OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced Subsidiary GCE

PHYSICS A

2822

Electrons and Photons

Thursday **12 JANUARY 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 in the space above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- 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.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- 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	13	
2	4	
3	5	
4	10	
5	4	
6	8	
7	16	
TOTAL	60	

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

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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,	$n = \dfrac{1}{\sin C}$
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 Fig. 1.1 shows an electrical circuit.

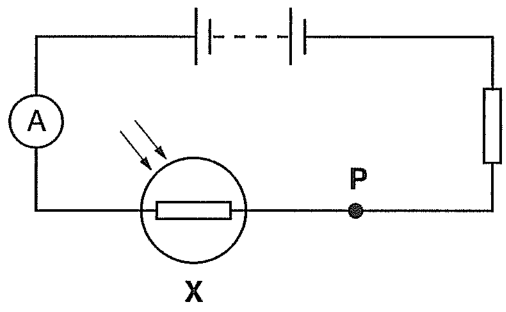

Fig. 1.1

(a) On Fig. 1.1, show how a voltmeter may be connected to measure the potential difference (voltage) across the component **X**. [1]

(b) State the effect, if any, on the ammeter reading when the ammeter is moved from the position shown to position **P** in the circuit.

....

....[1]

(c) The resistance of component **X** is affected by the intensity of visible light falling on it.

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

....[1]

(ii) State how the resistance of **X** changes as the intensity of visible light is **increased**.

....[1]

(iii) State the range of the wavelength of visible light.

....m to ....m [1]

(d) The current measured by the ammeter is 4.8×10^{-3} A when the p.d. across the component **X** is 1.8 V.

(i) Calculate the resistance of component **X**.

resistance = ... Ω [2]

(ii) For a time interval of 30 s, calculate

1 the charge passing through the ammeter

charge = ... C [3]

2 the electrical energy transformed by the component **X**.

energy = ... unit .... [3]

[Total: 13]

2 The statements below are either laws of physics or definitions of physical quantities or units. In the space provided, name the law, quantity or unit being stated.

(a) The sum of the e.m.f.s in a loop of an electrical circuit is equal to the sum of the p.d.s in that loop.

This is a statement of .... law. [1]

(b) The current in a metallic conductor kept at a constant temperature is directly proportional to the potential difference across its ends.

This is a statement of .... law. [1]

(c) The potential difference divided by the current.

This is the definition for .... [1]

(d) The energy transformed by an electron travelling through a potential difference of one volt.

This is the definition for the .... [1]

[Total: 4]

3 Fig. 3.1 shows an electrical circuit including three resistors.

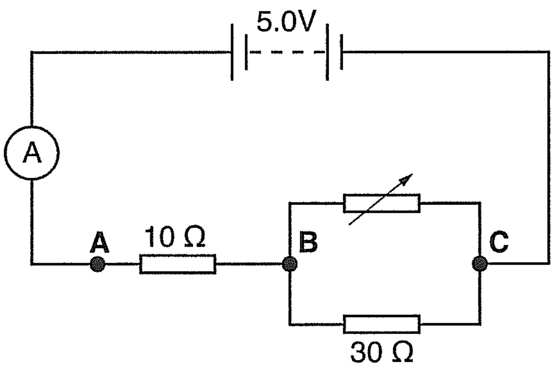

Fig. 3.1

(a) The variable resistor is set on its maximum resistance of 20 Ω. Calculate the resistance between points

(i) **B** and **C**

resistance = ... Ω [2]

(ii) **A** and **C**.

resistance = ... Ω [1]

(b) In the circuit shown in Fig. 3.1, the battery has negligible internal resistance and an e.m.f. 5.0 V. The variable resistor is now set on its lowest resistance of 0 Ω. Calculate the ammeter reading.

reading = ... A [2]

[Total: 5]

4 **(a)** Fig. 4.1 shows a long straight wire carrying current **into** the plane of the paper.

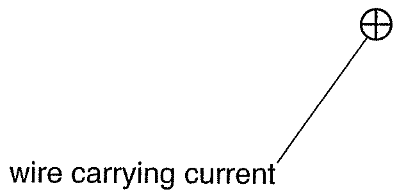

Fig. 4.1

On Fig. 4.1, sketch the magnetic field pattern produced by this current-carrying wire. [2]

(b) Fig. 4.2 shows a current-carrying conductor in the shape of a rectangular frame **ABCD** placed in a uniform magnetic field.

