Assessment Schedule – 2018

Scholarship Earth and Space Science (93104)

Evidence Statement

ONE

Evidence	1 – 2	3 – 4	5 – 6	7 - 8
Well labelled, accurate diagrams will be considered as evidence. *Answer must show understanding of the key concepts such as the Greenhouse Effect, carbon cycle, importance of volcanism and the role of water at some stage of the answer, even if these concepts are not explicitly described.* • Where is the carbon dioxide (CO_2)? On Venus it is in the atmosphere, on Earth it is locked up in carbonates and on Mars it is frozen as dry ice. • Venus is too close to the Sun to have liquid water on its surface, which means that CO_2 can't be dissolved in it. This breaks its carbon cycle, leading to an overabundance of greenhouse gases and high surface temperatures. • Because Venus has a very high troposphere, the top (tropopause) will be very warm and any water will be exposed to the UV light coming through the stratosphere. Most of Venus's early water would have been broken down into hydrogen and oxygen this way, which would have also affected the carbon cycle and the consequent formation of any carbonates. • Venus has a very thick atmosphere; the atmospheric pressure at the surface is 90 times that at Earth's surface (90 bars) and is 96% CO_2. The Venusian atmosphere has a runaway Greenhouse Effect, which results in very high surface temperatures (about 470°C). The thick CO_2 acts as a blanket, making it very difficult for the infrared (heat) radiation from the ground to get back into space. As a result, the surface heats up. • On Earth liquid water removes CO_2 from the atmosphere and puts it into the crust of the Earth as carbonates (*about 35 to 50 entire Earth atmospheres)*. Venus has no liquid water and Mars has very little because all water is frozen therefore neither Venus nor Mars has a carbon cycle. • In the early days, carbonates may have formed on the Venetian surface when there was liquid water to dissolve atmospheric CO_2. CO_2 dissolved in water droplets in clouds falls as acidic rain; this then would react with calcium, producing calcium hydrogen carbonate. When the water evaporates, there is a deposit of solid calcium carbonate remaining. As the surface heated up, CO_2 would have been released back out of the rocks and added to the CO_2 accumulating in the atmosphere.	Very little understanding of 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.

• Mars is too small to have a hot interior anymore, which means all volcanism stopped millions of years ago. Therefore, no CO_2 or any other greenhouse gases are being released into the atmosphere. The surface temperature is cold because of distance from the Sun and because of the lack of CO_2 in the atmosphere and the resulting lack of insulation. • There is evidence from old, dried up river beds that Mars once had running water. The water is still there, locked up in the ice caps and in permafrost beneath the surface. Mars probably also has CO_2 locked up in its crust, deposited there billions of years ago by the action of water. • The Martian atmosphere, although nearly pure CO_2, is very thin: less than 1% the pressure of Earth's. Mars barely has any Greenhouse Effect – it has only warmed about 10°C above what it would be without some Greenhouse Effect. • Venus does have volcanoes and there is evidence that these may still be active which means that CO_2 will still be entering the atmosphere and enhancing the runaway Greenhouse Effect. • A fully active carbon cycle acts as a thermostat, regulating a planet's climate. If the Earth gets too warm, more water will evaporate from the oceans, which will remove CO_2 from the atmosphere, moderating the Greenhouse Effect and cooling the planet. If the planet cools too much, less water will evaporate and there will be less precipitation to remove CO_2; the CO_2 will build up, warming the planet. • Venus is too hot because it has a runaway Greenhouse Effect, caused by a broken carbon cycle, from too little water; Mars is too cold because its carbon cycle is also broken, lacking active volcanoes, and therefore it has too small a Greenhouse Effect. Earth is lucky, with a fully functioning carbon cycle and therefore a moderate and moderated Greenhouse Effect. • With only about one-eighth the mass of the Earth, Mars cooled so rapidly it lost a lot of heat by conduction which, for a while, caused volcanoes to erupt. There is evidence of some tectonic activity but not enough to suggest active convection currents in the mantle. • Earth volcanoes are generally subduction ones. The volcanoes on Venus, and the ex-volcanoes on Mars, were all formed from hotspots. • Venus is the same size as Earth, and so its interior stayed hot enough to support volcanism. Venus lacks plate tectonics which might be because water is necessary to “lubricate” the action of plate tectonics. • Mars is smaller and less massive than the relatively similar Earth and Venus and has a smaller gravity compared to Earth and Venus. This low gravitational force means that Mars only has a thin atmosphere with low atmospheric pressure, which has meant that an effective Greenhouse Effect				

cannot develop. As a result, the surface of the planet has only slightly warmed up meaning that very little water can evaporate, and consequently no CO_2 can dissolve in the water.				

