THIS IS A LEGACY SPECIFICATION

OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE

PHYSICS A

Electrons and Photons

2822

CUP/T52982

Candidates answer on the question paper

OCR Supplied Materials:
None

Other Materials Required:
- Electronic calculator

Tuesday 13 January 2009
Afternoon

Duration: 1 hour

2822

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 **20** pages. Any blank pages are indicated.

FOR EXAMINER'S USE		
Qu.	**Max.**	**Mark**
1	**8**	
2	**8**	
3	**8**	
4	**8**	
5	**9**	
6	**7**	
7	**5**	
8	**7**	
TOTAL	**60**	

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)** Define the ohm.

.....

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

(b) Fig. 1.1 shows the *I/V* characteristics of a resistor (resistance wire) and a filament lamp.

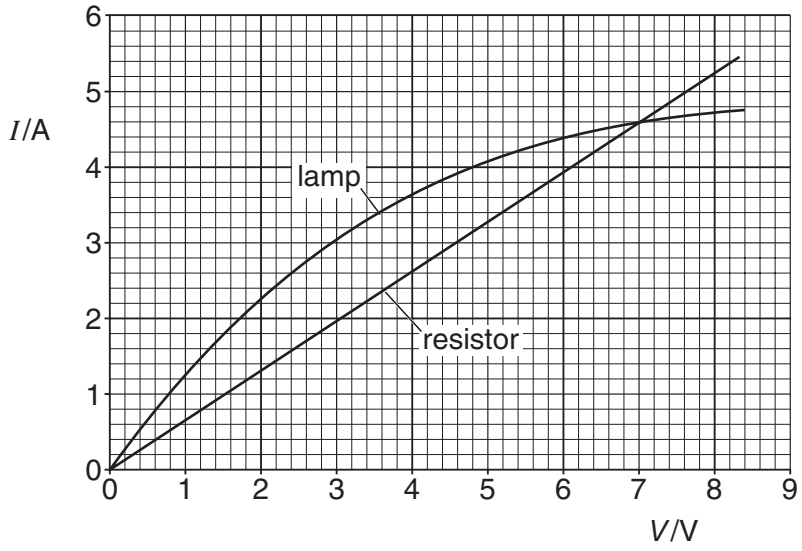

Fig. 1.1

(i) State how the resistance varies with the potential difference *V*

1 across the resistor

.....

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

2 across the filament lamp.

.....

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

(ii) State the value of the potential difference when the resistor and the filament lamp have the same resistance. Explain your answer.

.....

.....

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

(iii) The filament lamp and the resistor are connected in **parallel** to a d.c. supply of e.m.f. 4.0 V. This supply has negligible internal resistance. Use Fig. 1.1 to determine the total resistance of the circuit.

resistance = ... Ω **[3]**

[Total: 8]

2 Fig. 2.1 shows an electrical circuit.

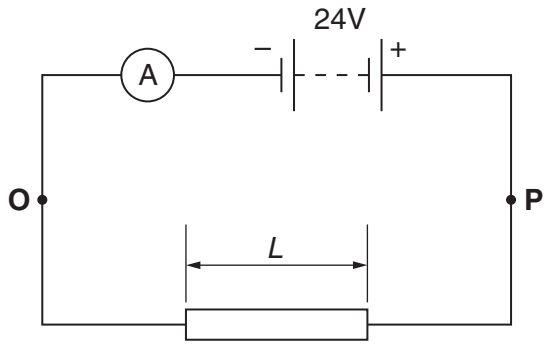

Fig. 2.1

The d.c. supply has e.m.f. of 24 V and has negligible internal resistance.

(a) The ammeter in the circuit measures the current in amperes (A). From the list below, circle a unit that is equivalent to the ampere.

JC^{-1} Cs^{-1} Js^{-1} VsC^{-1} **[1]**

(b) On Fig. 2.1 draw arrows to show the direction of the conventional current at points **O** and **P**. **[1]**

(c) The number of electrons passing through point **P** in a time of 30 s is 9.4×10^{20}. The charge on an electron is 1.6×10^{-19} C. Show that the current at **P** is 5.0 A.

[3]

(d) The length of the resistor is *L*. On Fig. 2.2 sketch a graph to show how the current varies with distance from one end of the resistor. **[1]**

Fig. 2.2

(e) Calculate the energy transformed by a single electron as it passes through the d.c. supply.

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

[Total: 8]

3 **(a)** In terms of energy transfers, state one major difference between electromotive force (e.m.f.) and potential difference (p.d.).

.....

