Diploma Programme
Programme du diplôme
Programa del Diploma

Physics
Standard level
Paper 2

8 November 2024

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

Candidate session number

1 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 **[50 marks].**

8824 – 9594

16 pages

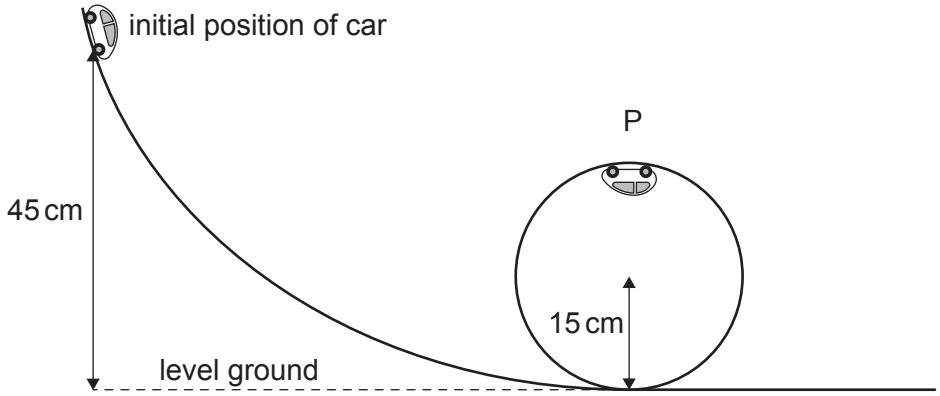
Please **do not** write on this page.

Answers written on this page
will not be marked.

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

1. (a) In a "loop-the-loop" toy, a car of mass 0.12 kg is released from rest. The initial position of the car is 45 cm above level ground. The radius of the circular loop is 15 cm. The car reaches the top of the loop at position P. Frictional and air resistance forces are negligible.

diagram not to scale



(i) Show that the speed of the car at P is 1.7 m s^{-1}. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

(ii) Determine the normal force exerted by the loop on the car at P. [3]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

(iii) State why the car stays in contact with the loop. [1]

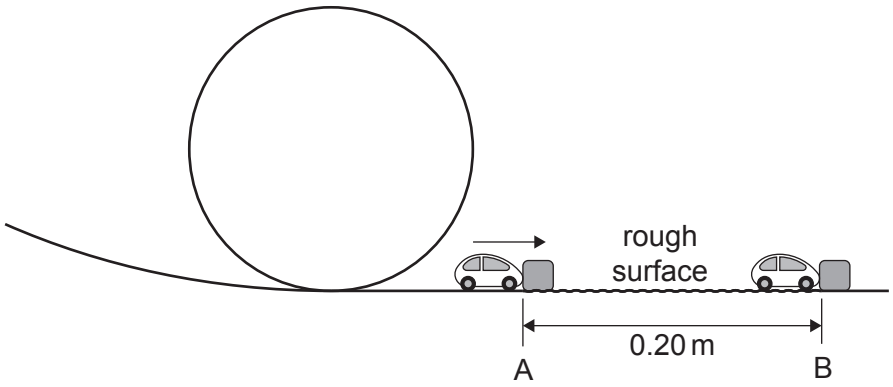
. . . . . .
. . . . . .

(This question continues on the following page)

(Question 1 continued)

(b) At point A the car collides with a block of mass 0.18 kg and sticks to it. After the collision, the car and the block move together with speed $1.2\,m\,s^{-1}$.

diagram not to scale



(i) Calculate the speed of the car just before it collides with the block. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(ii) The surface from A to B is rough and the combined car and block come to rest at B. The distance AB is 0.20 m. Determine the rate of change of momentum of the combined car and block from A to B. [3]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 1 continued)

(iii) Calculate the dynamic coefficient of friction between the rough surface and the combined car and block. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Please **do not** write on this page.

Answers written on this page
will not be marked.

2. (a) Outline, by reference to Newton's third law, how a gas in a container exerts pressure on the container walls. [2]

. . . . . .

. . . . . .

. . . . . .

