22096511

International Baccalaureate®
Baccalauréat International
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PHYSICS
STANDARD LEVEL
PAPER 2

Tuesday 12 May 2009 (afternoon)

1 hour 15 minutes

Candidate session number

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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.
- Section A: answer all of Section A in the spaces provided.
- Section B: answer one question from Section B in the spaces provided.
- At the end of the examination, indicate the numbers of the questions answered in the candidate box on your cover sheet.

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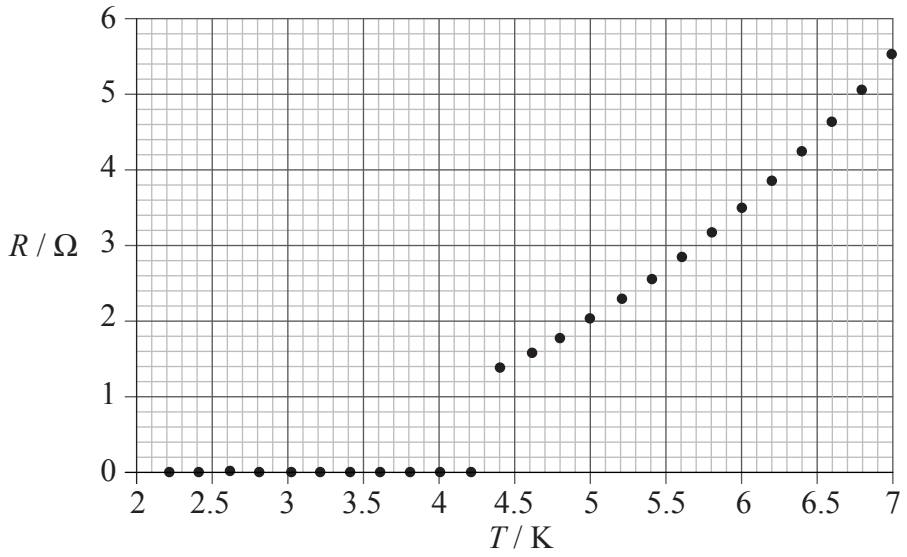
SECTION A

*Answer **all** the questions in the spaces provided.*

A1. This question is about electrical resistance of the metal mercury.

The resistance R of a sample of mercury was measured as a function of the temperature T of the sample. The sample was cooled and data points were taken at temperature intervals of 0.2 K. The uncertainties in R and T are too small to be shown on the graph.



The hypothesis is that resistance is proportional to absolute temperature for temperatures greater than 4.5 K.

(a) (i) Suggest whether the data supports the hypothesis. *[1]*

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(ii) Draw a line of best fit through the data. *[2]*

(b) State the value of R for which the rate of change of resistance of the sample with temperature is least. *[1]*

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(This question continues on the following page)

(Question A1 continued)

(c) At a temperature T_C the resistance suddenly becomes zero.

(i) Use the graph to determine the possible range of the temperature T_C. *[1]*

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(ii) State, to the correct number of significant figures, the value of T_C and its uncertainty. *[2]*

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(iii) Outline how the temperature T_C could be measured more precisely. *[1]*

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(d) Outline **two** reasons why you could not use the data to determine an accurate value for R at room temperature. *[2]*

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A2. This question is about impulse.

(a) A net force of magnitude F acts on a body. Define the *impulse* I of the force. *[1]*

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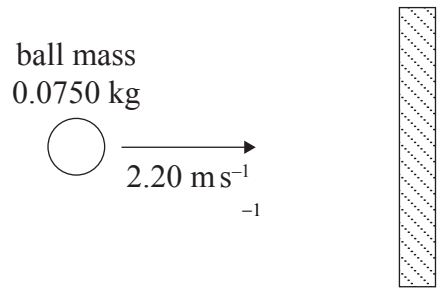
(b) A ball of mass 0.0750 kg is travelling horizontally with a speed of 2.20 $m\,s^{-1}$. It strikes a vertical wall and rebounds horizontally.



Due to the collision with the wall, 20 % of the ball's initial kinetic energy is dissipated.

