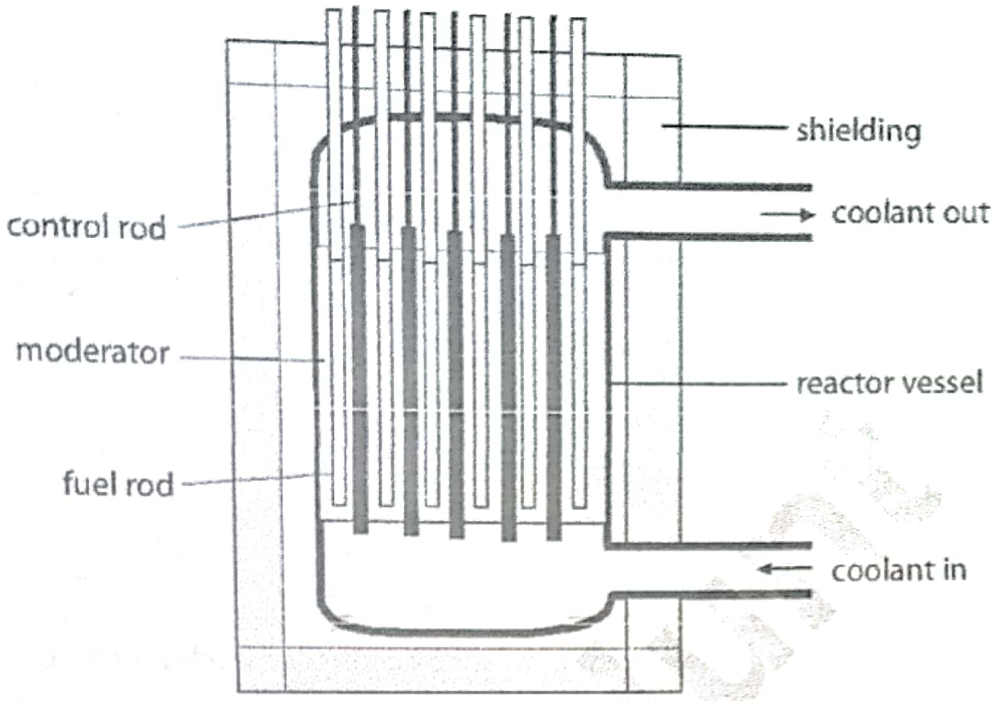
1 The diagram shows the main parts of a nuclear reactor.



(a) Draw a line linking each part of the reactor with its main function.

The first one has been done for you.

part of reactor	main function
control rod	controls the rate of fission
coolant	absorbs dangerous radiation
fuel rod	contains uranium for fission
shielding	removes energy from the reactor

(b) State the type of energy released in a fission reaction.

Kinetic energy

(c) Explain the role of the moderator in a fission reaction.

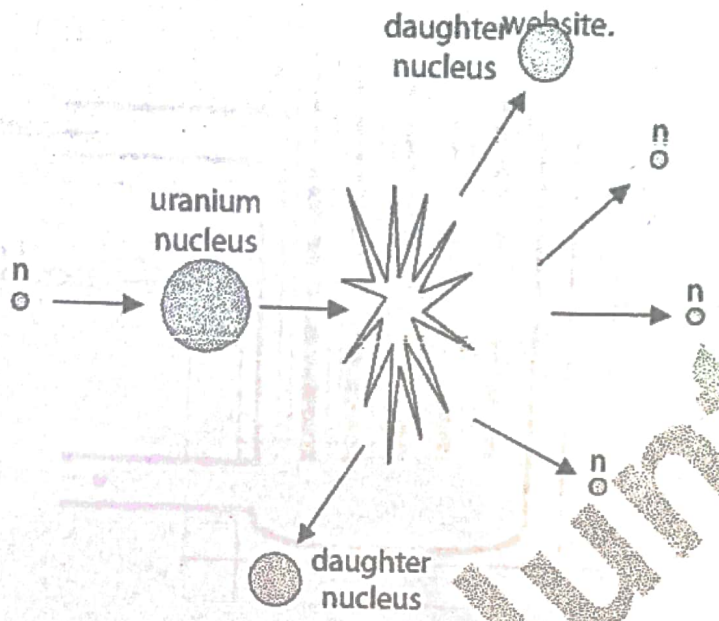
The moderator slows down the neutrons so that neutrons can be absorbed by uranium

(d) Explain, in terms of neutrons, what is meant by controlled nuclear fission.

The nuclear fission is caused by a single neutron. When a nucleus absorbs a neutron, it decays and split into daughter nucleus and releases more than one neutron. These excess neutrons can speed up the reaction. Control rods absorb neutrons to regulate the rate of fission

(Total for Question 1 = 8 marks)

2 A student finds this representation of nuclear fission on a website.



(a) Describe what happens when nuclear fission of uranium occurs.

(3)

Uranium absorbs a neutron and becomes unstable. It decays and splits into two daughter nucleus, Barium and Krypton and 3 neutrons. These neutrons are then absorbed by other uranium atoms.

(b) The daughter nuclei move off with high speed.

Name the type of energy that this gives them.

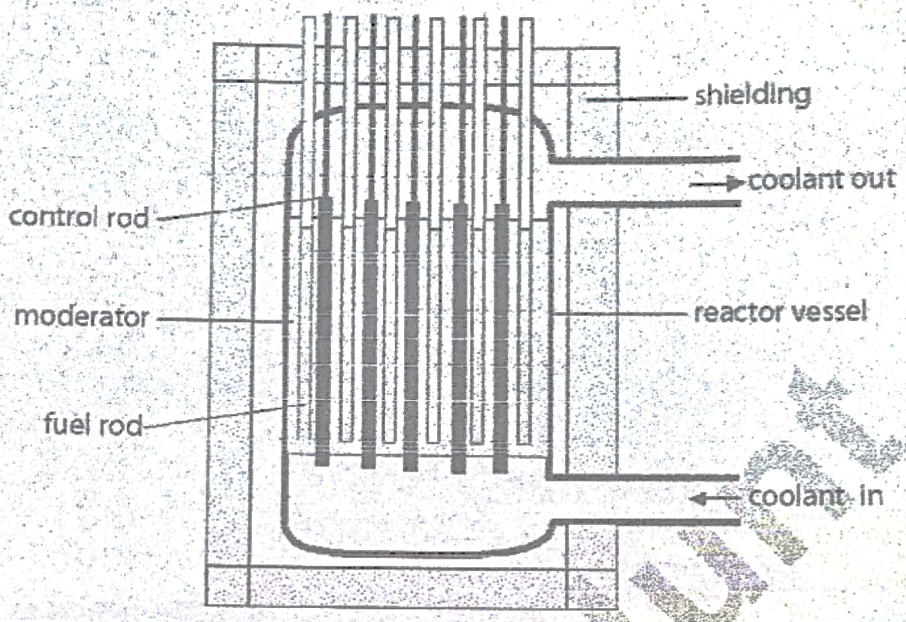
(1)

Kinetic energy

(Total for Question 2 = 4 Marks)

3 The diagram shows the main parts of a nuclear reactor.

In the nuclear reactor uranium-235 nuclei undergo fission in a controlled chain reaction.



(a) Describe nuclear fission and how the chain reaction is controlled.

Use terms from the diagram to help you.

(5)

Uranium absorbs neutron and becomes unstable. It then decays and splits into two daughter nucleus, barium and Krypton and releases extra neutron, and energy. The moderator slows down the neutrons, so that it can be absorbed by other Uranium atoms. Extra neutrons speed up the rate of fission and control rods absorb neutrons to regulate the rate of fission.

(b) State the form of energy that is released during fission.

kinetic energy

(c) How does the shielding improve safety?

(1)

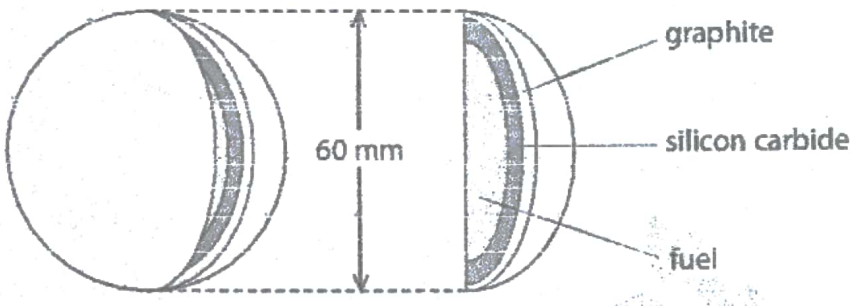
The shielding absorbs radiation and stops radiation from escaping.

