Nuclear Power (Fission and Fusion)

Total marks:19

Q1.

Stars may originate as a nebula.

(i) Describe the process that then occurs to produce the conditions necessary for nuclear fusion in a new star.

(3)

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.....

(ii) The energy, E, released in nuclear fusion is equivalent to loss in mass, m, according to the equation.

$$E = mc^2$$

where c is the velocity of light.
$c = 3.00 \times 10^8$ m/s
In 1 second, the energy radiated by the Sun is 3.86×10^{26} J.
Calculate the loss in mass of the Sun in 1 second.

(2)

loss in mass = ... kg

(Total for question = 5 marks)

Q2.

Figure 8 shows a helium nucleus.

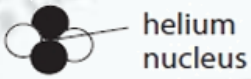

Figure 8

The energy released per kilogram of fuel in a fusion reaction is 845 000 GJ.

The energy released per kilogram of fuel in burning oil is 0.0394 GJ.

(i) Calculate the ratio of the energy released in fusion compared with the energy released in burning oil.

Use the equation

$$\text{ratio} = \frac{\text{energy released from fusion}}{\text{energy released by burning oil}}$$

(2)

ratio = ...

(ii) State **two** advantages of using a fusion reactor rather than burning oil in a power station.

(2)

1 .....

.....

2 .....

.....

(iii) State **two** of the difficulties that need to be overcome to produce a fusion reactor.

(2)

1 .....

.....

2 .....

.....

(Total for question = 6 marks)

Q3.

Both using nuclear fuel and burning oil produce harmful waste products.

State **one** harmful waste product from each process.

(2)

using nuclear fuel .....

.....

burning oil .....

.....

(Total for question = 2 marks)

Q4.

Nuclear power is used for generating electricity.

(i) State **two** advantages of generating electricity using nuclear power compared with generating electricity from gas-fired power stations.

(2)

1 .....

.....

2 .....

.....

(ii) Using nuclear power stations to generate electricity is unpopular with many people.

State **two** reasons why nuclear power stations are unpopular.

(2)

1 .....

.....

2 .....

.....

(Total for question = 4 marks)

Q5.

Figure 1 is a diagram of a nuclear reactor, used in the generation of electricity.

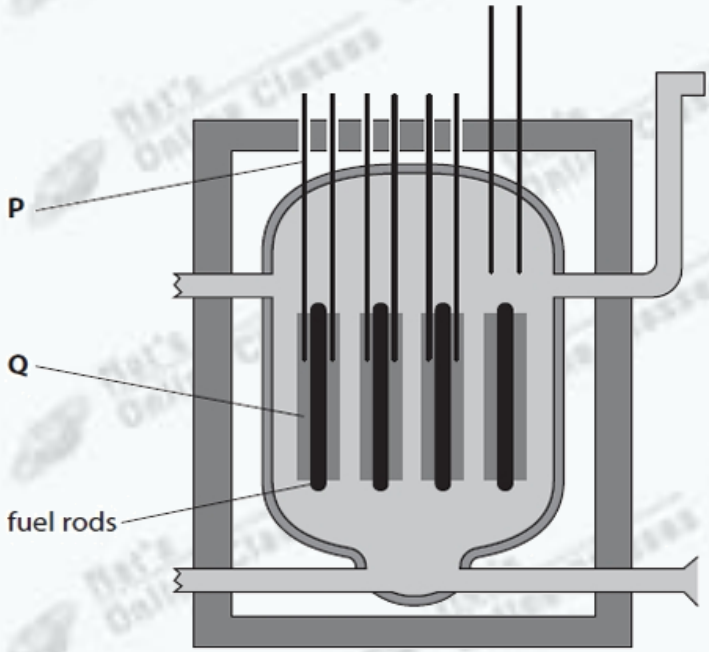

Figure 1

P may be used to shut down the reactor when necessary.
Q slows down neutrons to enable a chain reaction to take place.

State the name of the two parts labelled **P** and **Q**.

(2)

P .....

Q .....

(Total for question = 2 marks)

Mark scheme:

Q1.

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)**

Question Number	Answer	Additional guidance	Mark
(ii)	rearrangement **and** substitution (1) (m =) $\frac{3.86 \times 10^{26}}{(3.00 \times 10^{8})^2}$ evaluation (1) (m =) 4.29×10^{9} (kg)	 ignore Power Of Ten (POT) error until evaluation allow numbers that round to 4.3×10^{9} (kg) award full marks for the correct answer without working 4.3 to any other power of ten scores 1 mark	**(2)**

Q2.

Question Number	Answer	Additional guidance	Mark
(i)	substitution (1) $\frac{845\,000}{0.0394}$ evaluation (1) 21 000 000	answers that round to 21 000 000 $2.1(45) \times 10^7$ etc. award full marks for the correct answer without working	(2) AO 2 1

Question Number	Answer	Additional guidance	Mark
(ii)	any two from: • fusion power gives (many) more times the energy output (for the same mass used) • no greenhouse gases / CO_2 emissions (produced with the fusion alternative) • does not lead to global warming • no (radioactive) waste • does not deplete / use up a finite resource (e.g. oil)	may quote numbers here accept no or less pollution / no or less harmful gases etc. sustainable reference oil is running out ignore references to costs	(2) AO 1 1

Question Number	Answer	Additional guidance	Mark
(iii)	any two from: • problem of containment (the fusion gases / isotopes at high temperatures) • (maintaining) high temperature • (maintaining) high pressure		(2) AO 2 1

Q3.

Question number	Answer	Additional guidance	Mark
	using nuclear fuel: radioactive substances (1) burning oil: carbon dioxide (1)	 named radioactive substance / nuclear waste greenhouse gases named pollutant toxic/poisonous gases atmospheric pollutant / acid rain	(2)

Q4.

Question Number	Answer	Additional guidance	Mark
(i)	Any two advantages from: no CO_2 produced / reduces global warming more energy (per kg) no cross-country pipelines no cross-country pipelines	 no harmful waste gases to atmosphere high energy density fuel IGNORE reference to unqualified non-pollution cost renewable efficiency sped of production	(2)

Question Number	Answer	Additional guidance	Mark
(ii)	Any **two** reasons for unpopularity from **mp1** public perception that radioactivity is dangerous **mp2** radiation leaks from plant **mp3** nuclear accidents **mp4** risks of terrorist attacks **mp5** production/storage of nuclear waste **mp6** (nuclear) waste radioactive for a long time		(2)

Q5.

Question number	Answer	Additional guidance	Mark
	P - control rods (1) Q - graphite/moderator (1)	boron steel rods heavy water	(2)