Nuclear physics – 2021 O Level 5054

1. Nov/2021/Paper_11/No.38

Technetium-99m is a radioactive isotope used in medical scanning. It is injected into the body and its emissions are detected outside the body.

Which characteristics of technetium-99m make it suitable for use in medical scanning?

A It has a long half-life and emits alpha radiation.

B It has a long half-life and emits gamma radiation.

C It has a short half-life and emits alpha radiation.

D It has a short half-life and emits gamma radiation.

2. Nov/2021/Paper_11/No.39

Which statement about the production of electricity in a nuclear power station is correct?

A In the reactor, the main reaction occurs when protons hit uranium nuclei.

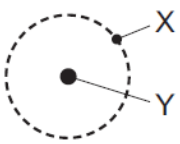
B The process taking place in the reactor is called nuclear fusion.

C The reactor produces energy to boil water and to produce steam.

D Carbon dioxide is the major waste product from the reactor.

3. Nov/2021/Paper_11/No.40

In the simple model of an atom, X orbits around Y.



What are X and Y?

	X	Y
A	electron	nucleus
B	neutron	electron
C	nucleus	proton
D	proton	neutron

4. Nov/2021/Paper_12/No.37

Which statement about the production of electricity in a nuclear power station is correct?

A In the reactor, the main reaction occurs when protons hit uranium nuclei.

B The process taking place in the reactor is called nuclear fusion.

C The reactor produces energy to boil water and to produce steam.

D Carbon dioxide is the major waste product from the reactor.

5. Nov/2021/Paper_12/No.38

A radioactive sample contains an isotope that emits alpha particles.

Which quantity stays constant?

A the half-life of the isotope

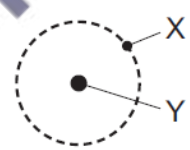
B the mass of the sample

C the number of neutrons in the sample

D the rate of decay of the isotope

6. Nov/2021/Paper_12/No.39

In the simple model of an atom, X orbits around Y.



What are X and Y?

	X	Y
A	electron	nucleus
B	neutron	electron
C	nucleus	proton
D	proton	neutron

7. Nov/2021/Paper_12/No.40

How do the proton numbers (atomic numbers) and the nucleon numbers (mass numbers) of two different isotopes of the same element compare with each other?

	proton number	nucleon number
A	different	different
B	different	same
C	same	different
D	same	same

8. Nov/2021/Paper_21/No.10

The isotope yttrium-90 ($^{90}_{39}Y$) is radioactive. It is a beta-particle emitter that decays to product Q. Product Q is stable.

(a) State one feature that is common to all isotopes of yttrium.

..... [1]

(b) Describe how a **neutral atom** of Q differs from a **neutral atom** of yttrium-90.

.....

.....

.....

..... [3]

(c) A sample of yttrium-90 is placed close to a radiation detector in a laboratory. There are no other radioactive samples in the laboratory. A counter records the count rate.

Fig. 10.1 is a graph of the count rate plotted against time.

