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Level 2 Earth and Space Science 2022

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 may be cut off when the booklet is marked.

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

Excellence

TOTAL 22

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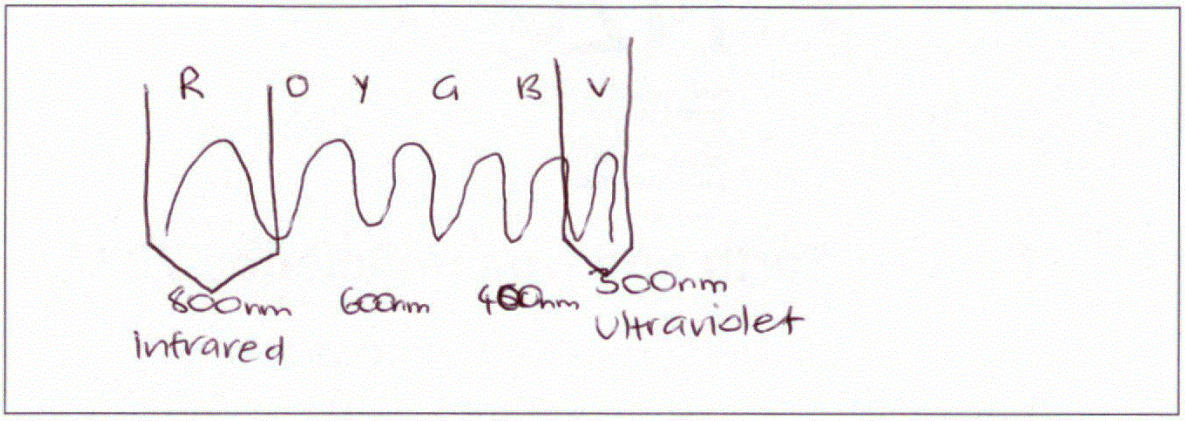
QUESTION ONE: VISIBLE LIGHT IN THE ATMOSPHERE

Visible light travels through space to Earth from the Sun.

(a) Describe the visible light spectrum in terms of wavelength, frequency and colour.
An annotated diagram may assist your answer.



The visible light spectrum is the only part of the electromagnetic spectrum that the human eye can detect. It ranges from red (infrared), orange, yellow, green, blue and violet (ultraviolet).

Red visible light has the longest wavelength, of around 800nm and the lowest frequency and energy.

Violet visible light has the shortest wavelength, of about 300nm, and the highest frequency and energy.

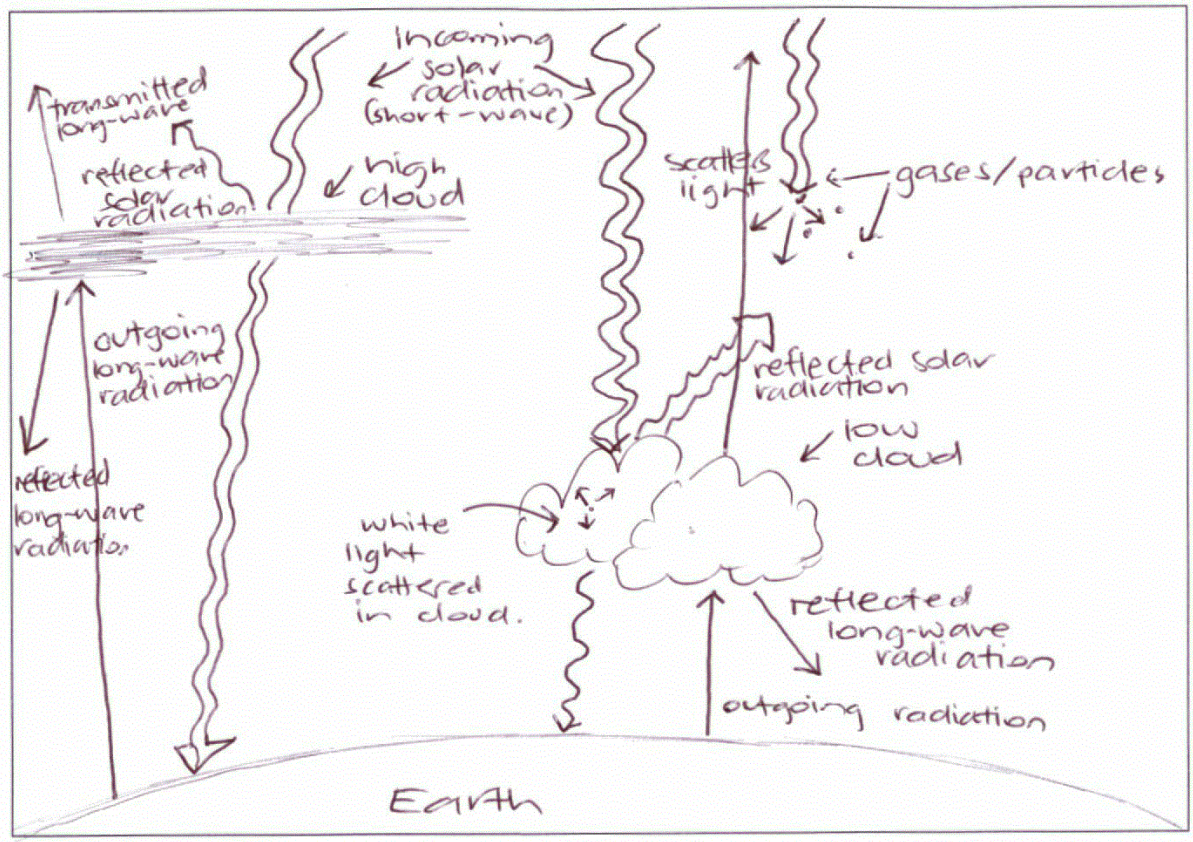
When all the colours in the visible light spectrum are combined, it creates white light.

