2023-DSE
PHY

PAPER 1B

B

DIOCESAN BOYS' SCHOOL

HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION 2023

G 12 FINAL EXAMINATION

PHYSICS PAPER 1

SECTION B: Question-Answer Book B

This paper must be answered in English

INSTRUCTIONS FOR SECTION B

(1) After the announcement of the start of the examination, you should first write your Name, Class and Class Number in the spaces provided on Page 1.

(2) Refer to the general instructions on the cover of the Question Paper for Section A.

(3) Answer **ALL** questions.

(4) Write your answers in the spaces provided in this Question-Answer Book.

(5) Graph paper and supplementary answer sheets will be provided on request. Write your Name, Class, Class Number, and fill in the question number box on each sheet. Fasten them with string INSIDE this Question-Answer Book.

(6) No extra time will be given to candidates for filling in the question number boxes after the 'Time is up' announcement.

(7) Unless otherwise specified, numerical answers should be either exact or correct to 3 significant figures.

(8) Take $g = 9.81$ m s^{-2}.

Name	
Class	
Class Number	

	Teacher's Use Only
Question No.	Marks
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
Total	

Section B: Answer **ALL** questions. Write your answers in the spaces provided.

Structured Questions (84 marks)

Question No.	1	2	3	4	5	6	7	8	9	10	11
Marks	8	8	10	8	7	8	6	6	8	7	8

Question 1 (8 marks)

The following experimental items are provided for estimating the temperature inside an oven.

- a copper rod of mass 0.5 kg hung with a thread at room temperature
- a beaker containing 1 kg of water at room temperature
- an oven maintained at T °C
- a thermometer
- a stirrer

(a) Write down the procedure of the experiment in the box below. The last step of the procedure is provided inside the box. (2 marks)

Measure the final temperature of water with a thermometer.

(b) State **ONE** major precaution to be taken for a more accurate result. (1 mark)

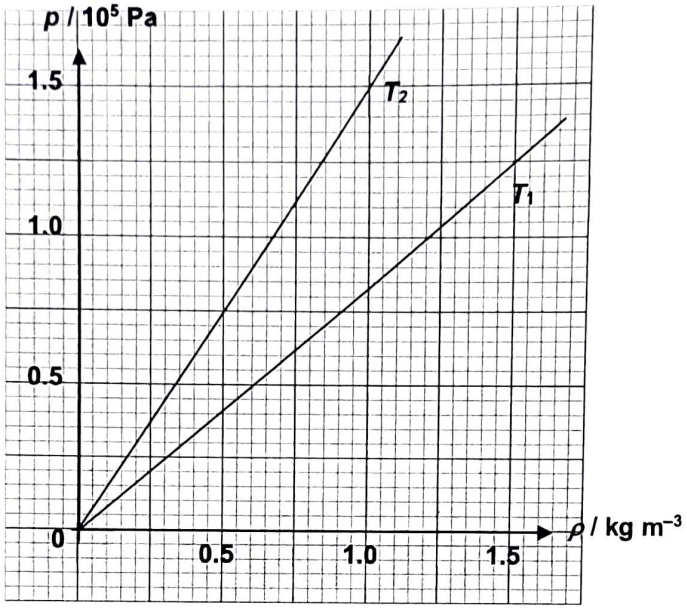
(c) Given: specific heat capacity of water = 4200 J kg^{-1} $°C^{-1}$
specific heat capacity of copper = 380 J kg^{-1} $°C^{-1}$
heat capacity of beaker = 200 J $°C^{-1}$
room temperature = 25°C
final temperature of water = 33°C

Find the temperature T inside the oven. (3 marks)

(d) John uses the above hot oven in the experiment. He finds that when his hands are inside the hot air of the oven (at temperature T), he feels quite uncomfortable but still tolerable. However, he burns one of his hands when he touches the inside of the oven. Explain briefly. (2 marks)

Question 2 (8 marks)

The graph below shows how the pressure p of a fixed mass of ideal gas varies with its density ρ at two different constant temperatures, $T_1 = 300$ K and T_2.



