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91192



Draw a cross through the box (☒) if you have NOT written in this booklet

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Mana Tohu Mātauranga o Aotearoa  
New Zealand Qualifications Authority

## Level 2 Earth and Space Science 2025

### 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 2–16 in the correct order and that none of these pages is blank.

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

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

**Achievement**

**TOTAL 9**

## RESOURCE

**HR (Hertzsprung-Russell) diagram**

Effective temperature, K



Luminosity compared to Sun

Adapted from: [http://www.atnf.csiro.au/outreach/education/senior/cosmicengine/stars\\_hrDiagram.html](http://www.atnf.csiro.au/outreach/education/senior/cosmicengine/stars_hrDiagram.html)

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The assessment begins on the following page.**

### QUESTION ONE: LEPUS

The constellation Lepus sits near the Orion constellation in the southern sky.

The constellation's brightest star is Arneb. The star has a mass of 14  $M_{\text{sun}}$ , and is approximately 1250 light years from the Sun. In the same constellation is the Gliese 229 system. The star Gliese, has a mass of 0.6  $M_{\text{sun}}$ , and is 19 light years from the Sun.

- (a) Using the HR diagram on page 2, complete the table comparing the properties of Arneb with Gliese 229.

Star	Colour	Temperature	Luminosity
Arneb	light yellow <del>to</del> white	6,700 K	$10^{4.83.9}$
Gliese 229	Orange	3,800 K	$10^{2.8-1.8}$

- (b) Explain, in detail, using the information from the HR diagram and the star properties, the differences in luminosity between Arneb and Gliese 229.

In your answer you should consider:

- what luminosity refers to
- the mass of each star
- the temperature of each star
- the current fusion process.

Arneb ~~Gliese 229~~ is much brighter when compared to ~~Arneb~~ <sup>Gliese 229</sup> with it ~~been~~ having a luminosity of  $10^{3.9}$  and a ~~Arneb~~ <sup>Gliese 229</sup> having a luminosity of  $10^{-1.8}$ . Luminosity refers to the brightness of the <sup>star</sup> with the standard being our Sun, at a luminosity of 1.

Gliese 229 has a much lower <sup>mass</sup> density than Arneb, with it being a mass of 0.6  $M_{\text{sun}}$  and Arneb has a mass of 14  $M_{\text{sun}}$ .

Having the larger mass allows Arneb

to burn more fuel more brightly. Arneb is much hotter than Gliese 229 with it being  $6,700\text{K}$  and Gliese 229 being  $3,800\text{K}$ . That is a difference of  $2,900\text{K}$ .

The fusion process that Gliese 229 is currently at as a main sequence star is more than likely hydrogen and Arneb being a super giant is more than likely to be burning denser elements such as carbon.

- (c) There are two brown dwarfs orbiting Gliese.



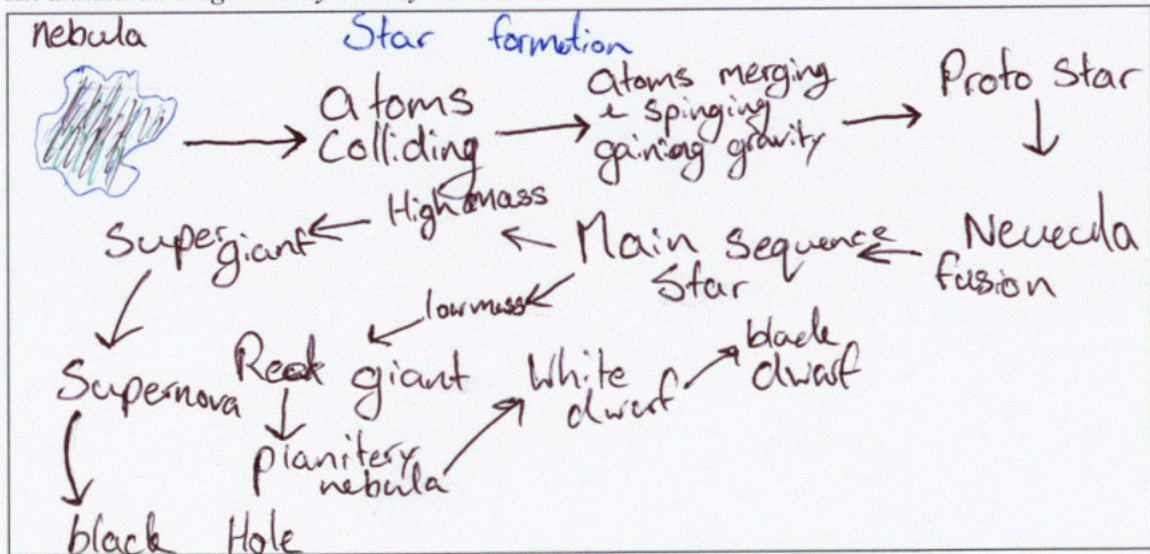
Adapted from: <https://hubblesite.org/contents/media/images/1995/48/372-Image.html?news=true>

Explain, in detail, why these brown dwarfs would not be found on the HR diagram.

