

1. In the UK some vegetables are sterilised by radiation during processing in order to extend their shelf-life.

The radiation is from a radioactive source.



A label on the pack states that the vegetables have been irradiated.

Donna is shopping and reads the information on the pack. She expresses her concerns to her friend.

'I'm worried that I will be contaminated if I eat these vegetables.'

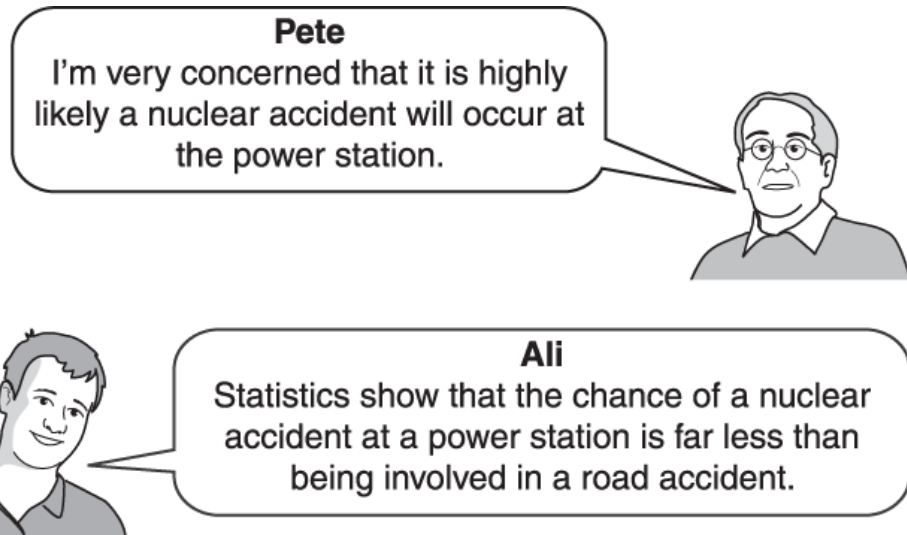
Explain how irradiating vegetables extends their shelf-life and give reasons why Donna's concerns are unfounded.



The quality of written communication will be assessed in your answer.

[6]

2(a). Pete expresses another concern to Ali.

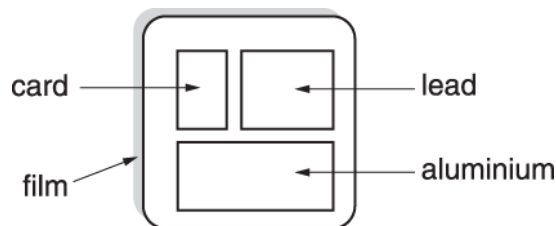


Suggest reasons why Pete over-estimates the risks from a nuclear accident at a power station.

[3]

(b). People who work in nuclear power stations wear a badge to monitor the type of ionising radiation they are exposed to.

One type of badge consists of a photographic film behind three windows made of different materials, aluminium, lead and card.



The film becomes fogged (darkened) if radiation passes through the window.

Fogged areas are shown as  in the following diagrams.

(i) Suggest why this badge cannot be used to detect α radiation.

----- [1]

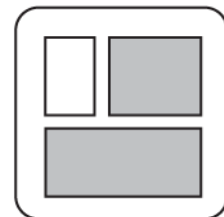
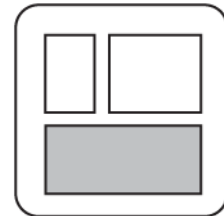
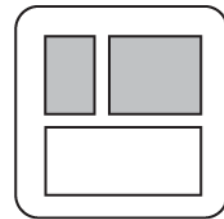
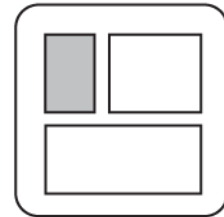
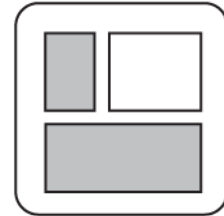
(ii) Draw one straight line from each **type of radiation** to its correct **film**.

Type of radiation

β only

γ only

Film



[2]

3(a). Nuclear fuel rods used by nuclear power stations consist of radioactive uranium sealed inside tubes of zirconium metal, which is not radioactive.

When the fuel has provided as much energy as possible, the used fuel rods, containing the waste, are sent to reprocessing centres. At these centres, the radioactive waste is removed from the zirconium tubes, stored securely and eventually made safe for disposal.

Workers working with the radioactive materials in nuclear fuel and nuclear waste might be at risk from irradiation or from contamination.

Put a tick (✓) in the **one** correct box for each row.

	At risk from irradiation only	At risk from contamination only	At risk from both	At risk from neither
Workers at the power station	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Workers at the reprocessing centre	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

[2]

(b). Give **two** reasons why irradiation is usually less hazardous than contamination.

