Mark Scheme

Q1.

	Answer	Acceptable answers	Mark
	axes labelled correctly With label or unit (1) correct shaped smooth curve (1) line does not reach zero activity (1)	activity / Bq / count rate ignore radioactivity time/ seconds/ any time unit	**(3)**

Q2.

	Answer	Acceptable answers	Mark
	☒ **D**		**(1)**

Q3.

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

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

Q4.

	Answer	Acceptable answers	Mark
(i)	Any **two** of: Gamma is a wave (1) Alpha is a helium nucleus (1) Alpha is charged (1) Alpha has a mass (1) Gamma penetrates further/ highly (1) Gamma weakly ionising (1) Gamma travels	Reverse arguments em radiation Gamma has no charge Gamma has no mass examples of penetrating power alpha highly ionising ignore vague comments eg stronger Ignore uses and	**(2)**

	faster (1)	dangers	

Q5.

Question number	Answer	Additional guidance	Mark
(i)	Geiger-Müller tube	accept Geiger (counter) geiger (counter) GM (tube) gm(tube) accept any recognisable (phonetic) spelling	(1)

Question number	Answer	Additional guidance	Mark
(ii)	any **two** from: keep a safe distance (1) point the source away from people (1) handle the source with tongs/at a distance (1) limit exposure time/return source to store (asap) (1) use shielding (1) use of gloves (1) use of mask (1) protective clothing (1) wear a film badge/monitor (1)	 use of screen Do not credit goggles	(2)

Question number	Answer	Additional guidance	Mark
(iii)	a description to include four from: take measurement without source (1) place source in front of/near/close to detector (1) increase the distance (between source and detector) (1) measure distance (from source to detector) (1) take reading from the screen/counter (1) until reading gets to background value /constant value (1) use same time for each count (1) repeat / check when down to low values (1)	 measure/account for background (count) DO NOT allow 'inside' allow reverse argument by starting with detector long way away from source allow zero as constant value mention of (count) <u>rate</u>	(4)

Q6.

Question Number	Answer	Acceptable answers	Mark
	A description including any four from: (there are) 89 particles in the nucleus (1) protons (1) (there are) 36 (protons) (1) neutrons (1) (there are) 53 (neutrons) (1) i.e. 36 protons and 53 neutrons gains four marks	ignore all references to electrons (its) {mass/nucleon} number / RAM / A_r / A <u>is 89</u> {atomic/proton} number / positive charge / Z <u>= 36</u> Numbers must be correctly linked to gain credit e.g. 36 neutrons gets 1 mark (for neutrons) 53 protons and 36 neutrons gains two marks (for protons and neutrons) 89 protons and neutrons gets 3 marks (altogether there are) 89 protons and neutrons. 36 are protons gains 4 marks	**(4)**

Q7.

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

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

Q8.

	Answer	Acceptable answers	Mark
(i)	any one of X-ray (machines) / smoke alarms/ nuclear/ radioactive waste (1)	nuclear weapons (tests) nuclear power plants (medical) tracers/technetium	**(1)**
(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 the first.	**(2)**

Q9.

	Answer	Acceptable answers	Mark
(i)	does not emit (ionising) radiation / no (radioactive) decay	it is not radioactive	**(1)**
(ii)	**B** 5		**(1)**
(iii)	[redacted] A		**(1)**

Q10.

	Answer	Acceptable answers	Mark
(i)	☒ **A** electron		**(1)**
(ii)	suggestion to include **two** of • the ionisation is different (1) • correct difference in ionisation (1) • the masses are different (1) • alpha is bigger than beta (1) • alpha hits more (air) particles (1) • alpha loses its energy in shorter distance (1)	alpha more ionising (than beta) scores 2 marks RA (heavier for bigger) RA RA IGNORE references to penetration	**(2)**

Q11.

	Answer	Acceptable answers	Mark
(i)	D		**(1)**
(ii)	B		**(1)**

Q12.

Question Number	Answer	Additional guidance	Mark
	substitution (1) $\frac{1.6726 \times 10^{-27}}{9.1094 \times 10^{-31}}$ evaluation (1) 1836 evaluation to 2 sf (1) 1800	 Allow 1 mark for answers that round to 1.836 to any power of ten for this mark 1.836×10^3 OR 1.80×10^3 accept 1840 or any rounding of 1836.125 1.8×10^3 **any number** shown to 2 sf gets this mark award full marks for the correct answer without working	**(3)**

Q13.

	Answer	Additional guidance	Mark
(i)	260 (g)		**(1)** **AO2**

	Answer	Additional guidance	Mark
(ii)	(54 days is) 3 half-lives (1) 65 (1)	260 ÷ 2 (÷ 2) or 520 ÷ 2 ÷ 2 (÷ 2) 18, 36, 54 (represents 3 half-lives) 54/18 = 3 (half-lives) ecf answer to 4ci ÷ 4 130 scores 1 mark award full marks for the correct answer without working	(2) AO2

Q14.

Question number	Answer	Mark
(i)	434	(1)

Question number	Answer	Additional guidance	Mark
(ii)	34	allow 29 to 39	(1)

Question number	Answer	Additional guidance	Mark
(iii)	Radioactive decay is a random process	allow because background count changes every time	(1)

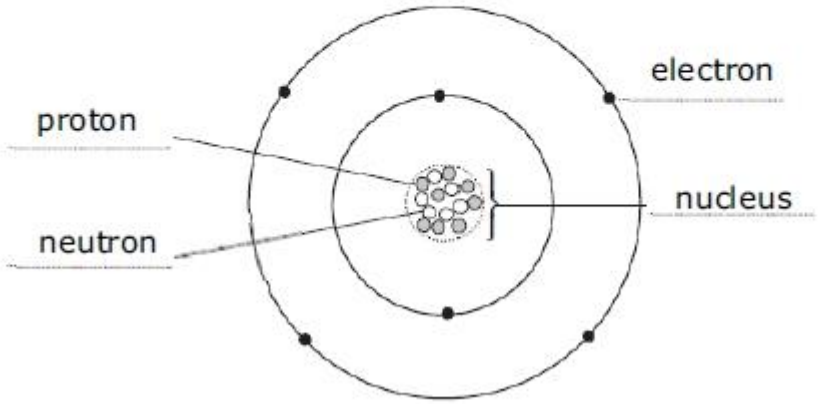
Q15.

