RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary GCE

PHYSICS A 2822

Electrons and Photons

Monday **18 JUNE 2001** Morning 1 hour 30 minutes

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

Candidate Name	Centre Number	Candidate Number

TIME 1 hour 30 minutes

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	12	
2	8	
3	12	
4	10	
5	8	
6	10	
7	11	
8	8	
9	7	
QWC	4	
TOTAL	90	

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

SB SJF1601/PW S02314/6

[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** questions.

1 **(a)** **(i)** State the unit of electric charge.

.... [1]

(ii) Name an instrument that may be used to measure the potential difference (p.d.) across an electrical component.

.... [1]

(b) A 36 W lamp draws a constant current of 3.0 A over a period of 600 s from a battery. Calculate

(i) the p.d. across the lamp,

p.d. = ... V [3]

(ii) the energy transferred by the lamp,

energy = ... J [2]

(iii) the charge passing through the lamp,

charge = ... C [3]

(iv) the number of electrons passing through the lamp.

number = ... [2]

For Examiner's Use

2 **(a)** Define electrical resistance.

.... [2]

(b) **(i)** State Ohm's law.

....

....

.... [2]

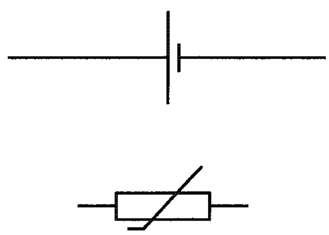
(ii) Place a tick (✓) in the box for any component that obeys Ohm's law and place a cross (✗) for any that does not.

metallic resistor ☐

diode ☐

thermistor ☐ [2]

(c) A cell is connected across a thermistor. Using appropriate circuit symbols, complete Fig. 2.1 to show how the current in the thermistor and the p.d. across it may be measured.



[2]

Fig. 2.1

For Examiner's Use

3 Fig. 3.1 shows the variation with the potential difference V of the resistance R of a tungsten filament lamp.

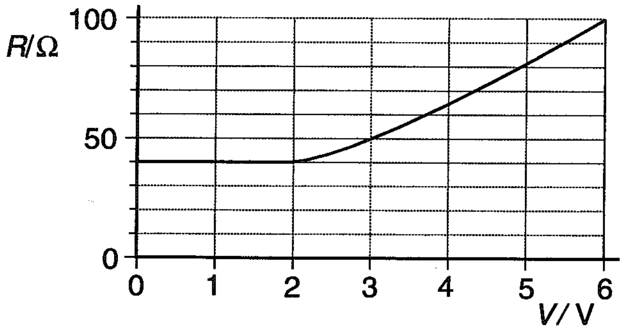


Fig. 3.1

(a) Use Fig. 3.1 to calculate, for a p.d of 3.0 V,

(i) the current in the lamp,

current = ... A [3]

(ii) the power dissipated by the lamp.

power = ... W [2]

For Examiner's Use

(b) (i) Suggest why the resistance of the lamp does not change significantly over the range 0 to 2.0 V.

.... [1]

(ii) The tungsten filament lamp is at room temperature when the p.d. across it is zero.

1. State the resistance of the lamp at room temperature.

resistance = ... Ω [1]

2. The resistivity of tungsten at room temperature is $5.4 \times 10^{-8}\,\Omega\,m$. The filament has a radius of $1.0 \times 10^{-5}\,m$. Calculate the cross-sectional area A and length l of the filament.

A = ... m^2

l = ... m

Comment on the length of the filament.

....

.... [5]

For Examiner's Use

4 (a) (i) Use energy considerations to distinguish between potential difference (p.d.) and electromotive force (e.m.f.)

p.d.: ....

....

....

e.m.f.: ....

....

.... [2]

(ii) Place a tick (✓) in the appropriate box opposite the correct answer for an alternative unit for e.m.f. or p.d.

$J\,s^{-1}$ ☐

$J\,A^{-1}$ ☐

$J\,C^{-1}$ ☐ [1]

(b) Kirchhoff's second law is based on the conservation of a quantity. State the law and the quantity that is conserved.

....

....

.... [2]

(c) A cell has an e.m.f of 1.28 V and an internal resistance *r*. Fig. 4.1 illustrates an external resistor of resistance 1.10 Ω placed across the terminals of this cell.