(b) Explain, in detail, the possible behaviour of visible light as it travels through the atmosphere during the middle of the day.

In your answer, you may wish to consider:

- transmission, absorption, reflection, and scattering
- high/low clouds ~ cirrus/cumulus ~ mie
- gases and particles in the atmosphere. ~ Rayleigh

An annotated diagram may assist your answer.



Visible light is radiated to Earth from the sun. Visible light is part of the electromagnetic spectrum. There are four things that can happen to visible light as it travels through Earth's atmosphere: transmission, absorption reflection and scattering. Transmission is when the visible light goes through a transparent or translucent object and continues on the other side. Clouds are an example of something that

There is more space for your answer to this question on the following page.

transmits visible light. Whether the cloud is a high cloud (e.g. cirrus) or a low cloud (e.g. cumulus) has an effect on how well the visible light is transmitted. High clouds will transmit most of the visible light and reflect very little. Low clouds will reflect a lot of visible light and transmit very little. Some visible light will be scattered via Mie scattering, in the cloud, to make the cloud appear white. The water vapour particles in the cloud (about the same size as incoming visible light wavelength) will scatter the colours in the visible light spectrum equally, making the clouds appear white. Rayleigh scattering is responsible for the sky's colour on a sunny day. Rayleigh scattering increases as the wavelength size decreases, which is why blue light is scattered the most during midday. As the visible light travels through the atmosphere, it will collide with gases and particles in the atmosphere which will scatter the blue light in random directions, making the sky appear blue.
If the visible light is not reflected or scattered on its path through the atmosphere it will be absorbed (or reflected) when it hits the Earth's surface. It will then be re-radiated back into the atmosphere in the form of [illegible] radiation.

Question One continues on page 6.

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The examination continues on the following page.

(c) The picture below shows a typical sunset over Auckland city.

