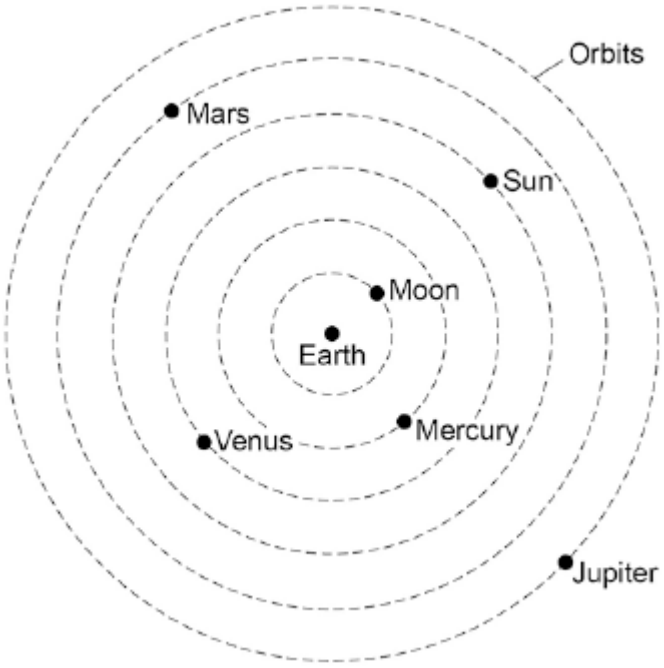
SOLAR SYSTEM, STABILITY OF ORBITAL MOTIONS, SATELLITES

Q1.

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?

_____

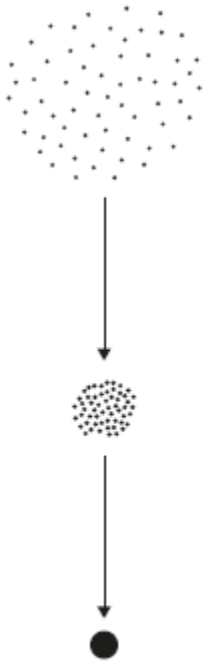
_____

(1)

(Total 5 marks)

Q2.

(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)

Q3.

(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)

Q4.

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)

Q5.

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.

_____

_____

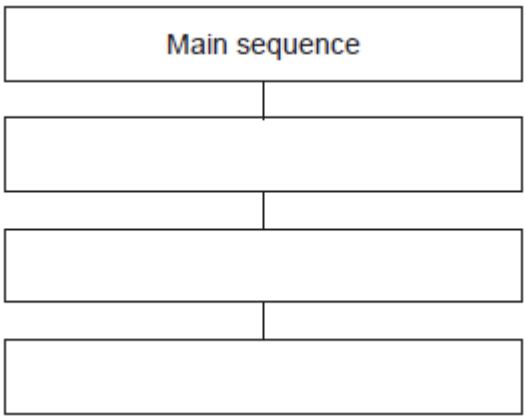
(1)

(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)

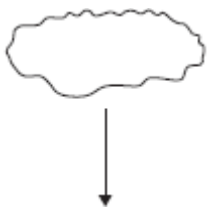
Q6.

(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**.

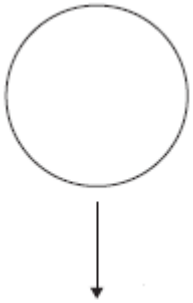
main sequence star	neutron star	supernova	white dwarf

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.

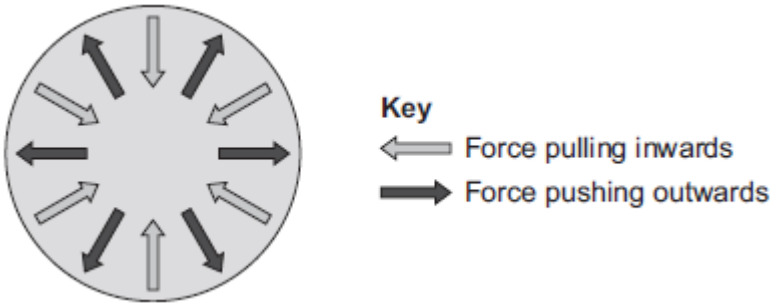
The outer layers of the star explode as a _____ .

