OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary GCE

PHYSICS A

Electrons and Photons

2822

Friday **9 JUNE 2006** 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, Centre Number and Candidate number in the boxes above.
- Answer **all** the questions.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Write your answers, in blue or black ink, in the spaces provided on the question paper.
- Pencil may be used for graphs and diagrams only.
- Do not write in the bar code. Do not write in the grey area between the pages.
- **DO NOT** WRITE IN THE AREA **OUTSIDE** THE BOX BORDERING EACH PAGE. ANY WRITING IN THIS AREA WILL NOT BE MARKED.

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	7	
2	7	
3	7	
4	13	
5	8	
6	12	
7	6	
TOTAL	60	

This question paper consists of 14 printed pages and 2 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, $p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$

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

Answer all the questions.

1 (a) Fig. 1.1 shows an electrical circuit.

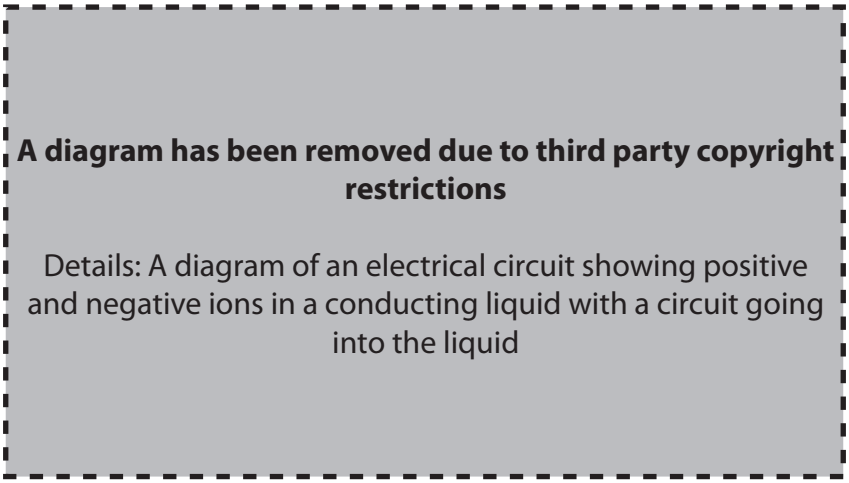

Fig. 1.1

(i) The directions of flow of ions in the liquid are shown. On Fig. 1.1, draw an arrow at X to show the direction of the electron flow in the wire. [1]

(ii) State what is meant by conventional current .

.....

.....[1]

(iii) A charge of 0.76C flows past point X in a time of 5.0 minutes. Calculate the current in the wire.

current = ... A [3]

(b) Fig. 1.2 shows a magnetic compass placed very near a current-carrying wire and in a plane at right angles to the wire. The compass needle aligns itself in the direction of the magnetic field due to the current in the wire.

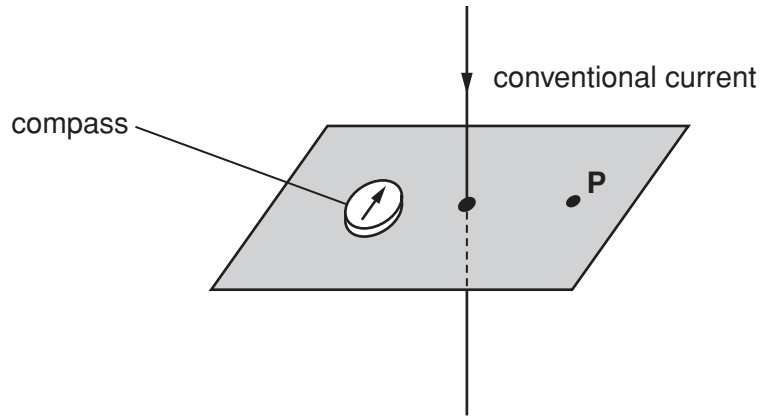

Fig. 1.2

State and explain the effect, if any, on the compass needle when the compass is placed at point **P**.

.....

.....

