BIRLA INSTITUTE OF TECHNOLGY AND SCIENCE, PILANI (RAJASTHAN)
Second Semester 2022-2023

Comprehensive Examination (Closed Book)

PHY F344	**Advanced Physics Lab**	**Weightage: 40%**
Date: 05/5/2023	**Duration: 2 hr.**	**Full Marks: 120**

Name: **ID No.** **Marks obtained:**

Materials Physics Lab questions: 24 Marks

Q1. Draw schematically the impedance spectroscopy Nyquist plots (Z′-Z′′) for (i) a metal (ii) a semiconductor (iii) single crystal ionic conductor, (iv) a polycrystalline ionic conductor, (v) a perfect insulator **[5]**

Q2. The first four peaks of a neutron diffraction pattern (You may consider the diffraction angles as 26, 30.1, 42.8 and 50.2 degrees) for a FCC crystal structure are obtained using neutron radiation having a wavelength of 0.109 nm. (a) Index (i.e., give h,k, and l indices for) each of these peaks (b) Determine the interplanar spacing for each of the peaks and (c) Lattice parameter from each peak **[6]**

Q3. Find, (i) electrical conductivity and its corresponding temperature and (ii) from the conductivity-temperature data, the activation energy for ionic conduction in electron volts from the following data in the Table. Room temperature you may take as 30 °C. The sample is in the shape of a cylindrical pellet of 5 mm thickness and 10 mm diameter. **[8]**

Thermocouple voltage (mV)	Resistance (Ω)
0.12	248916
0.70051	137875
1.24	82820
1.6731	53304
2.04	41486

Q4. Drawing a schematic diagram, explain the working principle of differential scanning calorimetry. **[5]**

Microwave Lab questions: 24 Marks

1. Draw the cross-sectional (along the length)view with the electrical connections of a Klystron tube. **[4]**

2. Draw the top view of Michelson's experimental setup with the name of the most 3 important components in the set up excluding power supply and oscilloscope. **[4]**

3. What should be the exact difference between (the position one reflector plate) the successive minima (in cm) for a microwave of frequency 12 GHz in Michelson's experiment. Write only the value in cm. **[5]**

4. Draw (side view) a clear design of the set up to measure E-plane characteristic of pyramidal horn antenna within the radiation zone approximately from -50^0 to 50^0 without using 'twist' component. Hint. Think about the symmetry planes of the set up geometry. **[5]**

5. Calculate the wavelengths of microwaves represented as λ_{21}, λ_{22}, λ_{13} and λ_{31} for microwave propagation in TE mode inside a rectangular waveguide of H- and E- plane dimensions are 3.0 cm and 2.5 cm respectively. Write only the value of λ in cm. No need to show the derivations/calculations. [**1.5×4]**

Liquid Crystals Lab questions: 24 Marks

(Given $\varepsilon_o = 8.854 \times 10^{-12}$F/m)

1) Using the interferometric technique for measuring the thickness of the cell, a student reports she observed the 0^{th} fringe at 463nm, _____will be the value of 6^{th} fringe as reported by the student. Given the thickness and area of an empty cell used in this experiment is 9μm and 60 mm^2 respectively. The geometrical capacitance of the cell is _____. **[3+3]**

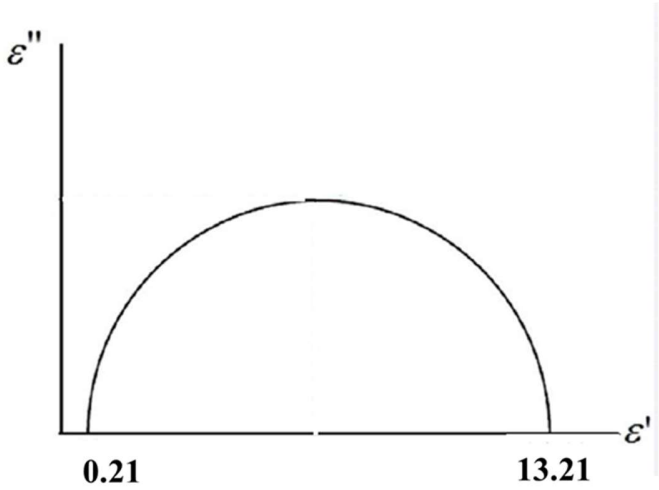
2) For a nematic LC filled in a 10 μm thick cell, the values of splay elastic constant (K_{11}) and dielectric anisotropy ($\Delta\varepsilon$) measured at certain temperature is 6 pN and 8 respectively. The threshold voltage (V_{th}) of nematic liquid crystal at this temperature is _____. **[6]**

