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NZQA

Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 2 Earth & Space Science 2023

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 (DO NOT WRITE IN THIS AREA DO NOT WRITE). 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 23

QUESTION ONE: HEAT DISTRIBUTION AROUND EARTH

Global Surface Currents

Source: https://serc.carleton.edu/eslabs/climate/4a.html

(a) Describe the role of the wind in the formation of surface ocean currents.

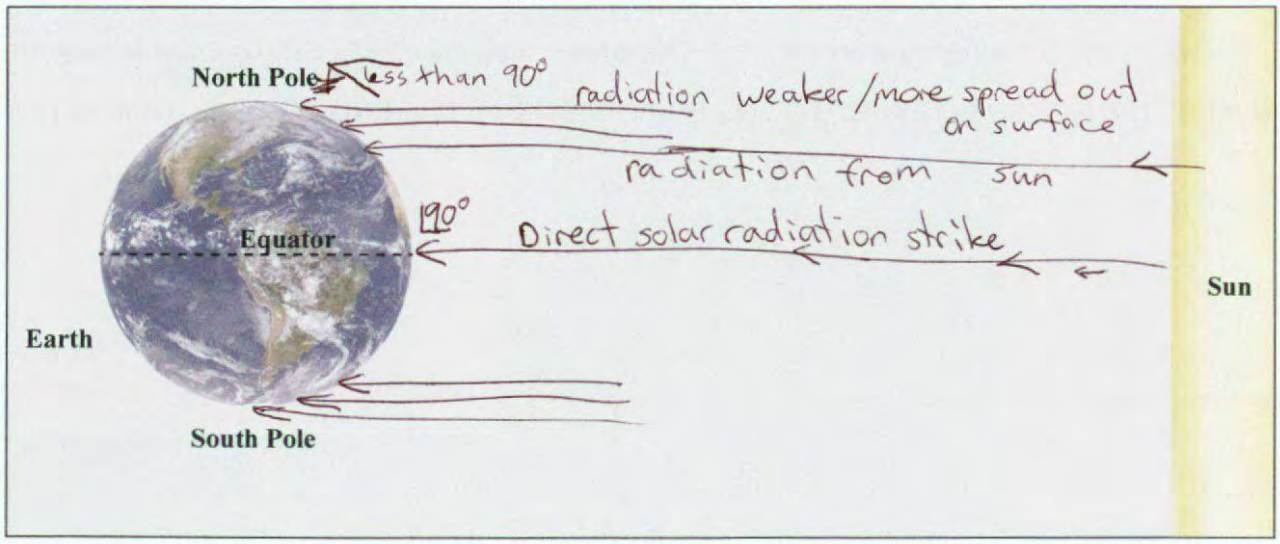
Because the earth is unevenly heated due to it's ~~the~~ spherical shape, surface temperatures are higher at equator than the poles. ~~Therefore~~ This creates wind from the poles, toward the equator. This wind creates friction with the surface of the water, causing surface currents to move generally in the direction of the wind.

(b) Explain, in detail, why ocean and land temperatures at the Equator are significantly higher than at the poles.

In your answer you should consider:

- the angle of the incoming radiation
- the curvature of the Earth.

Fully annotate the diagram below in support of your answer.



Sources: https://a-z-animals.com/blog/how-does-the-sun-produce-energy/
https://solarsystem.nasa.gov/planets/earth/overview/

