IB DIPLOMA PROGRAMME
PROGRAMME DU DIPLÔME DU BI
PROGRAMA DEL DIPLOMA DEL BI

SPEC/4/PHYSI/SP2/ENG/TZ0/XX

PHYSICS
STANDARD LEVEL
PAPER 2

SPECIMEN PAPER

1 hour 15 minutes

Candidate session number

0	0							

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.

23 pages

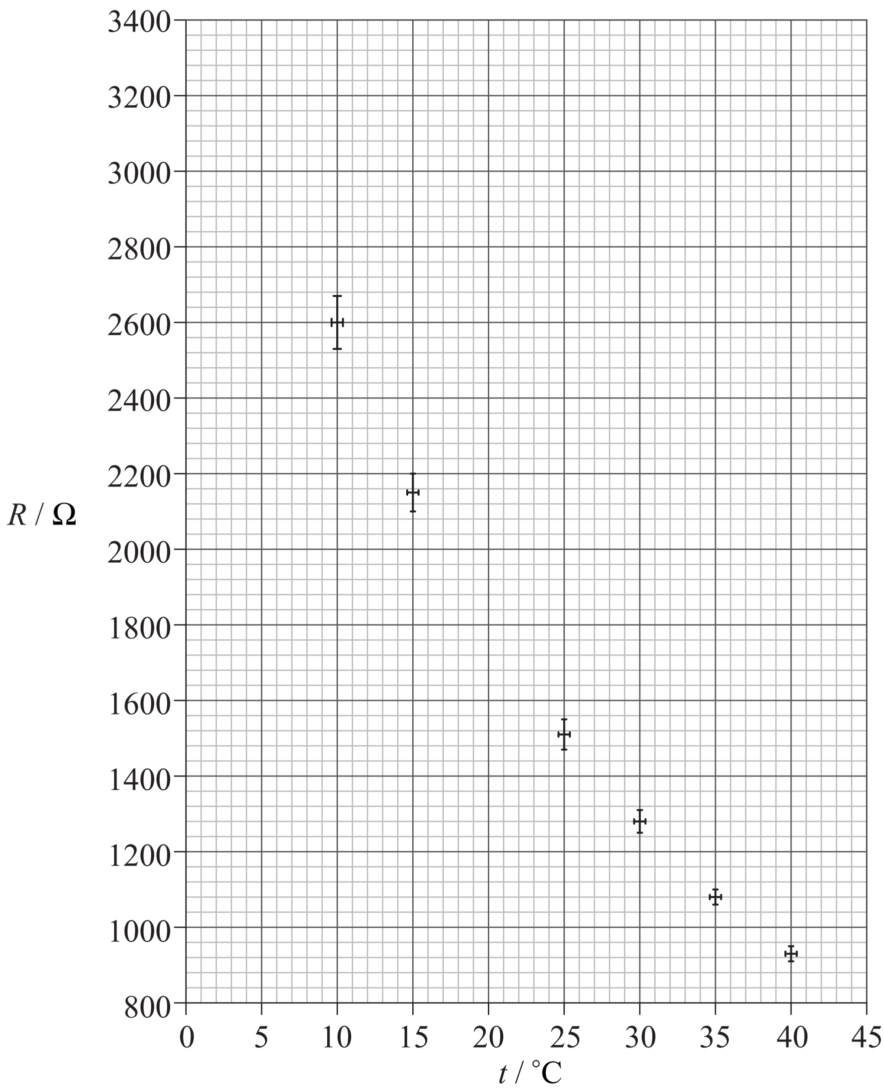
SECTION A

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

A1. Some data for the resistance *R* of an electrical component at different temperatures are shown below.

t / °C	*R* / Ω
10.0	2600
15.0	2150
25.0	1510
30.0	1280
35.0	1080
40.0	925

A graph of the variation with temperature *t* of the resistance *R* of the component is shown below. Error bars have been included.



(This question continues on the following page)

(Question A1 continued)

(a) Estimate the

(i) uncertainty range in the temperature measurements. *[1]*

. . . .

(ii) percentage uncertainty in the resistance at 10.0 °C. *[2]*

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(b) Use the graph to determine the

(i) most probable resistance of the component at 20.0 °C and at 5.0 °C.

Resistance at 20.0 °C . . . . *[1]*

Resistance at 5.0 °C . . . . *[2]*

(ii) rate of change of resistance with temperature at 20.0 °C. *[3]*

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(c) The relationship between resistance and temperature is not linear. Describe, and explain, the evidence for a non-linear relationship that is provided by the graph. *[2]*

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(This question continues on the following page)

(Question A1 continued)

(d) A student suggests that the relationship between the resistance R and temperature is of the form

$$R = \frac{c}{T}$$

where c is a constant and T is the thermodynamic (absolute) temperature.

