

P.G. Semester-IV Examination, 2023**PHYSICS**

Course ID : 42451

Course Code : PHYS-401C

**Course Title : Molecular Spectroscopy-II &
Nonlinear Dynamics**

Time : 2 Hours

Full Marks : 40

*The figures in the right-hand margin indicate marks.**Candidates are required to give their answers in
their own words as far as practicable.***(Molecular Spectroscopy-II)****UNIT-I**1. Answer any **three** of the following questions:

2×3=6

- What are the Stokes and anti-Stokes lines in molecular vibrational spectroscopy?
- What is LCAO approximation?
- Give the electronic configuration of N₂.
- Find the symmetry element of ethylene.
- What do you mean by fluorescence and phosphorescence?

2. Answer any **two** of the following questions:

4×2=8

- What are bonding and anti-bonding orbitals? Illustrate with diagram, the combination of two 1s orbitals forming bonding and anti-bonding orbitals.
- Show the angle between two of sp³ hybrids is 109°28'.
- Derive the expression of dissociation energy of a di-atomic molecule.
- Explain NMR spectroscopy with an appropriate diagram.

3. Answer any **one** of the following questions:

6×1=6

- Compare the MO wave function of the hydrogen molecule with that of the valence bond theory. Using MO concept of electronic configuration of molecules, show that (i) oxygen is paramagnetic and (ii) removal of an electron from O₂ increases the equilibrium dissociation energy and decreases the bond length.
- Deduce the multiplication table for NH₃. Deduce the three-dimensional representation of each of the operations of the point group C₃ for NH₃. Show that C₃ = σ_vC₃²σ_v in C_{3v} point group.

[Turn over]

401/Phs.

[2]

(Nonlinear Dynamics)

UNIT-II

4. Answer any **three** of the following questions :

2×3=6

- a) What is Saddle-Node bifurcation?
- b) Find the fixed points of $\dot{x} = x^2 - 1$, and classify their stability.
- c) What is potential? Explain in the context of nonlinear dynamics.
- d) Mention the differences between a *spiral* and a *limit cycle*.
- e) What type of bifurcation occurs in Logistic Map?

5. Answer any **two** of the following questions :

4×2=8

- a) State and explain Poincare-Bendixon theorem. How does the existence of closed orbit from this theorem ascertained? 3+1=4
- b) Construct the Liapunov function of the system

$$\dot{x} = -x + 4y$$

$$\dot{y} = -x - y^3$$

Prove that the system has no closed orbit.

2+2=4

c) Draw the phase portrait of (i) $\dot{x} = -x^3$ (ii) $\dot{x} = 0$.

d) Consider a particle of unit mass moving in a double well potential: $V(x) = \frac{1}{2}x^2 + \frac{1}{4}x^4$. Find and classify the fixed points. Hence draw the qualitative phase portraits. 2+2=4

6. Answer any **one** of the following questions :

6×1=6

a) Write short notes on any **two** of the following:

3+3=6

- i) Pitchfork bifurcation,
- ii) Transcritical bifurcation,
- iii) Normal form of a bifurcation.

b) Define a limit cycle. How does it differ from a center? With the proper normal form explain supercritical and subcritical Hopf bifurcations.

1+1+4=6