

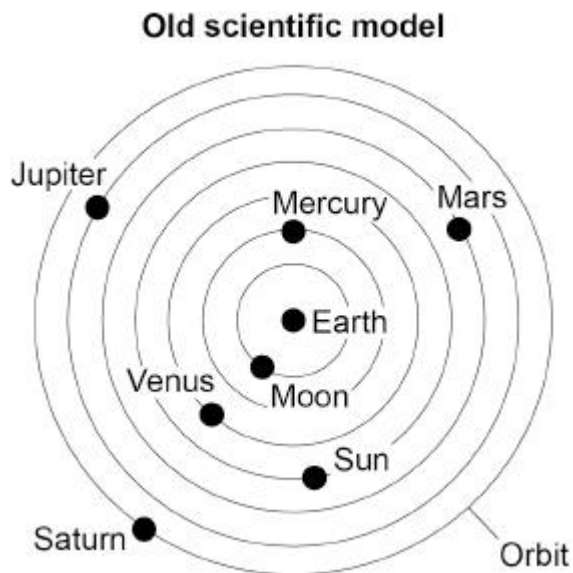
Space (Triple Only)

1	Name the star of our solar system	The Sun
2	Name the 8 planets in the solar system	Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune
	What is a satellite?	An object that orbits a planet : the moon is a natural satellite of Earth, and man-made satellites orbit at different heights.
3	What is a dwarf planet?	A planetary body that has not cleared its local area of debris. If it has a moon, they orbit a centre of mass outside their own radius
4	What is the name of the galaxy that our solar system is a part of?	The Milky Way
5	What was the Sun made from?	A cloud of dust and gas (nebula) which was pulled together by gravitational attraction
6	What force causes fusion to start in the centre of a star?	Gravity
7	Why doesn't a star collapse?	The fusion reactions lead to an equilibrium between the gravitational collapse of the star and the expansion due to fusion energy / pressure
8	Describe the lifecycle of a star which is the same size as the Sun	Cloud of gas and dust (nebula) → protostar → main sequence star → Red giant → white dwarf → black dwarf
9	Describe the lifecycle of a star which is the much more massive than the Sun	Cloud of gas and dust (nebula) → protostar → main sequence star → Red super giant → supernova → either neutron star or black hole
10	What does fusion lead to the production of?	All naturally occurring elements. Elements heavier than iron are produced in supernova
11	What does a supernova cause to happen to the elements?	Distributes them throughout the universe
12	What is the name of the force that holds planets and satellites in orbit?	Gravity
13	(HT) What can happen if the velocity of an orbit changes?	The stable radius would change
14	What is red-shift?	The increase in the observed wavelength of galaxies travelling away from us. The further away the galaxies, the faster they are moving and the bigger the observed red shift
15	What is the Big Bang theory?	The theory that the universe began from a very small region that was extremely hot and dense.
16	What do observations of space tell us?	<ul style="list-style-type: none"> • That red-shift of the light from galaxies tells us they are receding • The change of each galaxy's speed with distance is evidence of an expanding universe <ul style="list-style-type: none"> • Red-shift provides evidence of the Big Bang model • There is still much about the universe that is not understood, for example dark matter and dark energy

Q1.

Figure 1 shows an old scientific model of the solar system that has now been replaced.

Figure 1



- (a) Which statement is a reason for replacing an old scientific model with a newer scientific model?

Tick (✓) **one** box.

The old model cannot explain new observations.

☐

The old model has been used by scientists for a long time.

☐

The old model is too simple.

☐

(1)

- (b) Compare the model of the solar system used now with the old model of the solar system shown in **Figure 1**.

(4)

The table below shows data about four planets.

