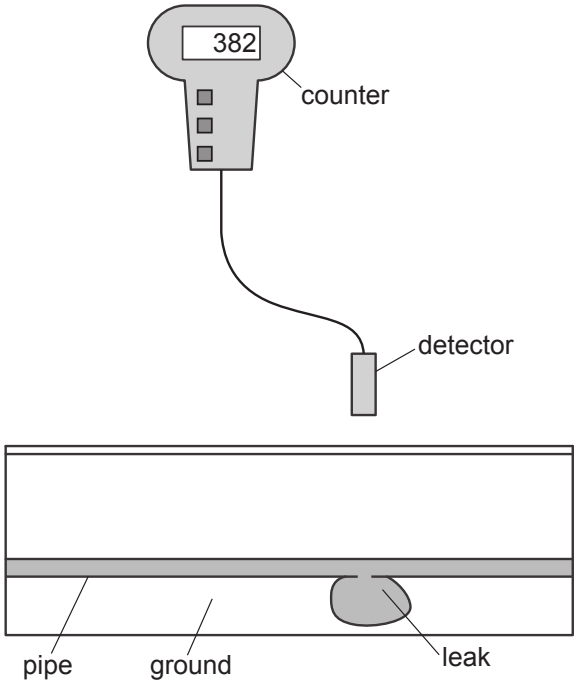


Fig. 10.1

(b) Suggest which radioactive emission, alpha, beta or gamma, is suitable for detecting the leak in the water pipe.

Explain your answer.

（2024 夏季 0625/43 第10题(b)）

2. Which properties must a radioisotope have for its radiation to make it suitable to kill bacteria in food?

	half-life	type of radiation emitted
A	less than one minute	γ only
B	several hours	α only
C	several hours	γ only
D	several thousand years	α only

（2025 冬季 0625/21 第36题）

3. **(b)** Table 9.1 shows five radioactive sources, the main type of radiation emitted by each source and the half-life of each source.

Table 9.1

radioactive source	type of radiation emitted	half-life
P	alpha	460 years
Q	alpha	10 days
R	beta	29 years
S	beta	14 days
T	gamma	30 years

(i) Define half-life of a radioactive isotope.

(ii) Fig. 9.2 shows a simplified diagram of a machine that produces thin sheets of aluminium of constant thickness.

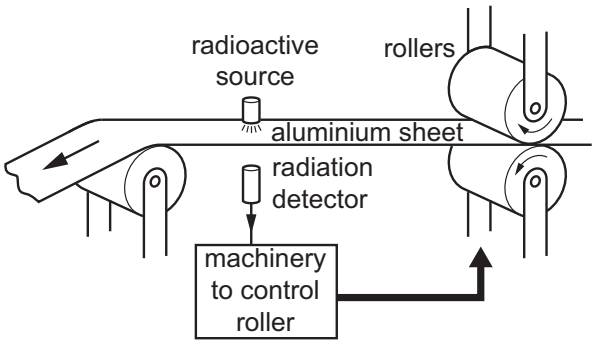


Fig. 9.2

The radiation detector is used to measure the thickness of the aluminium sheets and control the gap between the rollers.

State the most suitable radioactive source in Table 9.1 for the machine in Fig. 9.2.

Explain why this radioactive source is the most suitable and why the other sources are unsuitable.

（2025 冬季 0625/42 第9题(b)）

5.2.3 放射性衰变

题型 1：看核变化判断衰变影响（考频★★★★☆）

知识点 放射性衰变是不稳定原子核发生的变化，可能发射 α 粒子、β 粒子和/或 γ 射线；衰变会_____发生，且具有_____性。

不能预知某个原子核何时衰变；在相同时间间隔内，每个尚未衰变的同种原子核发生衰变的概率相同，且不随已经存在的时间改变。

中子过多或核过重都可能造成原子核不稳定；α 衰变或 β 衰变会使原子核变为另一种元素，γ 发射不改变元素。以上性质判断不涉及单位。

答案：自发；随机

怎么认 题目出现原子核不稳定、随机变化或发出辐射时，先判定为自发的放射性衰变。

一. 抓住不稳定自发且随机

例题 1 Which statement about the random decay of the nuclei in a sample of uranium-238 is correct?

A The probabilities of an alpha-particle, a beta-particle or a gamma ray being emitted from a nucleus in the sample are equal.

B The probability of a nucleus in the sample decaying decreases as time passes.

C The probability of a nucleus decaying in any ten minute interval is the same for all the nuclei in the sample.

D The probability of a nucleus in the sample decaying increases as time passes.

（2023 夏季 0625/11 第36题）

解：铀-238 的原子核不稳定，其衰变自发且随机；任一尚未衰变的铀-238 原子核在同一十分钟时段内的衰变概率相同，且不随已存在时间改变。

A 错，铀-238 并非以相等概率发射三类辐射；B、D 错，衰变概率不随时间改变；C 对。故选 C。

针对练习

1. Isotope X is radioactive.

Which statement about X **must** be correct?

A A nucleus of X is unstable.

B X emits α-particles.

C X emits β-particles.

D X emits γ-radiation.

（2025 夏季 0625/23 第36题）

2. The nuclei of the atoms in a substance are changing randomly and emitting radiation.

What is happening to the substance?

A It is undergoing electromagnetic induction.

B It is undergoing magnetisation.

C It is undergoing solidification.

D It is undergoing radioactive decay.

（2024 夏季 0625/13 第35题）

3. **(b)** Lead-208 ($^{208}_{82}Pb$) has the highest nucleon number of the stable isotopes of lead.

Explain why lead-214 ($^{214}_{82}Pb$) is radioactive.

（2023 冬季 0625/43 第9题(b)）

4. Which row correctly describes an example of radioactive decay?

	original nucleus	emission	change or no change of element
A	stable	γ	change of element
B	unstable	α	change of element
C	unstable	α	no change of element
D	unstable	β	no change of element

（2023 冬季 0625/12 第35题）

二. 用质子数判断元素改变

知识点 放射性衰变是不稳定原子核自发、随机发生的变化，可放出 α 粒子、β 粒子和 γ 射线中的一种或多种。

α 衰变使质量数 A 减少 _____，质子数 Z 减少 _____。

β^- 衰变使 A 不变、Z 增加 _____；γ 发射不改变 A 和 Z。

质子数决定元素种类，Z 改变时，原子核变成另一种元素的原子核。

答案：4；2；1

怎么认 题目出现质子数、质量数或元素是否改变时，先写三种辐射对 A、Z 的影响。

例题 2 A nucleus spontaneously emits radiation and becomes a nucleus of a different element.

What could the emitted radiation be?

A alpha or beta

B alpha or gamma

C beta or neutron

D gamma or neutron

（2024 春季 0625/12 第34题）

解： 元素种类由质子数 Z 决定。

α 衰变使 Z 减少 2，β^- 衰变使 Z 增加 1，二者均使元素改变。

γ 发射和中子发射均不改变 Z，元素不变。

故选 A。

针对练习

5. Which statement about alpha decay is correct?

A The nucleus loses electrons.

