Physics
Standard level
Paper 2

30 April 2025

Zone A morning | **Zone B** morning | **Zone C** morning

Candidate session number

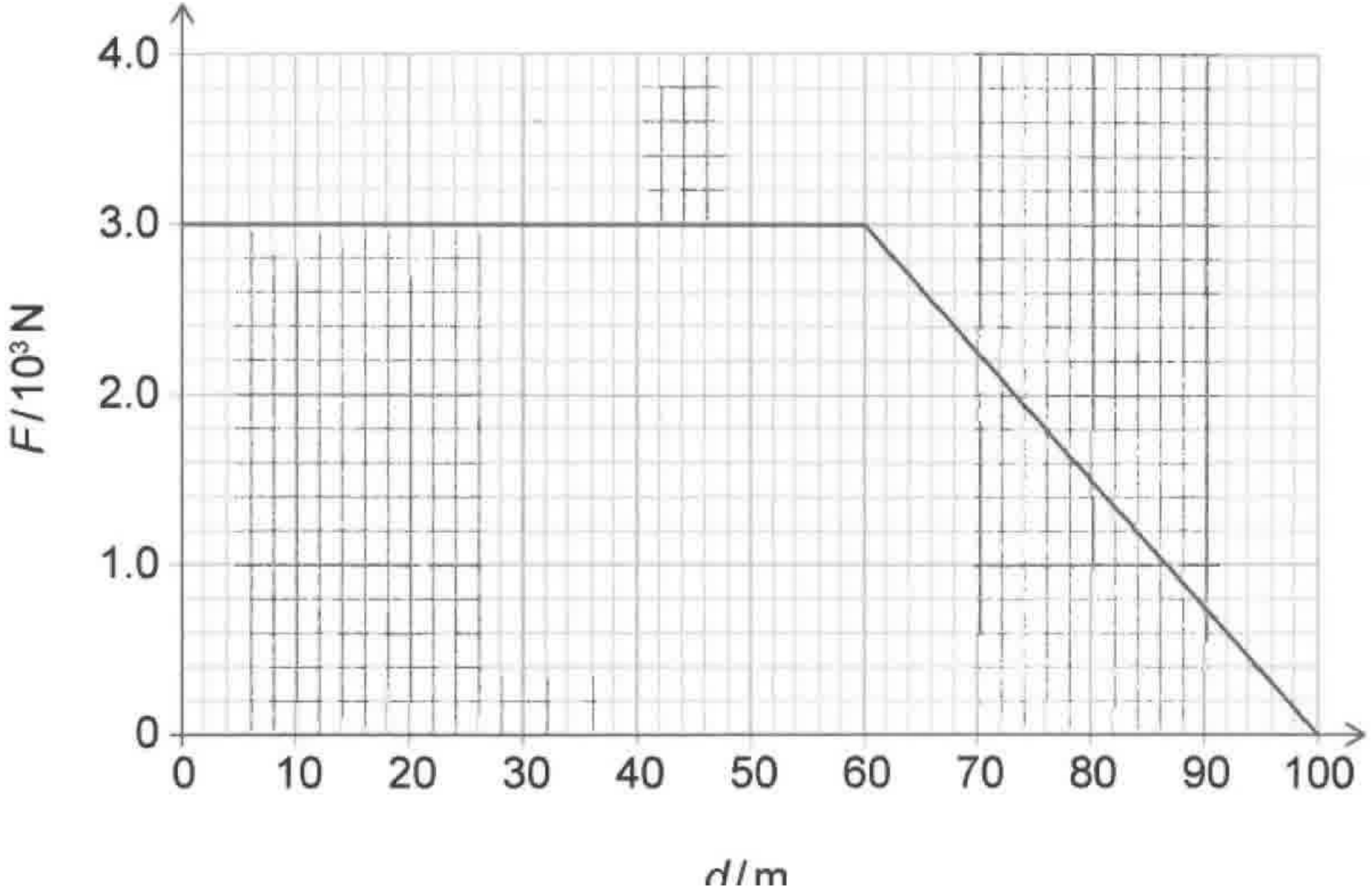
1 hour 30 minutes

Instructions to candidates

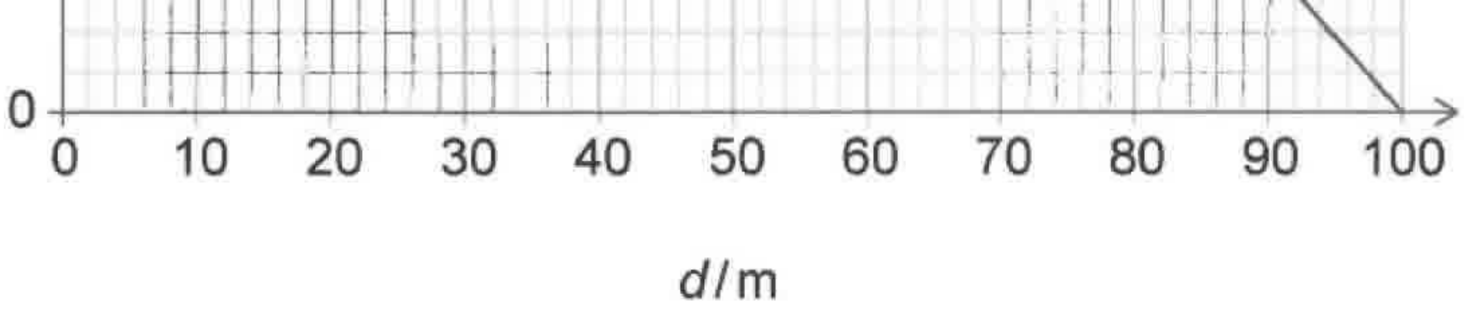
- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- A clean copy of the **physics data booklet** is required for this paper.
- The maximum mark for this examination paper is **[50 marks]**.

1. (a) A car of mass 1600 kg accelerates from rest.

The graph shows how the resultant force F acting in the direction of motion of the car varies with the distance d travelled by the car.



d / m



(i) State what is represented by the area under the graph. [1]

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(ii) Calculate the final speed of the car. [2]

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(Question 1 continued)

A different car travels on a horizontal road at a constant speed of $45\,\text{m}\,\text{s}^{-1}$. The engine of the car develops a power of 140 kW. The resistive force F_d acting on the car is given by

$$F_d = cv^2$$

where v is the speed of the car and c is a constant.

(b) Determine c. State the fundamental SI unit for your answer. [3]

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2. Venus is a planet in the Solar System. The following data are given:

Orbital period of Venus = 225 days
Orbital period of Earth = 365 days

(a) Calculate the ratio $\frac{\text{orbital radius of Venus}}{\text{orbital radius of Earth}}$. [2]

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(b) Explain how observations of the motion of the planets allow scientists to determine the mass of the Sun. [2]

