**M1.** (a) J

*reason only scores if J is chosen*

**1**

(only) stars (about) the same / smaller size / mass as the Sun become black dwarfs

*accept smaller than the Sun*

*accept it is the smallest*

*accept (only) small stars become black dwarfs*

**1**

(b) (i) become a supernova
**or**
it will explode

*ignore subsequent correct stages*

**1**

(ii) cannot take measurements needed
**or**
do not have the technology

*do **not** accept cannot measure mass*

**1**

(iii) advances in (measuring) techniques / technology / knowledge

**1**

(c) any **five** from:

*ignore any information up to the end of the main sequence*

*Apply the list rule if more than 5 points are made*

- star expands (to become)
- a red giant

*red supergiant is incorrect*

- heavier elements are formed (by fusion)

*elements heavier than iron are formed is incorrect*

- star shrinks (to become)
- a white dwarf

*supernova, neutron star, black hole are incorrect*

- star cools / fades

- star stops emitting energy / radiation
  *star loses all energy is insufficient*

5

**[10]**

**M2.** (a)

| Particle | Relative Mass | Relative charge |
|---|---|---|
| Proton | 1 | |
| Neutron | | 0 |

*accept one, accept +1*
*do **not** accept –1*

**1**

*accept zero*
*do **not** accept no charge/ nothing/neutral unless given with 0*

**1**

(b) equal numbers/amounts of protons and electrons

**1**

protons and electrons have equal but opposite charge
*accept protons charge +1 and electron charge –1*
*accept (charge) on proton*
*cancels/balances (charge) on electron*
*accept positive (charges) cancel out the negative(charges)*
*neutrons have no charge is neutral*
*do **not** accept total charge of protons, electrons (and neutrons) is 0 unless qualified*

**1**

(c) (i) (3) fewer neutrons
*accept lower/ smaller mass number*
*do **not** accept different numbers of neutrons*
*any mention of fewer/more protons/electrons negates mark*
*accept answers in terms of U-238 providing U-238 is specifically stated i.e. U-238 has (3) more neutrons*

**1**

(ii) neutron

**1**

(iii) (nuclear) fission

*accept fision*
*do **not** accept any spelling that may be taken as fusion*

**1**

**[7]**

**M3.** *The answer to this question requires ideas in good English in a sensible order with correct use of scientific terms. Quality of written communication should be considered in crediting points in the mark scheme.*

*Maximum of **1** mark if ideas not well expressed*

any **two** from:

dust <u>and</u> gas **or** remnants of a super nova

*accept hydrogen for dust and gas*
*do **not** accept hydrogen burns*

pulled together by (force of) <u>gravity</u>

nuclear fusion starts

*although candidates may include more detail these points are essential to score the credit*

**[2]**

**M4.** (a) (i) (two) nuclei (of light elements) join

*accept hydrogen atoms for nuclei*

**1**

forming a larger / heavier nucleus / one

*accept comparative term equivalent to larger*

*accept forms a helium (nucleus / atom) this mark only scores if fusion is in terms of hydrogen atoms*

**1**

(ii) stars

*accept a named star*

*e.g. the Sun*

*accept nebula*

*mention of planets negates answer*

**1**

(b) (i) any **one** from:

- (currently) only experimental
- reaction does not last long enough
- use more energy than they produce

*allow difficult to control*

*do **not** allow inefficient on its own*

**1**

(ii) any **one** from:

- will give another source of energy
- unlimited fuel supplies / energy

*accept unlimited hydrogen*

- would not produce any radioactive waste

*accept less radioactive waste*

*accept nuclear for radioactive*

*do **not** accept toxic waste*

- want to show that it can be done

  *accept any sensible suggestion*

  *do **not** accept answers only in terms of fossil fuels or carbon dioxide*

**1**

**[5]**

**M5.** (a) (i) (nuclear) fission is the splitting of a (large atomic) nucleus

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

**1**

(nuclear) fusion is the joining of (two atomic) nuclei (to form a larger one)