	Answer	Acceptable answers	Mark
(a)	A		(1)
(b)	axes labelled correctly With label or unit (1) correct shaped smooth curve (1) line does	activity / Bq / count rate ignore radioactivity time/ seconds/ any time unit	(3)

	not reach zero activity (1)		
(c)(i)	Idea of 2 half-lives (1) 11 400 = 2 × 5700 Idea of halving activity twice (1) 0.55 × 2 × 2 Calculation (1) 2.2 (Bq)	11 400 / 5700 = 2 2.2 (Bq) for three marks	**(3)**
(c)(ii)	Explanation linking two of: • Background radiation affects the measurement (1) • Needs to be subtracted from readings (1) • Background radiation is variable (1) • Background radiation needs to be averaged (1)	accept interfering / including varies with place/time/random nature repeating test improves reliability	**(2)** **t**
(c)(iii)	One relevant idea: (New method) more accurate (1) Hard to measure a small activity (1) Background radiation affects readings (1) Need to find difference of two small quantities (1) Can test smaller samples (1)	ignore better method/results / more reliable difficult to distinguish between the reading and background	**(1)** **grad**

Total for question = 10 marks

Q16.

Question number	Answer	Mark
(i)	One mark for each correct label (4)  	(4)

Question number	Answer	Mark
(ii)	B	(1)

Question number	Answer	Mark
(iii)	zero/0/no charge	(1)

Q17.

Question number	Answer	Additional guidance	Mark
	same number of protons (1) different number of neutrons (1)	same atomic number different mass number	(2) AO2

Q18.

Question number	Answer	Additional guidance	Mark
	<table><tr><th>mass in g</th><th>time in days</th></tr><tr><td>1600</td><td>0</td></tr><tr><td>800 (1)</td><td>29</td></tr><tr><td>400</td><td>58 (1)</td></tr></table>	numbers in correct boxes	(2)

Q19.

Question Number	Answer	Additional guidance	Mark
	<table><tr><td></td><td></td><td></td></tr><tr><td></td><td>7</td><td>6</td></tr><tr><td></td><td>8</td><td>6</td></tr></table> (1) (1)	one mark for each column must have both numbers in a column correct to get the mark	(2)

Q20.

Question number	Indicative content	Mark
*	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. **Dangers of exposing people to radioactive sources/radiation.** • it is ionising • may cause cancer • may destroy /kill cells • can mutate DNA • can burn the skin **Protection of hospital staff using radioactive sources/radiation.** • use tongs to carry radioactive sources • use lead containers to store sources • stay at a distance from radioactive sources • use sources for as short a time as possible • wear (lead lined) protective clothing (PPE) • give treatments from behind a shield /wall • wear a radiation badge (dosimeter)	**(6)** **AO1**

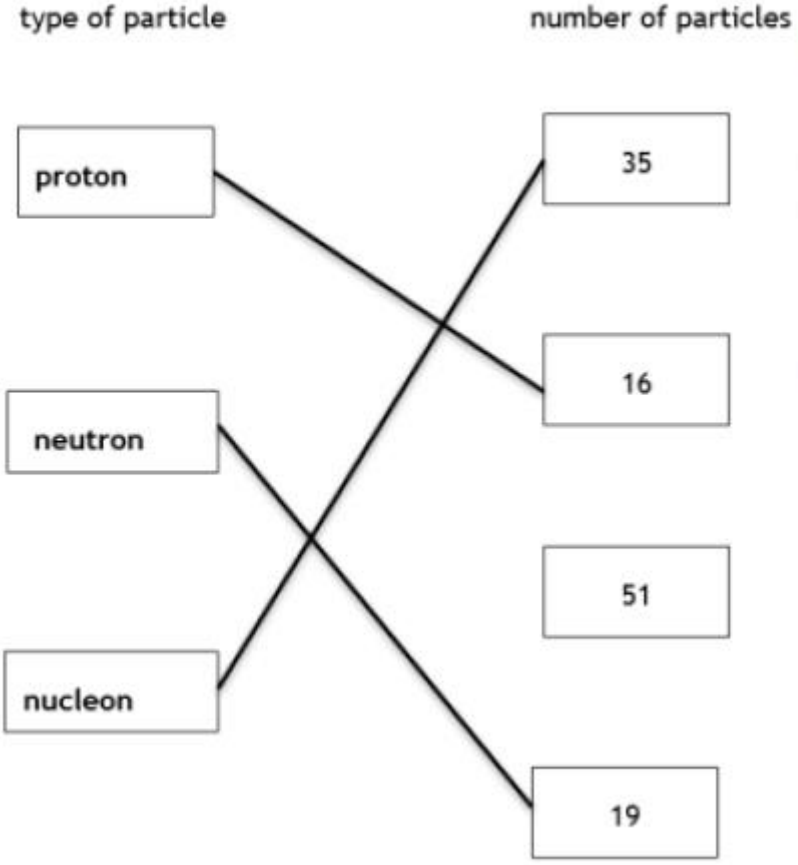
Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–2	Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific, enquiry, techniques and procedures lacks detail. (AO1) Presents a description which is not logically ordered and with significant gaps. (AO1)
Level 2	3–4	Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas, enquiry, techniques and procedures is not fully detailed and/or developed. (AO1) Presents a description of the procedure that has a structure which is mostly clear, coherent and logical with minor steps missing. (AO1)
Level 3	5–6	Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas, enquiry, techniques and procedures is detailed and fully developed. (AO1) Presents a description that has a well-developed structure which is clear, coherent and logical. (AO1)

