Do not write outside the box

0 7 Alpha particles, beta particles and gamma rays are types of nuclear radiation.

0 7 . 1 What does an alpha particle consist of?

[1 mark]

____

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0 7 . 2 A krypton (Kr) nucleus decays into a rubidium (Rb) nucleus by emitting a beta particle.

Complete the nuclear equation for this decay by writing the missing number in each box.

[2 marks]

$$^{\square}_{36}\mathrm{Kr} \longrightarrow {}^{85}_{\square}\mathrm{Rb} + {}^{0}_{-1}\mathrm{e}$$

0 7 . 3 Internal contamination of the human body means radioactive material is inside the human body.

Explain how the risk from internal contamination is different to the risk from external irradiation by a source of alpha radiation.

[5 marks]

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8

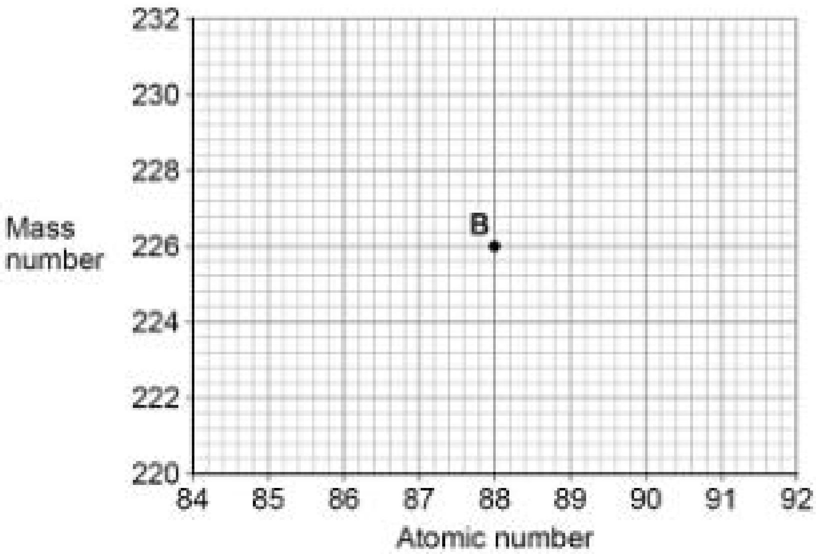
Do not write outside the box

0 6 . 3 Nucleus **B** decays by emitting an alpha particle.

Draw an arrow on **Figure 7** to represent the alpha decay.

[2 marks]

Figure 7



0 6 . 4 What is meant by the 'random nature of radioactive decay'?

[1 mark]

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Do not write outside the box

0 5 Radioactive waste from nuclear power stations is a man-made source of background radiation.

0 5 . 1 Give **one** other man-made source of background radiation.

[1 mark]

Nuclear power stations use the energy released by nuclear fission to generate electricity.

0 5 . 2 Give the name of **one** nuclear fuel.

[1 mark]

0 5 . 3 Nuclear fission releases energy.

Describe the process of nuclear fission inside a nuclear reactor.

[4 marks]

Do not write outside the box

0 5 . 4 A new type of power station is being developed that will generate electricity using nuclear fusion.

Explain how the process of nuclear fusion leads to the release of energy.

[2 marks]

0 5 . 5 Nuclear fusion power stations will produce radioactive waste. This waste will have a much shorter half-life than the radioactive waste from a nuclear fission power station.

Explain the advantage of the radioactive waste having a shorter half-life.

[2 marks]

10

Turn over for the next question

0 9 A student models the random nature of radioactive decay using 100 dice.

He rolls the dice and removes any that land with the number 6 facing upwards.

He rolls the remaining dice again.

The student repeats this process a number of times.

Table 1 shows his results.

Table 1

Roll number	Number of dice remaining
0	100
1	84
2	70
3	59
4	46
5	40
6	32
7	27
8	23

0 9 . 1 Give **two** reasons why this is a good model for the random nature of radioactive decay.

