**OR**

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| **DSE-2**<br><br>**Application of thermodynamics in petrology (L3, P1)** | **4** | **3** | **0** | **1** | **12th pass with science** | **Studied Earth System Science and Structural Geology or Equivalent** |

**Learning Objectives**
The course intends to provide the concept of various thermodynamic parameters and application of the laws thermodynamics in different petrological systems. It attempts to demonstrate the effect of pressure temperature and chemical compositions in controlling stability of different mineral associations in open and closed systems. The course intends to demonstrate the application of thermobarometers in natural systems.

**Learning Outcome**
After completing the course, students will learn to calculate the free energy of the system. Students will learn to construct the stability fields of different mineral associations through Gibb's free energy minimization. Student will be able to apply the thermobarometers and will be able to calculate the pressure temperature conditions of stability of different magmatic, metamorphic and economically valuable mineral associations.

**Theory (45 hours)**

**UNIT 1 (9 hours)**

Introduction to thermodynamics, Irreversible and Reversible Processes, Thermodynamic Systems and variables, Energy in the form of heat and work, First law of thermodynamics, enthalpy, entropy, second and third law of thermodynamics, concept of free energy, Gibbs equation: thermodynamic potentials, free energy of formation at any temperature and pressure, equilibrium condition in closed system.

**UNIT 2 (9 hours)**

Free energy surface in G–T–P space, Clausius–Clapeyron equation, Schreinemakers rules, petrogenetic grid, Concept of stability (phase) diagrams, Phase rule, Free energy of solutions, ideal and non-ideal solutions, fugacity and activity, equilibrium constant,

**UNIT3 (9 hours)**

Temperature and pressure dependence of equilibrium constant, Geothermometry, geobarometry, mineral reactions among solid solutions, computer-generated phase relations, Introduction to pseudosections.

**UNIT 4 (9 hours)**

Partial melting and fractional crystallisation in magmatic systems along different geothermal gradients, modelling the role of magmatic processes in controlling the major, trace and REE budget in the crust, modelling the effect of composition on phase stability.

**UNIT 5 (9 hours)**
Thermodynamics of open system, Mass and heat transfer, effect of fluid ingress and composition of fluid in controlling the stability of different phases.

**Practical (30 hours)**
Calculation of free energy of formation at any temperature and pressure, Plotting univariant lines in P–T diagrams, Geothermo-barometric calculation, construction of pseudosections, use of mass balancing techniques on natural rocks

**Essential/Recommended readings**
Philpotts, A.R. and Ague, J.J., 2022. *Principles of igneous and metamorphic petrology*. Cambridge University Press.

Spear, F.S., 1993. Metamorphic phase equilibria and pressure-temperature-time paths. *Mineralogical Society of America Monograph*, *799*.

Ganguly, J., 2008. *Thermodynamics in earth and planetary sciences* (p. 501). Berlin: Springer.