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TOP SCHOLAR

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

QUALIFY FOR THE FUTURE WORLD
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# 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.

methane released
gas shifting in crust & sediment. - more methane can be released.

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.

contributes to global warming.
20-25x more effective GH gas than $CO_2$

*Well labelled diagrams may assist your answer.*

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The methane gas releases ~~eds~~ from the permafrost and accumulates in the sediment. It does this much like magma in volcanic eruptions gathers in a magma chamber before the eruption. The gas builds up enough pressure to make it's way to the sea floor and bubble up to the surface. Like before volcanic eruptions, the moving of this gas beneath the surface can create large amounts of small earthquakes. These small earthquakes are a possible cause of the slow-moving underwater landslides as each small earthquake ~~could~~ could cause the seafloor sediment to move slightly. Another possible cause of these slow-moving underwater landslides could be the pressure of sediment accumulating above it, slowly causing the sediment to move down the slope of the continental shelf. It would be important to research these possible causes as they may give a further understanding of what is causing the methane to be released from the permafrost under the sea. It is possible that the slow moving underwater landslides are disturbing the ground/sediment within the continental shelf below and causing the methane hydrates to be released. If this is correct, then it would have been a small change within the continental shelf (such as an earthquake or larger landslide) to first start this, but the released methane hydrates

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are causing the ground to be unstable, creating the long, slow-moving underwater landslides. These in turn disrupt the continental shelf, causing more of the methane hydrates and methane gas to be released, creating a positive feedback loop. More research is needed in this field to find out the causes of the landslides and to find out if it is possible to break time positive feedback loop.

The methane gas entering the environment has a lot of consequences. It upsets the carbon cycle as there is no longer large amounts of carbon stored in the seafloor sediment. The usefulness of the ocean as a large carbon sink will no longer be that great. This is because ~~the~~ normally the carbon that entered the ocean sediments or deep ocean would stay there for 10's of thousands of years until it would be bought up to the surface once more. However, the ocean is now not as effective a carbon sink, as the carbon, (in the form of methane), is leaving the ocean sediments and making it's way to the atmosphere. As there is less carbon stored in the ocean sediments, both the ocean and the atmosphere will have higher amounts than usual. Methane is a greenhouse gas (GHG) that is almost 20-25 times more effective than carbon.

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As more methane is released from the ocean sediments and added to the atmosphere, the amount of methane in the atmosphere will increase. The sun's energy reaches the Earth in long wavelength radiation. This is absorbed by the Earth's surface and re-radiated out to the atmosphere as short wavelength radiation (infra red). This infra red is then absorbed by the greenhouse gasses within the atmosphere, which use it to heat up the planet. As methane is a very effective GHG, only a small amount of extra methane gas in the atmosphere is needed to make a change in the global temperatures. This is because the methane will effectively trap the ~~greenhouse ga~~ infra red in the atmosphere, causing the planet to warm up. This is a very important topic to research as the rising of global temperatures could cause more/different areas of permafrost to melt, releasing even more methane into the ~~environment~~. atmosphere, and warming the planet up even more. Eventually the amount of methane in the atmosphere will be so high that we will not be able to make any significant reductions, and the global temperature will keep rising. We need to research more about this topic in order to halt the melting of the

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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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Liquid water rarely exists on Mars. It has such a thin atmosphere that the temperature is mostly too cold for liquid water to form. The small atmosphere also means that there is not as much pressure on Mars as there is on Earth. Water boils at different Temperatures at different pressures. The lower the pressure, the lower the boiling point. Because Mars has an atmosphere that is only 0.006 of Earth's atmospheres, water is only liquid within a temperature range of 0-10°C, 10 times smaller than that on Earth. As the amount of pressure decreases with altitude, the lowest points on Mars would have the highest chances of having liquid water. One of such places is the Hellas Basin, which is 7km deep. As this point is closer to the centre of Mars, it will have more atmosphere exerting gravitational force on it, and will there-fore be under slightly more pressure. Because of this, water can exist as a liquid in a larger (higher BP) temperature range than it can on other places of Mars, meaning it is likely to find liquid water in such a place. The poles of Mars are covered in caps of ground ice, sometimes covered by a large layer of frozen carbon dioxide (dry ice). On Earth, ice usually insulates the water below it, as it floats on top. This means

