Mr Baker's Science-Stuff

Space

Name: _____

Class: _____

Date: _____

Time: **152 minutes**

Marks: **150 marks**

Comments:

Q1.

(a) There are eight planets in orbit around the Sun.

Which other type of object orbits the Sun?

Tick **one** box.

Dwarf planet ☐

Galaxy ☐

Moon ☐

Star ☐

(1)

(b) Complete the sentences.

Choose the answers from the box.

black hole	**gravity**	**friction**
nebula	**protostar**	**upthrust**

The Sun was formed when a _____ in space was pulled together by _____ .

(2)

(c) The Sun has reached the Main Sequence stage in its lifecycle.

What stage in the lifecycle of the Sun will follow the Main Sequence stage?

_____

(1)

The table shows some data about the eight planets that orbit the Sun.

Planet	Distance from the Sun compared to the Earth	Time to orbit the Sun in years	Mean surface temperature in °C
Mercury	0.4	0.2	+125
Venus	0.7	0.6	+465
Earth	1.0	1.0	+22
Mars	1.5	1.9	–48
Jupiter	**X**	12	–108
Saturn	9.6	30	–180
Uranus	19.3	84	–216
Neptune	30.0	165	–201

(d) What pattern links the distance a planet is from the Sun and the time taken by the planet to orbit the Sun?

_____

_____

_____

(1)

(e) Estimate the value of **X** in the table.

Distance = _____

(1)

(f) A student looked at the data in the table and wrote the following conclusion:

'The mean surface temperature of a planet decreases the further the planet is from the Sun.'

Explain why this conclusion is **not** totally correct.

_____

_____

_____

_____

_____

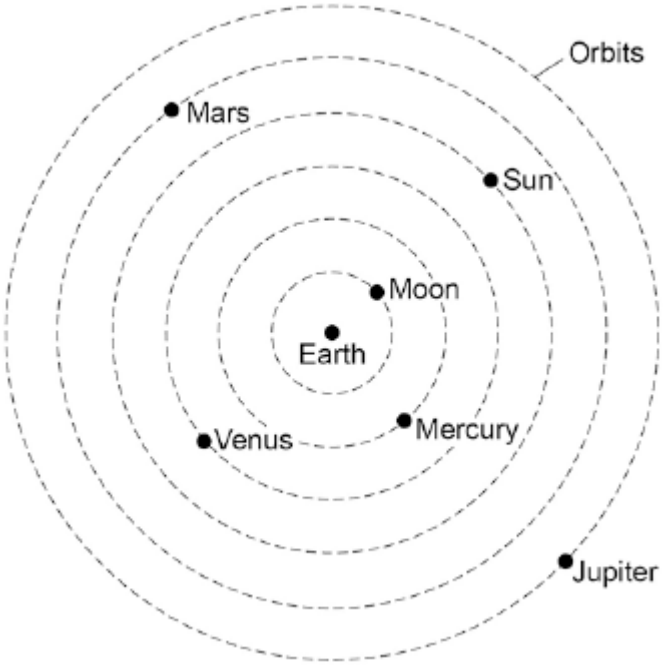
_____

(3)

(Total 9 marks)

Q2.

The figure below shows what scientists over 1000 years ago thought the solar system was like.



(a) Give **one** way that the historical model of the solar system shown in the figure above is different from what we now know about the solar system.

_____

_____

(1)

(b) Give **one** way that the solar system shown in the figure above is the same as what we now know about the solar system.

_____

_____

(1)

(c) The first artificial satellite to orbit the Earth was launched into space in 1957.

Describe the orbit of an artificial satellite.

_____

_____

(1)

(d) What provides the force needed to keep a satellite in its orbit?

Tick **one** box.

friction ☐

gravity ☐

tension ☐

(1)

(e) All stars go through a lifecycle.

The star Mira will go through a supernova stage in its lifecycle but the Sun will not.

How is the star Mira different to the Sun?

_____

_____

(1)

(Total 5 marks)

Q3.

(a) The Sun is a star.

Which galaxy is the Sun in?

Tick **one** box.

Cartwheel ☐

Milky Way ☐

Starburst ☐

Tadpole ☐

(1)

(b) Light takes 500 seconds to travel from the Sun to the Earth.

Light travels at 300 000 kilometres per second.

Calculate the distance between the Sun and the Earth.

Use the equation:

distance = speed × time

_____

_____

_____

_____

Distance = _____ kilometres

(2)

The table below gives information about some of the planets in our solar system.

The planets are in order of increasing distance from the Sun.

Planet	**Time to orbit the Sun in years**
Mercury	0.2
Venus	0.6
Earth	1.0
Mars	
Jupiter	12.0

(c) There are some planets in our solar system missing from the table above.

How many planets are missing?

_____

(1)

(d) Estimate how many years it takes Mars to orbit the Sun.

_____ years

(1)

(e) Calculate how many times Venus will orbit the Sun in 9 years.

_____

_____

_____

_____

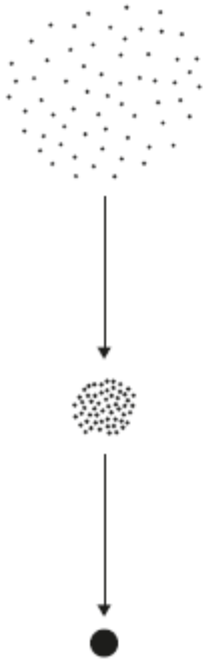
In 9 years, Venus will orbit the Sun _____ times.

(2)

(Total 7 marks)

Q4.

(a) The figure below shows how a star is formed.
Use **one** answer from each box to complete the sentences.



gas	**rock**	**water**

A star starts as a huge cloud of dust and _____ particles in space.

friction	**fusion**	**gravity**

The force of _____ pulls the particles in the cloud closer together.

protostar	**red giant**	**white dwarf**

The compressed mass of particles

forms a _____ .

(3)

(b) Elements heavier than iron are formed in a supernova.
What is a supernova?

Tick (✓) **one** box.

the explosion of a massive star	☐
a very bright, hot young star	☐
a very cool super giant star	☐

(1)

(c) Brown dwarf stars are small stars too cool to give out visible light. They were first discovered in 1995. Scientists think that there are millions of these stars spread throughout the Universe.

Which **one** of the following is the most likely reason why brown dwarf stars were not discovered before 1995?

