Chapter 16 Space

Name: _____

Class: _____

Date: _____

Time: **161 minutes**

Marks: **161 marks**

Comments:

1 (a) Scientists have observed that the wavelengths of the light from galaxies moving away from the Earth are longer than expected.

(i) What name is given to this observation?

.....

(1)

(ii) Draw a ring around the correct answer to complete each sentence.

This observation gives scientists evidence that

light can be stretched.
galaxies are changing colour.
the Universe is expanding.

(1)

(iii) There is a pattern linking the size of the observed increase in the wavelengths of light from a galaxy and the distance the galaxy is from the Earth.

Which **one** of the graphs, **L**, **M** or **N**, shows the correct pattern?

Write the correct answer in the box. ☐

(1)

(b) Observations help scientists answer questions about the Universe.

Scientists **cannot** answer every question.

Which **one** of the following questions **cannot** be answered by scientists?

Tick (✓) **one** box.

How old is the Universe? ☐

Why was the Universe created? ☐

How fast does light travel through the Universe? ☐

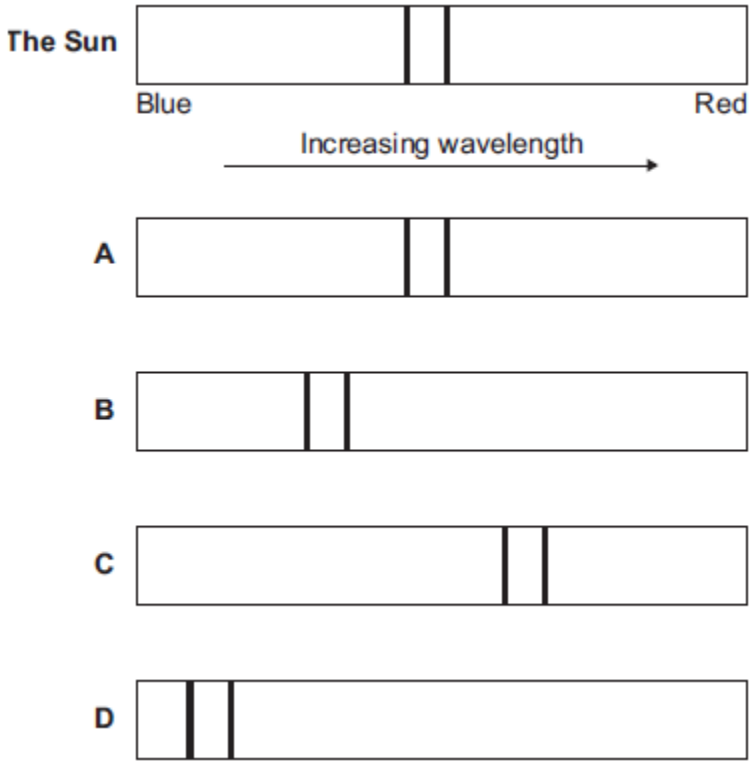
(1)

(Total 4 marks)

2 Scientists can use the visible light spectrum from distant stars to determine whether the stars are moving.

The visible light spectrum from stars includes dark lines at specific wavelengths.

(a) The diagram shows the visible light spectrum from the Sun and from four other stars, **A**, **B**, **C** and **D**.



(i) Which star, **A**, **B**, **C** or **D**, is moving away from the Earth?

(1)

(ii) How does the speed of star **B** compare with the speed of star **D**?

Tick (✓) **one** box.

	Tick (✓)
The speed of star **B** is greater than the speed of star **D**.	
The speed of star **B** is less than the speed of star **D**.	
The speed of star **B** is the same as the speed of star **D**.	

(1)

(b) A radio wave is emitted by a star.
The radio wave has a wavelength of 1500 m and a frequency of 200 000 Hz.

Calculate the speed of this radio wave.

Use the correct equation from the Physics Equations Sheet.

Choose the correct unit from the list below.

m **m / s** **m / s²**

.....

.....

.....

Speed = ... unit .....

(3)

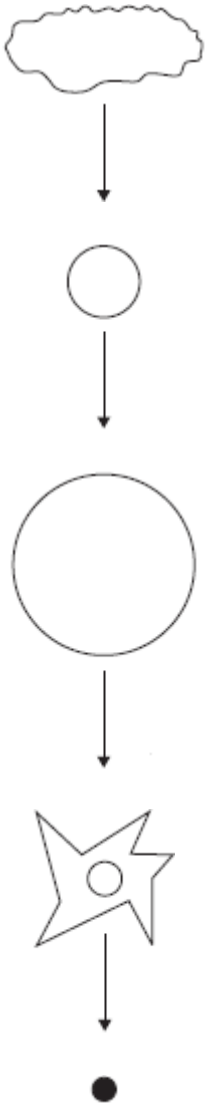
(Total 5 marks)

3 (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.

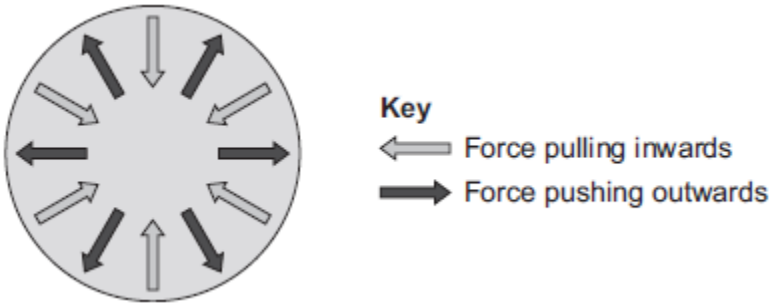
The outer layers of the star explode as a ..... .

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 [bigger than / smaller than / balanced by] the forces pulling inwards.

(1)

(Total 3 marks)

4 Starting with the smallest, list the following in order of increasing size.

Universe **Earth** **Milky Way** **Sun**

Smallest .....