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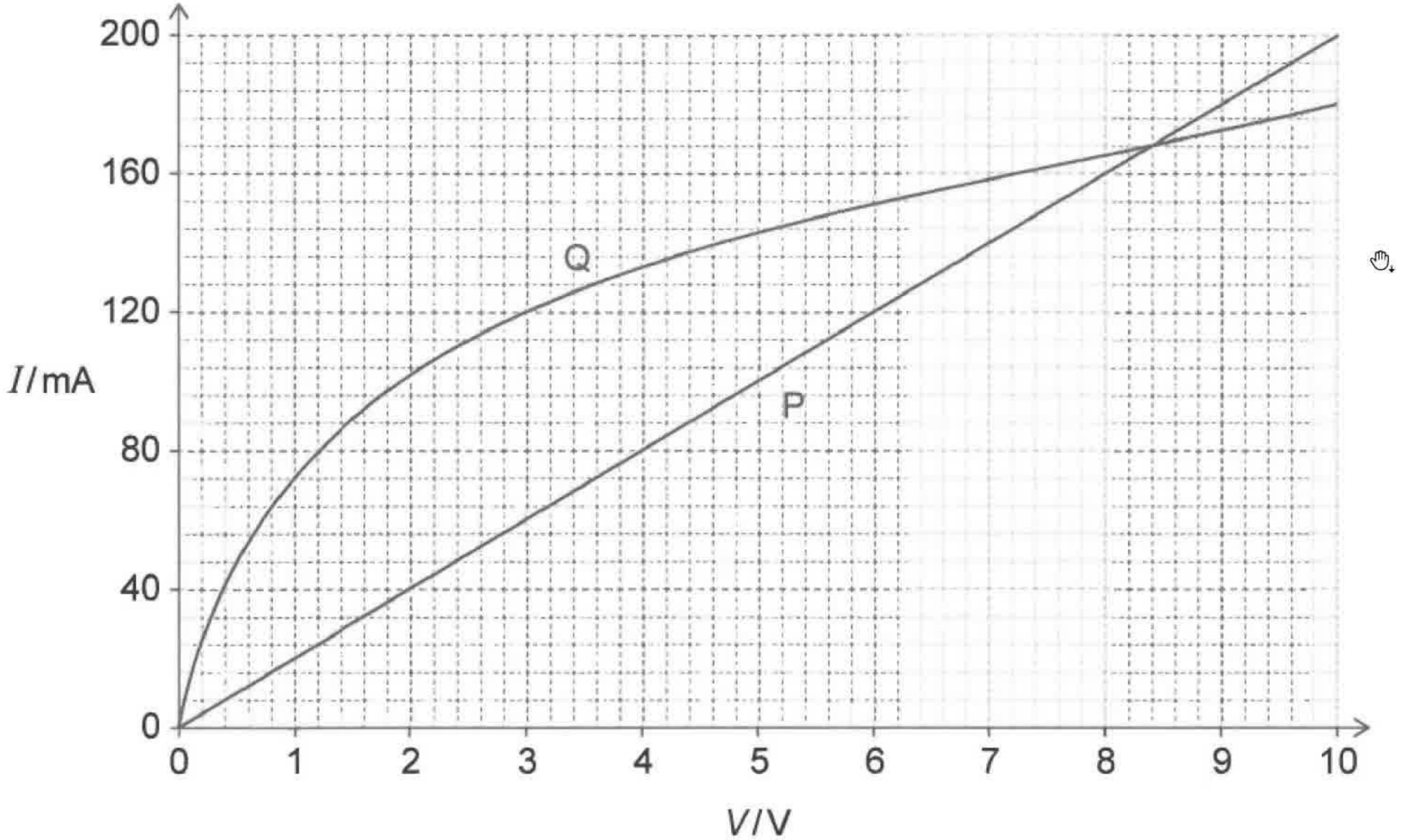
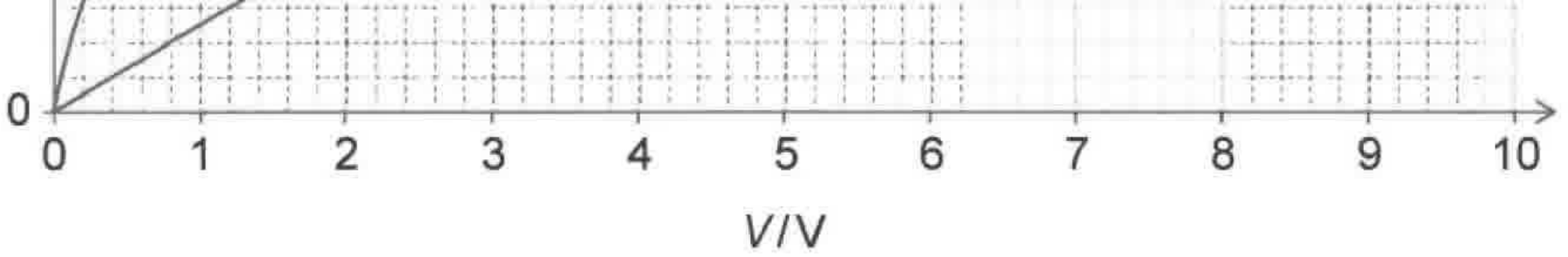
3. The graph shows the variation with the potential difference V of the current I in an ohmic resistor P and a non-ohmic component Q.