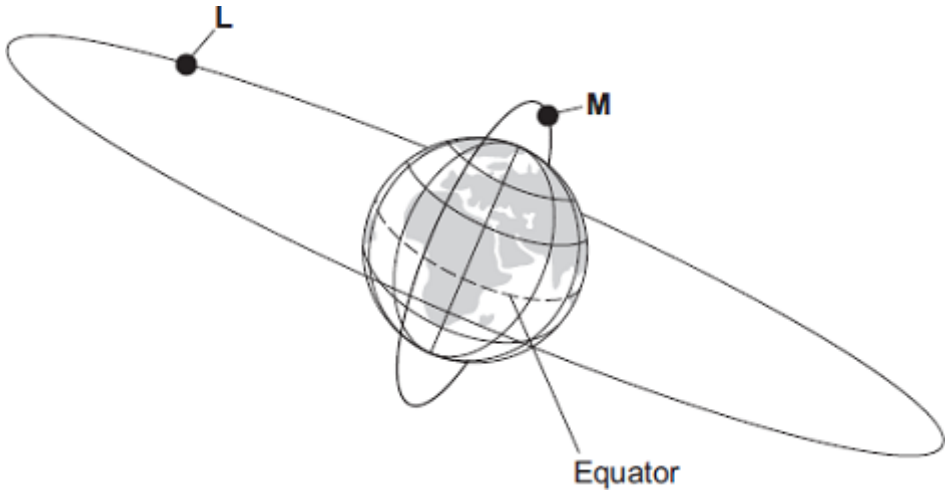
Tick (✓) **one** box.

Brown dwarf stars did not exist before 1995.	☐
Scientists were looking in the wrong part of the Universe.	☐
The telescopes and measuring instruments were not sensitive enough.	☐

(1)
(Total 5 marks)

Q5.

The diagram, which is not to scale, shows two satellites, **L** and **M**, orbiting the Earth.



(a) Complete the following table.

Each letter, **L** or **M**, may be used once, more than once, or not at all.

Statement about the satellite	**Letter for the satellite**
It is used as a monitoring satellite.	
It is a geostationary satellite.	
It takes 24 hours to complete its orbit.	

(2)

(b) Complete the following sentence.

To stay in its present orbit around the Earth, each satellite must move at a particular _____ .

(1)

(c) Thousands of satellites are now in orbit around the Earth. A student used the internet to collect information about some of them.

Name of satellite	Average distance from the centre of the Earth in kilometres	Speed in kilometres per second	Time taken to orbit the Earth
The Moon	391 400	1.01	28 days
GEO	42 200	3.07	1 day
Navstar	26 600	3.87	12 hours
Lageos	12 300	5.70	3.8 hours
HST	7 000	7.56	97 mins
ISS	6 700	7.68	92 mins

(i) The Moon takes a longer time than any of the other satellites to orbit the Earth.

Give **one** other way in which the Moon is different from the other satellites in the table.

_____

_____

(1)

(ii) What conclusion on the relationship between the *average distance* and *speed* can the student come to on the basis of this data?

_____

_____

(1)

(Total 5 marks)

Q6.

(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)

Q7.

In 1929, the astronomer Edwin Hubble observed that the light from galaxies moving away from the Earth had longer wavelengths than expected.

(a) What name is given to this effect?

_____

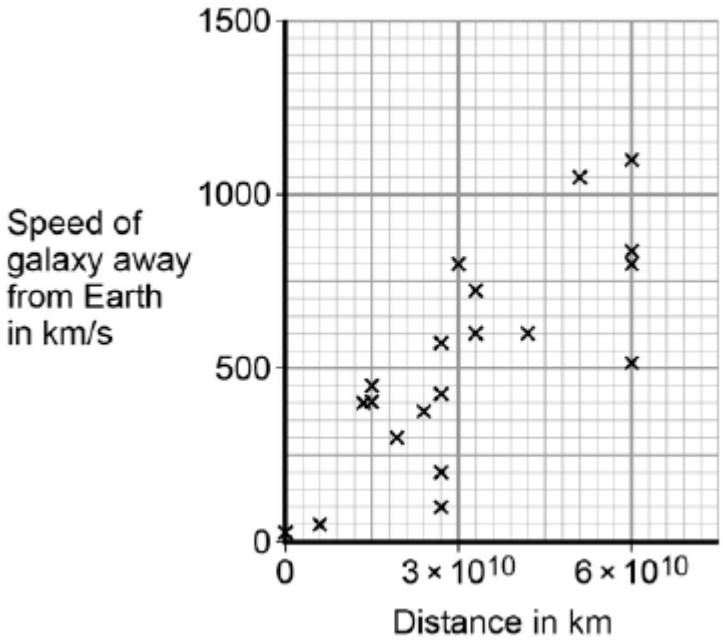
_____

(1)

(b) From his observations, Hubble was able to calculate the speed of a galaxy and the distance of the galaxy from the Earth.

Figure 1 shows the results of Hubble's calculations.

Figure 1



What relationship between the speed of a galaxy and the distance is suggested by Hubble's results?

_____

_____

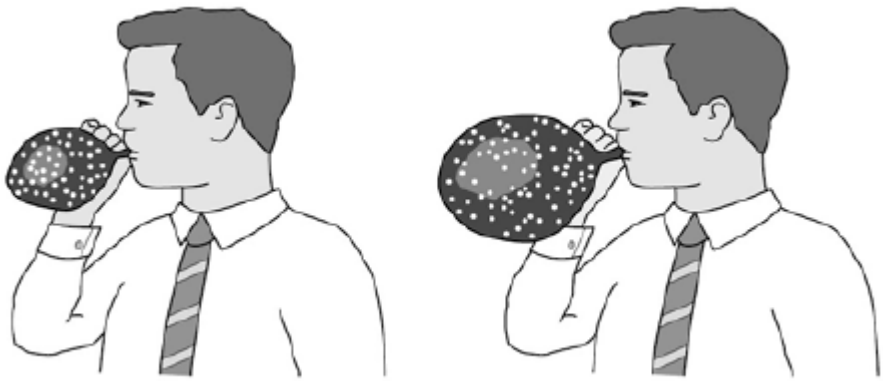
(1)

The observations made by Hubble support the idea that the Universe is expanding. This means that galaxies are continually moving away from each other and from the Earth.

Figure 2 shows a student using a balloon to model the idea of an expanding Universe.

Some dots, which represent galaxies, were marked on the balloon.
The balloon was then inflated.

Figure 2



(c) Give **one** strength and **one** weakness of this model in representing the idea of an expanding Universe.

Strength _____

_____

Weakness _____

_____

(2)

In the 1950s there were two main theories to explain how the Universe began.

Theory 1	The Universe has always existed, it is continually expanding. New galaxies are formed as older galaxies die out.
Theory 2	The Universe began from a very small region that was extremely hot and dense. The Universe has been expanding ever since.

(d) In what way do the observations made by Hubble support both Theory 1 and Theory 2?

