

PHYSICS



EXAM QUESTION PACK

TOPIC 6: RADIOACTIVITY (PACK 1)

SCORE

/83

PERCENTAGE

%

STEMUP

These questions belong to Pearson Edexcel, not to us.

The examination questions, mark schemes and examiner comments in this pack were written and published by Pearson Edexcel. They are past assessment materials, reproduced here so that students can revise from them.

What we do not own

STEMUP is not affiliated with Pearson Edexcel and does not own, and makes no claim to own, any of the question, mark scheme or examiner report material in this pack. Pearson Edexcel has not endorsed, approved or been involved in the production of it. Pearson Edexcel and the qualification titles used here belong to their respective owners and appear for identification only.

Where to find the originals

Pearson Edexcel publishes its past papers, mark schemes and examiner reports. Always check the current specification at [qualifications.pearson.com](https://www.pearson.com/qualifications) before you revise, because content and wording can change between series.

If you hold the rights to any material in this pack and would like it amended or removed, contact admin@stemup.co.uk and we will act on it.

Q1.

(a) Positrons are antiparticles of electrons.

The photograph shows a PET scanner that uses positrons to locate the site of a brain tumour.



Positrons are emitted by the radioactive isotope fluorine-18.

The fluorine-18 is attached to glucose.

The glucose is injected into the patient's blood stream and collects at the site of the tumour.

(i) Fluorine-18 has a half-life of 1.8 hours.

State one advantage and one disadvantage of using a substance with such a short half-life.

1. Advantage

(1)

.....

.....

2. Disadvantage

(1)

.....

.....

(ii) When a positron meets an electron they annihilate each other.

Explain how this enables the site of the tumour to be located.

(4)

.....

.....

.....

.....

.....

.....

*(b) Positrons (β^+ particles) are emitted from the nuclei of some atoms.

Electrons (β^- particles) are emitted from the nuclei of other atoms.

The table gives some information about quarks.

quark	charge (compared to the charge on a proton)
u	+2/3
d	-1/3

Describe, in terms of quarks, how β^+ particles are emitted from the nuclei of some atoms and β^- particles are emitted from the nuclei of others.

(6)

.....

.....

.....

.....

.....

.....

.....

.....

(Total for Question = 12 marks)

Q2.

Some rocks contained uranium when they were formed.

Radioactive decay in these rocks produces radon gas.

Explain why people living near these rocks have an increased health risk from background radiation.

(3)

.....

.....

.....

.....

.....

.....

Q3.

Some rocks contained uranium when they were formed.

Radioactive decay in these rocks produces radon gas.

Explain why people living near these rocks have an increased health risk from background radiation.

(3)

.....

.....

.....

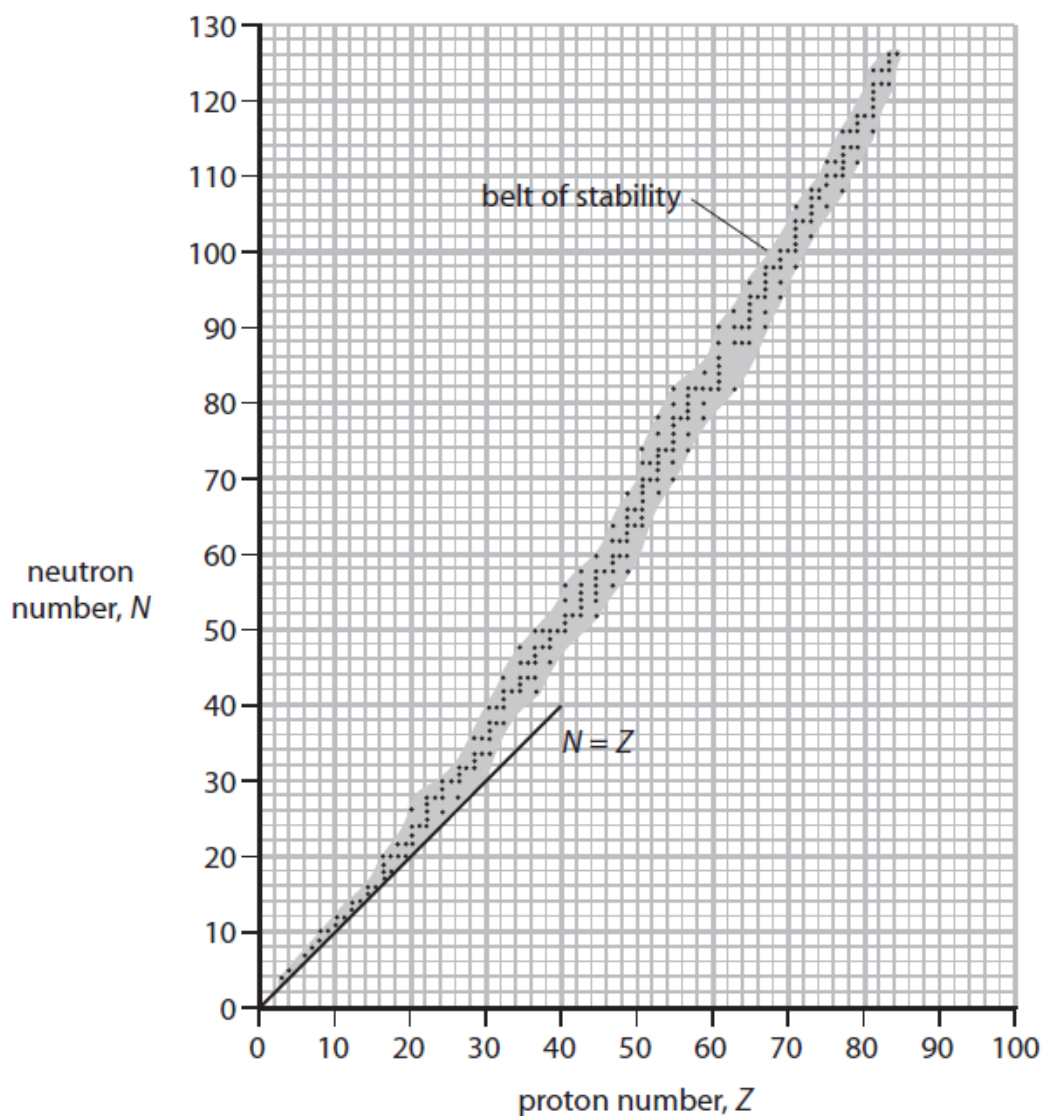
.....

.....

.....

Q4.

(a) The diagram shows the stability curve for nuclear isotopes.



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

An isotope above the curve will undergo β^- decay because it has

(1)

- ☐ **A** too few protons
- ☐ **B** too many protons
- ☐ **C** too few neutrons
- ☐ **D** too many neutrons

(b) Which statement is correct for β^+ and β^- particles?

