

**BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI**  
**ADVANCED PHYSICS LAB**  
**Midsemester Examination 2021-22 II semester**  
**Advanced Physics Laboratory**

**Closed Book**

**90 Marks**

**90 min.**

**12<sup>th</sup> March 2022**

**Answer all questions in respective section and in sequence ONLY**

**Answer all questions in sequence**  
**Exchange of calculators strictly not allowed.**

**You may require:**  $k_B = 1.38 \times 10^{-23}$  J/K,  $1\text{eV} = 1.6 \times 10^{-19}$  J,  $\epsilon_0 = 8.854 \times 10^{-12}$  F/m,  $h = 6.62 \times 10^{-34}$  J-s

**Section A : Materials Lab (30 Marks)**

**Q1.** Justify, despite of a significant different in ionic radii, why cation and anion vacancies always formed together. Plot schematically temperature dependence of defect concentration. [2+2]

**Q2.** (a) Plot Differential thermal analysis scans for as prepared glass (up to  $T >$  melting point) in (i) first heating cycle (ii) first cooling cycle and (iii) second heating cycle and (iv) second cooling cycle [4]

(b): Plot schematically the electrical conductivity versus inverse of temperature for (i) pure semiconductor (ii) a doped semiconductor (iii) NaCl type ionic conductor (iv) AgI in cooling cycle in separate plots. Plot should be in wide temperature range [4]

**Q3.** (a) Why ac measurements are required for measuring conductivity of ionic solids? [3]

**Q4.** From the following data, find the activation energy for ionic conduction in *electron volts*. The value of room temperature you may take as 27 °C. Sample is in the shape of a cylindrical pellet of 3 mm thickness and 8mm diameter. [6] **Write only answer in a box.**

Thermocouple voltage (mV)	Resistance ( $\Omega$ )
0.12	248916
0.70	137875
1.24	82820
1.67	53304
2.04	41486

**Q5.** 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 a 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. **write only answers for (a) (b) and (c) in a Table.** [3 x 3]

**Section B: Microwave Lab (30 marks)**

- Q.1. Draw a clear schematic diagram of the cross-sectional view of the Klystron tube. What do you mean by electrical tuning of Klystron tube? [5+5]
- Q.2. Draw the top view of Michelson’s experimental setup with 3 most important clear points. What are the precautions one has to take to perform the experiment? [5+5]
- Q.3. 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. [10]

**Section C: LC Lab (30 Marks)**

1. The planar cell of thickness 10 micron and empty capacitance 100 pF is filled with a nematic liquid crystal ( $\Delta\epsilon = 10$ ). The measured value of capacitance at room temperature by applying  $V < V_{th}$  is 540 pF. Calculate  $\epsilon_{||}$ ,  $\epsilon_{\perp}$  and  $\langle\epsilon\rangle$ . [5]
2. Calculate the rise time and decay time of the LC if rotational viscosity is  $0.05 \text{ N/m}^2$  and elastic constant is  $15\text{pN}$  at driving voltage of  $10\text{V}$ ? Given the threshold voltage is  $0.8\text{V}$ . [6]
3. A homeotropic cell having thickness 10 micron and area  $100 \text{ mm}^2$  is filled with positive anisotropy nematic liquid crystal. At applied field of  $5\text{kHz}$ ,
  - a) What is the ac conductivity of the filled cell if measured values of capacitance and resistance are  $900 \text{ pF}$  and  $200 \text{ k}\Omega$  respectively. [6]
  - b) Calculate the activation energy using data given in table below. [6]

Temperature (°C)	Relaxation Frequency
34	5.00
36	5.20
38	5.35
40	5.50

4. i) From the thickness measurement of the empty cell with electrode area  $80 \text{ mm}^2$  it was found that the wavelength corresponding to  $m^{\text{th}}$  maxima is  $480 \text{ nm}$ , and the wavelength corresponding to  $n^{\text{th}}$  maxima is  $550\text{nm}$ . Calculate the value of  $(m-n)$  and empty capacitance value. (Given, the thickness of the cell is  $10 \text{ micron}$ ). [4]
- ii) What is the difference between thermotropic and lyotropic liquid crystals? Give an example for lyotropic liquid crystals. [3]