CUP/T39893

OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE **2822**

PHYSICS A

Electrons and Photons

THURSDAY 22 MAY 2008

Afternoon
Time: 1 hour

Candidates answer on the question paper
Additional materials (enclosed): None

Additional materials (required):
Electronic calculator

Candidate Forename		Candidate Surname	
Centre Number		Candidate Number	

INSTRUCTIONS TO CANDIDATES

- Write your name in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided.

INFORMATION FOR CANDIDATES

- The number of marks for each question is given in brackets [ ] at the end of each question or part question.
- The total number of marks for this paper is **60**.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.

FOR EXAMINER'S USE		
Qu.	**Max.**	**Mark**
1	**6**	
2	**8**	
3	**14**	
4	**9**	
5	**6**	
6	**7**	
7	**10**	
TOTAL	**60**	

This document consists of **15** printed pages and **1** blank page.

SP (SM/CGW) T39893/8

[Turn over

Data

speed of light in free space,	$c = 3.00 \times 10^{8}\ \mathrm{m\,s^{-1}}$
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{H\,m^{-1}}$
permittivity of free space,	$\epsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\,m^{-1}}$
elementary charge,	$e = 1.60 \times 10^{-19}\ \mathrm{C}$
the Planck constant,	$h = 6.63 \times 10^{-34}\ \mathrm{J\,s}$
unified atomic mass constant,	$u = 1.66 \times 10^{-27}\ \mathrm{kg}$
rest mass of electron,	$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$
rest mass of proton,	$m_p = 1.67 \times 10^{-27}\ \mathrm{kg}$
molar gas constant,	$R = 8.31\ \mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant,	$N_A = 6.02 \times 10^{23}\ \mathrm{mol^{-1}}$
gravitational constant,	$G = 6.67 \times 10^{-11}\ \mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall,	$g = 9.81\ \mathrm{m\,s^{-2}}$

Formulae

uniformly accelerated motion,	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
refractive index,	$n = \dfrac{1}{\sin C}$
capacitors in series,	$\dfrac{1}{C} = \dfrac{1}{C_1} + \dfrac{1}{C_2} + \ldots$
capacitors in parallel,	$C = C_1 + C_2 + \ldots$
capacitor discharge,	$x = x_0 e^{-t/CR}$
pressure of an ideal gas,	$p = \frac{1}{3}\dfrac{Nm}{V}<c^2>$
radioactive decay,	$x = x_0 e^{-\lambda t}$
	$t_{\frac{1}{2}} = \dfrac{0.693}{\lambda}$
critical density of matter in the Universe,	$\rho_0 = \dfrac{3H_0^2}{8\pi G}$
relativity factor,	$= \sqrt{(1 - \dfrac{v^2}{c^2})}$
current,	$I = nAve$
nuclear radius,	$r = r_0 A^{1/3}$
sound intensity level,	$= 10 \lg\left(\dfrac{I}{I_0}\right)$

[Turn over

Answer **all** the questions.

1 **(a)** State the difference between the directions of conventional current and electron flow in a circuit.

....

....[1]

(b) Define *potential difference*.

....

....[1]

(c) **(i)** Define the *kilowatt-hour* (kW h).

....

....

....[2]

(ii) An electric kettle of power rating 1800 W can be operated for a total time of 1500 hours during its life. Calculate the total cost of operating this kettle given that the cost of each kW h is 9.0 p.

cost = £ .... [2]

[Total: 6]

2 **(a)** A student is given three resistors of resistances 10 Ω, 12 Ω and 22 Ω.

(i) Draw a sketch to show how all three resistors can be connected to give **maximum** resistance. Calculate the maximum resistance.

Arrangement:

Calculation for **maximum** resistance:

maximum resistance = ... Ω [2]

(ii) Draw a sketch to show how all three resistors can be connected to give **minimum** resistance. Calculate the minimum resistance.

Arrangement:

Calculation for **minimum** resistance:

minimum resistance = ... Ω [3]

(b) Some conducting putty is moulded into different cylindrical shapes. The putty has resistance of 36 Ω when it has length l and diameter d.
Complete the table below for different cylinders made from this putty.

length	diameter	resistance / Ω
l	d	36
$3l$	d	
l	$2d$	
$5l$	$2d$	

[3]

[Total: 8]

3 **(a)** Thermistors and light-dependent resistors are useful components in potential divider circuits.

(i) Draw the symbol for a thermistor and describe how the resistance of a negative temperature coefficient (NTC) thermistor is affected by temperature.

