Name: _____

Class: _____

Date: _____

Space Physics part 4 AQA Triple Physics

Time: **79 minutes**

Marks: **79 marks**

Comments:

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

(a) Describe how stars are formed.

_____

_____

_____

_____

_____

_____

(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.

_____

_____

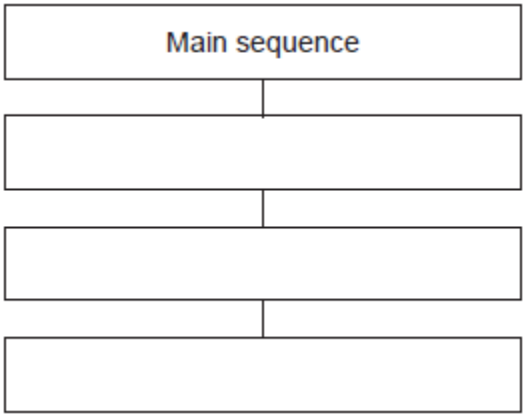
(1)

(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)

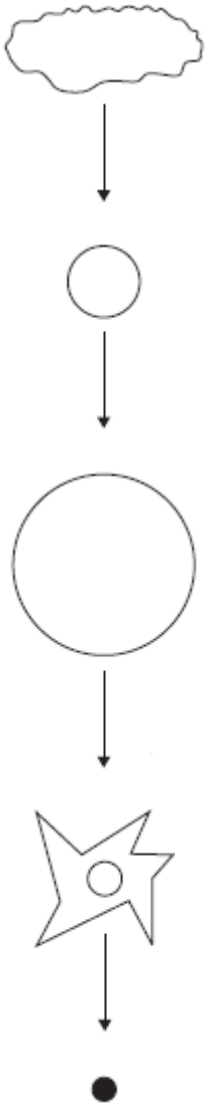
(Total 8 marks)

2. (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.

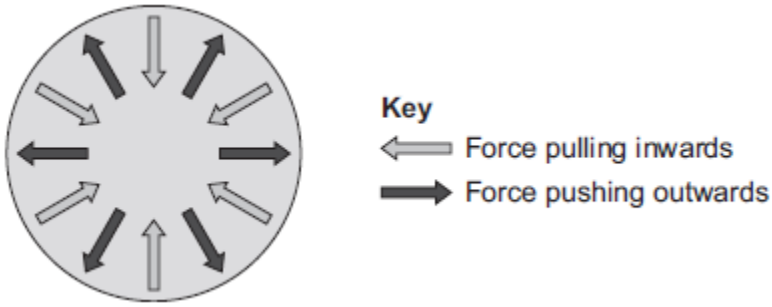
The outer layers of the star explode as a _____ .

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

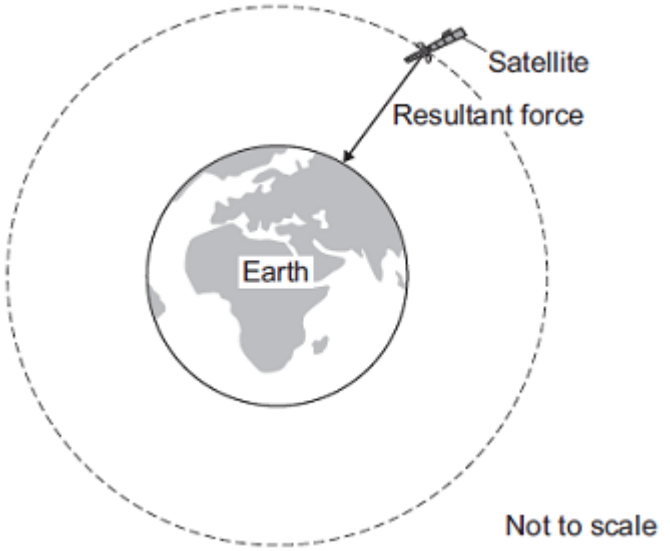
bigger than
smaller than
balanced by

the forces pulling inwards.

