THIS IS A LEGACY SPECIFICATION

OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE

PHYSICS A

Electrons and Photons

2822

Candidates answer on the question paper

OCR Supplied Materials:
None

Other Materials Required:
- Electronic calculator

Thursday 21 May 2009
Afternoon

Duration: 1 hour

CUP/T61221

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided, however additional paper may be used if necessary.

INFORMATION FOR CANDIDATES

- The number of marks 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 question.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
- This document consists of **16** pages. Any blank pages are indicated.

FOR EXAMINER'S USE		
Qu.	**Max**	**Mark**
1	**8**	
2	**8**	
3	**8**	
4	**9**	
5	**12**	
6	**15**	
TOTAL	**60**	

OCR is an exempt Charity

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)** The *I*/*V* characteristic of a particular component is shown in Fig. 1.1.

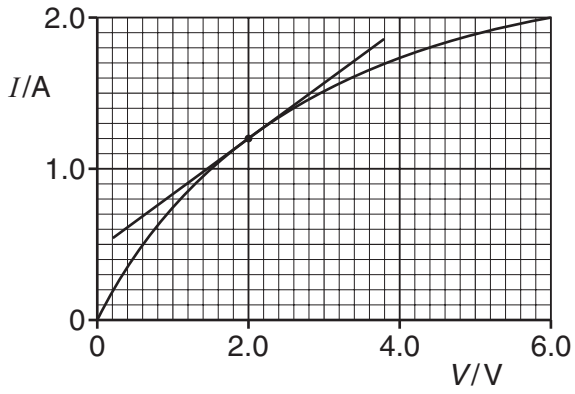

Fig. 1.1

(i) Name the component.

..... **[1]**

(ii) According to one student, the *'gradient of the graph at 2.0V can be used to determine the resistance of the component at 2.0V'*.
Explain why the student is wrong.

.....

..... **[1]**

(iii) Determine the resistance of the component at 2.0V.

resistance = ... Ω **[2]**

(b) Fig. 1.2 shows a sketch graph of the variation of resistance *R* of a different component with potential difference (voltage) *V*.

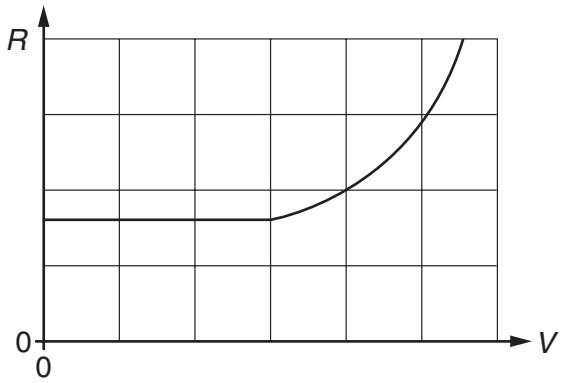

Fig. 1.2

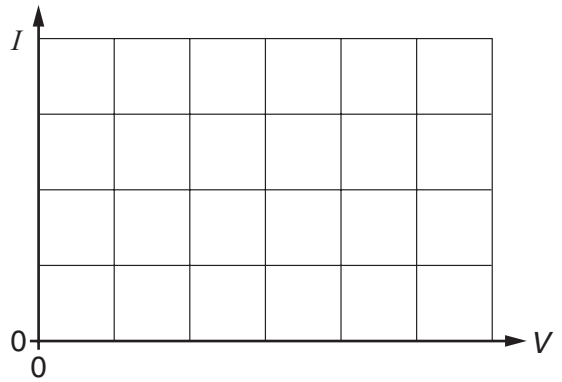

Fig. 1.3

Complete Fig. 1.3 by drawing a sketch graph to show the I/V characteristic of the component. **[2]**

(c) Fig. 1.4 shows an electrical circuit containing a semiconductor diode.