....

....

.... [2]

(ii) Draw the symbol for a light-dependent resistor and describe how its resistance is affected by the intensity of light.

....

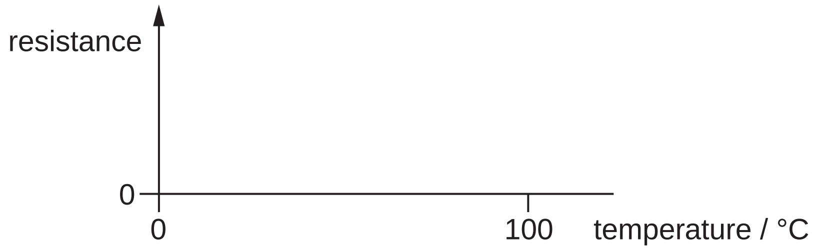
....

.... [2]

(iii) Draw a potential divider circuit that may be used to monitor the intensity of light in a room. You are not expected to show any values of the components used.

[2]

(b) (i) On the axes below, show how the resistance of a pure metal conductor in the form of a wire depends on its temperature.



[1]

(ii) In this question two marks are available for the quality of written communication.

Describe an experiment to determine how the resistance of a wire varies with its temperature. Assume that no ohmmeter is available.

....

....

....

....

....

....

....

....

....

....[5]

Quality of Written Communication [2]

[Total: 14]

4 Fig. 4.1 shows an electrical cable consisting of bare copper wires encased in plastic insulation.

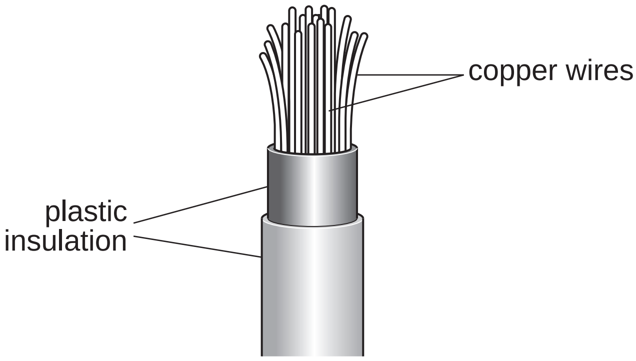


Fig. 4.1

(a) A particular cable contains 26 copper wires and is 12.0 m long. The radius of each copper wire is 3.50×10^{-5} m. The resistivity of copper is $1.70 \times 10^{-8}\,\Omega$ m.

(i) Show that the resistance of a single copper wire is about $53\,\Omega$.

[3]

(ii) Explain why the resistance of the electrical cable is about $2\,\Omega$.

[1]

(b) Fig. 4.2 shows two electrical cables used to connect a power supply to a lamp. Each cable has length 12.0 m and is identical to that described in **(a)**.

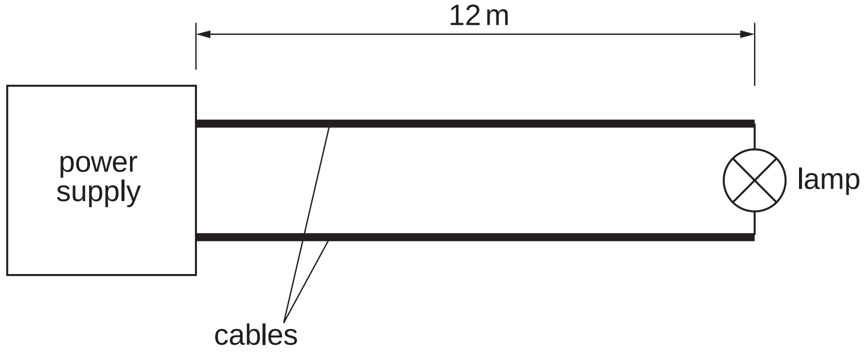


Fig. 4.2

The lamp is rated at 24 W, 6.0 V. The power supply has negligible internal resistance and its output is adjusted so that the potential difference across the lamp is 6.0 V.

(i) Calculate the resistance of the lamp when operating at 6.0 V.

resistance = ... Ω [2]

(ii) Explain why the e.m.f. of the power supply is greater than 6.0 V.

....

....

....[1]

(iii) Calculate the e.m.f. of the power supply.

e.m.f. = ... V [2]

[Total: 9]

5 **(a)** Write down the equation that defines *magnetic flux density*. State the meaning of each term.

....