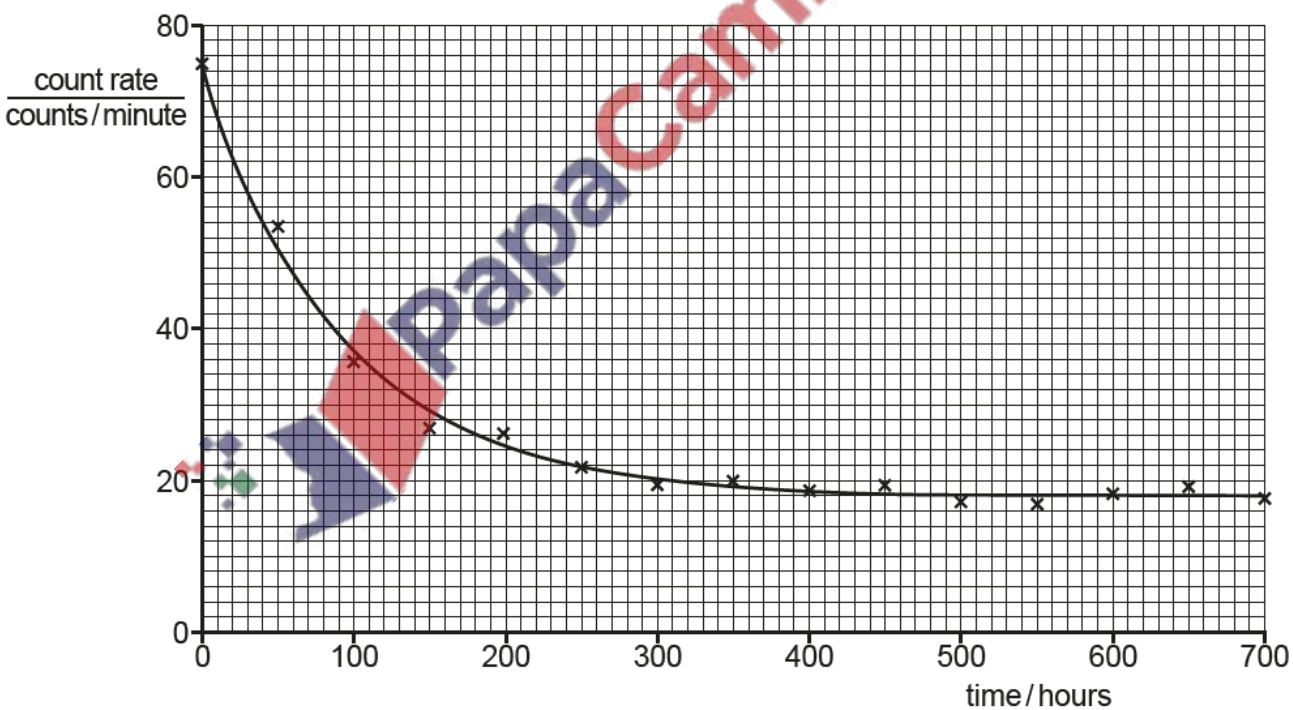


Fig. 10.1

(i) Using Fig. 10.1, determine the average background count rate.

average background count rate = ... [1]

(ii) Suggest **two** different origins for the background count.

1. .....

2. .....

[2]

(iii) Using Fig. 10.1, determine the half-life of yttrium-90. Show how the answer is obtained.

half-life = ... [4]

(iv) Many of the points plotted in Fig. 10.1 do not lie on the best-fit line.

Explain why.

.....

.....

..... [2]

(d) A beam of beta-particles, travelling in a vacuum, enters the region between two parallel, metal plates. One plate is negatively charged and the other is positively charged.

Fig. 10.2 shows the arrangement.

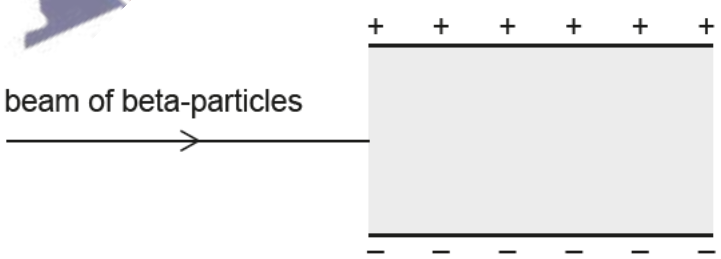


Fig. 10.2

On Fig. 10.2, draw the path taken by the beta-particles as they travel between the two plates.

[2]

[Total: 15]

9. Nov/2021/Paper_22/No.6

Isotope X is radioactive. It decays by alpha-particle emission to a stable isotope.

(a) State how a nucleus of X changes when it emits an alpha-particle.

.....

.....

..... [2]

(b) There is a radiation detector in a laboratory where there are no radioactive samples.

The detector is switched on and shows an average count rate of 22 counts / minute.

(i) State why the radiation detector shows a count rate.

.....

..... [1]

(ii) A sample of isotope X is placed 2 cm from the detector and the reading displayed is 8000 counts / minute.

The sample is moved a distance of 10 cm from the detector. The reading returns to an average value of 22 counts / minute.

Explain why the reading returns to the original value.

.....

.....

..... [2]

(c) An alpha-particle passes into a region where there is a magnetic field. In the magnetic field, a force acts on the alpha-particle so that it follows a circular path. Fig. 6.1 shows that the particle passes through point J.