In your answer you should consider:

- the process of star formation
- temperature and energy source in main sequence stars
- the role of mass in star formation.

An annotated diagram may assist your answer.



The reason why brown dwarfs do not show up on HR diagrams is that they are not bright or hot enough to show up. This is because as they were forming they didn't collect enough mass to fully form.

The process of star formation starts off in a nebula which is a collection of dust and gases eg. hydrogen.

These dusts and gases collide causing the atoms to start spinning and drawing in other atoms. It keeps gaining mass and gravitational pull and gravity until it forms a Protostar.

A main sequence star typically burns hydrogen as its energy source but their temperatures can vary depending on the mass of the star.

## QUESTION TWO: MOONS

- (a) All planets and moons within our solar system originated from material within the protoplanetary disk.

Describe what a protoplanetary disk is.

A protoplanetary disk is the collection of dust, rock and gases with the dust and rocks being inside the frost line and the gases being pushed out by the radiation of the star. They form in a disk on →

- (b) Earth and Mars are similar in that both rocky planets have moons.

Mars has two moons, Phobos and Deimos. Both moons are small and irregular in shape.



The Martian moons: Deimos and Phobos

Source: <https://www.skyatnightmagazine.com/space-science/the-moons-of-mars>

The orbits of Deimos and Phobos

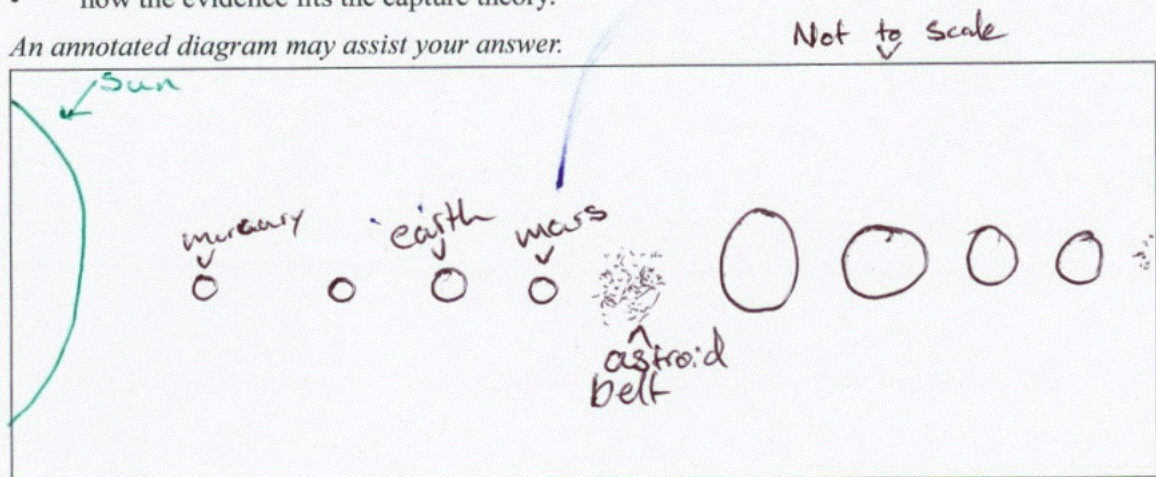
Source: <https://astronomynow.com/2018/07/30/find-martian-moons-phobos-and-deimos-at-the-red-planets-closest-approach/>

Using evidence from the diagrams above, explain in detail, why the capture theory is the most likely origin of Deimos and Phobos.

In your answer you should consider:

- the position of the asteroid belt
- how the evidence fits the capture theory.

An annotated diagram may assist your answer.



(a) Cont'd).

The axis of the stars rotation.

(b) The reason that the capture theory is the most likely origin of Deimos and Phobos is because Mars is the closest rocky planet to the Asteroid belt and if any rocks / asteroids went out of the Asteroid belt close to Mars' orbit the gravitational pull of Mars would most likely draw them in, most likely capturing them from their original direction.

- (c) The Earth's Moon is thought to be about 4.46 billion years old. Earth is 4.55 billion years old.

