

Physics
Standard level
Paper 2

Specimen paper

Candidate session number

1 hour 30 minutes

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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]**.



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Answers written on this page
will not be marked.

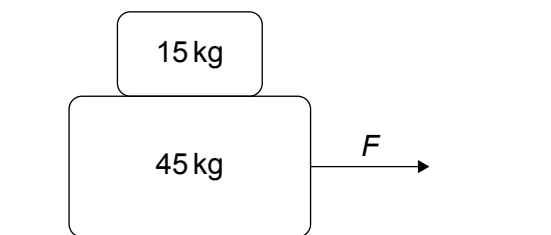


Answer **all** questions. Answers must be written within the answer boxes provided.

1. A block of mass 45 kg is placed on a horizontal table. There is no friction between the block and the table.

An object of mass 15 kg is placed on top of the block.

A force F acts on the block so that it accelerates. The acceleration of the object and the acceleration of the block are the same so that they do not move relative to each other.



The coefficient of static friction between the block and the object is 0.60.

- (a) State the nature and direction of the force that accelerates the 15 kg object. [1]

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- (b) Determine the largest magnitude of F for which the block and the object do not move relative to each other. [3]

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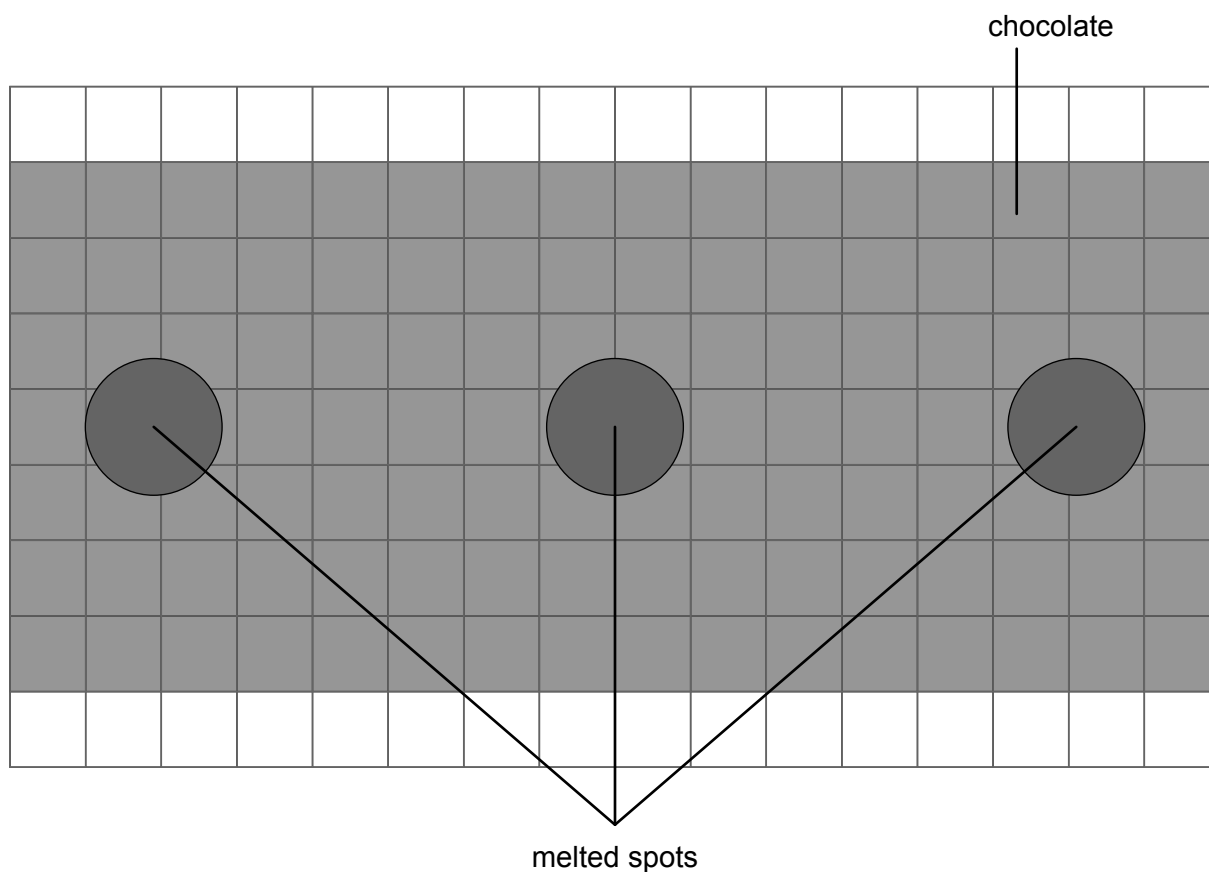
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2. In a microwave oven electromagnetic waves are emitted so that a standing wave pattern is established inside the oven.

