Assessment Schedule – 2022

Earth and Space Science: Demonstrate understanding of stars and planetary systems (91192)

Evidence Statement

Question One

<table>
<tr><th>Q</th><th>Expected Coverage</th><th>Achievement</th><th>Merit</th><th>Excellence</th></tr>
<tr><td>ONE (a)</td><td>
<table>
<tr><td>Star</td><td>Luminosity</td><td>Temperature</td><td>Colour</td></tr>
<tr><td>Rigel</td><td>$10^{4.5\text{-}5}$</td><td>10 500 – 12 000K</td><td>Blue</td></tr>
<tr><td>Vega</td><td>$10^{1.5\text{-}2.0}$</td><td>8 – 9 000K</td><td>White / blue-white</td></tr>
</table>
</td><td>• 4/6 (within parameters)</td><td></td><td></td></tr>
<tr><td>(b)</td><td>Rigel is a massive star which has used its hydrogen fuel rapidly due to its mass and is now fusing helium and other elements (He → C → Ne → O → Si → Fe sequence).
Rigel is much hotter than Vega, and luminosity indicates a higher energy output (luminosity defined as energy output per second), indicating rapid fusion is taking place.
Vega is a much lower mass star than Rigel, with a lower energy output, as indicated by its luminosity. This indicates hydrogen fusion is occurring at a much slower rate than Rigel.</td><td>Describes:
• fuel use of Rigel / Vega
• rate of fuel use for Rigel / Vega</td><td>Explains:
• links Rigel’s rate of fuel use, to luminosity / mass.
• links Vega’s rate of fuel use to luminosity / mass</td><td>Explains comprehensively:
• a comparison of the current fuel use and rate of both Rigel and Vega in relation to their luminosity and mass</td></tr>
</table>

(c)	Rigel is in the latter part of its life cycle and is a supergiant; due to its large mass the hydrogen fuel is nearly exhausted. The massive size means there will be huge gravitational forces in the core that will create conditions for the fusion of heavier elements up to Fe. Rigel will eventually supernova, leaving behind either a neutron star or black hole. Vega is a main sequence star with a lower mass. It will fuse hydrogen fuel until exhausted in its core. At this point, the star will expand and cool to become a red giant, sufficient gravitational forces will cause helium fusion in the core. Helium will fuse to form heavier elements up to carbon and oxygen. Outer material will drift off, escaping the gravitational force of a small core, forming a nebula, and a white dwarf of extremely hot carbon remains. This cools to become a black dwarf. *Note:* *Evidence may be taken from annotated diagram.* *Evidence may be taken from any section of the question.*	• stages of fusion that will occur in Rigel • Rigel outcome to supernova and neutron star / black hole • stages of fusion that will take place in Vega • Vega outcome to nebula and white dwarf.	• the likely outcome of either Vega or Rigel linking to mass • the likely outcome of either Vega or Rigel linking to gravity.	• a comparison of the likely outcomes of Rigel and Vega to their mass & the role of gravity.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response or response does not relate to the question.	Describes ONE partial idea at the Achievement level.	Describes TWO ideas at the Achievement level.	Describes THREE ideas at the Achievement level.	Describes FOUR ideas at the Achievement level.	Explains ONE idea at Merit level.	Explains TWO ideas at Merit level.	Explains ONE point at Excellence level or TWO with minor errors.	Explains TWO points at Excellence level

Question Two

Q	Expected Coverage	Achievement	Merit	Excellence
(a)	A natural satellite refers to a naturally occurring space object in regular orbit about another object.	Describes: • a natural satellite	Explains:	Explains comprehensively:
(b)	Triton is considered a captured body. The capture theory states that a bypassing space object becomes trapped in a planet's gravitational field. These objects are often irregular in shape, orbits are elliptical. The reasons are: • Its orbit is retrograde, and the opposite to rotation of the planet and satellite system, including the rings. • It is the outermost satellite in the system. • The orbit is elliptical. Rather like it has been caught in a slingshot by Neptune's large gravitational field as it passed by. • Its large mass. The mass comprising of 99% of the total satellite system suggests that Triton comprises of a large mass of solid material. It also suggests that it could be a dwarf planet. The orbit represents a balance between the two gravitational fields, but with Neptune's large mass and field Triton could be drawn into closer orbit.	• a reason for the retrograde orbit of Triton with respect to the rest of the system • the large mass of Triton with respect to the rest of the system • the elliptical orbit of Triton with respect to the rest of the system • the position of Triton's orbit in the system with respect to the rest of the system.	• the link between the position, direction and shape of the orbit in relation to the rest of the satellite system (2 of 3) • the link between masses and gravitational fields in the establishment of Triton's orbit	• why Triton is part of the system, but also why it is different compared to the remainder of the satellite system