Level	Mark	Additional Guidance	General additional guidance – the decision within levels e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	Additional guidance At least one isolated fact about the dangers of radiation and/or protection from radiation	Possible candidate responses it's ionising causes cancer burns you kills cells mutates DNA wear a radiation badge use tongs work from behind a shield use protective clothing
Level 2	3–4	Additional guidance simple explanation of the dangers of radiation and a fact about protection or reverse OR detailed explanation of the dangers of radiation or protection from radiation	Possible candidate responses radiation is ionising and can kill cells so wear a radiation badge **or** use tongs and stay at a distance from radiation source as it can cause cancer **or** use tongs to stay at a distance from radiation sources and wear a radiation badge
Level 3	5–6	Additional guidance detailed explanation of the dangers of radiation and protection from radiation	Possible candidate responses radiation is ionising and can kill cells **and** use tongs and stay at a distance from the radiation source

Q21.

Question Number	Answer	Additional guidance	Mark
	processing (1) $\frac{125\ 000}{1\ 000\ 000}$ OR $\frac{1}{8}$ OR 3 half-lives or 3 x 5700 evaluation (1) 17 100	 accept an appropriate attempt using more than one halving 17 000 award full marks for the correct answer without working	**(2)**

Q22.

	Answer	Additional guidance	Mark
		1 mark for each correct line more than one line from a box in the left column ("type of particle") box loses the mark for the box	(3) AO2

Q23.

	Answer	Acceptable answers	Mark
(a)(i)	Gamma/ γ (wave(s)/ ray(s)/radiation)	X-rays/ radiation	**(1)**
(a)(ii)	Any two from It fluoresces (1) UV (radiation) transfers/gives energy to ink/ink absorbs energy from UV (radiation) (1) (energy from UV is)(re-)radiated/(re)-emitted by ink at lower frequency/as (visible) light (1)	fluorescent Ink/it absorbs UV (light/radiation) Ignore UV is reflected as visible light Ignore luminous emits visible light	**(2)**
(b)	transposition λ = v/f (1) substitution λ = $3 \times 10^8/7$	Subst. and transform. either order 1 mark only can be scored for correct	**(3)**

	$\times 10^9$ (1) evaluation 0.043 (m) (1) Ignore any unit given by candidate	substitution after incorrect transposition. $3 \times 10^8/7 \times 10^9$ gains 2 marks Accept any number of sig.figs. that rounds to 0.04 0.04 , 0.0428 (m) (1) Give full marks for correct answer with no working. $0.04 \times$ any other power of 10 = 2 marks	

		Indicative Content	**Mark**
QWC	***c**	A discussion including some of the following points Possible dangerous e-m radiations Microwaves Infrared Ultraviolet (UV) X-rays gamma rays Correctly linked to Internal heating of body cells (microwaves) Skin burns (infrared) Damages skin cells/sunburn (UV) Damages eyes (UV) Can cause skin cancer (UV) Can cause cataracts (UV) Damage to cells inside the body(X-rays) Mutate/ kill cells in the body (gamma) Damages DNA (X-rays and gamma rays) Link to frequency As the frequency increases/wavelength decreases (microwave -> gamma) the waves become more penetrating and do more	**(6)**

		damage/danger as they have more energy.
Level	**0**	No rewardable content
1	**1 - 2**	• a limited description e.g. gives at least 2 correct radiations and links both to correct damage OR at least 2 correct radiations named with link to correct damage from one and idea that frequency is linked to damage OR just has link between higher frequency and more damage/dangerous e.g. infrared burns your skin and X-rays can damage cells. OR X-rays have a higher frequency than microwaves and can cause cancer OR Higher frequencies cause more damage to cells. • 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 e.g. gives most of the correct radiations and links to correct damage, at least one with detail of the damage that is caused OR links two to detail of the damage, AND has a link between frequency and energy/danger e.g. Microwaves are absorbed by water in body cells. UV can cause skin cancer and damages your eyes. Xrays and gamma rays can damage cells inside your body OR Gamma and X-rays can penetrate deep into the body. Gamma does most damage as it has the highest frequency. • 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 e.g. gives most of the correct radiations with links to detail of the damage AND explains the link between frequency and energy/danger. e.g Microwaves heat up the water in cells. UV can cause cataracts. Gamma rays are the most penetrating and can mutate cells inside the body because they have the highest frequency. • The answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors

Q24.

