SUPERVISOR'S USE ONLY

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Draw a cross through the box (☒) if you have NOT written in this booklet

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NZQA

Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 2 Earth and Space Science 2025

91193 Demonstrate understanding of physical principles related to the Earth System

Credits: Four

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of physical principles related to the Earth System.	Demonstrate in-depth understanding of physical principles related to the Earth System.	Demonstrate comprehensive understanding of physical principles related to the Earth System.

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

You should attempt 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.

Do not write in any cross-hatched area (▨). This area will be cut off when the booklet is marked.

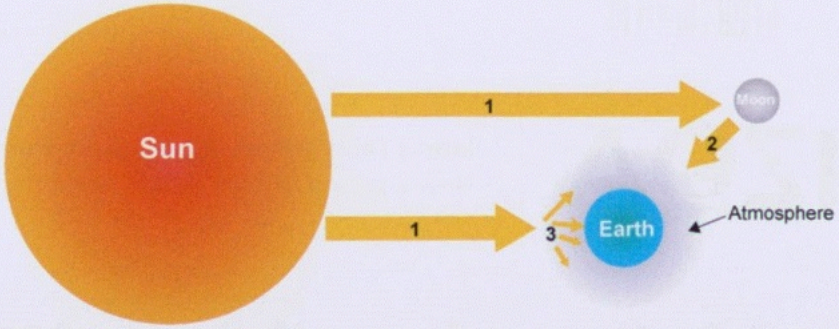
YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

Excellence

TOTAL 21

QUESTION ONE: LIGHT AND THE ATMOSPHERE

(a) Refer to the diagram below, which is not to scale, and complete the table below it by describing how visible light travels through space to the Earth's atmosphere and the Moon, for numbers 1 to 3.



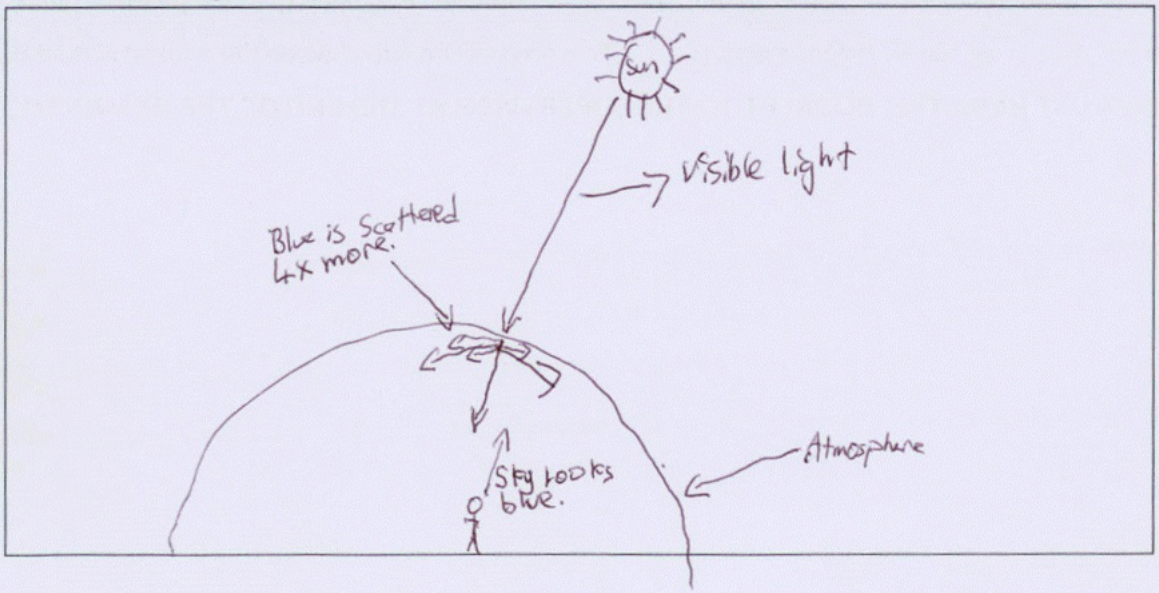
Number	Physical Process
1	Electromagnetic waves (radio, infrared, ultraviolet... etc (longwave radiation)
2	Reflects some of the suns longwave radiation back to earth.
3	Some of the waves are stopped by the earths atmosphere, and only waves such as visible light, radio, and infrared are let through. The visible light will be scattered. (longwave radiation.

(b) Explain, in detail, the properties of visible light, and why the Earth's atmosphere appears blue from the ground.

