UTHM
Universiti Tun Hussein Onn Malaysia

# UNIVERSITI TUN HUSSEIN ONN MALAYSIA

## FINAL EXAMINATION
## SEMESTER II
## SESSION 2022/2023

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| COURSE NAME | : | SOLID STATE PHYSICS |
| COURSE CODE | : | BWC 21003 |
| PROGRAMME CODE | : | BWC |
| EXAMINATION DATE | : | JULY/ AUGUST 2023 |
| DURATION | : | 3 HOURS |
| INSTRUCTIONS | : | 1. ANSWER ALL QUESTIONS<br>2. THIS FINAL EXAMINATION IS CONDUCTED VIA<br>☐ Open book<br>☒ Closed book<br>3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK |

THIS QUESTION PAPER CONSISTS OF **THREE (3)** PAGES

**Q1** (a) Sketch and show that face centred tetragonal (FCT) structure is equivalent to a body centred tetragonal (BCT) structure.

(6 marks)

(b) Describe the step-wise procedure for constructing Wigner-Seitz unit cell.

(4 marks)

(c) Determine the lattice constant of NaCl crystal. The molecular weight of NaCl is 58.44 and the density is 2.167 g/cm$^3$.

(6 marks)

(d) Calculate the interatomic potential between two Argon (Ar) gas atoms separated by 4.0 Å (use $\varepsilon = 0.997$ kJ/mol and $\sigma = 3.40$ Å).

(4 marks)

**Q2** (a) Identify the origin of cohesion in metals. Determine whether it is described by interatomic potentials or covalent bond or any other bonds.

(2 marks)

(b) Describe the following atomic bonding. Give one example for each.

(i) Covalent bond

(2 marks)

(ii) Metallic bond

(2 marks)

(iii) Ionic bond

(2 marks)

(c) State the differences between the Van der Waals and Hydrogen bonds.

(2 marks)

(d) Suppose that the energy required to remove a Sodium atom from the inside of a sodium crystal to the boundary is 1 eV. Calculate the concentration of Schottky vacancies at 300K. (Consider that Na concentration is $N = 2.5 \times 10^{22}$ atoms/cm$^3$)

(4 marks)

(e) Differentiate between line and screw dislocations by drawing 2D and 3D diagrams. Diagrams must include dislocation line and Burgers vectors.

(6 marks)

**Q3** (a) Describe in detail the atomic processes that can produce X-ray photons.

(6 marks)

(b) Explain the function of $\beta$-filter in X-ray diffraction measurement. List **TWO (2)** example of $\beta$-filter.

(4 marks)

(c) Write the the formula of $d$-spacing of the following crystal system:

(i) Tetragonal

(2 marks)

(ii) Hexagonal

(2 marks)

(iii) Orthorhombic

(2 marks)

(d) Discuss the comparison between phonons and photons in terms of dynamics atoms in crystals.

(4 marks)

**Q4** (a) Differentiate between Einstein's theory and Debye model on the specific heat.

(8 marks)

(b) Describe the main function of ultrasonic velocity measurement in dynamics of atoms in crystal.

(4 marks)

(c) Thermal expansion is an example to the anharmonicity effect. Using appropriate diagram, explain the anharmonicity effect.

(4 marks)

(d) Distinguish between thermal conductivity and thermal resistance in solid materials.

(4 marks)

**- END OF QUESTIONS -**