Name: _________________________
Class: _________________________
Date: _________________________

Time: 224 minutes

Marks: 223 marks

Comments:
The table gives information about the three types of particle that make up an atom.

<table>
<thead>
<tr>
<th>Particle</th>
<th>Relative mass</th>
<th>Relative charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proton</td>
<td></td>
<td>+1</td>
</tr>
<tr>
<td>Neutron</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Electron</td>
<td>very small</td>
<td>−1</td>
</tr>
</tbody>
</table>

(a) Complete the table by adding the two missing values.

(b) Use the information in the table to explain why an atom has no overall electrical charge.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(c) Uranium has two natural isotopes, uranium-235 and uranium-238. Uranium-235 is used as a fuel inside a nuclear reactor. Inside the reactor, atoms of uranium-235 are split and energy is released.

(i) How is the structure of an atom of uranium-235 different from the structure of an atom of uranium-238?

___________________________________________________________________
___________________________________________________________________

(ii) The nucleus of a uranium-235 atom must absorb a particle before the atom is able to split.

What type of particle is absorbed?

___________________________________________________________________

(iii) The nucleus of an atom splits into smaller parts in a reactor.

What name is given to this process?

___________________________________________________________________

(Total 7 marks)
The process of nuclear fusion results in the release of energy.

(a) (i) Describe the process of nuclear fusion.
______________________________________________________________
______________________________________________________________
______________________________________________________________
______________________________________________________________

(ii) Where does nuclear fusion happen naturally?
______________________________________________________________

(b) For many years, scientists have tried to produce a controlled nuclear fusion reaction that lasts long enough to be useful. However, the experimental fusion reactors use more energy than they produce.

(i) From the information given, suggest one reason why nuclear fusion reactors are not used to produce energy in a nuclear power station.
______________________________________________________________
______________________________________________________________
______________________________________________________________
______________________________________________________________

(ii) Suggest one reason why scientists continue to try to develop a practical nuclear fusion reactor.
______________________________________________________________

Q3.

(a) Nuclear fission is used in nuclear power stations to generate electricity. Nuclear fusion happens naturally in stars.

(i) Explain briefly the difference between nuclear fission and nuclear fusion.
______________________________________________________________
______________________________________________________________
______________________________________________________________
______________________________________________________________
______________________________________________________________

(ii) What is released during both nuclear fission and nuclear fusion?
Plutonium-$^{239}$ is used as a fuel in some nuclear reactors.

(i) Name another substance used as a fuel in some nuclear reactors.

(ii) There are many isotopes of plutonium. What do the nuclei of different plutonium isotopes have in common?

(Normal text)

Q4.

Nuclear fission and nuclear fusion are two processes that release energy.

(a) (i) Use the correct answer from the box to complete each sentence.

| Geiger counter | nuclear reactor | star |

Nuclear fission takes place within a ____________________________.

Nuclear fusion takes place within a ____________________________.

(ii) State one way in which the process of nuclear fusion differs from the process of nuclear fission.

(b) The following nuclear equation represents the fission of uranium-235 (U-235).

\[
\begin{align*}
\text{}^1_0\text{n} + \text{}^{235}_{92}\text{U} & \rightarrow \text{}^{236}_{92}\text{U} \\
\text{}^{236}_{92}\text{U} & \rightarrow \text{}^{141}_{56}\text{Ba} + \text{}^{92}_{36}\text{Kr} + 3\text{}^1_0\text{n} + \text{energy}
\end{align*}
\]

Chemical symbols:

- \(\text{Ba}\) - barium
- \(\text{Kr}\) - krypton

(i) Use the information in the equation to describe the process of nuclear fission.

(Normal text)
An isotope of barium is Ba-139. Ba-139 decays by beta decay to lanthanum-139 (La-139).

Complete the nuclear equation that represents the decay of Ba-139 to La-139.

\[ ^{139}\text{Ba} \rightarrow ^{139}\text{La} + \]
The diagram shows the cross-section through a nuclear reactor. The control rods, made from boron, are used to control the chain reaction. Boron atoms absorb neutrons without undergoing nuclear fission.

Why does lowering the control rods reduce the amount of energy released each second from the nuclear fuel?

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(Total 8 marks)
The ‘plum pudding’ model of the atom was used by scientists in the early part of the 20th century to explain atomic structure.

(a) Those scientists knew that atoms contained electrons and that the electrons had a negative charge. They also knew that an atom was electrically neutral overall. What did this allow the scientists to deduce about the ‘pudding’ part of the atom?

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(1)

(b) An experiment, designed to investigate the ‘plum pudding’ model, involved firing alpha particles at a thin gold foil.

If the ‘plum pudding’ model was correct, then most of the alpha particles would go straight through the gold foil. A few would be deflected, but by less than 4 °.

The results of the experiment were unexpected. Although most of the alpha particles did go straight through the gold foil, about 1 in every 8 000 was deflected by more than 90 °.

Why did this experiment lead to a new model of the atom, called the nuclear model, replacing the ‘plum pudding’ model?

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(1)

(c) The diagram shows the paths, A, B and C, of three alpha particles. The total number of alpha particles deflected through each angle is also given.
(i) Using the nuclear model of the atom, explain the three paths, A, B and C.

A  ______________________________________________________________
   _______________________________________________________________

B  ______________________________________________________________

C  ______________________________________________________________
   _______________________________________________________________

(ii) Using the nuclear model, the scientist E. Rutherford devised an equation to predict the proportion of alpha particles that would be deflected through various angles.

The results of the experiment were the same as the predictions made by Rutherford.

What was the importance of the experimental results and the predictions being the same?

___________________________________________________________________
   (1)
   (Total 6 marks)

Q7.  (a)  (i) Describe the structure of alpha particles.

___________________________________________________________________
   _______________________________________________________________
   _______________________________________________________________
   _______________________________________________________________
   _______________________________________________________________
   _______________________________________________________________
(ii) What are beta particles?

(b) Describe how beta radiation is produced by a radioactive isotope.

Q8.

Neptunium-237 ($^{237}$Np) is a radioactive element. The graph shows the numbers of neutrons and protons in the nuclei of the elements formed when $^{237}$Np decays.

(a) Use the periodic table on the Data Sheet to identify element X.

(b) Why are $^{235}$Pa and $^{233}$U considered to be different elements?

(c) What type of radiation is released when $^{237}$Np decays to form $^{233}$Pa?
(d) What change takes place in the nucleus when $^{233}\text{Pa}$ changes into $^{233}\text{U}$?

Q9.
A beta particle is a high-energy electron.

(i) Which part of an atom emits a beta particle?

(ii) How does the composition of an atom change when it emits a beta particle?

Q10.
Radon is a radioactive element. The graph shows how the number of radon atoms in a sample of air changes with time.

(i) How long did it take the number of radon atoms in the sample of air to fall from 1000 to 500?
(ii) How long is the half-life of radon?