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

(1)

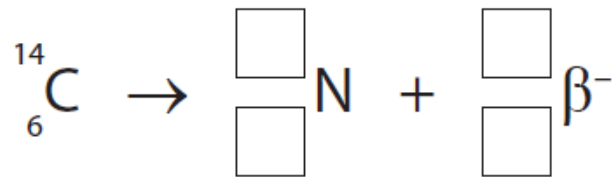
- ☐ **A** a β^+ is positively charged and a β^- is negatively charged
- ☐ **B** the mass of a β^+ is 1800 times the mass of a β^-
- ☐ **C** the charge on a β^+ is twice the charge on a β^-

☒ **D** a β^+ is a proton and a β^- is an electron

(c) Carbon-14 decays by emitting a β^- particle to form an isotope of nitrogen.

Complete the nuclear equation for this decay by filling in the boxes.

(2)



(d) Protons and neutrons both contain quarks.

Describe the arrangement of quarks in a proton.

(2)

.....

.....

.....

.....

(e) Explain what happens to a nucleus during β^+ decay.

(2)

.....

.....

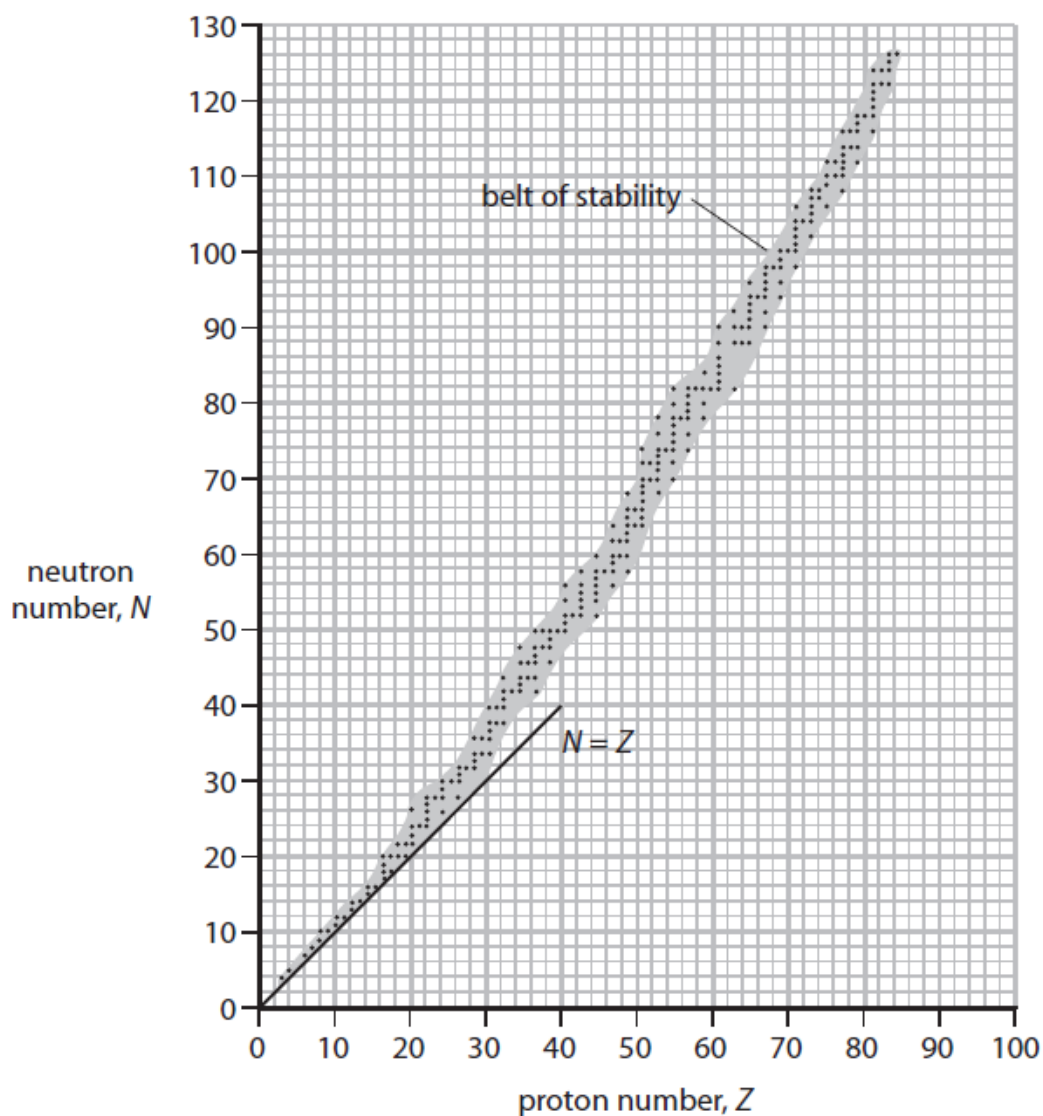
.....

.....

.....

Q5.

(a) The diagram shows the stability curve for nuclear isotopes.



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

An isotope above the curve will undergo β^- decay because it has

(1)

- ☐ **A** too few protons
- ☐ **B** too many protons
- ☐ **C** too few neutrons
- ☐ **D** too many neutrons

(b) Which statement is correct for β^+ and β^- particles?

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

(1)

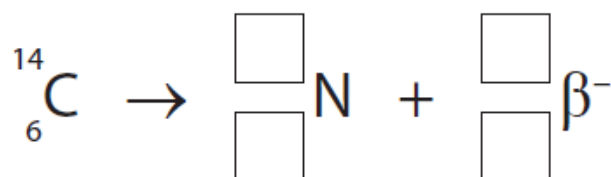
- ☐ **A** a β^+ is positively charged and a β^- is negatively charged
- ☐ **B** the mass of a β^+ is 1800 times the mass of a β^-
- ☐ **C** the charge on a β^+ is twice the charge on a β^-

☒ **D** a β^+ is a proton and a β^- is an electron

(c) Carbon-14 decays by emitting a β^- particle to form an isotope of nitrogen.

Complete the nuclear equation for this decay by filling in the boxes.

(2)



(d) Protons and neutrons both contain quarks.

Describe the arrangement of quarks in a proton.

(2)

.....

.....

.....

.....

(e) Explain what happens to a nucleus during β^+ decay.

(2)

.....

.....

.....

.....

.....

Q6.

A G-M tube is connected to a counter.

A teacher places the G-M tube near to a radioactive source.

A student starts the counter and clock at the same time and writes down the readings shown on the counter every 15 s.

The student plots the readings with a line of best fit, as shown in Figure 10.