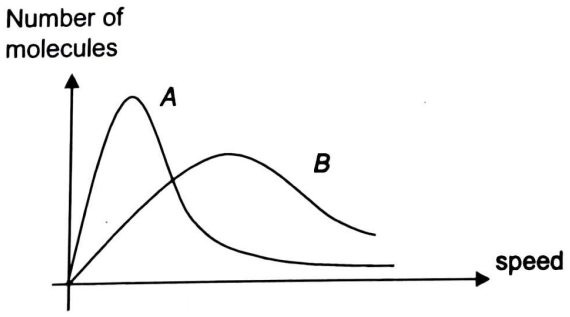
(a) Using the straight line showing the variation at T_1, find the mass of 1 mole of ideal gas in grams. (2 marks)

(b) Find the temperature T_2 in °C (2 marks)

(c) Express the slope of the straight line showing the variation at T_2 in terms of the mean-square speed $\overline{c^2}$ of the ideal gas. (1 mark)

(d) Using *part (c)*, or otherwise, find the root-mean-square speed of the ideal gas at T_2. (2 marks)

(e) The distributions of molecular speeds of the ideal gas at T_1 and T_2 are shown below. Write down the temperatures that correspond to curves *A* and *B*. (1 mark)

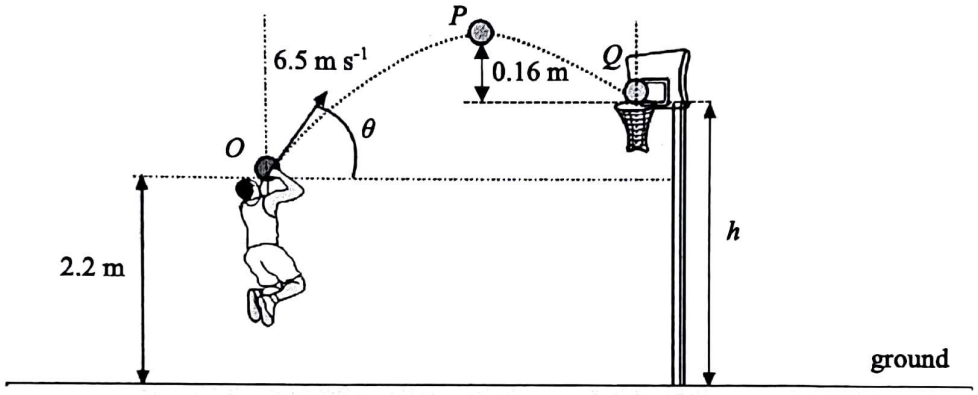


Curve *A*: _____ Curve *B*: _____

Question 3 (10 marks)

A basketball player, Aidan, throws a small ball at point O with an initial velocity of 6.5 m s^{-1} at an angle of projection θ to the horizontal. The ball is 2.2 m above the ground when released. The ball reaches its maximum height at point P and the top of the basket at point Q. Point P is 0.16 m above point Q, which is at a height h above the ground. It takes 0.69 s for the ball to move from point O to point Q.

Neglect air resistance in this question. Take upward and rightward directions as positive.



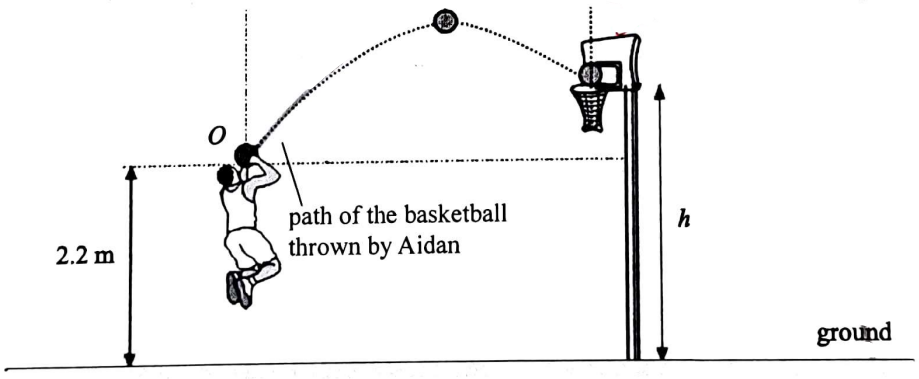
(a) (i) Express the time for the ball to travel from O to P in terms of θ and g, where g is the acceleration due to gravity. (2 marks)

(ii) Find the time for the ball to travel from P to Q. (2 marks)

(iii) Using (a)(i) and (a)(ii), show that the angle of projection $\theta \approx 50.2°$. (1 mark)