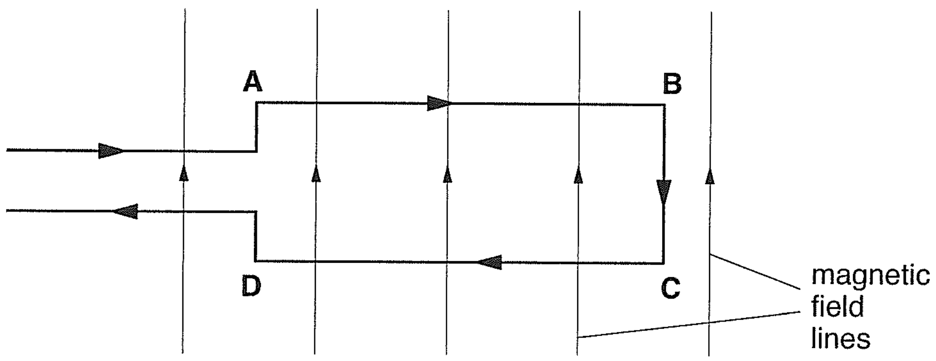

Fig. 4.2

The plane of the frame is parallel to the magnetic field.

(i) In Fleming's left-hand rule, state what quantities are represented by the directions of each of the following.

1 first (index) finger ....

2 second (middle) finger ....

3 thumb ....[2]

(ii) Suggest why the section **BC** of the frame does not experience a force due to the magnetic field.

....

....

....[1]

(iii) State the direction of the force experienced by the section **AB** of the frame.

....[1]

(iv) Suggest why the rectangular frame would start to rotate in the magnetic field.

....

....

....[1]

(v) The current in the rectangular frame is 5.2 A. The section **AB** of the frame has length 2.3×10^{-2} m and it experiences a force of 3.8×10^{-2} N when it is at right angles to the magnetic field.
Calculate the magnetic flux density.

magnetic flux density = ... T [3]

[Total: 10]

5 Fig. 5.1 shows a potential divider circuit used to monitor the temperature of a greenhouse.

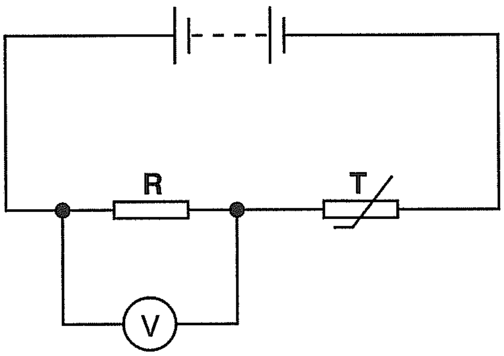

Fig. 5.1

The thermistor **T** is a negative temperature coefficient type. The voltmeter is placed across the resistor **R**. Describe and explain how the voltmeter reading changes as the temperature of the greenhouse **increases**.

....

....

....

....

....

....

....

....

....[4]

[Total: 4]

6 **(a)** A wire has length L, cross-sectional area A and is made of material of resistivity ρ. Write an equation for the electrical resistance R of the wire in terms of L, A and ρ.

[1]

(b) A second wire is made of the same material as the wire in **(a)**, has the same length but twice the diameter. State how the resistance of this wire compares with the resistance of the wire in **(a)**.

....

....

....[2]

(c) Fig. 6.1 shows a resistor made by depositing a thin layer of carbon onto a plastic base.

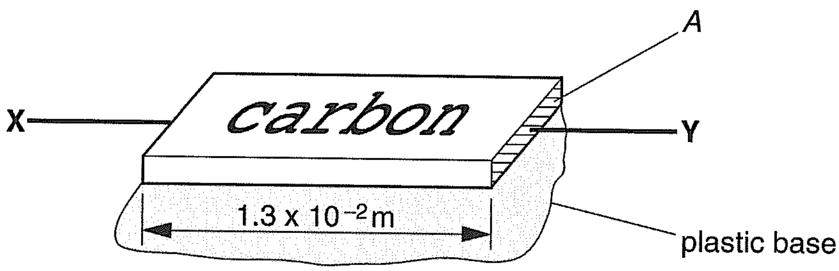

Fig. 6.1

The resistance of the carbon layer between **X** and **Y** is 2200 Ω. The length of the carbon layer is 1.3×10^{-2} m. The resistivity of carbon is 3.5×10^{-5} Ω m.

(i) Show that the cross-sectional area A of the carbon layer is about $2 \times 10^{-10}\,m^2$.

[2]

(ii) The maximum power that can be safely dissipated by the resistor is 0.50 W. Calculate the current in the resistor for this power.

current = ... A [3]

[Total: 8]

[Turn over

7 **(a)** In this question, two marks are available for the quality of written communication.

The Planck constant h is a very important fundamental constant in the study of wave-particle duality.

- With the aid of equations, discuss how this constant is used to describe the behaviour of electromagnetic waves and moving electrons.
- Describe the experimental evidence for the wave behaviour of the electron.