TWO

Evidence	1 – 2	3 – 4	5 – 6	7 - 8
Well labelled, accurate diagrams will be considered as evidence. • The westerly winds blow across the Tasman Sea towards the west coast of the South Island. The winds pick up moisture coming across the ocean. When the winds meet the north–south-oriented Southern Alps, they are lifted up, which results in clouds forming and water vapour condensing into rain. Some of this rain will spill over into the rivers that are flowing to the east from the Southern Alps. • This rain and also ice erodes the rock of Southern Alps. The initially sharp pieces of rock are tumbled around in the rivers, resulting in particles of sediment being knocked off. The rivers transport the eroded material and the river(s) that drains into Lake Ohau will drop its sediment load so that it is deposited on the bottom of the lake. • The resulting river flows and deposition of sediments in the lake are sensitive to variations in westerly wind flow. There are links between wind strength, precipitation, flood frequency, and sediment accumulation in Lake Ohau, which is reflected in the sediment cores. • The sediment cores also show records of flood events. These will affect the regular yearly deposition of sediment. The number of flood events give an indication of whether the WWB is further north (more floods) or south. • The sites in Patagonia are at similar latitudes to Lake Ohau and would also show the movement of WWB because they are also at the northern edge of the WWB. If these cores show similar variation then they would confirm the Lake Ohau data and give evidence that the data collected is about the WWB and not due to regional variation. • Campbell Island is thoroughly in the WWB, so data gathered from there would help sort out exactly what was WWB data and what wasn't from the Lake Ohau and Patagonia sites. • The Ross Sea is at the bottom / southern part of the WWB and so may provide data that shows variation of the WWB, which may correlate to the data gathered at the northern part (Lake Ohau and Patagonia). • The data gathered from Auckland volcanic craters would record the effect of the ENSO / El Nino Southern Oscillation plus large weather events such as cyclones. This data would show when such weather events may have affected recording of WWB variations.	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.	• 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.

THREE

Evidence	1 – 2	3 – 4	5 – 6	7 - 8
Well labelled, accurate diagrams will be considered as evidence. *Any well-developed points on the environmental soundness or reliability of wave and tidal energy will be considered.* • Tidal and wind energy / power are carbon neutral, because there are no fossil fuels used, and they generate very little pollution, including sound pollution, which is generally transmitted through the water. • Since most other marine uses avoid areas of high swells and / or currents, marine energy projects would be complementary to other activities. • Areas set aside for marine energy farms are likely to act as de facto marine reserves. • Most marine energy technologies will be submarine and will have no visual impact and very little impact on surface activities because the energy sources are generally underwater tidal currents or swells. • Tidal energy is a result of the gravitational fields from both the sun and the moon, combined with the earth's rotation around its axis, resulting in high and low tides. There is about 12.5 hours between one high tide and the next. The tidal range varies, being smallest at neap tides and greatest at spring tides. • When the sun and moon are in line, their gravitational attraction on the earth combine and cause a "**spring**" tide. When they are as positioned in the second diagram below, 90° from each other, their gravitational attraction each pulls water in different directions, causing a "**neap**" tide. The rotational period of the moon is around 4 weeks, while one rotation of the earth takes 24 hours; this results in a tidal cycle of around 12.5 hours. (*Diagram is not essential, but, if correctly annotated, can be considered as evidence).*	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.	• 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.

