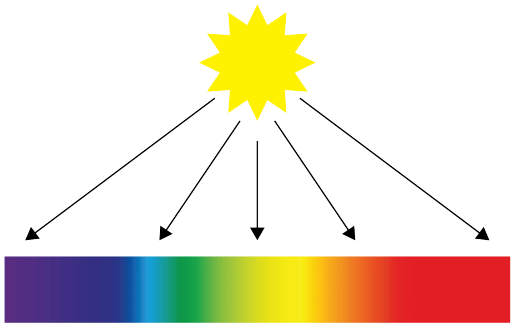
Assessment Schedule – 2024

Earth and Space Science: Demonstrate understanding of physical principles related to the Earth System (91193)

Evidence Statement

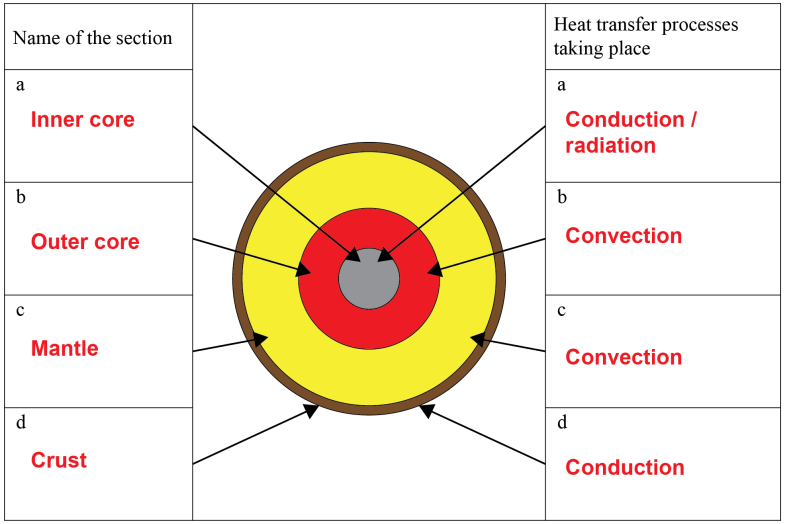
Question One

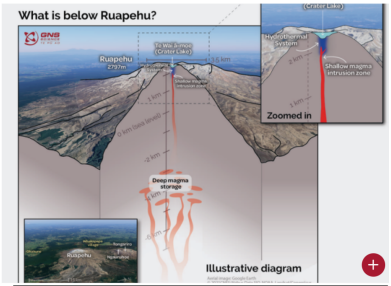
<table>
<tr><th>Q</th><th>Expected Coverage</th><th>Achievement</th><th>Achievement with Merit</th><th>Achievement with Excellence</th></tr>
<tr><td>(a)</td><td> 
</td><td rowspan="2">Describes with understanding:
• 2 lines completed correctly
• the relationship between transmission / absorption of short (blue light) or long wavelengths (red light) in water
• the relationship between transmission / absorption of high energy blue or low energy red light in water
• that short wavelengths / blue light able to penetrate greatest, due to high energy
• that blue wavelengths are scattered in water
• that long wavelengths of red, yellow, and orange are absorbed by water in the glacial lake
• that suspended material will scatter green and blue light
• that the deeper clear water is, the greater the scattering of blue wavelengths
• that violet and indigo wavelengths are absorbed by suspended material.</td><td rowspan="2">Explains in detail:
• that blue light has shorter wavelength and higher energy therefore travels further through clear water and is scattered by water molecules
• that red light has a longer wavelength and lower energy, therefore travels only a small distance and is easily absorbed
• that water molecules are similar in size to blue wavelengths and selectively scatter these wavelengths to great depth
• that glacial silt is very small and scatters the blue and green wavelengths to give the turquoise colour.</td><td rowspan="2">Explains comprehensively:
• the difference in wavelength properties and energy levels of blue and red light provides for the differing behaviour in clear lake water
• how glacial silt affects the absorption and scattering of different components of the visible spectrum to leave a turquoise colouration.</td></tr>
<tr><td>(b)</td><td>Blue light has the shortest wavelength (higher frequency) of visible light, red is the longest (lower frequency). For this reason, blue light is transmitted the furthest in water. It has a higher energy than the red light, so travels further than the red light, hence seeming to penetrate further into the water. The red light travels the least, as it has the longest wavelength (lowest frequency) and is absorbed easily, so doesn't penetrate to the extent that blue light does.
The blue colour is enhanced as water molecules scatter the light in all directions. The shorter wavelength blue light is scattered more than other colours.</td></tr>
</table>

