

Mark schemes

1

(a) any **one** from:

- Earth is at the centre (not the Sun)
- there are fewer planets
accept there is no asteroid belt shown
accept there are only 5 planets (and not 8)
accept other planets have no moons shown

1

(b) Shows the moon in orbit around the Earth

accept the planets have circular orbits

1

(c) circular

accept elliptical

1

(d) gravity

1

(e) Mira is much more massive

1

[5]

2

(a) gas

correct order only

1

gravity

1

protostar

accept correct word circled in box provided no answer given in answer space

1

(b) the explosion of a massive star

1

(c) The telescopes and measuring instruments were not sensitive enough.

1

[5]

3

- (a) (i) (enough) dust and gas (from space) is pulled together

accept nebula for dust and gas

accept hydrogen for gas

accept gas on its own

dust on its own is insufficient

mention of air negates this mark

1

by:

gravitational attraction

or

gravitational forces

or

gravitaty

ignore any (correct) stages beyond this

1

- (ii) joining of two (atomic) nuclei (to form a larger one)

do not accept atoms for nuclei

1

- (iii) more sensitive astronomical instruments / telescopes

or

infrared telescopes developed

accept better technology

more knowledge is insufficient

1

- (b) (i) (other) planets / solar systems

do not accept galaxy

moons is insufficient

1

- (ii) provided evidence to support theory

accept proves the theory

1

- (c) elements heavier than iron are formed only when a (massive) star explodes

accept materials for elements

accept supernova for star explodes

accept stars can only fuse elements up to (and including) iron

1

[7]

- 4**
- (a) hydrogen 1
 - (b) supernova 1
 - (c) red super giant 1
 - (d) any **four** from:
 - fusion takes place within stars
 - hydrogen formed into helium
 - fusion continued and formed larger elements
 - elements heavier than iron were formed in supernova
 - (heavy) elements were scattered by the supernova explosion.

accept light elements formed

4
- [7]**

- 5**
- (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)


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graph TD
    A[red giant] --- B[white dwarf]
    B --- C[black dwarf]
          
```

correct order only

ignore reference to planetary nebula

1
- [8]**

6	(a) main sequence star <i>correct order only</i>	1
	supernova	1
	(b) balanced by	1
		[3]
7	(a) gravitational attraction (between the satellite and the Earth) <i>allow gravity</i> <i>allow weight of the satellite</i>	1
	(b) any two from: <ul style="list-style-type: none"> • mass of satellite • speed / velocity (of satellite) • radius of orbit / circle <i>allow height above the Earth</i> <i>radius / height alone is insufficient</i>	2
	(c) (i) increasing the height (above the Earth's surface) increases the time (for one orbit) <i>allow a positive correlation</i> <i>allow as one gets bigger, the other gets bigger, or vice versa</i> <i>ignore they are directly proportional</i>	1
	(ii) there is no relationship / correlation	1
	(d) Isaac Newton was a respected scientist who had made new discoveries before	1
		[6]
8	red supergiant <i>do not accept red giant</i>	1
	supernova	1
	black hole	1
		[3]

9

- (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'

1

- (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

[5]

10

- (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]

11

- (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]

12

- (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]

13

- (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]

14

red supergiant

1

supernova

1

black hole

1

[3]

15

(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]

16

- (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]

17

- (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]

18

- (a) fusion (1)
of hydrogen/H (atoms)(1)
do not credit any response which looks like 'fission' or the 'word' 'fusion'
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]

19

- (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]

20

- (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]

21

(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]

22

giant

1

supernova

1

neutron

1

[3]

23

(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]

24

(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]

25

(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]

26	<p>(a) gravitational attraction <i>for 1 mark</i></p>	1	
	<p>(b) gravitational (in); high internal temperature generates force (out) <i>for 1 mark each</i></p>	2	
	<p>(c) star expands; to form red giant; then contracts/collapses; to form white dwarf/neutron star/black hole/pulsar; they may explode/become supernova <i>any four for 1 mark each</i></p>	4	
	<p>(d) engulfed by red giant/blown up by star/hit by debris from star; sucked into black hole <i>for 1 mark</i></p>	1	[8]
27	<p>formed from dust or gas (unless in atmosphere) which is pulled together by gravitational forces high temperature inside</p>		[2]
28	<p>(i) the nuclei of hydrogen/smaller atoms join to make helium/larger atoms <i>for 1 mark each</i></p>	3	
	<p>(ii) the mass of the large nucleus (atom) is less than the mass of the smaller nuclei (atoms) <i>for 1 mark</i></p> <p>mass loss converted into energy or small mass loss given a large amount of energy <i>for 1 mark</i></p>	2	[5]
29	<p>(a) the Sun is subject to two <u>balancing</u> forces / 2 forces in equilibrium the forces are: <u>gravity</u> making it contract or inward force due to gravity <u>and a force due to temperature / heat / energy / radiation pressure</u> making it expand or outward force due to temperature / heat / energy / radiation pressure <i>for 1 mark each</i></p>	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]

30

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]

31

(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]

32

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]

33

(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]

34

any **one** of

- * between (stage) 2 and (stage) 3
- * (in) the main sequence
- * (in) the main stable period
- * (it is a) yellow dwarf

[1]

35

(a) *evidence of conclusion* 4×1.007825 **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]

36

- (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

2.1×10^3

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 6.3×10^{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 mass²*

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]

37

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 form 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]