Q1.

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)

Q2.

Question Number	Answer	Acceptable answers	Mark
	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)**

Q3.

	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)**

Q4.

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)

Q5.

Question number	Answer	Additional guidance	Mark
	Substitution and rearrangement to find k (1) $k = 85000 \times 0.70^2$ Substitution to find new count rate (1) count rate = $\frac{85000 \times 0.70^2}{1.3^2}$ Answer (1) 25000 (counts per minute)	41650 24645 (counts per minute)	(3)

Q6.

Question number	Answer	Additional guidance	Mark
(i)	an explanation linking any **two** from readings fall (to almost zero) (1) radiation is (all) absorbed (1) after a few cm (of air) (1)	 accept graph / activity / measurements for readings stopped by air in a short distance (in air) reverse arguments must include beta **and** gamma	**2 AO2.1**

Question number	Answer	Additional guidance	Mark
(ii)	background radiation (1)	or words to that effect accept named examples ignore reference to original alpha source	**1 AO2.1**

Q7.

Question number	Answer	Additional guidance	Mark
(i) CS2	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) CS2	(idea of) background radiation	a named source of background radiation	(1) AO3

Question number	Answer	Additional guidance	Mark
(iii) CS2	becquerel	accept Bq accept close spelling	(1) AO1

Q8.

Question	Answer	Additional guidance	Mark
	an explanation linking three from use of G-M tube (with counter) (1) no (obvious) radioactive sources present (1) measure (number of) counts in a given time (1) divide number of counts by time (1) repeat readings (1) calculate the average value (1)	 allow Geiger counter / rate meter allow measure count rate / activity if rate meter used take readings in different positions in laboratory	**3** **AO3.3**

Q9.

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

Q10.

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
(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) rate	(4)

Q11.

Question number	Answer	Additional guidance	Mark
(i)	use of gradient on graph (1) $= \frac{1480}{97}$ evaluation (1) 15.3 (counts /s)	look for a triangle / line going up allow $\frac{1480}{100}$ accept other data from the graph allow numbers between 12.0 and 16.0 award full marks for answers in the correct range without working	**(2)**

Question number	Answer	Additional guidance	Mark
(ii)	explanation the process (of radioactive decay) is unpredictable / (occurs) random(ly) (1) so the count rate would not be constant / there will be variations with each reading (1)	 do not allow 'difficult to predict' ignore background results (expected to) scatter	**(2)**