SRINIVAS UNIVERSITY

Ph.D. (Physics) Course Work (2020 – 2021)

Subject (Code):	**Atomic and Nuclear Physics (20SPHDPH01)**
Time: 2 hours	Max. marks: 50

Module – 1

One electron System: Rutherford's experiment on scattering of ∝-particles, Rutherford's atom model and drawback of the model. Bohr model of the hydrogen atom. Quantization of Orbital radius and Orbital energy in the Bohr model. Schrodinger's equation and the hydrogen atom. Hydrogen spectrum. Wavelength of emitted spectral line. Limitations of Bohr model. Fine structure of spectral lines. Zeeman effect and Stark effect. Spectrum of singly ionized helium, Discovery of deuterium, Alkali atomic spectra.
Sommerfeld relativistic atom model.
Vector atom model – Spatial quantization, Spinning electron.

Module – 2

Properties of Nucleus: Nuclear constitution. Nuclear mass. Nuclear radius and its estimation from Rutherford's scattering experiment.
Binding energy. Binding energy curve and its characteristics. Packing fraction. Nuclear stability.
Coulomb potential inside the nucleus and the mirror nuclei. The nomenclature of nuclei, and nucleon quantum numbers. Nuclear spin and magnetic dipole moment. Nuclear electric moments and shape of the nucleus.

Module – 3

Nuclear Forces: General features of nuclear forces. Bound state of deuteron with square well potential, binding energy and size of deuteron. Deuteron electric and magnetic moments - evidence for non-central nature of nuclear forces. Yukawa's meson theory of nuclear forces.
Nuclear Energy: Fission process. Fission chain reaction. Energy released in fission reaction. Multiplication factor. Critical size and mass for maintenance of chain reaction. Fission reactor. Fusion process. Energy released in fusion reactions. Controlled thermonuclear reactions; Fusion reactor.

Module – 4

Nuclear Reactions: Types of reactions: Elastic scattering, Inelastic scattering, Radioactive capture, Disintegration, Photodisintegration.
Conservation laws: Conservation of Charge, Nucleons, Mass-Energy, Parity, Linear momentum, Angular momentum, Spin, Isotopic spin.
Energy balance in nuclear reactions and the Q-Value.
Nuclear Models: Liquid drop model, Shell model, Evidence for shell model, Magic numbers.
Detectors of Nuclear radiations: Ionization Chamber, Solid-state detectors, Proportional

Counters, Geiger-Muller Counter.
Particle Accelerators: Linear accelerator, The Cyclotron, The Betatron.

Module – 5

Nuclear Decays:
Alpha decay: Quantum mechanical barrier penetration, Gamow's theory of alpha decay.
Beta decay: Continuous beta spectrum, The neutrino theory of beta decay.
Gamma decay: Origin of gamma rays, Nuclear isomerism.
Fundamental Laws of Radioactivity: Soddy Fajan’s Displacement Law, Law of Radioactive Disintegration. Half-life period and Mean-life. Measurement of decay constant. Law of Successive Disintegration.

Question paper pattern:

The question paper will have TEN questions. Each full question is for 10 marks.
There will be 2 full questions (with a maximum of four sub questions in one full question) from each module. You need to answer any one question from each module.

REFERENCE BOOKS:

Introduction to Atomic Spectra	H E White	McGraw Hill	1934 Ed
Nuclear and Particle Physics	W.E. Burcham and M. Jobes	Addison Wesley	1998 Ed
Nuclear Physics	R R Roy and B P Nigam	New Age International	2nd Ed
Introduction to Nuclear Physics	S B Patel	New Age International	2006 Ed

Subject (Code):	**Analytical methods and Electronics(20SPHDPH02)**
Time:2 Hours	Max. marks: 50

Module – 1

Matter waves:
DeBroglie hypothesis, Equation for matter waves. Wavelength associated with electron accelerated through potential. Davisson-Germer experiment. Electron microscopy. Principle and working of Scanning Electron Microscope (SEM) and Transmission Electron Microscope (TEM). Working of Atomic Force Microscope (AFM).

Module – 2

X-ray Diffraction (XRD):
Fundamentals of x-ray diffraction. X-Ray Fluorescence method: Principles-Characteristics. x-ray emission. Instrumentation x-ray tube, radioactive sources. Wavelength dispersive instruments. Energy dispersive instruments. Analytical Applications- Qualitative Analysis-Quantitative Analysis, Theory of x-ray diffraction, diffraction of x-rays by crystals, determination of crystal Structure (powder as well as single crystals), Instrumentation, determination of lattice parameters, x-ray intensity calculations and application of x-rays.

Module – 3

Laser Based Techniques: Atomic Fluorescent Spectrometry (AFS). Resonant Ion Spectroscopy (RIS). Laser enhanced Ionization (LEI).
Microwave (Rotational) Spectroscopy, UV Spectroscopy, Fourier Transform Infra-red Spectroscopy (FT-IR), Molecular Spectroscopy, Raman Spectroscopy, Mass spectrometry-Instrumentation, Uses.

Module – 4

Physical methods of analysis:
Thermal methods: Differential Thermal Analysis (DTA). Differential Scanning Calorimetry (DSC). Thermo Gravimetric Analyses (TGA).
Magnetic Resonance Spectroscopy: Nuclear Magnetic Resonance (NMR) - principle, spectrometer and applications.
Electron Spin Resonance (ESR) - principle, spectrometer and applications.
Vacuum Technique: Production by rotary and diffusion pumps, measurement by Pirani and Penning gauges.