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that in places such as Lake Vostok in Antartica, liquid water can be found in sub-zero temperatures. The thick layer of ice above it keeps it insulated from the cold and stops it from freezing. Also, ~~ice~~ water expands when it freezes, meaning that under high enough pressure water can not freeze. It is possible that under the layer of ice on Lake Vostok, there ~~pre~~ is a very high pressure, causing some water to stay liquid. There could be liquid deep water under the ice of the polar caps on Mars. This water would exist under similar conditions to the water found 4km under ice in Lake Vostok. However, although this is likely, it is not as likely to occure as the water under lake Vostok. This is because the Earth is internally heated by a hot core wheras the core of Mars became cold a long time ago. This means that although it is likely that water can be found under the polar ice caps, it is not a garantuee.

The hygrated minerals found in the loose surface rock (regolith) could also be found under the polar ice caps. As these lower the ~~boiling~~ freezing point of water ~~to~~ to as low as -70°C, it ~~is~~ gives another reason why there may be liquid water under the polar caps. The presence of these perchlorates means that there could be liquid water

existing at a lower temperature under the ice of the polar caps.
Like Earth, Mars is on a tilted axis (of 25.2°) and therefore also has seasons. However, the orbit of mars is eccentric, meaning it is not a circular orbit. When it is Summer in the Northern Hemisphere (NH) it is cooler than when it is summer in the Southern Hemisphere (SH). The warmer average temperature in summer in the SH ~~is~~ means that there is more of a chance that the ~~water is~~ temperature is high enough to melt the water from the ice caps. Although when this happens the water does not stay as a liquid but instead sublimes to form water vapour. This occurs because the atmosphere is rarely saturated with water vapour. However during the warmer summer of the SH, there could be enough water ~~s~~ that sublimes to saturate the atmosphere with water vapour. If this happens, the melting ice can stay as liquid water for the duration of the summer. ~~If the winter~~ If the Summer in the SH coincides with a period of intense dust storms that Mars periodically has, the water will also be moved around. As moving water ~~does~~ does not freeze when it is moving, the water that is carried by the dust storms, or running down slopes created by the dust storms, tends

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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.*

As the Walker circulation and Hadley circulation are ~~is~~ increasing in strength, the trade winds are blowing stronger. This occurs because of a global rise in temperature as the warmer water and air will mean that more water will be evaporated. More evaporation in warmer regions will mean ~~stronger~~ lower low pressure zones and greater differences in pressure between high and low pressure zones. The increased pressure differences lead to stronger circulations in the SH (the Hadley & Walker) and stronger trade winds. The stronger trade winds will mean an abundance of water will pile up on the East coast of Australia. This is because the ~~water~~ winds will drag more of the warm equatorial pacific water towards the East ~~and result~~ in due to the friction between the water surface and the wind. As more water is piled up on the East coast of Australia, the surface currents will start moving quicker. This is because the stronger surface currents towards the West will bring more warm water to Australia in the same amount of time, and therefore all the surface currents will become faster. This means that the water will have less chance to cool off as it flows Southwards and to New Zealand from Australia's East coast. The water from Australia reaches New Zealand first at the bottom West of the South Island, and then will flow Northwards

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along the coast. This is why the water around New Zealand, and especially the bottom of the South Island will be warmer than it was before. *see top of pg 13 The warmer water in the subtropical currents along ~~the~~ from Tasmania to the South of the South Island will cause a larger difference in temperature between the ~~st~~ subtropical surface currents and the cold, Antarctic Circumpolar current. It is the difference in temperature along this sub-tropical front that causes the nutrients to circulate to the surface. As this difference in temperature grows more extreme, more nutrients are circulated, ~~and~~ resulting in larger plankton blooms and more fish production. ~~This is~~ Along the South, and East of the South Island, some of the sub-tropical water makes it's way between the SI and Stewart Island and up the coast ~~to the~~ Northwards. This means that this part of the South Island is also largely affected by the warmer surface currents reaching it. However, like on the West coast, the water does not get very far up the coast before traveling away from the South Island. This is because the surface currents are deflected by the continental shelf, and the water travels Eastward. The decrease in depth as the surface currents reach ~~New~~ the Chatham rise means that most of the water can

