OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced Subsidiary GCE

PHYSICS A

2822

Electrons and Photons

Friday **6 JUNE 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 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	6	
2	7	
3	8	
4	8	
5	9	
6	5	
7	11	
8	6	
TOTAL	**60**	

This question paper consists of 15 printed pages and 1 blank page.

[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, $= 10 \lg \left(\dfrac{I}{I_0}\right)$

Answer **all** the questions.

1 **(a)** State **two** main features of electromagnetic waves.

....

....[2]

(b) A mobile telephone company transmits microwave signals to an orbiting satellite at a frequency of 1.6×10^9 Hz. Calculate the wavelength λ of the microwaves.

λ = ... m [3]

(c) Soon after the creation of the Universe, space was occupied by very short wavelength electromagnetic waves, mainly in the form of γ-rays. State a typical value for the wavelength of γ-rays in metres.

....[1]

[Total: 6]

2 A simple cell may be constructed by inserting into a fresh lemon two electrodes made from different metals. The juice of the lemon acts as an electrolyte (conducting liquid). Positive and negative ions within the lemon move towards the metal electrodes. Fig. 2.1 shows such a lemon-cell. It has an e.m.f. of 1.32 V and can provide enough electrical energy to activate a digital clock for many days.

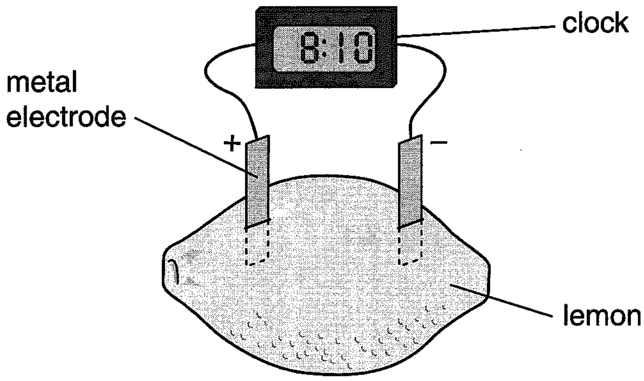

Fig. 2.1

(a) On Fig. 2.1, indicate with an arrow the direction in which negative charge moves within the lemon. [1]

(b) The lemon-cell is capable of providing a steady current of 1.2 mA for eight days (6.9×10^5 s). Calculate

(i) the charge passing through the clock during eight days

charge = ... C [3]

(ii) the power delivered by the lemon-cell.

power = ... unit .... [3]

[Total: 7]

[Turn over

For Examiner's Use

3 **(a)** Calculate the total resistance between the points X and Y for the circuit shown in Fig. 3.1.

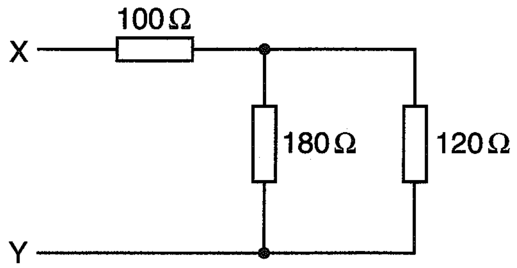

Fig. 3.1

resistance = ... Ω [3]

For Examiner's Use

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

A simple electrical thermometer circuit used to monitor the temperature of a water bath is shown in Fig. 3.2.

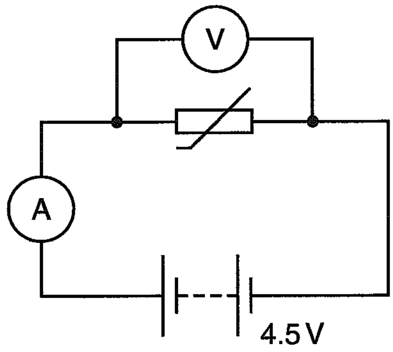

Fig. 3.2

The ammeter and the battery both have negligible internal resistances. The voltmeter connected across the negative temperature coefficient (NTC) thermistor has an infinite resistance.

Discuss how each meter responds to an increase in the temperature of the water.

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....[4]

Quality of Written Communication [1]

[Total: 8]

[Turn over

4 Fig. 4.1 shows a car battery of e.m.f. 12 V and internal resistance 0.014 Ω connected to the starter motor of a car. When the car engine is being started, the car battery provides a current of 160 A to the starter motor.

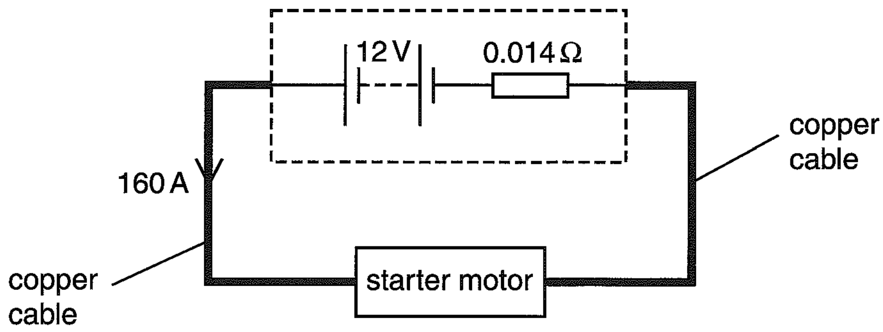

Fig. 4.1

(a) Show that the p.d. across the internal resistance is about 2.2 V.

[1]

(b) Determine the terminal p.d. across the battery.

p.d. = ... V [1]

For Examiner's Use

(c) The cables connecting the battery to the starter motor have total length 0.85 m and diameter 8.0 mm.

(i) Show that the cross-sectional area of the cable is $5.0 \times 10^{-5}\ \text{m}^2$.

[1]

(ii) The cables are made from copper of resistivity $1.7 \times 10^{-8}\ \Omega\,\text{m}$. Calculate the total resistance of the cables.

resistance = ... Ω [3]

(iii) State and explain how your answer to **(c)(ii)** would change if the cable had half the length but twice the diameter.

....

....

....

....[2]

[Total: 8]

For Examiner's Use

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

Draw a circuit diagram to show how a light-dependent resistor, a voltmeter, a variable resistor and a cell may be used as a potential divider circuit to monitor changes in the light intensity in the laboratory. Explain the operation of your circuit and suggest a reason for using a variable resistor.

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For Examiner's Use

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....[8]

Quality of Written Communication [1]

[Total: 9]

[Turn over

For Examiner's Use

6 **(a)** Fig. 6.1 shows the magnetic field pattern for a current-carrying conductor placed between the poles of a permanent magnet.

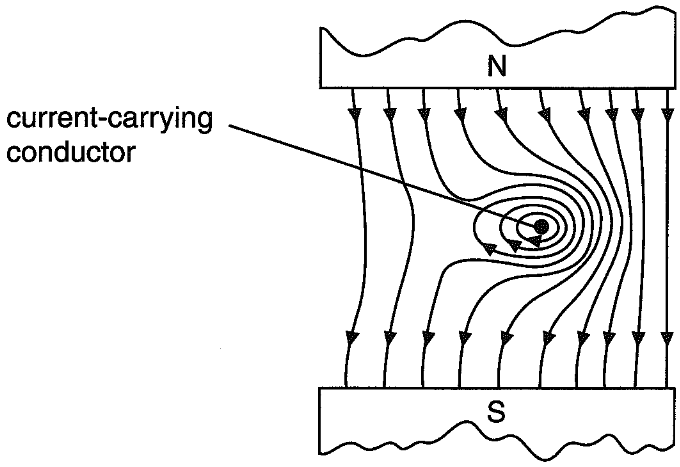

Fig. 6.1

(i) State the direction of the current in the conductor.

....[1]

(ii) On Fig. 6.1, mark with a cross (X) a point between the poles of the magnet where the magnetic field is weakest. [1]

(b) Like the Earth, the planet Jupiter has its own magnetic field.
A small spacecraft orbiting Jupiter records a tiny force of 3.0×10^{-6} N experienced on a 2.7 cm long conductor. The conductor carries a current of 200 mA and is at right angles to the magnetic field.
Determine the magnitude of the magnetic flux density B at the position of the spacecraft.

B = ... unit .... [3]

[Total: 5]

For Examiner's Use

7 **(a)** In atomic and nuclear physics, the electronvolt (eV) is a convenient unit of energy. Define one electronvolt and state its value in joules.

....

....

....[2]

(b) Insert the missing words in the following passage describing some important aspects of the photoelectric effect.

In the photoelectric effect, a single photon interacts with a single electron at the surface of the metal. In this interaction, ... is conserved. Albert Einstein summarised this interaction in terms of his famous Nobel prize-winning equation

$$hf = \phi + \tfrac{1}{2} m v_{max}^2$$

where hf is the energy of the .... , ϕ is the work function energy of the metal and $\tfrac{1}{2} m v_{max}^2$ is the maximum kinetic energy of the ....

[3]

(c) When the surface of a particular metal is exposed to a weak source of electromagnetic radiation of wavelength 3.2×10^{-7} m, electrons of **negligible** kinetic energy are released from the metal.

(i) Calculate the work function energy of the metal in joules and in electronvolts (eV).

work function energy = ... J

work function energy = ... eV [4]

(ii) Describe the effect on the electrons when the incident radiation is of longer wavelength.

....

....

....[2]

[Total: 11]

[Turn over

For Examiner's Use

8 In 1924, Prince Louis de Broglie suggested that all moving particles demonstrate wave-like behaviour.

(a) State the de Broglie equation and define all the symbols.

....

....

....[2]

(b) Neutrons may be used to study the atomic structure of matter. Diffraction effects are noticeable when the de Broglie wavelength of the neutrons is comparable to the spacing between the atoms. This spacing is typically 2.6×10^{-10} m.

(i) Suggest why using neutrons may be preferable to using electrons when investigating matter.

....

....[1]

(ii) Calculate the speed v of a neutron having a de Broglie wavelength of 2.6×10^{-10} m. The mass of a neutron is 1.7×10^{-27} kg.

v = ... m s^{-1} [3]

[Total: 6]

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