.....

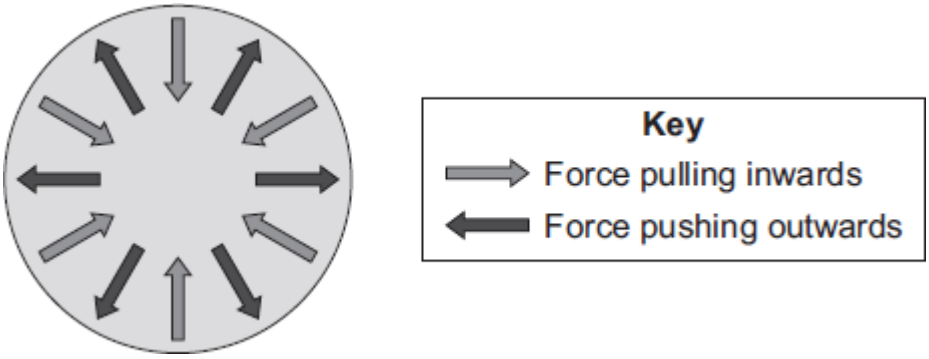
.....

Largest .....

(2)

(b) Stars pass through different stages during their life cycle.

The diagram shows the forces acting on the Sun during the stable stage of its life cycle.



Complete the following sentence by drawing a ring around the correct line in the box.

During the stable stage of the Sun's life cycle, the forces pulling inwards

are

smaller than
equal to
bigger than

the forces pushing outwards.

(1)

(c) During its life cycle, the Sun will never go through a *supernova* stage but the star Mira will.

(i) What is a *supernova?*

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(1)

(ii) Explain why the Sun will not go through the *supernova* stage but the star Mira will.

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(2)

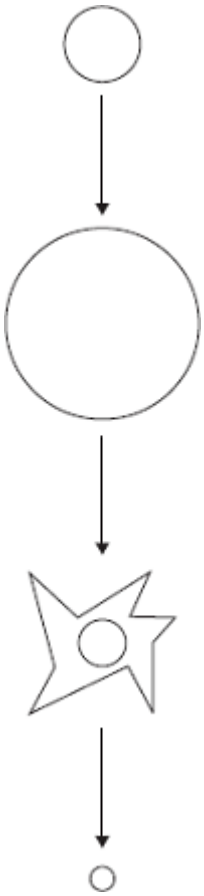
(Total 6 marks)

5 The diagram shows part of the lifecycle of a very large star.

Use words or phrases from the box to complete the sentences contained in the diagram.

black hole	**red supergiant**	**supernova**	**white dwarf**

(3)



The star is stable.

The star expands forming

a ..... .

The star collapses, the outer layers explode

as a ..... .

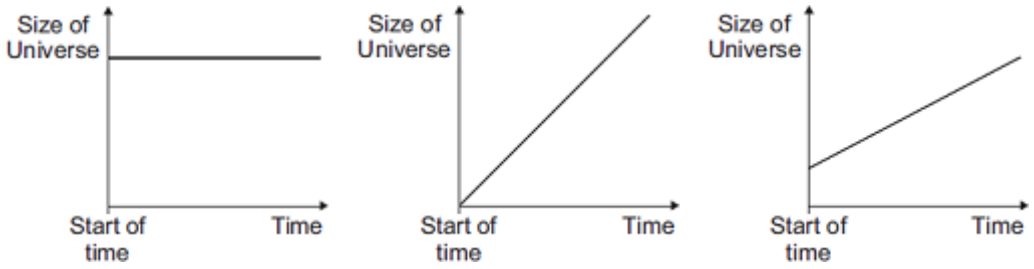
The centre collapses further and further until

it finally forms a ..... .

(Total 3 marks)

6 The ‘big bang’ theory is one theory explaining the origin of the Universe.

(a) The graphs **X**, **Y** and **Z**, show how the size of the Universe may have changed with time.



Which graph would the ‘big bang’ theory suggest is correct?

Write your answer, **X**, **Y** or **Z**, in the box. ☐

Explain the reason for your answer.

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(3)

(b) In 1948, an alternative to the ‘big bang’ theory, called the ‘steady state’ theory, was developed.
The ‘steady state’ theory suggested that the Universe, although expanding, has always existed without a beginning in time.

(i) Complete the following sentence by drawing a ring around the correct line in the box.

The measurement of red-shift in the light from distant galaxies provides evidence

to support

only the ‘big bang’ theory.
only the ‘steady state’ theory.
both the ‘big bang’ and ‘steady state’ theories.

(1)

(ii) In 1965, scientists rejected the ‘steady stat’ theory in favour of the ‘big bang’ theory.

Suggest what might cause scientists to stop supporting one theory and to start supporting an alternative theory.

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(1)

(Total 5 marks)

7 Stars go through a life cycle. About 90 % of all stars are in the ‘main sequence’ period of the life cycle.

(a) Stars are stable during the ‘main sequence’ period of the life cycle.

Why?

.....

.....

(1)

(b) The table gives an estimated time for the number of years that three stars, **X**, **Y** and **Z**, will be in the ‘main sequence’ period of their life cycle.

Star	Relative mass of the star compared to the Sun	Estimated ‘main sequence’ period in millions of years
X	0.1	4 000 000
Y	1.0	9 000
Z	40.0	200

(i) This data suggests that there is a pattern linking the mass of a star and the number of years the star is in the ‘main sequence’ period of its life cycle.

What is the pattern suggested by the data?

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(1)

(ii) Scientists cannot give the exact number of years a star will be in the 'main sequence' period.

Suggest why.

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(1)

(iii) Nuclear fusion is the process by which energy is released in stars.

Which **one** of the following can be concluded from the data in the table?

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

The rate of nuclear fusion in a large star is

faster than
the same as
slower than

in a small star.

Explain the reason for your answer.

