ENGINEERING TRIPOS PART IIB

Wednesday 6 May 2009 2.30 to 4

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.

STATIONERY REQUIREMENTS	SPECIAL REQUIREMENTS
Single-sided script paper	Engineering Data Book
Graph Paper	CUED approved calculators allowed

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

1 (a) Describe the molecular order characteristic of the nematic, chiral nematic and smectic A mesophase and describe an experiment by which such liquid crystal phases may be identified. [60%]

(b) Describe how an electro-optic light scattering device could be made:

(i) using a nematic phase;

(ii) using a smectic A phase.

Compare and contrast the static and dynamic properties of these devices [40%]

2 (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 16), 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 $\varepsilon_0 = 8.854 \times 10^{-12}$ Fm^{-1}

3 (a) Dichroic dyes may be incorporated in so called dye-guest-host liquid crystal devices. Describe the principles of operation of a polariser free single layer nematic electro-optic device based on the dye-guest-host effect. Why would this device be wavelength specific? [50%]

(b) A dye-guest-host nematic device has a peak absorption at 600 nm and a dichroic ratio of 8:1. Sketch the absorption curves for the 'on' and 'off' states of the device and calculate the order parameter of the nematic material. [30%]

(c) Compare and contrast the relative merits of a dye-guest-host based nematic device with one constructed using a twisted nematic geometry. How would you make such devices appear emissive? [20%]

4 (a) Based on Landau theory, explain how the concept of a weakly first order and a second order phase transition arises in a nematic liquid crystal. [20%]

(b) Describe the construction and operating principles of a thermal sensor that relies on a second order phase transition in a chiral nematic material for its operation. [20%]

(c) Describe how such a chiral nematic material may be used to construct a microscopic laser cavity. Discuss the operating principles of such a laser and describe the main features of the output light, in terms of the liquid crystalline properties, assuming the laser is driven by nanosecond light pulses. How would you differentiate between laser and other forms of light emission? Describe how you could tune the wavelength output of the laser and give typical data. [60%]

END OF PAPER