OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced Subsidiary GCE

PHYSICS A 2822

Electrons and Photons

Friday **10 JUNE 2005** Morning 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	12	
2	11	
3	7	
4	10	
5	4	
6	16	
TOTAL	60	

This question paper consists of 14 printed pages and 2 blank pages.

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[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, $n = \frac{1}{\sin C}$

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

Answer **all** the questions.

1 **(a)** All electromagnetic waves travel at the same speed in free space.
State this speed in $m\,s^{-1}$.

.....[1]

(b) A television remote control has a battery of electromotive force (e.m.f.) 3.0 V. When the remote control is operated, the battery delivers a current of 1.4×10^{-3} A and infra-red radiation of wavelength 8.8×10^{-7} m is emitted.

(i) Calculate the frequency of the infra-red radiation.

frequency = ... Hz [2]

(ii) State what is meant by *electromotive force*.

.....

.....[1]

(iii) In a time interval Δt, an amount of charge ΔQ flows through the battery. Write an equation for the magnitude of the electric current I in terms of Δt and ΔQ.

[1]

(iv) Calculate the charge flowing through the battery when the remote control is operated for a time interval of 0.20 s.

charge = ... C [2]

(v) Calculate the chemical energy transformed into electrical energy by the charge calculated in **(iv)** flowing through the battery.

energy = ... J [2]

(c) Fig. 1.1 shows an incomplete 'matching pairs' diagram.

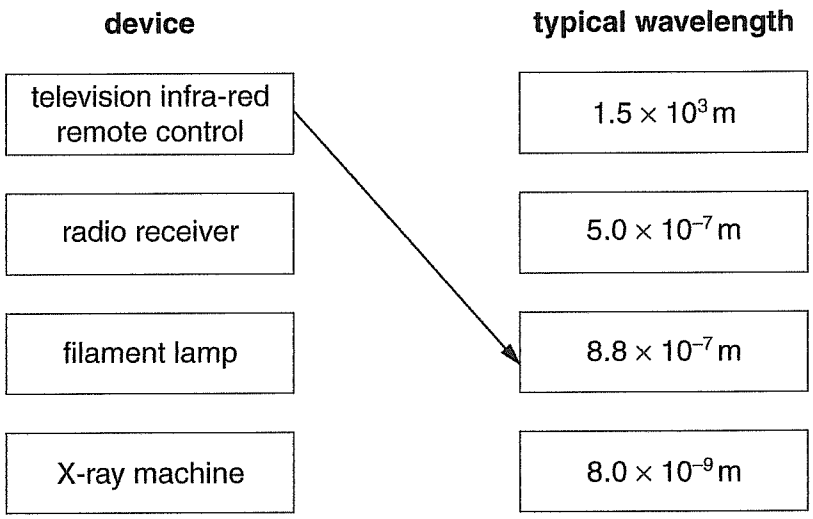

Fig. 1.1

The television remote control emitting infra-red radiation in **(b)** has been 'matched' to the wavelength 8.8×10^{-7} m. Complete Fig. 1.1 by drawing three arrows to match each device to its typical wavelength. [3]

[Total: 12]

[Turn over

2 **(a)** The electrical resistance of a wire depends on its temperature and on the resistivity of the material. List **two** other factors that affect the resistance of a wire.

1. .....

2. .....

[2]

(b) Fig. 2.1 shows an electrical circuit that contains a thin insulated copper wire formed as a bundle.

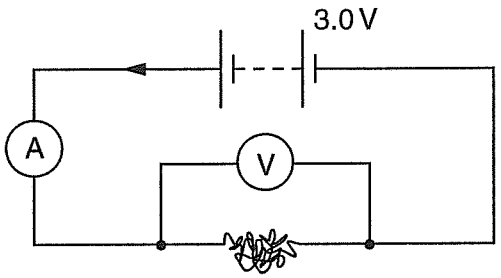

Fig. 2.1

The ammeter and the battery have negligible resistance and the voltmeter has an infinite resistance.
The copper wire has length 1.8 m and diameter 0.27 mm. The resistance of the wire is 0.54 Ω.

(i) Calculate the resistivity of copper.

resistivity = ... unit ..... [4]

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

State and explain the effect on the ammeter reading and the voltmeter reading when the temperature of the copper wire bundle is increased.

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.....[4]

Quality of Written Communication [1]

[Total: 11]

3 **(a)** Complete Fig. 3.1 to show the magnetic field pattern for a long solenoid.

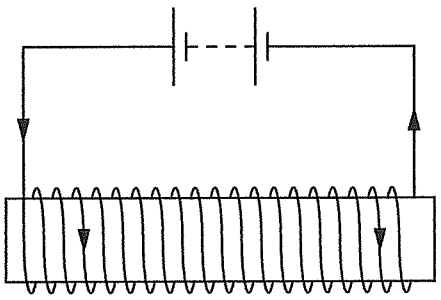

Fig. 3.1 [3]

(b) **(i)** Define *magnetic flux density*.