[2]

4. The radioactive waste from nuclear power stations can be a hazard through contamination or irradiation.

Which of the following statements are correct?

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

Contamination results in a long period of exposure to radiation.

Contamination causes cancer, but irradiation just damages cells.

Ionising radiation causes contamination.

Exposure to radiation from an external source is irradiation.

Protective clothing mainly protects from irradiation.

[2]

5(a). Read the following article.

Some cancers are treated with a form of radiation therapy called permanent brachytherapy. A small radioactive source is placed inside a tumour. The source then decays over time, releasing ionising radiation that breaks down the tumour.

(i) Link each phrase from the article to its correct meaning.

phrase	meaning
radioactive source	particles or waves that can break apart atoms
ionising radiation	a substance that produces alpha, beta or gamma radiation
decay	the time taken for half of a radioactive substance to turn into another substance
	the particles in a sample naturally change from one element to another
	energy is released by a chain reaction

[3]

(ii) The radioactive source in the tumour gives out one type of ionising radiation.

A small amount of the radiation can be detected outside the body.

This shows that one type of radiation is definitely **not** produced by the source.

Put a **ring** around the correct choice to complete each sentence.

The source does not produce **alpha / beta / gamma** radiation.

This is the least **penetrating / evaporating / decaying** type of radiation,

so it **would / would not** pass out of the body.

[2]

(b). Which two statements, when taken together, explain why the ionising radiation “breaks down the tumour”?

Put ticks (✓) in the boxes next to the **two** correct statements.

Ionising radiation...

... can cause chemical reactions to take place.

... is not affected by chemical processes.

... can cause cells to become cancerous.

... is produced from the nuclei of atoms.

... decays over time.

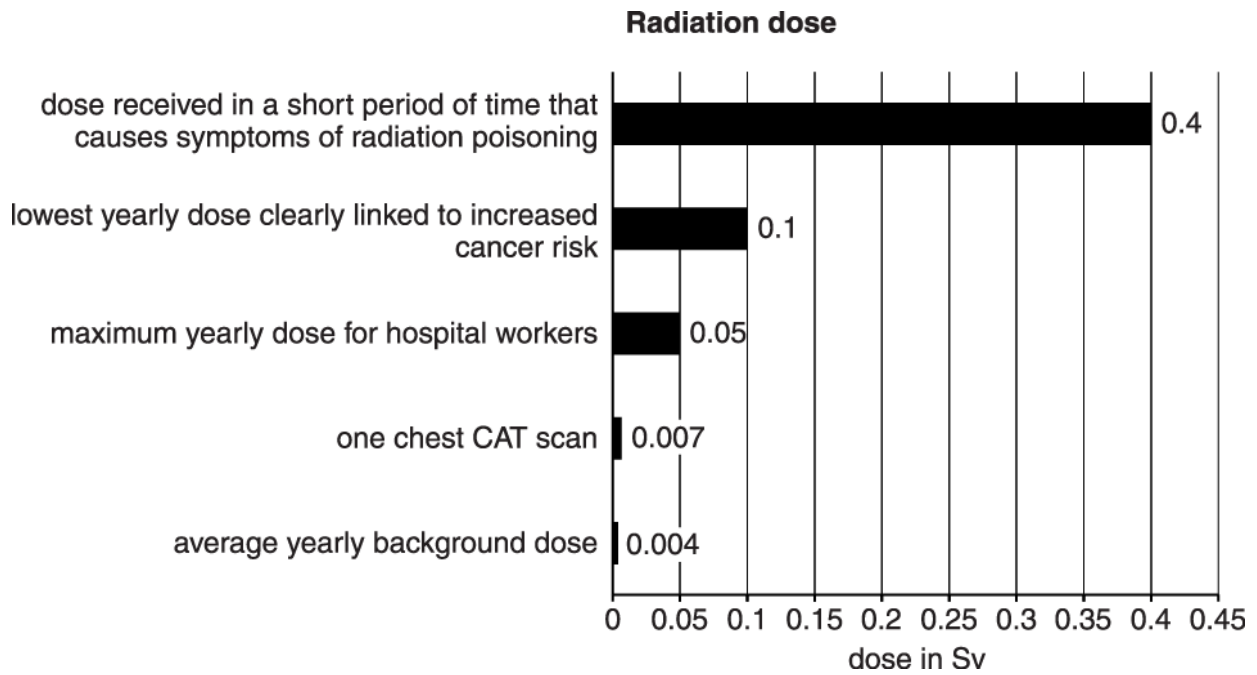
... kills living cells.

[2]

6. Zoe has a problem with her chest. Her doctor suggests that she has a series of CAT scans over a period of time.

CAT scans do not use radioactive sources, but do produce ionising radiation.

Zoe researches CAT scans on the internet and finds this information.



Use the data to help you discuss the issues that need to be thought about when Zoe makes a decision about whether or not to have the CAT scan.



The quality of written communication will be assessed in your answer.