(a) Calculate the resistance of P. [1]

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(b) Outline how the resistance of Q changes when the current in it increases. [1]

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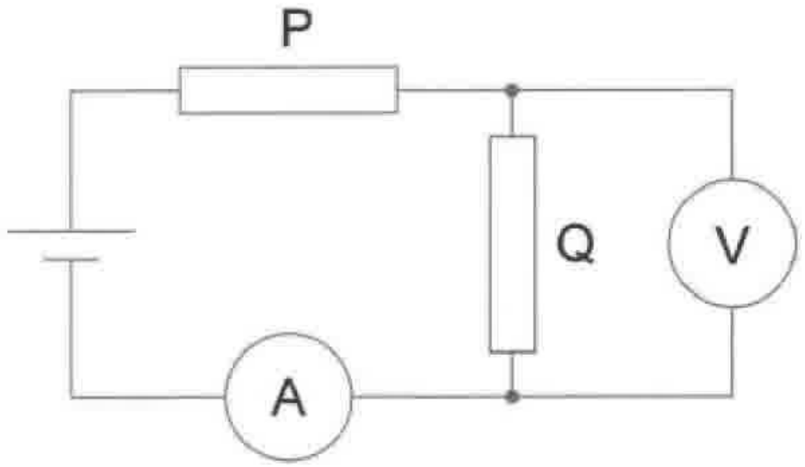
(Question 3 continued)

P and Q are connected in a circuit with a cell of negligible internal resistance as shown.
The ammeter and the voltmeter are ideal.



The reading of the voltmeter is 3.0 V.

(c) State, in mA, the reading of the ammeter. [1]

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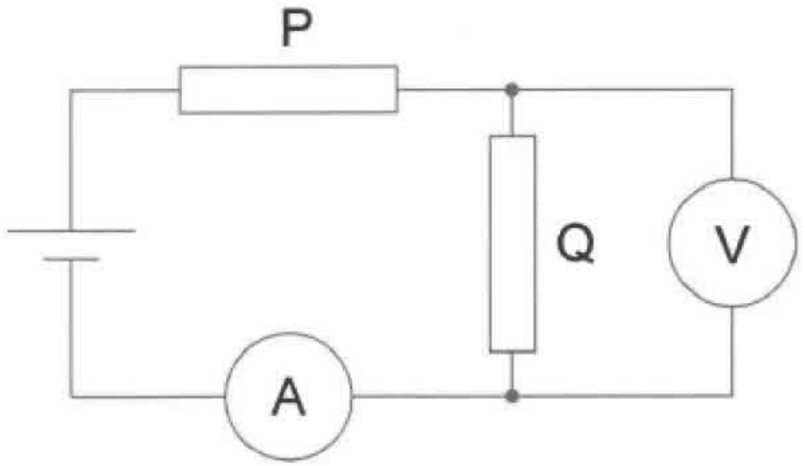

The reading of the voltmeter is 3.0 V.

(c) State, in mA, the reading of the ammeter. [1]

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(d) Determine the emf of the cell. [2]

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4. (a) One difference between sound waves and electromagnetic waves is that sound waves are longitudinal and electromagnetic waves are transverse.

Outline **one** other difference between sound waves and electromagnetic waves. [1]

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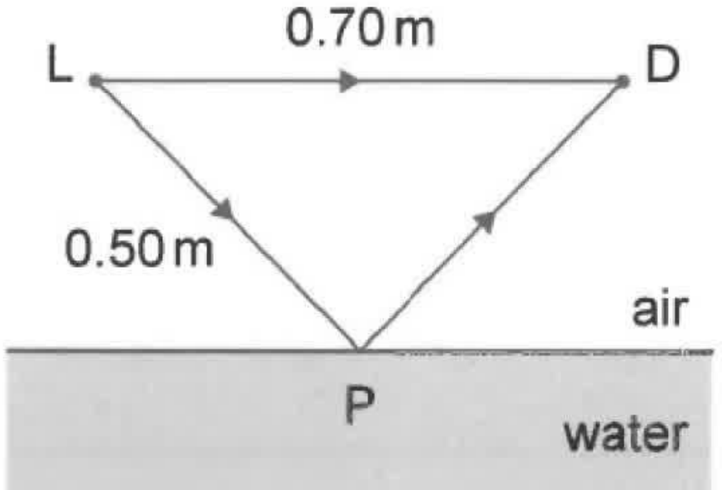
A loudspeaker is placed at point L above a surface of water. A sound detector is placed at point D at the same height above the surface of water as L. The sound reaches D by two routes: along the direct path LD and the reflection-path LPD.



