18 ICESat-2 is a satellite launched into space by NASA in 2018. One purpose of the satellite is to measure the thickness of ice on the Earth's surface. The satellite is powered using solar panels. A laser in the satellite produces a beam of photons, which travel to the Earth and back.

(a) Calculate the intensity of solar radiation as it reaches ICESat-2.

distance from the Sun to ICESat-2 = 1.50×10^{11} m
power of the Sun = 3.83×10^{26} W

(3)

Intensity of solar radiation = ...

(b) The laser emits light with a wavelength of 532 nm. Calculate the energy, in J, of each photon.

(3)

Energy of photon = ... J

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(c) The photons released by the laser are directed towards the Earth. The mean time for these photons to return to the satellite is 3.20 ms.

(i) Calculate the height that ICESat-2 orbits above the surface of the Earth.

(2)

Height above Earth = ...

(ii) When photons arriving at the satellite are detected, only those with a wavelength of exactly 532 nm are used in the analysis of the results.

Suggest why.

(1)

(d) At one point, ICESat-2 passes over a flat ice sheet. The ice sheet is 1000 m above sea level.

Explain how the measurements taken by ICESat-2 can be used to show that the ice sheet has a flat surface and is higher than sea level.

(2)

(Total for Question 18 = 11 marks)