OCR GCSE GATEWAY PHYSICS A · J249

PHYSICS



MARK SCHEME

P6.2 USES AND HAZARDS

SCORE	PERCENTAGE
/95	%

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Question			Answer/Indicative content	Marks	Guidance
1			**beneficial** **any one from** smoke detectors [1] tracer [1] cancer treatment [1] diagnosis [1] **how radiation can harm** **any one from** damages cells / causes mutations [1] causes cancer / tumours [1] ionises (cells) [1]	2	**Ignore** fire alarm **Ignore** cleaning surgical instruments **allow** other valid uses: e.g. using tracers to find leaks in pipes [1] e.g. allow helps filling containers to the correct level [1] e.g. sterilising medical equipment or food [1] Examiner's Comments Candidates generally knew that nuclear radiation was used to treat cancer and that it could also cause cancer. A common mistake was that candidates thought that nuclear radiation was used to generate electricity – confusing it with the nuclear fuel used in some power stations.
			Total	2	
2	a		(D) ➔ B ➔ E ➔ F ➔ A ➔ (C) [2]	2	all correct = 2 marks if incorrect, B anywhere before F scores [1] Examiner's Comments About a half could correctly put stage B before F [1]. A third got the complete order correct with B E F A [2].

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Question			Answer/Indicative content	Marks	Guidance
	b		the control rods absorbs neutrons [1] there must be enough (free) neutrons to keep the process going [1]	2	For absorb **allow** reduce/ stop / block [1] Not merely 'affect neutrons' **ignore** just control / slow down neutrons **BUT** control **numbers** of neutrons [1] **allow** neutrons are needed for fission [1] **allow** rate of fission or energy production would be too low [1] eg not enough power produced (if rods left inside) [1] eg. too many neutrons are absorbed [1] **Examiner's Comments** This question on the use of control rods in a reactor illustrated a few misconceptions about fission. Weaker answers referred to electrons rather than neutrons. Those that mentioned neutrons however usually gained the first mark with stopping or absorbing neutrons but all the answers in the scheme were given by the range of candidates. Some were too vague with answers like 'the rods control or help the neutrons'. Others thought that leaving the control rods inside the reactor would cause nuclear (or thermal) explosions. It was generally a well attempted question but about 40% fell short of both marking points.
			Total	**4**	

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Question			Answer/Indicative content	Marks	Guidance
3			alpha cannot get through the body (to reach the detector) [1] alpha is absorbed by the body / skin / tissue / flesh [1]	1	**allow** only beta **and** gamma can penetrate the skin / get through the body (to the reach the detector) [1] **allow** alpha does not penetrate (tissue / body / skin) [1] **ignore** references to alpha and paper **ignore** references to damage Examiner's Comments This question asked why alpha was not used as a tracer. Some answers referred to high ionising power but failed to develop that and say they the alpha was absorbed by the body. Others stated that alpha is stopped by paper but failed to develop that further. Weaker answers did not refer to penetration but to the damage caused by alpha.
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
4	a	i	(can cause) cancer / mutations [1] can damage or ionise cells / DNA / tissues / (named) organs [1]	1	**allow** can kill for idea of damage **eg** kills cells [1] **not** merely 'damage' **Examiner's Comments** This was quite well answered with more candidates mentioning damage or ionisation of **cells** than in previous years. Damage to tissues or organs was often seen and worthy of the mark.
		ii	half-life [1]	1	**allow** correct descriptions of half-life **allow** rate of (radioactive) decay ignore speed of decay / mass or amount of sample **ignore** because it decays quickly **Examiner's Comments** Over 60% of candidates answered correctly with 'half-life.' 'Rate of decay' was occasionally seen too [1]. Weaker answers included 'its radioactivity' or 'how old it is'.