(i) Show that the ball rebounds from the wall with a speed of 1.97 $m\,s^{-1}$. *[2]*

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(ii) Show that the impulse given to the ball by the wall is 0.313 N s. *[2]*

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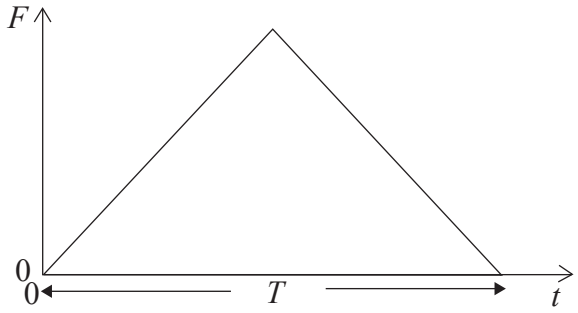
(This question continues on the following page)

(Question A2 continued)

(c) The ball strikes the wall at time $t = 0$ and leaves the wall at time $t = T$.

The sketch graph shows how the force F that the wall exerts on the ball is assumed to vary with time t.



The time T is measured electronically to equal 0.0894 s.

Use the impulse given in (b)(ii) to estimate the average value of F. *[4]*

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A3. This question is about energy transfers.

(a) Energy degradation takes place in the energy transformations which occur in the generation of electrical power. Explain what is meant in this context by energy degradation. *[2]*

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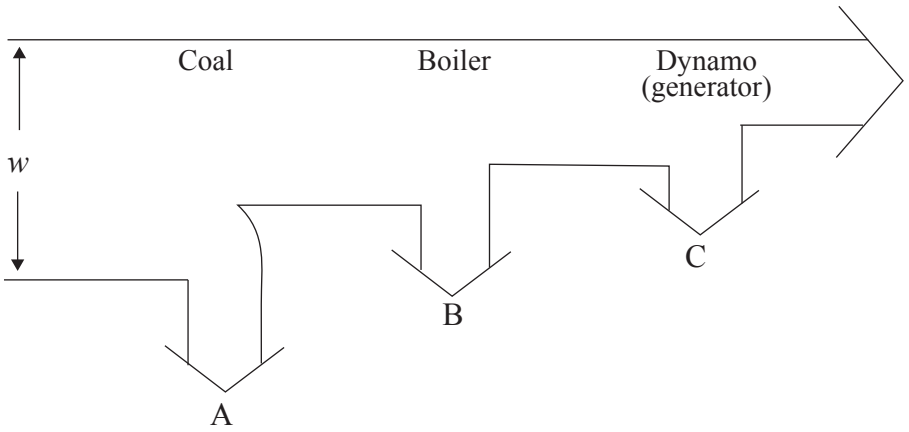
Some of the energy transformations that take place in a coal-fired power station are represented by the Sankey diagram below.



(b) (i) State what is represented by the width *w*. *[1]*

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(ii) At the three places marked A, B and C on the diagram, energy is degraded. Identify the process by which the energy is degraded in each of the places. *[3]*

A: . . . . . .

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B: . . . . . .

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C: . . . . . .