(Total for Question 3 = 7 marks)

4 (a) The diagram shows the fuel used in some nuclear reactors.

The fuel is contained inside spheres.

The silicon carbide layer of each sphere is designed to contain the fission products for at least one million years.



section through a fuel sphere

(i) Give the name of a fuel that could be used.

(1)

Uranium

(ii) Explain what is meant by the term **fission products**.

(2)

Fission products are particles that are formed after fission. The daughter nucleus, krypton and barium and the neutrons released are the fission product when Uranium decays.

(iii) Explain why it is important to contain these fission products for such a long time.

(2)

The fission products are still radioactive and emits radiation which may be harmful for people. They have a long halflife.

(iv) The graphite layer in every fuel sphere acts as a moderator.

What is the function of the moderator in a nuclear reactor?

The moderator slows down the neutrons so that it can be absorbed by the uranium

(v) The nuclear reactor also contains boron control rods.

Explain why it is dangerous to remove most of the control rods from the reactor.

Fewer neutrons would be absorbed, the rate of fission would increase, more energy will be released which may result in the meltdown of the reactor.

(b) The reactor is cooled with helium gas.

The gas enters the reactor at 500 °C.

(i) What is this temperature in kelvin?

(1)

temperature = 773 K

(ii) Helium gas enters the reactor at a pressure of 8.40 MPa and leaves the reactor at a temperature of 1170 K.

Calculate the pressure of the helium gas as it leaves the reactor.
[assume the volume of the gas does not change]

(3)

$$\frac{8.4}{773} = \frac{P_2}{1170}$$

$$\Rightarrow P_2 = \frac{1170 \times 8.4}{773}$$

$$= 13$$

pressure = 13 MPa

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

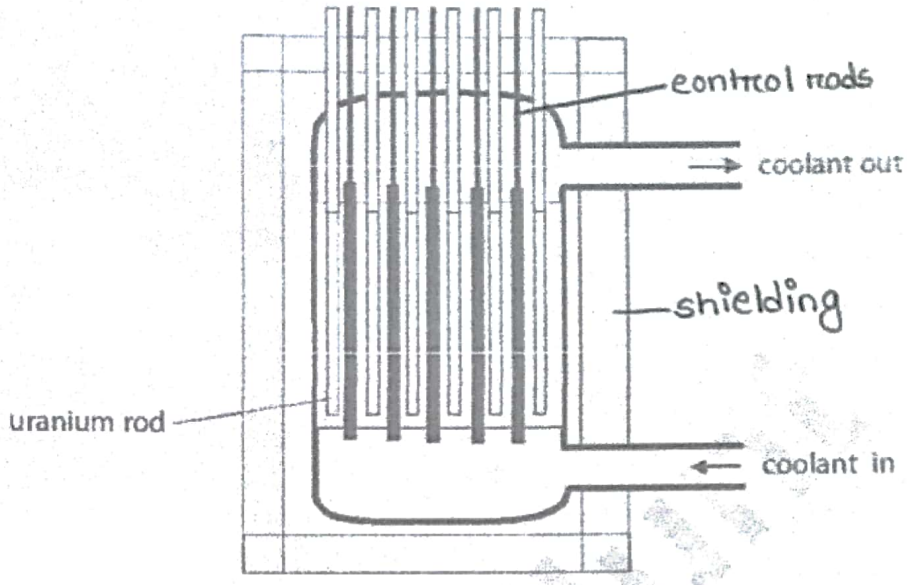
(a) Complete the equation below that shows a typical fission reaction.

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{142}_{56}Ba + ^{91}_{36}Kr + 3\,^{1}_{0}n$$

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

The nucleus of Uranium-235 absorbs a neutron and becomes unstable. It decays and splits into daughter nuclei and releases extra neutrons. These extra neutrons are then absorbed by other uranium nuclei, which leads to a chain reaction

(c) The diagram shows a nuclear reactor.



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

(ii) Explain why the shielding is needed.

The reactor waste are radioactive. These can damage cells and cause cancere. Shielding absorbs these dangerous radiation.

6

The table describes the nuclei of four atoms.

uranium-234	uranium-235	plutonium-238	americium-238
234 U 92	235 U 92	238 Pu 94	238 Am 95

(a) Atoms contain electrons.

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

- ☐ **A** uranium-234
- ☐ **B** uranium-235
- ☐ **C** plutonium-238
- ☒ **D** americium-238

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

Uranium - 234 and Uranium - 235

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

Plutonium - 238 and americium - 238

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

Uranium - 235 and Americium - 238

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

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

The term unstable refers to a nuclei that will decay and emit radiation

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

Half life is the amount of time taken for any radioactive substance to reduce to half. Each radioactive isotope decays in different speeds and has different half-life

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

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

$$\begin{matrix} 238 \\ 94 \end{matrix} \text{Pu} \longrightarrow \begin{matrix} 4 \\ 2 \end{matrix} \alpha + \begin{matrix} 234 \\ 92 \end{matrix} X + \begin{matrix} 0 \\ 0 \end{matrix} \gamma$$

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

element X = Uranium - 234

(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.

$$^{1}_{1}p + ^{0}_{-1}e \longrightarrow ^{1}_{0}n$$

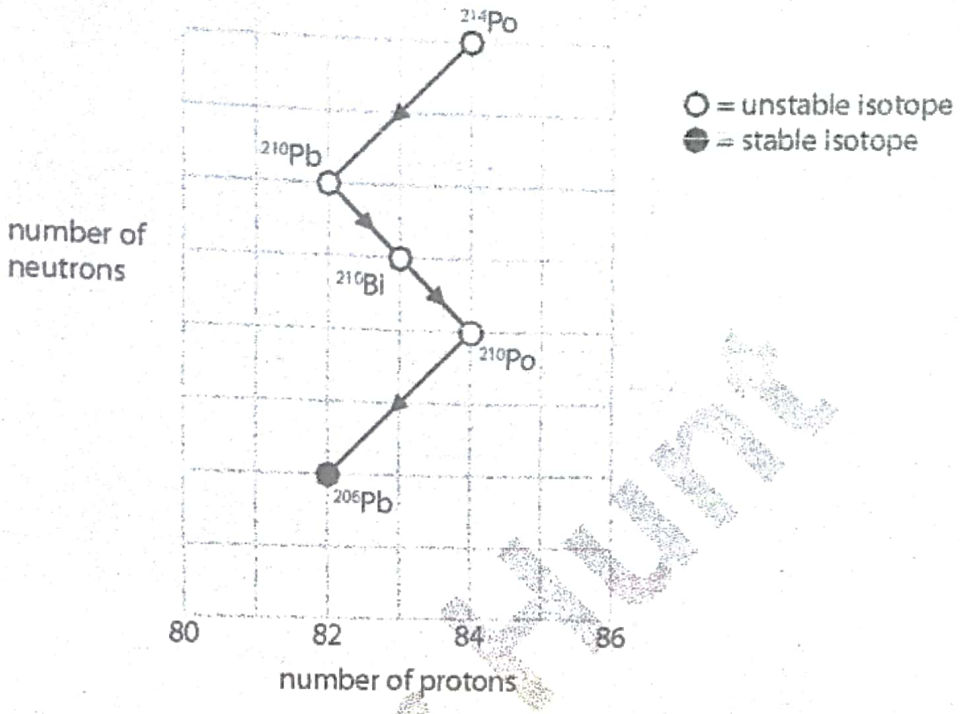
(i) Describe how this process affects the proton number and the nucleon number of the nucleus that absorbs the electron.

The nucleon number remains unchanged.
The proton number decreases by 1.

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

Plutonium -238

7 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)

Isotopes are atoms of the same element that has the same atomic number but different mass number

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

(1)

because they do not emit radiation

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

number of neutrons = 126

(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.

Proton number increases by 1.
Neutron number decreases by 1.

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

Beta

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

Gamma rays donot have a mass number or proton number.
Gamma is a electromagnetic radiation.

8 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?

- [x] 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.

Radon is a gas so the alpha particles are mobile. While, americium is solid so the particles stay in place. Radon can be inhaled, but solid americium stays within the smoke alarm.

(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?

