

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	NFMC514	Advanced Thermodynamics and Kinetics	3	1	0	4

<b>Course Objective</b>
The main objective of the course is to understand the principles of thermodynamics and kinetics
<b>Learning Outcomes</b>
On completion of the course, students will be able to understand various metallurgical processes and its fundamental thermodynamic and kinetics principles.

Unit No.	Topics to be Covered	Lecture Hours	Tutorial Hours	Learning Outcome
1	Simple and composite systems, stable equilibrium states. Adiabatic work interaction, heat interaction, internal energy, First law.	3	1	Knowledge about thermodynamics systems.
2	Reversible processes, heat engines, Second law, Theorem of Clausius, entropy, combined first and second law.	4	2	Knowledge about laws of thermodynamics
3	Legendre transforms, representations of the fundamental equation. Equilibrium: extremum principles, membrane, phase and reaction equilibria.	5	2	Knowledge about what constitute equilibrium.
4	Single phase systems: Thermodynamic relations among variables	2	0	Understanding of single-phase systems.
5	Solutions, partial molal properties, solution models. Phase rule, unary, binary and ternary phase diagrams.	4	2	Basics of solution thermodynamics and metallurgical systems.
6	Thermodynamics of phase diagrams. Reacting systems, gas phase reactions, Ellingham diagrams, Pourbaix diagrams.	5	4	Equilibrium in metallurgical systems.
7	Thermodynamics of Phase Transformations: Melting and solidification, precipitation, eutectoid, massive, spinodal, martensitic and order disorder transformations. First and second order transitions.	8	2	Understanding about different metallurgical systems and equilibrium in them.
8	Ficks laws of diffusion, Diffusion mechanisms, Random walk model, Kirkendall effect, Grain growth and coarsening, Analytical and numerical solutions, Diffusion in semi-infinite and finite media, Concept of Johnson-Mehl equation.	6	1	Mass transfer in metallurgical systems
9	Chemical Kinetics: Rate of reaction, Order of reactions, Homogeneous reactions, Heterogeneous reactions, fluid-solid reactions, fluid-fluid reaction, Type of reactors	5	0	Kinetics of metallurgical systems involving different reactions.
<b>Total</b>		<b>42</b>	<b>14</b>	

#### Text Books:

1. Introduction to thermodynamics of materials by D.R. Gaskell, 5<sup>th</sup> ed., 2008, CRC Press
2. Thermodynamics and its application by M. Modell and R.C. Reid, 2<sup>nd</sup> ed., 1983, Prentice Hall

#### Reference Books:

1. Thermodynamics and an introduction to thermostatics by H.B. Callen, 2<sup>nd</sup> ed., 2006, John Wiley.
2. Thermodynamics in Materials Science by R.T. DeHoff, 2<sup>nd</sup> ed., 2006, CRC Press
3. Chemical reaction engineering by O. Levenspiel. 3<sup>rd</sup> ed., 2021, Wiley
4. Kinetics of materials by R.W. Balluffi, S.M. Allen and W.C. Carter, 1<sup>st</sup> ed., 2005, John Wiley