In your answer you should consider:

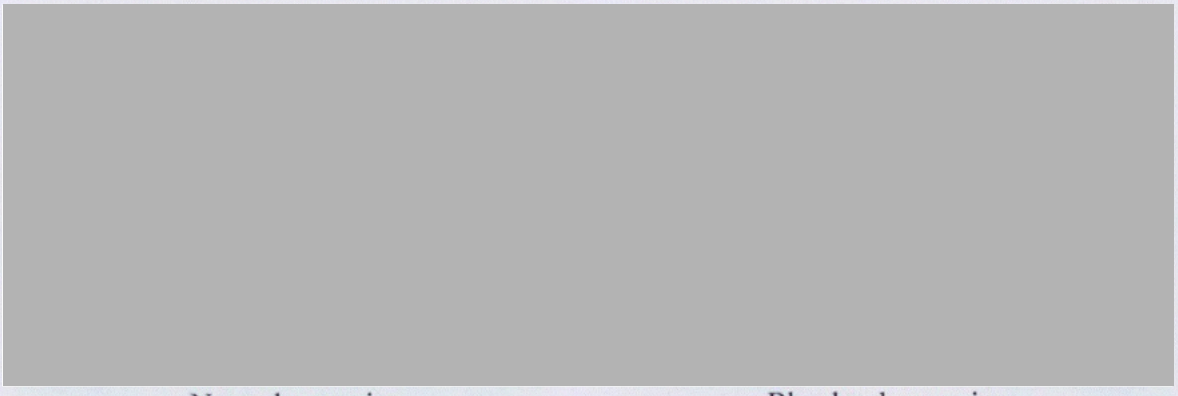
- how the colours of the visible spectrum differ from each other
- the relationship between wavelength and colour
- the relationship between wavelengths and the colour of the sky.

An annotated diagram may assist your answer.



The different colors of the visible light spectrum come to the earth in the form of electromagnetic waves. Each different color varys in terms of wavelength, frequency, and energy. Colors such as red and orange have a long wavelength, a low frequency, and therefore lower energy than colors such as blue and violet which has a short wavelength and high frequency. When the visible light spectrum enters the earths atmosphere, Rayleigh scattering occurs. Rayleigh scattering occurs higher up in the atmosphere and is when particles such as oxygen and nitrogen which are smaller than the wavelengths of visible light scatter the visible light. With Rayleigh scattering, the shorter the wavelength the more light that color will be scattered. This is why blue is scattered 4 x more than most other colors of the visible light spectrum, because it has one of the shortest wavelengths on the spectrum. So blue is scattered high up in the atmosphere while the other colors with longer wavelengths continue down where they too will be scattered. Because blue is scattered much more and much higher in the atmosphere than the other colors on the visible light spectrum, the atmosphere appears blue to our eyes.

(c) In the summer of 2022, bushfires in Australia caused the Moon to appear a blood-red colour at moonrise in the early evening.



Normal moonrise
Source: www.boffamiskell.co.nz/news-insights/moonrise-over-mount-victoria

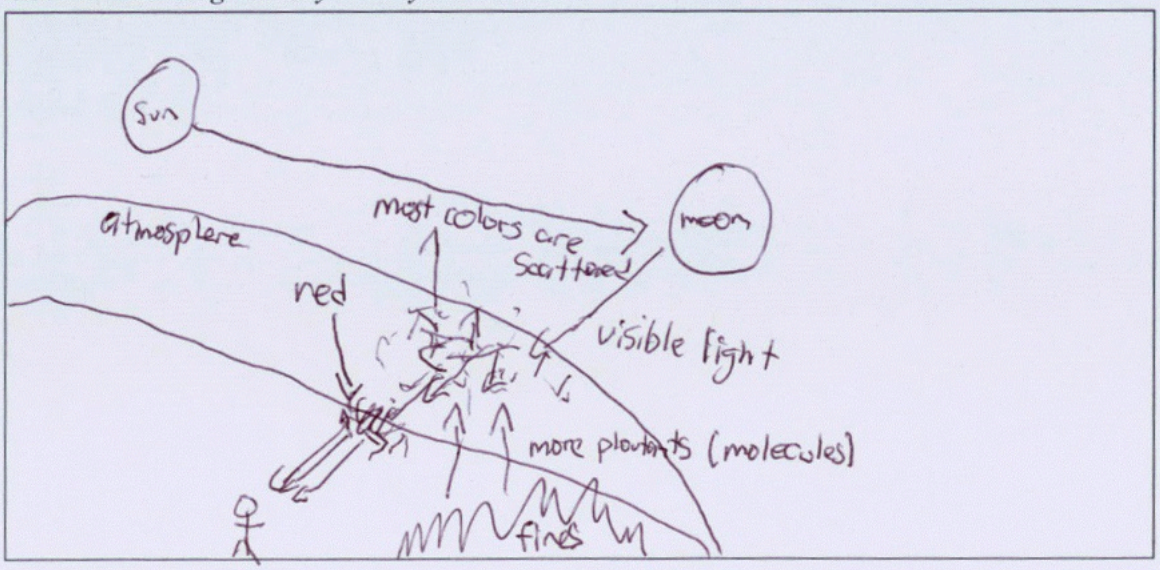
Blood-red moonrise
Source: https://inhabitat.com/how-to-watch-the-blood-moon-rising-across-north-america-tonight/

