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OUTSTANDING SCHOLARSHIP EXEMPLAR

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

QUALIFY FOR THE FUTURE WORLD
KIA NOHO TAKATŪ KI TŌ ĀMUA AO!

Scholarship 2016
Earth and Space Science

2.00 p.m. Friday 25 November 2016
Time allowed: Three hours
Total marks: 24

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

Pull out Resource Booklet 93104R from the centre of this booklet.

You should answer ALL the questions in this booklet.

If you need more room for any answer, use the extra space provided at the back of this booklet.

Check that this booklet has pages 2–16 in the correct order and that none of these pages is blank.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

QUESTION ONE: SEAFLOOR METHANE HYDRATES AND GAS SEEPS

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Use the information provided on pages 2 and 3 of your resource booklet to answer this question.

Recently, a vast amount of permafrost containing frozen methane hydrates plus numerous methane gas seeps has been discovered within the continental shelf sediments off the east coast of the North Island. Preliminary investigations have shown that methane gas is also reaching the ocean surface.

The continental shelf in this area has active, slow-moving, underwater landslides, up to 15 km long and 100 m thick. This is a phenomenon which is largely uninvestigated, and which may, at least in part, be caused by the presence of methane hydrates and methane gas seeps.

Much more research is needed to determine the extent and effects of these methane hydrates and gas seeps.

Justify the need for extra research considering the possible causes and implications of slow-moving underwater landslides, and the consequences of the release of methane gas.

Well labelled diagrams may assist your answer.

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The movement of the slow-moving underwater landslides is suspected to be caused, in part, by methane hydrates below the sea floor and by methane gas seeps. Methane is produced in the sediment beneath the ocean floor by the decomposition of organic matter trapped within the sediment. The methane particles become surrounded by water particles, forming a water cage, and therefore forming ~~a~~ methane hydrates. ~~Thus~~ These methane hydrates are believed to cause these underwater landslides. Water usually has a ~~melting~~ freezing temperature of 0°C, but in the case of a methane hydrate, the presence of the methane molecule amongst the water molecules will disrupt the formation of the ice crystals, decreasing the freezing point of the methane hydrate. The friction caused by the slow moving landslide as it moves down the continental shelf may produce enough heat to melt these metal hydrates, and this fluid would act as a lubricant for the land slide, aiding its flow. The methane gas seeps themselves also influence the ~~flow~~ movement of these underwater landslides. When the methane gas is produced in the sediment then bubbles through the sea floor, the formation and destruction of these methane gas pockets could cause shifting and movement of the sediment, triggering landslides. However, this depends on the size of these gas seeps. Effects of these slow moving landslides are not extremely dangerous due to their slow nature. If they

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were sudden events involving large amounts of sediment being displaced, it is possible that they could cause events such as Tsunami. But due to their slow nature, it is impossible for them to ~~occur~~ produce such effects. Implications of these landslides may include the destruction of underwater habitats on the ocean floor, such as ~~th~~ regions where life-sustaining gases are released from ~~the~~ chimney s on the ocean floor, and also with the shifting sediment, more methane gas will be able to escape from the sediment and released into the water. Methane is a very effective greenhouse gas. When UV light enters our atmosphere, it is absorbed by Ozone particles in the stratosphere, then re-emitted as infrared radiation. Greenhouse gases have an excellent ability to absorb this infrared radiation, therefore the greater the concentration of these greenhouse gases in our atmosphere such as carbon- dioxide and methane, the more of this infrared radiation is absorbed as heat. Therefore, the temperature of our earth's atmosphere increases. The methane that seeps out from the ocean floor rises through the ocean and into our atmosphere, where it acts as a greenhouse gas. Therefore, these methane gas seeps will aid in the rise of our planet's temperatures. It is very important that further research is done on how these landslides are caused, and whether they do in fact have an impact on the amount of methane release. If my hypothesis is correct in that the melting of ~~[illegible]~~ methane hydrate molecules is aiding in the movement of these landslides, then it is very possible that with the rising temperature of our oceans, these molecules may be more able to melt, meaning more lubrication for the landslides, resulting in more methane gas being displaced and seeping from the ocean floor. Research off the coast of New Zealand has shown that the methane seeps are reaching levels of up to 250m above the ocean floor. In some parts of the ocean this will be ~~[illegible]~~ high enough to reach the surface, but this depends on the location of the methane seeps. This gas will only be particularly harmful if it reaches the surface and joins the atmosphere, where it will aid climate change. Research must be done to deduce the effect of ocean temperature on the rise of the gas. In warmer ~~oceans~~ waters, this warm liquid will have a lower density than cold waters. Therefore, it is a possibility that warmer waters as a result of climate change will mean that due to its lower density, these methane seeps will be able to rise higher, therefore more methane will escape from the ocean and become a greenhouse gas in our atmosphere