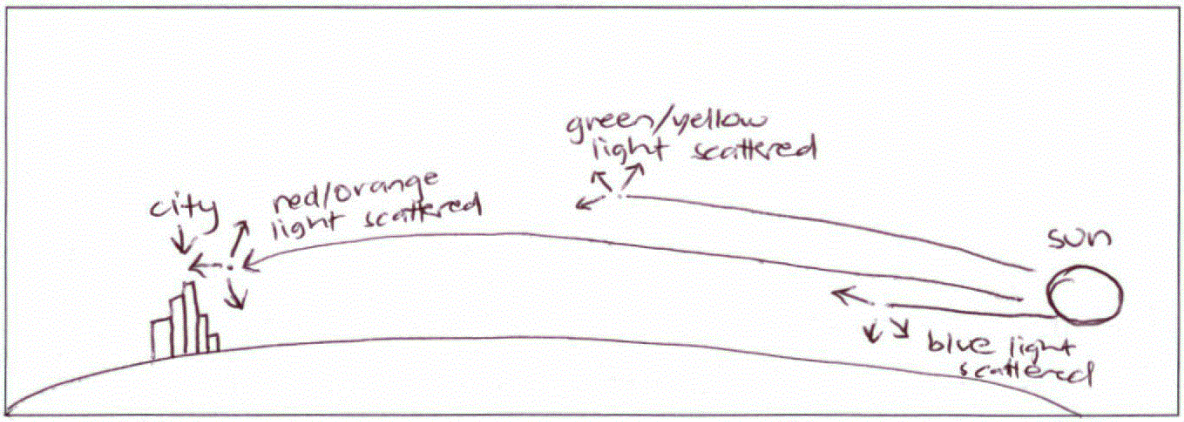
https://www.heletranz.co.nz/red-sunset-auckland/

Explain why visible light from the Sun is seen as a red colour at sunset.

In your answer, you should consider:

- the angle of the Sun relative to the Earth's surface at sunset
- the colours and relative wavelengths of visible light
- what scattering of light depends on.

An annotated diagram may assist your answer.



At sunset, the sun is much lower in the sky, so its angle relative to Earth's surface means the path of visible light radiated from the sun is much longer, (it must travel further in the sky). As the visible light travels through the

Rayleigh scattering increases as the ~~particle~~ wave-length size decreases, which accounts for the fact that the blue/violet light is scattered first. Red (infrared) visible light has the longest wavelength ↑ 800nm and lowest frequency, blue/violet light (ultraviolet) has the shortest wavelengths, 300nm, and the highest frequency. This is why blue/violet light is scattered first.

As the visible light, from the sun, travels through the atmosphere, a large amount of blue/violet light is scattered leaving a higher proportion of red/orange visible light. As the red/orange light encounters particles in the atmosphere it is scattered and the red/orange colour becomes visible to the human eye, lighting up clouds and the sky.

The scattering of light is dependant on the number of particles ~~and~~ and gases in the atmosphere. The visible light collides with the particles and is scattered in random directions, giving the sky (clouds) the colour apparant to the human eye.

If the atmosphere is polluted (e.g. aerosol gases) the scattering of green/yellow visible light will occur on the ^ visible light's path through the atmosphere, leaving an even higher proportion of red/orange light to be scattered at sunset.

QUESTION TWO: EARTH'S CLIMATE REGULATOR:

Earth's climate is partially regulated by the Antarctic and Arctic ice sheets. This is due to the ice sheet's high reflective ability (high albedo).

(a) Complete the table below to compare how well solar radiation is reflected and absorbed by ice and water. You should use the words (descriptors) GOOD or POOR.

	Reflection	Absorption
Ice	GOOD	POOR
Water	POOR	GOOD

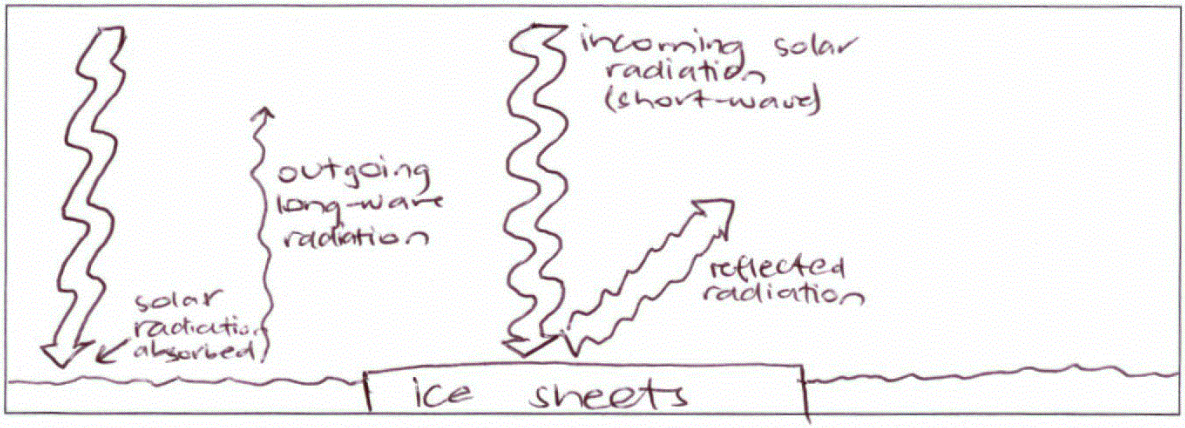
(b) Explain, in detail, how the high reflective ability (high albedo) of ice sheets regulates the temperature of the atmosphere.

