Nuclear fission and fusion

Mark Scheme

Name: _____

Class: _____

Date: _____

Time: **84 minutes**

Marks: **84 marks**

Comments:

Mark schemes

1 (i) sensible answers e.g. risk of radioactive leak during transport eliminated
cheaper transport

1

(ii) 4 half-lives 4 × 6 = 24 seconds

3

[4]

2 (a) *evidence of conclusion* 4 × 1.007825 **or** 4.0313
each gain 1 mark

based on use of data that there is a (very small) loss of mass
or 0.0276 **but** a loss of mass of 0.0276 **for every helium atom or** 0.69%/0.7%
gains 3 marks

3

(b) *idea that* loss of mass results in release of energy
gains 1 mark

but small loss of mass results in huge energy release
gains 2 marks

2

[5]

3 (a) (i) splitting of a(n atomic) nucleus
do not accept splitting an atom

1

(ii) Neutron

1

(b) (i) nuclei have the same charge
or
nuclei are positive
accept protons have the same charge

1

(ii) (main sequence) star
accept Sun or any correctly named star
accept red (super) giant

1

(c) (i) any **two** from:

- easy to obtain / extract
- available in (very) large amounts
- releases more energy (per kg)

*do **not** accept figures only*

- produces little / no radioactive waste.

naturally occurring is insufficient

seawater is renewable is insufficient

less cost is insufficient

2

(ii) any **one** from:

- makes another source of energy available
- increases supply of electricity
- able to meet global demand
- less environmental damage
- reduces amount of other fuels used.

accept any sensible suggestion

accept a specific example

accept a specific example

1

(d) 12

*allow **1** mark for obtaining 3 half-lives*

2

[9]

4 (a) (i) (large) nucleus hit by a neutron

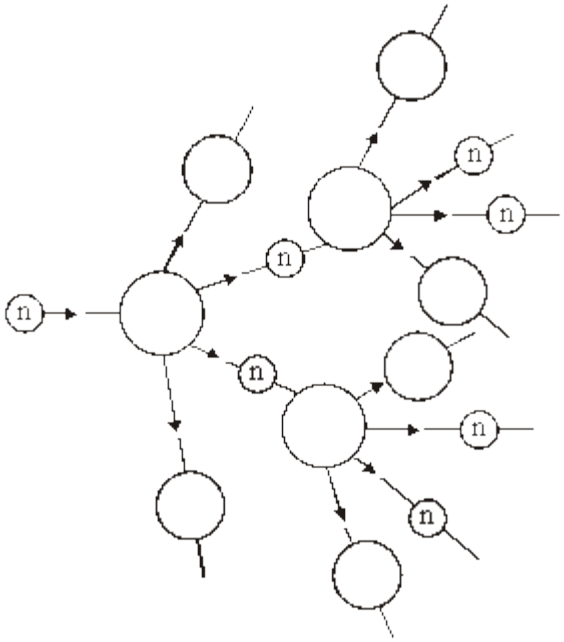
1

splits into (smaller) nuclei **and** neutron(s) (+ energy)

1

(ii) additional neutrons collide with nuclei causing further fission

allow full credit for a correct labelled diagram
accept 2 or more neutrons given out at each fission reaction
diagram shows 3 discernible sizes, with smaller nuclei and neutrons at same stage



1

(b) cost of (building and) de-commissioning is very high **or**
cost of building is higher

accept a correct description of de-commissioning
accept high cost to keep the power station safe / secure
accept high cost of reprocessing / storage of nuclear waste

1

(c) less pollution from transport carrying the fuel

accept coal produces more pollutant gases
accept correct named gases
accept more radiation pollution from coal than nuclear
accept more waste from coal than nuclear
*do **not** accept any reference to burning uranium*
*do **not** accept answers in terms of global warming **or** acid rain unless developed*

1

[5]

5 (a) isotopes

1

(b) $^{231}_{90}Th$

1

correct order only

1

(c) (i) (nuclear) fission

accept fision

*do **not** accept any spelling that may be confused with fusion*

1

(ii) neutron / neutrons

1

(d) plutonium (239)

accept MOX (mixed oxide)

accept Pu

*do **not** accept uranium 238 / hydrogen*

1

[6]

6 (a) (i) (nuclear) fission

*accept fision providing clearly **not** fusion*

1

(ii) (released) neutrons are absorbed by further (uranium) nuclei

accept hit nuclei for absorbed / hit

*do **not** accept atom for nuclei*

1

more neutrons are released (when new nuclei split)