.....

.....

.....[2]

(ii) A conductor carrying a current I and of length L experiences a force F when placed at right angles to a uniform magnetic field of flux density B.

Determine, in terms of F, the magnitude of the force experienced by the current-carrying conductor when the flux density is $4B$, the current is $3I$ and the length of the conductor in the field is $\frac{L}{2}$.

[2]

[Total: 7]

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

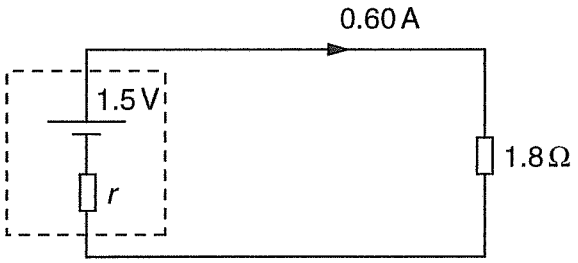

Fig. 4.1

The cell has e.m.f. 1.5 V and internal resistance *r*. The current drawn from the cell is 0.60 A. Calculate the internal resistance of the cell.

r = ... Ω [3]

(b) Fig. 4.2 shows a filament lamp and two resistors connected to a d.c. supply.

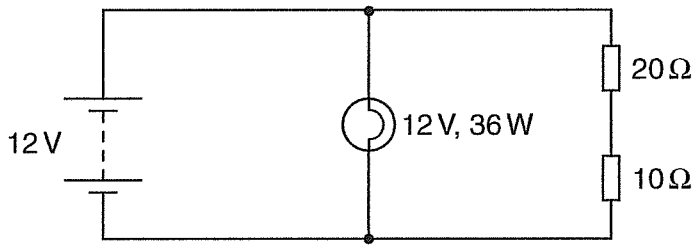

Fig. 4.2

The d.c. supply has negligible internal resistance.

(i) The filament lamp is rated as '12 V, 36 W'. Calculate the resistance of the filament lamp when used in this circuit.

resistance = ... Ω [2]

(ii) Calculate the total resistance of this circuit.

resistance = ... Ω [3]

(iii) Calculate the ratio

$$\frac{\text{current in the filament lamp}}{\text{current in the 20 Ω resistor}}$$

ratio = ... [2]

[Total: 10]

5 Fig. 5.1 shows a potential divider circuit designed as a touch-sensor.

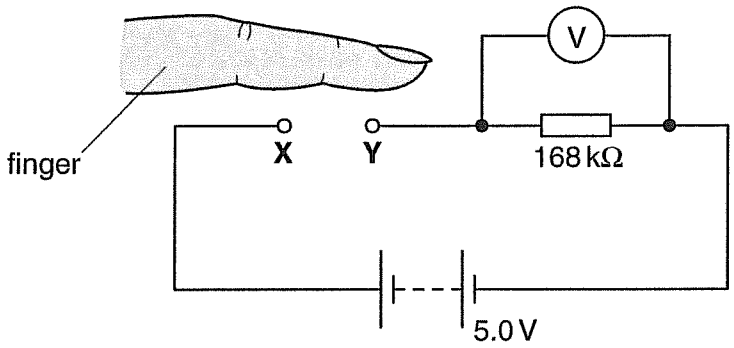

Fig. 5.1

The battery has negligible internal resistance and the voltmeter has infinite resistance.

(a) Explain why the voltmeter reading is zero when there is nothing connected between the contacts **X** and **Y**.

.....

.....[1]

(b) When the finger makes contact between **X** and **Y**, the voltmeter reading changes from 0 V to 3.4 V because of the electrical resistance of the skin. Use this information to calculate the electrical resistance of the skin between the two contacts.

resistance = ... kΩ [3]

[Total: 4]

6 **(a)** Fig. 6.1 shows four statements that may or may not be true about a photon. Place a tick (✓) next to each statement if it is correct and a cross (✗) if it is incorrect.

	place ✓ or ✗ here
A photon has a negative charge.	
A photon travels at the speed of $3.0 \times 10^8 \text{ m s}^{-1}$ in a vacuum.	
A photon is a quantum of electromagnetic radiation.	
An X-ray photon has less energy than a photon of radio waves.	

Fig. 6.1 [2]

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

Describe and explain the photoelectric effect in terms of photons interacting with the surface of a metal.

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.....[6]

Quality of Written Communication [1]

(c) An X-ray machine in a hospital emits X-rays of wavelength 4.0×10^{-10} m and of power 1.4 W.

(i) Calculate the energy of each X-ray photon

1. in joules

energy = ... J

2. in electronvolts (eV).

energy = ... eV
[4]

(ii) Calculate the number of photons emitted per second from the X-ray machine.

number = ... s^{-1} [3]

[Total: 16]

END OF QUESTION PAPER

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