Surname		Other Names	
Centre Number		Candidate Number	
Candidate Signature			

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General Certificate of Education
June 2002
Advanced Level Examination

PHYSICS (SPECIFICATION A) **PHA7/W**
Unit 7 Nuclear Instability: Applied Physics Option

Friday 21 June 2002 Afternoon Session

In addition to this paper you will require:
- a calculator;
- a pencil and a ruler.

Time allowed: 1 hour 15 minutes

Instructions
- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions in the spaces provided. All working must be shown.
- Do all rough work in this book. Cross through any work you do not want marked.

Information
- The maximum mark for this paper is 40.
- Mark allocations are shown in brackets.
- The paper carries 10% of the total marks for Physics Advanced.
- A *Data Sheet* is provided on pages 3 and 4. You may wish to detach this perforated sheet at the start of the examination.
- You are expected to use a calculator where appropriate.
- In questions requiring description and explanation you will be assessed on your ability to use an appropriate form and style of writing, to organise relevant information clearly and coherently, and to use specialist vocabulary where appropriate. The degree of legibility of your handwriting and the level of accuracy of your spelling, punctuation and grammar will also be taken into account.

For Examiner's Use			
Number	Mark	Number	Mark
1			
2			
3			
4			
5			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

Data Sheet

- A perforated *Data Sheet* is provided as pages 3 and 4 of this question paper.
- This sheet may be useful for answering some of the questions in the examination.
- You may wish to detach this sheet before you begin work.

DATA SHEET

DATA SHEET

TURN OVER FOR THE FIRST QUESTION

SECTION A NUCLEAR INSTABILITY

Answer **all** parts of the question.

1 (a) State which type of radiation, α, β or γ,

(i) produces the greatest number of ion pairs per mm in air,

....

(ii) could be used to test for cracks in metal pipes.

....

(2 marks)

(b) Specific radioisotope sources are chosen for tracing the passage of particular substances through the human body.

(i) Why is a γ emitting source commonly used?

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(ii) State why the source should **not** have a very short half-life.

....

....

(iii) State why the source should **not** have a very long half-life.

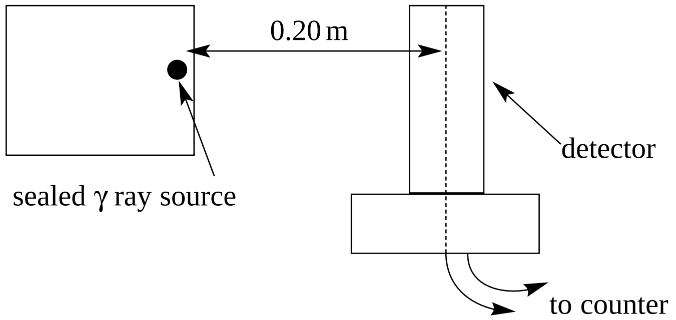
....

....

(3 marks)

LEAVE MARGIN BLANK

(c) A detector, placed 0.20 m from a sealed γ ray source, receives a mean count rate of 2550 counts per minute. The experimental arrangement is shown in the diagram below. The mean background radiation is measured as 50 counts per minute.



Calculate the least distance between the source and the detector if the count rate is not to exceed 6000 counts per minute.

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(5 marks)

10

TURN OVER FOR THE NEXT QUESTION

SECTION B APPLIED PHYSICS

Answer **all** questions.

2 A spinning flywheel is used for short-term energy storage in a new model of a delivery van. When the van makes one of its many stops, some of the kinetic energy of its forward motion is transferred to the flywheel instead of being dissipated as heat in the brakes. The rotational energy stored is recovered when the van re-starts.

(a) When the loaded van comes to rest from a speed of $60\,\text{km}\,\text{h}^{-1}$, 75% of its translational kinetic energy is transferred to the flywheel. The mass of the loaded van is 1800 kg. The flywheel is spinning at its maximum safe angular speed of $360\,\text{rad}\,\text{s}^{-1}$.

Calculate

(i) the translational kinetic energy of the van when travelling at $60\,\text{km}\,\text{h}^{-1}$,

....

....

(ii) the moment of inertia of the flywheel needed to store 75% of this energy.

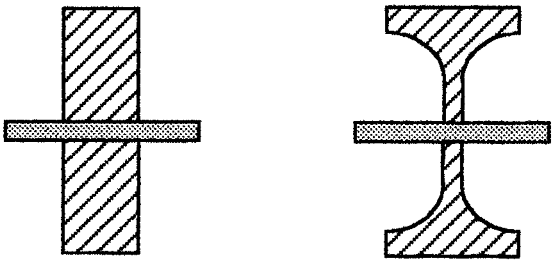
....

....

....

(4 marks)

(b) The diagram shows the cross-section of two flywheels. They have the same moment of inertia, are made of the same material and are designed to spin at the same maximum speed.



A B

State **one** advantage which flywheel B has over flywheel A when used in the delivery van. Explain the reason for this advantage.