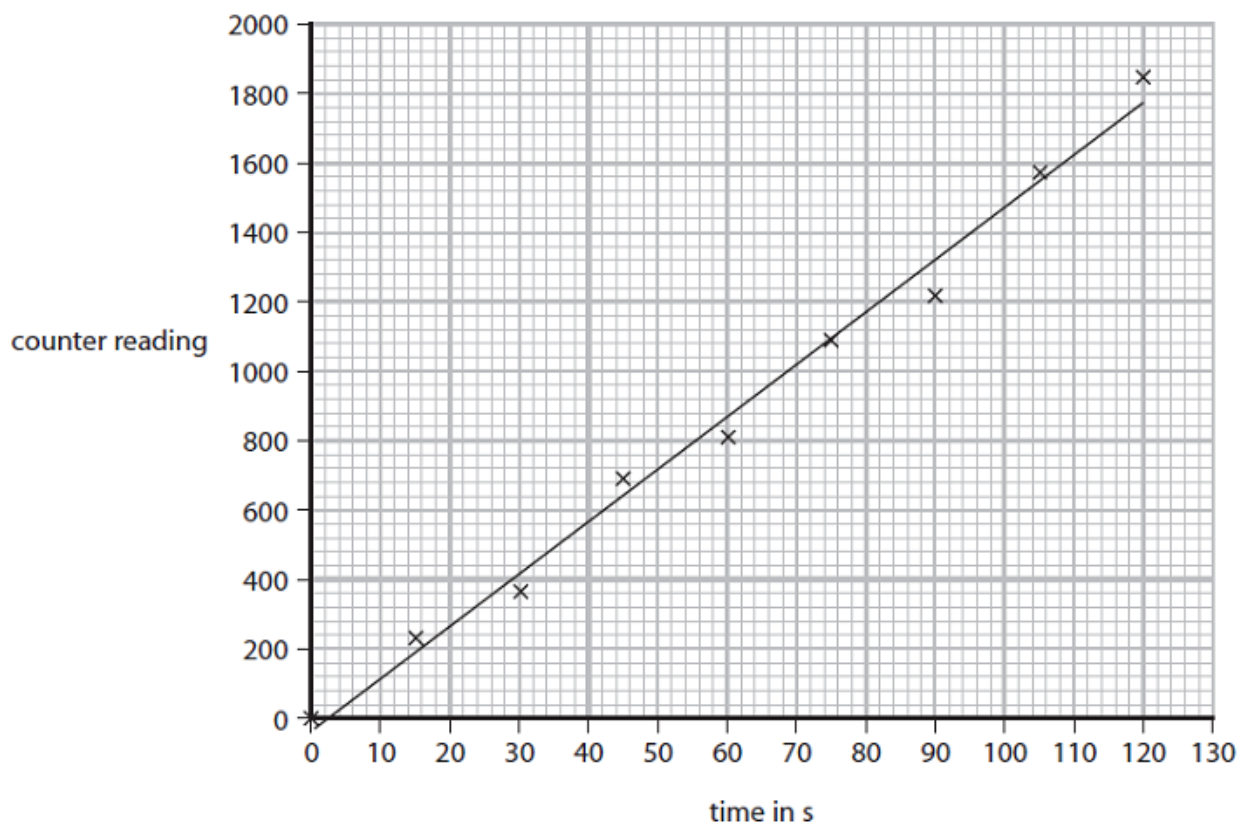


Figure 10

(i) Calculate the average count rate, in counts / s, from the graph.

Show your working on the graph.

(2)

average count rate = ... counts / s

(ii) The student says that the experiment must have been done carelessly because the data seemed quite scattered away from the best fit line.

The teacher claims such results should be expected in radioactivity experiments.

Justify the teacher's claim.

(2)

.....

.....

.....

.....

(Total for question = 4 marks)

Q7.

A G-M tube is connected to a counter.

A teacher places the G-M tube near to a radioactive source.

A student starts the counter and clock at the same time and writes down the readings shown on the counter every 15 s.

The student plots the readings with a line of best fit, as shown in Figure 8.

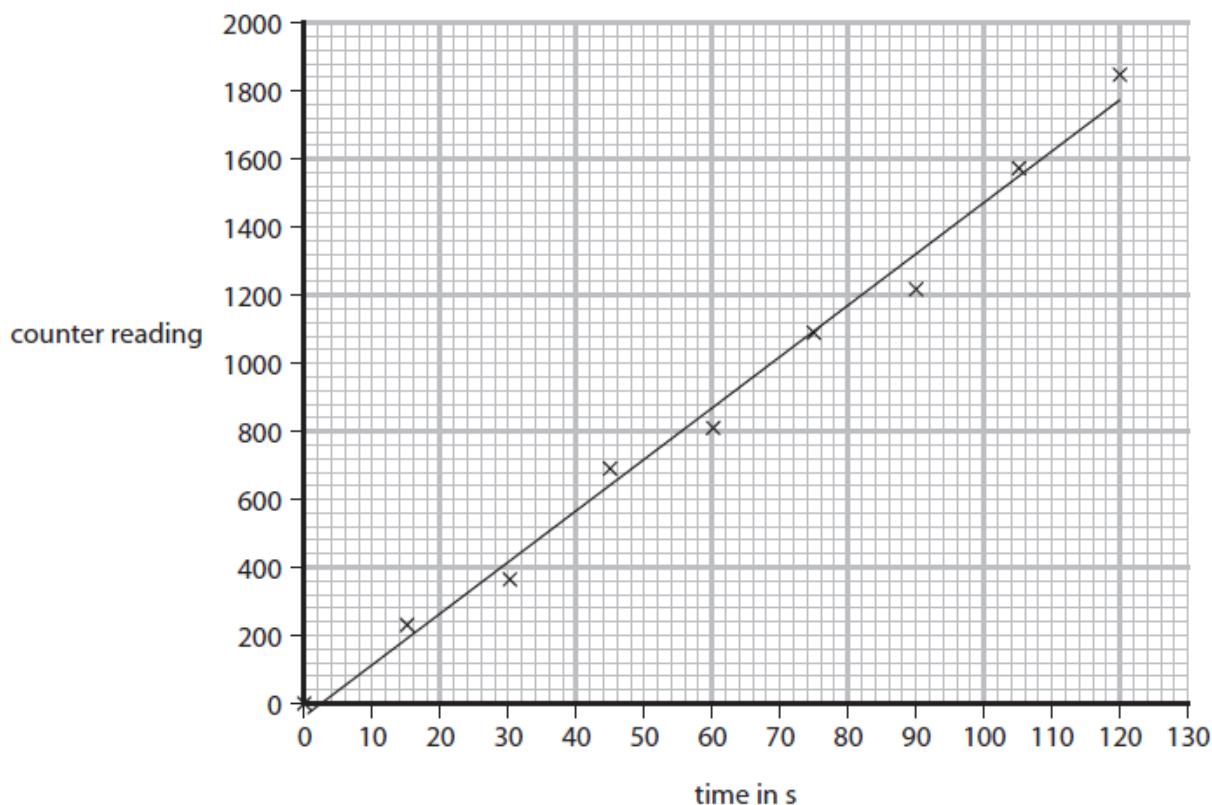


Figure 8

(i) Calculate the average count rate, in counts / s, from the graph.

Show your working on the graph.

(2)

average count rate = ... count / s

(ii) The student says that the experiment must have been done carelessly because the data seemed quite scattered away from the best fit line.

