1 In a nuclear reactor, a uranium-235 nucleus absorbs a neutron and fission occurs.

(a) Complete the equation below that shows a typical fission reaction.

(2)

$$^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow {}^{142}_{\ \ }\text{Ba} + {}^{\ \ }_{36}\text{Kr} + 3\,{}^{1}_{0}\text{n}$$

(b) Explain how nuclear fission can lead to a chain reaction.

(3)

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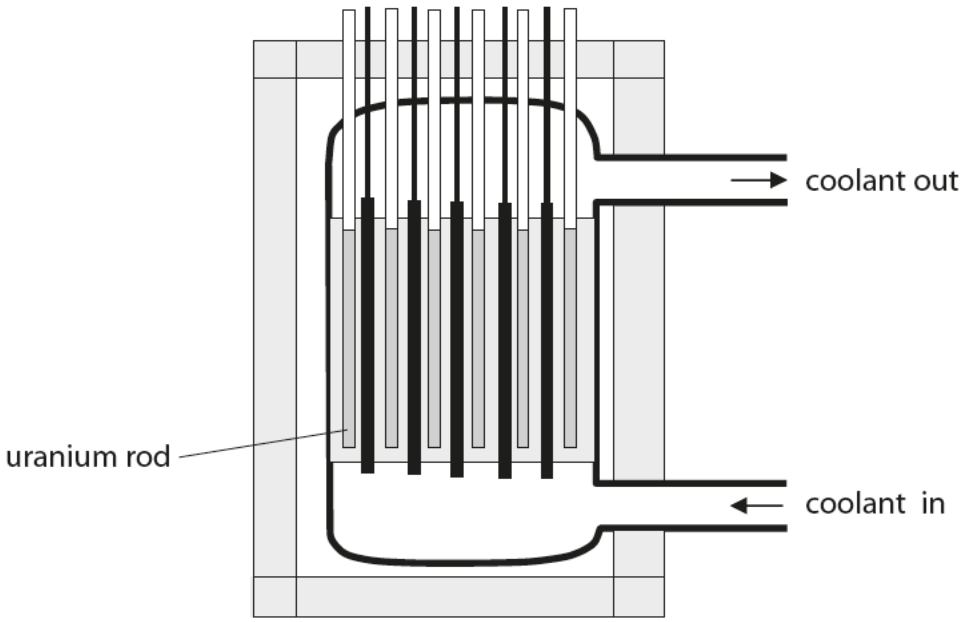
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(c) The diagram shows a nuclear reactor.



(i) On the diagram, label the control rods and the shielding.

(2)

(ii) Explain why the shielding is needed.

(2)

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(Total for Question 1 = 9 marks)

2 The table describes the nuclei of four atoms.

uranium-234	uranium-235	plutonium-238	americium-238
$^{234}_{92}U$	$^{235}_{92}U$	$^{238}_{94}Pu$	$^{238}_{95}Am$

(a) Atoms contain electrons.

Which nucleus needs the largest number of electrons to form a neutral atom?

(1)

☒ **A** uranium-234

☒ **B** uranium-235

☒ **C** plutonium-238

☒ **D** americium-238

(b) (i) Which two nuclei have the same number of protons?

(1)

..... and .....

(ii) Which two nuclei have the same number of nucleons?

(1)

..... and .....

(iii) Which two nuclei have the same number of neutrons?

(1)

..... and .....

(c) All of the nuclei are unstable and have a different half-life.

(i) Explain what is meant by the term **unstable**.

(1)

.....

.....

(ii) Explain what is meant by the term **half-life**.

(2)

.....

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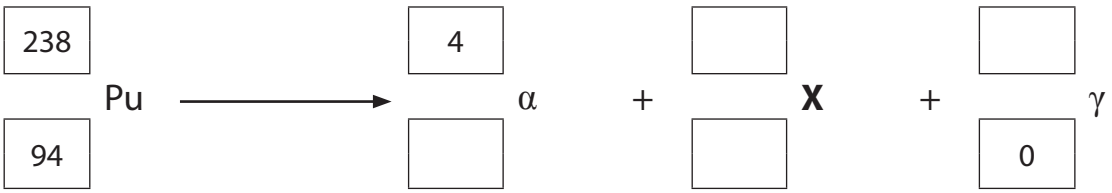
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(d) When plutonium decays, it emits an alpha particle and a gamma ray.