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....

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....

(2 marks)

6

3 **Figure 1** shows the *speed regulator fly* of a clockwork musical box movement. When the movement is switched on, a spring accelerates the fly to a high angular speed which then remains constant as the spring unwinds. **Figure 2** shows how the speed of the fly changes over the first 800 ms after switching on.

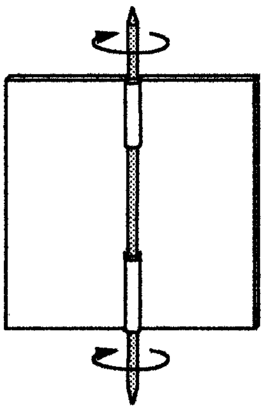

Figure 1

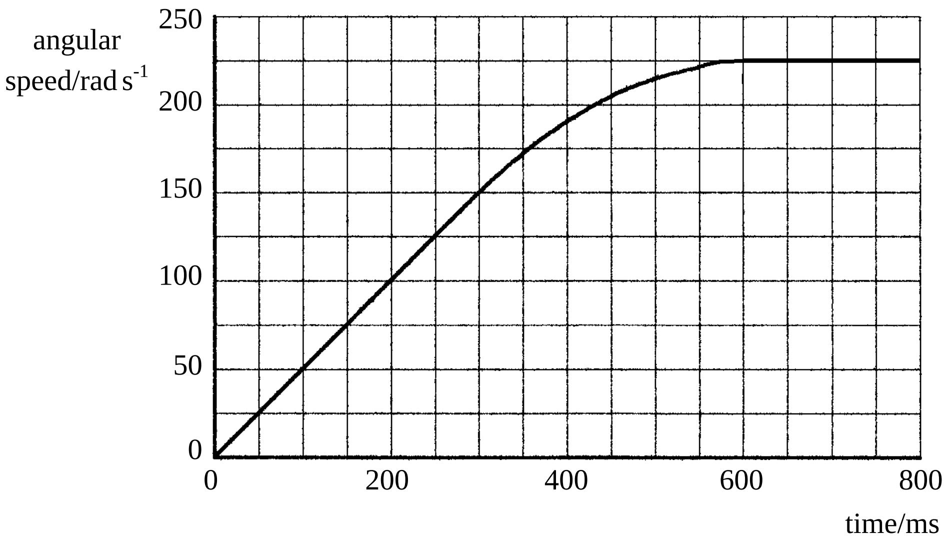

Figure 2

(a) The fly has a moment of inertia of 4.20×10^{-7} kg m^2.

Calculate

(i) the angular acceleration of the fly immediately after the movement is switched on,

....

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....

(ii) the torque acting on the fly during this initial acceleration.

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(3 marks)

(b) The torque applied to the fly by the spring is constant during the time it takes the fly to reach its maximum angular speed.

(i) Explain why the fly initially accelerates uniformly but eventually reaches a steady angular speed.

....

....

....

....

....

(ii) Calculate the power which the spring must supply to keep the fly rotating at a steady angular speed of 225 rad s^{-1}.

....

....

....

(iii) Estimate the energy which the spring supplies to keep the fly rotating at 225 rad s^{-1} for 1 minute.

....

....

....

(5 marks)

$\overline{}$ *8*

4 **Figure 1** shows part of a system used to study bubble formation and motion in molten volcanic rock. Hot gas in the pump cylinder is compressed by the piston, which is driven forward at a slow, steady rate. When the pressure of gas in the cylinder reaches 2.7×10^5 Pa, the valve opens and allows gas to flow to the bubble-head to form the bubble.
Figure 2 is the p - V diagram for the gas during one compression stroke of the piston. Details of the return stroke are **not** required in this question.

