NATIONAL OPEN UNIVERSITY OF NIGERIA
14-16 AHMADU BELLO WAY, VICTORIA ISLAND LAGOS
SCHOOL OF SCIENCE AND TECHNOLOGY
MARCH/APRIL 2015 EXAMINATION

SCHOOL OF SCIENCE AND TECHNOLOGY

COURSE CODE: **PHY407**
COURSE TITLE: **Solid State Physics II**
TIME: **3 Hours**

INSTRUCTION: Answer question 1 and any four questions.

PHYSICAL CONSTANTS:
Speed of light $c = 2.9979 ms^{-1}$; mass of electron $m_e = 9.11 \times 10^{-31} kg$; Electronic charge $e = 1.6022 \times 10^{-19} C$; Avogadro's number $N_A = 6.0221 \times 10^{26} kmol^{-1}$;
Boltzmann constant $k = 1.3806 \times 10^{-23} J K^{-1}$; Plank's constant $h = 6.6257 \times 10^{-34} Js$

1. (a) (i)What are dielectrics? Give two examples. **3 ½ marks**
(ii) List five (5) properties of a dielectric. **2 ½ marks**
(b) (i) What is an electric dipole? **2 marks**
(ii) Show that the field of an electric dipole may be expressed as

$$\vec{E} = \frac{1}{4\pi\epsilon_0}\left[\frac{3(\vec{p}.\vec{r} - r^2\vec{p})}{r^5}\right]$$

The symbols have their usual meaning. **6 marks**

2(a) (i) Write down the classical Langevin expression for the diamagnetic susceptibility and explain all the symbols giving their SI units. **3 marks.**
(ii) Assuming one electron, $\langle r_0 \rangle = 0.1 nm$ and $N = 5 \times 10^{28}/m^3$ in your relation in 2(a)(i), obtain a value for the classical susceptibility. **4 marks.**
(b) (i) Calculate the magnitude of the Lamor frequency of an electron of the hydrogen atom placed in a magnetic field $\vec{B} = 0.1 T$ **3 marks**
(ii) Calculate the current due to the precession of the electron of the hydrogen atom in 2(b)(i) **4 marks**

3. (a) (i) What are *ferromagnetic materials?* Give two examples. **4 marks**
(i) Briefly explain the *domain theory* of ferromagnetism. **4 marks**
(b) The Curie temperature of iron is 1043 K. Assume that iron atoms, when in the metallic form, have moments of two Bohr magneton per atom. Iron is body-centred with lattice parameter $a = 0.285\,nm$. Calculate the saturation magnetization and the Curie constant. **6 marks**

4.(a) (i) Define electric susceptibility and polarizability. **4 marks**
(ii) Obtain the frequency dependence of the electronic polarizability of an electron having the resonance frequency ω_o, treating the system as a simple harmonic oscillator. **4 marks**

(b) Obtain the Clausius – Mossotti equation relating the macroscopic dielectric constant with the atomic polarizabilities. **6 marks**

5. (a) (i) List the main classification of materials based on their magnetic properties. **3 marks**
(ii) Explain the term *magnetization.* Mention three origins of the magnetic moment of a material from the atomic point of view. **3 marks**
(b) (i) The magnetic dipole moment μ associated with an orbiting electron of a hydrogen atom is given as
$|\mu| = IA$
where I is the current produced and A the area enclosed by the electron. Starting with this definition, show that
$|\mu| = \frac{e}{2m}|\vec{L}|$ **4 marks**
where L is the angular momentum, e and m are the electronic charge and mass of the electron respectively.

(ii) In the Bohr hydrogen atom, the orbital angular momentum of the electron is quantized in units of $\hbar$. Calculate the smallest allowed magnitude of the atomic dipole moment in $J\,t^{-1}$. (This quantity is known as Bohr magneton). **4 marks**
6. (a) (i) Using relevant examples, distinguish between *point defects* and *dislocations.* **4 marks**

(ii) Explain the possible effects of planar defects. **3 marks**

(b) (i) Define the term grain boundary **4 marks**

(ii) What s an intersticialcy? **3 marks**

7.(a) (i) Explain the term *linear defect* **3**

marks

(ii) List four categories of point defect.

3marks

(b) (i) Distinguish between Schottky and Frenkel defects **4 marks**

(ii) Write short notes on twin boundaries, stacking faults, phase boundaries and ferromagnetic domain wall.

4 marks