Use data from the table to determine, without drawing a graph, whether this suggestion is correct. *[3]*

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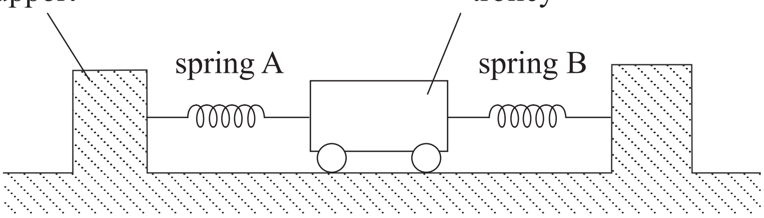
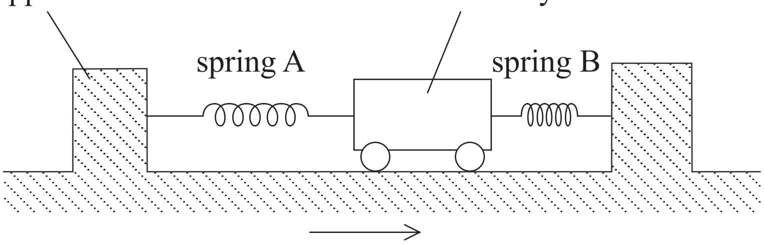
A2. Two identical springs A and B each have a force constant (force per unit extension) of 2.5 $N\,cm^{-1}$. One end of each spring is attached to a trolley and the other ends are attached to rigid supports, as shown.



The springs are horizontal and, when the trolley is at rest, the extension of each spring is 3.0 cm. The trolley is displaced 1.2 cm to the right.



(a) Calculate the magnitude of the force on the trolley due to

(i) spring A alone. *[2]*

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(ii) spring B alone. *[1]*

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(b) The trolley is released. Determine the initial acceleration of the trolley of mass 0.75 kg. *[2]*

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A3. This question is about gravitational fields.

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

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(b) The gravitational field strength at the surface of Jupiter is $25\,\text{N}\,\text{kg}^{-1}$ and the radius of Jupiter is $7.1 \times 10^{7}\,\text{m}$.

(i) Derive an expression for the gravitational field strength at the surface of a planet in terms of its mass M, its radius R and the gravitational constant G. *[2]*

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(ii) Use your expression in (b)(i) above to estimate the mass of Jupiter. *[2]*

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SECTION B

This section consists of two questions: B1 and B2. Answer ***one*** *question.*

B1. This question is in **two** parts. **Part 1** is about momentum and **Part 2** is about simple harmonic motion and its connection with the greenhouse effect.

Part 1 Momentum

(a) Define

(i) *linear momentum*. *[1]*

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(ii) *impulse*. *[1]*

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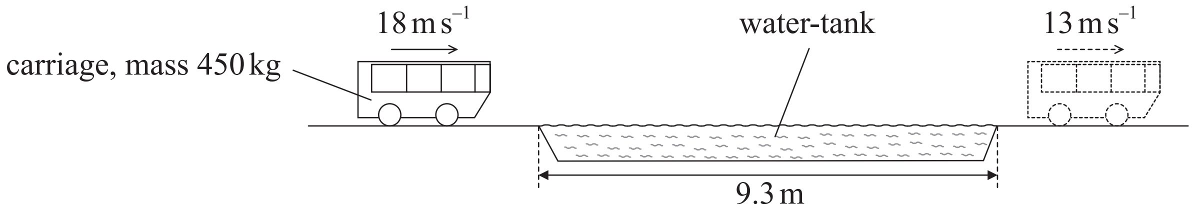
(This question continues on the following page)

(Question B1, part 1 continued)

(b) In a ride in a pleasure park, a carriage of mass 450 kg is travelling horizontally at a speed of $18\,\text{m}\,\text{s}^{-1}$. It passes through a shallow tank containing stationary water. The tank is of length 9.3 m. The carriage leaves the tank at a speed of $13\,\text{m}\,\text{s}^{-1}$.



As the carriage passes through the tank, the carriage loses momentum and causes some water to be pushed forwards with a speed of $19\,\text{m}\,\text{s}^{-1}$ in the direction of motion of the carriage.

