Assessment Schedule – 2019

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

Evidence Statement

Question One

Q	Expected Coverage	Achievement	Merit	Excellence
ONE	As a star is forming from a nebula / giant molecular cloud (GMC), there are leftover gas and dust particles. These particles rotate around the young star and flatten into a gaseous protoplanetary disc. The protoplanetary disc contains particles that condense together. Once they have enough mass, they collect more particles, due to their increasing gravity forming planetesimals As it is hotter closer to the forming sun, the lighter (lower boiling point) elements are vaporised and blown to the outer solar system by solar winds. Once they pass the point where it is cool enough for these gases to condense (the frost line), these lighter elements may also be collected by forming planets. As there are far more lighter elements (H and He) in the protoplanetary disc than heavier elements, the outer planets will have a large mass of mainly lighter elements formed around a core of heavier elements. As the planet is still forming, gravity is pulling the gases together, which results in a large amount of friction / compression, generating heat from within the planet and causing the high surface temperature.	Describes: • the formation of a protoplanetary disc. • how planetesimals / planets form due to gravity / accretion. • the composition of outer (Jovian / Gas Giant) planets as mainly lighter elements (H / He). • the vaporisation of gases within the frost line / closer to the star OR the solar wind pushing lighter elements to the outer solar system. • the temperature of the planet as being high due to gravity / friction / collisions / compresson.	Explains in detail: • Gravity causes particles in the protoplanetary disk to accrete into larger and larger bodies. • Cooler temperatures further from the star lead to condensation of lighter elements. • Solar wind pushes vaporised (lighter) elements to the outer solar system (to be collected around rocky cores of forming gas giants). • As the planet is formed (accretes), gravitational / potential energy is changed into heat (friction), making the surface hot.	Explains comprehensively: • The stages in the formation of outer planets including protoplanetary disc, accretion, and sorting of material. • Vaporisation of lighter elements (within frost line) linked to solar wind increasing abundance of lighter elements in outer planets. • Increasing mass linked to increasing gravity, which pulls the particles within the planet together and generates heat (friction), making the planet hot.

Not Achieved			Achievement		Achievement with Merit		Achievement with Excellence	
NØ	**N1**	**N2**	**A3**	**A4**	**M5**	**M6**	**E7**	**E8**
No response: no relevant evidence.	Partially describes one point.	Describes one point.	Describes two points.	Describes three points.	Explains one point.	Explains two points.	Explains comprehensively one point, or two with minor omissions.	Explains comprehensively two points.

Question Two

<table>
<tr><th>Q</th><th>Expected Coverage</th><th>Achievement</th><th>Merit</th><th>Excellence</th></tr>
<tr>
<td>TWO
(a)

(b)</td>
<td>
<table>
<tr><th>Star</th><th>Colour</th><th>Temperature</th><th>Luminosity</th></tr>
<tr><td>Achernar A</td><td>Blue</td><td>~15 000 K (±5000 K)</td><td>10^3</td></tr>
<tr><td>DX Cancri</td><td>Red</td><td>~2800 K (±1000 K)</td><td>10^{-4}</td></tr>
</table>
DX Cancri is a Red Dwarf with a luminosity of about 10^{-3} and a surface temperature of < 4000 K. It is a very small mass main sequence star (< $0.1M_{sun}$).
Achernar A is a-blue-white main sequence star with a luminosity of 10^3 and a surface temperature of ~15000 K (±5000 K). It is a very hot, bright star of about $6M_{sun}$.
Both stars are currently fusing H → He, as they are both in the main sequence stage of their life cycle.
However, as Achernar A has a much greater mass the greater force of gravity will cause it to use up its fuel much more rapidly and therefore have a much shorter life cycle. This can also be seen by the larger amount of energy given out (luminosity nearly 5 million times greater) by Achernar A as a result of this larger rate of fusion.