The teacher claims such results should be expected in radioactivity experiments.

Justify the teacher's claim.

(2)

.....
.....

.....

.....

(Total for question = 4 marks)

Q8.

This question is about radioactivity.

Radium-223 is a radioactive substance.

Radium-223 is an alpha emitter.

The half-life of radium-223 is 11 days.

A radioactive source contains 1.7×10^{23} nuclei of radium-223.

Calculate the number of radium-223 nuclei remaining in the source after a time of 33 days.

(2)

number of radium-223 nuclei remaining = ...

(Total for question = 2 marks)

Q9.

The intensity of gamma radiation can be measured using a Geiger-Müller tube and counter.

The count rate recorded by the counter tube depends on how far away the Geiger-Müller tube is from the gamma radiation source.

The equation relating count rate to distance from the source is

$$\text{count rate} = \frac{k}{d^2}$$

where d is the distance from the source and k is a constant.

A Geiger-Müller tube is placed 0.70 m from a source of gamma radiation.

The counter displays a count rate of 85 000 count per minute.

Calculate the count rate recorded when the Geiger-Müller tube is placed 1.3 m away from the same gamma radiation source.

(3)

count rate = ... counts per minute

(Total for question = 3 marks)

Q10.

Some questions must be answered with a cross in a box (☒). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).

Radioactive tracers can be used when scanning a person's kidneys.

A radioactive isotope is injected into a person's blood stream.

The isotope emits radiation.

As the blood flows through the kidneys, this radiation is detected outside the body by a scanner.

(i) What type of radiation travels from the kidney to the scanner?

(1)

- ☐ **A** alpha
- ☐ **B** beta plus
- ☐ **C** beta minus
- ☐ **D** gamma

(ii) During the scan, a technician needs to take readings for about 30 minutes.

The half-life of the isotope used is about 6 hours.

1. State why an isotope with a half-life of about 6 minutes is **not** suitable.

(1)

.....
.....

2. State why an isotope with a half-life of about 6 days is **not** suitable.

(1)

.....

.....

(iii) State **two** ways of reducing the radiation risks to the technician.

(2)

1

.....

2

.....

(Total for question = 5 marks)

Q11.

Radio waves and gamma radiation are at opposite ends of the electromagnetic spectrum.

Compare how these two electromagnetic radiations are produced.

(6)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 6 marks)

This image shows a full page of white paper with horizontal blue or grey ruling lines. The lines are evenly spaced and run across the width of the page, providing a template for handwriting practice or general writing. There are no margins, text, or other markings on the page.

(Total for question = 6 marks)

Q13.

* Nuclear fission and nuclear fusion are two non-renewable sources of energy.

Compare nuclear fission and nuclear fusion as possible sources of energy for generating electricity using a nuclear reactor.

Your comparison should refer to

- the differences between nuclear fission and nuclear fusion
- the relative advantages and difficulties involved in using these sources.

(6)

[illegible]

(Total for question = 6 marks)

Q14.

Fluorine-19 is a stable isotope of the element fluorine.

The element fluorine also has several radioactive isotopes.

Describe **one** similarity and **one** difference between the numbers of particles in one nucleus of fluorine-19 and one nucleus of a radioactive isotope of fluorine.

(2)

similarity

.....

difference

.....

(Total for question = 2 marks)

Q15.

* Gamma radiation is produced by radioactive decay.

Alpha radiation and beta radiation are also produced by radioactive decay.

Compare the processes of alpha decay and beta decay.

Your answer should include what each radiation is and what effect each decay has on the original nucleus.

(6)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 6 marks)

Q16.

* Gamma radiation is produced by radioactive decay.

Alpha radiation and beta radiation are also produced by radioactive decay.

Compare the processes of alpha decay and beta decay.

Your answer should include what each radiation is and what effect each decay has on the original nucleus.

(6)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

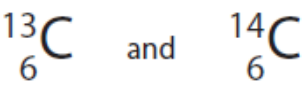
.....

(Total for question = 6 marks)

Q17.

Carbon-13 and carbon-14 are isotopes of carbon.

Nuclei of carbon-13 and carbon-14 can be represented by these symbols



Complete the table for an atom of carbon-13 and an atom of carbon-14.

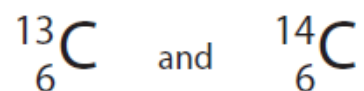
	number of neutrons in the nucleus	number of electrons in orbit around the nucleus
carbon-13		
carbon-14		

(Total for question = 2 marks)

Q18.

Carbon-13 and carbon-14 are isotopes of carbon.

Nuclei of carbon-13 and carbon-14 can be represented by these symbols



Complete the table for an atom of carbon-13 and an atom of carbon-14.

(2)

	number of neutrons in the nucleus	number of electrons in orbit around the nucleus
carbon-13		
carbon-14		

(Total for question = 2 marks)

Q19.

State what is meant by the term 'half-life'.

(1)

.....

.....

(Total for question = 1 mark)

Q20.

Students are given the apparatus shown in Figure 12 and a protractor.

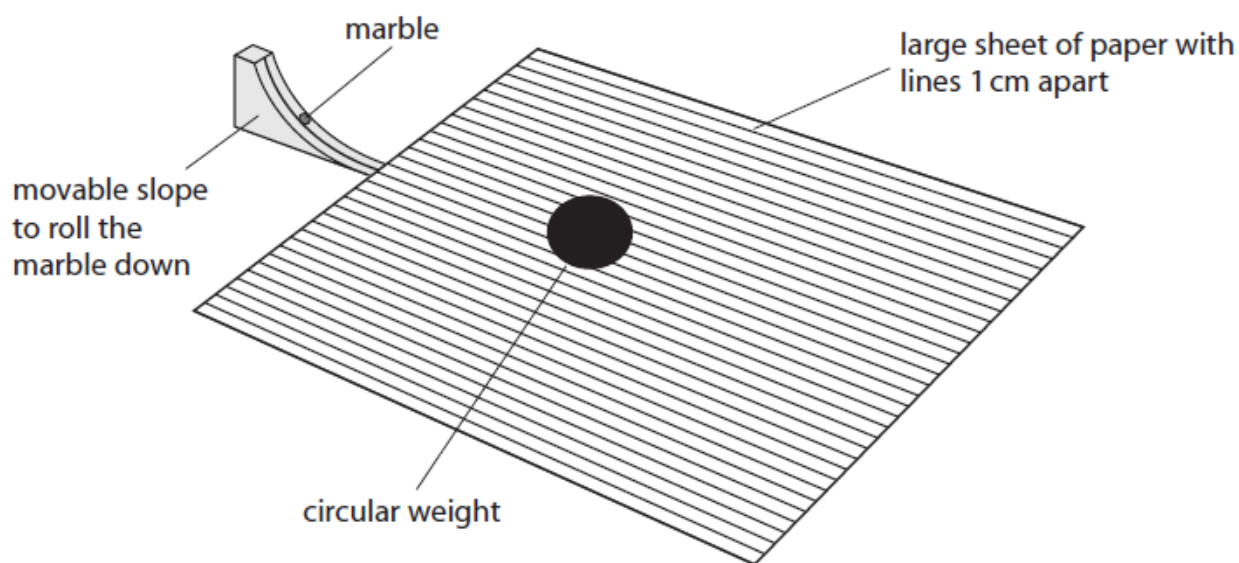


Figure 12

(i) Describe how the students could use the apparatus to model the scattering of alpha particles.

