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**NATIONAL OPEN UNIVERSITY OF NIGERIA**

**14-16 AHMADU BELLO WAY, VICTORIA ISLAND LAGOS**

**SEPTEMBER/OCTOBER 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$m\_{e}=9.11×10^{-31}kg$; Electronic charge $e=1.6022×10^{-19}C$; Avogadro’s number $N\_{A}= 6.0221×10^{26}kmol^{-1};$ Boltzmann constant $k=1.3806×10^{-23}JK^{-1}$; Plank’s constant $h=6.6257×10^{-34}Js$

1.(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**

2. (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

$$\vec{E}=\frac{1}{4πϵ\_{0}}\left[\frac{3\left(\vec{p}.\vec{r}-r^{2}\vec{p}\right)}{r^{5}}\right]$$

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

3.(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, $\left〈r\_{0}\right〉=0.1 nm$ and $N=5×10^{28}/m^{3}$ 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 $\rightharpoonaccent{B}=0.1 T$**3 marks**

(ii) Calculate the current due to the precession of the electron of the hydrogen atom in 2(b)(i)

**4 marks**

4. (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**

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

$$\left|μ\right|=IA$$

where$I$ is the current produced and $A$ the area enclosed by the electron. Starting with this definition, show that

$\left|μ\right|=\frac{e}{2m}\left|\vec{L}\right|$**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 $ℏ$. Calculate the smallest allowed magnitude of the atomic dipole moment in$ Jt^{-1}$.

(This quantity is known as Bohr magneton). **4marks**

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**