(c)	Glacial silt is extremely low in mass and will remain suspended in the water. As this material is carried down the rivers and streams into the lake, it remains suspended. The material is known as glacial flour. When sunlight hits the water, the long wavelengths of red, orange, and yellow are absorbed by the water. The violets and indigos are absorbed by the silt materials. This leaves only the blue and green wavelengths. As these wavelengths penetrate the glacial water, they are scattered by the silt particles and water molecules, resulting in the blue green appearance of the lake. In deep water lakes, there is no interference from silt or particles, meaning the blue wavelengths can travel further. This results in greater scattering by water molecules, enhancing the blue colouration even further. *Note:* *Evidence may be taken from annotated diagram.* *Evidence may be taken from any section of the question.*			

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	Describes ONE Achievement level.	Describes TWO points at Achievement level.	Describes THREE points at Achievement level.	Describes FOUR points at Achievement level.	Explains ONE point at Merit level.	Explains TWO points at Merit level.	Explains fully ONE point at Excellence level, with minor errors or omissions.	Explains TWO points at Excellence level with minor errors or omissions

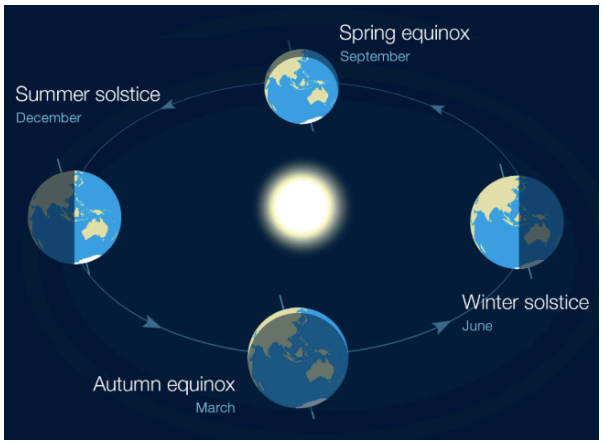
Question Two

	Expected Coverage	Achievement	Achievement with Merit	Achievement with Excellence
(a)		Describes with understanding: • THREE in each section, completed correctly • how radioactive decay of heavier elements releases heat energy • how the Earth's interior heat originates from Earth's formation • how heat is produced by friction in the mantle • how latent heat of fusion in the outer core releases heat • how heat energy can be transported through Earth's interior • how heat energy is transferred into the solid rock of the lake bed and lake water by conduction • how heat energy is transferred from the magma plume into the lake water by conduction • how heat energy is transferred throughout the lake water by convection currents.	Explains in detail: • the origin of a heat energy source and its location within the Earth's interior • how heat energy can be generated within the Earth interior by moving material • how heat energy is transferred to the lake waters via conduction and convection from the lake floor • how heat energy is transferred to lake waters from a magma plume.	Explains comprehensively: • the links between the origins of heat energy in the Earth's interior and the different layers within the interior • how the lake waters are heated from the material below the lake bed.
(b)	Approximately half of the heat energy contained within Earth's interior originates from Earth's formation and is known as primordial heat. This residual heat originates from the accretion of material through gravity during the planetesimal stage, when gaseous material condenses releasing heat energy. The other major heat contributor is the decay of radioactive isotopes. Nuclear fission of heavy elements such as Uranium-235 releases radiation and heat. This and the decay of other radioactive isotopes, including uranium-238, thorium, and potassium, occur throughout the mantle. Heat energy is also produced through friction from the movement of molten material as the cooler material moves towards the core. The movement is the result of convection currents as heat is transferred through the liquid outer core and semi-solid mantle.			

(c)	Plumes of magma can make its way up through cracks in the rock in and around the volcano's crater. As the material moves up, it not only heats the surrounding rock, but can also reach the base of the crater lake. Heat energy is conducted between the two surfaces, i.e. from the hot magma to the cold water. Heat transfer by conduction is carried out through contact between vibrating particles. The increased kinetic energy is transferred through the solid material by collisions between neighbouring particles. The heated water becomes less dense than its surrounding water and rises towards the surface, transferring heat to the surrounding water. Eventually, as the water cools, its density increases, and it sinks back down to the crater floor. *Note:* *Evidence may be taken from annotated diagram.* *Evidence may be taken from any section of the question*	 https://www.gns.cri.nz/news/science-takes-centre-stage-at-active-mount-ruapehu/			

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	Describes ONE Achievement level.	Describes TWO points at Achievement level.	Describes THREE points at Achievement level.	Describes FOUR points at Achievement level.	Explains ONE point at Merit level.	Explains TWO points at Merit level.	Explains fully ONE point at Excellence level, with minor errors or omissions.	Explains TWO points at Excellence level with minor errors or omissions

Question Three

Q	Expected Coverage	Achievement	Achievement with Merit	Achievement with Excellence
(a)	Earth's surface is heated by solar radiation / shortwave radiation from the Sun, which is absorbed on the Earth's surface and re-radiated into the atmosphere.	Describes with understanding: • heating of the Earth from shortwave radiation from the Sun • that seasons are the result of the Earth orbiting on a tilt • that in summer months the solar radiation is more direct / greater energy per sq metre on the Earth's surface • that in winter months the solar radiation is indirect / less energy per square metre on the Earth's surface • that shortwave radiation is absorbed by the Earth's surface and released as longer wave infrared • that the Earth's atmosphere is heated by absorption of longer wave (infrared) radiation • that snow has a high albedo, reflecting incoming radiation back into space • that rock / bare earth absorbs incoming solar radiation due to its dark colour/low albedo • that in winter there is less heating of the atmosphere due to poor absorption of incoming radiation.	Explains in detail: • how the Earth is heated from incoming solar radiation and emission of longer wavelength radiation • why seasonal heating occurs in terms of direct and indirect solar heating • the relationship between the dark rock and heating of the environment in the summer months • the relationship between the snow and lack of heating of the environment in the winter months.	Explains comprehensively: • the links between incoming solar radiation and seasonal heating of the Earth • the links between environment and seasonal heating for the climate differences between summer and winter in Central Otago.
(b)	The Earth orbits the Sun on an approximate 23-degree tilt. This alters the angle of the Sun's incident rays on the Earth's surface as it completes the yearly cycle.  Source: www.weatherwatch.co.nz/content/saturday-is-the-shortest-day-of-the-year-the-winter-solstice-is-at-354am In winter, the tilt of the Earth on its axis means that the Sun's incident rays are more indirect, i.e. the angle of the sunlight is less acute. The amount of solar radiation per square metre reaching the surface will be less, resulting in reduced solar radiation absorption by the surface. Reduced heat absorption by the surface means less heat energy is released to the atmosphere and cooler air temperatures.			

(c)	In the winter months, less heat is released into the atmosphere as infrared radiation. Additionally, the snow-covered mountains of Central Otago create an added albedo effect. The snow will effectively reflect the incoming solar radiation back into space, limiting atmospheric warming as less absorption occurs. In the summer months, the opposite is the case. More direct incoming solar radiation and increased daylight hours will result in an increase of the absorption of shortwave solar radiation by the Earth's surface. Additionally, this is enhanced by the dark colour of the rock, which absorbs more shortwave radiation from the Sun during the day. The rock acts as a 'night store', effectively releasing heat energy at night, thereby warming the atmosphere during the summer nights, leading to higher night temperatures. Heat energy is also released from the rock to the atmosphere by conduction, and then convection. Absorbed radiation is released back into the atmosphere as infra-red radiation, warming the surrounding atmosphere. As daylength is longer in summer, the infrared release is spread over a longer period of day. *Note:* *Evidence may be taken from annotated diagram.* *Evidence may be taken from any section of the question.*			

NØ	N1	N2	A3	A4	M5	M6	E7	E8
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Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 06	07 – 12	13 –18	19 – 24