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91192

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Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 2 Earth & Space Science 2023

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.

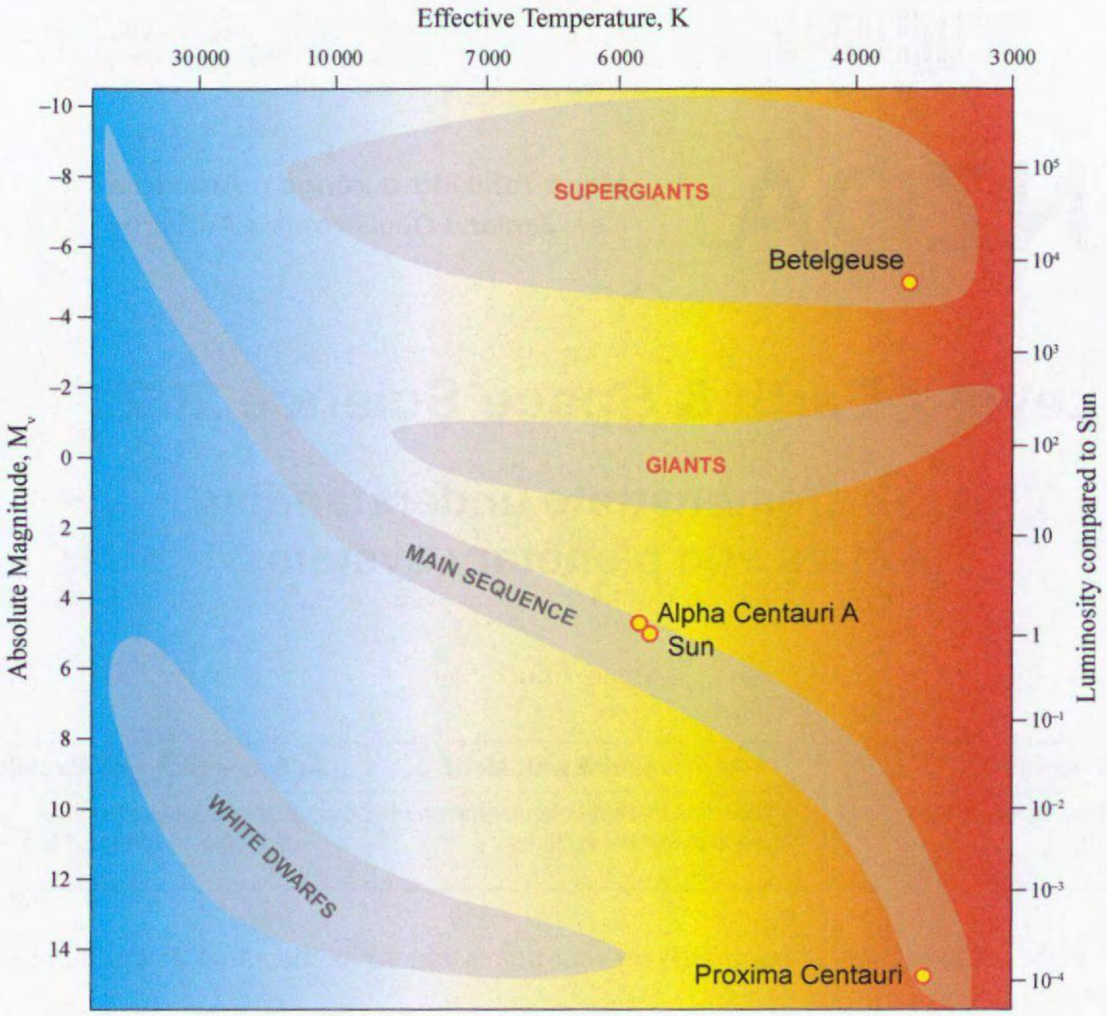
YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

Achievement

TOTAL 11

RESOURCE

HR (Hertzsprung-Russell) diagram



Adapted from: 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: RED STARS

Betelgeuse and Proxima Centauri are both red stars. Betelgeuse is easily seen in the constellation of Orion. Proxima Centauri is a star that forms part of the triple star system in the constellation of Centauri. Betelgeuse is 642.5 light years away from Earth, and has a mass of approximately 17 solar masses, while Proxima Centauri is only 4.2 light years away, and has a solar mass of 0.12.

(a) Using the HR diagram on page 2, complete the table comparing the properties of Betelgeuse and Proxima Centauri.

Star	**Life Stage**	**Temperature**	**Absolute Magnitude**	**Luminosity**
Betelgeuse	Supergiant	3800K	−5	10^4
Proxima Centauri	Red Dwarf	3400K	14	10^{-4}

(b) Explain, in detail, using the information from the HR diagram and the star properties in part (a), the reason for the difference in absolute magnitudes of Betelgeuse and Proxima Centauri.

