

# PH 701: CHARACTERIZATION TECHNIQUES AND NON-EQUILIBRIUM THERMODYNAMICS (3-0-0: 3)

## **Vacuum Techniques**

Kinetic Theory of Gases: Behaviour of gases, pressure of gases, Maxwell's law, gas transport phenomenon; viscous, molecular and transition flow regimes. Vacuum Generation: Measurement of pressure, residual gas analyses; production of vacuum - mechanical pumps, rotary vane pumps, diffusion pump, cryopumps, turbo-molecular pumps, getter and ion pumps, choice of pumping process. Vacuum Measurement: Fundamentals of low-pressure measurement, vacuum gauges-McLeod gauge, pirani gauge, penning gauge, thermal conductivity gauges - cold cathode and hot cathode ionisation gauges, materials in vacuum; high vacuum, and ultra high vacuum systems, leak detection.

## **Cryogenics**

Properties of engineering materials at low temperature, cryogenic fluids and their physical properties, super-fluidity, refrigeration; pomeranchuk cooling, thermoelectric coolers, closed cycle refrigeration, single and double cycle He<sup>3</sup> refrigerator, He<sup>4</sup> refrigerator, cryostat design; cryogenic level sensors, handling of cryogenic liquids; cryogenic fluid storage, insulations, cryogenic fluid transfer systems, cryogenic thermometry.

## **Characterization Techniques**

X-ray Diffraction, X-ray fluorescence, X-ray photoelectron spectroscopy UV-Visible- IR spectroscopy, FTIR spectroscopy, Raman spectroscopy, Photoluminescence spectroscopy, Scanning Electron Microscopy, Tunneling Electron Microscopy, Atomic Force Microscopy, Impedance spectroscopy, Electronic (resistivity, Hall effect), Thermal (DTA, TGA, DSC).

## **Non-Equilibrium Thermodynamics**

Introduction review of statistical mechanics, phase transitions, critical phenomena, Landau Approach. Non-equilibrium phenomena, simple discussion of Brownian motion fluctuations, random walk and Brownian motion, the Langevin equation, Fokker-Planck equation.

## **References:**

1. K. Jousten, "Handbook of Vacuum Technology", Wiley-VCH.
2. D. Hoffman, B. Singh, and J. H. Thomas, "Handbook of Vacuum Science and Technology", Academic Press.
3. R. Egerton, "Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM", Springer.
4. C. Suryanarayana and M. G. Norton, "X-Ray Diffraction: A Practical Approach", Springer.
5. J. M. Hollas, "Modern Spectroscopy", Wiley.
6. V. Balakrishnan, "Elements of Nonequilibrium Mechanics", Ane Books Pvt. Ltd.