RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree in Applied Sciences
Third Year - Semester II Examination – February / March 2019

PHY 3210 – PROPERTIES OF MATERIALS

Time: Two (02) hours

Answer **four (04)** questions only.

Symbols have their usual meaning.
Use of a non-programmable calculator is permitted.

Planck's constant $h = 6.626 \times 10^{-34}$ J s
Velocity of light $c = 3.0 \times 10^{8}$ m s^{-1}

01. (a) What are dislocations in metals? (04 marks)

(b) Explain in detail why the actual shear strength of metals is very much less than the theoretical shear strength? (05 marks)

(c) Define the "dislocation line $\underline{t}$" and the "Burgers vector $\underline{b}$" of an edge dislocation. (06 marks)

(d) Use the **F**inish to **S**tart **R**ight **H**and **S**crew Convection (**FS/RHS** Convention) and show that the Burgers vector $\underline{b}$ is perpendicular to the dislocation line $\underline{t}$ in an edge dislocation. (10 marks)

02. Atoms emit light by spontaneous emission when electrons in excited states drop down to a lower level by radiative transitions. In solids the radiative emission process is called luminescence. Luminescence can occur by a number of mechanisms.

(a) i. Discuss briefly two different mechanisms of luminescence. (06 marks)

ii. Using schematic diagrams explain what is meant by direct gap materials and indirect gap materials. (06 marks)

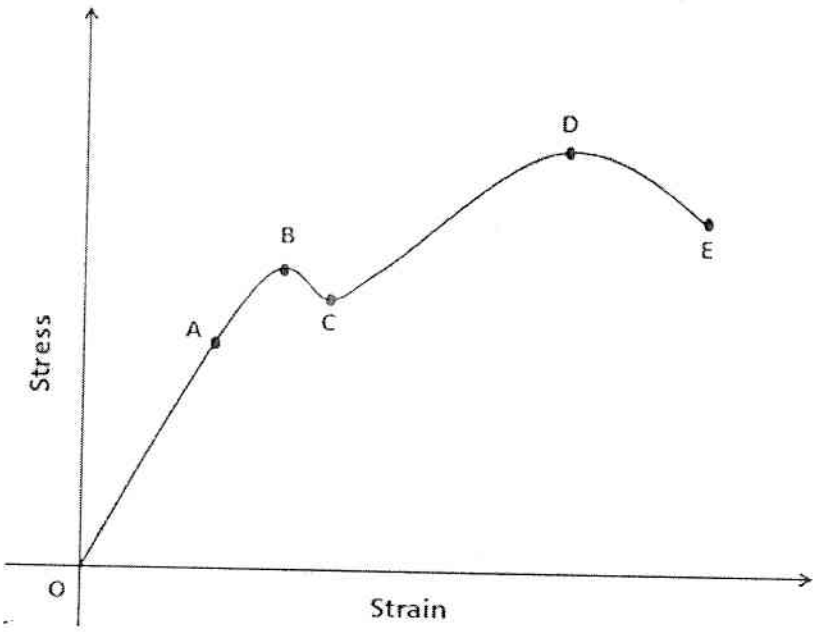
Contd...

(b) The band gap of the III-V semiconductor alloy $Al_xGa_{1-x}As$ at $k = 0$ varies with composition according to $E_g(x) = (1.420 + 1.087x + 0.438x^2)$ eV. The material is direct for $x \leq 0.43$, and indirect for larger values of x. Light emitters for specific wavelengths can be made by appropriate choice of the composition.

i. Calculate the composition of the alloy in a device emitting at 800 nm. (06 marks)

ii. Calculate the useful range of wavelengths that can be obtained from AlGaAs emitter. (07 marks)

03. (a) **Engineering stress vs. strain** curve for a ductile material is shown in the figure below.



Explain different points (O, A, B, C, D and E) and regions (O-A, A-B, B-C, C-D and D-E) of the above curve. (10 marks)

(b) Draw engineering stress vs. strain curves for the following.

(i) Low ductile and high toughness material. (03 marks)
(ii) High ductile, low strength and low toughness material. (03 marks)
(iii) Brittle and low toughness material. (03 marks)

Contd...

(c) Sketch the **true stress vs. strain** curve based on the engineering stress vs. strain curve shown in part (a) above. (06 marks)

04. Characteristics of motion of an electron under the influence of a uniform magnetic field play a key role in determining some important properties of electrons, such as details of the Fermi surface in metals and the effective mass in semiconductors.

(a) i. Show that an electron of mass m and charge e performs circular orbits around a magnetic field with and angular frequency (cyclotron frequency) $\omega_c = \frac{eB}{m}$, where B is the field strength. (06 marks)

ii. Explain what is meant by cyclotron resonance. (04 marks)

iii. Use the uncertainty principle to show that the basic condition for the cyclotron resonance is $\omega_c \tau >> 1$. (04 marks)

(b) i. In a cyclotron resonance set-up, a klystron radiation of 2.4×10^{10} Hz is used. For a sample, the resonance absorption occurs at a magnetic field of 8.6×10^{-2} T. Calculate the effective mass of the charge carriers. (06 marks)

ii. Determine the range of relaxation time over which a resonance is observable. (05 marks)

05. Write **short notes** on the following:

(a) Charpy impact test. (06 marks)
(b) Resilience vs. toughness of a material. (06 marks)
(c) Brinell hardness. (06 marks)
(d) 3-point bending test. (07 marks)

-END-