UGC MODEL SYLLABUS
PHYSICS, B.Sc. SECOND YEAR

COURSE 4: KINETIC THEORY, THERMODYNAMICS AND STATISTICAL PHYSICS

4.1 KINETIC THEORY OF MATTER — 25

Ideal Gas: Kinetic model, deduction of Boyle's law, interpretation of temperature, estimation of rms speeds of molecules. Brownian motion, estimate of the Avogadro number. Equipartition of energy, specific heat of monatomic gas, extension to di- and triatomic gases, Behaviour at low temperatures. Adiabatic expansion of an ideal gas, applications to atmospheric physics. (7)

Real Gas: Van der Waals gas, equation of state, nature of Van der Waals forces, comparison with experimental P-V curves. The critical constants, gas and vapour. Joule expansion of ideal gas, and of a Van der Waals gas, Joule coefficient, estimates of J-T cooling. (6)

Liquefaction of gases: Boyle temperature and inversion temperature. Principle of regenerative cooling and of cascade cooling, liquifaction of hydrogen and helium. Refrigeration cycles, meaning of efficiency. (5)

Transport phenomena in gases: Molecular collisions, mean free path and collision cross sections. Estimates of molecular diameter and mean free path. Transport of mass, momentum and energy and interrelationship, dependence on temperature and pressure. (7)

4.2 THERMODYNAMICS — 25

The laws of Thermodynamics: The Zeroth law, various indicator diagrams, work done by and on the system, first law of thermodynamics, internal energy as a state function and other applications. Reversible and irreversible changes, Carnot cycle and its efficiency, Carnot theorem and the second law of thermodynamics. Different versions of the second law, practical cycles used in internal combustion engines. Entropy, principle of increase of entropy. The thermodynamic scale of temperature; its identity with the perfect gas scale. Impossibility of attaining the absolute zero; third law of thermodynamics. (8)

Thermodynamic Relationships: Thermodynamic variables; extensive and intensive, Maxwell's general relationships, application to Joule-Thomson cooling and adiabatic cooling in a general system, Van der Waals gas, Clausius-Clapeyron heat equation. Thermodynamic potentials and equilibrium of thermodynamical systems, relation with thermodynamical variables. Cooling due to adiabatic demagnetization, production and measurement of very low temperatures (10)

Blackbody Radiation: Pure temperature dependence, Stefan-Boltzmann law, pressure of radiation. Special distribution of BB radiation, Wien's displacement law, Rayleigh-Jean's law, the ultraviolet catastrophy, Planck's quantum postulates, Planck's law, complete fit with experiment. Interpretation of behaviour of specific heats of gases at low temperature. (7)

4.3 STATISTICAL PHYSICS 25

The statistical basis of Thermodynamics: Probability and thermodynamic probability, principle of equal a priori probabilities, probability distribution and its narrowing with increase in number of particles. The expressions for average properties. Constraints, accessible and inaccessible states, distribution of particles with a given total energy into a discrete set of energy states. (6)

Some universal laws: The mu space representation, division of mu space into energy sheets and into phase cells of arbitrary size, applications to one-dimensional harmonic oscillator and free particles. Equilibrium before two systems in thermal contact, bridge with macroscopic physics. Probability and entropy, Boltzmann entropy relation. Statistical interpretation of second law of thermodynamics. Boltzmann canonical distribution law and its applications; rigorous from of equipartition of energy. (9)

Maxwellian distribution of speeds in an ideal gas: Distribution of speeds and of velocities, experimental verification, distinction between mean, rms and most probable speed values. Doppler broadening of spectral lines. (4)

Transition to Quantum Statistics: 'h' as a natural constant and its implications, cases of particle in a one-dimensional box and one-dimensional harmonic oscillator. Indistinguishability of particles and its consequences, Bose-Einstein, and Fermi-Dirac conditions; applications to liquid helium, free electrons in a metal, and photons in blackbody chamber. Fermi level and Fermi energy. (6)

