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PHYSICS
STANDARD LEVEL
PAPER 2

Candidate session number

0	0							

Wednesday 6 November 2013 (morning)

1 hour 15 minutes

Examination code

8	8	1	3	–	6	5	0	5

INSTRUCTIONS TO CANDIDATES

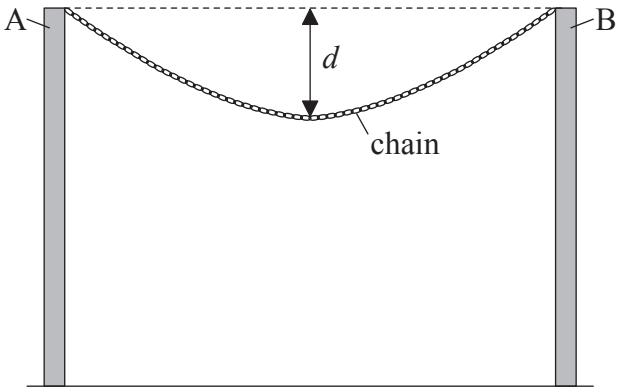
- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all questions.
- Section B: answer one question.
- Write your answers in the boxes provided.
- A calculator is required for this paper.
- A clean copy of the ***Physics*** *Data Booklet* is required for this paper.
- The maximum mark for this examination paper is *[50 marks]*.

SECTION A

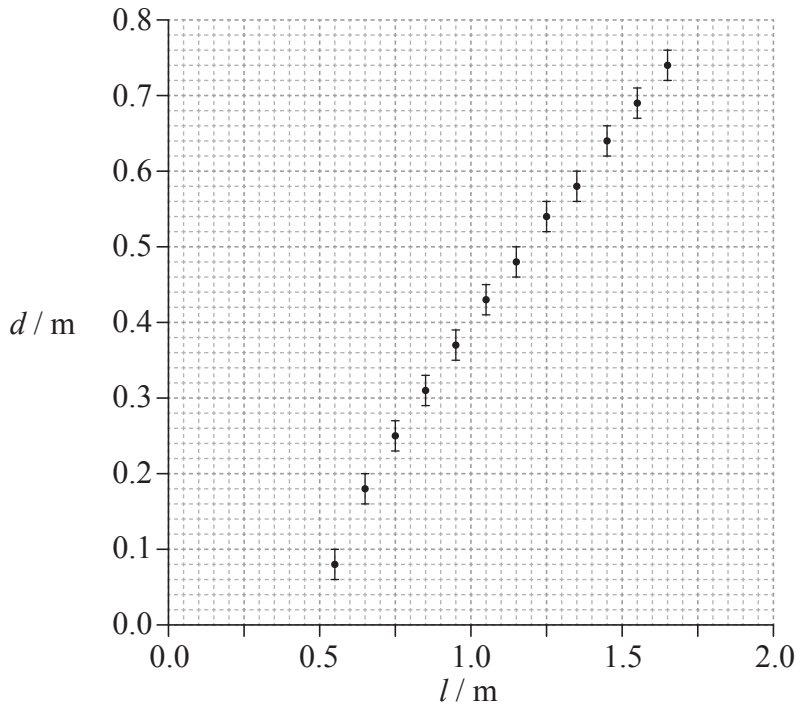
*Answer **all** questions. Write your answers in the boxes provided.*

1. Data analysis question.

A chain is suspended between two vertical supports A and B. The chain is made of a number of identical metal links.



The length l of the chain can be increased by adding extra links. An experiment was undertaken to investigate how the sag d of the midpoint of the chain, measured from the horizontal between A and B, varies with l. The data obtained are shown plotted below. The uncertainties in l are too small to be shown.



(This question continues on the following page)

(Question 1 continued)

(a) Draw a best-fit line for the data points on the graph opposite. *[1]*

(b) With reference to your answer to (a),

(i) explain why the relationship between d and l is not linear. *[2]*

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(ii) estimate the horizontal distance between the supports A and B. *[2]*

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(c) Before the experiment was carried out, it was hypothesized that d depends on $\sqrt{l}$. Determine, using your answer to (a), whether this hypothesis is valid. *[4]*

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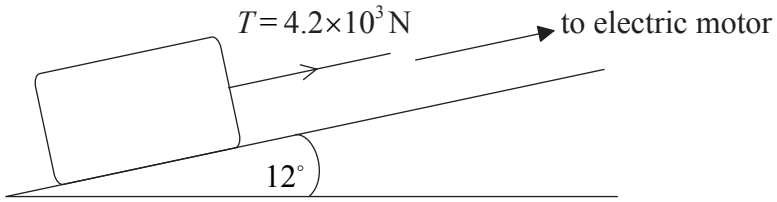
2. This question is about forces.