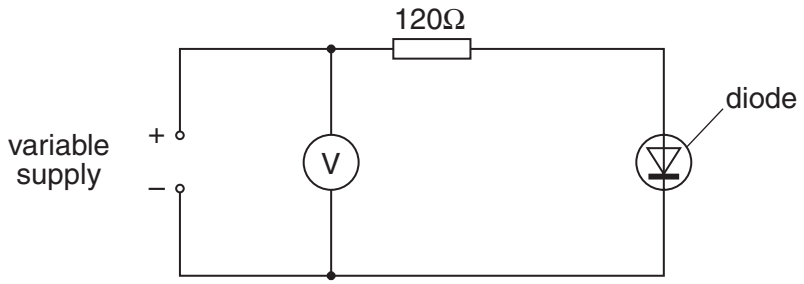

Fig. 1.4

This diode has a very low resistance when it conducts. It has an infinite resistance when the potential difference across it is less than 0.6 V. The variable supply is adjusted to give a reading of 0.4 V on the voltmeter.

(i) State the current in the 120 Ω resistor.

current = ... A **[1]**

(ii) State the potential difference across the diode.

potential difference = ... V **[1]**

[Total: 8]

2 **(a)** X-rays and radio waves are examples of electromagnetic waves. State one similarity and one difference between X-rays and radio waves.

similarity .....

.....

difference .....

..... **[2]**

(b) An artificial satellite orbiting the Earth broadcasts radio signals of frequency 4.0×10^9 Hz. Calculate the wavelength λ of these radio signals.

λ = ... m **[2]**

(c) **(i)** Circle a typical value for the wavelength of X-rays from the list below.

5×10^2 m 5×10^{-7} m 5×10^{-10} m 5×10^{-16} m

[1]

(ii) Use your answer in **(i)** to determine the energy of a single X-ray photon in joules and in electronvolts (eV).

energy = ... J

energy = ... eV **[3]**

[Total: 8]

3 A negative temperature coefficient (NTC) thermistor is connected across the terminals of a battery of e.m.f. 6.0 V and of negligible internal resistance. Fig. 3.1 shows the variation of current I with time t from the moment the thermistor is connected to the battery.

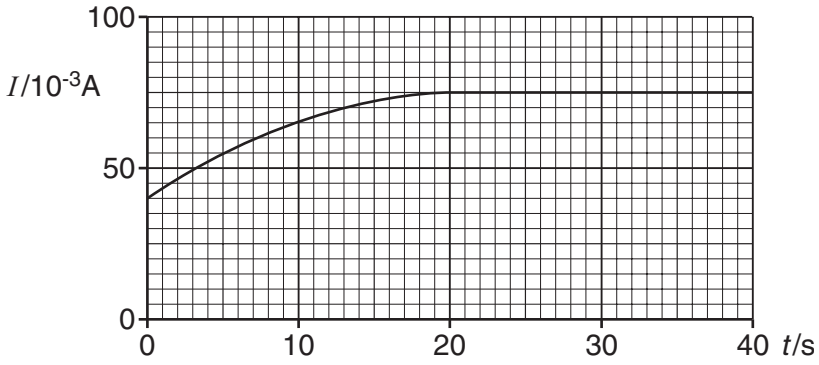

Fig. 3.1

(a) Calculate the power dissipated by the thermistor at time $t = 0$.

power = ... W **[2]**

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

Explain the shape of the graph of Fig. 3.1.

.....

.....

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.....

.....

..... **[4]**

Quality of Written Communication [2]

[Total: 8]

4 **(a)** Write an equation that defines magnetic flux density *B*. Define all terms.

.....

.....

..... **[2]**

(b) Fig. 4.1 shows part of a long current-carrying wire.