(i) For the carriage passing through the water-tank, deduce that the magnitude of its total change in momentum is 2250 N s. *[1]*

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(ii) Use the answer in (b)(i) to deduce that the mass of water moved in the direction of motion of the carriage is approximately 120 kg. *[2]*

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(iii) Calculate the mean value of the magnitude of the acceleration of the carriage in the water. *[3]*

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(This question continues on the following page)

(Question B1, part 1 continued)

(c) For the carriage in (b) passing through the water-tank, determine

(i) its total loss in kinetic energy. *[3]*

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(ii) the gain in kinetic energy of the water that is moved in the direction of motion of the carriage. *[1]*

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(d) By reference to the principles of conservation of momentum and of energy, explain your answers in (c). *[3]*

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B1.

Part 2 Simple harmonic motion and the greenhouse effect

(a) A body is displaced from equilibrium. State the **two** conditions necessary for the body to execute simple harmonic motion. *[2]*

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2. . . . .

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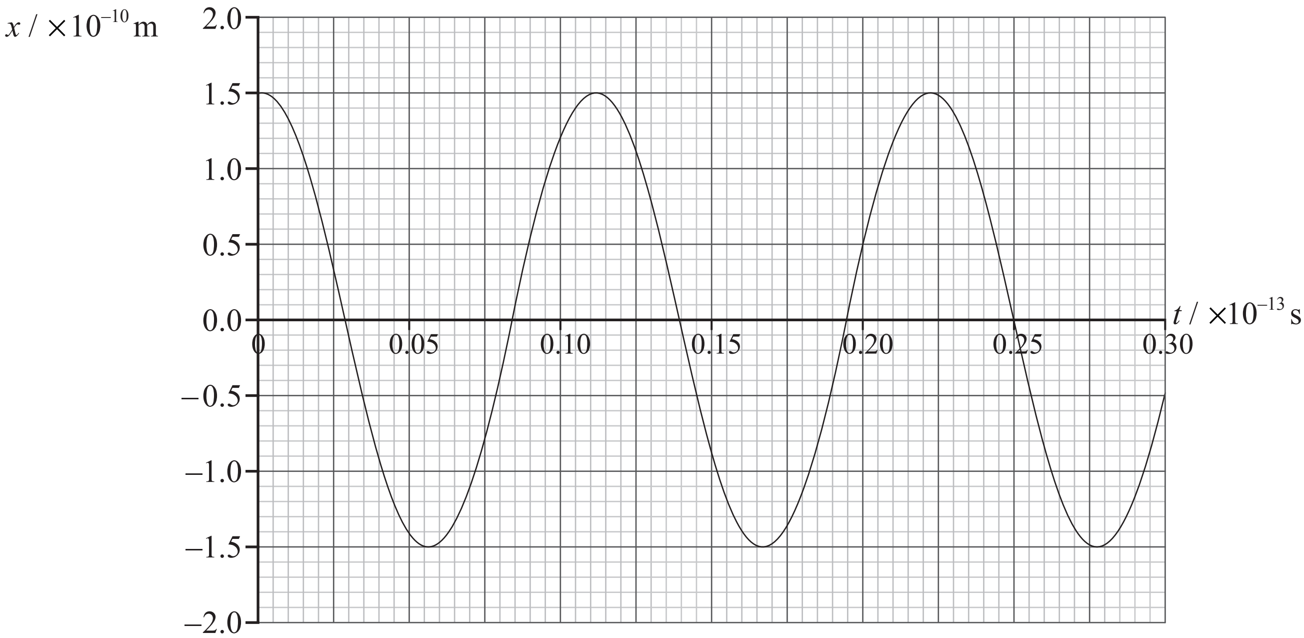
(This question continues on the following page)

(Question B1, part 2 continued)

(b) In a simple model of a methane molecule, a hydrogen atom and the carbon atom can be regarded as two masses attached by a spring. A hydrogen atom is much less massive than the carbon atom such that any displacement of the carbon atom may be ignored.

The graph below shows the variation with time t of the displacement x from its equilibrium position of a hydrogen atom in a molecule of methane.



The mass of hydrogen atom is 1.7×10^{-27} kg. Use data from the graph above

(i) to determine its amplitude of oscillation. *[1]*

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(ii) to show that the frequency of its oscillation is 9.1×10^{13} Hz. *[2]*

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(iii) to show that the maximum kinetic energy of the hydrogen atom is 6.2×10^{-18} J. *[2]*

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(This question continues on the following page)

(Question B1, part 2 continued)

(c) Assuming that the motion of the hydrogen atom is simple harmonic, its frequency of oscillation f is given by the expression

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m_p}},$$

where k is the force per unit displacement between a hydrogen atom and the carbon atom and m_p is the mass of a proton.

