

Q1.

Question number	Answer	Mark
	B neutron	(1)

Q2.

Question Number:	Answer	Mark
(i)	<input type="checkbox"/> C a neutron <b>The only correct answer is C (neutron causes U-235 fission)</b> A is not correct – incorrect particle B is not correct – incorrect particle D is not correct – incorrect particle	(1)

Question Number	Answer	Additional guidance	Mark
(ii)	<p>recall and substitution (1)</p> $1.2 \times 10^{-11} = \frac{1}{2} \times 1.4 \times 10^{-25} \times v^2$ <p>rearrangement (1)</p> $v^2 = \frac{2 \times 1.2 \times 10^{-11}}{1.4 \times 10^{-25}}$ <p>evaluation (1)</p> <p>(v=) <math>1.3 \times 10^7</math> (m/s)</p>	<p>accept rearrangement and substitution in either order</p> <p>ignore POT until evaluation</p> $v^2 = 1.71 \times 10^{14}$ <p>allow numbers that round to <math>1.3 \times 10^7</math> (m/s)</p> <p>1.3 to any other power of ten scores 2 marks</p> <p>award full marks for the correct answer without working</p>	(3)

Q3.

Question number	Answer	Additional guidance	Mark
	<p>An explanation linking two of</p> <p>a neutron collides with/fired at a (uranium) nucleus (1)</p> <p>releasing (2/3) extra neutron(s) (1)</p> <p>which go on to collide with more nuclei (1)</p>	<p>neutron absorbed by nucleus. accept atom for nucleus</p> <p>accept atom for nucleus</p>	<b>(2)</b>

Q4.

Question number	Answer	Mark
	<p>An answer that combines the following points of understanding to provide a logical description:</p> <ul style="list-style-type: none"><li>• the reactor is surrounded by a coolant (1)</li><li>• the thermal energy release from the chain reaction heats the coolant (1)</li><li>• the hot coolant is used to generate steam which is used to drive the turbine (1)</li></ul>	<b>(3)</b>

Q5.

Question Number	Answer	Acceptable answers	Mark
<b>(b)</b>	A description to include  Thermal energy used to create steam / boil water(1) (Steam used to drive) turbine (1) (Turbine used to turn) generator (1)	Ignore detail of fission process.	<b>(3)</b>

Q6.

	Answer	Additional guidance	Mark
<b>(iii)</b>	A description to include:  (from) kinetic energy (of fission fragments) (1)  (transferred to) thermal energy (of coolant) (1)	accept references to energy stores  accept energy in nuclear store accept nuclear energy / gamma radiation energy / binding energy / mass  (to) thermal store (in coolant)  accept heat for thermal  if no other marks awarded allow steam transfers thermal energy/heat from reactor to kinetic energy of turbine for 2 marks	<b>(2)</b> <b>AO1</b>

Q7.

Question number	Answer	Additional guidance	Mark
	<p>An explanation that combines identification – knowledge (1 mark) and reasoning/justification – knowledge (2 marks):</p> <ul style="list-style-type: none"><li>• reaction will slow down (1)</li><li>• because there are fewer fissions (1)</li><li>• because fission more likely with slow neutrons (1)</li></ul>	<p>allow</p> <p>reactor shuts down/eq</p> <p>fission requires slow neutrons</p> <p>thermal neutrons for slow neutrons</p>	<p>(3)</p>

Q8.

Question number	Answer	Additional guidance	Mark
	<p>an explanation linking any <b>three</b> from</p> <p>neutron absorbed (into uranium) (1)</p> <p>(causing) nucleus becomes unstable (1)</p> <p>(so nucleus) breaks up/splits (into two other nuclei) (1)</p> <p>(then) releasing (more) neutron(s) (1)</p> <p>releases gamma rays / energy (1)</p>	<p>allow collides/hits/joins with</p> <p>do not allow atom for nucleus</p> <p>if no other marks scored award 1 mark for neutrons go on to hit other nuclei</p>	<p><b>(3)</b> <b>A01.1</b></p>

