OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary GCE

PHYSICS A

2822

Electrons and Photons

Thursday **16 JANUARY 2003** 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	10	
4	9	
5	11	
6	6	
7	10	
8	7	
TOTAL	60	

This question paper consists of 17 printed pages and 3 blank pages.

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,	$n = \frac{1}{\sin C}$
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,	$p = \frac{1}{3}\frac{Nm}{V}<c^2>$
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

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Answer **all** the questions.

1 Fig. 1.1 shows an electrical circuit.

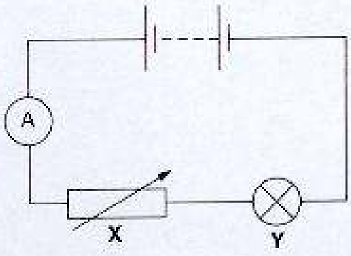

Fig. 1.1

(a) Name the component marked **X**.

....[1]

(b) Suggest **one** reason why component **X** may be useful in the electrical circuit.

....[1]

(c) On Fig. 1.1 indicate the direction of flow of electrons. [1]

(d) State the energy changes taking place in the component **Y**.

....[1]

[Total: 4]

2 **(a)** Some of the ultra-violet radiation from the Sun is blocked by the ozone layer surrounding the Earth.

(i) State a typical value for the wavelength of ultra-violet radiation in metres.

....[1]

(ii) Suggest what damage ultra-violet radiation may cause to humans.

....[1]

(b) Gamma rays and X-rays are used for medical purposes. State **one** major difference between these two principal radiations.

....

....[1]

[Total: 3]

[Turn over

For Examiner's Use

3 (a) Define electrical resistance.

....

....

....[2]

(b) Fig. 3.1 shows part of an electrical circuit.

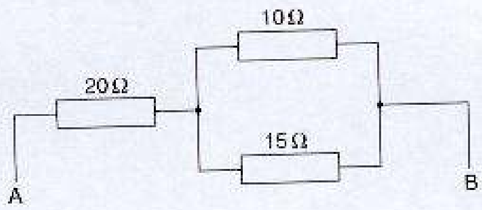

Fig. 3.1

Calculate the total resistance between A and B.

resistance = ... Ω [3]

For Examiner's Use

(c) Fig. 3.2 shows a negative temperature coefficient (NTC) thermistor connected to a 24 V power supply of negligible internal resistance. The ammeter has negligible resistance.

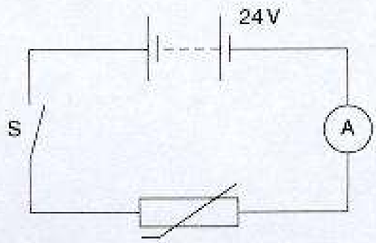

Fig. 3.2

(i) When the switch S is closed, the ammeter reading is 28 mA. Calculate the power dissipated by the thermistor.

power = ... W [3]

(ii) A few minutes after closing the switch, the current has increased to a constant value of 40 mA. Explain why the current increases.

....

....

....[2]

[Total: 10]

4 (a) Show that the unit for electrical resistivity is Ω m.

[1]

(b) Fig. 4.1 shows a simple design for a 'movement' sensor used in an earthquake region. The supply has negligible internal resistance.

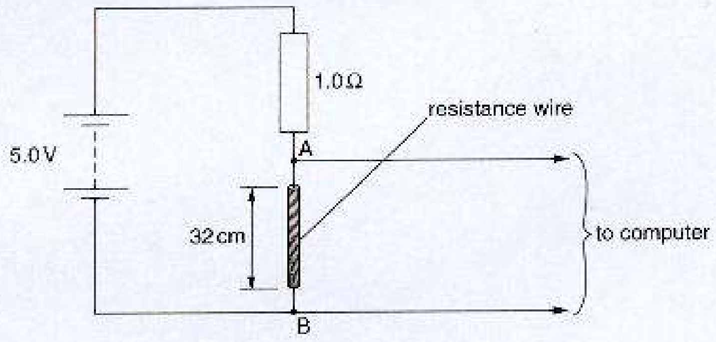

Fig. 4.1

A resistance wire is stretched between two rigid steel plates, not shown in the diagram. During an earthquake, ground movement changes the separation between the plates and so the length of wire changes.

The wire has a radius of 0.62 mm and length 32 cm. It is made of a material of resistivity 6.8×10^{-6} Ω m.

(i) Show that the resistance of the wire is 1.8 Ω.

[3]

For Examiner's Use

(ii) Calculate the potential difference (p.d.) between A and B.

p.d. = ... V [3]

(iii) The length of the wire increases. State and explain the effect on the p.d. between A and B.

....

....

....[2]

[Total: 9]

For Examiner's Use

5 In this question, two marks are available for the quality of written communication.

The concept of energy is important in many branches of physics. Energy is usually measured in joules, but sometimes the *kilowatt-hour* (kW h) and the *electronvolt* (eV) are more convenient units for energy.
Define the *kilowatt-hour* and the *electronvolt* and determine their values in joules.

....

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....

....

Suggest why the kW h and eV may be more convenient than joules.
Illustrate your answer by determining

- the energy dissipated by a 100 W filament lamp left on for 12 hours
- the kinetic energy of an electron accelerated through a p.d. of 1.0 MV in a particle accelerator.

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For Examiner's Use

[9]

Quality of Written Communication [2]

[Total: 11]

[Turn over

For Examiner's Use

6 (a) A diagram of a loudspeaker is shown in Fig. 6.1.

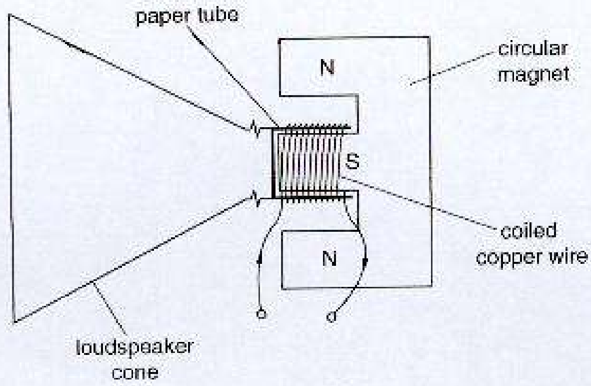

Fig. 6.1

The thin copper wire is wound onto a paper tube that surrounds the south pole of the circular magnet. The copper coil has 250 turns and has a mean radius of 1.5 cm. The magnet provides a field of magnetic flux density 3.6×10^{-2} T at right angles to the wire.

(i) Show that the length of the copper wire in the magnetic field is about 24 m.

[2]

(ii) Calculate the magnitude of the force acting on the copper wire due to the magnetic field when carrying a constant current of 48 mA.

force = ... N [3]

For Examiner's Use

(b) Name an important electrical unit that is based on the force experienced between two current-carrying conductors.

....[1]

[Total: 6]

7 **(a)** The concept of the photon was important in the development of physics throughout the last century. Explain what is meant by a photon.

....

....[1]

(b) Fig. 7.1 shows a photocell.

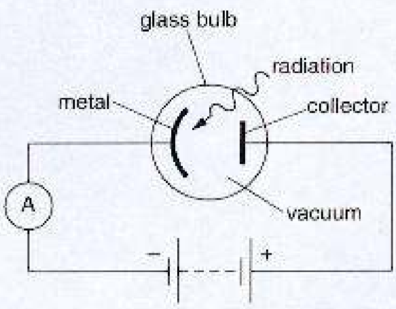

Fig. 7.1

When the metal surface is exposed to electromagnetic radiation, photoelectrons are ejected. The collector collects the photoelectrons and the sensitive ammeter indicates the presence of a tiny current.

(i) For a certain frequency and intensity of radiation, the ammeter shows a current of 1.2×10^{-7} A. Calculate

1. the charge reaching the collector in 5.0 s

charge = ... C

2. the number of photoelectrons reaching the collector in 5.0 s.

number of electrons = ...

[3]

(ii) The work function energy of the metal is 3.5×10^{-19} J and the incident radiation has frequency 7.0×10^{14} Hz. Calculate the maximum kinetic energy of an ejected photoelectron.

energy = ... J [3]

[Turn over

For Examiner's Use

(iii) The intensity of the incident radiation is doubled but the wavelength is kept constant. State the effect this has on each of the following

1. the energy of each photon

....

....

2. the maximum kinetic energy of each photoelectron

....

....

3. the current in the photocell.

....

.... [3]

[Total: 10]

8 (a) How did de Broglie explain electron diffraction?

....

.... [1]

(b) The internal structure of nuclei may be investigated by using high speed electrons. Calculate *mv* (momentum) of an electron that has a wavelength of 1.6×10^{-15} m.

mv (momentum) = ... unit .... [4]

For Examiner's Use

(c) State and explain, with the aid of a calculation, why a ball of mass 200 g thrown at 6.0 m s^{-1} through an open window of width 0.80 m does **not** show any noticeable diffraction.

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....[2]

[Total: 7]