For Examiner's Use

General Certificate of Education
January 2009
Advanced Level Examination

AQA

PHYSICS (SPECIFICATION A)　　　　　　　　　　　　**PA04**
Unit 4　Waves, Fields and Nuclear Energy

Section B

Wednesday 21 January 2009　　9.00 am to 10.30 am

For this paper you must have:
- a pencil and a ruler
- a calculator
- a Data Sheet Insert.

Time allowed: The total time for Section A and Section B of this
　　　　　　　paper is 1 hour 30 minutes.

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Answer the questions in the spaces provided. Answers written on margins or on blank pages will not be marked.
- Show all your working.

Information
- The maximum mark for this section is 45.
  This includes up to two marks for the Quality of Written Communication.
- The marks for questions are shown in brackets.
- You are expected to use a calculator where appropriate.
- A *Data Sheet* is provided as a loose insert.
- Questions 2(b) and 3(a) should be answered in continuous prose.
  In these questions you will be marked on your ability to use good English, to organise information clearly and to use specialist vocabulary where appropriate.

Answer **all** questions.

You are advised to spend about one hour on this section.

1 (a) Explain why, when a body is moving in simple harmonic motion, an equation of the form $a = -kx$ must be satisfied. In this equation, k is a positive constant and a and x have their usual meanings.

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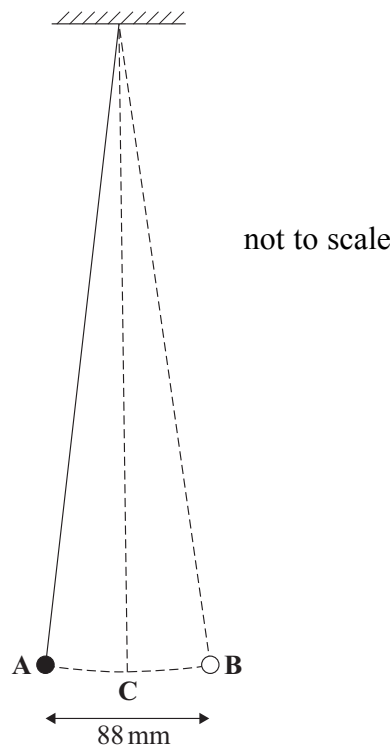*(2 marks)*

1 (b) The length of a simple pendulum, from the point of support to the centre of mass of the bob, is 0.64 m. The mass of the bob is 1.5×10^{-2} kg. The pendulum is set into small amplitude oscillations. The distance from one extreme position of the oscillations, **A**, to the other extreme position, **B**, is 88 mm, as shown in **Figure 1**.

Figure 1

1 (b) (i) As the bob oscillates it passes through the equilibrium position **C**. Calculate the time taken for the bob to travel from **A** to **C**.

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1 (b) (ii) Determine the maximum kinetic energy of the pendulum bob.

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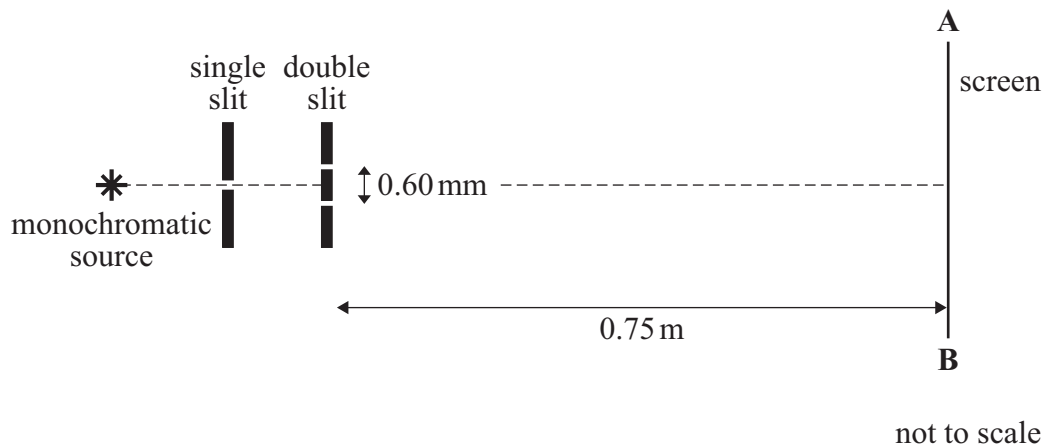
(7 marks)

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2 (a)

Figure 2

Figure 2, which is not drawn to scale, shows an arrangement which is used to produce interference fringes in the central part of the screen. Light from a monochromatic source illuminates a single slit. The diffracted light then passes through a double slit which acts as a pair of coherent sources. Interference occurs where the diffracted beams overlap. The slit separation of the double slit is 0.60 mm, and the distance from the double slit to the screen is 0.75 m.

Calculate how many interference fringes will be formed along a 5.0 mm length of the line **AB** near the centre of the screen when the monochromatic light is

2 (a) (i) blue light of frequency 6.5×10^{14} Hz,

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2 (a) (ii) red light of frequency 4.6×10^{14} Hz.

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(4 marks)

2 (b) Interference experiments such as that described in part (a) usually use monochromatic light. Interference fringes can also be produced when white light, instead of monochromatic light, is incident on the double slit system.

Compare the appearance of the monochromatic light fringe pattern with that of the white light fringe pattern.

You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer.

