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NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

Scholarship 2005
Science

2.00 pm Friday 9 December 2005
Time allowed: Three hours
Total Marks: 64

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

Answer ALL questions.

Write all your answers in this booklet.

For all questions, the answers should be written or drawn clearly with all logic fully explained.

If you need more space for any answer, use the page(s) provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2–22 in the correct order.

Question	Number of Marks	Suggested Time
One	24	70 minutes
Two	24	70 minutes
Three	16	40 minutes

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

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PERFORMANCE CATEGORY

QUESTION ONE: DOLPHINS, WHALES AND SOUND (24 marks)

Dolphins and whales use echolocation to locate objects and to orientate themselves in the ocean. They use the fact that water is an excellent transmitter of sound to compensate for reduced vision in the sometimes cloudy sea water. Sound waves travel about 4.5 times faster in water than they do in air.

Dolphins and whales send out a series of rapid chirps, clicks, whistles and squeals, of a range of frequencies, generated by the nasal sacs in their heads. These sounds are then transmitted to the water via a flexible, oval, fat-filled organ in the forehead, called the melon. The fats in the melon have fatty acid chains that are shorter in length than those found in fats elsewhere in the body, and some have branching fatty acids. The melon can change shape to focus the sound waves into a beam. The beam is projected forward into the water in front of the dolphin or whale. This beam reflects off objects and back to the dolphin or whale.

Dolphin showing bulbous forehead containing the melon

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http://www.turbosquid.com/FullPreview/Index.cfm/ID/227731/Action/FullPreview

The reflected sound waves are received in the fat-filled cavities of the lower jawbone and conducted to the brain, where the information is interpreted to create a sound picture of the environment.

Generation and reception of sound waves in dolphins

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http://www.seaworld.org/infobooks/Bottlenose/echodol.html

(a) The fat-filled melon can change shape to focus the sound beam. Discuss the properties that the fats would need in order to be used in such a flexible melon. These could include:

- the possible melting point of the fats
- the density of the fats
- other properties that may make the fats suitable to be in a flexible melon. (8 marks)

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Dolphins and whales can use echolocation to determine the size, shape, speed, distance, and even some of the internal structure, of objects in the water.

Sound waves travel through water at a speed of about 1500 metres per second. Low frequency sounds produced by dolphins and whales travel further in water than high frequency sounds.

Dolphin and whale sounds are sent out at a range of frequencies. Low frequency sounds are groans, grunts, and low rumbles. High frequency sounds are high-pitched whistles and shrieks. The sounds that dolphins and whales generate and hear have a wide range of frequencies from 10 to 170 000 hertz.

Dolphins produce bursts of sound, called clicks. Individual clicks are composed of a mix of frequencies and are often emitted in rapid succession, anywhere from five to several hundred per second.

There are two main kinds of clicks:

- discrimination clicks – high frequencies and high repetition rate to classify objects according to shape, size and material
- orientation clicks – low frequencies and low repetition rate for detection and orientation.

Dolphin echolocation

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http://oceanlink.island.net/oinfo/acoustics/acoustics.html#Anchor-49575

(b) Discuss how dolphins and whales use sonar to navigate, feed and find mates in the complex underwater world. Consider how they would:

- locate close objects
- locate distant objects
- avoid acoustic interference
- tell the difference between objects of different size
- tell the difference between objects of similar size. (8 marks)

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Sounds in the ocean come from many different sources, both natural and human-generated.

- Natural noise sources include earthquakes, underwater landslides, rainstorms on the surface, wind, icebergs breaking off and other animals.

- Human-generated sound includes ship noise, oil exploration and navy surveillance operations using sonar.

A present day scientific issue centres on whether noise created by humans is having a serious negative impact on marine mammals, especially whales. The impacts are not known but potential effects may range from minor behavioural disturbances to severe injury and perhaps death. Such threats to whales have sparked deep public concern and debate.

Shipping lanes across the globe are getting more and more crowded with tankers that generate low-frequency noise which may be harming whales, although this is not proven. Ship noise may mask the sounds from whales, meaning that the distance over which they communicate is shortened, affecting their ability to locate one another to mate.

Oil exploration uses various methods to locate oil deposits under the seabed, including air guns which emit bubbles that burst, creating immense sound shock waves over 250 decibels. These shock waves give information about the sub-surface structure. Any whales within range would be immediately deafened, concussed or even killed from the effects of the shock waves.

Intense sonar that navies sometimes use could be damaging to whales in several ways. Sonar may directly cause tissue damage such as haemorrhages (bleeding) in small blood vessels in the ears and in the acoustic fats. Sonar may also frighten whales into making too rapid an ascent. This could cause similar haemorrhages or cause bubbles to form in whale tissue, in the same way as divers suffer from decompression sickness known as “the bends”. The skeletons of some whales also show bone damage from the bends. Sonar may also disorientate whales, causing them to strand.