[6]

7(a). Radon gas comes from the ground and emits alpha radiation.

The government has regulations about how buildings must be built.

Some of these regulations are about including protection against radon gas when a house is built.

Why would radon gas in houses be dangerous to humans?

----- [2]

(b). The following chart shows the risk of cancer from exposure to different levels of radon gas.

Indoor radon level	Lifetime risk of cancer
low	less than 1 in 200
medium	1 in 190
high	1 in 100

The building regulations insist that houses in high level radon areas have radon protection measures installed.

A politician proposes that people in areas with medium levels of indoor radon should also install the protection measures and that the government should pay for the change.

How would different groups of people be affected by this change?

----- [3]

8. Radioactive sources are used in medicine.

Which of the following use radioactive sources?

Put ticks (✓) in the boxes next to each correct answer.

- | | |
|----------------------------------|--------------------------|
| treating cancer | <input type="checkbox"/> |
| sterilising surgical instruments | <input type="checkbox"/> |
| using a tracer in the body | <input type="checkbox"/> |
| using a vaccine | <input type="checkbox"/> |
| using X-rays | <input type="checkbox"/> |

[1]

9. Priya is going to work in a laboratory where radioactive sources are used.

She knows that radioactive sources can be dangerous.

Her supervisor has reassured her that the risk is low if she follows the safety procedures.

Here are some safety procedures:

- wear disposable gloves
- use long-handled tongs to handle the sources
- wear a monitoring badge

What are the risks from handling radioactive sources and how do these safety procedures reduce the risks?



The quality of written communication will be assessed in your answer.

[6]

10. Ali lives near the site of a proposed new nuclear power station.

He is very worried about the effects of a nuclear accident.

He knows that the risk of an accident at the power station is much less than the risk when driving his car.

Suggest why Ali is concerned, even though the risk is so low.

----- [2]

11. A teacher sets up a demonstration experiment. She uses a radioactive source to measure how its activity changes during a lesson.

She handles the radioactive source very carefully to avoid the risk of **irradiation** and **contamination**.

Explain why contamination from the source is more hazardous than irradiation from the source.

[2]

12(a) Ionising radiation can damage and kill living cells.

Which of the following uses of radiation work by killing living cells?

Put ticks (✓) in the boxes next to the **three** correct answers.

detecting cracks in metal pipes

as a tracer in the body

sterilising surgical instruments

irradiating food

treating cancer

detecting smoke

[2]

(b). People working with radioactive sources often wear detectors to measure how much ionising radiation they are exposed to.

One type of detector is a badge with photographic film covered by three different materials.

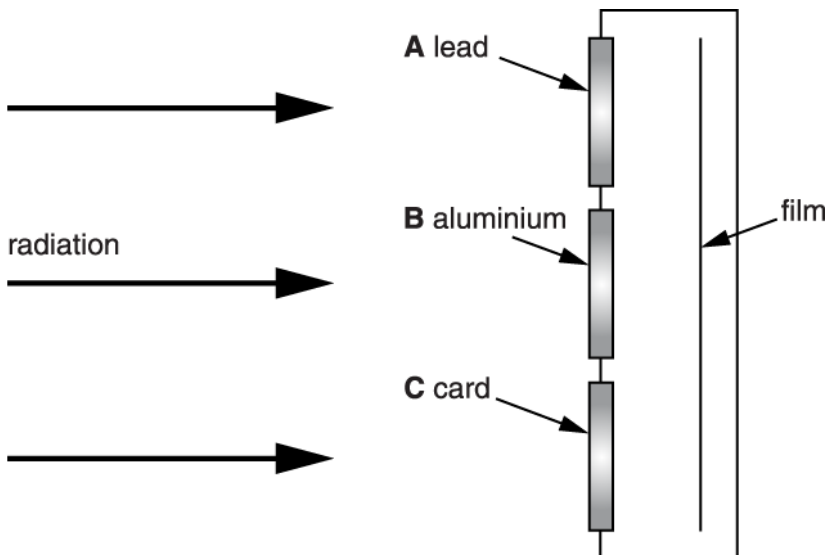
The photographic film records the amount of radiation that reaches it.

The badge has three sections.

Section **A** is covered with lead.

Section **B** is covered with aluminium.

Section **C** is covered with card.



(i) Which sections can be used to detect beta and gamma radiation?
Explain your answer.

[2]

(ii) The badge cannot be used to detect alpha radiation.
Explain why.

[1]

13. Sam has been advised by the hospital to have radiotherapy to treat a cancerous tumour.

The hospital proposes to use a 'gamma knife'. The 'gamma knife' technique is non-invasive and involves directing many beams of gamma rays from 200 different directions so they meet at the tumour.

Sam has read about the risks of radiation and has found this information about radiation doses.