*accept for **both** marks a correctly drawn diagram*

1

(iii) increases by 1

or goes up to 236

1

(b) any **two** from:

- (more) neutrons are absorbed

  accept there are fewer neutrons

- (chain) reaction slows down / stops

  accept keeping the (chain) reaction controlled

- less energy released

  accept heat for energy

  accept gases (from reactor) are not as hot

2

[6]

7 (a) (i) centre

1

(ii) protons and neutrons

2

(iii) different number of neutrons

gets 1 mark

heavier

gets 1 mark

3 more neutrons or specified numbers

gets 2 marks

2

(b) atom hit by neutron;
splits into smaller nuclei;
further neutrons released;
neutrons released when one atom splits
cause further fission;
energy released.

any 4 for 1 mark each

4

[9]

8 (a) it use $E = mc^2$

mass in kg i.e. $0.001 \times \frac{0.7}{100}$

each gains 1 mark

but 000007

gains 2 marks

2.1×10^3

gains 3 marks

evidence of 0.000007

mass in kg (i.e. 0.0007 **or** 0.7/100000)

each gains 1 mark

squaring the speed of light

but 6.3×10^{11} *(credit alternative ways of stating this)*

gains 3 marks

units J/joule

for 1 further mark

(N.B credit kJ, MJ, GJ but check power of 10 for full credit)

4

(b) (i) *idea that* the bigger the mass the shorter the life

gains 1 mark

but *idea that* decrease in life is much more than proportional to increase in mass

or more than proportional to mass^2

gains 2 marks

2

(ii) *ideas that*:

greater mass means greater **core** temperature/pressure

greater core temperature/pressure means greater rate of fusion

increase in mass produces a proportionally much greater increase in the rate of fusion

each for 1 mark

3

[9]

9 (a) (i) (atoms with the) same number of protons

allow same atomic number

or *same proton number*

1

(atoms with) different number of neutrons

allow different mass number

1

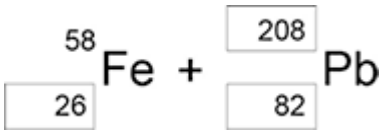
(ii) 82

1

(iii) 124

1

(b) (i)



1 *mark for each correct box*

3

(ii) (a) neutron

1

(iii) 4.0×10^{-4} (s)
or
0.0004

$3.00 \times 10^{8} \times 0.1 = 12\,000 / t$
*gains **1** mark*

2

(iv) particles need to travel a large distance

1

equipment would have to be very long

1

with circular paths long distances can be accommodated in a smaller space

1

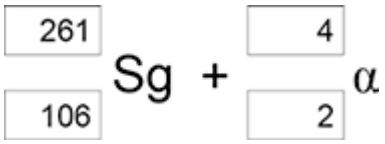
(c) (i) the average time for the number of nuclei to halve

1

the time for count rate to halve

1

(ii)



1 *mark if top boxes total = 265*
and *bottom boxes total = 108*
1 *mark for 4 and 2 for alpha*

2

(d) (i) 3 plotted points

± ½ small square

1

best line through points

1

(ii) 190−205 (pm)

or correct from student's line

1

[20]

10 (a) (same) number of protons

same atomic number is insufficient

1

(b) (i) nuclei split

*do **not** accept atom for nuclei / nucleus*

1

(ii) (nuclear) reactor

1

(c) beta

1

any **one** from:

- atomic / proton number increases (by 1)

  accept atomic / proton number changes by 1
- number of neutrons decreases / changes by 1
- mass number does not change

  (total) number of protons and neutrons does not change
- a neutron becomes a proton

1

(d) (average) time taken for number of nuclei to halve
or
(average) time taken for count-rate / activity to halve

1

(e) (i) 6.2 (days)

Accept 6.2 to 6.3 inclusive
*allow **1** mark for correctly calculating number remaining as 20 000*
or
*allow **1** mark for number of*
80 000 plus correct use of the graph (gives an answer of 0.8 days)

2

(ii) radiation causes ionisation

allow radiation can be ionising

1

that may then harm / kill healthy cells

accept specific examples of harm, eg alter DNA / cause cancer

1

(iii) benefit (of diagnosis / treatment) greater than risk (of radiation)

accept may be the only procedure available

1

[11]