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

(b) State one similarity between potential difference and electromotive force.

.....

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

(c) Fig. 3.1 shows two resistance wires **X** and **Y** connected in series to a battery.

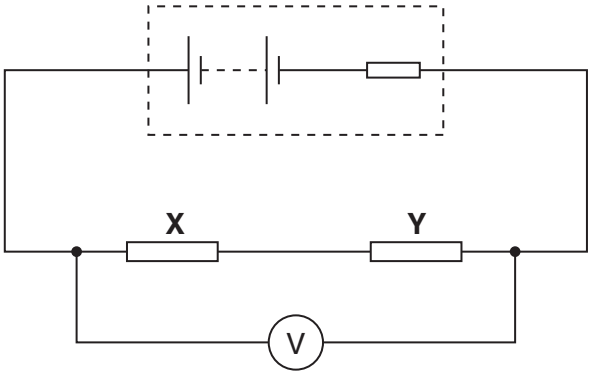

Fig. 3.1

(i) The voltmeter has an infinite resistance. Explain why the voltmeter reading is not equal to the e.m.f. of the battery.

.....

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

(ii) The resistance of wire **X** is four times greater than the resistance of wire **Y**. The voltmeter reading is 6.0 V. Use your knowledge of potential divider circuits to calculate the potential difference across the wire **Y**.

potential difference = ... V **[3]**

(iii) The wires **X** and **Y** are connected in **parallel** to the battery. Explain which of the two wires will dissipate greater power.

.....

.....

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

[Total: 8]

4 **(a)** Write an equation for resistivity ρ of a material in terms of the length L of a conductor, its cross-sectional area A and its resistance R.

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

(b) Fig. 4.1 shows a cube made from a material of resistivity ρ.

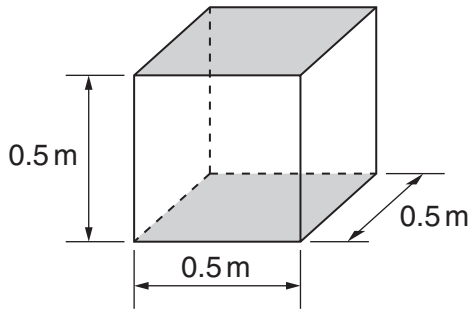

Fig. 4.1

Determine the resistance between any two opposite faces of the cube in terms of the resistivity ρ.

resistance = ... **[2]**

(c) A metal rod has volume $1.6 \times 10^{-5}\,m^3$, length 5.3×10^{-2} m and resistance $7.8 \times 10^{-5}\,\Omega$.

(i) Show that the cross-sectional area of the rod is $3.0 \times 10^{-4}\,m^2$.

[1]

(ii) Calculate the resistivity of the metal.

resistivity = ... Ω m **[2]**

(d) State and explain how your answer to **(c)(ii)** would change, if at all, when the volume of the metal rod is halved but the length is kept the same.

.....

.....

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

[Total: 8]

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

This question is about the conservation of physical quantities in physics. For each statement below, state the law or describe the effect, and make clear reference to the physical quantity conserved.

- Kirchhoff's first law
- Kirchhoff's second law
- photoelectric effect

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..... **[7]**

Quality of Written Communication **[2]**

[Total: 9]

6 **(a)** Write the de Broglie equation in words. Without the aid of calculations, explain why electrons can be diffracted by matter (e.g. graphite), whereas a ball thrown through an open window does not show any observable diffraction effects.

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

(b) Calculate the de Broglie wavelength of an electron travelling at a speed of 2.5% of the speed of light in a vacuum.

wavelength = ... m **[3]**

[Total: 7]

7 **(a)** The magnetic flux density B may be defined as the force acting per unit length of a conductor carrying a unit current. Place a tick (✓) in the box next to the statement that is an essential condition for this definition.

The current must be at right angles to the conductor.	☐
The magnetic field must be parallel to the conductor.	☐
The magnetic field must be at right angles to the current.	☐

[1]

(b) Fig. 7.1 shows a student's sketch of the magnetic field pattern for a long current-carrying wire.

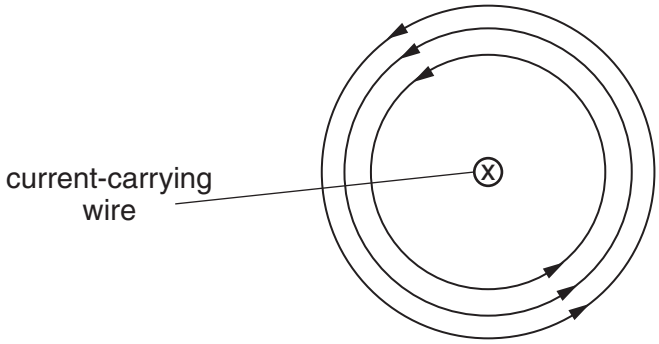

Fig. 7.1

The direction of the magnetic field is wrong. State something else that is wrong with this magnetic field pattern.

