1 (a) Americium-241 is a radioactive isotope that emits alpha particles.

Americium-241 is used in smoke alarms.

Give a reason why it is safe to use americium-241 in smoke alarms.

(1)

.....

.....

(b) Iodine-131 is a radioactive isotope with a half-life of 8 days.

The activity of a sample of iodine-131 is 480 Bq.

Calculate the activity of the sample after 16 days.

(2)

activity = ... Bq

(c) A student uses 59 dice to model radioactive decay.

He starts by rolling all the dice at the same time.

He removes all the dice that show a six.

He then rolls the remaining dice.

The student repeats this process five more times.

State **two** improvements the student could make to his model of radioactive decay.

(2)

1 .....

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2 .....

.....

*(d) Radioactive isotopes can be used to investigate cancer and other illnesses.

The thyroid gland in the neck absorbs most of the iodine that our bodies need.

A person can become ill if their thyroid absorbs too little iodine.

Explain how a radioactive isotope with suitable properties may be used to investigate the uptake of iodine by this gland.

(6)

(Total for Question 10 = 11 marks)

Cyclotrons and collisions

2 (a) Cyclotrons are used to make radioactive isotopes for medical purposes.

Charged particles move in a circular path.

(i) Complete the sentence by putting a cross (☒) in the box next to your answer.

The field used to keep charged particles moving in a circular path in a cyclotron is

(1)

☐ **A** nuclear

☐ **B** magnetic

☐ **C** gravitational

☐ **D** electric

(ii) State what causes the charged particles to increase their speed as they go around the cyclotron.

(1)

.....

(iii) Describe how scientists use the charged particles from a cyclotron to produce radioactive isotopes.

(2)

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(b) Some radioacti

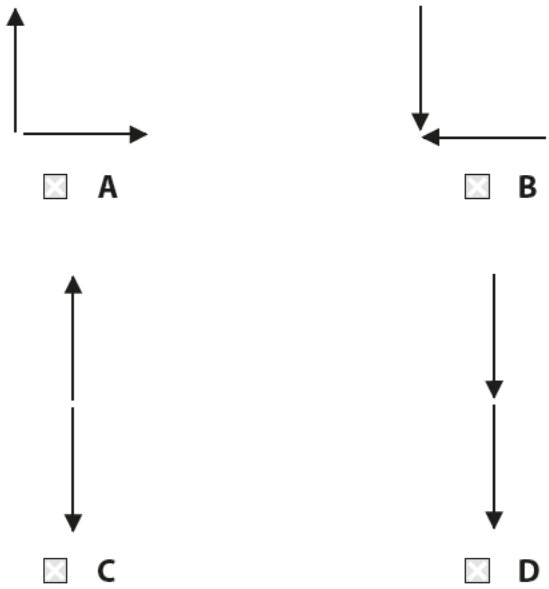
Positrons are used to make gamma rays.

When a positron annihilates an electron, two gamma rays are produced.

(i) Which diagram shows the directions of the two gamma rays produced?

Put a cross (☒) in the box next to your answer.

(1)



(ii) Explain how charge is conserved when an electron annihilates a positron.

(3)

.....

.....

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(iii) Explain how mass and energy are conserved when an electron annihilates a positron.

(2)

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(Total for Question 4 = 10 marks)

Radioactive sources

3 (a) Cobalt-60 is a radioactive substance.
A nucleus of cobalt-60 contains 27 protons and 33 neutrons.

(i) Complete the sentence by putting a cross (☒) in the box next to your answer.

The number of electrons in a neutral atom of cobalt-60 is

(1)

☐ **A** 87

☐ **B** 60

☐ **C** 33

☐ **D** 27

(ii) Cobalt-60 decays by emitting gamma radiation.

Explain what happens to the mass of a cobalt-60 atom when a gamma ray is emitted.

(2)

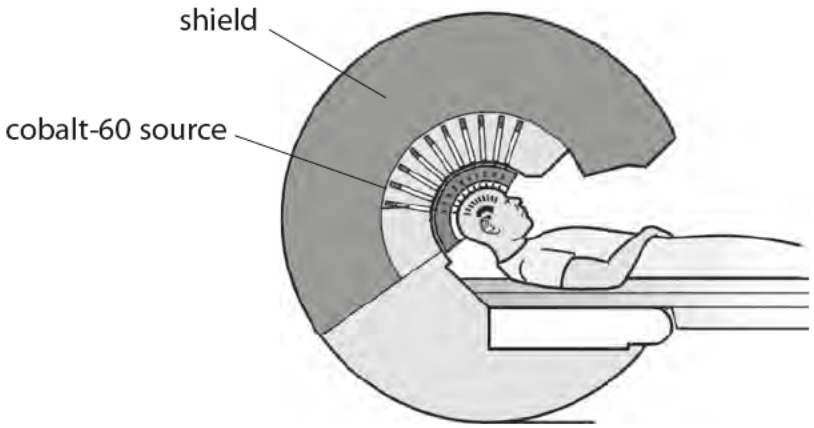
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(b) Gamma radiation from cobalt-60 can be used to destroy tumours.
The diagram shows how gamma radiation is used to destroy a brain tumour.



(i) Complete the sentence by putting a cross (☒) in the box next to your answer.

Gamma radiation is used because

(1)

☒ **A** gamma can penetrate further than alpha or beta

☒ **B** gamma is more ionising than alpha or beta

☒ **C** gamma is always safer than alpha or beta

☒ **D** gamma has a shorter half-life than alpha or beta

(ii) Describe what the shield is used for.

(2)

.....

.....

.....

.....

(iii) Suggest **two** advantages that this kind of treatment has over other forms of treatment for tumours.

(2)

1 .....

.....

2 .....

.....

(iv) Explain why several beams of gamma radiation are used instead of just one.

(2)

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(Total for Question 4 = 10 marks)