(2)

.....

.....

.....

.....

(ii) Give **one** limitation of this model.

.....

.....

(Total for question = 3 marks)

Q21.

Describe how the energy released in the chain reaction in a nuclear reactor is used to drive a turbine in a nuclear power station.

.....

.....

.....

.....

.....

.....

(Total for question = 3 marks)

Q22.

Students are given the apparatus shown in Figure 8 and a protractor.

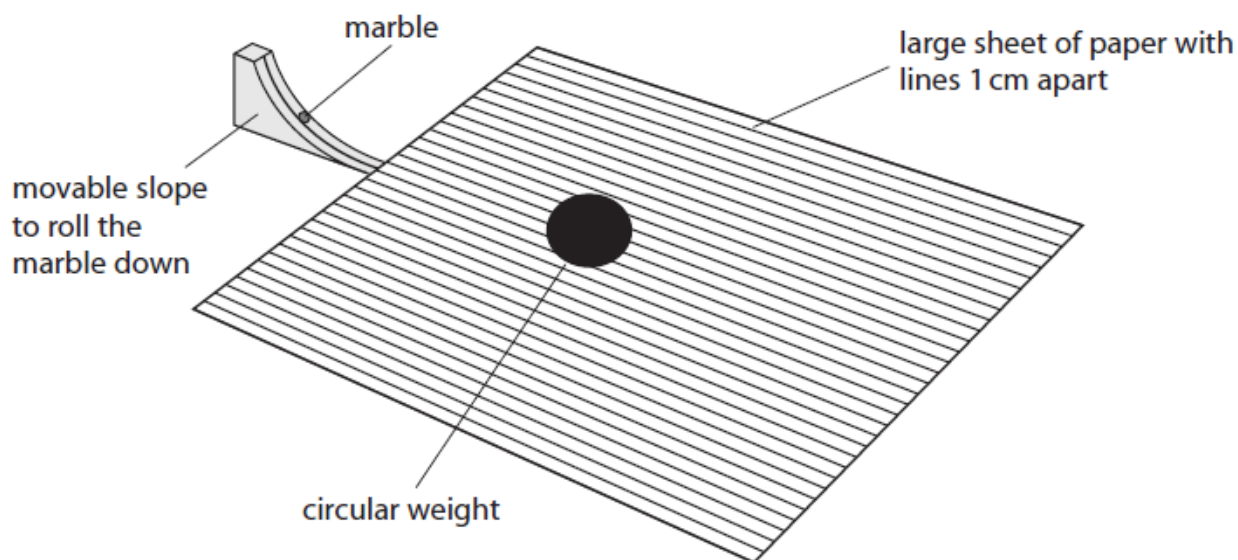


Figure 8

(i) Describe how the students could use the apparatus to model the scattering of alpha particles.

(2)

.....

.....

.....

.....

(ii) Give **one** limitation of this model.

(1)

.....

.....

(Total for question = 3 marks)

Q23.

Describe how the thermal energy from nuclear fission can be used to turn the electrical generator in a power station.

(2)

.....

.....

.....

.....

.....

.....

(Total for question = 2 marks)

Q24.

Stars may originate as a nebula.

(i) Describe the process that then occurs to produce the conditions necessary for nuclear fusion in a new star.

(3)

.....

.....

.....

.....

.....

.....

(ii) The energy, E , released in nuclear fusion is equivalent to loss in mass, m , according to the equation.

$$E = mc^2$$

where c is the velocity of light.

$$c = 3.00 \times 10^8 \text{ m/s}$$

In 1 second, the energy radiated by the Sun is $3.86 \times 10^{26} \text{ J}$.

Calculate the loss in mass of the Sun in 1 second.

(2)

loss in mass = ... kg

(Total for question = 5 marks)

Q25.

Radium-223 is a radioactive substance.

Radium-223 is an alpha emitter.

The half-life of radium-223 is 11 days.

A radioactive source contains 1.7×10^{23} nuclei of radium-223.

Calculate the number of radium-223 nuclei remaining in the source after a time of 33 days.

(2)

number of radium-223 nuclei remaining = ...

(Total for question = 2 marks)

Q26.

Sometimes food can become contaminated with radioactive substances.

Describe the harmful effects of eating food contaminated with radioactive substances.

(2)

.....

.....

.....

.....

(Total for question = 2 marks)

Q27.

Sometimes food can become contaminated with radioactive substances.

Describe the harmful effects of eating food contaminated with radioactive substances.

(2)

.....

.....

.....

.....

(Total for question = 2 marks)

Q28.

Answer the question with a cross in the box you think is correct ☐ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐ .

This question is about radioactivity.

Alpha (α), beta (β) and gamma (γ) are three types of radioactive emissions.

Which statement describes **all** of these radioactive emissions?

(1)

- ☐ **A** ionising and emitted by stable nuclei
- ☐ **B** ionising and emitted by unstable nuclei
- ☐ **C** neutral and emitted by stable nuclei
- ☐ **D** neutral and emitted by unstable nuclei

(Total for question = 1 mark)

Q29.

Nuclear fusion provides the energy source for stars including the Sun.

Describe what happens during nuclear fusion.

(3)

.....

.....

.....

.....

.....

.....

(Total for question = 3 marks)

Q30.

Carbon-14 is radioactive and has a half-life of 5 700 years.

The number of radioactive carbon-14 atoms in a very old piece of wood is found to have decreased from 1 000 000 to 125 000.

Determine the age of the piece of wood.

(2)

age of wood = ... years

(Total for question = 2 marks)

Mark Scheme

Q1.