.....

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

(c) Fig. 7.2 shows two long parallel current-carrying wires **C** and **D**.

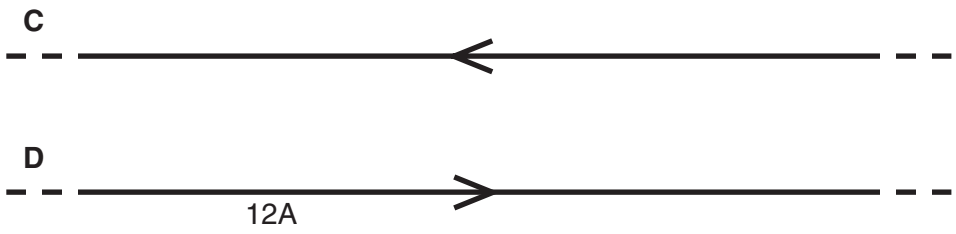

Fig. 7.2

The magnetic flux density B in tesla due to wire **C** is given by the expression

$$B = \frac{1.26 \times 10^{-5}}{r}$$

where r is the distance in metres from the centre of the wire **C**.

The wire **D** experiences a force because it lies in the magnetic field created by the current in the wire **C**. The current in the wire **D** is 12 A and the force experienced by 0.15 m of the wire **D** is 9.5×10^{-4} N. Calculate

(i) the magnetic flux density at the wire **D**

magnetic flux density = ... T **[2]**

(ii) the separation between the two current-carrying wires.

separation = ... m **[1]**

[Total: 5]

8 **(a)** Describe two properties of a photon.

.....

.....

.....

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

(b) Our Sun is one of the many billions of stars in our galaxy. The Sun emits photons at all energies. The Sun emits electromagnetic radiation intensely in the visible range of average wavelength 5.5×10^{-7} m as shown in Fig. 8.1.

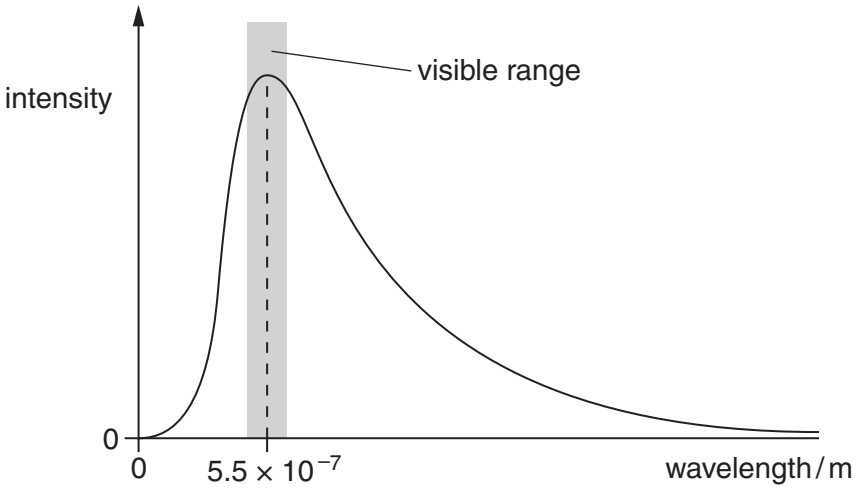

Fig. 8.1

In the visible range of average wavelength 5.5×10^{-7} m, the radiant power emitted per unit area of the Sun's surface is 6.3×10^{7} W m^{-2}. The total surface area of the Sun is 6.1×10^{18} m^{2}.

(i) Calculate the energy of a single photon of wavelength 5.5×10^{-7} m.

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

(ii) Calculate the total number of photons emitted per second from the surface of the Sun in this visible range of average wavelength 5.5×10^{-7} m.

number of photons per second = ... s^{-1} **[2]**

(iii) Some cooler stars in our galaxy emit electromagnetic radiation intensely at a wavelength that is 100 times longer than the wavelength of 5.5×10^{-7} m. Name the region of the electromagnetic spectrum in which the radiation of such stars will be most intense.

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

[Total: 7]

END OF QUESTION PAPER

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