_____

_____

_____

(1)

(e) Most scientists now believe that Theory 2 is correct.
Suggest what is likely to have caused scientists to start thinking Theory 1 is wrong.

_____

_____

_____

(1)

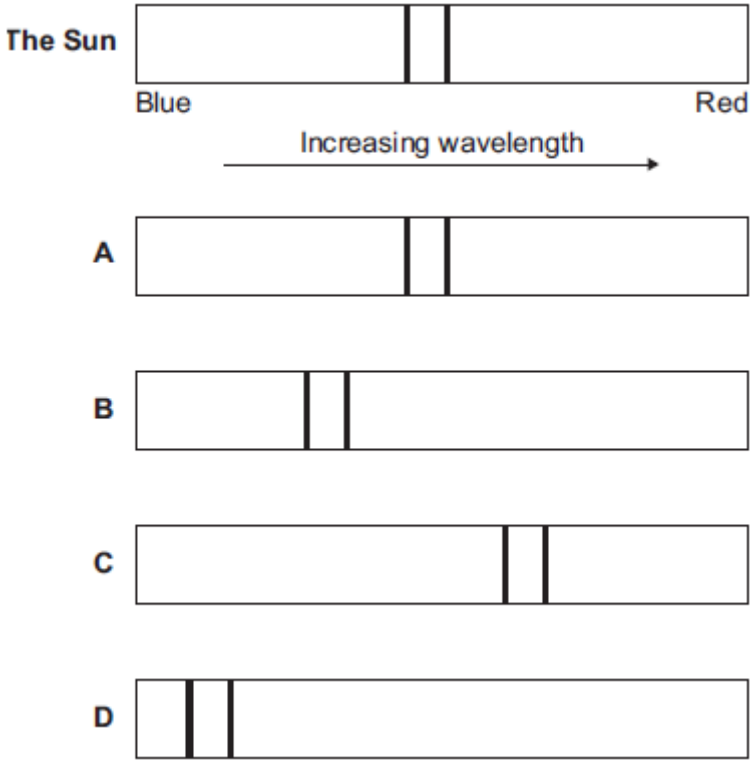
(Total 6 marks)

Q8.

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.

Choose the correct unit from the list below.

m **m/s** **m/s²**

_____

_____

_____

Speed = _____ unit _____

(3)

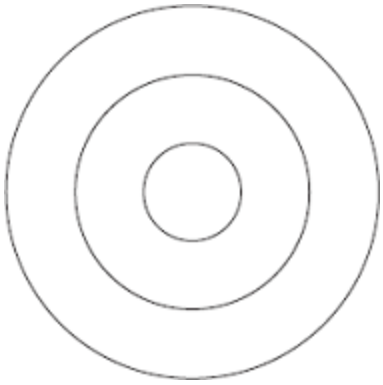
(Total 5 marks)

Q9.

A teacher demonstrates the production of circular waves in a ripple tank.

Diagram 1 shows the waves at an instant in time.

Diagram 1



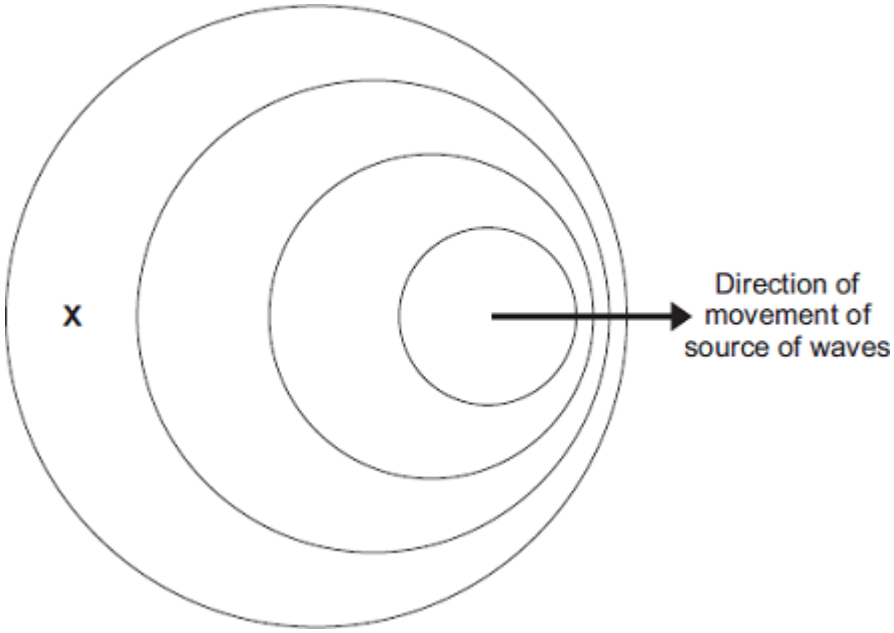
(a) Show on **Diagram 1** the wavelength of the waves.

(1)

(b) The teacher moves the source of the waves across the ripple tank.

Diagram 2 shows the waves at an instant in time.

Diagram 2
(Actual size)



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

decreased	**increased**	**stayed the same**

In **Diagram 2**, the observed wavelength of the waves at **X**

has _____ .

In **Diagram 2**, the frequency of the waves at **X**

has _____ .

(2)

(ii) Take measurements from **Diagram 2** to determine the wavelength of the waves received at **X**.

Give the unit.

_____

_____

Wavelength = _____

(3)

(c) The teacher uses the waves in the ripple tank to model the changes in the wavelengths of light observed from distant galaxies.

When observed from the Earth, there is an increase in the wavelength of light from distant galaxies.

(i) State the name of this effect.

_____

(1)

(ii) What does this increase in wavelength tell us about the movement of most galaxies?

_____

_____

(1)

(iii) Explain how this observation supports the Big Bang theory of the formation of the Universe.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(iv) State **one** other piece of evidence that supports the Big Bang theory of the formation of the Universe.

_____

_____

(1)

(Total 13 marks)

Q10.

(a) Which one of the following types of electromagnetic wave has the highest frequency?

Tick **one** box.

Gamma rays ☐

Infrared ☐

Microwaves ☐

Ultraviolet ☐

(1)

(b) What makes microwaves suitable for sending communications to a satellite in space?

_____

_____

(1)

(c) Scientists have detected short bursts of radio waves emitted from a distant galaxy.

The scientists think that the radio waves may have been emitted from a neutron star.

What event leads to a neutron star forming?

_____

_____

(1)

(d) Some of the radio waves from the distant galaxy have a frequency of 1.2 gigahertz (GHz).

Which of the following is the same as 1.2 GHz?

Tick **one** box.