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Question			Answer/Indicative content	Marks	Guidance
	b		**any two from** so (all) gamma is (only) concentrated / focussed on the **tumour / cancer cells** AW [1] so that healthy / normal / other / non-cancerous cells receive less gamma / AW [1] otherwise (if patient moves) gamma may damage / affect (more) healthy / normal cells or tissue / ora [1]	2	Eg. idea that tumour has maximum exposure / cancer cells get a lethal dose [1] cancer cells rather than healthy cells get a lethal dose [2] **allow** (clamp is needed to hold the patients head still) to avoid damage to other tissue [1] **Examiner's Comments** Many referred rather vaguely to gamma hitting the 'right place' or the 'wrong place'. Better answers explained that gamma is meant to be focussed on the tumour [1] but (if the head moved) it may damage (surrounding) healthy cells [1].
			Total	4	
5			fission [1] splitting [1]	2	**allow** 'fission' for 2nd answer [1] **Examiner's Comments** This question on electricity generation was quite well answered across the full range of candidates. Most scored at least 2 out of 4 marks. Almost all knew about nuclear fission. There was far less confusion with fusion this year.
			Total	2	

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Question			Answer/Indicative content	Marks	Guidance
6	a		any one from cancer treatment or radiotherapy [1] sterilisation (of equipment or instruments) [1]	1	 **not** breaking down kidney stones **not** neo natal scans Examiner's Comments This question was focussed on the use of radiation in hospitals. Although many knew of another use beyond tracers candidates frequently incorrectly stated that X rays used radiation
	b		any two from stay behind a screen [1] use a remote control [1] stay at a (safe) distance [1] wear protective clothing [1]	2	 **allow** stay behind a lead screen [2] **allow** go into another room [1] **allow** wear lead (lined) clothing [2] **allow** idea of limit exposure e.g. monitor exposure or wear a film badge [1] Examiner's Comments This question was focussed on the use of radiation in hospitals. Most candidates correctly described one way to reduce exposure of the radiographer to ionising radiation. This was most frequently using protective clothing. Many candidates described in detail appropriate ways to reduce exposure.
			Total	3	

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Question			Answer/Indicative content	Marks	Guidance
7			**Level 3: (5 – 6 marks)** **Reference to the three types of radiation AND two safety precautions.** Quality of written communication does not impede communication of the science at this level. **Level 2: (3 – 4 marks)** **Reference to two types of radiation AND a simple safety precaution.** Quality of written communication partly impedes communication of the science at this level. **Level 1: (1 – 2 marks)** **Simple reference to two types of radiation OR a simple safety precaution.** Quality of written communication impedes communication of the science at this level. **Level 0: (0 marks)** Insufficient or irrelevant science. Answer not worthy of credit.	6	This question is targeted up to grade E Indicative scientific points may include: **radiations** • alpha • beta • gamma **safety precautions** • use tongs • keep a safe distance • do not point at people or body part • protective clothing • short exposure time • shielded storage • labelled storage Use the L1, L2, L3 annotations in Scoris; do not use ticks. **Examiner's Comments** About 10% of candidates did not attempt the question. There were some excellent responses to this question. The majority of candidates correctly identified the three types of radiation. In terms of safety precautions the most common was protective clothing. Candidates wrote at length about gloves, goggles, aprons etc., but this was only one point. Other precautions were safe handling and safe storage.
			Total	**6**	