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

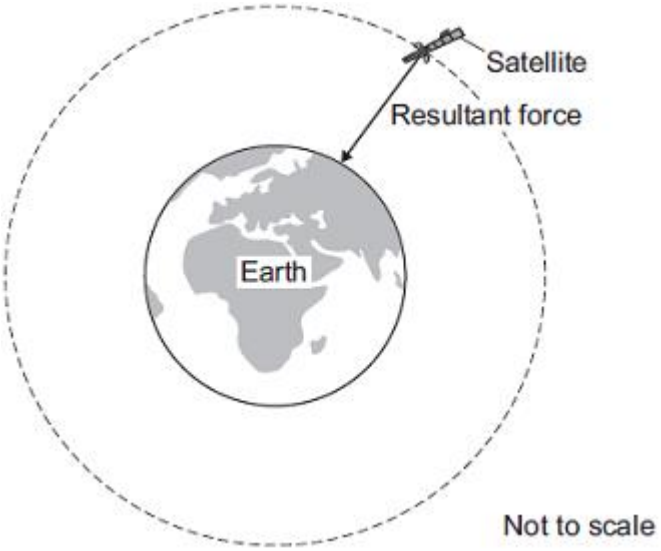
the forces pulling inwards.

(1)

(Total 3 marks)

Q7.

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)

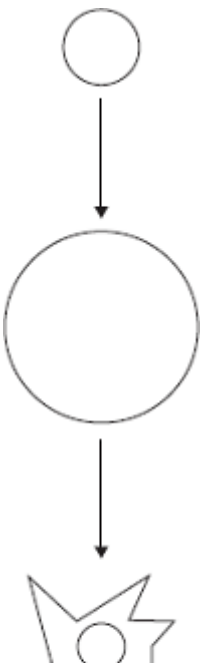
Q8.

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 _____ .

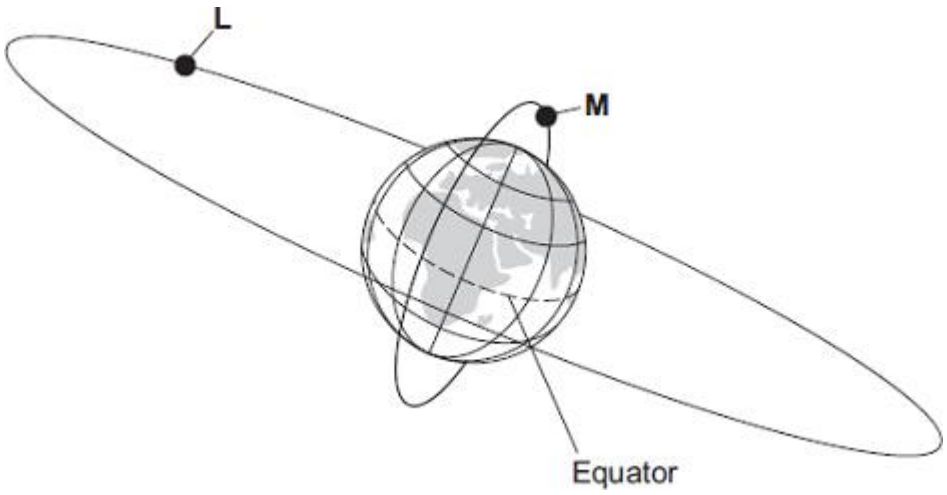
The centre collapses further and further until

it finally forms a _____ .

(Total 3 marks)

Q9.

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**	**Speed in kilometres per second**	**Time taken to orbit the Earth**

	kilometres		
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)

Q10.

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

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

Smallest _____

_____

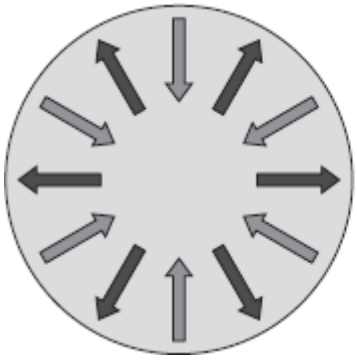
_____

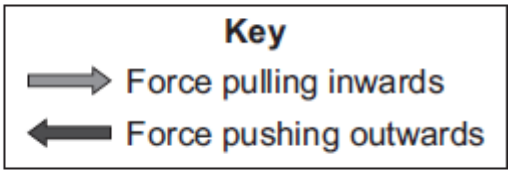
Largest _____

(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)

Q11.

(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.

