COURSE ID SHEET

Course No.	**5088**		**NTUA**					
Semester:	**3**	Core	**X**	Elective		Specialization		

Title: **STRUCTURE AND STATES OF MATTER**

Aim: Understanding and quantitative description of molecular-level structure, motion, and interactions in gaseous, liquid, and solid phases formed by pure substances and mixtures. Establishing connections between these microscopic aspects and macroscopically exhibited properties. Introduction to phase diagrams and interfacial phenomena.

Content:

- **INTRODUCTION TO STATISTICAL MECHANICS**: Microscopic degrees of freedom. Intramolecular and intermolecular interactions and potential energy functions for their description. Microstates and their probability distribution. The canonical ensemble. Boltzmann distribution. Canonical partition function and its connection with macroscopic thermodynamics. Statistical interpretation of entropy. Applications to the calculation of properties of an ideal gas. Ideal gas heat capacity: Translational, rotational, vibrational contributions. Semiclassical partition function. Theorem of equipartition of energy. Derivation of an equation of state from molecular constitution and interactions.
- **KINETIC THEORY OF DILUTE GASES**: Maxwell-Boltzmann distribution, mean free path, numbers of collisions. Viscosity, thermal conductivity, diffusivity.
- **REAL GASES**: van der Waals equation of state and its predictions for vapor-liquid phase equilibrium and criticality. Virial equation of state and its connection with intermolecular interactions. Joule-Thomson coefficient.
- **LIQUIDS**: Structure and dynamics, vapor pressure, viscosity, surface tension, wetting and spreading, capillary phenomena.
- **SOLIDS**: Crystal systems and lattices. Point defects. Heat capacity of solids: Einstein and Debye theories. Amorphous solids.
- **MULTICOMPONENT SYSTEMS**: Partial molar properties. Ideal and real solutions. Principles for the calculation of fugacity and activity. Colligative properties (vapor pressure depression, boiling point elevation, freezing point depression, osmotic pressure). Vapor-liquid equilibria, azeotropes. Partial miscibility in the liquid state. Solid-liquid phase diagrams of binary systems. Ternary systems.
- **SORPTION OF FLUIDS IN/ON SOLIDS**: Physisorption and chemisorption, sorption isotherms, heat of sorption. Gibbs adsorption isotherm, surface active substances.
- **COLLOIDS**: Flocculation and stabilization of colloids. Van der Waals, electrostatic, steric, depletion interactions. Elements of DLVO theory. Scattering of light from colloidal solutions.

LABORATORY EXERCISES OFFERED:

- Surface tension
- Azeotropic mixtures
- Rast’s cryoscopy
- Adsorption from solution onto a solid

- Colloids
- Flocculation of colloids by electrolytes
- Phase equilibria – ternary mixture
- Study of crystal structure with X-ray diffraction
- Viscosity measurement
- Computational problems in structure and states of matter

Hours per semester:

LECTURE	**52**	EXERCISES	**26**	LABORA-TORY	**26**	HOME-WORK	**78**	**TOTAL HOURS: 182**

Student performance /evaluation:

The evaluation of students' performance will be based

- on a Final written Examination (FE) which will include solution of quantitative exercises without access to notes or other aids.
- on an evaluation of performance in the laboratory exercises. The laboratory grade, is calculated as the mean of individual grades given in each laboratory exercise, L. For each laboratory exercise, the student receives two grades: one (L1) based on an oral or written examination by the instructor responsible for the laboratory exercise, and a second one (L2) based on the laboratory report and on the student's participation in the lab work. The grade for the exercise is calculated as L=1/2(L1+L2). If $\overline{L}<5$, the student is not allowed to take the final written examination.

The final grade results as follows: Final Grade = 0.6 x (FE) + 0.4 x ($\overline{L}$)