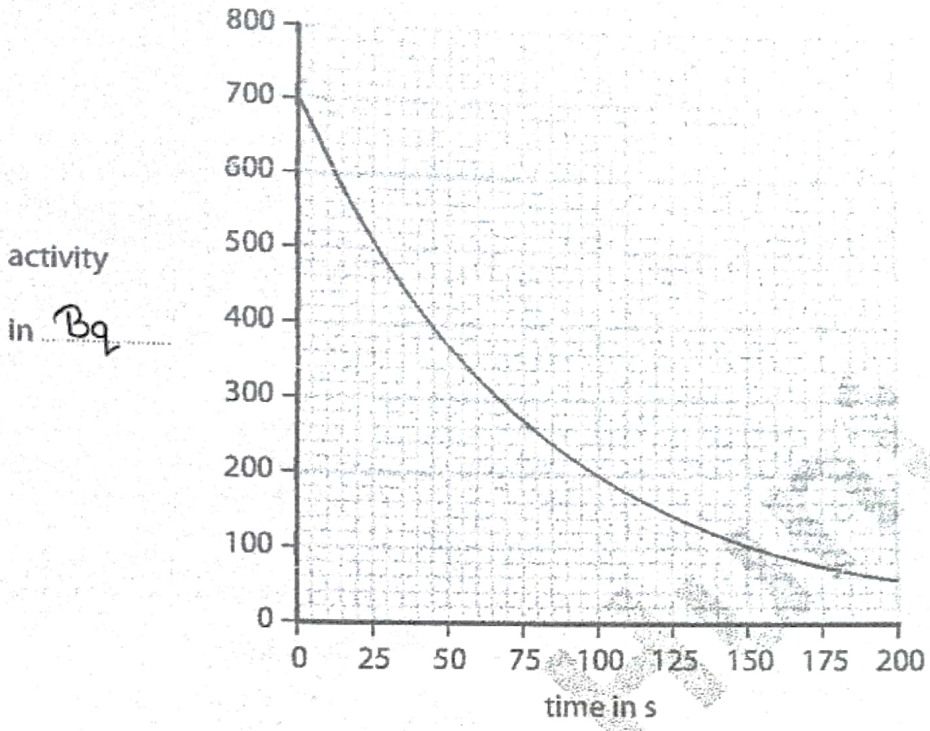
- [x] A 86
- [ ] B less than 86
- [ ] C more than 86
- [ ] D none

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

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

- [ ] A 86
- [x] 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.

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

Half life is the amount of time taken for any radioactive substance to reduce to half. Each radioactive isotope decays in different speed and has different half-life.

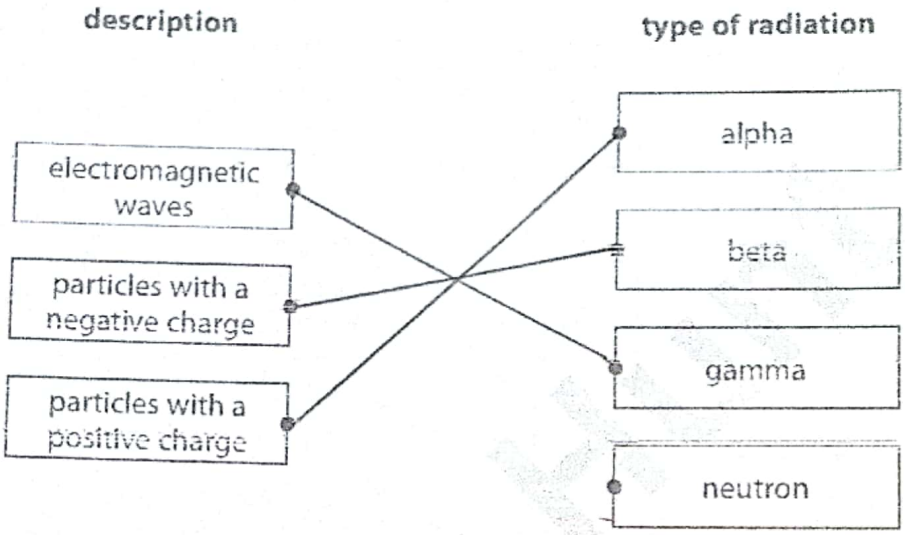
(iii) Use the graph to find a value for the half-life of radon-220.

Half-life = 55 s

9 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.



(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.

least ionising → most ionising

gamma	beta	alpha

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

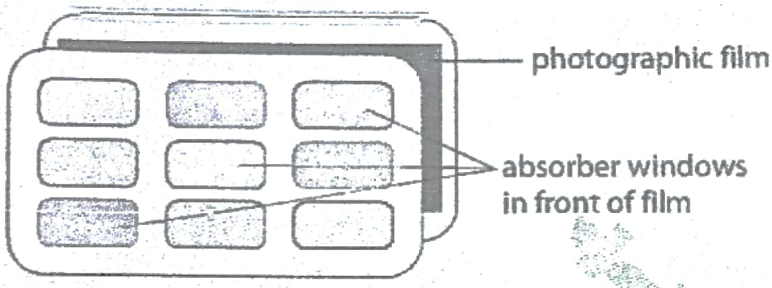
1. can damage cells

2. Can cause cancer.

(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	stopped	stopped
beta radiation	goes through	stopped	stopped
gamma radiation	goes through	goes through	goes through

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

(1)

Geiger Muller Tube

10 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.

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.

number of neutrons 2

number of protons 2

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

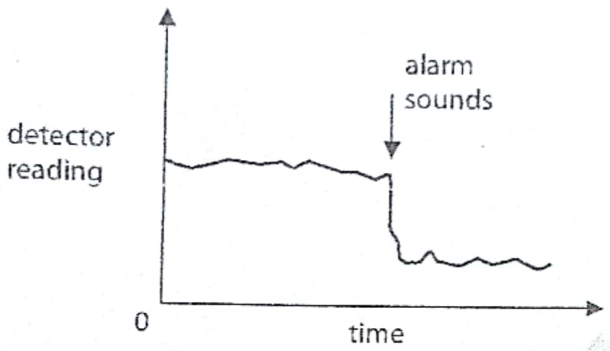
Alpha radiation has more charges

(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?

because there is backgreound readiation

(ii) Why is the detector reading never constant?

Radioactivity is random

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

The alpha particles are absorbed
The smoke blocks the alpha particles

11 A scientist placed a radioactive source in front of a Geiger Muller detector and measured the count rate every 20 minutes.

The table shows her data.

Time in minutes	Count rate in counts per minute	Corrected count rate in counts per minute
0	660	630
20	462	432
40	330	300
60	240	210
80	180	150
100	142	112

(a) The scientist corrects the count rate readings to allow for background radiation.

(i) State two sources of background radiation.

