

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

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



General Certificate of Education
Advanced Level Examination
June 2011

Physics A

PHYA5/1

Unit 5 Nuclear and Thermal Physics Section A

Monday 27 June 2011 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.

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.



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Section A

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

- 1** The fissile isotope of uranium, ${}^{233}_{92}\text{U}$, has been used in some nuclear reactors. It is normally produced by neutron irradiation of thorium-232. An irradiated thorium nucleus emits a β^- particle to become an isotope of protactinium.

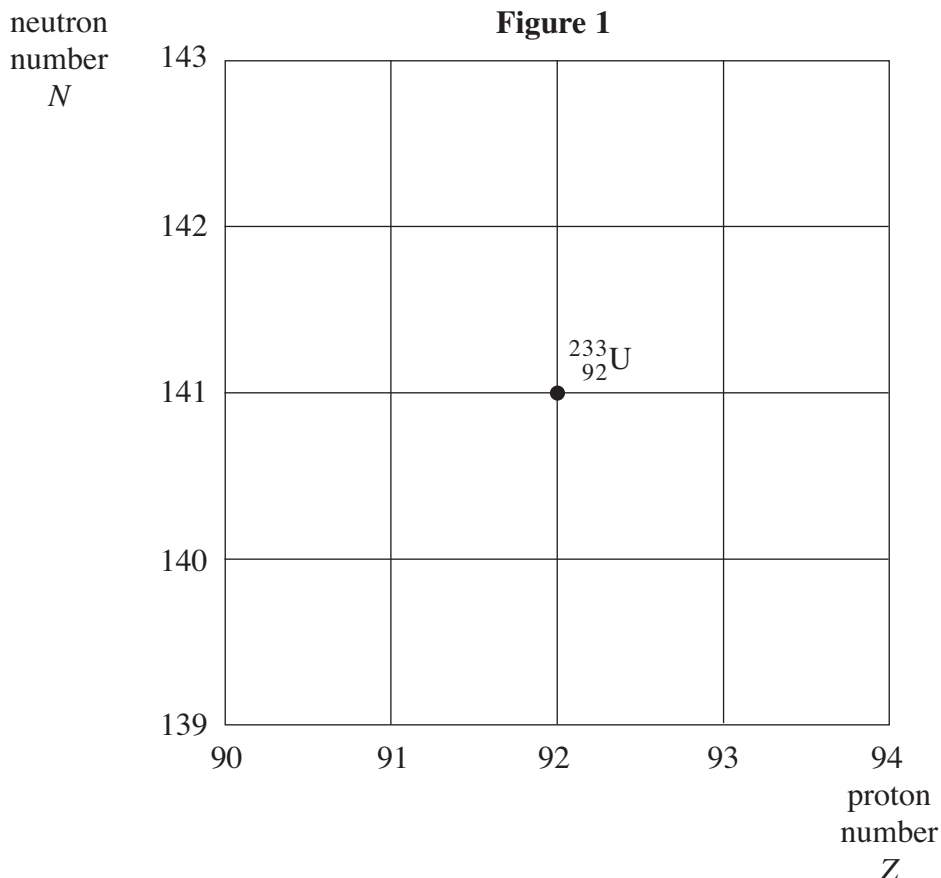
This isotope of protactinium may undergo β^- decay to become ${}^{233}_{92}\text{U}$.

- 1 (a)** Complete the following equation to show the β^- decay of protactinium.



(2 marks)

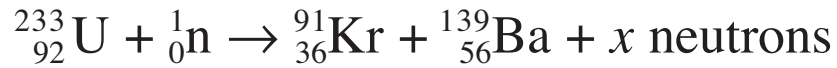
- 1 (b)** Two other nuclei, **P** and **Q**, can also decay into ${}^{233}_{92}\text{U}$.
P decays by β^+ decay to produce ${}^{233}_{92}\text{U}$.
Q decays by α emission to produce ${}^{233}_{92}\text{U}$.
Figure 1 shows a grid of neutron number against proton number with the position of the ${}^{233}_{92}\text{U}$ isotope shown.
On the grid label the positions of the nuclei **P** and **Q**.



