Assessment Schedule – 2016

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

Evidence Statement

Question One

Expected Coverage	Achievement	Merit	Excellence
Blue light is the shortest wavelength (higher frequency) of visible light, red is the longest (lower frequency). Blue light is seen furthest in water because it has the shortest wavelength in visible light. It also 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 the **most** and hence doesn't penetrate to the depth blue light does. Red light is the **lowest** energy wavelength of visible light. Water molecules affect the amount of scattering and absorption of visible light, but not to the same extent for the varying wavelengths that make up the visible spectrum. The shorter wavelengths are scattered the most since wavelength size is similar to molecular size. The colour of the ocean is independent of the colour of the sky.	Describes: • wavelength of blue light shorter than red or vice versa OR blue light is of higher frequency or vice versa • red light scattered least / absorbed the most (or first) or vice versa • blue wavelengths are scattered in water • blue wavelengths have more energy and can penetrate further or vice versa for red light. • water molecules (particles) scatter light. • (most) visible light is reflected at the surface of the ocean.	Explains in detail: • blue light shorter wavelength / higher energy; therefore scatters most / absorbed least in water • red light longest wavelength / lower energy; therefore absorbed most in water • water selectively scatters / absorbs wavelengths of visible light. • blue wavelength scattering due to wavelength size relative to water molecules.	Explains comprehensively: • how blue light has higher energy / shorter wavelength than red therefore absorbed the least by water and so penetrates the most and is seen to greater depths.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	Partial description of difference between blue and red light.	ONE point.	TWO points.	THREE points.	Explains ONE point in detail	Explains TWO points in detail.	Point explained comprehensively with minor omission.	Point comprehensively explained.

Question Two

Expected Coverage	Achievement	Merit	Excellence
Nuclear fission occurs in the Earth's inner core due to its heavy elements being unstable (radioactive isotopes) which produces 50% or more of the heat energy that heats the internal Earth. Other internal heat energy sources are from Earth's formation, friction due to the downward movement of fluids (Gravitation heat energy) and latent heat due to phase change. From the **inner core,** the heat is transferred to the outer core by **conduction,** as the inner core is solid. Heat transfer through contact between vibrating particles is defined as conduction. Conduction occurs mainly in solids. The **outer core** is liquid – heat transfer through the outer core is by **convection**. Convection is heat transfer caused by the less dense material moving upward and being replaced by the denser, cooler material. Heat is transferred through to the mantle from the outer core by conduction. The heat is transferred through the **mantle** mostly by **convection,** as the particles move and transfer heat energy, but there is also heating by conduction through direct contact between the particles. As the mantle is a very thick (viscous) liquid, the movement is slow but the heat does cause the particles to move apart and become **less dense** and so rise. The heat energy is transferred into the solid crust by conduction. Molten magma can rise through cracks in the crust (lithosphere) slowly solidifying. Ground water gets into gaps in the crust and comes into contact with the hot liquid magma or solidified magma / hot solid material deep in the crust. Initially this water is heated by **conduction**, but as it becomes hotter and less dense, it rises which sets up a **convection** current with the ground water source above. As this hot ground water makes its way to the surface the cool dense ground water descends through the rock structure to be heated again by the magma.	Candidate describes: • how heat originates in the core of earth • how heat is transferred by conduction through the inner core • how heat is transferred by convection in the outer core • how heat is transferred from the outer core to the mantle by conduction • how heat is transferred through the mantle up to the crust by convection • how heat is transferred to ground water by conduction • how convection currents maintain the heat in the geothermal pools.	Candidate explains in detail: • how nuclear reaction / nuclear fission / radioactivity causes heating of core. • how the process of conduction allows for the transfer heat in the inner core, and / or between the outer core and mantle, and / or mantle and crust. • how the process of convection allows for the heat transfer in the outer core, and / or the mantle. • how ground water is heated by magma / hot rock in crust by conduction • how convection currents in the groundwater heat the geothermal pool.	• Explains comprehensively the links between the heating of earth by fission to heating of layers of the earth by convection and conduction. • Explains comprehensively the links between the continuous heating of ground water by magma in crust to convection current that causes cool ground water to drop down to be heated again.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	Partial description given of heat source or transfer from core or heating of water.	ONE point.	TWO points.	THREE points.	Explains ONE point in detail.	Explains TWO points in detail.	ONE point comprehensively explained.	BOTH points comprehensively explained.