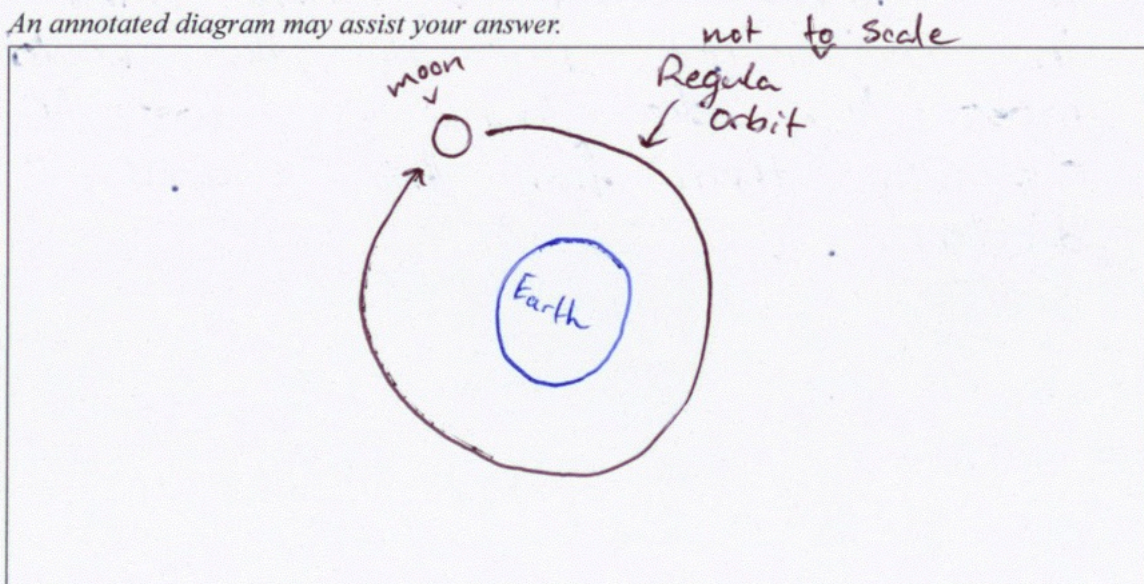
The final Apollo mission in 1972 brought back rock samples from the Earth's Moon. These samples were chemically analysed and found to have a similar chemical composition to rocks on the Earth, but showed evidence of lower levels of iron and gaseous substances.

Using evidence explain, in detail, how the collision theory could explain the Moon's origin.

In your answer you should consider:

- the Moon's orbit
- evidence from rock samples
- how the evidence fits the collision theory
- how the evidence discounts other theories.

An annotated diagram may assist your answer.



When looking at the origin of the moon the collision theory is more than likely correct. This is because of the similarities in the rock found on earth when compared to the rock found on the moon.

The moon's orbit is a regular circle orbit with one side of the moon constantly facing earth.

Source: <https://en.wikipedia.org/wiki/Moon#/media/File:FullMoon2010.jpg>



### QUESTION THREE: DEATH OF A STAR

Māori and Pacific astronomical traditions refer to Māhutonga, a bright star that became invisible. This was recorded in the southern sky around AD 185, and has been traced to the likely occurrence of a supernova in the constellation of Centauri.



Source: <https://www.skyatnightmagazine.com/space-science/when-stars-collapse-what-is-a-supernova>

- (a) What is a supernova?

A supernova is <sup>when</sup> at the end of a high mass star runs out of fuel and therefore goes supernova and implodes forming a black hole or a (planetary nebula) neutron star.

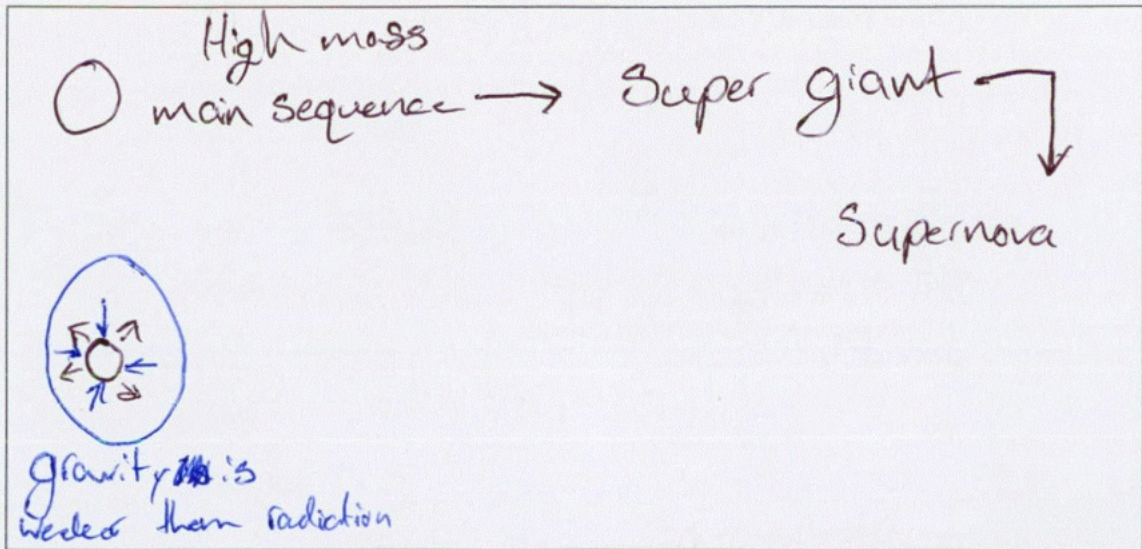
- (b) Explain, in detail, the type and behaviour of a star from its main sequence stage until it goes supernova.

