Mark Scheme

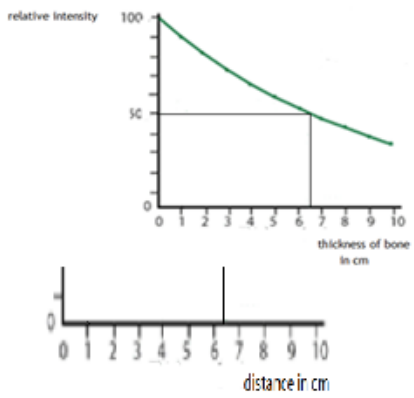
Q1.

	Answer	Acceptable answers	Mark
	A description including **two** of: • Kill/damage cells(1) • affecting DNA (1) • (causing) mutation (1) • by ionisation (1) • make cell reproduce rapidly (1) • cause cancer (1) • (radiation) burns (1) • (radiation) sickness (1)		**(2)**

Q2.

Question Number	Answer	Acceptable answers	Mark
	Any three from: • keep distant from sources / (stand) in a separate room (behind leaded window etc.) • limit **time** exposed to the radioactivity • use lead shielding for the sources / handle sources with tongs etc. / dispose radioactive material(s) safely • wear lead aprons / used lead-lined clothing / lead-lined gloves • monitor exposure with some detector / badge / use of (radiation) meters	 (distance also involved if you) use computer controlled equipment the time aspect must be clear here. ignore goggles / (special) gloves without detail. Similarly ignore 'radiation resistant' (clothes)	**(3)**

Q3.

Question Number	Answer	Additional guidance	Mark
(i)	Constructs a line across at an intensity of 50 (with a vertical to the thickness axis) (1) e.g.  (thickness =) 6.5 - 6.7 (cm) (1)	award full marks for the correct answer without working	(2)

Question Number	Answer	Mark
(ii)	**The only correct answer is B J/kg** None of the other options have units which are the same as J/kg	(1)

Q4.

	Answer	Acceptable answers	Mark
(i)	suitable lines on graph to show halving after about 200 000 years (2)	use of data from graph to show halving after about 200 000 years 1500/2 =750(Bq) or	(2)

	• horizontal line at 750 +or –50 Bq on y-axis to curve (1) • meeting (by eye) vertical line from x-axis between 190,000 years and 230,000 years (1)	1600/2=800(Bq) gives a half-life of 210,000 +or- 20 000 (years)	
(ii)	any one of • penetrates/passes through the skin (1) • ionises (1) • damages tissue/ cells/DNA (1) • mutates cells/DNA(1) • causes cancer(1)		**(1)**

Q5.

Question Number	Answer	Additional guidance	Mark
(i)	one from: (radiation from them) (can cause) cancer / tumours (1) radiation sickness / radiation poisoning (1) (radiation from them can) mutate / alter/ deform / damage / ionise / kill {cells OR DNA OR genes} (1) burns skin (1)	 accept any named type of cancer accept birth defects OR sterilisation Ignore unqualified poisoning kills you skin damage	**(1)**

Question Number	Answer	Additional guidance	Mark
(ii)	**neutron** (in the nucleus) (1) becomes a **proton** (and an electron) (1)	**down quark / d** (in the neutron) OR mass/nucleon number stays same becomes an **up quark / u** OR atomic/proton number increases by 1 $n > p + e^{-}$ scores 2 marks if no other mark scored allow for 1 mark (it) emits an electron OR beta (minus) is an electron OR energy is released OR loses a proton and gains a neutron IGNORE gaining/losing/becoming electron(s)	(2)

Q6.

Question Number	Answer	Additional guidance	Mark
(i)	A description to include: diagnosing / locating / identify/look for (1) tumour (1)	 brain scan cancer award 2 marks for 'seeing where the cancer is'	(2)

Question Number	Answer	Additional guidance	Mark
(ii)	Any two precautions to do with: **mp1** short half-life isotopes (1) **mp2** shielding (1) **mp3** distance (1) **mp4** isolation (1) **mp5** exposure time (1) **mp6** transportation (1) **mp7** storage (1)	protective clothing lead shielding working in another room working radiation badges to and around the hospital appropriate containers	**(2)**

Q7.