	Dose (millisievert)
Average background dose per year	2.7
Lowest dose per year definitely linked to an increase in cancer later in life	100
Fatal dose	5000
Recommended highest dose per year	50
Chest X-ray	0.10
Dental X-ray	0.01
Eating one banana or 100 g of Brazil nuts	0.01

The hospital has told Sam that the 'gamma knife' delivers a total dose of 2000 millisievert to the tumour.

Explain the risks of this treatment and how the hospital can minimise these.

Use the data to support your answer.

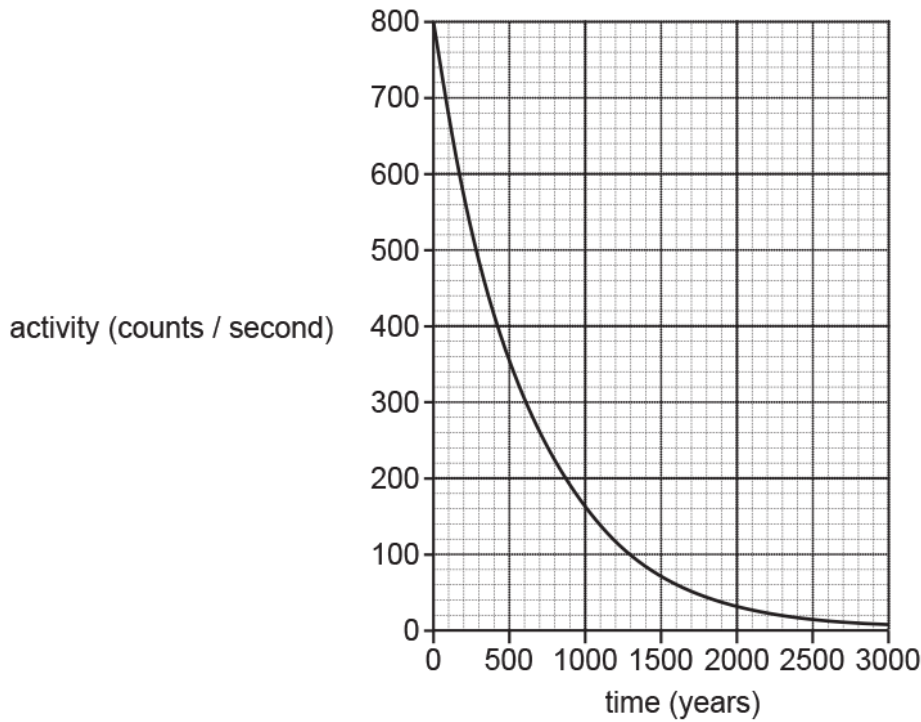


The quality of written communication will be assessed in your answer.

[6]

14. This question is about the radioactive isotope americium-241, which is found in smoke detectors.

The graph shows how the activity of a sample of americium-241, with an initial activity of 800 counts per second, would change with time.



Americium-241 decays by emitting alpha-particles.

A smoke detector is not a hazard in your house. They usually last 10 years.

Explain why a smoke detector should be disposed of carefully when it no longer works.

[4]

15. Table 8.1 shows data for four radioactive isotopes.

Isotope	Half life	Type of decay
molybdenum-98	stable	
molybdenum-99	66 hours	beta
technetium-99m	6 hours	gamma
thallium-201	73 hours	gamma

Table 8.1

Production of technetium-99m is becoming more expensive. An alternative for many medical procedures is thallium-201.

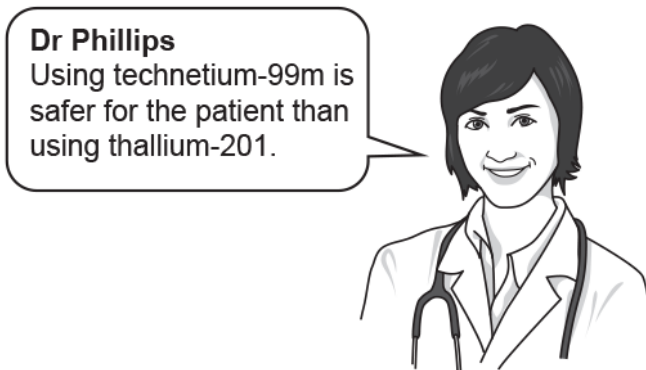
A patient is injected with a compound containing thallium-201. After 24 hours, 80% of the thallium-201 has not decayed.

A second patient is injected with a compound containing technetium-99m.

(i) Calculate the percentage of technetium-99m remaining after 24 hours.

Percentage remaining = % [2]

(ii) A doctor is deciding which radioactive isotope is best to use.



Evaluate this statement.

Use the data in Table 8.1 and the information above in your answer.

