Surname		Other Names	
Centre Number			Candidate Number									
Candidate Signature												

For Examiner's Use

General Certificate of Education
June 2009
Advanced Level Examination

AQA

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

Section B

Wednesday 10 June 2009 1.30 pm to 3.00 pm

For this paper you must have:
- a pencil and a ruler
- a calculator
- a data sheet insert (enclosed in Section A).

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.
- You must answer the questions in the spaces provided. Answers written in margins or on blank pages will not be marked.
- Show all your working.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The maximum mark for this Section is 45. This includes up to 2 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 to Section A.
- Questions 1(c) and 5(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.

For Examiner's Use			
Question	Mark	Question	Mark
1			
2			
3			
4			
5			
Total (Column 1) →			
Total (Column 2) →			
Quality of Written Communication			
TOTAL			
Examiner's Initials			

SECTION B

Answer **all** questions.

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

1 (a) A white light source emits wavelengths from 410 nm to 680 nm.

What colour of light has a wavelength of 680 nm?

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(1 mark)

1 (b) Light from the source in part (a) is incident normally on a plane diffraction grating. The first and second order spectra are fully visible and do not overlap. Light of wavelength 410 nm appears at a diffraction angle of 62° in the third order image.

1 (b) (i) Show that the grating has about 7×10^5 rulings per metre.

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1 (b) (ii) Calculate the diffraction angle of light of wavelength 680 nm in the second order spectrum.

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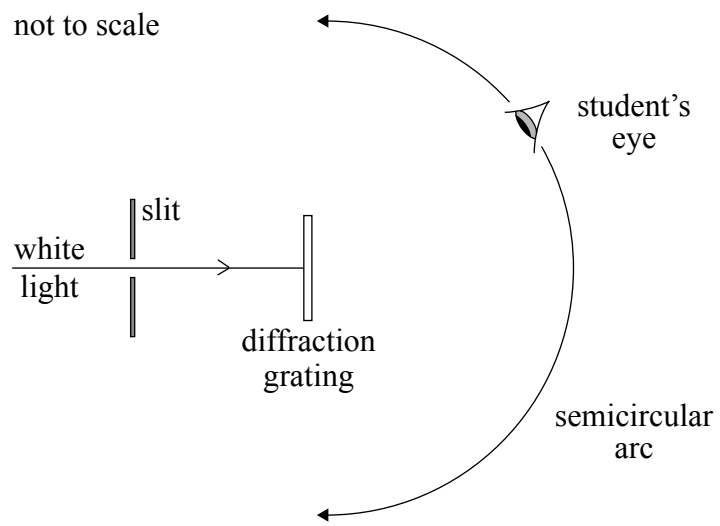
(5 marks)

1 (c) A student observes the light emerging from the grating in part (b) by looking into the grating from various positions along a semicircular arc around the grating. His experiment is shown diagrammatically in **Figure 1**, which is not to scale.

Describe what he should see as he moves his eye along this arc from one extreme end of the arc to the other. You may draw on **Figure 1** to illustrate your answer.
You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer.

Figure 1



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(4 marks)

10

2 (a) Define the *capacitance* of a capacitor.

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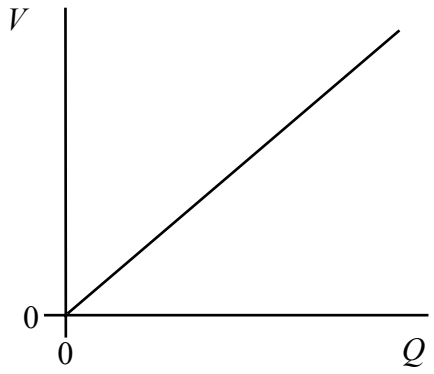
(2 marks)

2 (b) **Figure 2** shows how the pd, *V,* across a capacitor varies with the charge, *Q*, it stores.

Figure 2



By reference to **Figure 2**, show that the energy stored by a capacitor is given by

$$E = \tfrac{1}{2} Q V.$$

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(3 marks)

2 (c) A capacitor stores 9.0 μC of charge when the pd across it is 45 V.

Calculate

2 (c) (i) the capacitance of the capacitor,

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2 (c) (ii) the energy stored by the capacitor when the charge on it is 3.0 μC.