In your answer you should:

- state where on the HR diagram this type of star would have been during main sequence
- the energy changes
- the fuel use
- the role of gravity.

An annotated diagram may assist your answer.

During the main sequence stage the star would have been higher up on the curve, with a bluish colour, and hotter temperature and brighter luminosity than other stars. At this stage in its



cycle it would have been burning hydrogen. As it got older and its fuel changed, it would have shifted from a main sequence star up to a super giant. As it shifts it would be using more energy therefore getting brighter but as it burns more fuel and uses more energy radiation from nuclear fusion increases pushing out the outer core (~~the outer~~) because the radiation is stronger than the gravitational pull.

Question Three continues on the next page.

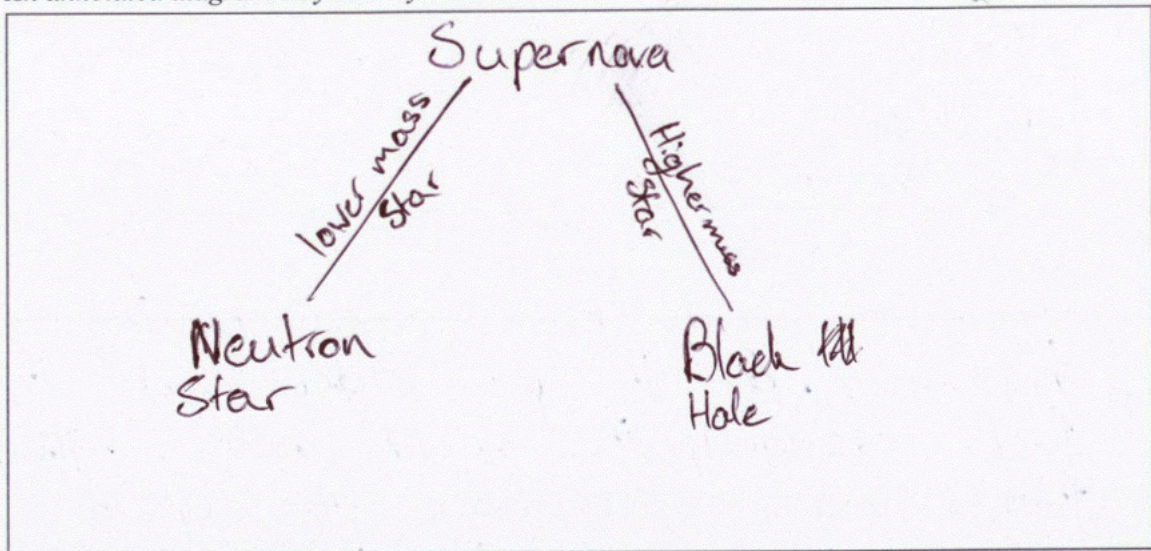
- (c) Following the supernova, there are two possible outcomes.

Explain, in detail, the critical factors that would lead to either of these outcomes.

In your answer you should:

- state the two possible outcomes
- consider the role of mass
- consider the role of gravitational forces.

An annotated diagram may assist your answer.



For a star to go supernova it has to be extremely high in mass. The two possible outcomes that can occur during a supernova is the formation of a neutron star or a black hole.

With a lower mass star going supernova forming a neutron star and a higher mass star going supernova forming a black hole.

A black hole occurs when there is so much mass in a finite amount of space.





## Achievement

**Subject:** L2 Earth & Space Science

**Standard:** 91192

**Total score:** 9

Q	Grade score	Marker commentary
One	A4	<p>The candidate correctly completes the data table from the HR diagram. A description is given of Arneb and Gliese is given in terms of their current fusion process and reference made to luminosity in terms of comparison of values to the Sun. No detail or explanation is given related to star surface area and energy release.</p> <p>A brown dwarf is described with some detail given as to the origins of star formation. This could be expanded to compare the difference between the formation of a main sequence star and a brown dwarf.</p>
Two	A3	<p>The protoplanetary disk is described. The reference to Mar's moons being captured and their origins in the asteroid belt described. The only reference to the Moon's origin is given in terms of its orbit. Reference could have been made to the origin of the moons material or how the orbit can differ in the different origin theories.</p>
Three	N2	<p>The candidate refers to the changes in fusion process (fuel) as the star progresses through from main sequence to giant. The outcomes of a supernova are described without referencing the original star mass. Further detail could have given on the fusion process and the role of gravity in the fusion process.</p>