OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE UNIT **2822**

PHYSICS A

Electrons and Photons

FRIDAY 8 JUNE 2007 Morning

Time: 1 hour

Additional materials:
Electronic calculator

Candidate Name

Centre Number

Candidate Number

INSTRUCTIONS TO CANDIDATES

- Write your name, Centre Number and Candidate number in the boxes above.
- Answer **all** the questions.
- Use blue or black ink. 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 outside the box bordering each page.
- WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED. ANSWERS WRITTEN ELSEWHERE WILL NOT BE MARKED.

INFORMATION FOR CANDIDATES

- The number of marks for each question is given in brackets [ ] at the end of each question or part question.
- The total number of marks for this paper is 60.
- You will be awarded marks for the quality of written communication where this is indicated in the qustion.
- 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	8	
2	9	
3	10	
4	17	
5	16	
TOTAL	60	

This document 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, $p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2 \rangle$

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)** Fig. 1.1 shows the magnetic field pattern for a flat circular coil.

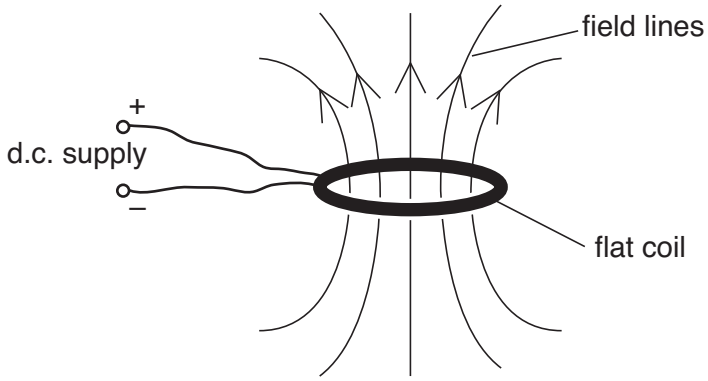

Fig. 1.1

Describe the change in the pattern of the magnetic field lines when the current in the coil is

(i) reversed

.....

..... [1]

(ii) increased in magnitude.

.....

..... [1]

(b) The force experienced by a current-carrying conductor placed at right angles to a uniform magnetic field may be determined using Fleming's left-hand rule. On Fig. 1.2, identify the directions of the magnetic field, the conventional current and the force experienced by the conductor by inserting the words **field**, **current** and **force** in the boxes.

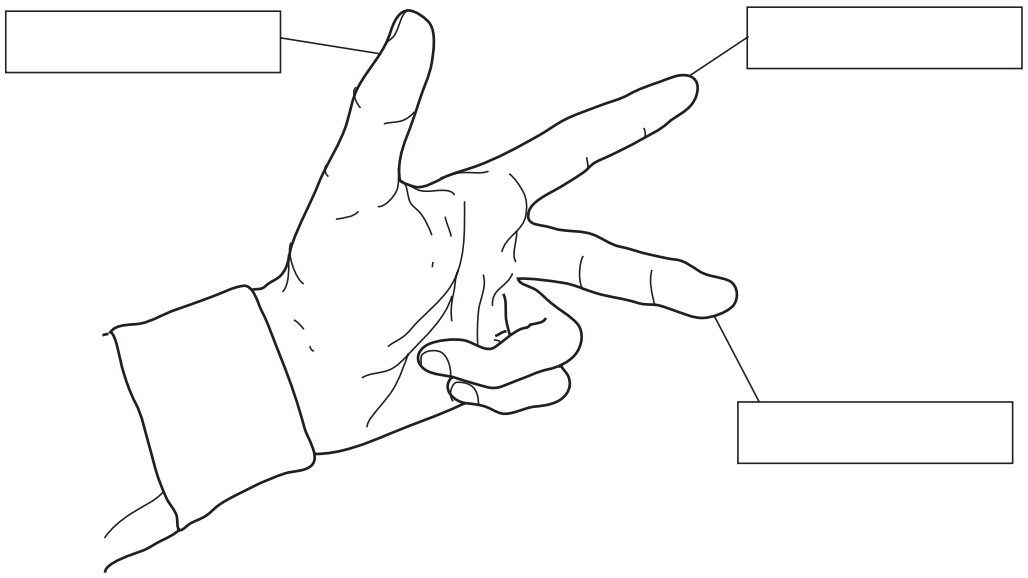

Fig. 1.2 [2]

(c) The force F experienced by a current-carrying conductor placed at right angles to a magnetic field is given by the equation

$$F = BIL.$$

Identify the labels used in this equation.

B .....

I .....