.... [2]

(b) Fig. 5.1 shows two long current-carrying wires **X** and **Y**.

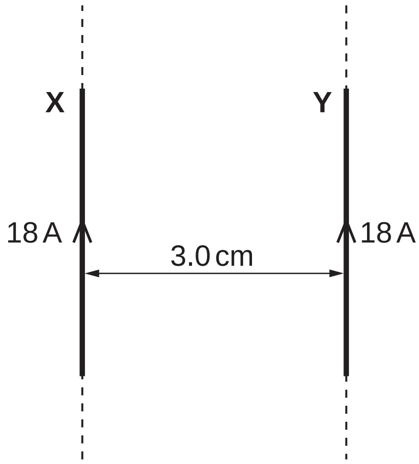


Fig. 5.1

The current in each wire is 18 A. The wires are parallel to each other and are 3.0 cm apart. The current creates a magnetic field around each wire.

(i) At the position of the wire **Y**, the direction of the magnetic field due to the current in wire **X** is into the plane of the paper.
Draw an arrow to show the direction of the force experienced by the wire **Y**. Label this arrow **F**. [1]

(ii) Fig. 5.2 shows how the magnetic flux density B due to the current-carrying wire **X** varies with distance r from the centre of this wire.

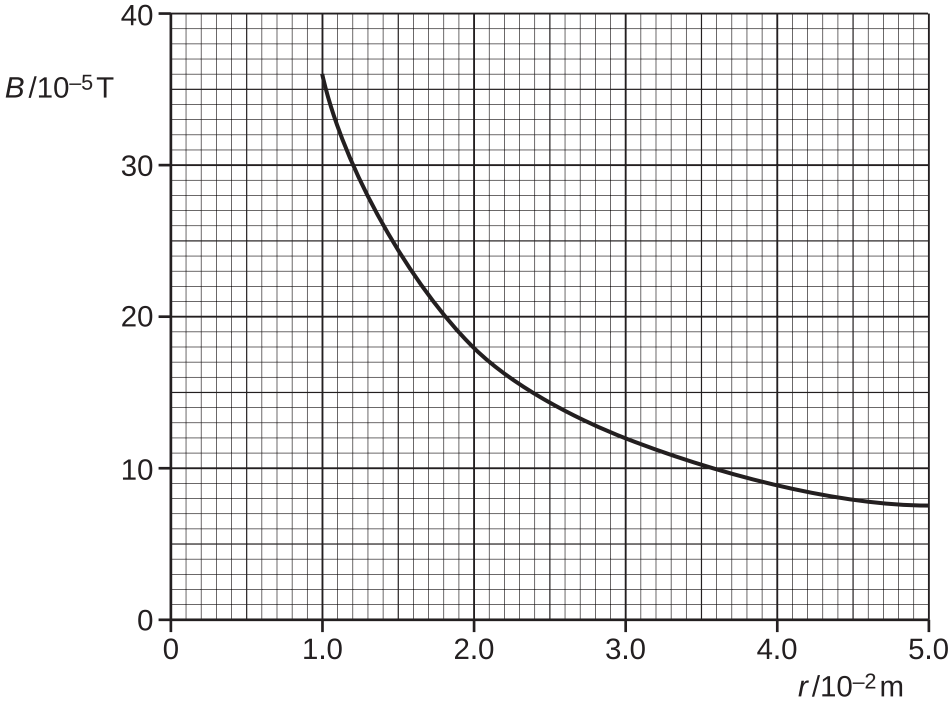


Fig. 5.2

Use the information provided in Fig. 5.2 to determine the force acting on a 0.25 m length of the wire **Y** when the wires are 3.0 cm apart.

force = ……………............… unit …................… [3]

[Total: 6]

6 Fig. 6.1 shows part of the apparatus for an experiment in which electrons travel through a thin layer of graphite (carbon atoms) and emerge to produce concentric rings on a fluorescent screen.

