THIS IS A LEGACY SPECIFICATION

OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE

PHYSICS A

Materials

2825/03

CUP/T58378

Candidates answer on the question paper

OCR Supplied Materials:
None

Other Materials Required:
- Electronic Calculator

Tuesday 27 January 2009
Morning

Duration: 1 hour 30 minutes

2825503

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use 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, however additional paper may be used if necessary.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **90**.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
- The first seven questions concern Materials. The last question concerns general physics.
- This document consists of **16** pages. Any blank pages are indicated.

FOR EXAMINER'S USE		
Qu.	**Max.**	**Mark**
1	**11**	
2	**9**	
3	**12**	
4	**8**	
5	**6**	
6	**17**	
7	**7**	
8	**20**	
TOTAL	**90**	

SP SHW 00108 11/07 T58378/5

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,	$\mathrm{u} = 1.66 \times 10^{-27}\ \mathrm{kg}$
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, $p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$

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

Answer **all** the questions.

1 **(a)** **(i)** State what is meant by

1 a crystalline structure .....

2 a polycrystalline solid .....

3 a single-crystal solid. ..... **[3]**

(ii) State an example of

1 a single-crystal solid .....

2 a polycrystalline solid. ..... **[2]**

(b) Draw 2-dimensional sketches of a section of a crystal structure which includes

(i) a point defect

[1]

(ii) a dislocation.

[2]

(c) A crystalline material has atoms of diameter 2.5×10^{-10} m. A rod of this material is placed under stress and is found to undergo a permanent extension of 0.050 mm. This extension is due only to the creation and subsequent movement of dislocations.

(i) Calculate the minimum number of dislocations which move to cause this extension.

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

(ii) Suggest why the number calculated in **(i)** is the minimum number.

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

[Total: 11]

2 **(a)** The graph in Fig. 2.1 shows the variation of the resultant force F between a pair of atoms in a solid with the separation x of the atoms.

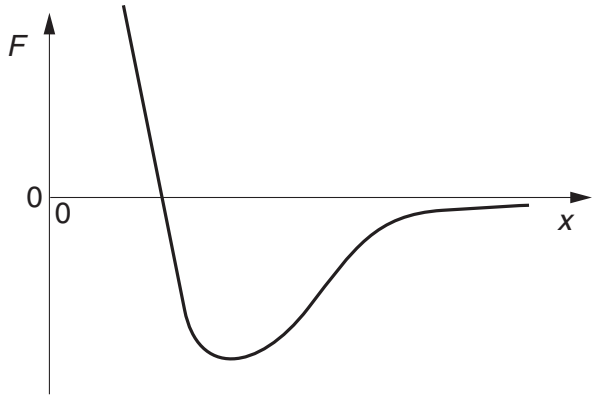

Fig. 2.1

Sketch on Fig. 2.1 a graph to show the variation of F with x for another solid in which

- the equilibrium separation of the atoms is smaller
- the maximum attractive force between the atoms is greater
- the solid is more resistant to compression. **[3]**

(b) Copper has a close-packed crystal structure. The volume of the atoms themselves is 74% of the volume occupied by the metal. The density of copper is $8\,930\,\text{kg}\,\text{m}^{-3}$. The mass of a copper atom is $1.06 \times 10^{-25}\,\text{kg}$.

(i) Show that the volume of a copper atom is about $9 \times 10^{-30}\,\text{m}^3$.

[3]

(ii) Calculate the equilibrium separation of copper atoms.

equilibrium separation = ... m **[3]**

[Total: 9]

3 Germanium is a semiconductor with resistivity $0.60\,\Omega\,\text{m}$.

(a) Calculate the conductivity of germanium stating the unit of the answer.

conductivity = ... unit ..... **[2]**

(b) Fig. 3.1 shows a rectangular block of germanium with dimensions $12\,\text{mm} \times 7.5\,\text{mm} \times 1.5\,\text{mm}$.

The block is connected as shown to a 9.0 V battery of negligible internal resistance.