Evidence of tissue damage has been gained from whales that have died from strandings.

However, even when intense levels of sound are being emitted, it is not known whether the sound is a significant problem to whales. For example dolphins, which have similar acoustic systems to whales, sometimes ride the bow waves of military vessels while the sonars on those vessels are operating at high intensities. Is this comparable to the fact that humans work in noisy environments or voluntarily attend loud rock concerts that can cause permanent hearing loss? It is not known whether whales are sustaining hearing damage despite not showing behaviour indicating that they may be, such as avoiding the noise.

Dolphin and whale ears are very resilient and have probably always been exposed to very loud sounds such as underwater earthquakes. There is no evidence to show that older marine mammals have impaired hearing from natural events. It is important to safeguard whales from the loud sounds humans make, but also to not jump to the conclusion that all loud noises are a problem.

Adapted from http://www.pbs.org/odyssey/voice/20020906_vfts_transcript.html

(c) Determining whether human-generated noise directly or indirectly causes damage or the death of whales is a difficult task. Using the information on page 6, discuss this issue considering:

- the key points
- the problems in collecting sufficient, reliable and valid data
- possible solutions. (8 marks)

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QUESTION TWO: ISOTOPES, DNA AND FORENSICS (24 marks)

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Police need to investigate any unexplained death that has occurred within the last 75 years. It is important to know how long ago the person died but, until now, the date of death was determined by how old the skeletal remains looked.

New methods have been developed that use radioactive isotopes. Three isotopes that could be used are:

- the isotope carbon-14, which is used for the dating of skeletons found on archaeological excavations. It has a half-life of 5 730 years. C-14 from food eaten accumulates in human body tissues including bones.
- the isotope lead-210, which has a half-life of 22.3 years. Pb-210 naturally accumulates in bones. It has been present in our environment for thousands of years at unchanged levels. It accumulates in human body tissues via eating, drinking and breathing.
- the isotope polonium-210, which has a half-life of 138 days. Po-210 also accumulates in human body tissues from food eaten.

(a) Compare and contrast the use of the three isotopes mentioned above, when extracted from skeletal remains, in accurately determining the date of death. Include a comment on the possible time span for which each isotope could be used. (8 marks)

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Once a person dies, lead-210 stops accumulating in bones and the amount present decreases over time. Scientists have put special detectors on living people to study the amount of lead-210 in their skeletons, to set a benchmark that can be used for the better dating of skeletal remains.

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(b) How could a benchmark (data to get accurate comparisons) be created so that skeletal remains could be accurately dated? (8 marks)

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DNA profiling has revolutionised forensic science. A new development called familial searching has been successful in solving serious crimes, even when no direct DNA match is found. Familial searching involves the comparison of crime scene DNA profiles to those of known suspects or their relatives for close matches.

Investigators have begun to solve not just crimes committed by criminals whose DNA profiles are in police databases, but also those committed by relatives whose profiles are not on file. Siblings, parents, and other relatives are increasingly being investigated because their genetic fingerprints closely resemble the DNA of a known criminal.

Traditional forensic DNA profiling compares genetic markers and seeks to find a perfect match between the DNA evidence and known DNA samples. In a perfect match, genetic markers will match between the evidence and the sample.

Familial searching compares genetic markers between the DNA evidence and known DNA samples for a good match only. A certain proportion of the genetic markers will match. Crime investigators can then compare crime scene DNA profiles with the profile of known individuals in the hope of finding a partial relationship between the two. For example, Y chromosome profiles are shared amongst all male relatives related to one another through the father's bloodline. Therefore a volunteer's DNA might not match the crime scene evidence, but it could be close enough to implicate a relative – like a son, a brother or nephew.

Familial searching to solve crimes can occur in two ways:

- DNA databases contain the DNA profiles of known criminals. DNA from a crime scene may partially match a known criminal's DNA. This indicates that a relative possibly committed the crime being investigated.
- a suspect of a crime may refuse to give a DNA sample. A relative may be asked to provide one instead. If the DNA profile of the relative partially matches the DNA taken from the crime scene, the suspect can then be linked to the crime scene.

(c) Evaluate the use of familial searching, considering the important ethical issues this technique raises. (8 marks)

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QUESTION THREE: TECTONIC ACTIVITY ON EARTH AND MARS (16 marks)

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(a) On Earth there is plenty of evidence of tectonic activity, especially in New Zealand.