A stone block is pulled at constant speed up an incline by a cable attached to an electric motor.



The incline makes an angle of 12° with the horizontal. The weight of the block is 1.5×10^4 N and the tension T in the cable is 4.2×10^3 N.

(a) On the diagram draw and label arrows that represent the forces acting on the block. *[2]*

(b) Calculate the magnitude of the friction force acting on the block. *[3]*

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3. This question is about nuclear power production.

(a) State **two** advantages of power production using fossil fuels compared to using nuclear fuels. *[2]*

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(b) Outline the reason why fuel enrichment is necessary for the fuel used in a commercial nuclear reactor. *[3]*

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(Question 3 continued)

(c) A domestic water tank contains 620 kg of water. You are asked to compare raising the temperature of the water by 25 K using the energy available from nuclear fission and the energy available from the Sun. The following data are available.

Energy density of uranium-235	$=2.0\times10^{13}\,\text{J kg}^{-1}$
Area of solar panels used	$=23\,\text{m}^2$
Average solar power during daylight	$=0.74\,\text{kW m}^{-2}$
Specific heat capacity of water	$=4.2\times10^{3}\,\text{J kg}^{-1}\,\text{K}^{-1}$

Determine the

(i) mass of uranium-235 that is needed to raise the temperature of the water by 25 K. *[2]*

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(ii) time in hours required to raise the temperature of the water by 25 K using the solar panels. *[2]*

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(This question continues on the following page)

(Question 3 continued)

(d) The solar energy in (c) is used to heat the water directly, whereas the nuclear energy must first be converted into electrical energy in the nuclear power station. Outline the energy transformations that take place within the nuclear power station in the production of electrical power. *[2]*

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SECTION B

*This section consists of three questions: 4, 5 and 6. Answer **one** question. Write your answers in the boxes provided.*

4. This question is in **two** parts. **Part 1** is about electric fields and radioactive decay. **Part 2** is about change of phase.

Part 1 Electric fields and radioactive decay

(a) Define *electric field strength*. *[2]*

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(b) A simple model of the proton is that of a sphere of radius 1.0×10^{-15} m with charge concentrated at the centre of the sphere. Estimate the magnitude of the field strength at the surface of the proton. *[2]*

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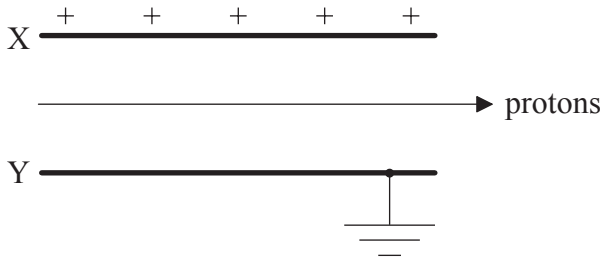
(This question continues on the following page)

(Question 4, part 1 continued)

(c) Protons travelling with a speed of $3.9\times10^{6}\,\text{m s}^{-1}$ enter the region between two charged parallel plates X and Y. Plate X is positively charged and plate Y is connected to earth.



A uniform magnetic field also exists in the region between the plates. The direction of the field is such that the protons pass between the plates without deflection.

(i) State the direction of the magnetic field. *[1]*

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(ii) The magnitude of the magnetic field strength is $2.3\times10^{-4}\,\text{T}$. Determine the magnitude of the electric field strength between the plates, stating an appropriate unit for your answer. *[3]*

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(Question 4, part 1 continued)

(d) Protons can be produced by the bombardment of nitrogen-14 nuclei with alpha particles. The nuclear reaction equation for this process is given below.

$$^{14}_{7}\mathrm{N} + ^{4}_{2}\mathrm{He} \rightarrow \mathrm{X} + ^{1}_{1}\mathrm{H}$$

Identify the proton number and nucleon number for the nucleus X. *[1]*

Proton number: . . . . . .

Nucleon number: . . . . . .

(e) The following data are available for the reaction in (d).

