Diploma Programme
Programme du diplôme
Programa del Diploma

Physics
Higher level
Paper 2

Monday 15 May 2017 (afternoon)

Candidate session number

2 hour 15 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 **[95 marks]**.

2217 – 6508

23 pages

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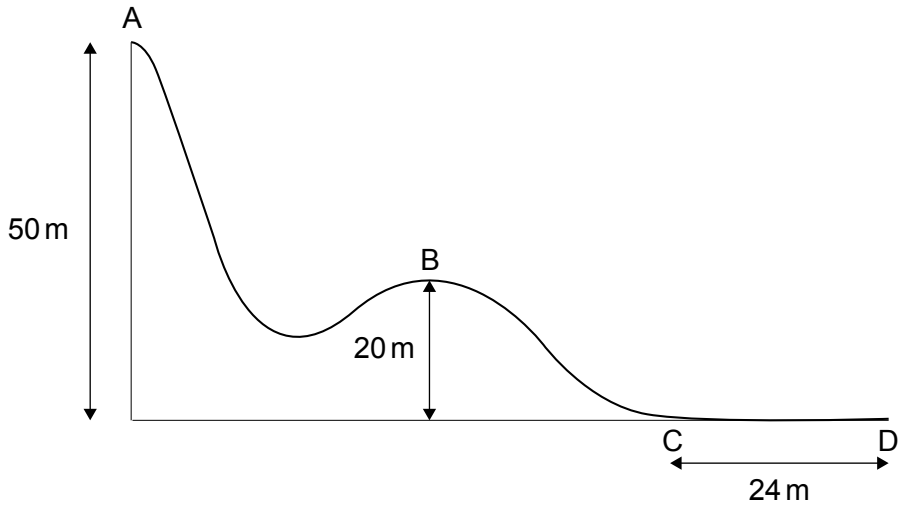
Answer **all** questions. Answers must be written within the answer boxes provided.

1. The diagram below shows part of a downhill ski course which starts at point A, 50 m above level ground. Point B is 20 m above level ground.



(a) A skier of mass 65 kg starts from rest at point A and during the ski course some of the gravitational potential energy transferred to kinetic energy.

(i) From A to B, 24 % of the gravitational potential energy transferred to kinetic energy. Show that the velocity at B is 12 m s^{-1}. [2]

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(ii) Some of the gravitational potential energy transferred into internal energy of the skis, slightly increasing their temperature. Distinguish between internal energy and temperature. [2]

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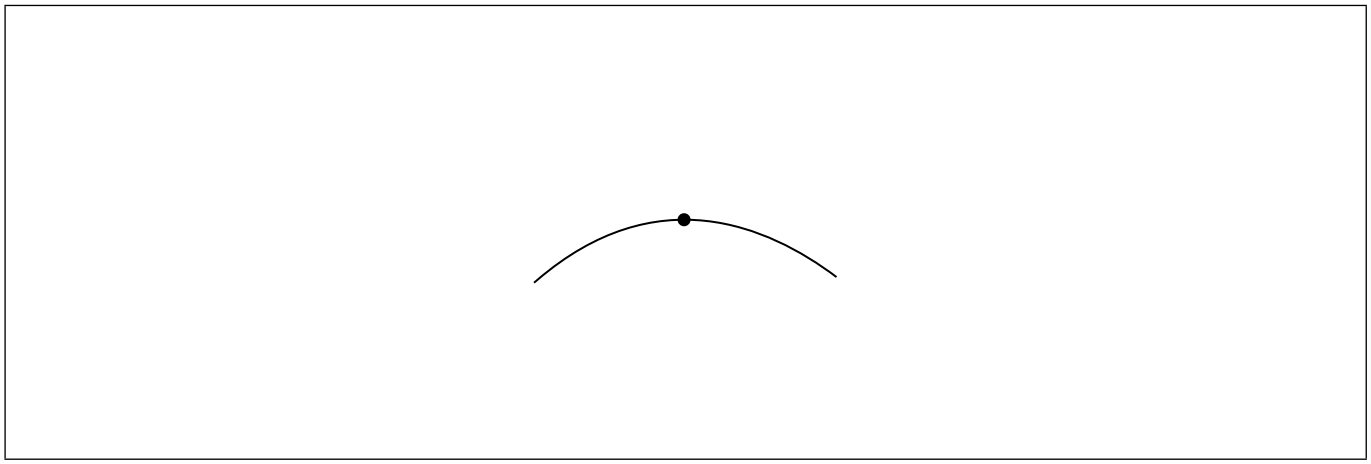
(Question 1 continued)

(b) (i) The dot on the following diagram represents the skier as she passes point B. Draw and label the vertical forces acting on the skier. [2]



(ii) The hill at point B has a circular shape with a radius of 20 m. Determine whether the skier will lose contact with the ground at point B. [3]

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(c) The skier reaches point C with a speed of $8.2\,m\,s^{-1}$. She stops after a distance of 24 m at point D.