Question Number	Answer	Acceptable answers	Mark
(a)(i)	1. advantage (1) minimises patient's exposure to radioactivity 2. disadvantage (1) (has to be produced) close to the {place / time} of use	Does not stay in the (patient's) body for a long time / Decays quickly Any time constraint (in diagnosis/scanning/treatment) Ignore confusion between biological and physical half-life	(2)

Question Number	Answer	Acceptable answers	Mark
(a)(ii)	An explanation linking four from: - gamma (rays emitted) (1) - two (gamma rays) (1) - in opposite directions (1) (because) momentum is conserved (1) - detectors / sensors placed around the patient (1) - simultaneous detection (1)	pair at 180°(to each other) gamma cameras/scintillation crystals idea of triangulation	(4)

Question Number		Indicative Content	Mark
QWC	* (b)	An explanation including some of the following points - protons and neutrons are made up of quarks - quarks can change (flavour) - proton made up of uud - neutron made up of udd - for β^+ a u changes to a d - for β^- a d changes to a u - for β^+ a p changes to a n - for β^- a n changes to a p	(6)
Level	0	No rewardable content	
1	1 - 2	- a limited description e.g. for β^+ a proton changes to a neutron OR protons and neutrons are made up of quarks which can change (flavour) - the answer communicates ideas using simple language and uses limited scientific terminology - spelling, punctuation and grammar are used with limited accuracy	
2	3 - 4	- a significant description e.g. a u changes to a d, changing a proton to a neutron and emitting a β^+. A u changes to a d [error] changing a neutron to a proton and a β^- [errors in u and d] OR one of the processes with the correct detail e.g. A u goes to a d therefore a proton goes to a neutron and emits a β^+ - the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately - spelling, punctuation and grammar are used with some accuracy	
3	5 - 6	- a detailed, accurate description of both processes e.g. A u goes to a d therefore a proton goes to a neutron and emits a β^+. A d goes to a u therefore a neutron goes to a proton and emits a β^-. - the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately - spelling, punctuation and grammar are used with few errors	

(Total marks for question = 12 marks)

Q2.

Question Number	Answer	Acceptable answers	Mark
	An explanation linking any three from • Radon is radioactive (1) • Radon can escape from rocks and buildings (1) • Radon can be inhaled (1) • Radiation (from radon) can cause cancer (1) • Radon emits alpha (1)	Ignore radiation from rocks themselves Radon enters/gets trapped in buildings/homes / increases background radiation (breathed into) lungs (DNA) mutation / cell damage (Highly) ionising radiation	(3)

Q3.

Question Number	Answer	Acceptable answers	Mark
	An explanation linking any three from • Radon is radioactive (1) • Radon can escape from rocks and buildings (1) • Radon can be inhaled (1) • Radiation (from radon) can cause cancer (1) • Radon emits alpha (1)	Ignore radiation from rocks themselves Radon enters/gets trapped in buildings/homes / increases background radiation (breathed into) lungs (DNA) mutation / cell damage (Highly) ionising radiation	(3)

Q4.

Question Number	Answer	Acceptable answers	Mark
(a)	☒ D too many neutrons.		(1)

Question Number	Answer	Acceptable answers	Mark
(b)	☒ A a β^+ is positively charged and a β^- is negatively charged		(1)

Question Number	Answer	Acceptable answers	Mark
(c)	14 N 7 + 0 β^- -1 Any two numbers correct (1) All four numbers correct (2)		(2)

Question Number	Answer	Acceptable answers	Mark
(d)	A description to include: Up and down (quarks) / Three (quarks) (1) Correct arrangement (quarks) (1)	Accept for two marks: uud up, up, down two up quarks and one down quark Ignore charges	(2)

Question Number	Answer	Acceptable answers	Mark
(e)	An explanation linking the following: Either proton changes to a neutron (1) positron/anti-electron (emitted) (1) OR up quark changes to a down quark (1) positron/anti-electron (emitted) (1) OR proton number goes down by one / neutron number goes up by one (1) number of nucleons stays the same (1)	Accept any correct set of statements for two marks $P \rightarrow n + \beta^+$ (1) Ignore positive electron atomic number goes down by one mass number is constant	(2)

Q5.

Question Number	Answer	Acceptable answers	Mark
(a)	☒ D too many neutrons.		(1)

Question Number	Answer	Acceptable answers	Mark
(b)	☒ A a β^+ is positively charged and a β^- is negatively charged		(1)

Question Number	Answer	Acceptable answers	Mark
(c)	14 7 N 0 -1 β^- Any two numbers correct (1) All four numbers correct (2)		(2)

Question Number	Answer	Acceptable answers	Mark
(d)	A description to include: Up and down (quarks) / Three (quarks) (1) Correct arrangement (quarks) (1)	Accept for two marks: uud up, up, down two up quarks and one down quark Ignore charges	(2)

Question Number	Answer	Acceptable answers	Mark
(e)	An explanation linking the following: Either proton changes to a neutron (1) positron/anti-electron (emitted) (1) OR up quark changes to a down quark (1) positron/anti-electron (emitted) (1) OR proton number goes down by one / neutron number goes up by one (1) number of nucleons stays the same (1)	Accept any correct set of statements for two marks $P \rightarrow n + \beta^+$ (1) Ignore positive electron atomic number goes down by one mass number is constant	(2)

Q6.

Question number	Answer	Additional guidance	Mark
(i)	use of gradient on graph (1) $= \frac{1480}{97}$ evaluation (1) 15.3 (counts /s)	look for a triangle / line going up allow $\frac{1480}{100}$ accept other data from the graph allow numbers between 12.0 and 16.0 award full marks for answers in the correct range without working	(2)

Question number	Answer	Additional guidance	Mark
(ii)	explanation the process (of radioactive decay) is unpredictable / (occurs) random(ly) (1) so the count rate would not be constant / there will be variations with each reading (1)	do not allow 'difficult to predict' ignore background results (expected to) scatter	(2)

Q7.

Question number	Answer	Additional guidance	Mark
(i)	use of gradient on graph (1) $= \frac{1480}{97}$ evaluation (1) 15.3 (counts /s)	look for a triangle / line going up allow $\frac{1480}{100}$ accept other data from the graph allow numbers between 12.0 and 16.0 award full marks for answers in the correct range without working	(2)

Question number	Answer	Additional guidance	Mark
(ii)	explanation the process (of radioactive decay) is unpredictable / (occurs) random(ly) (1) so the count rate would not be constant / there will be variations with each reading (1)	do not allow 'difficult to predict' ignore background results (expected to) scatter	(2)

Q8.

Question number	Answer	Additional guidance	Mark
CS2	33 days is 3 half-lives (1) $2.1(25) \times 10^{22}$ (1)	$\frac{1.7 \times 10^{23}}{2 (\times 2 \times 2)}$ 2.1(25) to any other power of ten scores mp1 only award full marks for correct answer without working.	(2) AO2

Q9.

Question number	Answer	Additional guidance	Mark
	Substitution and rearrangement to find k (1) $k = 85000 \times 0.70^2$ Substitution to find new count rate (1) count rate = $\frac{85000 \times 0.70^2}{1.3^2}$ Answer (1) 25000 (counts per minute)	41650 24645 (counts per minute)	(3)

Q10.

Question Number	Answer	Mark
(i)	D gamma <i>A is not correct because alpha cannot pass through and out of the body</i> <i>B is not correct because beta plus cannot pass through and out of the body</i> <i>C is not correct because beta minus cannot pass through and out of the body</i>	(1) AO1

	Answer	Additional guidance	Mark
(ii) CLIP with (ii)	decays too quickly to give a reading (1)	accept (half-life) not long enough for reading to be taken ignore disappear after 12 min	(1) AO1

	Answer	Additional guidance	Mark
(ii) CLIP with (ii)	stays in the body too long (1)	accept could harm / damage other organs patients stay radioactive for too long so the patient does not get too high a dose of radiation	(1) AO1

	Answer	Additional guidance	Mark
(iii)	Two from: shielding (1) time limiting exposure (1) distance limiting exposure (1) wear PPE / protective clothing (1)	accept stand behind barriers / store (source) in lead box radiation monitoring badges leave the room / go outside / stay away from the patient / use tongs lead aprons / gloves ignore goggles / masks	(2) AO1

Q11.

