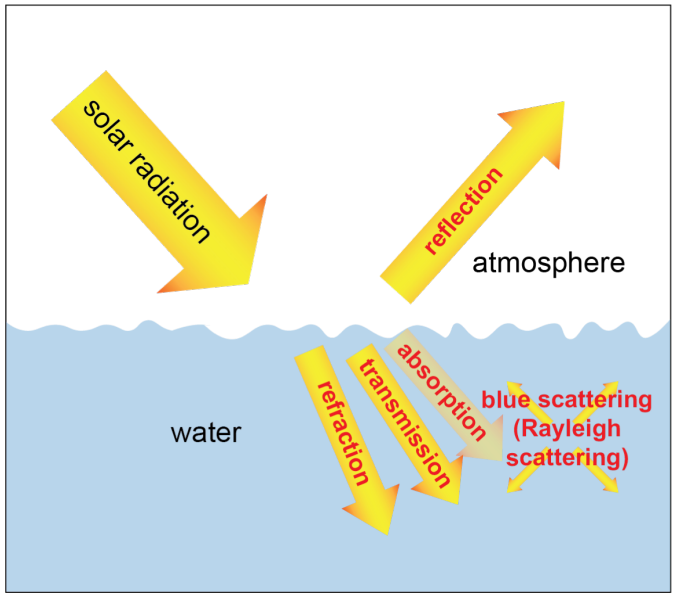
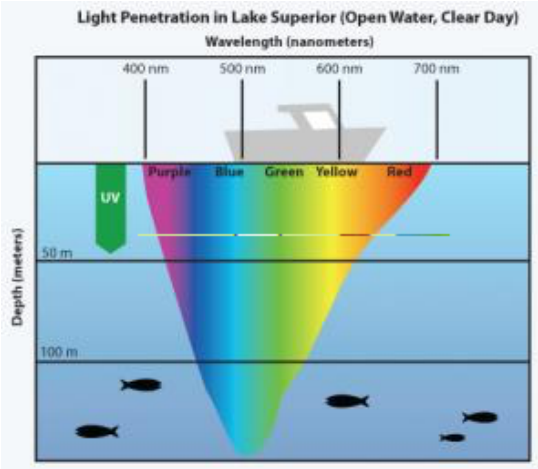
Assessment Schedule – 2021

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

Evidence Statement

Question One

	Expected Coverage	Achievement	Merit	Excellence
(a)		• Identifies 3 properties on the diagram that may occur with light at the air and water interface.		

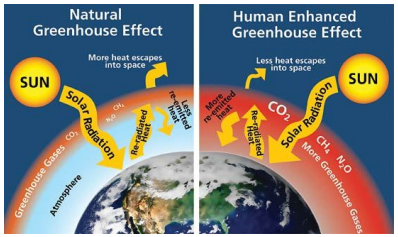
(b)	Visible spectrum is made up of various colours (wavelengths) of light, ranging from red (long wavelength) to blue / violet (short wavelength). Blue light has the shorter wavelengths (higher frequencies), while at the other end, red light has the longest wavelength (lowest frequency) in the visible spectrum. The blue end of the spectrum (the shorter wavelength) has the higher energy. When solar radiation strikes the ocean surface, it can be reflected or transmitted into the ocean. Although much of the light is reflected from the surface of the ocean, large amounts enter the ocean. Red light, having the longest wavelength, lowest frequency / lowest energy is absorbed the most once it enters the water, and does not penetrate very far.  Source: https://manoa.hawaii.edu/exploringourfluidearth/physical/ocean-depths/light-ocean	Describes with understanding: • the difference in wavelengths between the blue and red regions of the visible spectrum. • that blue light penetrates further than other colours in water. • long wavelength / red light is absorbed at shallower depths in water.	Explains in detail: • the behaviour of the shorter wavelength blue light and longer wavelength red light in terms of their transmission and absorption in water. • the relationship between the energy levels of the visible spectrum with reference to transmission or absorption in water.	Explains comprehensively: • the relationship between the differing parts of the visible spectrum as they travel through water.