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(3)

(c) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate*.

Describe what happens to a star **much bigger** than the Sun, once the star reaches the end of the 'main sequence' period of its life cycle.

Your answer should include the names of the stages the star passes through.

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(6)

(Total 12 marks)

8 Stars go through a life cycle.

Some stars will finish their life cycle as a black dwarf and other stars as a black hole.

(a) The table below gives the mass, relative to the Sun, of three stars, **J**, **K** and **L**.

Star	Mass of the star relative to the Sun
J	0.5
K	14.5
L	20.0

Which **one** of the stars, **J**, **K** or **L**, will become a black dwarf? .....

Give a reason for your answer.

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(2)

(b) Scientists can take the measurements needed to calculate the mass of many stars.

Scientists cannot calculate the mass of the star Betelgeuse.

They estimate that the star has a mass between 8 and 20 times the mass of the Sun.

(i) Betelgeuse is in the red super giant stage of its life cycle.

What will happen to Betelgeuse at the end of the red super giant stage?

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(1)

(ii) Suggest **one** reason why scientists can only estimate and **not** calculate the mass of Betelgeuse.

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(1)

(iii) In the future, it may become possible for scientists to calculate the mass of Betelgeuse.

Suggest **one** reason why.

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(1)

(c) Describe what happens to a star, after the main sequence period, for the star to eventually become a **black dwarf**.

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(5)

(Total 10 marks)

9 (a) In 1929, the astronomer Edwin Hubble observed that the light from galaxies that are moving away from the Earth showed a *red-shift*.

What is *red-shift* ?

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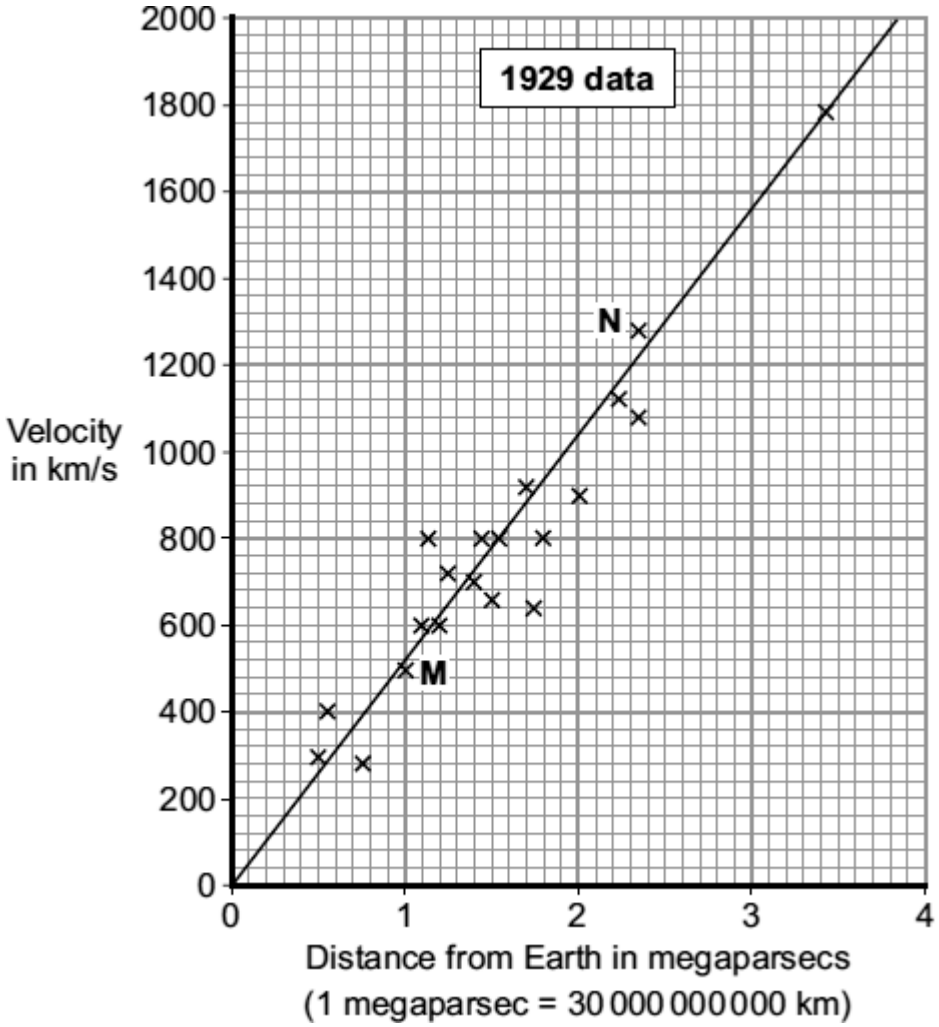
(1)

(b) By measuring the *red-shift*, Hubble was able to calculate the speed at which the galaxies are moving away from the Earth. He was also able to calculate the distance of these galaxies from the Earth.

The graph shows some of the data calculated by Hubble.



(i) The data from two galaxies, **M** and **N**, has been included in the graph. The light from galaxy **M** has a smaller *red-shift* than the light from galaxy **N**.

What does the difference in *red-shift* tell scientists about the two galaxies, **M** and **N**?

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(2)

(ii) The gradient of the line drawn on the graph gives a number known as the Hubble constant. The Hubble constant can be used to estimate when the universe began.

Use the graph to calculate the value of the Hubble constant.

Show clearly how you obtained your answer.