COURSE 5: WAVES, ACOUSTICS AND OPTICS

5.1 WAVES 11

Waves in Media: Speed of transverse waves on a uniform string, speed of longitudinal waves in a fluid, energy density and energy transmission in waves, typical measurements. Waves over liquid surface: gravity waves and ripples. Group velocity and phase velocity, their measurements. (5)

Superposition of Waves: Linear homogeneous equations and the superposition principle, nonlinear superposition and consequences. (3)

Standing Waves: Standing waves as normal modes of bounded systems, examples, Harmonics and the quality of sound; examples. Chladni's figures and vibrations of a drum. Production and detection of ultrasonic and infrasonic waves and applications. (4)

5.2 ACOUSTICS 13

Noise and Music: The human ear and its responses; limits of human audibility, intensity and loudness, bel and decibel, the musical scale, temperament and musical instruments. (4)

Reflection, Refraction and Diffraction of sound: Acoustic impedance of a medium, percentage reflection and refraction at a boundary, impedance matching for transducers, diffraction of sound, principle of a sonar system, sound ranging. (4)

Applied Acoustics: Transducers and their characteristics. Recording and reproduction of sounds, various systems, Measurements of frequency, waveform, intensity and velocity. The acoustics of halls, reverberation period, Sabine's formula. (5)

5.3 GEOMETRICAL OPTICS 18

Fermat's Principle: Principle of extremum path, the aplanatic points of a sphere and other applications. (4)

General theory of image formation: Cardinal points of an optical system, general relationships, thick lens and lens combinations. Lagrange equation of magnification, telescopic combinations, telephoto lenses and eyepieces. (5)

Aberration in images: Chromatic aberrations, achromatic combination of lenses in contact and separated lenses. Monochromatic aberrations and their reductions; aspherical mirrors and Schmidt corrector plates, aplanatic points, oil immersion objectives, meniscus lens. (4)

Optical Instruments: Entrance and exit pupils, need for a multiple lens eyepiece, common types of eyepieces. (5)

5.4 PHYSICAL OPTICS 36

Interference of light: The principle of superpositions, two-slit interference, coherence requirement for the sources, optical path retardations, lateral shift of fringes, Rayleigh refractometer and other applications. Localised fringes; thin films, applications for precision measurements for displacements. (5)

Haidinger Fringes: Fringes of equal inclination. Michelson interferometer, its application for precision determination of wavelength, wavelength difference and the width of spectral lines. Twymann-Green interferometer and its uses. Inensity distribution in multiple beam interference, Tolansky fringes, Fabry-Perot interferometer and etalon. (8)

Fresnel Diffraction: Fresnel half-period zones, plates, straight edge, rectilinear propagation (2)

Fraunhofer Diffraction: Diffraction at a slit, half-period zones, phasor diagram and integral calculus methods, the intensity distribution, diffraction at a circular aperture and a circular disc, resolution of images, Rayleigh criterion, resolving power of telescope and microscopic systems, outline of phase contract microscopy. (9)

Diffraction Gratings: Diffraction at N parallel slits, intensity distribution, plane diffraction grating, reflection grating and blazed gratings. Concave grating and different mountings. Resolving power of a grating and comparison with resolving powers of prism and of a Fabry-Perot etalon (6)

Double refraction and Optical rotation: Refraction, in uniaxial crystals, its electromagnetic theory. Phase retardation plates, double image prism. Rotation of plane of polarisation, origin of optical rotation in liquids and in crystals. (3)

5.5 LASERS 12

Laser system: Purity of a special line, coherence length and coherence time, spatial coherence of a source, Einstein's A and B coefficients, Spontaneous and induced emissions, conditions for laser action, population inversion. (4)

Application of lasers: Pulsed lasers and tunable lasers, spatial coherence and directionality, estimates of beam intensity, temporal coherence and spectral energy density. (5)

Lasers and Non-linear Optics: Polarization P including higher order terms in E and generation of harmonics, momentum mismatch and choice of the right crystal and direction for compensation. (3)