M1. (a) (i) the bigger the <u>masses</u> (of the dust and gases then) the bigger the force / gravity (between them)

accept the converse

1

(ii) the greater the distance (between the dust and gases then) the smaller the force / gravity (between them)

accept the converse

1

(b) <u>radiation 'pressure'</u> and gravity / gravitational attraction
these are balanced / in equilibrium

1

must be in correct context
*do **not** accept are equal*

or there is sufficient / a lot of hydrogen / fuel to last a very long time

second mark consequent on first

1

(c) any **two** from:

- hydrogen runs out / is used up
- nuclei larger than helium nuclei formed

  *accept bigger atoms are formed however do **not** accept any specific mention of an atom with a mass greater than that of iron*
- (star expands to) / become(s) a <u>red giant</u>

2

[6]

M2. (i) from a (giant) cloud of gas or hydrogen

1

condensed **or** pulled into a smaller volume by gravity

1

(ii) any three from:

- fusion decreases or stops
- collapses rapidly causing the (core) temperature to rise
- (inward) gravitational forces no longer balance (outward) pressure
- expands
- and becomes a red giant
- it cools
- then becomes a white dwarf
- helium may fuse

*if the sequence is incorrect deduct [1] therefore maximum **2** marks*

3

[5]

M3. (a) fusion

accept fussion

1

energy producing process

accept heat and/or light for energy

accept fussion

1

(b) up to **2** points from:

***3** marks for 3 points in sequence with no contradiction*

- expands

***2** marks for 2 points in sequence with no contradiction*

- cools
- forms a red giant

***1** mark for a correct point which is not contradicted*

up to **2** points from:

*do **not** accept 'it turns red'*

- contracts
- increases in temperature
- forms a white dwarf

ignore further reference to black dwarfs, black holes, nebulae, supernovae

3

[5]

M4. (a) converted into helium

accept helium created
accept converted into heavier elements
accept used up in nuclear fusion / to produce energy
*do **not** accept any reference to burning*

1

(b) turns / expands into a red giant

contradictions negate mark

1

contracts **and** explodes **or** becomes a supernova

1

may form a (dense) neutron star **or** (if enough mass shrinks to) form a black hole

accept forms a neutron star and (then) a black hole

1

Quality of written communication

correct points must be in sequence

1

(c) (i) supernova **or** remains of an earlier star

ignore super nebula

1

(ii) younger **or** not formed at the time of the Big Bang

1

[7]

M5. (a) any **two** from:

- nuclei / atoms of light elements fuse
  accept hydrogen or helium for light elements
  accept join for fuse
  *accept for **1** mark, by nuclear fusion*
  answers about fission negates a mark
- each (fusion) reaction releases energy / heat / light
- lots of reactions occur

2

(b) presence of nuclei of the heaviest / heavy / heavier elements
accept atom for nuclei

1

(c) (i) (matter / mass) with such a high density / strong gravitational (field)

1

electromagnetic radiation / light is pulled in
accept nothing can escape
*do **not** accept answers in terms of an empty void*

1

(ii) X-rays
accept e-m radiation / e-m waves

1

[6]

M6. (a) runs out of hydrogen (in its core)

accept nuclear fusion slows down

*do **not** accept fuel for hydrogen*

*do **not** accept nuclear fusion stops*

ignore reference to radiation pressure / unbalanced forces

1

(b) temperature decreases / (relative)luminosity increases as it changes to a redgiant

if both temperature and luminosity are given both must be correct

1

temperature increases / (relative) luminosity decreases as it changes to awhite dwarf

if both temperature and luminosity are given both must be correct

1

correct change in temperature **and** (relative) luminosity as Sun changes to ared giant and then to a white dwarf

*an answer changes to a red giant and then white dwarf with no mention or an incorrect mention of temperature or (relative) luminosity change gains **1** mark only if no other marks awarded*

ignore correct or incorrect stages given beyond white dwarf

1

[4]

M7. (a) fusion (1)

of hydrogen/H (atoms)(1)

*do **not** credit any response which looks like 'fission' **or** the 'word' 'fussion'*

credit only if a nuclear reaction

2

(b) fusion of other/lighter atoms/elements (1)

reference to big bang nullifies both marks

during super nova/explosion of star(s) (1)

2

(c) explosion of star(s)/super nova (1)

reference to big bang nullifies both marks reference to the star running out of energy/material nullifies both marks

at the end of the 'life' of star(s) / when they 'die' (1)

2

[6]

M8. (a) (enough) <u>dust and gas</u> (from space)

accept nebula for dust and gas

accept hydrogen for gas
mention of air negates this mark

1

pulled together by:

- gravitational attraction
  or
- gravitational forces
  or
- gravity

1

(b) forces (in the star) are balanced

accept equal and opposite for balanced
accept in equilibrium for balanced

1

forces identified as gravity and radiation pressure

both forces are required
*gravitational forces inwards balance / equal radiation pressure outwards for **2** marks*
*accept for **2** marks an answer in terms of sufficient hydrogen to keep the fusion reactions going*
*accept for **1** mark an answer in terms of sufficient fuel to keep the fusion reactions going*

1

(c) (explodes as) a supernova

1

any **one** from:

- outer layer(s) thrown into space
  *do **not** accept just 'thrown into space'*
- scatters dust and gas into space (for the formation of new stars)
  *do **not** accept just 'dust and gas'*
- elements distributed throughout space

*do **not** accept just 'distributed'*

- matter left behind / core may form a neutron star
  *do **not** accept just 'neutron star'*

- a black hole will form if the gravitational forces are enormous / sufficient mass is left behind
  *do **not** accept just 'black hole'*
  *do **not** accept any references to 'dark bodies' or 'black dwarfs'*
  black hole forms if star is large enough is insufficient

1

[6]

M9. (a) gravitational force(s) (1)

accept 'gravity'

balanced by (force(s) due to) <u>radiation</u> pressure (1)

accept equal

2

(b) by (nuclear) <u>fusion</u> (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 <u>supernova</u> (1)

allow dense for heavy

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

3

[5]

M10. (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]