Name

Date

Quiz - Energy, Power, Climate Change

1. It is hypothesized that global warming may lead to significant changes in the average sea-level. This hypothesis assumes that:

   A. average rainfall will increase.

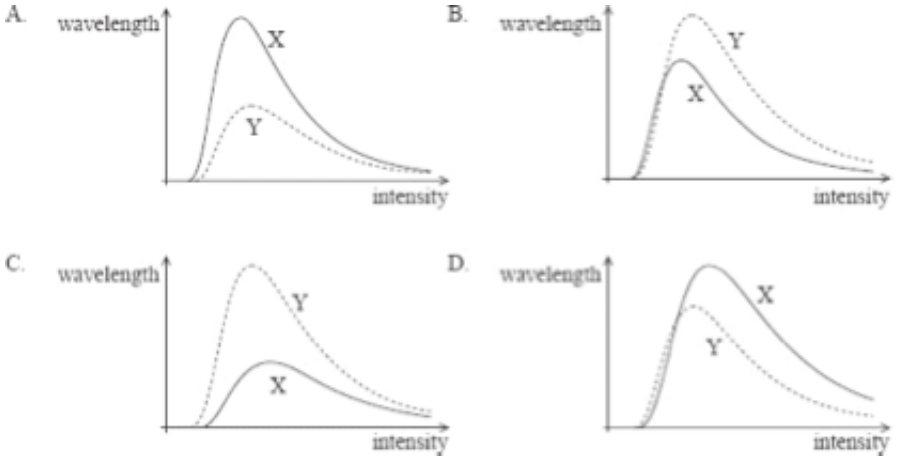
   B. icebergs will melt.

   C. glaciers will melt.

   D. the rate of evaporation of seawater will increase.

   [1]

2. Two black bodies X and Y are at different temperatures. The temperature of body Y is higher than that of body X. Which of the following shows the black body spectra for the two bodies?



   [1]

3. This question is about solar power.

   A. Distinguish, in terms of energy conversion, the difference between a photovoltaic cell and an active solar heater.

   Photovoltaic Cell: .....

   Active Solar Heater: .....

   [2]

   B. An outside tank, open to the air, contains 4.0×10^3 kg of water. During daylight hours, the average temperature of the water decreases at a rate of $0.38\ K \cdot h^{-1}$. In order to maintain a constant temperature during daylight hours, it is proposed to heat the water using an active solar heater. The average solar power density during the day is $7.2 \times 10^2 W \cdot m^2$ and the specific heat capacity of water is $4.2 \times 10^3 J \cdot kg^1 K^1$.

   Estimate the minimum effective area of the solar heater needed in order to keep the temperature of the water constant.

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[3]

4. This question is about wind power.

The maximum theoretical wind power P for air of speed v moving normally through area A where ρ is the density of air is given by:

$$P = \frac{\rho A v^3}{2}$$

A. i. Air of density $1.3\,kg \cdot m^{-3}$ and speed of 9.0 $\text{m}\cdot\text{s}^{-1}$ is incident on a wind turbine having blades of diameter 15 m. Calculate the maximum wind power incident on the turbine.

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[2]

ii. State why it is impossible in practice to extract all of the power P in (i) from the air.

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[1]

iii. State two reasons why wind turbines are not placed close to one another.

1. .....

2. .....

[2]

B. A nuclear power station has an output power of 200 MW. It is proposed to replace the power station with a series of wind turbines each with an energy output of 750 kW. State and discuss one advantage and one disadvantage such a change might bring if this proposal was to take place.

Advantage: .....

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Disadvantage: .....

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[4]

5. This question is about solar power.

A. Describe, in terms of energy transformations, the difference between a photovoltaic cell and an active solar heater.

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[2]

B. A photovoltaic cell of area 6.5 x 10^{-4} m^2 is situated on the roof of a house. The cell has an efficiency of 8%. At a time when the power of the solar radiation incident on the photovoltaic cell is a maximum, the cell delivers a power of 47 mW to the external circuit.

i. Deduce that the maximum value of the power of the solar radiation incident on the cell is approximately 0.90 $kW \cdot m^{-2}$.

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[2]

ii. State one reason why the power of solar radiation at any particular region does not have a constant value.

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[1]

C. A power of 3.0 kW is required to produce adequate hot water for the house.

i. Use the data from (b) to determine the minimum area of the photovoltaic cells required to generate this power.

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[2]

ii. The efficiency of energy conversion in an active solar heater is 24%. Calculate the minimum area of this solar heater required to generate this power.

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[1]

iii. State and explain whether it is more practical to use photovoltaic cells or an active solar heater to provide hot water for the house.