Half-life = _______________________ seconds

(iii) Complete this sentence by crossing out the two lines in the box that are wrong.

As a radioactive material gets older, it emits

| less | a constant level of | more |

radiation per second.

Q11.

In the early part of the 20th century, scientists used the ‘plum pudding’ model to explain the structure of the atom.

Following work by Rutherford and Marsden, a new model of the atom, called the ‘nuclear’ model, was suggested.

(a) Describe the differences between the two models of the atom.

_________________________________________________________________________

_________________________________________________________________________

_________________________________________________________________________

_________________________________________________________________________
(b) In their investigation, Rutherford and Marsden fired positively charged alpha particles at a very thin sheet of gold. Over a period of several months, the scientists made over 100 000 measurements. These measurements showed that:

- a very small number of alpha particles were deflected backwards from the gold foil.

Use the nuclear model to explain this experimental result.

(c) Why did the work of Rutherford and Marsden convince many scientists that the ‘plum pudding’ model of the atom was incorrect?

Q12.

(a) Uranium-234 \(^{234}\text{U}\) is a radioactive element. The graph shows the number of protons and neutrons in the nuclei of the elements formed when uranium-234 decays.
(i) How does the graph show that uranium-234 \(^{234}\text{U}\) and thorium-230 \(^{230}\text{Th}\) emit alpha particles?

(ii) What makes uranium and thorium different elements?

(iii) Radioactive decay may also produce gamma radiation.

Why does the emission of gamma radiation **not** cause a new element to be formed?

(b) The graph shows how the thickness of different materials needed to absorb 90% of the gamma radiation emitted by a source depends on the energy of the radiation. The energy of the gamma radiation is given in units called electron-volts.

(i) Which of the materials shown is least effective at absorbing gamma radiation? Use the information in the graph to give a reason for your answer.

(ii) For gamma radiation of energy 1.5 million electron-volts, how many times more effective is steel than water at absorbing the radiation? Show clearly
how you obtain your answer.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(2)

(c) Scientists in the early twentieth century thought that atoms were made up of electrons scattered inside a ball of positive charge. This was called the ‘plum-pudding’ model of the atom.

![Plum pudding model](image.png)

**Plum pudding model**

Rutherford and Marsden did an experiment, in which a beam of alpha particles was aimed at a thin sheet of gold. Explain how the results of this experiment led to a new model of the atom. You may include one or more diagrams in your answer.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(3)

(Total 9 marks)
Q13.

(a) The diagrams represent three atoms X, Y and Z.

Which two of the atoms are from the same element?

___________________________________________________________________

Give a reason for your answer.

___________________________________________________________________

___________________________________________________________________

(2)

(b) In the early part of the 20th century some scientists investigated the paths taken by positively charged alpha particles into and out of a very thin piece of gold foil. The diagram shows the paths of three alpha particles.

Explain the different paths A, B and C of the alpha particles.

To gain full marks in this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.

___________________________________________________________________

___________________________________________________________________
Q14.

(a) Uranium atoms do not always have the same number of neutrons. What are atoms of the same element that have different numbers of neutrons called?

(b) By emitting an alpha particle, an atom of uranium-235 decays into an atom of thorium.

An alpha particle, which is the same as a helium nucleus, is represented by the symbol $^4_2\text{He}$.

The decay can be represented by the equation below.

Complete the equation by writing the correct number in each of the two boxes.

\[ ^{235}_{92}\text{U} \rightarrow \quad \quad \quad \quad \text{Th} + ^4_2\text{He} \]

(c) The diagram shows an atom of uranium-235 being split into several pieces.

(i) Name the process shown in the diagram.

(ii) Name the particles labelled X.
Uranium-235 is used as a fuel in some nuclear reactors. Name another substance used as a fuel in some nuclear reactors.

_________________________  (1)

(Total 6 marks)

Q15.

The diagram shows a helium atom.

(a)  (i) Use the words in the box to label the diagram.

|  electron  | neutron | proton |

(ii) An alpha particle is the same as the nucleus of a helium atom. How is an alpha particle different from a helium atom?

_______________________________________________________________________________

_______________________________________________________________________________  (1)

(b) The graph shows how the count rate from a sample of radioactive sodium-24 changes with time.
(i) How many hours does it take for the count rate to fall from 100 counts per second to 50 counts per second?

Time = _______________ hours

(ii) What is the half-life of sodium-24?

Half-life = _______________ hours

(c) A smoke detector contains a small amount of americium-241.

Americium-241 is a radioactive substance which emits alpha particles. It has a half-life of 432 years.

(i) Which one of the following statements gives a reason why the americium-241 inside the smoke detector will not need replacing?

Put a tick (✓) in the box next to your answer.

The alpha particles have a low energy. 

People replace smoke detectors every few years.

Americium-241 has a long half-life.

(ii) The diagram shows the label on the back of the smoke detector.
Why do people need to know that the smoke detector contains a radioactive material?

________________________________________________________________________
________________________________________________________________________

(1)
(Total 7 marks)

Q16.

Most elements have some isotopes which are radioactive.

(a) What is meant by the terms:

(i) isotopes

________________________________________________________________________
________________________________________________________________________

(1)

(ii) radioactive?

________________________________________________________________________
________________________________________________________________________

(1)

(b) The graph shows how the number of nuclei in a sample of the radioactive isotope plutonium-238 changes with time.
Use the graph to find the half-life of plutonium-238.

Show clearly on the graph how you obtain your answer.

Half-life = ______________ years

(c) The Cassini spacecraft launched in 1997 took seven years to reach Saturn.

The electricity to power the instruments on board the spacecraft is generated using the heat produced from the decay of plutonium-238.

(i) Plutonium-238 decays by emitting alpha particles.

What is an alpha particle?
______________________________________________________________

(ii) During the 11 years that Cassini will orbit Saturn, the output from the generators will decrease.

Explain why.
______________________________________________________________
______________________________________________________________
______________________________________________________________
______________________________________________________________
(d) Plutonium-238 is highly dangerous. A tiny amount taken into the body is enough to kill a human.

(i) Plutonium-238 is unlikely to cause any harm if it is outside the body but is likely to kill if it is inside the body.

Explain why.

(ii) In 1964, a satellite powered by plutonium-238 was destroyed, causing the release of radioactive material into the atmosphere.

Suggest why some environmental groups protested about the launch of Cassini.

Q17.

(a) Complete the following table for an atom of uranium-238 (\(^{92}\text{U}\))

<table>
<thead>
<tr>
<th>mass number</th>
<th>238</th>
</tr>
</thead>
<tbody>
<tr>
<td>number of protons</td>
<td>92</td>
</tr>
<tr>
<td>number of neutrons</td>
<td></td>
</tr>
</tbody>
</table>

(b) Complete the following sentence.

The name given to the number of protons in an atom is the proton number or the

(c) An atom of uranium-238 (\(^{92}\text{U}\)) decays to form an atom of thorium-234 (\(^{90}\text{Th}\)).