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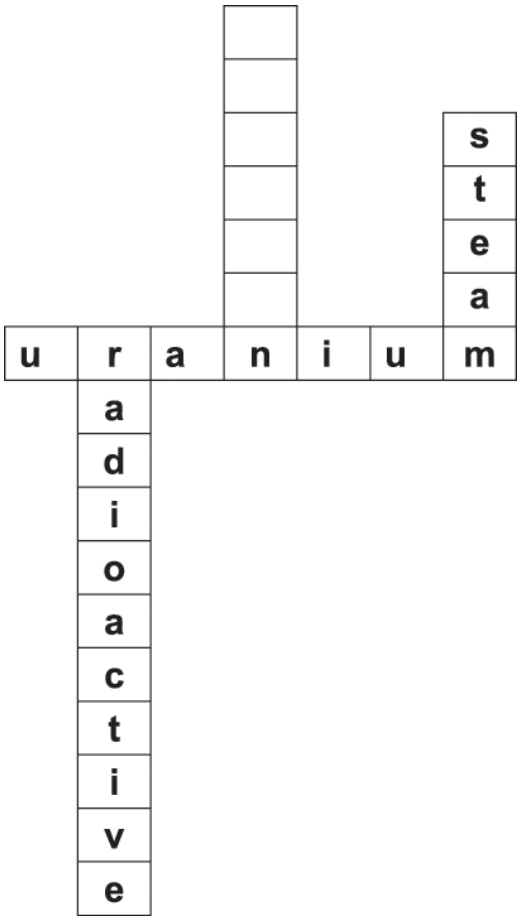
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Question			Answer/Indicative content	Marks	Guidance
8		i	(idea that nuclear radiation) can increase risk of cancer or cell damage [1]	1	**allow** (idea that) the radioactivity is not in the body for a long time (to cause damage) [1] **Examiner's Comments** This discriminated very well. Better candidates understood the dangers of using medical tracers with a longer half life and often made a good link to cell damage.
		ii	beta and gamma [1]	1	more than one scores 0 marks if answer line blank allow correct answer indicated in list **Examiner's Comments** In general most knew that beta and gamma radiation can penetrate skin. The most common error was to identify that gamma only can penetrate skin.
			Total	2	
9			**any one from** to track dispersal of waste [1] to find leaks / blockages in underground pipes [1] to find the route of underground pipes / checking thickness or condition of metal [1]	1	**ignore** medical tracers **Examiner's Comments** Despite the fact that the use of tracers in identifying leaks or blockages was a6 mark question in 2013, only higher ability candidates tended to score on thisquestion.
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
10	a		 (2)	2	answers in crossword take precedent but if crossword blank **allow** answers next to the clues 1 or 2 correct = 1 mark 3 correct = 2 marks **Examiner's Comments** Most candidates achieved at least 1 mark and about a third achieved 2 marks. Lack of knowledge of uranium as nuclear fuel and that nuclear waste was recycled (rather than radioactive) frequently prevented the gaining of 2 marks.

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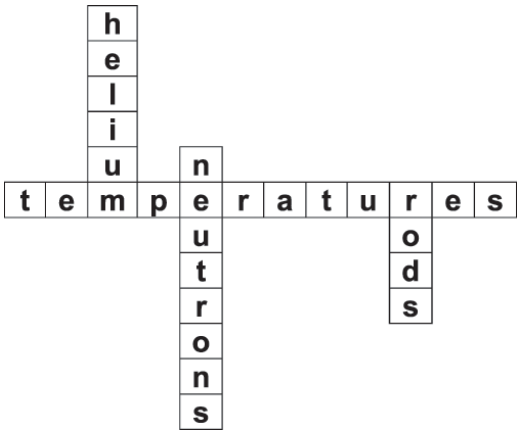
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Question			Answer/Indicative content	Marks	Guidance
	b		idea of a (large) nucleus splitting (1) to give two nuclei (1)	2	**reference to neutron splitting maximum one mark** **allow** (large) nucleus breaks up / breaks down / divides **allow** to give two nucleus **ignore** nuclei are produced **allow** nucleus splits into two (nuclei) (2) **but** nucleus splits into two atoms / nucleus splits into two molecules (1) as extra marking points: **allow** energy released (1) **allow** more neutrons are given out (1) **Examiner's Comments** Most candidates achieved at least 1 mark. Misconceptions in describing the model mainly related to the initial neutron (becoming the large nucleus) and the production of additional neutrons as a result of fission of the daughter nuclei.
			Total	4	

