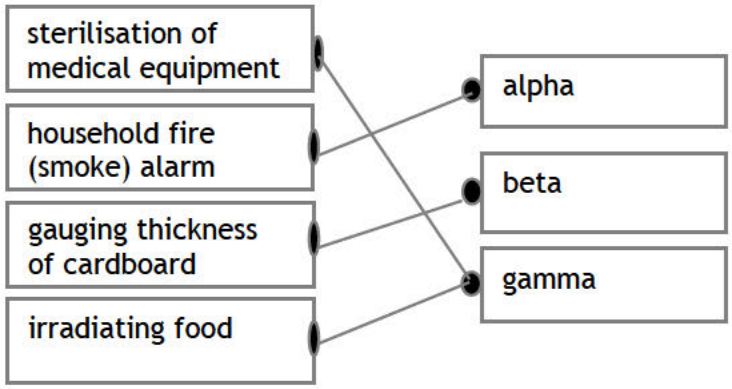
Question Number	Answer	Acceptable answers	Mark
1(a)		one mark for each correct line	**(4)**

Question Number	Answer	Acceptable answers	Mark
1(b)	☒ **D**		**(1)**

Question Number	Answer	Acceptable answers	Mark
1(c)	☒ **B** becquerel		**(1)**

Question Number	Answer	Acceptable answers	Mark
1(d)	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) • protect other people (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 sources shielded /stand behind shields short time wear film badge/use Geiger counter (to monitor radiation levels) warning signs / barriers / restricted areas /controlled areas	**(2)**

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

Question Number	Answer	Acceptable answers	Mark
2(b)	{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)**

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

Question Number	Answer	Acceptable answers	Mark
2(d)(i)	alpha	Alpha ray, alpha particle, α Ignore capital letters	**(1)**

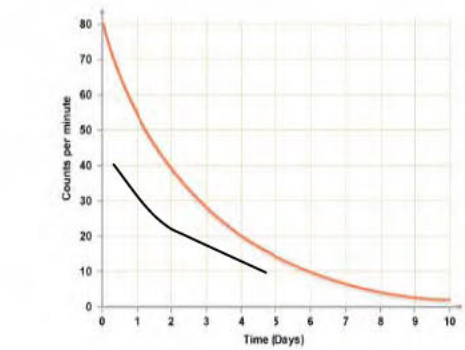
Question Number	Answer	Acceptable answers	Mark
2(d)(ii)	A description including two of one increases as other increases (1) rate of increase is in the range from 1.17 to 1.33 (cm/MeV) (1) range gradually increases more with energy (1)	 the particles with higher energy travel further accept values quoted from graph not (quite) linear/not proportional /curves upwards accept values quoted from graph	**(2)**

Question Number	Answer	Acceptable answers	Mark
2(e)	chain reaction needs a neutron from one fission to reach another uranium nucleus/atom (at the right speed) (1) (fission of 238) needs {fast/high(er) energy} neutrons (1)	idea of continuous nature of chain reaction the neutrons would be going too slowly /do not have enough energy / lose energy too fast	**(2)**

Question Number	Answer	Acceptable answers	Mark
3(a)	A description to include • name of detector / move detector over the ground (1) • where leak is, there will be an increased rate (1)	(move) until a {leak/high reading} is found	**(2)**

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

Question Number	Answer	Acceptable answers	Mark
3(c)i	1.9-2 (days)		**(1)**

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

Question Number		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** 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}	**(6)**
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

Question Number	Answer	Acceptable answers	Mark
4(a)(i)	☒ **C** the same as the charge on the proton		**(1)**

Question Number	Answer	Acceptable answers	Mark
4(a)(ii)	☒ **A** electrons		**(1)**

Question Number	Answer	Acceptable answers	Mark
4(b)(i)	222	4 less/4fewer	**(1)**

Question Number	Answer	Acceptable answers	Mark
4(b)(ii)	86	2 less/2fewer	**(1)**

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

Question Number	Answer	Acceptable answers	Mark
4(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)**

Total mark question 1= 8

Question Number	Answer	Acceptable answers	Mark
5(a)(i)	☒ **B** highest frequency		**(1)**

Question Number	Answer	Acceptable answers	Mark
5(a)(ii)	☒ **D** positively charged		**(1)**

Question Number	Answer	Acceptable answers	Mark
5(a)(iii)	an explanation linking: • (when) the filament is {heated/very hot} (1) with **one** of: • electrons escape (have enough energy) (1) • electrons escape from the surface (1)	cathode / metal (for filament) released accept boil off IGNORE produces / emits	**(2)**

Question Number	Answer	Acceptable answers	Mark
5(a)(iv)	a suggestion that electrons do not reach target	otherwise electrons collide with (air) particles electrons are absorbed electrons ionise air stops electrons reaching target	**(1)**

Question Number	Answer	Acceptable answers	Mark
5(b)	transposition $2 \times e \times V / m = v^2$ (1) substitution $v^2 = 2 \times 1.6 \times 10^{-19} \times 40\,000 / 9.1 \times 10^{-31}$ (1) evaluation of v 1.2×10^8 (m/s) (1)	Either order ignore powers of ten until evaluation give full marks for correct answer, no working accept 1.19×10^8	**(3)**