_____

_____

_____

_____

_____

_____

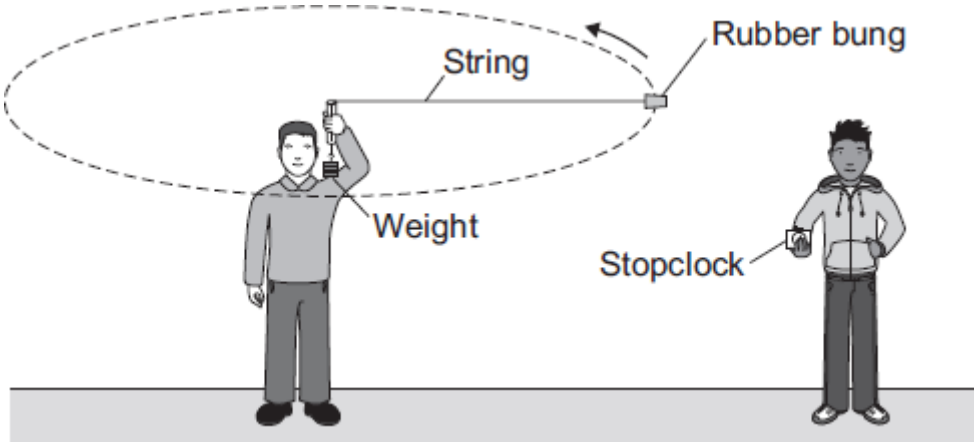
(3)

(Total 5 marks)

Q12.

Objects moving in a circle experience a force called **centripetal** force, which acts to the centre of the circle.

The diagram shows the apparatus used by two students to find out how the centripetal force acting on an object affects the speed of the object.



(a) (i) In which direction does the centripetal force act on the rubber bung?

_____

(1)

(ii) In this investigation, what provides the centripetal force?

_____

_____

(1)

(b) One student swung the rubber bung around in a circle at constant speed. The second student timed how long it took the rubber bung to complete 10 rotations. The students then calculated the speed of the rubber bung, using the radius of the circle and the time to complete one rotation. The students repeated this for several

different values of centripetal force.

(i) During the investigation, the radius of the circle and the mass of the rubber bung were not changed.

Explain why.

_____

_____

_____

_____

(2)

(ii) One of the variables in this investigation was the time taken by the rubber bung to complete 10 rotations.

Which **two** words can be used to describe this variable?

Draw a ring around each of your **two** answers.

continuous **control** **dependent** **independent**

(1)

(iii) The students timed 10 rotations of the rubber bung, rather than just one rotation.

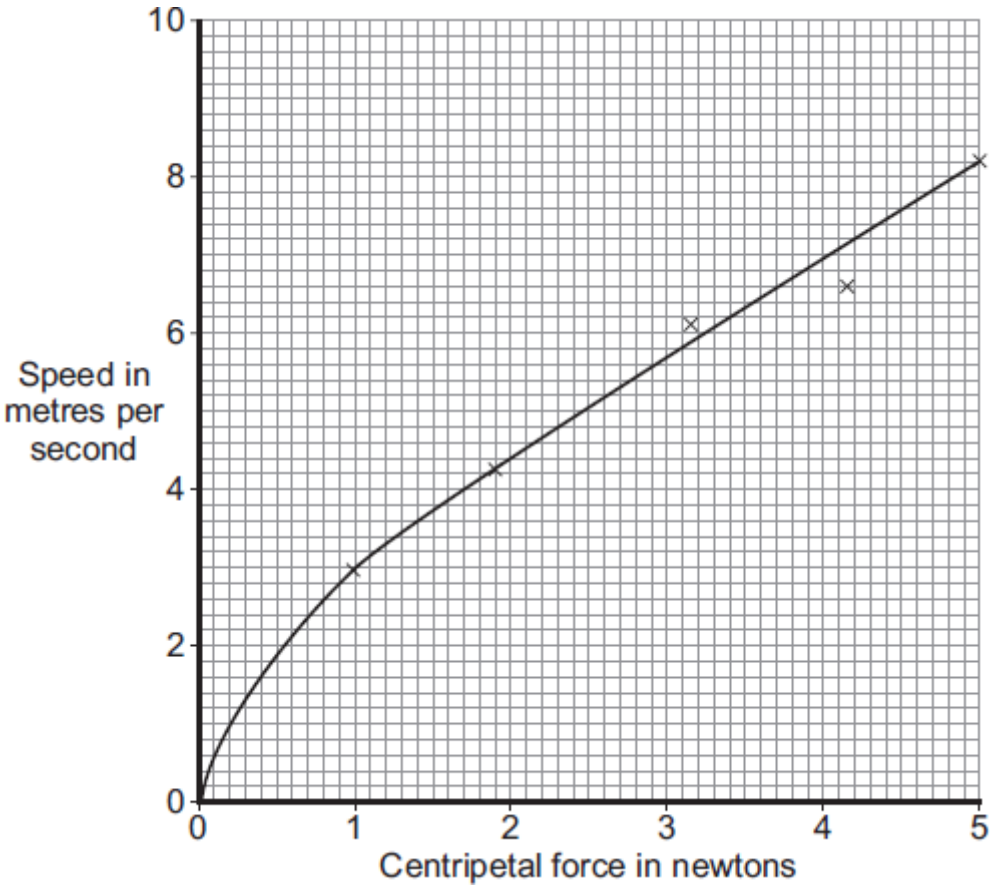
Suggest why.