Rest mass of nitrogen-14 nucleus	= 14.0031 u
Rest mass of alpha particle	= 4.0026 u
Rest mass of X nucleus	= 16.9991 u
Rest mass of proton	= 1.0073 u

Show that the minimum kinetic energy that the alpha particle must have in order for the reaction to take place is about 0.7 MeV. *[3]*

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(Question 4, part 1 continued)

(f) A nucleus of another isotope of the element X in (d) decays with a half-life $T_{\frac{1}{2}}$ to a nucleus of an isotope of fluorine-19 (F-19).

(i) Define the terms *isotope* and *half-life*. *[2]*

Isotope: . . . . . .

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Half-life: . . . . . .

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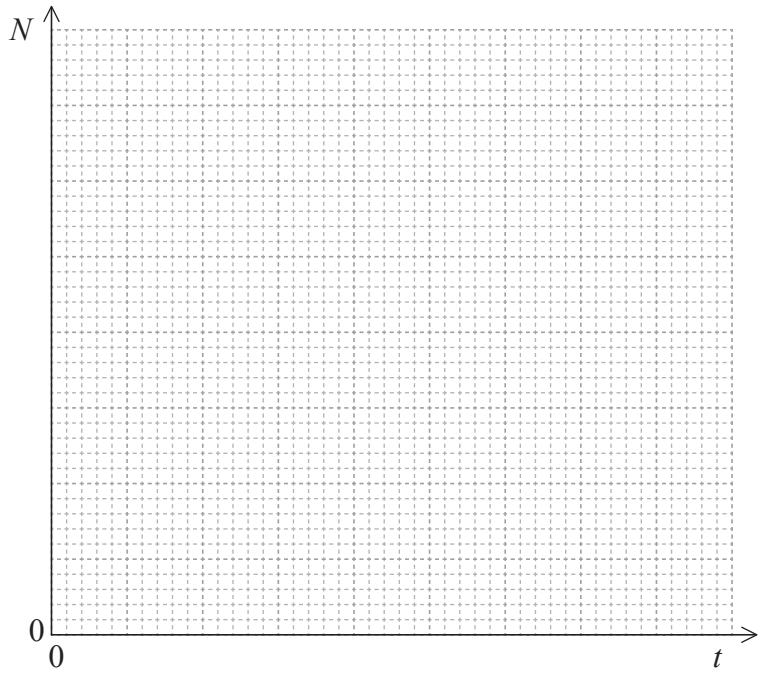
(ii) Using the axes below, sketch a graph to show how the number of atoms N in a sample of X varies with time t, from $t = 0$ to $t = 3T_{\frac{1}{2}}$. There are N_0 atoms in the sample at $t=0$. *[3]*



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(Question 4 continued)

Part 2 Change of phase

(g) Water at constant pressure boils at constant temperature. Outline, in terms of the energy of the molecules, the reason for this. *[2]*

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(h) In an experiment to measure the specific latent heat of vaporization of water, steam at 100 °C was passed into water in an insulated container. The following data are available.

Initial mass of water in container	= 0.300 kg
Final mass of water in container	= 0.312 kg
Initial temperature of water in container	= 15.2 °C
Final temperature of water in container	= 34.6 °C
Specific heat capacity of water	= $4.18\times10^{3}\,\text{J kg}^{-1}\,\text{K}^{-1}$

Show that the data give a value of about $1.8\times10^{6}\,\text{J kg}^{-1}$ for the specific latent heat of vaporization L of water. *[4]*

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(Question 4, part 2 continued)

(i) Explain why, other than measurement or calculation error, the accepted value of L is greater than that given in (h). *[2]*

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5. This question is in **two** parts. **Part 1** is about simple harmonic motion (SHM) and waves. **Part 2** is about voltage–current (V–I) characteristics.

Part 1 Simple harmonic motion (SHM) and waves

(a) A particle P moves with simple harmonic motion. State, with reference to the motion of P, what is meant by simple harmonic motion. *[2]*