[2 marks]

1 ____

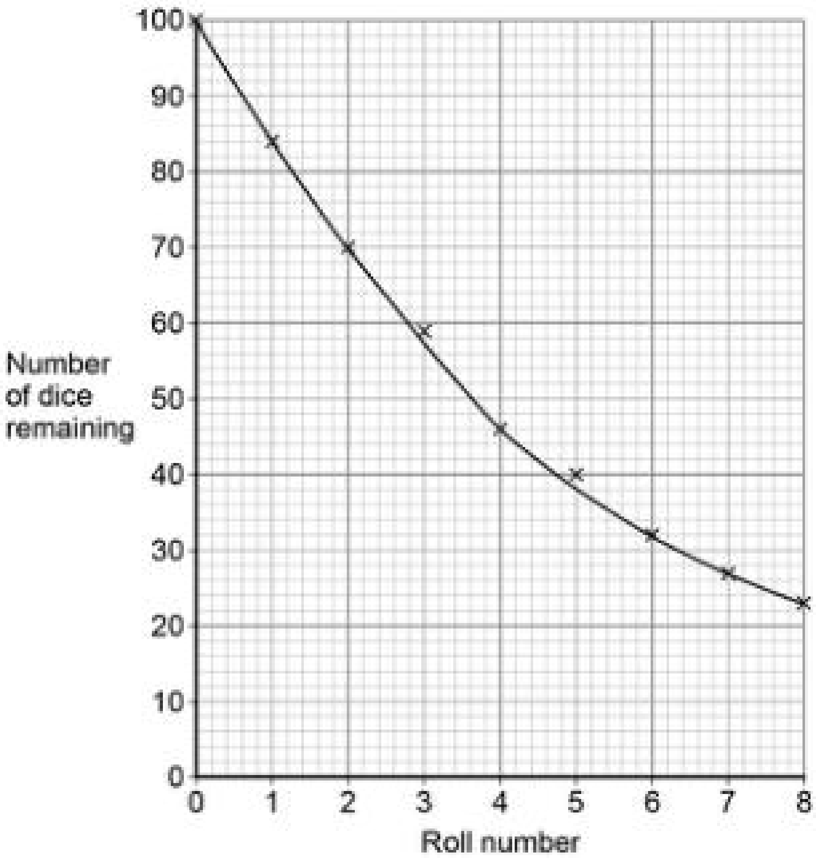
____

2 ____

____

The student's results are shown in **Figure 11**.

Figure 11



0 9 . 2 Use **Figure 11** to determine the half-life for these dice using this model.

Show on **Figure 11** how you work out your answer.

[2 marks]

Half-life = ____________________ rolls

Question 9 continues on the next page

A teacher uses a protactinium (Pa) generator to produce a sample of radioactive material that has a half-life of 70 seconds.

In the first stage in the protactinium generator, uranium (U) decays into thorium (Th) and alpha (α) radiation is emitted.

The decay can be represented by the equation shown in **Figure 12**.

Figure 12

$$^{238}_{92}U \longrightarrow \,^{234}_{\boxed{}}Th + \alpha$$

0 9 . 3 Determine the atomic number of thorium (Th) 234.

[1 mark]

Atomic number = ____________________

When protactinium decays, a new element is formed and radiation is emitted.

The decay can be represented by the equation shown in **Figure 13**.

Figure 13

$$^{234}_{91}Pa \rightarrow \,^{234}_{92}X + radiation$$

0 9 . 4 When protactinium decays, a new element, **X**, is formed.

Use information from **Figure 12** and **Figure 13** to determine the name of element **X**.

[1 mark]

____

A teacher uses a protactinium (Pa) generator to produce a sample of radioactive material that has a half-life of 70 seconds.

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[1 mark]

Atomic number = ____________________

When protactinium decays, a new element is formed and radiation is emitted.

The decay can be represented by the equation shown in **Figure 13**.

Figure 13

$$^{234}_{91}Pa \rightarrow {}^{234}_{92}X + radiation$$

0 9 . 4 When protactinium decays, a new element, **X**, is formed.

Use information from **Figure 12** and **Figure 13** to determine the name of element **X**.

[1 mark]

____

0 9 . 5 Determine the type of radiation emitted as protactinium decays into a new element.

Give a reason for your answer.

