OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced GCE

PHYSICS A **2825/03**

Materials

Thursday **26 JANUARY 2006** Morning 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 provided 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 may use an electronic calculator.
- You are advised to show all the steps in any calculations.
- The first six questions concern Materials. The last question concerns general physics.

FOR EXAMINER'S USE		
Qu.	**Max.**	**Mark**
1	9	
2	9	
3	12	
4	9	
5	17	
6	14	
7	20	
TOTAL	90	

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

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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,	$p = \frac{1}{3}\frac{Nm}{V}<c^2>$
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,	$= 10 \lg\left(\frac{I}{I_0}\right)$

[Turn over

For Examiner's Use

Answer **all** the questions.

1 **(a)** A close-packed crystal structure incorporates many planes of atoms. Fig. 1.1 represents two such planes.

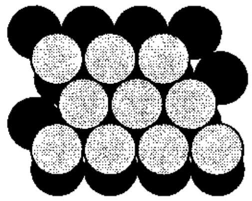

Fig. 1.1

For an atom inside the crystal, state

(i) the number of nearest neighbour atoms in its own plane ....

(ii) the total number of nearest neighbour atoms. .... [2]

(b) The molar mass of gold is 0.197 kg mol^{-1}. The density of gold is 1.93×10^4 kg m^{-3}.

Show that

(i) the mass of a gold atom is about 3.3×10^{-25} kg

[2]

(ii) the number of atoms in 1.0 m^3 of gold is about 5.9×10^{28}.

[1]

(c) Gold has a close-packed crystal structure in which the volume of the atoms themselves is 74 % of the volume of the metal. Calculate

(i) the volume of a gold atom

volume = ... m^3 [2]

(ii) the radius of a gold atom.

radius = ... m [2]

[Total: 9]

For Examiner's Use

2 **(a)** Describe the microstructure of a polycrystalline material.

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....[3]

(b) Diamond and graphite are different crystalline forms of carbon. Suggest in terms of their crystal structures why

(i) graphite is less dense than diamond

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....[1]

(ii) graphite has a lower melting-point than diamond

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....[1]

(iii) graphite is used as a lubricant

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....[2]

(iv) diamond is used as an abrasive.

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....[2]

[Total: 9]

For Examiner's Use

3 At its normal working temperature, the tungsten filament of a light bulb has a resistance of 71 Ω. The length and radius of the filament are 0.61 m and 5.9×10^{-5} m respectively. The bulb is connected to a voltage source using thick copper wire.

(a) Calculate the electrical conductivity of tungsten at the working temperature, stating the unit of the answer.

conductivity = ...unit .... [4]

(b) State an expression for the drift velocity of free electrons in a metal wire. Identify the symbols.

[2]

(c) The circuit incorporates a fuse consisting of a thin wire made of a tin-lead alloy. Suggest

(i) **two** reasons why the drift velocity of free electrons in the fuse is greater than that in the copper connecting wire

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....[2]

(ii) in terms of free electrons and atoms, why the fuse may be at a much higher temperature than the copper wire.

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....[4]

[Total: 12]

For Examiner's Use

4 An iron bar is placed inside a solenoid wound with many turns of copper wire.
B is the flux density of the magnetic field within the iron. I is the current in the solenoid.
I is increased from zero to a value which produces magnetic saturation in the iron.
The iron bar is **initially unmagnetised.**

Fig. 4.1

(a) On the axes of Fig. 4.1, sketch a graph to show the variation of B with I. [2]

(b) Describe in terms of domains the changes which take place in the iron as I is increased from zero to its maximum value. Include explanations for the changing gradient of the graph.

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....[7]

[Total: 9]

5 **(a)** The energy-band gap of silicon is 1.1 eV. Sketch a labelled energy-band diagram to illustrate this information.

[3]

(b) A light-dependent resistor (LDR) has a resistance in daylight of less than 1 kΩ, and in the dark about 1 MΩ. Explain in terms of band theory why the resistance changes with light intensity.

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....[4]

(c) An experiment is to be carried out to investigate how the resistance of the LDR in **(b)** varies with the intensity of light incident upon it. An ohmmeter is **not** available.

(i) Sketch a suitable electric circuit.

[2]

For Examiner's Use

(ii) *Describe the procedure to be carried out, including the following aspects*

- suggestions about the control and measurement of the light intensity
- suitable ranges for the meters used in the circuit
- the readings and calculations to be carried out.

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....[8]

[Total: 17]

6 A light-emitting diode (LED) emits infra-red radiation with a range of wavelengths. The mean wavelength of the radiation is 1.5 μm. This radiation is transmitted through a 1.0 km length of optic fibre of refractive index 1.47 for the mean wavelength.

