Question Number	Answer	Acceptable answers	Mark
1(a)	Any one of Treatment of cancer / radiotherapy Imaging e.g.: looking at broken bones, tracers sterilizing (equipment/dressings) (1)	NOT ultrasound applications/ chemotherapy accept(to) cure/kill/detect cancer (cells) accept X-ray(s)/X-ray machine accept PET/CT scans ignore MRI scans accept (to) kill bacteria ignore medical treatment and similar vague statements	**(1)**

Question Number	Answer	Acceptable answers	Mark
1(b)	12 hours = 2 half lives (1) 10 (mg) (1)	idea of halving seen e.g. 40 ÷ 2 or 20 (mg) ignore 80 (mg) and 99 ÷ 2 OR idea of 2 half lives seen or 40/4 OR (6 is 1 half-life and)12 is 2 (half-lives) OR 1/4 Give full marks for correct answer with no working.	**(2)**

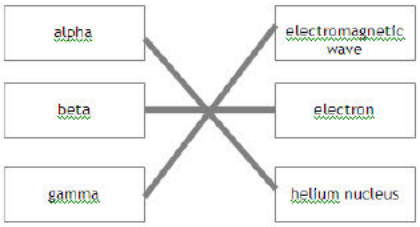
Question Number	Answer	Acceptable answers	Mark
1(c)(i)	An explanation to include two from: Radiation is ionising (1) Radiation can cause specified damage e.g. cancer or damage/mutate DNA (1) if dose/exposure is too high (1)	 (causes) ionisation/ (can) ionise/ mutate cells/tissue ignore radiation poisoning/death/make 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
1(c)(ii)	☒ **C** we have a better understanding of the risks from radiation (1)		**(1)**

Question Number		Indicative Content	Mark
QWC	***1(c)(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

Total for Question 6 = 12 marks

Question Number	Answer	Acceptable answers	Mark
2(a)	Three lines as shown:  (2)	Any one line correct only scores 1 mark	**(2)**

Question Number	Answer	Acceptable answers	Mark
2(b)	An explanation linking Absorb (more) neutrons (1) (to) reduce the number of fission reactions (1)	ignore slow down neutrons slow down (the rate of) the reaction/fission	**(2)**

Question Number	Answer	Acceptable answers	Mark
2(c)(i)	**B** electrostatic repulsion of protons		**(1)**

Question Number	Answer	Acceptable answers	Mark
2(c)(ii)	A description to include • (two/or more/smaller) nuclei combine/fuse/join (1) • (to produce) a larger nucleus (1)	 {(two or more) hydrogen nuclei/protons OR deuterium and tritium} combine/fuse (forming) helium nucleus ONLY penalise use of atoms instead of nuclei ONCE ignore references to release of energy as this is given earlier in the question.	**(2)**

Total for Question 1 = 7 marks

Question Number	Answer	Acceptable answers	Mark
3 (a)(i)	**B 21**		**(1)**

Question Number	Answer	Acceptable answers	Mark
3 (a)(ii)	**A** $^{39}_{19}K$		**(1)**

Question Number	Answer	Acceptable answers	Mark
3(a)(iii)	A description to include any two of • (nucleus/isotope is) unstable (1) • (nucleus/isotope is) radioactive (1) • decay is random (1) • long half life (1)		**(2)**

Question Number	Answer	Acceptable answers	Mark
3(b)(i)	1250 (million years) (1)	Between 1200 and 1300 (my) inclusive	**(1)**

Question Number	Answer	Acceptable answers	**Mark**
3(b)(ii)	2 half lives (1) 2500 (million years) (1)	 Allow ecf from (bi) Give full marks for answer between 2400 and 2600 with no working.	**(2)**

Question Number	Answer	Acceptable answers	Mark
3(c)	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)**

Total for Question 4 = 10 marks

Question Number	Answer	Acceptable answers	Mark
4 (a) (i)	A protons B neutrons C electrons	OR A neutrons B protons C electrons	**(3)**

Question Number	Answer	Acceptable answers	Mark
4(a) (ii)	**12**		**(1)**

Question Number	Answer	Acceptable answers	Mark
4(b)	**B** It is very ionising		**(1)**

Question Number	Answer	Acceptable answers	Mark
4 (c)	gamma (1) beta (1)		**(2)**

Question Number	Answer	Acceptable answers	Mark
4(d)	**A decreases by 2** **decreases by 4**		**(1)**

Total for Question 1 = 8 marks

Question Number	Answer	Acceptable answers	Mark
5(a)	**A** gamma		**(1)**

Question Number	Answer	Acceptable answers	Mark
5 (b)	An explanation linking the following:- (it is) ionising (can cause) (1) damage to tissue/ mutation/cancer/tumours (1)	 has high frequency/energy kill cells / (causes) burns	**(2)**

Question Number	Answer	Acceptable answers	Mark
5(c)	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)**

Question Number		Indicative Content	Mark
QWC	**5(d)**	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

Total for Question 6 = 12 marks