Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
TOTAL	

AQA

General Certificate of Education
Advanced Level Examination
June 2013

Physics A PHYA5/1

Unit 5 Nuclear and Thermal Physics
Section A

Thursday 20 June 2013 9.00 am to 10.45 am

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.
- Show all your working.

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 (a) (i) Define the atomic mass unit.

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(1 mark)

1 (a) (ii) State and explain how the mass of a $^{4}_{2}He$ nucleus is different from the total mass of its protons and neutrons when separated.

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(2 marks)

1 (b) Explain why nuclei in a star have to be at a high temperature for fusion to take place.

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(3 marks)

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1 (c) (i) In massive stars, nuclei of hydrogen ${}^{1}_{1}\text{H}$ are processed into nuclei of helium ${}^{4}_{2}\text{He}$ through a series of interactions involving carbon, nitrogen and oxygen called the CNO cycle.

Complete the nuclear equations below that represent the last two reactions in the series.

$$ {}^{\cdots\cdots}_{8}\text{O} \rightarrow {}^{15}_{7}\text{N} + \ldots\ldots\ldots + \nu_e $$

$$ {}^{15}_{7}\text{N} + {}^{1}_{1}\text{H} \rightarrow {}^{\cdots\cdots}_{6}\text{C} + {}^{4}_{2}\text{He} $$

(3 marks)

1 (c) (ii) The whole series of reactions is summarised by the following equation.

$$ 4\,{}^{1}_{1}\text{H} \rightarrow {}^{4}_{2}\text{He} + 2\text{e}^{+} + 2\nu_e $$

Calculate the energy, in MeV, that is released.

nuclear mass of ${}^{4}_{2}\text{He}$ = 4.00150 u

energy .... MeV

(3 marks)

12

Turn over ▶

Do not write outside the box

2 (a) Describe the changes made inside a nuclear reactor to reduce its power output and explain the process involved.

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(2 marks)

2 (b) State the main source of the highly radioactive waste from a nuclear reactor.

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(1 mark)

2 (c) In a nuclear reactor, neutrons are released with high energies. The first few collisions of a neutron with the moderator transfer sufficient energy to excite nuclei of the moderator.

2 (c) (i) Describe and explain the nature of the radiation that may be emitted from an excited nucleus of the moderator.

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(2 marks)

2 (c) (ii) The subsequent collisions of a neutron with the moderator are elastic.

Describe what happens to the neutrons as a result of these subsequent collisions with the moderator.

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(2 marks)

7

3 A cola drink of mass 0.200 kg at a temperature of 3.0 ºC is poured into a glass beaker. The beaker has a mass of 0.250 kg and is initially at a temperature of 30.0 ºC.

specific heat capacity of glass = 840 J kg^{-1} K^{-1}
specific heat capacity of cola = 4190 J kg^{-1} K^{-1}

3 (i) Show that the final temperature, T_f, of the cola drink is about 8 ºC when it reaches thermal equilibrium with the beaker.
Assume no heat is gained from or lost to the surroundings.

(2 marks)

3 (ii) The cola drink and beaker are cooled from T_f to a temperature of 3.0 ºC by adding ice at a temperature of 0 ºC.
Calculate the mass of ice added.
Assume no heat is gained from or lost to the surroundings.

specific heat capacity of water = 4190 J kg^{-1} K^{-1}
specific latent heat of fusion of ice = 3.34×10^5 J kg^{-1}

mass .... kg
(3 marks)

5

4 (a) Outline what is meant by an *ideal gas*.

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(2 marks)

4 (b) An ideal gas at a temperature of 22 °C is trapped in a metal cylinder of volume $0.20\,m^3$ at a pressure of 1.6×10^6 Pa.

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

number of moles .... mol

(2 marks)

4 (b) (ii) The gas has a molar mass of $4.3 \times 10^{-2}\,kg\,mol^{-1}$.

Calculate the density of the gas in the cylinder.

State an appropriate unit for your answer.

density .... unit ....

(3 marks)

4 (b) (iii) The cylinder is taken to high altitude where the temperature is –50 ºC and the pressure is 3.6×10^4 Pa. A valve on the cylinder is opened to allow gas to escape.

Calculate the mass of gas remaining in the cylinder when it reaches equilibrium with its surroundings.

Give your answer to an appropriate number of significant figures.

mass .... kg
(3 marks)

10

5 A radioactive source used in a school laboratory is thought to emit α particles and γ radiation. Describe an experiment that may be used to verify the types of radiation emitted by the source. The experiment described should allow you to determine how the intensity of radiation varies with distance in air or with the thickness of suitable absorbers.

Your answer should include:

- the apparatus you would use and any safety precautions you would take
- the measurements you would make
- how the measurements would be used to reach a final decision about the emitted radiation.

The quality of your written communication will be assessed in your answer.

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Do not write outside the box

(6 marks)

6

END OF SECTION A