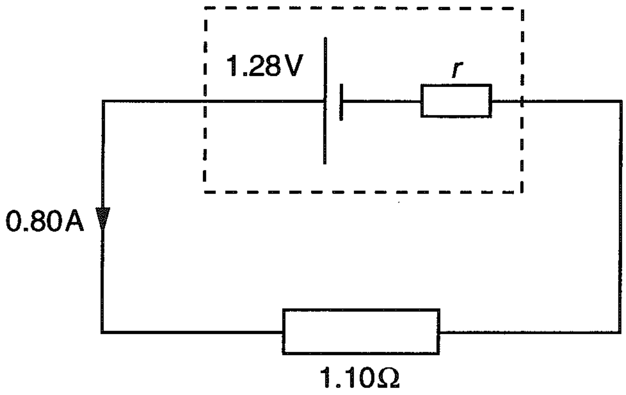


Fig. 4.1

The cell provides a current of 0.80 A. Calculate

(i) the total resistance of the circuit,

resistance = ... Ω [2]

(ii) the internal resistance *r*,

r = ... Ω [2]

(iii) the p.d. across the terminals of the cell.

p.d = ... V [1]

For Examiner's Use

5 A potential divider circuit based on a light-dependent resistor (LDR) is shown in Fig. 5.1. The supply has negligible internal resistance.

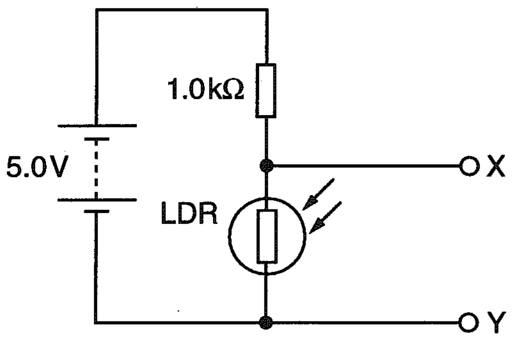


Fig. 5.1

(a) The light intensity falling upon the LDR is increased. State

(i) how the resistance of the LDR changes,

....

.... [1]

(ii) how the p.d. across the LDR changes.

....

.... [1]

(b) At a particular light intensity, the resistance of the LDR is 420 Ω.

(i) Calculate the p.d across the LDR.

p.d. = ... V [3]

(ii) An electronic circuit of resistance 50 Ω is connected between the terminals X and Y.

1. Show that the total resistance of the parallel combination of this electronic circuit and the LDR is about 45 Ω.

[1]

2. Calculate the p.d. across this electronic circuit.

p.d. = ... V [2]

6 (a) Fig. 6.1 shows a plan view of a long wire carrying current into the plane of the paper.

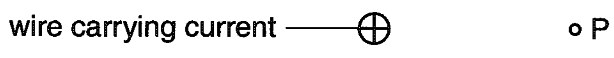


Fig. 6.1

(i) Complete Fig. 6.1 to show the magnetic field pattern for the current-carrying wire. [3]

(ii) Another wire, also carrying a current into the plane of the paper, is placed parallel to the original wire at point P.

1. Name the rule that may be used to find the direction of the force experienced by a current-carrying conductor placed in a magnetic field.

.... [1]

2. State the direction of the force experienced by the wire placed at point P.

.... [1]

(b) (i) Define magnetic flux density.

....

....

.... [3]

(ii) An overhead electric cable lies horizontally in the Earth's magnetic field. It carries a current of 3.0 A. The component of the Earth's field at right angles to the cable has a magnetic flux density 2.5×10^{-5} T. Calculate the magnitude of the force experienced by a 2.0 m length of the cable.

force = ... N [2]

For Examiner's Use

7 **(a)** Einstein's photoelectric equation may be written as

$$hf = \phi + \tfrac{1}{2}mv_{max}^{2}$$

Identify the terms

hf ....

ϕ ....

$\tfrac{1}{2}mv_{max}^{2}$ .... [3]

(b) The surface of sodium metal is exposed to electromagnetic radiation of wavelength 6.5×10^{-7} m. This wavelength is the maximum for which photoelectrons are released.

(i) Calculate the threshold frequency.

frequency = ... unit: .... [3]

(ii) Show that the work function energy of the metal is 1.9 eV.

[3]

(c) For a particular wavelength of incident light, sodium releases photoelectrons. State how the rate of release of photoelectrons changes when the intensity of light is doubled. Explain your answer.

....

....

....

.... [2]

For Examiner's Use

8 Electrons travelling through matter may be diffracted. Describe and interpret the evidence provided by this observation about the nature of electrons. Explain why a person of mass 70 kg running at 5 m s^{-1} fails to show diffraction effects when passing through an open door of width 1.0 m.

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

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.... [8]

For Examiner's Use

9 State one main feature of electromagnetic waves. Name three principal regions of the electromagnetic spectrum and suggest a practical application of each.

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

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Quality of written communication [4]

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