WJEC Physics GCSE
Topic 2.9: Nuclear decay and nuclear energy
Mark Schemes for Questions by topic

1.

Question			Marking details	Marks
2.			slow neutrons (1) fission (1) moderator (1) neutrons (1) control rods (1) **Question total**	5 [5]

2.

Sub-section			Mark	Answer	Accept	Neutral answer	Do not accept
			6	**Indicative content:** A fission reaction in a nuclear reactor occurs a when slow moving neutron is captured by a uranium atom with which it collides. The uranium nucleus splits into 2 daughter nuclei, releasing two or three fast moving neutrons in addition to releasing energy. These neutrons have to be slowed down in order to successfully fission with other uranium nuclei and this is achieved by a moderator (of graphite or water). The reactions are controlled by absorbing neutrons with control rods, thus allowing (on average) one neutron per fission to go on to achieve fission with another uranium nucleus. In this way an uncontrolled series of fission reactions is avoided. **5-6 marks** The candidate constructs an articulate, integrated account correctly linking relevant points, such as those in the indicative content, which shows sequential reasoning. The answer fully addresses the question with no irrelevant inclusions or significant omissions. The candidate uses appropriate scientific terminology and accurate spelling, punctuation and grammar.			
				3-4 marks The candidate constructs an account correctly linking some relevant points, such as those in the indicative content, showing some reasoning. The answer addresses the question with some omissions. The candidate uses mainly appropriate scientific terminology and some accurate spelling, punctuation and grammar. **1-2 marks** The candidate makes some relevant points, such as those in the indicative content, showing limited reasoning. The answer addresses the question with significant omissions. The candidate uses limited scientific terminology and inaccuracies in spelling, punctuation and grammar. **0 marks** The candidate does not make any attempt or give a relevant answer worthy of credit.			
Total			6				

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Total			6				

3.

Sub-section	Mark	Answer	Accept	Neutral answer	Do not accept
(i)	4	Moderator slows down neutrons (1) so absorbed / captured by uranium nuclei / atoms (1) More than one neutron emitted [at fission] (1) but some absorbed /all but 1 neutron absorbed by control rods (1) **The 1st mark must be linked to the 2nd mark and the 3rd mark must be linked to the 4th mark.**		Collide with Causes fission Neutrons are introduced Raising or lowering the control rods	
(ii)	2	Fusion requires high temperature **and** pressure (1) which is difficult to contain (1) **The 1st mark must be linked to the 2nd mark.**		References to stars	
Total	6				

4.

Question			Answer / Explanatory Notes	Marks Available
4.	*(a)*	(i)	graphite / moderator	1
		(ii)	to cause [fission / chain] reactions / if too quick, reaction won't work	1
	(b)	(i)	boron / control rods	1
		(ii)	to prevent an uncontrolled chain reaction / control the chain reaction / prevent overheating or meltdown / Don't accept "to stop fission" only must be qualified.	1
	(c)	(i)	235	1
		(ii)	36	1
		(iii)	[91 – 36] = 55 (No ecf for 91 – (ii))	1
	(d)		$^{136}_{56}$Ba circled	1
	(e)		37 (1) 0 (1)	2
			Question total	**[10]**

5.

Question			Marking details	Marks
4.	(a)		[He] 2 (1) [Fe] 56 (1)	2
	(b)		H or hydrogen	1
	(c)	(i)	$^{207}_{82}Pb$	1
		(ii)	$^{90}_{36}Kr + ^{144}_{56}Ba$ (1) $2^{1}_{0}n$ (1)	2
			Do not accept krypton and barium written in full	
			Do not accept Kr^{90}_{36} or Ba^{144}_{56}	
	(d)	(i)	slows down	
		(ii)	absorb	2
			Question total	**[8]**

6.

Question				Marking details	Marks
7.	(a)	(i)		38 (1) 2 (1)	2
		(ii)		Neutrons produced [go on to] cause more reactions **or** collisions **or** bombards (1), number of neutrons doubles (accept increase / multiply / triple) [each time] (1) Treat reference to fast neutrons as neutral. N.B. reference to 3 neutrons could arise from the equation above. **To award both marks both statements must be linked.**	2
	(b)			They contain same number of protons / 1 proton (1) but different number of neutrons / 1 neutron and the other has 2 neutrons (1) Reference to electrons loses 1 mark. **Don't accept** nucleons / mass number / atomic number	2
	(c)			**Indicative content:** In fission a heavy element such as [U 235] absorbs a neutron and splits into lighter nuclei [releasing energy]. In fusion, light elements [such as hydrogen isotopes] collide [in high energy collisions and join together] to produce a heavier element, [also releasing energy]. The main problem with nuclear fission is that it produces waste products which are highly radioactive for a long time. The main problem with nuclear fusion is that it requires very high temperatures and pressures which need lots of energy so it is not yet easily contained. **5 – 6 marks** The candidate constructs an articulate, integrated account correctly linking relevant points, such as those in the indicative content, which shows sequential reasoning. The answer fully addresses the question with no irrelevant inclusions or significant omissions. The candidate uses appropriate scientific terminology and accurate spelling, punctuation and grammar. **3 – 4 marks** The candidate constructs an account correctly linking some relevant points, such as those in the indicative content, showing some reasoning. The answer addresses the question with some omissions. The candidate uses mainly appropriate scientific terminology and some accurate spelling, punctuation and grammar. **1 – 2 marks** The candidate makes some relevant points, such as those in the indicative content, showing limited reasoning. The answer addresses the question with significant omissions. The candidate uses limited scientific terminology and inaccuracies in spelling, punctuation and grammar. **0 marks** The candidate does not make any attempt or give a relevant answer worthy of credit.	6
				Question total	**[12]**
				Foundation tier paper total	**[60]**

7.

