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PHYSICS
STANDARD LEVEL
PAPER 2

Candidate session number

SPECIMEN PAPER

Examination code

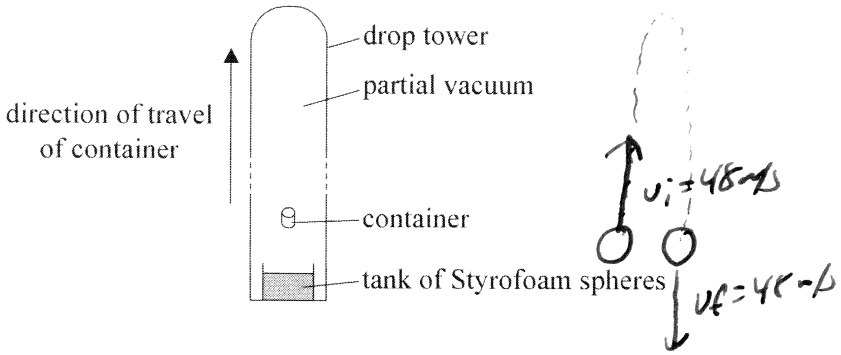
1 hour 15 minutes

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.
- Write your answers in the 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]*.

*Answer **all** questions. Write your answers in the boxes provided.*

1. In the drop tower shown, containers with experiments inside of them are fired upwards inside a vertical tower.



The container moves under the influence of gravity and eventually falls back to the bottom of the tower. Most of the air is removed from the tower so that air resistance is negligible. While in flight, the container and its contents are in free-fall.

(a) The container is fired vertically upwards with initial speed $48\ m\,s^{-1}$. Determine the time that the container is in flight. *[2]*

Given.

$v_i = 48\ m/s \quad v_f = -48\ m/s \quad a = -9.8\ m/s^2 \quad t = ??$

$v_f = v_i + at$

$-48\ m/s = 48\ m/s + (-9.8\ m/s^2)\,t$

$\frac{-96}{-9.8} = \frac{-9.8t}{-9.8} \quad t = 9.795\ s \approx t = 9.8\ s$

(This question continues on the following page)

(Question 1 continued)

(b) At the end of the flight, the container of total mass 480 kg falls into a tank of expanded Styrofoam (polystyrene) spheres to slow it. The container stops after moving a distance of 8.0 m in the Styrofoam. Calculate the average force that acts on the container due to the spheres. *[3]*

Given $d = -8m$ $v_i = -48 m/s$ $v_f = 0 m/s$ Stop. Solve for a

① $v_f^2 = v_i^2 + 2ad$

$(0 m/s)^2 = (-48 m/s)^2 + 2a(-8m)$

$a = -144 m/s^2$

② $F_{net} = ma$

$480kg(-144 m/s^2)$

$= -6.9 \times 10^4 m/s^2$

③ $F_g = mg = 480kg(9.8 m/s^2)$

$= -4704N$

④ Avg Force $= -6.9 \times 10^4 + .47 \times 10^4 = 7.4 \times 10^4 N$

(c) Outline why the experiments inside the container could be considered to be in "weightless" conditions. *[2]*

- Reaction Force is 0
- Object & Container fall at the same rate

(This question continues on the following page)

(Question 1 continued)

$d =$

(d) The tower is 120 m high with an internal diameter of 3.5 m. When most of the air has been removed, the pressure in the tower is 0.96 Pa.

(i) Determine the number of molecules of air in the tower when the temperature of the air is 300 K. *[3]*

① Volume = Area × h = $\pi r^2 h = \pi (1.75\text{m})^2 (120\text{m}) = 1154\text{m}^3$

② $PV = nRT$ $.96\text{Pa}(1154\text{m}^3) = n(8.31)(300\text{K})$

$n = .44\text{ moles}$

③ $N = 6.02\times10^{23}(.44) = 2.68\times10^{23} \approx 2.7\times10^{23}$ molecules

(ii) Outline whether the behaviour of the remaining air in the tower approximates to that of an ideal gas. *[2]*

