Assessment Schedule – 2023

Scholarship Earth and Space Science (93104)

Evidence Statement

Question One: Phytoplankton and the carbon cycle

Evidence	1 – 2	3 – 4	5 – 6	7 – 8
Global carbon budget • Phytoplankton return carbon dioxide back to the atmosphere through respiration. • Phytoplankton store very small amounts of carbon for the size of their bodies compared to plants / trees. • Phytoplankton use dissolved carbon dioxide to photosynthesise, whereas plants / trees absorb carbon dioxide from the atmosphere. • Phytoplankton consume carbon dioxide on a scale equivalent to forests and other land plants, despite their small size. • Storage is shorter term with phytoplankton, as they don't live as long. When phytoplankton die, they fall as marine snow and can become part of the ocean floor, where they can be stored for a very long period of time as part of sediments. • Phytoplankton can also be consumed by zooplankton or other marine animals, who then respire or excrete carbon dioxide back into the atmosphere. • Carbon moving in the ocean is much more active because of dynamics of the ocean. It still remains out of the atmosphere, potentially for longer periods of time than when it is stored on land. • When carbon dioxide is absorbed by plants / trees, it is stored in their bodies until they are burnt or respire it back into the atmosphere. This means that the length of the short-term storage is longer than with phytoplankton. • The length of storage is also dependent on the type of plant; trees can potentially store carbon longer than other plants. This could also be affected by the use of the plant / tree. • Solubility decreases with temperature, so as the temperature of the ocean changes, more carbon dioxide is released to the atmosphere, compared to forests, where it is stored in the plants or trees, and not affected by solubility. **Climate change** • Due to warming, the sea will be less able to hold onto carbon dioxide and this will be released into the atmosphere, which means that there is less available for the phytoplankton, but not to the point of being an issue for photosynthesis. • An increase in smaller species of phytoplankton means that not as much carbon	• Very little understanding of question with very little development of ideas. • Resource booklet copied only.	• Shows some understanding of question with only some development of ideas. • Some synthesis and integration of the processes.	• Good understanding of question with good development of ideas. • Good analysis, synthesis, and integration of the context, exhibiting well developed understanding of the context. • Must show a good sense of practicality and impacts of global changes.	• Thorough understanding of question with excellent development of ideas. • Sophisticated analysis, synthesis, and integration of the concept, showing perception and insight applied to the context. • Reflection on the answer resulting in extrapolation. • All aspects of answer expressed with convincing communication. • Must show integration of ideas, e.g. flow-on effects etc.

dioxide can be photosynthesised and stored in their bodies. This could mean that the amount of carbon dioxide moving through the oceans is less, which will have a flow-on effect to the animals that eat phytoplankton. Also, it could influence the amount of marine snow that makes its way to the ocean floor.

- Oceans' acidification will decrease phytoplankton growth, as their shells are made of calcium carbonate, and this will dissolve.

Human intervention

- Algal blooms need to be slowed down, as they block out light, and this is what phytoplankton need to photosynthesise. Humans need to reduce the amount of nutrients that is entering the oceans in order to slow down algal bloom growth.
- Adding minerals such as iron, particularly in the Southern Ocean, could increase phytoplankton growth, as this is an essential nutrient.
- If we could increase the amount of carbon fixation however, this may reduce carbon dioxide in the atmosphere, which could address issues of global warming and climate change.
- If we could farm phytoplankton in large amounts and stop them from breaking down and releasing carbon dioxide, it could be an efficient form of carbon trapping that might be able to reduce atmospheric carbon.
- Whale excretion contains important nutrients that phytoplankton need for growth; humans should allow whale populations to increase so that there is more phytoplankton in the oceans.

Other points to consider

- Larger animals will store more significant amounts of carbon per animal, and there will be less turnover compared to the very fast carbon turnover of phytoplankton.
- Changes in phytoplankton composition and species would likely have significant impacts on the biological pump. It is possible that these changes will have a net negative effect on the carbon dioxide in the oceans or atmosphere.
- Phytoplankton help regulate the amount of carbon dioxide in the atmosphere, and keep the climate in balance.
- Areas of high production are most likely those at the poles, where there is not a strong pycnocline allowing the mixing of deep waters, which are nutrient-rich. Also in the summer constant sunlight allows phytoplankton to photosynthesise for 24 hours a day.