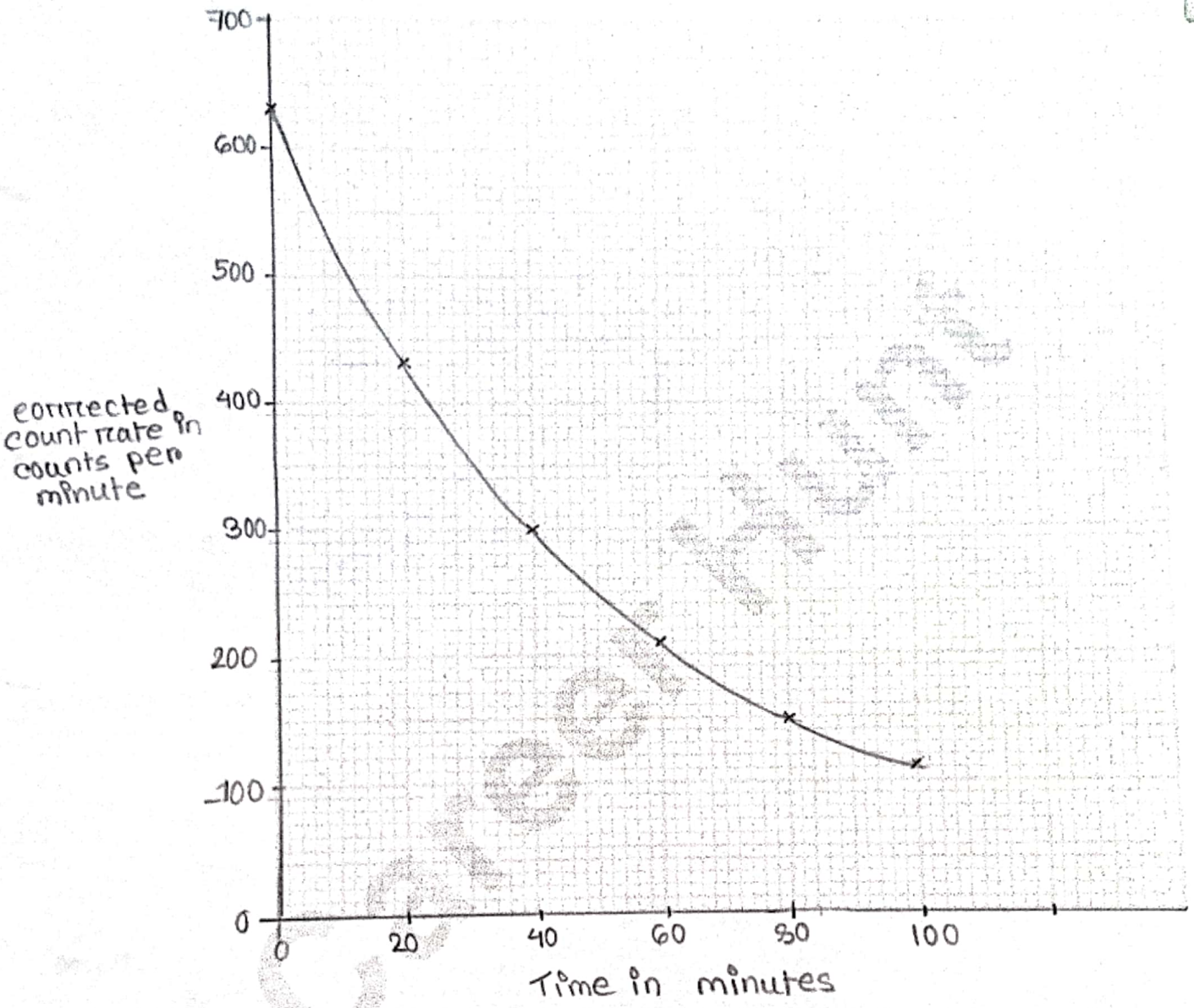
1 radiation from sun and stars

2 radiation from rock and buildings

(ii) Describe how the scientist should measure the background radiation and correct the count rate readings.

Remove the radioactive source.
Measure the background radiation count rate
Repeat the measurement
Subtract the background radiation from each readings

(iii) Plot a graph of corrected count rate against time and draw the curve of best fit.



(iv) Use your graph to find the half-life of the radioactive source.

(2)

half-life = 36 minutes

(b) The radioactive nuclei in the source emit beta radiation.

What effect does the emission of a beta particle have on a nucleus?

The neutron number decreases by 1.
The proton number increases by 1.

(c) The scientist needs to reduce the risks when working with radioactive sources.

(i) Explain why radioactive sources can be dangerous.

They emit ionising radiation
These radiation can damage skin cells
and can cause cancer.

(ii) Describe how the risks of working with radioactive sources can be reduced.

(3)

Take safety precautions, wear mask, gloves, googles
Reduce exposure time
Stay at a distance

12 Carbon-14 is a radioactive isotope of carbon.

It has the symbol

$$^{14}_{6}C$$

(a) (i) The number of **nucleons** in a carbon-14 nucleus is

- ☐ A 6
- ☐ B 8
- ☒ C 14
- ☐ D 20

(ii) The number of **neutrons** in a carbon-14 nucleus is

- ☐ A 6
- ☒ B 8
- ☐ C 14
- ☐ D 20

(iii) The number of **electrons** in a neutral carbon-14 atom is

- ☒ A 6
- ☐ B 8
- ☐ C 14
- ☐ D 20

(b) When carbon-14 decays it emits a beta particle.

What is a **beta particle**?

- [x] **A** an electron
- [ ] **B** a neutron
- [ ] **C** a nucleus
- [ ] **D** a proton

(c) Carbon-14 has a half-life of 5700 years.

A sample of cloth contains 6.0 g of carbon-14.

What mass of carbon-14 will remain in the cloth after 11 400 years?

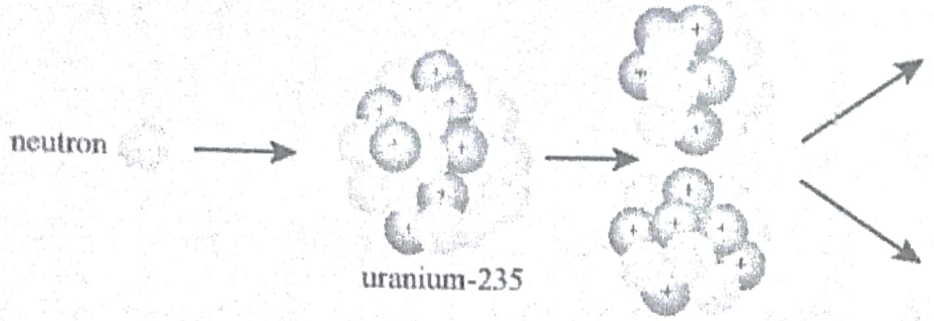
- [x] **A** 1.5 g
- [ ] **B** 2.0 g
- [ ] **C** 2.5 g
- [ ] **D** 3.0 g

(d) The carbon atoms in the cloth are mainly atoms of carbon-12, a different isotope of carbon.

What are **isotopes**?

Isotopes are atoms of the same element that has the same atomic number but different mass number.

13 The diagram shows a neutron colliding with a nucleus of uranium-235, producing a number of products.



(a) Name the process shown in the diagram.

nuclear fission

(b) Explain how the process shown in the diagram can lead to a chain reaction.

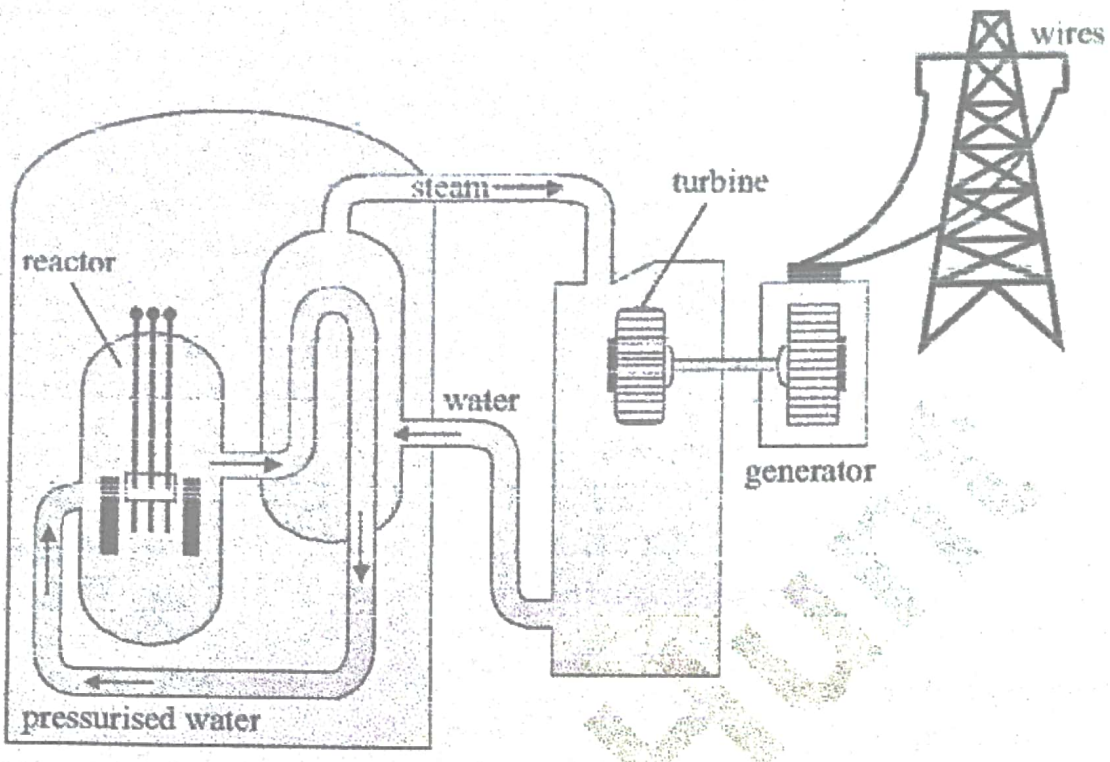
The nucleus of Uranium-235 absorbs a neutron and becomes unstable. It decays and it's nucleus splits into two daughter nuclei, barium and Krypton, and extra neutrons. These free neutrons are then absorbed by other uranium nucleus, which leads to a chain reaction.

(c) This process releases energy.

Explain the form that this energy takes.

Kinetic energy of fission products

(d) The energy released in this process can be used in a nuclear power station.



(i) The pressurised water acts as a coolant. It also acts as a moderator.