Determine the coefficient of dynamic friction between the base of the skis and the snow. Assume that the frictional force is constant and that air resistance can be neglected. [3]

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(Question 1 continued)

(d) At the side of the course flexible safety nets are used. Another skier of mass 76 kg falls normally into the safety net with speed 9.6 m s^{-1}.

(i) Calculate the impulse required from the net to stop the skier and state an appropriate unit for your answer. [2]

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(ii) Explain, with reference to change in momentum, why a flexible safety net is less likely to harm the skier than a rigid barrier. [2]

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2. (a) Outline what is meant by the principle of superposition of waves. [2]

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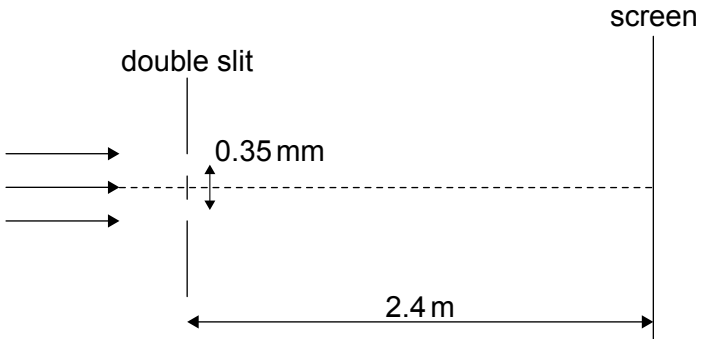
(b) Red laser light is incident on a double slit with a slit separation of 0.35 mm. A double-slit interference pattern is observed on a screen 2.4 m from the slits. The distance between successive maxima on the screen is 4.7 mm.



(not to scale)

Calculate the wavelength of the light. Give your answer to an appropriate number of significant figures. [3]

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(Question 2 continued)

(c) Explain the change to the appearance of the interference pattern when the red-light laser is replaced by one that emits green light. [2]

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(d) One of the slits is now covered.

Describe the appearance of the pattern on the screen. [2]

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3. Two renewable energy sources are solar and wind.

(a) Describe the difference between photovoltaic cells and solar heating panels. [1]

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(b) A solar farm is made up of photovoltaic cells of area 25 000 m^2. The average solar intensity falling on the farm is 240 $W\,m^{-2}$ and the average power output of the farm is 1.6 MW. Calculate the efficiency of the photovoltaic cells. [2]

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(c) An alternative generation method is the use of wind turbines.

The following data are available:

Length of turbine blade = 17 m
Density of air = 1.3 $kg\,m^{-3}$
Average wind speed = 7.5 $m\,s^{-1}$

(i) Determine the minimum number of turbines needed to generate the same power as the solar farm. [3]

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(Question 3 continued)

(ii) Explain **two** reasons why the number of turbines required is likely to be greater than your answer to (c)(i). [2]

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4. A heater in an electric shower has a power of 8.5 kW when connected to a 240 V electrical supply. It is connected to the electrical supply by a copper cable.

The following data are available:

Length of cable = 10 m
Cross-sectional area of cable = 6.0 mm^2
Resistivity of copper = $1.7 \times 10^{-8}\ \Omega m$

(a) (i) Calculate the current in the copper cable. [1]

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(ii) Calculate the resistance of the cable. [2]

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(iii) Calculate the power dissipated in the cable. [1]

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(Question 4 continued)

(b) Explain, in terms of electrons, what happens to the resistance of the cable as the temperature of the cable increases. [3]

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(c) The heater changes the temperature of the water by 35 K. The specific heat capacity of water is 4200 $J\,kg^{-1}\,K^{-1}$.

Determine the rate at which water flows through the shower. State an appropriate unit for your answer. [4]

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5. (a) State the quark structures of a meson and a baryon. [2]

Meson: . . . . . .

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Baryon: . . . . . .

