# M. Sc. Physics Examination, 2023

( 2nd Year, 2nd Semester )

( 3rd Year, 2nd Semester )

**Subject : Soft Condensed Matter Physics**

**Paper – 305**

Time : 2 hours Full Marks : 40

Answer **four** questions, one from each section

See the bottom for the description of Course Outcomes (COs)

## Section A

1. (a) What is the basic criteria for molecules to exhibit liquid crystalline phases? Describe how can you identify isotropic, nematic and smectic liquid crystalline phases in an experiment.
   (b) Give an example of molecule which can exhibit nematic phase at room temperature
   (c) Define tensor order parameter of nematic liquid crystal. Discuss the properties of the tensor order parameter. 1+3+1+2+3 (CO1)

OR

2. (a) What is Lennard-Jones potential?
   (b) Describe with the help of a suitable diagram how induced dipole-induced dipole moment is generated between two neutral species.
   (c) What are the weak interactions observed in an aqueous system? Describe why H-bond plays a significant role in an aqueous system in spite of having low dissociation energy.
   (d) Derive the Stoke-Einstein equation for the diffusion of spherical particles.
   2+2+(1+2)+3 (CO1)

## Section B

3. (a) Total free energy change per molecule in going from isotropic to nematic phase transition is

$$\Delta F = -\frac{uS^2}{2} + K_B T \int f(\theta) \ln\left(4\pi f(\theta)\right) d\Omega$$

Discuss how will you obtain the most probable distribution function $f(\theta)$.

(b) Plot the free energy as a function of order parameter. Discuss the nematic-isotropic transition for different values of strength of interaction parameter $u$. In the onset of nematic phase, what is the critical values of order parameter and $\frac{u}{K_BT}$? Show the behavior of coupling parameter $u/K_BT$ with order parameter. 3 + 2 + 3 + 2 (CO4)

OR

4. (a) How do you determine the glass transition temperature? What is isothermal volume recovery in glass? Describe with the help of a suitable figure.
(b) What is the main difference between the information obtained from small angle X-ray scattering and the small angle neutron scattering for a polymer sample?
(c) What is hydrodynamic radius? Describe a technique which can determine the hydrodynamic radius of particles in suspension.
(2+2)+2+(1+3) (CO4)

## Section C

5. (a) What are the different modes of deformation in the nematic liquid crystals. Write the elastic free energy per unit volume of a nematic liquid crystal.
(b) Sketch and explain the structure of smectic A and cholesteric liquid crystals.
(c ) Why do liquid crystalline sample show birefringence under cross polarizer ?
(d) What are the different types of defects in nematic liquid crystal? Can you suggest any experiment where the manifestation of such defects can be observed?
2+2+4+1+1 (CO2)

OR

6. (a) Derive the Poisson-Boltzmann equation for a charged colloidal particle in an electrolyte solvent. Describe the formation of an electric double layer for a charged particle.
(b) From the DLVO theory, how can we describe the stability of colloidal suspension? Using a suitable plot, show the three possible types of colloidal suspensions. How can the stability of the colloidal particles be improved?
(d) What are the Flick's laws for translational diffusion of particles?
(3+1)+(2+1+1)+2 (CO2)

## Section D

7. (a) What is hydrophobic interaction?
(b) State the conditions of thermodynamic equilibrium of self assembly phenomenon of amphiphiles.
(c ) Describe typical phase diagram of surfactant-water system. State the factors affecting the phase behavior of the surfactant-water system.
(d) Discuss with schematic diagram of fluid lamellar phase formed by lipid-water system.
(2 + 2 + 2 +2 + 2) (CO3)

OR

8. (a) What is rheology? With the help of a suitable diagram, distinguish between shear thinning and shear thickening.
(b) With the help of a simple experiment, describe viscoelastic fluid behavior of a non-Newtonian fluid.
(c) Describe the steps involved in free radical polymerization. What is the basic difference between cationic and anionic polymerizations?
(2+2)+2+(3+1) (CO3)

CO1: to learn basics of soft materials and its applications
CO2: Introduce various soft materials, such as liquid crystal, polymer, colloids etc
CO3: Know the viscoelastic properties of liquid crystal and other soft materials and to study different molecular interactions present in soft materials
CO4: Gain insights into the structure of soft materials and to learn physics of phase transition in these systems.