(i) What type of radiation, alpha, beta or gamma, is emitted by uranium-238?

(ii) Why does an atom that decays by emitting alpha or beta radiation become an
atom of a different element?

________________________________________________________________________

(1)

(Total 4 marks)

Q18.
(a) The diagram represents 3 atoms, K, L and M.

(i) Which two of the atoms are isotopes of the same element?

__________ and __________

(1)

(ii) Give a reason why the two atoms that you chose in part (a)(i) are:

(1) atoms of the same element _______________________________________

________________________________________________________________________

(2) different isotopes of the same element. ___________________________

________________________________________________________________________

________________________________________________________________________

(b) The table gives some information about the radioactive isotope thorium-230.

| mass number | 230 |
| atomic number | 90 |

(i) How many electrons are there in an atom of thorium-230?

________________________________________________________________________

(1)

(ii) How many neutrons are there in an atom of thorium-230?

________________________________________________________________________

(1)

(c) When a thorium-230 nucleus decays, it emits radiation and changes into
What type of radiation, alpha, beta or gamma, is emitted by thorium-230?

Explain the reason for your answer.

Q19.
The diagram represents an atom of lithium.

(a) (i) Complete the following table of information for an atom of lithium.

<table>
<thead>
<tr>
<th>Number of protons</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of electrons</td>
<td></td>
</tr>
<tr>
<td>Number of neutrons</td>
<td></td>
</tr>
</tbody>
</table>

(ii) What is the mass number of a lithium atom?

Draw a ring around your answer.
Give a reason for your answer.

______________________________________________________________

______________________________________________________________

(2)

(b) Complete the following sentence by drawing a ring around the correct line in the box.

An atom that has lost an electron is called

- an ion
- an isotope
- a positive atom

(1)

(c) When an alpha particle is emitted from the nucleus of a radon atom, the radon changes into polonium.

Radon \[\rightarrow\] Alpha particle + Polonium

Not to scale

An alpha particle consists of 2 protons and 2 neutrons.

(i) Complete the following sentence by drawing a ring around the correct line in the box.

The mass of a polonium atom is

- greater than
- the same as
- smaller than

the mass of a radon atom.

(1)

(ii) Give a reason for your answer to part (c)(i).

________________________________________________________________________
________________________________________________________________________

(1)

(Total 7 marks)

Q20.

When the nucleus of a radium-225 atom decays, it changes into a nucleus of actinium-225.

\[^{225}_{88} \text{Ra} \rightarrow ^{225}_{89} \text{Ac} + \text{Radiation} \]
What type of radiation is emitted by radium-225?

Draw a ring around your answer.

alpha  beta  gamma

Explain the reason for your answer.

_______________________________________________________________________

_______________________________________________________________________

_______________________________________________________________________

_______________________________________________________________________

_______________________________________________________________________

TOTAL 3 marks

Q21.

Alpha, beta and gamma are types of nuclear radiation.

(a) Draw one line from each type of radiation to what the radiation consists of.

<table>
<thead>
<tr>
<th>Type of radiation</th>
<th>What radiation consists of</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha</td>
<td>Electron from the nucleus</td>
</tr>
<tr>
<td>Beta</td>
<td>Two protons and two neutrons</td>
</tr>
<tr>
<td>Gamma</td>
<td>Electromagnetic radiation</td>
</tr>
<tr>
<td></td>
<td>Neutron from the nucleus</td>
</tr>
</tbody>
</table>

(b) A teacher demonstrates the penetration of alpha, beta and gamma radiation through different materials.

The demonstration is shown in the figure below.
Complete the figure above by writing the name of the correct radiation in each box.

(2)

(c) Give two safety precautions the teacher should have taken in the demonstration.
1. _________________________________________________________________
   ______________________________________________________________________
2. _________________________________________________________________
   ______________________________________________________________________

(2)

(d) The table below shows how the count rate from a radioactive source changes with time.

<table>
<thead>
<tr>
<th>Time in seconds</th>
<th>0</th>
<th>40</th>
<th>80</th>
<th>120</th>
<th>160</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>in counts / second</td>
<td>400</td>
<td>283</td>
<td>200</td>
<td>141</td>
<td>100</td>
</tr>
</tbody>
</table>

Use the table to calculate the count rate after 200 seconds.

___________________________________________________________________
___________________________________________________________________

(2)

(e) The half-life of the radioactive source used was very short.

Give one reason why this radioactive source would be much less hazardous after 800 seconds.

___________________________________________________________________

(1)

(Total 10 marks)

Q22.

(a) Atoms of the isotope bismuth-212 decay by emitting either an alpha particle or a beta particle.
   The equation represents what happens when an atom of bismuth-212 decays by
beta emission into an atom of polonium-212.

\[
\begin{array}{c}
\text{Bi}^{212}_{83} \rightarrow \text{Po}^{212}_{84} + \text{beta particle}
\end{array}
\]

(i) The bismuth atom and the polonium atom have the same mass number (212).
What is the mass number of an atom?

_______________________________________________________________________________________

(1)

(ii) Beta decay does not cause the mass number of an atom to change.
Explain why not.

_______________________________________________________________________________________
_______________________________________________________________________________________
_______________________________________________________________________________________
_______________________________________________________________________________________

(2)

(b) When an atom of bismuth-212 emits an alpha particle, the atom decays into an atom of thallium.

An alpha particle is the same as a helium nucleus.
The symbol below represents an alpha particle.

\[
\begin{array}{c}
\text{He}^{4}_{2}
\end{array}
\]

(i) The equation below represents the alpha decay of bismuth-212.
Complete the equation by writing the correct number in each of the two boxes.

\[
\begin{array}{c}
\text{Bi}^{212}_{83} \rightarrow \boxed{\text{Tl}} + \boxed{\text{He}^{4}_{2}}
\end{array}
\]

(2)

(ii) It is impossible for the alpha decay of bismuth-212 to produce the same element as the beta decay of bismuth-212.
Explain why.

_______________________________________________________________________________________
_______________________________________________________________________________________
_______________________________________________________________________________________
_______________________________________________________________________________________

(2)

(Total 7 marks)
Atoms contain three types of particle.

(a) Draw a ring around the correct answer to complete the sentence.

The particles in the nucleus of the atom are

- electrons and neutrons.
- electrons and protons.
- neutrons and protons.

(b) Complete the table to show the relative charges of the atomic particles.

<table>
<thead>
<tr>
<th>Particle</th>
<th>Relative charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electron</td>
<td>–1</td>
</tr>
<tr>
<td>Neutron</td>
<td></td>
</tr>
<tr>
<td>Proton</td>
<td></td>
</tr>
</tbody>
</table>

(c) (i) A neutral atom has no overall charge.

Explain this in terms of its particles.

______________________________________________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

(ii) Complete the sentence.

An atom that loses an electron is called an _____________________

and has an overall _________________________ charge.

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

Some substances are radioactive. They may emit alpha or beta particles.