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Question			Answer/Indicative content	Marks	Guidance
11	a			2	answers in crossword take precedent but if crossword blank **allow** answers next to the clues 0 or 1 correct = 0 marks 2 or 3 correct = 1 mark 4 correct = 2 marks **Examiner's Comments** Most gave two or three correct answers in the crossword [1]. One common error was 'reactant' (instead of neutrons).
	b		**any two ideas from:** • no data / no evidence • secrecy • cannot be proved / be reproduced / cannot get similar or reliable results • disagrees with fundamental physics	2	Eg. Not all data published (1) Eg. (some) experimental details are (still) secret (1) Eg. fusion needs high temps or pressures / won't happen at low temperatures or pressures / AW (1) **Examiner's Comments** In this How Science Works question most gained marks by explaining that the method or catalyst was secret [1]. Some focussed on how fusion usually occurs at high temperatures and pressures [1]. Others wrote of the unrepeatability of the experiment [1].
			Total	**4**	

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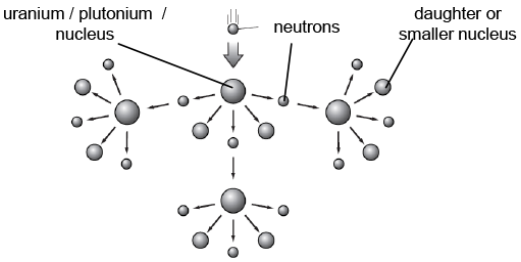
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Question			Answer/Indicative content	Marks	Guidance
12		i	gamma has a greater / high penetration power (than alpha of beta) / ORA (1) so it (gamma) can be detected through industrial apparatus / metal / soil / earth / pipes / ORA (1)	1	**Eg.** Alpha / Beta stopped or absorbed **more** easily (1) **Eg.** Alpha and beta cannot get through but gamma can get through / AW (1) **Allow** gamma is **less** ionising / ORA (1) **Ignore** references to paper, aluminium and lead unless linked to tracers.
		ii	**C** any number greater than 27 **and** the idea that the blockage stops the flow of tracer so it builds up before the blockage / it emits more radiation (1) **D** any number less than 26 **and** the idea that less or no tracer can get past the blockage / it emits less radiation (1)	2	**allow** the readings in the table if no readings given on answer lines If no marks scored then: C greater (than 27) and D less (than 26) scores (1)
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Question			Answer/Indicative content	Marks	Guidance
13			**Level 3: (5–6 marks)** **Diagram with two correct labels** **AND** **DETAILED description of a chain reaction** **AND** **One difference described.** Quality of written communication does not impede communication of science at this level. **Level 2: (3–4 marks)** **Any two from:** **Diagram with two correct labels** **OR** **DETAILED description of a chain reaction** **OR** **one difference described.** Quality of written communication partly impedes communication of science at this level. **Level 1: (1–2 marks)** **Diagram with two correct labels** **OR** **simple description of a chain reaction** **OR** **one difference described.** Quality of written communication impedes the communication of science at this level **Level 0: (0 marks)** Insufficient or irrelevant science. Not worthy of credit.	6	This question is targeted up to grade A* Indicative scientific points may include (but are not limited to) the following: **Diagram labelled**  **Simple description of chain reaction (two from)** • Neutron(s) involved • (uranium) nucleus splits **Detailed description of chain reaction (two from)** • neutron hits (uranium) nucleus / nucleus 'absorbs' a neutron • (uranium) nucleus becomes unstable / splits • two or more neutrons given out • (these) neutrons hit other nuclei and cause more uranium nuclei to split • Daughter / smaller nuclei produced • (large amount of) energy produced **Differences described (one from)** • nuclear reactor is a controlled (chain) reaction • nuclear bomb is an uncontrolled (chain) reaction • nuclear reactor uses control rods / controls the (number of) neutrons

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Question			Answer/Indicative content	Marks	Guidance
			Total	6	
14			blockage at C / blockage between C and D / blockage after C (1) mean in area **C** = 34 **and** mean in area **D** = 4 (1)	2	**allow** indication of blockage location on the diagram (1) if answer line does not contain the mean values allow answers in the table
			Total	2	