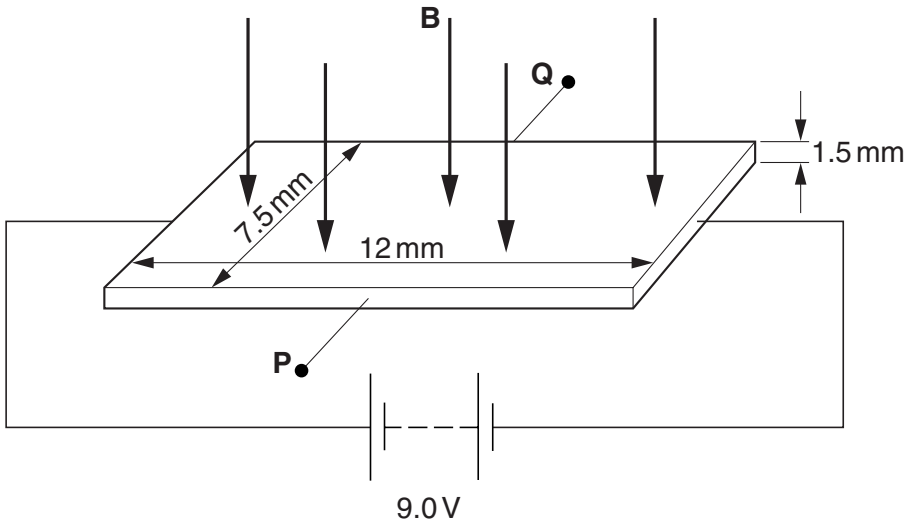

Fig. 3.1

(i) Show that the current through the block is about 15 mA.

[3]

(ii) A uniform magnetic field of flux density 0.25T is applied in the direction of the arrows labelled **B** in Fig. 3.1. A Hall voltage of 3.4 mV is measured between the points **P** and **Q**.

Calculate

1 the drift velocity of charge carriers in the germanium

drift velocity = ... $m\,s^{-1}$ **[2]**

2 the charge carrier density in the germanium.

charge carrier density = ... m^{-3} **[2]**

(c) The germanium block in Fig. 3.1 is replaced with one of length greater than 12 mm, all other dimensions remaining unchanged. The battery e.m.f. and magnetic flux density remain the same. State and explain the change which takes place in the Hall voltage.

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..... **[3]**

[Total: 12]

4 State and explain the changes in the electrical conductivity of metals and semiconductors when their temperature is raised. Include references to *valence band*, *conduction band* and *energy gap* in your answer.

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..... **[8]**

[Total: 8]

5 **(a)** Explain what is meant by a *magnetic domain*.

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..... **[2]**

(b) **(i)** Describe what happens to domains during the magnetisation of a magnetic material.

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..... **[2]**

(ii) Explain, in terms of their microstructure, why **soft** magnetic materials are more easily magnetised than **hard** magnetic materials.

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..... **[2]**

[Total: 6]

6 **(a)** In Fig. 6.1 **C** is the core of a transformer, **P** is the primary coil and **S** the secondary coil. An investigation is to be carried out to determine how the efficiency of the transformer varies with the frequency of the supply.

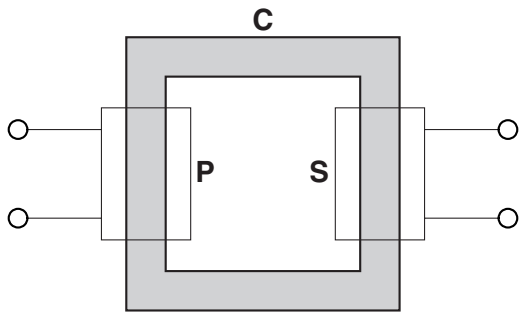

Fig. 6.1

(i) Sketch on Fig. 6.1 the circuits and components, with appropriate labels, required to carry out the investigation. **[3]**

(ii) Describe in detail the procedure to be carried out, with particular reference to

- how the apparatus is to be used to obtain data
- how the data are to be used to show how the efficiency varies with frequency.

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..... **[8]**

(b) Explain **two** processes which can cause the efficiency of this transformer to decrease as the frequency of the supply is increased.

1. .....

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2. .....

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..... **[6]**

[Total: 17]

7 **(a)** Explain how the intensity of infra-red radiation passing through an optic fibre is reduced by Rayleigh scattering.

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..... **[2]**

(b) **(i)** Infra-red radiation of wavelengths 1550 nm and 1750 nm pass through the same length of the optic fibre. Due to Rayleigh scattering the intensity of the radiation of wavelength 1550 nm is reduced by 5.0%. Show that the % reduction in the intensity of the 1750 nm radiation due to Rayleigh scattering is about 3%.

[3]

(ii) Rayleigh scattering has less effect on the intensity of the 1750 nm radiation than on the 1550 nm radiation. However, the 1550 nm radiation is chosen for fibre-optic communication. Explain why.

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..... **[2]**

[Total: 7]

8 The speed with which a bullet emerges from the barrel of a gun can be measured by a number of different techniques. This question relates to **two** experiments performed using the same rifle and bullets.

Data:

- mass of rifle 4.3 kg
- mass of bullet 28 g
- length of rifle barrel 72 cm

(a) Fig. 8.1 shows the first experiment where the rifle fires the bullet into a measured distance *D* between two fast optical sensors each of which is connected to a timer.

