OCR

RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary GCE

PHYSICS A 2822

Electrons and Photons

Monday **14 JUNE 2004** Afternoon 1 hour

Candidates answer on the question paper.
Additional materials:
Electronic calculator

Candidate Name	Centre Number	Candidate Number

TIME 1 hour

INSTRUCTIONS TO CANDIDATES

- Write your name in the space above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers in the spaces provided on the question paper.
- Read each question carefully and make sure you know what you have to do before starting your answer.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [ ] at the end of each question or part question.
- 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	4	
2	3	
3	5	
4	8	
5	10	
6	11	
7	13	
8	6	
TOTAL	60	

This question paper consists of 12 printed pages.

SP (MML 5251 3/03) S552788
© OCR 2004 [T/100/3701]

Registered Charity Number: 1066969

[Turn over

Data

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

Formulae

uniformly accelerated motion, $s = ut + \frac{1}{2}at^2$

$v^2 = u^2 + 2as$

refractive index, $n = \frac{1}{\sin C}$

capacitors in series, $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots$

capacitors in parallel, $C = C_1 + C_2 + \ldots$

capacitor discharge, $x = x_0 e^{-t/CR}$

pressure of an ideal gas, $p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$

radioactive decay, $x = x_0 e^{-\lambda t}$

$t_{\frac{1}{2}} = \frac{0.693}{\lambda}$

critical density of matter in the Universe, $\rho_0 = \frac{3H_0^2}{8\pi G}$

relativity factor, $= \sqrt{(1 - \frac{v^2}{c^2})}$

current, $I = nAve$

nuclear radius, $r = r_0 A^{1/3}$

sound intensity level, $= 10 \lg \left(\frac{I}{I_0}\right)$

[Turn over

For Examiner's Use

Answer **all** the questions.

1 Mobile phones use electromagnetic radiation in the form of microwaves.

(a) State a typical value for the wavelength of microwaves.

wavelength = ... m [1]

(b) State **one** property of microwaves.

..... [1]

(c) A particular mobile phone battery transforms 78 J of chemical energy into electrical energy for every 24 C of charge. Calculate the electromotive force (e.m.f.) of the battery.

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

[Total: 4]

2 A convenient unit of energy is the kilowatt hour (kW h).

(a) Define the *kilowatt hour*.

.....

..... [1]

(b) A 120 W filament lamp transforms 5.8 kW h. Calculate the time in seconds for which the lamp is operated.

time = ... s [2]

[Total: 3]

3 Fig. 3.1 shows a cell of e.m.f. E and internal resistance r connected to a variable resistor.

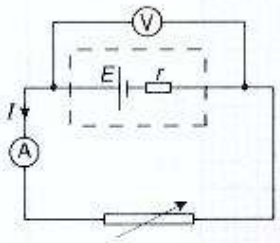

Fig. 3.1

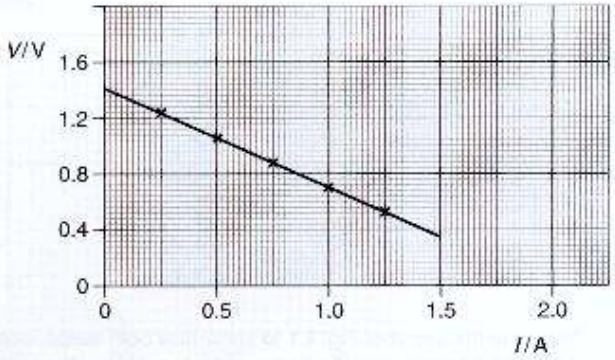

Fig. 3.2

Fig. 3.2 shows the variation of the p.d. V across the terminals of the cell with the current I drawn from the cell.

(a) Explain how Fig. 3.2 shows that the e.m.f. E is 1.4 V.

.....