Question Number	Answer	Acceptable answers	Mark
(a)(i)	X-ray	X	**(1)**

Question Number	Answer	Acceptable answers	Mark
(a)(ii)	(visible) light	visible (waves)	**(1)**

Question Number	Answer	Acceptable answers	Mark
(a)(iii)	radio (waves)		**(1)**

Question Number	Answer	Acceptable answers	Mark
(a)(iv)	gamma / X-rays / ultraviolet	☐☐☐ X / UV	**(1)**

Question Number	Answer	Acceptable answers	Mark
(b)	an explanation linking: • travel with same speed (1) • in a vacuum / in space (1)	They travel at the speed of light / same numerical speed for all	**(2)**

Question Number		Indicative Content	Mark
QWC	* **(c)**	A description including some of the following points • Harmful effects include (skin) burns, eye damage, (skin) cancer, cell damage, mutation • IR and UV are on either side of visible light (in the em spectrum) • UV has shorter wavelength than IR • UV has higher frequency than IR • higher energy (associated) with UV • IR causes (skin) burns • UV causes damage to eyes / (skin) cancer / damage to cells (not just damage to skin) / sunburn • (potential) danger increases with frequency Ignore • irrelevant information e.g. UV used to scan unborn babies	**(6)**
Level	**0**	No rewardable content	
1	**1 - 2**	• a limited description stating one fact about a harmful effect or frequency e.g. skin burns **OR** UV has high frequency (no comparison) • 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 making a correct comparison of harmful effects **OR** a frequency comparison e.g. IR causes skin burns and UV causes (skin) cancer **OR** the higher the frequency the more harm they cause **OR** UV has a higher frequency (than IR) • 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 including harmful effects of both UV and IR **AND** relating at least one to frequency e.g. UV causes skin cancer but IR (only) causes skin burns as UV has a high(er) frequency • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors	

Q25.

Question Number	Answer	Acceptable answers	Mark
(a)(i)	C travel with the same speeds in a vacuum, have different frequencies		**(1)**

Question Number	Answer	Acceptable answers	Mark
(a)(ii)	{damage to/ionise/mutate} {cells / DNA/tissue/ organs/ fetus} / cause {cancer/tumour}	kills cells/bacteria	**(1)**

Question Number	Answer	Acceptable answers	Mark
(b)(i)	Gamma, γ, 8, Y	UV, ultraviolet (rays/waves/radiation) Ignore X-rays	**(1)**

Question Number	Answer	Acceptable answers	Mark
(b)(ii)	one correct use (for UV/X-ray/gamma ray)	for example, (UV) – sunbeds, sterilise, detect banknotes (X-ray) - viewing internal organs / broken bones/airport security (gamma ray) – treat /cure cancer, kill {cells/bacteria} If one incorrect example is given, this mark is lost	**(1)**

Question Number	Answer	Acceptable answers	Mark
(c)(i)	one from: MP1 heating of (body/human/internal) {cells / organs/tissues} (1) MP2 {heating/boiling/exciting / vibrating} water (in the body) (1)	Accept heating of blood Ignore damages, burns, cancer, mutates, heating (on its own), skin	**(1)**

Question Number	Answer	Acceptable answers	Mark
(c)(ii)	explanation to include any **three** of: MP1 (Phones/ they) use lower frequencies / RA (1) MP2 lower frequency: lower energy / RA (1) MP3 lower {frequency/energy} less (potential) danger / RA (1) MP4 (phones /they) emit less (intense) radiation RA (1) MP5 phones are less powerful (1)	wavelength can suitably replace frequency eg use longer wavelength condone use lower MHz (comparison needed not just values quoted) Accept lower frequency (not energy) does {less /no} {damage/harm} for 2 marks ignore references to penetration ignore references to energy replacing power here For 2 marks -The resonant frequency of water molecules is the same as the oven frequency	**(3)**

Q26.

	Answer	**Acceptable answers**	**Mark**
(i)	negative (1)		**(1)**
(ii)	(much) smaller than a neutron (1)		**(1)**

Q27.

Question Number	Answer	Mark
	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. **AO3 Strand 2a and 2b (6 marks)** • shows some idea that the data can support arguments about alpha, beta and gamma radiation being present • argues that there is some evidence that alpha might be emitted (count rate going down with paper interposed) • argues that there is a lot of evidence that beta particles are emitted (count rate goes down a lot when the aluminium is inserted) • argues that there might be some gamma getting through (lead stopping everything apart from gamma) OR that with the lead present the count rate has gone down to a level consistent with background, so no gamma was present a level 3 answer will use data effectively	**(6)** AO 1 1

Level	Mark	Descriptor
	0	• No rewardable material.
Level 1	1-2	• Deconstructs scientific information but understanding and connections are flawed. An unbalanced or incomplete argument that provides limited synthesis of understanding. • Judgements are supported by limited evidence. (AO3)
Level 2	3-4	• Deconstructs scientific information and provides some logical connections between scientific concepts. An imbalanced argument that synthesises mostly relevant understanding, but not entirely coherently. • Judgements are supported by evidence occasionally. (AO3)
Level 3	5-6	• Deconstructs scientific information and provide logical connections between scientific concepts throughout. A balanced, well-developed argument that synthesises relevant understanding coherently. • Judgements are supported by evidence throughout. (AO3)

Q28.

		Indicative Content	Mark
QWC	*	An explanation including some of the following ideas **Need for measurement (N)**Background radiation • is always present/all around us • has (natural) source(s) exemplified by space, living things, rocks, food, nuclear/medical sources etc. • would give false reading in experiment **How and why to measure(H)** Background radiation measurement • is taken at site of experiment **because**	**(6)**

		it is different in different places • is taken with all apparatus **except** source in place • is taken before and after **because** it can change with time / they need an average • must be worked out for same time as (or longer than) experiment / rate found **so** analysis is simpler • It is taken several times/ averaged **because** it is random **Analysis (A)** Background radiation measurement • must be subtracted from measurements with source /main count rate	
Level	**0**	No rewardable content	
1	**1 - 2**	• A limited explanation mentioning any **two** from N or **one** from H or A e.g. Background comes from space and rocks.(N) It is there all the time. (N) OR Readings for background must be repeated because they are random. (H) OR Background must be taken away from all other readings (A) • 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 ***linking*** aspects of two ideas i.e. **N** + **H** OR **N** + **A** OR **H** + **A** e.g Take readings without source (H) and subtract them from the main readings with source present.(A) OR It should be taken several times because it is random (H)so that the average can be subtracted from the main readings (A) • 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 ***linking*** **A** with EITHER N + an idea from **H** OR two or more ideas from **H** e.g.Background radiation is there all the time. (N) You need to take readings at the place where you will do the experiment and with all the apparatus set up except the source because BR changes from place to place.(H) Then you should subtract background readings from the main experimental readings.(A) OR Take several readings of count rate for averaging since the effect is random (H) and make sure that they are taken in the same place.(H) Then subtract from readings in main experiment.(A) • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors

Q29.