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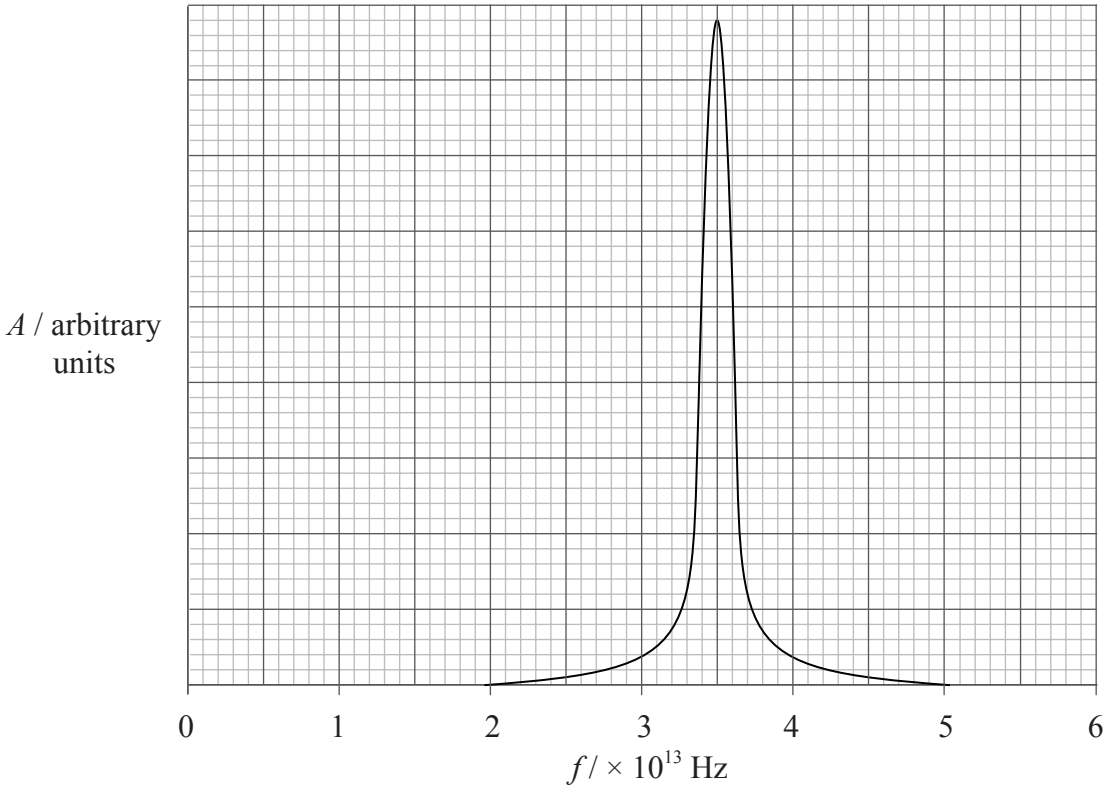
SECTION B

*This section consists of three questions: B1, B2, and B3. Answer **one** question.*

B1. This question is in **two** parts. **Part 1** is about greenhouse effect and **Part 2** is about motion of a ball falling in oil.

Part 1 Greenhouse effect

(a) The graph shows part of the absorption spectrum of nitrogen oxide (N_2O) in which the intensity of absorbed radiation A is plotted against frequency f.



(i) State the region of the electromagnetic spectrum to which the resonant frequency of nitrogen oxide belongs. *[1]*

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(ii) Using your answer to (a)(i), explain why nitrogen oxide is classified as a greenhouse gas. *[2]*

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(This question continues on the following page)

(Question B1, part 1 continued)

(b) Define *emissivity* and *albedo*. *[3]*

Emissivity: . . . . . .

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Albedo: . . . . . .

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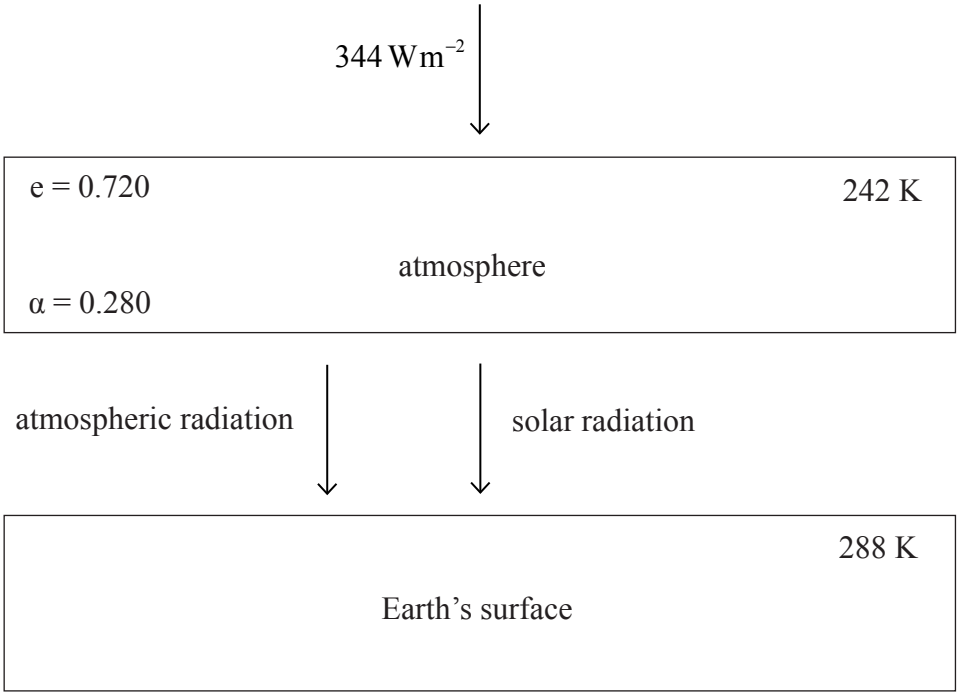
(c) The diagram shows a simple energy balance climate model in which the atmosphere and the surface of Earth are two bodies each at constant temperature. The surface of the Earth receives both solar radiation and radiation emitted from the atmosphere. Assume that the Earth's surface behaves as a black body.