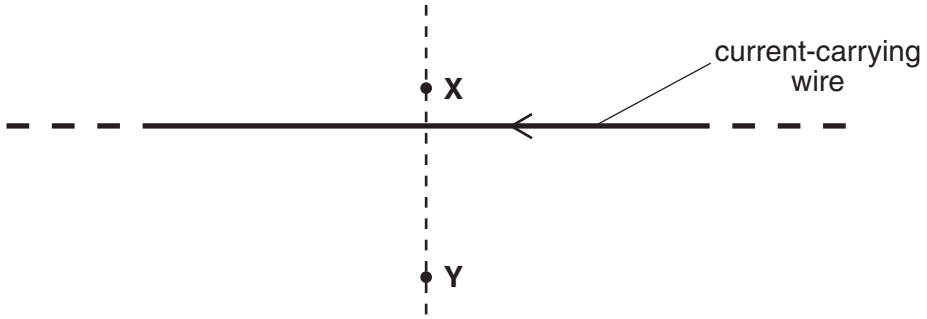

Fig. 4.1

The current creates a magnetic field round this wire. State two ways in which the magnetic field at **X** differs from the magnetic field at **Y**.

.....

.....

..... **[2]**

(c) Fig. 4.2 shows a current-carrying wire placed at right angles to the magnetic field between the poles of a magnet.

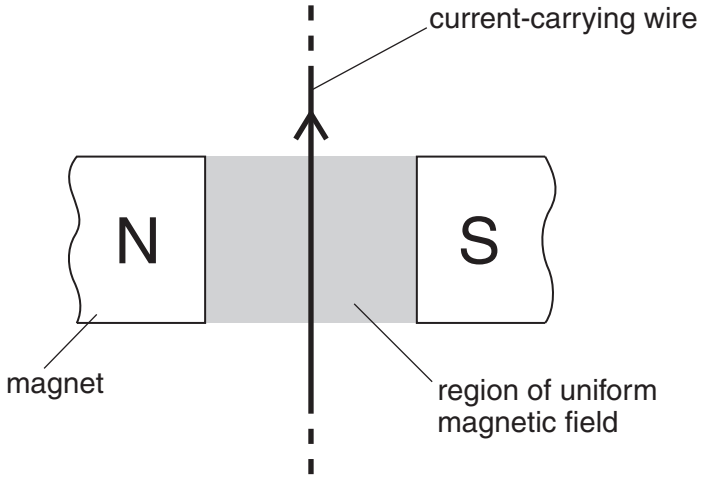

Fig. 4.2

(i) Determine the direction of the force experienced by the wire due to the magnetic field.

..... **[1]**

(ii) The length of the wire in the magnetic field is 2.5 cm. The magnetic flux density between the poles of the magnet is 0.18 T. The current in the wire is 8.0 A.

1 Calculate the force experienced by the wire.

force = ... N **[2]**

2 The force on the wire is the result of each free electron within the wire experiencing a force as it travels in the magnetic field between the poles. The wire has a cross-sectional area $1.2 \times 10^{-7}\,m^2$ and it contains 8.5×10^{28} free electrons per cubic metre (m^3). Calculate the average force experienced by one of these free electrons.

force = ... N **[2]**

[Total: 9]

5 **(a)** A battery delivers a constant current through a circuit when a switch is closed at time $t = 0$.

(i) On Fig. 5.1, sketch a graph to show how the total charge that has been supplied by the battery varies with time t.

[1]

Fig. 5.1

(ii) The battery delivers a constant current of 5.2 A for a time of 3.5 hours. Calculate the total charge supplied by the battery after a time of 3.5 hours.

charge = ... unit ..... **[3]**

(b) Fig. 5.2 shows an electrical circuit.

