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NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

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

Scholarship 2018
Earth and Space Science

9.30 a.m. Wednesday 7 November 2018

RESOURCE BOOKLET

Refer to this booklet to answer the questions for Scholarship Earth and Space Science 93104.

Check that this booklet has pages 2–7 in the correct order and that none of these pages is blank.

YOU MAY KEEP THIS BOOKLET AT THE END OF THE EXAMINATION.

Resource for
QUESTION ONE: VENUS AND MARS

Photo 1: The relative sizes of Venus (surface view), Earth, and Mars

https://commons.wikimedia.org/w/index.php?curid=39782734

Table 1. Properties of Venus, Earth, and Mars

Property	Venus	Earth	Mars
Distance from Sun (AU)	0.72	1.00	1.52
One orbit (year)	0.61	1.00	1.88
One rotation	243 days	23.9 hours	24.6 hours
Mass (Earth = 1)	0.82	1.00	0.11
Gravity (Earth = 1)	0.91	1.00	0.38
Nature of interior	Molten metallic core	Molten metallic core	Cool, solid core
Thickness of atmosphere compared to Earth’s	Very thick		Very thin
Atmospheric pressure (bars) at surface	90.00	1.00	0.007
Carbon dioxide (% of each planet’s atmosphere)	96%	0.03%	95.3%
Average surface temperature with greenhouse effect	470°C	15°C	–47°C
Average surface temperature if no greenhouse effect	about 30°C	–18°C	–57°C

Volcanism on Venus and Mars

Mars' volcanoes have been extinct for many millions of years, if not longer. However, Venus may still be volcanically active. There is evidence of recent lava flows that show very little weathering. Also, the atmosphere of Venus has high levels of sulfur compounds, which do not remain in an atmosphere for long.

There is no evidence of active tectonic plate movement on either planet.

Diagram 1: The relative heights of the troposphere of Venus, Earth, and Mars

Note that the x-axes are not comparable.

Venus **Earth** **Mars**

adapted from: https://courses.lumenlearning.com/astronomy/chapter/the-massive-atmosphere-of-venus/
https://lifeng.lamost.org/courses/astrotoday/CHAISSON/AT310/HTML/AT31005.HTM
https://lifeng.lamost.org/courses/astrotoday/CHAISSON/AT307/HTML/AT30702.HTM

Water molecules at high altitudes can be split by ultraviolet radiation into water's component gases, oxygen and hydrogen. The lighter hydrogen molecules escape into space and the oxygen reacts with other chemicals.

Diagram 2: Dissociation of water

https://online.science.psu.edu/astro140fa14/node/10693

Resource for
QUESTION TWO: THE WESTERLY WIND BELT

Map 1: Lake Ohau relative to the Southern Alps

https://en.wikipedia.org/wiki/South_Island#/media/File:Turbid_Waters_Surround_New_Zealand_-_crop.jpg

The westerly wind belt (WWB) influences the strength and position of cold fronts and mid-latitude storm systems over New Zealand, and consequently, the amount of rainfall, especially in the South Island.

When the WWB moves south, the belt tightens, bringing:

- relatively light winds and more settled weather over New Zealand
- stronger westerly winds over the Southern Ocean.

When the WWB moves north, the belt expands, bringing:

- stronger westerlies over New Zealand, with more unsettled weather
- weaker westerly winds and fewer storms in the Southern Ocean.

The WWB is currently moving south with long-term implications for New Zealand's weather. In southern New Zealand, summer rainfall has decreased by as much as 40% in the past three decades.

Note that the WWB is also called the Southern Annular Mode or SAM.

Map 2: The position of the WWB when it moves south

Map 3: The position of the WWB when it moves north

http://agriculture.vic.gov.au/agriculture/weather-and-climate/understanding-weather-and-climate/climatedogs/sam

Diagram 1: Drilling sites on Lake Ohau

google maps

Photo 1: Part of a sediment core showing thin sediment layers

https://geodiscovery.gns.cri.nz/Geodiscovery/On-Land/In-Lakes/Lake-Ohau-Climate-History/Latest-News

Four sediment cores, 7 cm in width and up to 80 m long, were collected after drilling into the floor of Lake Ohau, giving a 17 000-year record of climate variability.