The following data are available for this model.

average temperature of the atmosphere of Earth	= 242 K
emissivity, e of the atmosphere of Earth	= 0.720
average albedo, α of the atmosphere of Earth	= 0.280
solar intensity at top of atmosphere	= 344 W m^{-2}
average temperature of the surface of Earth	= 288 K

(This question continues on the following page)

(Question B1, Part 1 (c) continued)

Use the data to show that the

(i) power radiated per unit area of the atmosphere is $140\,\text{W}\,\text{m}^{-2}$. *[2]*

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(ii) solar power absorbed per unit area at the surface of the Earth is $248\,\text{W}\,\text{m}^{-2}$. *[1]*

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(d) It is hypothesized that, if the production of greenhouse gases were to stay at its present level then the temperature of the Earth's atmosphere would eventually rise by 6.0 K. Calculate the power per unit area that would then be

(i) radiated by the atmosphere. *[1]*

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(ii) absorbed by the Earth's surface. *[1]*

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(e) Estimate, using your answer to (d)(ii), the increase in temperature of Earth's surface. *[3]*

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(Question B1 continued)

Part 2 Motion of a ball falling in oil

(a) Distinguish between average speed and instantaneous speed. *[2]*

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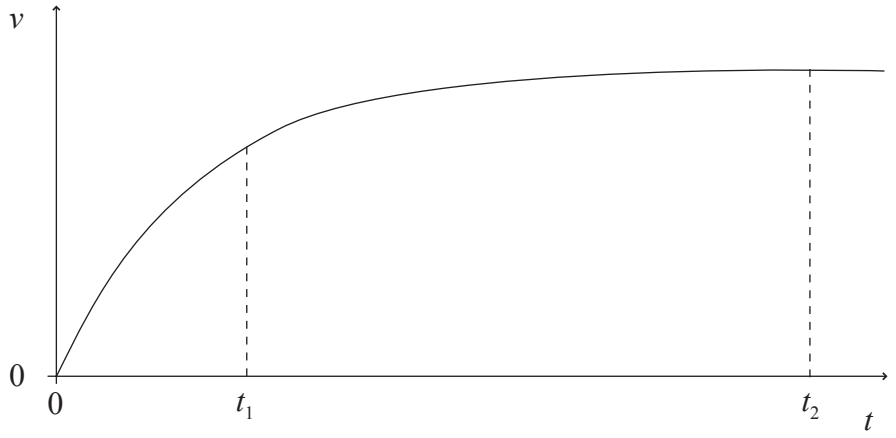
(b) A small steel ball of mass M is dropped from rest into a long vertical tube that contains oil.

The sketch graph shows how the speed v of the ball varies with time t.



Explain how you would use the graph to find the average speed of the ball between $t = 0$ and $t = t_1$. *[3]*

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(Question B1, part 2 continued)

(c) The gradient of the graph at $t = t_1$ is k. Deduce an expression in terms of k, M and g, the acceleration of free fall, for the magnitude of the frictional force F acting on the ball at $t = t_1$. *[3]*

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(d) State and explain the magnitude of the frictional force acting on the ball at $t = t_2$. *[3]*

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B2. This question is in **two** parts. **Part 1** is about simple harmonic motion and waves and **Part 2** is about the decay of radium-226.

