ACADEMIC AFFAIRS OFFICE
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

No. Acd./ 3722 /IAPC-83   Dated: April 24, 2020

Head, Department of Metallurgical & Materials Engineering

      The IAPC in its 83rd meeting held on 15.04.2020 vide **Item No. 83.2.3(i)** considered and accepted the proposal to introduce a PEC MTN-548: Diffusion in Solids w.e.f. Autumn Semester 2020-21. The approved syllabus is attached as **Appendix-A**.

Reeti

Assistant Registrar (Curriculum)

Encl: as above

Copy to (through e mail):-
1. All faculty
2. All Heads of Departments/ Centres
3. Dean, Academic Affairs
4. Associate Dean of Academic Affairs (Curriculum)
5. Channel I/ Academic webpage of iitr.ac.in

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: Department of Metallurgical and Materials Engineering

1. Subject Code: MTN-548   **Course Title:** Diffusion in Solids

2. Contact Hours: **L:** 3   **T:** 1   **P:** 0

3. Examination Duration (Hrs.):   **Theory:** 3   **Practical:** 0

4 Relative Weightage: CWS: 20-35   **PRS:** 0   **MTE:** 20-30   **ETE:** 40-50   **PRE:** 0

5. Credits: 4   **6. Semester:** Both   **7. Subject Area:** PEC

8. Pre-requisite: Nil

9. Objective: To develop an understanding of- the driving force for diffusion based on thermodynamics, and the different kinds of diffusion process encountered in the various conditions

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1	**Review of thermodynamics and defects in solids:** Concept of free energy, enthalpy and entropy, Gibb's free energy change with temperature in a single component system, Thermodynamic parameters in a binary system, Thermodynamics and phase diagrams, Defects in the ordered phases, Point defects: Equilibrium vacancy concentration in a pure element, Equilibrium concentration of interstitial atoms, Calculation of thermodynamic parameters.	7
2	**Diffusion under chemical potential gradient:** Concept of the chemical potential and the activity of elements, Diffusion under the thermodynamic driving forces, Few examples of coupled diffusion in the presence of non-thermodyanmic driving force, Product phase formations because of diffusion in real systems, Diffusion process as a tool to make products.	6
3	**Fick's laws and its applications:** Fick's laws of diffusion and thin film solution, Solution in semi–infinite diffusion couples (error function analysis); A few practical applications such as Homogenization, Carburization and decarburization; Definition and description of different diffusion terms.	6
4	**Determination of different kinds of diffusion parameters:** Matano–Boltzmann analysis, Calculation of diffusion parameters using the Matano-Boltzmann analysis in ideal case, Problem of finding the initial contact plane in non-ideal case, Effect of molar volume in a hypothetical diffusion couple. The inter diffusion coefficients in solid-solutions: Den Broeder and Wagner's approach, Integrated inter diffusion coefficient in line compounds, Calculation of the integrated diffusion coefficients.	8
5	**The Kirkendall effect and beyond:** The Kirkendall effect, The intrinsic diffusion coefficients: Darken analysis and the van Loo relation, Tracer diffusion coefficient and the vacancy wind effect, Recent developments on the Kirkendall effect, Physico–chemical approach, Grain boundary diffusion.	8

| 6 | **Atomic mechanism of diffusion:** Interstitial diffusion, Concept of random walk, Substitutional diffusion, Activation energy for diffusion, Orientation dependence, Diffusion in the ordered phases. | 7 |

11. Suggested Books:

Sl. No.	Authors/Name of Books/ Publisher	Year of Publications / Reprint
1	David A. Porter, Kenneth E. Easterling, and Mohamed Y. Sherif, Phase Transformations in Metals and Alloys, 3rd Edition, CRC Press	2009
2	Paul Shewmon, Diffusion in Solids, 2nd Edition, Springer International Publishing	2016
3	Aloke Paul, Chapter 3-Estimation of Diffusion Coefficients in Binary and Pseudo-Binary Bulk Diffusion Couples**,** *Pages 79-201 in* A. Paul, S. Divinsky (Eds.), Handbook of Solid State Diffusion, Vol. 1, Diffusion Fundamentals and Techniques, Elsevier	2017
4	Aloke Paul, Tomi Laurila, Vesa Vuorinen, and Sergiy V. Divinski, Thermodynamics, Diffusion and the Kirkendall Effect in Solids, Springer International Publishing	2014