.....[2]

[Total: 7]

2 State **three** main features common to all types of radiations in the electromagnetic spectrum. Name **three** principal radiations in the electromagnetic spectrum other than visible light. For **one** of these radiations, give a useful application.

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.....[7]

[Total: 7]

3 Fig. 3.1 shows a rectangular block of electrically conducting material.

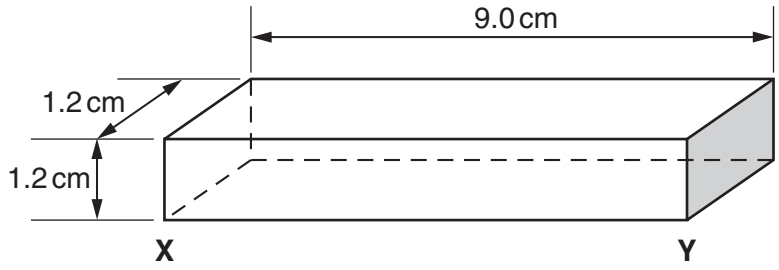

Fig. 3.1

(a) The conducting block obeys Ohm's law. State Ohm's law, in words.

.....

.....

.....[2]

(b) When the ends **X** and **Y** of the block are connected to a 0.15 V d.c. supply of negligible internal resistance, the current drawn is 4.3 A.

(i) Show that the block has a resistance of $3.5 \times 10^{-2}\ \Omega$.

[1]

(ii) Calculate the resistivity of the material.

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

[Total: 7]

4 Fig. 4.1 shows an arrangement of three filament lamps used to illuminate a room.

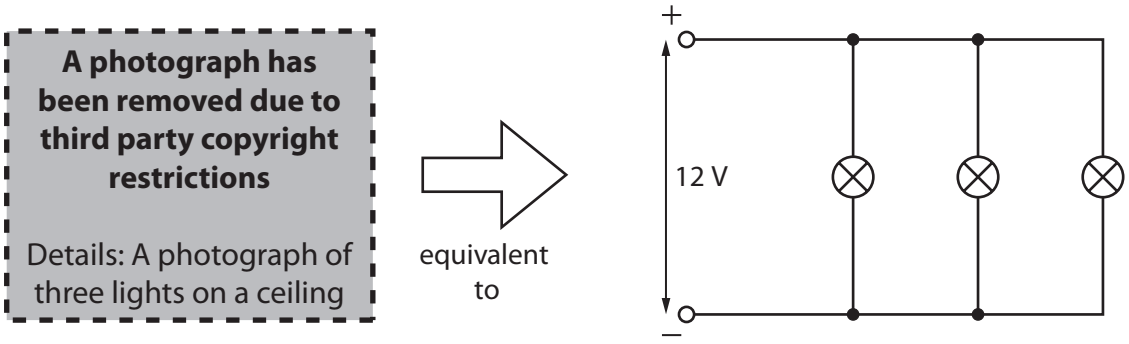

Fig. 4.1

(a) Name the arrangement in which the three lamps are connected.

.....[1]

(b) Each lamp has resistance 8.0 Ω when operating at 12V.

Calculate

(i) the current drawn by each lamp

current = ... A [2]

(ii) the power dissipated by each lamp

power = ... W [3]

(iii) the total resistance of the lamps as connected in Fig. 4.1

resistance = ... Ω [3]

(iv) the **total** energy transformed by the three lamps in kilowatt hour when operated for 12 hours.

energy = ... kW h [2]

(c) One of the lamps is replaced by another lamp that also operates at 12V but has a smaller resistance than 8.0 Ω. State and explain how its brightness will compare with one of the other two remaining lamps.

.....

.....

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.....[2]

[Total: 13]

5 **(a)** Complete the following sentence for a statement of Kirchhoff's first law.

The sum of the ..... into a point in a circuit is equal to the sum of the ..... out from that point. [1]

(b) Complete the following statement about Kirchhoff's second law.

In an electrical circuit, the sum of the e.m.f.s around a closed loop is equal to the sum of the p.d.s around the same loop. This is a consequence of conservation of ..... . [1]

(c) Fig. 5.1 shows a part of an electrical circuit.