(i) Complete the decay equation for plutonium-238.

(4)



(ii) Use information from the table to identify element X.

(1)

element X = ...

(e) The nucleus of americium-238 can absorb an electron.

When this happens, one of the protons in the nucleus becomes a neutron.

This equation describes the process.

$$\begin{array}{ccccc} 1 & & 0 & & 1 \\ p & + & e & \longrightarrow & n \\ 1 & & -1 & & 0 \end{array}$$

(i) Describe how this process affects the proton number and the nucleon number of the nucleus that absorbs the electron.

(2)

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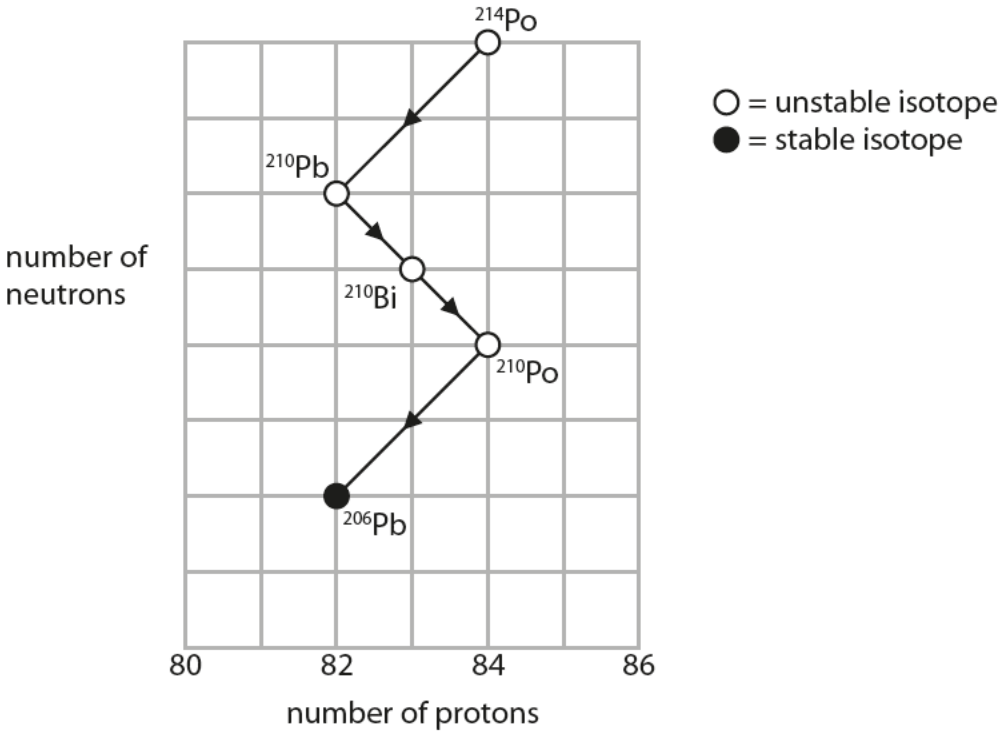
(ii) Identify the new nucleus formed by this process.

(1)

.....

(Total for Question 2 = 15 marks)

3 The grid shows the number of neutrons and the number of protons in some isotopes formed during successive radioactive decays.



(a) (i) What are **isotopes**?

(2)

.....

.....

.....

.....

(ii) Why are some isotopes described as **stable**?

(1)

.....

.....

(b) (i) Use the grid to **calculate** the number of neutrons in a ^{210}Po nucleus.

(1)

number of neutrons = ...

(ii) Describe what happens to the number of protons and the number of neutrons when a nucleus of ^{210}Pb decays to form ^{210}Bi.

