Candidates answer on the question paper.

OCR supplied materials:
- Data, Formulae and Relationships Booklet

Other materials required:
- Electronic calculator

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Answer all the questions.
- Do not write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [ ] at the end of each question or part question.
- The total number of marks for this paper is 60.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
- Where you see this icon you will be awarded marks for the quality of written communication in your answer.

This means for example you should:
- ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
- organise information clearly and coherently, using specialist vocabulary when appropriate.
- This document consists of 12 pages. Any blank pages are indicated.
1 (a) (i) State the principle of conservation of linear momentum.
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(ii) Explain what is meant by an inelastic collision.
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(iii) Fig. 1.1 shows the head-on-collision of two blocks on a frictionless surface.

![Fig. 1.1]

 BEFORE COLLISION

3.0 m s$^{-1}$  2.0 m s$^{-1}$
2.4 kg  1.2 kg

 AFTER COLLISION

 v

Before the collision, the 2.4 kg block is moving to the right with a speed of 3.0 m s$^{-1}$ and the 1.2 kg block is moving to the left at a speed of 2.0 m s$^{-1}$. During the collision the blocks stick together. Immediately after the collision the blocks have a common speed $v$.

1 Calculate the speed $v$.

\[
 v = \ldots.......................\text{ m s}^{-1} [2]
\]

2 Show that this collision is inelastic.
(b) Fig. 1.2 shows a helicopter viewed from above.

The blades of the helicopter rotate in a circle of radius 5.0 m. When the helicopter is hovering, the blades propel air vertically downwards with a constant speed of 12 m s\(^{-1}\). Assume that the descending air occupies a uniform cylinder of radius 5.0 m.

The density of air is 1.3 kg m\(^{-3}\).

(i) Show that the mass of air propelled downwards in a time of 5.0 seconds is about 6000 kg.
(ii) Calculate

1. the momentum of this mass of descending air

\[ \text{momentum} = \ldots \quad \text{kg m s}^{-1} \quad [1] \]

2. the force provided by the rotating helicopter blades to propel this air downwards

\[ \text{force} = \ldots \quad \text{N} \quad [2] \]

3. the mass of the hovering helicopter.

\[ \text{mass} = \ldots \quad \text{kg} \quad [1] \]

[Total: 13]
2 (a) (i) State, in terms of force, the conditions necessary for an object to move in a circular path at constant speed.

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(ii) Explain why this object is accelerating. State the direction of the acceleration.

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(b) A satellite moves in a circular orbit around the Earth at a constant speed of 3700 m s\(^{-1}\).

The mass \(M\) of the Earth is 6.0 \(\times\) \(10^{24}\) kg.

Calculate the radius of this orbit.

\[
\text{radius} = \text{.................................................... m} \quad [4]
\]

(c) In order to move the satellite in (b) into a new smaller orbit, a decelerating force is applied for a brief period of time.

(i) Suggest how the decelerating force could be applied.

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(ii) The radius of this new orbit is 2.0 \(\times\) \(10^{7}\) m. Calculate the speed of the satellite in this orbit.

\[
\text{speed} = \text{............................................... m s}^{-1} \quad [2]
\]

[Total: 10]
3 (a) (i) Define the *kilowatt-hour*.

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.......................................................................................................................................................... [1]

(ii) A domestic refrigerator works at a mean power of 70 W. Calculate the cost of running this refrigerator for one week at a cost of 12 p per kWh.

$$\text{cost} = \£ \text{ ........................................................} \quad [2]$$

(b) A large jug containing 2.0 kg of milk is placed in a refrigerator. The milk cools from 18 °C to 3.0 °C over a time period of 100 minutes. The specific heat capacity of milk is 3800 J kg\(^{-1}\) K\(^{-1}\).

Calculate

(i) the thermal energy removed from the milk as it cools from 18 °C to 3 °C

$$\text{energy removed} = \text{ ...................................................... J} \quad [2]$$

(ii) the rate at which thermal energy is removed from the milk.

$$\text{rate} = \text{ ................................................ } \text{Js}^{-1} \quad [1]$$
(c) Another container full of milk is placed in a freezer and cooled from 18 °C to –18 °C.

Assume that thermal energy is removed at a constant rate and that the freezing-point of milk is 0 °C. The specific heat capacity of milk below 0 °C is significantly less than its value above 0 °C.

On Fig. 3.1 sketch a graph to show the variation with time of the temperature of the milk over the range 18 °C to –18 °C. Numbers are not required on the time axis.

Fig. 3.1

[Total: 9]
For a body undergoing simple harmonic motion describe the difference between

(i) displacement and amplitude

In your answer, you should use appropriate technical terms spelled correctly.

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(ii) frequency and angular frequency.

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(b) A harbour, represented in Fig. 4.1, has vertical sides and a flat bottom. The surface of the water in the harbour is calm.

Fig. 4.1

The tide causes the surface of the water to perform simple harmonic motion with a period of 12.5 hours. The maximum depth of the water is 18 m and the minimum depth is 13 m.
(i) For the oscillation of the water surface, calculate

1 the amplitude

\[ \text{amplitude} = \ldots \text{m} \quad [1] \]

2 the frequency.

\[ \text{frequency} = \ldots \text{Hz} \quad [2] \]

(ii) Calculate the maximum vertical speed of the water surface.

\[ \text{maximum speed} = \ldots \text{m s}^{-1} \quad [2] \]

(iii) Write an expression for the depth \( d \) in metres of water in the harbour in terms of time \( t \) in seconds.

[2]

[Total: 11]
(a) A student investigates Brownian motion by observing through a microscope smoke particles suspended in air.

(i) Describe the behaviour of the smoke particles as observed by the student.

In your answer, you should use appropriate technical terms spelled correctly.

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(ii) State how the observations lead to conclusions about the nature and properties of the molecules of a gas.

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(b) The molar masses of hydrogen and oxygen are 0.0020 kg mol\(^{-1}\) and 0.032 kg mol\(^{-1}\) respectively. The mean speed of hydrogen molecules at room temperature is 1800 m s\(^{-1}\).

Calculate the mean speed of oxygen molecules at the same temperature.

mean speed = ............................................ m s\(^{-1}\) [3]

[Total: 7]
6 (a) (i) State Boyle's law.

..............................................................................................................................
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(ii) For a gas which obeys Boyle's law, sketch

1 on Fig. 6.1 a graph of pressure $p$ against volume $V$

2 on Fig. 6.2 a graph of $p$ against $1/V$. [3]

![Fig. 6.1](image1)

![Fig. 6.2](image2)

Question 6 continues over the page.
(b) A cylinder of fixed volume 0.040 m$^3$ is filled with nitrogen gas at a pressure of $5.0 \times 10^5$ Pa and temperature 15 °C. The molar mass of nitrogen is 0.028 kg mol$^{-1}$.

(i) Calculate the number of moles of nitrogen in the cylinder.

\[
\text{number of moles} = \text{..........................} \quad [2] 
\]

(ii) After a period of 100 days the pressure has fallen to $4.5 \times 10^5$ Pa, at the same temperature, because of leakage. Calculate the mass of nitrogen that has escaped.

\[
\text{mass} = \text{..........................} \quad \text{kg} \quad [3] 
\]

[Total: 10]