In your answer, you should consider:

- how the Earth's surface is heated by the Sun
- behaviour of solar radiation on ice.

greenhouse warming
↓ ice ↑ temp

An annotated diagram may assist your answer.



The Earth's surface is heated by the Sun via solar radiation. The heat from the Sun (generated from nuclear fusion in the sun) travels via short-wave radiation to Earth. If the solar radiation is not absorbed or reflected by ~~things~~ objects while it passes through the atmosphere, it will hit Earth and be absorbed or reflected depending on the surface it hits.

Ice works as a temperature regulator for Earth. Due to it's high albedo affect, the majority of incoming solar radiation is reflected away from Earth, when it collides into icesheets. The low absorption rate of ice means that little heat is gained from incoming radiation that hits ice. * The sea, on the other hand, is much more likely to absorb the incoming solar radiation and reflect very little ^incoming solar radiation. The ocean (due to its darker colour) absorbs more incoming solar radiation causing it to increase in heat. The heated ocean then emits long-wave radiation back into the atmosphere, heating the atmosphere. Both ice and oceans are needed to keep a steady temperature on Earth. As the ice caps melt (due to global warming), more heat will be absorbed by the ocean and less incoming solar radiation will be reflected back into space. This will cause the ocean to heat up even more, contributing to further melting of the ice caps. The ocean would then emit long-wave radiation, further warming the atmosphere. It is essential that the icesheets are preserved in order to maintain a regulated temperature on Earth. (* Ice is a

(c) Scientists monitoring Earth's climate have a major concern over the gradual reduction in the size of the Arctic ice sheet. The image below shows the change in the extent of the ice sheet at the end of the Arctic summer over the last 40 years.

Source: www.sciencealert.com/arctic-sea-ice-could-vanish-in-the-summer-even-before-2050-new-simulations-predict

Explain, in detail, the effect on the Earth's climate of any reduction in the Arctic ice sheet.

In your answer, you should consider:

- changes in the reflective ability of the Arctic
- changes in the ice sheet's extent over the 40 years
- the role of the heat capacity of water.

The ice sheet in the Arctic is essential in maintaining a regulated temperature on Earth. As the ice sheet melts, the reflective ability of the Artic decreases. The high albedo of ice allows it to reflect the majority of incoming solar radiation, away from Earth back into the atmosphere. This prevents the solar radiation from being absorbed and heating up the Earth.

There have been significant changes in the ice sheet's extent over the past 40 years which will have led to much more absorbtion of

incoming solar radiation. The icesheet appears to have almost halved in size meaning the reflective ability of the Artic would also have dropped by a significant amount.
The icesheet that has melted has left behind ocean which will absorb much more incoming solar radiation than the ice. Due to the dark colour of water, the incoming solar radiation will be absorbed and will heat up the ocean. As the icesheet melts and more solar radiation is absorbed, the ocean's temperature will increase. There will also be more outgoing long-wave radiation from the ocean, further warming the atmosphere and reducing the size of the icesheet (melting due to increased heat).
The specific heat capcity of water is much higher than that of the land around. Specific heat capicity refers to how much radiation is needed to raise 1 kg of substance by 1°C.
Although the sea heats slower than the land, once it has gained heat, it is much slower to lose its heat than land. This means that the sea around the icesheet that has gained heat will be slow to lose its heat, negatively impacting the size of the icesheet (melting).

QUESTION THREE: NGAWHA HOT SPRINGS

Located near Kaikohe, in the Far North of New Zealand, Ngawha Springs is a geothermal hot pool complex with long historical and cultural links to local Māori.

www.ngawha.nz/uploads/3/2/1/2/32123857/image-file-formats-1-8_orig.jpeg

(a) The source of heat for the hot pools is the Earth's core.

Describe the origins of the heat in the Earth's core.

