**RAJARATA UNIVERSITY OF SRI LANKA**
**FACULTY OF APPLIED SCIENCES**

**B.Sc. (Honours) Degree in Chemistry**
**Fourth Year - Semester I Examination – September / October 2019**

**CHE 4215 – SOLID STATE CHEMISTRY**

**Time: Two (02) hours**

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Answer all questions.

R= 8.314 J $K^{-1}$ $mol^{-1}$, e = 1.602 × $10^{-19}$ C, h = 6.63 × $10^{-34}$ J s, $k_B$ = 1.381 × $10^{-23}$ J $K^{-1}$, $N_A$ = 6.022×$10^{23}$ $mol^{-1}$, c = 3.0 × $10^8$ m $s^{-1}$

Use of a non-programmable calculator is permitted.

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1. a) Nickel crystalize in a cubic group where the unit cell length is 0.3542 nm. Assuming all the atoms are at the lattice points, calculate the number of Ni atoms in a unit cell. Determine the type of cubic lattice nickel possesses.
( Ni; d = 8.90 g $cm^{-3}$, M = 58.693 mol $g^{-1}$). (30 marks)

b) Calculate the packing efficiency for the FCC unit cell. (10 marks)

c) Ascertain the number of atoms in the unit cell each of following cubic unit cells.

i. Primitive ii. Face centered iii. Body centered (30 marks)

d) Determine the crystal structure and calculate the packing factor for potassium chloride (KCl), ($r^+$ = 0.133 nm and $r^-$ = 0,181 nm).

| ρ | Coordination number |
|---|---|
| ≥ 0.732 | 8:8 |
| 0.414 – 0.732 | 6:6 |
| 0.225 – 0.414 | 4:4 |

(30 marks)

2. a) On each of three separate drawings of one face of an FCC unit cell, indicate one of each of followings.

   i. Vacancy ii. Interstitial impurity iii. Substitutional impurity (30 marks)

   b) Elaborate two types of defects Scotty and Frenkel defects. (30 marks)

   c) Define all the terms of the equation and calculate the number of vacancies per one $cm^3$ in iron at 850 °C where $Q_v$ = 1.08 eV/atom, $\rho$ = 7.65 g $cm^{-3}$, M = 55.85 g $mol^{-1}$ for iron.

$$N_v = N_s \exp\left(-\frac{Q_v}{k_B T}\right)$$ (20 marks)

   d) X-rays of wavelength 0.150 nm are diffracted from a crystal at an angle of 20.17. Assuming that n = 2, obtain the distance (in meters) between the layers in the crystal. In addition, calculate the minimum interlayer spacing that can be measured using this X-Ray. (20 marks)

3. a) Discuss the three modes used in in AFM. (30 marks)

   b) In AFM you may observe signals as well as drifts. State how to distinguish two of them and explain the course of the drift. (10 marks)

   c) Sketch the main components of a SEM apparatus and explains how SEM functions. (40 marks)

   d) Compare the advantages and disadvantages of the TEM vs AFM. (20 marks)

4. a) Describe how to use XRD to identify different phases of a material with the same chemical component. (20 marks)

   b) Ge can be doped with Ga or As. How would you see this doping in a crystallographical point of view? Comment on the electrical conductance of Ge after doping of each Ga and As. (20 marks)

   c) Describe the DSC technique in detail. (30 marks)

   d) Details of decomposition thermogram of $CaC_2O_4.H_2O$ is given below. The decomposition occurred in three steps. In each step, percentage of the weight losses are 12.57% (100 – 226 °C), 19.47% (346 – 420 °C) and 30.07% (600 – 840 °C) for first, second and third steps respectively. The temperature range in which the weight losses are indicated in brackets. Draw the thermogram for the $CaC_2O_4.H_2O$ decomposition and predict the mechanism. (30 marks)

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