1.2×10^3 Hz ☐

1.2×10^6 Hz ☐

1.2×10^9 Hz ☐

1.2×10^{12} Hz ☐

(1)

(e) Radio waves travel through space at a speed of 3.0×10^8 m/s

Calculate the wavelength of the 1.2 GHz radio waves emitted from the distant galaxy.

Wavelength = _____ m

(3)

(f) When radio waves are absorbed by an aerial they may create an alternating current in an electrical circuit.

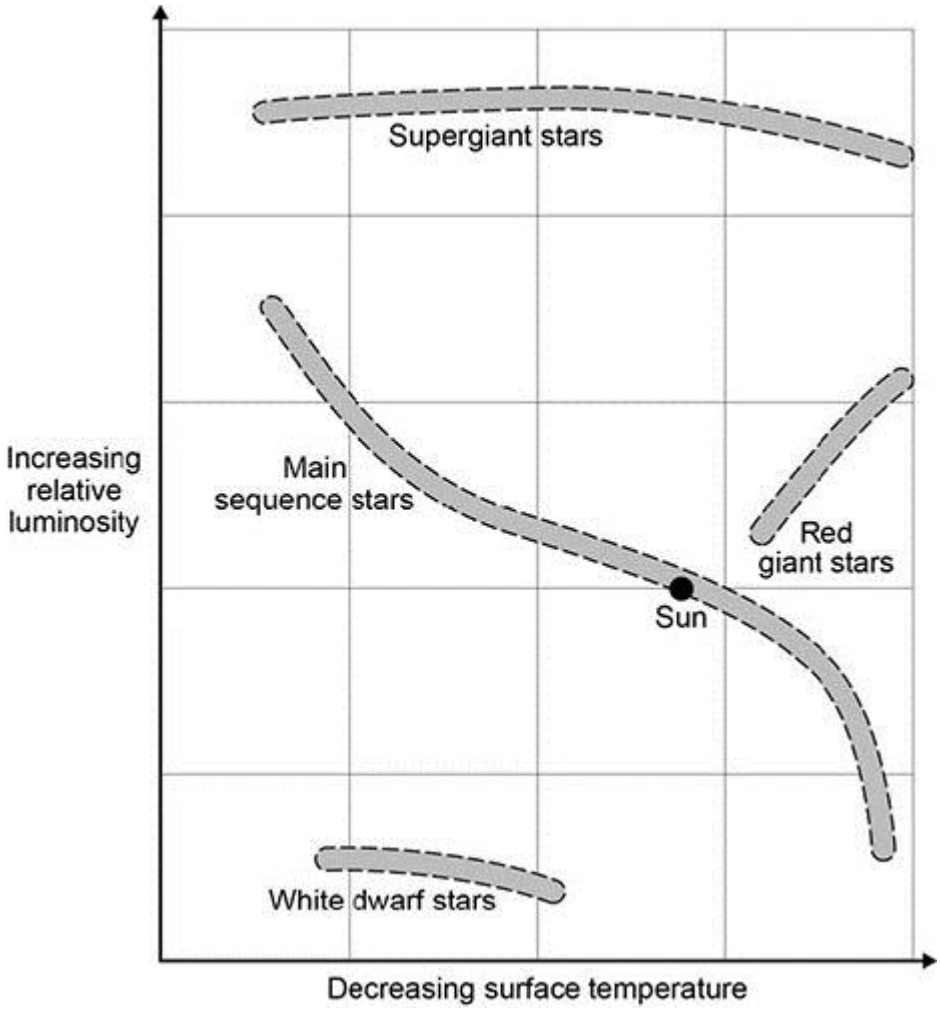
If an alternating current is created what frequency would it have?

(1)

The diagram shows four groups of stars.

The surface temperature and relative luminosity determine which group a star is in.

A star with a relative luminosity of 1 emits the same amount of energy every second as the Sun.



(g) The Sun is in the group of main sequence stars. These stars are stable.

Explain why a star remains stable.

_____

_____

_____

_____

(2)

(h) At different points in their lifecycle stars change from one group to another.

Describe what will happen to the Sun between it leaving the main sequence group and becoming a white dwarf.

Use information from the diagram.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 8 marks)

Q11.

The early Universe contained only the lightest element.

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

hydrogen	**iron**	**uranium**

The early Universe contained only _____ .

(1)

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

main sequence star	**protostar**	**supernova**

The heaviest elements are formed only in a _____ .

(1)

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

red giant	**red super giant**	**white dwarf**

Only a star much bigger than the Sun can become a _____ .

(1)

(d) The Universe now contains a large variety of different elements.

Describe how this happened.

(4)
(Total 7 marks)

Q12.

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?

_____

_____

(1)

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

Suggest why.

_____

_____

(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.

_____

_____

_____

_____

(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.

_____

_____

_____

_____

_____

_____

_____

_____

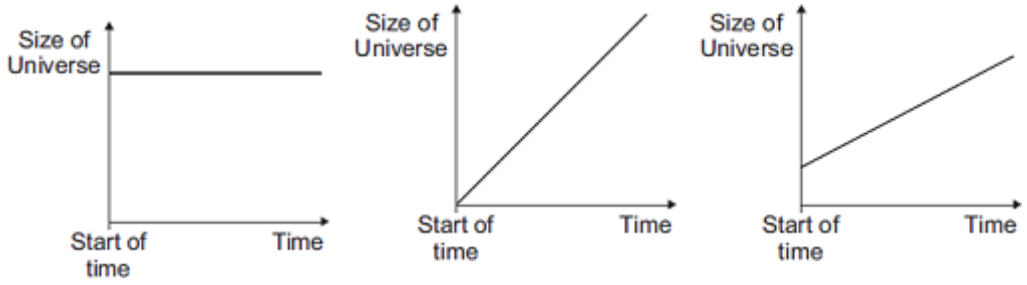
(6)

(Total 12 marks)

Q13.

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.

_____

_____

_____

_____

(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 state' 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.

_____

_____

_____

(1)

(Total 5 marks)

Q14.

Galaxies emit all types of electromagnetic wave.

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

_____

(1)

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

_____

_____

(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.

_____

_____

_____

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?

_____

_____

(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?

_____

_____

_____

_____

(2)

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

_____

_____

(1)

(Total 9 marks)

Q15.

(a) Brown dwarf stars are thought to have been formed in the same way as other stars. They are too small for nuclear fusion reactions to take place in them.
Brown dwarf stars emit infrared radiation but are not hot enough to emit visible light.

(i) Describe how a star is formed.

_____

_____

_____

_____

(2)

(ii) Describe the process of nuclear fusion.

_____

_____

_____

(1)

(iii) Scientists predicted that brown dwarf stars existed before the first one was discovered in 1995.