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(4 marks)

8

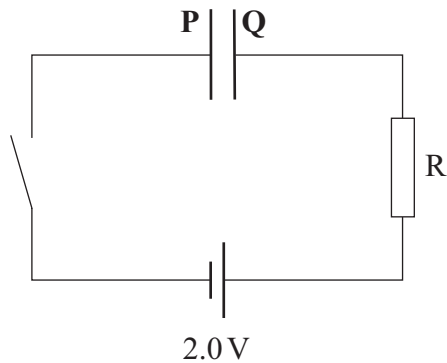**Turn over for the next question**

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3 (a)

Figure 3

2.0 V

You may be awarded additional marks to those shown in brackets for the quality of written communication in your answers.

Figure 3 shows a circuit containing a capacitor connected in series with a fixed resistor R, a cell of emf 2.0 V, and a switch. Initially the capacitor is uncharged. The switch is closed at time $t = 0$, causing the capacitor plates **P** and **Q** to begin charging.

Describe what happens in the circuit from $t = 0$ until the capacitor becomes fully charged, in terms of

3 (a) (i) electron flow round the circuit,

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3 (a) (ii) the potential differences across the capacitor and the resistor.

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(5 marks)

3 (b) (i) Calculate the final energy stored by the capacitor if its capacitance is 50 µF.

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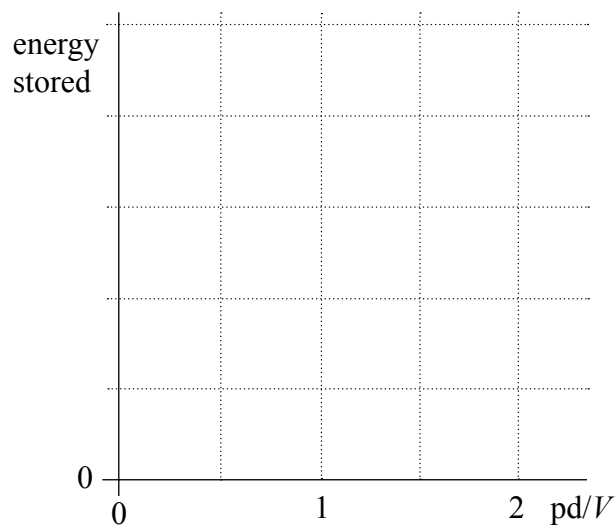
3 (b) (ii) On **Figure 4** sketch a graph to show how the energy stored by the capacitor varies with the pd across it whilst it is being charged during the process described in part (a).

Figure 4

energy
stored

0
0   1   2   pd/*V*

(4 marks)

Turn over ▶

4 **(a)** Experiments are carried out to measure the electromotive force induced in coils when they are removed quickly from magnetic fields.

State **four** factors which, if increased, would increase the magnitude of the induced electromotive force in these experiments.
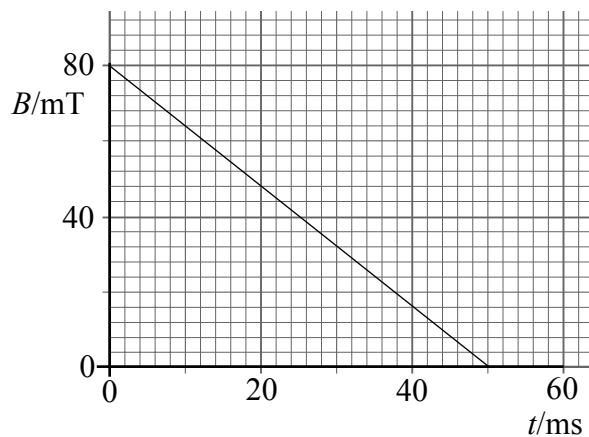
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(2 marks)

4 **(b)** A rectangular coil of dimensions 60 mm × 35 mm and having 48 turns is placed with its plane perpendicular to the magnetic field of an electromagnet.
The current in the electromagnet is reduced to zero, causing the flux density, *B*, of the magnetic field it produces to decrease with time, *t*, as shown.

Calculate

4 **(b)** **(i)** the rate of change of magnetic flux through the coil,

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4 (b) (ii) the emf induced in the coil.

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(6 marks)

8

5 (a) The principal thermonuclear fusion process by which the Sun produces energy is a sequence of three separate fusion reactions. This process effectively combines four protons into one helium nucleus, releasing an amount of energy that is equivalent to the mass difference between four $_1^1$H atoms and one $_2^4$He atom.

Show that the energy released by the process is about 27 MeV.

mass of $_1^1$H atom　= 1.00783 u

mass of $_2^4$He atom　= 4.00260 u

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(2 marks)

5 (b) It has been calculated that, in the absence of any atmospheric absorption, energy from the Sun would reach the Earth at a rate of 1350 W m^{-2}.

Show that the mean rate of energy production by the Sun is approximately 4×10^{26} W. Assume that there is no absorption between the Sun and the Earth.

mean radius of Earth's orbit = 1.50×10^{11} m

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(2 marks)

5 (c) From parts (a) and (b), and any data needed from the *Data Sheet*, calculate

5 (c) (i) the rate at which the mass of the Sun is decreasing,

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5 (c) (ii) the number of $_2^4$He nuclei that are produced per day by the fusion process described in part (a).

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(5 marks)

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Quality of Written Communication *(2 marks)*

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END OF QUESTIONS

There are no questions printed on this page

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