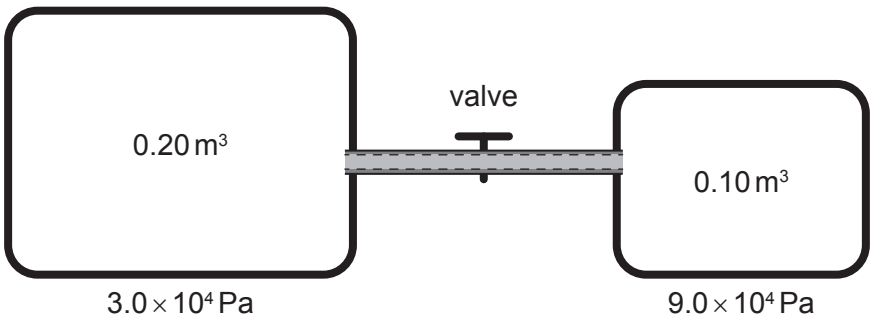
. . . . . .

(b) State **one** difference between an ideal gas and a real gas. [1]

. . . . . .

. . . . . .

(c) Two containers of volume $0.20\,m^3$ and $0.10\,m^3$ are filled with an ideal gas. The pressure in the larger container is 3.0×10^4 Pa. The pressure in the smaller container is 9.0×10^4 Pa. The temperature of the gas in both containers is the same. A thin tube with a valve joins the containers. The valve is initially closed.



The valve is opened so that gas can move from one container to the other. The temperature remains unchanged.

Determine the new pressure of the gas. [3]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

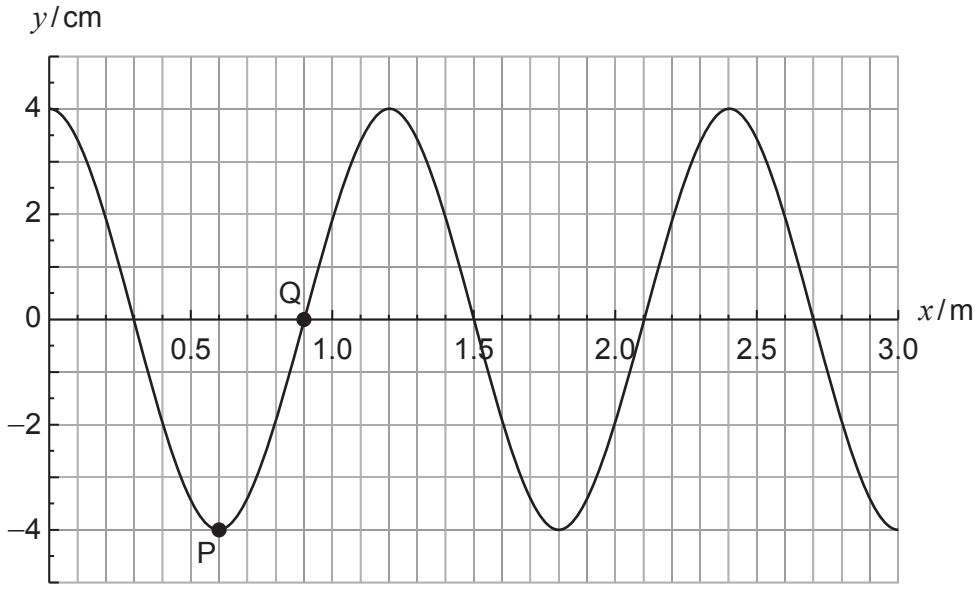
. . . . . .

3. (a) (i) State what is meant by a transverse wave. [1]

. . . . . .

. . . . . .

A transverse wave is travelling to the right on a string. The graph shows, at one particular time, the variation of the displacement y with distance x along the string. Two points, P and Q, on the string have been marked.



(ii) Explain whether P or Q has the greater acceleration. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 3 continued)

(iii) The speed of the wave is $62\,m\,s^{-1}$. Calculate the period of the wave giving your answer to the correct number of significant figures. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(iv) Calculate the average speed of P during one complete oscillation. [2]

. . . . . .

. . . . . .

(b) The string is now stretched between an oscillator and a fixed point. When the oscillator is set to a frequency of 120 Hz the standing wave shown in the diagram is observed on the string.