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Question			Answer/Indicative content	Marks	Guidance
15	a		Contamination occurs when radioactive **source / material** is on or in the body / object ✓ Irradiation occurs when object is exposed to radiation (from outside of the body / object) ✓	**2** (AO1.1) (AO1.1)	**ALLOW** material becomes radioactive / becomes a source of radiation Examiner's Comments Only a small number of candidates were unable to explain the difference between irradiation and contamination. A common misconception was candidates that confused the terms 'radiation' and 'radioactive source' in their explanation.
	b		Bacteria is killed / AW ✓ Slows food decay / AW ✓	**2** (AO2.2) (AO2.2)	**ALLOW** idea that food does not go mouldy / off / rot (so quickly) **IGNORE** just that food lasts longer / food does not go stale / food stays fresh Examiner's Comments A complete explanation linking the bacteria being killed by gamma rays to the slowing down of the decay of the food was only given by higher ability candidates. Many candidates did not know that gamma rays kill bacteria. A common misconception was that gamma rays 'give energy to the food'.

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Question			Answer/Indicative content	Marks	Guidance
	c		May cause food to become radioactive ✓ May allow food (to be sold) which is old but looks fresh / AW ✓	2 (AO2.2) (AO2.2)	ALLOW food becomes contaminated / risk of cancer / they are taking in radiation ALLOW food might taste different / strange / out of date food might be eaten IGNORE food is poisonous / just unsafe Examiner's Comments The majority of candidates gained one mark for sating the concern that the food may become radioactive or cause cancer. It was rare for a second valid concern to be given by a candidate.
			Total	6	
16			Any two from: Keeping a safe distance (from source) ✓ Use tongs ✓ Point sources away from people ✓ Keep sources in sealed containers ✓ Keep exposure time as short as possible ✓	2 (AO 2 x 1.2)	ALLOW behind (lead) screen IGNORE gloves/goggles ALLOW lead box Examiner's Comments Many candidates answered this question in general terms suggesting general laboratory rules rather than specific safety precautions relevant to the experiment. A large number of candidates suggested keeping a safe distance from the source. Some candidates were confused about whether the barrier was part of the experiment or a safety device. Higher ability candidates gave relevant precautions including the use of tongs to hold the source (in effect adding some distance), using the sources for a short period of time (to minimise exposure) and storing the sources in lead lined boxes.
			Total	2	

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Question			Answer/Indicative content	Marks	Guidance
17		i	Fossil fuel may run out / is non-renewable / be in short supply / become very costly ✓ Named damage to environment: Eg (increased) greenhouse gases / global warming / sea levels rise / carbon dioxide / climate change / acid rain ✓	2 (AO 3.1b) (AO 3.1b)	ALLOW being used faster than being produced / finite resource ALLOW ice caps melting / droughts and storms / more polluting gases / other named polluting gases e.g. SO_2 / carbon emissions IGNORE just pollution or bad for the environment / more CFCs Examiner's Comments Most candidates recognised that fossil fuels may run out or be in short supply or stating that they are non-renewable. However, fewer candidates went on to give specific scientific reasons for scientists concerns that were creditable. Most candidates gave generalised responses about fossil fuels damaging the environment or causing 'pollution'.
		ii	To meet demand for electricity / not enough energy from renewable resources ✓ Less named damage to environment: (decreased) greenhouse gases / global warming / sea levels may fall / carbon dioxide / climate change / acid rain / ORA for coal ✓	2 (AO 1.2) (AO 1.2)	ALLOW will not run out as fast (as coal) / to preserve fossil fuels / produces more energy (per kg than coal) ALLOW less polluting gases / carbon emissions / ice caps melting / droughts and storms IGNORE just less pollution or just better for the environment / less CFCs Examiner's Comments Higher ability candidates said that there were not enough renewable energy resources and nuclear power stations would assist in meeting the demand for electricity, or help in preserving fossil fuels. Answers which gave detail about less damage to the environment were also credited, although a number of candidates thought that nuclear power stations would not cause any potential damage to the environment.
			Total	4	

