Q1.

Question number	Answer	Additional guidance	Mark
	D it does not change A, B and C are incorrect because the number of nucleons does not change in gamma emission		**1** **AO1.1**

Q2.

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

Q3.

	Answer	Additional guidance	Mark
	description to include: proton (1) becomes a neutron (1)	award 2 marks for p → n award 2 marks for answers in terms of quarks: u→d or up → down or uud→udd if no other mark scored, allow 1 mark for any **one** of neutron becomes proton n → p d→u decrease in atomic number <u>by one</u> mass number stays the same gains a neutron reduce charge (of nucleus) <u>by one</u> responses referring to emission of gamma or neutrino	**(2)** **AO1**

Q4.

Question number	Answer	Mark
(i)	An answer that combines the following points of application of knowledge and understanding to provide a logical description: • proton number/atomic number decreases by 1 (1) • nucleon number/mass number remains unchanged (as p and n have same mass and mass of electron is (assumed) negligible) (1)	(2)

Question number	Answer	Mark
(ii)	C	(1)

Q5.

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)

Q6.

Question Number	Answer	Additional guidance	Mark
	An explanation linking: neutron (decays) to proton (1) beta emitted (1)	 mass number stays the same but atomic number increases by 1 accept answers in terms of quarks (dud becomes uud) beta decay / β seen NOT β^+/beta plus allow (fast) electron emitted allow for 2 marks: n □ p + e OR $^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}\beta^{(-)}$	**(2)**

Q7.

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)

Q8.

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)**

Q9.

	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)**

Q10.

	Answer	Acceptable answers	Mark
(a)	P and M OR M and P OR N and Q OR Q and N	one mark for a pair	**(1)**
(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)**
(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)**
(d)(i)	alpha	Alpha ray, alpha particle, α Ignore capital letters	**(1)**
(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)**
(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)**

Q11.

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. AO1 1 **(6 marks)** **alpha** • a particle (not a wave) • made up of 4 particles • helium nucleus • has a positive charge • when emitted by a nucleus, atomic number goes down by 2 • mass number goes down by 4 **beta** • a particle (not a wave) • made up of 1 particle • electron (or positron) • has a negative charge • when emitted, atomic number goes up by 1 • mass number does not change Ignore references to range, penetration, ionisation.	**(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 ideas lacks detail. (AO1) • Presents an explanation with some structure and coherence. (AO1)
Level 2	3-4	• Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5-6	• Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • Presents an explanation 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 isolated facts	Possible candidate responses A beta particle is an electron. An alpha particle is a helium nucleus
Level 2	3–4	Additional guidance effect of alpha and beta decay or nature and effect of alpha or beta	Possible candidate responses A beta particle is an electron. When emitted the mass number doesn't change but atomic number goes up by one
Level 3	5–6	Additional guidance detailed comparison that includes nature of alpha and nature of beta and effect of either alpha or beta OR effect of alpha and beta and nature of either alpha or beta	Possible candidate responses Alpha particle is a helium nucleus AND A beta particle is an electron. When emitted the mass number doesn't change but atomic number goes up by one