A flat piece of chocolate is placed inside the oven and the microwaves are switched on. The chocolate is stationary.

Melted spots form on the surface of the chocolate. The diagram shows the pattern of melting on the chocolate. Each square has a length of 1 cm.



- (a) Outline how this standing wave pattern of melted spots is formed.

[2]

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(Question 2 continued)

- (b) Determine, taking appropriate measurements from the diagram, the frequency of the electromagnetic waves in the oven.

[3]

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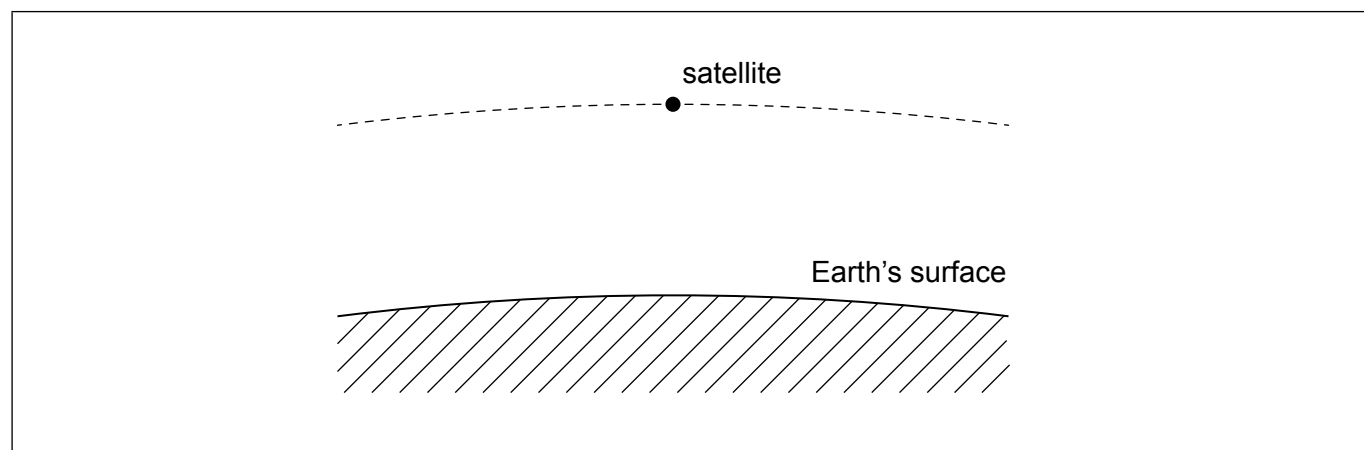


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3. A satellite moves around Earth in a circular orbit.



- (a) Draw an arrow on the diagram to represent the direction of the acceleration of the satellite.

[1]

- (b) The following data are given:

Mass of Earth, $M = 5.97 \times 10^{24} \text{ kg}$

Radius of Earth, $R = 6.37 \times 10^6 \text{ m}$

Orbital period of the satellite, $T = 5.62 \times 10^3 \text{ s}$

- (i) Kepler's Third Law of orbital motion states that $T^2 = kr^3$ where k is a constant and r is the orbital radius of the satellite.