(1)

(Total 3 marks)

3. Man-made satellites can orbit the Earth, as shown in the figure below.



The satellite experiences a resultant force directed towards the centre of the orbit.

The resultant force is called the centripetal force

(a) What provides the centripetal force on the satellite?

_____

(1)

(b) State **two** factors that determine the size of the centripetal force on the satellite.

1. _____

2. _____

(2)

(c) The table below gives data for five different satellites orbiting the Earth.

Satellite	Average height above Earth's surface in kilometres	Time taken to orbit Earth once in minutes	Mass of satellite in kilograms
A	370	93	419 000
B	697	99	280
C	827	103	630
D	5 900	228	400
E	35 800	1440	2 030

(i) State the relationship, if any, between the height of the satellite above the Earth's surface and the time taken for the satellite to orbit the Earth once.

_____

_____

(1)

(ii) State the relationship, if any, between the time taken for the satellite to orbit the Earth once and the satellite's mass.

_____

_____

(1)

(d) Over 300 years ago, the famous scientist Isaac Newton proposed, with a 'thought experiment', the idea of satellites.

Newton suggested that if an object was fired at the right speed from the top of a high mountain, it would circle the Earth.

Why did many people accept Isaac Newton's idea as being possible?

Tick (✓) **one** box.

Isaac Newton was a respected scientist who had made new discoveries before. ☐

Isaac Newton went to university. ☐

It was a new idea that nobody else had thought of before. ☐

(1)

(Total 6 marks)

4. (a) Observation of the spectra from distant galaxies provides evidence to support the 'Big Bang' theory.

(i) Complete the following sentence.

Many scientists think that the 'Big Bang' theory describes the _____

_____

(1)

(ii) Tick (✓) **one** box to complete the sentence.

The discovery of cosmic microwave background radiation was important because it ...

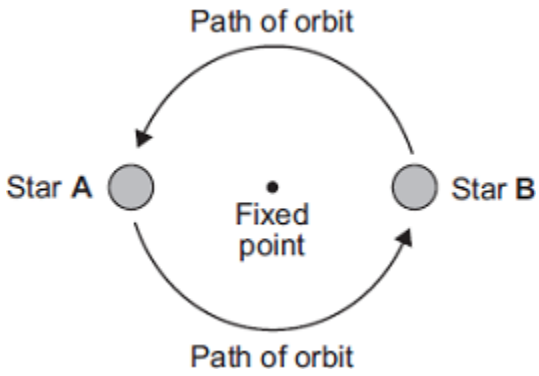
proved the 'Big Bang' theory to be correct. ☐

provided more evidence to support the 'Big Bang' theory. ☐

proved the Universe will continue to expand forever. ☐

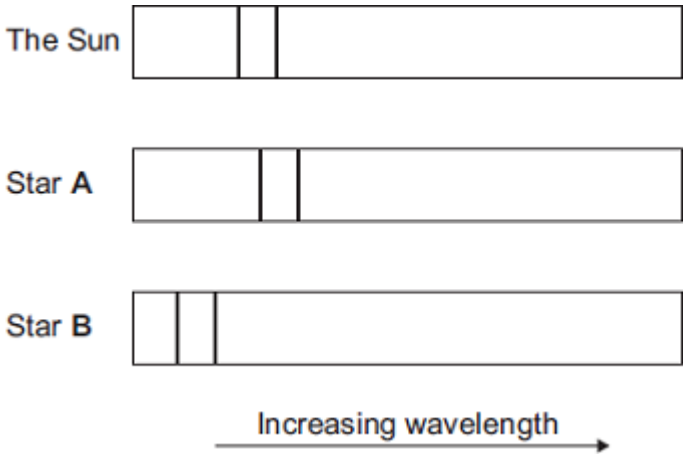
(1)

(b) Many stars are part of a binary star system. Binary star systems have two stars.