Question number	Answer	Additional guidance	Mark
	An explanation that combines understanding (1 mark) and reasoning (1 mark) linking: • number of neutrons decreases by one (1) • number of protons increases by one.(1)	a neutron becomes a proton plus an electron for (2) marks	**(2)**

Q30.

Question number	Answer	Additional guidance	Mark
	An explanation that combines identification - application of knowledge (1 mark) and reasoning/justification - application of understanding (2 marks): • heat energy gained/absorbed by an electron. • electron changes orbit • electron loses energy	electron excited /unstable (by) emitting radiation	(3)

Q31.

Question Number	Answer	Mark
	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. **AO3 and AO2 (6 marks)** **AO3** • most go straight through to P • some are deflected through small angles to Q • few have deflections greater than 90° to R • or are even reflected (bounce back off the foil) to R **AO2** • alpha positive is repelled by positive nucleus • atom being mostly empty space • atoms have a small nucleus • nucleus has a big mass / density • +ve charge concentrated into a very small space	(6)

Level	Mark	Descriptor
	0	• No awardable content
Level 1	1–2	• Interpretation and evaluation of the information attempted but will be limited with a focus on mainly just one variable. Demonstrates limited synthesis of understanding. (AO3) • 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)
Level 2	3–4	• Interpretation and evaluation of the information on both variables, synthesising mostly relevant understanding. (AO3) • 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)
Level 3	5–6	• Interpretation and evaluation of the information, demonstrating throughout the skills of synthesising relevant understanding. (AO3) • 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)

Summary for guidance			
Level	**Mark**	**Additional Guidance**	**General additional guidance – the decision within levels** Eg - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	Additional guidance unlinked statement from the diagram or table or knowledge of the atom	Possible candidate responses most particles go to P *(from table)* OR particles refract/bend to Q *(from diagram)*
Level 2	3–4	Additional guidance One link between any TWO of diagram, table, knowledge about atoms.	Possible candidate responses Most particles go straight through (the gold) to P *(from table and diagram)* OR Most particles go to P which means an atom is mainly space *(from table and knowledge)* OR particles are reflected because there is a nucleus (*diagram and knowledge)*
Level 3	5–6	Additional guidance One link between diagram **AND** table **AND** knowledge about atoms	Possible candidate responses Most particles go straight through (the gold) to P which means an atom is mainly space OR A few particles reflected back to R which means an atom has a nucleus

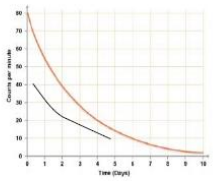
Q32.

	Answer	**Acceptable answers**	**Mark**
	atomic /proton number drops by 2 **and** mass/nucleon number by 4 (1) (which is) alpha decay (1)	2 protons **and** 2 neutrons are lost 92 → 90 **and** 238 → 234 helium nucleus given off (which is) alpha particle	**(2)**

Q33.

	Answer	Acceptable answers	Mark
	same mass/nucleon number but atomic/proton number increases by 1 (1) (negative) beta decay (1)	a neutron changes to a proton ignore GAINS a proton beta particle /electron given off	**(2)**

Q34.

	Answer	Acceptable answers	Mark
i	1.9-2 (days)		**(1)**
ii	 plotting (0,40), (2,20) and (4,10) **OR ANY** line which passes through those coordinates (1) smooth curve through those points (1)	Ignore any part of line after 4 days	**(2)**

Q35.

Question number	Answer	Mark
	one from • same atomic number (1) • same number of protons (1) • same element (1) and one from • different numbers of neutrons (1) • different mass numbers (1)	**(2)**

Q36.

	Answer	Acceptable answers	Mark
	A		**(1)**

Q37.

	Answer	Acceptable answers	Mark
	D It is the time it takes for half the atoms to decay		**(1)**

Q38.

Question number	Answer	Mark
(i)	☒ **A** 38 B is number of neutrons C is mass number D is an irrelevant addition of two numbers	**(1)**

Question number	Answer	Mark
(ii)	☒ **B** 52 A is number of protons C is mass number D is an irrelevant addition of two numbers	**(1)**

Q39.

Question number	Answer	Mark
	C a helium nucleus	**(1)**

Q40.

Question number	Answer	Mark
	B 10^{-10} m	**(1)**

Q41.

Question Number	Answer	Mark
	B 10^{-10} m	**(1)**

Q42.

	Answer	Acceptable answers	Mark
	An explanation linking: electron(s) (1) is/are lost/gained (1)	do not allow positive electron knocked off / removed/ released	**(2)**

Q43.