Answers can also refer to DX Cancri as having a smaller mass / slower rate of nuclear fusion / longer lifecycle etc
</td>
<td>Describes:
• 3 characteristics of DX Cancri /Achernar A listed from HR diagram.
• Both stars are fusing hydrogen → helium.
• Archernar A is using up its fuel at a much faster rate
• Achernar A will have a much shorter life than DX Cancri.
• Archernar A has a much greater mass than DX Cancri.</td>
<td>Explains in detail:
• Achernar A has a much greater mass (therefore gravity will be much larger), which will increase the rate of fusion in the core.
• While both stars are fusing H → He in their cores, Achernar A has a much greater rate of fusion; it therefore has a much higher luminosity.
• The much higher rate of fusion in the larger star results in a much higher surface temperature.
• As the larger star Achernar A is using its fuel more quickly, its lifecycle will be much shorter than the smaller DX Cancri.</td>
<td>Explains comprehensively:
• Justifies a faster rate of fuel use (H → He) by linking higher mass to increased gravity and therefore a faster rate of nuclear fusion.
• Justifies why Achernar A will have a shorter life cycle by linking faster rate of fusion with a greater energy output.
• Links faster energy use to HR diagram as larger surface temperature / larger luminosity / blue-white colour.</td>
</tr>
</table>

Not Achieved			Achievement		Achievement with Merit		Achievement with Excellence	
NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response: no relevant evidence.	Partially describes one point.	Describes two points.	Describes three points.	Describes four points.	Explains one point.	Explains two points.	Explains comprehensively one point, or two with minor omissions.	Explains comprehensively two points.

Question Three

Expected Coverage	Achievement	Merit	Excellence
Stars are formed in a nebula (GMC) when static then gravity pulls matter together into increasingly larger bodies. How much matter is pulled together will result in the mass of the main sequence star. The amount of mass and therefore gravity will affect the processes which occur as the star progresses through its lifecycle. Once there is enough gravitational force then fusion of hydrogen → helium will occur, forming a main sequence star. Once the hydrogen runs out, the core will collapse until there is enough pressure to fuse helium to larger elements like carbon and oxygen. This produces more energy, which causes the outer layers to expand and become a (red) giant star. Once fusion is finished, then the outer layers will drift off, leaving the core in a smaller (≤ 8 M_{sun}) star, whereas a larger star will result in a supernova. The amount of mass in the remaining core at the end of the red giant phase will determine the death of the star. More mass means more gravity, and if the mass remining is less than 1.4 M_{sun}, then a white dwarf consisting of mainly carbon and oxygen will result. If the remaining mass is more than 1.4 M_{sun}, there will be enough gravity to collapse the core / elements, leaving only neutrons remaining, which will have a much smaller volume, but a much greater mass.	Describes: • White dwarfs / neutron stars are formed from the collapse /death of red giant stars. • During a star's life, gravity generates heat / pressure, which causes nuclear fusion. • Mass increases at the start of a star's life. • Smaller stars lose their outer layers at the end of the red giant phase leaving a white dwarf. • Larger stars undergo a supernova explosion / core collapses when fusion finishes to form a neutron star.	Explains in detail: • The link between mass and gravity and how this results in the star ending as a white dwarf / neutron star. • Gravity will produce enough heat / pressure to cause fusion in the star's core (either hydrogen → helium OR helium → larger elements). • The mass increases as the star is born OR how mass is lost when the star reaches the end of the red giant phase. • The greater amount of mass and therefore gravity in larger stars will result in a greater reduction in volume to form a neutron star.	Explains comprehensively: • The star gains mass as the star forms, which remains relatively stable until it reaches the end of the red giant phase, where it loses its outer layers. • Gravity causes mass to accumulate from a nebula as the star forms, and generates heat until there is enough to cause nuclear fusion of H → He then He → larger elements. • The mass of the remaining core causes the formation of either a white dwarf or neutron star due to gravity acting on the remaining matter.

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Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 6	7 – 12	13 – 18	19 – 24