Heat in the Earth's core originates from 4 things; residual heat, which is left over from the Earths formation, latent heat (of fusion), which is when the Earth cools from the outside in, the liquid outer core begins changing state, releasing huge amounts of latent heat. Gravitational heat is caused from dense material inside Earth being carried in towards the centre, creating huge amounts of friction.

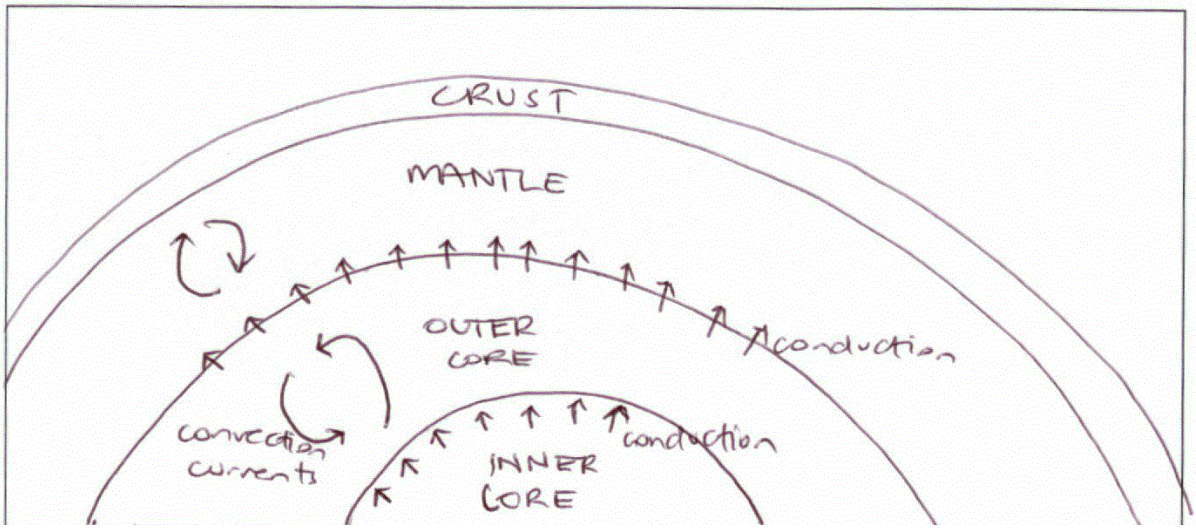
CONT PG 16..

(b) Explain, in detail, how heat energy from the Earth's core is transferred to the mantle.

In your answer, you should consider:

- methods by which heat is transferred
- the inner core, the outer core, the lower and upper mantle
- how heat is transferred through the layers.

An annotated diagram may assist your answer.



Heat from the Earth's inner core conducts out towards ~~the~~ the outer core. As the ~~liquid~~ solid ~~outer~~ inner core begins to heat, the particles begin to move faster, due to gained kinetic energy. As they move faster they collide into the cooler, less energy, particles in the bottom of the liquid outer core. This causes the particles of the liquid outer core to gain heat and kinetic energy. As the particles in the outer core gain kinetic energy, they will move further apart and cause the liquid to become less dense. The less dense liquid then rises (due to buoancy forces) and the dense, cooler liquid at the top of the outer core, sinks, to replace the rising liquid. This convection current (convective cell) in the outer core, then heats the bottom layer of the mantle via conduction. The mantle then begins to heat up. The mantle is refered to as plastic, due to the way it becomes flexible under the pressure of heat. As the bottom of the mantle heats, the substance becomes less dense and rises, creating a convection current in the mantle. Heat from the mantle is then conducted to the crust - heating it.