B The nucleus changes to that of a different element.

C The nucleus does not decay until after one half-life.

D After two half-lives, alpha decay always stops.

（2024 冬季 0625/21 第36题）

6. An atomic nucleus decays by one or more radioactive decay processes.

What causes the proton number to **decrease** by 1?

A α-decay followed by β-decay

B α-decay only

C β-decay followed by γ-decay

D β-decay only

（2024 冬季 0625/23 第35题）

7. Which type of radioactive decay causes the nucleus of one element to change into the nucleus of another element?

	emission of an alpha-particle	emission of a beta-particle	emission of a gamma ray
A	✓	✓	✗
B	✓	✗	✗
C	✗	✓	✓
D	✗	✓	✗

（2023 冬季 0625/13 第36题）

8. The unstable nucleus of an element undergoes radioactive decay. The proton number remains unchanged.

Which description of this radioactive decay event is correct?

A The nucleus emits an α-particle.

B The nucleus emits a β-particle.

C The nucleus emits γ-radiation.

D The nucleus emits an α-particle, a β-particle and γ-radiation together.

（2025 夏季 0625/11 第35题）

三. 写 β 核内中子转化

知识点 放射性衰变是不稳定原子核自发、随机发生的变化，可发射 α 粒子、β 粒子和/或 γ 辐射。

在 β^- 衰变中，一个中子转化为一个质子和一个电子，即 $n \to p + e^-$，发射的 β 粒子是_____。

因此中子数_____，质子数_____，核子数不变，原子核变为另一种元素的原子核。

质子数、中子数和核子数均为计数值，无单位。

答案：电子；减 1；加 1

怎么认 题目出现发射 β 粒子并询问核内变化时，先写 $n \to p + e^-$。

例题 3 Which row shows what happens when a nucleus decays by emitting a β-particle?

	change in the nucleus	particle emitted
A	a neutron changes to a proton and an electron	electron
B	a neutron changes to a proton and an electron	proton
C	a proton changes to a neutron and an electron	electron
D	a proton changes to a neutron and an electron	neutron

（2025 春季 0625/22 第35题）

解： 由 β^- 衰变的核内变化得
$n \to p + e^-$。
发射的 β 粒子是电子，故选 A。

针对练习

9. Which change occurs in the nucleus of a radioactive atom when a beta-particle is emitted?

A neutron → alpha-particle

B neutron → proton + electron

C proton → neutron

D proton → neutron + electron

（2025 冬季 0625/23 第36题）

10. **(b)** State how β-decay changes the nucleus of an atom.

（2023 夏季 0625/42 第9题(b)）

11. **(a)** During β-decay, one of the neutrons in the nucleus changes.

(i) State what happens to this neutron.

(ii) Explain how charge is conserved during this change.

（2023 夏季 0625/43 第8题(a)）

12. The nuclide notation for the radioactive isotope carbon-14 is $^{14}_{6}C$.

(c) Carbon-14 decays by beta (β) emission.

(i) State the name of a particle that is identical to a beta-particle.

(ii) Describe the change that takes place in carbon-14 as a beta-particle is emitted.

（2024 冬季 0625/41 第8题(c)）

题型 2：守恒 A 与 Z 补衰变方程（考频★★★☆☆）

知识点 核素符号上方的 A 为核子数，符号下方的 Z 为质子数；中子数 $N=A-Z$，三者均没有单位。

发生 α 衰变时，放出的 α 粒子含 _____ 个核子和 _____ 个质子。

由核子数和质子数守恒，子核的 A 比母核小 4，Z 比母核小 2。

连续衰变应逐次更新 A 与 Z；发生 β^- 衰变时，A 不变，Z 增加 1。

答案：4；2

怎么认 题目出现 α 衰变、核素符号或补全核素方程时，先将母核的 A 减 4、Z 减 2。

一. α 后 A 减 4 且 Z 减 2

例题 1

The radioactive isotope radon, $^{222}_{86}$Rn, is an alpha (α) emitter.

During this radioactive decay, an isotope of polonium, Po, is produced.

How many neutrons does a nucleus of this isotope of polonium contain?

A 130　　**B** 132　　**C** 134　　**D** 136

（2024 春季 0625/22 第34题）

解：α 衰变放出含 4 个核子、2 个质子的粒子，由核子数和质子数守恒得

$A=222-4=218$

$Z=86-2=84$

钋核的中子数为

$N=A-Z=218-84=134$

故选 C。

针对练习

1. **(b)** Complete the nuclide equation for the α-decay of radon-212 to form an isotope of polonium, symbol Po.

$$^{212}_{86}\mathrm{Rn}\rightarrow$$

（2023 夏季 0625/43 第8题(b)）

2. A uranium nucleus $^{238}_{92}$U decays to form thorium by emitting an α-particle. Thorium decays to protactinium by emitting a β-particle.

Which row gives the atomic number and mass number of this isotope of protactinium?

	atomic number	mass number
A	89	234
B	90	235
C	91	234
D	95	235

（2025 春季 0625/22 第34题）

3. **(b)** Radioactive isotopes are used in some medical treatments.

Radium-223 ($^{223}_{88}Ra$) is an isotope of radium. Radium-223 decays by the emission of alpha (α) particles to an isotope of radon (Rn).

(i) Complete the nuclide equation for this decay.

$$^{223}_{88}Ra \longrightarrow {}^{\cdots\cdots}_{\cdots\cdots}Rn + {}^{\cdots\cdots}_{\cdots\cdots}\alpha$$

(ii) Radium-223 is injected into the body to treat a specific organ.

Explain why the source must be inside the body.

（2025 夏季 0625/42 第9题(b)）

4. Many household smoke alarms contain a sample of the radioactive isotope americium-241 (Am).

(b) Americium-241 decays to an isotope of neptunium (Np) by alpha-particle (α-particle) emission.

(i) Complete the equation for this decay.

$$^{241}_{\cdots\cdots}Am \longrightarrow {}^{\cdots\cdots}_{93}Np + {}^{\cdots\cdots}_{\cdots\cdots}\alpha$$

(ii) One reason for using an isotope that emits α-particles in a smoke detector is that α-particles are more strongly ionising than beta-particles (β-particles).

Explain why α-particles are more strongly ionising than β-particles.

(iii) The isotope of neptunium produced by americium-241 is also radioactive.

The decay of this isotope of neptunium produces an isotope of protactinium which decays by β-emission. β-particles are more penetrating than α-particles.

The half-life of neptunium is longer than two million years.

Using this information, explain the advantage of this long half-life for the use and safe disposal of a household smoke alarm.