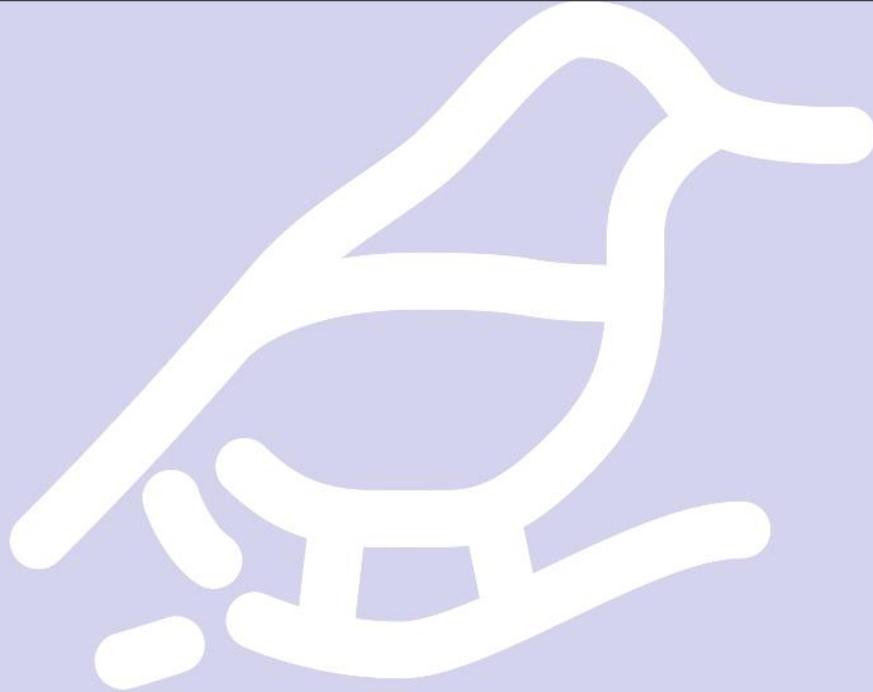
Q9.

Question number	Answer	Additional guidance	Mark
(i)	<p>An explanation that combines identification – knowledge (1 mark) and reasoning/justification – knowledge (3 marks):</p> <ul style="list-style-type: none"><li>• causes 2 or 3 neutrons to be released (1)</li><li>• (and) one or more of these (released) neutrons are absorbed by other (U) nuclei (1)</li><li>• which cause further fission of U nuclei (1)</li><li>• and release further neutrons that can be absorbed, causing a chain reaction (1)</li></ul>	<p>ignore U nucleus 'splits up'/eq</p>	(4)
Question number	Answer		Mark
(ii)	<p>Idea that to get a chain reaction the particle that impacts the nucleus must be the same as the one released (1)</p>		(1)

Q10.

Question number	Indicative content	Mark
	<p>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.</p> <p>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.</p> <p style="text-align: center;"><b>AO1 1 (6 marks)</b></p> <p><u>Arguments for using nuclear power</u></p> <ul style="list-style-type: none"><li>• we are running out of fossil fuels SO the use of nuclear can play its part where we have previously used fossil fuels</li><li>• no carbon emissions SO does not contribute towards global warming, rise in sea-levels etc.</li><li>• low running costs SO a good economical alternative to other power sources</li><li>• with reprocessing can last hundreds of years</li><li>• large power output compared with wind farms / solar etc.</li></ul> <p><u>Arguments against using nuclear power</u></p> <ul style="list-style-type: none"><li>• expensive to set up and decommission SO the use of other sources could be more economical</li><li>• nuclear disasters possible SO there could be a loss of life / contamination of an area</li><li>• nuclear toxic waste lasts a long time</li><li>• waste storage issues – contamination of ground water</li><li>• terrorism / bomb making</li></ul>	<p><b>(6)Exp</b></p>

Level	Mark	Descriptor
	0	<ul style="list-style-type: none"> <li>No rewardable material.</li> </ul>
Level 1	1-2	<ul style="list-style-type: none"> <li>Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1)</li> <li>Presents an explanation with some structure and coherence. (AO1)</li> </ul>
Level 2	3-4	<ul style="list-style-type: none"> <li>Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1)</li> <li>Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)</li> </ul>
Level 3	5-6	<ul style="list-style-type: none"> <li>Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1)</li> <li>Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)</li> </ul>



