



Mark schemes

- 1** (a) (enough) dust / gas (from space) 1
- are pulled together 1
- by gravitational attraction 1
- (b) fusion 1
- accept fusion circled in box*
- (c) forces within it are balanced 1
- (d)
- ```

graph TD
    A[red giant] --> B[white dwarf]
    B --> C[black dwarf]
    
```
- correct order only* 1
- ignore reference to planetary nebula* 1
- [8]**
- 2** (a) main sequence star 1
- correct order only*
- supernova 1
- (b) balanced by 1
- [3]**

- 3** (a) gravitational attraction (between the satellite and the Earth)  
*allow gravity*  
*allow weight of the satellite* 1
- (b) any **two** from:  
 • mass of satellite  
 • speed / velocity (of satellite)  
 • radius of orbit / circle  
*allow height above the Earth*  
*radius / height alone is insufficient* 2
- (c) (i) increasing the height (above the Earth's surface) increases the time (for one orbit)  
*allow a positive correlation*  
*allow as one gets bigger, the other gets bigger, or vice versa*  
*ignore they are directly proportional* 1
- (ii) there is no relationship / correlation 1
- (d) Isaac Newton was a respected scientist who had made new discoveries before 1
- [6]**
- 4** red supergiant  
*do **not** accept red giant* 1
- supernova 1
- black hole 1
- [3]**
- 5** (a) all correct  
**M**  
**L**  
**L**  
*allow 1 mark for one correct* 2
- (b) speed  
*accept 'velocity'* 1

- (c) (i) any **one** from:
- it's natural
  - slowest
  - furthest (from the centre of the Earth)  
*accept 'others are artificial / made by humans'*
- (ii) as the (average) distance decreases the speed increases  
*accept 'there is a negative correlation (between them)'*  
*do **not** accept 'they are inversely proportional'*

1

1

**[5]****6**

- (a) Earth  
Sun  
Milky Way  
Universe  
*all four in correct order*  
*allow **1** mark for Earth and Universe in correct places*

2

- (b) equal to

1

- (c) (i) explosion (of a star)  
*ignore implosion*

1

- (ii) only very massive stars become supernova

1

Mira large enough but sun too small  
*allow **1** mark for each statement*  
*Sun too small to give a supernova*  
**or**  
*Mira large enough to give a supernova*

1

**[6]****7**

- (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]

8

(a) (i) towards the centre of the circle

*accept inwards*

*accept a correct description*

*'along the string' is insufficient*

1

(ii) tension (in the string)

*accept pull of the string*

*'the string' is insufficient*

**or**

weight (on the end of the string)

*'the student' is insufficient*

*'turning action' is insufficient*

1

(b) (i) each may (also) affect the speed

*accept results for speed*

1

so only one independent variable

*accept only one variable affects dependent variable*

*'fair test' is insufficient*

*'they are control variables' is insufficient*

1

(ii) continuous  
*both required*  
 dependent 1

(iii) reduces (absolute) timing error (for one rotation)  
*accept too fast to time one*  
**or**  
 increases / improves reliability / accuracy (for one rotation)  
*ignore checking for anomalous results*  
*to work out an average is insufficient* 1

(c) speed increases with centripetal force  
*accept positive correlation*  
*do **not** accept proportional* 1

(d) (i) gravitational pull (of the Earth)  
*accept gravity* 1

(ii) **No**  
*both parts required – however this may have been subsumed within the reason*  
 geostationary orbits once every 24 hours  
*accept a correct comparative description* 1

[9]

9

(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 red giant  
*if both temperature and luminosity are given both must be correct* 1

temperature increases / (relative) luminosity decreases as it changes to a white dwarf  
*if both temperature and luminosity are given both must be correct* 1

correct change in temperature **and** (relative) luminosity as Sun changes to a red 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]****10**

red supergiant

1

supernova

1

black hole

1

**[3]****11**

(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]**

12

- (a) (enough) dust and gas (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]****13**

- (a) (i) gases (1)  
gravity (1)  
*correct order essential for credit*

2

(ii) fusion

1

(iii) billions

1

(b) Milky Way

*u.c. initials not essential*

1

**[5]****14**

(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]**

**15**

- (a) gravitational  
*accept gravity  
 do **not** accept weight* 1
- (b) (i) planet(s)  
*accept comet(s)  
 accept asteroid(s)  
 do **not** accept moon(s)* 1
- (ii) balanced  
*accept equal / the same / are in equilibrium* 1
- (iii) Milky Way  
*accept milky way* 1
- [4]**

**16**

- (a) (i) the bigger the masses (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) radiation 'pressure' 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 red giant

2

**[6]****17**

- (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]****18**

giant

1

supernova

1

neutron

1

**[3]****19**

- (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]**

**20**

- (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]**

**21**

- (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]