（2023 冬季 0625/41 第9题(b)）

二. β 后 A 不变且 Z 加 1

知识点 在 β^- 衰变中，母核内一个中子转变为质子并放出电子；β^- 粒子的质量数为_____，电荷数为_____。

核方程两边的总质量数 A 和总下标数 Z 分别相等，因此子核的 A 不变，Z 增加_____。

γ 射线没有质量和电荷，发射前后原子核的质量数和质子数不变。

原子核可能因中子过多或质量过大而不稳定；放射线具有电离作用，过量照射会危害人体。

答案：0；−1；1

怎么认 题目出现 β^- 衰变和未配平的核方程时，先写出 ${}^{0}_{-1}\beta$，再分别守恒 A 和 Z。

例题 2 The isotope thallium-208 (${}^{208}_{81}\mathrm{T}l$) is radioactive. It decays by β-decay.

(a) Thallium-208 decays to an isotope of lead (Pb).

(i) Complete the equation for this decay.

$$^{208}_{81}\mathrm{T}l \longrightarrow$$

(ii) The β-emission of thallium-208 is accompanied by γ-emission from the nucleus.

Explain why this γ-emission does **not** affect the numbers in the equation in **(a)(i)**.

(iii) Suggest **one** reason why a nucleus of thallium-208 is unstable.

（2024 夏季 0625/41 第8题(a)）

解： 将 β^- 粒子写成 ${}^{0}_{-1}\beta$。

由质量数守恒，$208 = 208 + 0$；由下标数守恒，$81 = 82 + (-1)$，得

${}^{208}_{81}\mathrm{Tl} \rightarrow {}^{208}_{82}\mathrm{Pb} + {}^{0}_{-1}\beta$

γ 射线没有质量和电荷，故不会改变核方程中的质量数和质子数。

铊-208 原子核可能含有过多中子，因而不稳定。

答：${}^{208}_{81}\mathrm{Tl} \rightarrow {}^{208}_{82}\mathrm{Pb} + {}^{0}_{-1}\beta$；$\gamma$ 发射不改变质量数和质子数；铊-208 原子核可能含有过多中子。

针对练习

5. Sodium-24 is a radioactive isotope that emits beta radiation.

Which nuclear equation shows how sodium-24 decays?

A ${}^{24}_{11}\mathrm{Na} \rightarrow {}^{24}_{12}\mathrm{Mg} + {}^{0}_{-1}\beta$

B ${}^{24}_{11}\mathrm{Na} \rightarrow {}^{24}_{10}\mathrm{Ne} + {}^{0}_{-1}\beta$

C ${}^{24}_{11}\mathrm{Na} \rightarrow {}^{20}_{9}\mathrm{F} + {}^{4}_{2}\beta$

D ${}^{24}_{11}\mathrm{Na} \rightarrow {}^{20}_{13}\mathrm{A}l + {}^{4}_{2}\beta$

（2025 夏季 0625/21 第36题）

6. **(b)** Sodium-24 is an isotope of sodium (Na) that has a proton number of 11 and a nucleon number of 24.

Sodium-24 decays by emission of a beta-particle to form an isotope of magnesium (Mg).

Use nuclide notation to write down the nuclide equation for this decay.

（2024 夏季 0625/42 第9题(b)）

7. Strontium-90 (${}^{90}_{38}\mathrm{Sr}$) is a radioactive isotope that contains 38 protons and 52 neutrons. Strontium-90 decays to form an isotope of yttrium (Y) by emitting beta (β) particles.

(a) **(i)** Suggest how the nucleus of a stable isotope of strontium differs from a nucleus of strontium-90. Explain your answer.

(ii) Complete the nuclide equation for the decay of strontium-90 to yttrium.

$$^{90}_{38}\mathrm{Sr} \longrightarrow {}^{\cdots\cdots}_{\cdots\cdots}\mathrm{Y} + {}^{\cdots\cdots}_{\cdots\cdots}\beta$$

(iii) Explain why scientists limit the amount of time they are exposed to radioactive strontium.

（2025 夏季 0625/41 第9题(a)）

8. **(b)** A protactinium (Pa) nucleus decays into a uranium (U) nucleus by the emission of a beta particle (β-particle).

(i) Complete the nuclear equation for the decay.

$$^{234}_{91}\mathrm{Pa} \rightarrow$$

(ii) State the change that occurs in the nucleus during the decay.

（2025 夏季 0625/43 第11题(b)）

5.2.4 半衰期

题型 1：把读数减半找半衰期（考频★★★☆☆）

知识点 放射性同位素的半衰期，是任一样品中_____的不稳定原子核发生衰变所需的时间。

经过一个半衰期，样品中未衰变的不稳定原子核数变为原来的_____，相应的计数率也变为原来的一半。

半衰期由同位素种类决定，常用单位有 s、min、h 和 year。

答案：半数；$\frac{1}{2}$

怎么认 题目出现定义半衰期或询问其含义时，先确定对象是不稳定原子核，再写半数原子核衰变所需的时间。

一. 写清半数核发生衰变

例题 1 **(a)** Define the half-life of a radioactive source.

（2025 夏季 0625/43 第11题(a)）

解：答：放射源中半数不稳定原子核发生衰变所需的时间。

针对练习

1. Which definition of half-life is **not** correct?

A the time it takes for the count rate from a radioactive sample to fall to half its original value

B the time it takes for half of the unstable nuclei in a radioactive sample to decay

C the time it takes for the mass of radioactive material in a sample to halve

D the time it takes for half of the neutrons in a radioactive sample to decay

（2024 冬季 0625/23 第36题）

2. Fig. 9.1 represents all the particles in a neutral atom of a radioactive isotope X1.

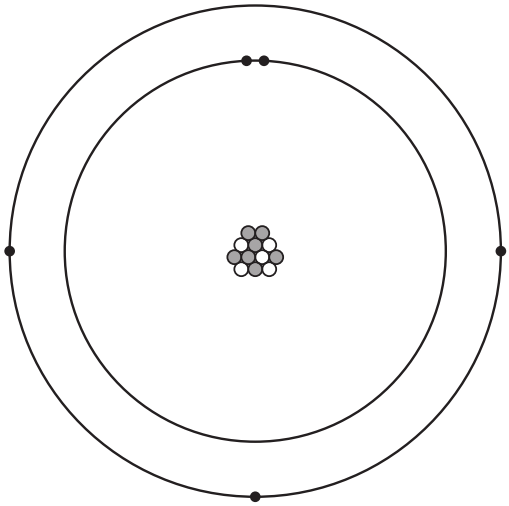


Fig. 9.1 (not to scale)

(c) The half-life of X1 is approximately 20 ms.

(i) Define the term half-life.

(ii) Suggest **one** reason why isotopes with very short half-lives are especially hazardous.