Question Three continues on the following page

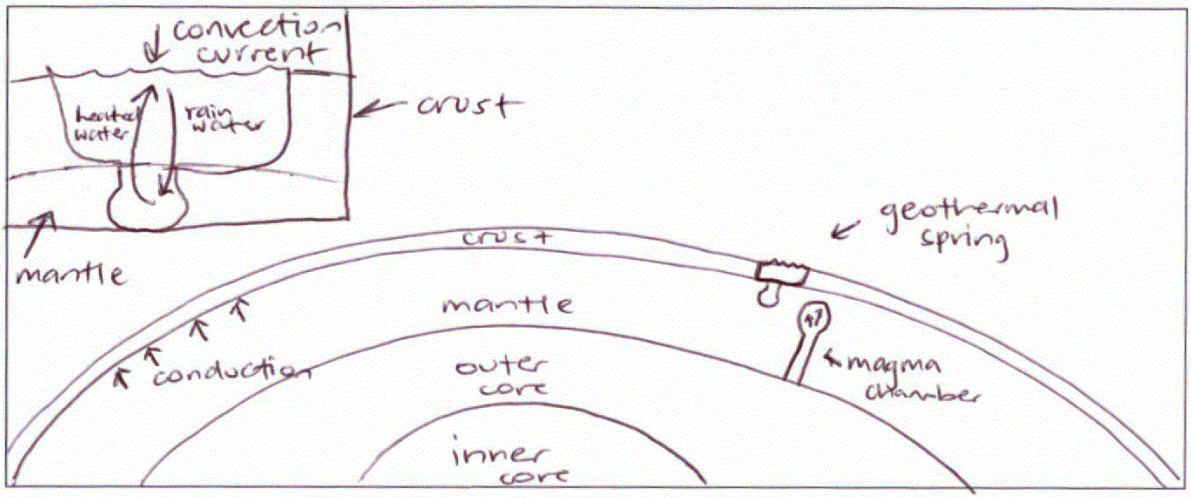
(c) The water source for geothermal springs is rainwater or groundwater that seeps into the crust through cracks.

Explain, in detail, how the water in the geothermal springs becomes heated.

In your answer, you should consider:

- the source of the heat in the crust
- how the heat is transferred from the mantle to the crust
- the role of heat transfer in the water reaching the surface.

An annotated diagram may assist your answer.



The Earth's crust is heated from the mantle. The heat from the inner core is transferred, by conduction, to the liquid outer core, convection then heats the outer core, conduction begins to heat the bottom of the mantle, convection currents then heat the mantle and conduction carries heat from the mantle to the crust. The particles in the heated mantle are vibrating fast due to kinetic energy. The fast moving (high energy) particles then collide with the cooler (low energy) particles in the crust. As they collide, heat is transferred from the warmed particle to the cooler one and the crust

gets heated, through this continued process.
When rainwater or groundwater percolates into the crust through cracks, in geothermal areas, it becomes heated which is how geothermal springs are made.
As the groundwater flows down through cracks in the lithosphere, it is heated by conduction, from the mantle. Sometimes the water will come near a magma chamber which further heats it.
As descending groundwater flows into the underground pool, it will sink as it is cooler (hence denser) than the heated water. the ~~water~~ heated water will rise due to being ~~denser~~ less dense, and will be replaced by the sinking rainwater. This creates a convection current in the geothermal hotsprings.
The warmed water (by the mantle) will gain heat and kinetic energy causing the particles to move further apart and the liquid becomes less dense. This causes it to rise and the denser, sinking water replaces it.
Convection currents bring the heated water to the surface, creating hotsprings and geothermal pools.

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

QUESTION NUMBER

CONT FROM PG 12
Q 3 (a)

Friction releases heat into the Earth's core. Decay of radioactive isotopes also contributes to the heat in Earth's core (50% of heat comes from decay of isotopes). Radio active isotopes have unequal amounts of neutrons in their nucleas; as they undergo nuclear fission, the nucleas breaks into smaller more stable elements. This releases heat into the core of Earth.

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Standard	91193	Display ID	Script: 6186962. NSN 139092497	**Total score**	22 = E
Q	**Grade score**	**Annotation**			
1	E7	The candidate links different wavelengths to the colours of the visible spectrum. The diagram and commentary give a comprehensive explanation of the interactions of visible light with gases and clouds in the atmosphere, both during the middle of the day and evening. Rayleigh scattering is a feature of the explanation given with regard to the sunset context, as is also the reflection of red light caused cloud cover.			
2	E7	The candidate gives a reasoned explanation of the behaviour of incoming solar radiation on land water and ice. The interaction of water/land and atmosphere is commented on, as is also the result of ocean warming on the ice cap due to ice loss. The discussion is further extended with regard to water's high absorption and heat capacity which negatively impacts on the Arctic ice cap.			
3	E8	The candidate gives a comprehensive discussion of the heat transfer processes from the inner core to the crust, and the groundwater that has filtrated through Earth's crust to create the hot springs.			