

Question Number	Answer	Acceptable answers	Mark
1(a)(i)	B a few hours		(1)

Question Number	Answer	Acceptable answers	Mark
1(a)(ii)	<p>An explanation including three of the following:</p> <p>MP1 alpha/the radiation is (highly) ionising (1)</p> <p>MP2 the radiation destroys cancers/tumours (1)</p> <p>MP3 alpha particles/ do not penetrate very far in the body/inserted close to the cancer (1)</p> <p>MP4 half-life is long enough for the treatment to take effect (1)</p> <p>MP5 half-life is short enough so that the pellets do not need to be removed (1)</p>	<p>kills/ destroys/mutates cells mutates DNA</p> <p>alpha particles do not/ get out of the organ being treated/ damage cells in other organ</p> <p>Ignore patients being radioactive Ignore replacement of pellets</p>	(3)

Question Number	Answer	Acceptable answers	Mark
1(b)	<p>An explanation to include:</p> <p>reduces the size of tumours/cancers (1)</p> <p>reduces pain/ relieves symptoms / extends life expectancy / Improves quality of life (1)</p>	<p>stops tumours growing/ slows rate of growth or spread of cancer</p>	(2)

Question Number	Answer	Acceptable answers	Mark
1(c)(i)	<p>An explanation linking two of the following:-</p> <p>CT scan lasts much longer / X-ray short exposure (1)</p> <p>CT scan is many X-ray (slices) (1)</p> <p>The <u>intensity</u> of radiation for CT scans is higher than for normal X-rays (1)</p>	<p>For CT scan X-ray machine moves (slowly) around the body</p> <p>many pictures / series of X-rays/ 3D image</p>	(2)

Question Number	Answer	Acceptable answers	Mark
1(c)(ii)	<p>Justification including:-</p> <p>appreciation that there would be risks (1)</p> <p>ONE from:-</p> <p>non-invasive/ not painful (1) OR more accurate/better/earlier diagnosis (1) OR life-saving/ provide cure (1)</p>	<p>the benefits outweigh the risks/drawbacks/concerns/dangers</p> <p>gives more useful information</p>	(2)

Total for question 4 = 10 marks

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

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

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

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

Question Number	Indicative Content	Mark
QWC	<p>*2()</p> <p>A discussion including some of the following points</p> <p>Advantages</p> <ul style="list-style-type: none"> - (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 <ul style="list-style-type: none"> - Conserves fossil fuel supplies - (Spent) fuel can be processed (to produce fuel for other reactors) <ul style="list-style-type: none"> - Provides employment/jobs <p>Disadvantages</p> <ul style="list-style-type: none"> - Produces nuclear/radioactive {waste/materials} - nuclear/radioactive waste/materials can cause mutations in <ul style="list-style-type: none"> DNA/cells/people/animals - Non- renewable (energy source) - Difficulties in transporting nuclear/radioactive waste/material <ul style="list-style-type: none"> - difficulty in (safely) storing/disposing nuclear waste/material <ul style="list-style-type: none"> - Nuclear accidents (can) pollute large areas - Nuclear accidents pollute for a long time - Accept named example of accidents eg Fukushima, Chernobyl, 3-mile island <ul style="list-style-type: none"> - Mining and processing fuel both produce large amounts of carbon dioxide - Expensive to build and/or decommission (nuclear power stations) <ul style="list-style-type: none"> - Reference to target for terrorist attacks - Produces material which can be used to develop nuclear weapons/by terrorists <ul style="list-style-type: none"> - Negative public perception OWTTE <p>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.</p>	(6)

Level		No rewardable content
1	1 - 2	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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 5 = 12 marks)

Question Number	Answer	Acceptable answers	Mark
3 (a)	C - kill microbes in the food		(1)

Question Number	Answer	Acceptable answers	Mark
3 (b)(i)	From the graph Time taken to fall (from 8000) to 4000 (1) = 5.3 (years) (1)	Any other suitable pair of readings from the graph. Between 5.1 and 5.5 Full marks for correct answer even if no working is evident	(2)

Question Number	Answer	Acceptable answers	Mark
3 (b)(ii)	3 x 5.3 (= 15.9 years)	Allow attempt at extrapolation only if the answer is between 15.5 and 16.5 Allow ecf of 3 half lives from bi.	(1)

Question Number	Answer	Acceptable answers	Mark
3 (c)(i)	Comparison including any two from Same number of protons (1) Different number of neutrons (1) Cobalt-60 is unstable (1)	Same atomic/proton number/charge Different nucleon number/mass number/atomic mass Cobalt 60 is radioactive Ignore reference to electrons	(2)