(c)	Possible theories of moon formation include: **Collision** A large mass space object, e.g. asteroid or bypassing interstellar object, collides with the planet, having been drawn in by the gravitational field. The resulting collision produces large amounts of debris (dust, rock material) that orbits the planet. This material slowly collides, accumulating to form larger bodies with small gravitational fields. These can draw in other material to form larger bodies. Orbits tend to be regular and in the same direction as the planet, prograde. **Accretion from a Circumplanetary disk** As a planet forms, some matter (dust, ice, small rocks etc.) remains in orbit around the planet. This is the accretion ring. Slowly this material can coalesce as collisions occur, until larger masses develop with sufficient gravitational field to accelerate accumulation of material. Such objects are spherical and have regular orbits. The ring system is the orbiting remains of dust, rocks etc. that has not combined. Orbits are in the same rotation as the planet, prograde and regular. **Fission Theory** That the satellite has formed from the splitting of the original planet into two bodies; the planet and the moon. *Note:* *Evidence may be taken from annotated diagram.* *Evidence may be taken from any section of the question*	• describes one of: - collision theory - accretion theory - fission theory.	• links the size and formation of the satellite / satellite system to at least ONE of the formation theories • links the properties and motion of the satellites / satellite system to at least ONE of the formation theories.	• a comparison of the characteristics of formation and properties of satellites / satellite systems in terms of ONE formation theory.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response or response does not relate to the question.	Describes ONE idea at the Achievement level.	Describes TWO ideas at the Achievement level.	Describes THREE ideas at the Achievement level.	Describes FOUR ideas at the Achievement level.	Explains ONE idea at Merit level.	Explains TWO ideas at Merit level.	Explains ONE point at Excellence level or TWO with minor errors.	Explains TWO points at Excellence level

Question Three

	Expected Coverage	Achievement	Merit	Excellence
(a)	Stars that become neutron stars or black holes are usually high-mass stars found in the **upper left** of the main sequence. Higher-mass stars have a higher temperature / faster fuel use / luminosity.	Describes: • position on main sequence of likely massive stars that become neutron stars or black holes given		
(b)	Massive main sequence stars fuse H → He rapidly. On completion of hydrogen fusion in the core, the giant star becomes a red supergiant. Core compression increases temperature and results in helium fusion, energy emissions push out the star's boundary until they are balanced, making the star appear larger and cooler. The fusion process from helium continues through to heavier elements. Once the core consists of iron nuclei there is insufficient temperature to fuse the nuclei. Since there is no energy being produced gravity takes over and the star rapidly implodes pulling in all of the star's molecular and gas material before blasting it back out into deep space due to the electrostatic repulsive forces of the iron nuclei. What remains is a core of highly dense material called a neutron star.	• the fusion process taking place in a main sequence star. (H → He) • the fusion process taking place in the red supergiant stage. (He → C → - → Fe) • the role gravity takes in the fusion of heavier elements • the role of gravity in the collapse of the star	Explains: • the HR diagram use in locating grouping stars in terms of their characteristics and life cycle with high mass stars located at the top • the influence of gravity to enable fusion to heavier elements supergiant size stars • the role gravity plays in the formation of a supernova and subsequent link to neutron stars / black holes	Explains comprehensively: • the life cycle of the giant star, including the role gravity plays in the collapse / compression of the core resulting in hydrogen fusion, then helium and heavier elements until death • the formation of the supernova once fusion ceases, i.e. forces of gravity and external pressure are no longer balanced, leaving a neutron star / black hole depending on size of remaining core

(c)	A critical factor in determination is the mass during the main sequence stage. Stars at the top of the main sequence with masses of greater than 8 times the mass of the sun form the supergiants that become Neutron Stars or black holes. Once all the hydrogen is fused, the star expands, leaving a helium core with a mass of greater than $1.4M_{sun}$. This creates sufficient gravitational forces to allow for fusion to heavier elements up to iron. If the remaining core is between $1 – 3M_{sun}$ the resulting body is a neutron star. The gravitational forces have caused the iron protons and electrons to fuse. Greater than $3M_{sun}$ the gravitational force is so large that all the material is drawn into a "singular point" with a huge gravitational field that can absorb visible light. This is called a black hole. *Note:* *Evidence may be taken from annotated diagram.* *Evidence may be taken from any section of the question.*	• the mass of main sequence star as greater than $8M_{sun}$ to form either neutron stars or black holes • the mass of main sequence star greater than 30Msun will form a black hole • the supernova and the remaining core that will form a neutron star • the supernova and the remaining star mass core that will form a black hole.	• the link between the mass of main sequence stars and formation of neutron stars and black holes • the link between the star core mass during life cycle and formation of neutron star ($1.4M_{sun}$) / black hole ($3.0M_{sun}$).	• the relation between star mass during its formation and the subsequent outcome with the core mass size and gravity determining the formation of either a neutron star or black hole.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response or response does not relate to the question.	Describes ONE idea at the Achievement level.	Describes TWO ideas at the Achievement level.	Describes THREE ideas at the Achievement level.	Describes FOUR ideas at the Achievement level.	Explains ONE idea at Merit level.	Explains TWO ideas at Merit level.	Explains ONE point at Excellence level or TWO with minor errors.	Explains TWO points at Excellence level

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 06	07 – 12	13 – 18	19 – 24