Draw the standing wave that would be observed on the same string when the oscillator is set to a frequency of 180 Hz. [1]

(c) Physicists and engineers study simple harmonic oscillations even though most oscillations are not simple harmonic. Suggest why this is a useful thing to do. [1]

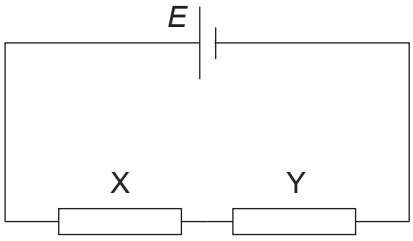
. . . . . .

. . . . . .

Please **do not** write on this page.

Answers written on this page
will not be marked.

4. (a) Two resistors, X and Y, are connected in series to a cell of emf *E* and negligible internal resistance. The resistances of X and Y are constant.

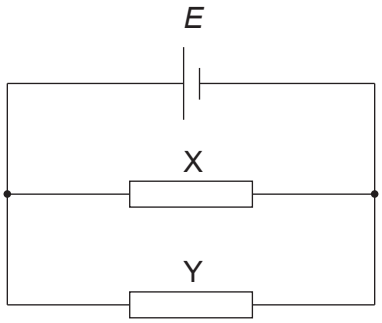


The power dissipated in X is greater than that in Y.

State and explain how the resistance of X compares with the resistance of Y. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

(b) X and Y are now connected in parallel to the same cell.



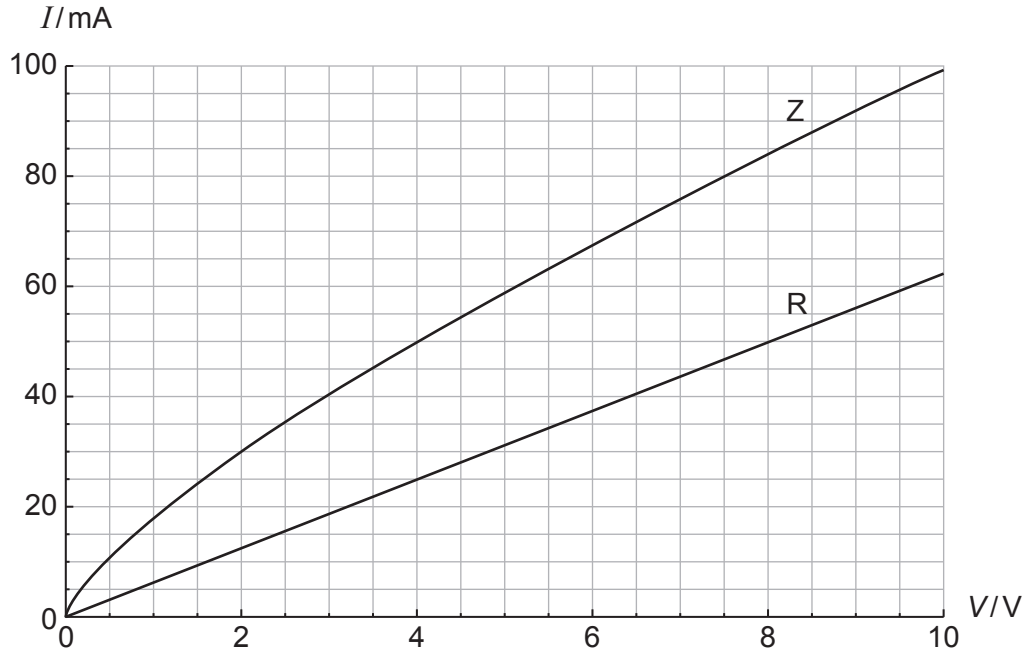
State and explain which resistor has the greater power dissipation. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

(This question continues on the following page)

(Question 4 continued)

(c) A lamp Z and a resistor R have the I-V characteristics shown in the graph.



(i) Calculate the resistance of R. [1]

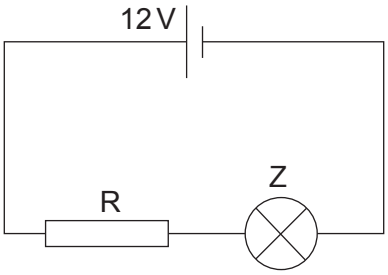
. . . . . .

. . . . . .

(This question continues on the following page)

(Question 4 continued)

(ii) R and Z are connected in series to a cell of emf 12 V and negligible internal resistance.