L ..... [3]

(d) Underline the correct electrical unit below that is defined in terms of the force between two current-carrying conductors.

coulomb tesla ampere ohm [1]

[Total: 8]

2 **(a)** On Fig. 2.1, sketch the variation with temperature of the resistance of a pure metallic conductor.

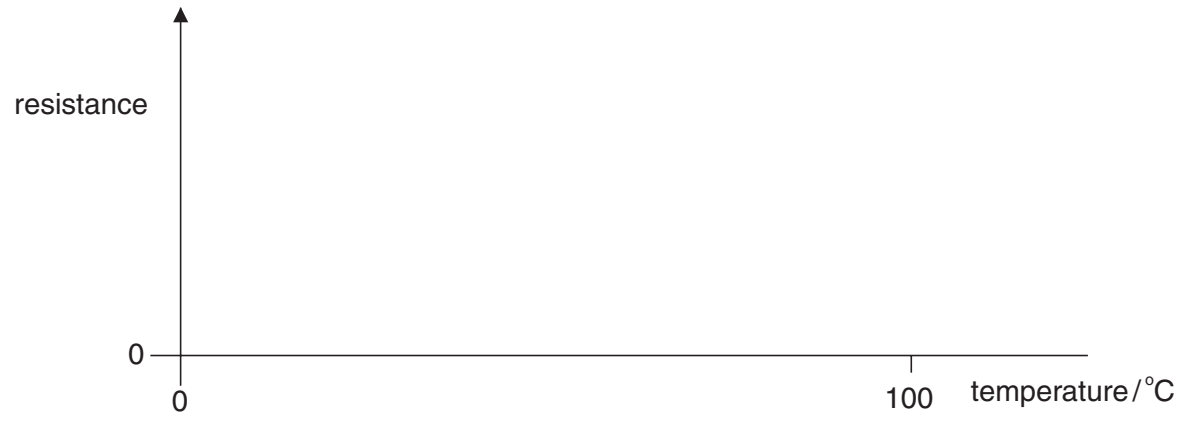

Fig. 2.1 [2]

(b) Fig. 2.2 shows a circuit used to monitor the changes in the temperature of a room.

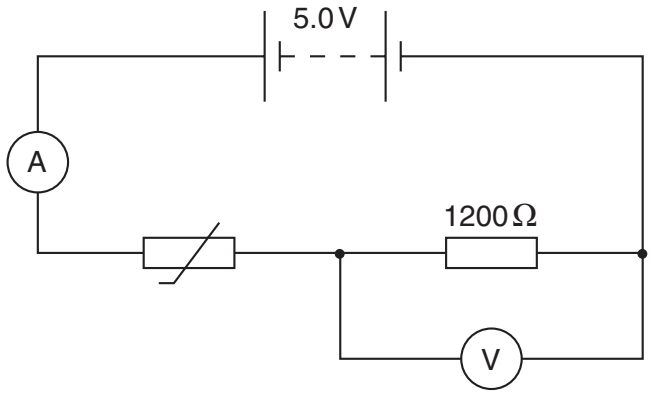

Fig. 2.2

The thermistor is connected in series with a resistor of fixed value 1200 Ω. The battery has e.m.f. 5.0 V and negligible internal resistance. Assume that the ammeter has negligible resistance and the voltmeter has very high resistance.

(i) The thermistor is a negative temperature coefficient (NTC) thermistor. State and explain the changes in the ammeter and voltmeter readings as the temperature of the thermistor is increased.

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..... [4]

(ii) At a particular temperature, the reading on the voltmeter is 3.6 V. Calculate the resistance of the thermistor at this temperature.

resistance = ... Ω [3]

[Total: 9]