----- [2]

END OF QUESTION PAPER

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
1	<p>[Level 3] Detailed explanation of sterilisation process AND gives at least two reasons why concerns are unfounded. Quality of written communication does not impede communication of the science at this level.</p> <p style="text-align: right;">(5 – 6 marks)</p> <p>[Level 2] Simple explanation of sterilisation process AND gives at least two reasons why concerns are unfounded. Detailed explanation of sterilisation process without any reasons why concerns are unfounded gains max 3 marks. Quality of written communication partly impedes communication of the science at this level.</p> <p style="text-align: right;">(3 – 4 marks)</p> <p>[Level 1] Simple explanation of sterilisation process OR gives at least two reasons why concerns are unfounded Quality of written communication impedes communication of the science at this level.</p> <p style="text-align: right;">(1 – 2 marks)</p> <p>[Level 0] Insufficient or irrelevant science. Answer not worthy of credit.</p> <p style="text-align: right;">(0 marks)</p>	6	<p>This question is targeted at grades up to A*</p> <p>Indicative scientific points may include:</p> <p>Sterilisation of vegetable:</p> <p>Simple explanation</p> <ul style="list-style-type: none"> • penetrates the vegetables • damage living cells / mutates DNA • kill living cells / bacteria • bacteria causes rotting / decaying • sterilisation/irradiation stops vegetables rotting / decaying <p>Detailed explanation</p> <ul style="list-style-type: none"> • gamma or beta used because it will penetrate the vegetables and packaging • vegetables are sterilised while they are in the packet to avoid re-infection by microbes • irradiation produces ions/breaks molecules into bits • ions can take part in other chemical reactions and so kill bacteria • ions cause mutations in DNA <p>At L3, allow partial credit only for explanations using alpha radiation or x-rays</p> <p>Reasons why concerns are unfounded:</p> <ul style="list-style-type: none"> • vegetable not radioactive / not a source of radiation • the source is not on / in contact with the vegetables • the vegetables are not contaminated (by the source) • contamination means direct contact with source • irradiation is used for sterilising other things e.g. medical eqpt.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					<p>Use the L1, L2, L3 annotations in RM Assessor; do not use ticks.</p> <p>Examiner's Comments</p> <p>Of the three extended writing questions in this examination paper, candidates found this the most difficult to answer. There were very few level 3 answers, which required a detailed explanation of the process using the idea of ionisation and the action of ions. Many candidates stated that the radiation killed bacteria which gave access to levels 1 and 2. Many reasons to explain why Donna's concerns were unfounded were confused and did not correctly differentiate between irradiation and contamination.</p>
			Total	6	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
2	a		any THREE from: perceived risks; more serious consequence; cannot see radiation; reports from news / media / past events; lack of control; he doesn't want the power station built near him	3	e.g Chernobyl / Fukushima Examiner's Comments Candidates often only gave one reason. They did not refer to the number of marks to direct their answer. Many answers failed to address the question as they tried to justify why he need not worry, such as descriptions of safety and control methods at power stations. Most common correct reasons were previous events publicised in the media and consequences of a disaster.
	b	i	? will not penetrate any of the windows/materials in the badge	1	not just ?/it won't penetrate the badge / won't even penetrate card allow: Alpha is absorbed by air (before reaching badge) Examiner's Comments Many answers just stated a property of alpha rather than applying it to the situation in the badge, examples such as 'alpha does not pass through paper', 'alpha only goes through a few cm of air' and 'alpha is the least penetrating'. In order to gain the mark candidates needed to say that alpha does not go through card, aluminium or lead, or to say it does not penetrate any of the windows.
		ii	? only_____2 nd from top film ? only_____top film	2	1 mark for each correct line Examiner's Comments The line for beta was correct more often than that for gamma. Some candidates ignored the instructions in the question and drew multiple lines from each of the types of radiation.
			Total	6	

Mark Scheme

Question		Answer/Indicative content	Marks	Guidance										
3	a	irradiation only (1); both (1)	2											
	b	irradiation means no physical contact with source / contamination means physical contact with source(1); so exposed for less time with irradiation (1); irradiation can be screened off/can move away from source (1)	2	Any two accept examples e.g. lead screens ORA for mp2 & mp3 Examiner's Comments This question revealed the confusion of candidates clearly: radiation is thought of as a substance rather than a transfer of energy via tiny particles or photons, and so contamination is not so clearly distinct from irradiation as it is to physics teachers and examiners. Many responses to this question seem to suggest that irradiation is less harmful than contamination in the same way that alpha particles are less penetrating than gamma radiation. The understanding that irradiation is transient, occurring only while in the vicinity of the source, is often absent.										
		Total	4											
4		<table border="1" style="width: 100%;"> <tr> <td>Contamination results in a long period of exposure to radiation.</td> <td style="text-align: center;">✓</td> </tr> <tr> <td>Contamination causes cancer, irradiation just damages cells.</td> <td></td> </tr> <tr> <td>Ionising radiation causes contamination.</td> <td></td> </tr> <tr> <td>Exposure to radiation from an external sources is Irradiation.</td> <td style="text-align: center;">✓</td> </tr> <tr> <td>Protective clothing mainly protects from irradiation.</td> <td></td> </tr> </table>	Contamination results in a long period of exposure to radiation.	✓	Contamination causes cancer, irradiation just damages cells.		Ionising radiation causes contamination.		Exposure to radiation from an external sources is Irradiation.	✓	Protective clothing mainly protects from irradiation.		2	
Contamination results in a long period of exposure to radiation.	✓													
Contamination causes cancer, irradiation just damages cells.														
Ionising radiation causes contamination.														
Exposure to radiation from an external sources is Irradiation.	✓													
Protective clothing mainly protects from irradiation.														
		Total	2											

