Assessment Schedule – 2018

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

Evidence Statement

Question One

Expected Coverage	Achievement	Merit	Excellence
Heat energy is transmitted through space (vacuum) and Earth's atmosphere by radiation, which is the transmission of energy by electromagnetic waves. As infra-red radiation passes through the atmosphere, molecules in the atmosphere absorb the radiation which effectively raises air temperature. The Arctic ice cap is white and so acts as a heat reflector, reflecting a lot of heat energy (infra-red radiation) back out into space. Therefore the total amount of radiation heating the earth from the Sun is reduced. The white Arctic Ice Cap acts as a reflector of heat due to its high reflective ability (albedo). The land and oceans absorb infra-red radiation which is re-released into the atmosphere as longer wavelength infra-red radiation. This radiation is absorbed by atmospheric molecules and subsequently heats up the atmosphere. The land and oceans act as a heat sink. Earth's temperature is therefore a balancing act between the albedo effect of the ice caps and the absorption of infra-red radiation (heat energy) by the ocean and land. If the Arctic ice cap were to reduce in size, it would mean that less energy from the Sun would be reflected back out into space More heat energy would be absorbed into the darker oceans now exposed by the melted ice. This would lead to a rise in temperature and a further decrease in the amount of polar ice, which would then lead to an even faster rise in the Earth's temperature, i.e., when the polar ice reduced in size, more of the darker, less reflective ocean surface is exposed; the ocean reflects less heat energy back to space and therefore, more heat energy would be absorbed, and re-emitted causing a rise in atmospheric and ocean temperatures.	Describes: • transfer of heat energy from Sun to Earth as solar radiation or electromagnetic waves. • transfer of heat energy from Earth's surface as re-emitted radiation, and upwards in the atmosphere • ice reflects more energy/radiation back into space than oceans / land • ice albedo / reflectivity of radiation leads to maintaining a temperature balance • the polar ice caps help reduce any increase in Earth's atmospheric temperature • reduction in the polar ice caps leads to increase in Earth's atmospheric / ocean temperature • water / earth absorbs more radiation / infra-red / heat than ice due to non-reflectivity • Oceans (water) acts as a heat sink storing heat energy from the Sun.	Explains in detail: • transfer of heat energy, e.g. from the Sun is by radiation and then re-radiated / reflected back through the atmosphere and into space • ice is a reflector of solar heat back into space, which means less heat is absorbed by the land and ocean and therefore the earth does not heat up as much • if ice disappears less heat energy will be reflected back into the atmosphere / space and ocean temperatures / atmospheric temperatures will rise • the rate of ice melt will increase as more ocean / water is exposed to solar heating increasing Earth's temperature further.	Explains comprehensively: • ocean vs ice as a regulator of temperature due to different reflective abilities of ice compared with ocean • how reducing the reflective ability of the Earth (the Arctic ice cap diminishing) will lead to an increase in temperature of the Earth over time.

Not Achieved			Achievement		Achievement with Merit		Achievement with Excellence	
NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	Describes ONE point.	Describes TWO points.	Describes THREE points.	Describes FOUR points.	Explains ONE point in detail.	Explains TWO points in detail.	Comprehensively explains ONE point OR TWO points explained with minor errors.	Comprehensively explains BOTH points.

Question Two

Expected Coverage	Achievement	Merit	Excellence
The heating of Earth occurs by radiation of the Sun's heat energy through space and then the atmosphere to the Earth's surface, transmitted as shortwave radiation, including infra-red. The heat energy from the Sun is radiated back out into the atmosphere from the Earth's surface and into space, transmitted as long wavelength radiation (infrared radiation). If the atmosphere contains few greenhouse gases such as methane, water and carbon dioxide, then not all the heat energy is transferred directly into space, but radiated back to Earth's surface, which enables the planet to maintain a fairly constant temperature. When infra-red radiation (heat) from the Earth is absorbed by methane in the atmosphere, the molecule gains energy. The increase in energy causes an increase in molecular movement within the molecule. The following can happen: • The absorbed energy is eventually released and re-emitted in all directions; transferring heat energy to other greenhouse molecules in the atmosphere, and the atmosphere becomes warmer. • The methane molecule radiates heat energy back into space and back to the Earth's surface, warming the surface of the Earth again. If the number of methane molecules increased in our atmosphere, then the rate of heat absorption by the molecules would also increase, which would mean that there would be an increase in the Earth's temperature, as less heat energy would be radiated out to space via the atmosphere.	Describes: • how energy is transferred from the Sun to Earth • how heat is transferred from the Earth's surface to the atmosphere • how heat is transferred to other molecules in the atmosphere • how heat is transferred from a methane molecule to space and Earth • how the increase in methane molecules would heat up the Earth.	Explains in detail: • how the Earth is heated by the Sun • the effect of methane molecules in absorbing heat energy or infrared radiation in the atmosphere OR effect of methane molecules in re-radiating heat energy or infrared radiation to Earth • how Earth's temperature would increase as a result of the increase in methane in the atmosphere.	Explains comprehensively: • effect methane has on absorption of heat energy from the Earth OR effect methane has on radiation of heat energy from the Earth • effect of increased methane on the heat energy content of the Earth atmosphere and temperature.

Not Achieved			Achievement		Achievement with Merit		Achievement with Excellence	
NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	Describes ONE point.	Describes TWO points.	Describes THREE points.	Describes FOUR points.	Explains ONE point in detail.	Explains TWO points in detail.	Explains ONE point comprehensively OR TWO points explained with minor errors.	Explains TWO points comprehensively.

Question Three

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 (primordial heat), 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. This 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.	Describes: • how heat originates in the core of earth • how heat is transferred through the inner core • how heat is transferred through the outer core • how heat is transferred through the mantle • how heat is transferred between layers • how heat is transferred to ground water in the crust.	Explains in detail: • how nuclear reaction / nuclear fission / radioactivity causes heating of core • how the processes of conduction and convection transfer heat energy in the core • how the process of convection allows for the heat transfer in the mantle • how heat is transferred to ground water to form geothermal pools.	Explains comprehensively: • the links between the heating of earth by fission to heating of layers of the earth by convection and conduction • 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.

Not Achieved			Achievement		Achievement with Merit		Achievement with Excellence	
NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	Describes ONE point	Describes TWO points	Describes THREE points	Describes FOUR points	Explains TWO points in detail.	Explains THREE points in detail.	ONE point comprehensively explained OR TWO points explained with minor errors.	BOTH points comprehensively explained.

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 6	7 – 12	13 –18	19 – 24