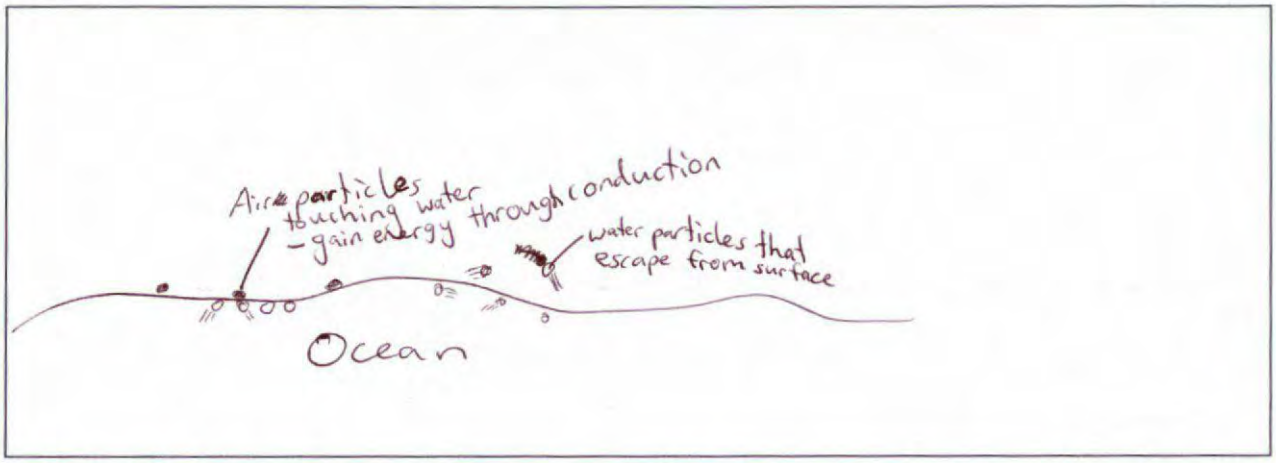
The earth is spherical, which means that incoming radiation from the sun hits the centre line (the equator) at a more direct angle of insolation than at the poles. This means that the shortwavelength solar radiation travels towards the earth at the same rate, however once it hits earth, there is more radiation per m^2 at the equator than at the poles. This is because it is hitting the poles at a lower angle, so the energy is more spread out. Therefore the same amount of energy being received by 1 square metre at the equator, is being received by a larger area at the poles. This means that the land and oceans at the poles are receiving less solar energy per m^2 than the land and oceans at the equator. Therefore the land and water particles at the equator gain more energy, meaning the move around or vibrate more (depending on the material) than those at the poles where energy concentration is less. This means that the temperature of oceans and land at the equator is significantly higher than the temperatures of oceans and land at the poles.

(c) Explain, in detail, how heat is transferred from the ocean to the atmosphere, as the ocean currents move away from the Equator towards the poles.

In your answer you should consider:

- methods of heat transfer
- the heat capacity of water.

An annotated diagram may assist your answer.



~~Ocean~~ The ocean at the ~~eq~~ equator is warmed by the intense heat from the direct solar radiation there. This means that the water particles are moving around more because they have more energy. Because ~~of the~~ water has a higher specific heat capacity than land, as it moves towards the poles, the heat transferred from the water to the atmosphere has a big effect on the ~~atmosphe~~ temperatures still being relatively warm further from the equator, because the ocean can retain heat for longer than land. This means that when currents are further away from the equator, the still have heat energy left which can spread to the ~~equator~~ atmosphere. The ocean transferrs heat to the atmosphere through both conduction and convection. Through conduction, the air particles touching the surface of the water gain energy. They come in contact with the water particles on the surface, which have high levels of heat energy. This energy is transferred to the air particles which are touching them on the surface, making the air particles which