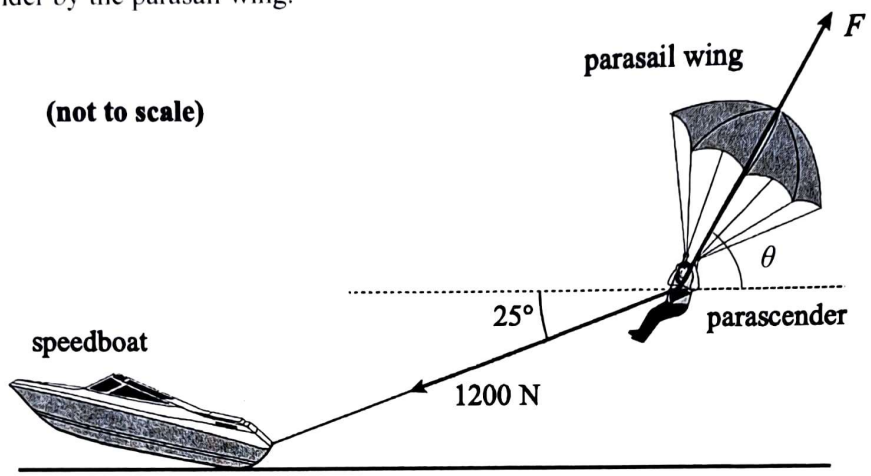
(b) Find the height h of the top of the basket Q above the ground. (3 marks)

(c) Another basketball player, Dominic, throws the ball at point O with a higher initial velocity at the same angle of projection. Sketch the path of the basketball thrown by Dominic in the figure below.
(The dotted line shows the path of the basketball thrown by Aidan.) (2 marks)



Question 4 (8 marks)

Parasailing is a recreational activity where a person, known as the parascender, is towed behind a speedboat while attached to a parasail wing. The following figure shows a parascender with mass 70 kg pulled to the left at a constant speed and height by a speedboat. A light rope connects the parascender and the speedboat at an angle of 25° to the horizontal and exerts a force of 1200 N on the parascender. Another force F at an angle θ with the horizontal is exerted on the parascender by the parasail wing.



(a) (i) By considering the forces on the parascender in the vertical and horizontal directions respectively, write down two force equations in terms of F and θ. (2 marks)

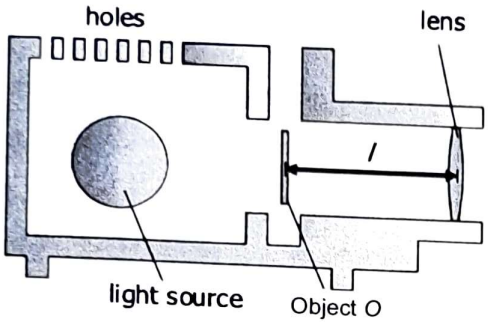
(ii) Hence, find the magnitude of the force F. (3 marks)

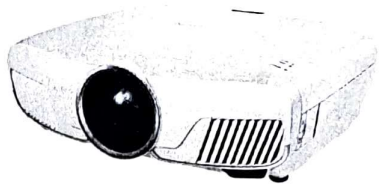
(b) A student claims that when the parascender releases the rope, he initially rises higher. Do you agree with this claim? Explain in terms of the forces acting on the parascender.

(3 marks)

Question 5 (7 marks)

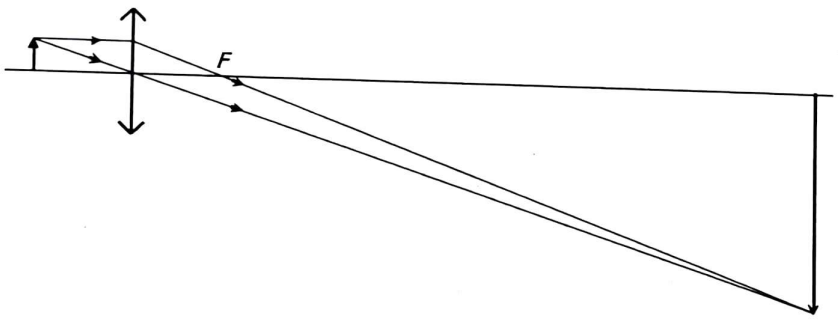
A video projector is an optical device that projects still or moving images onto a projection screen. It is commonly used in conference presentations, classroom teaching and home cinemas. Most projectors create an image by shining light through a small transparent lens.