Part 1 Simple harmonic motion and waves

(a) A particle of mass m that is attached to a light spring is executing simple harmonic motion in a **horizontal direction**.

State the condition relating to the net force acting on the particle that is necessary for it to execute simple harmonic motion. *[2]*

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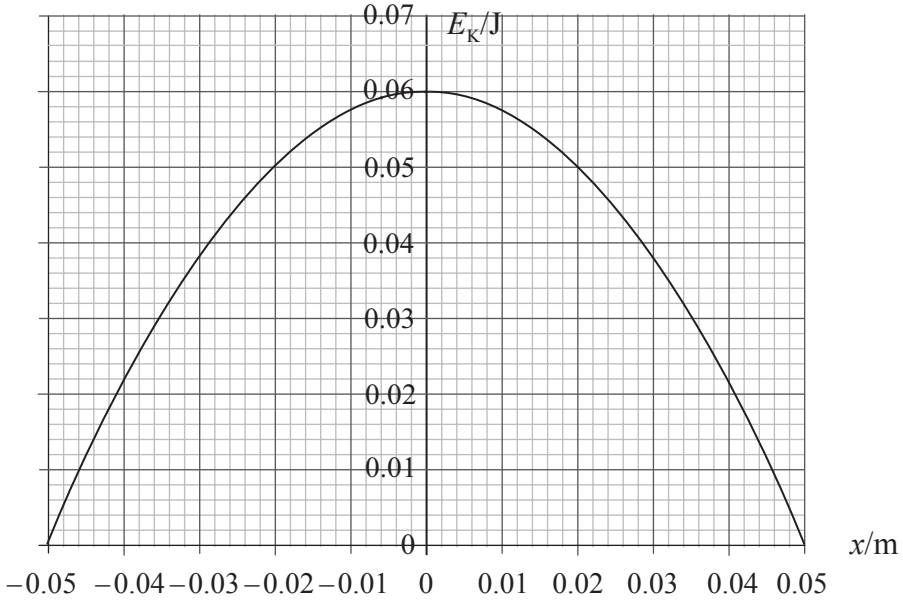
(b) The graph shows how the kinetic energy E_K of the particle in (a) varies with the displacement x of the particle from equilibrium.



(i) Using the axes above, sketch a graph to show how the potential energy of the particle varies with the displacement x. *[2]*

(This question continues on the following page)

(Question B2, Part 1 continued)

(ii) The mass of the particle is 0.30 kg. Use data from the graph to show that the frequency f of oscillation of the particle is 2.0 Hz. *[4]*

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(c) The particles of a medium M_1 through which a transverse wave is travelling, oscillate with the same frequency and amplitude as that of the particle in (b).

(i) Describe, with reference to the propagation of energy through the medium, what is meant by a transverse wave. *[2]*

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(ii) The speed of the wave is 0.80 m s^{-1}. Calculate the wavelength of the wave. *[1]*

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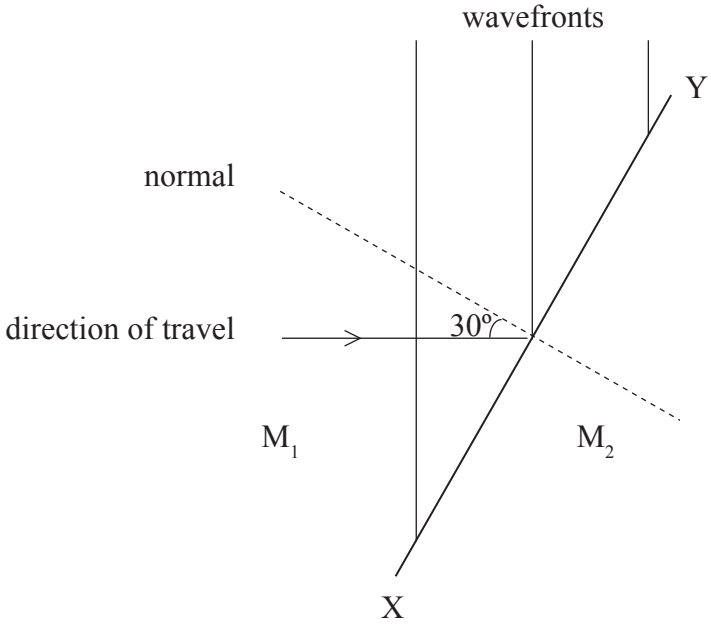
(Question B2, part 1 (b) continued)

(d) The diagram shows wavefronts of the waves in (c) incident on a boundary XY between medium M_1 and another medium M_2.



