RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree
Third Year – Semester II Examination – March/ April 2015

PHY 3309- STRUCTURE AND PROPERTIES OF MATERIALS

Answer question **one** and **any other five** questions Time: Three hours
Use of a non-programmable calculator is permitted.

1. a) What are crystalline solids? [10 marks]

   b) How a solid is determined whether it is a polycrystalline or single crystal by the way it forms? [10 marks]

   c) Why the bonding between atoms is so important in a solid? [10 marks]

   d) List the different type of bonds that exist between atoms. (give an example for each) [10 marks]

   e) Define the term *'space lattice'*. [10 marks]

   f) Distinguish between primitive cell and unit cell. [10 marks]

   g) Discuss briefly "hexagonal close packed" in a crystal. [10 marks]

   h) Draw the primitive cell for f.c.c. [15 marks]

   i) Sketch the three Bravias lattices, which exist in cubic crystal system. [15 marks]

2. a) For the packing of spheres of radius R in a

i. b.c.c. and

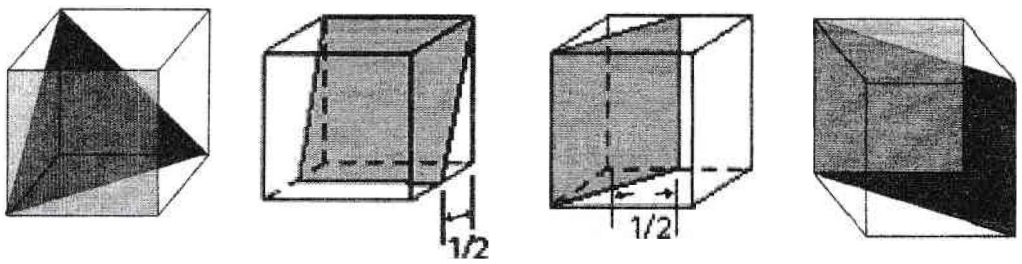
ii. f.c.c lattice, show that the cube edge a and the fraction of the volume occupied by the spheres, f are given by

b.c.c.	$a = 4R/\sqrt{3}$	$f = \pi\sqrt{3}/8$
f.c.c	$a = 4R/\sqrt{2}$	$f = \pi\sqrt{2}/6$

[30 marks]

b) The molecular weight of copper is 63.54 g mol^{-1} and the atomic radius of copper is 1.276×10^{-6} m. Copper crystallizes as f.c.c. Avogardo's number, N_0 is 6.023×10^{23}. Calculate the density of copper. [30 marks]

c) Give the Miller indices for the following planes. [20 marks]



d) Sketch the following directions in a cubic unit cell. [20 marks]

[2 0 1] [0 1 1] [1 1 0] [2 0 0]

3. (a) "Useful information about the structure of crystalline materials can be deduced from the diffraction patterns produced by suitable radiation."

What do you mean by suitable radiation in the above statement? Give examples [20 marks]

(b) How are the crystal structures of solids usually determined? [20 marks]

(c) Give the x-ray diffraction methods and compare them. [30marks]

(d) The cube edge of b.c.c. lattice of **Fe** at room temperature is 2.86 A. Calculate

i. the spacing between (110) planes,

ii. the wave length of the 1st order diffracted X-ray beams, if the Bragg angle is 55^0. [30 marks]

4. (a) A long chain molecules is composed of identical atoms evenly spaced. The potential energy of interaction (between nearest neighbours only) is given by

$$V_{(X)} = -\frac{A}{X^3} + \frac{B}{X^6}$$

Determine,

i. the equilibrium spacing x_0 of the atoms and
ii. If the chain gradually stretched at what strain will it break? [30 marks]

(b) Considering the variation of interatomic potential energy with the separation between two atoms, explain

i. why crystalline solids normally expand with increasing temperature and
ii. why Young's modulus for a crystalline solid decreases as the temperature increases. [30 marks]

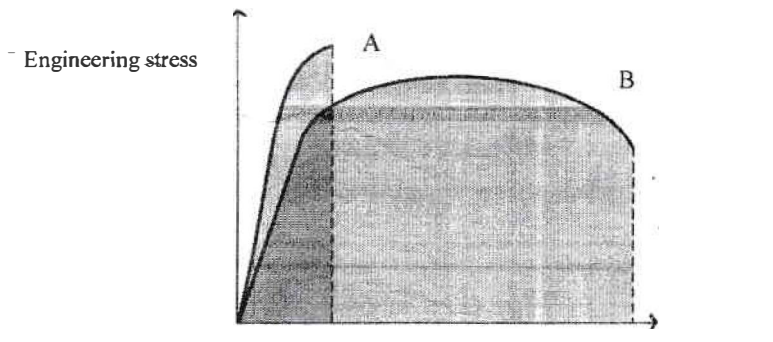
(c) Show the energy per unit length of an screw dislocation is $\frac{E}{l} = Gb^2$.

Where, E- Energy, l- length, G- Shear modulus and b- Burgers vector. [40 marks]

5. (a) Distinguish between ductile and brittle fracture. [10 marks]

(b) Describe the following material properties naming a product that needs a material with the particular property.
Strength, ductility and hardness. [30 marks]

(c) Engineering stress vs engineering strain curves for two materials are given below. Explain their properties giving an example for each curve. [20 marks]



(d) What do you mean by fatigue? Define Fatigue limit and fatigue strength for a particular material. [20 marks]

(e) In the creep test of an aluminum alloy at 180°C various stresses were applied and the corresponding creep rates were determined. A creep rate of 0.0025/ hour noted when subjected to a stress of 55 MPa and a creep rate of 0.0066/hour noted when stressed to 62 MN/m^2. Assuming steady state creep, determine the creep rate for the stress of 59 MPa. [20 marks]

6. (a) The actual strength of a brittle material is usually much lower in magnitude. Why? [20 marks]

(b) Show that the theoretical cohesive strength of a solid is $\sigma_C = \sqrt{\frac{E\gamma_s}{a_0}}$.

Where, σ_C - cohesive strength of the solid, E - Young's modulus, γ_s - surface energy. a_0- equilibrium distance between atomic centers. [30 marks]

(c) What is meant by:
a) the stress concentration factor?
b) the stress intensity factor? [20 marks]

(d) A plate of steel has a yield stress of 1000 MPa. The plate was fractured when the tensile stress is increased to 800 MPa and it was therefore hypothesized that a surface crack was present. If the fracture toughness for this steel is 60 MPa $m^{1/2}$, approximately what crack size is expected? [30 marks]

7. (a) Give the assumptions made in Sommerfeld's model. [25 marks]

(b) What is Density of States in energy space [D (E)]? [15 marks]

(c) Find the number of energy levels in a small energy range dE for a particle having half spin in a very large potential box. [40 marks]

(d) Define "Fermi level". What is given by Fermi- Dirac function? [20 marks]