Question Two: Slow-slip events

<table>
<tr><th>Evidence</th><th>1 – 2</th><th>3 – 4</th><th>5 – 6</th><th>7 – 8</th></tr>
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<td>Differences
• The amount of stress they transfer to other faults is more spread out. Whereas earthquakes have a large stress transfer concentrated over a smaller region.
• Energy is released slowly, and over a longer period of time, rather than all at once.
• Unlikely to have a large number of aftershocks and cause as much damage as large earthquakes.
• Slow-slip events occur only along the subducting plate boundary, whereas sudden-release earthquakes can occur along any fault line in the country.
• Eketahuna earthquake probably occurred because the Kapiti slow-slip event caused an increase in stress on that fault which then ruptured.
• As the seismic energy from the Kaikōura quake moved north, it temporarily added more stress to the subduction zone, triggering the slow-slip event.
• Energy released also caused the Marlborough after-slip to occur, because it is on the same fault line.

Information that geologists can find out
• Information collected can help further understand how the transfer of energy from earthquake to slow-slip event and vice versa occurs.
• How the movement of energy occurs along the plate boundary.
• How slow-slip events can release stress on a fault and therefore could cause an earthquake to be postponed.

Difficulties with measuring on land and at sea
• Earthquakes are occurring further off land, so the land displacement cannot be measured using GPS.
• Strong currents at the bottom of the ocean could affect the data, not giving a good indication that a slow-slip event has occurred.
• Height of water column and pressure changes could be due to something else, e.g. tsunami.
• Accessibility in getting out to sea and its expense.
• GPS needs to be monitored regularly, as it could be difficult to discern large earthquakes from slow-slip events.</td>
<td>• Very little understanding of question with very little development of ideas.
• Resource booklet copied only.</td>
<td>• Shows some understanding of question with only some development of ideas.
• Some synthesis and integration of the processes.</td>
<td>• Good understanding of question with good development of ideas.
• Good analysis, synthesis, and integration of the context, exhibiting well developed understanding of the context.
• Must show a good sense of practicality and why slow-slip merits further research.</td>
<td>• Thorough understanding of question with excellent development of ideas.
• Sophisticated analysis, synthesis, and integration of the concept, showing perception and insight applied to the context.
• Reflection on the answer resulting in extrapolation.
• All aspects of answer expressed with convincing communication.
• Must show integration of ideas, e.g. difficulties of measuring.</td>
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Question Three: Jupiter's atmospheric cells

Evidence	1 – 2	3 – 4	5 – 6	7 – 8
Differences between cells • Due to this much stronger Coriolis effect, the bands around Jupiter will be comparatively smaller. • Jupiter's faster spin rate means that the Coriolis effect is stronger than Earth's. • Due to this effect being stronger, any gas from the Equator to the poles would deflect more significantly, and not be able to travel as far poleward. • Jupiter is much further away from the Sun than Earth is, and with such a significant size, the warming and cooling of the atmosphere by the Sun maybe less significant. This would mean that the cells may be more regularly sized, compared to the Hadley cell on Earth. • This would also mean that compared to Earth, Jupiter may not have the same closed cells, such as the Hadley and polar cells. • Ferrel cells on Earth are powered by friction from the Hadley and polar cells on either side. If the Jupiter stripes are similar to Ferrel cells, then they must be powered by the friction of the cells on either side also. • The faster spin rate means that the winds on Jupiter are stronger and move faster. • The cells must be a reaction to a hot core from Jupiter's interior, which remains hot due to its massive size. This can be compared to the surface area to volume ratio that means that the moon and Mars do not have a hot core any longer. • The rising and falling gases appear to have different compositions that give the different coloured stripes the different layers due to the powerful Coriolis effect. • Stripes next to each other will be moving in opposite directions, and will have different densities, due to some rising and some falling. **Cells and Giant Red Spot** • The cells are deeper, because there is a lack of land mass and oceans like on Earth to stop them. • Bigger planet so larger atmosphere, no land. • The Giant Red Spot is an anticyclone, and it has no landmass or temperature differences, which is why it has been going for so long. • It's located between two powerful jet streams that move in opposite directions. • Giant Red Spot is located in the southern hemisphere of Jupiter at a similar latitude to where anticyclones are found on Earth. • Giant Red Spot looks to be a dark band on Jupiter, which means that the gas in the storm is sinking.	• Very little understanding of question with very little development of ideas. • Resource booklet copied only.	• Shows some understanding of question with only some development of ideas. • Some synthesis and integration of the processes.	• Good understanding of question with good development of ideas. • Good analysis, synthesis, and integration of the context, exhibiting well developed understanding of the context. • Must show a good sense of practicality and impacts of global changes.	• Thorough understanding of question with excellent development of ideas. • Sophisticated analysis, synthesis, and integration of the concept, showing perception and insight applied to the context. • Reflection on the answer resulting in extrapolation. • All aspects of answer expressed with convincing communication. • Must show integration of ideas, e.g. flow on effects etc.

Cut Scores

Scholarship	Outstanding Scholarship
15 – 19	20 – 24