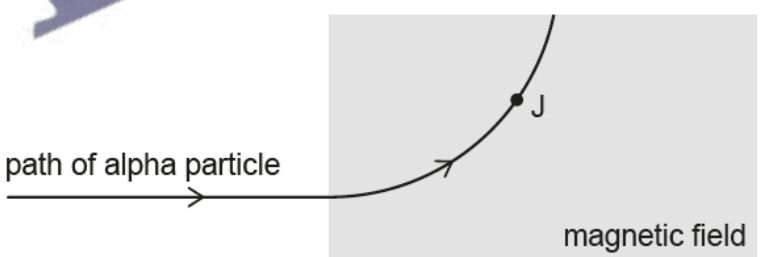


Fig. 6.1

(i) On Fig. 6.1, draw an arrow through point J to show the direction of the force on the alpha-particle at J. [1]

(ii) Determine the direction of the magnetic field and mark a tick in the box (✓) that indicates this direction.

- ☐ to the left
- ☐ to the right
- ☐ towards the top of the page
- ☐ towards the bottom of the page
- ☐ into the page
- ☐ out of the page

[1]

(iii) Explain whether this force does work on the alpha-particle as the particle moves along the circular path.

.....

.....

..... [2]

[Total: 9]

10. June/2021/Paper_11/No.37

Which statement about nuclear fusion is correct?

A Nuclear fusion occurs at low temperatures.

B Nuclear fusion occurs only between heavy nuclei.

C Nuclear fusion occurs in the formation of many stars.

D Nuclear fusion powers most electricity-generating stations.

11. June/2021/Paper_11/No.38

In one radioactive decay, radium-226 decays to radon-222 as shown.

$$^{226}_{88}\text{Ra} \rightarrow {}^{222}_{86}\text{Rn}$$

Which particles are also produced?

A both an alpha-particle and a beta-particle

B an alpha-particle only

C a beta-particle only

D a neutron

12. June/2021/Paper_11/No.39

The count rate from a radioactive source falls from 4000 counts per minute to 500 counts per minute in 72 minutes.

What is the half-life of the source?

A 8 minutes

B 9 minutes

C 18 minutes

D 24 minutes

13. June/2021/Paper_11/No.40

Which particles are found inside the nucleus of an atom?

A neutrons and electrons

B electrons and protons

C neutrons only

D neutrons and protons

14. June/2021/Paper_12/No.39

What does an alpha-particle consist of?

A two electrons and four neutrons only

B two protons and two neutrons only

C two protons and four neutrons only

D two protons, two electrons and two neutrons

15. June/2021/Paper_12/No.40

The count rate from a radioactive source falls from 4000 counts per minute to 500 counts per minute in 72 minutes.

What is the half-life of the source?

A 8 minutes

B 9 minutes

C 18 minutes

D 24 minutes

16. June/2021/Paper_21/No.10

Table 10.1 contains details of the nature and some properties of alpha, beta and gamma emissions.

Table 10.1

	alpha	beta	gamma
nature	2 protons and 2 neutrons		
charge		negative	
penetrating power		stopped by 5 mm of aluminium	

(a) Complete Table 10.1 by filling in the missing details. [6]

(b) Surgical instruments in sealed plastic bags are placed in thin plastic boxes. A conveyor belt takes the boxes close to a cobalt-60 source which sterilises the instruments.

This is shown in Fig. 10.1.

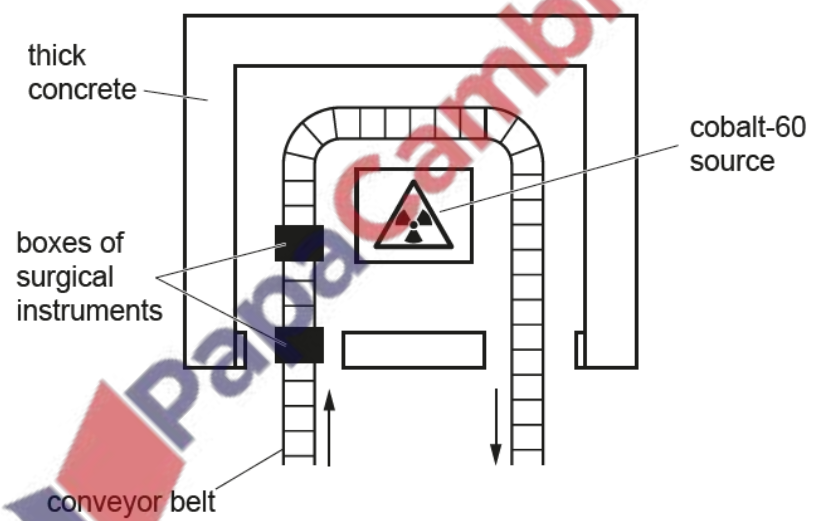


Fig. 10.1 (viewed from above)

The cobalt-60 source is a radioactive isotope of cobalt that emits gamma-radiation.