In your answer you should consider:

- the difference between luminosity and absolute magnitude
- surface temperature
- surface area.

Luminosity is the amount of energy emitted per second. Absolute magnitude is the measurement of a stars actual brightness.

Betelgewe may be at the end of its cycle and so its ~~depleti~~ depleting its fuel relatively quickly. In this case, there would not be as much energy being emitted and so the ster is dimmer. But as the star does contract, the surface temperature may increase due to pressure.

Surface area contributes to the amount of energy being emitted per second. ~~Sine~~ Since PC is more luminous means that there is a larger surface area of energy emitted.

But as a red dwarf, the energy being emitted per second is relatively slow.

(c) Explain, in detail, how the luminosity of Betelgeuse will change over its life stages, whereas the luminosity of Proxima Centauri will not change until the end of its life.

In your answer you should consider:

- star mass
- surface area
- surface temperature
- life stages.

An annotated diagram may assist your answer.

(Planning Space)

- contraction?
- emission (p/s)

Betelgeuse's luminosity will change because its a high mass star. When it reaches the end of the supergiant phase, the star will lose mass but increase in temperature before it collapses and goes supernova. After the short lived explosion, it will leave behind a very small but luminous ball of gas, a neutron star. While the star is forcing electrons and protons to fuse, the surface temperature is increasing, moreso than how Betelgeuse was as a supergiant. It's currently more luminous because of the energy emitted per second.

Proxima Centauri is a low mass star and its luminosity will not change until it's death. This is because of its current magnitude and mass.

It is of similar magnitude and luminosity as a white dwarf. Especially its size. The star is currently stable and is releasing enough energy to counter the inward pressure of gravity. The amount of energy being emitted contributes to its size. Since, Betelgeuse might be contracting, the surface area of PC may be effectively larger and so is burning and releasing energy at a stable rate, avoiding contraction. When PC becomes a white dwarf its luminosity will remain the same until its burned off the remaining fuel. It's luminosity will now decrease as it becomes a dim and dull black dwarf.

QUESTION TWO: MATARIKI

Source: www.sciencelearn.org.nz/images/697-matariki-pleiades-star-cluster

Matariki is a star cluster indicating the beginning of the New Year to many Māori iwi. It contains many young stars, the brightest of these being 14 young, blue, main-sequence stars that have formed in the associated stellar nebula. These stars have masses in the range of 3 solar masses to 6 solar masses for the largest.

(a) Describe what is meant by the term "stellar nebula".

A stellar nebula is a cloud of dust and gas a star is born from.

(b) Explain, in detail, how these young blue stars would have formed.

In your answer you should consider the role gravity plays in star formation.

An annotated diagram may assist your answer.

(Planning Space)

nebula → protostar → main sequence

- very hot
- relatively bright
- stable (H → He)
- gravitational (potential energy conversion?) maybe?
- friction

It starts as a ~~nebulae~~ nebula. Dust and gas particles come together under the force of gravity. When these particles clump, they gain slight mass and rise in temperature. The rise in temperature causes the particles to collide at a faster rate which causes expansion in the birth of a protostar. The young star still lacks mass and a prominent source of energy. However, the star continues to pull in dust and gas particles due to its developing gravity. The collision of the particles causes friction in the protostar which leads to an increase in temperature ~~Eventually, the stars will actually~~ Because the stars are blue main sequence, the protostar would've accumulated so much dust and gas ~~that it so~~ that friction caused the stars temperature to increase rapidly. The amount of friction occurring may differ depending on the different sizes of each of the 14 stars.

(c) Explain, in detail, the life cycle of the smallest (3 solar masses) of these young blue stars from main sequence to the end of its life.

In your answer you should consider:

- the role of gravity in the changing life stages
- fuel usage during the different life stages
- energy changes during the different life stages.

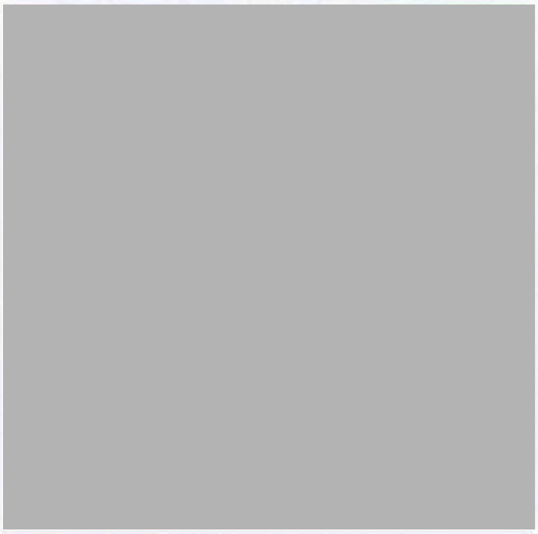
An annotated diagram may assist your answer.