[2 marks]

0 9 . 6 The teacher wears polythene gloves as a safety precaution when handling radioactive materials.

The polythene gloves do **not** stop the teacher's hands from being irradiated.

Explain why the teacher wears polythene gloves.

[2 marks]

Turn over for the next question

2 (a) (ii) Over one year, a person may get a higher than average dose of radiation from cosmic rays.

Suggest **one** reason why.

[1 mark]

___

___

2 (a) (iii) Some sources of background radiation are man-made.

Name **one** man-made source of background radiation.

[1 mark]

___

___

2 (b) Before using a radioactive source a teacher measured the background radiation in her laboratory. She did this three times. The measurements were taken correctly but the three measurements were different.

Why were the three background measurements different?

[1 mark]

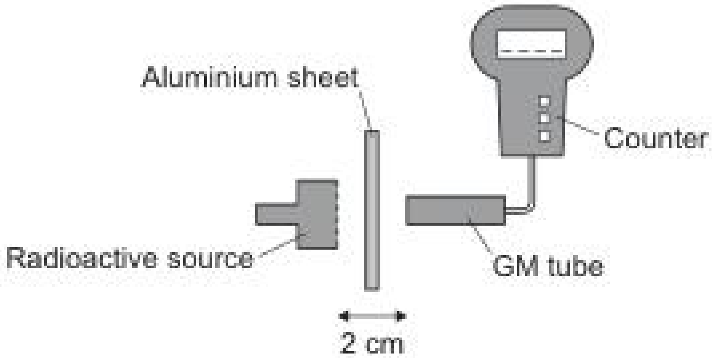
___

___

Question 2 continues on the next page

2 (c) **Figure 2** shows the apparatus the teacher used to investigate the radiation emitted by a source.

Figure 2



The teacher changed the thickness of the aluminium between the source and the Geiger-Müller (GM) tube.

The number of counts recorded for each thickness is given in **Table 1**.
The mean background measurement was 20 counts in one minute.

Table 1

Thickness of aluminium in millimetres	**Counts in one minute**
2	350
4	68
6	20

2 (c) (i) A student concluded that the radioactive source emits beta radiation.

Explain how the information in **Table 1** supports this conclusion.

[2 marks]

Do not write outside the box

2 (d) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

The type of radiation emitted from a radioactive source can be identified by comparing the properties of the radiation to the properties of alpha, beta and gamma radiation.

Describe the properties of alpha, beta and gamma radiation in terms of their:

- penetration through materials
- range in air
- deflection in a magnetic field.

[6 marks]

Extra space

10

Turn over ▶

Do not write outside the box

3 (c) In 1991, scientists produced the first controlled release of energy from an experimental nuclear **fusion** reactor. This was achieved by fusing the hydrogen isotopes, deuterium and tritium.

Deuterium is naturally occurring and can easily be extracted from seawater. Tritium can be produced from lithium. Lithium is also found in seawater.

Table 2 gives the energy released from 1 kg of fusion fuel and from 1 kg of fission fuel.

Table 2

Type of fuel	Energy released from 1 kg of fuel in joules
Fusion fuel	3.4×10^{14}
Fission fuel	8.8×10^{13}

3 (c) (i) Suggest **two** advantages of the fuel used in a fusion reactor compared with plutonium and the other substances used as fuel in a fission reactor.

[2 marks]

1 ....

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2 ....

....

....

3 (c) (ii) Some scientists think that by the year 2050 a nuclear fusion power station capable of generating electricity on a large scale will have been developed.

Suggest **one** important consequence of developing nuclear fusion power stations to generate electricity.

[1 mark]

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....

Question 3 continues on the next page

Turn over ▶

Do not write outside the box

3 (d) Tritium is radioactive.

After 36 years, only 10 g of tritium remains from an original sample of 80 g.

Calculate the half-life of tritium.

Show clearly how you work out your answer.

[2 marks]

....

....

Half-life = ... years

9

Do not write outside the box

3 (d) Tritium is radioactive.

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Calculate the half-life of tritium.

Show clearly how you work out your answer.

[2 marks]

....

....

Half-life = ... years

9