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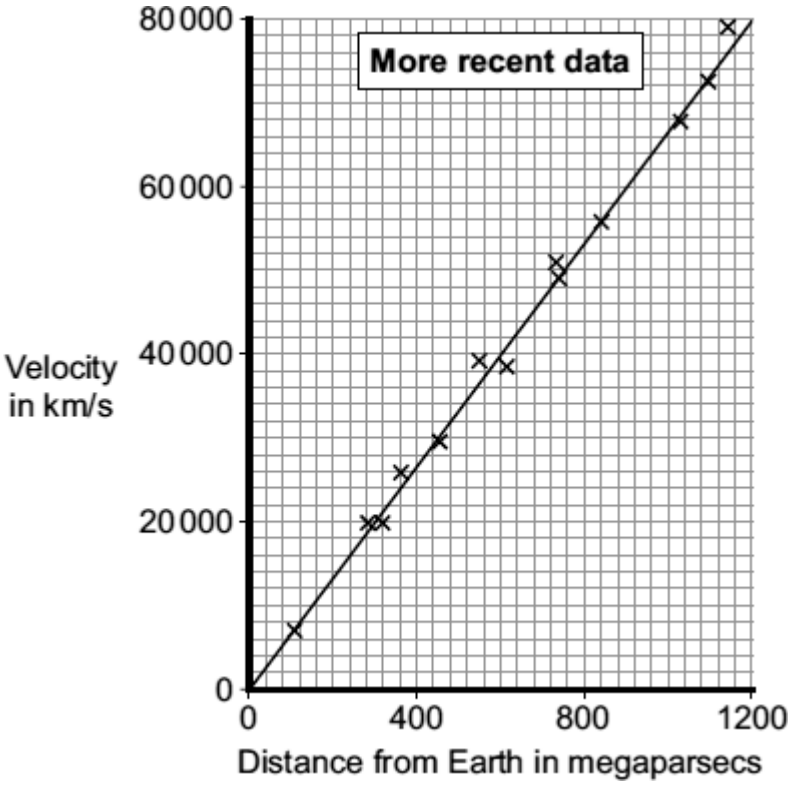
Hubble constant = ... km/s per megaparsec

(2)

(iii) More recently, data has been obtained from more distant galaxies.



The results from the more recent data give a totally different value for the Hubble constant to the one calculated from the 1929 data.

Which set of data, the 1929 or the more recent, is most likely to give the value closest to the true value for the Hubble constant?

Draw a ring around your answer.

1929 **more recent**

Give a reason for your answer.

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(1)

(c) The Andromeda galaxy is not moving away from the Earth. It is actually moving towards the Earth. This means that the light from Andromeda shows a blue-shift.

How do the wavelength and frequency of the light from Andromeda seem to have changed when viewed from the Earth?

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(2)

(Total 8 marks)

10 Every star goes through a 'life cycle'.

(a) Describe how a star forms.

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(2)

(b) During a long period of its life, a star remains in a stable state.

Explain why a star remains stable.

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(2)

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

Describe what will happen to a star, originally much more massive than the Sun, after it reaches its red giant stage.

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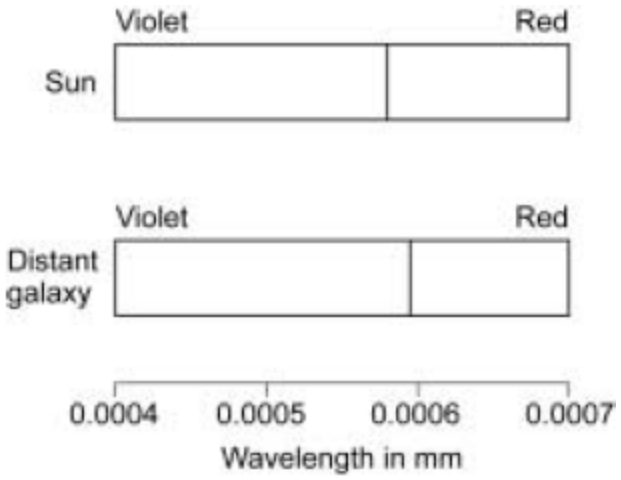
(2)

(Total 6 marks)

11 The visible part of the electromagnetic spectrum from a star includes a dark line. This line is at a specific wavelength.

The diagram shows the position of the dark line in the spectrum from the Sun and in the spectrum from a distant galaxy.



(a) Explain how the spectrum 'shift' of the dark line supports the theory that the Universe began from a very small initial point.

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(3)

(b) Name **one** other piece of evidence that supports the theory that the Universe began from a very small initial point.

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(1)

(Total 4 marks)

12 (a) The light spectrum from a distant galaxy shows a red shift.

What is meant by *red shift* and what does it tell us about distant galaxies?

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(2)

(b) What name is given to the theory that the Universe started with a massive explosion?

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(1)

(Total 3 marks)

13 Describe, in as much detail as you can:

- the evidence that the size of the observable Universe is changing;
- the evidence that, billions of years ago, all the matter in the Universe was tightly packed together in the same place.

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(Total 5 marks)

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

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

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(2)

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

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(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.

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(2)

(Total 6 marks)

15 The Big Bang theory attempts to explain the origin of the Universe.

(i) What is the Big Bang theory?

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(1)

(ii) What can be predicted from the Big Bang theory about the size of the Universe?

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(1)

(Total 2 marks)

16 Explain how observations at the red end of the spectrum of light from galaxies have led to one theory about the origin of the Universe.

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(Total 6 marks)

17 Stars do not stay the same forever.

(a) Over billions of years the amount of hydrogen in a star decreases. Why?

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(1)

(b) Describe how a massive star (at least five times bigger than the Sun) will change at the end of the main stable period.

To gain full marks in this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.

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(4)

(c) The inner planets of the solar system contain atoms of the heaviest elements.

(i) Where did these atoms come from?

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(1)

(ii) What does this tell us about the age of the solar system compared with many of the stars in the Universe?

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(1)

(Total 7 marks)

18 Read the passage.

> In the Solar System, the inner planets, such as the Earth, contain elements which are eavier than the elements hydrogen and helium.
>
> Our star, the Sun, is a medium sized star. If a star is much more massive than the Sun it will eventually swell into a red giant, start to contract, continue to contract and finally explode.