_____

_____

(1)

(c) The graph shows the students' data.



There is a relationship between the speed of an object moving in a circle and the centripetal force acting on the object.

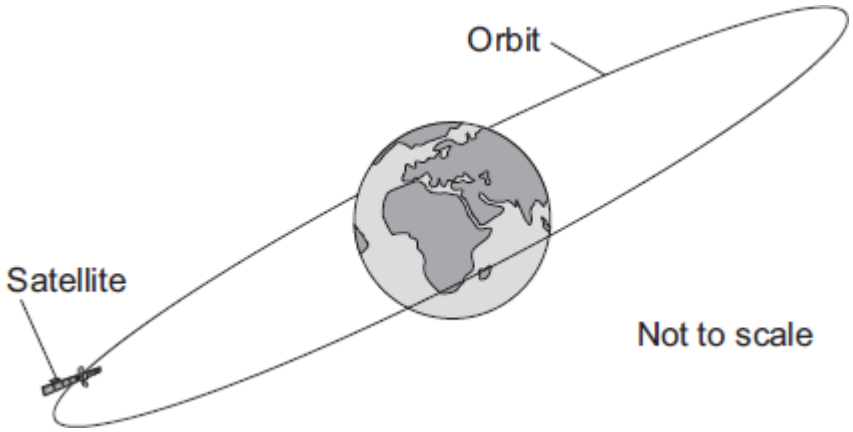
What conclusion about this relationship can the students make from their data?

_____

_____

(1)

(d) The diagram shows a satellite in a circular orbit above the Earth.
The satellite is part of the global positioning system (GPS).
The satellite orbits the Earth **twice** every 24 hours.



(i) What provides the centripetal force needed to keep the satellite in its orbit around the Earth?

_____

(1)

(ii) Is this satellite in a geostationary orbit?

Draw a ring around your answer. **Yes** **No**

Give a reason for your answer.