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* The increase in water temperature affects the bottom of the South Island the most, because not only does the warmer water from Australia first arrive there, but there is no continental shelf along the coast. This means that the surface currents can transport more warmer water to what is normally a colder part of NZ's ocean, making the increase in water temperature felt more.

not continue traveling in the same direction but is forced Eastward.

Along with the abundance of plankton blooms and more fish, the warming of the ocean has more consequences. As the ocean warms up, it can absorb less $CO_2$ from the atmosphere. This is because $CO_2$ is more readily soluble in colder water than in warm. As less $CO_2$ is absorbed into the ocean, there is more in the atmosphere, absorbing the infrared rays re-radiating from the Earth's Surface. ~~As it does~~ The increase in $CO_2$ in the atmosphere will ~~increase~~ mean an increase in global temperatures because the excess $CO_2$ in the atmosphere warms the planet up. ~~More~~ A higher global temperature will mean that once again, more water is evaporated, and the Walker and Hadley circulations becoming stronger, leading to warmer oceans. This is a positive feedback

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

Q 1 permafrost before it is too late. By doing extra research into this topic, that is relatively unknown so far, we will be able to understand more about what is causing the ~~melting of the perm~~ slow-moving landslides and the methane seeps within the continental crust off the East coast of New Zealand. As we learn ~~to know~~ more about this topic, we will better understand the consequences of it and actions we can take against it.

Q2 to stay liquid for a longer period of ~~thi~~ time. Evidence of this occuring, (running water) is shown on the dark streaks in the photographs of Mars's surface. These dark streaks show the path water has traveled along before it eventually was evaporated or froze.

However, the warmest annual temperature on Mars is 35°C, warmer than the boiling point of water on Mars. This means that during the height of summer ~~during~~ in the SH, (and possible also NH depending on the temperature), there will be no liquid water on Mars (where it is

Still Q2

* cont. summer and day) as it will all have evaporated. The combination of these factors means that water can not stay liquid for a very long period of time on Mars.

evidence suggests that there are places on ~~the~~ Mars where it is possible liquid water forms

Q3 loop as ~~water~~ warmer temperatures mean warmer oceans which means more $CO_2$ in the atmosphere and so on.

The increase in $CO_2$ in the atmosphere will eventually lead to more $CO_2$ being absorbed by the oceans, even though the temperatures are higher. This is because a large percentage of $CO_2$ in the atmosphere will cause more to be absorbed into the oceans. With more $CO_2$ being absorbed into the ocean with warmer temperatures, the position of the $CO_2$ ~~equilibr~~ equilibrium shifts.

$$H_2O + CO_2 \rightleftharpoons H_2CO_3 \rightleftharpoons H^+ + HCO_3^- \rightleftharpoons 2H^+ + CO_3^{2-}$$

More of the carbon will go on to making carbonic acid instead of the carbonate which plankton use to build their shells with. This carbonic acid will lead to ocean acidification, meaning that the oceans will become more acidic. As they do so

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Achievement Standard Number 9 3 1 0 4

Question Number 3

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more of the Calcium carbonate shells ~~with~~ of microorganisms within the ocean will be dissolved. These plankton etc. can not survive without their shells or exoskeletons. As a result of this many of them die and drift down to the ocean floor as marine snow. Without the abundance of microorganisms such as plankton, larger species will lose their food source and will also die off. This means that ~~the~~ global warming will have negative consequences on the oceans and ecosystem, even though it produces more plankton blooms and fish production at the sub-tropical front. The negative consequences of global warming outweigh the positive ones.

This extra answer page MUST be placed inside the plastic bag with your answer booklet and handed in.

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