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

The diagram shows the position of two dark lines in the spectrum from the Sun. It also shows the same lines in the spectra from two stars **A** and **B** in a binary star system at the same point in time.



(i) What name is given to the effect shown in the spectrum from star **A**?

_____

(1)

(ii) Scientists have concluded that the two stars in a binary star system orbit around a fixed point between the two stars.

A comparison of the spectra from the two stars in a binary star system provides evidence to support this conclusion.

Explain how.

_____

_____

_____

_____

_____

_____

_____

_____

(3)

(Total 6 marks)

5. (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)

6. 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)

7. 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?

_____

_____

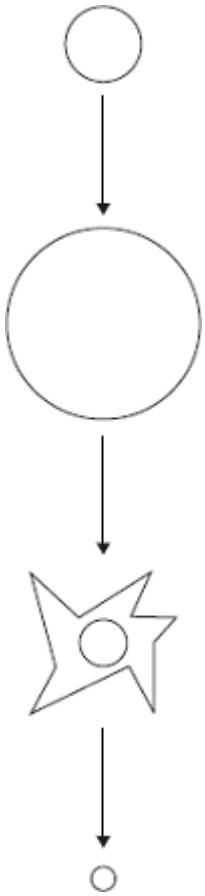
(1)

(Total 9 marks)

8. 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**



The star is stable.

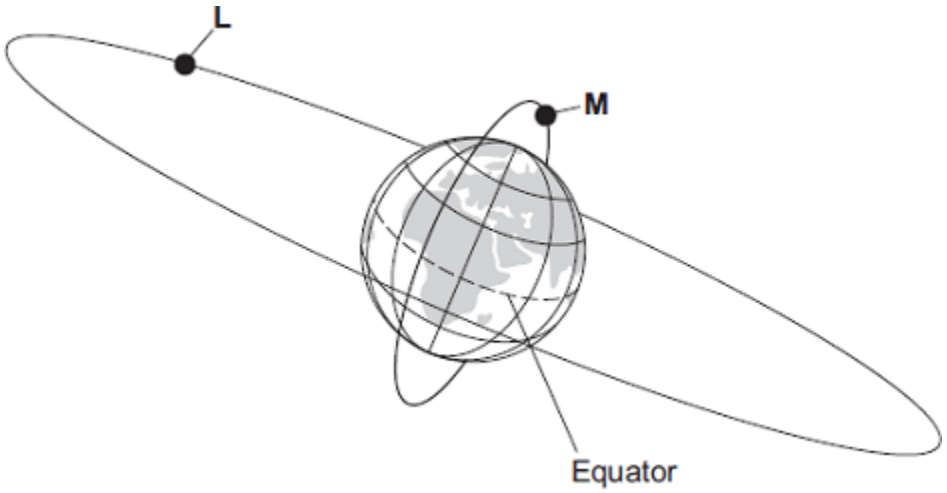
The star expands forming
a _____ .

The star collapses, the outer layers explode
as a _____ .

The centre collapses further and further until
it finally forms a _____ .

(Total 3 marks)

9. 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)

10. 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)

11. (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.

(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.

(3)

(Total 5 marks)

12. (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?

(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?

_____

_____

(1)

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

_____

_____

(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.

_____

_____

(2)

(Total 7 marks)

13. (a) Starting with the smallest, list the following in order of increasing size.

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

Smallest _____

_____

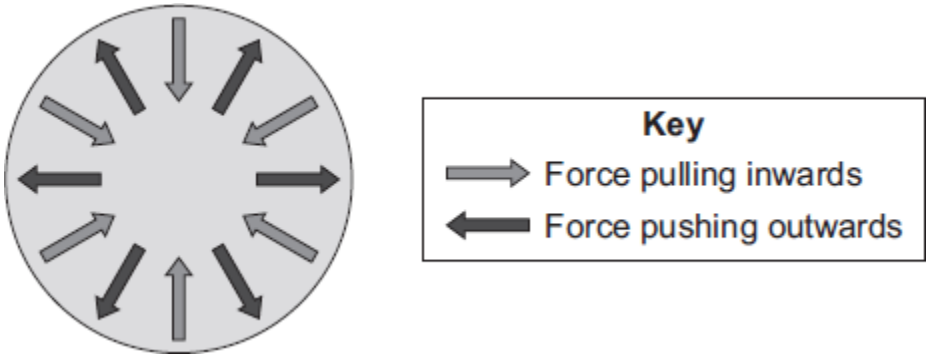
_____

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?*

_____

(1)