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
5	a	i		3	<p>1 mark per correct line</p> <p>Examiner's Comments</p> <p>This objective style question was well answered, although weaker candidates seemed unsure of the meaning of the term 'ionising radiation'.</p>
		ii	<p>alpha (1) both penetrating and would not (1)</p>	2	<p>Examiner's Comments</p> <p>Most candidates could identify alpha as the source, and therefore that it is least penetrating and that it would not pass out of the body. Candidates who failed to identify the source correctly for the first mark usually failed to score the second mark too, although the mark scheme did treat these as independent marking points.</p>
	b		<p>can cause chemical reactions to take place <input checked="" type="checkbox"/></p> <p>kills living cells <input checked="" type="checkbox"/></p>	2	<p>Examiner's Comments</p> <p>Knowledge that ionising radiation kills living cells was secure for almost all candidates. Very few candidates seemed to relate this to causing chemical reactions to take place, which was required to explain how a tumour would be 'broken down'. Many candidates incorrectly selected the statement 'can cause cells to become cancerous', which is not relevant to this explanation.</p>
Total				7	

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
6	<p>(Level 3) Explains in detail the risks due to exposure to ionising radiation and compares to the benefits. Considers other factors relevant to decision. Makes good use of data to justify answer. Quality of written communication does not impede communication of the science at this level. (5–6 marks)</p> <p>(Level 2) Describes risks and compares to benefit. Makes some use of data to support their decision. May consider other factors relevant to decision. Quality of written communication partly impedes communication of the science at this level. (3–4 marks)</p> <p>(Level 1) Describes risks and / or makes relevant comment based on data. May comment on benefit. Quality of written communication impedes communication of the science at this level. (1–2 marks)</p> <p>(Level 0) Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)</p>	6	<p>This question is targeted at grades up to A*</p> <p>Risk due to ionising radiation:</p> <ul style="list-style-type: none"> • increased dose means more ionising radiation • ionising radiation can damage / mutate cells / dna • so risk of radiation is cancer • therefore higher dose leads to an increased risk of cancer. <p>Other factors relevant to the decision:</p> <ul style="list-style-type: none"> • Zoe's background / work dose (e.g. radon in house / air stewardess) • previous treatment that may contribute to dose • whether she is pregnant • number of CAT scans is not specified • idea that dose is cumulative • other techniques that do not use ionising radiation may be available. <p>Benefit:</p> <ul style="list-style-type: none"> • need to know the details of the problem / need to understand the risks of not having the scan • her doctor thinks that the benefit outweighs the risk. <p>Data: refers to data in article in a comparative way</p> <p>Use the L1, L2, L3 annotations in Scoris; do not use ticks.</p> <p>Examiner's Comments</p> <p>This question was a six mark extended writing question targeted at grades up to A*. A limited range of responses were seen, with most candidates operating at Level 1. Very few candidates displayed appropriate awareness of ionising radiation and its effects as applied to this specific context. Only a minority of the most able</p>

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					managed to evaluate the data presented in the article correctly and use this to form a coherent argument. This style of question is to be expected as part of this examination series and candidates of all abilities would hopefully benefit from the opportunity to reflect on examples from this paper and from exemplar materials to help in their preparation.
			Total	6	

Mark Scheme

Question		Answer/Indicative content	Marks	Guidance
7	a	when inside the body (1) could cause (lung) cancer / damage DNA or cells / cause cells to mutate / alpha highly ionising (1)	2	<p>ignore reference to ionising cells</p> <p>Examiner's Comments</p> <p>This question on radioactivity seemed to differentiate well. Most candidates knew the harmful effects of alpha radiation, but fewer explained the increased risk only being significant when the radon gas was inhaled/ taken into the body. Weaker candidates did not pick up on the detail of the proposal.</p>
	b	max 2 marks from any one group economic argument residents	3	<p>economic arguments idea of cost / who pays</p> <p>consequence of less money for other areas / services reduced healthcare costs (as less cases of cancer) increase in local employment</p> <p>residents reduced risk (of cancer for medium radon level) correct use of data to discuss level of risk idea that not everyone benefits disruption during fitting</p> <p>Examiner's Comments</p> <p>Weaker candidates did not pick up on the detail of the proposal often mixing the groups who would benefit and those that would not. More able candidates put together a clear argument, usually identifying a benefit to a group and a drawback to a group but often missed out on a third marking point.</p>
		Total	5	

