



**UNIVERSITY EXAMINATIONS**  
**FOURTH YEAR EXAMINATION FOR THE AWARD OF THE**  
**DEGREE OF BACHELOR OF SCIENCE**  
**SECOND SEMESTER 2022/2023**  
**[JANUARY-APRIL, 2023]**

**PHYS 421: SOLID STATE PHYSICS**

**STREAM: Y4S2**

**TIME: 2 HOURS**

**DAY: TUESDAY, 3:00 – 5:00 PM**

**DATE: 28/03/2023**

**INSTRUCTIONS**

1. *Do not write anything on this question paper.*
2. *Answer question ONE and any other TWO questions.*

**QUESTION ONE**

- (a) Outline the difference between crystalline and an amorphous solid and give three characteristics of each type. (5 marks)
- (b) State and explain Bragg's equation for a beam of X-rays incident on the atoms, which constitute a plane. (4 marks)
- (c) Explain the following terms as applied in solid state physics. (3 marks)
- (i) Polarization (2 marks)
  - (ii) Electric dipoles (2 marks)
  - (iii) Electric dipole moment (2 marks)
- (e) Using a parallel plate capacity with a dielectric material, a charge  $q$  on each plate and on induced charge  $q'$  on the surface of the dielectric, establish a relation between Electric field  $E$ , flux Density  $D$  and Polarization  $P$ . (5 marks)
- (f) Define dielectric polarizability and relate how it is affected by the strength of the external field. (4 marks)

(g) define susceptibility and show how it relates to permittivity of free space  $\epsilon_0$ .

(3 marks)

### QUESTION TWO

(a) Give the three types of polarization (3 marks)

(b) Show that the charge enclosed in a sphere of radius  $x$  is equal to

$$-\frac{Zex^3}{R^3}$$

(5 marks)

(c) (i) The Lorentz force of repulsion experienced by the electron cloud due to applied field  $E$  is

$$F_L = -ZeE$$

Show that the separation between the two charge centres is proportional to the field  $E$ . (5 marks)

(ii) Hence, show that the electric dipole moment is given as

$$\mu_e = 4\pi\epsilon_0 R^3 E$$

(7 marks)

### QUESTION THREE

(a) What is the significance of Clausius-Mosotti relation? (3 marks)

(b) Derive the Clausius-Mosotti relation. (7 marks)

(c) Describe the BCS theory of Superconductivity and mention its two failures.

(10 marks)

### QUESTION FOUR

(a) Distinguish between direct lattice and reciprocal lattice. (4 marks)

(b) Consider one dimensional crystal of monoatomic lattice under vibration. Obtain a dispersion relation for the nearest neighbor atomic configuration.

(16 marks)

### QUESTION FIVE

(a) Consider one dimensional crystal of diatomic lattice under vibration. Obtain a dispersion relation for the nearest neighbor atomic configuration.

(20 marks)