Show that $k = \frac{4\pi^2}{GM}$.

[1]

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- (ii) Determine the height of the satellite above the Earth's surface.

[2]

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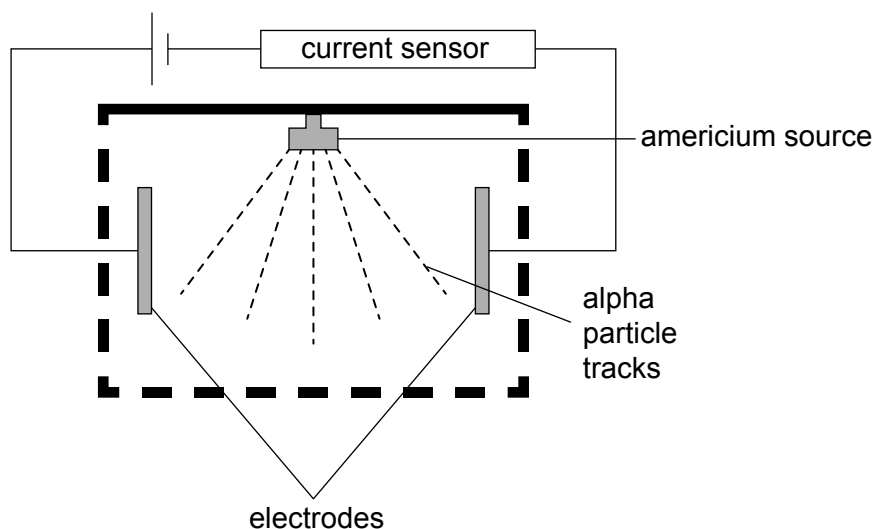
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4. A smoke detector uses the radioactive nuclide americium-241.

The americium is contained in a chamber that is open to the air. There are two electrodes in the chamber that are connected to a power supply and a current sensor.



Americium-241 emits alpha particles that ionize the air in the chamber. Each ionization forms one positive ion and one electron; these are called an ion pair. The electrons and the positive ions move towards the electrodes and the sensor detects a current in the air.

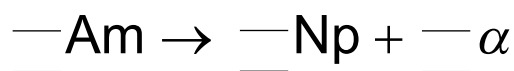
When smoke enters the chamber, fewer ion pairs are formed and the current in the sensor decreases, sounding an alarm.

The chamber is 0.10 m in each dimension.

- (a) A nucleus of americium-241 has 146 neutrons. This nuclide decays to neptunium through alpha emission.

Complete the nuclear equation for this decay.

[2]



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(Question 4 continued)

- (b) Outline why the radioactive source is safe for use in a house.

[1]

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The initial activity of the source is 42 kBq. 33 % of the alpha particles emitted by this source enter the chamber and form an ion pair.

Each alpha particle has an initial kinetic energy of 5.5 MeV.

The energy required to form one ion pair is 15 eV.

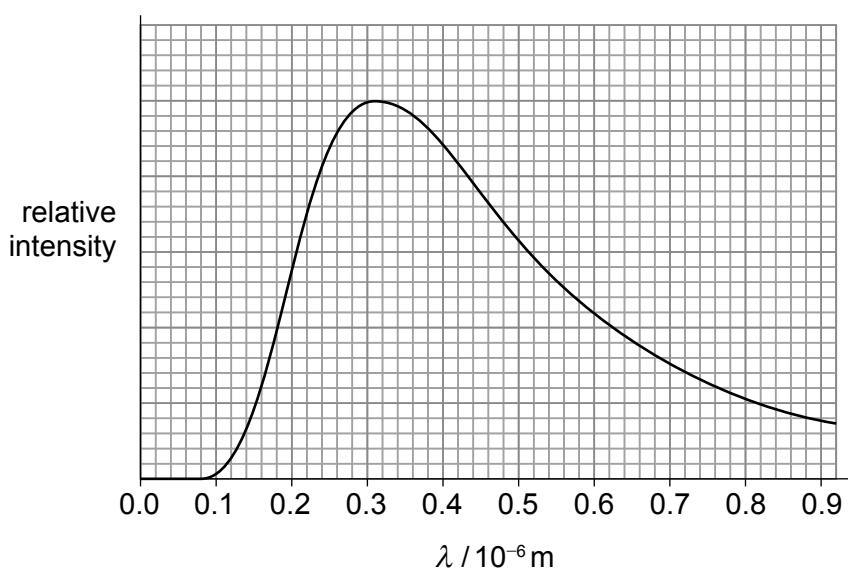
- (c) Calculate the maximum current in the chamber due to the electrons when there is no smoke in the chamber.