Suggest **one** reason why scientists are now able to observe and identify brown dwarf stars.

_____

_____

_____

(1)

(b) In the 18th century some scientists suggested a theory about how the planets formed in the Solar System. The theory was that after the Sun formed, there were cool discs of matter rotating around the Sun. These cool discs of matter formed the planets. The scientists thought this must have happened around other stars too.

(i) Thinking about this theory, what would the scientists have predicted to have been formed in other parts of the Universe?

_____

_____

(1)

(ii) Since the 1980s scientists studying young stars have shown the stars to be surrounded by cool discs of rotating matter.

What was the importance of these observations to the theory the scientists suggested in the 18th century?

_____

_____

(1)

(c) The Earth contains elements heavier than iron.

Why is the presence of elements heavier than iron in the Earth evidence that the Solar System was formed from material produced after a massive star exploded?

_____

_____

(1)

(Total 7 marks)

Q16.

Read this statement from a website.

> Immediately after the 'big bang', at the start of the Universe, there were only atoms of the element hydrogen (H).
>
> Now there are over one hundred elements.
> Scientists think that all the elements on Earth are also present throughout the Universe.

(a) Explain how atoms of the element (He) are formed in a star.

(2)

(b) Explain how atoms of very heavy elements, such as gold (Au), were formed.

(2)

(c) Scientists have only examined a tiny fraction of the Universe.

What is the basis for scientists thinking that the elements found on Earth are present throughout the Universe?

(1)

(Total 5 marks)

Q17.

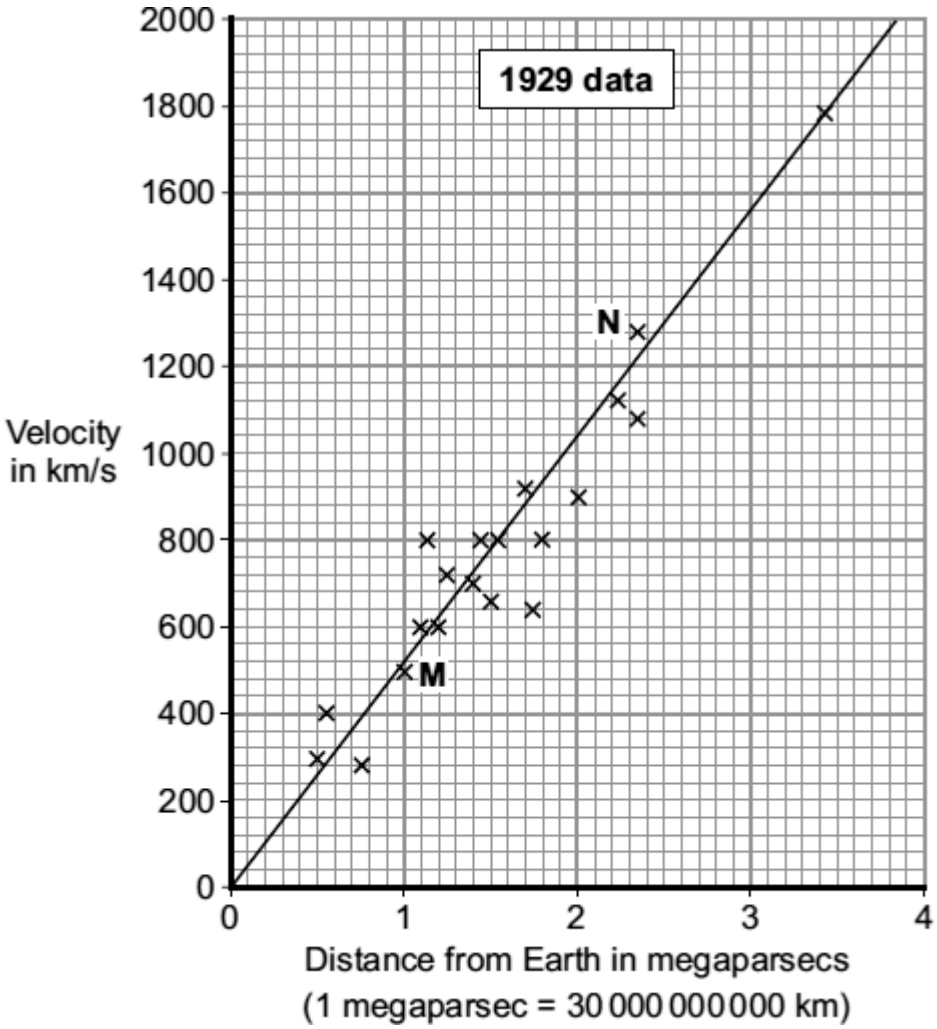
(a) In 1929, the astronomer Edwin Hubble observed that the light from galaxies that are moving away from the Earth showed a *red-shift*.

What is *red-shift* ?

(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**?

_____

_____

_____

(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.

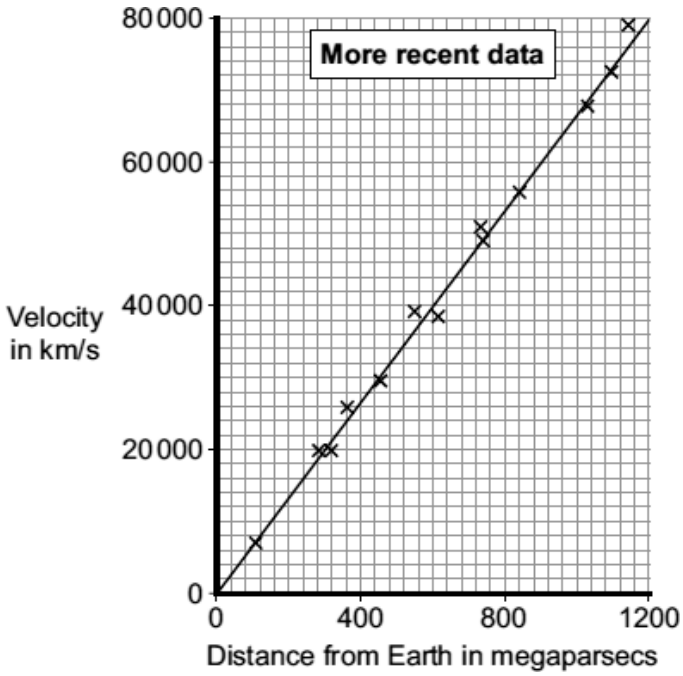
_____

_____

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.

_____

_____

(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?

_____

_____

_____

_____

(2)

(Total 8 marks)

Q18.

Stars do not stay the same forever.

