OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced Subsidiary GCE

PHYSICS A 2822

Electrons and Photons

Thursday **17 JANUARY 2002** Afternoon 1 hour 30 minutes

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

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	11	
2	10	
3	6	
4	7	
5	14	
6	12	
7	12	
8	6	
9	8	
QWC	4	
TOTAL	90	

This question paper consists of 18 printed pages and 2 blank pages.

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, $p = \frac{1}{3}\dfrac{Nm}{V}<c^2>$

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, $= 10 \lg \left(\dfrac{I}{I_0}\right)$

For Examiner Use

Answer **all** questions.

1 **(a)** Electric current is the flow of charged particles. Name the charged particle responsible for electric current in

(i) a metal,

.... [1]

(ii) an electrolyte (conducting solution).

.... [1]

(b) Name the two quantities required to calculate the electrical resistance of a component in an electric circuit.

1. ....

2. .... [2]

(c) A digital watch uses a 1.3 V cell. It delivers a charge of 650 C at a constant rate during its lifetime of 1.6×10^7 s. Calculate

(i) the current delivered by the cell,

current = ... A [3]

(ii) the resistance of the electrical circuit in the watch,

resistance = ... Ω [2]

(iii) the total number of electrons passing through the cell during its lifetime of 1.6×10^7 s.

number = …………………… [2]

[Total: 11]

2 **(a)** On Fig. 2.1, sketch the *I*/*V* characteristics of

- a metallic conductor at constant temperature
- a filament lamp
- a semiconducting diode.

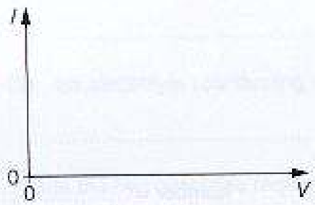

Fig. 2.1(a): Metallic conductor

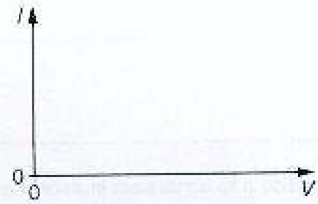

Fig. 2.1(b): Filament lamp

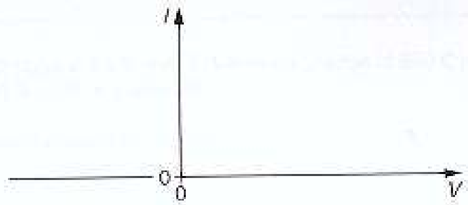

Fig. 2.1(c): Semiconducting diode [3]

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

Explain, in terms of resistance, the shape of the *I*/*V* graphs in

Fig. 2.1(a) ....

....

....

....

....

....

Fig. 2.1 (b) ....

....

....

....

....

....

Fig. 2.1 (c) ....

....

....

....

....

....

[7]

[Total: 10]

For Examiner's Use

3 (a) Fig. 3.1 shows the circuit symbol for a particular component.

Fig. 3.1

Name the component and state how its resistance changes as the temperature of the component is increased.

....

....

.... [2]

(b) Fig. 3.2 shows a potential-divider circuit. The battery has negligible internal resistance and the voltmeter has very high resistance.

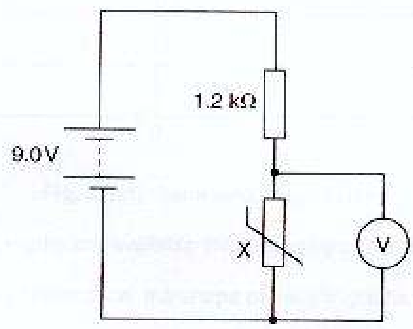

Fig. 3.2

(i) At a particular temperature, the resistance of component X is 4.2 kΩ. Calculate the voltmeter reading.

voltmeter reading = ... V [3]

(ii) State how your answer to **(b)(i)** changes when the temperature of the component X is **increased.**

....

.... [1]

[Total: 6]

4 (a) Define electrical *resistivity*.

....

.... [2]

(b) Fig. 4.1 shows a conducting paint in a cylindrical glass vessel.

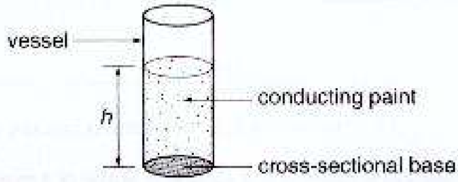

Fig. 4.1

The volume of the paint is $1.2 \times 10^{-5}\,m^3$ and the vessel has base of area $3.0 \times 10^{-4}\,m^2$.

(i) Show that the height h of the paint column is 4.0 cm.

[1]

For Examiner's Use

(ii) Calculate the resistance of the paint column of height 4.0 cm. The resistivity of the paint is $6.9 \times 10^{-2}\,\Omega\,m$.

resistance = ... Ω [2]

(c) State and explain how your answer to **(b)(ii)** changes when the same volume of paint is poured into a cylindrical glass vessel having a base of double the cross-sectional area.

....

....

....

....

.... [2]

[Total: 7]

5 (a) A student solders two resistors together as shown in Fig. 5.1.