（2023 夏季 0625/41 第9题(c)）

二. 从表或曲线找一半

知识点 放射性同位素的半衰期，是任一样品中该同位素有_____的原子核发生衰变所需的时间。在相同测量条件且本底计数可忽略时，计数率降为原值的_____，所经历的时间为一个半衰期。在表格或曲线上找计数率 C 与 $\frac{C}{2}$ 对应的时刻 t_1、t_2，则 $T_{\frac{1}{2}} = t_2 - t_1$；半衰期的单位与时间轴单位_____。

答案：一半；一半；相同

怎么认 题目出现计数率–时间表或衰变曲线并求半衰期时，先取计数率 C 并求 $\frac{C}{2}$。

例题 2 The count rate due to a sample of a radioactive isotope is measured for 80 minutes.

time / minutes	count rate / counts / second
0	480
20	380
40	300
60	240
80	190

What is the half-life of the isotope?

A 20 minutes **B** 40 minutes **C** 60 minutes **D** 80 minutes

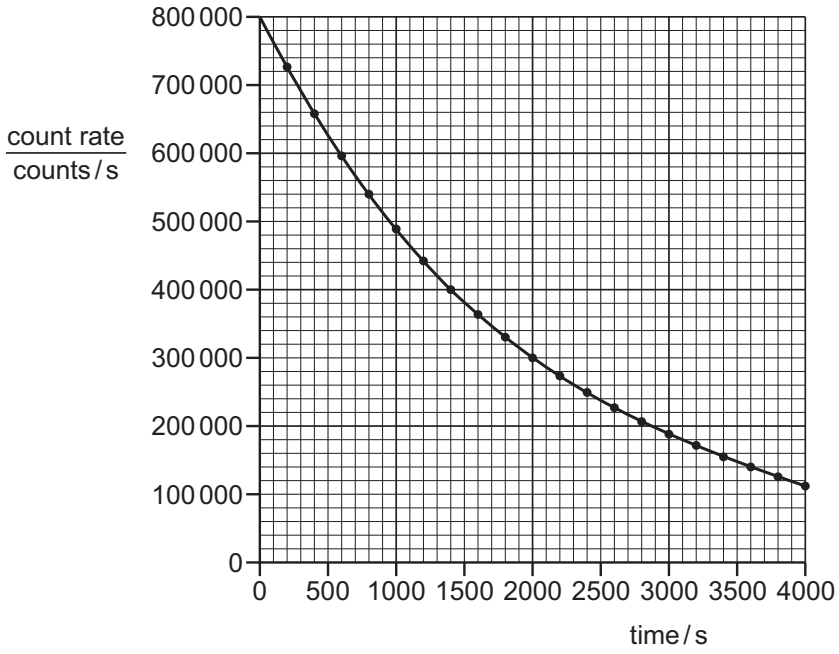
（2023 夏季 0625/11 第37题）

解：取表中计数率 $C_1 = 480$ counts/s，其一半为 $C_2 = \frac{C_1}{2} = 240$ counts/s。

由表得 $t_1 = 0\ \text{min}$，$t_2 = 60\ \text{min}$，
$T_{\frac{1}{2}} = t_2 - t_1 = 60\ \text{min}$。
故选 C。

针对练习

3. A student collects data for a new radioactive substance.



Using the graph, what is the approximate half-life of the substance?

A 1400 s **B** 2000 s **C** 100 000 s **D** 800 000 s

（2025 冬季 0625/13 第37题）

4. A detector is used to monitor the emissions from a radioactive source over several days.

The table shows the count rate from the source at different times.

time / days	count rate / counts / s
0	250
1	215
2	180
3	148
4	120
5	100

What is the half-life of the source?

A between 1 and 2 days

B between 2 and 3 days

C between 3 and 4 days

D between 4 and 5 days

（2023 冬季 0625/12 第36题）

5. **(c)** A teacher demonstrates radioactive decay by using a sample of protactinium-234m.

(i) The sample emits beta (β)-particles.

State the nature of a beta (β)-particle.

(ii) The teacher obtains data for a decay curve. Fig. 10.1 shows the decay curve for the sample of protactinium-234m.

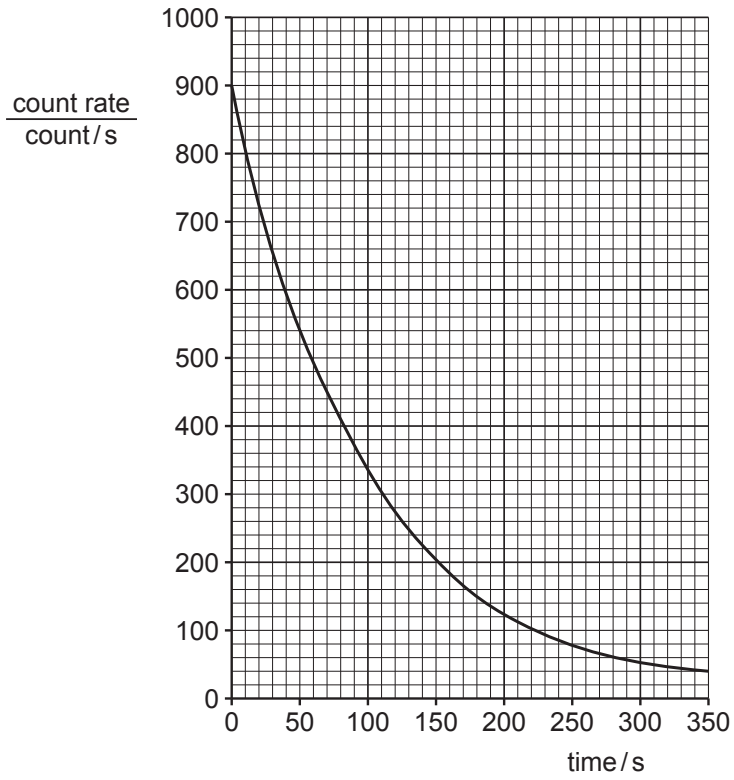


Fig. 10.1

Calculate the half-life of protactinium-234m using the information in Fig. 10.1. Clearly show your working on the graph or in the space provided.

(iii) Suggest a reason why the half-life of protactinium-234m makes it suitable for this demonstration in a lesson.

（2024 夏季 0625/33 第10题(c)）

6. Unstable nuclei emit ionising radiation when they decay.

(b) Iodine-131 is an unstable isotope of iodine.

(i) State the meaning of the term isotope.

(ii) Fig. 9.1 shows the decay curve for a sample of iodine-131.

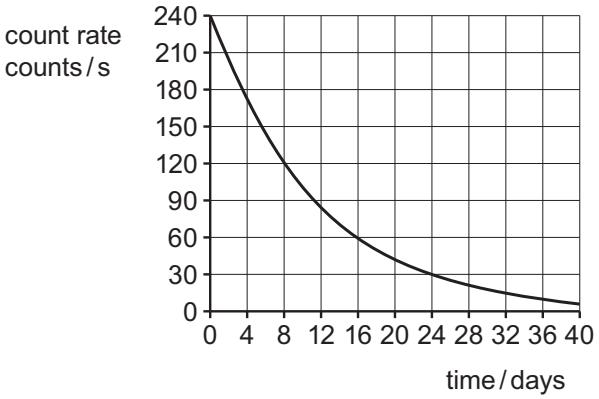


Fig. 9.1

Determine the half-life of iodine-131. Show your working clearly.