(a) What is the explosion called?

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(1)

(b) Explain why scientists believe that the Solar System was formed from the material produced when earlier stars exploded.

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(3)

(Total 4 marks)

19 The 'Big Bang' theory is one theory of the origin of the Universe.

(a) (i) Explain what is meant by the 'Big Bang' theory.

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(2)

(ii) The light arriving from distant galaxies provides scientists with evidence to support the 'Big Bang' theory.

Explain how.

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(2)

(b) At a meeting held in 2005, a group of scientists claimed that new data had been collected that showed the 'Big Bang' theory to be wrong. Other scientists said that there was no reason to doubt the 'Big Bang' theory.

What should scientists do when a theory does **not** appear to be supported by new data?

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(2)

(c) 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.

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(1)

(Total 7 marks)

20 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?

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(2)

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

(i) What is *red-shift*?

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(1)

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

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(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.

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(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.

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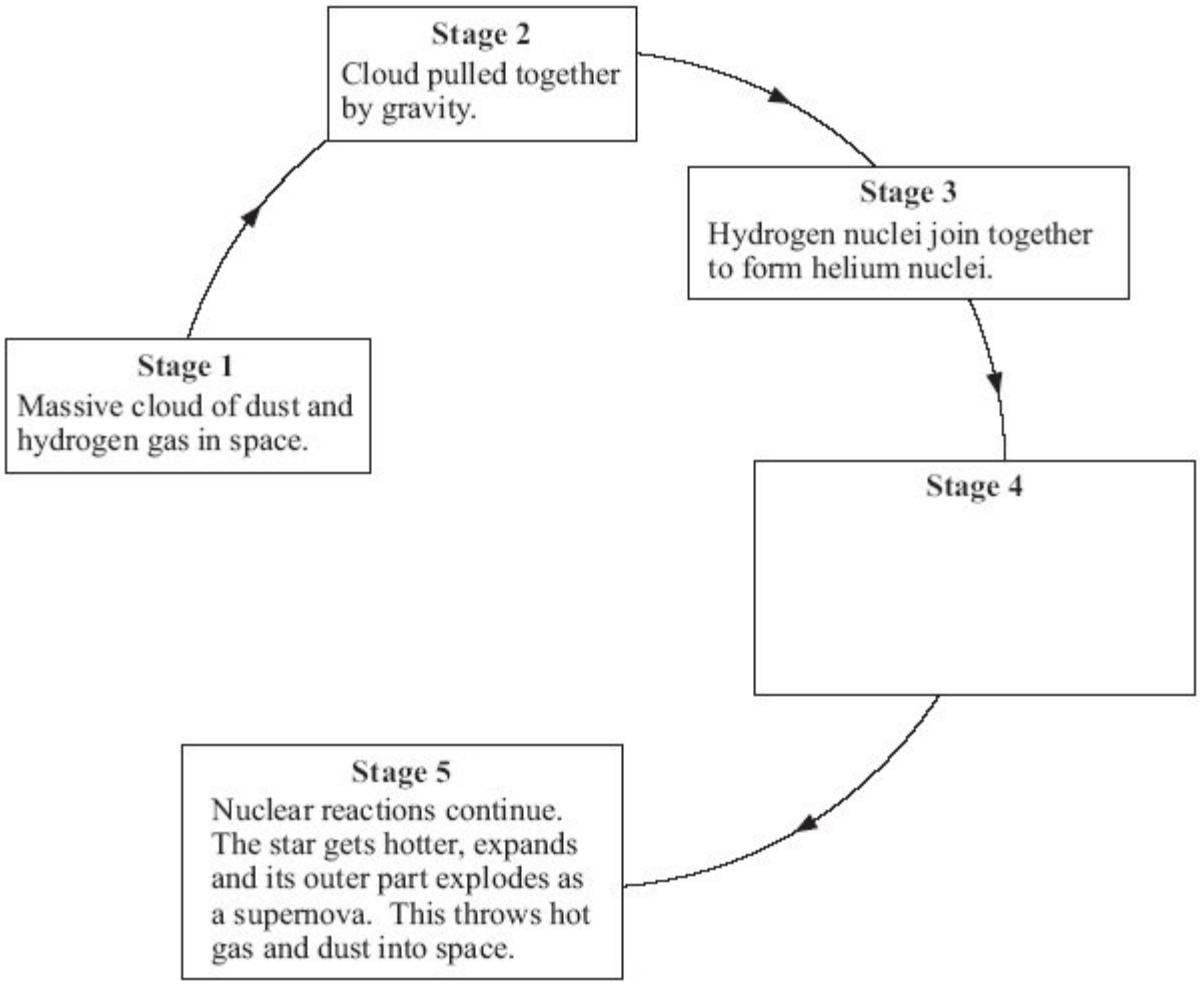
(1)

(Total 7 marks)

21 The diagram shows part of the life cycle of a star which is much bigger than the Sun.



(a) (i) What is the relationship between the masses of the dust and gas in the cloud in **Stage 2** and the force of gravity between them?

.....

.....

(1)

(ii) What is the relationship between the distance apart of the dust and gas in the cloud in **Stage 2** and the force of gravity between them?

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(1)

(b) In **Stage 3** the star remains stable for millions of years.

Explain why.

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(2)

(c) What happens in **Stage 4**?

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(2)

(Total 6 marks)

22 (a) The 'Big Bang' theory uses red-shift as evidence to explain the beginning of the Universe.

How does the red-shift from distant galaxies provide evidence for the beginning of the Universe?

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(3)

(b) Cosmic microwave background radiation (CMBR) is a type of electromagnetic radiation. CMBR fills the Universe. It was first discovered in 1965 by two astronomers called Penzias and Wilson.

(i) What do scientists believe is the origin of CMBR?

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(1)

(ii) Why was the discovery of CMBR so important to the scientists believing the 'Big Bang' theory to be correct?