(Planning Space)
main sequence → ~~blue~~ white? yellow or red giant? — nebula — white dwarf

- rate of fusion
- low mass
- small, may ~~lose~~ lose temp and energy

The low mass stars are currently fusing H → He, counteracting the inward force of gravity with its energy emitted. Once the stars run out of fuel, the pressure of gravity dominates because there is not enough energy being released to counter it. So the core contracts. During contraction, the stars may ~~lose~~ drop in temperature because of the lack of fuel. It may become ~~a~~ a yellow-red giant. It becomes a giant after ~~enough~~ the temperature of the core is hot enough to commence nuclear fusion (H → He) once more. The star regains a relatively stable fuel source. ~~except it's now currently fusing helium hydrogen nuclei into carbon~~. In this stage, more energy is being emitted. The stars couldn't become supergiants due to its low mass ($3M_{sun}$), and ~~inabitt~~ inability to fuse helium nuclei into carbon. The star is not as stable in this stage as the energy can only briefly counter the inward pressure of gravity contracting again. Through a lot of contracting and expanding the star will eventually burn off its remaining fuel and energy, causing them to ~~expell~~ expel their outer layers of gas, leaving behind a hot, small dense, and bright white dwarf. This star is no longer doing nuclear fusion and effectively has no fuel. It's burning and radiating the remaining energy leftover when it was once a giant. With time the star has burned off ~~the~~ the last of its energy, leaving behind a cold, black dwarf.

QUESTION THREE: JUPITER AND THE SOLAR SYSTEM



Source: https://blogs.nasa.gov/Watch_the_Skies/2022/09/16/jupiter-to-reach-opposition-closet-approach-to-earth-in-70-years/

Our solar system consists of eight planets, with Jupiter the largest.

(a) Describe the difference between a star and planet.

A star is a luminous ball of hot gas that doesn't orbit anything. A planet is a celestial body that orbits a star, can be rocky or gaseous.

(b) Explain, in detail, how gas giant planets like Jupiter are formed.

In your answer you should consider:

- the role of gravity
- temperature
- solar winds.

An annotated diagram may assist your answer.

(Planning Space)

- frost line
- planetesimals
- mass
- composition (and the core)
- moons ?
- rotation speed ?.
- accretion
- planetary disk

Gas giants may have formed from planetary disks. The debris accreted to form planetismals that also accreted. With enough mass to generate its own gravitational pull, the protoplanet would be accumulating more debris, dust and gas particles. This will cause it to expand with great masses because solar winds do not affect it. The central star (our sun) didn't blow off any gas layers due to the far distance. ~~F~~ Gas giants are located beyond the frost line where its cooler. As the planet expands, the temperature within its core will increase as more friction is built up by the collision of dust and gas particles. Gas giants are larger than rocky planets, and are made up of more volatile materials such as methane, ice, and CO_2.

Question Three continues on the next page.

(c) The picture below shows Jupiter's three rings, and the four rocky moons that accompany the rings. The rings are mainly made up of very fine dust particles.

Source: https://upload.wikimedia.org/wikipedia/commons/thumb/b/b8/Jupiter_Rings_ca.svg/2560px-Jupiter_Rings_ca.svg.png

Explain, in detail, how Jupiter's four rocky moons and ring system could possibly have been formed.

In your answer you should consider:

- the planet's gravity
- how moons may have formed around Jupiter
- the material making up Jupiter's rings.

An annotated diagram may assist your answer.

(Planning Space)

- circumplanetary disk
- accretion
- dust, gas, rocks, ice

Because Jupiter would've been made up of dust, gar and the accretion of planetismals, the debris remaining may be the material Jupiters rings are composed of. ~~Since Jupiters~~ Because of Jupiters gravity, the debris remained in orbit as a circumplanetary disk. Moons may have formed from the accretion of remaining debris which would continue ~~to~~ grow in size and remain in orbit around Jupiter.

Jupiter s gravitational pull may have also pulled larger planetismals into orbit but not strong enough to be pulled towards its surface.

Extra space if required.
Write the question number(s) if applicable.

QUESTION NUMBER

91192

Achievement

Subject: Earth & Space Science

Standard: 91192

Total score: 11

Q	Grade score	Marker commentary
One	A3	The candidate provides the relevant definitions and information from the HR diagram, but does not interpret the information correctly. The mistaken life cycle quoted for red dwarf stars is a common misconception.
Two	A4	The role gravity takes in star formation is described. The initial fusion process is described as is the final outcome of these stars.
Three	A4	The role of gravity and the solar winds is described in the formation of solar system planets. Accretion of leftover material is described in the formation of Jupiter’s moons.