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....[6]

Quality of Written Communication [2]

(b) A negatively charged metal plate is exposed to electromagnetic radiation of frequency f. Fig. 7.1 shows the variation with f of the maximum kinetic energy E_k of the photoelectrons emitted from the surface of the metal.

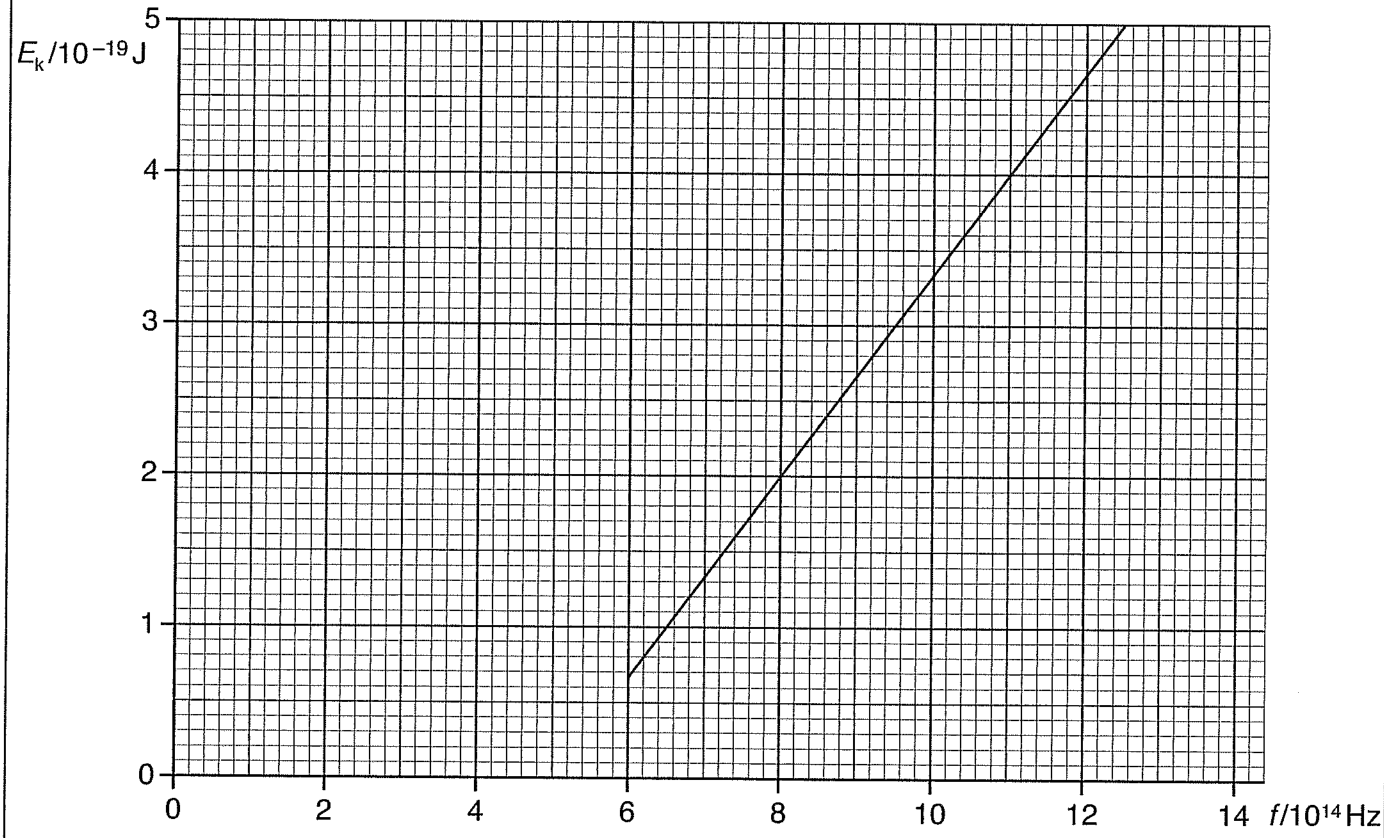

Fig. 7.1

(i) Define the *threshold frequency* of a metal.

....

....[1]

(ii) **1** Explain how the graph shows that the threshold frequency of this metal is 5.0×10^{14} Hz.

....

....[1]

2 Calculate the work function energy of this metal in joules.

work function energy = ... J [2]

(iii) Electromagnetic radiation falls on the surface of a metal having work function energy greater than your answer in **b(ii)**.

1 State and explain the change, if any, to the gradient of the line shown in Fig. 7.1.

....

....

....[2]

2 State and explain the change, if any, to the position of the line shown in Fig. 7.1.

....

....

....[2]

[Total: 16]

END OF QUESTION PAPER

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