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Question			Answer/Indicative content	Marks	Guidance
18			B ✓	1 (AO 1.1)	<u>Examiner's Comments</u> This question required candidates to apply their scientific knowledge and analyse the information in the table about nuclear radiation in order to choose the best isotope to use as medical tracer.  **Misconception** Many candidates could identify that gamma was the best radiation to use but had the misconception that a half-life of 6 minutes was long enough. Therefore, they incorrectly chose option C. Teaching often emphasises the need for a short half-life to reduce patient exposure to radiation, but this time cannot be shorter than the time required to carry out the procedure.
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
19	a	i	Neutron(s) ✓	1 (AO 1.1)	IGNORE gamma Examiner's Comments About two thirds of the candidates did not know that neutrons were also produced in a fusion reaction. Common misconceptions included water, carbon dioxide and protons.
		ii	Any one from: Gravity ✓ (very) high temperatures ✓ high pressure ✓	1 (AO 1.1)	ALLOW (high) gravitational field strength ALLOW hot (temperatures) / lots of heat IGNORE just heat Examiner's Comments The majority of candidates answered this correctly.
	b	i	Any one from: Both produce energy ✓ Both convert mass to energy / have a "loss" in mass ✓ Both produce neutrons	1 (AO 1.1)	
		ii	Any one from: In fusion nuclei join / in fission nuclei split/decay/break up / AW ✓ fusion occurs at higher temperatures or pressures / fission occurs at lower temperatures or pressures ✓ larger/heavier nucleus forms in fusion / smaller/lighter/daughter nuclei forms in fission ✓ more energy released in fusion / less energy released in fission ✓ fission causes a chain reaction / fusion does not cause a chain reaction ✓ fusion does not produce (radioactive) waste / fission does produce radioactive waste ✓	1 (AO 1.1)	ALLOW atom IGNORE molecules / particles / ions ALLOW only fission reactors are used at present to produce electricity

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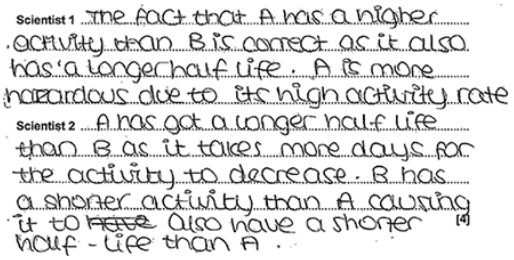
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Question			Answer/Indicative content	Marks	Guidance
			Total	4	

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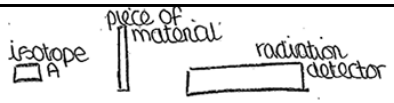
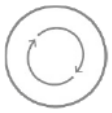
Question			Answer/Indicative content	Marks	Guidance
20	a	i	C ✓	1 (AO 2.2)	**ALLOW** answer from diagram if clear Examiner's Comments A large majority of the candidates correctly identified C as taking the longest time to decay. The common error was A.
		ii	**Any four from:** A is more hazardous / B is safer (for most of the time on the graph) ✓ A has a higher activity (for most of the time) ✓ B is more hazardous at the beginning ORA ✓ B has a higher activity at the beginning ORA ✓ A has a longer half-life / B has a shorter half-life ✓	4 (AO 4×3.1b)	Examiner's Comments This type of question gives candidates opportunities to demonstrate their knowledge of radioactivity as well as their skills in interpreting graphical information. In answering this type of question, candidates should look at the information from the graph and discuss what happens initially while B had the higher activity and then discuss what happened after the two graphs crossed. There should also be a link between activity and hazardousness. For the highest marks, there needed to be a comparison between the relative activity / hazardousness of the isotopes initially during the first day compared to activity / hazardousness of the isotopes after two days. Candidates could not gain the same mark twice, i.e. A had a longer half-life and B had a shorter half-life would only gain one mark. Again, the physics term "half-life" was expected to be seen. **Exemplar 4**  Scientist 1 The fact that A has a higher activity than B is correct as it also has a longer half life. A is more hazardous due to its high activity rate Scientist 2 A has got a longer half life than B as it takes more days for the activity to decrease. B has a shorter activity than A causing it to ~~here~~ also have a shorter half-life than A. [4] This candidate makes the link clearly between hazardous and activity and also clearly states on two occasions that A has the longer half-life. The candidate says that

