(Question 5 continued)

(ii) Describe the subsequent motion of the electron. [3]

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6. Wind is incident on the blades of a wind turbine. The radius of the blades is 12 m. The following data are available for the air immediately before and after impact with the blades.

	Before	**After**
Density of air	$1.20\,\text{kg}\,\text{m}^{-3}$	$1.32\,\text{kg}\,\text{m}^{-3}$
Wind speed	$8.0\,\text{m}\,\text{s}^{-1}$	$4.0\,\text{m}\,\text{s}^{-1}$

(a) Determine the maximum power that can be extracted from the wind by this turbine. [3]

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(b) Suggest why the answer in (a) is a maximum. [1]

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7. The average temperature of ocean surface water is 289 K. Oceans behave as black bodies.

(a) Show that the intensity radiated by the oceans is about 400 $W m^{-2}$. [1]

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(b) Explain why some of this radiation is returned to the oceans from the atmosphere. [3]

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Higher level only

(c) The intensity in (b) returned to the oceans is 330 $W m^{-2}$. The intensity of the solar radiation incident on the oceans is 170 $W m^{-2}$.

(i) Calculate the additional intensity that must be lost by the oceans so that the water temperature remains constant. [2]

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(ii) Suggest a mechanism by which the additional intensity can be lost. [1]

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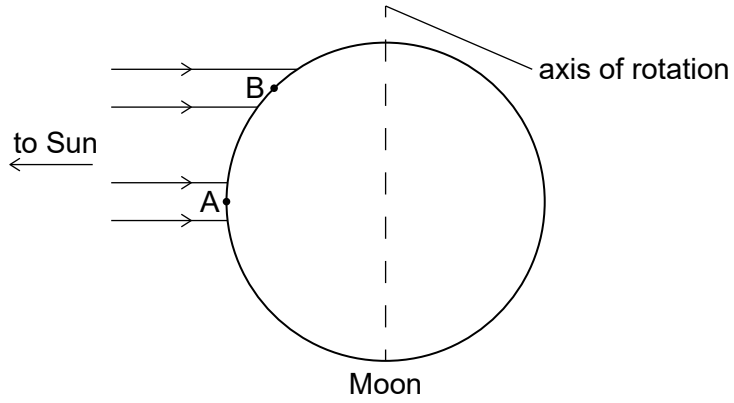
6. The Moon has no atmosphere and orbits the Earth. The diagram shows the Moon with rays of light from the Sun that are incident at 90° to the axis of rotation of the Moon.



(a) (i) A black body is on the Moon's surface at point A. Show that the maximum temperature that this body can reach is 400 K. Assume that the Earth and the Moon are the same distance from the Sun. [2]

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(ii) Another black body is on the Moon's surface at point B.

Outline, without calculation, why the maximum temperature of the black body at point B is less than at point A. [2]

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(This question continues on the following page)

(Question 6 continued)

(b) The albedo of the Earth's atmosphere is 0.28. Outline why the maximum temperature of a black body on the Earth when the Sun is overhead is less than that at point A on the Moon. [1]

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(c) The Moon orbits the Earth in a circular path.

Outline why

(i) a force acts on the Moon. [1]

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(ii) this force does no work on the Moon. [1]

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6. The ratio $\frac{\text{distance of Mars from the Sun}}{\text{distance of Earth from the Sun}} = 1.5$.

(a) Show that the intensity of solar radiation at the orbit of Mars is about 600 W m^{-2}. [2]

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(b) Determine, in K, the mean surface temperature of Mars. Assume that Mars acts as a black body. [2]

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(c) The atmosphere of Mars is composed mainly of carbon dioxide and has a pressure less than 1 % of that on the Earth. Outline why the greenhouse effect is not significant on Mars. [2]

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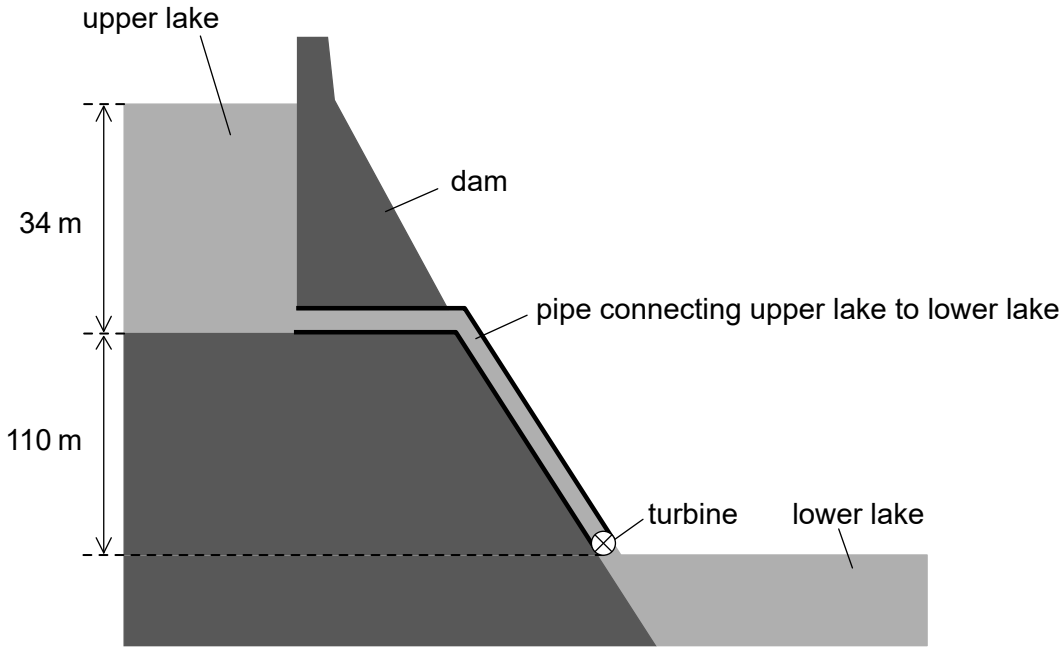
7. In a pumped storage hydroelectric system, water is stored in a dam of depth 34 m.



The water leaving the upper lake descends a vertical distance of 110 m and turns the turbine of a generator before exiting into the lower lake.

(a) Water flows out of the upper lake at a rate of 1.2×10^5 m^3 per minute. The density of water is 1.0×10^3 kg m^{-3}.

(i) Estimate the specific energy of water in this storage system, giving an appropriate unit for your answer. [2]

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(This question continues on the following page)

(Question 7 continued)

(ii) Show that the average rate at which the gravitational potential energy of the water decreases is 2.5 GW. [3]

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(iii) The storage system produces 1.8 GW of electrical power. Determine the overall efficiency of the storage system. [1]

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(b) After the upper lake is emptied it must be refilled with water from the lower lake and this requires energy. Suggest how the operators of this storage system can still make a profit. [1]

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