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St Aloysius College (Autonomous)
Mangaluru

Semester IV – P.G. Examination – M.Sc. Physics

April - 2025

ATOMIC AND MOLECULAR PHYSICS

Time: 3 Hours

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Max. Marks: 70

PART - A

Answer all questions choosing ONE from each unit.

(15x4=60)

UNIT -I

1. a) Discuss how space quantization of angular momentum is demonstrated by Stern Gerlach experiment. (9)
- b) Define and elaborate on quantum numbers in the context of atomic structure. (6)

OR

2. a) Distinguish between normal and anomalous Zeeman effect. Give the quantum theory of normal Zeeman effect and obtain expression for Zeeman shift. (6)
- b) Explain the Vector Atom Model and how it differs from the Bohr model in describing atomic structure. Discuss the vectorial nature of angular momentum and its role in understanding the electronic configuration of atoms. Highlight the advantages of the Vector Atom Model over the Bohr model. (9)

UNIT -II

3. a) Define transition matrix element. Using the dipole approximation deduce the equation for transition rate for a spontaneous emission. (6)
- b) Explain Induced absorption, Spontaneous and Stimulated emissions processes. (9)

OR

4. a) Discuss the central field approximation in detail, in the context of many-electron atoms. Evaluate its strengths and limitations, and illustrate its application in understanding the electronic structure of complex atoms. (9)
- b) Describe various factors that contribute to the width of spectral lines (6)

UNIT -III

5. a) Explain the rotational fine structure in electronic spectra. Discuss the formation of bands and the shading of bands in the electronic spectra of diatomic molecules. (6)
- b) Explain the theory behind the rotational spectra of diatomic molecules. Discuss the factors that influence the rotational transitions and how they provide structural information about molecules. (9)

OR

6. a) Provide a detailed explanation of the theory of vibrating rotator and its role in the vibration-rotation spectra of diatomic molecules. Discuss the significance of vibration-rotation transitions in understanding molecular properties. (9)
- b) Explain the theory behind infrared (IR) spectroscopy and its application in chemical analysis. (6)

UNIT -IV

7. a) Discuss the effect of applied external fields on the behavior of nuclear and electron spins in NMR and ESR spectroscopy. Explain how these fields influence the energy levels and transitions in spin resonance. (9)
- b) Obtain an expression for the rate of energy absorption in ESR. (6)

OR

8. a) Explain the instrumentation used in Mossbauer spectroscopy. Discuss the key components and their functions in acquiring Mossbauer spectra. Highlight the technical aspects that make Mossbauer spectroscopy a powerful tool in materials science and other disciplines. (9)
- b) Explain: 1) spin-lattice and 2) spin-spin relaxation processes (6)

PART - B

Answer any TWO questions:

(2x5=10)

9. a) Explain how atomic states are represented in L-S and j-j coupling schemes.
- b) Discuss the correction to the Hamiltonian in terms of first order perturbation of the hydrogen atom.
- c) The bond length of HF molecule is 0.0927nm (mass of H=1u, mass of F=19u) a) What is its moment of inertia? b) What is the value of rotational constant? c) Find the wavenumbers of the first three transitions.
- d) Calculate the recoil velocity of a free Mossbauer nucleus Fe when emitting a gamma ray of frequency 3.5×10^{18} Hz. (mass number of Fe=57), what is the Doppler shift of the gamma ray frequency to an outside observer?

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Semester IV – P.G. Examination – M.Sc. Physics

April - 2025

NUCLEAR AND PARTICLE PHYSICS

Time: 3 Hours

PART - A

Max. Marks: 70

Answer all questions choosing ONE from each unit.

(15×4=60)

UNIT -I

1. a) How do we estimate nuclear size from mirror nuclei? (6)
- b) Explain the Fermi's theory of beta decay. (9)

OR

2. a) Explain beta and gamma decay selection rules. (6)
- b) What are the assumptions of the liquid drop model? Derive the expression for the semiempirical mass formula. (9)

UNIT -II

3. a) Write a brief note of detection of neutrons. (6)
- b) Discuss the interaction of charged particles with matter and arrive at Bethe formula for the specific energy loss of particles. (9)

OR

4. a) Explain the working principle of an inorganic scintillation detector. (9)
- b) Explain the principle of G.M Counter. (6)

UNIT -III

5. a) Explain Yukawa's theory of nuclear forces. (6)
- b) Discuss ground state of Deuteron using square well potential and deduce the relation between depth and range of nuclear potential in terms of binding energy of Deuteron. (9)