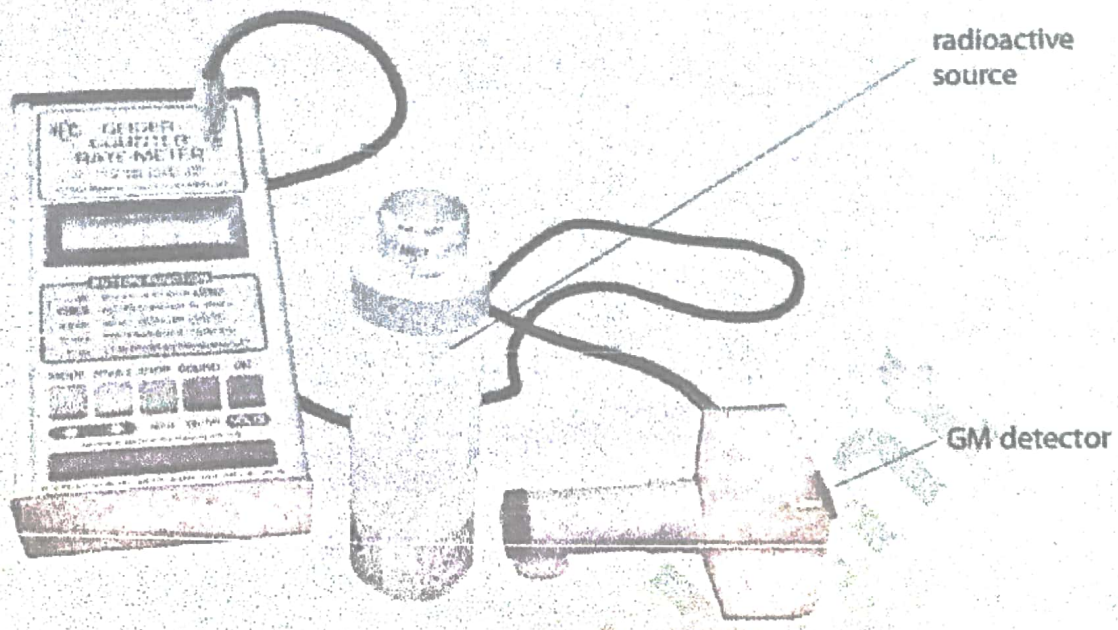
- What is the purpose of a **moderator**?

The moderator slows down the electrons.

(ii) Complete the chart below to show the main useful energy transfers in a nuclear power station.

Heat energy released by reactor	→	heat energy in water/steam	→	kinetic energy in turbine	→	kinetic energy in generator	→	electrical energy in wires

14 A teacher shows his class how to investigate the half-life of a radioactive source.



(a) The readings from the counter need to be corrected for background radiation.

(i) State **one** source of background radiation.

Radiaton from sun and stars

(ii) Describe the method the teacher should use to correct for background radiation.

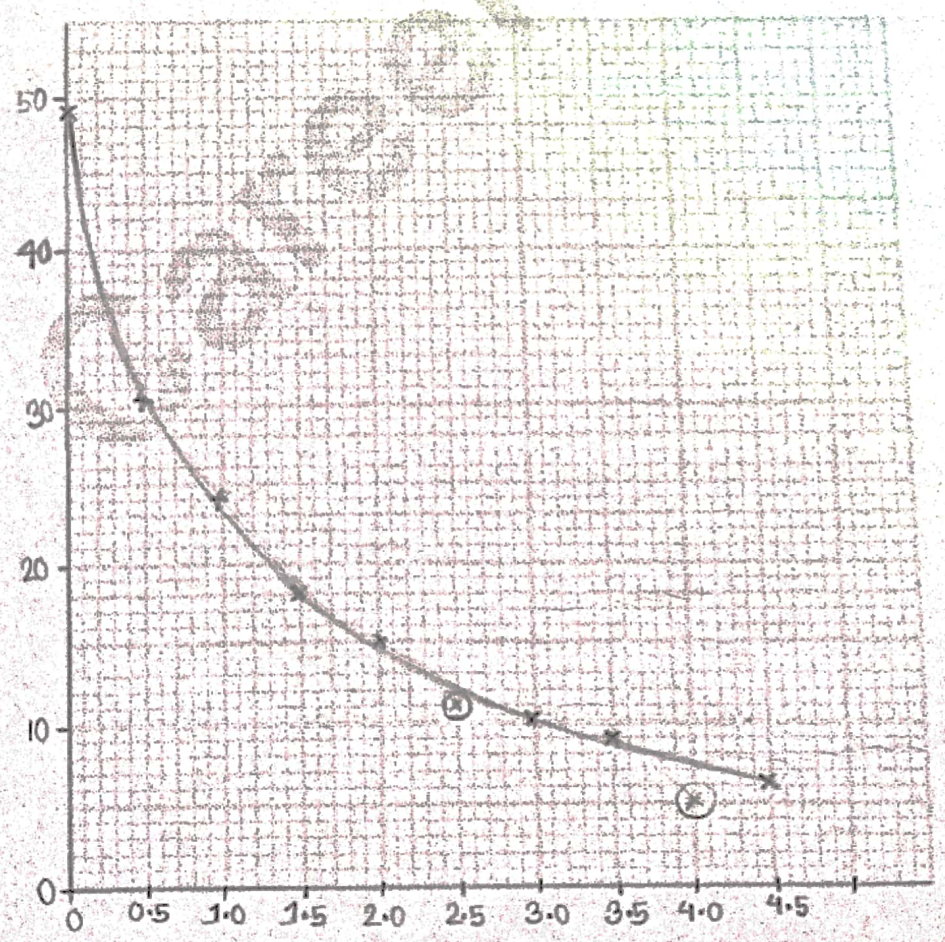
Remove the radioactive source.
Measure the background radiotion
Repeat the measurement and take an average.
Subtract the background radiation from the readings of the radioactive source.

(b) Every half a minute, the teacher records the count rate.

He corrects for background radiation and produces this results table.

Time in minutes	Corrected count rate in Bq
0	49
0.5	30
1.0	24
1.5	18
2.0	15
2.5	11
3.0	10
3.5	9
4.0	5
4.5	6

(i) Draw a graph of corrected count rate against time for these results.



(ii) Use your graph to estimate the half-life for this material.

Half-life = 0.95 minutes

(c) The isotope technetium-99 is a gamma emitter with a half-life of 6 hours. It is used as a radioactive tracer in medicine.

The technetium-99 is injected into a patient's bloodstream and carried around the body by the blood. The radiation it emits is detected outside the body.

Explain why technetium-99 is suitable for use as a tracer in this way.

Technetium-99 is a gamma emitter and can pass through the body. Technetium-99 has a short half life and falls to low level soon after use, but its half life is long enough to get around the body.

15 John Leslie was a scientist who investigated heat and thermometers.

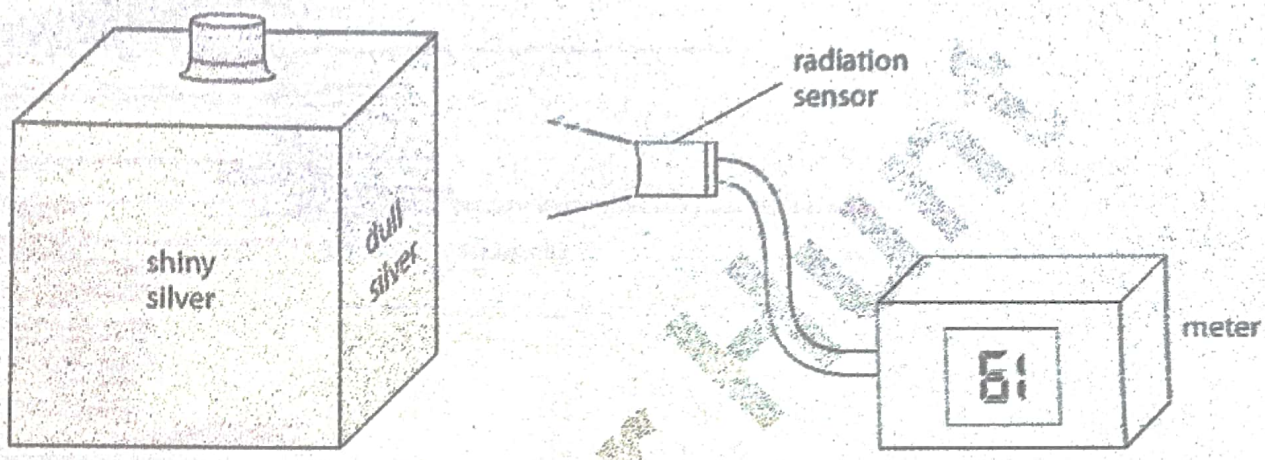
He experimented with a hollow metal cube. The cube had different surfaces on each side and was filled with boiling water.