Many of New Zealand's major geological features are formed by the interaction of the Pacific and Australian Plates. The Hikurangi Trough, which ends just north of Kaikoura, indicates where the Pacific Plate is subducted beneath the Australian Plate. However, for most of the length of the South Island, the Pacific plate slides past and is also pushed up over the Australian Plate creating the Southern Alps.

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http://www.otago.ac.nz/geology/af/alpinefault.htm

The Pacific Plate is pushed up over the Australian Plate in the South Island forming the Southern Alps.

Discuss this statement. Your answer should include:

- consideration of the composition of the crusts of each tectonic plate
- why the Alpine Fault splits into several large faults at the top of the South Island.

(8 marks)

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(b) The photograph below shows a large tectonic crack on Mars, called the Valle Marineris. This is evidence of past tectonic activity on Mars. However, scientists are still searching for evidence of present-day tectonic activity. (8 marks)

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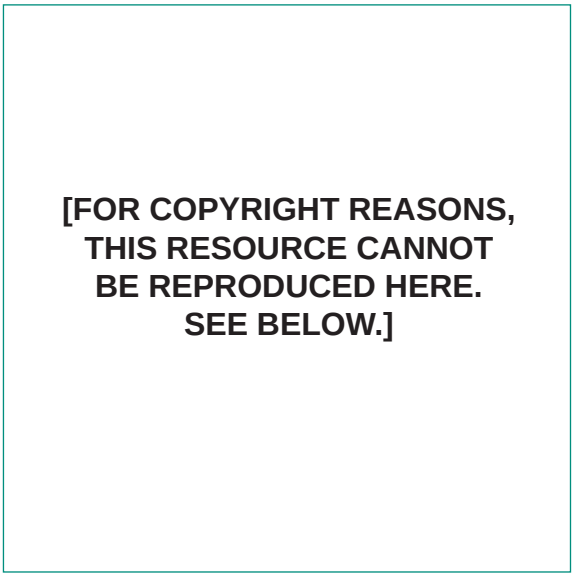

www.ottosell.de/space/valmar.jpg

(i) Discuss what would need to be observed and measured on Mars to show evidence of present-day tectonic activity.

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Note that this question continues on Page 18.

The diagram below shows the cross section of Mars as is currently understood.

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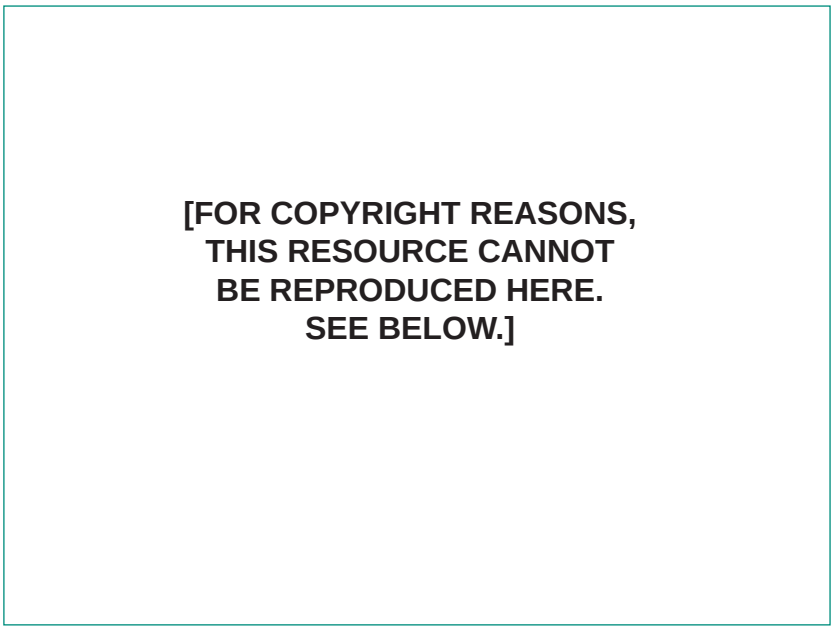

http://www.solarviews.com/cap/mars/marsint.htm

Both Earth and Mars have a core, a mantle and a thin layer of crust. The outer core of Earth is still molten, whereas the whole core of Mars is frozen solid.

(ii) Is there likely to be tectonic activity on Mars at the moment? Justify your answer.

Extra paper for continuation of answers if required.
Clearly number the question.

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Question number	

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	Marks
Q1(a)	(8)
Q1(b)	(8)
Q1(c)	(8)
Q2(a)	(8)
Q2(b)	(8)
Q2(c)	(8)
Q3(a)	(8)
Q3(b)	(8)
TOTAL	(64)

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Keep Flap Folded In.