The following data are given:

$$\text{Frequency of the sound wave} = 1700\,\text{Hz}$$

$$\text{Speed of sound in air} = 340\,\text{m s}^{-1}$$

$$\text{Speed of sound in water} = 1500\,\text{m s}^{-1}$$

$$\text{Distance LD} = 0.70\,\text{m}$$

$$\text{Distance LP} = 0.50\,\text{m}$$

(Question 4 continued)

(b) (i) Calculate the wavelength of the sound wave in air. [1]

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(ii) Outline why sound from L undergoes destructive interference at D. [2]

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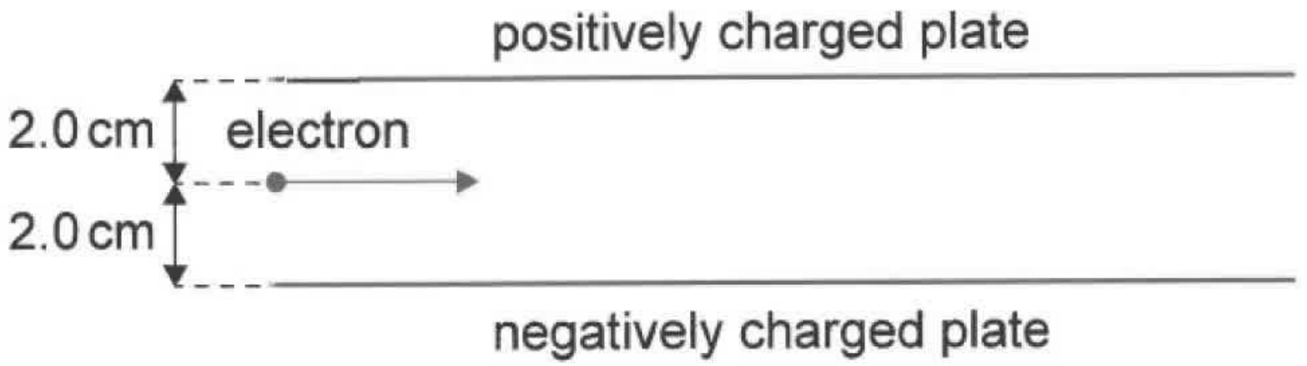
(c) Predict whether the sound wave can enter the water at P. [3]

5. An electron enters a region of a uniform electric field between two parallel charged plates. The electron is initially halfway between the plates and its initial velocity is parallel to the plates.



The following data are given:

Initial speed of the electron $= 9.4 \times 10^6\,\text{m s}^{-1}$

Potential difference between the plates $= 30\,\text{V}$

Distance between the plates $= 4.0\,\text{cm}$

(a) (i) State the direction of the acceleration of the electron. [1]

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Distance between the plates = 10 cm.

(a) (i) State the direction of the acceleration of the electron. [1]

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(ii) Show that the magnitude of the acceleration of the electron is about $10^{14}\,m\,s^{-2}$. [2]

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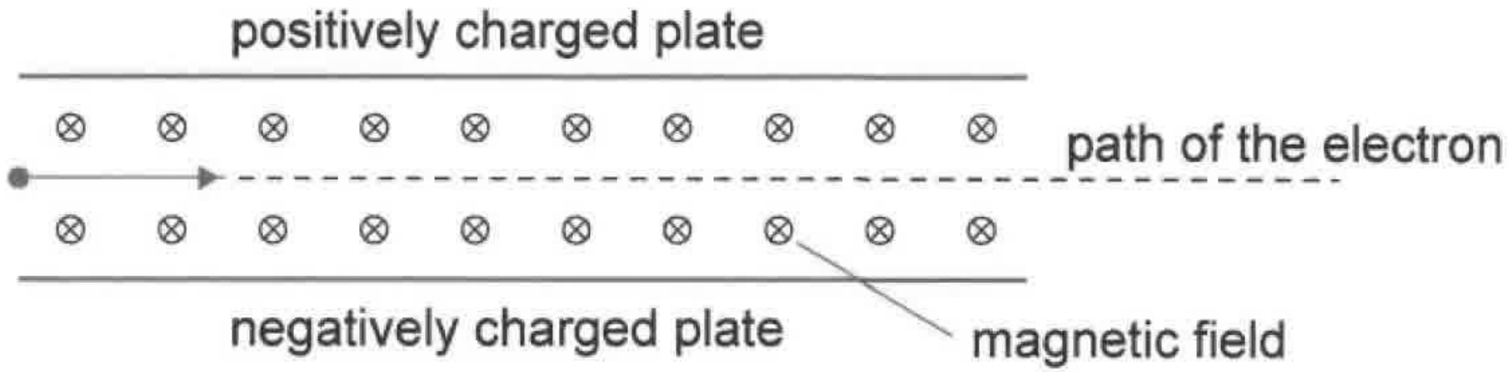
(b) The electron collides with one of the plates. Determine the distance the electron travels parallel to the plates. [3]

