Q1.

Question	Answer	Mark
	D it requires high temperature and pressure **A** no emission of daughter nuclei **B** not a chain reaction **C** does not produce radioactive waste	**1** **AO1.1**

Q2.

Question Number	Answer	Additional guidance	Mark
(i)	description to include (small) nuclei join / fuse / combine (1) to create larger nuclei (1)	do not accept atoms / particles for nuclei accept named nuclei hydrogen nuclei join to become helium (nuclei)	**(2)** **AO1.1**

Q3.

Question number	Answer	Additional guidance	Mark
	A description to include any three of the following		**(3)**
	(smaller) nuclei / atoms / particles (1)	two named eg hydrogen (nuclei)	
	come together / join (1)	allow fuse not 'bond'	
	to produce a larger nucleus / atom / particle (1)	helium for nucleus	
	needing high temperature / pressure (1)	accept fast (moving) nuclei	
	overcoming repulsion (between nuclei) (1)		
	energy released (1)	ignore energy created	

Q4.

Question Number	Answer	Additional guidance	Mark
(i)	a description to include: nebula collapses (1) under **gravity** (1) plus any one from: GPE converted into KE (1) OR (very) **high** temperatures/pressures reached (1)	 allow gas/dust for nebula allow condensing/coming together for collapses allow gravitational force producing (large) increase in **KE** of particles / more (frequent) collisions Ignore references to hot / heat	**(3)**

Q5.

Question number	Answer	Additional guidance	Mark
	An explanation that makes reference to identification - knowledge (2 marks) and reasoning/justification - knowledge (1 mark): • fusion requires high temperatures and pressures (1) • (in order to overcome) electrostatic repulsion of nuclei (1) • (we are currently) unable to maintain these conditions (in a commercial reactor) (1)		**(3)**

Q6.

Question Number	**Answer**	**Additional guidance**	**Mark**
(i)	an explanation linking: (high temperature means) high energy (1) (needed) to overcome (force of) repulsion (1) between nuclei / because they both have the same charge (1)	accept "them" / hydrogen for nuclei	**(3)** AO 2 1

Q7.

Question Number	Answer	Acceptable answers	Mark
(a) (ii)	A suggestion to include Neutrons do not need to be captured (by another nucleus) / do not play a part in the fusion process	 Fusion does not use neutrons No chain reaction	**(1)**

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

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Question Number		Indicative Content	Mark
QWC	*** (c)**	An explanation including some of the following points • Description of the problem - Nuclei have positive charge - Repel each other - Reduces possibility of suitable collisions - Rate of fusion too small to be useful • Description of how this can be overcome ○ Very high temperature (of fuel) ○ Very high KE / speed of nuclei ○ High KE can overcome repulsion ○ Very high density / pressure ○ Increases possibility of suitable collisions	**(6)**
Level	**0**	No rewardable content	
1	**1 - 2**	A limited explanation e.g. The fuel has to be at a high temperature to start the reaction/to make particles collide. Or The fuel has to be at a very high temperature and pressure. • 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. e.g. We need to overcome repulsion of nuclei to make them collide. This is achieved by having a high temperature and pressure. • 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 • e.g. The nuclei repel each other. To overcome this they need very high kinetic energy which is achieved by generating high temperature and pressure. • 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 = 12 marks)

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Q8.

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)** **fission** • (heavy) nucleus split • by a neutron • releases 2 daughter nuclei + more neutrons + energy • starts chain reaction **advantages** • already in use **disadvantages** • waste is radioactive • hard to dispose of • risk of accident	**(6)** **AO1**

	fusion • (light) nuclei joined • at high energy/temperature/pressure/particle density • releases (eg) helium + energy **advantages** • no harmful waste products **disadvantages** • not achieved yet (on a practicable scale) • difficulty in achieving high energy/temperature/pressure/particle density	

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 fission involves a nucleus being split by a neutron
Level 2	3–4	Additional guidance simple comparison of fission and fusion	Possible candidate responses fission involves a nucleus being split by a neutron whereas fusion requires combining two light nuclei.
Level 3	5–6	Additional guidance detailed comparison of fission and fusion and one advantage or one difficulty compared to the other	Possible candidate responses Fission involves nuclei split by a neutron. Fusion involves combining two light nuclei. The waste from fission is radioactive. Practicable fusion has not been achieved.