Assessment Schedule – 2022

Scholarship Earth and Space Science (93104)

Evidence Statement

Question One: Wildfire Effects

Evidence	1 – 2	3 – 4	5 – 6	7 – 8
Well-labelled, accurate diagrams are considered as evidence. **Comparison and contrast between Volcanoes and Wildfires** • PyroCbs and volcanic eruptions both can send sun-blocking particles into the stratosphere, but those particles are distinct. Large volcanic eruptions often eject huge quantities of sulfur dioxide. Sulfur dioxide can also be produced in wildfires, but to a lesser extent. Once in the upper atmosphere, it can react with water vapour to form highly reflective droplets of sulphuric acid that bounce sunlight back into space. • Heat generated by black carbon as it absorbs sunlight makes the surrounding air more buoyant, causing the smoke plume to rise through the stratosphere and be more persistent. • Particles from forest fires are likely to remain in the stratosphere for a shorter time and be smaller in volume, so have a shorter-term cooling effect, while volcanic particulates are of much greater volume in the stratosphere, remain for longer, and have long-term and more global cooling effect. • With fires, the increase in GHG and associated climate-warming effect offsets much of the temporary cooling from increased albedo. • Volcanism can lead to forest fires through the ejection of hot ash and eruption-related lightning. • Fires tend to travel, whereas volcanoes do not; therefore a larger fire may be required to punch into the stratosphere, as the effect would be over a larger area. • Volcanoes are orders of magnitude larger than fires, so will be more likely to enter the stratosphere. • Long-term forest fires and volcanism would create a heating effect, as the release of GHG will persist longer than light scattering ash. Sulphuric acid clouds would persist longer than ash, but not as long as CO_2. May cause more environments for ozone depletion. Overall a net heating. • Ash and chemicals getting into the stratosphere will stay for a longer time than those in the troposphere, as it has very little water to rain out debris, although these clouds would deliver a significant amount of moisture. High winds in the stratosphere spread ash and gases globally long term.	• Very little understanding of the question with very little development of ideas. • Resource booklet copied only.	• Shows some application of understanding with some development of ideas. • Some synthesis and integration of the processes.	• Good application of understanding with good development of ideas. • Good analysis, synthesis, and integration of the processes, exhibiting well-developed understanding of the context.	• Thorough application of understanding with excellent development of ideas. • Sophisticated analysis, synthesis, and integration of the processes, showing perception and insight applied to the context. • Reflection on the answer resulting in extrapolation. • All aspects of answer expressed with convincing communication.

• Both forest fires and volcanic eruptions can contribute to global warming, as they release CO_2 into the atmosphere. This traps in infrared radiation therefore warming the planet. • Large wildfires will impact local water cycle, as loss of evapotranspiration via forests may reduce local precipitation, causing drought and loss of water sources. This will fuel further heating and increase potential for more fires. **Human interactions and management of environment** • Forest management could lead to the reduction of wild fires, and management of water resources could reduce drought effects, which could reduce wild fire frequency and severity, whereas volcanos are monitorable, but no significant action can be taken to reduce their effect. • CO_2 from fires is coming from a short-term carbon sink, whereas volcanoes release very long-term stored carbon. Human impacts. • Warming world temperatures would mean a likelihood of more forest fires, and therefore carbon dioxide emissions from human activity is important, and would effect a positive feedback loop of released carbon. • As our climate changes, these unusual but significant storms could occur more frequently, primarily due to hotter and drier conditions increasing the risk of wildfires due to destroyed vegetation and property. • Potential for acid rain from fires and volcanoes, as SO_2 reacts with water to form sulfuric acid. • Rapid and unpredictable changes to weather systems are dangerous and could cost the lives of firefighters, and damage to property and infrastructure.				

Question Two: An Unexpected Balance

Evidence	**1 – 2**	**3 – 4**	**5 – 6**	**7 – 8**
Well-labelled, accurate diagrams are considered as evidence. It's still not understood why the native forests absorb so much carbon dioxide. But due to the complex eco systems in NZ and perhaps other native forests, there are more interactions and therefore more organisms that contain carbon that could lead to longer-term storage of carbon. Here is a list of possible reasons. **Possible reasons** • New Zealand has very few native deciduous trees, which means that they can photosynthesise year round and take up more carbon than deciduous trees in Northern Hemisphere forests or elsewhere in a year. • Greater diversity of vegetation and animals in native forest allow for carbon uptake by more organisms, increasing the efficiency of carbon storage. • Soils are important carbon stores. Native, mature forest soils are undisturbed, therefore supporting the soil ecosystem and increasing the length and efficiency of carbon storage. • Species present are important. It may be that trees and other plants with larger leaves photosynthesise more and thus store more carbon. Photosynthesis efficiency of different forests could be investigated as it links to leaf size, type, and abundance. • New Zealand's trees such as the Kauri can take a long time to grow and also have a long lifespan this means that they can sequester carbon over a longer period of time. **Placement of stations and future initiatives** In order to identify the "additional strong sink" in the North Island, exotic forests need to be compared to native forests, and stations downwind of native vs exotic forests can be compared to determine difference in average carbon uptake. Accurate information about wind direction and weather patterns from older sites like the Ashburton site allows a better understanding of where the gases might come from, and would be useful to explain any data that is produced. The station at Winchmore will be important for studying methane as it is in dairy country. Should prevailing south-westerlies travel between McCracken or Monowai and Winchmore, it may further be possible to determine if dairy farming adds more carbon than is removed by forests or pasture. Atmospheric measurements across Auckland will help decision makers monitor the effectiveness of steps taken to reduce urban emissions. Changes in CO_2 concentrations above the city will directly reflect the impact of tree	• Very little understanding of the question with very little development of ideas. • Resource booklet copied only.	• Shows some application of understanding with some development of ideas. • Some synthesis and integration of the processes.	• Good application of understanding with good development of ideas. • Good analysis, synthesis, and integration of the processes, exhibiting well-developed understanding of the context.	• Thorough application of understanding with excellent development of ideas. • Sophisticated analysis, synthesis, and integration of the processes, showing perception and insight applied to the context. • Reflection on the answer resulting in extrapolation. • All aspects of answer expressed with convincing communication.

