OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE

PHYSICS A

Fields, Particles and Frontiers of Physics

G485

Candidates answer on the question paper.

OCR supplied materials:
- Data, Formulae and Relationships Booklet

Other materials required:
- Electronic calculator

Wednesday 2 February 2011
Afternoon

Duration: 1 hour 45 minutes

OCE/17327

G4835

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined pages at the end of this booklet. The question number(s) must be clearly shown.
- Answer **all** the questions.
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **100**.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
-  Where you see this icon you will be awarded marks for the quality of written communication in your answer.

  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- This document consists of **20** pages. Any blank pages are indicated.

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Answer **all** the questions.

1 **(a)** Fig. 1.1 shows a circuit consisting of two parallel plates **A** and **B** connected to a high voltage power supply.

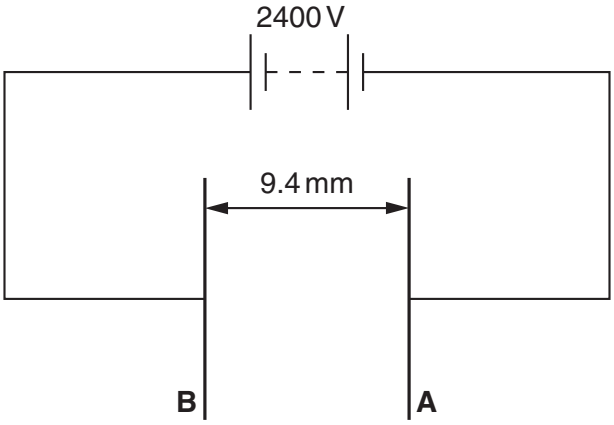


Fig. 1.1

The separation of the plates is 9.4 mm and the p.d. across the plates is 2400 V. There is a vacuum between the plates. Electrons are accelerated from plate **A** to plate **B**.

Calculate

(i) the force acting on an electron when it is between the plates

force = ... N **[2]**

(ii) the gain in kinetic energy of an electron when it travels from **A** to **B**

kinetic energy = ... J **[2]**

(iii) the speed of the electron when it reaches plate **B**. Assume that the speed of the electron is initially zero at plate **A**.

speed = ... $m\ s^{-1}$ **[1]**

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(b) The separation between the plates is doubled but the p.d. across the plates is kept the same. Explain how this would affect the answer to **(a)(ii)**.

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..... **[2]**

[Total: 7]

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2 **(a)** Define the *farad*.

..... **[1]**

(b) Fig. 2.1 shows a capacitor **C** of capacitance 5.4 nF connected to a battery. The switch S_1 is closed and the capacitor is charged to a p.d. of 12 V.

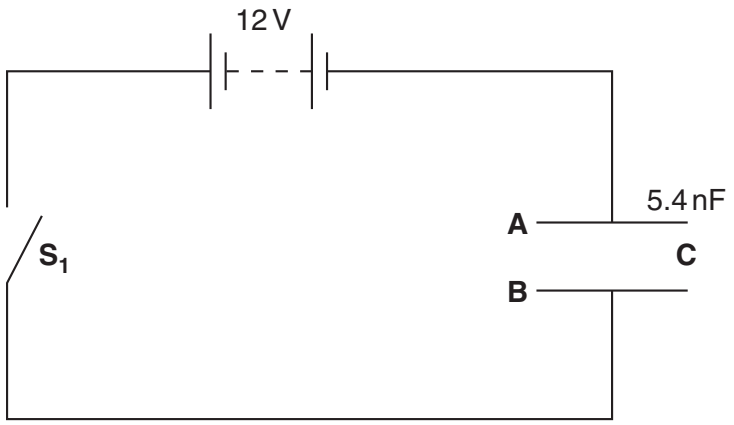


Fig. 2.1

The plates of the capacitor are labelled **A** and **B**.

(i) Explain how the plates of the capacitor become charged in terms of the movement of charged particles in the circuit.

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..... **[2]**

(ii) Calculate

1 the charge stored by the capacitor

charge = ... C **[1]**

2 the energy transferred to the capacitor.

energy = ... J **[1]**

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(c) Fig. 2.2 shows the capacitor **C** connected to a resistor **R**.