Question			Answer/Indicative content	Marks	Guidance
					A has a higher activity which is assumed as overall. The writing at the end has been ignored and it would seem that the candidate did not fully understand the term half-life. To improve on this answer, some comment should have been made with regard to the graph initially during the first day. This answer was given 3 marks.
		iii	**Maximum two from:** One absorber placed between detector and isotope A ✓ (Idea of) change absorber and repeat experiment ✓ Measures (background) count with no source✓ **Maximum two from:** Drop in count rate with cardboard indicates alpha ✓ Drop in count rate with aluminium indicates beta ✓ Drop in count rate with lead OR cardboard and aluminium / all materials are penetrated indicates gamma ✓	4 (AO 2×2.2) (AO 2×1.2)	May be described or drawn in a diagram **ALLOW** stopped / absorbed for drop in count rate <u>Examiner's Comments</u> Good candidates drew a diagram to indicate the experimental set-up. Many candidates were able to describe how they would place the absorbers in front of the detector. It would be better if they had stated in turn. A few candidates under the procedure section stated that they would take a reading with no absorber present. A few candidates also stated that would take a reading without a source, i.e. taking a background count. Several candidates were confused as to which absorber would stop which type of radiation. **Exemplar 5**

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Question	Answer/Indicative content	Marks	Guidance
			 The scientist should detect how much radiation the isotope has on its own and then place each material (one at a time) between the isotope and the detector. Gamma radiation is the strongest, therefore should pass through everything except aluminium. Alpha is the weakest, so it should be stopped by cardboard. Beta should be stopped by lead. [4] This candidate has a clear diagram, indicating the piece of material placed between the isotope and the detector. In the text, the candidate clearly states that each of the materials should be placed between the detector and isotope in turn ("one at a time"). The candidate's understanding of the likely results is muddled and not always correct (gamma radiation stopped by thin aluminium), but the candidate does correctly state that alpha should be stopped by cardboard. This answer was given 3 marks.  AfL Candidates should be able to explain experimental procedures using a labelled diagram.

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Question			Answer/Indicative content	Marks	Guidance
	b	i	Nuclei join (in fusion) ✓	1 (AO 1.1)	ALLOW fuse / combine Examiner's Comments There were many vague answers in terms of hydrogen reacting to produce large amounts of energy. Ideally candidates should understand that fusion is where nuclei join together.
		ii	Any two from: High temperature ✓ High pressure ✓ Large gravitational forces (due to large mass) ✓	2 (AO 2×2.1)	IGNORE heat Examiner's Comments Examiners were keen that correct physics terms were used. Answers such as a lot of heat were not credited. Some candidates did mention very high temperatures. Other acceptable answers included high pressure and large gravitational forces. There needed to be some idea of size, e.g. high, large Often only one comment was made when the mark bracket was [2] which indicates two points need to be made.
		iii	The sun will expand / become a red giant / (ultimately) become a white dwarf ✓	1 (AO 1.1)	ALLOW fusion of helium / heavier elements Examiner's Comments The question required candidates to state what would happen when the sun ran out of hydrogen. Many candidates state what would happen to the sun eventually.

