Assessment Schedule – 2016

Scholarship Earth and Space Science (93104)

Evidence Statement

ONE

Evidence	1 – 2	3 – 4	5 – 6	7 - 8
Methane is being released by the water molecules of methane hydrates (clathrates) / permafrost melting. If the methane bubbles are reaching the surface of the ocean, that means methane will enter the atmosphere. *(Methane released in shallower water doesn't dissolve in water before reaching surface).* Methane is a potent greenhouse gas (GHG) when it is in the atmosphere, being more effective than carbon dioxide at absorbing and re-emitting long-wave infrared (heat) radiation, warming the atmosphere. Methane is short-lived in the atmosphere, breaking down to CO_2 after about 10 years. However, a large release of methane would cause significant global warming before it broke down to CO_2 (also a GHG). Extra methane in the atmosphere will cause a feedback loop – the atmosphere and consequently the ocean will be become warmer which will cause more of the permafrost / hydrates to be melted. Because methane seeps indicate the presence of methane hydrates beneath the sea floor, evidence will be needed to be gathered to try and determine the amount of methane being released as gas, which could then be used to determine the amount of methane hydrates below the surface. Mapping in finer detail showed a considerable increase in the number of seeps found, so therefore just how fine a detail would be needed to gain the best data must be determined. Ongoing surveys of methane release would help determine if the rate of methane release is increasing. A survey of the amount of permafrost and methane hydrates stored in continental shelves around the world is also needed, so that can be factored into climate models. A large amount of methane being released into the atmosphere will dramatically affect global warming. When the methane hydrates / permafrost melt pockets of methane gas are formed. When the methane gas, because it has a lower density than the sediment, seeps up towards the surface, sediment moves to fill the pockets / gaps in the sediment causing the landslide to creep.	Limited understanding of question with very little development of ideas. Resource booklet not referenced or sections copied.	Shows some understanding of question with 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.

Methane gas from melting permafrost / hydrates becomes trapped in pockets in the sediments, and is under pressure from the sediments and rocks above. This gas will expand and gas pockets increase in size, causing rocks and frozen sediment to move slowly down the continental shelf due to gravity. The stability of the landslide would be affected by the fact that this is area is tectonically active and a subduction zone. Any type of earthquake that shook the sediment would open up cracks through which methane could escape. *(If the earthquake was strong enough to cause a landslide and therefore a tsunami then the landslide wouldn't be slow moving anymore).* Ocean current flows around the bottom of the continental slope may destabilise the bottom (toe) of the slip, causing it to move faster and / or further. Friction from small sediment movements would generate heat, melting the permafrost / hydrates further. The permafrost could be also be melting because the shallow depth means that the seawater is not as cold. Also, if the permafrost is deep within the sediments, the warmth of the earth could also be melting the permafrost. The permafrost / methane hydrates may directly cause movement, because ice enhances slippage of sediment. Also, as the ice melts, the water will act as a lubricant, causing further slippage. One of the big implications of slow-moving landslides is that there will **not** be catastrophic collapses of sediment or the continental slope causing tsunamis because slow landslides do not displace water. The speed of movement of the landslide may slightly increase though. *Note:* *Methane gas does not directly cause ocean acidification. Some methane may dissolve in water and be aerobically decomposed by bacteria forming* CO_2 *which will cause ocean acidification. But methane gas that quickly reaches the ocean surface because of the relatively shallow continental shelf does not have time to dissolve in sea water.* *Global warming is not caused by the ozone hole. Global warming is primarily caused by excess* CO_2 *in the atmosphere. The ozone hole forms when ozone in the stratosphere, which protects the earth from UV radiation, is destroyed by the break-down products of CFCs.* *Well labelled, accurate diagrams are considered as evidence.*				

