DEPARTMENT OF PHYSICS, IIT DELHI
MAJOR EXAM (EPL-206)
May 4 (Friday), 2006

Time : *13:00 – 15:00 Hrs* Max. Marks: *50*

1. Gold has the FCC Crystal Structure, a density of *19.3 gm/cm*^{3} and an atomic mass of *196.97 amu (gm/mol).*
   (a) Calculate the atomic concentration, lattice parameter, and the atomic radius of gold.
   (b) If an X-ray diffraction of this gold crystal is done find the condition for which the first two lines are only seen. *5*

2. If α_1 is the temperature coefficient of resistivity ρ at temperature T_1 and α_0 is the temperature coefficient of resistivity at T_0, show that $\alpha_1 = \dfrac{\alpha_0}{1+\alpha_0(T_1 - T_0)}$ *4*

3. Consider a semi-classical model of the ground state of the hydrogen atom in an electric field normal to the plane of the orbit. Show that the polarizability of atomic hydrogen in this model is proportional to a_H^3, where a_H is the radius of the unpurturbed orbit. *4*

4. A parallel plate capacitor has an area of *20 cm*^{2} and separation between the plates, *0.2 mm*. The space between the plates is filled with a dielectric material having the real part of the dielectric constant, *2.5* when subjected to a *2* volt alternating voltage at *1 MHz*. The loss tangent at this frequency is 4×10^{-3}. Find the elements of an equivalent parallel *R-C* circuit. *3*

5. State if the following statement (i to iii) are true or false: *7*
   (i) "Saturation magnetization $\mathbf{M_s}$ is a structure-sensitive property of a magnetie material"
   (ii) "That μ_{atom}=0, is valid for diamagnetic as well as paramagnetic material"
   (iii)"Each domain in a FM material has a saturation value of magnetization $\mathbf{M_s}$ in its demagnetized state"
   (iv) Why amorphous magnetic materials have lower coercivities?
   (v) What is the origin of hum noise that one hears near the power transformers?
   (vi) Why the *4s*-band in iron does not possess spin imbalance?
   (vii) Alloys like MnBi and Cu_2MnSn do not possess any ferromagnetic element, and yet they are ferromagnetic. Why?

6. (a) From the view point of origin, describe the difference between the Anisotropic and Giant Magnetoresistance effects. *4*
   (b) Discuss qualitatively as how does single domain particles possess higher coercivity. *2*

7. An alloy of copper and cobalt consists of spherical precipitates, averaging *10 nm* diameter, of pure cobalt in a matrix of pure copper. The precipitates form *2 %* by volume of the alloy. Cobalt is ferromagnetic, with saturation magnetization of *1.4 MA/m*. Each cobalt precipitate is a single domain, and acts as a string dipole. Calculate the susceptibility of the alloy at *300K*. *6*

8. (a) With the help of diagrams only (No description!), show the flux distribution when (i) a perfect conductor and (ii) a superconducting sample are subjected to an applied field of strength H_a ($<H_c$ of the superconducting sample) following the two history of field application i.e., Zero Field Cooling (ZFC), and Field Cooling (FC). *4*

   (b) A hollow superconducting cylinder is cooled below the transition temperature T_C; (a) in presence of applied magnetic field H_a (i.e., FC) and in another case (b) it was initially cooled in absence of H_a, then a field was applied at the lowest $T < T_C$ (i.e., ZFC). Draw diagrams showing the hollow superconductor and the induced currents in the two cases. *2*

9. (a) What is the frequency of the cleetromagnetic waves radiated by a Josephson junction having a static voltage of 650μV across its terminals. *2*

   (b) Calculate the value of London penetration depth λ at 0K and 3.61K for lead whose density is 11.3×10^3 kg/m^3 and the atomic weight is 207.19. The T_c of lead is 7.22K. *3*

10. Compare the magnetization versus field strength curve of a Type-I superconductor in bulk and thin film form. Explain briefly the origin of the different magnetization in the two cases. *4*

Useful constants:

$h=6.62\times10^{-34}$ J s; $e=1.6\times10^{-19}$ C; $m_o=9.1\times10^{-31}$ kg; $\mu_o=4\pi\times10^{-7}$ H/m, $\varepsilon_o=8.85\times10^{-12}$ F/m; $k_B=1.38\times10^{-23}$ J/K