..... [1]

(b) **(i)** Use Fig. 3.2 to determine the maximum possible current that can be drawn from the cell.

current = ... A [1]

(ii) Calculate the internal resistance r of the cell.

r = ... Ω [2]

(iii) Suggest why it may not be advisable to maintain the current determined in **(b)(i)** for a long time.

.....

..... [1]

[Total: 5]

For Examiner's Use

4 **(a)** Fig. 4.1 shows components of an incomplete electrical circuit.

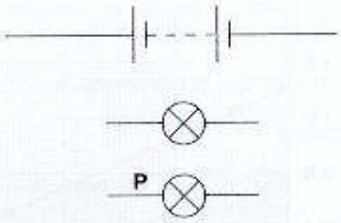

Fig. 4.1

Complete the circuit of Fig. 4.1 to show how both lamps, connected in parallel, may be lit using the battery. Include an ammeter to measure the current in the lamp **P**. [2]

(b) Fig. 4.2 shows a circuit designed to monitor the speed of rotation of a small fan.

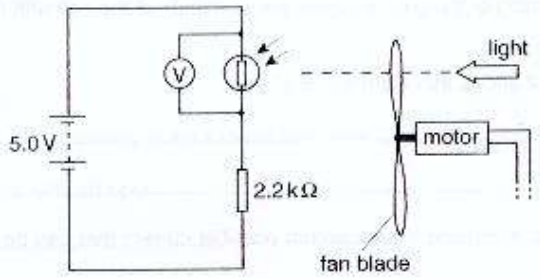

Fig. 4.2

The battery has negligible internal resistance. The output voltage V from the circuit is equal to the potential difference across the LDR. Fig. 4.3 shows the variation of the output voltage V with time t.

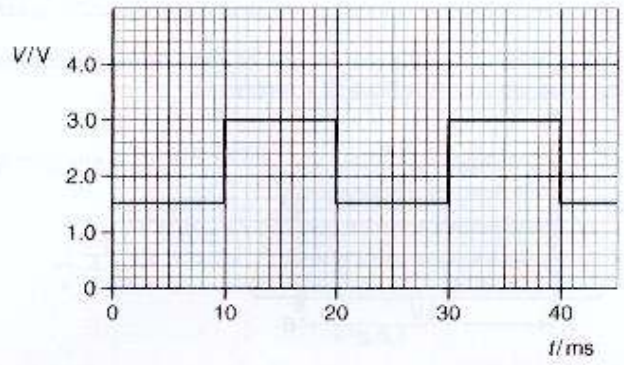

Fig. 4.3

(i) Explain why the graph of Fig. 4.3 shows two levels of output voltage.

.....

.....

.....

.....

.....

.....

..... [3]

(ii) For the **maximum** value for the output voltage V, calculate

1. the potential difference across the 2.2 kΩ resistor

potential difference = ... V [1]

2. the resistance of the LDR.

resistance = ... Ω [2]

[Total: 8]

For Examiner's Use

5 **(a)** Define *electrical resistance*.

.....

..... [2]

(b) Fig. 5.1 shows a method of demisting the rear window of a car. Three identical metal strips attached to the glass are connected to a 12 V supply.

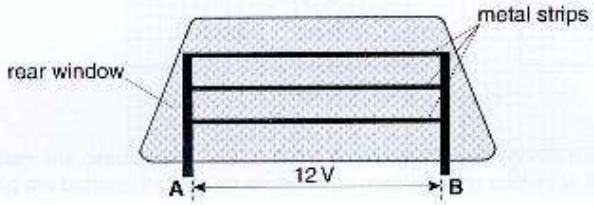

Fig. 5.1

(i) State whether the strips are connected in series or in parallel.

..... [1]

(ii) Each strip has length 85 cm and resistance 18 Ω. The material of the metal strip has resistivity 6.9×10^{-5} Ω m. Calculate

1. the resistance of the three strips between **A** and **B**

resistance = ... Ω [2]

2. the total power dissipated by the three strips

power = ... W [2]

3. the cross-sectional area of **each** strip.

cross-sectional area = ... m^2 [3]

[Total: 10]

6 Fig. 6.1 shows a lightning strike between a storm cloud and the ground.

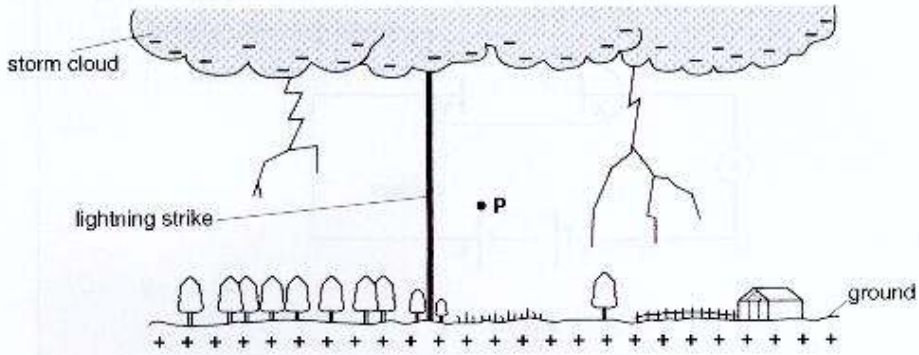

Fig. 6.1

(a) On Fig. 6.1, indicate with an arrow, the direction of the conventional current in the lightning strike. [1]

(b) State the direction of the magnetic field at point **P** due only to the lightning strike.

..... [1]

(c) The current in the lightning strike is 7800 A. The strike lasts for a time of 230 ms.

(i) Calculate

1. the charge flowing between the cloud and the ground

charge = ... C [3]

2. the number of electrons transferred to the ground.

number = ... [2]

(ii) The component of the magnetic flux density of the Earth's magnetic field at right angles to the current is 42 μT. Consider the lightning strike to be a straight conductor of length 250 m. Calculate the force experienced by the lightning strike due to the Earth's magnetic field.

force = ... unit ..... [4]

[Total: 11]

[Turn over

For Examiner's Use

7 Fig. 7.1 shows an electrical circuit including a photocell.

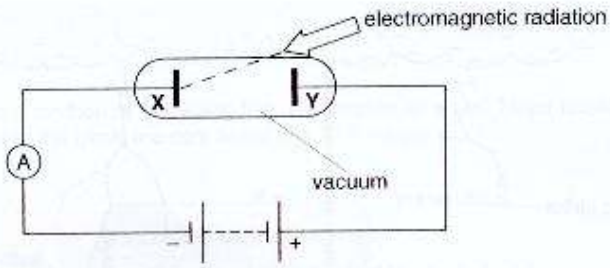

Fig. 7.1

The photocell contains a metal plate **X** that is exposed to electromagnetic radiation. Photoelectrons emitted from the surface of the metal are accelerated towards the positive electrode **Y**. A sensitive ammeter measures the current in the circuit due to the photoelectrons emitted by the metal plate **X**.

(a) In this question, one mark is available for the quality of written communication.

Name and describe the process by which the photoelectrons are released from the metal plate **X** by the electromagnetic radiation.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

Quality of Written Communication [1]

(b) The metal of plate **X** has work function energy of 2.2 eV. The maximum kinetic energy of an emitted photoelectron from this plate is 0.3 eV. Calculate

(i) the energy of a single photon in

1. electronvolts (eV)

energy = ... eV [1]

2. joules

energy = ... J [2]

(ii) the frequency of the incident electromagnetic radiation.

frequency = ... Hz [2]

(c) Deduce the effect on the current if the radiation has the same intensity but the frequency of the electromagnetic radiation is greater than **(b)(ii)**.

.....

.....

..... [2]

[Total: 13]

Question 8 over the page

8 In this question, one mark is available for the quality of written communication.

Describe and interpret the experimental evidence for the wave-like behaviour of electrons.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

Quality of Written Communication [1]

[Total: 6]