JYOTI NIVAS COLLEGE AUTONOMOUS
SYLLABUS FOR 2018 BATCH AND THEREAFTER

Programme: B.Sc. **Semester: VI**

PHYSICS PAPER VII
ATOMIC, MOLECULAR AND NUCLEAR PHYSICS

Course Code: 18VIPH7 **No. of Hours: 45**

COURSE OBJECTIVES:

- Explore the structure and nature of the atom Explore the basic concepts of Quantum Mechanics
- Explain rotational, vibrational, electronic and Raman spectra of molecules.
- The goal is to develop knowledge and skills in the laws of nuclear physics and various types of nuclear reactions and their energetics

LEARNING OUTCOMES:

- Describe theories explaining the structure of atoms and the origin of the observed
- Spectra and Identify atomic effect such as Zeeman effect and Stark effect.
- Students develop knowledge and an understanding of nuclear energy and the differences in nuclear fission and nuclear fusion and methods to extract energy from nuclei in real life and can apply knowledge of atomic and nuclear physics to explain natural physical processes and related technological advances.

UNIT I:
ATOMIC AND MOLECULAR PHYSICS
Vector Model of the Atom
Review of Bohr's theory of hydrogen atom, Sommerfeld's modification of the Bohr atomic model (qualitative). Spatial quantization and spinning electron. Different quantum numbers associated with the vector atom model, Spectral terms and their notations, Selection rules, Coupling schemes(*l*-s and j-j coupling in multi electron systems), Pauli's Exclusion Principle, Expression for maximum number of electrons in an orbit. Spectra of alkali elements (sodium D-line), Larmor precession, Bohr magneton, Stern-Gerlach Experiment. Zeeman Effect- Experimental study, theory of normal Zeeman effect based on quantum theory. **10 HRS**
Molecular Physics: Pure rotational motion, Spectrum and selection rules; Vibrational motion, vibrational spectrum and selection rules; Rotation-Vibration spectrum; Scattering of light-Tyndall scattering, Rayleigh scattering and Raman scattering. Experimental study of Raman effect, Quantum theory of Raman effect - Applications . **05 HRS**

UNIT II
RADIOACTIVE DECAY, DETECTORS AND ACCELERATORS
Alpha particle scattering : Rutherford's theory of alpha scattering (assuming the path to be hyperbolic) **02 HRS**

Radioactive Decay : Laws of radioactive decay, half – life, mean life, decay constant; theory of successive disintegration (expression for number of atoms of n^{th} element in the chain – Bateman equations); radioactive equilibrium (secular and transient - cases of long lived parent, short lived parent, daughter and parent of nearly equal half – life). **04 HRS**

Alpha decay : Range and energy, Geiger- Nuttal law , Characteristics of alpha spectrum, Barrier penetrability factor [p]e (no derivation). Derivation of Q-value-of alpha decay; Exact energy of alpha particle emitted **02 HRS**

Beta decay : Types of beta decay (electron, positron decay and electron capture) Characteristics of beta spectrum and Pauli's neutrino hypothesis **02 HRS**

Detectors : Variation of ionization current with applied voltage in a gas counter, GM Counter (Construction, working, characteristics, efficiency and quenching) **03 HRS**

Particle accelerators : Linear accelerator, Cyclotron, Betatron **02 HRS**

UNIT III

NUCLEAR REACTIONS AND PARTICLE PHYSICS

Nuclear Reactions: Types of reactions, Conservation laws in nuclear reactions with examples, derivation of Q – value for reactions using the energy – momentum conservation, exoergic and endoergic reactions, threshold energy , reaction rate, reaction cross – section, concept of direct and compound reactions, resonance reaction; Power reactors. **09 HRS**

Elementary Particles: Classification of elementary particles, Fundamental interactions (Gravitational, Electromagnetic, Weak, strong – range, relative strength, particle interactions for each);
Symmetries and Conservation Laws (momentum, energy, charge, parity, lepton number, baryon number, isospin, strangeness and charm); Concept of Quark Model, Color quantum number and gluons; **06 HRS**

REFERENCE:

1. Concepts of Modern Physics, Beiser 3rd edition, Student edition, New Delhi (1981).
2. Introduction to Atomic Physics – H.E. White
3. Introduction to Modern Physics – H.S. Mani, G.K. Mehta-West Press (1989).
4. Principles of Modern Physics, A.P. French, John Wiley, London (1958).
5. Modern Physics - S.N. Ghoshal, Part 1 and 2 S. Chand and Company (1996).
6. Physics of the Atom, Wehr et. al. McGraw Hill
7. Atomic and Nuclear Physics, S. N. Ghoshal: Vol. II. (2000).
8. Alpha, beta and gamma spectroscopy, K. Seighbahn: Vol. I and II, John Wiley (1967)
9. Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
10. Nuclear Physics, D C Tayal, Himalaya Publishing House, 5^{th} Edition
11. Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
12. Introduction to the physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004)
13. Introduction to Elementary Particles, D. Griffith, John Wiley & Sons 2^{nd} revised ed (**2008**)
14. Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi(**2008**)
15. Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (IOP-Institute of Physics Publishing, (2004).
16. Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, (**2000**).
17. Theoretical Nuclear Physics, J.M. Blatt & V.F.Weisskopf (Dover Pub.Inc., (**1991**)

PHYSICS – PRACTICAL
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1. Study of hydrogen spectrum.
2. Sommerfeld's fine structure constant determination.
3. Determination of e/m by Thomson's method.
4. Characteristics of GM counter.
5. Determination of half-life of K^{40}.
6. Millikan's Oil drop experiment
7. Analysis of band spectrum of PN molecule.
8. Analysis of rotational spectrum of nitrogen.
9. Analysis of rotational vibrational spectrum of a diatomic molecule (HBr).
10. Absorption spectrum of $KMnO_4$.
11. Verification of Curie – Weiss Law
12. To convert a Boolean Expression into Logic Gate Circuit and assemble it using logic gate ICs.
13. Half Subtractor & Full Subtractor, using logic gate ICs
14. Verification of inverse square law using GN counter (with a radioactive source).
15. Determination of mass absorption coefficient of gamma rays.

Note: A minimum of EIGHT experime.nts must be performed.

REFERENCES:

1. IGNOU : Practical Physics Manual
2. Saraf : Experiment in Physics Vikas Publications
3. S.P. Singh : Advanced Practical Physics
4. Melissons : Experiments in Modern Physics
5. Misra and Misra, Physics Lab. Manual, South Asian publishers, 2000
6. Gupta and Kumar, Practcal physics, Pragati prakashan, 1976