（2025 冬季 0625/32 第9题(b)）

题型 2：数减半次数做计算（考频★★★★☆）

知识点 某同位素的半衰期，是任一样品中该同位素尚未衰变的原子核数减为原来_____所需的时间。

若经过时间 t 是半衰期 $T_{\frac{1}{2}}$ 的整数倍，则减半次数为 _____，剩余量为 $Q=Q_0\left(\frac{1}{2}\right)^n$。

t 与 $T_{\frac{1}{2}}$ 必须使用相同时间单位；Q 与 Q_0 使用相同单位。

答案：一半；$\frac{t}{T_{\frac{1}{2}}}$

怎么认 题目出现半衰期、初始量和经过时间并求剩余量时，先算减半次数 $n=\frac{t}{T_{\frac{1}{2}}}$。

一. 已知时间求剩余量

例题 1 Americium-241 is a radioactive nuclide. The nuclide notation for a nucleus of americium-241 is

$$^{241}_{95}\mathrm{Am}$$

(b) Americium-241 has a half-life of 430 years.
A radioactive source contains 12 mg of americium-241.
Calculate the mass of americium-241 that remains in the source after 860 years.

（2023 春季 0625/32 第11题(b)）

解：经过的半衰期数为

$n=\frac{860}{430}=2$

剩余质量为

$m=12\left(\frac{1}{2}\right)^2=3.0\ \mathrm{mg}$

答：剩余镅-241 的质量为 3.0 mg。

针对练习

1. **(b)** Plutonium-241 has a half-life of 14 years.

A sample of radioactive material contains 72 mg of plutonium-241.

Calculate the mass of plutonium-241 remaining in the sample after 42 years.

（2025 夏季 0625/31 第10题(b)）

2. The half-life of the radioactive isotope caesium $^{137}_{55}Cs$ is 30 years.

Starting with 30 g of the isotope, which mass of the isotope remains after 90 years?

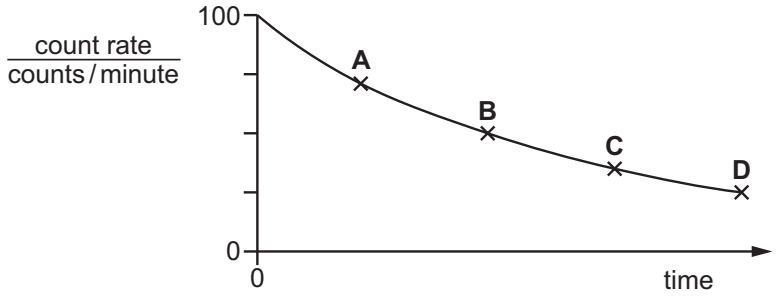
A 10.0 g **B** 7.50 g **C** 3.75 g **D** 1.25 g

（2024 冬季 0625/11 第37题）

3. The half-life of carbon-14 is 5700 years.

An object containing carbon-14 has a count rate of 100 counts / minute when it is first formed. The graph shows how the count rate decreases over time.

Which point on the graph corresponds to a time 11 400 years after the formation of the object?



（2023 冬季 0625/13 第35题）

4. **(b)** A source contains a radioactive isotope of strontium. This isotope decays by emission of β-particles. The half-life of this isotope is 29 years.

(i) State the change in the nucleus which occurs when a β-particle is emitted.

(ii) The initial mass of this isotope of strontium in the source is 25 μg.

Calculate the mass of the strontium isotope that decays in 87 years.

（2024 春季 0625/42 第9题(b)）

二. 已知衰减求经过时间

知识点 半衰期是样品中某种放射性同位素的原子核数衰变到原来_____所需的时间。

经过一个半衰期，未衰变原子核数、质量或放射性计数率均减为原来的_____；经过 n 个半衰期后，剩余量为初始量的 $\left(\frac{1}{2}\right)^n$。

初始量与最终量必须是同一种物理量，时间单位与半衰期单位应_____；计算时不计本底辐射。

答案：一半；一半；一致

怎么认 题目出现初始量、衰减后的量和半衰期并求时间时，先连续减半并数出半衰期次数。

例题 2 A sample of a radioactive isotope has an initial rate of emission of 128 counts per minute and a half-life of 4 days.

How long will it take for the rate of emission to fall to 32 counts per minute?

A 2 days **B** 4 days **C** 8 days **D** 12 days

（2023 春季 0625/12 第37题）

解：$128 \to 64 \to 32$，共经过 2 个半衰期。
$t = 2 \times 4\ \text{days} = 8\ \text{days}$。
故选 C。

针对练习

5. **(b)** A sample contains another isotope of uranium. The half-life of this isotope is 24 minutes.

Calculate the time taken for the mass of this isotope in the sample to decay from 16.0 mg to 4.0 mg.

（2024 夏季 0625/32 第10题(b)）

6. Radium is a radioactive element with the chemical symbol Ra. The proton number for radium is 88. Radium-223 is an isotope of radium that has a nucleon number of 223.

(c) The half-life of radium-223 is 11 days. A sample contains 32 mg of radium-223.

Calculate the time taken for the mass of radium-223 in the sample to decay from 32 mg to 4 mg.

（2025 冬季 0625/31 第10题(c)）

7. Carbon-14 ($^{14}_{6}C$) is a radioactive isotope of carbon. Carbon-12 ($^{12}_{6}C$) is not radioactive.

(b) All living organisms contain both carbon-12 atoms and carbon-14 atoms. The ratio of carbon-14 to carbon-12 is $1 : 1 \times 10^{12}$.

Carbon-14 has a half-life of 5700 years.

(i) When an organism dies no new carbon is absorbed. The amount of carbon-12 in the dead organism remains fixed.

Describe how the amount of carbon-14 in the dead organism decreases with time.

(ii) A sample of wood contains carbon-14 to carbon-12 atoms in the ratio $1 : 4 \times 10^{12}$.

Calculate how many years ago the tree died.

（2024 冬季 0625/42 第10题(b)）

三. 由次数反求半衰期或初值

知识点 某种放射性核素的半衰期，是任一样品中该核素的原子核有_____发生衰变所用的时间。
在不考虑本底辐射且测量量与未衰变原子核数成正比时，质量、发射率或计数率每经过一个半衰期均变为原来的_____。
若初量与末量之比为 2^n，则经历了 n 个半衰期，$T_{\frac{1}{2}} = \frac{t}{n}$；反求初量时，末量乘 2^n。
半衰期的单位是时间单位，如 s、h、天或年。

答案：一半；一半

怎么认 题目出现初末质量、发射率或计数率及间隔时间时，先由初末量比值确定减半次数。

例题 3 A sample of a radioactive isotope emits 9600 α-particles per second.

