

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced Subsidiary GCE

PHYSICS A
Electrons and Photons

2822

Friday 31 MAY 2002 Afternoon 1 hour

Candidates answer on the question paper.
Additional materials:
Electronic calculator

Candidate Name	Centre Number	Candidate Number										
	<table border="1" style="display: inline-table;"> <tr> <td style="width: 15px; height: 15px;"></td> <td style="width: 15px; height: 15px;"></td> <td style="width: 15px; height: 15px;"></td> <td style="width: 15px; height: 15px;"></td> <td style="width: 15px; height: 15px;"></td> </tr> </table>						<table border="1" style="display: inline-table;"> <tr> <td style="width: 15px; height: 15px;"></td> <td style="width: 15px; height: 15px;"></td> <td style="width: 15px; height: 15px;"></td> <td style="width: 15px; height: 15px;"></td> <td style="width: 15px; height: 15px;"></td> </tr> </table>					

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 the spaces on the question paper.
- Read each question carefully and make sure you know what you have to do before starting your answer.

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	6	
2	5	
3	10	
4	7	
5	7	
6	6	
7	9	
8	8	
QWC	2	
TOTAL	60	

This question paper consists of 16 printed pages.

Data

speed of light in free space,	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$
permittivity of free space,	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$
elementary charge,	$e = 1.60 \times 10^{-19} \text{ C}$
the Planck constant,	$h = 6.63 \times 10^{-34} \text{ J s}$
unified atomic mass constant,	$u = 1.66 \times 10^{-27} \text{ kg}$
rest mass of electron,	$m_e = 9.11 \times 10^{-31} \text{ kg}$
rest mass of proton,	$m_p = 1.67 \times 10^{-27} \text{ kg}$
molar gas constant,	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
the Avogadro constant,	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
gravitational constant,	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
acceleration of free fall,	$g = 9.81 \text{ m s}^{-2}$

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, $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \dots$

capacitors in parallel, $C = C_1 + C_2 + \dots$

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, $x = x_0 e^{-\lambda t}$

$$t_{1/2} = \frac{0.693}{\lambda}$$

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 questions.

- 1 (a) Fig. 1.1 shows the electromagnetic spectrum.

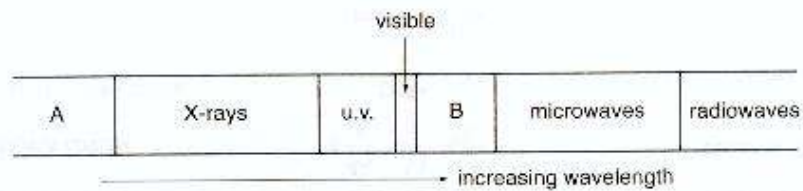


Fig. 1.1

In the spaces of Fig. 1.2, identify the principal radiations A and B and suggest a typical value for their wavelength λ .

	principal radiation	λ/m
A		
B		

Fig. 1.2

[4]

- (b) State **two** features common to all types of radiation in the electromagnetic spectrum.

.....

.....

.....

..... [2]

[Total: 6]

- 2 (a) (i) State what is meant by *electric current*.

[1]

- (ii) A mobile phone is connected to a charger for 600s. The charger delivers a constant current 350 mA during this interval. Calculate the total charge supplied to the mobile phone.

charge = C [3]

- (b) Fig. 2.1 shows a resistor connected to a d.c. supply.

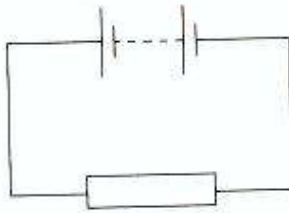


Fig. 2.1

- On Fig. 2.1, indicate the direction of the electron flow in the circuit.

[1]

[Total: 5]

[Turn over

- 3 (a) The electrical resistance of a conducting wire depends on a number of factors. Complete the sentence below.

The resistance of a wire is directly proportional to its and inversely proportional to its It also depends on the type of used for the wire and on its [4]

- (b) Fig. 3.1 shows the dimensions of a pencil lead.

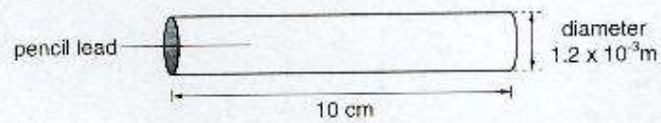


Fig. 3.1

The lead is made of a material of resistivity $8.0 \times 10^{-6} \Omega \text{ m}$.

- (i) Calculate the resistance of the pencil lead.

resistance = Ω [4]

- (ii) A student connects the ends of the pencil lead to a d.c. supply. The potential difference across the ends is 12 V. Calculate the current in the pencil lead.

current = A [2]

[Total: 10]

- 4 Fig. 4.1 shows an electrical circuit for a small dryer used to blow warm air.

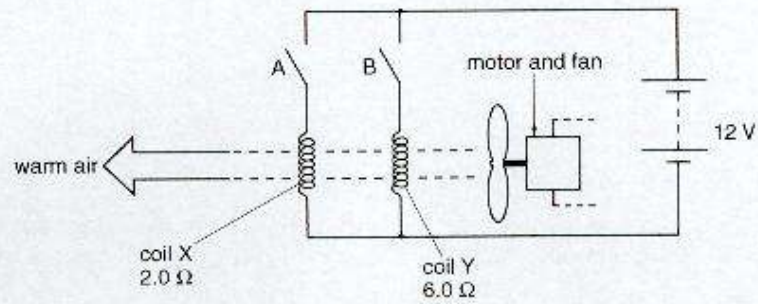


Fig. 4.1

It may be assumed that coils X and Y have constant resistances of $2.0\ \Omega$ and $6.0\ \Omega$ respectively. The 12 V supply has negligible internal resistance.