(a) A student uses a modern version of Leslie's cube to investigate how the surface of a hot object affects the radiation emitted.

She uses a cube with four different vertical surfaces.

She fills the cube with boiling water so that the temperature of each surface is the same.

She uses the radiation sensor to measure the radiation emitted from each surface.



(i) The student's results are shown below.

Draw a line linking each surface colour with its correct meter reading.

One has been done for you.

surface colour	meter reading
shiny black	87
dull black	61
dull silver	70
shiny silver	47

(ii) The temperature of each surface is the same, but the radiation sensor gives a different reading for each surface.

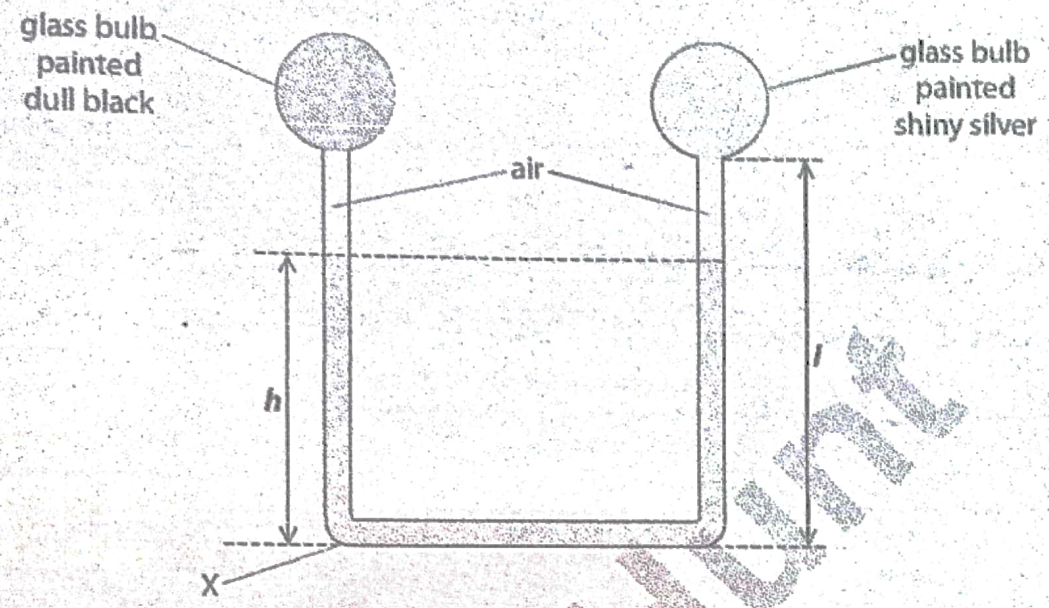
What can you conclude from this?

Different surface emits radiation at different rates

(b) John Leslie also invented a differential thermometer.

The diagram shows this thermometer.

The bulbs are filled with air and are connected by a tube which contains liquid.



(i) State the equation linking pressure difference, height, density and g.

(1)

Pressure difference = height X density X g

(ii) The density of the liquid is 1260 kg/m³.

Calculate the pressure due to the liquid at X when the height, h, of the column of liquid is 0.25 m.

Give the unit.

(3)

P = 0·25 X 1260 X 10

pressure = 3150 unit Pa

(iii) The student places the differential thermometer in bright sunlight for a few minutes.

She observes that the liquid level

- falls on the side of the dull black bulb making *h* lower
- rises on the side of the shiny silver bulb

Use ideas about heat transfer and particle theory to explain these observations.

[3]

dull black absorbs more heat than shiny silver surface. The particles of the dull black bulb has more kinetic energy, so pressure on this side is more.

(iv) Explain what would happen to the levels of the liquid if the student repeated the experiment with a denser liquid in the thermometer.

[2]

The different in height of the liquid will be less as high density liquid is harder to move

(v) Two students discuss the effect of changing the length, l, of the tube on both sides, while keeping the total volume of liquid constant.

If the length of the tube is increased, the thermometer can measure higher temperatures.

Changing the length of the tube will not make any difference to the range of temperatures that the thermometer can measure.

Explain which of these ideas is correct.

[2]

The girl's idea is correct.
If length of tube is increased, there will be bigger temperature range and more difference in the height of the liquid.

16 Unstable nuclei can emit particles.

(a) Which of these particles has the largest charge?

- ☒ A alpha particle
- ☐ B beta particle
- ☐ C neutron
- ☐ D proton

(b) Which of these particles has the largest mass?

- ☒ A alpha particle
- ☐ B beta particle
- ☐ C neutron
- ☐ D proton

(c) The maximum range of a beta particle in air is about

- ☐ A 50 mm
- ☒ B 50 cm
- ☐ C 50 m
- ☐ D 50 km

(d) When a nucleus emits a beta particle

- ☐ A the nucleon number decreases by 1
- ☐ B the nucleon number increases by 1
- ☐ C the proton number decreases by 1
- ☒ D the proton number increases by 1

17 The photograph shows an old camera lens that contains several pieces of glass.

One of the pieces of glass includes a radioactive isotope, thorium-232.

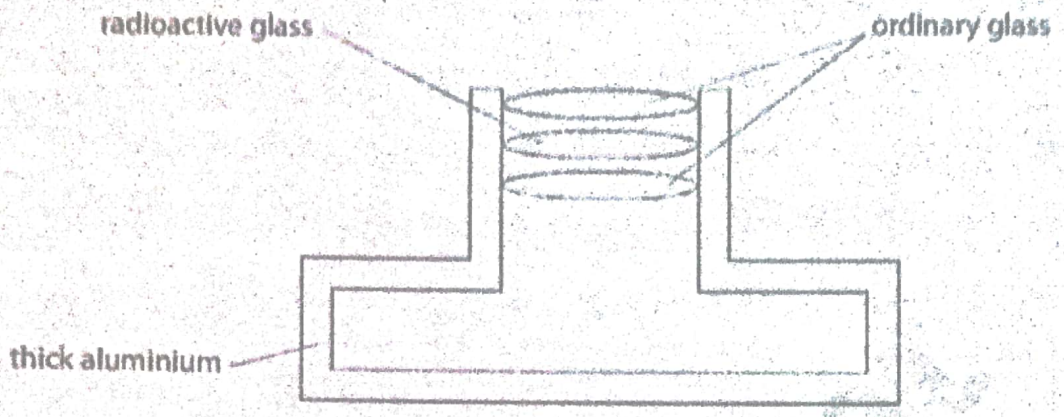
(a) Thorium-232 undergoes alpha decay and produces an isotope of radium, Ra.

Complete the equation for this decay.

$$^{232}_{90}\text{Th} \longrightarrow {}^{228}_{88}\text{Ra} + {}^{4}_{2}\alpha$$

(b) The radioactive glass also emits beta particles from a different isotope.

The diagram shows the position of the radioactive glass in the camera.



(i) Suggest why it is safe to use radioactive glass in the camera as shown.

The thick aluminium will absorb the beta or alpha radiation of the radioactive glass.

(ii) Amateur astronomers sometimes remove an old camera lens to use as a lens in a homemade telescope.

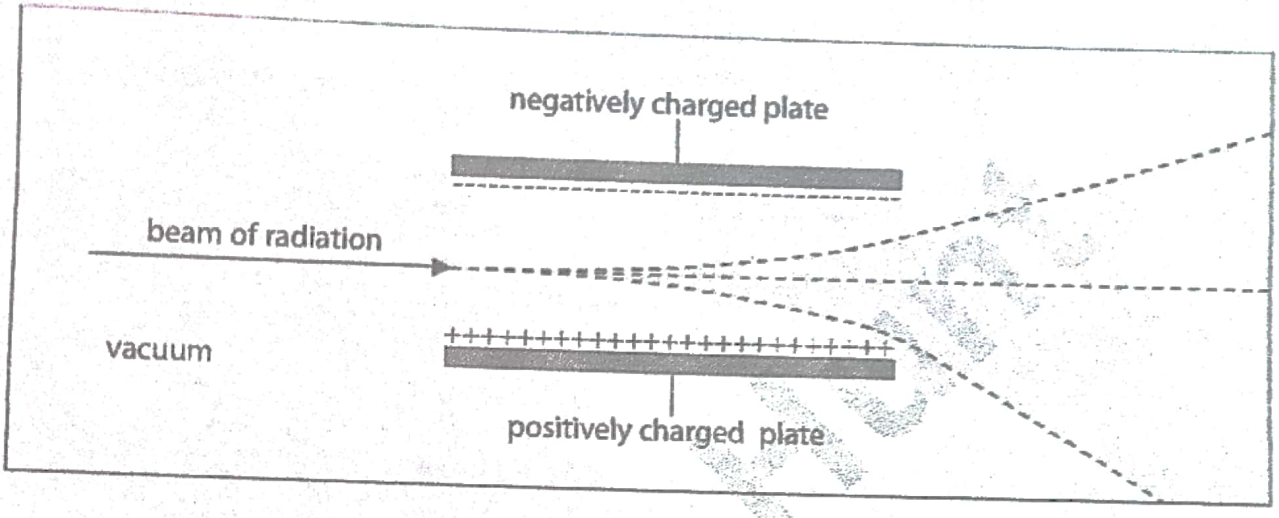
Suggest why an astronomer should not use a lens with radioactive glass close to their eye.