	Answer	Acceptable answers	Mark
(a)(i)	☒ **A** electron		**(1)**
(a) (ii)	suggestion to include **two** of • the ionisation is different (1) • correct difference in ionisation (1) • the masses are different (1) • alpha is bigger than beta (1) • alpha hits more (air) particles (1) • alpha loses its energy in shorter distance (1)	alpha more ionising (than beta) scores 2 marks RA (heavier for bigger) RA RA IGNORE references to penetration	**(2)**
(b)	☒ **A** gamma radiation		**(1)**
(c)(i)	A description linking the following: • neutron decays / changes / becomes (1) • (neutron) into proton (1) • (plus an) electron (1)	quark changes (quark changes) from down to up / d to u e^- (do not accept β^-) accept n and p for neutron and proton $n > p + e^-$ scores 3 marks IGNORE references to atomic and mass numbers; unstable nuclei; too	**(3)**

		many neutrons; gamma emitted	
(c)(ii)	An explanation linking **three** of the following: • mass number doesn't change (1) • (because) same number of nucleons / quarks (1) • atomic number goes up by one (1) • (because) there is an extra proton (1)	emitted electron mass is negligible proton and neutron have same mass a neutron has (decayed in)to a proton	**(3)**

Q44.

	Answer	**Acceptable answers**	**Mark**
(a)(i)	Any **two** of: Gamma is a wave (1) Alpha is a helium nucleus (1) Alpha is charged (1) Alpha has a mass (1) Gamma penetrates further/ highly (1) Gamma weakly ionising (1) Gamma travels faster (1)	Reverse arguments em radiation Gamma has no charge Gamma has no mass examples of penetrating power alpha highly ionising ignore vague comments eg stronger Ignore uses and dangers	**(2)**
(b)(i)	D		**(1)**
(b)(ii)	B		**(1)**
(c)	An explanation linking: electron(s) (1) is/are lost/gained (1)	do not allow positive electron knocked off / removed/ released	**(2)**

		Indicative Content	**Mark**
QWC	***(d)**	An explanation including some of the following points: <u>Radiation from the front of the lens</u> Alpha particles absorbed by glass Beta particles do not penetrate glass Gamma rays pass through glass Background radiation varies There is a large	**(6)**

		difference in size between front and back counts Radiation detected is gamma rays only <u>Radiation from side of the lens</u> Alpha particles cannot penetrate aluminium Beta particles are absorbed by aluminium Gamma rays pass through aluminium There is a small/no difference in size between front and side counts Perhaps a few gamma rays absorbed by aluminium Background radiation varies Likely to contain gamma rays only May be different from front count due to random nature of emissions <u>Radiation from the back of the lens</u> Alpha particles absorbed by coating and/or glass Beta particles are emitted the from rear surface Gamma rays emitted from radioactive glass There is a large difference in size between front and back counts Background radiation varies Radiation is both beta particles and gamma rays Difference between front and back counts due to beta particles	
Level	**0**	No rewardable content	
1	**1 - 2**	• a limited explanation mentioning two unrelated points, but without linking them	

		properly, e.g. beta particles are stopped by thick aluminium, there is most radiation behind the lens • 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 some points with an appropriate linkage to **one** of the readings e.g. no beta particles escape forwards because the glass absorbs them OR only gamma rays escape to the side because the aluminium stops alpha and beta particles • 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 some of the points with appropriate linkage to a comparison of at least **two** of the readings e.g. no beta particles escape forwards because the glass absorbs them, but beta particles can escape backwards so that count is higher OR only gamma rays can get through the glass and the thick aluminium, so the front and side counts are about the same • 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 = 12 marks

Q45.

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

Q46.

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

Q47.

Question Number	Answer	Acceptable answers	Mark
	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)**

Q48.

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)**

Q49.

	Answer	Acceptable answers	Mark
	P and M OR M and P OR N and Q OR Q and N	one mark for a pair	**(1)**

Q50.

Question Number	Answer	Additional guidance	Mark
	a description to include: 1. put rock(s) in front of/near tube (1) 2. measure (count rate) separately for the two different rocks (1) 3. measure each count for the same time period (1) 4. keep source-detector distance the same for both rocks (1) 5. take (into account)/measure background count (1) 6. repeat readings and take average(s) (1)	not 'in' tube keep rocks apart	**(4)** AO 2 2

Q51.

Question Number	Answer	Additional guidance	Mark
(i)	Geiger (Müller counter) (1)	GM {tube/meter} or other appropriate detector e.g. dosimeter, film badge, scintillation counter accept incorrect spellings such as "giga" ignore radioactive counter	(1)

Question Number	Answer	Additional guidance	Mark
(ii)	any **two** acceptable sources from : **cosmic** (rays) (1) Sun (1) rocks / ground (1) {nuclear / atomic} tests / nuclear waste (1) (nuclear) power stations (1) plant (sources) (1) buildings (1) food (1) water (1) medical (1) radon (1)	cosmic microwave background radiation (CMBR) accept nuclear accidents (Chernobyl, Fukushima etc) accept named foods accept X-rays, radiotherapy ignore alpha, beta, gamma	(2)

Q52.

	Answer	Acceptable answers	Mark

(i)	alpha	Alpha ray, alpha particle, α Ignore capital letters	**(1)**
(ii)	A description including two of one increases as other increases (1) rate of increase is in the range from 1.17 to 1.33 (cm/MeV) (1) range gradually increases more with energy (1)	the particles with higher energy travel further accept values quoted from graph not (quite) linear/not proportional /curves upwards accept values quoted from graph	**(2)**

Q53.

	Answer	**Acceptable answers**	**Mark**
	☒ **A** gamma radiation		**(1)**

Q54.