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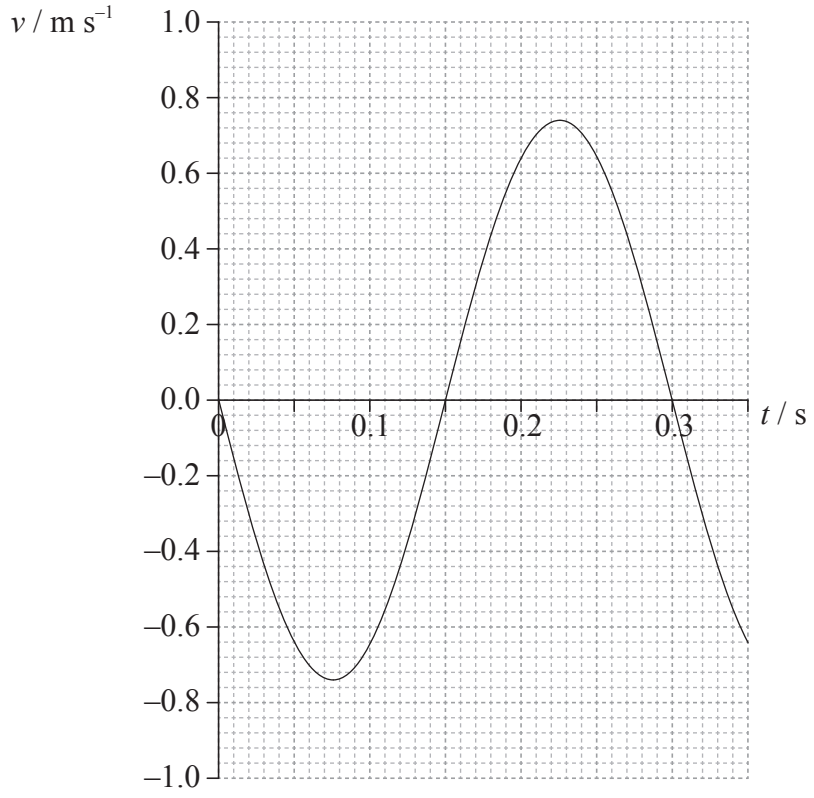
(b) The graph shows how the velocity v of particle P varies with time t.



(This question continues on the following page)

(Question 5, part 1 continued)

Use the graph opposite to determine for the motion of P the

(i) period. *[1]*

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(ii) amplitude. *[4]*

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(iii) displacement of P from equilibrium at $t = 0.2\,\text{s}$. *[2]*

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(Question 5, part 1 continued)

(c) The particle P in (b) is a particle in medium M_1 through which a transverse wave is travelling.

(i) Describe, in terms of energy propagation, what is meant by a transverse wave. *[1]*

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(ii) The speed of the wave through the medium is $0.40\,m\,s^{-1}$. Calculate, using your answer to (b)(i), the wavelength of the wave. *[2]*

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(iii) The wave travels into another medium M_2. The refractive index of M_2 relative to M_1 is 1.8. Calculate the wavelength of the wave in M_2. *[2]*

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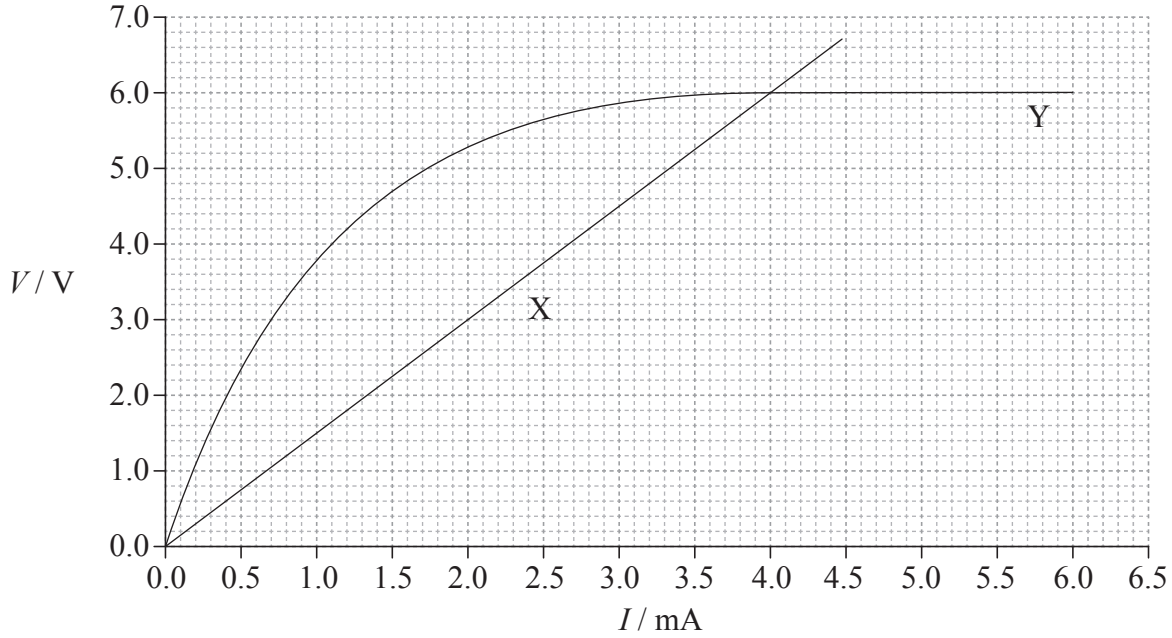
(Question 5 continued)

Part 2 Voltage–current (*V–I*) characteristics

The graph shows the voltage–current (*V–I*) characteristics, at constant temperature, of two electrical components X and Y.



