OCR RECOGNISING ACHIEVEMENT

ADVANCED GCE **2825/03**

PHYSICS A

Materials

TUESDAY 17 JUNE 2008

Afternoon

Time: 1 hour 30 minutes

Candidates answer on the question paper

Additional materials (enclosed): None

Additional materials (required):
Electronic calculator

CUP/T41114

Candidate Forename		Candidate Surname	
Centre Number		Candidate Number	

INSTRUCTIONS TO CANDIDATES

- Write your name in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided.

INFORMATION FOR CANDIDATES

- The number of marks for each question is given in brackets [ ] at the end of each question or part question.
- The total number of marks for this question paper is **90**.
- 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	**12**	
2	**16**	
3	**11**	
4	**12**	
5	**10**	
6	**9**	
7	**20**	
TOTAL	**90**	

This document consists of **16** printed 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, $s = ut + \tfrac{1}{2}at^2$

$v^2 = u^2 + 2as$

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

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

Answer **all** the questions.

1 **(a)** State the molecular structure of the following:

a diamond gem-stone ....

a metallic-glass transformer core. .... [2]

(b) State

(i) a type of point defect .... [1]

(ii) what is meant by the terms

close-packing

....

.... [1]

plastic deformation.

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.... [1]

(c) Fig. 1.1 represents a part of a plane of atoms in a crystal structure which contains a defect. The arrows show forces *F* sufficient to cause plastic deformation of the structure.

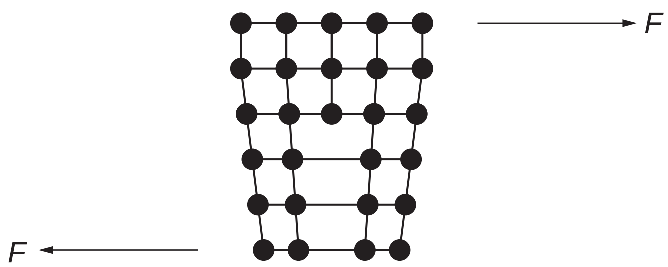

Fig. 1.1

(i) State the type of defect present in the crystal structure in Fig. 1.1.

.... [1]

(ii) Sketch in the space next to Fig. 1.1 an arrangement of the atoms which occurs as the plastic deformation takes place. [2]

(iii) Explain why the force required to cause the plastic deformation would be much greater if the structure did not contain this defect.

....

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....[2]

(d) State

(i) an example of a useful metal object produced by plastic deformation

....

(ii) the process involved in producing the required shape of the object.

....

....[2]

[Total: 12]

2 **(a)** A small 3.0 W torch bulb emits 10% of its power as light. It can be assumed to be a point source emitting light equally in all directions. The light falls on a light-dependent resistor (LDR) of face-area $8.0 \times 10^{-5}\,m^2$.

(i) Show that the power per unit area, the intensity, of light incident on a spherical surface 0.10 m from the bulb is about $2.4\,W\,m^{-2}$.

[2]

(ii) Calculate the power of the light incident on the face of the LDR when placed 0.10 m from the bulb.

power = ... W [1]

(b) The bulb and the LDR in **(a)** are used to investigate how the resistance of an LDR varies with the power of light incident upon its face. The resistance is to be found using an ammeter and a voltmeter.

(i) Sketch the circuit containing the LDR.

[2]

(ii) Describe the procedure to be followed to obtain the required data. State how the data is used to determine the relationship.

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(iii) State and explain, using band theory, the change in resistance of the LDR due to an increase in light intensity.

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.... [3]

[Total: 16]

3 Fig. 3.1 shows a length of metal foil of width d and thickness t carrying a current I in a magnetic field of flux density B. The directions of the conventional current and the magnetic field are shown by arrows.

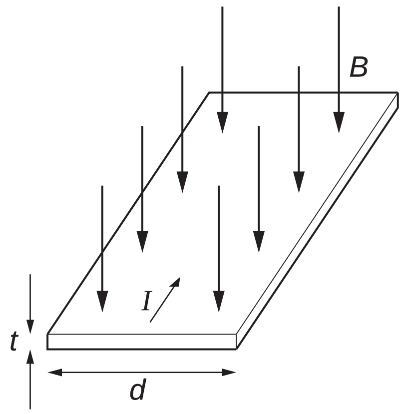

Fig. 3.1

(a) The current in the foil is due to the movement of free electrons. Add + and – signs to Fig. 3.1 to show the charge separation in the foil caused by the Hall effect. Explain the separation.

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.... [3]

(b) In Fig. 3.1, d = 6.0 mm and t = 0.25 mm. When I = 0.35 A, the Hall voltage is measured to be 0.080 mV. The free-electron concentration n in the metal is $1.1 \times 10^{25}\,\text{m}^{-3}$.

(i) Show that the drift velocity of free electrons in the foil is about $0.13\,\text{m}\,\text{s}^{-1}$.

[2]

(ii) Calculate the flux density B.

flux density = ... T [2]

(c) In an experiment to measure the flux density of a magnetic field, a slice of semiconductor with the same dimensions as the metal foil is used. State and explain the practical advantage gained by this.

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.... [4]

[Total: 11]

4 **(a)** Explain in terms of magnetic dipoles

(i) what is meant by a *magnetic domain*

....

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.... [2]

(ii) the behaviour of a magnet at the *Curie temperature*.

....

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.... [2]

(b) A transformer is required to be as small as possible, and to operate with maximum possible efficiency in an environment where the temperature may be very high. State and explain the necessary properties for the core of this transformer.