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

_____

_____

(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.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

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

(i) Where did these atoms come from?

_____

_____

(1)

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

_____

(1)

(Total 7 marks)

Q19.

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

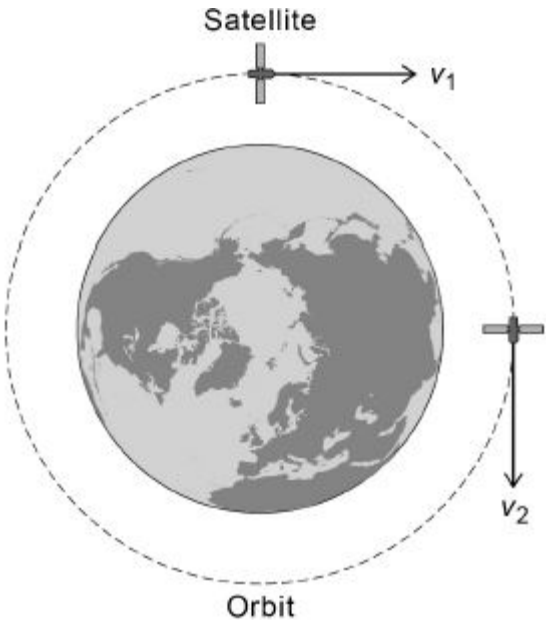
(Total 6 marks)

Q20.

A satellite is in a circular orbit around the Earth.

Figure 1 shows the velocity of the satellite at two different positions in the orbit.

Figure 1

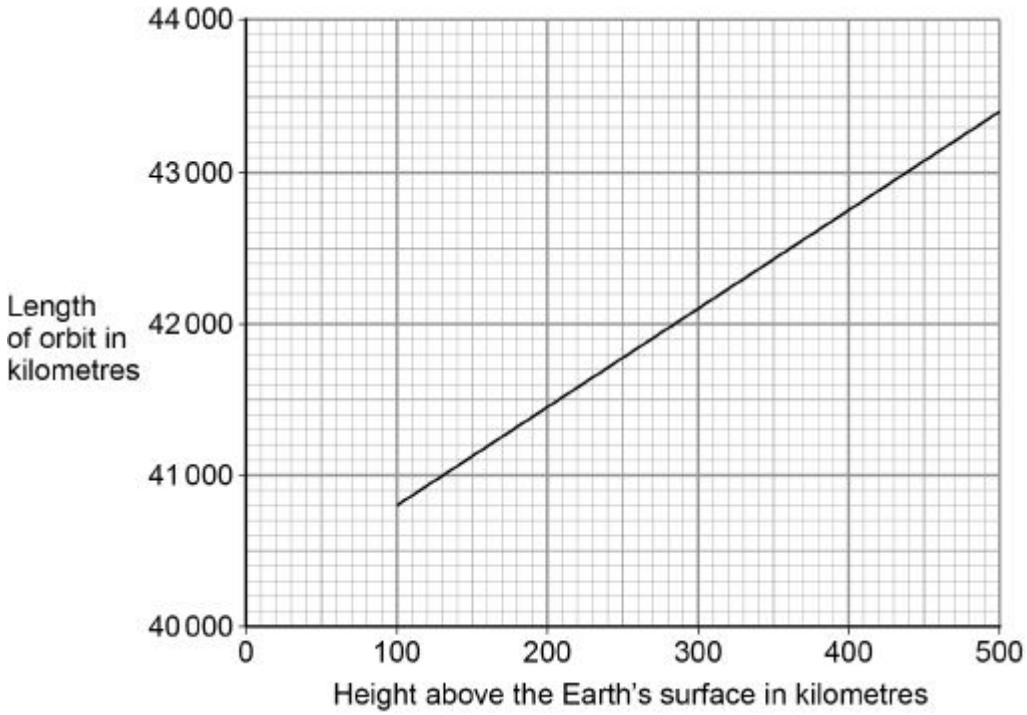


(a) Explain why the velocity of the satellite changes as it orbits the Earth.

(3)

(b) **Figure 2** shows how the length of a satellite orbit depends on the height of the satellite above the Earth's surface.

Figure 2



A satellite orbits 300 km above the Earth's surface at a speed of 7.73 km/s.

Calculate how many complete orbits of the Earth the satellite will make in 24 hours.

Number of complete orbits = _____

(5)

In 1772, an astronomer called J Bode developed an equation to predict the orbital radii of the planets around the Sun.

The table shows Bode's predicted orbital radii and the actual orbital radii for the planets that were known in 1772.

Planet	**Predicted orbital radius in millions of kilometres**	**Actual orbital radius in millions of kilometres**
Mercury	60	58
Venus	105	108
Earth	150	150
Mars	240	228
Jupiter	780	778
Saturn	1500	1430

(c) The predicted data can be considered to be accurate.

Give the reason why.

_____

_____

(1)

(d) J Bode used his equation to predict the existence of a planet with an orbital radius of 2940 million kilometres.

The planet Uranus was discovered in 1781.

Uranus has an orbital radius of 2875 million kilometres.

Explain why the discovery of Uranus was important.

_____

_____

_____

_____

(2)

(Total 11 marks)

Q1.

(a) dwarf planet

1

(b) nebula

correct order only

1

gravity

1

(c) (becomes a) red giant

1

(d) the greater the distance (from the Sun) the greater the time taken to orbit the Sun

1

(e) any value between 3 and 7 inclusive

1

(f) because some planets do not fit the pattern

1

named planet that does not fit pattern

eg Venus

1

reason why named planet does not fit pattern

its temperature is higher than expected

or

Uranus: its temperature is lower than expected

or

Neptune: its temperature is higher than expected

or

Mercury: its temperature is lower than expected

1

[9]

Q2.

(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]

Q3.

(a) Milky Way

1

(b) distance = 300 000 × 500

1

d = 150 000 000 (km)

1

*an answer of 150 000 000 scores **2** marks*

(c) 3

1

(d) accept any number greater than 1.0 and less than 12.0

1

(e) $\frac{9}{0.6}$

1

15

1

*an answer of 15 scores **2** marks*

[7]

Q4.

(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]

Q5.

(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]

Q6.

(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]

Q7.

(a) red–shift

1

(b) the further away from the Earth, the faster a galaxy is moving

1

(c) **strength**

as the balloon expands the dots get further apart, representing the galaxies moving apart

1

weakness
dots are only on the surface of the balloon, galaxies are throughout the universe
or
there is a limit to how far the balloon can expand

1

(d) both theories suggest that the Universe is expanding

1

(e) new evidence / observations that cannot be explained by Theory 1

accept specific example of new evidence ie CMBR

1

[6]

Q8.