3 Fig. 3.1 shows the I-V characteristic of a particular electrical component.

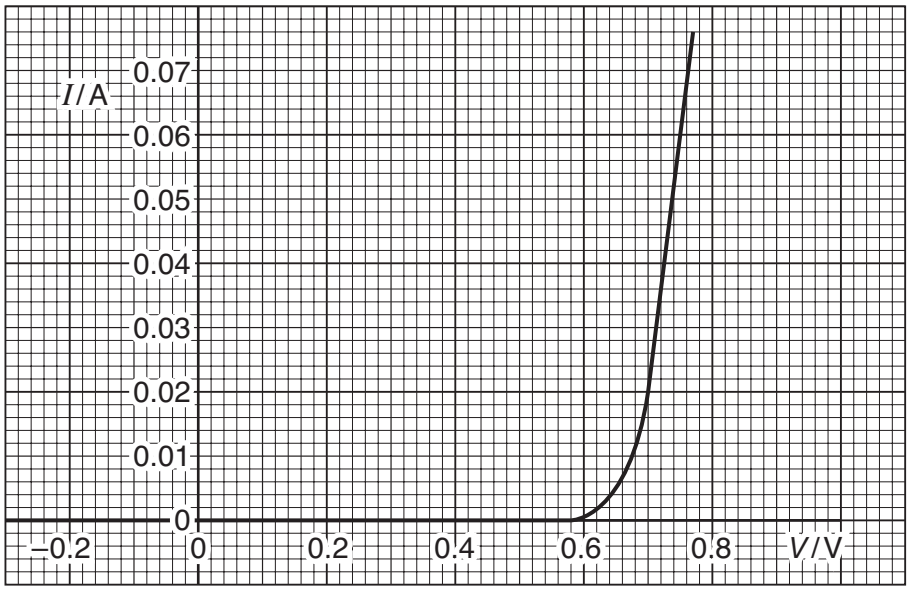
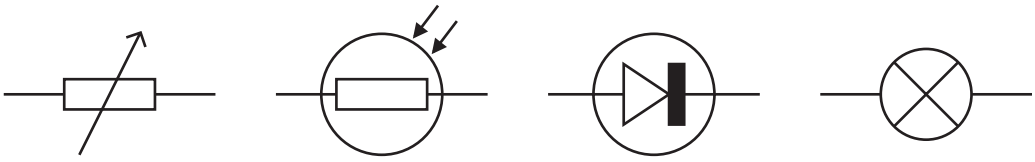


Fig. 3.1

(a) Name the component.

..... [1]

(b) Circle the correct circuit symbol for the component. [1]



(c) Use Fig. 3.1 to calculate the resistance of the component at 0.20V and 0.70V.

resistance at 0.20V = ... Ω

resistance at 0.70V = ... Ω [3]

(d) Fig. 3.2 shows the component with the I-V characteristic shown in Fig. 3.1 connected in series with a resistor of resistance R and a supply of e.m.f. 4.5 V.

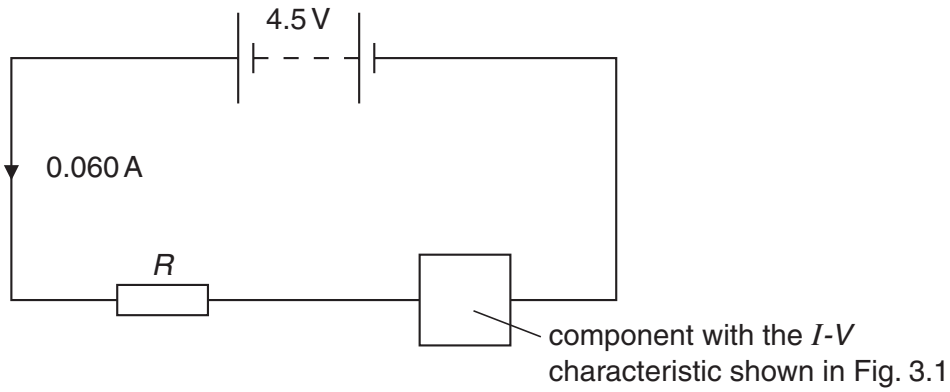


Fig. 3.2

The supply has negligible internal resistance. The current in the resistor is 0.060 A.

Use Fig. 3.1 to determine the resistance R of the resistor.

R = ... Ω [3]

(e) On the axes of Fig. 3.1, draw the I-V characteristic of a metallic conductor kept at a constant temperature and having the same resistance as your answer to **(d)**. Label your line **M**.

[2]

[Total: 10]

4 **(a)** Name a quantity that has the same unit as potential difference or voltage.

..... [1]

(b) State the electrical unit defined as 'a potential difference of 1 volt per ampere'.

..... [1]

(c) State the SI unit for electrical charge.

..... [1]

(d) State Kirchhoff's first law.

.....

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..... [2]

(e) Fig. 4.1 shows an electrical circuit.

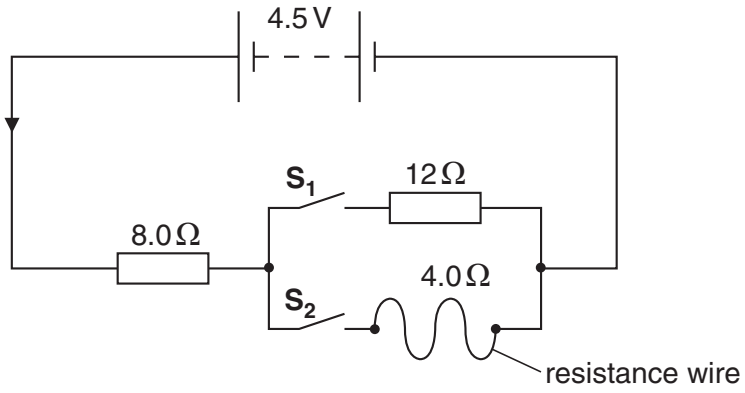

Fig. 4.1

The battery has e.m.f. 4.5 V and has negligible internal resistance. The resistance wire has resistance 4.0 Ω, length 15 cm and cross-sectional area $2.3 \times 10^{-8}\,m^2$.

