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D 42176 (Pages : 3) Name.....

Reg. No.....

FIFTH SEMESTER B.TECH. (ENGINEERING) DEGREE EXAMINATION, DECEMBER 2007

EE 04 506—ELECTRICAL ENGINEERING MATERIAL SCIENCE

(2004 admissions)

Time : Three Hours Maximum : 100 Marks

Constants :

$K = 1.38 \times 10^{-23}$ JK^{-1}

$h = 6.62 \times 10^{-34}$ JS

$e = 1.60 \times 10^{-19}$ C

$m = 9.11 \times 10^{-31}$ kg

$\epsilon_0 = 8.85 \times 10^{-12}$ Fm^{-1}

I. (a) Use diffusion and energy band diagrams to illustrate how a *pn* junction is formed, showing clearly in the band diagram, the position of E_f and any band bending that may result. Annotate the diagrams with all information, especially the built in potential V_o.

(b) Illustrate some applications of Hall magnetic switches and summarise briefly their main features.

(c) Draw a diagram which clearly shows the energy levels and sublevels associated with electron energies in an atom and the maximum population of each of these levels. How do the 4 quantum numbers relate to these energy levels ?.

(d) Name and describe the types of primary bonding that can occur between atoms. How is primary bonding different to secondary bonding ?

(e) Use diagrams to describe *n*-type and *p*-type doping of Group IV semiconductors. Explain carrier flow under an electric field for intrinsic and for impurity semiconductors.

(f) Calculate the built in voltage developed by a *pn* junction operating in the saturation region, with $N_A = 10^{22}/m^3$. $N_D = 10^{18}/m^3$ and an nintrinsic carries density of $10^{16}/m^3$.

(g) Name some applications where the installation of a PV system is fuly justifiable on the grounds of conventional economic arguments.

(h) What advantages do PV systems have in comparison to diesel pumping ?

(8 × 5 = 40 marks)

II. (a) The electron density in the conduction band of a semiconductor can be derived as $N_e = N_c \exp -\left(\frac{E_u - E_f}{KT}\right)$ where $NC = 2\left\{\frac{2\pi M_e KT}{h^2}\right\}^{3/2}$. Use this term and a similar one for holes in the valence band to show that E_f in an intrinsic semiconductor lies close to Ec/2.

Or

Turn over

(b) Show that the magnetisation (M) of a ferromagnetic material can be expressed in the form

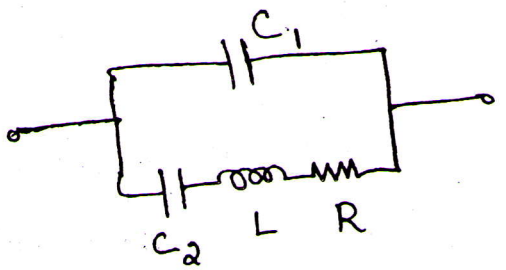
$$\frac{M}{N\mu_m} = \frac{T}{3T_c}\left\{\frac{\mu_m \mu_o \lambda M}{KT}\right\}$$

where H = 0. Discuss the significance of this equation at $T < T_c$ and $T > T_c$. T_c is curie temperature.

(15 marks)

III. (a) (i) Using the complex permittivity $\epsilon^* = \varepsilon' - j\epsilon''$, show β and tan δ of the capacitor can be written as : $\beta = \tan\lambda = \frac{\sigma}{w\varepsilon'}$. Comment on the significance of the above equation.

(ii) Consider the circuit in the figure. Show that the admittance of their circuit is given by



$$Y^* = jC_1 w + \frac{jw/L}{w_o^2 - w^2 + jRw/L} \quad \text{where } w_o^2 = 1/LC_2.$$

(15 marks)

Or

(b) (i) An atom has a polarizability of 10^{-40} farad m^2. It finds itself at a distance of 10 angstroms from a proton. Calculate the dipole moment induced in the atom and the force with which the proton and the atom attract each other.

(7 marks)

(ii) A point dipole of μ coulomb m finds itself at a distance of α meters from the centre of an atom of polarizability α farad m^2, the direction of μ is parallel to the line joining the dipole and the centre of the atom. Find the dipole moment induced in the atom.

(8 marks)

IV. (a) The magnetic field strength in a piece of Fe_2O_3 is 10^6A Ampere m^{-1}. Given that the susceptibility of Fe_2O_3 at room temperature is 1.4×10^{-3}. Find the flux density and the magnetization in the material. Compare the answer with those of the preceding problem. What is the magnetization at the temperature of liquid nitrogen ?

Or

(b) The temperature difference between the inside and outside at a glass window is 72° Fahrenheit. The glass has a thermal conductivity of 0.0025 calories $sec^{-1}Cm^{-1}$ $degree^{-1}$ and is 1 mm thick. Find the energy loss in joules through the window per m^2 per hour.

(ii) Explain the liquid insulators.

(15 marks)

V. (a) **Explain the following terms :**

(i) **Magnetic resonance.**

(ii) **Electron magnetic resonance.**

(iii) **Electron spin resonance.**

(iv) **Ferromagnetic resonance.**

(15 marks)

Or

(b) **What is the difference between photothermal conversion and photovoltaic conversion with examples.**

(15 marks)

(4 × 15 = 60 marks)