The angle between the normal, and the direction of travel of the wavefronts is $30°$.

(i) The speed of the wave in M_1 is $0.80\,m\,s^{-1}$. The speed of the waves in M_2 is $1.2\,m\,s^{-1}$. Calculate the angle between the direction of travel of the wavefronts in M_2 and the normal. *[3]*

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(ii) On the diagram, sketch the wavefronts in M_2. *[1]*

(This question continues on the following page)

(Question B2 continued)

Part 2 Decay of radium-226

(a) A nucleus of the isotope radium-226 (Ra) undergoes α-decay with a half life of 1.6×10^3 yr to form a nucleus of radon (Rn).

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

Isotope: . . . . . .

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Half-life: . . . . . .

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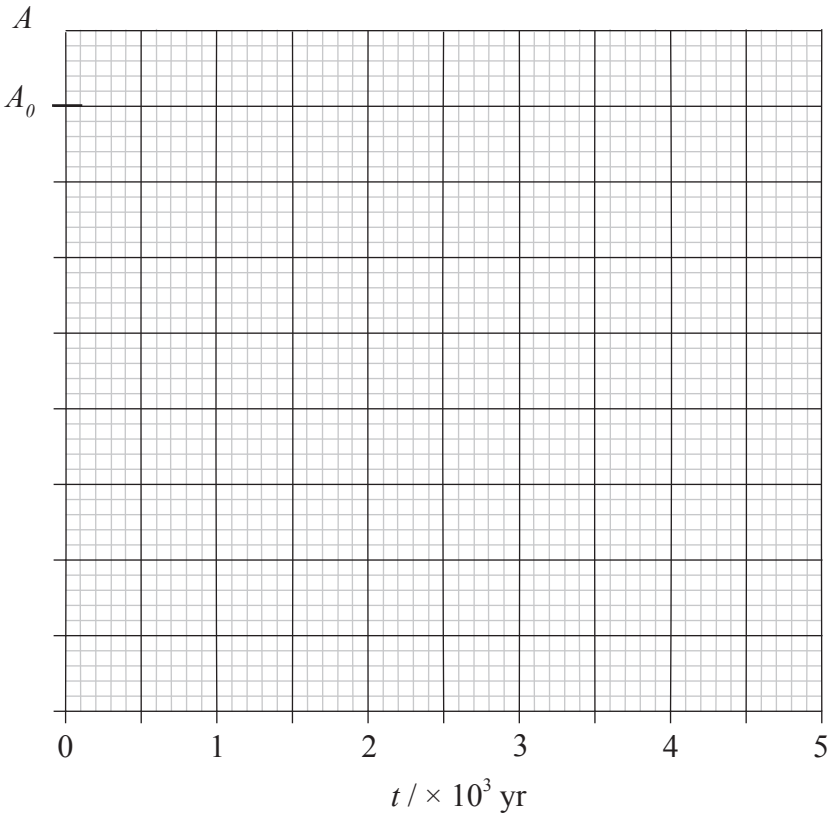
(b) Using the grid below, sketch a graph to show how the activity A of a sample of radium-226 (Ra) would be expected to vary with time t over a period of about 5.0×10^3 yr. The activity of the sample at time $t = 0$ is A_0. *[3]*



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(Question B2, Part 2 continued)

(c) The nuclear reaction equation for the decay of radium-226 (Ra) may be written as

$$^{226}_{88}\text{Ra} = \text{Rn} + \alpha$$

(i) State the value of the proton number and neutron number of the isotope of radon (Rn). *[1]*

Proton number: . . . . . .

Neutron number: . . . . . .

(ii) Outline why the binding energy of Ra is less than that of Rn. *[2]*

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(d) The following data are available.

mass of Ra = 226.0254 u
mass of Rn = 222.0175 u
mass of α = 4.0026 u

Show that the energy released in the decay of a Ra nucleus is 4.94 MeV. *[2]*

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B3. This question is in **two** parts. **Part 1** is about internal energy, heat and ideal gases and **Part 2** is about electric fields and electric circuits.