The alpha and beta radiation are ionising and can travel the short distance between the lens and eyes ∴ This can cause blindness.

18 (a) Scientists use deflection in an electric field to help distinguish between different radiations.

The diagram shows a beam containing several types of radiation. This beam travels in a vacuum between two charged plates.

Some of the radiations are deflected upwards, some are deflected downwards and some are not deflected at all.



Put one tick in each row to show the correct deflection for each type of radiation.

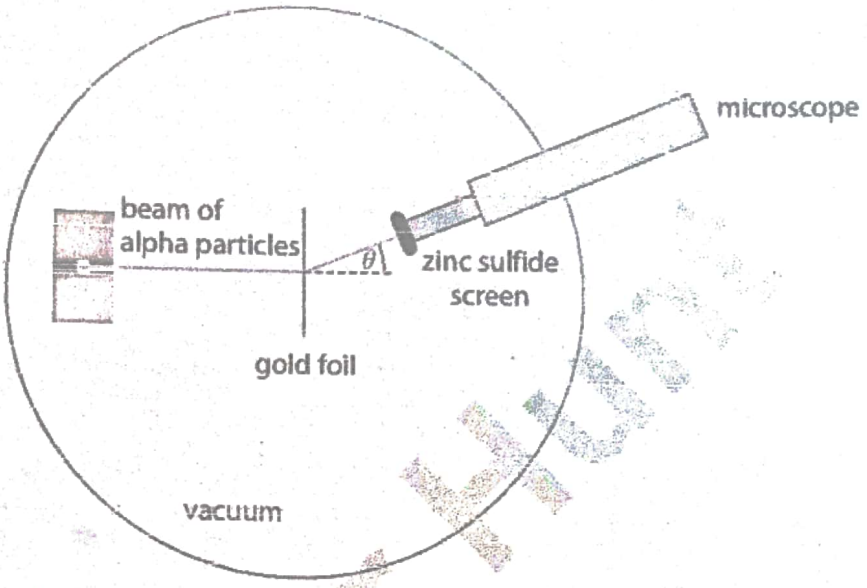
One has been done for you.

Type of radiation	Deflected upwards	Deflected downwards	Not deflected
alpha	✓		
beta		✓	
gamma			✓
neutrons			✓
protons	✓		

(b) The diagram shows the apparatus Geiger and Marsden used to investigate the structure of an atom.

They aimed a beam of alpha particles at a very thin sheet of gold foil.

They used a zinc sulfide screen to detect the alpha particles.



(i) Suggest why Geiger and Marsden removed the air from the apparatus.

alpha particles would ionise the air

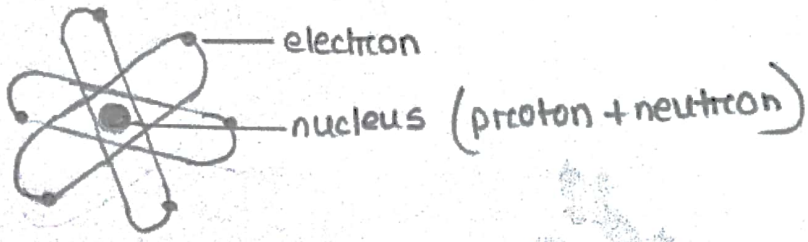
(ii) Describe Geiger and Marsden's results.

Most alpha particles went straight through the gold foil but some got deflected through an obtuse angle

(c) Rutherford produced a model of the atom.

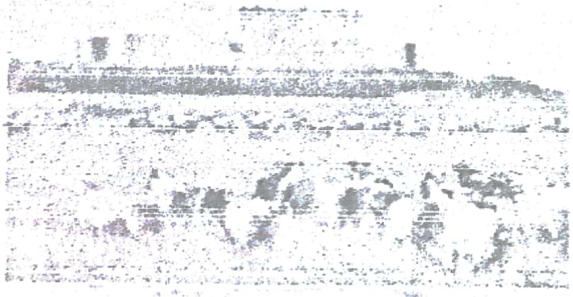
Describe how Rutherford's model explains Geiger and Marsden's results.

You may draw a diagram to help your answer.



Rutherfold's model of atom shows that the atoms have a small nucleus and is mostly empty space. So, most of the alpha particles can pass straight through them, and fewer alpha particles is deflected as alpha particles are positively charged and so is proton, so they repel.

19 In 2013, the UK Government decided to build another nuclear power station at Hinckley Point. Hinckley Point is in Somerset, a major agricultural area of the UK. This will be the third nuclear power station at the site.



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Discuss the advantages and disadvantages of nuclear power stations and biomass power stations.

Nuclear power station produces clean energy and is reliable & efficient. It does not contribute to global warming but it is expensive to build and is dangerous as there are chances of radiation leak. Biomass power stations uses renewable resources and is relatively cheap but it is less efficient and require large lands.

20 Use the following information to help you answer the questions.

The gold foil experiment

Scientists used to think that electrons were spread out through a positively charged atom.

They called this the 'plum pudding' model.

To test this idea, scientists aimed alpha particles at thin gold foil. They expected the alpha particles to pass straight through.

The results showed that **almost** all the alpha particles did pass straight through, but a few did not. About 1 in every 8000 was deflected away at a very large angle.

It was these 'anomalous' results that led to a new understanding of the atom.

(a) What was the prediction in this experiment?

All the alpha particles will pass straight through the foil

(b) (i) What do scientists mean by **anomalous results**?

The results that do no follow the trend.

(ii) How should scientists deal with anomalous results?

Work out why the anomalous result occurred.

(c) Describe how a teacher should measure the activity of a radioactive source using a Geiger-Muller detector.

Connect the Geiger muller tube to a rate meter.
Measure the background radiation.
Measure the count rate for the source.
Now, subtract the countrate of background radiation from the countrate of the source to get corrected count rate for the radioactive source.
Repeat this process several times and take an average to ge more accurate results
Make sure to use sheilding as a safety precaution

21 Alpha and beta particles may be emitted by unstable nuclei.

(a) (i) When an unstable nucleus emits an alpha particle, its atomic (proton) number

- ☐ A increases by 1
- ☐ B stays the same
- ☒ C decreases by 2
- ☐ D decreases by 4

(ii) When an unstable nucleus emits an alpha particle, its mass (nucleon) number

- ☐ A increases by 1
- ☐ B stays the same
- ☐ C decreases by 2
- ☒ D decreases by 4

(b) Compared to a beta particle, an alpha particle

- ☐ A causes less ionisation
- ☐ B has less charge
- ☐ C has less mass
- ☒ D has less penetrating power

(c) Describe how a teacher should measure the activity of a radioactive source using a Geiger-Muller detector.

Connect the Geiger muller tube to a rate meter
Measure the background radiation.
Take safety precautions, wear goggles, gloves, mask, protective clothing.
Measure for the activity of the radioactive source. at regular time intervals in Becquerels.
Subtract the background radiation from each reading on the rate meter, and tabulate the results.

22 These questions are about radioactivity.

(a) Which of these is measured in becquerel (Bq)?

- ☒ **A** activity
- ☐ **B** frequency
- ☐ **C** half-life
- ☐ **D** radiation

(b) Which of these has a mass (nucleon) number of 4?

- ☒ **A** alpha particle
- ☐ **B** beta particle
- ☐ **C** gamma ray
- ☐ **D** x-ray

(c) Which of these is the same as an electron?

- ☐ **A** alpha particle
- ☒ **B** beta particle
- ☐ **C** gamma ray
- ☐ **D** x-ray

(d) Which of these is the most ionising?

- ☒ **A** alpha particle
- ☐ **B** beta particle
- ☐ **C** gamma ray
- ☐ **D** x-ray

23

The table shows the nature of alpha and beta particles.

Particle	Nature
alpha	helium nucleus
beta	tron

Explain why alpha particles and beta particles have different penetrating powers.