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(4 marks)

9

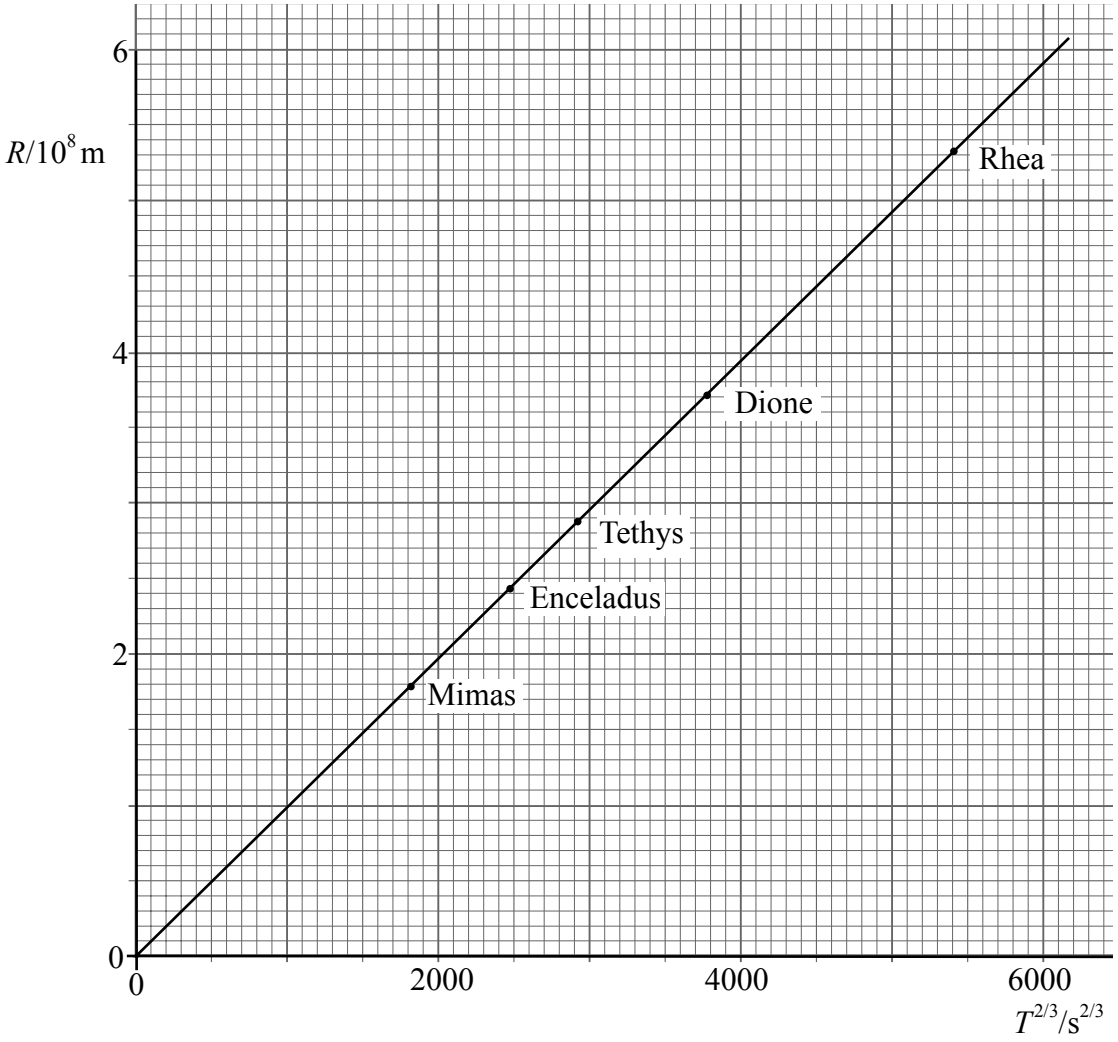
Turn over for the next question

3 (a) For a satellite in orbit around a planet, theory shows that the relationship between the mean orbital radius, R, and the orbital period, T, is

$$R^3 = \frac{GMT^2}{4\pi^2}$$, where M is the mass of the planet.

The graph in **Figure 3**, which is constructed from measurements based on observations, shows how R varies with $T^{2/3}$ for five of the inner satellites of the planet Saturn, named Mimas, Enceladus, Tethys, Dione and Rhea.

Figure 3



3 (a) (i) Determine the gradient of the graph in **Figure 3** in $m\,s^{-2/3}$.

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3 (a) (ii) Explain how the relationship between R and T in the equation given in part (a) is supported by this graph.

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3 (a) (iii) Use your value for the gradient, together with any other necessary data, to calculate the mass of Saturn.

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(6 marks)

3 (b) It is possible to plot a graph of R against $T^{2/3}$ for the orbits of the planets around the Sun.

State and explain **one** similarity, and **one** difference, between the properties of this graph and the graph shown in **Figure 3**.

Similarity:.....

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Difference:.....

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(2 marks)

8

4 (a) (i) With the aid of a diagram, describe the electric field around an isolated point negative charge (shown below as $-Q$).

$\bullet -Q$

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4 (a) (ii) Draw a dashed line (- - - - - - - - - - - -) on your diagram, along which a small charge could be moved without changing its potential energy. Label this line **L**.