(2)

.....

.....

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.....

(iii) State the type of decay that occurs when ^{210}Pb decays to form ^{210}Bi.

(1)

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(c) Explain why the mass (nucleon) number and the atomic (proton) number do not change when a gamma ray is emitted from a nucleus.

(2)

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(Total for Question 3 = 9 marks)

4 Radon is a gas produced by some types of rocks.

(a) Radon is a natural source of radioactivity.

What is the name for this radioactivity?

(1)

- ☒ **A** background radiation
- ☒ **B** chain reaction
- ☒ **C** radioactive dating
- ☒ **D** radiotherapy

(b) There are two sources of alpha radiation in some houses:

- radon gas in the air
- solid americium in a smoke alarm

The alpha particles from radon are a greater risk to health than the alpha particles from americium.

Explain why.

(2)

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(c) Radon-222 and radon-220 are both isotopes of radon.

(i) A nucleus of radon-222 has 86 protons.

How many protons are there in a nucleus of radon-220?

(1)

- ☒ **A** 86
- ☒ **B** less than 86
- ☒ **C** more than 86
- ☒ **D** none

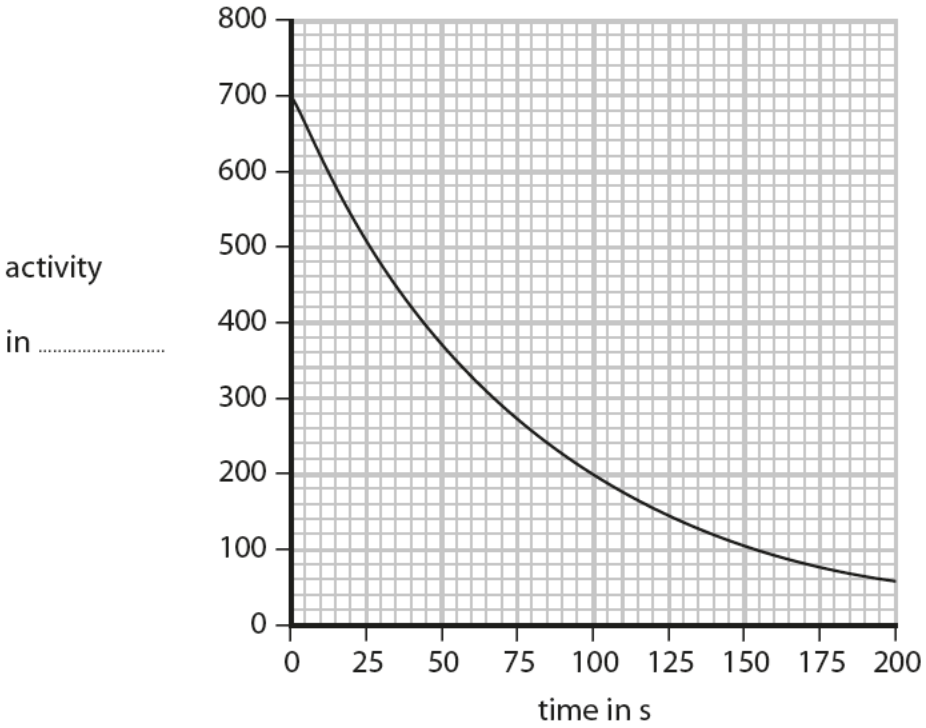
(ii) A nucleus of radon-222 has 136 neutrons.

How many neutrons are there in a nucleus of radon-220?

(1)

- ☒ **A** 86
- ☒ **B** 134
- ☒ **C** 136
- ☒ **D** 220

(d) The graph shows how the activity of a sample of radon-220 changes with time.



(i) Complete the graph by adding the missing unit for activity.

(1)

(ii) Explain what is meant by the term **half-life**.

(2)

.....

.....

.....

(iii) Use the graph to find a value for the half-life of radon-220.