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(1)

(iii) How is the wavelength of CMBR likely to change, if at all, over the next billion years?

.....

Give a reason for your answer.

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(2)

(Total 7 marks)

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

(a) How is the image produced by an optical telescope on a satellite in space better than the image produced by an optical telescope on the Earth?

.....

Give a reason for your answer.

.....

.....

(2)

(b) 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?

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(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.

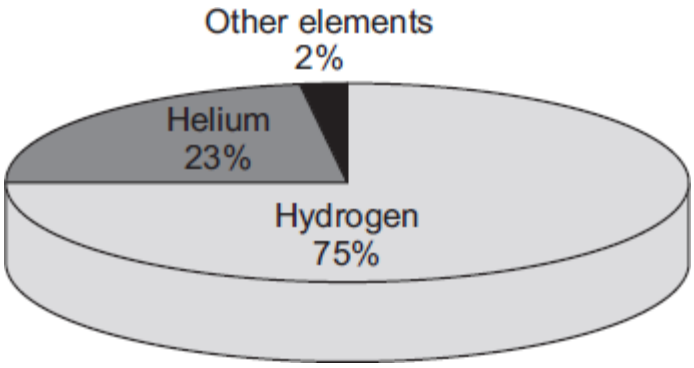
(1)

(Total 4 marks)

24 This passage is from a web page.

Our nearest star, the Sun

The pie chart shows the proportions of chemical elements in the Sun.



Most of the Sun's helium has been produced from the Sun's hydrogen by the process of nuclear fusion. This process also produces vast quantities of energy. The process takes place in the core of the Sun at a temperature of about 15 million °C and has been going on for about 4.5 billion years. During this period of time, the Sun has remained stable and scientists think that it will remain stable for several billion years into the future.

(a) Explain why the Sun remains stable.

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(3)

(b) A scientific opinion is expressed on this web page.

Identify this opinion and suggest how scientists could justify it.

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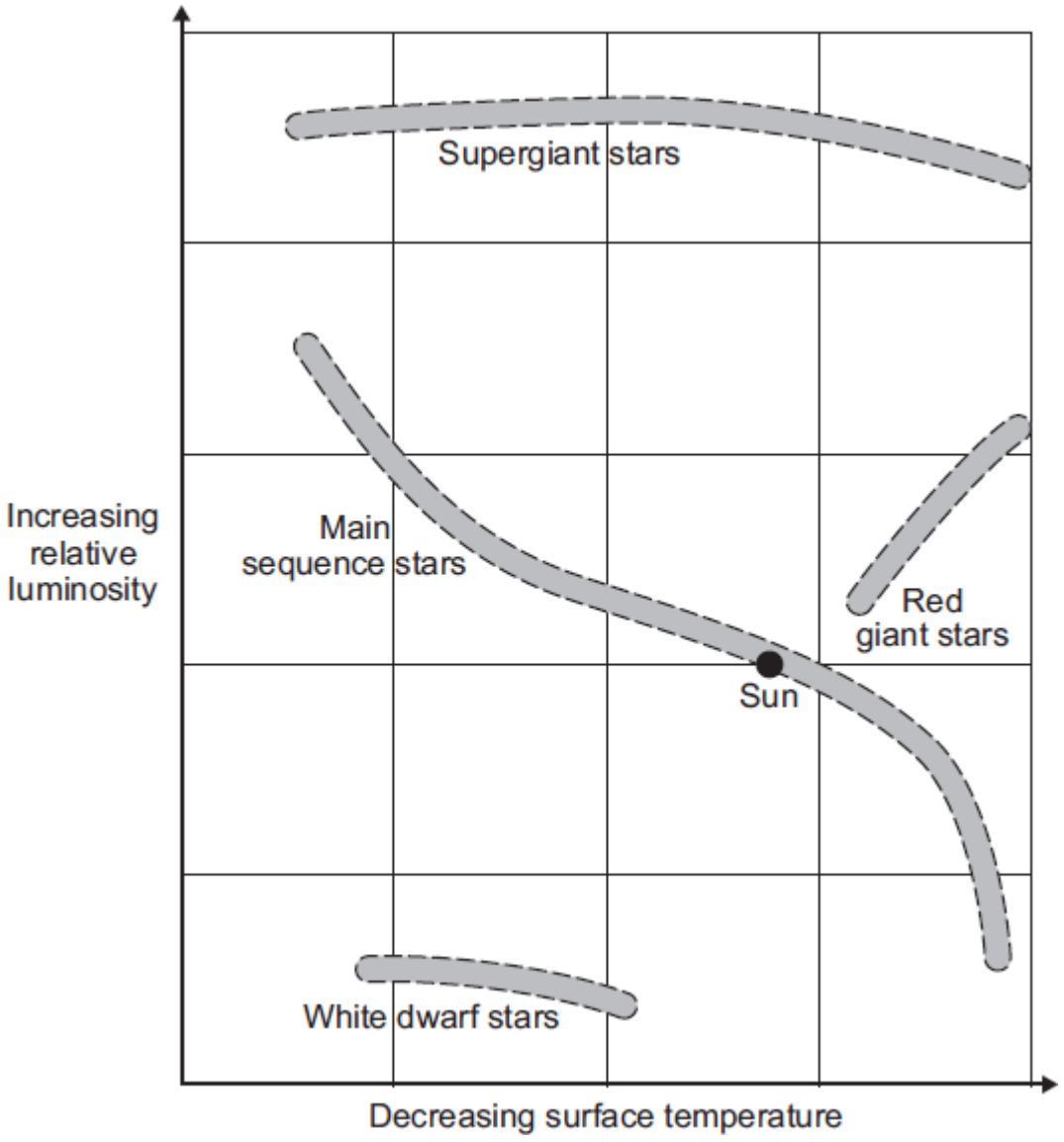
(2)

(Total 5 marks)

25 The diagram, drawn below, places stars in one of four groups.
Where a star is placed on the diagram is determined by the surface temperature and relative luminosity of the star.
A star with a relative luminosity of 1, emits the same amount of energy every second as the Sun.