.... continued pg 14

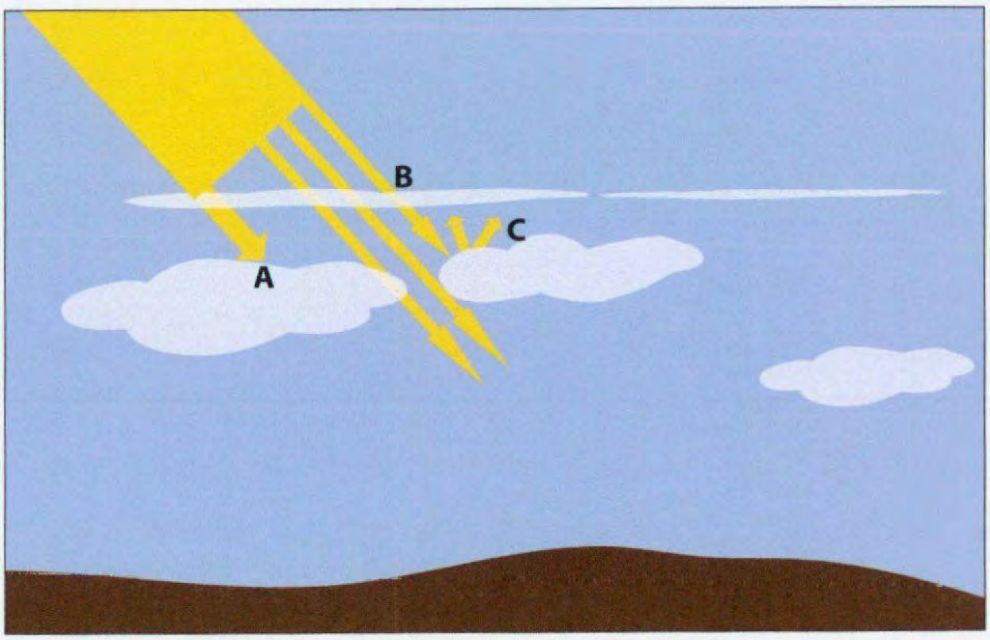
QUESTION TWO: CLOUDS

Cumulus clouds

Source: https://commons.wikimedia.org/wiki/File:Cumulus_humilis_Sch%C3%B6nwald_im_Schwarzwald_20180810.jpg

Clouds affect the amount of light that reaches the Earth's surface. Many clouds appear white in colour and can reach from the Earth's surface to heights of up to 20 km.

(a) As light travels through the atmosphere, different interactions can take place between the light waves and clouds. The letters A, B, and C represent three of those processes.



Complete the table below, labelling the processes that are taking place as light travels through the atmosphere.

A	Absorbtion – when the ~~heat~~ ~~energy~~ radiation from the sun is taken on as energy by the clouds itself
B	Transmission – when radiation travels through a cloud or any other transperent or translucent object
C	Reflection – when incoming radiation is sent back out to space by clouds.

(b) Explain, in detail, why cumulus clouds appear white from below.

In your answer you should consider:

- the visible light spectrum
- what clouds are made up of
- what happens to light as it travels through clouds.

An annotated diagram may assist your answer.

The human eye can only see wavelengths of the visable light spectrum, which goes from the color red to violet. Different sorts of particles absorb and reflect different wavelengths within this spectrum. Particles in the sky ~~absorb~~ only usually scatter blue and violet light - the shorter wavelengths, and not the longer wavelengths like red and orange. When the light enters a cloud, however, ~~it is scattered~~ the water vapor particles in the cloud are larger than the wavelengths ~~than~~ of ~~the~~ all ~~the~~ the colours of the visable light spectrum, and because ~~when~~ when all colours are scattered we see white, the clouds appear white to us. Clouds are mostly made up of condensed water vapor within the atmosphere, which is

why the large water particles scatter the light on the visable light spectrum as it travels through the cloud. While all the wavelengths of the different colours on the light spectrum are big enough for us to see, they are not bigger than the water particles in a cumulus cloud, therefore all colours are scattered, making the cloud appear white from below.

(c) Rain is often associated with dark grey cumulonimbus clouds. These clouds can contain six times more water than cumulus clouds.