(i) Suggest how you can arrange switches S_1 and S_2 (e.g. opened or closed) so that the circuit has a total resistance of 12 Ω.

.....

..... [1]

(ii) Calculate the resistivity of the material of the resistance wire.

resistivity = ... unit …… [4]

(iii) When both switches are **closed**, calculate

1 the **total** resistance of the circuit

resistance = ... Ω [3]

2 the **total** electrical power delivered by the battery

power = ... W [3]

3 the ratio

$$\frac{\text{current in the } 12\,\Omega \text{ resistor}}{\text{current in the resistance wire}}\ .$$

ratio = ... [1]

[Total: 17]

5 **(a)** Two of the most important equations from quantum physics are listed below.

equation 1 $E = hf$

equation 2 $\lambda = \frac{h}{mv}$

Complete the following sentences:

(i) Equation 1 describes the …… behaviour of electromagnetic waves. [1]

(ii) Equation 2 describes the …… behaviour of a particle such as an electron. [1]

(b) In this question two marks are available for the quality of written communication.

A negatively charged metal plate is illuminated by light. Electrons escape from the metal when blue light of weak intensity is used. No electrons are released when weak or intense red light is used. Use the ideas of the photoelectric effect to explain these observations.

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..... [6]

Quality of Written Communication [2]

(c) In a laser beam, each photon has energy 2.0 eV.

(i) Show that the wavelength of the electromagnetic waves emitted by the laser is about 6×10^{-7} m.

[2]

(ii) Identify the region of the electromagnetic spectrum to which the waves emitted by the laser belong.

..... [1]

Question 5 is continued over the page.

(d) Lithium ions are accelerated to a speed v. Fig. 5.1 shows a graph of the de Broglie wavelength λ of the ions against $\frac{1}{v}$.

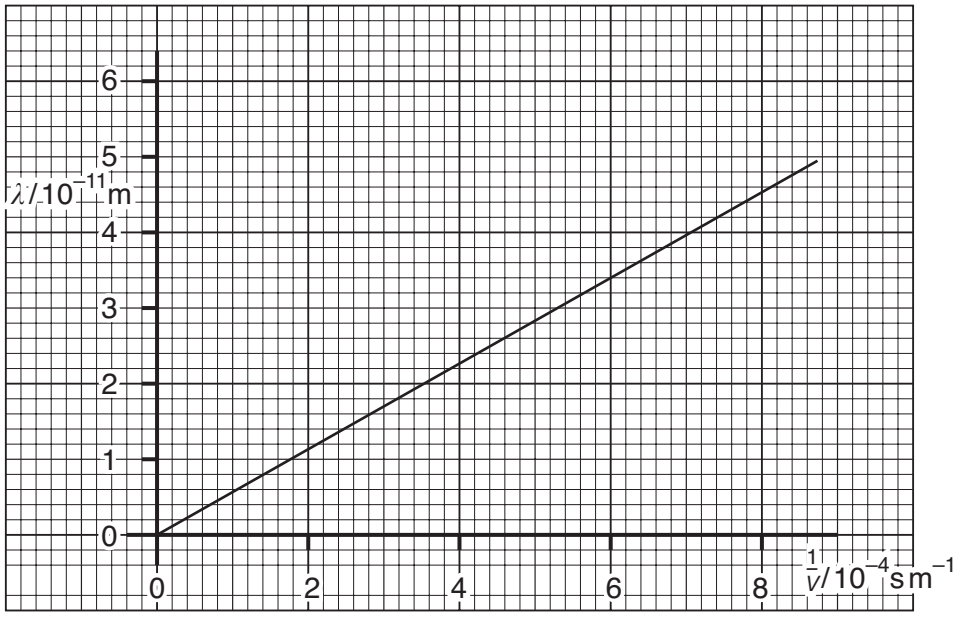

Fig. 5.1

Determine the gradient of the graph of Fig. 5.1 and hence calculate the mass m of a single ion of lithium.

m = ... kg [3]

[Total: 16]

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