3) The birefringence ($\Delta\mu$) of a NLC at room temperature is 0.15. If a laser of 630 nm is incident on a 7.5 μm planar cell filled with this NLC kept between crossed polarizers with its rubbing direction making angle of 45° with either of the polarizers then the phase retardation ($\Delta\varphi$) of the NLC enclosed in this cell at room temperature is_____. **[4]**

4) A homeotropic cell having thickness 10 micron and area 120 mm^2 is filled with positive anisotropy nematic liquid crystal. An ac signal is applied to this cell **[5+1+1+1]**

a) Estimate the loss factor of this NLC at 5kHZ, if measured values of capacitance and resistance are 980 pF and 250 kΩ respectively . _____

b) The static and high frequency values of dielectric permittivity of NLC exhibiting a relaxation frequency of 10 MHz shown figure given below are _____ and _____respectively. What is this plot shown in this figure called?_____



Surface Physics Lab questions: 24 Marks

Each terms have their usual meaning. Answer to the point

1. Answer short type questions related to ellipsometry: **[3+6]**

   a) During the measurement, if P1 is found to be 78°, what is the value of P2?

   b) The ellipsometric parameters are given as $\psi = 60^o$, $\Delta = 25^o$. The Fresnel's coefficient r_p and r_s are related as: $r_s = 0.25 + r_p$, calculate the coefficient r_p and r_s.

a)	b)

2. For the given redox reaction at the surface of working electrode during the electrochemical measurements,

$$[Fe(CN)_6]^{3-} + e^- \leftrightarrow [Fe(CN)_6]^{4-}$$

   a) If the peak anodic current observed at 27°C is 1.26 μA. Find out its value at 100°C, if all the physical parameters were kept constant. **[3+4]**

   b) Further at 100°C, if the scan rate is changed from 100mv/s to 400mV/s (rest parameters are still the same), will there be any change in the peak anodic current value? If yes, then calculate the value.

a)	b)

3. a). Draw and illustrate the schematic for atomic force microscopy. **[4+4]**

   b). If the potential of interaction between the tip and the sample is defined by $\boldsymbol{U = \frac{75A}{r^8} - \frac{125B}{r^4}}$, where A and B are constants and r is the tip-surface separation. Find the distance (in terms of A and B) between tip-surface for which the tip will feel equilibrium force.

a)	b)

Nanotechnology Lab questions: 24 Marks

Each question of this section carries 4 marks **[6×4]**

Q1. Two separate vacuum deposition units can reach to vacuum levels of 3×10^{-6} mbar and 5×10^{-6} mbar, respectively. If the mean free path of metal vapour atoms during the deposition is found to be 30 cm in Unit-1, what will be maximum possible dimension of the Unit-2 chamber?

Q2. During the operation which of the following pumps does not need any roughing pump? (a) Oil diffusion pump, (b) Ion getter pump, (c) Turbo molecular pump, (d) Cryo-pump (e) Rotary pump and (f) Titanium sublimation pump.

Q3. Electrical conductivity and electron mobility for copper are 3×10^{6} $(\Omega\text{-m})^{-1}$ and 0.01 m^2/V-s, respectively. Find the Hall voltage generated within a copper sheet of thickness 2 mm when a current of 3 A flows and a magnetic field of 1 T is applied mutually perpendicular to that. [electronic charge e $=1.6\times10^{-19}$ C]

Q4. Within a metal ***X,*** another metal ***Y*** is present as an impurity. At what atomic percentage of metal ***Y***, the resistivity due to impurity (ρ_i) will be maximum?

Q5. A material is placed in an external magnetic field of 10 units and shows a magnetization of 60 units. Find the magnetic permeability μ_m and flux density B of the material. [Given that free space permeability $\mu_0 = 1$ unit]

Q6. Write down the *Curie-Weiss Law* related to the temperature (T) dependent magnetic susceptibility χ_m of a ferromagnetic material mentioning each parameters.