(4 marks)

4 (b) (i) Point P is 40 mm from a point charge of –0.80 nC.

Calculate the magnitude of the electric field strength at P.

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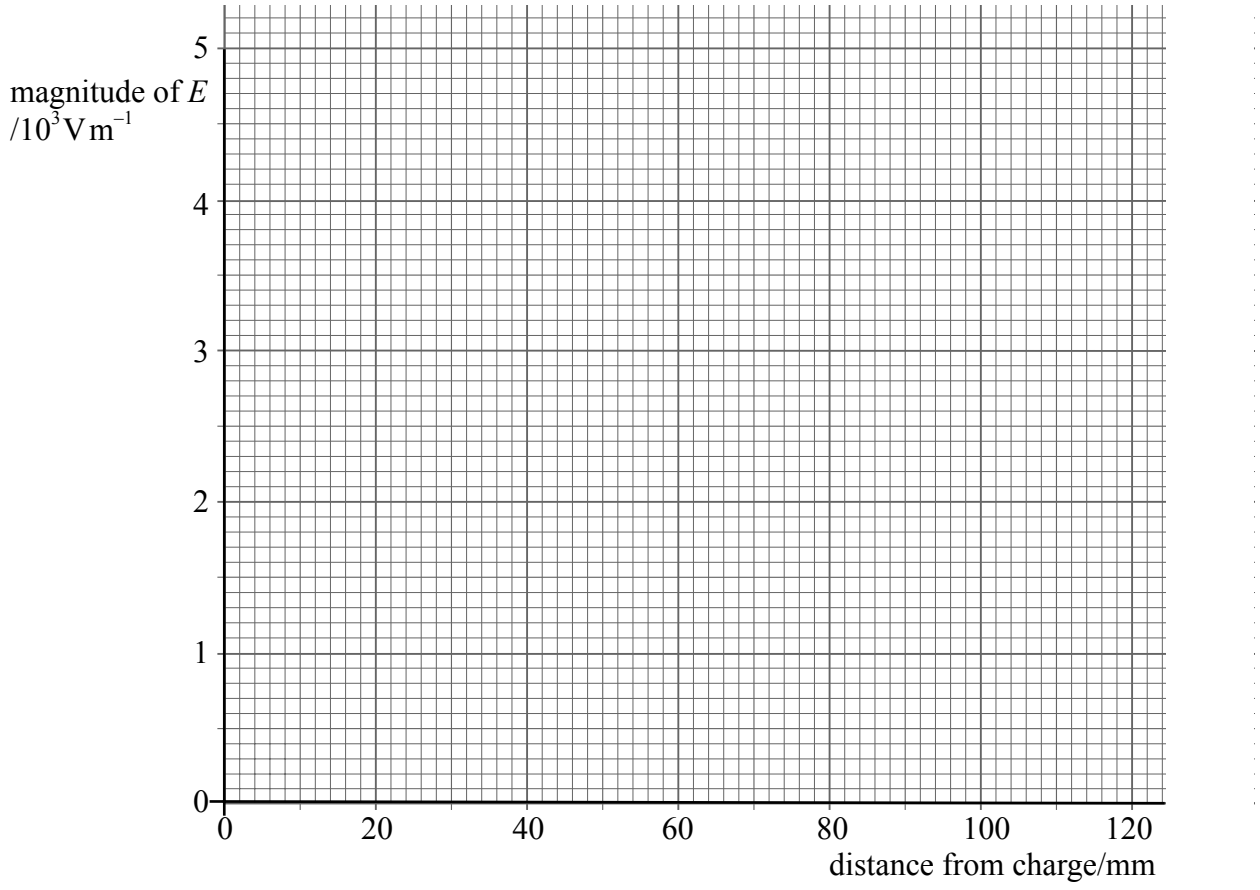
4 (b) (ii) Insert your value for the electric field strength at P, from part (b)(i), on **Figure 4**. Then complete, as accurately as you can, a graph on **Figure 4** to show how the magnitude of the electric field strength varies with distance, for points which are at distances greater than 40 mm from the –0.80 nC charge.

Figure 4



(5 marks)

9

5 (a) Distinguish between the *mass difference* and the *binding energy* of an atomic nucleus and state how these quantities are related.

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

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(3 marks)

5 (b) Calculate the binding energy, in J, of the iron nucleus $^{56}_{26}Fe$.

mass of $^{56}_{26}Fe$ atom = 55.93493 u
electron rest mass = 0.00055 u
proton rest mass = 1.00728 u
neutron rest mass = 1.00867 u

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(4 marks)

7

Quality of Written Communication *(2 marks)*

2

END OF QUESTIONS

There are no questions printed on this page

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