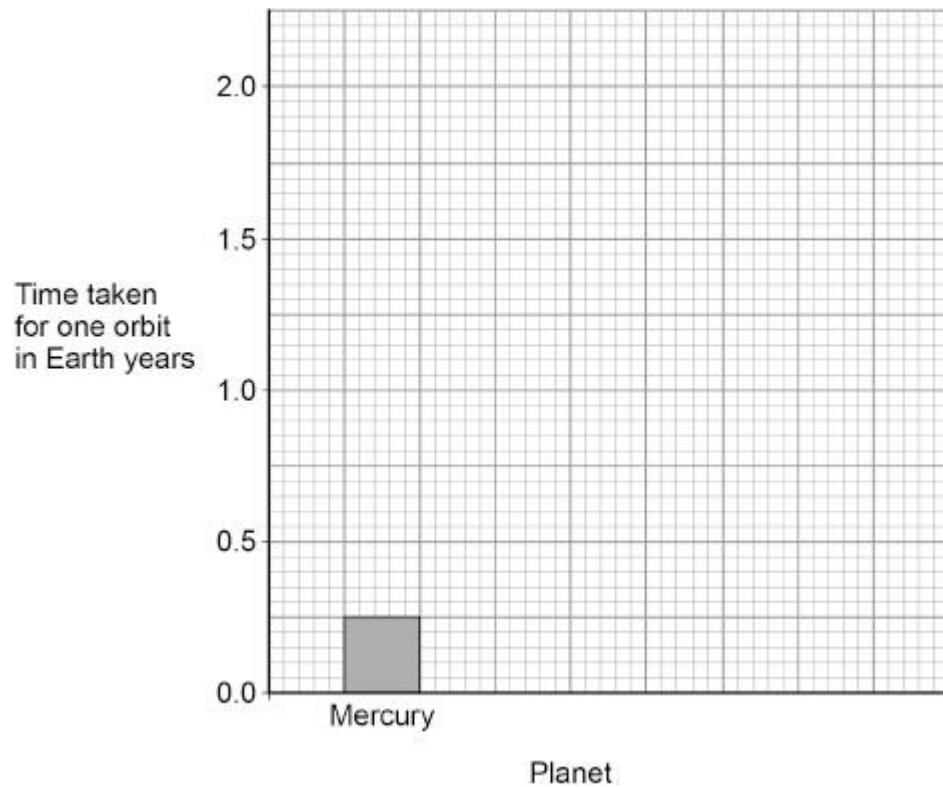
Planet	Mean distance from the Sun in millions of kilometres	Time taken for one orbit in Earth years
Mercury	58	0.25
Venus	108	0.60
Earth	150	1.00
Mars	228	1.90

- (c) How does the time taken for one orbit change as the mean distance from the Sun increases?

(1)

- (d) The bar chart in **Figure 2** shows some of the data from the table above.

Figure 2



Complete the bar chart.

Use data from the table above.

(2)

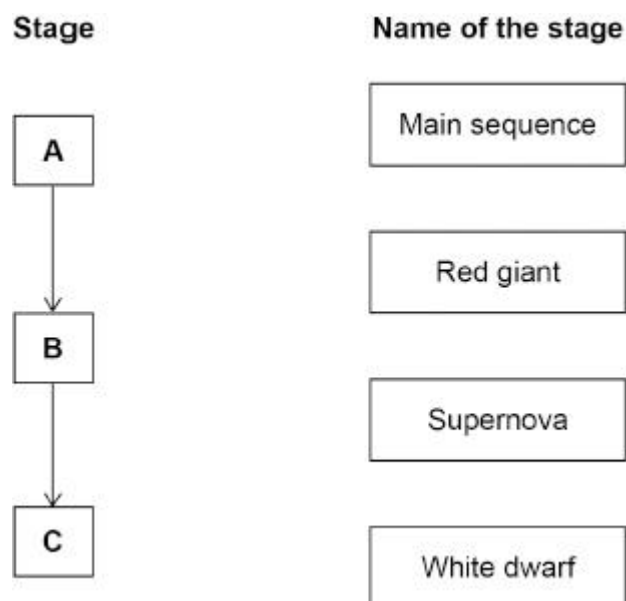
- (e) All stars have a life cycle.

A, B and **C** in **Figure 3** represent three stages in the life cycle of the Sun.