(d) Outline, with reference to the graph and to Ohm's law, whether or not each component is ohmic. *[3]*

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Y: . . . . . .
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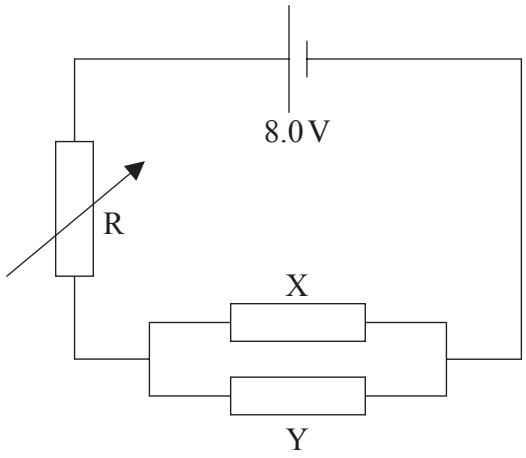
(Question 5, part 2 continued)

(e) Components X and Y are connected in parallel. The parallel combination is then connected in series with a variable resistor R and a cell of emf 8.0 V and negligible internal resistance.



The resistance of R is adjusted until the currents in X and Y are equal.

(i) Using the graph, calculate the resistance of the parallel combination of X and Y. *[3]*

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(ii) Using your answer to (e)(i), determine the resistance of R. *[2]*

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(Question 5, part 2 continued)

(iii) Determine the power delivered by the cell to the circuit. *[3]*

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6. This question is in **two** parts. **Part 1** is about Newton's laws and momentum. **Part 2** is about the greenhouse effect.

Part 1 Newton's laws and momentum

(a) State the condition for the momentum of a system to be conserved. *[1]*

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(b) A person standing on a frozen pond throws a ball. Air resistance and friction can be considered to be negligible.

(i) Outline how Newton's third law and the conservation of momentum apply as the ball is thrown. *[3]*

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(ii) Explain, with reference to Newton's second law, why the horizontal momentum of the ball remains constant whilst the ball is in flight. *[2]*

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(Question 6, part 1 continued)

(c) The maximum useful power output of a locomotive engine is 0.75 MW. The maximum speed of the locomotive as it travels along a straight horizontal track is $44\,m\,s^{-1}$. Calculate the frictional force acting on the locomotive at this speed. *[2]*

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(Question 6, part 1 continued)

(d) The locomotive engine in (c) gives a truck X a sharp push such that X moves along a horizontal track and collides with a stationary truck Y. As a result of the collision the two trucks stick together and move off with speed v. The following data are available.

Mass of truck X $= 3.7 \times 10^3\,\text{kg}$
Mass of truck Y $= 6.3 \times 10^3\,\text{kg}$
Speed of X just before collision $= 4.0\,\text{m s}^{-1}$

(i) Calculate v. *[2]*

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(ii) Determine the kinetic energy lost as a result of the collision. *[2]*

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(e) The trucks X and Y come to rest after travelling a distance of 40 m along the horizontal track. Determine the average frictional force acting on X and Y. *[3]*

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(This question continues on the following page)

(Question 6 continued)

Part 2 The greenhouse effect

(f) Nuclear fuels, unlike fossil fuels, produce no greenhouse gases.

(i) Identify **two** greenhouse gases. *[1]*

1. . . . . .

2. . . . . .

(ii) Discuss, with reference to the mechanism of infrared absorption, why the temperature of the Earth's surface would be lower if there were no greenhouse gases present in the atmosphere. *[4]*

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(Question 6, part 2 continued)

(g) Outline how an increase in the amount of greenhouse gases in the atmosphere of Earth could lead to an increase in the rate at which glaciers melt and thereby a reduction of the albedo of the Earth's surface. *[3]*

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(h) Certain climate models predict that by the end of this century the average depth of the Earth's oceans will have increased by 0.025 %. Determine the average temperature rise of the oceans that is predicted by these models. Take the coefficient of volume expansion of water to be $6.2\times10^{-5}\,K^{-1}$. *[2]*

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