Alpha particles have more charge and have more mass. Alpha particle have more ionizing power and is more likely to collide with atoms. So, Alpha particles speed is less.
While, beta particles have less charge and less mass, its speed is more as compared to alpha. That's why alpha particles penetrating powers are less than that of beta particles.

24 A teacher investigates the half-life of a radioactive isotope that decays quickly.

(a) The teacher measures the background activity.

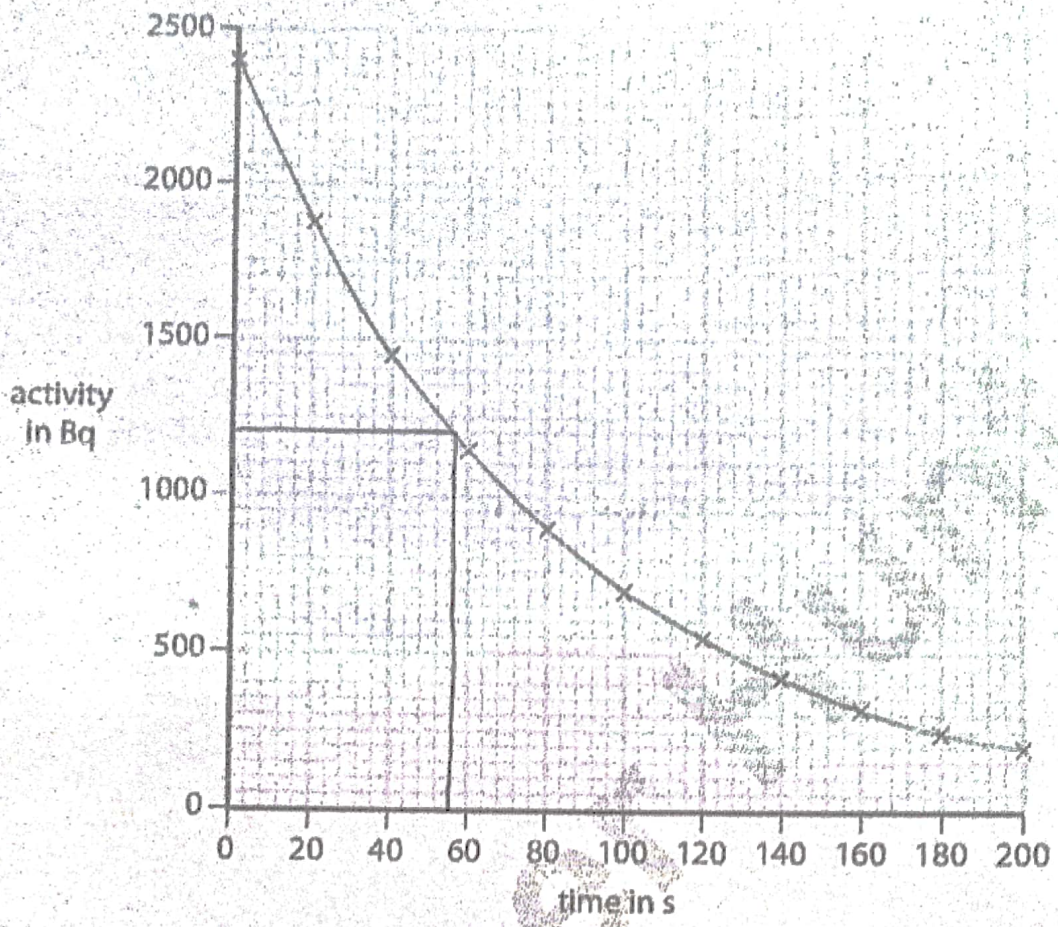
Explain how this value should be used in the investigation.

The background radiation should be subtracted from each reading for the radioactive isotope.

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

Half life is the amount of time taken for any radioactive isotope to reduce to half.

(c) The graph shows how the activity of a sample of the radioactive isotope changes with time.



(i) Use the graph to find the half-life of the isotope.

(2)

half-life = 56 s

(ii) The teacher takes a new reading every 20 s.

Suggest why the teacher measures the activity so frequently.

(1)

So that the curve is more accurate

25 An unstable isotope of strontium has a half-life of 28.8 years.

It is a beta emitter and can be represented by this symbol.

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

(a) (i) What is the mass number of this isotope?

90

(ii) Explain the meaning of the term **half-life**.

Half life is the amount of time taken for any radioactive isotope to reduce to half.

(iii) A person can absorb strontium atoms, which stay in their bones.

Explain why strontium-90 in the bones is a serious health hazard.

(2)

Strontium-90 has a very long half life, so the beta radiation will be absorbed by the body and can damage cells and cause cancer

(b) When a strontium 90 nucleus emits a beta particle, it decays to form yttrium 90.

(i) Complete the equation for this decay.

$$^{90}_{38}Sr \rightarrow {}^{90}_{39}Y + {}^{0}_{-1}\beta^-$$

(ii) Yttrium-90 is also an unstable isotope.

Explain why strontium-90 and yttrium-90 can both be described as isotopes, even though they have different numbers of protons.

(2)

Strontium-90 and Yttrium-90 can both be described as isotopes but of different elements

Strontium-90 has the same proton number as other strontium atoms and Yttrium-90 has the same proton number as other Yttrium atoms

26 Iodine-131 is a radioactive isotope that emits beta particles.

(a) The equation for this decay is

$$^{131}_{53}I \rightarrow ^{A}_{Z}Xe + ^{0}_{-1}e$$

(i) The atomic (proton) number for iodine-131 is

- ☐ **A** 0
- ☒ **B** 53
- ☐ **C** 78
- ☐ **D** 131

(ii) The mass (nucleon) number for Xe is

- ☐ **A** −1
- ☐ **B** 0
- ☐ **C** 53
- ☒ **D** 131

(b) Iodine-131 is used to treat thyroid cancer.

This radioactive isotope is allowed to enter the tumour.

Explain why iodine-131 is suitable for this treatment.

Beta particle is ionising & has a short range. Iodine-131 has a short half life. Therefore, it will only kill the tumour cells and would not cause much damage to healthy cells.

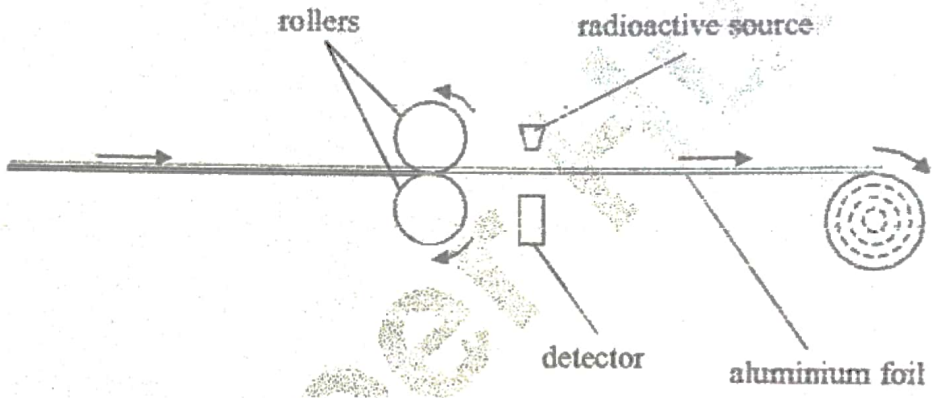
27 There are different types of ionising radiation.

(a) Complete the table to show the properties of each type.

Type of ionising radiation	Charge	Emitted by
alpha particle	++	unstable nuclei
beta particle	−	unstable nuclei
gamma ray	0	unstable nuclei

(b) The diagram shows a machine which makes aluminium foil.

The machine uses a radioactive source to measure the thickness of the foil.



The radioactive source emits beta particles.

The output from the detector indicates the thickness of the foil.

Explain why beta particles are used, rather than alpha particles or gamma rays.

Alpha particles are not penetrative enough and is stopped by a paper. Gamma rays are very penetrative. Beta particles would be absorbed less if the foil is thinner and more if the foil is thicker. So, beta particles are used.

(c) The radioactive source contains strontium-90.

A strontium-90 nucleus emits a beta (β) particle.

(i) Complete the equation to show how strontium-90 decays.

$$^{90}_{38}Sr \rightarrow \; ^{90}_{39}Y + \; ^{0}_{-1}\beta$$

(ii) Which of these describes what happens to the strontium-90 nucleus when it emits a beta (β) particle?

- ☐ A the number of protons stays the same
- ☒ B the number of protons increases
- ☐ C the number of neutrons stays the same
- ☐ D the number of neutrons increases