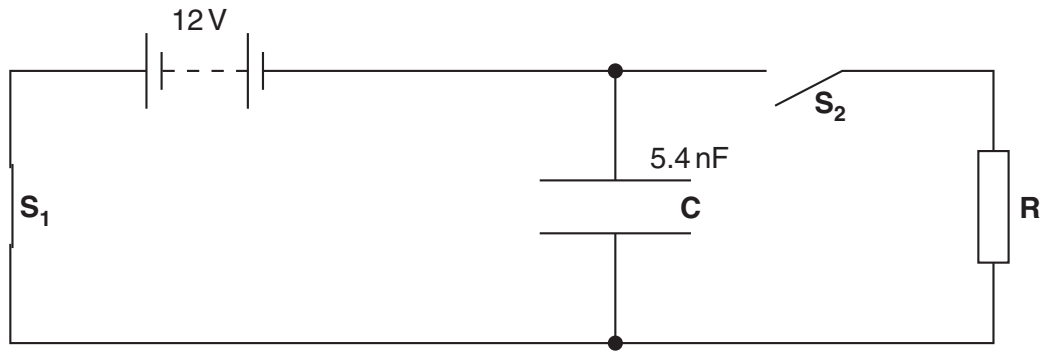


Fig. 2.2

The switch S_1 is now opened and switch S_2 is closed. The current in the resistor **R** is monitored. The initial current through **R** is 3.24 μA.

(i) Show that the resistance of the resistor **R** is 3.7 MΩ.

[1]

(ii) Calculate the current through **R** after a time $t = 0.080$ s.

current = ... μA **[2]**

(d) Explain the effect on the initial rate of discharge of the capacitor when a second resistor of resistance 3.7 MΩ is connected in parallel with the resistor **R**.

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..... **[2]**

Total: [10]

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3 Fig. 3.1 shows part of an accelerator used to produce high-speed protons. The protons pass through an evacuated tube that is shown in the plane of the paper.

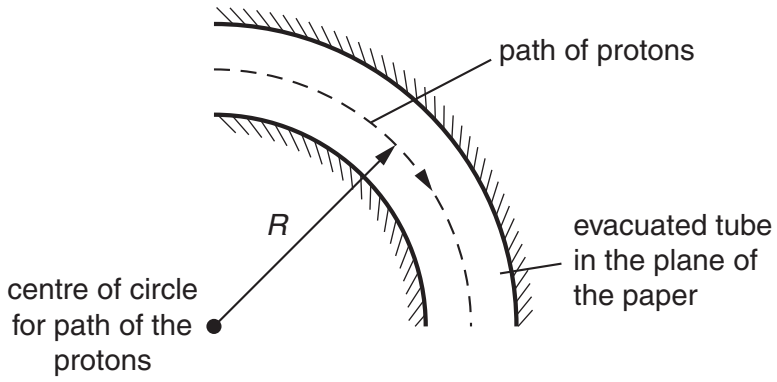


Fig. 3.1

The protons are made to travel in a circle of radius R by a magnetic field of flux density B.

(a) State clearly the direction of the magnetic flux density B that produces the circular motion of the protons.

..... **[1]**

(b) Show that the relationship between the velocity v of the protons and the radius R is given by $v = \frac{BQR}{m}$ where Q and m are the charge and mass of a proton respectively.

[1]

(c) Calculate the magnetic flux density B of the magnetic field needed to keep protons in a circular orbit of radius 0.18 m. The time for one complete orbit is 2.0×10^{-8} s.

B = ... T **[3]**

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(d) Explain why the magnetic field does not change the speed of the protons.

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..... **[2]**

[Total: 7]

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4 **(a)** State Hubble's Law.

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..... **[1]**

(b) The dark lines of the spectrum observed from a distant galaxy are red-shifted by 15% of their normal wavelengths.

The Hubble constant is estimated to be 65 $km\,s^{-1}$ Mpc^{-1}. One parsec = 3.1×10^{16} m.

(i) Show that the speed of the galaxy is $4.5 \times 10^{7}\,m\,s^{-1}$.

[1]

(ii) Estimate the distance of the galaxy from the Earth.

distance = ... m **[2]**

(iii) Estimate the age of the universe in years.

1 year = 3.2×10^{7} s

age = ... y **[2]**

(c) The age of the universe is calculated from the time of the big bang. Describe **two** observations that directly support the idea of the big bang.

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..... **[2]**

[Total: 8]

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5 **(a)** Define the *parsec*. Draw a diagram to illustrate your answer.

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..... **[2]**

(b) The star Tau Ceti has a parallax of 0.275 seconds of arc.

Calculate the distance of Tau Ceti from Earth

(i) in parsec (pc)

distance = ... pc **[1]**

(ii) in light year (ly).

1 pc = 3.1×10^{16} m

distance = ... ly **[2]**

[Total: 5]

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6 (a) (i) Describe the formation of a star such as our Sun and its most probable evolution.



In your answer you should make clear how the steps in the process are sequenced.

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..... **[6]**

(ii) Describe the probable evolution of a star that is much more massive than our Sun.

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..... **[2]**

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(b) The present mass of the Sun is 2.0×10^{30} kg. The Sun emits radiation at an average rate of $3.8 \times 10^{26}\,J\,s^{-1}$. Calculate the time in years for the mass of the Sun to decrease by one millionth of its present mass.