The stages are in the correct order.

Draw **one** line from each stage to the name of the stage.

Figure 3



(2)

- (f) Stars act like black bodies.

Which statement is true for perfect black bodies?

Tick (✓) **one** box.

They are good reflectors of radiation.

☐

They are the best emitters of radiation.

☐

They easily transmit radiation.

☐

(1)
(Total 11 marks)

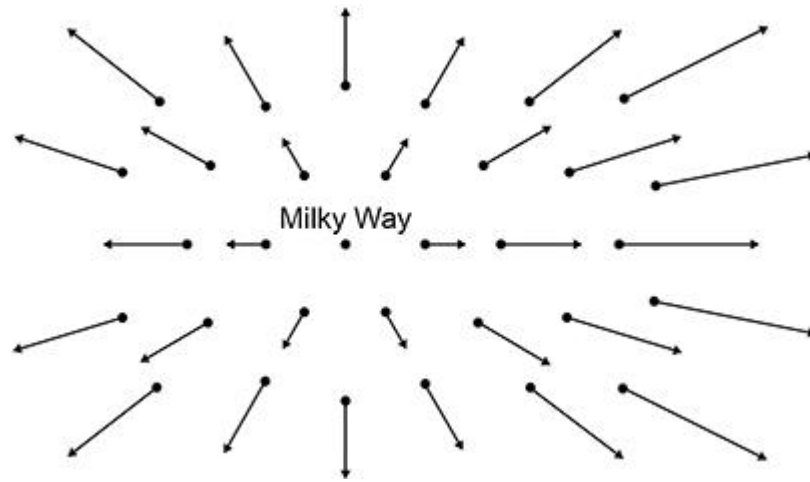
Q2.

Galaxies contain billions of stars.

- (a) Compare the formation and life cycles of stars with a similar mass to the Sun to stars with a much greater mass than the Sun.

(6)

The points on diagram below represent galaxies that are moving away from the Milky Way.



Each arrow represents the velocity of the galaxy relative to the Milky Way.

- (b) Light from all galaxies represented in diagram above is red-shifted.

Describe what is meant by red-shift.

(2)

- (c) Explain how above diagram provides evidence for the Big Bang theory.

(2)

- (d) Sometimes scientists have to change theories about the universe.

Give the reason why.

(1)

(Total 11 marks)

Q3.

- (a) Complete the sentences.

The Sun is a stable star. This is because the forces pulling inwards caused

by _____ are in equilibrium with the forces pushing outwards caused by

the energy released by nuclear _____.

(2)

- (b) Write down the equation that links distance travelled (s), speed (v) and time (t).

(1)

- (c) The mean distance between the Sun and the Earth is 1.5×10^{11} m.

Light travels at a speed of 3.0×10^8 m/s.

Calculate the time taken for light from the Sun to reach the Earth.

Time = _____ s

(3)

- (d) Some stars are much more massive than the Sun.

Describe the life cycle of stars much more massive than the Sun, including the formation of new elements.

(6)

- (e) Stars emit radiation with a range of wavelengths.

Which property of a star does the range of wavelengths depend on?

Tick (✓) **one** box.

Density

☐

Mass

☐

Temperature

☐

Volume

☐

(1)

(Total 13 marks)

Q4.

(a) **Figure 1** shows the life cycle of a very large star.

Use the correct answers from the box to complete the sentences in **Figure 1**.

main sequence star

neutron star

supernova

white dwarf

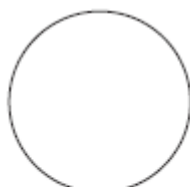
Figure 1



Gas and dust join together to become a protostar.

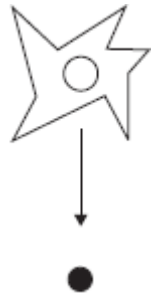


The star is stable as a _____.



The star expands to become a red super giant.