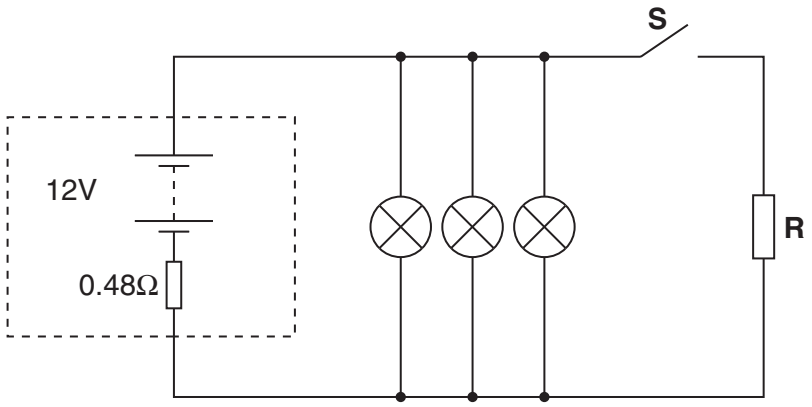

Fig. 5.2

The switch **S** is open. The battery has e.m.f. 12V and an internal resistance 0.48Ω. The three lamps are identical, each of resistance 3.6Ω. The filament of each lamp is a coiled wire of cross-sectional area of $2.0 \times 10^{-8}\,m^2$. The material of the filament has resistivity $7.9 \times 10^{-7}\,\Omega m$.

(i) Calculate the length of the filament wire in each lamp.

length = ... m **[3]**

(ii) With the switch **S open**, determine

1 the total resistance of the circuit

total resistance = ... Ω **[2]**

2 the current from the battery.

current = ... A **[1]**

(iii) With the switch **S closed**, the current in the resistor **R** is 20 A. Explain why the lamps dim when the switch is closed.

.....

.....

.....

..... **[2]**

[Total: 12]

6 **(a)** State what is meant by the *photoelectric effect*.

.....

..... **[1]**

(b) Explain why electrons are released from a particular metal when it is illuminated by weak blue light, but not when it is illuminated by very intense red light.

.....

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.....

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.....

..... **[4]**

(c) Electromagnetic waves are incident on the surface of a particular metal. Fig. 6.1 shows a graph of the maximum kinetic energy KE_{max} of the electrons released from the surface against the frequency f of the electromagnetic waves.

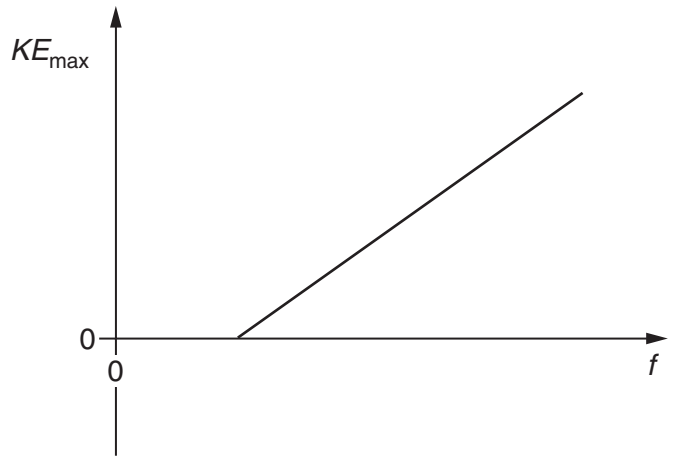

Fig. 6.1

(i) On Fig. 6.1

1 mark with a letter **F** a point corresponding to the threshold frequency of the metal **[1]**

2 mark with a letter **W** on the vertical axis a point corresponding to the work function energy of the metal. **[1]**

(ii) State and explain how the graph of Fig. 6.1 will change when a metal of higher work function energy is illuminated by electromagnetic radiation. You may support your answer by drawing on Fig. 6.1.

.....

.....

.....

.....

..... **[3]**

(d) For a particular metal, electromagnetic radiation of frequency 1.36×10^{15} Hz incident on its surface releases electrons with a maximum kinetic energy of 5.82×10^{-19} J.

(i) Suggest why the electrons emitted from the metal have a range of kinetic energies.

.....

..... **[1]**

(ii) Use Einstein's photoelectric equation to calculate

1 the work function energy of the metal

work function energy = ... J **[2]**

2 the maximum kinetic energy of the electrons when the frequency of the incident radiation is halved.

kinetic energy = ... J **[2]**

[Total: 15]

END OF QUESTION PAPER

PLEASE DO NOT WRITE ON THIS PAGE