Mark Scheme

Question		Answer/Indicative content		Marks	Guidance	
8			to treat cancer	?	1	all correct for 1 mark Examiner's Comments A majority of candidates included X-rays in their selection, often with the other three answers correctly selected.
			to sterilise surgical instruments	?		
			as a tracer in the body	?		
			as a vaccine			
			in X-rays			
		Total			1	

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
9	<p>(Level 3) Identifies two or more risks and explains how all three procedures reduce risk. Quality of written communication does not impede communication of the science at this level. (5–6 marks)</p> <p>(Level 2) Identifies two or more risks and explains how two procedures reduce risk. Quality of written communication partly impedes communication of the science at this level. (3–4 marks)</p> <p>(Level 1) Identifies one risk and explains how one procedure reduces risk. Quality of written communication impedes communication of the science at this level. (1–2 marks)</p> <p>(Level 0) Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)</p>	6	<p>This question is targeted at grades up to A Indicative scientific points may include:</p> <p>Risks:</p> <ul style="list-style-type: none"> • Radioactive sources emit ionising radiation • Radiation damages human cells • Radiation damages DNA • Radiation can cause cancer • Radiation ionises molecules, which can take part in chemical reactions • Contamination / irradiation <p>Explanations of how procedures reduce risk</p> <p>Gloves:</p> <ul style="list-style-type: none"> • Barrier to prevent contamination • Barrier to alpha irradiation <p>Tongs:</p> <ul style="list-style-type: none"> • Increase distance (to reduce irradiation) • To avoid direct contact with / contamination by source • To direct the source away from observers <p>Monitoring badge:</p> <ul style="list-style-type: none"> • Monitoring exposure over time • Indicates when to avoid further exposure • Idea of safe limit of exposure <p>Use the L1, L2, L3 annotations in Scoris; do not use ticks.</p> <p>Examiner's Comments</p> <p>This question was answered well by many candidates. The majority obtained at least level 2 and answered both parts of the question about risks and safety procedures. A few candidates limited the level they could achieve by not giving more than one risk or not mentioning any. The</p>

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					way in which long handled tongs reduce the risks was usually well explained. Gloves stopping radiation was not always linked to alpha. Quite a number of candidates thought the monitoring badge acted like a GM tube or that it was some sort of security pass or a warning to other people. A few candidates wrote about nuclear waste or went through the penetrative power of each type of radiation without linking these to the precautions in the question.
			Total	6	
10			any TWO from: <ul style="list-style-type: none"> • consequences of nuclear accidents / radiation exposure • the perceived risk is high • it is not his decision to build the power station • he does not control the risk • it will affect his house price / damage the environment 	2	Examiner's Comments Most candidates gave one reason, which was usually the consequence of a nuclear accident such as irradiation or causing illness such as cancer. Very few candidates gave more than one reason. Only a few candidates mentioned perceived risk or that Ali was not in control.
			Total	2	

Mark Scheme

Question		Answer/Indicative content	Marks	Guidance
11		<p>any TWO from:</p> <ul style="list-style-type: none"> ◦ irradiation: no direct contact with radiation source ◦ contamination: radiation source material on clothes / body / breathed in / swallowed ◦ idea that contamination with alpha is ionizing / more hazardous ◦ nothing to protect internal organs (if swallowed or breathed in) ◦ clothes / skin is some protection from irradiation • idea that exposure time is greater with contamination 	2	<p>Examiner's Comments</p> <p>The idea of contamination was better known and described than irradiation. Many answers were vague as the candidate did not distinguish between or confused the source and radiation. A common misconception was that contamination is radiation inside a body whereas irradiation only happens outside.</p>
		Total	2	

Mark Scheme

Question		Answer/Indicative content	Marks	Guidance												
12	a	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 80%;">detecting cracks in metal pipes</td> <td style="width: 20%;"></td> </tr> <tr> <td>as a tracer in the body</td> <td></td> </tr> <tr> <td>sterilising surgical instruments</td> <td style="text-align: center;">?</td> </tr> <tr> <td>irradiating food</td> <td style="text-align: center;">?</td> </tr> <tr> <td>treating cancer</td> <td style="text-align: center;">?</td> </tr> <tr> <td>detecting smoke</td> <td></td> </tr> </table>	detecting cracks in metal pipes		as a tracer in the body		sterilising surgical instruments	?	irradiating food	?	treating cancer	?	detecting smoke		2	<p>3 correct = 2 marks 2 correct = 1 mark 1 or 0 correct = 0 marks</p> <p>Examiner's Comments</p> <p>The use of radiation where cells are killed seemed to be general well known. Few candidates failed to score any marks on this part. Over half the candidates gained both marks by choosing the three correct answers. There was no evidence of candidates choosing more than three options, though a few only chose two or one.</p>
detecting cracks in metal pipes																
as a tracer in the body																
sterilising surgical instruments	?															
irradiating food	?															
treating cancer	?															
detecting smoke																
	b	i	2	<p>allow aluminium for B; card for C throughout</p> <p>Examiner's Comments</p> <p>Responses were often not creditworthy as candidates confused 'detect' with 'stopped by'. Such answers stated what gamma and beta did not go through but did not explicitly say which they passed through and therefore would be recorded by the film. There were also misconceptions that lead allowed gamma to pass through it, and that aluminium allowed beta.</p>												
		ii	1	<p>Examiner's Comments</p> <p>Many of the responses that did not get awarded the mark stated a property of alpha particles (eg can only pass through a thin sheet of paper) but did not relate it to the badge. Candidates needed to say that alpha particles could not penetrate any of the window coverings in order to gain the mark. Some responses only mentioned that it could not go through card, but failed to mention the other window coverings.</p>												
Total			5													