$1\ y = 3.2 \times 10^{7}\,s$

time = ... y **[3]**

(c) The following nuclear equation summarises a typical fusion reaction cycle that occurs in the Sun.

$$4\ {}^{1}_{1}H \longrightarrow {}^{4}_{2}He + 2\ {}^{0}_{1}e + 2\nu$$

(i) Explain the process of nuclear fusion in the core of the Sun. In your explanation refer to the conditions necessary for fusion to occur.

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..... **[4]**

(ii) Name two forms of energy produced in thermonuclear reactions.

1. .....

2. ..... **[2]**

(iii) The binding energy per nucleon of ${}^{1}_{1}H$ and ${}^{4}_{2}He$ are 0 and 7.2 MeV respectively. Calculate the energy produced in joules for the fusion reaction above.

energy = ... J **[2]**

[Total: 19]

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7 **(a)** Describe the *piezoelectric effect*.

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..... **[1]**

(b) Describe how ultrasound scanning is used to obtain diagnostic information about internal structures of a body. In your description include the differences between an A-scan and a B-scan.

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..... **[4]**

(c) Fig. 7.1 shows the speed of ultrasound, density and acoustic impedance for muscle and bone.

material	speed of ultrasound / $m\,s^{-1}$	density / $kg\,m^{-3}$	acoustic impedance / $10^6\,kg\,m^{-2}\,s^{-1}$
muscle	1590	1080	1.72
bone	4080	1750	7.14

Fig. 7.1

(i) Show that the unit for acoustic impedance is $kg\,m^{-2}\,s^{-1}$.

[1]

(ii) An ultrasound pulse is incident at right angles to the boundary between bone and muscle. Calculate the fraction of reflected intensity of the ultrasound.

fraction of reflected intensity = ... **[2]**

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(iii) What is meant by *acoustic impedance matching*? Explain why a gel is used to produce an effective ultrasound image.

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..... **[2]**

(iv) The frequency of the ultrasound in the muscle is 1.2 MHz. Calculate the wavelength of the ultrasound in millimetres (mm).

wavelength = ... mm **[2]**

(v) Suggest why it is desirable to have ultrasound of short wavelength for a scan.

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..... **[1]**

[Total: 13]

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8 **(a)** Describe the use of image intensifiers and contrast media when X-rays are used to produce images of internal body structures.



In your answer, you should make clear how the appearance of the image is linked to the techniques used.

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..... **[5]**

(b) A student suggests an image intensifier uses the photoelectric effect. Explain why this suggestion is **incorrect**.

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..... **[1]**

(c) **(i)** Explain how the production of a CAT scan image differs from that of a simple X-ray image.

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..... **[2]**

(ii) Describe the advantages of a CAT scan compared to an X-ray image.

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..... **[2]**

Total: [10]

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9 (a) (i) Complete Fig. 9.1 to show the quark composition and charge for neutrons and protons.

	quark composition	charge
neutron		
proton		

Fig. 9.1

[2]

(ii) Complete Fig. 9.2 to show the composition of quarks.

quark	charge	baryon number	strangeness
up		+ 1/3	
down			0

Fig. 9.2

[2]

(b) When a neutron decays it can produce particles that include an electron.

(i) Complete the decay equation below for a neutron.

$${}^{1}_{0}n \rightarrow$$

[2]

(ii) Name the interaction responsible for the decay of the neutron.

..... **[1]**

(iii) Electrons and neutrons belong to different groups of particles. Name the group of particles to which each belongs.

electrons .....

neutrons ..... **[1]**

[Total: 8]

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10 **(a)** Describe what is meant by the **spontaneous** and **random** nature of radioactive decay of unstable nuclei.

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..... **[2]**

(b) Define the *decay constant*.

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..... **[2]**

(c) Explain the technique of radioactive carbon-dating.

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..... **[4]**

(d) The activity of a sample of living wood was measured over a period of time and averaged to give 0.249 Bq. The same mass of a sample of dead wood was measured in the same way and the activity was 0.194 Bq. The half-life of carbon-14 is 5570 years.

(i) Calculate

1 the decay constant in y^{-1} for the carbon-14 isotope

decay constant = ... y^{-1} **[1]**

2 the age of the sample of dead wood in years.

age = ... y **[2]**

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(ii) Suggest why the activity was measured over a long time period and then averaged.

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..... **[1]**

(iii) Explain why the method of carbon-dating is not appropriate for samples that are greater than 10^5 years old.

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..... **[1]**

[Total: 13]

END OF QUESTION PAPER

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ADDITIONAL PAGE

If additional space is required, you should use the lined pages below. The question number(s) must be clearly shown.

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