(a) The Sun will spend most of its life cycle as a main sequence star. This is the stable period of the Sun's life cycle.

What happens to cause the stable period in the life cycle of a star to end?

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(1)

(b) Use the information in the diagram to describe what will happen to the Sun after the stable period ends.

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(3)

(Total 4 marks)

26 (a) As part of its life cycle, a star changes from being a protostar to a main sequence star.

Explain the difference between a protostar and a main sequence star.

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(2)

(b) The early Universe contained only atoms of hydrogen. The Universe now contains atoms of over one hundred different elements.

Explain how the different elements now contained in the Universe were formed.

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(3)

(Total 5 marks)

27 Galaxies emit all types of electromagnetic wave.

(a) (i) Which type of electromagnetic wave has the shortest wavelength?

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(1)

(ii) State **one** difference between an ultraviolet wave and a visible light wave.

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(1)

(b) Electromagnetic waves travel through space at a speed of 3.0×10^8 m/s.

The radio waves emitted from a distant galaxy have a wavelength of 25 metres.

Calculate the frequency of the radio waves emitted from the galaxy and give the unit.

Use the correct equation from the Physics Equations Sheet.

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Frequency = ...

(3)

(c) Scientists use a radio telescope to measure the wavelength of the radio waves emitted from the galaxy in part (b) as the waves reach the Earth. The scientists measure the wavelength as 25.2 metres. The effect causing this observed increase in wavelength is called red-shift.

(i) The waves emitted from most galaxies show red-shift.

What does red-shift tell scientists about the direction most galaxies are moving?

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(1)

(ii) The size of the red-shift is **not** the same for all galaxies.

What information can scientists find out about a galaxy when they measure the size of the red-shift the galaxy produces?

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(2)

(iii) What does the observation of red-shift suggest is happening to the Universe?

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(1)

(Total 9 marks)

28 Astronomers claim that there are about 300 billion stars in the Milky Way.

(a) Describe how stars are formed.

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(3)

(b) Use the correct answer from the box to complete the sentence.

decay	**fission**	**fusion**

Energy is released in stars by the process of nuclear ..... .

(1)

(c) State why a star is stable during the 'main sequence' period of its life cycle.

.....

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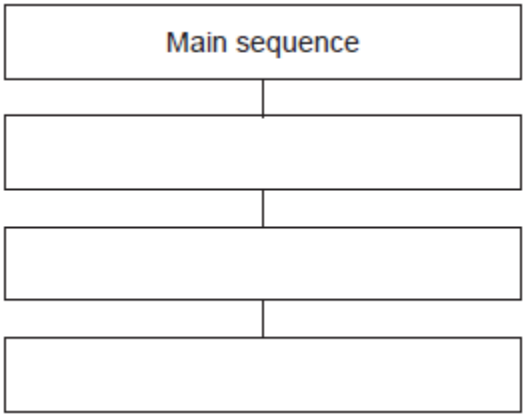
(1)

(d) The life cycle of a star after the ‘main sequence’ period depends on the size of the star.

A particular star is the same size as the Sun.

What are the stages, after the main sequence, in the life cycle of this star?

State them in order by writing in the boxes.



(3)

(Total 8 marks)

1 (a) (i) red-shift

accept Doppler (effect)

1

(ii) the Universe is expanding

1

(iii) N

1

(b) Why was the Universe created?

1

[4]

2 (a) (i) C

1

(ii) The speed of star **B** is less than the speed of star **D**.

1

(b) 300 000 000

*allow **1** mark for correct substitution ie 200 000 × 1500 provided no subsequent step shown*

2

m / s

allow unit correctly indicated in list if not written in answer space

1

[5]

3 (a) main sequence star

correct order only

1

supernova

1

(b) balanced by

1

[3]

4 (a) Earth

Sun

Milky Way

Universe

all four in correct order

*allow **1** mark for Earth <u>and</u> 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]

5 red supergiant

*do **not** accept red giant*

1

supernova

1

black hole

1

[3]

6 (a) **Y**

*accept cannot be **X** as size is increasing*

1

shows Universe expanding

*this scores if **Y** or **Z** is chosen*

accept exploding outwards

1

from a (very small) point

*this only scores if **Y** is chosen*

accept from zero (size)

answers in terms of planets

negate the last two mark points

1

(b) (i) both the ‘big bang’ and ‘steady state’ theories

1

(ii) (new) evidence that supports / disproves a theory

accept proves for supports

or

(new) evidence not supported by current theory

accept there may be more evidence supporting one (theory) than the other (theory)

accept new evidence specific to this question eg measurement of CBR

or

some types of star only found in distant parts of Universe (steady state suggests should be same throughout Universe)

1

[5]

7 (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]

8 (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]

9 (a) wavelength (of light appears to) increase

accept frequency (appears to) decrease

accept light moves to the red end of the spectrum

*do **not** accept it moves to the red end of the spectrum*

*do **not** accept light becomes redder*

1

(b) (i) **M** is closer (to the Earth) than **N**

1

M is moving (away from the Earth) slower than **N**

1

(ii) 520

*an answer between 510 and 530 inclusive gains **1** mark*

2

(iii) more recent

no mark for this but must be given to gain reason mark

data more reliable

accept data is more accurate

or

improved equipment / techniques

more technology is insufficient

or

data obtained from more (distant) galaxies

accept a wider range of data

accept data closer to the line of best fit

***or** data less scattered*

accept no anomalous result(s)

accept all data fits the pattern

1

(c) wavelength is decreased

1

frequency is increased

1

[8]

10 (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]

11 (a) the observed wavelength of the dark line from the distant galaxy has increased

