READ THE FOLLOWING DIRECTIONS CAREFULLY

1. You MUST use this answer booklet when responding to the questions. For each question, write your answer in the space provided and return the answer booklet at the end of the examination.

2. ALL WORKING MUST BE SHOWN in this booklet, since marks will be awarded for correct steps in calculations.

3. Attempt ALL questions.

4. The use of non-programmable calculators is allowed.

5. Mathematical tables are provided.

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO
1. (a) A teacher asks her students to measure the density of the glass from which marbles are made. Each group of students is provided with 20 identical marbles.

The students are told that the volume of a sphere is \( \frac{4}{3} \pi r^3 \), where \( r \) is the radius. Thus, the volume may be calculated if the radius \( \left( \frac{\text{diameter}}{2} \right) \) is known.

They measure the diameter of one of the marbles with a micrometer. The reading obtained is shown in the magnified diagram below.

![Diagram of a micrometer scale showing measurements from 0 to 45 mm with a reading of 15 mm.]

Figure 1

(i) What is the reading shown in Figure 1 above?

\[
\text{Diameter} = \quad \text{mm.} \quad (1 \text{ mark})
\]

(ii) Express this reading in metres using, standard scientific form.

\[
\text{Diameter} = \quad \text{m.} \quad (1 \text{ mark})
\]

(iii) Find the volume of ONE marble.

\[
\text{Volume of ONE marble} = \quad \text{cubic mm.} \quad (2 \text{ marks})
\]

(iv) If the only available balance is calibrated to measure to the nearest gram, suggest a method, which students could use, to accurately find the mass of ONE marble.

\[
\text{Mass of ONE marble} = \quad \text{g.} \quad (2 \text{ marks})
\]

(v) The mass of one marble was found to be 1.1 g. Express the mass in kilograms.

\[
\text{Mass} = \quad \text{kg.} \quad (1 \text{ mark})
\]
(vi) Calculate the density of the glass used to make the marbles.

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( 2 marks)

(b) Figure 2 below shows the outline of a girl’s shoe heel, drawn on graph paper.

![Figure 2](image)

(i) Estimate the area of the heel of her shoe.

Area of heel = ........................................

( 2 marks)

(ii) The girl’s mass is 45 kg. What pressure does she exert on the ground when she is standing on one heel? \( (g = 10 \, \text{N kg}^{-1}) \)

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( 3 marks)

Total 14 marks
2. (a) If an object is allowed to fall in the laboratory, it accelerates.

   (i) Define the term *acceleration*.

   (1 mark)

   (ii) Explain why the object accelerates.

   (1 mark)

   (iii) Why is the acceleration of free fall the same for all objects at the same place, if air resistance is negligible?

   (2 marks)

(b) The apparatus shown in Figure 3 above, may be used to determine the acceleration due to gravity, of the small iron ball. The height of fall, $h$, and the time of fall, $t$, need to be measured.

   (i) Explain how the apparatus works.

   (3 marks)
(ii) Using this apparatus, a student obtains a value of 0.490 s for \( t \), when \( h \) is 1.16 m. Calculate the average speed of the ball during the fall.

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(2 marks)

Hence, calculate the final speed of the ball just before its impact with the trap door.

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(2 marks)

(iii) In the space below, sketch the velocity-time graph for the motion of the ball.

![Velocity-time graph](image)

Using the graph, or otherwise, calculate the acceleration of the ball during its fall.

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(4 marks)

Total 15 marks
3. (a) Figure 4 below shows the structure of a neutral atom of carbon. The nucleus has six protons. Complete the diagram to show the correct number of electrons in the outer shell of the atom.

![Diagram of an atom]

Figure 4

(1 mark)

Fill in the blanks in the following sentences.

(i) The other particles in the nucleus are known as ..........................................

(1 mark)

The nuclide can be represented by the symbol $^{A}_{Z}C$.

(ii) $A$ is known as the .................................................. and its value is ..............

(2 marks)

(iii) $Z$ is known as the .................................................. and its value is ..............

(2 marks)

(b) Three isotopes of carbon are radioactive, with half lives as shown in Table 1 below.

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Half Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon – 10</td>
<td>10 seconds</td>
</tr>
<tr>
<td>Carbon – 14</td>
<td>5730 years</td>
</tr>
<tr>
<td>Carbon – 15</td>
<td>2.5 seconds</td>
</tr>
</tbody>
</table>

Table 1

In Figure 5 opposite, the decay curve for 4 g of the carbon – 10 isotope has been drawn. On the same axes, draw graphs to show

(i) the decay of 4 g of carbon – 14

(ii) the decay of 4 g of carbon – 15.

Label the graphs CLEARLY.
(c) When the carbon – 14 isotope decays by β emission, it becomes an isotope of nitrogen. The mass of a carbon – 14 nucleus is $2.324538 \times 10^{-26}$ kg, and the mass of a nitrogen – 14 nucleus is $2.324510 \times 10^{-26}$ kg.

(i) Calculate the difference in mass between nuclei of carbon – 14 and nitrogen – 14.

(ii) Determine the energy released when one carbon – 14 nucleus decays. ($c = 3.00 \times 10^8$ m s$^{-1}$)

Total 15 marks
4.

Figure 6

(a) The circuit shown in Figure 6 above, may be used to investigate the relationship between applied potential difference and current, for a 10 Ω carbon resistor. The battery has an e.m.f. of 3.0 V and negligible internal resistance. The ammeter has negligible resistance. A 20 Ω rheostat is used to control the current.

(i) Draw a circuit diagram to represent this arrangement of components.

(3 marks)
(ii) Explain why it is necessary for the voltmeter to have a high resistance.

(1 mark)

(iii) Complete Table 2 below, to show how the meter readings change when the sliding contact on the rheostat is moved from end X to the other end Y.

(You may use the space below the table for your calculations.)

<table>
<thead>
<tr>
<th>Rheostat setting</th>
<th>Resistance of whole circuit/Ω</th>
<th>Ammeter reading/A</th>
<th>Voltmeter reading/V</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2

(5 marks)
(b) The graph in Figure 7 below, shows how the currents through a small lamp and a piece of resistance wire change as the potential difference across each is varied.

![Graph showing currents through a lamp and resistance wire vs. voltage](image)

**Figure 7**

(i) Find the resistance of the resistance wire.

\[ \text{Resistance} = \frac{\text{Voltage}}{\text{Current}} \]

\[ R = \frac{V}{I} \]

\[ R = \frac{3.0 \text{ V}}{0.25 \text{ A}} = 12 \Omega \]

\[ R = \frac{4.0 \text{ V}}{0.20 \text{ A}} = 20 \Omega \]

\[ \text{Average resistance} = \frac{12 \Omega + 20 \Omega}{2} = 16 \Omega \]

(3 marks)
(ii) Find the resistance of the lamp when the current flowing is 0.20 A.

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

(2 marks)

(iii) The lamp, resistance wire and a battery are now connected in series. If the current in the circuit is 0.20 A, determine the total potential difference across the lamp and resistance wire.

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(2 marks)

Total 16 marks

END OF TEST