Explain, in detail, why the bushfires made the Moon appear a blood-red colour, compared to the colour of a normal moonrise.

In your answer you should consider:

- why the Moon normally appears yellow / orange at moonrise
- why the bushfires made the Moon appear blood-red.

An annotated diagram may assist your answer.



During sunset, the visible light from the Sun has to travel much further to the moon than during the day. This means that only ~~the wave~~ colors with a longer wavelength such as yellow and orange reach our eyes because they can travel further than colors such as blue which has a shorter wavelength. With bushfires lots of smoke and pollutants

are released into the lower atmosphere. This increases the amount of molecules in the atmosphere which increases scatter and decreases how far the light will travel. ~~Rayleigh Light~~ This means that the yellow and orange light reflected off the moon will be scattered much higher in the atmosphere, to the point that our eyes cannot see it anymore. Because red has a longer wavelength and higher frequency than yellow and orange, it can penetrate much deeper into the atmosphere once it is reflected off the moon. Because it can reach lower in the atmosphere, Mie scattering occurs which scatters most of the light straight forward rather than out the sides or backwards. Therefore the red visible light that is reflected off the moon travels into the lower atmosphere due to its longer wavelength, once there, Mie scattering occurs and most of the red visible light is scattered straight forward, directly into our eyes. The increased amount of molecules in the air as well as Mie Scattering is why the moon looked red in Australia after the bushfires.

QUESTION TWO: COASTAL CLIMATES

(a) Describe how the Earth's surface is heated.

The suns shortwave radiation is responsible for 99.97% of the heating of the earth. And it penetrates our atmosphere to strike the earths surface and transfers heat energy which heats up the particles of the earths surface.

(b) During the day, the average land surface temperatures are higher than the average ocean surface temperatures. At night, these reverse.

Explain, in detail, why there is a difference between the land surface temperatures and the ocean surface temperatures during the day and night.

In your answer you should consider:

- absorption and emission of radiation
- what heat capacity is.

An annotated diagram may assist your answer.

The Specific heat capasity means how much heat energy it takes to heat up a particle, or molecule or in this case the land and Ocean. Water has a much higher specific heat energy than land which means that it takes much more of the Suns Shortwave radiation to heat it up, but at night it takes much longer to lose its heat energy than land does. When the Suns Shortwave radiation strikes both the land and ocean at an equal rate,

the particles on the land begin to heat up and vibrate much faster than the particles of the ocean do. This means that while the sun heats both surfaces at an even rate, the surface tempreture of the land will be higher than the surface tempreture of the ocean because it requires much less heat energy from the sun. However at night, because water has a much higher specific heat capasity it emits the heat much slower than the land does. This is because the ocean has a much greater capasity than land to store heat and because it can absorb much more heat energy, it takes much longer to release all of it. So in conclusion, because land has a much lower specific heat capasity than water, it heats up much faster during the day, and cools down much faster during the night than the ocean does.

(c) Coastal cities, such as New Plymouth, generally experience a mild climate during the winter months.