After 40 hours the rate of emission has fallen to 600 α-particles per second.

What is the half-life of this isotope?

A 4.0 hours **B** 8.0 hours **C** 10 hours **D** 20 hours

（2023 夏季 0625/12 第36题）

解：由初末发射率之比得
$\frac{9600}{600} = 16 = 2^4$
故 40 h 内经历了 4 个半衰期，

$T_{\frac{1}{2}} = \frac{40\ \text{h}}{4} = 10\ \text{h}$
故选 C。

针对练习

8. **(b)** A sample containing 60 mg of radon-222 decays to 7.5 mg in 11.5 days.

Calculate the half-life of radon-222.

（2025 夏季 0625/32 第10题(b)）

9. **(c)** Curium-242 is a radioactive isotope. It emits alpha particles. It has a half-life of 160 days.

After 480 days, the mass of curium-242 in a sample is 2.4×10^{-3} g.

Calculate the initial mass of curium-242 in the sample.

（2025 冬季 0625/43 第8题(c)）

10. Fig. 11.1 represents all the particles in a beryllium atom.

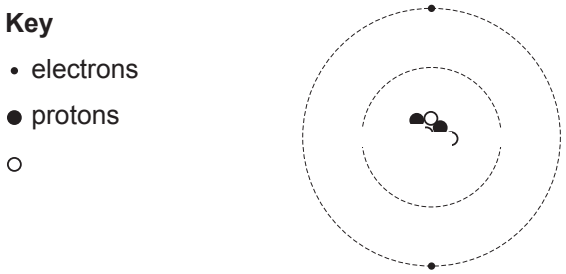


Fig. 11.1 (not to scale)

(c) A scientist uses a detector and counter to measure the count rate due to radiation emitted from a radioactive source.

The first measurement is 400 counts / min.

The scientist takes another measurement 6 hours later. This measurement is 50 counts / min.

Calculate the half-life of the radioactive source.

（2023 冬季 0625/32 第11题(c)）

11. An explosion in a nuclear reactor spreads the isotope caesium-137, $^{137}_{55}Cs$, across a large area.

After 90.0 years have passed, the quantity of caesium-137 present is 12.5% of its original level.

What is the half-life of caesium-137?

A 11.3 years **B** 22.5 years **C** 30.0 years **D** 45.0 years

（2024 冬季 0625/21 第37题）

题型 3：先扣本底再做减半（考频★★☆☆☆）

知识点 某种同位素的半衰期，是该同位素任一样品中_____的原子核发生衰变所需的时间；经过一个半衰期，放射源的净计数率减为原来的一半。

探测器的实测计数率满足 $R_{测}=R_{源}+R_{本}$；有本底辐射时，初始净计数率为 $R_{源,0}=R_{测,0}-R_{本}$。

若本底计数率保持不变，经过 $n=\frac{t}{T_{\frac{1}{2}}}$ 个半衰期后，$R_{源}=R_{源,0}\left(\frac{1}{2}\right)^{n}$；求探测器读数时要把本底计数率_____。

计数率单位常用 counts/min 或 counts/s；t 与 $T_{\frac{1}{2}}$ 必须使用_____的时间单位。

答案：一半；加回；相同

怎么认 题目出现实测计数率、本底计数率、半衰期和经过时间时，先从实测值中扣除本底。

例题 1 A detector is placed near a radioactive isotope and records a count rate of 700 counts / min.

The half-life of the isotope is 8 min.

The average background count rate is 60 counts / min.

What is the count rate measured by the detector after 16 min?

A 100 counts / min

B 160 counts / min

C 175 counts / min

D 220 counts / min

（2025 春季 0625/22 第37题）

解：初始实测计数率含本底辐射，故放射源的初始净计数率为

$R_{源,0}=700-60=640\ \ \text{counts/min}$。

$\frac{16}{8}=2$，经过两个半衰期，

$R_{源}=640\left(\frac{1}{2}\right)^{2}=160\ \ \text{counts/min}$。

探测器的最终读数还包含本底计数率，

$R_{测}=160+60=220\ \ \text{counts/min}$。

故选 D。

针对练习

1. The reading on a detector placed near a radioactive material is 536 counts per second.

The background count rate is 44 counts per second.

The half-life of the radioactive material is 34 hours.

What is the reading on the detector after 68 hours?

A 44 counts per second

B 123 counts per second

C 134 counts per second

D 167 counts per second

（2024 夏季 0625/21 第36题）

2. **(c)** A radiation detector used in a laboratory detects a background count rate of 30 counts / min. A radioactive source is placed in front of the radiation detector. The initial reading on the detector is 550 counts / min. The half-life of the source is 25 minutes.

Calculate the expected reading on the detector after 75 minutes.

（2023 夏季 0625/42 第9題(c)）

3. Strontium-90 ($^{90}_{38}Sr$) is a radioactive isotope that contains 38 protons and 52 neutrons. Strontium-90 decays to form an isotope of yttrium (Y) by emitting beta (β) particles.

(b) Yttrium is also unstable. A scientist places a sample of yttrium near a radiation detector. Table 9.1 shows the count rate recorded by the detector as the sample decays.

Table 9.1

time / h	recorded count rate / counts / min
0	68
50	49
100	38
150	32
200	26
250	24
300	20
350	21
400	20

Fig. 9.1 shows a graph of the count rate **due to yttrium** against time.