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
13	<p>[Level 3] Describes a risk and a risk mechanism and states risk minimizations with use of data. Quality of written communication does not impede communication of the science at this level. (5–6 marks)</p> <p>[Level 2] Describes a risk and a risk mechanism and states risk minimizations OR describes a risk and states risk minimizations with use of data. Quality of written communication partly impedes communication of the science at this level. (3–4 marks)</p> <p>[Level 1] Any TWO correct points from TWO of the four areas. Quality of written communication impedes communication of the science at this level. (1–2 marks)</p> <p>[Level 0] Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)</p>	6	<p>This question is targeted at grades up to A*</p> <p>Indicative scientific points may include:</p> <p>risk:</p> <ul style="list-style-type: none"> • Damage / mutate living cells • kill living cells • cause cancer <p>risk mechanism:</p> <ul style="list-style-type: none"> • produces ions / ionisation (NOT ionises cells) • ions can take part in other chemical reactions <p>risk minimization</p> <ul style="list-style-type: none"> • protection of patient / staff by shielding • spread treatment over time / no more x-ray treatments • each beam low intensity • any other sensible precaution <p>use of data</p> <ul style="list-style-type: none"> • many/200 beams used • dose from each beam = 10mSV (2000/200) < 100mSv • each beam below lowest dose to cause cancer later • total dose above recommended highest dose • other calculations using data in the table <p>Use the L1, L2, L3 annotations in RM Assessor; do not use ticks.</p>
	Total	6	

Mark Scheme

Question		Answer/Indicative content	Marks	Guidance
14		<p>Any four from: (Alpha particles are highly) ionising ✓</p> <p>This can damage cells/DNA/cause cancer ✓</p> <p>(After 10 years the) activity will still be very high (due to long half-life) ✓</p> <p>Am-241 may escape from a discarded detector ✓</p> <p>Can be ingested by animals/absorbed by plants / enter the food webs ✓</p>	<p>(AO 1.1)</p> <p>4 (AO 2.1 x 3)</p>	<p>Alpha radiation is in the stem, so 'this ionising radiation can damage cells' gets mp2 & mp3</p> <p><u>Examiner's Comments</u></p> <p>Many candidates gained a couple of marks for stating that alpha radiation is ionising, and that it can damage cells. Some also stated that after 10 years the radioactive material is still emitting alpha particles. There were a number of familiar and persistent misconceptions such as radiation/the alpha particles could escape from the smoke detector and contaminate the environment. Better candidates did recognise that a smoke detector crushed in landfill could release radioactive material which could then enter the food chain</p>
		Total	4	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
15		i	<p>FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 6.25 (%) award 2 marks</p> <p>4 half lives ✓ = 6.25 (%) ✓</p>	<p>2 (AO 2.2 ×2)</p>	<p>ALLOW $24 \div 6 = 4$ seen ALLOW evidence of four successive halvings ALLOW 93.75(%) (percent of Tc-99m that has decayed)</p> <p>Examiner's Comments</p> <p>To answer this question, candidates first needed to refer back to the data table to find that Tc-99m has a half-life of 6 hours. Most candidates were able to show some understanding that the number of 6-hour half-lives in 24 hours is 4. A common error is to divide 100% by 4.</p>
		ii	<p>longer time for thallium (because it has a longer half-life) / ORA ✓</p> <p>causing greater radiation dose/ risk of cancer / ORA ✓</p>	<p>2 (AO 3.1b ×2)</p>	<p>ALLOW more damage to cells ALLOW for 2 marks exposure is greater if the patient is exposed for more time</p> <p>Examiner's Comments</p> <p>Most candidates were able to express the idea that Tc-99m spends less time in the body compared with Ti-201. Very few candidates were able to address the 'safer' aspect of this comment however. These candidates recognised that with less time in the body, there would be less exposure to radiation or express this in some other comparative way such as 'less damage to cells'.</p>
			Total	4	