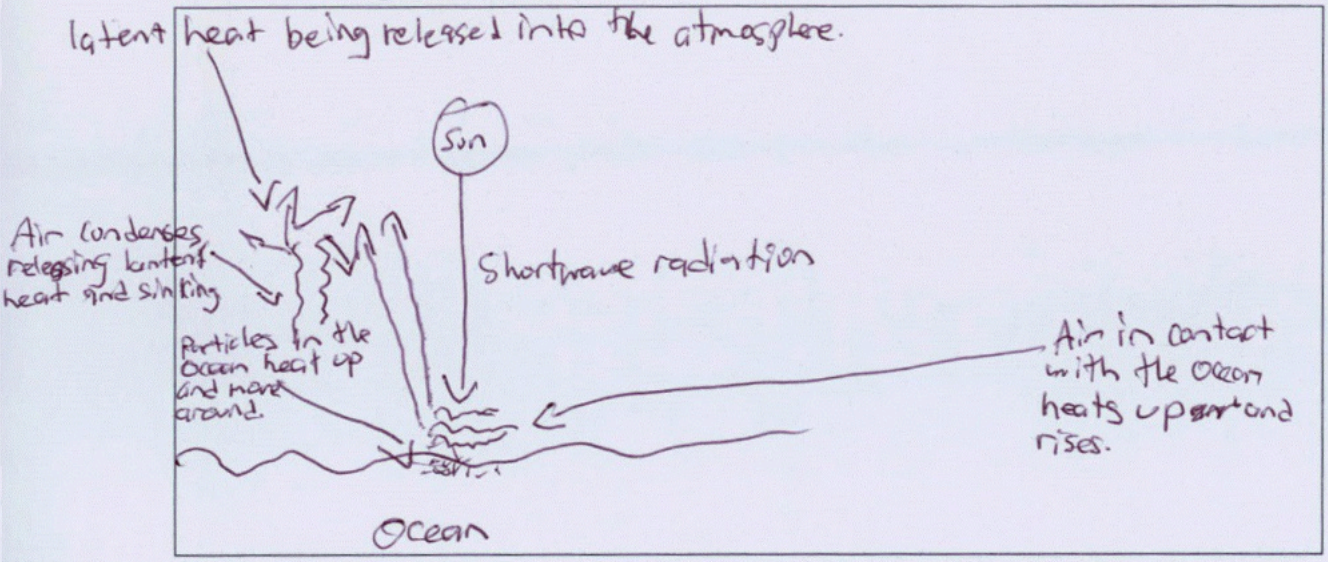
During the month of June, the average atmospheric temperature in New Plymouth is 12 °C, whilst the ocean temperature averages 15 °C.

Explain, in detail, how the ocean temperature can contribute to the mild June climate in New Plymouth.

In your answer you should consider:

- conduction, convection, and radiation
- the transfer of heat from the ocean to the atmosphere.

An annotated diagram may assist your answer.



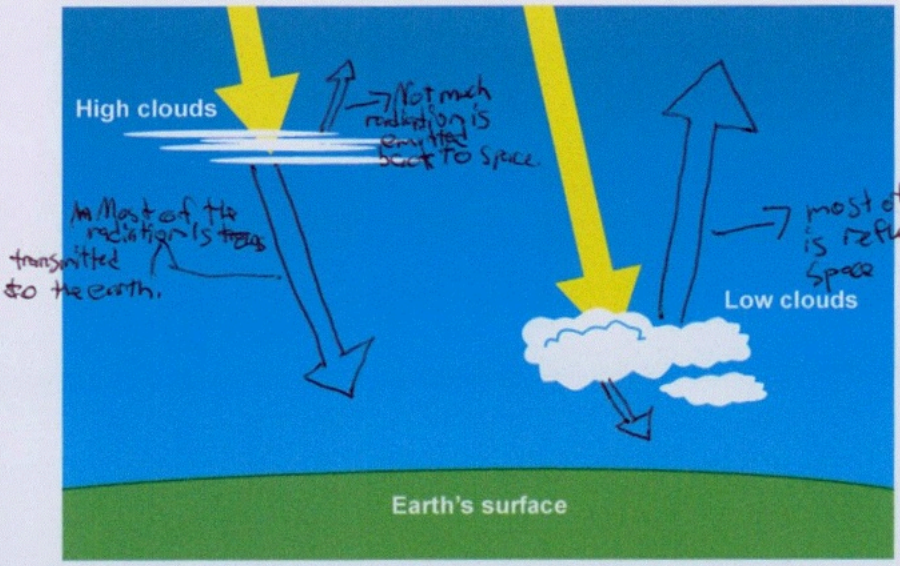
The suns shortwave radiation is primarly responsible for heating up the ocean. When the radiation strikes the ocean ~~ESCAPE~~, it causes the water molecules to heat up and move more. This heat energy is then transfered to the air in contact with the ocean surface through ~~conduct~~ Conduction. ~~or the movement~~ This is when the hot, moving molecules from the ocean bump into the air particles that are in contact with the oceans surface, which causes them to heat up and move around as well. This causes the layer of air in contact with the ocean to become less dense, and expand, which causes it to rise in a process known as convection. This air is replaced by cooler, more dense air which ~~forms~~ the comes into contact with the ocean and the ~~proce~~ process is repeated, forming convection currents.