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

_____

_____

_____

_____

(2)

(Total 6 marks)

1. (a) (enough) dust / gas (from space)

1

are pulled together

1

by gravitational attraction

1

(b) fusion

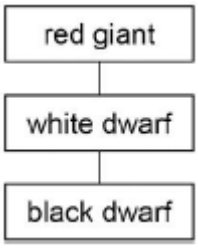
accept fusion circled in box

1

(c) forces within it are balanced

1

(d)



correct order only

1

ignore reference to planetary nebula

1

1

[8]

2. (a) main sequence star

correct order only

1

supernova

1

(b) balanced by

1

[3]

3.

(a) gravitational attraction (between the satellite and the Earth)

allow gravity

allow weight of the satellite

1

(b) any **two** from:

- mass of satellite
- speed / velocity (of satellite)
- radius of orbit / circle

allow height above the Earth

radius / height alone is insufficient

2

(c) (i) increasing the height (above the Earth's surface) increases the time (for one orbit)

allow a positive correlation

allow as one gets bigger, the other gets bigger, or vice versa

ignore they are directly proportional

1

(ii) there is no relationship / correlation

1

(d) Isaac Newton was a respected scientist who had made new discoveries before

1

[6]

4.

(a) (i) origin of the Universe

accept (why) the Universe is expanding

*do **not** accept origin of the Earth*

1

(ii) provided more evidence to support the 'Big Bang' theory

1

(b) (i) red-shift

accept Doppler (shift)

1

(ii) (at the point in time shown the observed spectrum from) star A (shows it) is moving away from the Earth

accept star A is moving away

star A shows red-shift is insufficient

1

light from star B shows a decrease in wavelength

accept light from star B shows blue-shift

accept light from star B shows an increase in frequency

1

so star B is moving towards Earth

1

[6]

5. (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]

6. (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]

7. (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]

8. red supergiant

*do **not** accept red giant*

1

supernova

1

black hole

1

[3]

9. (a) all correct

M
L
L

*allow **1** mark for one correct*

2

(b) speed

accept 'velocity'

1

(c) (i) any **one** from:

- it's natural
- slowest
- furthest (from the centre of the Earth)

accept 'others are artificial / made by humans'

1

(ii) as the (average) distance decreases the speed increases

accept 'there is a negative correlation (between them)'
*do **not** accept 'they are inversely proportional'*

1

[5]

10. (a) 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]

11. (a) a protostar is at a lower temperature
or
a protostar does not emit radiation /energy

1

as (nuclear) fusion reactions have not started
accept heat or light for energy

1

(b) by (nuclear) fusion
accept nuclei fuse (together)
nuclear fusion and fission negates this mark

1

of hydrogen to helium

1

elements heavier than iron are formed in a supernova
accept a specific example e.g. heavier elements such as gold are formed in a supernova
accept heavier elements (up to iron) formed in red giant/red super giant
reference to burning (hydrogen) negates the first 2 marks

1

[5]

12. (a) 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]

13. (a) Earth

Sun

Milky Way

Universe

all four in correct order

*allow **1** mark for Earth and Universe in correct places*

2

(b) equal to

1

(c) (i) explosion (of a star)

ignore implosion

1

(ii) only very massive stars become supernova

1

Mira large enough but sun too small

*allow **1** mark for each statement*

Sun too small to give a supernova

or

Mira large enough to give a supernova

1

[6]