[3]

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5. The star δ Vel A is a main sequence star that has a black-body spectrum as shown.



- (a) Show that the surface temperature of δ Vel A is about 9000 K. [1]

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- (b) The apparent brightness of δ Vel A is $2.2 \times 10^{-9} \text{ W m}^{-2}$ and it is $6.2 \times 10^{14} \text{ km}$ from Earth.

Estimate the radius of δ Vel A. [3]

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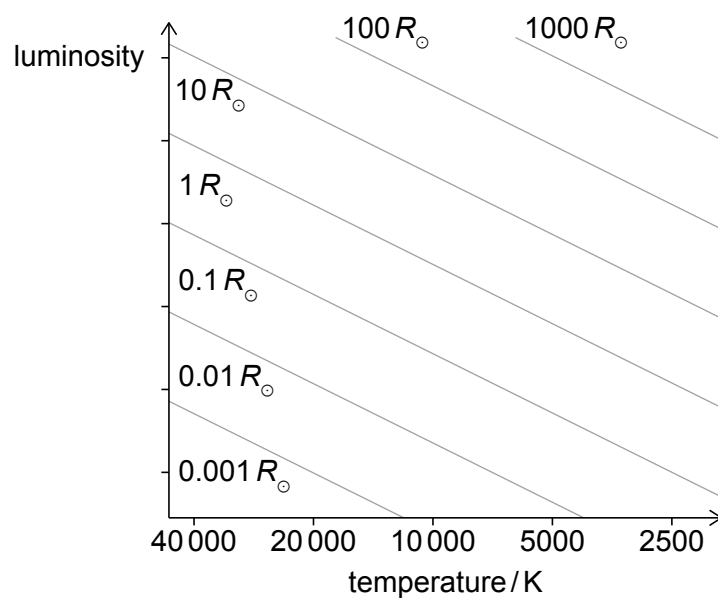


(Question 5 continued)

- (c) The radius of the Sun, $R_{\odot}$, is 7.0×10^5 km.

Sketch, on the Hertzsprung-Russell diagram, the position of δ Vel A.

[2]



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6. Small pieces of solid paraffin with a total mass of 30 g at a temperature of 42 °C are mixed with 150 g of liquid paraffin at a temperature of 240 °C. The mixture is stirred until an equilibrium temperature is reached.

The following data for paraffin are available:

Specific heat capacity of solid paraffin = 0.7 kJ kg⁻¹ K⁻¹
 Specific heat capacity of liquid paraffin = 2.13 kJ kg⁻¹ K⁻¹
 Specific latent heat of fusion of paraffin = 220 kJ kg⁻¹
 Melting point of paraffin = 47 °C

- (a) Calculate the theoretical equilibrium temperature of the mixture. [3]

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- (b) When the experiment was carried out, the equilibrium temperature of the mixture was found to be different from the theoretical value.