Part 1 Internal energy, heat and ideal gases

(a) The internal energy of a piece of copper is increased by heating.

(i) Explain what is meant, in this context, by internal energy and heating. *[3]*

Internal energy: . . . . . .

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Heating: . . . . . .

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(ii) The piece of copper has mass 0.25 kg. The increase in internal energy of the copper is 1.2×10^3 J and its increase in temperature is 20 K. Estimate the specific heat capacity of copper. *[2]*

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(b) An ideal gas is kept in a cylinder by a piston that is free to move. The gas is heated such that its internal energy increases and the pressure remains constant. Use the molecular model of ideal gases to explain

(i) the increase in internal energy. *[1]*

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(ii) how the pressure remains constant. *[3]*

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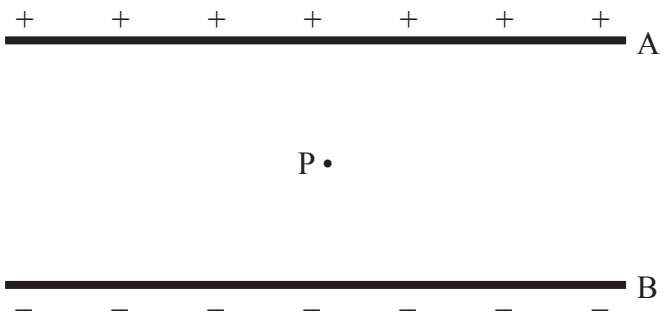
(Question B3 continued)

Part 2 Electric fields and electric circuits

(a) Two parallel, charged metal plates A and B are in a vacuum.



At a particular instant an electron is at point P.

On the diagram, draw

(i) the electric field pattern due to the plates. *[3]*

(ii) an arrow to represent the direction of the force on the electron at P. *[1]*

(b) The acceleration of the electron at P is $8.8\times10^{14}\,\text{m s}^{-2}$. Determine the magnitude of the electric field strength at the point P. *[3]*

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(c) The electric potential energy of the electron changes by $1.9\times10^{-17}\,\text{J}$ as it moves from one plate to the other. Show that the potential difference between the plates is 120 V. *[1]*

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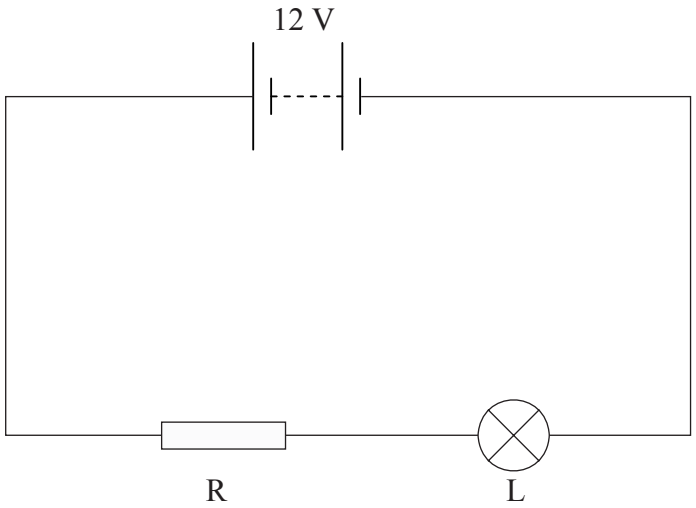
(This question continues on the following page)

(Question B3, part 2 continued)

(d) A resistor R and a filament lamp L are connected in series with a battery. The battery has an emf of 12 V and internal resistance 4.0 Ω. The potential difference across the filament of the lamp is 3.0 V and the current in the filament is 0.25 A.



(i) Define *emf* and describe the concept of internal resistance. *[2]*

emf:

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Internal resistance:

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(ii) Calculate the total power supplied by the battery. *[1]*

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(iii) Calculate the power dissipated in the external circuit. *[2]*

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(Question B3, part 2 (d) continued)

(iv) Determine the resistance of the resistor R. *[3]*

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