

- M1.**
- (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

M2. (a) gravitational force(s) (1)

accept 'gravity'

balanced by (force(s) due to) radiation pressure (1)

accept equal

2

(b) by (nuclear) fusion (1)

of hydrogen to helium (other light elements) (1)

allow 'low density' for light

accept hydrogen nuclei / atoms form helium

response must clearly link one element(s) producing others

fusion to produce helium (2)

heavy element / elements heavier than iron are only produced (by fusion) in a supernova (1)

allow dense for heavy

ignore any reference to elements undergoing radioactive decay (to form other elements)

3

[5]

M3. beta

reason may score even if alpha or gamma given

1

any **two** from:

- mass number does not change **or**
total number of protons and neutrons does not change

- atomic / proton number increases by 1 **or**
number of protons increases by 1

- number of neutrons goes down by 1

allow for 2 marks a neutron splits / changes into a proton and electron / beta

candidates that answer correctly in terms of why alpha and gamma are not possible, gain both marks

2

[3]

M4. (a) (forces due to) gravity and radiation pressure 1

correct direction of forces 1

(forces) are balanced / equilibrium / equal
*accept for 3 marks an answer in terms of
sufficient hydrogen (1)
to keep fusion reaction (1)
reference to burn / burning negates this mark
going at a continuous / steady rate (1)
if fuel is used instead of hydrogen maximum of 2 marks* 1

(b) the Sun will remain stable (for several billion years) 1

based on evidence
*accept a specific example of evidence
eg that the Sun has remained stable during the life of our
planet / for 4.5 billion years
or
still contains more than 50 % hydrogen
or
by comparison with the lifecycle of (similar) stars
allow a refutation
eg not based on prejudice / whim / hearsay / folk law /
historical or religious authority* 1

[5]

M5. (a) gravitational attraction
accept 'gravity'
accept (nuclear) fusion 1

(b) radiation 'pressure' and gravity / gravitational attraction
must be in correct context 1

are balanced / in equilibrium
accept are equal and opposite
*do **not** accept 'equal'*
orthere is sufficient / a lot of hydrogen / fuel
*do **not** accept constant supply of hydrogen*

to last a very long time / for (nuclear) fusion
this mark only scores if linked to the supply of hydrogen / fuel
reference to burning negates both marks 1

(c) (i) (conversion of) hydrogen to helium
accept (conversion of) lighter elements to heavier elements 1

by (nuclear) fusion
*note do **not** credit spelling of 'fusion' which could be 'fission'*
reference to burning negates both marks 1

(ii) massive supply / lots of hydrogen 1

(d) distributed throughout the Universe / space
*do **not** accept Solar System for Universe* 1

[7]

M6. (a) a protostar is at a lower temperature
or
a protostar does not emit radiation /energy 1

as (nuclear) fusion reactions have not started
accept heat or light for energy 1

(b) by (nuclear) fusion
accept nuclei fuse (together)
nuclear fusion and fission negates this mark 1

of hydrogen to helium 1

elements heavier than iron are formed in a supernova
accept a specific example e.g. heavier elements such as gold are formed in a supernova
accept heavier elements (up to iron) formed in red giant/red super giant
reference to burning (hydrogen) negates the first 2 marks 1

[5]

- M7.** (a) (i) plutonium (239)
accept Pu / Thorium / MOX (mixed oxide)
*do **not** accept uranium-238 **or** hydrogen* 1
- (ii) (energy) used to heat water and 1
- produce (high pressure) steam 1
- the steam drives a turbine (which turns a generator) 1
- (b) Neutron(s) shown 'hitting' other U-235 nuclei
one uranium nucleus is sufficient 1
- U-235 nuclei (splitting) producing 2 or more neutrons 1
- (c) any **two** from:
- neutrons are absorbed (by boron / control rods)
 - there are fewer neutrons
 - chain reaction slows down / stops
accept fewer reactions occur

2

[8]

M8. (a) *answers must be in terms of nuclear fuels*

concentrated source of energy

idea of a small mass of fuel able to generate a lot of electricity

1

that is able to generate continuously

accept it is reliable

or can control / increase / decrease electricity generation

idea of available all of the time / not dependent on the weather

ignore reference to pollutant gases

1

the energy from (nuclear) fission

1

is used to heat water to steam to turn turbine linked to a generator

1

(b) carbon dioxide is not released (into the atmosphere)

1

but is (caught and) stored (in huge natural containers)

1

[6]

- M9.** (a) fusion
do not credit any response which looks like 'fission' 1
- of hydrogen / H (atoms)
credit only if 1st mark point scores 1
- (b) fusion of other / lighter atoms / elements
reference to big bang nullifies both marks 1
- during supernova / explosion of star(s) 1
- (c) the (available) evidence: supports this idea **or** does not contradict this
 idea **or** can be extrapolated to this idea **or** (electromagnetic) spectrum from other
 stars is similar to sun 1

[5]