Cumulonimbus clouds

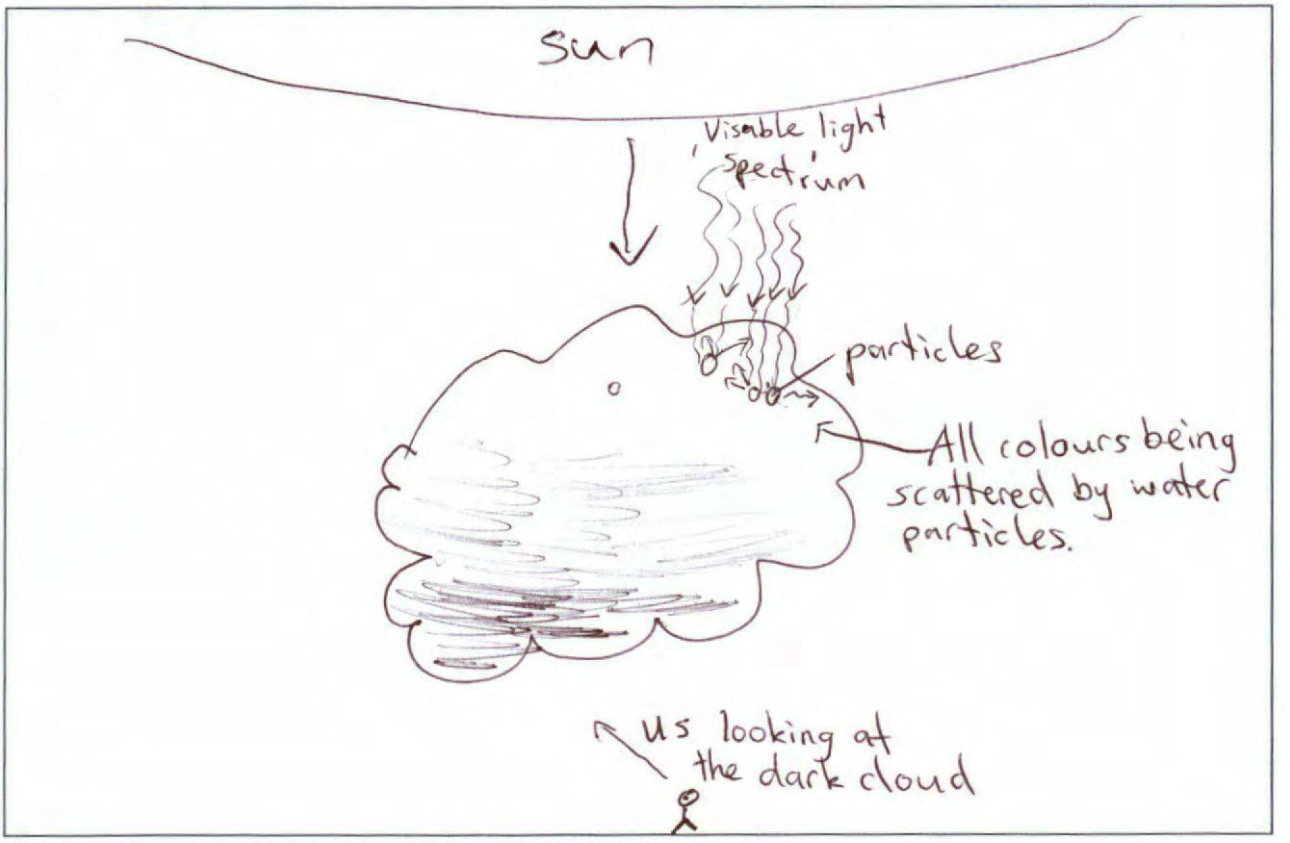
Source: https://www.weatherwatch.co.nz/content/how-to-spot-a-thunderstorm-in-the-making

Explain, in detail, why cumulonimbus clouds usually appear dark.

In your answer you should consider:

- what happens to light as it travels through the cloud
- why the clouds appear dark grey or black when viewed from the Earth's surface.

An annotated diagram may assist your answer.



When we veiw a Cumulonibus cloud from earth, we see the lowere side of it obviously, and because of gravity, the heaviest, densest part of the cloud is lower than the lighter, less dense areas of water vapor. The light travels through the cloud and, much like with the cumulus cloud, all the colors of the visable light spectrum are scattered, due to the large size of water particles in relation to the wavelength size of the visable light spectrum. However, because there is six times more water in a Cumulonibus cloud than in a Cumulus cloud, the light is scattered more before it gets through the cloud, meaning that there are more particles in the cloud to scatter the light. Therefore once the light gets through to the lower side of the cloud which we see from earth, there is not much light left because it has all been scattered as it passes through the thick cloud. This lack of light is what creates the darkness that we see when looking at a Cumulonimbus cloud from Earth's surface.

QUESTION THREE: VOLCANIC ERUPTIONS AND GREENHOUSE GASES

Source: www.climate.gov/news-features/feed/eruption-provides-rare-opportunity-study-volcanic-gas-and-ash-injected-0

Volcanoes release greenhouse gases, such as carbon dioxide and water vapour, into the atmosphere when they erupt.

(a) Describe what is meant by a greenhouse gas.

A greenhouse gas is a gas that is able to somewhat allow the shortwave radiation from the sun to penitrate through it, but absorbs and traps longwave radiation that has been re emitted from earth, therefore having a warming effect on earth and earths atmosphere.

(b) Explain, in detail, the role of greenhouse gases in regulating the Earth's temperature.