TWO

Evidence	1 – 2	3 – 4	5 – 6	7 - 8
A selection of the following points developed into a well developed argument: Liquid water can result from ice melting or water vapour condensing. Because of the low atmospheric pressure of Mars ice sublimes rather than melts and water vapour becomes ice rather than liquid water first. Liquid water could be on or, more likely, below the surface. Any liquid water, especially on top of the ground, is likely to be transient i.e. not last before long before becoming vapour or ice, and found in small amounts. Solar energy striking Mars is absorbed by the surface and re-emitted as infrared / heat, but this heat would be radiated away from Mars because the atmosphere is too thin to retain it. However, rock or dust may be heated up enough to transfer heat underground, which may melt ice. The axial tilt of Mars (which is similar to Earth's) means that the equatorial region will absorb the most solar energy because the sun's rays will be more direct, and the solar energy focused onto a smaller area. Because of the eccentricity of the Martian orbit, when Mars is at perihelion it is a lot closer to the Sun. The southern hemisphere (SH) gets warmer than the northern hemisphere because the former has spring and summer when Mars is closest to the Sun in its orbit. So more solar energy would be absorbed by Mar's surface, especially near the equator. Because the average temperature of Mars is so low, good places to look for liquid water would be during the SH summer or in the equatorial regions. Mars is closest to the Sun at that time and the axial tilt means that the SH is tilted towards the Sun. Liquid water is most likely to be found in low altitude areas where the air pressure may be higher than 6 millibars and the temperature is below 10°C. An example is an impact basin such as the Hellas Basin because its depth means that the atmospheric pressure is high enough to allow ice to melt. If the temperature of the basin gets above 10°C, the water will boil away because of the low atmospheric pressure. Also, the high diurnal temperature range means that any liquid water would quickly freeze at night. Regolith could absorb solar energy, especially if it was a dark colour. The temperature could get high enough for water to become liquid, especially if the water contains perchlorates / is briny which will lower the freezing point of water. So liquid water could form well below zero degrees. If regolith absorbed solar energy on a slope facing the Sun, water may start to	Limited understanding of question with very little development of ideas.	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.

move and stay liquid because moving liquid water is less likely to freeze. Water may be liquid deep underground under the polar caps or glaciers because the pressure would be more than 0.006 atmospheres. The liquid may be protected by a layer of water ice, which would insulate the liquid. An incline / steep / long slope may mean that deep liquid water breaks through – e.g. an ice barrier – and flows down the slope. The water flow may be short-lived because liquid water would evaporate quickly in the dry atmosphere. Dust storms might deposit or deepen a layer of dust on the Martian surface, which will have an insulating effect. This may prevent liquid water forming or protect any liquid that has already formed. Strong winds may increase evaporation so protection from them would increase the chance of liquid water being formed. Perchlorate brine / brine (hydrated minerals in water) reduce the freezing point of water forming liquid water. This means that there could be liquid water near the surface. Water vapour condenses at night out of the atmosphere into the ground and is absorbed by the perchlorate brine. The liquid then evaporates in the morning. Brine that is deeper in the ground would wick towards the surface to replace water that had just been lost. Other geological features, well argued, could be considered. For example, a line of volcanoes could break a strong wind, causing the conditions on the lee side of the volcano, especially if the Sun was shining on the slope and the slope was about 90° to the Sun, to be potentially suitable for liquid water to break through to the surface. *Well labelled, accurate diagrams are considered as evidence.* *An example of a well-integrated paragraph:* Liquid water is most likely to be found in the Hellas Basin, which is 7 km deep. Here the air pressure will be higher than 6 millibars and the temperature below 10°C for at least some of the time and year. Therefore, liquid water could form, even if it is only for a short period of time. Also, a slope on the edge of the basin facing the sun may result in liquid water flowing down the slope, especially if the water contained perchlorates which would lower the freezing point of the water. The liquid may exist for longer before evaporating because of the thin atmosphere or freezing because of the low temperature. The Hellas basin is also in the Southern Hemisphere, which is closer to the Sun in summer because of the eccentricity of the Martian orbit. Sun angles would be more direct; raising the daytime temperature, because of the axial tilt of Mars. *Well labelled, accurate diagrams are considered as evidence.*				

