| Centre Number | | | | | | Candidate Number | | | | |
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| Surname | | | | | | | | | | |
| Other Names | | | | | | | | | | |
| Candidate Signature | | | | | | | | | | |

| For Examiner's Use | |
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| Examiner's Initials | |
| Question | Mark |
| 1 | |
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AQA

General Certificate of Education
Advanced Level Examination
June 2010

# 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 327ºC is poured into an iron mould where it solidifies. The temperature of the iron mould rises from 27ºC to 84ºC, 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 = $2.5 \times 10^4$ 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 = ...................................... $\mathrm{J\,kg^{-1}\,K^{-1}}$
*(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**

**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)*

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**2 (b)** Uranium is an $\alpha$ 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**

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**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 $3.00 \times 10^{23}$ 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 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 $3.00 \times 10^{23}$ 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**

**4**

**Figure 1**

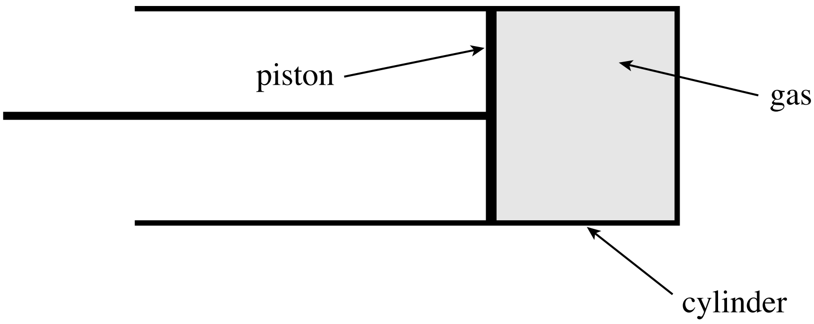
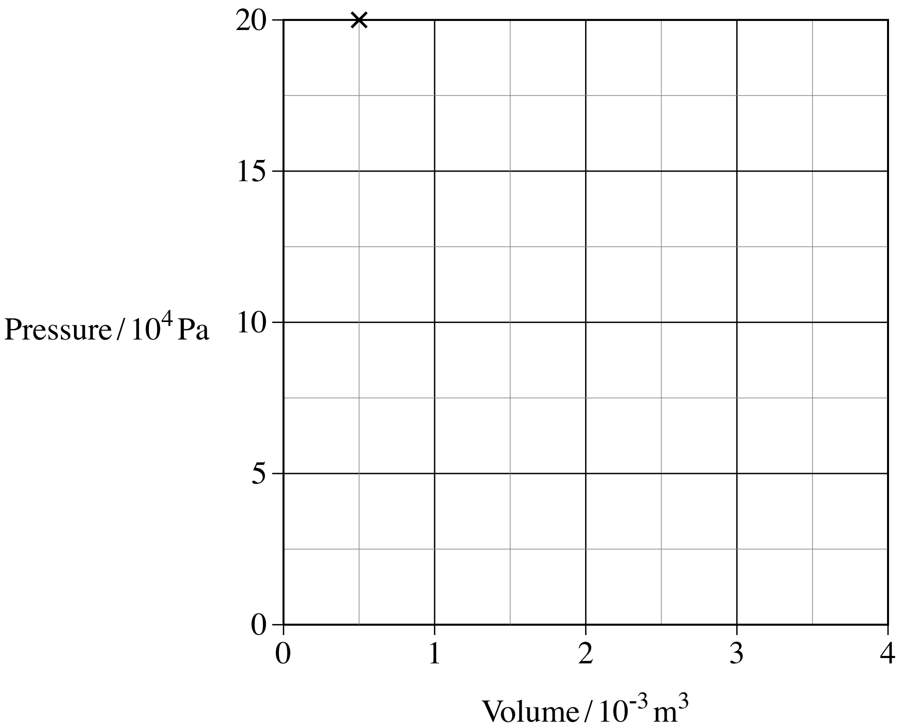



**Figure 1** shows a cylinder, fitted with a gas-tight piston, containing an ideal gas at a constant temperature of 290 K. When the pressure, $p$, in the cylinder is $20 \times 10^4$ Pa the volume, V, is $0.5 \times 10^{-3}$ m$^3$.

**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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