Uva Wellassa University of Sri Lanka
Faculty of Science and Technology
Department of Science and Technology
300 level 1st Semester Examination – May/July 2017
SCT 351-3 Materials Physics (Repeat)

Uva Wellassa University

Instructions to candidates
Duration: Three (03) hours
Number of questions: Six (06)
Answer **all** questions
Mark allocation: 140

Charge of an electron = 1.6×10^{-19} C
Mass of an electron = 9.1×10^{-31} kg
Speed of light c = 2.98×10^{8} ms^{-1}
Plank constant h = 6.63×10^{-34} J.s
Avagadro's Number = 6.022×10^{23}
1 eV = 1.6×10^{-19} C
hc = 1240 eV. nm

1.

a. Write down an equation for the internal energy of a thermodynamical system in differential form (dU). **Neglect** the term associated with particle number N and chemical potential μ.

(04 marks)

b. What are the natural variables of internal energy U ?

(04 marks)

c. Write down equations for T and p as partial derivatives of internal energy.

(06 marks)

d. Assuming S and V are two independent variables and assuming that the order of partial derivatives can be exchanged, prove the Maxwell relation given below associated with internal energy.

$$\left(\frac{\partial T}{\partial V}\right)_S = -\left(\frac{\partial p}{\partial S}\right)_v$$

(06 marks)

37 33

2.

a. Briefly explain photoelectric effect using a schematic diagram.

(06 marks)

b. Name three observations of photoelectric effect which were contradictory to the predictions done using classical physics.

(06 marks)

c. The work function for silver metal is 4.73 eV.

I. What is the cutoff wavelength λ_c for silver?

(06 marks)

II. What is the maximum kinetic energy of the electrons when radiation of wavelength 198 nm is used?

(06 marks)

III. What is the stopping potential in this case?

(06 marks)

3.

a. Write down the four quantum numbers which are needed to describe the wavefunction of the electron in the hydrogen atom.

(04 marks)

b. Write down the range of values of the above mentioned quantum numbers.

(06 marks)

c. If the electron in the hydrogen atom is in the **2^{nd} excited state**, label the different states of the wavefunction using the four quantum numbers you mentioned in part "a ". How many different states are there ?

(08 marks)

d. What is the degeneracy of the **2^{nd} excited state** of the hydrogen atom ?

(03 marks)

e. Write down the relationship between the degeneracy of a certain energy level and the principle quantum number associated with that energy level.

(04 marks)

4.

a. What are the three distribution functions that you studied in statistical physics?

(06 marks)

b. Plot the graphs of distribution function *f(E) vs E* for each distribution function you mentioned in part "a".

(06 marks)

c. What is meant by Fermi energy?

(05 marks)

d. Compute the Fermi energy for magnesium. Assume magnesium provides two free electrons to free electron gas. The density of magnesium is 1.74 g/cm^3 and the molar mass of magnesium is 24.30 mol/g.

(08 marks)

5.

a. Describe "Band Theory of Solids" .

(05 marks)

b. Draw three energy band diagrams to represent a conductor, an insulator and a semiconductor respectively. Clearly show the Fermi energy level in each diagram.

(09 marks)

c. Using the above diagrams **briefly** explain the difference between conductors, semi conductors and insulators on the basis of band theory of solids.

(06 marks)

6.

a. Write an equation for the energy of a particle with mass m trapped in a **two dimensional infinite potential well in terms of its ground state energy E_0 and relevant quantum numbers.**

(04 marks)

b. Give an example of an energy level (in terms of ground state energy E_0) which is **two fold degenerate** for a particle trapped in a 2D infinite potential well.

(04 marks)

c. Write the n_x and n_y values of the two different states corresponding to the energy you mentioned in part (b).

(04 marks)

d. Give an example of an energy level (in terms of ground state energy E_0) which is **three fold degenerate** for a particle trapped in a 2D infite potential well.

(04 marks)

e. Write the n_x and n_y values of the three different states corresponding to the energy you mentioned in part (d).

(04 marks)