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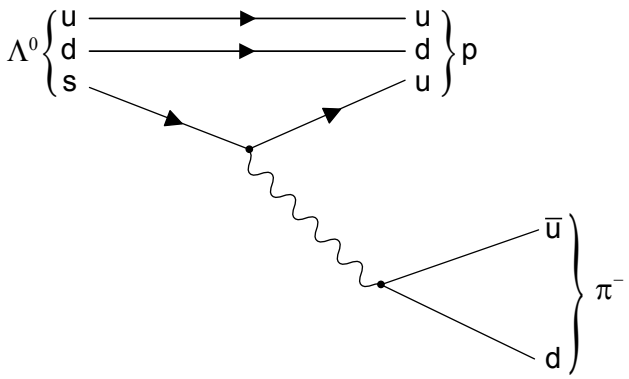
(b) A possible decay of a lambda particle (Λ^0) is shown by the Feynman diagram.



(i) Explain which interaction is responsible for this decay. [2]

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(ii) Draw arrow heads on the lines representing $\bar{u}$ and d in the π^-. [1]

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(Question 5 continued)

(iii) Identify the exchange particle in this decay. [1]

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(c) Outline **one** benefit of international cooperation in the construction or use of high-energy particle accelerators. [1]

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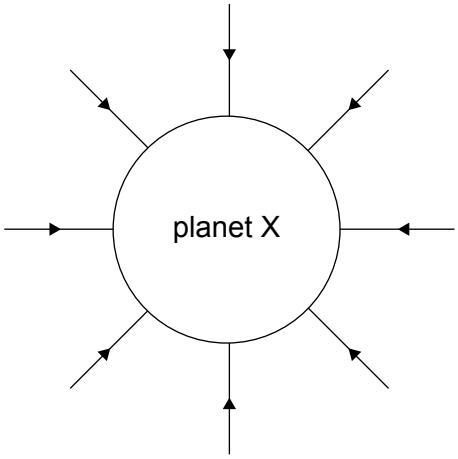
6. The diagram shows the gravitational field lines of planet X.



(a) Outline how this diagram shows that the gravitational field strength of planet X decreases with distance from the surface. [1]

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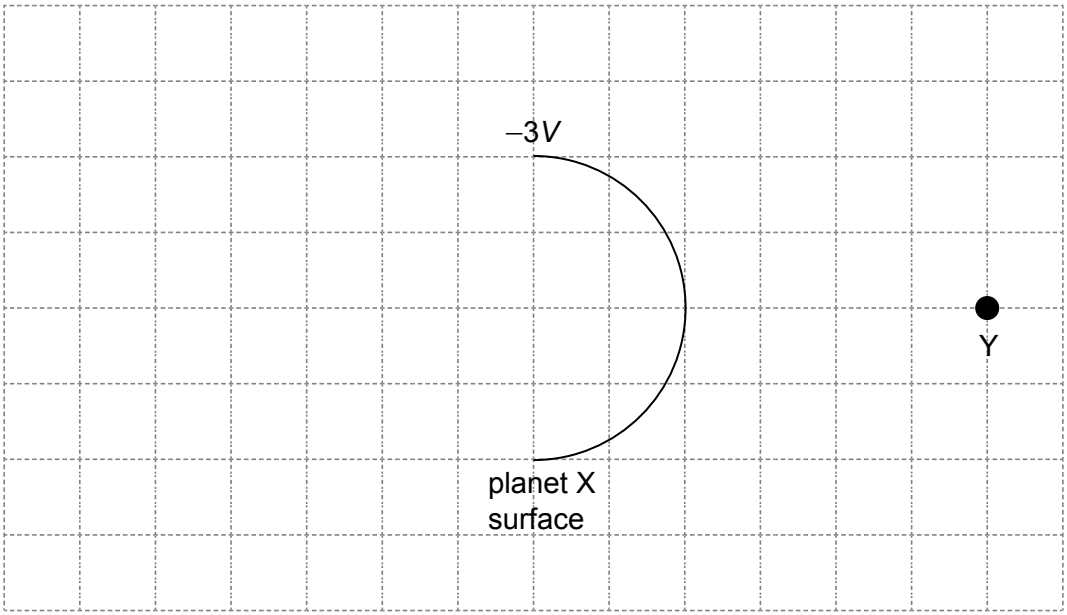
(b) The diagram shows part of the surface of planet X. The gravitational potential at the surface of planet X is $-3V$ and the gravitational potential at point Y is $-V$.