Describe the characteristics of alpha particles and beta particles in terms of their:

- structure
- penetration through air and other materials
- deflection in an electric field.

___________________________________________________________________

___________________________________________________________________
Q24.  
(a) The figure below shows a helium atom.

(i) Which **one** of the particles in the atom is **not** charged?

Draw a ring around the correct answer.
(ii) Which two types of particle in the atom have the same mass?
__________________________ and __________________________

(iii) What is the atomic number of a helium atom?
Draw a ring around the correct answer.
2  4  6
Give a reason for your answer.
______________________________________________________________
______________________________________________________________

(b) Alpha particles are one type of nuclear radiation.

(i) Name one other type of nuclear radiation.

(ii) Use the correct answer from the box to complete the sentence.

electrons  neutrons  protons

The difference between an alpha particle and a helium atom is that the alpha particle does not have any ____________________.

(iii) Which one of the following is a property of alpha particles?
Tick (✓) one box.

Have a long range in air

Are highly ionising

Will pass through metals

(c) Doctors may use nuclear radiation to treat certain types of illness.
Treating an illness with radiation may also harm a patient.

(i) Complete the following sentence.
The risk from treating a patient with radiation is that the radiation may
(i) Draw a ring around the correct answer to complete the sentence.
Radiation may be used to treat a patient if the risk from the radiation is
much bigger than about the same as much smaller than the possible benefit of having the treatment.

Q25.
(a) The names of three types of radiation are given in List A. Some properties of these three types of radiation are given in List B.

Draw one line from each type of radiation in List A to its correct property in List B.

<table>
<thead>
<tr>
<th>List A</th>
<th>List B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of radiation</td>
<td>Property of radiation</td>
</tr>
<tr>
<td>alpha</td>
<td>will pass through paper but is stopped by thin metal</td>
</tr>
<tr>
<td>beta</td>
<td>has the shortest range in air</td>
</tr>
<tr>
<td>gamma</td>
<td>will not harm human cells</td>
</tr>
<tr>
<td></td>
<td>is very weakly ionising</td>
</tr>
</tbody>
</table>

(b) The radioactive isotope iodine-123 can be used by a doctor to examine the thyroid gland of a patient. The iodine, taken as a tablet, is absorbed by the thyroid gland. The gamma radiation emitted as the iodine atoms decay is detected outside the body.
The doctor uses an isotope emitting gamma radiation to examine the thyroid gland rather than an isotope emitting alpha or beta radiation.

Which **one** of the following gives a reason why gamma radiation is used?

Tick (✔) one box.

- Gamma radiation will pass through the body. [ ]
- Gamma radiation is not deflected by a magnet. [ ]
- Gamma radiation has a long range in air. [ ]

(c) Iodine-123 has a half-life of 13 hours.

Use a word from the box to complete the sentence.

all  half  most

After 13 hours ______________________ of the iodine-123 atoms the thyroid absorbed have decayed.

(d) Iodine-123 and iodine-131 are two of the isotopes of iodine.

Draw a ring around the correct answer to complete the sentence.

The nucleus of an iodine-123 atom has the same number of _______ as the nucleus of an iodine-131 atom.

- electrons
- neutrons
- protons

(Q26)

A teacher measured the amount of radiation from a radioactive source, during the same lesson each week, over a period of six weeks.

The results are shown on the graph.
How long does it take for the radiation to fall from 68 counts per minute to half that value?

Show clearly how you work out your answer.

_______________________________________________________________________

_______________________________________________________________________

Time taken for radiation to halve ________________________________________

(Total 3 marks)

Q27.

The diagram below shows a method of controlling the thickness of paper produced at a paper mill. A radioactive source which emits beta radiation is placed on one side of the paper and a radiation detector is placed on the other.

(a) How will the amount of radiation reaching the detector change as the paper gets thicker?
(b) Explain, as fully as you can:

(i) why a radioactive source which emits alpha (α) radiation could not be used for this application.

(ii) why a radioactive source which emits gamma (γ) radiation could not be used for this application.

(iii) why a radioactive source which emits beta (β) radiation can be used for this application.

(c) Americium-241 is a radioisotope used in smoke detectors. It has a proton number of 95 and a mass number of 241.

How long would it take the americium-241 in a smoke detector to decrease to one eighth of its original number of radioactive atoms?

Answer = ____________________

Q28.
The pie chart shows the average proportions of background radiation from various sources in the UK.

(a) Three sources of background radiation are given in List A. Statements about sources of background radiation are given in List B.

Draw one line to link each source of background radiation in List A to the statement about that source given in List B.

Draw only three lines.

<table>
<thead>
<tr>
<th>List A</th>
<th>List B</th>
</tr>
</thead>
<tbody>
<tr>
<td>X-rays</td>
<td>Are used to show broken bones.</td>
</tr>
<tr>
<td>Cosmic rays</td>
<td>The radiation comes from outer space.</td>
</tr>
<tr>
<td>Radon gas</td>
<td>Comes from soil containing a radioactive isotope of potassium.</td>
</tr>
<tr>
<td></td>
<td>On average gives 50% of all background radiation.</td>
</tr>
</tbody>
</table>

(b) The level of background radiation from cosmic rays is not the same everywhere. For every 30 metres above sea level, the amount of background radiation increases by one unit.

The diagram shows the position of two villages, A and B, built on a hill.
How is the amount of background radiation from cosmic rays different in village A compared to village B?

To obtain full marks, you must include a calculation in your answer.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
____________________________________________________

(3)
(Total 6 marks)

Q29.
(a) The diagram represents a helium atom.

(i) Which part of the atom, K, L, M or N, is an electron?
(ii) Which part of the atom, K, L, M or N, is the same as an alpha particle?

Part

(b) A radioactive source emits alpha particles.

What might this source be used for?

Put a tick (✓) in the box next to your answer.

to monitor the thickness of aluminium foil as it is made in a factory

to make a smoke detector work

to inject into a person as a medical tracer

(1)

(c) The graph shows how the count rate from a source of alpha radiation changes with time.

![Graph showing count rate vs. time]

What is the count rate after 4 hours?

______________________ counts per second

(1)

(Total 4 marks)

Q30.

People who work in places where radiation is present, for example in X-ray departments
in hospitals, have to wear a “film badge”. These badges are sent away regularly to check on the amount of radiation to which the person has been exposed. Simply described, the badge is some photographic film in a suitable holder.

(a) (i) Why is the “film badge” of little use in detecting alpha particles?
___________________________________________________________________________
(1)

(ii) How does the “film badge” show radiation has reached it?
___________________________________________________________________________
(1)

(b) Radioactivity can cause harm. It also has a number of valuable uses.

(i) How can radioactivity harm our bodies?
___________________________________________________________________________
___________________________________________________________________________
(1)

(ii) Give two medical uses of radioactive isotopes.

1. ____________________________________________________________________________

2. ____________________________________________________________________________
(2)

(c) A radioactive isotope of lead has a half-life of 10.6 hours.