(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]

Q9.

(a) wavelength correctly shown

1

(b) (i) increased

1

decreased

1

(ii) 17-18 inclusive

1

evidence of measurement divided by 3 or mean of 3 separate measurements

1

mm

accept cm if consistent with answer

1

(c) (i) red shift

1

(ii) moving away

1

(iii) the furthest galaxies show the biggest red shift

1

(meaning that) the furthest galaxies are moving fastest

1

(so the) Universe is expanding

1

(extrapolating backwards this suggests that) the Universe started from an initial point

1

(iv) cosmic microwave background radiation

allow CMBR

1

[13]

Q10.

(a) gamma rays

1

(b) can travel through the atmosphere

1

(c) explosion of a red super giant
or
a supernova

1

(d) 1.2×10^9 Hz

1

(e) $3.0 \times 10^8 = 1.2 \times 10^9 \times \lambda$

*an answer of 0.25 (m) scores **3** marks*

*allow ecf from **(d)***

1

$$\lambda = \frac{3.0 \times 10^8}{1.2 \times 10^9}$$

1

$\lambda = 0.25$ (m)

1

(g) same as the radio wave

1

(f) expansion due to fusion energy

1

in equilibrium with gravitational collapse

*forces acting inwards equal forces acting outwards gains **1** mark*

1

(h)

Level 2: Scientifically relevant facts, events or processes are identified and given in detail to form an accurate account.	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 • Sun goes from main sequence to red giant • then from red giant to white dwarf • when the Sun changes to a red giant the surface temperature will decrease • and the relative luminosity will increase • when changing from a red giant to a white dwarf the surface temperature increases • and the relative luminosity decreases	

4

[14]

Q11.

(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]

Q12.

(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]

Q13.

(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]

Q14.

(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]

Q15.

(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]

Q16.

(a) fusion

*do **not** credit any response which looks like 'fission'*

1

of hydrogen / H (atoms)

credit only if 1st mark point scores

1

(b) fusion of other / lighter atoms / elements

reference to big bang nullifies both marks

1

during supernova / explosion of star(s)

1

(c) the (available) evidence: supports this idea
or
does not contradict this idea
or
can be extrapolated to this idea
or
(electromagnetic) spectrum from other stars is similar to sun

1

[5]

Q17.

(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]

Q18.

(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]

Q19.

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]

Q20.

(a) (force of) gravity causes the satellite to accelerate (towards the Earth)

allow satellite is (constantly) accelerating

1

the acceleration causes a change in direction

acceleration causes a change in speed negates this mark point

1

velocity changes because direction changes

1

(b) length of orbit taken from graph = 42 100 (km)

1

42 100 = 7.73 × time
or
$\text{time} = \frac{42100}{7.73}$

allow
their distance = 7.73 × time

1

time (1 orbit) = 5446(s)

allow a value consistent with their distance

1

$\text{number of orbits} = \left(\frac{24 \times 3600}{5446}\right)$

= 15.86

allow $\left(\frac{24}{1.51}\right) = 15.86$

allow a value consistent with their distance

1

number of orbits = 15

allow a value consistent with their distance

*an answer of 16 scores **4** marks*

1

or

length of orbit taken from graph = 42 100 (km) (1)

$$7.73 = \frac{\text{distance}}{24 \times 3600} \text{ (1)}$$

distance = 667 872 (km) (1)

$$\text{number of orbits} = \left(\frac{667872}{42100}\right)$$

= 15.86 (1)

allow a value consistent with their two distances

number of orbits = 15 (1)

allow a value consistent with their two distances
up to full marks can be awarded for a method
calculating velocity in km/h and time in hours

*an answer of 15 scores **5** marks*

(c) the predicted data is very close to the actual data

1

(d) supported the prediction (made by Bode)

allow predicted and actual values are very close

1

so provides evidence that the equation is true / correct / works / accurate

allow proves for provides evidence

1

[11]

Q3.

(a) Most students completed this calculation correctly. A small minority scored one mark by showing a correct substitution followed by an incorrect numerical answer.

(b) Just under half of the students gave the correct answer. Many of those students giving an incorrect answer of 4 were including Pluto as a planet.

(c) Over 90% of students gave a value within the correct range.

(d) The majority of students multiplied the given numbers, rather than dividing 9 by 0.6.

Q4.

(a) Most students scored at least one mark with about one third scoring all three marks. A common error was to give 'friction' as the force that pulls particles together.

(b) The majority of the students scored this mark.

(c) The majority of the students scored this mark.

Q5.

This question on satellites was generally well answered although only under half of students could correctly link all the statements to the correct satellite in part (a).

Q6.

(a) (i) About half of the students knew that this observation is called red-shift.

(ii) The great majority of students knew that the observation gives scientists evidence that the Universe is expanding. The most popular incorrect answer was that light can be stretched.

(iii) Most students correctly identified graph **N** as representing the relationship between observed increase in wavelength and distance from Earth.

(b) Most students knew that the question “Why was the Universe created?” is one that scientists are unable to answer. The most popular wrong choice was “How fast does light travel through the Universe?”

Q8.

(a) (i) The majority of students correctly identified star C as being the one that is moving away from the Earth. However, a large number of students thought that it was star D.

(ii) A large number of students incorrectly thought that the speed of star B is greater than the speed of star D, although just less than half of students answered correctly.

(b) Most students gave the correct substitution but many failed to derive a correct answer, often being out by a factor of 10. Sometimes this may have been caused by students not using comma separators and therefore being unsure of the number of

zeroes they had put in their answer.

Almost half of students scored all three marks; many only scored 2 marks either because of a miscalculation or because of choosing the wrong unit.

A significant number of students made no attempt at the calculation, although some of these did manage to circle one of the units in the question.

Q11.

(a) Nearly all students selected the correct terms for parts (a) and (c). However, fewer were able to identify that the heaviest elements are formed only in a supernova, in part (b).

(b) Nearly all students selected the correct terms for parts (a) and (c). However, fewer were able to identify that the heaviest elements are formed only in a supernova, in part (b).

(c) Nearly all students selected the correct terms for parts (a) and (c). However, fewer were able to identify that the heaviest elements are formed only in a supernova, in part (b).

(d) This question carried four marks; the spread of marks was fairly even with around a fifth of students achieving zero marks, one-fifth gaining 1 mark, one-fifth gaining 2 marks and so on. Many were able to identify that nuclear fusion in stars was the mechanism by which different elements were formed. Also, many answers correctly identified the fusion of hydrogen to form helium. Thereafter, descriptions relating to the formation of heavier elements tended to be vague or confused, although a fair number correctly stated that elements heavier than iron were formed in a supernova.

Q12.