Determine, using the graph, the power dissipated in lamp Z. [3]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

5. The binding energy of the stable nuclide $^{131}_{54}Xe$ is 1.105 GeV.

(a) (i) Outline what is meant by binding energy. [1]

. . . . . .

. . . . . .

(ii) Calculate, in GeV c^{-2}, the mass of a nucleus of $^{131}_{54}Xe$. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) $^{133}_{54}Xe$ and $^{131}_{54}Xe$ are two isotopes of xenon.

(i) Outline what is meant by isotopes. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(ii) $^{133}_{54}Xe$ is radioactive. Suggest how the binding energy per nucleon for $^{131}_{54}Xe$ compares with that of $^{133}_{54}Xe$. [1]

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 5 continued)

(iii) Determine the number of up quarks (u quarks) in the nucleus of $^{131}_{54}Xe$. [2]

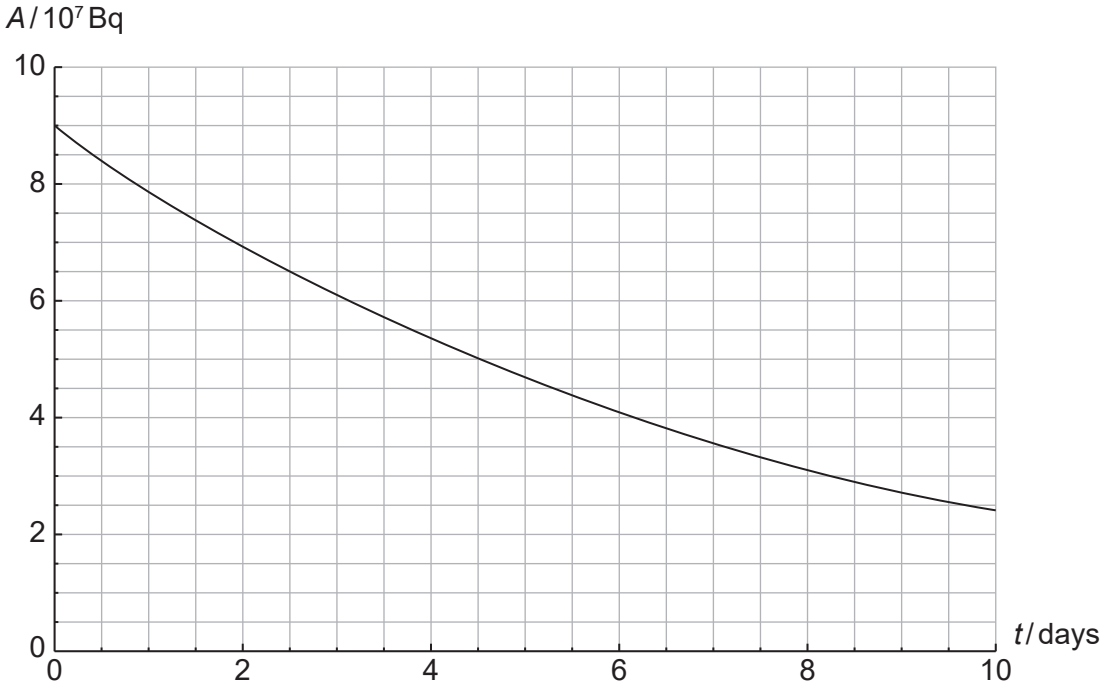
. . . . . .

. . . . . .

. . . . . .

. . . . . .

(c) The graph shows the variation with time of the activity of a pure sample of $^{133}_{54}Xe$.



Estimate the half-life of $^{133}_{54}Xe$. [1]

. . . . . .

. . . . . .

6. (a) Describe the energy transfers taking place in a wind generator. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

(b) The maximum power that can be extracted from a wind generator is given by $P = \frac{1}{2}\rho A v^3$.

State **one** assumption made in deriving this equation. [1]

. . . . . .
. . . . . .

(c) The following data are available for a wind generator:

Blade radius	$= 2.5\,\text{m}$
Air density	$= 1.2\,\text{kg m}^{-3}$
Wind speed incident on blades	$= 6.8\,\text{m s}^{-1}$
Wind speed after leaving blades	$= 2.6\,\text{m s}^{-1}$

Determine the maximum power, stating the correct unit, produced by this wind generator. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .