NATIONAL OPEN UNIVERSITY OF NIGERIA
PLOT 91, CADASTRAL ZONE, NNAMDI AZIKIWE EXPRESSWAY, JABI - ABUJA
FACULTY OF SCIENCES

DEPARTMENT OF PURE AND APPLIED SCIENCE

2021_1 EXAMINATIONS

COURSE CODE: **PHY407**
COURSE TITLE: **SOLID STATE PHYSICS II**
CREDIT UNIT: **3**
TIME ALLOWED: **(2½ HRS)**

INSTRUCTION: ***Answer question 1 and any other four questions***

Charge on an electron = $1.602*10^{-19}C$

Mass of an electron = $9.118*10^{-31}Kg$

Permitivity of free space = $8.85*10^{-12}Fm^{-1}$

Boltzmann constant = $8.617*10^{-5}eVK^{-1}$

QUESTION 1

a. Briefly discuss the following:

i Magnetic Dipole (4 marks)

ii Magnetic Field Strength (H) (4 marks)

iii Magnetic Induction or Flux density (B) (4 marks)

b. State five (5) differences between Soft and Hard magnetic materials (10 marks)

QUESTION 2

a Apply the Hund rules to find the ground state of an ion that has an outer shell of $3d^3$. Write your answer in atomic notation. (4 marks)

b Let the magnetic moment of the above ion be μ. Find the magnetization as a function of magnetic field and temperature for a system formed by these ions with a concentration of n.

(8 marks)

QUESTION 3

State six (6) properties each for both diamagnetic and paramagnetic materials (12 marks)

QUESTION 4

For an fcc lattice of magnetic spins it is impossible to find an antiferromagnetic arrangement in which all the nearest neighbors of any spin are antiparallel to it. The best that can be achieved,

for example by having spins in alternate (2 0 0) planes ↑ and ↓, is eight antiparallel and four parallel neighbours. (Miller indices are referred to the conventional cubic unit cell).

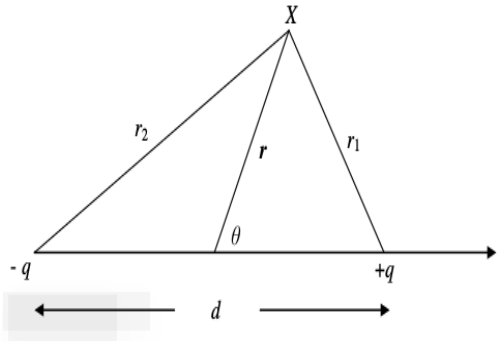
Develop a Neel theory appropriate to the case of two sublattices when only nearest neighbour exchange interactions are important; the effective field acting on an ion on the A sublattice would then be $B_A = B_a - \mu M_B - \varepsilon M_A$ with a similar expression for B_B. Show that the high-temperature susceptibility is of the form $\mathcal{X} = C/(T + \theta)$, where θ is related to the Neel temperature T_N by

$$\frac{\theta}{T_N} = \frac{\mu + \varepsilon}{\mu - \varepsilon}$$

(12 marks)

QUESTION 5

Suppose the charges -q and +q are placed at d/2 and -d/2 as shown in the figure below,



a. Hence or otherwise, show that $\phi(r) = \frac{\rho \cos\theta}{4\pi\varepsilon_0 r^2} = \frac{\vec{\rho}.\vec{r}}{4\pi\varepsilon_0 (r)^3}$ **6 marks**

b. Define Point defect and explain two types of point defects **6 marks**

QUESTION 6

a. Describe two types of bulk defect **4 marks**

b. At what temperature will the probability of finding a vacancy be 10^{-3}, if it requires 3.5 eV to remove an atom from inside the crystal to the surface? Take the Boltzmann constant as $8.617 * 10^{-5} eVK^{-1}$ **4 marks**

c. Differentiate between edge and screw dislocation **4 marks**