Question Number	Answer	Mark
	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. AO1 strand 1 (6 marks) • radio waves are (often) produced intentionally (by humans) • gamma rays are (often) produced spontaneously / randomly • radio waves are produced by (free) electrons • radio waves are produced by oscillating (free) electrons / alternating current (ac) • radio waves are produced in electrical circuits / aerials • gamma rays may result from radioactive decay • gamma rays produced in the nucleus • gamma rays produced by energy changes / rearrangement in the nucleus • gamma rays produced to stabilise the nucleus • gamma rays produced in annihilations (PET scanning etc) • gamma rays may be produced as a result of (nuclear) fission or fusion	(6)

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1-2	- Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) - Presents an explanation with some structure and coherence. (AO1)
Level 2	3-4	- Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) - Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5-6	- Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) - Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)

Summary for guidance

Level	Mark	Additional Guidance	General additional guidance – the decision within levels e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	<u>Additional guidance</u> isolated fact(s) about one radiation	<u>Possible candidate responses</u> gamma rays are (often) produced spontaneously / randomly
Level 2	3–4	<u>Additional guidance</u> Some understanding shown i.e. a limited comparison made including some facts about the production of each radiation OR more detailed facts given about the production of one of them	<u>Possible candidate responses</u> radio waves produced in wires and gamma produced in nucleus radio waves produced by AC in wires

Level 3	5–6	<u>Additional guidance</u> Understanding is detailed and fully developed. detailed comparison made with linked facts about the production of each (one radiation may have significantly more detail than the other but both should feature for level 3)	<u>Possible candidate responses</u> radio waves produced by electrons oscillating in wires; gamma produced by annihilation of electrons interacting with positrons
---------	-----	--	---

Q12.

Question Number	Answer	Mark
	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.	(6) exp

	AO1 strand 1 (6 marks) • radio waves are (often) produced intentionally (by humans) • gamma rays are (often) produced spontaneously / randomly • radio waves are produced by (free) electrons • radio waves are produced by oscillating (free) electrons / alternating current (ac) • radio waves are produced in electrical circuits / aerials • gamma rays may result from radioactive decay • gamma rays produced in the nucleus • gamma rays produced by energy changes / rearrangement in the nucleus • gamma rays produced to stabilise the nucleus • gamma rays produced in annihilations (PET scanning etc) • gamma rays may be produced as a result of (nuclear) fission or fusion	
--	---	--

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–2	- Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) - Presents an explanation with some structure and coherence. (AO1)
Level 2	3–4	- Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) - Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5–6	- Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) - Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)

Summary for guidance

Level	Mark	Additional Guidance	General additional guidance – the decision within levels
	0	No rewardable material.	e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
Level 1	1–2	<u>Additional guidance</u> isolated fact(s) about one radiation	<u>Possible candidate responses</u> gamma rays are (often) produced spontaneously / randomly
Level 2	3–4	<u>Additional guidance</u> Some understanding shown i.e. a limited comparison made including some facts about the production of each radiation OR more detailed facts given about the production of one of them	<u>Possible candidate responses</u> radio waves produced in wires and gamma produced in nucleus radio waves produced by AC in wires

Level 3	5–6	<u>Additional guidance</u> Understanding is detailed and fully developed. detailed comparison made with linked facts about the production of each (one radiation may have significantly more detail than the other but both should feature for level 3)	<u>Possible candidate responses</u> radio waves produced by electrons oscillating in wires; gamma produced by annihilation of electrons interacting with positrons
---------	-----	--	---

Q13.

Question number	Indicative content	Mark
*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive, and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. A01 1 (6 marks) fission • (heavy) nucleus split • by a neutron • releases 2 daughter nuclei + more neutrons + energy • starts chain reaction advantages • already in use disadvantages • waste is radioactive • hard to dispose of • risk of accident	(6) A01

	fusion • (light) nuclei joined • at high energy/temperature/pressure/particle density • releases (eg) helium + energy advantages • no harmful waste products disadvantages • not achieved yet (on a practicable scale) • difficulty in achieving high energy/temperature/pressure/particle density	
--	---	--

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1-2	- Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) - Presents an explanation with some structure and coherence. (AO1)
Level 2	3-4	- Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) - Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5-6	- Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) - Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)

Level	Mark	Additional Guidance	General additional guidance – the decision within levels e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	<u>Additional guidance</u> isolated facts	<u>Possible candidate responses</u> fission involves a nucleus being split by a neutron
Level 2	3–4	<u>Additional guidance</u> simple comparison of fission and fusion	<u>Possible candidate responses</u> fission involves a nucleus being split by a neutron whereas fusion requires combining two light nuclei.
Level 3	5–6	<u>Additional guidance</u> detailed comparison of fission and fusion and one advantage or one difficulty compared to the other	<u>Possible candidate responses</u> Fission involves nuclei split by a neutron. Fusion involves combining two light nuclei. The waste from fission is radioactive. Practicable fusion has not been achieved.

Question number	Answer	Additional guidance	Mark
	same number of protons (1)	same atomic number	(2) AO2
	different number of neutrons (1)	different mass number	

Q15.

Question number	Indicative content	Mark
*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive, and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. AO1 1 (6 marks) alpha • a particle (not a wave) • made up of 4 particles • helium nucleus • has a positive charge • when emitted by a nucleus, atomic number goes down by 2 • mass number goes down by 4 beta • a particle (not a wave) • made up of 1 particle • electron (or positron) • has a negative charge • when emitted, atomic number goes up by 1 • mass number does not change Ignore references to range, penetration, ionisation.	(6) AO1

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1-2	- Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) - Presents an explanation with some structure and coherence. (AO1)
Level 2	3-4	- Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) - Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5-6	- Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) - Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)

Level	Mark	Additional Guidance	General additional guidance – the decision within levels
	0	No rewardable material.	e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
Level 1	1–2	<u>Additional guidance</u> isolated facts	<u>Possible candidate responses</u> A beta particle is an electron. An alpha particle is a helium nucleus
Level 2	3–4	<u>Additional guidance</u> effect of alpha and beta decay or nature and effect of alpha or beta	<u>Possible candidate responses</u> A beta particle is an electron. When emitted the mass number doesn't change but atomic number goes up by one
Level 3	5–6	<u>Additional guidance</u> detailed comparison that includes nature of alpha and nature of beta and effect of either alpha or beta OR effect of alpha and beta and nature of either alpha or beta	<u>Possible candidate responses</u> Alpha particle is a helium nucleus AND A beta particle is an electron. When emitted the mass number doesn't change but atomic number goes up by one