(c)	**Why does the ocean look blue** When white light enters the ocean, the water molecules absorb most of the higher wavelengths of the visible spectrum – red, orange, yellow, green – within a short distance (10 m red, 100 m green), meaning these wavelengths do not penetrate far into the ocean. Blue light however, is scattered by water molecules, due to the similar size of the water molecule to the blue wavelength, making the water appear blue. Without this scattering all oceans would appear black. **Possible reasons for variations in shade** As the ocean deepens, there is greater scattering and absorption of blue light, and less light is able to reach the surface creating a deeper / darker colour. In shallower depths, more light reaches the surface of the ocean leading to ligher shades of blue. Scattering from suspended particles also plays an important role in the colour of the ocean, causing water to look greener or bluer in different areas. Variations in colour may also be due to suspended living material and minerals, which reflect light upwards. *Note:* *Evidence may be taken from annotated diagram.* *Evidence may be taken from any section of the question.*	Describes with understanding: • water appears blue due to scattering of blue light / short wavelength • increased scattering at greater depths intensifies blue colouring • less light reaches greater depths resulting in darker blue colour compared to shallow depths.	Explains in detail: • water scatters the blue wavelengths due to similarity in size between molecule and wavelength • the further the blue light travels through water, the greater the scattering, and the less light that reaches the surface, leading to deeper blue colouration.	Explains comprehensively: • blue light is scattered randomly by water molecules with a similar size to the blue wavelength, with the blue colouration intensifying as scattering increases with depth, whilst at shallow depths the lighter blue colouration is due light scattering by suspended particles or increased range of wavelengths being scattered.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response or response does not relate to the question.	Describes ONE point at the Achievement level.	Describes TWO points at the Achievement level.	Describes THREE points at the Achievement level.	Describes FOUR points at the Achievement level.	Explains ONE point at Merit level.	Explains TWO points at Merit level.	Explains comprehensively ONE point at Excellence level, or TWO with minor omissions.	Explains comprehensively TWO points at Excellence level.

Question Two

	Expected Coverage	Achievement	Merit	Excellence
(a)	A greenhouse gas is one that contributes to the greenhouse effect by absorbing infrared radiation / long wavelength radiation, e.g. carbon dioxide, methane.	Describes with understanding: • property of greenhouse gases • how energy is transferred from the Sun to the Earth • how energy is transferred from the Earth's surface to the atmosphere • rhe relationship between the radiation wavelengths from the Sun and from Earth's surface • the role greenhouse gases play in warming Earth's atmosphere • how an increase in methane and carbon dioxide increases atmospheric temperature.	Explains in detail: • how the Earth's atmosphere is heated by the Sun's radiation • how the Earth's atmosphere is heated from the surface of the Earth • how greenhouse gases act to maintain Earth's temperature by absorption or emission of longwave/infrared radiation • how additional methane and carbon dioxide will absorb and re-emit more infra radiation, hence further warming the atmosphere.	Explains comprehensively: • how the energy transmission from the Sun warms Earth's atmosphere and surface • how the melting of permafrost affects the energy processes involved in heating the Earth's atmosphere referring to greenhouse gases, energy processes, and wavelength
(b)	Shortwave radiation from the Sun is transmitted through space as electromagnetic waves. This energy transmission is the result of fusion taking place in the Sun. The majority of the shortwave solar radiation that penetrates the Earth's atmosphere is absorbed by Earth's surface. Some of the radiation is absorbed by clouds, water vapour, dust, and carbon dioxide in the atmosphere. Some is reflected back into space. Radiation absorbed by Earth's surface is emitted as long wavelength (infrared) radiation into the atmosphere. As the long-wave (infrared) radiation travels through the atmosphere, it encounters "greenhouse gas" molecules, which include water, carbon dioxide and methane. These molecules absorb the radiation and then re-emit the radiation randomly back towards Earth's surface and atmosphere, warming the atmosphere.			

(c)	When the permafrost melts, carbon dioxide and methane are released into the atmosphere, increasing the concentration of greenhouse gases. This leads to an enhanced greenhouse effect. Carbon dioxide is a long-lived greenhouse gas. Methane does not last as long in the atmosphere as carbon dioxide, but its effect as a greenhouse gas is far greater. The increase in greenhouse gases means more long wavelength (infra-red) radiation is absorbed and re-emitted either back into the atmosphere or to Earth's surface, meaning less is emitted back into space. This means the Earth's atmosphere becomes warmer.  Source: https://mrgeogwagg.files.wordpress.com/2015/06/natural-and-enhanced-greenhouse-effect.jpg?w=750 *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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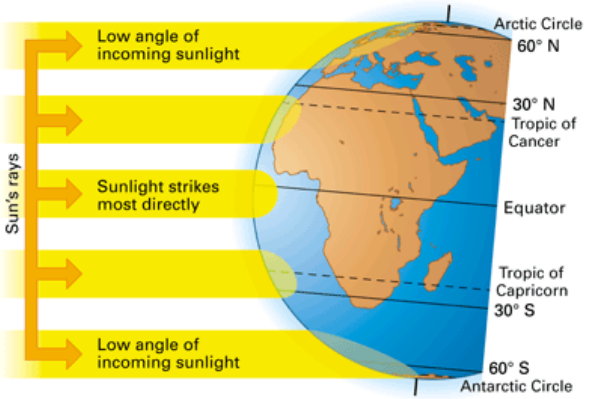
Question Three

	Expected Coverage	Achievement	Merit	Excellence
(a)	• solar radiation • landmass • wind and friction • Coriolis effect • gravity	Names three factors that influence ocean currents from: • solar radiation • landmass • wind and friction • Coriolis effect • gravity		
(b)	At the Equator the radiated heat from the Sun is more concentrated (more solar energy per surface square metre) than at higher latitudes. Consequently, oceans in the equatorial region absorb more radiant heat energy than at higher latitudes and are warmer.  Source: https://bodell.mtchs.org/OnlineBio/BIOCD/text/chapter34/concept34.2.html Equatorial easterly winds push these warm ocean waters towards the Australian landmass.	Describes with understanding: • how the Earth is warmed unevenly by the Sun • how the warm currents can originate at the Equator.	Explains in detail: • why the Sun warms the ocean more at the Equator than higher latitudes • how the East Auckland current originates and travels from the warm ocean waters of the Equator.	Explains comprehensively: • how warming at the Equator generates heat storage in the oceans, and this heat energy is carried to coastal New Zealand.

(c)	The East Auckland Current is a sub-tropical ocean current that has broken away from the East Australian current. The East Australian current originates close to the Equator. Water's high heat capacity means it has the ability to absorb large amounts of heat energy for small temperature rises. Effectively the Equatorial oceans act as a heat storage system, and the ocean currents can distribute this heat around Earth. The East Auckland current carries stored heat energy from the equator to New Zealand. As the warm ocean currents move, they are in contact with the cooler atmosphere above. The stored heat energy will move from a state of high to low energy, i.e. hot to cold. This occurs via conduction. The faster-moving water molecules collide with the slower-moving air molecules directly above the surface. The slower molecules gain energy, move faster, become less dense and establish a convection current. The convection current increase atmospheric. Warm air is carried onto the land mass by winds and weather systems. *Note:* *Evidence may be taken from annotated diagram.* *Evidence may be taken from any section of the question.*	• how the ocean can act as a heat store, (water's high heat capacity) • how the ocean influences the temperature of the atmosphere or land • how heat energy flows from warm ocean to cooler atmosphere.	• why waters in the East Auckland Current act as a heat store • why warm ocean water influences air temperatures (heat transfer).	• how the stored heat energy carried by the East Auckland surface current influences the coastal land mass via heat transfer from ocean to atmosphere.

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 – 6	7 – 12	13– 18	19 – 24