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 <u>iron</u> are formed in a <u>supernova</u>

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) <u>fission</u>

1

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

1

(b) <u>carbon dioxide</u> 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]