Birla Institute of Technology & Science, Pilani
Hyderabad Campus

SECOND SEMESTER 2023-2024

Course Handout (Part - II)

Date: 09-01-2024

In addition to part-I (General Handout for all courses appended to the time table) this portion gives further specific details regarding the course.

Course No. : **CHEM F412**
Course Title : **Photochemistry and Laser Spectroscopy**
Instructor-in-charge : **Subit Kumar Saha**
Instructors : **Durba Roy, Subit Kumar Saha**

1. Course Description: This course is based on the exposure to theories on photophysical chemistry and LASER spectroscopy and their applications in different fields of biology/chemistry/physics. The course is normally available to students of third year onward or higher level.

2. Scope and Objective of the Course: Common photochemical and photophysical processes and mechanisms, interaction of excited states with their surroundings, photoinduced electron and excitation energy transfer, Different types of applications of fluorescence. Basic knowledge on the construction and function of LASERS, and its use in biophysics, chemistry, and diagnostics. The students will gain knowledge about modern lasers, spectrometers and detectors.

3. Text Books:

T1: K. K. Rohatgi-Mukherjee, Fundamentals of Photochemistry, John Wiley & Sons.
T2: J. R. Lakowicz, Principles of Fluorescence Spectroscopy, Springer; 3rd edition.
T3: W. T. Silvast, Laser Fundamentals, Cambridge University Press; 2nd edition.

4. Reference Books:

R1: Nicholas J. Turro, Modern Molecular Photochemistry, University Science Books, U.S.; New edition.

The syllabus also includes lectures notes.

5. Course Plan:

Lec. No.	Learning Objectives	Topics to be Covered	Learning Outcomes of the Lectures	Chapter in the Text Book
1-3	Basic Laws of Photochemistry	The laws of photochemistry, potential energy surfaces, Frank Condon Principle, absorption, Beer's law, absorption cross-section.	Understand why photochemistry is basic to the world we live in. Appreciate the relevance of photochemistry in varied applications of science and technology. The origin of life itself is a photochemical act!	T1: Chapter 1; Section 1.2 T1: Chapter 4; Sections 4.3-4.5
4-6	Photochemical Processes	Primary processes in photochemical reactions, quantum yield and lifetime.	Understand and compare the efficiency of different photochemical reactions.	T1: Chapter 7; Sections 7.1-7.2 T2: Chapter 1; Section 1.4
7-9	Electronic transitions and excited state photophysics	Excited electronic states, Jablonski diagram, radiative and non-radiative transitions, vibrational relaxation, internal conversion, intersystem crossing, fluorescence, phosphorescence, excimer and exciplex.	Learn different emission processes of a molecule from electronically excited state along with their timescale.	T1: Chapter 5; Sections 5.1-5.3 T2: Chapter 1; Sections 1.1-1.4
10-13	Introduction to LASER	Einstein coefficients and physical principles of laser action. Stimulated emission, population inversion and light amplification.	Learn what it takes to make a laser from a material and why laser is so special.	T1: Chapter 3; Sections 3.2-3.2.1 T3: Chapter 7; Sections 7.1-7.3 Class Notes
14-18	LASER construction and functions	Construction and function of the laser, Laser types: dye lasers, continuous lasers, pulsed lasers, ultra-fast lasers, semiconductor lasers. Pulsed laser: cavity dumping, Q-	Learn about different types of lasers as per their operational principles. How to build a laser?	T3: Chapter 5; Sections 5.2-5.4 Class Notes and study materials supplied by instructor

		switching, mode locking.		
19-20	Applications of LASER	Laser applications in molecular physics and chemical physics and diagnostic purposes	Visualize and appreciate the advancement what laser has brought into, which would not have been possible without it.	Class Notes and study materials
21-23	Electron transfer and energy transfer processes/reactions	Electron transfer reactions and Fluorescence Resonance Energy Transfer (FRET)	Learn various aspects of FRET and know why it is a popular technique to measure nm scale distances in complex environments in biology. Why it is called spectroscopic ruler?	T1: Chapter 3; Sections 3.10.1-3.10.3 T2: Chapter 1; Section 1.6 T2: Chapter 13; Sections 13.1, 13.2, 13.4.
24-25	Solvent Effect on electronic transitions	Solvent effect on absorption and emission, Lippert equation.	Understand why studying solvent effect on absorption and emission is so difficult.	T2: Chapter 6; Section 6.1-6.2.2.
26-28	Molecular interactions and quenching of fluorescence	dynamic and static quenching, Stern Volmer equation, Combined dynamic and static quenching, deviation from Stern-Volmer equation: quenching sphere of action, fractional accessibility to quenchers. Applications of quenching to proteins and membranes	Understand various molecular interactions that can lead to decrease in fluorescence intensity of an emitter. Application of fluorescence quenching processes.	T2: Chapter 8; Sections 8.1-8.6, 8.8-8.10
29-31	Excited state relaxation processes, Dynamic stokes shift	Theory of Time-resolved Emission Spectra (TRES), measurement of TRES and its application	Understand solvation dynamics using pulsed laser and its applications.	T2: Sections 7.1, 7.3, 7.4

32-34	Fluorescence anisotropy: Extent of polarization of emission	Definition and theory of fluorescence anisotropy. Measurement of fluorescence anisotropy and its application.	Understand fluorescence anisotropy and its important applications.	T2: 10.1, 10.2, 10.4, 10.8
35-37	Applications of Photochemical Reactions	Examples of photochemical reactions, the solar spectrum, reaction centers, photo processes in solar cells, Metal Enhanced Fluorescence, PDT.	Learn about various applications of photochemistry in important natural processes as well as modern day applications in nanotechnology, theranostic medical applications etc.	R1: Chapter 10; Sections 10.1-10.3 Class Notes and study materials supplied by instructor
38-40	Lab components based on some topics discussed in the lectures.	Experiments on (1) Relative fluorescence quantum yield, temperature and viscosity dependence of non-radiative rates. (2) fluorescence quenching and Stern Volmer plot, (3) Measurements of intensity decays in dynamic quenching, determination of lifetime and Stern Volmer plot, and (4) Measurements of anisotropy decays in homogeneous and microheterogeneous media, and determination of rotational relaxation times.	Students will have exposures to methods of preparation of samples for fluorescence measurements, instrumental techniques involved, and determination of some photophysical parameters.	Write-ups for the experiments will be provided.

6. Evaluation Scheme:

Component	Duration	Weightage (%)	Date and Time	Nature of component
Mid Semester Test	1.5 hrs.	30	15/03 - 11.00 - 12.30PM	Closed Book
Quizzes/Assignments*	-	20	Continuous	Open Book
Lab component and lab records.#	-	10	TBA	Open Book
Comprehensive Examination	3 hrs.	40	16/05 AN	Closed Book

* **There will be a total of 2 quizzes and 2 assignments, no makeup will be allowed for these components**.

Marks will be awarded for attending and performing experiments and submitting lab record.

7. **Chamber Consultation Hours**: To be announced through a separate notice.

8. **Notices**: Notices, if any, concerning the course will be displayed on CMS, and appropriate online platform.

9. Academic Honesty and Integrity Policy: Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

1. **10. Make-up-policy**: Makeup would be considered only for very genuine reasons (*such as institute deputation outside for sports/cultural fest, hospitalization (with appropriate documentary proof)*.

Instructor-In charge