The figures above show a video projector and a simplified schematic diagram. Object O represents the source of the video signal to be magnified by the lens. The focal length of the lens is 50 mm. The position of the lens can be adjusted so that the distance l between the object and the lens can vary from 51 mm to 54 mm.

(a) The ray diagram below shows how the image of an object is captured on the screen.



(i) Find the maximum distance between the lens and the screen (in m) so that a sharp image can be obtained. (2 marks)

(ii) State the nature of the magnified image formed by the lens. (1 mark)

(iii) Object O has a width of 35 mm and a height of 25 mm. Within the range of l, determine the minimum area (in m^2) of the projection screen so that the whole image can be projected onto it. (2 marks)

(b) The projector is packaged with a replacement lens for projection in rooms of different sizes. The difference in the focal lengths of the replacement lens and the original one is 5 mm. Which one, 45 mm or 55 mm, is a possible focal length of the replacement lens? Briefly explain your answer. (2 marks)

Question 6 (8 marks)

A plane transmission grating with 400 slits per mm and a dichromatic light source of wavelengths 400 nm (violet) and 650 nm (red) are used in an experiment. A screen is placed 80 cm behind the grating.

(a) What is the slit separation d (in m) of the plane transmission grating? (1 mark)

(b) For the violet light, find the distance between the second-order fringe and the zeroth-order fringe on the screen. (2 marks)

(c) A student calculated $2\Delta y$ using the Young double-slit equation $\Delta y = \frac{D\lambda}{a}$ in *part (b)* and found that the percentage error of the result was large.

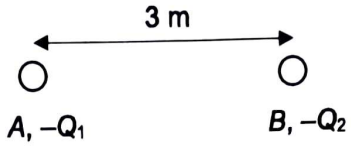
Briefly explain why the equation is not applicable in this case. (2 marks)

(d) Determine the angular position of the fringe for (i) the second order of the red light θ_{2r} and (ii) the third order of the violet light θ_{3v}. (2 marks)

(e) Which fringe, the second order of the red light or the third order of the violet light, is closer to the zeroth-order fringe? (1 mark)

Question 7 (6 marks)

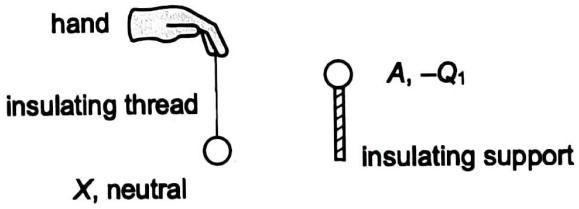
Two identical small conducting spheres, A and B, carrying negative charges $-Q_1$ and $-Q_2$ respectively are held at positions 3 m apart as shown. The electric force between them is 0.075 N .



(a) (i) Explain why both spheres experience the same magnitude of electric force. (1 mark)

(ii) The difference in the magnitudes of the charges in the spheres is 10 μC with sphere A carrying more charge. Find the amount of charge carried by each sphere in the unit of C . (3 marks)

(b) Sphere A is then fixed on an insulating support. You are now given another identical neutral conducting sphere X held by an insulating thread. Describe how you can charge sphere X using sphere A such that sphere X carries a positive charge. (2 marks)



Question 8 (6 marks)

A light-emitting diode (LED) is a non-ohmic circuit component that gives out light when connected in a circuit. The current-voltage characteristic curve of an LED is shown in **Fig. A** .

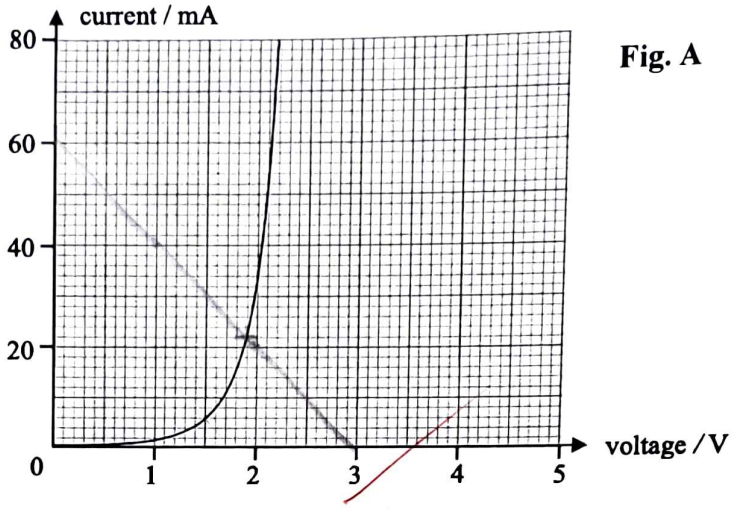


Fig. A

(a) Determine the resistance of the LED when the voltage across it is 1.5 V. (2 marks)

(b) The LED is then connected in series with a 50-Ω resistor and a 3-V battery of negligible internal resistance, as shown in **Fig. B** .