When the hotter less dense air rises, it becomes cooler because the higher the altitude, the lower the temprature. This particles now begin to move around less forcing the air to condense and Sink back down to the earths Surface. When the air Condenses, and changes form, latent heat is released into the atmosphere which increases/maintains its temprature and ensures that the climate in New Plymouth remains mild.

QUESTION THREE: CLOUDS

Clouds affect the Earth's surface temperature. Satellites and ground observations are used to measure the effect of cloud cover.

(a) Complete the diagram below by drawing arrows to show how incoming and outgoing radiation interacts with both high- and low-level clouds.



Adapted from: https://scijinks.gov/solar-energy-and-clouds/

(b) Explain, in detail, the effect high- and low-level clouds can have on incoming solar radiation and re-radiated outgoing radiation, and how this relates to the Earth's atmospheric temperature.

In your answer you should consider:

- your answer to part (a)
- the difference between the incoming solar and re-radiated outgoing radiation
- the greenhouse effect
- the relationship to Earth's atmospheric temperature.

An annotated diagram may assist your answer.

Low Low level clouds tend to be thicker and therefore it is much harder for the suns ~~short wave~~ short wavelength radiation to penetrate it and make it to the earths surface. For low level clouds, most of because the suns radiation is either absorbed or reflected back into space, leaving not much radiation to make it to the earths surface and heat it up. The thick Low Level clouds increase the greenhouse effect and act like a blanket around the earths surface - preventing too much short wavelength radiation from reaching the earths surface and re-emiting too much of it back to space. This is why on days where there are thick, low-level clouds, the temperature is cooler as low-level clouds have a cooling effect on the earth. In contrast, high-level clouds are thinner so they transmit most of the suns short wavelength radiation down to the earths surface. Higher clouds also tend to be cooler as they are higher up in the atmosphere which means that they dont re-radiate as much outgoing radiation as lower clouds do. This means that on days with thin, high-level clouds, the earths surface recieves much more of the suns short wavelength radiation which allows it to absorb and re-emit much more than it would on days with thick low cloud and as a result, the Earths atmospheric temperature is higher because it can recycle much more of the suns heat energy rather than it being wasted into space.

Question Three continues on the next page.

(c) Climate warming is resulting in an increase in the amount of cloud cover to mountainous regions like the Himalayas.

Explain, in detail, how the change in cloud cover could increase the atmospheric temperatures and climate in this region.

In your answer you should consider:

- the change in high- and low-level cloud cover
- changes in the greenhouse effect
- atmospheric temperatures and climate in mountainous regions.

An annotated diagram may assist your answer.

Because the Himalayas is experiencing much more cloud cover, the clouds are now much thicker and denser. This means that unlike high-level cloud cover, much more of the suns short wave radiation will be absorbed by the clouds and reflected back into space. The earths surface will recieve much less heat energy from radiation which will mean that land temperatures will increase slower, and the atmosphere will become cooler. This will affect the greenhouse effect as less radiation will be re-emitted from the earths surface and so less heat energy will be trapped in the earths atmosphere.

The change in cloud cover will increase temperatures in the hinterlands because it will mean that the clouds are even higher and colder due to the cold climates of mountainas regions. This will increase the amount of shortwave radiation that is transmitted to the earths surface, because the cooler the clouds, the less energy they absorb or emit. This will increase the greenhouse effect because it will mean that more heat energy will be re-emitted from the earths surface which will mean that more heat will be trapped in the atmosphere, increasing the temprecture

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QUESTION NUMBER

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QUESTION NUMBER

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Excellence

Subject: L2 Earth & Space Science

Standard: 91193

Total score: 21

Q	Grade score	Marker commentary
One	E7	The candidate uses the space for diagrams to support their response. They clearly differentiate the visible spectrum in terms of colour, wavelength, frequency, and energy. The colour of the sky is explained in terms of Rayleigh scattering. In part c, the follow up explanation as to the Moon's colour is missing some key components in the discussion and misinterprets reason the red colour of the Moon.
Two	E7	The candidate references shortwave radiation to heating Earth's surface. A comparison is made of the heat capacity of land and ocean and how this can affect the retention of heat energy and temperature changes, day and night. The movement of heat energy from ocean to atmosphere is explained with the inclusion of latent heat, however this is misinterpreted of air changing state.
Three	E7	The influence of clouds on incoming shortwave radiation and outgoing longwave radiation is discussed. This includes the duality of low-level clouds which can prevent incoming radiation reaching Earth's surface and act to retain heat within Earth's lower atmosphere. The change in cloud cover combined with the greenhouse effect is used to justify warming in the mountains.