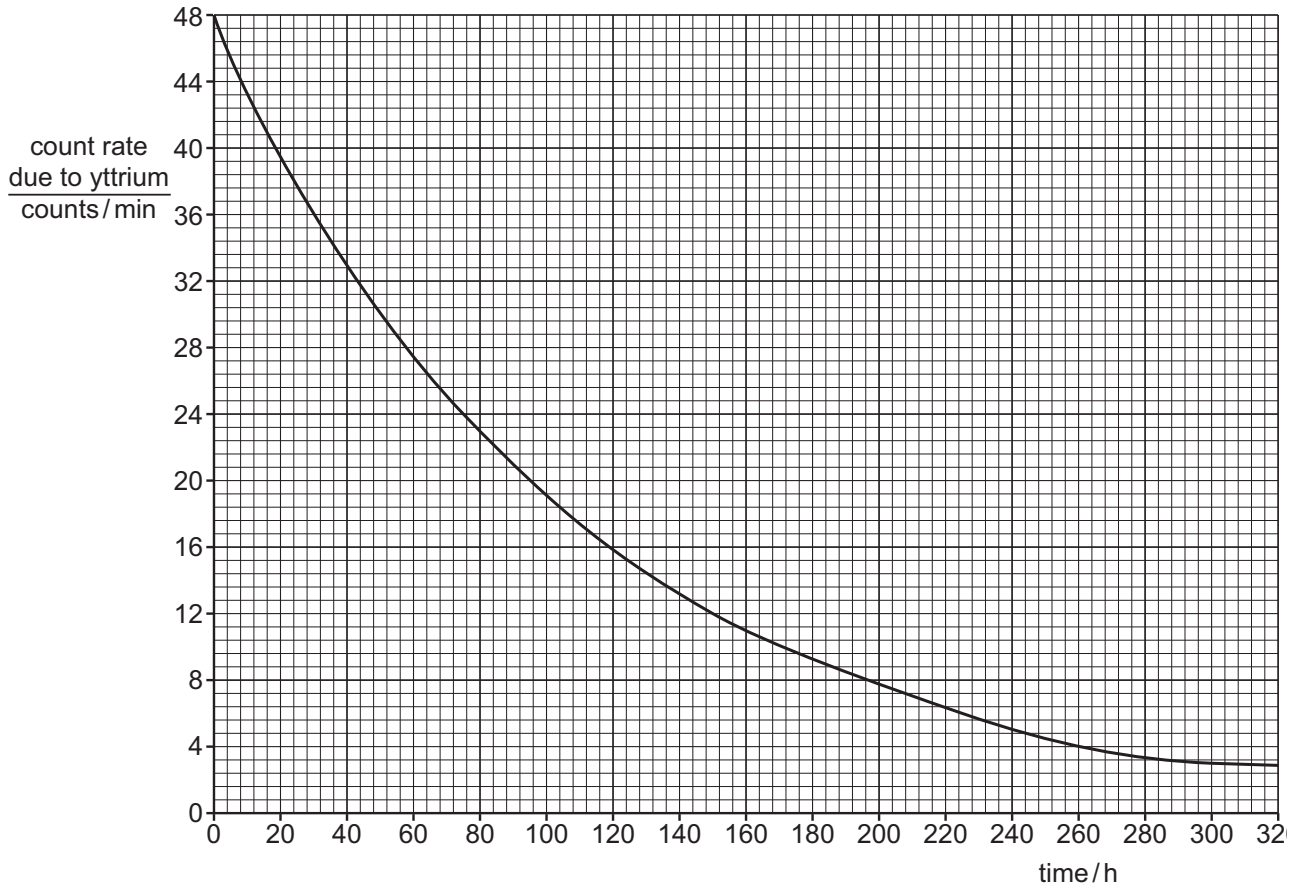


Fig. 9.1

(i) Use Fig. 9.1 to determine the half-life of yttrium. Show your working.

(ii) Explain the difference between the count rate in Table 9.1 and the count rate due to yttrium plotted on the graph in Fig. 9.1.

（2025 夏季 0625/41 第9题(b)）

4. A radioactive isotope of sodium has a half-life of 15 h.

The table gives data from an experiment to show how the rate of decay of the isotope varies with time.

The background count rate has not been subtracted from these data.

time / h	0	10	20	30
count rate / counts / s	400	260	170	115

What is the background radiation count rate?

A 12 counts / s

B 15 counts / s

C 20 counts / s

D 30 counts / s

（2023 冬季 0625/22 第36题）

题型 4：按穿透与时效选用途（考频★★☆☆☆）

知识点 半衰期是样品中某种同位素未衰变的原子核数减少到原来一半所需的时间，单位可用小时、天或年。

放射源的用途由辐射的穿透能力、电离能力和半衰期共同决定；半衰期应足以完成使用，同时避免不必要的长期活度。

家用烟雾报警器选电离能力强、穿透能力弱且半衰期_____的 α 源。

金属薄片测厚选穿透能力适中的 β 源，厚度越大，探测器计数率越低，所用放射源的半衰期通常_____。

体内示踪选能穿出人体的 γ 源，且半衰期较_____，使检查后活度较快降低。

答案：较长；较长；短

怎么认 题目出现烟雾报警、金属测厚或体内示踪时，先判断穿透或电离需求，再判断半衰期。

例题 1 Which row correctly matches three radioactive sources to their uses?

	emits alpha-particles and has a long half-life	emits beta-particles and has a long half-life	emits gamma radiation and has a short half-life
A	monitoring the thickness of aluminium foil	smoke alarm	tracer to be injected to detect cancer
B	monitoring the thickness of aluminium foil	tracer to be injected to detect cancer	smoke alarm
C	smoke alarm	monitoring the thickness of aluminium foil	tracer to be injected to detect cancer
D	smoke alarm	tracer to be injected to detect cancer	monitoring the thickness of aluminium foil

（2024 夏季 0625/23 第36题）

解： 烟雾报警器需用 α 粒子电离空气；其穿透能力弱，且长半衰期适合长期使用。

铝箔测厚需用能穿过薄铝且吸收量随厚度变化的 β 粒子，长半衰期可维持长期测量。

体内示踪需用能穿出人体的 γ 射线，短半衰期使检查后活度较快降低。

三者对应表中 C 行。故选 C。

针对练习

1. **(c)** An isotope of technetium is injected into the body to detect cancer in one of the organs. The half-life of this isotope is 6 hours and it decays by emitting gamma (γ) radiation. The radiation is detected outside the body.

(i) Explain why a source of gamma radiation is used.

(ii) Explain why a source with a short half-life must be used.

（2025 夏季 0625/42 第9题(c)）

2. Carbon-14 ($^{14}_{6}C$) is a radioactive isotope of carbon. Carbon-12 ($^{12}_{6}C$) is not radioactive.

(c) Other radioactive isotopes have different half-lives.

Suggest a use of a radioactive isotope with a half-life of one hour.

Explain why a short half-life is suitable for this use.

（2024 冬季 0625/42 第10题(c)）

3. **(a)** For each application of radioactive isotopes, state and explain which type of radioactive emission is suitable and suggest an appropriate half-life for the isotope.

(i) household smoke alarm

(ii) measuring the thickness of aluminium strips produced in a factory

（2023 冬季 0625/43 第9题(a)）

4. Strontium-90 is a radioactive isotope of strontium. The nuclide notation for strontium-90 is:

$$^{90}_{38}Sr$$

(b) Strontium-90 is used to measure the thickness of metal sheets in industry.
Strontium-90 decays by emitting beta (β) particles which pass through a metal sheet to a detector.

(i) One metal sheet is 0.75 mm thick. Suggest why strontium-90 is a suitable radioactive source to measure the thickness of the metal sheets.

(ii) The half-life of strontium-90 is approximately 27 years. Fig. 9.1 shows the shape of a decay curve.