Sketch on the grid the equipotential surface corresponding to a gravitational potential of $-2V$. [2]

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(Question 6 continued)

(c) A meteorite, very far from planet X begins to fall to the surface with a negligibly small initial speed. The mass of planet X is 3.1×10^{21} kg and its radius is 1.2×10^{6} m. The planet has no atmosphere. Calculate the speed at which the meteorite will hit the surface. [3]

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(d) At the instant of impact the meteorite which is made of ice has a temperature of 0 °C. Assume that all the kinetic energy at impact gets transferred into internal energy in the meteorite. Calculate the percentage of the meteorite's mass that melts. The specific latent heat of fusion of ice is $3.3 \times 10^{5}\,\text{J kg}^{-1}$. [2]

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7. A student is investigating a method to measure the mass of a wooden block by timing the period of its oscillations on a spring.

(a) Describe the conditions required for an object to perform simple harmonic motion (SHM). [2]

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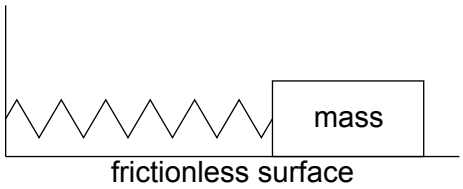
(b) A 0.52 kg mass performs simple harmonic motion with a period of 0.86 s when attached to the spring. A wooden block attached to the same spring oscillates with a period of 0.74 s.



Calculate the mass of the wooden block. [2]

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(c) In carrying out the experiment the student displaced the block horizontally by 4.8 cm from the equilibrium position. Determine the total energy in the oscillation of the wooden block. [3]

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(Question 7 continued)

(d) A second identical spring is placed in parallel and the experiment in (b) is repeated. Suggest how this change affects the fractional uncertainty in the mass of the block. [3]

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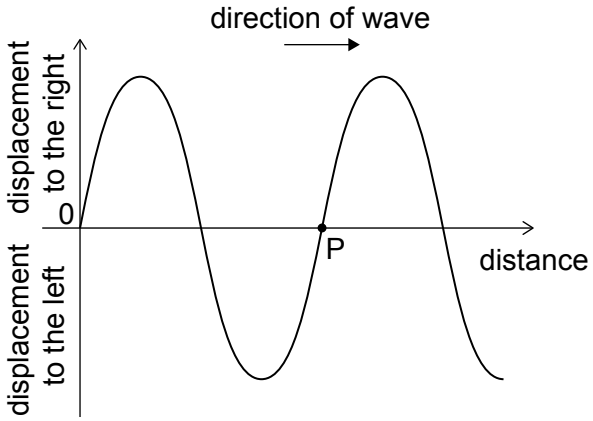
(e) With the block stationary a longitudinal wave is made to travel through the original spring from left to right. The diagram shows the variation with distance x of the displacement y of the coils of the spring at an instant of time.



A point on the graph has been labelled that represents a point P on the spring.

(i) State the direction of motion of P on the spring. [1]

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(ii) Explain whether P is at the centre of a compression or the centre of a rarefaction. [2]

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8. (a) State Faraday's law of induction. [2]

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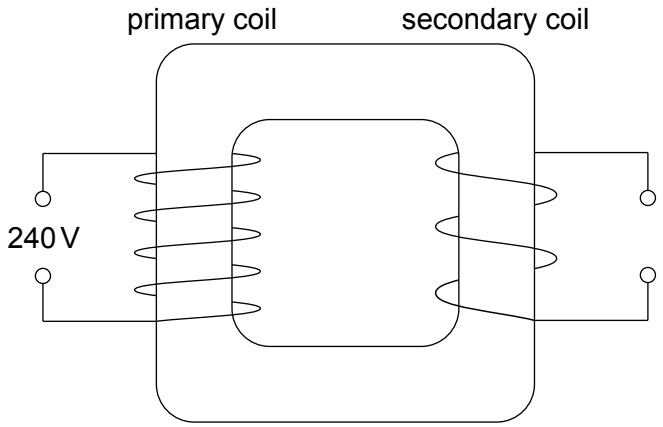
(b) The diagram shows a sketch of an ideal step-down transformer.



The number of turns in the primary coil is 1800 and that in the secondary coil is 90.

(i) Explain, using Faraday's law of induction, how the transformer steps down the voltage. [4]

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(Question 8 continued)

(ii) The input voltage is 240 V. Calculate the output voltage. [2]

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(c) Outline how energy losses are reduced in the core of a practical transformer. [2]

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(d) Step-up transformers are used in power stations to increase the voltage at which the electricity is transmitted. Explain why this is done. [2]

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9. Two observations about the photoelectric effect are

Observation 1: For light below the threshold frequency no electrons are emitted from the metal surface.

Observation 2: For light above the threshold frequency, the emission of electrons is almost instantaneous.