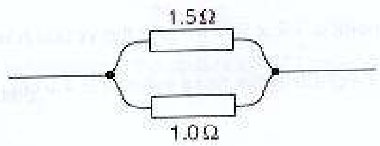

Fig. 5.1

(i) State whether the two resistors are connected in a series or in a parallel combination.

.... [1]

(ii) Show that the total resistance of the combination of resistors is 0.6 Ω.

[2]

(b) Fig. 5.2 shows the soldered resistors from **(a)** connected across the terminals of a cell.

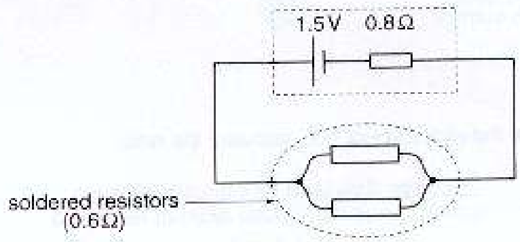

Fig. 5.2

The cell has internal resistance 0.8 Ω and e.m.f. 1.5 V.

(i) Define *e.m.f.* in terms of energy transformed and electric charge.

....

....[2]

(ii) Suggest why a cell has internal resistance.

.... [1]

(iii) Calculate the total resistance *R* of the circuit in Fig. 5.2.

R = ... Ω [2]

For Examiner's Use

(iv) Hence calculate the current I in the circuit.

I = ... A [2]

(v) 1. Write an equation for the power dissipated by a current-carrying resistor.

2. For the circuit in Fig. 5.2, calculate the ratio:

$$\frac{\text{power dissipated by internal resistance}}{\text{power dissipated by total external resistance}}.$$

ratio = ... [4]

[Total: 14]

6 (a) Explain why a compass needle placed very close to a wire may deflect when the current in the wire is switched on.

....

.... [1]

(b) Fig. 6.1 shows a cross section of a current-carrying conductor.

Fig. 6.1

On Fig. 6.1, draw the magnetic field pattern. [3]

(c) The magnetic flux density B at a point is defined in terms of the equation

$$B = \frac{F}{Il}$$

Identify the symbols in this equation.

F : ....

I : ....

l : .... [3]

[Turn over

For Examiner's Use

(d) Fig. 6.2 shows a current-carrying metal rod that can roll freely on two parallel metal rails. The rod is at right angles to the magnetic field lines.

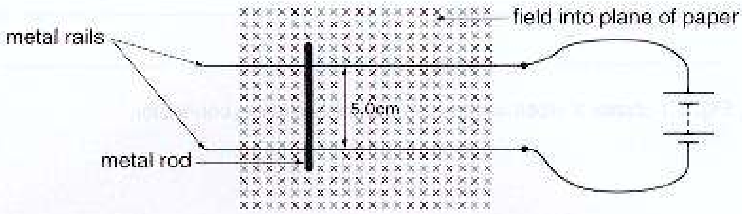

Fig. 6.2

(i) Determine the direction of the force experienced by the rod. Explain how you determined this direction.

....

.... [2]

(ii) The current in the metal rod is 2.0 A and it has a length 5.0 cm between the two metal rails. Calculate the force experienced by the metal rod given the magnetic flux density is 1.8×10^{-3} T.

force = ... unit = ... [3]

[Total: 12]

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

....

....

....

.... [2]

(b) A radioactive material emits photons, each having an energy of 1.0 MeV.

(i) Explain what is meant by a *photon*.

....

.... [1]

(ii) Show that the energy of each photon is 1.6×10^{-13} J.

[2]

(iii) Calculate the frequency of the electromagnetic radiation emitted by the radioactive material.

frequency = ... unit = ... [4]

[Turn over

(iv) Calculate the wavelength λ of the radiation.

λ = ... m [2]

(v) State the principal type of electromagnetic radiation emitted by the material.

.... [1]

[Total: 12]

8 Fig. 8.1 shows an isolated zinc plate exposed to weak ultra violet (u.v.) light.

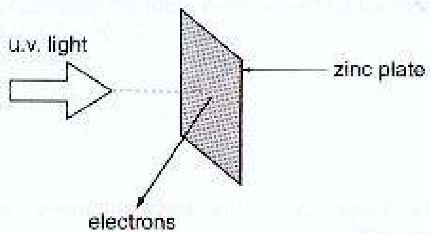

Fig. 8.1

The u.v. light causes electrons to be emitted from the surface of the plate.

(a) Name this phenomenon.

.... [1]

(b) Initially, the plate is neutral in charge. State and explain the effect on the charge of the plate as the zinc plate is exposed to the u.v. light.

....

....

....

.... [2]

(c) State and explain the effect on the rate of emission of electrons when the intensity of the u.v. light is **increased**.

....

....

....

.... [2]

(d) In a databook, the *work function energy* of zinc is quoted as 4.24 eV. Explain what is meant by work function energy (no calculations are necessary).

....

.... [1]

[Total: 6]

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

According to wave-particle duality, an electron can either behave as a *wave* or as a *particle*. Describe the behaviour which supports this dual nature of electrons.

Wave behaviour: ....

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For Examiner's Use

Particle behaviour: ....

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[Total: 8]
[QWC: 4]