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QUESTION TWO: LIQUID WATER ON MARS

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Use the information provided on pages 4 and 5 of your resource booklet to answer this question.

There is no doubt that water exists on Mars as ice and water vapour, but recent evidence suggests that liquid water may be present just under, and occasionally on top of, the Martian surface.

Discuss in detail how and where liquid water could form on Mars, considering factors such as relevant geological features, and the axial tilt of Mars and its eccentric orbit around the Sun.

Well labelled diagrams may assist your answer.

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it is much more difficult for liquid water to form on Mars than on Earth, mostly due to the very small temperature range that liquid water can be formed on the planet. The melting point of water is the same as on Earth, 0°C, but the boiling point is much lower, the maximum boiling point being 10°C, due to mars having a much lower Average air pressure, only 0.006 atmospheres compaired to Earth. Mars has a much lower mass compared to Earth and therefore has a smaller gravitational force. This means that due to its weaker forces of gravity, less gas is accumulated in its atmosphere, it cannot attract as much gas as the earth. Therefore, the atmosphere of mars is 100 times thinner than Earth. The boiling point of a liquid is heavily influenced by the air pressure surrounding it. The smaller the air pressure on the liquid water, the less force is being exerted on the water particles and this makes it easier for them to break free of their ~~intermolec~~ intermolecular bonds and transition from the liquid state to the gaseous state. Due to the thinner atmosphere of mars, the average air pressure is much lower then on earth and therefore water will boil at much lower temperatures. As $F_g = \frac{GMm}{r^2}$, F_g being the gravitational force and r being the distance between the centre of mass of the two objects, the closer the centre of masses of the two objects are, therefore the closer to the

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centre of Mars a molecule is, the larger the force of gravity. This means that ~~on~~ the closer to the centre of the planet, the more gas will accumulate (greater density of gas) and therefore the greater the air pressure. This means that at the deepest points ~~on~~ the surface of mars, such as within the Hellas Basin which is 7km deep, or under the surface of mars in cave systems, the air pressure will be greater and therefore the boiling point of water will be higher and there is a larger temperature gap in which liquid water may form. However, the issue with the Mars climate is that temperature can drop to temperatures of up to -133°C, which is a temperature much too low ~~for~~ for liquid water to be present. Then, during the summers, the temperatures ~~can~~ rise to up to 35°C. At this temperature, ice will sublime, changing directly from solid to gas due to the low air pressure. The seasons are caused by the tilt of the axis of the planet, as on earth, but Mars possesses an eccentric orbit which causes the planet to move close to the sun at one point of its orbit and further away at another. Therefore, during the Southern summer where the southern pole is tilted towards the sun and a higher concentration of sunlight is incident to the southern hemisphere, at this point the planet is closer to the sun than at any other point of its orbit, and during the northern summer and southern winter, the

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planet is at its furthest point from the sun. Therefore, during the southern summer, the temperatures will reach their maximum. During this time I believe that temperatures would be above 10°C and far too high for water to be liquid anywhere on the surface of mars, and the northern winter at the time far too cold for liquid water to be present. Therefore, I believe that the most likely time and location for liquid water to be present on the surface of mars to be in the northern hemisphere during the northern summers, as the temperature is likely to rise above 0°C, but more likely to be low enough for liquid water to exist. One likely location for liquid water to be found is within or below the glaciers of the norther hemisphere during the summer. These glaciers have a thick layer of dust, which has a much lower albedo than ice, which is its ability to reflect sunlight. Therefore, the dust will absorb more sunlight which is then absorbed by the ice in the glacier, heating it up. There is then a possibility for water to form within the glaciers as they heat up. Also, below the glaciers, as they move over regolith, perchlorates may be contained within these rocks. Water containing other minerals has a lower freezing point as the minerals obstruct the water from freezing, lowering the melting point. As these perchlorates then move with the glacier, the ability for ice crystals to form is further decreased. Despite the ~~[illegible]~~ below 0°C temperature under the glacier, it is very possible for this brine solution to be liquid.