_____

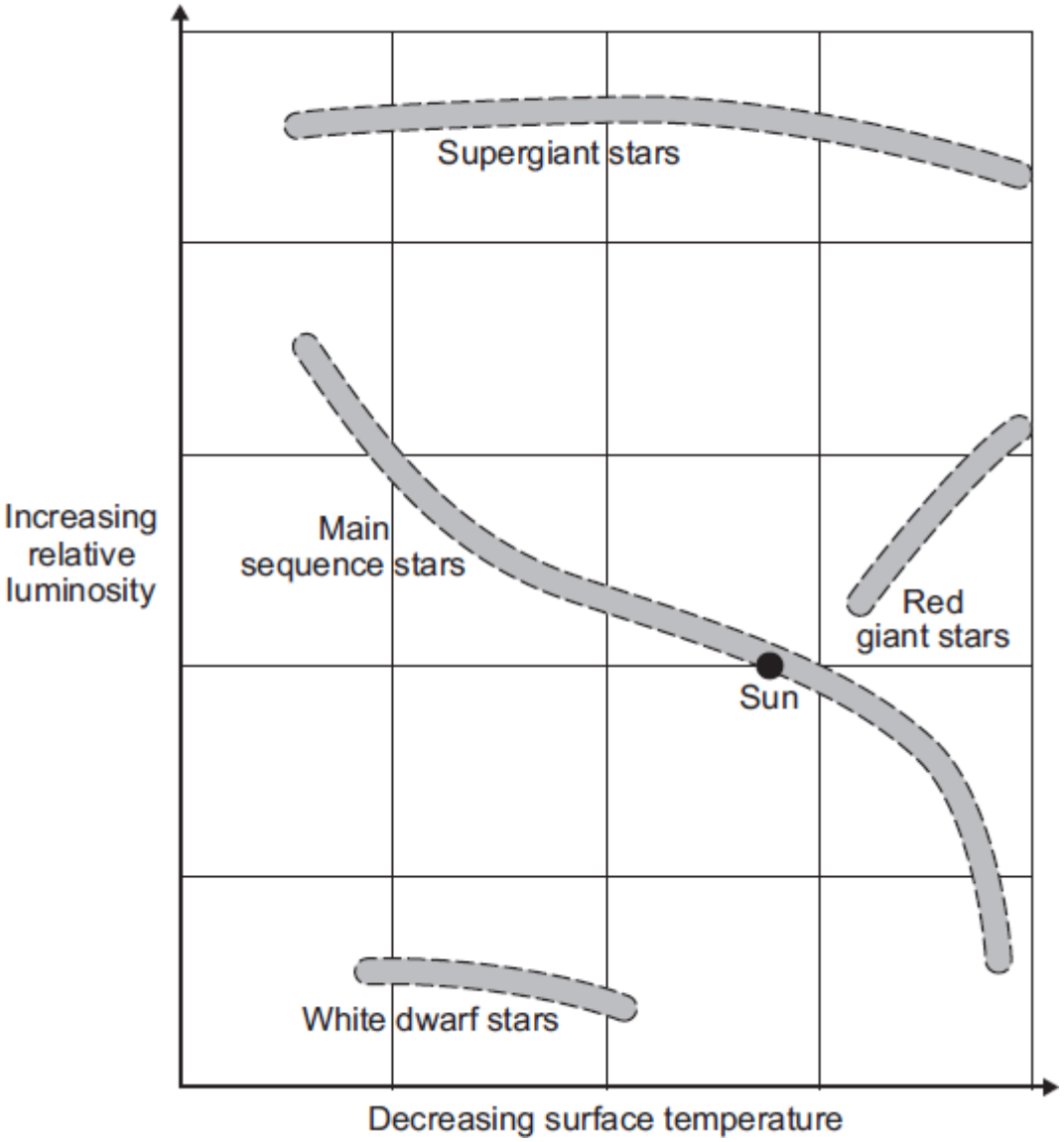
_____

(1)

(Total 9 marks)

Q13.

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?

_____

_____

(1)

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

_____

_____

_____

_____

_____

_____

_____

(3)

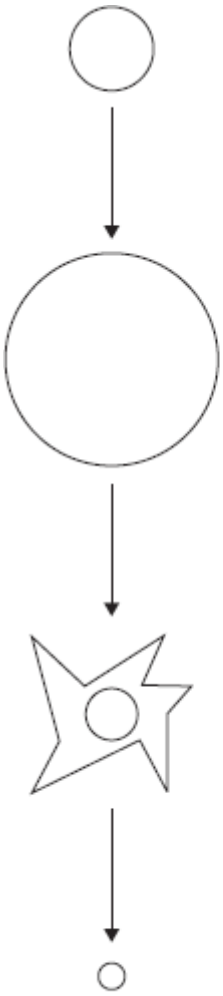
(Total 4 marks)

Q14.

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)

Q15.

(a) Our star, the Sun, is stable.

Explain what the conditions need to be for a star to remain stable.

_____

_____

_____

_____

_____

_____

(2)

(b) Shortly after the 'big bang', hydrogen was the only element in the Universe.

Explain how the other elements came to be formed.

_____

(3)

(Total 5 marks)

Q16.

Every star goes through a ‘life cycle’.

(a) Describe how a star forms.

(2)

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

Explain why a star remains stable.

(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.

_____

(2)

(Total 6 marks)

Q17.

(a) Choose the best words from the box to complete the following sentences.

billions	**fission**	**friction**	**fusion**	**gases**
gravity	**liquids**	**millions**	**thousands**	

(i) Stars form when enough dust and _____ from space are pulled together by _____ .

(2)

(ii) Stars are able to give out energy for millions of years by the process of

_____

(1)

(iii) The Sun is one of many _____ of stars in our galaxy.

(1)

(b) What is the name of our galaxy?

_____

(1)

(Total 5 marks)

Q18.

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 the Universe contains atoms of over one hundred elements.

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

_____

_____

_____

_____

(2)

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

_____

_____

_____

_____

(2)

(c) Explain how, and when, atoms of different elements may be distributed throughout the Universe.

_____

_____

_____

_____

(2)

(Total 6 marks)

Q19.

This passage is from a science magazine.

> *A star forms when enough dust and gas are pulled together.*
> *Masses smaller than a star may also be formed when dust and gas are pulled together.*

(a) What is the force which pulls the dust and gas together?

_____

(1)

(b) Complete the sentences.

(i) The smaller masses may be attracted by the star and become

_____ .

(1)

(ii) Our nearest star, the Sun, is stable because the gravitational forces and the radiation pressure are _____ .

(1)

(iii) The Sun is one of billions of stars in the galaxy called the

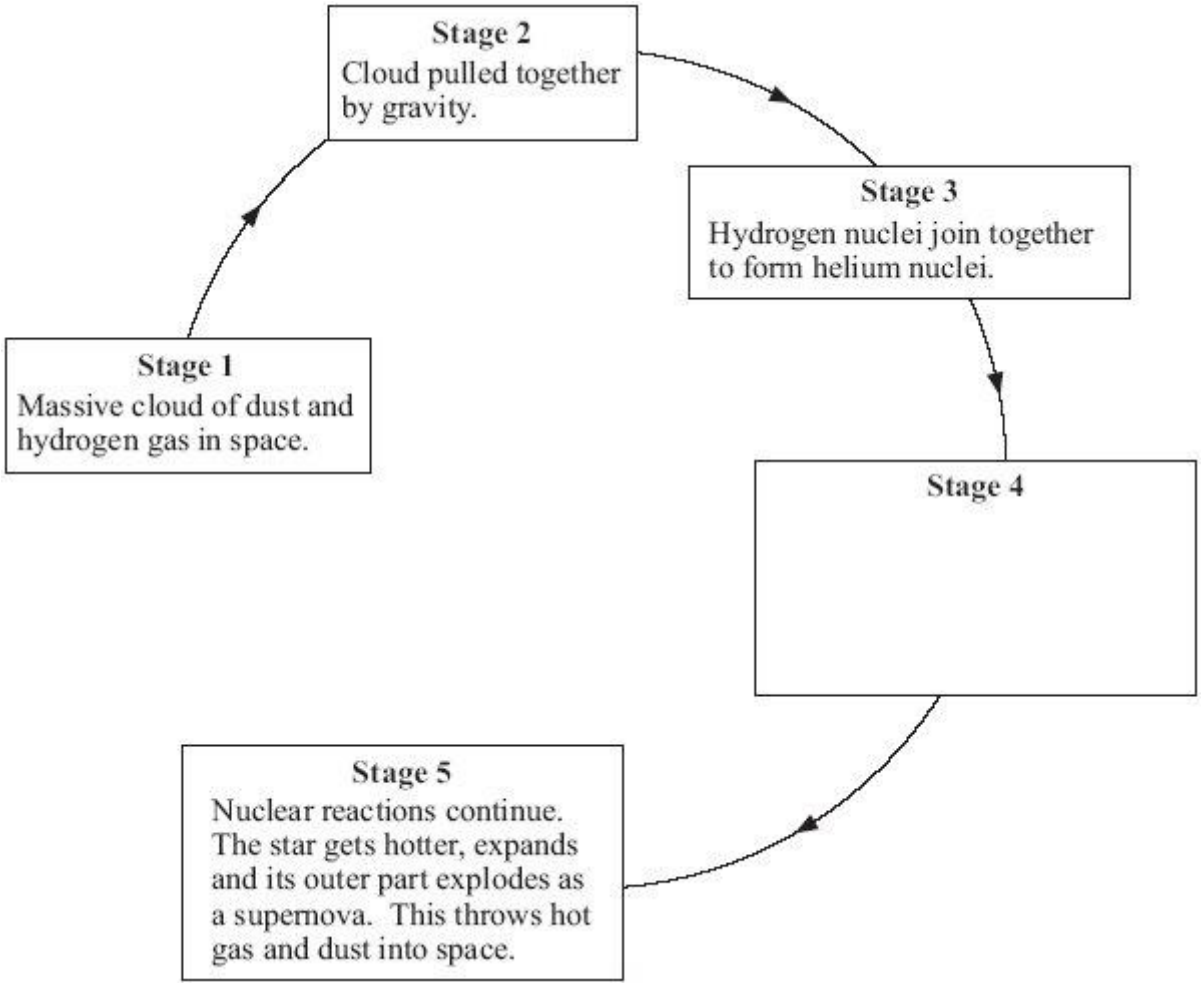
_____ .

(1)

(Total 4 marks)

Q20.

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?

_____

_____

(1)

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

Explain why.

_____

_____

_____

_____

_____

(2)

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

_____

_____

_____

_____

_____

(2)

(Total 6 marks)

Q21.

(a) Explain how stars produce energy.

_____

_____

_____

_____

(2)

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

_____

_____

(1)

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

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

_____

_____

(2)

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

_____

(1)

(Total 6 marks)

Q22.

Complete the following sentences by choosing the correct words from the box. Each word may be used once or not at all.

dwarf	**giant**	**neutron**	**proton**	**supernova**

If a red _____star is large enough, it may eventually blow

up in an explosion called a _____, leaving behind a very

dense _____ star.

(Total 3 marks)

Q23.

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)

Q24.

(i) Explain how stars like the Sun were formed.

_____

_____

_____

(2)

(ii) The Sun is made mostly of hydrogen. Eventually the hydrogen will be used up and the Sun will "die".

Describe what will happen to the Sun from the time the hydrogen is used up until the Sun "dies".

_____

_____

_____

_____

_____

(3)

(Total 5 marks)

Q25.

(a) Most of the Sun is hydrogen. Inside the core of the sun, hydrogen is being converted to helium. What name is given to this process and why is the process so important?

_____

_____

_____

(2)

(b) Describe what will happen to the Sun as the core runs out of hydrogen.

_____

_____

_____

_____

_____

(3)

(Total 5 marks)

Q26.

Stars are formed from massive clouds of dust and gases in space.

(a) What force pulls the clouds of dust and gas together to form stars?

_____

(1)

(b) Once formed a star can have a stable life for billions of years. Describe the **two** main forces at work in the star during this period of stability.

_____

_____

(2)

(c) What happens to this star once this stable period is over?

_____

_____

_____

_____

_____

(4)

(d) Suggest what might then happen to a planet close to this star.

_____

_____

(1)

(Total 8 marks)

Q27.

Describe briefly how stars such as the Sun are formed.

_____

_____

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(Total 2 marks)

Q28.

Nuclear fusion in the Sun releases large amounts of energy.

(i) Explain what is meant by nuclear fusion.

(3)

(ii) Why is energy released by such nuclear fusion reactions?

(2)

(Total 5 marks)

Q29.

(a) The Sun is at the stable stage of its life.

Explain, in terms of the forces acting on the Sun, what this means.

(3)

(b) At the end of the stable stage of its life a star will change.

Describe and explain the changes that could take place.

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(6)

(Total 9 marks)

Q30.

Our Sun is just one of many millions of stars in a galaxy called the Milky Way.

Our Sun is in the main stable period of a star's lifetime. The massive force of gravity draws its matter together. This force is balanced by the very high temperatures, from the fusion of hydrogen atoms, which tend to make the Sun expand. Describe and explain what will happen to the Sun as the hydrogen is eventually used up.

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(Total 3 marks)

Q31.

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.

(2)

(Total 6 marks)

Q32.

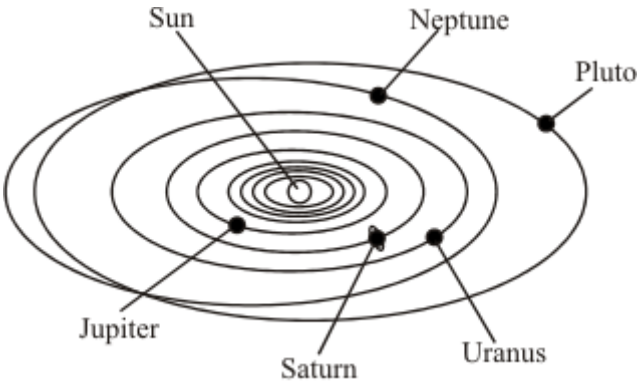
One theory of the origin of the Universe was that billions of years ago all matter was in one place, then it exploded (‘big bang’).
Describe, in as much detail as you can, how our star (the Sun) formed from the time when there was just dust and gas (mostly hydrogen) up to now when it is in its main stable 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.

(Total 5 marks)

Q33.

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



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

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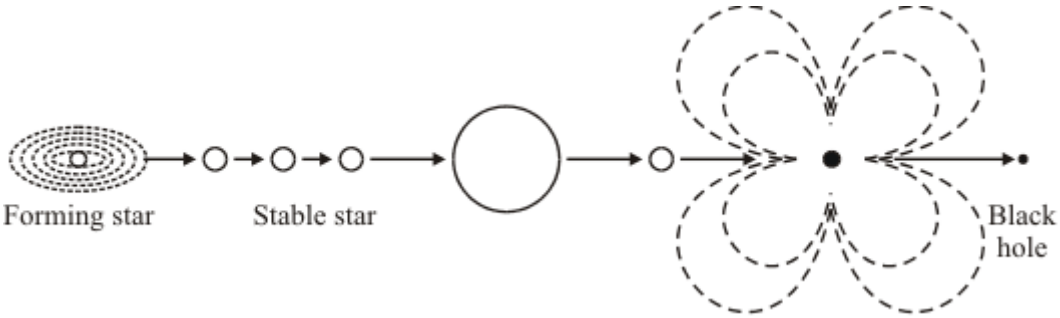
(1)

(b) Stars form from gas (mostly hydrogen) and dust.



Describe, in as much detail as you can, what forces allow a stable star to exist and how the star may eventually form a black hole.

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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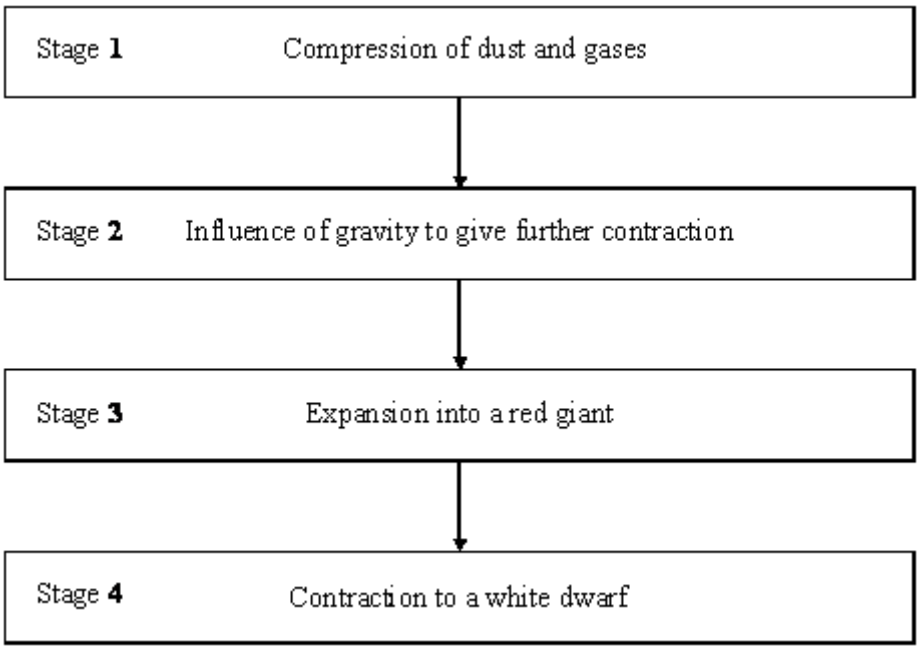
(6)

(Total 7 marks)

Q34.

The flowchart shows four stages thought to occur in the evolution of a star such as our Sun.



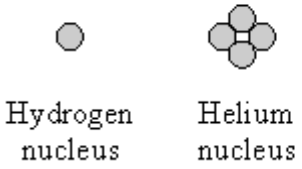
At a particular time a star might have reached one of these stages or be between stages or be at a further stage. What period in its evolution has our star, the Sun, reached?

(Total 1 mark)

Q35.

At the very high temperatures in the sun, hydrogen is converted into helium. It takes four hydrogen nuclei to produce one helium nucleus.

The table shows the relative masses of hydrogen and helium nuclei.



Nucleus	Relative Mass
hydrogen	1.007825
helium	4.0037

(a) Use these figures to calculate what happens to the mass of the sun as hydrogen is converted to helium.

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(3)

(b) Use your answer to part (a) to explain how the sun has been able to radiate huge amounts of energy for billions of years.

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(2)

(Total 5 marks)

Q36.

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

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

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

  energy released [J] = loss of mass [kg] × (speed of light [m/s^2])

  (The speed of light is 3×10^8 m/s)

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

(*Show your working*.)

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(4)

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

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

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

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

_____

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_____

(2)

(ii) Suggest an explanation for this relationship.

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(3)

(Total 9 marks)

Q37.

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

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(Total 6 marks)