(a) Explain how each observation provides support for the particle theory but not the wave theory of light. [4]

Observation 1: . . . . . .

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Observation 2: . . . . . .

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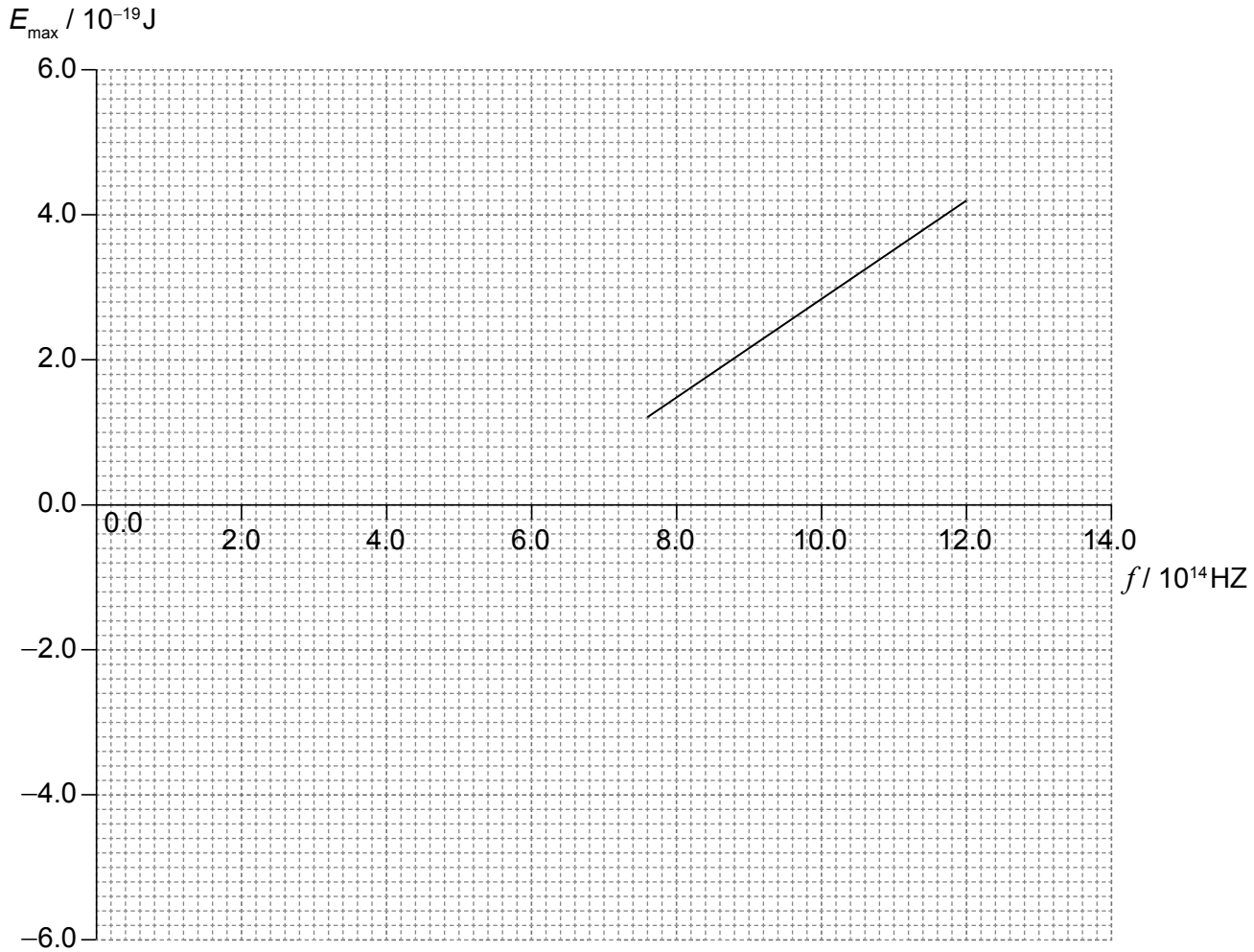
(Question 9 continued)

(b) The graph shows how the maximum kinetic energy E_{max} of electrons emitted from a surface of barium metal varies with the frequency f of the incident radiation.



(i) Determine a value for Planck's constant. [2]

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(Question 9 continued)

(ii) State what is meant by the work function of a metal. [1]

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(iii) Calculate the work function of barium in eV. [2]

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(c) The experiment is repeated with a metal surface of cadmium, which has a greater work function. Draw a second line on the graph to represent the results of this experiment. [2]

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