(2 marks)



1 (c) A typical fission reaction in the reactor is represented by



1 (c) (i) Calculate the number of neutrons, x .

answer =neutrons
(1 mark)

1 (c) (ii) Calculate the energy released, in MeV, in the fission reaction above.

mass of neutron = 1.00867 u

mass of ${}_{92}^{233}\text{U}$ nucleus = 232.98915 u

mass of ${}_{36}^{91}\text{Kr}$ nucleus = 90.90368 u

mass of ${}_{56}^{139}\text{Ba}$ nucleus = 138.87810 u

answer =MeV
(3 marks)

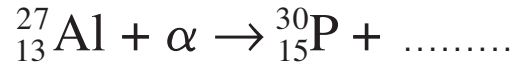
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Turn over ►



2 The first artificially produced isotope, phosphorus ${}_{15}^{30}\text{P}$, was formed by bombarding an aluminium isotope, ${}_{13}^{27}\text{Al}$, with an α particle.

2 (a) Complete the following nuclear equation by identifying the missing particle.



(1 mark)

2 (b) For the reaction to take place the α particle must come within a distance, d , from the centre of the aluminium nucleus.
Calculate d if the nuclear reaction occurs when the α particle is given an initial kinetic energy of at least 2.18×10^{-12} J.

The electrostatic potential energy between two point charges Q_1 and Q_2 is equal to $\frac{Q_1 Q_2}{4\pi\epsilon_0 r}$ where r is the separation of the charges and ϵ_0 is the permittivity of free space.

answer =m
(3 marks)

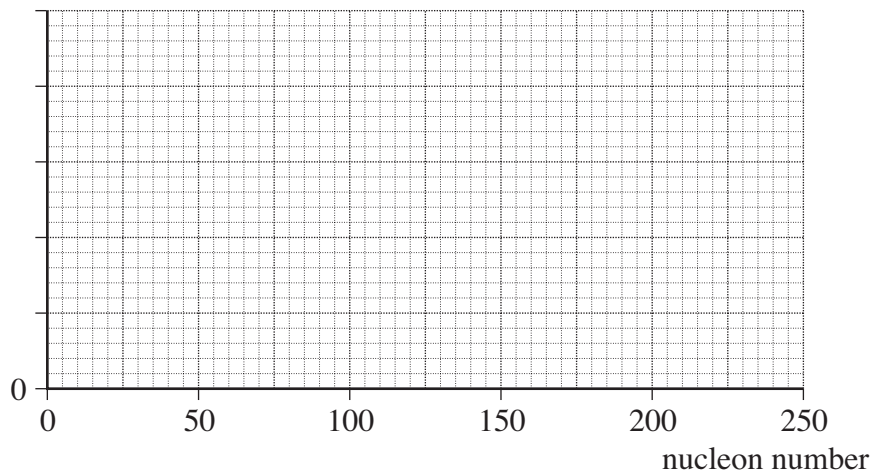
4



- 3 (a) Sketch a graph of binding energy per nucleon against nucleon number for the naturally occurring nuclides on the axes given in **Figure 2**. Add values and a unit to the binding energy per nucleon axis.

Figure 2

binding energy
per nucleon



(4 marks)

- 3 (b) Use the graph to explain how energy is released when some nuclides undergo fission and when other nuclides undergo fusion.

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(3 marks)

7

Turn over ►



4 An electrical heater is placed in an insulated container holding 100 g of ice at a temperature of -14°C . The heater supplies energy at a rate of 98 joules per second.

4 (a) After an interval of 30 s, all the ice has reached a temperature of 0°C . Calculate the specific heat capacity of ice.

answer = $\text{J kg}^{-1} \text{K}^{-1}$
(2 marks)

4 (b) Show that the final temperature of the water formed when the heater is left on for a further 500 s is about 40°C .

specific heat capacity of water = $4200 \text{ J kg}^{-1} \text{K}^{-1}$
specific latent heat of fusion of water = $3.3 \times 10^5 \text{ J kg}^{-1}$

(3 marks)

4 (c) The whole procedure is repeated in an uninsulated container in a room at a temperature of 25°C . State and explain whether the final temperature of the water formed would be higher or lower than that calculated in part (b).