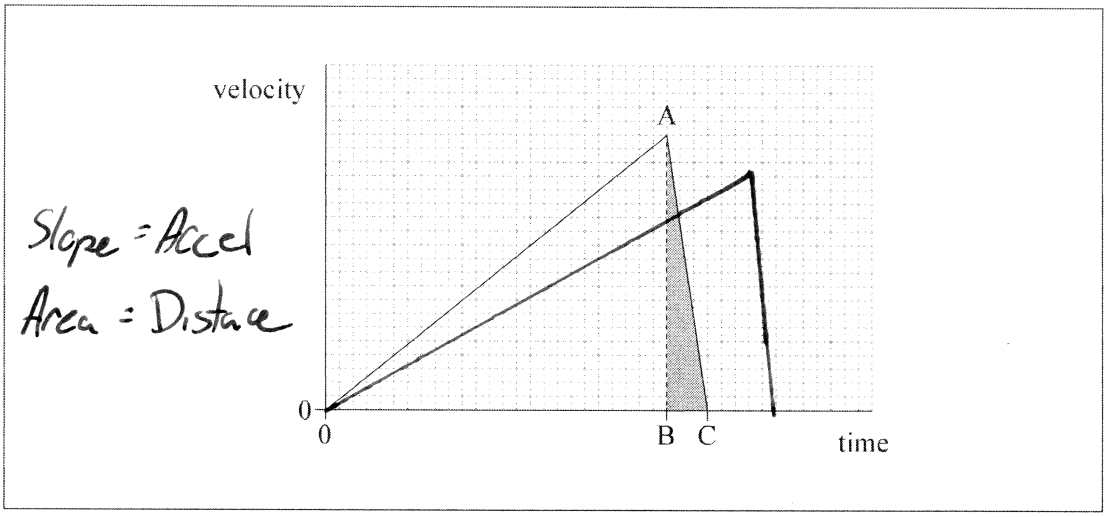
Yes Low Pressure

High Temperature

(This question continues on the following page)

(Question 1 continued)

(e) The container can also be released from rest at the top of the tower. The graph shows how the container velocity varies with time from release with the tower in a partial vacuum.



Slope = Accel
Area = Distance

(i) State the quantity that is represented by the shaded area ABC. *[1]*

Stopping Distance

(ii) Air is introduced into the tower. The container is released from the top of the tower when the air in the tower is at atmospheric pressure. Using the axes in (e), sketch a graph to show how the container velocity varies with time from release when the air is at atmospheric pressure. *[3]*

↑ Air Resistance

Result: - Lower Maximum Speed
- Lower Slope Value (Not in pure free Fall)
- Graph must go longer before decel. since distance is still constant
- Areas should be the same between Graphs (by eye)

2. (a) State Ohm's law. *[1]*

$R = \frac{V}{I}$ ..... Voltage is proportional to current .....
..... (temp is constant) .....

(b) (i) A copper wire has a length of 0.20 km and a diameter of 3.0 mm. The resistivity of copper is $1.7 \times 10^{-8}\,\Omega\,m$. Determine the resistance of the wire. *[3]*

$L = .20\,km$ or $200\,m$ $r = 1.5\,mm$ or $.0015\,m$
$\rho = 1.7 \times 10^{-8}\,\Omega m$
$R = \frac{\rho L}{A} = \frac{(1.7 \times 10^{-8}\,\Omega m)(200\,m)}{\pi (.0015\,m)^2} = \frac{3.4 \times 10^{-6}}{7.07 \times 10^{-6}}$
$.48\,\Omega$

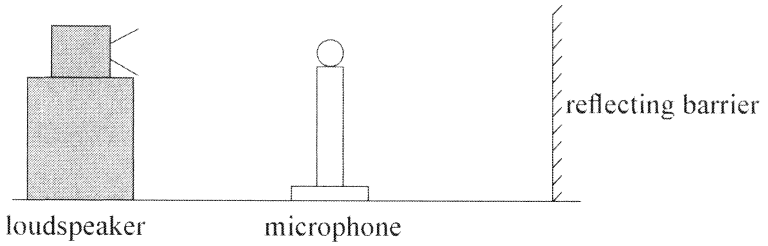
(ii) A potential difference of 6.0 V is maintained across the ends of the wire. Calculate the power dissipated in the wire. *[1]*

$P = \frac{V^2}{R} = \frac{(6\,V)^2}{.48\,\Omega} = \frac{36}{.48} = 75\,W$

(iii) Explain how the flow of electrons in the wire leads to an increase in the temperature of the wire. *[3]*

- Loss of K.E. of Electrons
- Electrons collide with lattice ions
- Increase of internal energy of lattice ions

3. A loudspeaker emits sound waves of a single frequency towards a reflecting barrier.



A microphone is moved along a straight line between the loudspeaker and the barrier. A sequence of equally spaced maxima and minima of sound wave intensity is detected.