(Question 5 continued)

In another experiment, a uniform magnetic field directed into the plane of the diagram is established between the charged plates. The initial velocity of the electron, the distance between the plates and their electric potential difference remain unchanged.



The electron passes undeflected through the region of the electric and magnetic fields.

(c) Calculate the magnetic field strength. [2]

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6. (a) State what is meant by the solar constant. [1]

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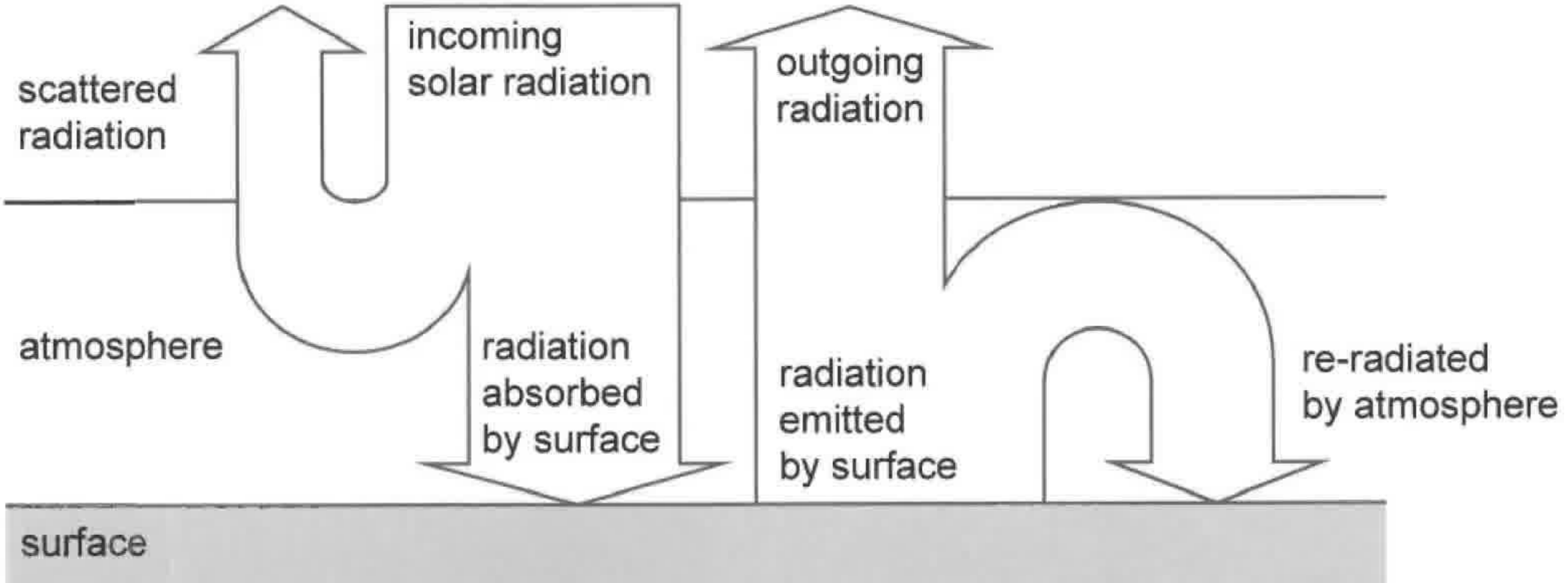
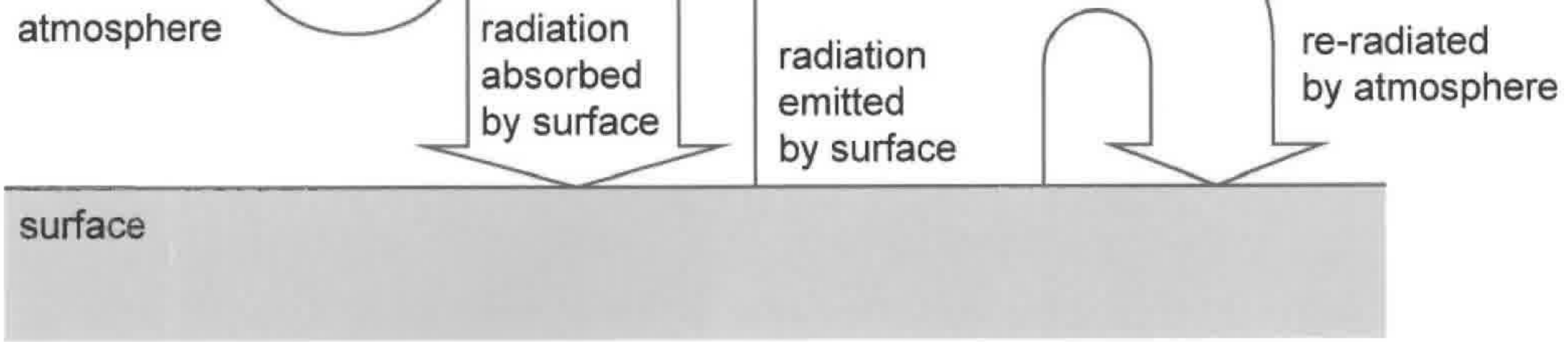
The diagram shows a simplified energy-balance model for the Earth surface–atmosphere system.





The following data are given:

Average albedo of Earth $= 0.30$

Average global temperature of the surface $= 288\,\text{K}$

Average Earth–Sun distance $= 1.5 \times 10^{11}\,\text{m}$

(b) (i) Outline the physical mechanism by which some of the radiation emitted by the surface is absorbed by greenhouse gases in the atmosphere and re-radiated towards the surface. [2]

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(Question 6 continued)

(ii) Show that the average global intensity of radiation absorbed by the surface is about $240\,W m^{-2}$. [2]

(iii) Determine the average intensity re-radiated by the atmosphere towards the surface. Assume that the emissivity of the surface is 0.90. [3]

(c) Show, with reference to the solar constant, that the total power radiated by the Sun is about 4×10^{26} W.

[2]

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(Question 6 continued)

(d) The primary energy source of the Sun is the proton–proton (p–p) chain of fusion reactions. Four protons and two electrons produce a helium nucleus together with neutrinos and gamma photons. The overall reaction is:

$$4\,{}^{1}_{1}\mathrm{p} + 2\,{}^{0}_{-1}\mathrm{e} \rightarrow {}^{4}_{2}\mathrm{He} + 2\,{}^{0}_{0}\nu_e + 4\gamma$$

(i) The mass of the helium nucleus is 4.001506 u. Calculate, in MeV, the energy released in the reaction. [2]

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(ii) Outline the role of fusion reactions in maintaining a stable radius of the Sun. [2]

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(iii) Outline how the presence of helium in the Sun can be confirmed empirically. [2]