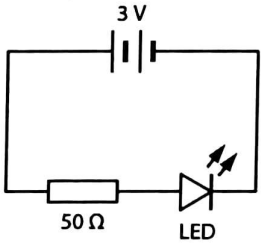


Fig. B

(i) Show that the current I and the voltage V across the LED in the circuit satisfy the following equation:

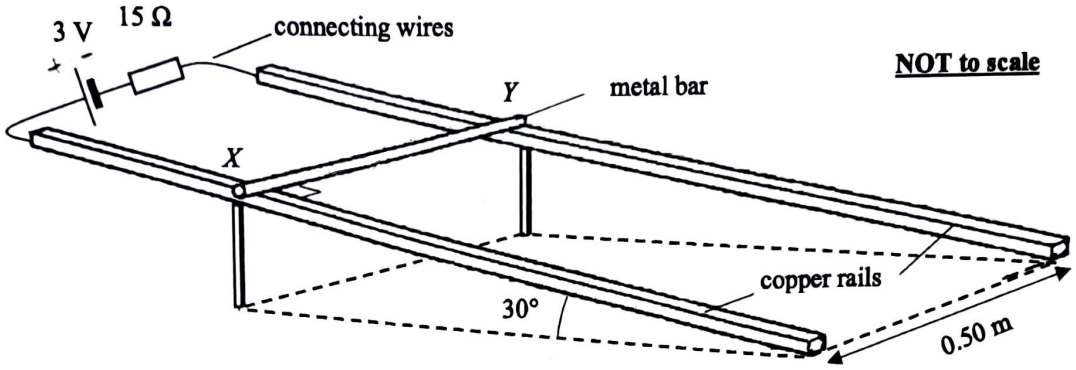
$$I = 0.06 - 0.02V$$

(2 marks)

(ii) Find the current through the LED in the above circuit by drawing a suitable straight line in **Fig. A** . (2 marks)

Question 9 (8 marks)

Two smooth parallel copper rails are shown below. The two rails are at an angle of 30° to the horizontal and are connected by connecting wires to a 15-Ω resistor and a 3-V dry cell with negligible internal resistance.



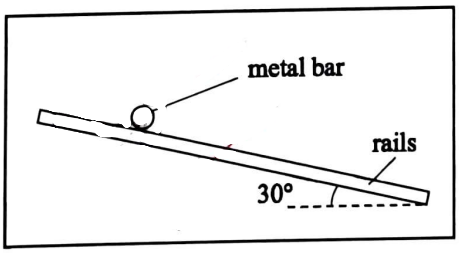
A metal bar XY remains at rest when a uniform magnetic field B is applied vertically (not shown in the figure) from $t = 0$ s to $t = 10$ s . The length and the mass of the metal bar are 0.50 m and 20 g respectively.

The metal bar, the rails and the connecting wires all have negligible resistance. Neglect Earth's magnetic field in this quesiton.

(a) (i) Write down the magnitude of the current passing through the metal bar. (1 mark)

(ii) State the direcuon (*upwards or downwards*) of the uniform magnetic field. Also, draw and label all the forces acting on the metal bar in the following box. (3 marks)

side view

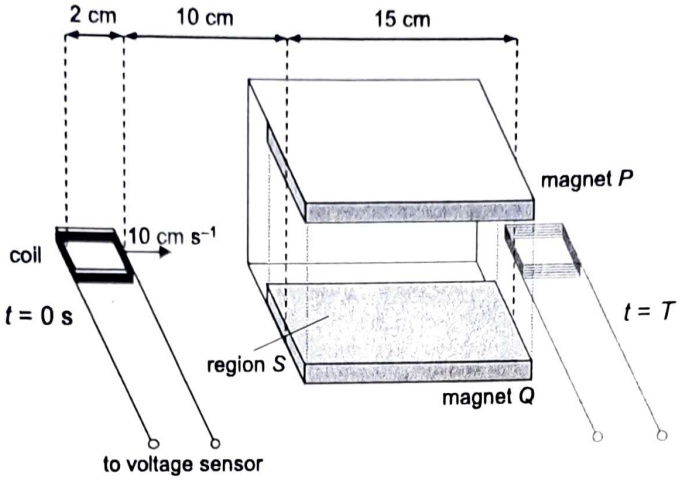


(iii) Hence, find the magnitude of the uniform magnetic field B. (3 marks)