Question Number	Answer	Acceptable answers	Mark
(i)	An explanation linking two of the following:- CT scan lasts much longer / X-ray short exposure (1) CT scan is many X-ray (slices) (1) The intensity of radiation for CT scans is higher than for normal X-rays (1)	 For CT scan X-ray machine moves (slowly) around the body many pictures / series of X-rays/ 3D image	**(2)**

Question Number	Answer	Acceptable answers	Mark
(ii)	Justification including:- appreciation that there would be risks (1) ONE from:- non-invasive/ not painful (1) OR more accurate/better/earlier diagnosis (1) OR life-saving/ provide cure (1)	 the benefits outweigh the risks/drawbacks/concerns/dangers gives more useful information	**(2)**

Q8.

Question Number		Indicative Content	Mark
QWC		A description including some of the following points :- Diagnosis • radioactive tracers used in the body • to check systems e.g. skeleton / bone, blood flow, thyroid activity, kidney function. • attached to some compound which targets a particular area of the body • radioactive tracers are isotopes with short half-lives put into the body • may go into PET scans, since this involves beta+ emitters • gamma cameras, used to detect emissions from radioactive tracers Treatment • radiotherapy, use of gamma rays (from cobalt 60) / gamma rays aimed at a tumour to destroy cancerous cells. (Use of multiple beams) May cause damage to normal cells. • radioactive inserts placed into the body to destroy cancerous cells, mainly used for prostate cancer. ignore chemotherapy, ultrasound scans, endoscopes etc.	**(6)**

Level	**0**	No rewardable content
1	**1 - 2**	• a limited description of one procedure used for either diagnosis **OR** treatment e.g. idea of tracers or an elementary notion of radiotherapy given • 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 simple description of one procedure used for either diagnosis **OR** treatment e.g. the tracer emits gamma rays which are detected using a gamma camera showing up area of high uptake / radioactivity; uses radioactive sources emitting beta / gamma radiation to destroy cancer cells. • 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 description a procedure used for diagnosis and a procedure used for treatment. e.g. a short-lived radioactive tracer is injected into the body which then shows up areas of high activity via a gamma camera **AND** radiotherapy uses gamma to destroy cancer cells in a targeted way, with some detail. PET scanning details acceptable on the diagnosis side. (N.B. The diagnosis aspect may be covered in more detail than the treatment or vice-versa) • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors

Q9.

Question Number	Answer	Acceptable answers	Mark
(i)	An explanation to include two from: Radiation is ionising (1) Radiation can cause specified damage e.g. cancer or damage/mutate DNA (1) if dose/exposure is too high (1)	 (causes) ionisation/ (can) ionise/ mutate cells/tissue ignore radiation poisoning/death/make you ill ignore {damage/kill} cells/tissue if absorb(ing) too much (radiation) or so you don't absorb too much (radiation) Accept for both marks: Too much radiation can cause cancer (after a while)	**(2)**

Question Number	Answer	Acceptable answers	Mark
(ii)	☒ **C** we have a better understanding of the risks from radiation (1)		**(1)**

Question Number		Indicative Content	Mark
QWC	***(iii)**	An explanation including some of the following points • identification of alpha, beta, gamma as possible types of radiation • identification of X-rays as possible type of radiation • film is dark(er)/changes colour where radiation is absorbed • different areas of the film are exposed to different types of radiation • gamma (or X-rays) affect all areas of film • beta absorbed/stopped by aluminium/passes through paper • beta only reaches (top) part of film • alpha unlikely to be detected at all • the lead will stop (some of) gamma or (some) gamma will pass through lead/aluminium/paper • the paper will stop/absorb alpha throughout the question accept symbols for types of radiation	**(6)**

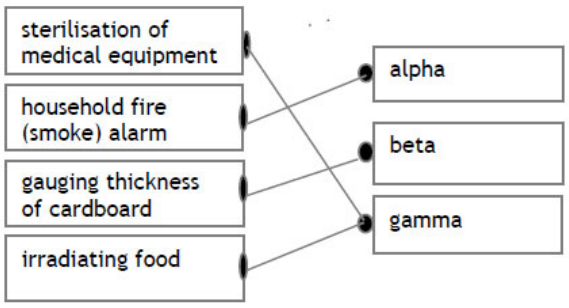
Level	0	No rewardable content
1	1 - 2	• a limited explanation which gives one relevant fact about types of radiation or the film badge e.g. types of radiation are alpha, beta and gamma OR beta absorbed by aluminium OR the radiation affects the film OR gamma can pass through lead • the answer communicates ideas using simple language and uses limited scientific terminology • spelling, punctuation and grammar are used with limited accuracy
2	3 - 4	• A simple explanation, giving more than one relevant fact about types of radiation OR the film badge OR at least one fact about both. e.g. The 3 types of radiation are alpha, beta and gamma. Gamma can pass through lead. OR The 3 types of radiation are alpha, beta and gamma. Radiation makes the film change colour. OR beta will get through the paper but alpha will be stopped (by paper). OR Radiation makes the film change colour. The lab. will compare how much got through the paper, aluminium and lead • 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 explanation giving more than two relevant points about the film badge OR at least one fact about the types of radiation AND more than one about the film badge e.g. Beta will get through the paper but alpha will be stopped (by paper).Gamma can penetrate the aluminium. OR The film detects radiation. The aluminium will stop beta but, not gamma. OR The 3 types of radiation are alpha, beta and gamma. Beta will get through the paper but alpha will be stopped (by paper). • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors

Q10.

	Answer	Acceptable answers	Mark
(a)(i)	☒ **C**the same as the charge on the proton		**(1)**
(a)(ii)	☒ **A**electrons		**(1)**
(b)(i)	222	4 less/4fewer	**(1)**
(b)(ii)	86	2 less/2fewer	**(1)**
(c)	A description including **two** of: • Kill/damage cells(1)		**(2)**

	• affecting DNA (1) • (causing) mutation (1) • by ionisation (1) • make cell reproduce rapidly (1) • cause cancer (1) • (radiation) burns (1) • (radiation) sickness (1)		
(d)	An explanation linking any suitable precaution to a sensible reason: Eg lead/shielding (1) (because it) stops/absorbs radiation (1) Use of radiation meters (1) {measure/warn of} radiation received (1) put up signs (1) (to)keep people away from radiation (1) increasing distance (1) (to)reduce intensity (1) to reduce dose(1) by limiting the number of X-rays taken (1)	source locked away for shielding (worker) leaves room inverse square law	**(2)**

Q11.

	Answer	**Acceptable answers**	**Mark**
(a)		one mark for each correct line	**(4)**
(b)	☒ **D**		**(1)**
(c)	☒ **B** becquerel		**(1)**
(d)	A description including any **two** from: • secure storage (1):	either the purpose, such as to prevent radiation getting out or a description such as lead-lined box/locked away when not in use.	**(2)**

	• avoid direct contact (1) • wear protective clothing (1) • minimise exposure (1) • shielding (1) • minimise dose (1) • monitor exposure (1) • protect other people (1)	do not touch / use tongs /wash after handling lead lined suits/aprons/masks/gloves ignore goggles long distance away / not pointing towards body/ keep sources shielded /stand behind shields short time wear film badge/use Geiger counter (to monitor radiation levels) warning signs / barriers / restricted areas /controlled areas	

Q12.

Question Number	Answer	Acceptable answers	Mark
(a)(i)	**D** 27 (1)		**(1)**

Question Number	Answer	Acceptable answers	Mark
(a)(ii)	an explanation linking: • no change in mass (number) (1) • (because) gamma is a wave (electromagnetic) / has no mass (itself) (1) OR • mass decreases (1) • idea of mass – energy equivalence (1) (must be clearly stated)	gamma is only energy / not a particle nucleus de-excites / rearranged for one mark do not allow 'mass number decreases'	**(2)**

Question Number	Answer	Acceptable answers	Mark
(b) (i)	**A** gamma can penetrate further than alpha or beta (1)		**(1)**

Question Number	Answer	Acceptable answers	Mark
(b) (ii)	description to include: • protects / stops radiation escaping (1) • affecting operator/doctor/nurse (1)	absorbs (radiation) other people / others	**(2)**

Question Number	Answer	Acceptable answers	Mark
(b) (iii)	two from: • non invasive / no surgery required (1) • no radioactive substances left in the body (1) • no anaesthetic used • patient does not become radioactive (1) • outpatient procedure (1) • does not affect the whole body (1) • (accurate) targeting of tumour (1) • painless (at the time) for the patient • procedure (may be) quicker	no need to operate / cut open patient / reduces risk of infection no harmful side effects like chemotherapy ignore answers\that apply equally to other treatments e.g. 'kills cancer'	**(2)**

Question Number	Answer	Acceptable answers	Mark
(b) (iv)	explanation linking two from: • idea of targeting / beams concentrate / focus on tumour (1) • avoid damage to healthy cells / tissue (1) • (reaching / getting to) all parts of the tumour (1)	more rays hit tumour / beams overlap at tumour ignore '(more) beams penetrate more' / (more) accurate	**(2)**

(Total for Question = 10 marks)

Q13.

	Answer	**Acceptable answers**	**Mark**
(a)(i)	any one of X-ray (machines) / smoke alarms/ nuclear/ radioactive waste (1)	nuclear weapons (tests) nuclear power plants (medical) tracers/technetium	**(1)**
(a)(ii)	an explanation linking: comes from granite / rocks (1) none/ less of these (rocks) in some areas (1)	in some areas/Cornwall/Aberdeen the second mark is dependent on	**(2)**

		the first.	
(b)(i)	suitable lines on graph to show halving after about 200 000 years (2) • horizontal line at 750 +or –50 Bq on y-axis to curve (1) • meeting (by eye) vertical line from x-axis between 190,000 years and 230,000 years (1)	use of data from graph to show halving after about 200 000 years 1500/2 =750(Bq) or 1600/2=800(Bq) gives a half-life of 210,000 +or- 20 000 (years)	**(2)**
(b)(ii)	any one of • penetrates/passes through the skin (1) • ionises (1) • damages tissue/ cells/DNA (1) • mutates cells/DNA(1) • causes cancer(1)		**(1)**

Total marks for question = 12

		Indicative Content	
QWC	***(c)**	an explanation which may include some of the followi <u>properties of nuclear waste</u> radioactivity is dangerous some isotopes in nuclear waste have long half-lives/ra thousands of years products of fission are warm identified radiation from nuclear waste e.g alpha, beta <u>problems caused by nuclear waste</u> leakage of radioactivity contamination of ground/sea water/lakes /rivers contamination of crops/fish/animals/drinking water harm to humans/cancer/radiation poisoning/ damage cells/mutation of cells or DNA difficulty in transporting safely/ stolen by terrorists fea people <u>solutions for dealing with nuclear waste safely</u> long term storage, underground /under the sea radiation shielding, lead/steel/concrete/ containers, se human safety, radiation suits, using tongs/lead jackets location, away from people/remote areas/sea cooling, information to persuade local people of safety	
Level	**0**	No rewardable content	
1	**1 - 2**	• a limited explanation mentioning at least one point, but without linking, e.g. radioactivity is dangerous ; nuclear waste should be stored underground ; terrorists might steal nuclear waste;	

		• 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 simple explanation mentioning two points with an appropriate linkage e.g. nuclear waste is dangerous and it must be stored underground ; the isotopes in nuclear waste have long half-lives so they must be stored for a long time; • 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 explanation mentioning a range of points with appropriate linkages e.g. gamma rays from nuclear waste causes damage to cells so it must be stored away from where people live ; the isotopes in nuclear waste have long half-lives so they must be stored underground or in remote areas; • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors	