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Level 2 Earth and Space Science 2022

91192 Demonstrate understanding of stars and planetary systems

Credits: Four

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of stars and planetary systems.	Demonstrate in-depth understanding of stars and planetary systems.	Demonstrate comprehensive understanding of stars and planetary systems.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

If you need more room for any answer, use the extra space provided at the back of this booklet.

Check that this booklet has pages 2–15 in the correct order and that none of these pages is blank.

Do not write in any cross-hatched area (▨). This area may be cut off when the booklet is marked.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

Achievement

TOTAL 12

RESOURCE

Adapted from: http://www.atnf.csiro.au/outreach/education/senior/cosmicengine/stars_hrdiagram.html

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The examination continues on the following page.

QUESTION ONE: VEGA AND RIGEL

Prominent in the winter night sky are the stars Rigel and Vega. Rigel is 20 times the mass of the Sun, whereas Vega is approximately twice the mass of the Sun.

(a) Using the HR diagram on page 2, complete the table below to list the properties of Vega and Rigel.

Star	Luminosity	Temperature	Colour
Rigel	10^5	12000°K	Blue/white
Vega	10^2	9500°K	Blue/White

(b) Explain the difference in fuel use of Rigel and Vega, by relating it to luminosity and mass.
In your answer, you should consider the rate at which the fuel is being used.

Vega is a main sequence star that is fusing H → He. It is not fusing at a high rate, as a main sequence star is very stable and stays as a main sequence star for most of it's life. Vega is also a smaller star than Rigel and so will be fusing at a slower rate. Vega's luminosity is also a lower number, 10^2, meaning it is not radiating as much energy.

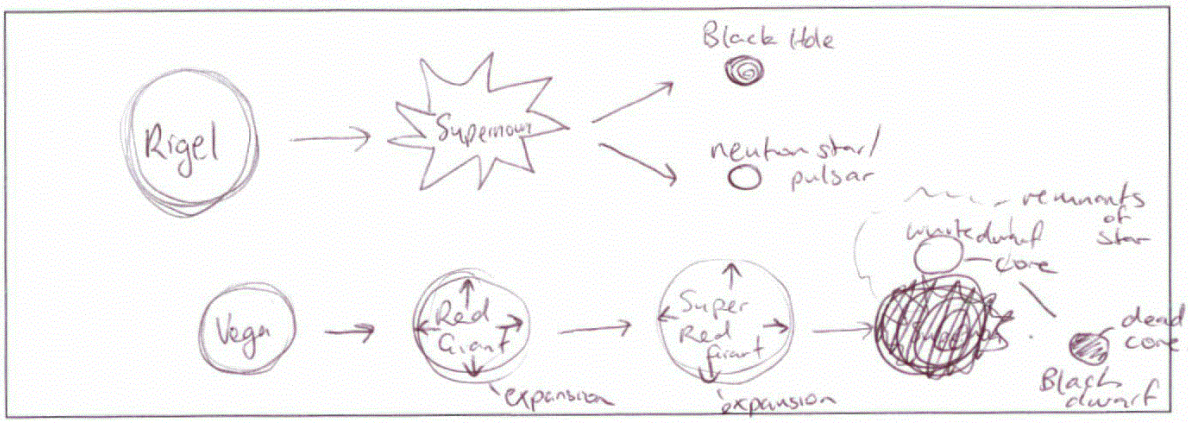
Rigel is a supergiant star, meaning it is fusing C → other elements. It is fusing at a very high rate, as it has a low magnitude of $-8 M_{sun}$, meaning it is a very big star and it has a high luminosity of 10^5. These factors mean that is fusing, and using up it's fuel very quickly and it is radiating a lot of energy per second.

(c) Compare the likely outcome of BOTH stars as they end their life cycle. (Note: you do not need to explain the various stages of each star's life cycle.)

In your answer, you should consider:

- the mass of the stars
- the role of gravity.

An annotated diagram may assist your answer.



Rigel is a supergrant star so as it ends its life cycle it will likely go supernova, exploding massively, and, if it is a massive star, it will turn into a black hole, or if its just a huge star, it will turn into a super dense neutron star.

Vega is a ~Sun-sized main sequence star. As it continues through it's life cycle, it will grow bigger then eventually turn into a white dwarf, the remaining core of the star, until it cools completely and turns into a black dwarf, a dead star.

QUESTION TWO: NEPTUNE'S SATELLITES

Neptune is the outermost planet of our solar system. It is a giant planet with 14 natural satellites.

The largest of the satellites is Triton. Its orbit is retrograde (rotates in the opposite direction to the planet), and it contains 99% of the total mass of all the satellites.

Adapted from: https://upload.wikimedia.org/wikipedia/commons/1/16/Orbits_of_inner_moons_of_Neptune_including_S_2004_N_1.jpg

(a) Describe what is meant by the term natural 'satellite'.

A ~~both~~ satellite is an object that orbits a planet. Also known as a moon. Also can be objects drifting in space.

There are a number of different theories about how satellites are formed.

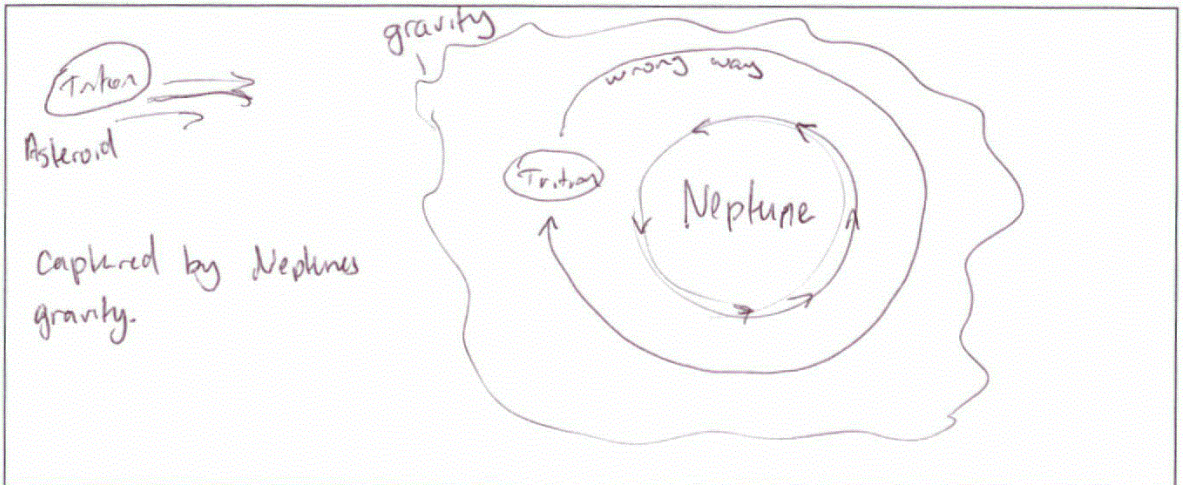
(b) Scientists think Triton may have been captured.

With reference to the diagram above and the information provided, explain why scientists may think this.

In your answer, you should consider:

- the capture theory of moon formation
- the mass of Triton
- the position of Triton's orbit and its motion around Neptune.

An annotated diagram may assist your answer.



There are three ways a moon may form. One way is the capture theory. As asteroids are floating through space, sometimes a planets gravity will "capture" them. The asteroid will then start to orbit that planet, in retrograde, meaning the opposite orbit to the planet that captures it. These captured moons are usually irregular in shape, as they are asteroids and don't have enough mass to compact into a spherical shape. Triton is likely a captured asteroid as it's orbit is retrograde, and it is quite large compared to the other moons. Asteroids moons are usually bigger as the other moons form by accretion and don't gain a lot of mass, whereas asteroids can begin with a lot of mass. It is likely Triton is a captured asteroid as it's orbit is further out from Neptune than the other moons.

(c) Explain, in detail, ONE theory of satellite formation, other than the capture theory, that may explain the formation of Neptune's other satellites.

In your answer, you should consider:

- the influence of gravity
- the mass of the satellites
- the orbits of the satellites.

An annotated diagram may assist your answer.

Another theory of satellite formation is the collision theory. During a planets early life, there is a lot of debris around from the proto-planetary disk. There are also smaller planetesimals that didn't gain enough mass to form a proper planet. As these planetesimals and various* debris travel around through space, they collide with each other. When the collide, the two planetesimals can combine and form a bigger planetesimal, which can become a moon. When the two collide, the friction heats the two bodies and they melt and meld together, forming a spherical moon that now orbits the planet.

* They can get captured by a planets gravity and as the planets gravity spins the planetesimals and debris around, they get faster and collide with each other.

Satellites that form from collision orbit the planet in the same way the planet is orbitting. Our Moon or Earth is believed to have been formed this way as well. When two planetesimals / small planets collide the two cores of the planetesimals meld together to create one planet (Earth) and the excess debris formed the Moon.

QUESTION THREE: NEUTRON STAR OR BLACK HOLE

Astronomers estimate that the Milky Way has anywhere from 10 million to one billion black holes, and around one billion neutron stars.

(a) With reference to the HR diagram on page 2, state where you would expect to find stars in the main sequence that will become neutron stars or black holes, and explain why they are found there.

Stars that are likely to become neutron stars are black holes will be found in the top left of the main sequence area as these are the biggest stars, and the biggest stars become neutron stars & black holes.

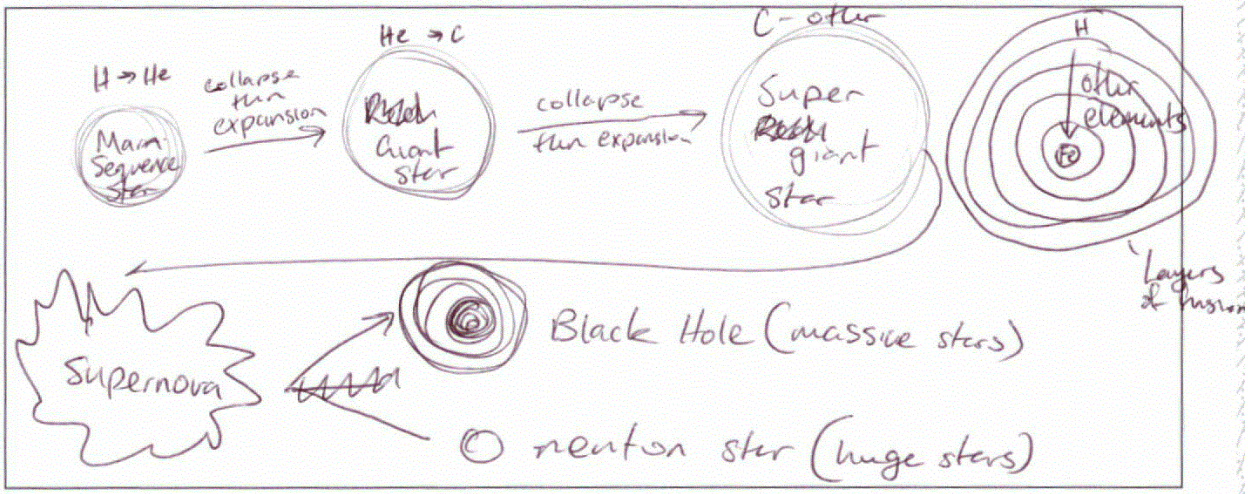
(b) Explain, in detail, the life cycle of stars that lead to the formation of neutron stars from the main sequence.

In your answer, you should explain:

- energy changes during the different life stages
- fuel use during the different life stages.

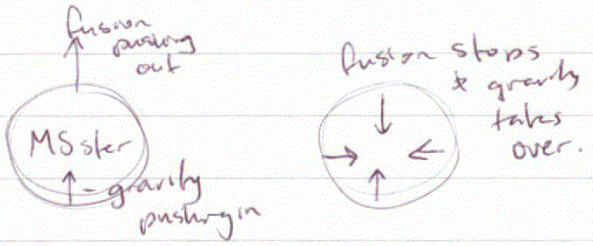
H, He, B, C, N, O, Ne, Mg, Si,

An annotated diagram may assist your answer.



When a main sequence star runs out of H, it stops fusing. When nuclear fusion stops pushing outward, gravity takes over and the star collapses in on itself. Then it heats up enough to start fusing He to C and nuclear fusion pushes the stars layers out again. Now it is a Red Giant star. When the giant star runs out of He it again stops fusing, collapses in on itself, heats up

again and starts fusing C into other elements (up to Fe). The star has layers of fusion starting with H in the outermost layer, He & C in the next and so on until the core which is Fe. Fe is the lightest element a star can fuse that releases energy instead of absorbing it. Once a supergiant runs out of fuel it collapses again and then explodes, creating all the other elements in the universe in an instant. This is a supernova. The remaining ~~dea~~ star can be one of two things. If it was a big main sequence star it will now turn into a neutron star, a highly dense core of a star. If it was a massive main sequence star, it will turn into a black hole, a highly dense rip in space that no light can escape from. Neutron stars are more likely to form as massive stars are less likely to exist.

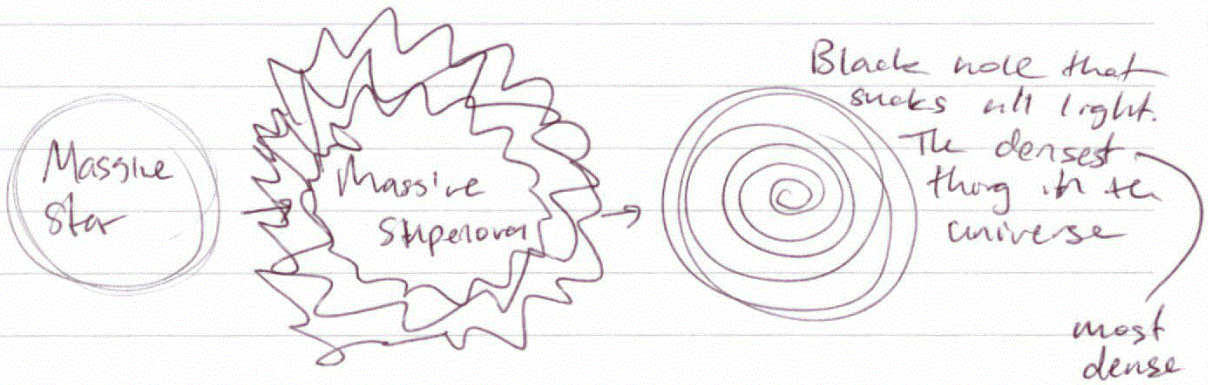


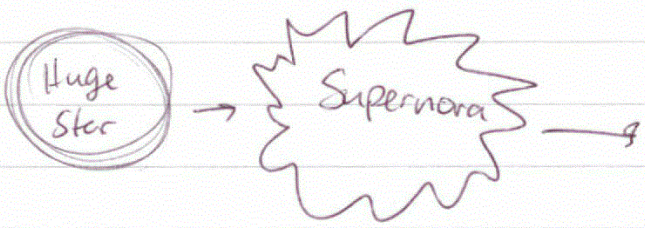
Question Three continues on the following page

(c) Explain why some dying stars form neutron stars, while others form black holes.
In your answer, you should consider the effects of mass and gravity.

This was answered on the page before.

Stars become different things based on their size. The biggest stars form black holes because the supernova is so massive and uses so much energy that it rips the fabric of space.





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QUESTION NUMBER

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Standard	91192	Display ID	Response 62194200 NSN 138040365	**Total score**	12 = A
Q	**Grade score**	**Annotation**			
1	A4	The data table is completed. The fuel use and different rates of the two stars are described, with the larger star consuming its fuel faster. Rigel's outcome is clearly described, however the description for Vega is missing the formation of the planetary nebula.			
2	A4	Satellite is defined. Annotated diagrams supplement the descriptions given for the candidate's reasoning for Triton's capture and behaviour. An interpretation of the formation of the inner moons uses collision theory as its base.			
3	A4	The correct location on the HR diagram is given. The description of star development is given with commentary on the elements involved in fusion but there is little reference to the role of gravity. No values are given regard to mass and star outcome. Annotated diagram is given for the answer to part c			