		Indicative Content	**Mark**
		An explanation including some of the following points: <u>Radiation from the front of the lens</u> Alpha particles absorbed by glass Beta particles do not penetrate glass Gamma rays pass through glass Background radiation varies There is a large difference in size between front and back counts Radiation detected is gamma rays only <u>Radiation from side of the lens</u> Alpha particles cannot penetrate aluminium Beta particles are absorbed by aluminium Gamma rays pass	**(6)**

		through aluminium There is a small/no difference in size between front and side counts Perhaps a few gamma rays absorbed by aluminium Background radiation varies Likely to contain gamma rays only May be different from front count due to random nature of emissions <u>Radiation from the back of the lens</u> Alpha particles absorbed by coating and/or glass Beta particles are emitted the from rear surface Gamma rays emitted from radioactive glass There is a large difference in size between front and back counts Background radiation varies Radiation is both beta particles and gamma rays Difference between front and back counts due to beta particles	
Level	**0**	No rewardable content	
1	**1 - 2**	• a limited explanation mentioning two unrelated points, but without linking them properly, e.g. beta particles are stopped by thick aluminium, there is most radiation behind the lens • 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 some points with an appropriate linkage to **one** of the readings e.g. no beta particles escape forwards because the glass absorbs them	

		OR only gamma rays escape to the side because the aluminium stops alpha and beta particles • 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 some of the points with appropriate linkage to a comparison of at least **two** of the readings e.g. no beta particles escape forwards because the glass absorbs them, but beta particles can escape backwards so that count is higher OR only gamma rays can get through the glass and the thick aluminium, so the front and side counts are about the same • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors

Q55.

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

Question Number	Answer	Acceptable answers	Mark
(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
(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)**

Q56.

Question Number	Answer	Acceptable answers	Mark
(a)(i)	proton(s) (1)	NOT photon	**(1)**

Question Number	Answer	Acceptable answers	Mark
(a)(ii)	electron(s) (1)		**(1)**

Question Number	Answer	Acceptable answers	Mark
(b)(i)	evidence of halving activity eg line on graph at 80 (Bq) or two lines at, say, 100 and 50. (1) 8 (days) gains both marks (2)	accept halving in answer space e.g. 160 -> 80 or 80 -> 40 or 160 ÷ 2 = 80 NOT 160 ÷ 40 or 131 ÷ {2 or 4} or 40 ÷ 2 (unless clearly an activity)	**(2)**

Question Number	Answer	Acceptable answers	Mark
(b)(ii)	idea of two half-lives (1) but, 16 (days) gains both marks (2)	halving of 800 twice, e.g. 400 AND 200 seen Allow ECF from graph eg allow half-life from graph x 2 for both marks	**(2)**

Question Number		Indicative Content	Mark
QWC	* **(c)**	A discussion including some of the following points Advantages - (currently) large resources of **fuel**/ **fuel** (reserves) will last a long time - (Produces) large amount of (electrical) energy/electricity - Does not produce (much/any) carbon dioxide - Does not produce (much/any) sulphur dioxide - Does not add to global warming/climate change - Good safety record (under normal operating conditions) - Only small amount of fuel needed to produce large amount of energy/electricity - Reliable supply/provides continuous supply of electricity (for a long time) - Reduces dependence on foreign supplies of energy - Conserves fossil fuel supplies - (Spent) fuel can be processed (to produce fuel for other reactors) - Provides employment/jobs Disadvantages - Produces nuclear/radioactive {waste/materials} - nuclear/radioactive waste/materials can cause mutations in DNA/cells/people/animals - Non- renewable (energy source) - Difficulties in transporting nuclear/radioactive waste/material - Difficulty in (safely) storing/disposing nuclear waste/material - Nuclear accidents (can) pollute large areas - Nuclear accidents pollute for a long time - Accept named example of accidents eg Fukishima, Chernobyl, 3-mile island - Mining and processing fuel both produce large amounts of carbon dioxide - Expensive to build and/or decommission (nuclear power stations) - Reference to target for terrorist attacks - Produces material which can be used to develop nuclear weapons/by terrorists - Negative public perception OWTTE ignore references such as unsightly, large area needed, noisy as true for most large buildings. Ignore cost of generation or restating stem ie generates electricity or supplies electricity to homes etc.	**(6)**

Level	0	No rewardable content
1	1 - 2	• A limited discussion giving one fact e.g. they give people jobs (in that area) OR they can have accidents like in Japan (after the tsunami). • 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 discussion that states one advantage and one disadvantage OR states more than one advantage OR states more than one disadvantage. e.g. they are a reliable energy source and do not produce any carbon dioxide. OR they do not cause any global warming as they do not produce sulphur dioxide. OR they produce radioactive waste and many people don't want them built. • 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 discussion of either advantages or disadvantages AND at least a mention of the other one. e.g. They produce large amounts of electricity and don't produce carbon dioxide but they produce radioactive materials (in the fuel rods). OR They are a reliable source of energy but they can damage large areas if there is an accident and the fuel is non-renewable. • 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 =12 marks)

Q57.

	Answer	Acceptable answers	Mark
	A description including any **two** from: • secure storage (1): • avoid direct contact (1) • wear protective clothing (1) • minimise exposure (1) • shielding (1) • minimise dose (1) • monitor exposure (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. do not touch / use tongs /wash after handling lead lined suits/aprons/masks/gloves ignore goggles long distance away / not pointing towards body/ keep	**(2)**

	• protect other people (1)	sources shielded /stand behind shields short time wear film badge/use Geiger counter (to monitor radiation levels) warning signs / barriers / restricted areas /controlled areas	

Q58.

	Answer	Acceptable answers	Mark
(i)	222	4 less/4fewer	**(1)**
(ii)	86	2 less/2fewer	**(1)**

Q59.

Question Number	Answer	Additional guidance	Mark
	• point after first half-life - 6, 40 (1) • point after second half-life - 12, 20 (1) • point after third half-life - 18, 10 (1)	within 1 small square by eye smooth curve starting at 80, with a decreasing gradient passing through one correct half-life point scores 2 marks smooth curve starting at 80, with a decreasing gradient passing through two correct half-life points scores 3 marks **if no other mark scored** smooth curve showing decreasing gradient but not going through any correct points scores 1 mark	**(3)** AO 3 1a

Q60.