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(2 marks)

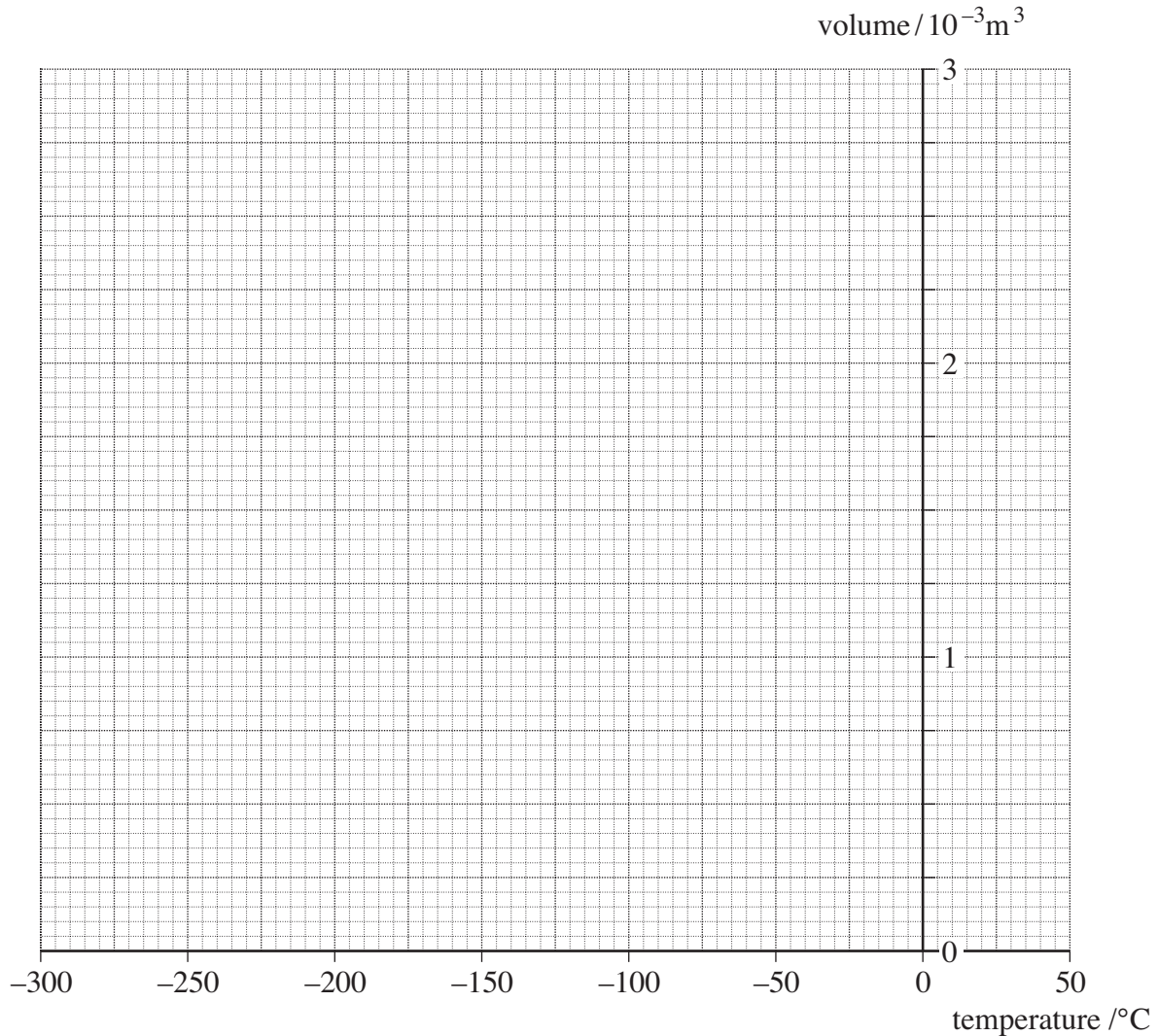
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- 5** A fixed mass of ideal gas at a low temperature is trapped in a container at constant pressure. The gas is then heated and the volume of the container changes so that the pressure stays at $1.00 \times 10^5 \text{ Pa}$.

When the gas reaches a temperature of 0°C the volume is $2.20 \times 10^{-3} \text{ m}^3$.

- 5 (a)** Draw a graph on the axes below to show how the volume of the gas varies with temperature in $^\circ\text{C}$.



(2 marks)

- 5 (b)** Calculate the number of moles of gas present in the container.

answer =moles
(2 marks)

Turn over ►



