

M.Sc. 4th Semester Examination, 2021
PHYSICS
(Molecular Spectroscopy-II & Nonlinear Dynamics)
Course Code: 401C
Course ID: 42451

Time: 2 Hours

Full Marks: 40

*The figures in the right hand side margin indicate full marks.
 Candidates are required to give their answers in their own words
 as far as practicable.*

Unit-I

- 1. Answer any three of the followings:** **2×3=6**
- (a) When do 'fluorescence' and 'phosphorescence' occur? Compare their lifetimes.
- (b) If an unpaired electron gives ESR at 30GHz when the magnetic field is 1.24 tesla, find the electron g -factor.
- (c) Draw the schematic diagram of an ESR spectrometer with essential components.
- (d) What do you mean by indistinguishable configuration?
- (e) What is the interaction energy when a nucleus interacts with magnetic field?
- 2. Answer any two of the followings:** **4×2=8**
- (a) (i) Why does Photoacoustic spectroscopy (PAS) require pulses of light instead of a continuous steady source of light to hit the sample?
- (ii) Which of vibrational and electronic excitations produce more heat? Why?
- 2+2=4
- (b) Prove that $i^2=E$ with the help of an octahedral molecule. What do you mean by symmetric elements under the property of group theory. 2+2=4
- (c) Explain the principle of Nuclear Magnetic Resonance (NMR). Why the microwave sources and detectors are used in ESR? 2+2=4
- (d) Discuss the splitting of energy levels during the interaction of nuclear spin with magnetic field.
- 3. Answer any one of the followings:** **6×1=6**
- (a) Find the symmetry elements present in the following molecules (i) H₂O, (ii) BF₃. 3+3=6
- (b) What do you mean by Mossbauer Spectroscopy? Discuss Quadruple shift (Δ) under Mossbauer Spectroscopy. What is spin-spin relaxation and spin-lattice relaxation mechanisms? How is Nuclear Quadrupole Resonance (NQR) spectrum of a compound experimentally studied? (1+2+2+1)=6

Please Turn Over

Unit-II

4. Answer any three of the followings:

2×3=6

- (a) What is Hopf bifurcation?
 (b) Write down Lorentz equation. Prove that it represents a dissipative system.
 (c) The refractive index n of a medium depends on frequency ω . Find the expression for the group velocity and the group velocity dispersion parameter.
 (d) Mention the differences between a *center* and a *limit cycle*.
 (e) Find the fixed points of $\dot{x} = x^2 - 1$, and classify their stability.

5. Answer any two of the followings:

4×2=8

- (a) Construct the Liapunov function of the system

$$\begin{aligned}\dot{x} &= -x + 4y, \\ \dot{y} &= -x - y^3.\end{aligned}$$

Prove that the system has no closed orbit.

2+2=4

- (b) State and explain Poincare-Bendixon theorem. How can you ascertain the existence of closed orbit from this theorem?
 (c) Draw the phase portrait of two-dimensional saddle-node bifurcation and discuss the stability in each cases, i.e., before, at and after the bifurcation.
 (d) Explain the solitary solution of the nondimensionalized Korteweg – de Vries (KdV) equation

$$\frac{\partial u}{\partial t} + 6u \frac{\partial u}{\partial x} + \frac{\partial^3 u}{\partial x^3} = 0.$$

The symbols have their usual meanings.

6. Answer any one of the followings:

6×1=6

- (a) What do you mean by maps? Consider the logistic map equation

$$x_{n+1} = rx_n(1 - x_n),$$

where r is a real positive parameter. Draw the x_n - x_{n+1} plot. Find all the fixed points and determine their stability.

1+1+4=6

- (b) (i) Classify the type of fixed point at the origin and draw the phase portrait for the system

$$\begin{aligned}\dot{x} &= x + y, \\ \dot{y} &= 4x - 2y.\end{aligned}$$

- (ii) Explain the supercritical pitchfork bifurcation of the equation $\dot{x} = -x + \beta \tanh(x)$ for the variation of β .

3+3=6