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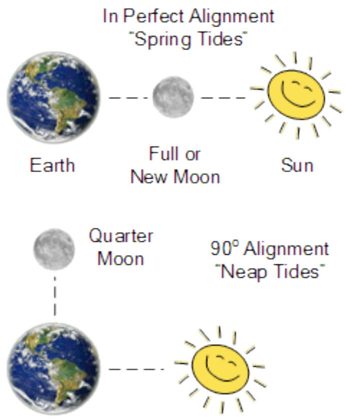

The tidal flow (movement of water because of tides) occurs between low and high tide and varies with spring and neap tides. The volume of water flowing will depend on the height of the tide, and so will be greater during spring tides and less during neap tides. At low and high tide, the water stops moving for several minutes.
Tidal ranges and times of high and low tides can be predicted years in advance, which means that the technology can be set to respond to that.
Tidal currents can flow through the rotors in both directions.
Tidal energy is predictable, but not a continuous source of energy because of the tidal rise and fall and the changes in the time of the tides at the place where the tidal energy is being utilised.
Areas around the country where the tide flows through narrow passages (the entrance to Kaipara harbour), or where tidal conditions create large tidal ranges (Cook Strait) are the best places for the generation of electricity because of the increased velocity of the flow.
Wave energy is a concentrated form of solar power generated by the action of the wind blowing across the surface of the oceans water. Differences in the temperature of the air masses around the globe causes the air to move from the hotter regions to the cooler regions, resulting in winds.
As the wind passes over the surface of the oceans, a portion of the wind's kinetic energy is transferred to the water below, generating waves. It is this energy, and not water, that moves along the ocean's surface.
The westerly winds, especially in the south of New Zealand, are steady winds, which cross a lot of sea before breaking on the west coast of New Zealand.

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- As these waves approach the shoreline and the depth of the water becomes shallower, their speed slows down, but they increase in size. The breaking waves release an enormous amount of kinetic energy which can be used for electricity production.
- A breaking wave's energy potential varies from place to place, depending upon its geographic location and time of year, but the two main factors which affect the size of the wave energy are the wind's strength and the uninterrupted distance over the sea that the wind can blow.
- The higher the amplitude of the wave, the greater the energy that it has. The amplitude of an ocean wave depends on the weather conditions at that time, as the amplitude of a smooth wave, or swell, will be small in calm weather but much larger in stormy weather with strong gales as the sea water moves up and down.
- The closer together the wave crests the greater the energy too.
- The westerly winds are reasonably constant, and because of the fetch of the Southern Ocean and the Tasman Sea, even when the wind isn't blowing there is generally a swell which can be utilised.
- Waves can be forecast several days ahead.
- Waves are hardly interrupted and almost always in motion. This makes generating electricity from wave energy a reasonably reliable energy source. The amount of energy that is being transported through waves does vary every year and from season to season. Wave energy has a larger potential during the winter because the waves are generally bigger.
- The westerly swells would be utilised the best along the West Coast of New Zealand, because of the persistent swells. There is enough coastline for recreation, such as surfing, and structures that generate electricity from wave energy. Generally the generators can be placed offshore beyond recreational uses.
- Climate changes will mean higher sea levels because of thermal expansion and some melting of ice sheets. This will add volume to tidal currents, adding more kinetic and potential energy in the currents.
- With Climate Change, the winds may get stronger, because of the greater temperature differences between the tropics and the Southern Ocean producing stronger winds. These winds would produce higher waves with more energy.
- Ocean wave energy plants can be put offshore, solving several of the issues that come with power plants closer to the land. The first benefit of offshore wave power is that there is a **larger energy potential** in these waves.
- Tidal energy would be best developed in areas around New Zealand that have a strong tidal current. This would limit it to a few key areas such as

Cook Strait, Foveaux Strait, big harbours with narrow entrances such as the Kaipara, Hokianga and Manukau Harbours and with narrow passages such as French Pass (top of the South Island). • Strong winds will also push tidal water higher – this may happen in Cook Strait under certain wind and tide conditions. • Tidal energy and wind energy will complement each other. Tidal energy will be used in fewer places than wind energy, because of the need for the geography of an area to constrict and therefore increase the tidal flow.				

Cut Scores

Scholarship	**Outstanding Scholarship**
13 – 18	19 – 24