THREE

<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>The factors that affect surface currents around NZ are:
• The northern part of the South Pacific Gyre, the South Equatorial Current (SEC), will become stronger because of a warmer atmosphere and ocean due to global warming. The atmosphere is warmer because of increased levels of carbon dioxide. The ocean is warmer because the ocean is absorbing most of the extra atmospheric heat.
• The Walker circulation will make the western Pacific around the Equator even warmer relative to the eastern Pacific, which will result in a stronger pressure gradient, stronger trade winds, and a stronger South Equatorial Current, piling up warm water in the western Pacific.
• The SEC reaches the eastern Australian coast and becomes the strong western boundary current called the East Australian Current (EAC), which moves down the east coast of Australia to Tasmania and across to New Zealand. The EAC is intensified by the stronger Trade winds and this and the warmer water will mean that the EAC will be pushed southwards as far as Tasmania.
• The EAC will meet the strong Antarctic Circumpolar Current (ACC) south of Tasmania. The Coriolis effect, Ekman spiral and the Sub-tropical front (STF) will direct the current towards the south of the South Island. The STF prevents the warmer water mixing with the cold ACC. The ACC is a wide, strong, cold and dominant current which prevents the southward flow of warm water.
• The EAC, assisted by the SI land mass and the Coriolis effect flows up both sides of the SI. So a warmer EAC will result in a warmer sea around the bottom of the SI.
• The EAC affected by Coriolis and Ekman spiral will also flow northwards. The “wall” effect of the STF means that the warmer water from the EAC is effectively contained within the Tasman Sea. This could cause sea level rises that could affect the west coast of NZ, and possibly other areas.</td>
<td>Limited understanding of the question with very little development of ideas.
Interpretation of resource material 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 processes, exhibiting well developed understanding of the context.
Good understanding of current flow around NZ using a mixture of general and specific examples.
Links to climate change consequences.</td>
<td>• 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.
• Good understanding of current flow around NZ using specific examples extensively.
• In depth links to climate change consequences.</td>
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Consequences of global warming on New Zealand: *only a selection of points, well argued, are needed.* • The warmer water around the bottom of the SI will result in a smaller pressure and temperature gradient between the top of the NI and the bottom of the SI. This may affect rainfall or winds – the weather may be more uniform up and down the country. • Alternatively, a warmer climate and consequently a larger Hadley cell may result in the Tropical Front moving southwards. This will cause the NI to also become warmer which may maintain or increase the pressure and temperature gradients between top of NI and bottom of SI. • The STF may not move very far south because of the strong ACC. This will stop warm water going too far south, and contain the warmer water in the Tasman and around NZ. • Warmer currents mean more evaporation, more rain, more energy being transferred into the atmosphere and consequently more unsettled weather and stronger weather systems. The water will be warmer for longer because of the high heat capacity of water. • More energy can also mean stronger winds, and if they're from the west, more orographic rain and a wetter west coast and drier Canterbury. • The warmer water flowing from Tasmania will mean a greater temperature gradient either side of the STF, resulting in larger phytoplankton blooms. This could result in healthier and more productive food chains and fishing. • Warmer sea temperatures off Southland would mean a significant change for marine ecosystems, affecting ocean currents, plankton, and the marine food chain and fish stocks. Marine ecosystems can be very sensitive to temperature changes. Sensitivity varies among species, which means that one species may move because of warmer water but another species that is a food source may not need to move. • Warmer oceans around New Zealand would put coastal communities at risk because of sea level rise and more energetic storms, increase infrastructure costs, and threaten coral reefs, fisheries and coastal wetlands. An increase in storm frequency means less time for these sensitive habitats to recover. • Sea-level rise can mean that saltwater intrudes into groundwater drinking supplies, contaminates irrigation supplies, or overruns				

agricultural fields. • Upwelling or downwelling around the coast may change, strengthening or weakening, due to less strong or more changeable wind patterns affecting nutrients for marine life and NZ fisheries. • Disease species may move into waters than once were too cold. *Note:* *The surface currents are more complex than just the gyres because of factors such as the influence of landmasses, continental shelves, and fronts like the TF and STF in the ocean.* *This question is not about the ENSO / El Nino, ocean acidification, ozone hole, melting of ice around Antarctica or changes in salinity.* *Well labelled, accurate diagrams will be considered as evidence.*				