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QUESTION THREE: THE WARMING OCEAN AND THE EFFECT ON NEW ZEALAND

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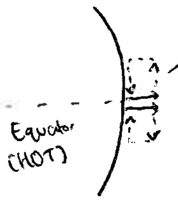
Use the information provided on pages 6 and 7 of your resource booklet to answer this question.

Over the next few decades, global warming will result in a warmer ocean and more energetic wind patterns in the South Pacific. As a result, sea temperatures around New Zealand may warm up by as much as 2°C, especially around the bottom half of the South Island.

By showing a comprehensive understanding of the factors that affect surface current flows around New Zealand, consider, in depth, the consequences of global warming on New Zealand and its surrounding ocean and ecosystems.

A well labelled diagram may assist your answer.



connection current, hot air rises, then cools and falls.

Hadley ~~cell~~ circulation

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It is undebatable that the temperature of our planet is rapidly increasing. With increased temperatures, this causes increasing sea temperatures. Atmospheric circulation patterns arise from convection currents, where ~~water~~ air is heated by the warmer waters, rises due to its lower density and then falls as it cools, producing a circular pattern, where it returns to the warm area and rises again. With increased temperatures the size and intensity of these convection currents will increase. These atmospheric circulation patters are what influence the direction and size of the trade winds. and also the ocean currents as the winds blow across the surface of the ocean. As the trade winds blow from ~~west~~ east to west across the South Pacific ~~ocean~~ ocean between South America and Australia, warm water is swept towards the West and accumulates there, causing the ocean here to rise up to two feet higher than on the east of the ocean. Where the warm surface area is displaced in the East, causing cold water to upwell from the ~~surface~~ bottom of the ocean, bringing with it nutrients. Cold water has a much greater ability to absorb ~~work~~ oxygen particles than warm waters, therefore in the Eastern South Pacific on the coasts of South America the waters are cool, oxygen and nutrient rich. This allows for rich plankton blooms supporting large fish populations, which then allows for the

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the establishment of other populations such as seals. With the rising earth temperatures, these circulation patterns that our ecosystems rely on will become larger and less predictable. If the trade winds ~~are~~ were to increase in strength, there would be many more occurences of La niña, where more warm surface water will pile up around Australia and Indonesia. This will cause the East Australian and South Equatorial Currents arriving to New Zealand to become much warmer. The South Pacific Gyre will also most likely increase in size due to these stronger and more energetic winds. With the increase of the size of this gyre, it is possible that much more warm currents will arrive to the north of New Zealand and less of the cooler currents such as the ACC will arrive to the south of New Zealand. This means that not only will the oceans at the north and east of New Zealand warm, but also the cooler oceans in the south of New Zealand. These cool oceans are nutrient and oxygen rich, as nutrients are carried along the Sub-tropical front. But as the oceans in these regions warm, they will be less able to absorb oxygen, leading to oxygen depletion and collapse of many populations. As plankton and fish cannot survive in these low oxygen waters, they will move further south to colder regions, and this will lead to the collapse of the seal colonies in the south Island. Also a

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problem with these gyres is that in their centres are massive islands of undecomposable, man-made waste such as plastics. As these gyres change with the changing winds due to global warming, the trash that was locked in their centres by the circulating waters may be swept onto our shores, causing harm to much of our wildlife as it may destroy their habitats, or they may attempt to eat the trash and die. Also associated with the Walker circulation is the rain fall associated with it. As the trade winds blow across the Pacific, they bring with them clouds that may cause increased rain fell in New Zealand. New Zealand is not in fact a small island, it is quite a large continent, but most of it is underwater. This means that surrounding New Zealand is shallow water, often extending far off shore. With the increasing climate, these waters will warm and due to their shallow nature, the amount of cold water surrounding New Zealand will decrease, as even the deepest water of the continental shelf will become too warm to support life with high oxygen requirements. Therefore, deep sea fish that cannot survive in warm, low oxygen surface water conditions will be forced to move away from New Zealand shores and into the deeper ocean, affecting New Zealand the fishing industry, as fishermen will need to journey further offshore to find the species they require and also affect seal ~~ma~~ ~~cardy~~ dolphin and whale populations that eat these species.