A small sample of lead containing this isotope has a count rate of 8000 counts per minute.

How long will it be before the count rate is 1000 counts per minute?
___________________________________________________________________________
___________________________________________________________________________

Time = _______________________________ hours
Q31.
Radon is a radioactive gas. Radon makes a major contribution to background radiation levels. Radon atoms decay by the emission of alpha particles.

(a) (i) What is an alpha particle?

(ii) From which part of the radon atom does the alpha particle come?

(b) (i) A sample of air contains 40,000 radon atoms. The half-life of radon is four days. Draw a graph to show how the number of radon atoms present in a sample of air will change over a period of 12 days.

(ii) After 20 days, how many of the radon atoms from the original sample of air will have decayed? Show clearly how you work out your answer.

(c) Fairly constant concentrations of radon gas have been found in some deep mine shafts.

(i) Suggest why the concentration of radon gas remains fairly constant although
the radon gas decays.

(ii) Explain why the long term exposure to large concentrations of radon gas could be a danger to health.

Q32.

The table shows how the count rate from a radioactive substance changes in 10 days.

<table>
<thead>
<tr>
<th>Time in days</th>
<th>0</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count rate in counts per minute</td>
<td>880</td>
<td>555</td>
<td>350</td>
<td>220</td>
<td>140</td>
<td>90</td>
</tr>
</tbody>
</table>

(a) Draw a graph of count rate against time.

The first two points have been plotted for you.
(b) (i) Use your graph to find out how long it takes for the count rate to fall from 880 counts per minute to 440 counts per minute.

Time = ____________________ days

(ii) What is the half-life of this substance?

Half-life = ____________________ days

(c) The table gives the half-life and type of radiation given out by four different radioactive isotopes.

<table>
<thead>
<tr>
<th>Radioactive isotope</th>
<th>Half-life in days</th>
<th>Radiation given out</th>
</tr>
</thead>
<tbody>
<tr>
<td>bismuth-210</td>
<td>5.0</td>
<td>beta</td>
</tr>
<tr>
<td>polonium-210</td>
<td>138.0</td>
<td>alpha and gamma</td>
</tr>
<tr>
<td>radon-222</td>
<td>3.8</td>
<td>alpha</td>
</tr>
<tr>
<td>thorium-234</td>
<td>24.1</td>
<td>beta and gamma</td>
</tr>
</tbody>
</table>

Some samples of each isotope have the same count rate today. Which sample will have the lowest count rate one month from today?
Q33.

Some rocks inside the Earth contain a radioactive element, uranium-238. When an atom of uranium-238 decays, it gives out an alpha particle.

(a) The following statement about alpha particles was written by a student. The statement is not correct.

Alpha particles can pass through a very thin sheet of lead.

Change one word in the statement to make it correct.

Write down your new statement.

(b) The graph shows how the count rate from a sample of uranium-238 changes with time.
The graph can be used to find the half-life of uranium-238. The half-life is 4 500 million years.

(i) Draw on the graph to show how it can be used to find the half-life of uranium-238.

(ii) There is now half as much uranium-238 in the rocks as there was when the Earth was formed.

How old is the Earth?

Draw a ring around your answer.

2250 million years  4500 million years  9000 million years

(iii) If a sample of uranium-238 were available, it would not be possible to measure the half-life in a school experiment.

Explain why.

______________________________________________________________
______________________________________________________________
______________________________________________________________
______________________________________________________________

(Total 5 marks)

Q34.

(a) Some rocks inside the Earth contain uranium-238, a radioactive isotope of uranium. When an atom of uranium-238 decays, it gives out radiation and changes into a thorium-234 atom.

(i) What type of radiation is emitted when a uranium-238 atom decays?

(ii) From which part of a uranium-238 atom is the radiation emitted?

(iii) Uranium-235 is another isotope of uranium.

How is an atom of uranium-235 similar to an atom of uranium-238?
(b) Uranium-238 has a half-life of 4500 million years.

(i) When the Earth was formed, there was twice as much uranium-238 in the rocks as there is now.

What is the age of the Earth?

(ii) Complete the graph to show how the number of nuclei in a sample of uranium-238 will change with time.
Initially, there were 100 000 nuclei in the sample.
Q1.

(a) | Particle | Relative Mass | Relative charge |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Proton</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Neutron</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Accept one, accept +1
Do not accept –1

Accept zero
Do not accept no charge/ nothing/neutral unless given with 0

(b) Equal numbers/amounts of protons and electrons

Protons and electrons have equal but opposite charge
Accept protons charge +1 and electron charge –1
Accept (charge) on proton
cancels/balances (charge) on electron
Accept positive (charges) cancel out the negative (charges)
Neutrons have no charge is neutral
Do not accept total charge of protons, electrons (and neutrons) is 0 unless qualified

(c) (i) (3) fewer neutrons
Accept lower/ smaller mass number
Do not accept different numbers of neutrons
Any mention of fewer/more protons/electrons negates mark
Accept answers in terms of U-238 providing U-238 is specifically stated i.e. U-238 has (3) more neutrons

(ii) Neutron

(iii) (nuclear) fission
Accept fission
Do not accept any spelling that may be taken as fusion

Q2.

(a) (i) (two) nuclei (of light elements) join
Accept hydrogen atoms for nuclei
forming a larger / heavier nucleus / one
   accept comparative term equivalent to larger
   accept forms a helium (nucleus / atom) this mark only scores
   if fusion is in terms of hydrogen atoms

(ii) stars
   accept a named star
e.g. the Sun
   accept nebula
   mention of planets negates answer

(b) (i) any one from:
   • (currently) only experimental
   • reaction does not last long enough
   • use more energy than they produce
     allow difficult to control
     do not allow inefficient on its own

(ii) any one from:
   • will give another source of energy
   • unlimited fuel supplies / energy
     accept unlimited hydrogen
   • would not produce any radioactive waste
     accept less radioactive waste
     accept nuclear for radioactive
     do not accept toxic waste
   • want to show that it can be done
     accept any sensible suggestion
     do not accept answers only in terms of fossil fuels or carbon dioxide

Q3.
(a) (i) (nuclear) fission is the splitting of a (large atomic) nucleus
   do not accept particle/atom for nucleus

(nuclear) fusion is the joining of (two atomic) nuclei (to form a larger one)
   do not accept particles/atoms for nuclei

(ii) energy
   accept heat/radiation/nuclear energy
   accept gamma (radiation)
do not accept neutrons/neutrinos

(b) (i) uranium (–235)
    accept U (–235)
    ignore any numbers given with uranium
    accept thorium
    accept MOX (mixed oxide)
    do not accept hydrogen

(ii) (same) number of protons
    accept (same) atomic number
    accept (same) positive charge
    ignore reference to number of electrons

Q4.