Question Three

Expected Coverage	Achievement	Merit	Excellence
Solar radiation originates from the sun through the process of nuclear fusion and reaches earth as electromagnetic radiation. In winter the tilt of the earth on its axis in relation to its rotation about the sun means that there is less solar radiation per square meter falling on the mountains around Queenstown and less atmospheric warming. This seasonal climatic condition means that the mountains are covered in white snow that is very reflective towards solar radiation (high albedo). The snow reflects the heat energy that hits the mountains back into the atmosphere and space, meaning that the incoming solar energy, which includes heat energy has little effect on the immediate environment. i.e. temperatures remain low. In summer the change in the tilt of the Earth means there is more solar radiation falling on the surface of the Earth per square metre. The darker rock is exposed on the mountains (due to snow melt) and absorbs more solar radiation (heat energy) than it reflects. The rock acts to store heat energy from the sun. This means that this environment absorbs more heat energy than it reflects. (Low albedo) As the atmosphere cools-in the late summer afternoons and evenings, the darker rock re radiates (emits) the heat energy (as longer wave IR) that it had absorbed to the surrounding air / atmosphere. This keeps the evening air warm. Heat energy is also conducted from the rock to the air above setting up convection currents. Hence in winter this area of the environment is overall a reflector of heat energy due to the highly reflective snow cover. This heat energy / IR radiation is virtually all reflected back into space. In summer this is reversed and the area reflects very little heat energy due to the darker rocks and becomes an absorber and re- radiates of heat energy back into the environment. Although the amount of solar radiation) falling on the mountains varies with the seasons (in winter the amount of solar radiation per square metre is less than in summer) the overall effect on the environment sees little change in the amount of energy absorbed and reflected back into space. In winter the snow cover means the effect on the heat energy input / output is more immediate, whereas in summer heat energy absorbed through the day is radiated back into atmosphere / space later in the day.	Describes: • solar radiation is the result of nuclear fusion in the sun • winter and summer seasons in relation to the tilt of the Earth on it rotational axis • solar radiation per square metre varies according to the seasons. (Winter less / summer more) • winter – reflects more solar radiation / heat energy due to white reflective snow (high albedo) • summer – absorbs more heat energy due to darker exposed mountain rock (low albedo) • winter – little heat energy can be absorbed by Earth's snow covered surface • more solar radiation (energy) appears to be reflected in winter than summer.	Explains in detail: • that solar radiation originates from the fusion of H atoms in the sun and is transmitted as electromagnetic radiation through space • how in winter the highly reflective white snow reflects more heat energy and absorbs little heat energy • how in summer the exposed darker mountain rock tends to absorb more heat as the rock is less reflective than snow and less heat energy is reflected • how in summer the absorbed heat is re-radiated (emitted) later in the day back into the environment maintaining warmer atmospheric temperatures.	Comprehensively explains: • the origin of solar radiation and how winter and summer differ in their absorption, transmission, reflection, and re-radiation of heat energy due to the nature of the materials that the solar radiation encounters. (i.e. snow in winter and darker mountain rock in summer), and how overall despite seasonal variation in solar radiation the heat input / output shows little variation throughout the day.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	Partial description of how heat is absorbed or reflected during summer or winter.	ONE point.	TWO points described.	THREE points described.	Explains ONE point in detail.	Explains TWO points in detail.	Comprehensive explanation that includes most of the key concepts.	Comprehensive explanation.

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 7	8 – 13	14 – 18	19 – 24