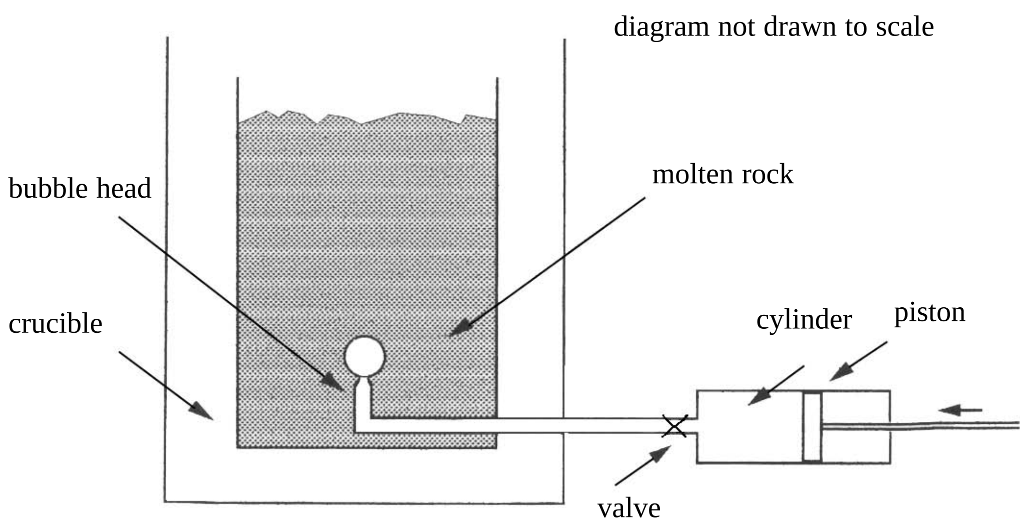

Figure 1

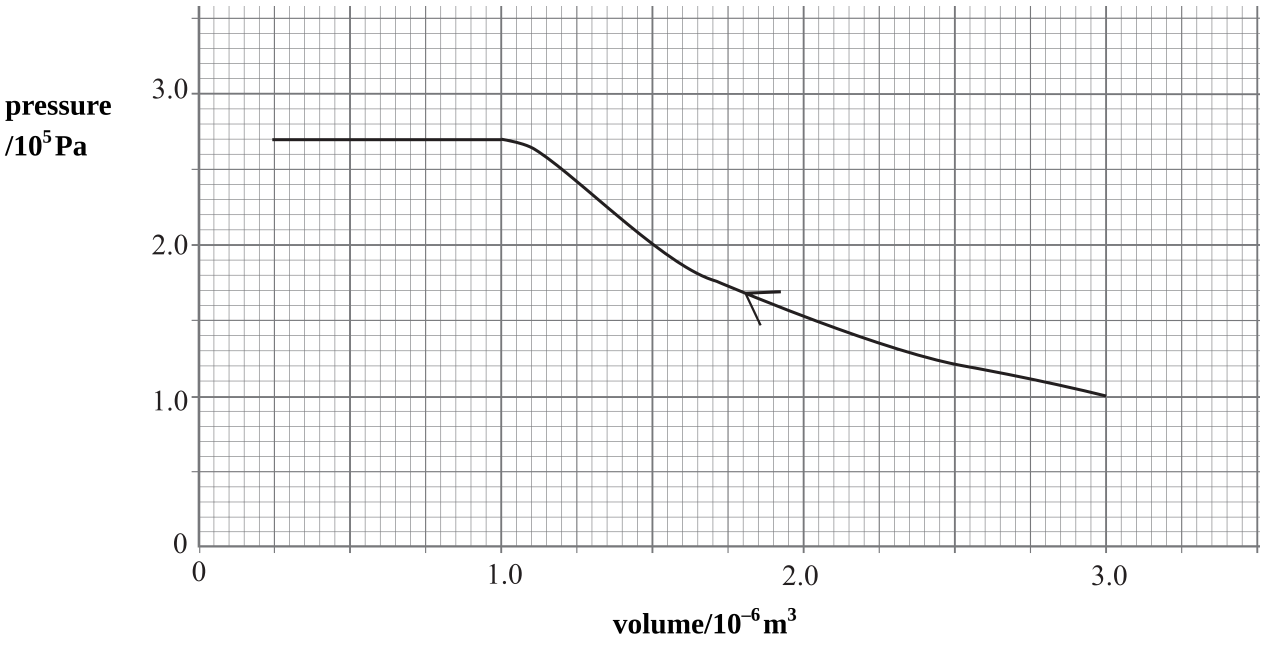

Figure 2

(a) Estimate the total work done on the gas during one compression stroke.

....

....

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....
(4 marks)

(b) Show that the compression of the gas before the valve opens is approximately isothermal.

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....

....
(1 mark)

(c) The slow compression helps in maintaining the gas at a constant temperature. Explain why this is the case.

....

....

....
(2 marks)

(d) The temperature of the gas during compression is 1600 °C. Calculate the number of moles of gas involved in each compression stroke.

....

....

....
(2 marks)

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9

5 A small geothermal power station in Iceland pumps cold water into hot rock strata far below the Earth's surface to be heated and returned at a constant temperature of 87 °C. The power station uses the hot water as the heat source for a heat engine which rejects energy to the much colder sea water near the station.

(a) When the temperature of the sea water is 7 °C the power output from the heat engine is 5.0 MW.

Calculate

(i) the maximum theoretical efficiency of the heat engine,

....

....

....

(ii) the rate at which heat energy must be transferred from the hot water if the engine works at the maximum theoretical efficiency,

....

....

(iii) the rate at which energy must be transferred to the sea water under these conditions.

....

....

(4 marks)

(b) The power station produces electrical power with an overall efficiency which is much lower than the maximum theoretical efficiency of the heat engine. Give **two** reasons for this lower efficiency.

....

....

....

(2 marks)

(c) The overall efficiency of an oil-fired power plant of similar size to the geothermal station is over four times as great. Suggest **one** reason, other than less pollution, why the geothermal source was preferred for the power station.

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(1 mark)

$\overline{}$ 7

END OF QUESTIONS

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