(a) (i) nuclear reactor
    star

(ii) nuclei are joined (not split)
    accept converse in reference to nuclear fission
    do not accept atoms are joined

(b) (i) any four from:
    • neutron
    • (neutron) absorbed by U (nucleus)
      ignore atom
      do not accept reacts
      do not accept added to
    • forms a larger nucleus
    • (this larger nucleus is) unstable
    • (larger nucleus) splits into two (smaller) nuclei / into Ba and Kr
    • releasing three neutrons and energy
      accept fast-moving for energy

(ii) 56 (Ba)

57 (La)
    if proton number of Ba is incorrect allow 1 mark if that of La
    is 1 greater

\[ ^{139}_{56}\text{Ba} \longrightarrow ^{139}_{57}\text{La} + ^0_{-1}\beta \]

accept e for β
Q5.

(a) (i) plutonium (239)
    accept Pu / Thorium / MOX (mixed oxide)
    do not accept uranium-238 or hydrogen

(ii) (energy) used to heat water and
    produce (high pressure) steam
    the steam drives a turbine (which turns a generator)

(b) Neutron(s) shown ‘hitting’ other U-235 nuclei
    one uranium nucleus is sufficient
    U-235 nuclei (splitting) producing 2 or more neutrons

(c) any two from:
    • neutrons are absorbed (by boron / control rods)
    • there are fewer neutrons
    • chain reaction slows down / stops
    accept fewer reactions occur

Q6.

(a) has an equal amount of positive charge
    accept pudding/it is positive

(b) (experimental) results could not be explained using ‘plum pudding’ model
    or
    (experimental) results did not support plum pudding model
    accept (experimental) results disproved plum pudding model

(c) (i) A – most of atom is empty space
    or
    most of atom concentrated at the centre

    B – nucleus is positive (so repels alpha particles)
    accept nucleus has the same charge as alpha

    C – nucleus is very small
    accept nucleus is positive if not scored for B
    or
nucleus is a concentrated mass

*accept nucleus has a very concentrated charge*

(ii) (if predictions correct, this) supports the new model

*answers should be in terms of the nuclear model*

*accept supports his/new/nuclear theory*

*accept proves for supports*

*accept shows predictions/ Rutherford was correct*

**Q7.**

(a) (i) two protons

2 neutrons

*if neither point gained allow 1 mark for helium nucleus*

(ii) electron

(b) neutron splits (to form proton and electron)

**Q8.**

(a) radium

*accept Ra*

(b) different numbers of protons

*accept one has 91 protons, one has 92*

*or Pa has 91 protons, U has 92*

*do not credit they have different atomic numbers*

*reject different numbers of protons and neutrons*

(c) alpha

(d) neutron changes into proton

*accept electron lost / beta radiation*

*accept singular or plural answers*

**Q9.**

(i) nucleus / neutron

*do not accept shells or orbits*

(ii) neutron changes to a proton or number of neutrons goes down 1 and the number of protons goes up by 1
do not accept becomes positive

Q10.

(i) 50 ± 5

(ii) 50 ± 5

accept their (b)(i)

(iii) less

accept any way of indicating the correct answer

Q11.

(a) any two pairs from:

• nuclear model mass is concentrated at the centre / nucleus (1)
  plum pudding model mass is evenly distributed (1)
  accept the nuclear model has a nucleus/the plum pudding model does not have a nucleus for 1 mark

• nuclear model positive charge occupies only a small part of the atom (1)
  plum pudding model positive charge spread throughout the atom (1)
  accept electrons in shells/orbits provided a valid comparison is made with the plum pudding model
do not accept on its own
do not accept electrons at edge of plum pudding

• nuclear model electrons orbit some distance from the centre / nucleus (1)
  plum pudding electrons embedded in the (mass) of positive (charge) (1)

• nuclear model the atom mainly empty space (1)
  plum pudding model is a 'solid' mass (1)
  to gain credit it must be clear which model is being described
do not accept simple descriptions on the diagram without comparison

(b) nucleus must be positive to deflect/repel alpha particles

answers in terms of electrons/negative charge causing deflection negates mark answers in terms of reflection negates mark

nucleus (very) small so few alpha particles deflected backwards

accept most of atom empty space so most pass through

(c) many/100000 measurements taken
findings could not be explained by plum pudding model
   accept a specific finding that could not be explained
      eg some alpha particles were deflected backwards

Q12.
   (a) (i) both lose 2 protons and (2) neutrons
      accept changes by 2 protons and 2 neutrons

   (ii) different number of protons (in the nucleus)
      accept different atomic number
      do not accept different number of protons and neutrons or
      different mass number
      ignore electrons

   (iii) gamma involves no change in the number of protons (in the nucleus)
      or gamma is a wave (not a particle)
      do not accept number of neutrons
      and / or protons
      ignore electrons

(b) (i) water because
      both material and reason required
      for all energy values the thickness
      of water needed to absorb (90% of)
      the radiation is more than the other materials
      accept thickness of water required is always more
      than the other materials

   (ii) 6
      allow 1 mark for obtaining both correct values 72
      and 12 from graph
      allow 1 mark for incorrect values 71 and / or
      11 from graph evaluated correctly

(c) any three from:
   may be scored on annotated diagram provided
   not negated elsewhere
   • most (alpha) particles passed
     undeflected / straight through the gold
   • suggesting most of the atom is empty (space)
   • a few (alpha) particles scattered / deflected through (very) large angles
     accept repelled
     do not accept reflected / rebound /
     bounce back
• suggesting a concentrated / small nucleus

• nucleus is positive because it repels the positive (alpha) particles

no reference to experiment, maximum 1 mark

Q13.

(a) $Y$ and $Z$

they have the same number of protons or same atomic number

accept they have the same number of electrons or same number of protons and electrons

allow only different in number of neutrons N.B. independent marks

(b) Quality of written communication

for correct use of terms underlined in B or C

A – alpha particle passes straight through the empty space of the atom

or it is a long way from the nucleus

describes 3 tracks correctly for 2 marks

describes 2 or 1 track correctly for 1 mark

B – alpha particle deflected / repelled / repulsed by the (positive) nucleus

C – alpha particle heading straight for the nucleus is deflected / repelled / repulsed backwards

do not accept hits the nucleus

do not accept answers referring to refraction

do not accept answers in terms of reflected backwards

unless qualified in terms of repulsion

mention of difference in charge on nucleus negates that track

max 2

Q14.

(a) isotopes

(b) $^{231}_{90}$Th

correct order only

(c) (i) (nuclear) fission

accept fission

do not accept any spelling that may be confused with fusion

(ii) neutron / neutrons
(d) plutonium (239)
   accept MOX (mixed oxide)
   accept Pu
   do not accept uranium 238 / hydrogen

Q15.
(a) (i) all 3 labels correct
    allow 1 mark for 1 correct label

   (ii) has no electrons
        it = alpha
        allow alpha has a positive(charge)
        allow a helium (atom) has no (charge)
        do not accept general properties of alpha
        do not accept general answers in terms of size / density / mass etc

(b) (i) 15 (hours)
        accept any answer between 14.8 and 15.2 inclusive

   (ii) 15 (hours) or their (b) (i)

(c) (i) americium-241 has a long half life

   (ii) any one from:
        • alpha (particles) are harmful to …
          accept radiation / radioactive material is harmful to …
          accept specific example of harm
          eg can cause cancer
          accept radiation is poisonous if ingested / inhaled
          do not accept it is poisonous / in case of leakage
• so they dispose of it safely / appropriately

• so they don’t break it open / open it
  accept do not touch the radioactive source

• so they can make a choice about having a radioactive source (in the house)
  it = radioactive material

Q16.