Question number	Indicative content	Mark
*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive, and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. AO1 1 (6 marks) alpha • a particle (not a wave) • made up of 4 particles • helium nucleus • has a positive charge • when emitted by a nucleus, atomic number goes down by 2 • mass number goes down by 4 beta • a particle (not a wave) • made up of 1 particle • electron (or positron) • has a negative charge • when emitted, atomic number goes up by 1 • mass number does not change Ignore references to range, penetration, ionisation.	(6) AO1

Level	Mark	Descriptor
	0	• No rewardable material.
Level 1	1-2	• Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) • Presents an explanation with some structure and coherence. (AO1)
Level 2	3-4	• Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5-6	• Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)

Level	Mark	Additional Guidance	General additional guidance – the decision within levels e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	<u>Additional guidance</u> isolated facts	<u>Possible candidate responses</u> A beta particle is an electron. An alpha particle is a helium nucleus
Level 2	3–4	<u>Additional guidance</u> effect of alpha and beta decay or nature and effect of alpha or beta	<u>Possible candidate responses</u> A beta particle is an electron. When emitted the mass number doesn't change but atomic number goes up by one
Level 3	5–6	<u>Additional guidance</u> detailed comparison that includes nature of alpha and nature of beta and effect of either alpha or beta OR effect of alpha and beta and nature of either alpha or beta	<u>Possible candidate responses</u> Alpha particle is a helium nucleus AND A beta particle is an electron. When emitted the mass number doesn't change but atomic number goes up by one

Q17.

Question Number	Answer	Additional guidance	Mark									
	<table><tr><td></td><td></td><td></td></tr><tr><td></td><td>7</td><td>6</td></tr><tr><td></td><td>8</td><td>6</td></tr></table> (1) (1)					7	6		8	6	one mark for each column must have both numbers in a column correct to get the mark	(2)
	7	6										
	8	6										

Q18.

Question Number	Answer	Additional guidance	Mark									
	<table><tr><td></td><td></td><td></td></tr><tr><td></td><td>7</td><td>6</td></tr><tr><td></td><td>8</td><td>6</td></tr></table> (1) (1)					7	6		8	6	one mark for each column must have both numbers in a column correct to get the mark	(2)
	7	6										
	8	6										

Q19.

Question number	Answer	Additional guidance	Mark
	The time taken for the activity of a radioactive nuclide to halve (1)	accept for nuclide: isotope sample	(1)

Q20.

	Answer	Additional guidance	Mark
(i)	A description including: roll / release / drop a marble (down the slope) (1) and one from record where the marbles go (1) OR measure the angle of path (1)	allow alpha particle for marble allow any method of recording	(2) AO3

	Answer	Additional guidance	Mark
(ii)	any one from marble / weight has no charge (1) the edge of the paper is not far enough away from the weight (1) the marble / weight is too big / small (1) there is only one marble / weight (1) it is 2 dimensional / not 3D (1) all marbles have the same speed / alpha particles different speed to marbles (1) marbles (only deflect on) hitting / contact with weight (1)	not to scale allow marble cannot pass through the weight (1)	(1) AO3

Q21.

Question number	Answer	Mark
	An answer that combines the following points of understanding to provide a logical description: - the reactor is surrounded by a coolant (1) - the thermal energy release from the chain reaction heats the coolant (1) - the hot coolant is used to generate steam which is used to drive the turbine (1)	(3)

Q22.

	Answer	Additional guidance	Mark
(i)	A description including: roll / release / drop a marble (down the slope) (1) and one from record where the marbles go (1) OR measure the angle of path (1)	allow alpha particle for marble allow any method of recording	(2) AO3

	Answer	Additional guidance	Mark
(ii)	any one from marble / weight has no charge (1) the edge of the paper is not far enough away from the weight (1) the marble / weight is too big / small (1) there is only one marble / weight (1) it is 2 dimensional / not 3D (1) all marbles have the same speed (1) marbles (only deflect on) hitting / contact with weight (1)	not to scale allow marble cannot pass through the weight (1)	(1) A03

Q23.

Question number	Answer	Additional guidance	Mark
	An answer that provides a description by making reference to: • (energy used to) create steam (1) • steam drives a turbine (1)		(2)

Q24.

Question Number	Answer	Additional guidance	Mark
(i)	a description to include: nebula collapses (1) under gravity (1) plus any one from: GPE converted into KE (1) OR (very) high temperatures/pressures reached (1)	allow gas/dust for nebula allow condensing/coming together for collapses allow gravitational force producing (large) increase in KE of particles / more (frequent) collisions Ignore references to hot / heat	(3)

Question Number	Answer	Additional guidance	Mark
(ii)	rearrangement and substitution (1) $(m =) \frac{3.86 \times 10^{26}}{(3.00 \times 10^8)^2}$ evaluation (1) $(m =) 4.29 \times 10^9 \text{ (kg)}$	ignore Power Of Ten (POT) error until evaluation allow numbers that round to 4.3×10^9 (kg) award full marks for the correct answer without working 4.3 to any other power of ten scores 1 mark	(2)

Q25.

Question number	Answer	Additional guidance	Mark
	33 days is 3 half-lives (1) $2.1(25) \times 10^{22} \text{ (1)}$	$\frac{1.7 \times 10^{23}}{2 \times 2 \times 2}$ 2.1(25) to any other power of ten scores mp1 only award full marks for correct answer without working.	(2) AO2

Q26.

	Answer	Additional guidance	Mark
	A description to include two from: (radioactive material/substances) inside the food/body (1) emit radiation from inside the body (1) damage body cells (1)	trapped in the body exposed to radioactivity cause cancer	(2) AO1

Q27.

	Answer	Additional guidance	Mark
	A description to include two from: (radioactive material/substances) inside the food/body (1) emit radiation from inside the body (1) damage body cells (1)	trapped in the body exposed to radioactivity cause cancer	(2) AO1

Q28.

Question number	Answer	Mark
CS2	B ionising and emitted by unstable nuclei A is incorrect stable nuclei do not give radioactive emissions C is incorrect not all radioactive emissions are neutral D is incorrect not all radioactive emissions are neutral	(1) AO1

Q29.

Question number	Answer	Additional guidance	Mark
	A description to include any three of the following (smaller) nuclei / atoms / particles (1) come together / join (1) to produce a larger nucleus / atom / particle (1) needing high temperature / pressure (1) overcoming repulsion (between nuclei) (1) energy released (1)	two named eg hydrogen (nuclei) allow fuse not 'bond' helium for nucleus accept fast (moving) nuclei ignore energy created	(3)

Q30.

Question Number	Answer	Additional guidance	Mark
	processing (1) <u>125 000</u> 1 000 000 OR <u>1</u> 8 OR 3 half-lives or 3 x 5700 evaluation (1) 17 100	accept an appropriate attempt using more than one halving 17 000 award full marks for the correct answer without working	(2)