## SUMMARY, for guidance

Level	Mark	Additional Guidance	General additional guidance – the decision within levels
	0	No rewardable material.	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.
Level 1	1–2	<u>Additional guidance</u> Unbalanced incomplete argument Elements of physics present isolated knowledge for or against	<u>Possible candidate responses</u> no CO <sub>2</sub> emissions high cost
Level 2	3–4	<u>Additional guidance</u> Argument linked with evidence, but not entirely coherent or balanced Uses evidence for <b>or</b> against but lacks balance / focus / with logical connections made on one side and statement from the other	<u>Possible candidate responses</u> no CO <sub>2</sub> emissions so no contribution to global warming large power output compared with wind farms
Level 3	5–6	<u>Additional guidance</u> Developed detailed arguments, including use of evidence, advanced both for <b>and</b> against the use of nuclear power	<u>Possible candidate responses</u> no CO <sub>2</sub> emissions so no contribution to global warming large power output compared with wind farms  nuclear toxic waste lasts a long time

**Q11.**

Question Number	Answer	Acceptable answers	Mark
<b>(a)</b>	C - kill microbes in the food		<b>(1)</b>

Question Number	Answer	Acceptable answers	Mark
<b>(b)(i)</b>	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	<b>(2)</b>

Question Number	Answer	Acceptable answers	Mark
<b>(b)(ii)</b>	$3 \times 5.3$  (= 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.	<b>(1)</b>

Question Number	Answer	Acceptable answers	Mark
<b>(c)(i)</b>	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	<b>(2)</b>

Question Number	Indicative Content	Mark
<b>QWC</b>	<p>* <b>(c)</b> <b>(ii)</b></p> <p>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>• In either option. <ul style="list-style-type: none"> <li>○ Rods are radioactive (H)</li> <li>○ Gamma radiation is highly penetrating / ionising (H)</li> <li>○ Radiation from them can cause cancer / damage to organisms / people / environment (H)</li> <li>○ Need for shielding (P)</li> <li>○ Security to prevent public access (P)</li> </ul> </li> <li>• Transportation / reprocessing <ul style="list-style-type: none"> <li>○ Danger of accident during transport (H)</li> <li>○ Need to be suitably protected against damage. (P)</li> <li>○ Danger of interception/high-jacking/terrorists (H)</li> <li>○ Need security (P)</li> <li>○ Workers could be exposed to radiation (H)</li> <li>○ Special facilities required (P)</li> </ul> </li> <li>• Disposal <ul style="list-style-type: none"> <li>○ Can damage environment if not properly contained (H)</li> <li>○ Special disposal facilities, not landfill (P)</li> <li>○ Remain radioactive for some time (H)</li> <li>○ Need to be kept secure while decaying to safe levels. (P)</li> <li>○ Relatively short half-life means that very long term storage is not necessary. (P)</li> </ul> </li> </ul>	<b>(6)</b>

<b>Level</b>	<b>0</b>	No rewardable content
<b>1</b>	<b>1 - 2</b>	<ul style="list-style-type: none"> <li>• 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.</li> <li>• the answer communicates ideas using simple language and uses limited scientific terminology</li> <li>• spelling, punctuation and grammar are used with limited accuracy</li> </ul>
<b>2</b>	<b>3 - 4</b>	<ul style="list-style-type: none"> <li>• a simple discussion of hazards for both options or a detailed discussion of one option.</li> <li>• A detail discussion may <b>either</b> expand on several descriptive points about the hazard <b>or</b> 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.</li> <li>• the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately</li> <li>• spelling, punctuation and grammar are used with some accuracy</li> </ul>
<b>3</b>	<b>5 - 6</b>	<ul style="list-style-type: none"> <li>• 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.</li> <li>• the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately</li> <li>• spelling, punctuation and grammar are used with few errors</li> </ul>

**(Total for Question = 12 marks)**