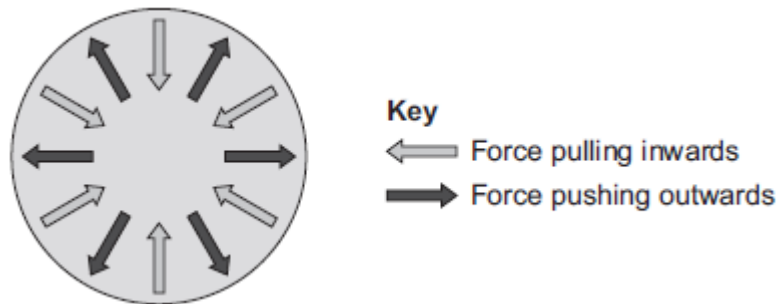
The outer layers of the star explode as a _____ .

The core of the star shrinks and a black hole is formed.

(2)

- (b) **Figure 2** shows the forces acting on a star when the star is stable.

Figure 2



Draw a ring around the correct answer to complete the sentence.

When a star is stable, the forces pushing outwards are
the forces pulling inwards.

bigger than smaller than balanced by

(1)

(Total 3 marks)

Q5.

Optical telescopes may be used to observe galaxies. Some optical telescopes are on the Earth and some are on satellites in space.

Scientists have observed that the wavelengths of the light from galaxies moving away from the Earth are longer than expected. This observation is called red-shift.

- (i) What does the size of the red-shift tell the scientists about the distance a galaxy is from the Earth?

(1)

- (ii) Complete the following passage.

Red-shift provides evidence to support the 'big bang' theory. The 'big bang' theory is

one of the ways of explaining the _____ of the Universe.

(1)

(Total 2 marks)

Q6.

The 'steady state' theory was once a popular alternative to the 'big bang' theory.

The 'steady state' theory suggested that the universe, although expanding, had no origin and it has always existed. As the universe expands, a small amount of matter is created to keep the universe looking exactly the same all of the time.

- (a) When considering the origin of the universe, what is the difference between the 'big bang' theory and the 'steady state' theory?

(2)

- (b) The light from distant galaxies shows a *red-shift*.

- (i) What is *red-shift*?

(1)

- (ii) Why does red-shift provide evidence to support both the 'big-bang' theory and the 'steady state' theory?

(2)

- (c) The 'steady state' theory was important in encouraging new research into the universe.

Suggest a reason why scientists were keen to carry out new research.

(1)

- (d) Scientists can answer many questions about the universe, but not the question:
'Why was the universe created?'

Suggest a reason why this question cannot be answered by scientists.

(1)

(Total 7 marks)

Q7.

- (a) Explain how stars produce energy.

(2)

- (b) What evidence is there to suggest that the Sun was formed from the material produced when an earlier star exploded?

(1)

- (c) It is thought that gases from the massive star Cygnus X-1 are spiralling into a black hole.



- (i) Explain what is meant by the term *black hole*.

(2)

- (ii) What is produced as the gases from a star spiral into a black hole?

(1)

(Total 6 marks)

Q8.

Studying stars gives scientists evidence about the evolution of the Universe.

- (a) (i) In astronomy, what is meant by a black hole?

(2)

- (ii) How is it possible to detect a black hole?

(2)

- (b) The changes which happen in stars result in new elements being formed.

Nuclei of the heaviest elements are found in the Sun.

Describe how these nuclei are formed.

(2)

(Total 6 marks)

Q9.

The energy radiated by a **main sequence** star like the Sun is released by a nuclear fusion reaction in its core.

Read the following information about this reaction then use it to answer the questions below.

- The net result of the nuclear fusion reaction is that four hydrogen nuclei produce one helium nucleus. There is a loss of mass of 0.7%.
- For nuclear fusion to occur nuclei must collide at very high speeds.
- The energy released during the reaction can be calculated as shown:

$$\text{energy released [J]} = \text{loss of mass [kg]} \times (\text{speed of light [m/s}^2\text{]})$$

(The speed of light is 3×10^8 m/s)

- (a) Calculate the energy released when 1g of hydrogen fuses to form helium.

(Show your working.)