1

therefore the distant galaxy must be moving away from the Earth

1

suggesting the Universe is expanding outwards from a small initial point

1

(b) existence of cosmic microwave background radiation

accept existence of CMBR

1

[4]

12 (a) longer wavelength waves **or** light moved towards red end of spectrum

1

(galaxy) moving away from the Earth **or** space is expanding **or** the galaxy and Earth are moving apart

accept us for Earth
*do **not** accept galaxies expanding*

1

(b) big bang

1

[3]

13 (NB. Answers referring to planets to gain zero marks
Answers in terms of stars – deduct 1 mark)

A light from (most) other galaxies shows a red-shift
B this means that these galaxies and our own galaxy are moving apart / Universe expanding
C the red-shift of more distant galaxies is greater
D this means that the further apart galaxies are the faster they are moving away from each other
E the relationship is proportional so this means that in the past they all set out from the same point

each properly related point

for 1 mark

[5]

14 (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]

15 (i) an enormous explosion causing matter to spread from one point

1

(ii) it is increasing **or** expanding

1

[2]

16 light from (distant) galaxies shows shift to red end of spectrum
wavelength increased explained by galaxies moving away from us
more distant galaxies have greater recession speed seen in all directions
suggests universe is **expanding** any sensible reference to similar effect on Earth

any 6 for 1 mark each

[6]

17 (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]

18 (a) (a) supernova (explosion)

1

(b) solar system contains heavy elements / elements heavier than hydrogen and helium (1)

these (heavy) elements are / were formed by (nuclear) fusion (1)

accept minor misspellings for 'fusion'
*but **not** anything which could also be 'fission'*

(at the very high temperature(s)) in a super nova / when stars explode (1)

3

[4]

19 (a) (i) Universe began at a (very) small (initial) point

'it' refers to Universe

1

'explosion' sent matter outwards
or
'explosion' causing Universe to expand

accept gas / dust for matter

accept rapid expansion for explosion

1

(ii) light shows a red shift

owtte

the term red shift on its own does not score a mark

1

galaxies moving away (from the Earth)

'it' refers to light

'they' refers to galaxies

accept star for galaxy

*do **not** accept planet for galaxy*

1

(b) check reliability / validity of data

accept check data

accept collect more data

1

amend theory
or
discount the data

accept replace old theory with new theory

1

(c) answer involves (religious) belief
or
no / insufficient evidence

accept it cannot be tested

1

[7]

20 (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]

21 (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]

22 (a) any **three** from:

- red-shift shows galaxies are moving away (from each other / the Earth)
- more distant galaxies show bigger red-shift

or

more distant galaxies show a greater increase in wavelength

accept correct reference to frequency in place of wavelength

- (in all directions) more distant galaxies are moving away faster

  accept (suggests) universe is expanding
- suggests single point of origin (of the universe)

3

(b) (i) (radiation produced shortly after) 'Big Bang'

accept beginning of time / beginning of the universe for 'Big Bang'

1

(ii) any **one** from:

- can only be explained by 'Big Bang'
- existence predicted by 'Big Bang'
- provides (further) evidence for 'Big Bang'

ignore proves 'Big Bang' (theory)
ignore reference to red-shift

1

(iii) increase

accept becomes radio waves

1

universe continues to accelerate outwards

accept as universe continues to expand

or

greater red-shift

1

[7]

23 (a) clearer / more detailed / sharper / less distorted image

image is better is insufficient

1

ignore image is bigger

any **one** from:

- no light pollution

accept no clouds to prevent observations

- light is not scattered by the atmosphere

accept air for atmosphere
accept (image) not distorted by the atmosphere
accept (light) does not have to pass through the atmosphere
*do **not** accept in terms of distance*

1

(b) (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

[4]

24 (a) (forces due to) <u>gravity</u> and <u>radiation pressure</u>

1

correct direction of forces

1

(forces) are balanced / equilibrium / equal

*accept for **3** marks an answer in terms of*

sufficient hydrogen (1)

to keep fusion reaction (1)

reference to burn / burning negates this mark

going at a continuous /steady rate (1)

*if fuel is used instead of hydrogen maximum of **2** marks*

1

(b) the Sun will remain stable (for several billion years)

1

based on evidence

accept a specific example of evidence

eg that the Sun has remained stable during the life of our planet / for 4.5 billion years

or

still contains more than 50 % hydrogen

or

by comparison with the lifecycle of (similar) stars

allow a refutation

eg not based on prejudice / whim / hearsay / folk law / historical or religious authority

1

[5]

25 (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]

26 (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]

27 (a) (i) gamma

accept correct symbol

1

(ii) any **one** from:

- (ultraviolet has a) higher frequency

  ultraviolet cannot be seen is insufficient

- (ultraviolet has a) greater energy

- (ultraviolet has a) shorter wavelength

  ignore ultraviolet causes cancer etc

1

(b) 1.2×10^7 / 12 000 000

*allow **1** mark for correct substitution, ie $3 \times 10^8 = f \times 25$*

2

hertz / Hz / kHz / MHz

*do **not** accept hz **or** HZ*

*answers 12 000 kHz **or** 12 MHz gain **3** marks*

for full credit the numerical answer and unit must be consistent

1

(c) (i) away (from each other)

accept away (from the Earth)
accept receding

1

(ii) distance (from the Earth)

accept how far away (it is)

1

speed galaxy is moving

1

(iii) (Universe is) expanding

1

[9]

28 (a) (enough) dust / gas (from space)

1

are pulled together

1

by gravitational attraction

1

(b) fusion

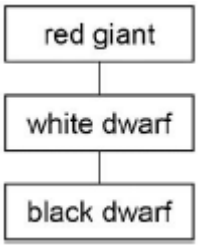
accept fusion circled in box

1

(c) forces within it are balanced

1

(d)



correct order only

1

ignore reference to planetary nebula

1

1

[8]