BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI (RAJ)

Comprehensive Examination (Closed Book)
SECOND SEMESTER 2022-2023
Soft Condensed Matter Physics (PHY F416)

Date:15th May 2023

Max. Time:3 hrs Max. Marks:120

I. Answer all questions. Each question carries 3 marks. **[30M]**

1. The collective diffusion constant of a polymer solution is _____

2. The osmotic pressure in lattice model of polymer solutions for dilute solutions is _____.

3. Expression of Vander Waals potential is_____.

4. Equilibrium thickness of a liquid film on a substrate is _____.

5. Two ways using which the interaction between colloidal particles can be changed from repulsive to attractive_____ _____

6. Peclet number of a colloidal system can be expressed as the ratio of _____ .

7. The order parameter of the nematic liquid crystal is written as _____

8. The gel fraction described using Flory Stockmeyer theory in terms of no. of reacted bonds *f* is written as_____

9. The force $F_i^{(e)}$ needed to change the slow variable x_i at rate $\dot{x}_i$ is related to the Rayleighian *R* of a system can be expressed as_____.

10. The free energy of a nematic LC without any spatial gradient in nematic ordering using Landau de Gennes theory is _____.

a. depends on both S and $\hat{n}$

b. depends only on $\hat{n}$ and not on S

c. depends only on S and not on $\hat{n}$

II. Answer any 6 questions. Each question carries 10 marks. **[60M]**

i. Calculate the value of critical magnetic field to switch the rod shaped nematic liquid crystal. Given some of the relevant parameters of the LC are: splay elastic constant = 12 pN, thickness of the sandwich LC cell = 10 μm, magnetic susceptibility anisotropy = 109 $\times 10^{-12}$ m^3 kg^{-1}.

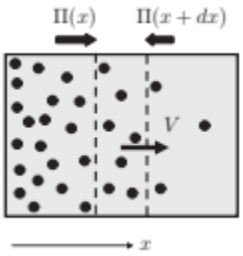
ii. What is Sol- gel transition? Name any two types of gels and explain the differences between them.

iii. By plotting the interaction potential as a function of gap between the colloidal particles discuss the condition for which a stable colloidal dispersion can be achieved.

iv. Plot the profile of the number density $n_i(z)$ of molecules of species *i* against the coordinate taken along the axis normal to the interface. With the help of this plot and proper expression define the term surface excess.

v. Derive the terminal velocity for a colloidal particle in a liquid using Stoke's law.

vi. Obtain the diffusion equation for brownian particles by consideration of the forces acting on brownian particles.



vii. Plot the typical behavior of the density correlation function g(r), and the scattering function S(k). Mark the number of correlated segments N_c and the correlation length l_c in this plots. Express the relation between S(k) and N_c, l_c in the Ornstein–Zernike form.

III. For a fluid flow in porous media using the Onsager principle derive the Rayleighian describing this system. **[15M]**

IV. Taking into effect spatial gradient on the nematic order, discuss how order parameter in a sandwich cell will get affected. Write down the correlation length in terms of the relevant elastic constants and other relevant parameters. Also sketch the Order parameter as a function of distance from one of the bounding walls. **[15M]**

(k_B= 1.3806452 x 10^{-23} J/K; N_A= 6.02214076×10^{23} mol^{-1}; ε_o=8.854×10^{-12}F/m)

-----All the best-----