UNIVERSITY OF CAMBRIDGE

ENGINEERING TRIPOS PART IIB

Tuesday 26th April 2005 9.00 to 10.30

Module 4B17

PHOTONICS OF MOLECULAR MATERIALS

*Answer not more than **three** questions*

All questions carry the same number of marks

*The **approximate** number of marks allocated to each part of a question is indicated in the right margin.*

There are no attachments.

You may not start to read the questions printed on the subsequent pages of this question paper until instructed that you may do so by the Invigilator

(TURN OVER)

1 (a) Describe the splay, twist and bend director deformations in a nematic liquid crystal. What is a Freedericksz transition? Describe how it may be used to measure experimentally the three elastic constants that characterize splay, twist and bend deformations. [40%]

(b) Explain the principles of operation of a twisted nematic device. Describe how such devices may be used to construct colour displays using passive matrix addressing. [30%]

(c) At room temperature a planar aligned nematic liquid crystal of dielectric anisotropy, $\Delta\varepsilon$ (equal to 12), has a threshold voltage of 1V. Calculate the elastic constant under these conditions and state which director deformation this corresponds to. [30%]

Note: The permittivity of free space $\varepsilon_o = 8.854 \times 10^{-12}$ Fm^{-1}

2. (a) Describe the main molecular features of a side chain polymer liquid crystal and explain how such materials may be used for "write many times" optical data storage. [60%]

(b) Describe an apparatus suitable for recording optical data on liquid crystal films. Include typical values of the key physical parameters in your description. [40%]

3. (a) Explain the differences between a weakly first-order phase transition and a second-order phase transition in liquid crystals. Describe an experiment that would allow you to differentiate between these two types of transitions and give typical data. [40%]

(b) Describe the construction and operating principles of a liquid crystal thermometric device. [60%]

4. (a) Explain how the chiral Smectic C phase may be used to give ferroelectric switching in a surface stabilised electro-optic shutter. [40%]

(b) Discuss how the cone angle θ and the birefringence δn vary as a function of temperature. Explain the significance of this variation for the operation of the shutter described above. You may assume that the transmitted intensity is given by

$$I_t = I_0 \sin^2(4\theta) \sin^2(\pi \delta n d / \lambda),$$

where I_0 and λ are the incident intensity and wavelength, respectively, and d is the thickness of the ferroelectric liquid crystal film. [20%]

(c) Compare and contrast the above device with one based on the dye guest-host effect in the ferroelectric phase. Discuss how the response time varies with applied field and temperature for one of these devices. [40%]

5. (a) A typical thermotropic liquid crystal mesogen may be considered as being composed of aromatic (or benzene) rings, bridging groups and terminal alkyl chains or polar head groups. Describe how changes in each of these components alter the phase diagram exhibited by such a liquid crystal as a function of temperature. What is the odd-even effect? [50%]

(b) Describe the construction and operation of a polymer dispersed liquid crystal display. Discuss how the optical switching properties might be optimised. [50%]

END OF PAPER