(2)

Half-life = ... s

(Total for Question 4 = 10 marks)

5 Scientists use the term radiation in different ways.

Sometimes radiation means streams of particles and sometimes radiation means high frequency waves.

(a) Draw a straight line from each description to the type of radiation it describes.

(3)

description	type of radiation
electromagnetic waves	alpha
particles with a negative charge	beta
particles with a positive charge	gamma
	neutron

(b) Alpha, beta and gamma radiations are described as ionising.

(i) Complete the table to show alpha, beta and gamma radiations in order of increasing ionisation.

(1)

least ionising → most ionising

(ii) Describe two ways in which these ionising radiations can cause harm.

(2)

1. .....

.....

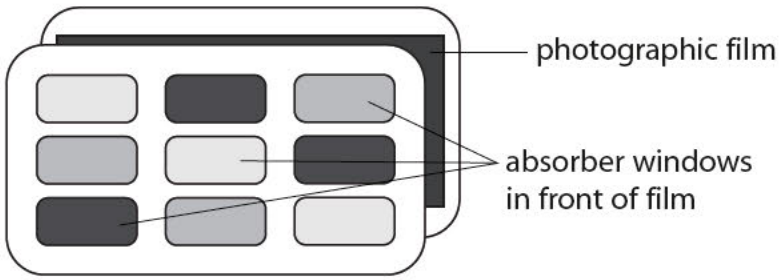
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(c) People who work with ionising radiations need to measure the amount of radiation they are exposed to.

For many years, a film badge was used to detect the radiations.

The diagram shows how a film badge is constructed.



Each absorber window is made from different thicknesses of paper, aluminium or lead.

Complete the table to show if alpha, beta and gamma radiations penetrate each material. Some have been done for you.

Use the words 'goes through' or 'stopped'.

(3)

	0.1 cm paper	**0.5 cm aluminium**	**0.5 cm lead**
alpha radiation			stopped
beta radiation		stopped	
gamma radiation	goes through		

(d) State the name of another device that can be used to detect alpha radiation.

(1)

.....

(Total for Question 5 = 10 marks)

6 Alpha particles, beta particles and gamma rays have different properties.

(a) Complete the table by ticking the correct type of radiation for each property.

The first one has been done for you.

(2)

Property	Type of radiation		
	alpha particles	**beta particles**	**gamma rays**
most ionising	✓		
largest mass			
most penetrating			
highest speed			
negatively charged			

(b) The symbol for the structure of an alpha particle is

$$^{4}_{2}\alpha$$

(i) State the number of neutrons and the number of protons in an alpha particle.

(2)

number of neutrons.....

number of protons.....

(ii) Suggest why alpha radiation is more ionising than beta or gamma radiation.

(1)

.....

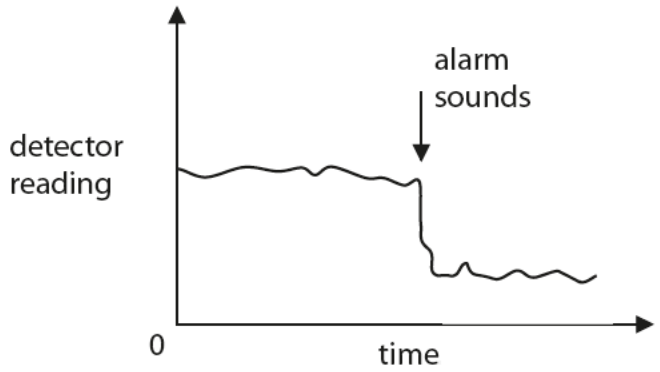
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(c) A smoke alarm contains a source of alpha particles and a detector.

The alpha particles reach the detector through a sample of air from the room.

The alarm sounds if there is a sudden drop in the detector reading.

This graph shows changes in the detector reading.



(i) Why is the detector reading never zero?

(1)

.....

.....

(ii) Why is the detector reading never constant?

(1)

.....

.....

(iii) Suggest why fewer alpha particles reach the detector if there is a fire.

(2)

.....

.....

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.....

(Total for Question 6 = 9 marks)