The cores show alternating bands of light and dark sediment, which vary in width from year to year, in response to changes in rainfall patterns and river inflow. The light bands represent the inflow during the summer time, and the dark bands represent the inflow and the mud being deposited in the winter. The thickness of the layers relates to the amount of rainfall, with wider layers showing flood events.

Each year is represented by a layer of sediment approximately 5 mm thick. These cores are minutely examined. Close examination of the cores shows differences in rainfall patterns with intervals as low as 10 years.

The cores have also been examined for leaves and twigs plus fossil pollen, spores, charcoal and diatoms (algae).

Data from other places in the Southern Hemisphere can be used to confirm the data from Lake Ohau.

Table 1: Key places where climate data has been gathered

Place	Data recorded in	Latitude (rounded)
Auckland	sediment cores from volcanic craters	37° S
Lake Ohau	sediment cores	44° S
Patagonia	sediment cores	45° S
Campbell Island	tree ring data	53° S
Antarctica (Ross Sea)	ice cores	77° S

Map 4: The WWB and the location of key places where sediment cores, ice cores, and / or tree ring data are collected to gather climate data

https://eos.org/project-updates/shifting-winds-write-their-history-on-a-new-zealand-lake-bed

Resource for
QUESTION THREE: RENEWABLE ENERGY FROM THE SEA

Tidal energy

Kinetic energy is gained from ebbing and flowing tidal currents, and potential energy from the difference in height (tidal range) between high and low tides.

Photo 1 **Photo 2**

Tidal currents flow across and turn rotor blades which then rotate a turbine which generates electricity (similar to how wind currents turn rotor blades for wind power).

http://www.alternative-energy-tutorials.com/tidal-energy/tidal-energy.html

Groups or arrays of such turbines operate just below the sea surface or are fixed to the sea bed.

https://www.niwa.co.nz/sites/niwa.co.nz/files/styles/medium/public/media-vimeo/27420679.jpg?itok=7TmFNySv

Wave energy

Wave power involves converting the energy in ocean surface waves into electricity using devices either fixed to the shore, the seabed, or floating out at sea. Wave energy depends on when and where the winds and storms that create the waves occur.

Devices at or near the shore use the energy of breaking or nearly breaking waves, whereas offshore devices use deep water waves and surges.

Photo 3 **Diagram 1**

A wave energy converter consists of a series of joints that generate power as the waves move them up and down, converting mechanical energy into electrical power. An underwater cable takes the electricity to the shore.

http://en.stonkcash.com/pelamis-wave-energy/

Map 1: Areas with high tidal current velocity

Map 2: Tidal energy in Cook Strait

Geographx

https://www.niwa.co.nz/sites/niwa.co.nz/files/styles/large/public/sites/default/files/images/cook_strait_tidal_energy.jpg?itok=AijUls-R

New Zealand tides generally have only a small tidal range, 2–3 m, which means that tidal currents have relatively low velocities (speed). Only a few sites have tidal currents with higher velocities and these are found where offshore islands, passages, and seabed irregularities focus the tidal current flow, increasing the velocity. Examples of these are Kaipara Harbour, Cook Strait, and Foveaux Strait.

The entrance to Kaipara Harbour narrows to a width of 6 kilometres and is over 50 m deep in parts. Spring tidal flows reach 9 km / hr in the entrance channel.

Cook Strait has very strong and complex tidal flows. On the Pacific Ocean side, the high tide occurs five hours before it occurs at the Tasman Sea side, so when one side has high tide, the other has low tide. The difference in sea level can result in tidal currents up to 9 km / hr across Cook Strait.

Two wind zones affect New Zealand. Easterly winds dominate in the north and westerlies in the south. The westerlies produce some of the stormiest seas in the world, with maximum wave heights regularly exceeding 4 m. The amount of energy in a wave is proportional to the square of its height, so a 2 m wave contains 4 times the energy of a 1 m wave.

Map 3: Wave energy around New Zealand

http://www.awatea.org.nz/marine-energy/

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