OR

6. a) Explain in detail the properties of nuclear forces. (6)
- b) Explain Q value of nuclear reactions. Obtain the expression for threshold energy for endoergic nuclear reaction. (9)

UNIT -IV

7. a) Write a note on Parity, Time reversal invariance and charge conjugation and hence discuss CPT theorem. (6)
- b) Explain the conservation laws and symmetries. (9)

OR

8. a) Explain basic forces in nature. (6)
- b) Classify elementary particles based on their spin and hence explain quark model of baryons and leptons. (9)

PART - B

Answer any TWO questions:

(2×5=10)

9. a) $^{212}_{83}\text{Bi}$ decays with a half-life of 60.5 min by emitting 5 groups of alpha disintegration energies 6.08, 6.04, 5.76, 5.62 and 5.60 MeV. Calculate the alpha disintegration energies.
- b) Calculate the Compton energy of a 4 MeV photon scattered at 90° angle.
- c) Predict the characteristics of the ground state and first excited spin parity of $^{17}_8\text{O}$, $^{33}_{16}\text{S}$, $^{63}_{29}\text{Cu}$ on the basis of shell model.
- d) Discuss Compton scattering and pair production mechanism of gamma rays.

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LASERS, VACUUM TECHNIQUES AND NONLINEAR OPTICS

Time: 3 Hours

Max. Marks: 70

PART - AAnswer all questions choosing **ONE** from each unit.

(3×18=54)

UNIT -I

1. a) What is Q switching and eletrooptic effect in laser? Explain. (8)
- b) Derive the expression for Second Harmonic Generation and explain the process. Obtain the expression for SHG efficiency. (10)

OR

2. a) Briefly discuss the construction and working of a Nd YAG laser with the energy level diagram. (9)
- b) Elucidate the absorption and emission process in LASER. Explain the properties of amplified optical radiation and mention the applications of LASER. (9)

UNIT -II

3. a) Define vacuum pump. Explain the construction and working principle of rotary pump. (9)
- b) Discuss the working principle of Pirani and Penning gauge. (9)

OR

4. a) Discuss the construction and working of turbo-molecular pump. (8)
- b) What is vacuum? Explain the classification of vacuum spectrum. Mention few application of vacuum in experimental physics. (10)

UNIT -III

5. a) Explain the sample preparation in TEM and give the details of contrast formation in TEM. Explain the working of TEM. (8)
- b) Discuss in detail Energy Dispersion Spectroscopy. (10)

OR

6. a) Explain the working principle of AFM. (10)
- b) Explain the working principle of Scanning electron microscopy. Mention its few advantages. (8)

PART - BAnswer any **FOUR** questions:

(4×4=16)

7. a) Explain the process of self-focusing of light.
- b) Explain the terms
 - a) Pumping speed
 - b) Throughput
 - c) Conductance of pipes.
- c) Discuss low energy electron diffraction.
- d) Discuss third harmonic generation.
- e) What is phenomenon of optical mixing? Explain.
- f) Write a note on Reynold's and Knudsen's number.

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CONDENSED MATTER PHYSICS III

Time: 3 Hours

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PART - A

Max. Marks: 70

Answer all questions choosing ONE from each unit.

(3x18=54)

UNIT -I

1. a) Explain the reflection and transmission of light by a thin film. (10)
- b) With a schematic diagram of the growth system, explain the growth of thin films using laser beam. (8)

OR

2. a) Write a note on the different properties of thin films. (8)
- b) Describe the thin film deposition technique using resistive heating. (10)

UNIT -II

3. a) What is Meissner effect? Explain. (9)
- b) Distinguish between DC and AC Josephson' effects. (9)

OR

4. a) Discuss the thermodynamic theory of superconductivity. (9)
- b) Discuss the salient features of BCS theory. (9)

UNIT -III

5. a) What are photo chromatic materials? (8)
- b) Explain phase transition in shape memory alloys. (10)

OR

6. a) What are i)electrochromic ii)thermo chromic iii)photochromic materials? (8)
- b) What are piezoelectrics? Discuss. (10)

PART - B

Answer any **FOUR** questions:

(4x4=16)

7. a) With the help of a schematic diagram explain chemical vapour condensation.
- b) What are the disadvantages nano materials?
- c) Describe laser ablation and microwave plasma processing technique of nanomaterial synthesis.
- d) Write a note on magnetic nanoparticles.
- e) Write a note on nanodrug delivery.
- f) Explain the properties of magnetic and semiconductor nanoparticles.