(4)

- (b) The table shows the lifetimes and surface temperatures of main sequence stars with different masses.

MASS OF STAR [SUN = 1]	LIFETIME ON MAIN SEQUENCE [MILLION OF YEARS]	SURFACE TEMPERATURE * [KELVIN]
0.5	200 000	4000
1	10 000	6000
3	500	11 000
15	15	30 000

[* The higher the surface temperature of a star, the higher the temperature and pressure in its core.]

- (i) Describe the relationship between the lifetime of a main sequence star and its mass.

(2)

- (ii) Suggest an explanation for this relationship.

(3)

(Total 9 marks)

Q10.

A main sequence star in a distant galaxy is the same size and mass as the Sun.

- (a) Explain why the star is stable while it is in the main sequence stage of its life cycle.

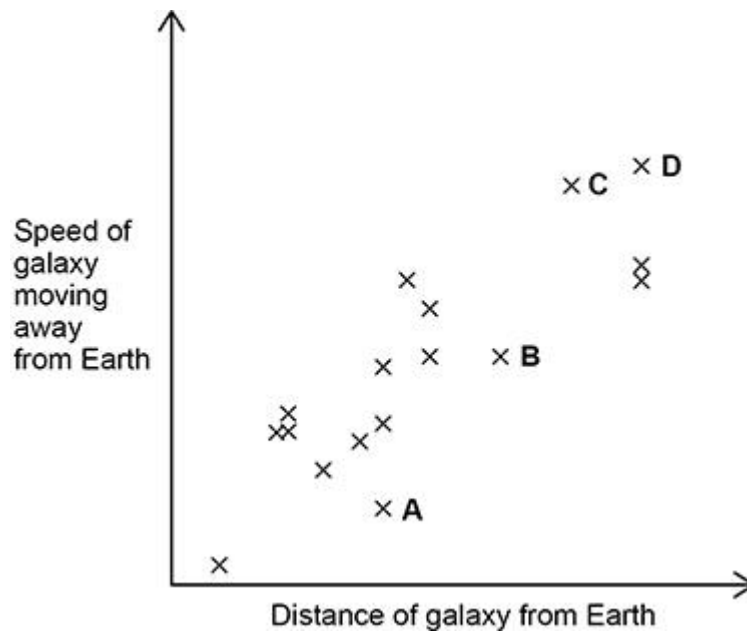
(2)

- (b) Describe what will happen to the star between the main sequence stage and the end of the star's life cycle.

You should include the names of the stages in the life cycle of the star.

(3)

- (c) The figure below shows how the speed of galaxies moving away from Earth varies with the distance of the galaxies from Earth.



Which galaxy would show the smallest observed change in the wavelength of visible light?

Give a reason for your answer.

Tick (✓) **one** box.

A ☐ B ☐ C ☐ D ☐

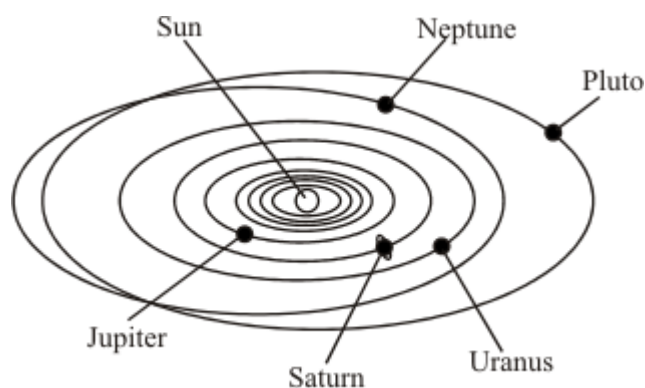
Reason _____

(2)

(Total 7 marks)

Q11.

The Sun at the centre of our solar system is a star.



- (a) The Sun contains nuclei of the heaviest elements. Atoms of these heaviest elements are also present in the planets of the solar system. What does this suggest about the material from which the solar system is formed?

Q12.

Explain, in as much detail as you can, the scientific evidence for the “big bang” theory of the origin of the Universe.