Sub-section			Mark	Answer	Accept	Neutral answer	Do not accept
(a)	(i)		1	(Making the gas) very hot / at a high temperature	Heats up a lot		"Make the particles hot". OR "Make them hot" or Increase temperature or High pressure
	(ii)		1	The container is in danger of melting / difficult to achieve such high temperatures / requires high energy	"The container melts" OR just "Containment" If pressure identified in (i) then accept leaking or bursting	Exploding	
(b)	(i)		1	Hydrogen underlined			
	(ii)		1	Protons underlined			
	(iii)		1	Fusion underlined			
(c)			2	**Any 2 × (1) from:** • Reactants are readily available from [water in] the oceans • Fossil fuels are likely to run out / are finite / it is a sustainable source of energy • [Producing electricity from it] does not increase global warming / add to acid rain • Releases a large amount of energy • Doesn't produce radioactive waste	Water / hydrogen / deuterium is readily available from the oceans	Reference to tritium	Other energy sources are running out / Cleaner energy supply / Reference to cost / reference to less pollution
Total			**7**				

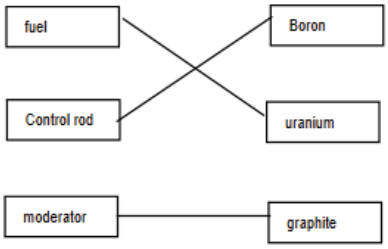
8.

Sub-section			Mark	Answer	Accept	Neutral answer	Do not accept
(a)			1	75 [%]			
(b)	(i)		1	4			
	(ii)		1	4			
	(iii)		1	Positron	positive electron / anti electron		
(c)	(i)		2	Gravity / gravitation (1) [Radiation / gas] pressure (1)			Radiation on its own / expanding force
	(ii)		1	Our Sun is not big enough / not massive or heavy enough	It is too small / only supernovae produce uranium / only very big stars produce uranium		Any answer that doesn't refer to size e.g. only produces elements up to iron
Total			**7**				

9.

Sub-section			Mark	Answer	Accept	Neutral answer	Do not accept
(a)	(i)		2	Uranium [nucleus] / it absorbs neutron[s] (1) splits into 2 [smaller] nuclei and neutrons [are released] (1)	Atoms Neutron capture Named elements		Force of impact shatters nucleus. Don't accept collides.
	(ii)		2	Slows down the neutrons (1) so they can be absorbed / captured by uranium [nuclei] (1) **The 2nd mark can only be awarded if it is linked to the 1st mark.**	For 2nd mark: Split uranium nuclei or they cause fission of uranium or the reaction of uranium		
	(iii)		2	Fewer or no neutrons absorbed (1) so increase [in rate of] fission [of uranium nuclei] (1) **The 2nd mark can only be awarded if it is linked to the 1st mark.**	For 1st mark: So more neutrons available for fission		Taken out / removed / more energy released
(b)	(i)		3	Ticks in the 2nd, 3rd and 4th boxes A nucleus of U-230 least number of neutrons (1) ✓ A nucleus of U-235 contains 143 neutrons (1) ✓ A nucleus of U-234 contains 92 protons (1) ✓			Extra tick attracts -1
	(ii)		2	234 (1) $^{234}_{92}U$ (1) as shown here			

10.

Question Number	Answer	Acceptable answers	Mark
5 (a) (i)		All three correct for 2 marks One or two only correct for 1 mark Reject any box with more than one line	**(2)**

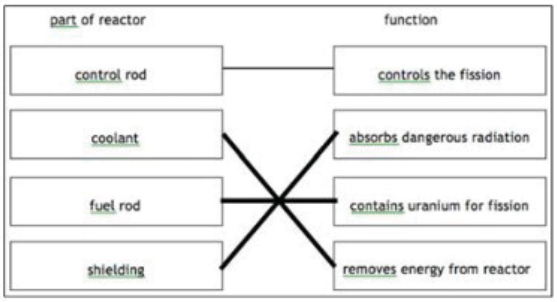
Question Number	Answer	Acceptable answers	Mark
5(a) (ii)	A suggestion to include Neutrons do not need to be captured (by another nucleus) / do not play a part in the fusion process	Fusion does not use neutrons No chain reaction	**(1)**

Question Number	Answer	Acceptable answers	Mark
5 (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)**

Question Number		Indicative Content	Mark
QWC	***5(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 o Very high temperature (of fuel) o Very high KE / speed of nuclei o High KE can overcome repulsion o Very high density / pressure o 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

11.

Question number	Answer	Notes	Marks
2 (a)	All lines correct = 2 marks Any correct added line = 1 mark  		2
(b)	kinetic energy;		1
(c)	slows neutrons/reduces KE of neutrons; and any one from (which)allows fission to continue; (which) causes (induced) fission; (so) neutrons can be absorbed by uranium;	makes the neutrons thermal/eq ignore moderator absorbs neutrons ignore • neutrons collide with uranium • successful collisions	2
(d)	any three of - MP1 each fission (of a nucleus) caused by a single neutron; MP2 each fission releases more than one neutron; MP3 excess neutrons can speed up the reaction; MP4 (more) fissions release excess energy; MP5 control rods absorb neutrons; MP6 control rods regulate the rate of fission/reaction;	e.g. a nucleus splits when neutron has been absorbed ignore 'block'/ eq allow control rods speed up/slow down rate of fission	3