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Question			Answer/Indicative content	Marks	Guidance
	c		**Any one from:** supplies of uranium are large enough / will not run out to consider it renewable / AW ✓ Uranium is not being replaced / used quicker than it is being replaced to consider it non-renewable	1 (AO 2.1)	<u>Examiner's Comments</u> Many candidates incorrectly referred to fusion rather than fission. Candidates are advised to underline key phrases in the question paper before answering the question. Many candidates answered the question in terms of the dangerous waste products or that the waste products could be re-used. Candidates had the opportunity to explain why either of the scientists could be correct in terms of the supplies of uranium being large enough so will not run out and therefore renewable or that the uranium is not being replaced so non-renewable.
			Total	**14**	
21			**B** ✓	1 (AO1.1)	
			Total	**1**	
22		i	So (most of) the radioactivity / gamma rays are absorbed by the lead/do not get to the doctor. ✓ So the doctor is not irradiated/to prevent the doctor's cells being damaged. ✓	2 (AO2 × 1.1)	**ALLOW** will absorb alpha and beta radiation **ALLOW** to stop the doctor getting cancer
		ii	Iodine-131 ✓ Gamma can pass through the body to the detector / alpha cannot pass through the body. ✓ Use a short half-life so patient's cells are less damaged. ✓	3 (AO3.2) (AO2.2) (AO2.2)	**ALLOW** this mark if Cobalt-60 or Iodine-131 is chosen **ALLOW** this mark if Radon-222 or Iodine-131 is chosen. 1
			Total	**5**	

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Question			Answer/Indicative content	Marks	Guidance
23	a		Decreases ✓ Stays the same ✓	2 (AO2 × 2.1)	
	b	i	(Partial) reflection/absorption at the front of the kidney ✓ (Partial) reflection at the back of the kidney ✓	2 (AO2 × 2.1)	Both of the marking points can be awarded by a suitably clear diagram (or additional drawings on the given diagram) **ALLOW** 1 mark maximum for just reflection/bounces back
		ii	Measure the <u>time</u> between reflections ✓ Use distance = ½ x speed x time (to find the size) ✓	2 (AO2 × 2.2)	**ALLOW** distance = speed x time and mention of time halve
	c		There is no (known) risk associated with ultrasound / ultrasounds are safer than X-rays / X-rays pass through soft tissue (so would not detect the kidney) / X-rays are ionising (radiation) ✓	1 (AO1.1)	**ALLOW** X-rays used to detect bones/pass through kidney **ALLOW** ultrasound detects soft tissue/organs
			Total	7	

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Question			Answer/Indicative content	Marks	Guidance
24	a		Beta and gamma would not be absorbed/stopped (by smoke) ✓	1 (AO1.1)	**ALLOW** beta and gamma would pass straight through / are too penetrating / penetrate further / less ionising
	b	i	The time it takes the number of (undecayed/radioactive) nuclei to halve ✓	2 (AO1.1)	**ALLOW** count-rate or activity for number of undecayed nuclei **ALLOW** the time it takes for half of the (radioactive) nuclei to decay **ALLOW** atoms for nuclei
		ii	It is long enough so the activity does not change significantly / source will not need to be replaced ✓	1 (AO2.1)	**ALLOW** it will last a long time
		iii	Thorium (is greatest risk to begin with) / ORA ✓ As thorium will have a higher activity/count-rate (at the beginning) / ORA ✓	2 (AO2 × 3.2a)	**ALLOW** thorium decays faster / ORA
	c		**Any two from:** (Agree) Smoke alarms use small amounts of americium-241 ✓ Mainly emits alpha particles which are stopped by skin/soil ✓ Americium-241 is contained within the foil / AW ✓ Americium-241 cannot move out of materials in detector / be inhaled ✓ Soil emits more radiation ✓ **Or** **Any two from:** (Disagree) Smoke alarm contains an isotope with a long half-life ✓ The smoke alarm/foil could be damaged ✓ Americium-241 may contaminate objects (in the waste) ✓ Americium-241 also emits gamma rays (which are more penetrating that alpha particles) ✓ Soil may not absorb all radiation ✓	2 (AO2 × 3.2a)	**IGNORE** vague answers such as 'bad for the environment' **ALLOW** gamma is not stopped by the foil
			Total	7	

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