(Total 5 marks)

Q13.

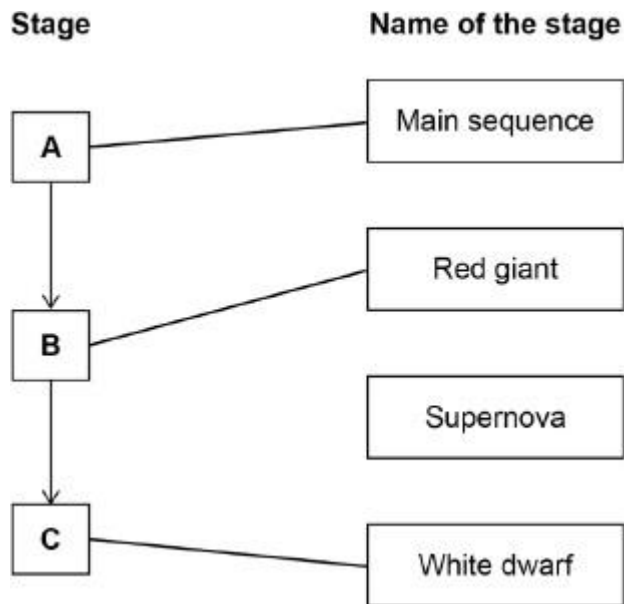
Describe, in as much detail as you can, the life history of a star like our Sun.

(Total 6 marks)

Mark schemes

Q1.

- (a) the old model cannot explain new observations 1
- (b) **Level 2:** Scientifically relevant features are identified; the way(s) in which they are similar / different is made clear and (where appropriate) the magnitude of the similarity / difference is noted. 3-4
- Level 1:** Relevant features are identified and differences noted. 1-2
- No relevant content.** 0
- Indicative content**
- Similarities**
in both models:
- the orbits of the Moon and / or planets are circular / elliptical
 - the Moon orbits the Earth
 - there is one star / Sun
- Differences**
In the current model:
- the planets orbit the Sun, whereas in the old model the planets orbit the Earth
 - there are (two) more planets
 - there are also dwarf planets, whereas no dwarf planets are shown in the old model
 - other planets have moons, whereas other planets have no moons shown in the old model
- (c) it increases 1
- (d) three bars drawn correctly
allow tolerance of half a small square 1
- three bars correctly labelled 1
- (e)



2 marks for all lines correct
1 mark for 2 lines correct

additional line from a box on the left negates the mark for that box

2

(f) they are the best emitters of radiation

1

[11]

Q2.

(a) **Level 2:** Scientifically relevant features are identified; the way(s) in which they are similar/different is made clear and (where appropriate) the magnitude of the similarity/difference is noted.

4–6

Level 1: Relevant features are identified and differences noted.

1–3

No relevant content

0

Indicative content

all stars:

- form in a cloud of gas and dust (nebula) by gravity – mostly hydrogen
- forms a protostar
- fusion begins
- fusion of small nuclei into larger nuclei (hydrogen into helium)
- main sequence star – stable period where gravitational forces (inwards) balance forces (outwards) due to fusion processes

comparisons:

- stars about the same size as the Sun expand to become a red giant, stars much bigger than the Sun expand to become a red super giant
- stars about the same size as the Sun contract (and temperature increases) to become a white dwarf, stars much bigger than the Sun explode in a supernova

- stars about the same size as the Sun (cool to) become a black dwarf, stars much bigger than the Sun become either a neutron star or black hole
- (b) the (observed) increase in wavelength (of light from galaxies)
ignore light waves are stretched 1
- as galaxies move away from us 1
- (c) the furthest galaxies are moving away (from the Milky Way) the fastest 1
- (which suggests that) at some time all galaxies / matter started at the same point 1
- (d) there are new observations / evidence that does not fit into current theory / model
allow specific examples of new observations / theories such as dark matter or dark energy 1

[11]

Q3.