Module – 5

Semiconductor Electronics:
Band theory of solids. Classification of insulators, conductors and semiconductors based on band theory. Intrinsic semiconductors. P-type and N-type extrinsic semiconductors. P-N junction. Forward and reverse bias characteristics of p-n junction diode. Full wave rectifier. Bridge rectifier. Zener diode and its reverse bias characteristics. Zener diode as voltage regulator. Transistor (n-p-n and p-n-p). Input and output characteristics of transistor. Transistor as switch and amplifier. Feedback mechanism - Oscillator.

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Each full question is for 10 marks.

There will be 2 full questions (with a maximum of four sub questions in one full question) from each module. You need to answer any one question from each module.

REFERENCE BOOKS:

Introduction to Instrumental Analysis	R.D. Braun	McGraw-Hill Ryerson Limited	1st Ed, 1987
Principles of Instrumental Analysis	Skoog, Hollar and Niemann	Harcourt Asian Pvt Ltd India	5th Ed, 1998
Instrumental Methods of Analysis	Willard, Merritt, and Dean	CBS Publishers	6th Ed.
Principles of Fluorescence Spectroscopy	Joseph R Lakowicz	Plenum Press, NewYork	1986
X-ray Crystallography	Woolfson, M. M	Cambridge University Press	1978
Thermal Method	Wendlandt, W.W. John	Wendlandt, W.W. John	1st Ed.
Semiconductor Physics and Devices	Neamen	McGraw Hill	4th Ed

Subject (Code):	Solid State Physics(20SPHDPH03)
Time: 2 hours	Max. marks: 50

Module – 1

Crystal structure:
Lattice points and space lattice, The basis and crystal structure, Unit cells and lattice parameters, Unit cell versus primitive cell, Crystal systems, Symmetry elements in crystals, Space groups, The Bravais space lattices, Metallic crystal structures, Directions, planes and Miller indices

Atomic packing: packing fraction, Co-ordination number. Examples of simple crystal structures: NaCl, ZnS and diamond. Symmetry operations, point groups and space groups.

X-ray diffraction: X-ray diffraction, Bragg's law. Concept of reciprocal lattice, Laue Equations, Brillouin Zones.

Experimental diffraction methods: Laue method, Rotating Crystal method and Powder Crystal method.

Module – 2

Crystal binding: Types of binding. Van der Waals-London interaction, Repulsive interaction. Modelung constant. Born's theory for lattice energy in ionic crystals and comparison with experimental results. Ideas of metallic binding, Hydrogen bonded crystals.

Lattice vibrations: Vibrations of monoatomic lattices. First Brillouin zone. Quantization of lattice vibrations - Concept of Phonon, Phonon momentum. Specific heat of lattice (qualitative).

Module – 3

Energy bands in solids: Formation of energy bands. Free electron model: free electrons in one and three dimensional potential wells, electrical conductivity, heat capacity, Fermi-Dirac distribution, density of states, concept of Fermi energy. Kronig-Penny model. Nearly Free Electron Model (qualitative). Tight Binding model (qualitative).

Defects in solids: Point defects: Schottky and Frenkel defects and their equilibrium concentrations. Line defects: Dislocations, multiplication of dislocations (Frank-Read mechanism). Plane defects: grain boundary and stacking faults.

Module – 4

Magnetic materials: Classification – paramagnetic, diamagnetic and ferromagnetic materials – Properties and examples. Magnetic susceptibility and magnetic permeability. Variation of susceptibility of paramagnetic materials with temperature. Curie law. Curie temperature. Behaviour of ferromagnetic materials for $T>T_C$ (Curie-Weiss Law). Ferromagnetic domains. Antiferromagnetism, Ferrimagnetism. Hard and soft ferromagnetic materials – applications. Magnetic hysteresis.

Superconductors: Superconductivity. Zero resistance. Meissner effect. Critical field. Classification.

Module – 5

Structure of Solids: The crystalline and Non-crystalline states, Covalent solids, Metals and alloys, Ionic solids, The structure of silica and silicates

Crystal growth: Crystal growth from melt: Bridgemann technique, Crystal pulling by Czochralski's method, Growth from solutions, Hydrothermal method,

Gel method, Zone refining method of purification.
Crystal imperfections: Point imperfections, Dislocation, Edge and Screw dislocation, Concept of Burger vector and Burger circuit, Surface imperfections, Colour centers in ionic solids.

Question paper pattern:
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Each full question is for 10 marks.
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REFERENCE BOOKS:

Elementary Solid State Physics	M. A. Omar	Addison	3rd Ed
Introduction to Solid State Physics	C. Kittel	Wiley Eastern	8th Ed
Solid State Physics	A. J. Dekkar	Macmillan India Limited	2014Ed
Solid State Physics	S. O. Pillai	New Age Publishers	2018 Ed
Materials Science and Engineering	V. Raghvan	Printice Hall of India	5th Ed, 2009
Materials Science and Processes	S. K. Hazra Chaudary	Indian Distr Co	3rd Ed-2009
Introduction to Solids	L. V. Azaroff	Tata McGraw Hill	New Ed-2017