(a) Very few students gained this mark. Most responses did not have any reference to forces or that the forces would be balanced.

(b) (i) This was well answered with the majority of the students being able to identify the relationship between the relative mass of the star and the estimated time.

(ii) This was poorly answered with many vague responses in terms of stars being ‘different’.

(iii) Just over half of the students gained one mark for correctly choosing ‘faster than’. However these students often went on to simply give a repetition of the question as the explanation. Few students referred explicitly to the time spent in the main sequence, instead using terms like ‘its life is shorter’.

(c) This was very poorly answered with a significant minority of students scoring zero. A small amount failed to attempt the question. The better students knew the stages that a large star passes through after the main sequence period but were often unable to give a description of what happens to a star. Simple statements such as ‘it expands to give a red supergiant’ were sufficient to gain some credit. A significant number of students described the life cycle up to the main sequence period whilst others described the lifecycle of the Sun. The vast majority of the students seemed to simply put down everything they could think of in a totally random order. Many students were very creative, with new types of stars being named, black holes forming new stars and the complete life cycle being described in terms of a butterfly!

Q13.

(a) Most students gained some credit here, mostly by correctly identifying 'Y' as the correct graph. Many students then went on to write that this graph showed the Universe expanding but fewer were able to state that the Universe had started at a point. A significant number of students confused the Universe with the Solar System or the Earth, and therefore could only score the first mark.

(b) (i) Only a minority of students thought that red-shift provides evidence for both the 'big bang' and 'steady state' theories.

(ii) Those students that scored the mark in this question tended to answer in terms of 'one theory having more evidence that the other'. The question was a general one about the support of the scientific community for a particular theory and those that answered in these terms tended to be more successful than those who attempted to discuss the evidence for the 'big bang' and 'steady state' theories in particular.

Q14.

(a) (i) Over half of students correctly identified gamma. There was a range of other responses, some of which were not electromagnetic waves, indeed some were not waves of any kind.

(ii) Almost half of the students gave a correct answer. Common incorrect responses referred to uses of these waves.

(b) Many students were able to identify the correct equation, and substitute numbers into it. Common errors were wrongly transposing the equation and attempting to convert 25 metres into cm or km.

(c) (i) Over three-quarters of the responses were correct.

(ii) Nearly two-thirds of students were able to identify at least one correct piece of information which can be obtained from the size of the red-shift.

(iii) The vast majority of responses were correct. There are still a number of students who confuse the 'Universe' with 'Earth'.

Q15.

(a) (i) Nearly half of the students failed to score a mark, with the other half split roughly equally between 1 and 2 marks. Many good answers were as per the mark scheme, with the term nebula quite often used for dust and gas. Incorrect responses included "rocks in the atmosphere / air", or dust on its own. Many students also did not refer to gravity being the attracting force. Many students incorrectly referred to fission. Some students referred to fusion, but this was not relevant to the question.

(ii) Just over a third of the students scored this mark. The most common error was to use "atom" for nuclei. Some students confused fusion and fission. This question was not attempted by a significant minority of the students.

(iii) "Better / Improved Technology ", was the most frequent correct answer given. Quite a few answers confused telescopes with microscopes. Similarly satellites were often mentioned without any further indication how they might improve observations. Some students did not score the mark because they thought that the reason scientists had not detected them before was because

they did not know what to look for or because light from these stars had only just reached us (in order to be observed).

(b) (i) "Other/different Planets", was the most common correct answer, scored by just over half of the students. It was strange to see that many students mentioned that the evidence might have proved there were other life forms in the universe as this didn't seem to be linked to the question.

(ii) Although the mark was scored by nearly half of all students, many correct answers were imprecise in their explanation of "proving / supporting ", the theory.

(c) Nearly one tenth of the students did not attempt this question. Of those that did less than a quarter scored the mark, as students failed to identify the key idea of "only". Too often the information in the stem of the question was fed back using slightly different words or simply the same words in a slightly different order.

Q16.

(a) Just over half of the students scored both marks. Some students failed to use the term “fusion” in respect of the conversion of hydrogen to helium.

(b) A small number of students scored both marks and nearly half scored one mark, usually for the “supernova”.

(c) Three-quarters of the students scored zero. There was little reference to evidence and most of the students merely said “the Big Bang”.

Q17.

(a) Only two fifths of candidates were able to give the meaning of ‘red-shift’. A common incorrect answer was to refer to galaxies moving towards the red end of the spectrum.

(b) (i) Whilst this question was quite well answered, a significant number of marks were lost by candidates contradicting themselves, eg ‘M is moving slower than M’, an error which could be avoided if candidates were to read through their response. Quite a few answers explained what information could be gathered from red-shift data, but did not refer to the two galaxies mentioned.

(ii) It was obvious that many candidates had not read the question carefully and as a consequence did not know that the gradient of a line needed to be calculated. Of those who did, many candidates counted squares up and across, rather than using values taken from the axes. When values were taken, common mistakes were not reading the values correctly or performing an incorrect calculation.

(iii) Just under two thirds of candidates answered this correctly. However, a significant number of candidates think that in the 80 years between the two data sets, the universe will have expanded considerably so that the initial value would be more accurate.

(c) This part was generally well answered by most candidates, although references to wavelength being .squashed. and frequencies being ‘longer’ were not uncommon.

Q18.

Answers to this question seemed either centre dependent or interest dependent, with some candidates scoring highly and some scoring virtually no marks. In part (a) the term fusion was not well known with many candidates incorrectly referring to 'burning'. Part (b) was often confused, with some candidates eventually getting to the correct answer having presumably spotted the 'at least 5 times bigger than the Sun' in brackets. Part (c) either scored full marks or none.

Q20.

(a) Just over half the students wrote answers that were worthy of some credit but often only gained a single mark, which was usually for a match to the third marking point. It was very unusual to see acceleration mentioned. Frequent incorrect answers were in terms of variations in the radius of the satellite's orbit, despite it being shown as circular in Figure 1. Other students commented on the physical geography of the Earth having an effect on the orbit or the velocity being affected by the Earth's magnetic field. A few students stated that the satellite was falling on the right hand side and getting faster as a result.

(b) Over 50% of the students completed this calculation correctly to score all five marks. A further 10% of the students scored four marks because they rounded the number of orbits to 16. Some of students incorrectly used 300 km as the length of the orbit.

(c) This part was generally well answered with just over 70% of students scoring this mark.

(d) About 50% of the answers matched one of the marking points but few students scored both marks. Some students expressed the view that the predicted and actual values for the radius of Uranus' orbit were too different to support the prediction. Many answers referred to Uranus or the Solar System rather than Bode's prediction or equation.