22

(a) gravitational attraction

*for 1 mark*

1

(b) gravitational (in);  
high internal temperature generates force (out)

*for 1 mark each*

2

(c) star expands;  
to form red giant;  
then contracts/collapses;  
to form white dwarf/neutron star/black hole/pulsar;  
they may explode/become supernova

*any four for 1 mark each*

4

(d) engulfed by red giant/blown up by star/hit by debris from star; sucked into black hole

*for 1 mark*

1

[8]

**23**

formed from dust or gas (unless in atmosphere) which is pulled together by gravitational forces high temperature inside

**[2]****24**

- (i) the nuclei  
of hydrogen/smaller atoms  
join to make helium/larger atoms

*for 1 mark each*

3

- (ii) the mass of the large nucleus (atom) is less than the mass of the smaller nuclei (atoms)

*for 1 mark*

mass loss converted into energy or small mass loss given a large amount of energy

*for 1 mark*

2

**[5]****25**

- (a) the Sun is subject to two balancing forces / 2 forces in equilibrium  
the forces are: gravity making it contract **or** inward force due to gravity  
and a force due to temperature / heat / energy / radiation pressure making it  
expand **or** outward force due to temperature / heat / energy / radiation pressure

*for 1 mark each*

3

- (b) Read all the answer first. Stop after 6 marks.

hydrogen / fuel used up owtte the star will expand and become a red giant  
it will contract under gravity become a white dwarf  
it may explode and become a supernova throwing dust and gas into space  
leaving a dense neutron star / black hole

*(no mark for contradiction)*

*any six for 1 mark each*

6

**[9]**

**26**any **three** from*max 2 if stages but no explanation*

- the star (Sun) expands because  
(inward) gravitational forces no longer balance (outward) force  
*accept the star collapses rapidly causing the core temperature to increase and the star to expand*  
*accept it expands because the forces are unbalanced*
- to become a red giant
- when the fusion stops it contracts / cools  
*accept (when hydrogen is used up) it collapses under gravity*  
*accept when fusion stops it contracts and explodes*
- to become a white dwarf  
*accept to become a supernova / pulsar / neutron star / black hole*  
*(only if red giant has exploded)*

**[3]****27**(a) (i) any **two** from

(matter from) exploded star / supernova

matter so dense / gravity so strong

that electromagnetic radiation / light cannot escape from it

2

(ii) X-rays emitted

1

when gases or matter released from nearby stars spiral into it

1

(b) fusion (of nuclei)

1

of lighter elements / hydrogen helium

1

**[6]**

**28**

Quality of written communication: One mark for using correct scientific sequence :  
gravity → fusion → balance

1

any **four** from

- (dust and gas) pulled together by gravity
- (star formed when) it is hot enough  
*accept (as mass is pulled together) it gets very hot*
- hydrogen (and helium) nuclei fuse
- (these nuclear fusion reactions) release the energy / heat / light  
(which is radiated by stars)
- energy causes expansion
- gravitational pull is balanced by the expansion (force)

4

**[5]****29**

(a) materials produced when earlier stars  
exploded

*accept the Sun is a second generation star*  
*accept formed from nebulae*

1

(b) **Quality of written communication:**

1 mark for correct sequencing balanced forces → expansion → contraction / explosion

1

any **five** from

gravity pulling matter together

*accept idea that a star is very massive so its force of gravity is very strong*

high temperatures that create expansion forces

*nuclear fusion releases energy that causes the very high temperatures*

these forces balance

star expands greatly

since expansion is greater than gravity

*accept fuel runs out*

forms a red giant

*give no further marks if red giant → white dwarf, red dwarf etc*

collapses inwards and explodes outwards

called a supernova

neutron star may form

leaves a small, dense object (a black hole)

*accept nothing can escape from it*

5

[7]

30

any **one** of

\* between (stage) 2 and (stage) 3

\* (in) the main sequence

\* (in) the main stable period

\* (it is a) yellow dwarf

[1]

**31**

- (a) *evidence of conclusion*  $4 \times 1.007825$  **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]****32**

- (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*

$2.1 \times 10^3$

*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**  $6.3 \times 10^{11}$  (*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<sup>2</sup>*

*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]

33

ideas that

- formed from dust/gases
- pulled together by gravity
- massive so very large gravitational forces (pulling inwards)
- hydrogen → helium / fusion releases energy [not fission or just 'nuclear']
- high temperature creates high pressure (pushing outwards)
- long period when forces balance
- then expands → red giant / red star
- then contracts to (dense) white dwarf / white star

*[credit if massive enough / more massive than sun, red giant → supernova → (very dense) neutron star but do not accept w.r.t. Sun itself]*

*[The whole of the (non bracketed part of) each idea must be present in some appropriate for in of words for each mark to be credited. To gain more than a single mark ideas must also be in correct sequence and/or appropriately related.]*

*any six 1 mark each*

[6]