(a) Calculate, for radiation of the mean wavelength

(i) the speed through the fibre

speed = ... $m\,s^{-1}$ [2]

(ii) the minimum time for it to travel through the fibre.

time = ... s [2]

(b) The speed through the fibre of the maximum wavelength in the emission is 1.001 times that of the mean wavelength. For radiation travelling along the axis of the fibre, calculate the difference in transit times for the mean and maximum wavelengths.

time difference = ... s [3]

(c) **(i)** Explain how the time difference calculated in **(b)** affects the transmission of infra-red radiation from the LED when it is pulsed.

....

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....[2]

(ii) The problem identified in **(i)** can be overcome using an alternative source of infra-red radiation. State a suitable source and explain your choice.

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....[2]

For Examiner's Use

(d) For optic fibre transmission

- infra-red wavelengths between 1.35 µm and 1.45 µm are unsuitable
- a wavelength of 1.5 µm is regarded as ideal
- wavelengths greater than 1.5 µm cannot be used.

Explain these observations.

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....[3]

[Total: 14]

For Examiner's Use

7 This question is about the design and use of Christmas tree lights.

Design of bulbs

An engineer intends to design light bulbs for use in a set of Christmas tree lights to be powered by a 240 V mains supply.

Each bulb, when operating normally, will use 0.50 W and will have a filament 6.0 mm long, made of tungsten.

resistivity of tungsten at normal working temperature = $1.1 \times 10^{-6}\ \Omega\,\text{m}$

(a) State **one** advantage of connecting these bulbs in parallel, rather than in series.

....

....

.... [1]

(b) Suppose the bulbs are connected in **parallel**. Calculate

(i) the current through each bulb

current = ... A [2]

(ii) the resistance of each bulb filament

resistance = ... Ω [2]

(iii) the radius of each bulb filament.

radius = ... m [3]

(iv) Hence suggest why these bulbs are impractical.

....

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.... [1]

For Examiner's Use

Use of bulbs

A householder has two sets of Christmas tree lights.

Set A consists of 24 bulbs, each of resistance 200 Ω, connected in series.

Set B consists of 48 bulbs, each of resistance 50 Ω, connected in series.

All bulbs fail when their power dissipation reaches 0.75 W.

(c) **Set A** is connected to a 240 V mains supply. Fig. 7.1 shows the wiring of four of these bulbs.

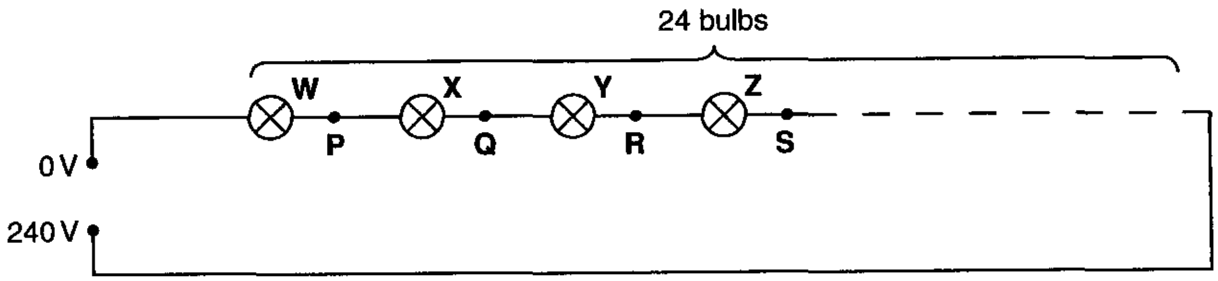

Fig. 7.1

During use, the filament of bulb **Y** fails and its resistance becomes infinite. In order to find which bulb has failed, the householder connects one terminal of a voltmeter to the 0 V terminal of the mains and notes the voltmeter reading when its other terminal is connected successively to points **P**, **Q**, **R** and **S**.
Enter in the table the voltmeter reading for each connection.
Explain your answer.

connection	reading / V
P	
Q	
R	
S	

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.... [4]

(d) **(i)** The householder has no correct replacement bulbs for **Set A**. Each time a **Set A** bulb fails, it is replaced by a **Set B** bulb.
Explain why this is unsatisfactory and what will happen as more bulbs are replaced in this way.

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.... [3]

(ii) Calculate how many bulbs from **Set A** can be replaced by **Set B** bulbs before the system fails altogether.
Assume that the resistance of each bulb is independent of the current.

number = ... [4]

[Total: 20]

END OF QUESTION PAPER

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