(i) Describe what is meant by the term *isotope*.

.....

..... [2]

(ii) Suggest a property of gamma-radiation that enables it to sterilise the instruments in the bags in the boxes.

..... [1]

(iii) State why a source emitting only alpha-radiation cannot be used in this way.

.....

..... [1]

(iv) The half-life of cobalt-60 is 5.3 years.

Explain why a source with a half-life of 5.3 minutes is unsuitable for use in this application.

.....

..... [1]

(c) Geiger and Marsden performed an experiment in which alpha-particles were fired at a thin film of gold.

(i) Fig. 10.2 shows an alpha-particle passing close to the nucleus of a gold atom.

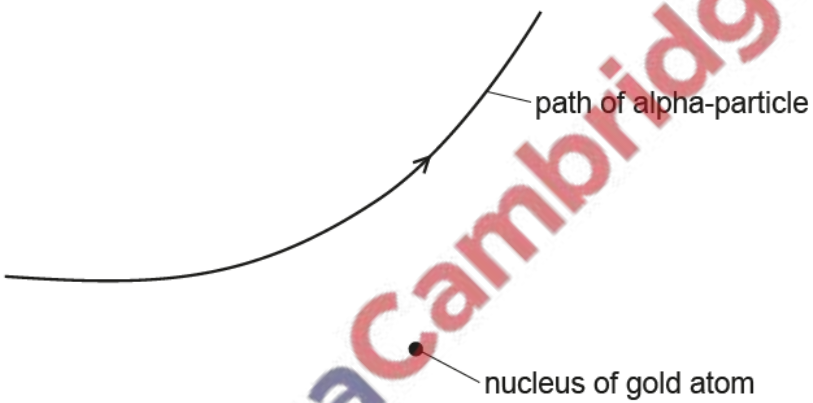


Fig. 10.2

Explain why the alpha-particle is deflected.

.....

..... [2]

(ii) In the experiment, most of the alpha-particles pass straight through the foil without deflection.

Explain, using ideas about the structure of the atom, why this happens.

.....

..... [2]

[Total: 15]

17. June/2021/Paper_22/No.11

A highly radioactive source that emits beta-particles is placed a few centimetres away from a detector, as shown in Fig. 11.1.

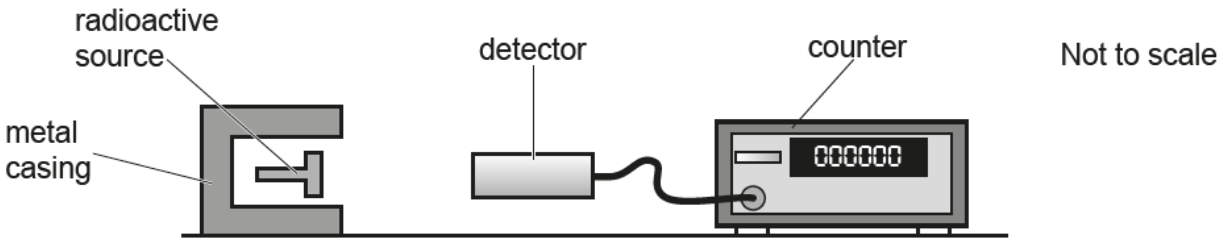


Fig. 11.1

(a) State the name of the particle which has the same mass and charge as a beta-particle.

..... [1]

(b) State and explain why the metal casing in Fig. 11.1 is used.

.....

..... [2]

(c) State and explain what happens to the number of particles detected in a minute as the radioactive source is moved:

(i) a few centimetres **further** away from the source

.....

.....

..... [2]

(ii) more than a metre away from the source.

.....

.....

..... [2]

(d) A nucleus of strontium-90 (Sr-90) decays by beta emission to a nucleus of yttrium (Y).

Complete the decay equation for this decay.

$$^{90}_{38}\text{Sr} \rightarrow {}^{\cdots\cdots}_{\cdots\cdots}\text{Y} + {}^{\cdots\cdots}_{-1}\beta$$

[3]

(e) Nuclear fusion and nuclear fission both release large amounts of energy.

(i) Describe how the process of nuclear fusion differs from the process of nuclear fission.

.....

.....

.....

.....

..... [3]

(ii) Describe the conditions needed for nuclear fusion to take place.

.....

.....

.....

..... [2]

[Total: 15]