6 (8)

Extra space if required.
Write the question number(s) if applicable.

Question Two continued.

Also, the friction between the bottom of the glacier and the surface of Mars as it moves along it, may produce enough heat for ice ~~water~~ to melt into liquid, and remaining liquid as it flows along with the glacier, as it is difficult for a moving liquid to form ice crystals.

At times of the year when dust storms are greater in intensity, more dust will collect on the surface of the glaciers, meaning that more heat will be absorbed by the glaciers.

The possibility of water existing beneath the surface of Mars is also very possible, as this is a largely unexplored possibility ~~be~~ due to the fact that it is very hard to explore beneath the surface of such a distant land mass. Mars no longer possesses volcanic activity, therefore the core of the planet has cooled and there is no internal heat source as we find on earth. All heat on the planet is originated from the sun's rays. Therefore, it is very unlikely that the temperatures beneath the planet's surface will climb higher than the maximum boiling point of water on the planet, 10° C. While the temperature of water beneath the surface of Mars is likely to plummet far below 0° C, it is very possible that water bound to minerals in rocks, forming perchlorates could exist below the surface of Mars. This brine has a freezing point up to −70° C, therefore making it able to exist in a liquid state at these temperatures.

These ~~undergr~~ underground waters are most likely to exist as ~~un~~ rivers under the surface of mars. As this water is moving, it further inhibits the ability of the water to form ice crystals and freeze, further increasing the chance of the water being in a liquid state.

I feel that it is very unlikely for liquid water to exist in the polar ice caps of mars. In winter, it will be far too cold for liquid water to exist. In the summer, this ice will likely sublime directly to a gas. It will require a very precise temperature, probably smaller than the 0 - 10°C gap for liquid water to be present in these regions. Therefore, I believe that it would be very unlikely for liquid water to exist in these regions.

Question Three Continued

The fronts, when two currents converge, are key in carrying nutrient rich waters to the seas of the north and south island. If these fronts were to move due to the changing circulation patterns, these nutrients may not be delivered to ~~seas~~ areas where they once where, causing ecosystems to collapse and populations to move to where they can find food.

With the North and South water temperatures becoming more similar, the highly changeable whether may decrease, possibly leading to less rainfall and even droughts.

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Earth and Space Science Scholarship (93104); 2016.

Panel leader comments

Outstanding paper:

This paper exhibited convincing communication, which is one of the essential requirements of an Outstanding paper. This was especially evident in the answer to question 2. Convincing communication means that the candidate's answers show logical and precise progression and development of ideas which can easily be followed and understood.

Q1: (6) This is a scholarship answer because the candidate has:

- shown a very good understanding of the causes of slow-moving landslides and the fact that such landslides will not cause tsunamis
- understood that the release of methane gas causes a feedback loop that results in warmer oceans and the consequent release of more methane from melting permafrost.

This is not an outstanding answer because the justification of the need for extra research has not been fully developed.

Q2: (7) This is an outstanding answer because the candidate has shown a comprehensive understanding of:

- the relationship between temperature and pressure in the formation of liquid water on Mars
- the conditions needed to have running water under ice caps and glaciers
- why areas such as the Hellas Basin may or may not have liquid water at various times of the year.

This is not a higher level answer because the candidate did not consider all the data given and realise the importance of the average temperature of Mars being -55^{0}C, which results in temperatures being much lower than often considered in the answer.

Q3: (6) This is a scholarship answer because the candidate understood:

- the effect on surface currents, such as the South Pacific gyre, of increasing atmospheric temperatures.
- the effect on the ocean and ecosystems around New Zealand.

This is not an outstanding answer because the candidate did not make sure that all comments addressed the question; for example, this question did not ask candidates to consider conditions in the Eastern Pacific; only around New Zealand.