(i) Show that the value of k is approximately $560\,\mathrm{N\,m^{-1}}$. *[1]*

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(ii) Estimate, using your answer to (c)(i), the maximum acceleration of the hydrogen atom. *[2]*

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B2. This question is in **two** parts. **Part 1** is about latent heat and specific heat and **Part 2** is about linear motion.

Part 1 Latent heat and specific heat

(a) (i) Define *specific latent heat of vaporization*. *[2]*

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(ii) Energy is supplied to a boiling liquid at a constant rate. Describe, in terms of molecular behaviour, why the temperature of the liquid remains constant. *[3]*

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(This question continues on the following page)

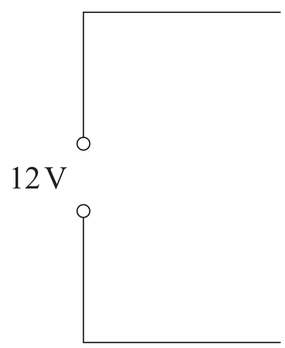
(Question B2, part 1 continued)

(b) A student determines the latent heat of vaporization of water by an electrical method. An electrical heater is used to boil water. When the water is boiling at a steady rate, the mass of water evaporated per minute is determined. The mass is determined for two different powers of the heater and the results are shown in the table below.

power of heater / *W*	**mass of water evaporated per minute / *g***
80.0	1.89
35.0	0.70

The power of the heater is determined using an ammeter and a voltmeter.

(i) The heater is labelled 9.0 V, 80.0 W. In the space below, draw an electrical circuit to show how the heater may be used correctly with a constant 12 V supply to provide different powers to the heater. Include the ammeter and voltmeter in your circuit. *[2]*



(ii) Calculate the current in the heater for a power output of 80.0 W. *[2]*

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(iii) Use the data in the table above to determine a value for the specific latent heat of vaporization of water. *[4]*

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(Question B2, part 1 continued)

(c) In one particular make of electric kettle, the heater must always be immersed in water when the kettle is in use. The minimum volume of water that can be heated is $650\,cm^3$.

The kettle is used six times each day to boil water for a single cup of tea. The cup has a volume of $350\,cm^3$. The mass of $1.0\,cm^3$ of water is 1.0 g.

(i) Calculate the mass of water that is heated, but not used, during one day. *[1]*

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(ii) The initial temperature of the water in the kettle before heating is 18°C. The specific heat capacity of water is $4.2\times10^3\,J\,kg^{-1}\,K^{-1}$. Deduce that the electrical energy wasted each day is $6.2\times10^5\,J$. *[1]*

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(iii) The cost of 1.0 MJ of electrical energy is 3.5 cents. Estimate the cost of the energy that is used each year to heat water that is not used to make tea. *[2]*

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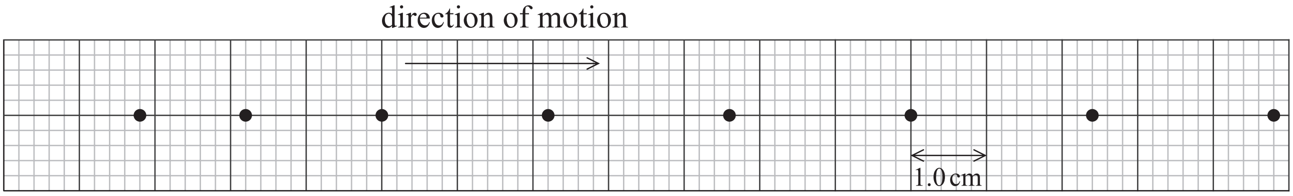
(This question continues on the following page)

(Question B2 continued)

Part 2 Linear motion

A car moves along a straight road. At time $t = 0$ the car starts to move from rest and oil begins to drip from the engine of the car. One drop of oil is produced every 0.80 s. Oil drops are left on the road. The position of the oil drops are drawn to scale on the grid below such that 1.0 cm represents 4.0 m. The grid starts at time $t = 0$.



(a) (i) State the feature of the diagram above which indicates that, initially, the car is accelerating. *[1]*

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(ii) On the grid above, draw further dots to show where oil would have dripped if the drops had been produced from the time when the car had started to move. *[2]*

(iii) Determine the distance moved by the car during the first 5.6 s of its motion. *[1]*

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(b) Using information from the grid above, determine for the car,

(i) the final constant speed. *[2]*

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(ii) the initial acceleration. *[2]*

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