	Answer	Additional guidance	Mark
(i)	**One** from: cell damage (1) cancer (1) radiation sickness / poisoning (1) mutation (1) chromosomal damage (1) dna damage (1) skin damage (1) (named) organ damage (1) burns (1) releases ionising radiation (1)	allow ionises / kills cells	(1) **AO1**

	Answer	Additional guidance	Mark
(ii)	**any one** from: Geiger (Muller) (tube/counter) photographic film dosimeter	accept recognisable spellings GM film badge	(1) **A01**

	Answer	Additional guidance	Mark
(iii)	**any two** from: beta(minus)/β(-) (1) beta + (1) x-rays (1) gamma/γ (1)	accept positron in place of beta + accept proton beam accept electron beam maximum of 1 mark if one incorrect radiation given zero marks if two incorrect radiations given	(2) AO1

Q61.

	Answer	Acceptable answers	Mark
(i)	☒ **C** the same as the charge on the proton		(1)
(ii)	☒ **A** electrons		(1)

Q62.

	Answer	Acceptable answers	Mark
(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)
(ii)	any one of • penetrates/passes through the skin (1)		(1)

	• ionises (1) • damages tissue/ cells/DNA (1) • mutates cells/DNA(1) • causes cancer(1)		

Q63.

	Answer	**Acceptable answers**	**Mark**
(i)	Gamma/ γ (wave(s)/ ray(s)/radiation)	X-rays/ radiation	**(1)**
(ii)	Any two from It fluoresces (1) UV (radiation) transfers/gives energy to ink/ink absorbs energy from UV (radiation) (1) (energy from UV is)(re-)radiated/(re)-emitted by ink at lower frequency/as (visible) light (1)	fluorescent Ink/it absorbs UV (light/radiation) Ignore UV is reflected as visible light Ignore luminous emits visible light	**(2)**

Q64.

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

Q65.

	Answer	**Acceptable answers**	**Mark**
	alpha particles (In the left section) gamma rays (centre section) infrared radiation (right section)	Any one in correct position for one mark, all three in correct position for two marks	**(2)**

	(2)		

Q66.

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)

Q67.

Question Number	Answer	Additional guidance	Mark
(i)	Atoms may form positive ions by **losing** electrons. (1) The electrons involved in forming positive ions are the **outer** electrons (1)	accept any clear indication that correct word is in gap	(2)

Question Number	Answer	Mark
(ii)	The only correct answer is **C gamma** A is not correct because alpha radiation is not electromagnetic B is not correct because beta minus radiation is not electromagnetic D is not correct because neutron radiation is not electromagnetic	(1)

Question Number	Answer	Mark
(iii)	The only correct answer is **A alpha** B is not correct because beta minus travels further in air than alpha C is not correct because beta plus travels further in air than alpha D is not correct because gamma travels further in air than alpha and beta	(1)

Q68.

	Answer	Acceptable answers	Mark
	☒ **B** becquerel		**(1)**

Q69.

	Answer	Acceptable answers	Mark
(i)	A description linking the following: • neutron decays / changes / becomes (1) • (neutron) into proton (1) • (plus an) electron (1)	quark changes (quark changes) from down to up / d to u e^- (do not accept β^-) accept n and p for neutron and proton $n > p + e^-$ scores 3 marks IGNORE references to atomic and mass numbers; unstable nuclei; too many neutrons; gamma emitted	**(3)**

(ii)	An explanation linking **three** of the following: • mass number doesn't change (1) • (because) same number of nucleons / quarks (1) • atomic number goes up by one (1) • (because) there is an extra proton (1)	emitted electron mass is negligible proton and neutron have same mass a neutron has (decayed in)to a proton	**(3)**

Q70.

	Answer	**Acceptable answers**	**Mark**
(i)	A 92		**(1)**
(ii)	neutron(s) (1)	allow phonetic spelling nutron, newtron, nuetron	**(1)**

Q71.

Question number	**Answer**	**Mark**
	B ionising and emitted by unstable nuclei A is incorrect stable nuclei do not give radioactive emissions C is incorrect not all radioactive emissions are neutral D is incorrect not all radioactive emissions are neutral	**(1)** **AO1**

Q72.

Question number	Answer	Additional guidance	Mark
(i)	An explanation to include; there is no aluminium to absorb β particles (1) (therefore) more β particles reach the G-M tube (1)	 aluminium absorbs/stops/blocks beta particles accept reverse arguments accept radiation for beta particles	(2) AO2

Question number	Answer	Additional guidance	Mark
(ii)	(idea of) background radiation	a named source of background radiation	(1) AO3

Question number	Answer	Additional guidance	Mark
(iii)	becquerel	accept Bq accept close spelling	(1) AO1

Q73.

	Answer	Acceptable answers	Mark
(i)	Idea of 2 half-lives (1) 11 400 = 2 × 5700 Idea of halving activity twice (1) 0.55 × 2 × 2 Calculation (1) 2.2 (Bq)	11 400 / 5700 = 2 2.2 (Bq) for three marks	(3)
(ii)	Explanation linking two of: • Background radiation affects the measurement (1) • Needs to be subtracted from	accept interfering / including varies with place/time/random nature repeating test improves reliability	(2) t

	readings (1) • Background radiation is variable (1) • Background radiation needs to be averaged (1)		
(iii)	One relevant idea: (New method) more accurate (1) Hard to measure a small activity (1) Background radiation affects readings (1) Need to find difference of two small quantities (1) Can test smaller samples (1)	ignore better method/results / more reliable difficult to distinguish between the reading and background	**(1)** **grad**