Uva Wellassa University, Sri Lanka
End Semester Examination – July 2010
SCT 351-3 Materials Physics

Time: Three (03) hours

Total 06 Questions
Answer ALL questions

PART - A

01) a. i. State Heisenberg uncertainty principle. (10 marks)

ii. Calculate the uncertainty in the position of a baseball thrown at a 150 kmh^{-1} if we measure its velocity to a millionth of 1 %. Mass of the baseball is 150 g. (10 marks)

b. i. Explain Einstein's photoelectric effect. (10 marks)

ii. The work function of a material refers to the minimum energy required to remove an electron from the material. Assume that the work function of gold is 4.90 eV and that of cesium is 1.90 eV. Calculate the maximum wavelength of light for the photoelectric emission of electrons for gold and cesium. (20 marks)

02) a. Write down the 1-D time independent Schrödinger equation. (10 marks)

b. By solving the 1-D time-independent Schrodinger equation for each case, show that although the energy of a particle confined into one-dimensional infinite potential well ("a particle in a box") is quantized, the energy of a particle moving in a free space with zero potential function is not quantized.

Show clearly the boundary conditions you used to solve the 1-D Schrödinger equation in each case. (25 marks)

c. A wave function $\Psi(x)$ has the form of $\Psi(x) = Axe^{-2x}$ for $0 \leq x \leq 1$. Find A so that

$$\int_0^1 |\Psi(x)|^2 \, dx = 1$$

Hence find the normalized wave function. (15 marks)

PART - B

03) a. Explain why most of the solids are crystalline in nature. (8 marks)

b. Distinguish between *single crystals* and *polycrystalline* solids. (8 marks)

c. If atoms are considered as contacting hard spheres, show that the *bcc* packing fraction is 0.68. (10 marks)

d. Describe the prescription for indexing a plane in the miller system. Illustrate the following planes (011), (311), (201) of a simple cubic lattice, in separate sketches. (12 marks)

e. AgI has zincblend type structure and its cell constant is 6.47 Å. Find the least distance between Ag and I atoms. (12 marks)

04) a. Explain X-ray diffraction in determining the structures of crystalline materials. (10 marks)

b. Show that in *bcc* structure, reflections from odd $h' + k' + l'$ are missing. Here h', k' and l' are Miller indices of the planes. (Hint: find the diffraction amplitude of bcc structure.) (10 marks)

c. On an X-ray powder photograph of a cubic substance taken with Cu kα radiation ($\lambda = 1.542$ Å) lines are observed at Bragg angles 12.3, 14.1, 20.2, 24.0, 25.1, 29.3, 32.2 and 33.1. Determine the crystal structure and the lattice parameter. (30 marks)

PART – C

05) a. What are the differences between Maxwell Boltzmann, Bose- Einstein and Fermi-Dirac statistics?

(10 marks)

b. i. Write down the Maxwell Boltzmann law of distribution of speeds.

(8 marks)

ii. Graphically represent the Boltzmann velocity distribution of gas molecules for three different temperatures.

(10 marks)

iii. Briefly explain the effect of temperature on the distribution of speed.

(10 marks)

iv. Calculate the value of mean square speed of a molecule of oxygen at 27 °C.
Boltzmann constant = 1.38×10^{-23} m^2 kg s^{-2} K^{-1}
Avogadro number = 6.022×10^{23} mol^{-1} (12 marks)

06) a. State which statistics (classical Maxwell-Boltzmann; Fermi-Dirac; or Bose-Einstein) would be appropriate in these problems and explain why.

i. Density of ^4He gas at room temperature and pressure.

ii. Density of electrons in copper at room temperature.

iii. Density of electrons and holes in semiconducting Ge at room temperature.
(Ge band gap ~1 volt) (25 marks)

b. A cubically shaped vessel 20 cm on a side contains diatomic H_2 gas at a temperature of 300K. Each H_2 molecule consists of two hydrogen atoms with mass of 1.66×10^{-24}g each, separated by ~ 10^{-8} cm. Assume that the gas behaves like an ideal gas.

i. What is the average velocity of the molecules?

ii. Derive the values expected for the molar heat capacities C_p and C_v for such a gas.

(25 marks)

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