(a) Explain how the maxima and minima are formed. *[4]*

- A sound wave is reflected from the barrier and travels in the opposite direction to the original wave

Maxima - Caused by constructive Interference
Minima - Caused by destructive Interference

(This question continues on the following page)

(Question 3 continued)

(b) The microphone is moved through 1.0 m from one point of minimum intensity to another point of minimum intensity. It passes through seven points of maximum intensity as it moves. The speed of sound is 340 m s^{-1}.

(i) Calculate the wavelength of the sound waves. *[2]*

Max
Air $1/2\lambda \times 7 = 3.5\lambda$ $1 \text{ metre} \div 3.5\lambda$
$= .29\text{m}$
max

(ii) Outline how you could use this arrangement to determine the speed of sound in air. *[3]*

- Measure frequency using an oscilloscope, frequency meter, electronic tuner
- Use $v = f\lambda$
- Measure each position of several maxima/minima using a ruler

4. (a) A power station burns natural gas at a rate of $35\,kg\,s^{-1}$. The power output of the station is 750 MW and the efficiency of the station is 38%.

(i) Calculate the energy provided by the natural gas each second. *[1]*

$\frac{750,000,000\ J/s}{38} = \frac{x}{100}$

Power Output $= 1.97 \times 10^9\ J/s$

(ii) Calculate the specific energy of the natural gas. State appropriate units for your answer. *[3]*

Specific Heat = C. Amount of heat Energy to raise the temp of 1kg by 1°C

$C = \frac{1.97 \times 10^9\ J/s}{35\ kg/s} = 56,000,000\ \frac{J}{kg}$

(b) Outline why much of the world's energy is provided from fossil fuels. *[2]*

- Plentiful Supplies
- Existing Infrastructure

(This question continues on the following page)

(Question 4 continued)

(c) There is a suggestion that the temperature of the Earth may increase if the use of fossil fuels is not reduced over the coming years.

(i) Explain, with reference to the enhanced greenhouse effect, why this temperature increase may occur. *[3]*

- Inc. proportion of greenhouse gases in atmosphere
- Absorption of Infrared radiation by the atmosphere
- Extra Energy radiated back to ground

(ii) Outline how scientists continue to attempt to resolve the climate change debate. *[1]*

- Improved modeling / data collection
- Greater Collaboration

(This question continues on the following page)

(Question 4 continued)

(d) Nuclear power stations are one way in which energy can be generated without the use of fossil fuels. One example of a nuclear fission reaction is as shown.

$$^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{148}_{57}\mathrm{La} + {}^{85}_{35}\mathrm{Br} + x\,{}^{1}_{0}\mathrm{n}$$

(i) Identify the value of x. *[1]*

3 Need Mass Number to equal 3

(ii) The following data are available.

Mass of U-235 = 235.044 u
Mass of n = 1.009 u
Mass of La-148 = 148.932 u
Mass of Br-85 = 84.910 u

Determine, in MeV, the energy released when one uranium nucleus undergoes nuclear fission in the reaction in (d). *[3]*

$^{235}U + {}^{1}n = La + Br + 3\,{}^{1}n$

236.053u = 236.869u

Mass Defect = .816u $\times \frac{931\,MeV}{1u}$ = 760 MeV

(This question continues on the following page)

(Question 4 continued)

(iii) Outline, with reference to the speed of the neutrons, the role of the moderator in a nuclear reactor. *[3]*

- Neutrons emitted by uranium @ high speed
- Need to slow neutrons to cause fission
- Neutrons collide with the moderator atoms and slow down