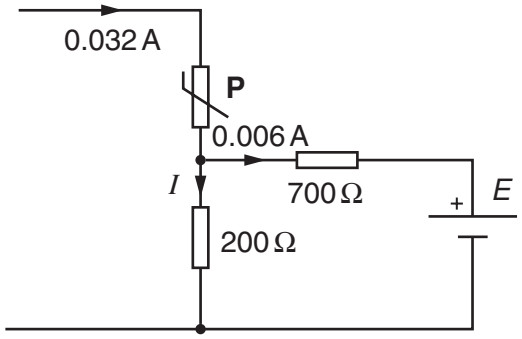

Fig. 5.1

(i) Name the component **P**.

.....[1]

(ii) State how the resistance of component **P** is affected by a change in its temperature.

.....

.....[1]

(iii) At a particular temperature, the currents are as shown in Fig. 5.1. Use Kirchhoff's laws to determine

1 the current I in the 200 Ω resistor

I = ... A [1]

2 the e.m.f. E of the cell.

E = ... V [3]

[Total: 8]

6 Fig. 6.1 shows a zinc plate attached to a charged gold-leaf electroscope. The arrangement is used to demonstrate the photoelectric effect.

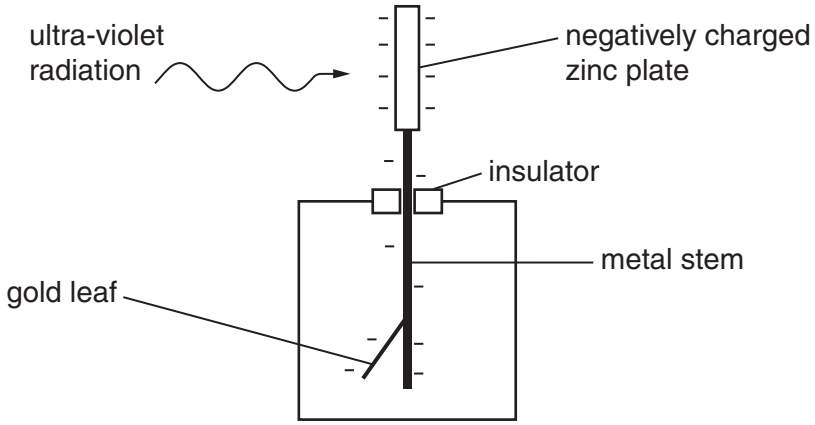

Fig. 6.1

The zinc plate, metal stem and gold leaf have an excess of electrons. This causes the leaf to deflect away from the stem.

(a) When the zinc plate is exposed to high frequency ultra-violet radiation, it loses electrons from its surface and consequently the gold leaf falls rapidly. If the demonstration is repeated with visible light, the leaf does not fall.
Use the photoelectric effect to describe how the ultra-violet radiation interacts with the surface electrons of the zinc plate. Explain why visible light, no matter how intense, does not release electrons from the zinc plate.

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

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.....[5]

Quality of Written Communication [2]

(b) Ultra-violet radiation of wavelength 3.9×10^{-7} m is incident on the surface of a metal plate. The maximum kinetic energy of an emitted photoelectron is 1.5 eV.

Calculate

(i) the maximum kinetic energy of a photoelectron in joules

kinetic energy = ... J [2]

(ii) the work function energy of the metal in joules.

work function energy = ... J [3]

[Total: 12]

7 **(a)** The table below shows four statements that may or may not be true about the wave-nature of the electron. Place a tick (✓) next to the statement if it is correct and a cross (✘) if it is incorrect.

	Place a ✓ or a ✘ here
Electrons can be diffracted by matter. This confirms their wave nature.	
The wavelength of the electron is given by the de Broglie equation.	
The wave associated with a moving electron is an electromagnetic wave.	
The kinetic energy of the electron is given by the equation $E = hf$.	

[3]

(b) Calculate the speed of a carbon atom of mass 2.0×10^{-26} kg travelling in space with a de Broglie wavelength of 6.8×10^{-11} m.

speed = ... $m\,s^{-1}$ [3]

[Total: 6]

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