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Physics 3
780

# CAMEROON GENERAL CERTIFICATE OF EDUCATION BOARD

## General Certificate of Education Examination

JUNE 2010 ADVANCED LEVEL

| | |
|---|---|
| Subject Title | Physics |
| Paper No | Paper 3 |
| Paper Code | 780 |

**Two and a half hours**

**Answer all questions**

*Section I of the paper is designed to be answered in one hour and Section II is designed to be answered in one and a half hours. You are advised to divide your time accordingly, and the invigilators should announce when one hour has elapsed.*

*You are reminded of the necessity for good English and orderly presentation in your answers.*

*In calculations you are advised to show all the steps in your working, giving your answers at each stage.*

*Non programmable calculators and formulae booklet may be used.*



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## SECTION I

**(One hour)**

**Read the following passage and answer the questions that follow.**

Material Scientists are interested in the behaviour of material under the action of external forces. These forces may be mechanical or electrical in nature. They apply properties obtained when selecting materials for particular jobs.

Physicists in an attempt to explain the properties of materials have limited themselves to regular patterns of atomic arrangements in crystals, even though complex patterns exist. Crystalline materials although not perfect can serve as a starting point in the study of materials. It is assumed that materials under consideration are homogeneous or of high purity. The regular pattern of crystalline materials can be ascertained by electron, X-rays, or neutron diffraction analysis. This analysis is valid, when the atoms are exactly at their right locations in the lattices.

In practice, crystalline materials always contain defect, which affect the general properties of the materials. A proper study of the structure of a perfect crystal leads to an understanding of the physical consequences of the defects. Defects in materials increase disorder called entropy, which increase at higher temperatures.

There are two important aspects of mechanical behaviour that can be highlighted by geometric defects. Impurity atoms introduce point defects that can either be localized or be of atomic dimensions. It occurs by substitution or by interstitial displacement of a host lattice. The impurity atom can then be found between the host atoms on a non-lattice site.

During crystallization, an incomplete plane of atoms may be introduced due to growth faults. This defect is known as dislocation. Thermal vibrations continually upset the lattice arrangement and the effect is more glaring at higher temperatures. When a lattice site is unoccupied a vacancy is created leading to slight distortion at the site. Vacancies enable atoms to diffuse fairly easily through the crystals leaving their own sites vacant. The energy required for such movement is low Ionic crystals that have positive-ion sites could upset the electrical neutrality around these sites. Thus the electrostatic energy of the system increases. To maintain electrical neutrality, positive and negative vacancy pairs are likely to be produced. Thus vacancies enhances ordinary diffusion in an ionic crystal and when an electric field is applied, diffusion assists in electrical conduction.

If $E_p$ is the energy to create a vacancy for a crystal containing N atoms and at equilibrium the number n of vacancies at a temperature T, is given by

$$n = N \exp\left[ - E_p / kT \right]$$

where k = Boltzmann constant. A similar expression holds if the vacancies are associated with ionic crystals. Defects created by such charge movement are colour centred, when crystals are irradiated with X-rays, gamma rays, neutrons or electrons, a colour change is often produced. These colours are due to the damage caused on the lattice.

In the production of materials, material scientists have specific properties of the materials in mind. This is because they can control the properties of the required material. Revolution in micro electronics in the last three decades has been enhanced by technological production of high purity materials and the alteration of their compositions by controlled additions of other materials. Designing materials is very important if two or more materials of the particles are present, since their atomic arrangement may be different leading to profound difference in physical properties. For example, snow is translucent and ice is transparent. Therefore, the microstructure of a material is determined by the way it is produced and the processes it undergoes. The microstructure of a material is determined if in the process of production the material is forged, worked or heated. The physical properties of the material eventually depends on



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these processes. The whole lot of materials can therefore have a wide range of applications. Impurities in a material affect the transparent, colour, optical as well as the commercial values of materials.

**Questions**

1. Explain the meaning of the following terms or phrases as used in the passage:
   (a) Homogeneous
   (b) Entropy
   (c) Geometric defect
   (d) Ordinary diffusion

**(8 marks)**

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2. "The properties of a material depends on the arrangement of its particles."
   (a) List the three properties that are referred to here.
   (b) Give with justification and one practical example where the above statement is applicable.

**(5 marks)**

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3. (a) Why is there need to design new materials given that there are a wide range of naturally occurring materials?
   (b) (i) How does temperature affect the number of vacancies in a crystalline material
   (ii) Write out the energy equation required for the creation of vacancies

**(6 marks)**

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4. (a) Name three methods that can be used to study the structure of a material
   (b) How does dislocation differ from the other forms of defects
   (c) Briefly discuss the origin of colours in crystal

**(6 marks)**

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5. (a) Draw a diagram in each case to show substitution and interstitial defect.
   (b) Explain briefly in which area of physics can the processes describe in (a) above appear significant?

**(5 marks)**

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## SECTION II

***(One and a half hours)***

**Read the following account of an experimental investigation and answer the question that follow.**

**In planetary motion the centripetal force is provided by the gravitational attraction. Kepler in 1630 came out with the relationship between period T of a planet moving about the sun and the distance R of the planet from the sun as**

$$T^2 = \frac{4\pi^2}{GM} R^3 \quad \ldots\ldots\ldots\ldots (i)$$

where G is the gravitational constant and M the mass of the sun

Equation (i) can be generalized to read.

$$T^a = \frac{4\pi^2}{GM} R^n \quad \ldots\ldots\ldots\ldots\ldots (ii)$$

Table 1 shows values of period T and distance R of the planet from the sun for various planets.

| $T/10^6$s | $R/10^{10}$m |
|---|---|
| 1.62 | 1.32 |
| 1.83 | 1.45 |
| 2.42 | 1.78 |
| 3.80 | 2.40 |
| 4.88 | 2.93 |
| 6.59 | 3.58 |
| 8.89 | 4.37 |

Table 1

6. (i) Plot a graph of T on the vertical axis and $R^{\frac{3}{2}}$ on the horizontal axis
(ii) The slope of the graph is given by the equation.

$$S = \frac{2\pi}{\sqrt{GM}}$$

Use it to determine a value of M

**(13 marks)**

7. (a) Using equation (ii) above plot a suitable graph to obtain values of n and M; if a = 2.
(b) From the graph determine a value for n and M. **(15 marks)**

8. Comment on the values of M obtained from 6 (ii) and 7(b) above **(2 marks)**

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