(b) The uniform magnetic field B is removed right after $t = 10$ s. Write down the acceleration of the metal bar right after the magnetic field is removed. (1 mark)

Question 10 (7 marks)

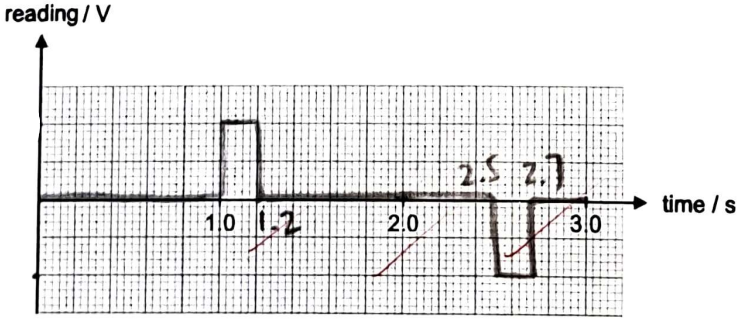
A square coil of side length 2 cm is moved between a pair of slab-shaped magnets with unlike poles facing each other. The figure below shows the position of the coil at time $t = 0$ s.



S is the region between the two magnets and is shaded in the figure. The coil is moved horizontally through region S at a constant speed of 10 cm s^{-1}. A uniform magnetic field points from magnet Q to magnet P in region S. The coil just leaves region S completely at $t = T$. Assume that there is no magnetic field outside region S.

(a) (i) The coil has 50 turns. The magnetic flux density in region S is 5×10^{-4} T. Calculate the maximum magnitude of the e.m.f. induced in the coil in the time interval from $t = 0$ s to $t = T$. (2 marks)

(ii) Sketch in the figure below the variation of the voltage sensor reading with time from $t = 0$ s to $t = 3$ s. (3 marks)



(b) Using the same coil, suggest **TWO** methods that can increase the maximum induced e.m.f. in the coil. (2 marks)

Question 11 (8 marks)

(a) A diffusion cloud chamber can be used to show visible tracks of nuclear radiation. **Figure 1** shows the schematic diagram of a cloud chamber.

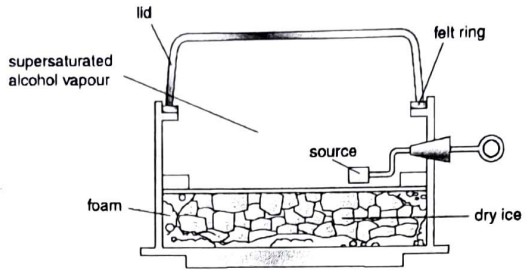


Figure 1

Figure 2 and **Figure 3** show the visible tracks produced by two different radioactive sources.

Figure 2

Figure 3

(i) Name the types of radiations producing the tracks in **Figure 2** and **Figure 3**.

(2 marks)

(ii) For the track in **Figure 3**, what is the type of gas inside the chamber?

(1 mark)

(iii) Suggest how the cloud chamber set-up can be modified so that the straight tracks in **Figure 3** would become the curved tracks in **Figure 4**. (1 mark)

Figure 4

(b) Carbon-14 ($^{14}_{6}C$) is a radioisotope of carbon with a half-life of 5700 years. Nitrogen is formed when carbon-14 decays by emitting a β particle.

(i) Write a nuclear equation to represent the decay of carbon-14. (1 mark)

(ii) A bone in a living human has an activity of 80 disintegrations per minute. A similar bone taken from an ancient skeleton has an activity of 15 disintegrations per minute. Estimate the age of the skeleton in years. (2 marks)

(iii) Explain briefly why carbon-14 is NOT suitable for dating a skeleton that is believed to be about 150 years old. (1 mark)

End of section B
END OF PAPER