Question number	Answer	Additional guidance	Mark
1(a)	alpha cannot penetrate casing	alpha only travel a few cm in air	(1)

Question number	Answer	Mark
1(b)	• evidence of division of activity by 2 (1) • 120 (Bq) (1)	(2)

Question number	Answer	Mark
1(c)	• increase number of starting dice (1) • do more rolls (1)	(2)

Question number	Indicative content	Mark

***1(d)**	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **AO2 (6 marks)** • use a radioactive isotope of iodine as this is taken up by the gland • isotope given by injection or orally • gland is in the neck, so cannot use an alpha emitter as alpha will not exit through the skin • use beta or gamma emitter • isotope has to have a short enough half-life to minimise exposure to radiation but long enough for the reading to be taken • allow time for isotope to reach gland • use Geiger-Müller tube and counter to determine count rate of isotope in gland • compare with normal count rate to determine whether uptake of iodine is normal	**(6)**

Level	Mark	Descriptor
	0	No awardable content.
1	1–2	• The explanation attempts to link and apply knowledge and understanding of scientific ideas, flawed or simplistic connections made between elements in the context of the question. (AO2) • Lines of reasoning are unsupported or unclear. (AO2)
2	3–4	• The explanation is mostly supported through linkage and application of knowledge and understanding of scientific ideas, some logical connections made between elements in the context of the question. (AO2) • Lines of reasoning mostly supported through the application of relevant evidence. (AO2)
3	5–6	• The explanation is supported throughout by linkage and application of knowledge and understanding of scientific ideas, logical connections made between elements in the context of the question. (AO2) • Lines of reasoning are supported by sustained application of relevant evidence. (AO2)

Question Number	Answer	Acceptable answers	Mark
2(a)(i)	**B** magnetic		**(1)**

Question Number	Answer	Acceptable answers	Mark
2(a)(ii)	(high frequency alternating) voltage	electric field / electrostatic force electrodes + and – (not just 'electrodes') potential difference (p.d.)	**(1)**

Question Number	Answer	Acceptable answers	Mark
2(a)(iii)	A description using the following:- (charged) particles bombard (1) atoms/molecules/nuclei / (stable) elements (1)	 (charged) particles {hit / shoot into / fired into / collide with} generally accept 'it' / 'they' as alternatives to 'charged particles' target (material) / nucleus / **stable** isotope 'neutrons hitting a target' would get second mark only (neutrons not charged) 2nd mark needs idea of hitting target nuclei / atoms, not (charged) particles hitting other particles.	**(2)**

Question Number	Answer	Acceptable answers	Mark
2(b)(i)	**C** 		**(1)**

Question Number	Answer	Acceptable answers	Mark
2(b)(ii)	An explanation linking any three of the following:- positron has a positive (charge) (1) electron has a {negative (charge) / opposite charge(s) } (1) these charges cancel out (1) gamma rays /waves have no charge (1)	 positron has +1 / +e (charge) positron charge is + electron has -1 / -e (charge) electron charge is – neutralise / overall charge is zero Accept for three marks: electron and positron have equal and opposite charges which cancel out.	**(3)**

Question Number	Answer	Acceptable answers	Mark
2 (b)(iii)	An explanation linking : positron and electron have mass(before the annihilation) (1) gamma (rays produced by annihilation) have energy (1) (the equation shows)	 mass (of particles) becomes energy of gamma (rays) (2) all the mass before the collision becomes the energy of the gamma (rays) after the particles have been annihilated (2) $E=mc^2$ reference (1) explained will get the other (1)	**(2)**

Total for Question 4 = 10 marks

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

Question Number	Answer	Acceptable answers	Mark
3(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
3(b) (i)	**A** gamma can penetrate further than alpha or beta (1)		**(1)**

Question Number	Answer	Acceptable answers	Mark
3(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
3(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
3(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 4 = 10 marks)