(a) (i) (atoms / elements with) the same number of protons but different numbers of neutrons
  accept (atoms / elements with) different mass number but same atomic number

(ii) substances that give out radiation
  accept alpha, beta or gamma for radiation
  accept an unstable nucleus that decays
  radioactive decay takes place is insufficient

(b) 85 years
  ± 2 years
  allow 1 mark for showing correct method on the graph

(c) (i) a helium nucleus
  accept 2 neutrons and 2 protons
  accept $^4_2\text{He}$
  do not accept helium atom

(ii) the rate of decay (of plutonium) decreases
  accept fewer (plutonium) nuclei (to decay)
  accept radioactivity decreases
  less heat produced
  do not accept energy for heat

(d) (i) (outside the body)
  alpha (particles) cannot penetrate into the body

  (inside the body)

  (heat produced from decay) damages / kills cells / tissues
  accept causes cancer for damages / kills cells / tissues
  accept highly toxic
any one from:

- worried same could happen again
- an accident may cause radiation to be spread around the Earth / atmosphere
- idea of soil contamination resulting from accident / release of radioactive material
- idea of negative effect on health resulting from accident / release of radioactive material

accept any sensible suggestion

Q17.
(a) 146

(b) atomic number

(c) (i) alpha

(ii) number of protons changes

accept atomic number changes
accept loses or gains protons

**do not** accept protons with any other particle e.g. number of protons and neutrons changes incorrect

**do not** accept any reference to mass number

Q18.
(a) (i) **K** and **L**

both answers required either order

(ii) (1) same number of protons

accept same number of electrons
accept same atomic number

(2) different numbers of neutrons

(b) (i) 90

(ii) 140

(c) alpha (particle)

reason may score even if beta or gamma is chosen
mass number goes down by 4 
or
number of protons and neutrons goes down by 4 
or
number of neutrons goes down by 2

candidates that answer correctly in terms of why gamma and beta decay are not possible gain full credit

atomic / proton number goes down by 2 
or
number of protons goes down by 2

accept an alpha particle consists of 2 neutrons and 2 protons for 1 mark

accept alpha equals \(^{4}_2\text{He}\) or \(^{3}_a\) for 1 mark

an alpha particle is a helium nucleus is insufficient for this mark

Q19.

(a) (i) all correct

accept presented as a tally chart

<table>
<thead>
<tr>
<th>Number of protons</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of electrons</td>
<td>3</td>
</tr>
<tr>
<td>Number of neutrons</td>
<td>4</td>
</tr>
</tbody>
</table>

allow 1 mark for 1 correct

(ii) 7

reason may score even if 7 not chosen

number of protons and neutrons

accept number of particles in the nucleus

accept number of nucleons

do not accept number of electrons and neutrons

(b) an ion

(c) (i) smaller than

(ii) radon loses an alpha (particle)
or
radon loses an (alpha) particle
or
(mass of) polonium plus an alpha = (mass) radon
or
radon loses 2 protons and 2 neutrons (to become polonium)

accept radon has less protons and neutrons
Q20.

\(\beta\) reason may score even if \(\alpha\) or \(\gamma\) given

any **two** from:

- mass number does not change
  or
total number of protons and neutrons does not change
- atomic / proton number increases by 1
  or
number of protons increases by 1
- number of neutrons goes down by 1
  allow for 2 marks a neutron splits / changes into a proton and
  electron / \(\beta\)
candidates that answer correctly in terms of why \(\alpha\) and
\(\gamma\) are not possible, gain both marks

Q21.

(a) Alpha – two protons and two neutrons

Beta – electron from the nucleus

Gamma – electromagnetic radiation

(b) Gamma

Beta

Alpha

allow 1 mark for 1 or 2 correct

(c) any **two** from:

- (radioactive) source not pointed at students
- (radioactive) source outside the box for minimum time necessary
- safety glasses **or** eye protection **or** do not look at source
- gloves
- (radioactive) source held away from body
- (radioactive) source held with tongs / forceps
  accept any other sensible and practical suggestion

(d) half-life = 80 s
counts / s after 200 s = 71

- accept an answer of 70

(e) very small amount of radiation emitted

- accept similar / same level as background radiation

<table>
<thead>
<tr>
<th>Q22.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
</tr>
<tr>
<td>(i)</td>
</tr>
<tr>
<td>(total) number of protons plus neutrons</td>
</tr>
<tr>
<td>accept number of nucleons</td>
</tr>
<tr>
<td>accept amount for number</td>
</tr>
<tr>
<td>do not accept number of particles in the nucleus</td>
</tr>
</tbody>
</table>

- 1

(ii) number of neutrons decreases by one

number of protons increases by one

- accept for both marks a neutron changes into a proton

- 1

(b)  |
| (i)  |
| 208 |
| 81  |
| Th  |
| correct order only |

- 1

(ii) the number of protons determines the element

- accept atomic number for number of protons

alpha and beta decay produce different changes to the number of protons

there must be a comparison between alpha and beta which is more than a description of alpha and beta decay alone

or alpha and beta decay produce different atomic numbers

ignore correct reference to mass number

- 1

<table>
<thead>
<tr>
<th>Q23.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
</tr>
<tr>
<td>neutrons and protons</td>
</tr>
</tbody>
</table>

- 1

(b) 0

- 1

(+1)

- 1

(c) (i) total positive charge = total negative charge

- accept protons and electrons have an equal opposite charge

- 1
(because) no of protons = no of electrons

(ii) ion

positive

(d) Marks awarded for this answer will be determined by the quality of communication as well as the standard of the scientific response. Examiners should apply a best-fit approach to the marking.

0 marks
No relevant content

Level 1 (1 – 2 marks)
There is a basic description of at least one of the particles in terms of its characteristics.

Level 2 (3 – 4 marks)
There is a clear description of the characteristics of both particles or a full description of either alpha or beta particles in terms of their characteristics.

Level 3 (5 – 6 marks)
There is a clear and detailed description of both alpha and beta particles in terms of their characteristics.

examples of the physics points made in the response:

structure

• alpha particle consists of a helium nucleus
• alpha particle consists of 2 protons and 2 neutrons
• a beta particle is an electron
• a beta particle comes from the nucleus

penetration

• alpha particles are very poorly penetrating
• alpha particles can penetrate a few cm in air
• alpha particles are absorbed by skin
• alpha particles are absorbed by thin paper
• beta particles can penetrate several metres of air
• beta particles can pass through thin metal plate / foil
• beta particles can travel further than alpha particles in air
• beta particles can travel further than alpha particles in materials eg metals

deflection

• alpha particles and beta particles are deflected in opposite directions in an electric field
• beta particles are deflected more than alpha particles
• alpha particles have a greater charge than beta particles but beta particles have much less mass or beta particles have a greater specific charge than alpha particles
Q24.
(a) (i) neutron

(ii) neutron proton

*both required, either order*

(iii) 2

number of protons

*do not accept number of electrons*

(b) (i) any one from:

- beta
- gamma

*accept correct symbols*

*accept positron / neutrino / neutron*

*cosmic rays is insufficient*

(ii) electrons

(iii) are highly ionising

(c) (i) mutate / destroy / kill / damage / change / ionise

*Harm is insufficient*

(ii) much smaller than

Q25.
(a) 3 lines correct
allow 1 mark for each correct line
if more than one line is drawn from any type of radiation box
then all of those lines are wrong

(b) Gamma radiation will pass through the body

(c) half

(d) protons

Q26.

2 weeks

if answer is incorrect 2 gains two marks weeks gains one mark

half of 68 or 34 gains one mark / allow working shown on graph

Q27.

(a) decrease

for 1 mark

(b) (i) none would go through paper

for 1 mark

(ii) all would go through paper

for 1 mark

(iii) only some absorbed/amount absorbed depends on thickness of paper

for 1 mark each

(c) 1 → 1/2 → 1/4 → 1/8
Q28.
(a) 1 mark for each correct line

<table>
<thead>
<tr>
<th>List A</th>
<th>List B</th>
</tr>
</thead>
<tbody>
<tr>
<td>X-rays</td>
<td>Are used to show broken bones.</td>
</tr>
<tr>
<td>Cosmic rays</td>
<td>The radiation comes from outer space.</td>
</tr>
<tr>
<td>Radon gas</td>
<td>Comes from soil containing a radioactive isotope of potassium.</td>
</tr>
<tr>
<td></td>
<td>On average gives 50% of all background radiation.</td>
</tr>
</tbody>
</table>

if more than 1 line has been drawn from a box in List A then all those lines are marked incorrect

(b) higher in village B by 6 units

allow 1 mark for correctly obtaining a height difference of 180 (m) / 4 times higher – this refers to height not radiation levels accept for 3 marks in village A it is 2 units (extra) and in village B it is 8 units (extra) allow 1 mark for a correct radiation calculation based on incorrect height readings

Q29.
(a) (i) L

(ii) M

(b) To make a smoke detector work.

(c) 40

no tolerance

[8]
Q30.

(a) (i) alpha particles cannot penetrate covering

\[ \text{do not credit any answer not relating to film badge or its case} \]  

(ii) film gets fogged or blackened

\[ \text{accept film gets exposed} \]

\[ \text{do not credit film changes colour or goes white or blotchy} \]  

(b) (i) any one from

may cause cancer may damage cells or cell nucleii causes mutations

\[ \text{changes DNA} \]

\[ \text{accept (causes) burns or kills cells} \]  

(ii) any two from

treating cancers

tracer in body

sterilising instruments or bandages

\[ \text{accept two descriptions of named treatments, eg thyroid} \]

\[ \text{check and circulation monitoring} \]

\[ \text{accept is a source of X-rays, eg for dentistry or taking X-rays of bones} \]  

(c) calculation that 1000 is 3 half lives on

\[ 8000 \rightarrow 4000 \rightarrow 2000 \rightarrow 1000 \]  

\[ \text{time elapsed is 3 \times \text{half life} = 31.8 \text{ hr}} \]

\[ \text{award both marks for 31.8 hr or 1 day 7.8 hr with no working shown} \]  

Q31.

(a) (i) a helium nucleus

\[ \text{accept } ^4 \text{He} \]

\[ \text{accept 2 protons + 2 neutrons} \]

\[ \text{do not accept He} \]

\[ \text{do not accept helium atom} \]  

(ii) nucleus

\[ \text{only answer, no alternative} \]  

(b) (i) each axis given a linear scale

\[ \text{time axis must go up to 12 days} \]

\[ \text{y-axis must go up to 40 000} \]  

\[ \text{curve concave to axis drawn} \]
curve shows correct half-life of four days

*do not* accept a straight line must show one half-life
check first two plotted points correct to ± half square
a curve drawn dot-to-dot scores a maximum of 1 mark

(ii) 38 750

*no tolerance*
allow 1 mark for 5 half-lives
allow 1 mark for showing that 1 250 are undecayed

(c) (i) more radon enters shaft (through cracks in the rock face)

*accept* radon emitted from surroundings

(ii) (alpha) radiation will damage cell structure or ionise cells

*accept* kill cells

causing cancerous growth

*an answer in terms of the daughter product polonium being a solid* or lodging in the throat and also emitting alpha gains full credit

Q32.

(a) all points correctly plotted

*tolerance* ± \( \frac{1}{2} \) square on y axis only

*allow* 1 mark for 3 correctly plotted points

attempt made to draw a smooth curve

*do not* accept dot-to-dot line

(b) (i) 3 days ± 0.2

*or* any value correctly obtained using their graph line

*if no line drawn in (a), answer must be exactly 3*

(ii) 3 days or their (b)(i)

(c) radon-222

*accept* radon or 222

*accept* alpha or 3.8

*correct isotope required for reason to score*

has the shortest half-life
accept the others have longer half-lives

Q33.
(a) alpha particles **cannot** pass through…
   *do not* accept gamma particles…
   or
   alpha particles can pass through a very thin sheet of **paper / card**
   *credit answers where correct amendments are made to boxed statement*

(b) (i) horizontal and vertical line drawn at correct positions on the graph
   *accept a cross drawn at 4500 / 500 on the curve*
   or
   two pairs of lines drawn, for example, at 600 and 300
   *accept a horizontal line drawn at 500 on its own*
   *do not* accept vertical lines only

   (ii) 4500 million years

   (iii) half-life too long
         *do not* accept simply its half-life is 4500 million years
         no (measurable) change in count rate
         *do not* accept have not got the equipment
         *do not* accept it's harmful (to children)
         if neither of the above points scored, accept not enough time
to measure it for 1 mark

Q34.
(a) (i) alpha (particle)

   (ii) (unstable) nucleus
        *accept (unstable) nuclei*
        *do not* accept middle
        *do not* accept helium nucleus

   (iii) same number of protons
        *accept same number of electrons*
        *accept same atomic / proton number*
        *accept they both have 92 protons*
        **same number of neutrons negates answer**

(b) (i) 4500 million years
do not accept 4500 years

(ii) curve starting at 100 000 with a correct general shape

passing through (4500, 50 000) and (9000, 25 000)

allow 1 mark for points plotted

or

line passing through (4500, 50 000) and (9000, 25 000)