Centre Number					Candidate Number				

Surname

Other Names

Candidate Signature

Physics A   PHYA5/1

Unit 5   Nuclear and Thermal Physics
Section A

Tuesday 29 June 2010   1.30 pm to 3.15 pm

For this paper you must have:
- a calculator
- a ruler
- a question paper/answer book for Section B (enclosed).

Time allowed
- The total time for both sections of this paper is 1 hour 45 minutes. You are advised to spend approximately 55 minutes on this section.

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Answers written in margins or on blank pages will not be marked.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this section is 40.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert in Section B.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use specialist vocabulary where appropriate.

Section A

The maximum mark for this section is 40 marks. You are advised
to spend approximately 55 minutes on this section.

1   Molten lead at its melting temperature of 327°C is poured into an iron mould where it
solidifies. The temperature of the iron mould rises from 27°C to 84°C, at which the
mould is in thermal equilibrium with the now solid lead.

mass of lead = 1.20 kg
specific latent heat of fusion of lead = 2.5×10^4 J kg^{-1}
mass of iron mould = 3.00 kg
specific heat capacity of iron = 440 J kg^{-1} K^{-1}

1 (a)   Calculate the heat energy absorbed by the iron mould.

answer = ... J
(2 marks)

1 (b)   Calculate the heat energy given out by the lead while it is changing state.

answer = ... J
(1 mark)

1 (c) Calculate the specific heat capacity of lead.

answer = ... $J\,kg^{-1}\,K^{-1}$

(3 marks)

1 (d) State **one** reason why the answer to part 1 **(c)** is only an approximation.

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(1 mark)

7

Turn over for the next question

Turn over ▶

2 (a) In a thermal nuclear reactor, one fission reaction typically releases 2 or 3 neutrons. Describe and explain how a constant rate of fission is maintained in a reactor by considering what events or sequence of events may happen to the released neutrons.

The quality of your written communication will be assessed in this question.

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(7 marks)

2 (b) Uranium is an α emitter. Explain why spent fuel rods present a greater radiation hazard than unused uranium fuel rods.

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(3 marks)

10

Turn over for the next question

Turn over ▶

3 The age of an ancient boat may be determined by comparing the radioactive decay of $^{14}_{6}C$ from living wood with that of wood taken from the ancient boat.
A sample of 3.00×10^{23} atoms of carbon is removed for investigation from a block of living wood. In living wood one in 10^{12} of the carbon atoms is of the radioactive isotope $^{14}_{6}C$, which has a *decay constant* of $3.84 \times 10^{-12}\,s^{-1}$.

3 (a) What is meant by the decay constant?

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(1 mark)

3 (b) Calculate the half-life of $^{14}_{6}C$ in years, giving your answer to an appropriate number of significant figures.

$$1 \text{ year} = 3.15 \times 10^{7}\,s$$

answer = ... years
(3 marks)

3 (c) Show that the rate of decay of the $^{14}_{6}C$ atoms in the living wood sample is 1.15 Bq.

(2 marks)

3 (d)   A sample of 3.00×10^{23} atoms of carbon is removed from a piece of wood taken from the ancient boat. The rate of decay due to the $^{14}_{6}C$ atoms in this sample is 0.65 Bq. Calculate the age of the ancient boat in years.

answer = ... years

(3 marks)

3 (e)   Give **two** reasons why it is difficult to obtain a reliable age of the ancient boat from the carbon dating described.

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(2 marks)

11

Turn over for the next question

Turn over ▶
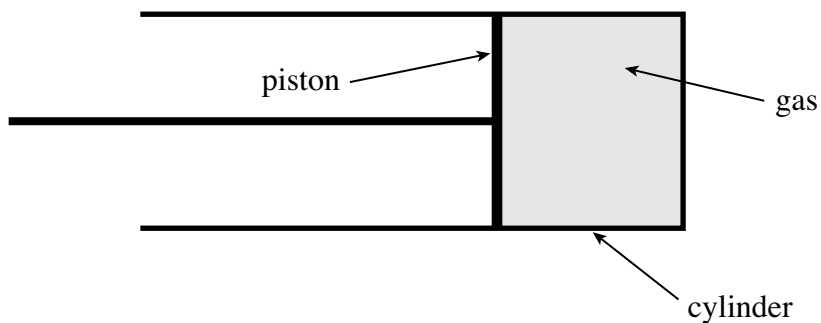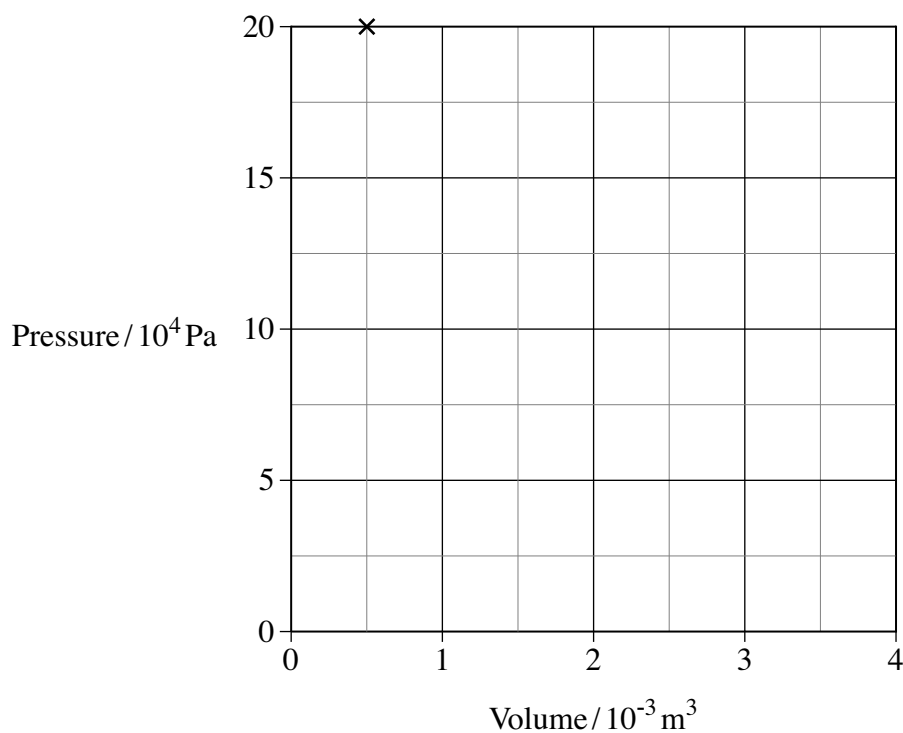
4

Figure 1

Figure 1 shows a cylinder, fitted with a gas-tight piston, containing an ideal gas at a constant temperature of 290 K. When the pressure, p, in the cylinder is 20×10^4 Pa the volume, V, is 0.5×10^{-3} m^3.

Figure 2 shows this data plotted.

Figure 2

4 (a) By plotting two or three additional points draw a graph, on the axes given in **Figure 2**, to show the relationship between pressure and volume as the piston is slowly pulled out. The temperature of the gas remains constant.

(3 marks)

4 (b) (i)   Calculate the number of gas molecules in the cylinder.

answer = ... molecules

(2 marks)

4 (b) (ii)   Calculate the total kinetic energy of the gas molecules.

answer = ... J

(3 marks)

4 (c)   State **four** assumptions made in the molecular kinetic theory model of an ideal gas.

(i) ....

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(ii)...

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(iii) ....

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(iv)...

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(4 marks)

END OF SECTION A

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