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.... [8]

[Total: 12]

5 **(a)** An infra-red light-emitting diode (LED) emits infra-red radiation of wavelength 950 nm. The LED is connected to a variable d.c. supply. The voltage of the supply is gradually increased from zero until radiation from the LED is just detected.

(i) Show that the energy of an infra-red photon of wavelength 950 nm is about 2×10^{-19} J.

[2]

(ii) Calculate the voltage output of the supply when radiation is just detected.

voltage = ... V [2]

(b) A remote control device for a television set emits infra-red radiation of wavelength 950 nm. The infra-red beam can pass through a sheet of glass to operate the TV, but not through a sheet of metal. Explain this in terms of band theory.

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.... [5]

(c) A beam of gamma-ray photons passes through a sheet of metal. Some of the gamma-ray photons lose part of their energy to electrons in the metal and are re-emitted. Suggest the effect of this loss of energy on these gamma photons.

.... [1]

[Total: 10]

6 **(a)** The intensity of a light beam is reduced as it passes through glass.

(i) State **two** ways in which the light can be absorbed as it passes through glass.

1. ....

2. ....[2]

(ii) State another process by which the intensity is reduced as it passes through glass.

.... [1]

(b) For light crossing a boundary into a material of higher refractive index, state what happens to the speed of the light.

.... [1]

(c) Fig. 6.1 shows the shape of a pulse of infra-red radiation produced by an LED. The pulse passes into a length of optic fibre. The pulse emerging from the other end of the fibre shows some distortion.

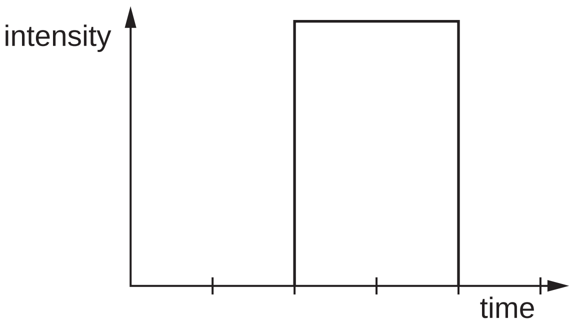

Fig. 6.1

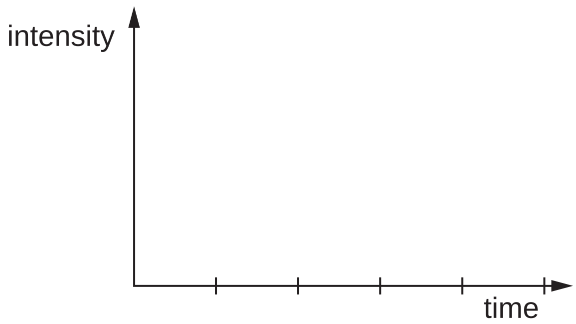

Fig. 6.2

(i) Sketch the distorted pulse on the axes of Fig. 6.2. [1]

(ii) State and explain **two** possible causes of the distortion.

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.... [4]

[Total: 9]

7 A photo-voltaic cell is an electrical component which can generate a current proportional to the intensity of light incident on its light-sensitive surface. One type of solar panel uses a number of photo-voltaic cells in series to provide a sufficient voltage to power a practical device.

(a) The measured intensity of the solar radiation received on the upper atmosphere of the Earth is 1400 W m^{-2}. The mean radius of the Earth's orbit round the Sun is 1.5×10^{11} m.

(i) Show that

1 the surface area of a sphere of radius 1.5×10^{11} m is about 3×10^{23} m^2

[1]

2 the Sun emits radiation with a total power of about 4×10^{26} W into the surrounding space.

[1]

(ii) Calculate the rate of conversion of mass to energy in the Sun.

rate of conversion = ... kg s^{-1} [2]

(b) Explain why, when the Sun is directly overhead at the equator

(i) the maximum intensity received on the surface of the Earth is less than 1000 W m^{-2}

....

.... [1]

(ii) the maximum intensity decreases with distance North and South of the equator.

....

.... [1]

(c) An ornamental water fountain is driven by a pump powered by the electrical output of a solar panel. The following data is relevant to the operation of the system, which is arranged to give maximum solar power input.

area of light-sensitive surface of panel:	0.080 m^2
solar intensity at the location of the panel:	750 $W\,m^{-2}$
voltage output of panel:	17 V
current delivered to the pump:	270 mA
delivery rate of the fountain:	0.50 m^3 per hour
efficiency of pump:	35%
density of water:	1000 $kg\,m^{-3}$

Calculate

(i) the solar power input to the panel

power input = ... W [1]

(ii) the electric power generated by the panel

power generated = ... W [1]

(iii) the efficiency of the panel in converting solar power to electrical power

efficiency = ... [2]

(iv) the height of the fountain of water.

maximum height = ... m [5]

(d) A solar panel of greater area than the one in **(c)** supplies 80 W of electrical power to a heating coil immersed in water.

(i) Calculate the time required to heat 0.50 kg of water from 25 °C to 100 °C, assuming no loss of heat to the surroundings. The specific heat capacity of water is 4200 $J\,kg^{-1}\,K^{-1}$.

time = ... s [3]

(ii) Suggest **two** reasons why this type of solar panel is unlikely to replace conventional mains-powered electric kettles as a means of boiling water, even when the solar power is a maximum.

1. ....

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....

2. ....

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.... [2]

[Total: 20]

END OF QUESTION PAPER

PLEASE DO NOT WRITE ON THIS PAGE