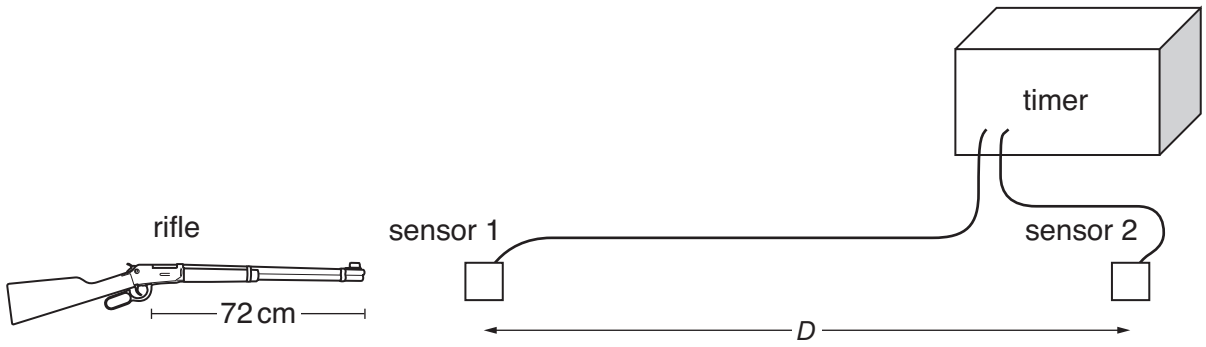

Fig. 8.1

When the bullet reaches sensor 1 the timer starts and when the bullet passes sensor 2 the timer stops.

distance *D* = 1.28 m
time *t* = 1.50 ms

(i) Show that the speed of the bullet is about 850 m s^{-1}.

[1]

(ii) The bullet accelerates as it travels along the rifle barrel. Show that the average acceleration in the barrel is about $5 \times 10^5\,\text{m}\,\text{s}^{-2}$.

[2]

(iii) Calculate the average force on the bullet in the barrel.

average force on bullet = ... N **[2]**

(iv) Discuss the effect this force has on the rifle.

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..... **[2]**

(b) Fig. 8.2 shows the second experiment where the same rifle fires the bullet horizontally into the middle of a block of lead resting on top of a vertical support.

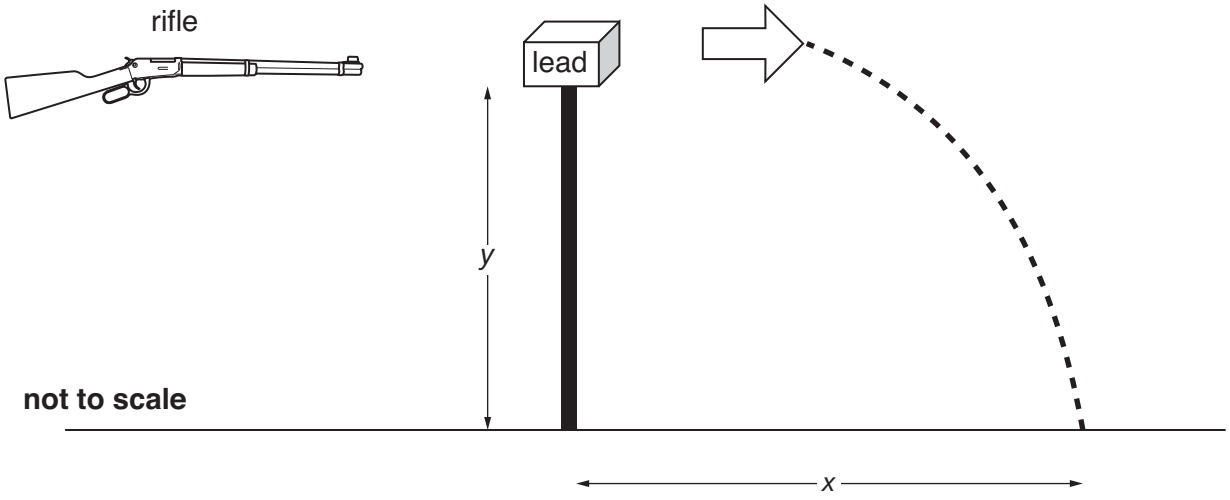

Fig. 8.2

When the bullet reaches the block it becomes embedded in the lead and the block is projected a horizontal distance *x* and falls a vertical distance *y* as shown. The following measurements are made;

mass of bullet	28 g
mass of lead block	3.60 kg
vertical distance *y*	2.41 m
horizontal distance *x*	4.60 m

(i) Show that the time taken for the block to fall through the vertical distance *y* is about 0.70 s.

[2]

(ii) Show that the horizontal projection speed of the block from the support is about $6.6\,m\,s^{-1}$.

[1]

(iii) Show that the speed of the bullet given by this collision experiment is also about $850\,m\,s^{-1}$.

[3]

(c) The initial kinetic energy of the bullet is transferred to the block as kinetic energy and thermal energy.

(i) Estimate the rise in temperature of the lead block. The specific heat capacity of lead is $126\,J\,kg^{-1}\,K^{-1}$.

rise in temperature = ... K **[5]**

(ii) Explain **two** assumptions you made in this calculation.

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..... **[2]**

[Total: 20]

END OF QUESTION PAPER