- (a) (force of) gravity
do not allow weight 1
- fusion 1
- (b) distance = speed × time
allow a correct re-arrangement
- or**
- $s = vt$
do not allow $d = st$ 1
- (c) $1.5 \times 10^{11} = 3.0 \times 10^8 \times t$ 1
- $$t = \frac{1.5 \times 10^{11}}{3.0 \times 10^8}$$
 1
- $t = 500 \text{ (s)}$ 1
- (d) **Level 3:** Scientifically relevant facts, events or processes are identified and given in detail to form an accurate account. 5–6

Level 2: Scientifically relevant facts, events or processes are identified and their relevance is clear. The account is not fully accurate.

3–4

Level 1: Facts, events or processes are identified and simply stated but their relevance is not clear.

1–2

No relevant content

0

Indicative content:

- fusion (processes in stars) produce new elements
- cloud of gas / hydrogen **and** dust **OR** nebula
- pulled together by gravity
- causing increasing temperature (to start the fusion process)
- (to become a) protostar
- hydrogen nuclei fuse to form helium nuclei
- and the star becomes main sequence
- hydrogen begins to run out
- helium nuclei fuse to make heavier elements
- up to iron
- the star expands (to become a)
- red super giant
- (the star collapses rapidly) and explodes
- called a supernova
- creating elements heavier than iron
- and distributing them throughout the universe
- leaving behind a neutron star
- or a black hole.

(e) Temperature

1

[13]

Q4.

(a) main sequence star

correct order only

1

supernova

1

(b) balanced by

1

[3]

Q5.

(i) bigger the red-shift, further the galaxy is from the Earth

accept red-shift and distance are directly proportional

accept there is a positive correlation

1

(ii) origin / start / beginning / creation

accept expansion

1

[2]

Q6.

- (a) big bang theory – universe started at one point (then expanded) 1
- steady state theory – universe has no origin / has always existed
accept an answer in terms of mass
eg steady state theory mass is created 1
- (b) (i) wavelength (of light) increases
accept answers in terms of frequency decrease
*accept wavelength stretched but **not** wave stretched*
or wavelength / light moves to red end of spectrum
*do **not** accept galaxy moves to the red end of the spectrum*
*do **not** accept light becomes red / redder* 1
- (ii) red-shift is evidence / supports idea of expanding universe
accept prove for support 1
- both theories use the idea / accept / explain why the universe is expanding 1
- (c) to find evidence to support one or both theories
accept prove for support
accept to gain more knowledge about the universe
or to find evidence to disprove one or both theories 1
- (d) answer involves (religious) belief
accept it cannot be tested
or no / insufficient evidence 1

[7]

Q7.

- (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]

Q8.

- (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
 when gases or matter released from nearby stars spiral into it

1

1

- (b) fusion (of nuclei)
 of lighter elements / hydrogen helium

1

1

[6]

Q9.

- (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]

Q10.

- (a) gravitational force inwards and forces as a result of fusion reactions outwards
allow fusion energy for fusion reactions outwards
allow radiation pressure for fusion reactions outwards

1

are in equilibrium / balanced
dependant on scoring 1st mark point
allow for 1 mark forces are in equilibrium

1

- (b) (the star will) expand to become a red giant
the answers must be in the correct sequence to score
all 3 marks

1

(the star will) collapse to become a white dwarf
allowed outer layers ejected for collapsed

1

(the star will) cool to become a black dwarf
if no other marks score, allow red giant, white dwarf,
black dwarf in the correct order for 1 mark

1

- (c) **A**

1

it is (moving away from Earth) the slowest
or

it is the closest (to the Earth)
reason only scores if A is chosen

1

[7]

Q11.

- (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]

Q12.

ideas that: galaxies show a red-shift

gains 1 mark

but more distant galaxies show bigger red-shift

gains 2 marks

galaxies moving away/Universe expanding

gains 1 mark

but more distant galaxies moving away faster

gains 2 marks

so all Universe once in one place

for 1 further mark

(only if the previous 2 marks are also gained)

[5]

Q13.

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]