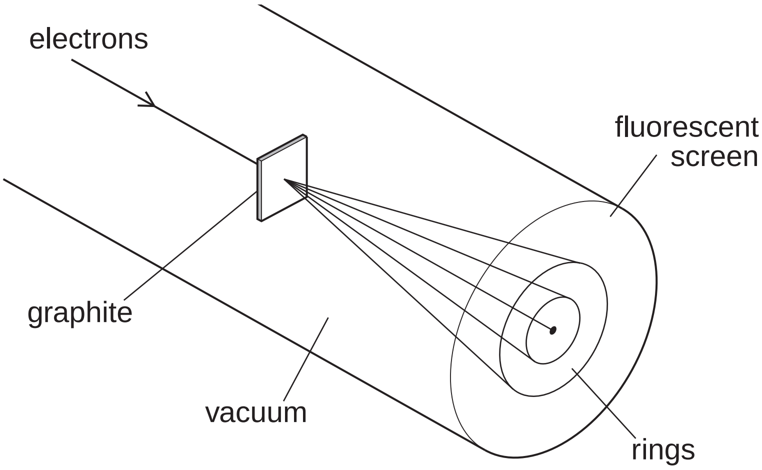


Fig. 6.1

(a) Use the ideas of de Broglie to explain how this experiment demonstrates the wave-nature of electrons.

....

....

....

....

....

....[4]

(b) Fast moving electrons can be used to investigate the structure of materials. The electrons should have a de Broglie wavelength similar to that of X-rays.

(i) State a typical value for the wavelength of X-rays in metres.

....[1]

(ii) Calculate the speed of an electron with a de Broglie wavelength equal to your value in **(b)(i)**.

speed = ... $m\,s^{-1}$ [2]

[Total: 7]

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Question 7 is on the next page.

7 Fig. 7.1 shows an electrical circuit, which includes a photocell.

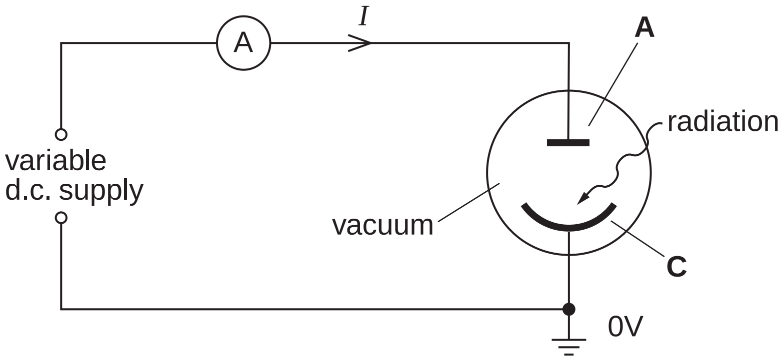

Fig. 7.1

The photocell consists of a metal plate **C** that is exposed to electromagnetic radiation. The photoelectrons emitted travel towards the electrode **A**. A sensitive ammeter measures the current in the circuit.

The plate **C** is illuminated with ultraviolet radiation of constant intensity and of wavelength 2.5×10^{-7} m. Fig. 7.2 shows how the photoelectric current I in the circuit varies with the potential difference V between **A** and **C**.

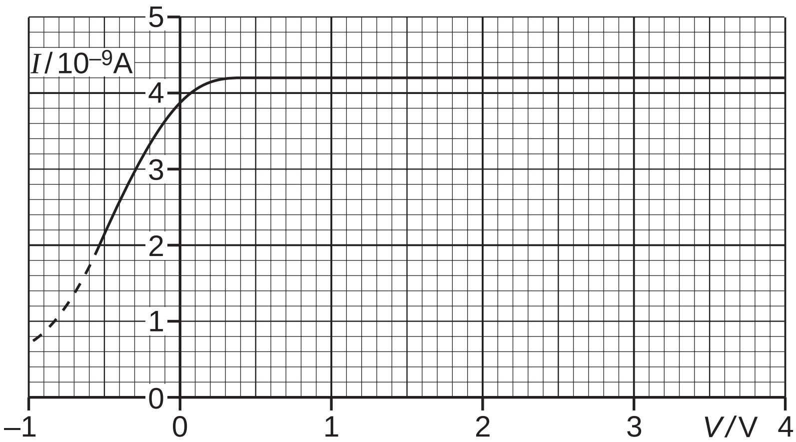

Fig. 7.2

(a) Use Fig. 7.2 to show that when the potential difference V is 2.0V the number of electrons reaching the electrode **A** per second is $2.6 \times 10^{10}\,s^{-1}$.

[3]

(b) The metal of plate **C** has work function energy 2.2 eV. Calculate the maximum kinetic energy in joules of the emitted photoelectrons from this plate.

kinetic energy = ... J [4]

(c) **(i)** State how the maximum energy of the photoelectrons emitted from plate **C** depends on the intensity of the incident radiation.

....

....[1]

(ii) State and explain how the photoelectric current depends on the intensity of the radiation.

....

....

....

....[2]

[Total: 10]

END OF QUESTION PAPER

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