Question Number	Indicative Content	Mark
QWC	<p data-bbox="334 130 423 198">*3() (ii)</p> <p data-bbox="456 130 1308 226">A discussion which includes description of the hazards (H) and / or possible precautions (P) to reduce risks arising from them such as</p> <ul style="list-style-type: none"> <li data-bbox="505 233 776 261">• In either option. <ul style="list-style-type: none"> <li data-bbox="594 267 980 296">○ Rods are radioactive (H) <li data-bbox="594 302 1312 363">○ Gamma radiation is highly penetrating / ionising (H) <li data-bbox="594 369 1317 431">○ Radiation from them can cause cancer / damage to organisms / people / environment (H) <li data-bbox="594 437 943 466">○ Need for shielding (P) <li data-bbox="594 472 1149 500">○ Security to prevent public access (P) <li data-bbox="505 506 963 535">• Transportation / reprocessing <ul style="list-style-type: none"> <li data-bbox="594 541 1192 570">○ Danger of accident during transport (H) <li data-bbox="594 576 1289 637">○ Need to be suitably protected against damage. (P) <li data-bbox="594 643 1273 705">○ Danger of interception/high-jacking/terrorists (H) <li data-bbox="594 711 881 739">○ Need security (P) <li data-bbox="594 746 1227 774">○ Workers could be exposed to radiation (H) <li data-bbox="594 780 1036 809">○ Special facilities required (P) <li data-bbox="505 815 667 844">• Disposal <ul style="list-style-type: none"> <li data-bbox="594 850 1203 911">○ Can damage environment if not properly contained (H) <li data-bbox="594 917 1198 946">○ Special disposal facilities, not landfill (P) <li data-bbox="594 952 1162 981">○ Remain radioactive for some time (H) <li data-bbox="594 987 1279 1048">○ Need to be kept secure while decaying to safe levels. (P) <li data-bbox="594 1054 1276 1116">○ Relatively short half-life means that very long term storage is not necessary. (P) 	(6)

Level		No rewardable content
1	1 - 2	<ul style="list-style-type: none"> a limited description of hazards or precautions in one option e.g. The rods are radioactive. Radiation can cause cancer. When the rods are disposed of then they will remain radioactive for some time. the answer communicates ideas using simple language and uses limited scientific terminology spelling, punctuation and grammar are used with limited accuracy
2	3 - 4	<ul style="list-style-type: none"> a simple discussion of hazards for both options or a detailed discussion of one option. A detail discussion may either expand on several descriptive points about the hazard or may include suitable precautions. e.g. The gamma radiation from the rods is highly penetrating. If they were simply put into landfill then they could damage the environment and so they would need special storage facilities until they had decayed to a safe level. 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	<ul style="list-style-type: none"> a detailed discussion of hazards for both options. e.g. Response as above PLUS if they were transported back to the reactor then they must be in very strong containers so that, if there was an accident, they would not be damaged and allow radioactive material to escape. 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 6 = 12 marks)

Question Number	Answer	Acceptable answers	Mark
4(a)(i)	Gamma/ γ (wave(s)/ ray(s)/radiation)	X-rays/ radiation	(1)

Question Number	Answer	Acceptable answers	Mark
4(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)

Question Number	Answer	Acceptable answers	Mark
4(b)	transposition $\lambda = v/f$ (1) substitution $\lambda = 3 \times 10^8/7 \times 10^9$ (1) evaluation 0.043 (m) (1) Ignore any unit given by candidate	Subst. and transform. either order 1 mark only can be scored for correct 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 x any other power of 10 = 2 marks	(3)

Question Number	Indicative Content	Mark
QWC	<p>A discussion including some of the following points</p> <ul style="list-style-type: none"> Possible dangerous e-m radiations Microwaves Infrared Ultraviolet (UV) X-rays gamma rays <p>Correctly linked to</p> <ul style="list-style-type: none"> 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) <p>Link to frequency</p> <p>As the frequency increases/wavelength decreases (microwave -> gamma) the waves become more penetrating and do more damage/danger as they have more energy.</p>	(6)
Level	0	No rewardable content
1	1 - 2	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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. X-rays 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	<ul style="list-style-type: none"> • a detailed description e.g. gives most of the correct radiations with detail of the damage AND explains the link between frequency

		<p>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.</p>
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- The answer communicates ideas clearly and coherently uses a range of scientific terminology accurately
- spelling, punctuation and grammar are used with few errors