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[2]

6. Simple harmonic motion and the greenhouse effect.

A. A body is displaced from equilibrium. State the two conditions necessary for the body to execute simple harmonic motion

i. .....

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ii. .....

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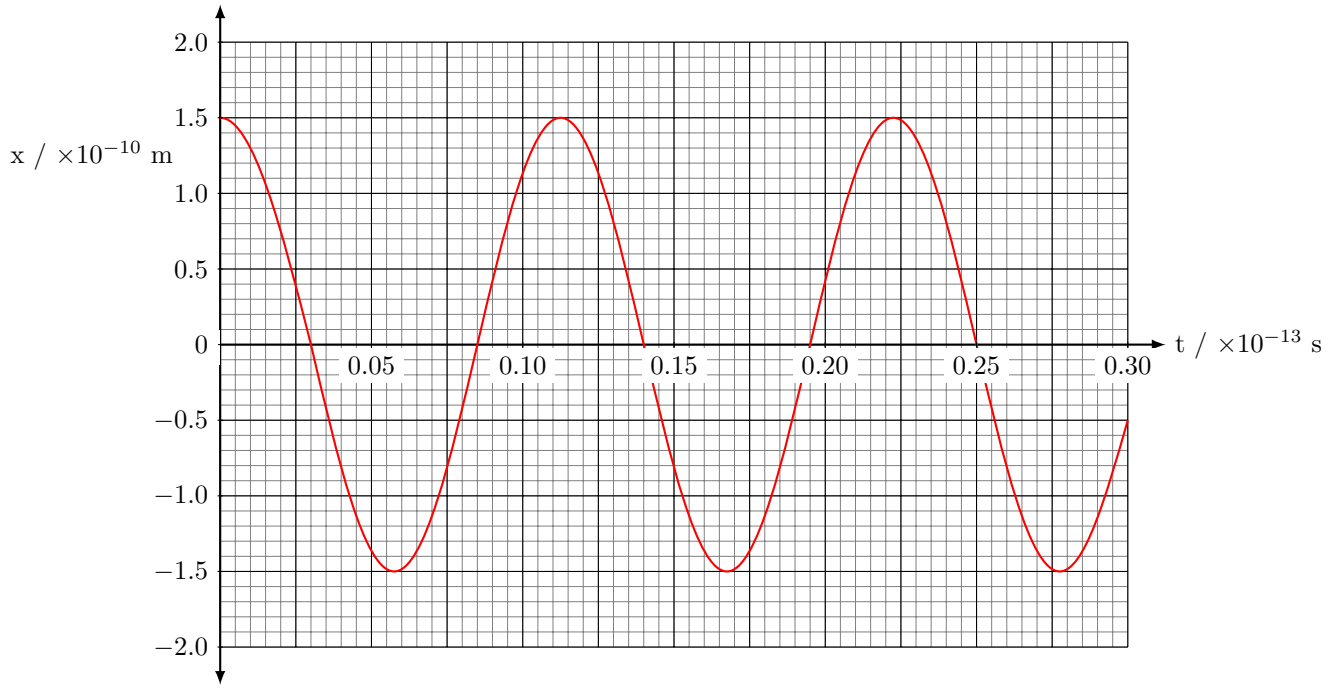
[2]

B. In a simple model of a methane molecule, a hydrogen atom and the carbon atom can be regarded as two masses attached by a spring. A hydrogen atom is much less massive than the carbon atom such that any displacement of the carbon atom may be ignored.

The graph below shows the variation with time t of the displacement x from its equilibrium position of a hydrogen atom in a molecule of methane.



The mass of hydrogen atom is 1.7 x 10^{-27} kg. Use data from the graph above

i. to determine its amplitude of oscillation.

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[1]

ii. to show that the frequency of its oscillation is 9.1 x 10^{13} Hz.

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[2]

iii. to show that the maximum kinetic energy of the hydrogen atom is 6.2 x 10^{-18} J.

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[2]

C. Assuming that the motion of the hydrogen atom is simple harmonic, its frequency of oscillation f is given by the expression:

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m_p}}$$

where k is the force per unit displacement between a hydrogen atom and the carbon atom and mp is the mass of a proton.

i. Show that the value of k is approximately 560 $\mathrm{N \cdot m^{-1}}$.

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[1]

ii. Estimate, using your answer to (c)(i), the maximum acceleration of the hydrogen atom.

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[2]

D. Methane is classified as a greenhouse gas.

i. Describe what is meant by a greenhouse gas.

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[2]

ii. Electromagnetic radiation of frequency 9.1 x 10^{13} Hz is in the infrared region of the electromagnetic spectrum. Suggest, based on the information given in (b)(ii), why methane is classified as a greenhouse gas.

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[2]