*do not accept particles/atoms for nuclei*

**1**

(ii) energy

*accept heat/radiation/nuclear energy*
*accept gamma (radiation)*
*do not accept neutrons/neutrinos*

**1**

(b) (i) uranium (–235)

*accept U (–235)*
*ignore any numbers given with uranium*
*accept thorium*
*accept MOX (mixed oxide)*
*do **not** accept hydrogen*

**1**

(ii) (same) number of protons

*accept (same) atomic number*
*accept (same) positive charge*
*ignore reference to number of electrons*

**1**

**[5]**

**M6.** (a) (i) nuclear reactor

**1**

star

**1**

(ii) nuclei are joined (not split)

*accept converse in reference to nuclear fission*

*do **not** accept atoms are joined*

**1**

(b) (i) any **four** from:

- neutron
- (neutron) absorbed by U (nucleus)

  *ignore atom*
  *do **not** accept reacts*
  *do **not** accept added to*
- forms a larger nucleus
- (this larger nucleus is) unstable
- (larger nucleus) splits into two (smaller) nuclei / into Ba and Kr
- releasing three neutrons and energy

  *accept fast-moving for energy*

**4**

(ii) 56 (Ba)

**1**

57 (La)

*if proton number of Ba is incorrect allow **1** mark if that of La is 1 greater*

**1**

$^{0}_{-1}\beta$

*accept e for β*

$^{139}_{56}Ba \longrightarrow {}^{139}_{57}La + {}^{0}_{-1}\beta$

*scores **3** marks*

**1**

**[10]**

**M7.**(a) forces (within the star) are balanced

*if specific forces are mentioned they must be appropriate*

**1**

(b) (i) bigger the mass (of the star) the shorter the 'main sequence' period

*accept bigger the star the shorter the time*

**1**

(ii) any **one** from:

- insufficient evidence
- do not know (exact) amount of hydrogen in star

  *accept do not know (exact) mass of star*
- time too long (to measure directly)
- may be other factors (not yet known) that determine length of 'main sequence' period
- values are based on theory / calculation

**1**

(iii) faster than

**1**

larger stars have a shorter 'main sequence' period so they must have the faster (rate of) nuclear fusion

*there must be a link between shorter 'main sequence' and nuclear fusion, this may be implied from the first marking point*

**1**

the end of 'main sequence' happens as the hydrogen in (the core of) a star is used up

**or**

(since) they use up hydrogen at a faster (rate)

*accept more massive stars (are brighter so) release energy faster*

**1**

(c) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information in the Marking guidance, and apply a 'best-fit' approach to the marking.

**0 marks** No relevant content.

**Level 1 (1-2 marks)** There is a basic description of what happens to a star much larger than the Sun after the 'main sequence' period. **OR** Two stages are correctly named and are in the correct sequence.

**Level 2 (3-4 marks)** There is a clear description of what happens to a star much larger than the Sun after the 'main sequence' period. **AND** At least two stages are correctly named and are in the correct sequence.

**Level 3 (5-6 marks)** There is a detailed description of what happens to a star much larger than the Sun after the 'main sequence' period. **AND** At least three stages are named, in the correct sequence. There are no additional incorrect stages given.

**Examples of the points made in the response:**

***extra information***

- (the core of the) star runs out of hydrogen
- (the star) expands (to form)
- (the star) cools (to form)
    - *the core shrinks*
    - *helium starts to fuse to form other elements*
- a red supergiant

  *accept super red giant*
  *do **not** accept red giant*

    - (outer layers) explode
        - *fusion of lighter elements to form heavier elements (up to iron)*
- as a supernova
    - elements heavier than iron are formed

      *accept heaviest elements are formed*

    - core shrinks
- becoming a neutron star
    - if mass large enough (core collapses)

- (to form) a black hole

*if a correct description and sequence for a star the same size as the Sun and much bigger than the Sun given without clearly indicating which is which is limited to Level 2*

**6**

**[12]**