OCR
RECOGNISING ACHIEVEMENT

**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.**



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

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).

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**(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 $1.6 \times 10^7$ 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 $1.6 \times 10^7$ s.

number = ......................... [2]

[Total: 11]

For Examiner's Use

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

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

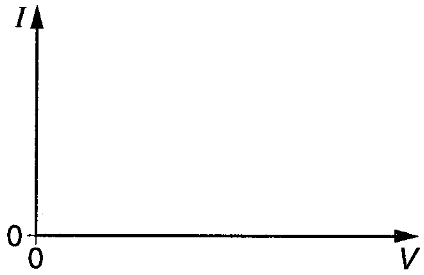


**Fig. 2.1(a)**: Metallic conductor

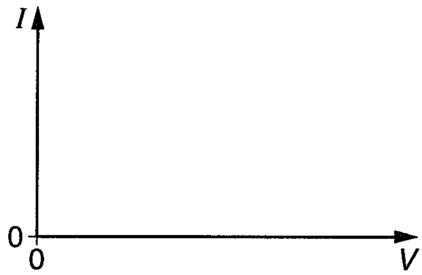


**Fig. 2.1(b)**: Filament lamp

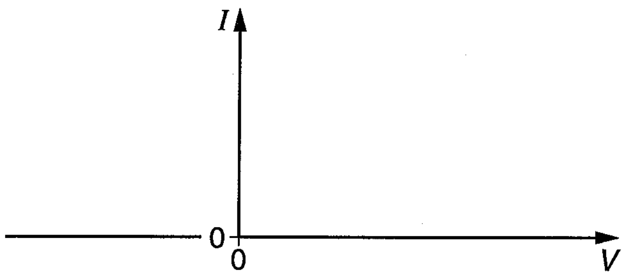


**Fig. 2.1(c)**: Semiconducting diode [3]

**(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) ..........................................................................................................

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For Examiner's Use

Fig. 2.1 (b) ..........................................................................................................

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Fig. 2.1 (c) ..........................................................................................................

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[7]

[Total: 10]

For Examiner's Use

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

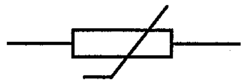

**Fig. 3.1**

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

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

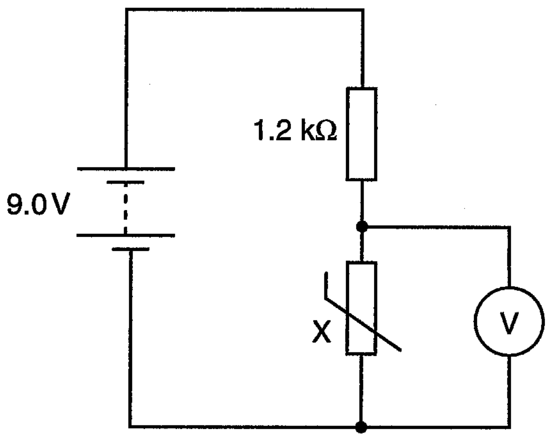


**Fig. 3.2**

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

voltmeter reading = ........................ V [3]

For Examiner's Use

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

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[Total: 6]

4 **(a)** Define electrical *resistivity*.

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

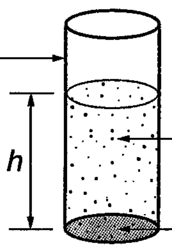


**Fig. 4.1**

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]



**[Turn over**

(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.

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[Total: 7]

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

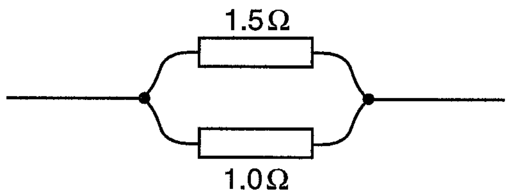


**Fig. 5.1**

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

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

For Examiner's Use

**(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.

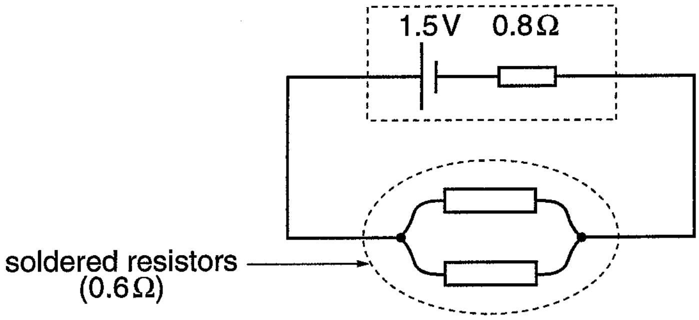


**Fig. 5.2**

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.

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.......................................................................................................................................[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]



**[Turn over**

**(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]

For Examiner's Use

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

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

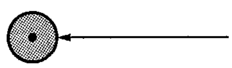


**Fig. 6.1**

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]

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.

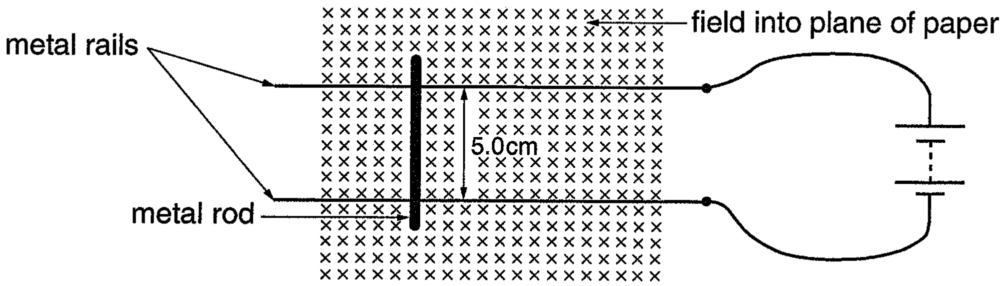


**Fig. 6.2**

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

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**(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 $1.8 \times 10^{-3}$ T.

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

[Total: 12]

For Examiner's Use

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

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

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

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

[2]

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

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

For Examiner's Use

**(iv)** Calculate the wavelength $\lambda$ of the radiation.

$\lambda$ = ........................ m [2]

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

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[Total: 12]

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

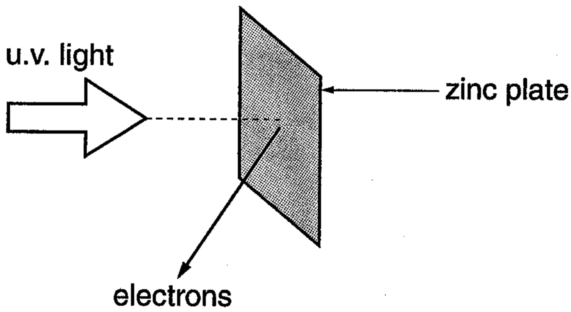


**Fig. 8.1**

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.

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

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**(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).

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[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]

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