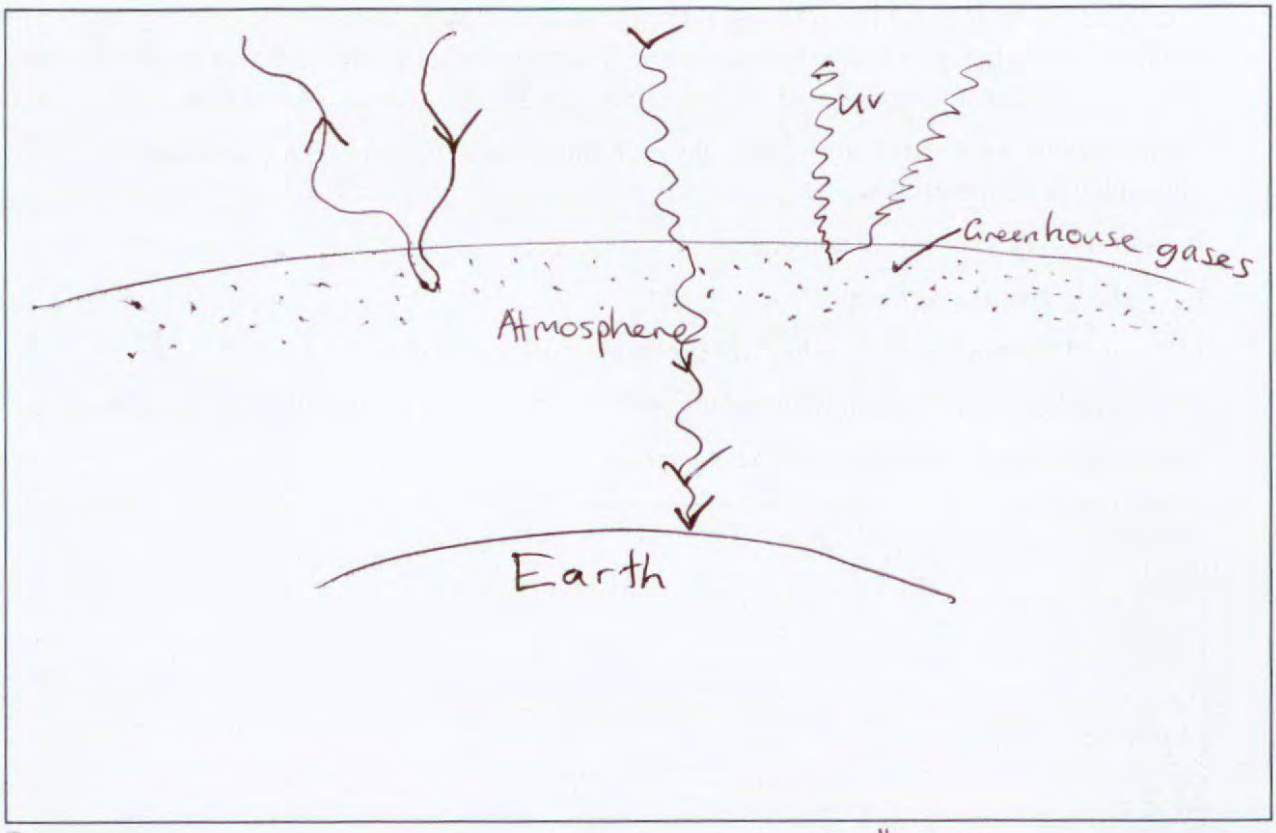
In your answer you should consider:

- the wavelength of incoming radiation
- what happens to incoming radiation once it reaches the Earth's surface
- the natural greenhouse effect.

An annotated diagram may assist your answer.

Greenhouse gases, such as water vapor and carbon dioxide in earth's atmosphere act as a 'blanket' around earth. While they do reduce the amount of solar radiation we receive, they mostly actually have a warming effect on Earth. Without greenhouse gases, earth would loose most of it's heat energy to space, and would be an average of -20°C.

Solar radiation comes to earth in many different wavelengths, but some, such as Ultra Violet, are mostly ~~scattered~~ reflected by the greenhouse gases, back to space by the time the radiation



reaches earth. Other longer wavelengths from the sun are absorbed by greenhouse gases higher in the atmosphere, and the energy is then re-emitted back to space from there. So the ~~gases~~ greenhouse gases somewhat reduce the amount of solar energy we receive, which is why ~~the~~ earth doesn't get extremely hot. However, there is still shortwavelength radiation which does transmit through the greenhouse gases and clouds, and this is the solar radiation that gives earth energy, which is converted into heat energy in the earth. This ~~convect~~ conversion happens because the particles on earth's surface receive the energy from the solar shortwave radiation, and this makes them vibrate more, so the bump into each other. The layer of air particles directly touching the earth's surface also get touched by the vibrating earth particles (this includes water surfaces too) so the air particles gain some heat energy too. Because air is technically a fleid, the heat transfers from this bottom layer of air, through the atmosphere by convection. The ~~heated~~ heated particles have more energy so....

Question Three continues on the next page.