planting programmes, or steps to cut vehicle numbers on city motorways. Urban measurements could show a real-time effect of strategies like increasing E-cars and public transport, as well as showing effects of events like lockdowns, for example, or large levels of congestion. Could be that indigenous forests elsewhere are also strong carbon sinks. More study of other untouched, long-standing forests could be useful in other countries.				

Question Three: Kuiper Belt Objects

Evidence	1 – 2	3 – 4	5 – 6	7 – 8
Albedo • The albedo provides an average value for the reflectivity over the whole surface of the KBO. KBOs are too far away for the detection of the normal variations in a body's albedo. For example, there are variations of albedo on Earth between snow and ocean reflectivity. • The albedo can be affected by the shape of KBO or differences in features. As the KBO rotates it could have a similar effect as seeing a light move on a lighthouse. Also, because the KBOs are so far away from the Sun it takes them a long time to complete one orbit so it would take a long time to observe a change in the albedo and not likely to see it in our lifetime. • An atmosphere around a KBO gives a relatively high albedo because clouds and droplets of certain gases are very reflective and they also can hide the surface. Ice made from frozen atmosphere has a very high reflectivity, and so a high albedo. The darker and rougher the surface, such as dull rock, organic compounds, and a rough or cratered surface, the lower the albedo will be. The albedo values are low for the icy KBOs. This is probably due to cosmic dust darkening the surface, and the rough surfaces that reflect less incoming radiation. • There is no direct relationship between distance and albedo. A KBO with a higher albedo is not necessarily closer to the Sun compared with one that has a low albedo. Another factor to be considered is that most KBOs have highly elliptical orbits, which means that at times a KBO is closer to the Sun, and other times further away. This may change the albedo, because atmospheric gases that may be solid when the KBO is furthest away from the Sun may melt closer to the Sun, reducing the albedo. • It could be challenging to determine exactly when the atmosphere starts freezing and falling as snow on Eris during its orbit, but is most likely to happen as it moves further away from the Sun. Thus, closest to the Sun when it has a gassy atmosphere, albedo may be lower than when it moves further away, and snow causes higher reflectivity. This assumes the reflectivity of methane and ethane increases during the freezing phase. • Makemake has been found to have frozen methane and ethane on its surface, and has a reddish-brown colour. This means that it has a lower albedo, as its surface is darker, and therefore does not reflect a large amount of light. However, during its orbit, it is thought to develop an atmosphere. This would increase its albedo, as the atmosphere would reflect light and hide the darker surface. • By comparing albedo from Earth surfaces to albedo from KBO surfaces, where the size and composition of the KBO and its atmosphere is known, we may be able to calculate the distance from the Sun at various points in their orbits and times in their seasonal cycle. • Similarly, the ice may have a lower albedo (this is the case when we compare Earth's	• 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 processes, exhibiting well developed understanding of the context. • Some aspects of answer expressed with convincing communication.	• Thorough understanding of question with excellent development of ideas. • Sophisticated analysis, synthesis, and integration of the processes, 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. albedo and shape of orbit.

snow and ice), thus reducing the albedo when Eris is furthest away from the Sun and approaching it again. **Hot and Cold classical KBOs** • The differences between these two types of bodies in the classical Kuiper Belt have everything to do with Neptune. The cold classical KBOs have orbits that never come very close to Neptune, and thus they remain "cool" and unchanged by the giant planet's gravity. This means that cold classical KBOs have relatively circular orbits that are not tilted much away from the plane of the planets. Therefore, the cold variety spend most of their time at about the same distance from the Sun, receiving the same amount of heat and light, and their surfaces reflect the same amount of albedo during their orbit. Their orbits likely haven't moved much for billions of years. • In contrast, the hot classical KBOs have had interactions with Neptune in the past (that is, with the giant planet's gravity). These interactions pumped energy into their orbits, which stretched them into an elliptical shape, and tilted them slightly out of the plane of the planets. As the hot classical KBOs have more elliptical and tilted orbits they wander over a larger range of distances from the Sun (meaning, in some parts of their orbits, they are closer to the Sun and sometimes they are farther away) and this can affect how much heat and light they receive as well as how reflective their surfaces are. **Further potential discussion** • Albedo does not always give an accurate indication of size. Eris was once thought to be bigger than Pluto, as Eris has a higher albedo due its surface thought to be covered with frozen atmosphere. This meant that its diameter was wrongly calculated because of its higher reflectivity. The diameter was more accurately measured when Eris passed in front of a dim star momentarily dimming the star's light, and showed that Eris is a similar size if not smaller than Pluto.				