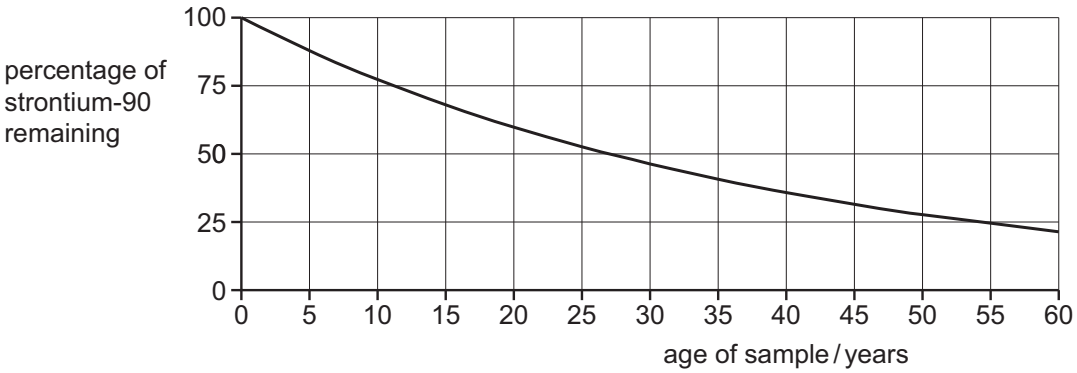


Fig. 9.1

The strontium-90 source is replaced with a new source after 15 years. Using Fig. 9.1, suggest why a strontium-90 source that is more than 15 years old needs to be replaced with a new source.

（2025 春季 0625/42 第9题(b)）

5.2.5 放射性的安全防护

题型 1：从细胞后果识别辐射危害（考频★★☆☆☆）

知识点 电离核辐射会破坏活细胞，可导致_____、_____和癌症。

放射治疗利用电离辐射定向杀死癌细胞，属于受控的医疗用途。

辐射对人体的危害可通过缩短照射时间、增大距离和使用屏蔽物来减小。

答案：细胞死亡；基因突变

怎么认 题目出现电离辐射对生物的影响时，先找细胞死亡、基因突变或癌症。

例题 1 What is an effect of ionising nuclear radiation on living things?

A cell mutation

B electric shock

C internal cooling of body cells

D broken bones

（2025 春季 0625/12 第39题）

解：电离核辐射可使活细胞发生突变。
故选 A。

针对练习

1. Which effect on living things is **not** caused by ionising radiation?

A cancer

B cell death

C infection

D mutation

（2025 夏季 0625/23 第35题）

2. Which row states a harmful effect and a beneficial effect of ionising radiation on living things?

	harmful effect	beneficial effect
A	kills cancer cells	kills cancer cells
B	kills cancer cells	mutates living cells
C	mutates living cells	kills cancer cells
D	mutates living cells	mutates living cells

（2023 夏季 0625/12 第37题）

题型 2：用时间距离屏蔽做防护（考频★★★☆☆）

知识点 电离辐射能使细胞死亡、引起突变，并增加患癌风险。

防护时应缩短_____、增大辐射源与活组织间的_____，并用合适材料_____辐射。

剂量率一定时，累积剂量与受照时间成正比；距离增大或辐射被屏蔽物吸收时，人体所受剂量减小。受照时间常用 s 或 h，距离常用 m。

答案：受照时间；距离；屏蔽并吸收

怎么认 题目出现放射源的安全规则或防护措施时，先逐项判断是否缩短时间、增大距离或使用屏蔽。

一. 逐项套时间距离屏蔽

例题 1

Several scientists are working in a laboratory. The scientists are experimenting with sources which emit ionising radiation. Each scientist is given a list of safety rules.

Three of the rules are shown.

1 Keep at least 2 m away from other people.

2 Do not stay longer than 4 hours per day in the laboratory.

3 Stay behind the lead-lined screen.

Which safety rules are for protection against the effects of ionising radiation?

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

（2023 春季 0625/22 第36题）

解：规则 1 要求与其他人保持距离，未增大人与辐射源的距离，不属于电离辐射防护。
规则 2 限制在实验室内的停留时间，可缩短受照时间。
规则 3 要求站在衬铅屏后，铅可吸收辐射，起屏蔽作用。
符合的是 2 和 3，故选 D。

针对练习

1. Which safety precautions must be taken when using a source of gamma radiation?

1 Reduce the distance between the source and the person.

2 Reduce the time of exposure to the radiation.

3 Use a suitable shielding material between the source and the person.

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

（2025 夏季 0625/21 第37题）

2. What is the most effective precaution to reduce the risk when handling, storing or using a radioactive source that emits γ-rays?

A Handle the source for the least possible time.

B Have a fire extinguisher nearby when using the source.

C Store the source at a low temperature.

D Wear plastic safety goggles when handling the source.

（2023 冬季 0625/12 第37题）

3. An isotope of boron is used in the treatment of cancer in the brain.

Boron sticks to cancer cells in the brain.

(c) Other cancers are treated with gamma radiation. Describe **one** safety precaution a nurse or radiologist takes during this treatment.

（2024 冬季 0625/43 第8题(c)）

4. **(a)** Radioactive isotopes that emit ionising radiation are used in hospitals.

(i) State and explain **two** safety precautions necessary for the use of these isotopes in medical procedures.

(ii) Give **two** reasons why alpha-emitters are **not** used as radioactive tracers inside the body.

（2024 夏季 0625/42 第9题(a)）

二. 用铅容器隔离并管控

知识点 电离辐射会使活细胞死亡，并可能引起突变和癌症。

存放放射性物质时，应缩短接触时间、增大与人体的_____，并用能吸收辐射的材料作_____。

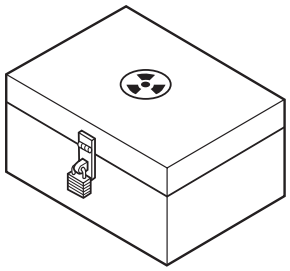
能同时放出 α 粒子、β 粒子和 γ 辐射的放射源，应密封在铅制或铅衬容器中，并锁存在远离人员处。

屏蔽只能减少逸出的辐射，不改变放射源的_____。

答案：距离；屏蔽；衰变速率

怎么认 题目出现放射源、储存容器或铅衬层时，先判断哪种材料能吸收辐射并减少逸出。

例题 2 The diagram shows a lead-lined box used for storing a radioactive source.



Why is the inside of the box lined with lead?

A It helps the source to stay radioactive for longer.

B It makes the box heavier.

C It makes the radioactive source more stable.

D It reduces the amount of radiation that can escape from the box.

（2024 春季 0625/12 第35题）

解：铅能吸收电离辐射，铅衬层可减少从箱内逸出的辐射，而不改变放射源的衰变速率。故选 D。

针对练习

5. A box is used for storing radioactive sources.

What is the best material to use for lining the box to prevent radiation from escaping?

A aluminium

B lead

C paper

D plastic

（2024 夏季 0625/11 第36题）

6. A radioactive source that emits α-particles, β-particles and γ-radiation is stored safely in a container.

From which material should the container be made?

A alumimium

B copper

C paper

D lead

（2025 冬季 0625/23 第37题）

7. **(c)** State **two** precautions for storing radioactive materials safely.

（2025 冬季 0625/33 第9题(c)）

8. What is the safest way to store a radioactive source?

A in a lead-lined box in a metal cabinet

B on a shelf away from other radioactive materials

C in a glass bottle containing oil

D in a fume cupboard

（2024 夏季 0625/13 第36题）