- (a) Calculate the total resistance of the circuit with both switches closed.

resistance = Ω [3]

- (b) Calculate the power dissipated by the coil X with only switch A closed.

power = unit = [4]

[Total: 7]

- 5 (a) (i) Place a tick (\checkmark) in the box for an alternative unit for the volt.

JC

Js^{-1}

JC^{-1}

[1]

- (ii) The statement below is that for Kirchhoff's second law.

The algebraic sum of the e.m.f.s around a loop in a circuit is equal to the algebraic sum of the p.d.s around the loop.

Fig. 5.1 shows an electrical circuit.

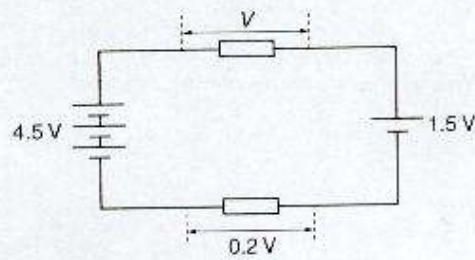


Fig. 5.1

Use this law to determine the p.d. V .

$V = \dots\dots\dots \text{V}$ [2]

(b) Fig. 5.2 shows a potential divider circuit.

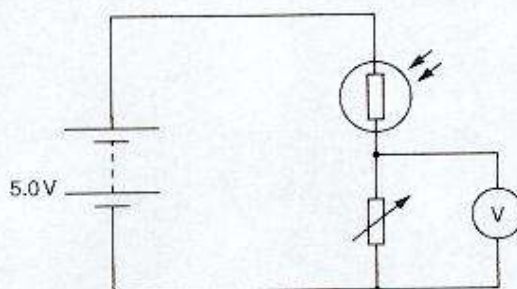


Fig. 5.2

The voltmeter has a very large resistance and the battery may be assumed to have negligible internal resistance.

For a particular intensity of light, the resistance of the LDR is $2.4\text{ k}\Omega$. The variable resistor is set on its maximum resistance of $4.7\text{ k}\Omega$.

(i) Calculate the reading on the voltmeter.

voltmeter reading = V [3]

(ii) State how the answer to (b)(i) changes when the light intensity is decreased.

.....

 [1]

[Total: 7]

- 6 (a) Fig. 6.1 shows a cell connected to two terminals on a plastic box. When the switch S is closed, a magnetic field pattern shown is detected around the box.

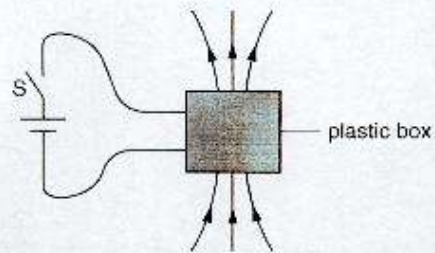


Fig. 6.1

State what is inside the box that produces this field pattern.

..... [1]

- (b) Fig. 6.2 shows a wire placed at right angles to a magnetic field. The wire rests on two metal supports.

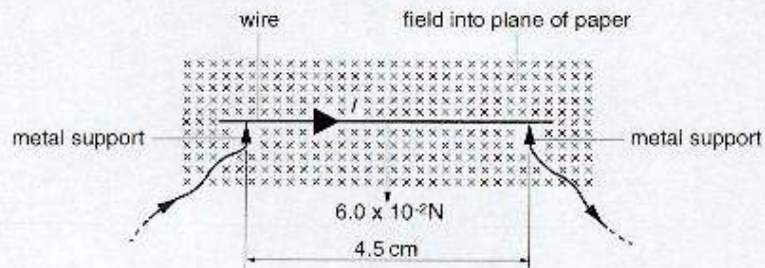


Fig. 6.2

The length of the wire between the supports is 4.5 cm, and this length has weight $6.0 \times 10^{-2} \text{ N}$. The current in the wire is slowly increased from zero until the wire starts to lift off the metal supports.

Calculate the current I in the wire. The magnetic flux density is 0.36 T.

$I = \dots\dots\dots$ A [3]

- (c) Suggest why the overhead cables for the National Grid cannot be freely supported by the Earth's magnetic field.

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

[Total: 6]

7 (a) State the de Broglie equation. Define any symbols used.

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

(b) Outline the evidence for believing that electrons behave like waves.

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

(c) High speed electrons may be used to probe inside atomic nuclei.

(i) Calculate the de Broglie wavelength for a single electron which has a momentum (mv) of $2.3 \times 10^{-19} \text{ kg m s}^{-1}$.

wavelength = m [2]

(ii) Explain how your answer to (c)(i) would change for

1. a neutron of the same momentum

.....
.....

2. an electron of half the momentum.

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

[Total: 9]

8 In this question, 2 marks will be available for the quality of written communication.

According to wave-particle duality, electromagnetic radiation can either behave as a *wave* or as a *photon* (which exhibits *particle-like* behaviour).

Describe the behaviour which supports this dual nature of electromagnetic radiation.

Wave behaviour:

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