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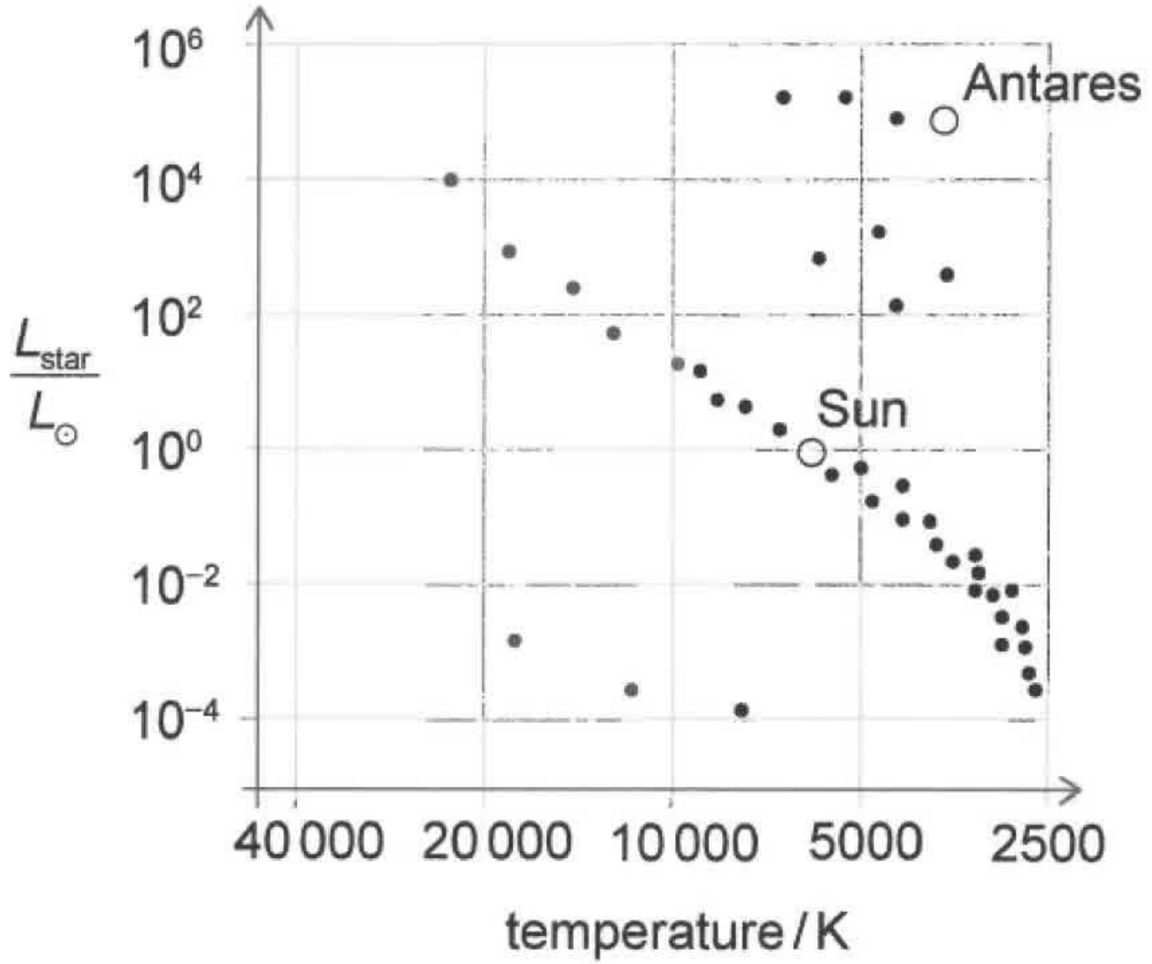
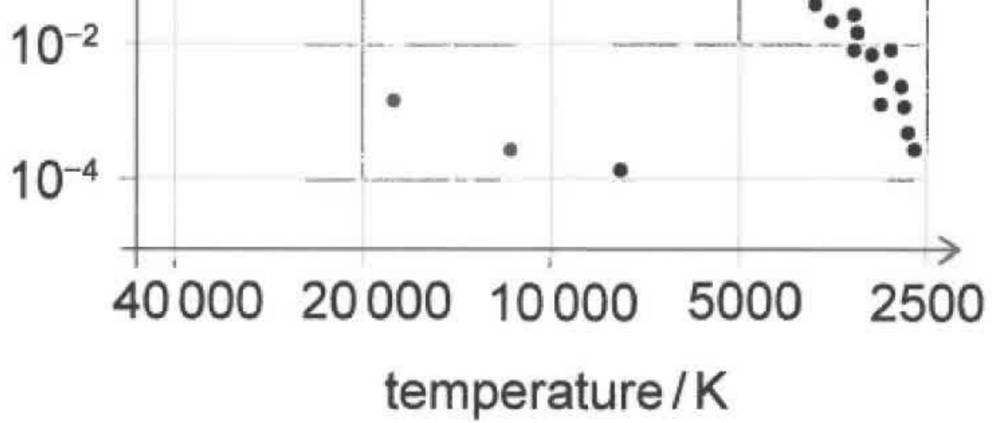
(e) The positions of the Sun and the star Antares are shown in the Hertzsprung-Russell (HR) diagram.



(i) State the star type of Antares. [1]



(i) State the star type of Antares. [1]

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(ii) Discuss how nuclear fusion processes in Antares are different from those in the Sun. [3]

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