Suggest the reason for this difference. [2]

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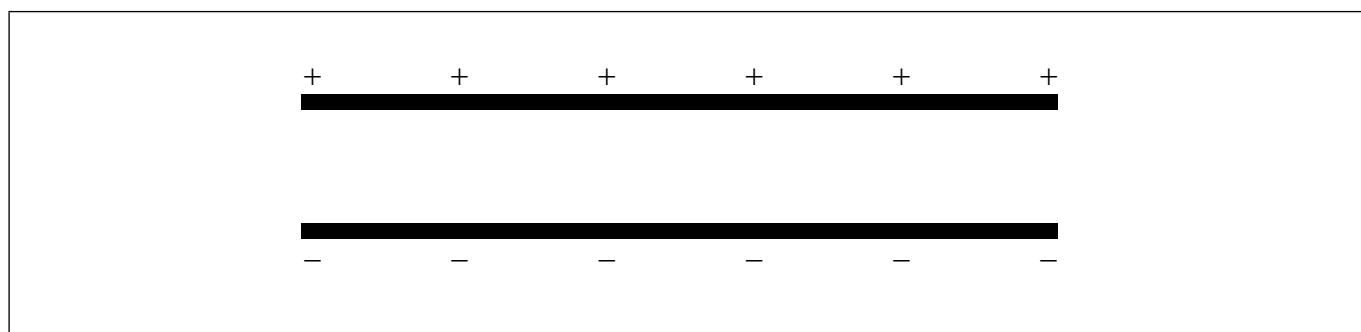
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7. The diagram shows two parallel conducting plates that are oppositely charged.



- (a) (i) Draw the electric field lines due to the charged plates. [2]
- (ii) The potential difference between the plates is 960 V and the distance between them is 8.0 mm. Calculate the electric field strength E between the plates. [2]

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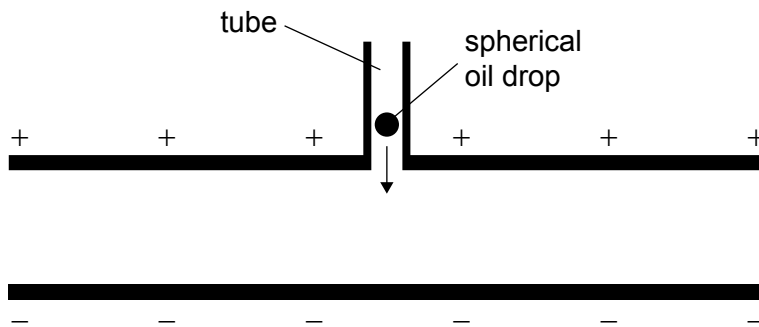
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(Question 7 continued)

In an experiment, an oil drop is introduced into the space between the plates through a small hole in the upper plate. The oil drop moves through air in a tube before falling between the plates.



(b) Explain why the oil drop becomes charged as it falls through the tube.

[1]

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(Question 7 continued)

- (c) The oil drop is observed to be stationary in the space between the plates. Buoyancy is one of the forces acting on the drop.

The density of oil is 730 times greater than that of air.

- (i) Show that the buoyancy force is much smaller than the weight. [3]

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- (ii) Draw the forces acting on the oil drop, ignoring the buoyancy force. [2]



oil drop

(This question continues on the following page)



(Question 7 continued)

- (iii) Show that the electric charge on the oil drop is given by

$$q = \frac{\rho_o g V}{E}$$

where ρ_o is the density of oil and V is the volume of the oil drop. [2]

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- (iv) State the sign of the charge on the oil drop. [1]

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(Question 7 continued)

(d) The electric field is turned off. The oil drop falls vertically reaching a constant speed v .

(i) Outline why, for this drop, $\rho_o g V = 6\pi\eta r v$ where η is the viscosity of air and r is the radius of the oil drop. [2]

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(ii) Show that the charge on the oil drop is about $4.8 \times 10^{-19} \text{ C}$.

The following data for the oil drop are available:

$$r = 1.36 \mu\text{m}$$

$$\eta = 1.60 \times 10^{-5} \text{ Pa s}$$

$$v = 0.140 \text{ mm s}^{-1}$$

[3]

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(iii) The oil drop splits into two parts of equal mass. Both are charged. Deduce the net charge on each part. [2]

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