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(c) The 2022 volcanic eruption in Tonga released approximately 45 million tonnes of water vapour into the atmosphere, and increased atmospheric carbon dioxide concentrations near the volcano by the equivalent amount of a whole year's carbon dioxide emissions on Earth.

Compare the likely effects of increased water vapour and carbon dioxide emissions on atmospheric temperatures.

In your answer you should consider:

- the greenhouse effect
- the differences between the two greenhouse gases involved
- whether the effects on temperature will be long- or short-term for each greenhouse gas.

An annotated diagram may assist your answer.

The extreme and sudden increase of water and CO^2 into the atmosphere from this volcano could have both longterm and short-term effects. The increase in water could have ~~the~~ short-term, heat-trapping greenhouse effects. This is because while short-wave radiation from the sun can still transmit through the greenhouse gases such as water vapor an CO^2, the long wave radiation re-emitted from earth when earth heats up, is trapped and absorbed, ~~as~~ ~~reflected~~ by the greenhouse gases. However this would

potentially only be short-term because the water will eventually drop into the ocean again as precipitation, once it loses it's heat energy, making the particles condense, become heavy and then drop. Once out of the atmosphere, the water particles will not have a greenhouse effect. However Carbon dioxide does not precipitate the same as water vapor, therefore the extreme and sudden increase in CO^2 in the atmosphere could have long-term warming effects on the earth. As a greenhouse gas, CO^2 transmits the shortwave radiation from the sun, but absorbs the longwave radiation re-emitted from earth. Therefore an increase of it could lead to an acceleration long term in earth's temperature rise. This could mean that we see more frequent extreme weather events such as floods because if the ocean increases in heat, it will rise due to thermal expansion. So this one volcano eruption could lead to negative effects and events both short-term and long term. Eventually, because water follows a cycle from evaporation to precipitation, the water vapor added to the atmosphere from the volcano is going to have to drop. So we could, in the short-term, see higher rainfall, floods and other extreme whether events as this water precipitates back to earth's surface.

Extra space if required.
Write the question number(s) if applicable.

QUESTION NUMBER

3b they move around more, and bump into each other, which both spreads energy to the other particles, and makes them more spaced apart. Therefore the warmer air is less dense, so it rises due to bouyancy. However the Greenhouse gases prevent all the heat from ~~escape~~ being lost to space because they just absorb the heat, which comes in ~~long wavelength~~ long wavelengths from the earth, and re-emit it back down to earth. Therefore the natural greenhouse ~~effect~~ of greenhouse gases is that they ~~absorb~~ allow solar radiation to reach earth, but trap outgoing longwave radiation from earth, which gradually warms the atmosphere, and eventually earth itself.

1c ...now have more heat energy, move around more, so they bump into each other which makes them more spaced out. This means that the warmer air that has gained heat energy from the ~~ocean~~ touching the ocean particles on the surface, is now less dense and rises due to bouyancy, and is replaced with cooler air ~~whic~~ which then warms with the same process. This creates a convection current in the air, and is how heat is transferred to the atmosphere from the ocean. The other way it is transferred is through just convection. ~~The~~ It ~~pe~~ happens when the particles in the water move around so much that some fly out of the water and become water vapor in the atmosphere. Because they are moving around so ~~much~~ much compared to the cooler air particles, they rise, due to ~~bouyancy~~ bouyancy because the water

Extra space if required.
Write the question number(s) if applicable.

QUESTION NUMBER

vapor is less dense. Their heat is then absorbed by other particles in the atmosphere.

Extra space if required.
Write the question number(s) if applicable.

QUESTION NUMBER

Excellence

Subject: Earth & Space Science

Standard: 91193

Total score: 23

Q	Grade score	Marker commentary
One	E8	Full discussion of the heating effect of incoming solar radiation linked to the curvature of the Earth. Annotated diagrams are used. Heat transfer processes are linked to explain the transfer of heat from the oceans to the atmosphere.
Two	E8	The candidate accounts for the white colour of clouds in terms of scattering of all wavelengths of visible light by water droplets. The sizes are linked. Additional use of an annotated diagram discusses the reason for the appearance of cumulonimbus clouds in terms of scattering and cloud density.
Three	E7	The influence of greenhouse gases on climate in terms of the behaviour of incoming and outgoing radiation is explained. A comparison of effects of the greenhouse gases, water and carbon dioxide is linked to their respective ability to remain in the atmosphere.