



# GUJARAT TECHNOLOGICAL UNIVERSITY

**Bachelor of Engineering**

**Subject Code: 3173624**

**Semester – VII**

**Subject Name: Physical Ceramics**

**Type of course:** Chemical Technology

**Prerequisite:** The students should have a clear concept on basic chemistry, geology and Mineralogy that will help them to have an easy grasp of the subject.

**Rationale:** The main objective of this subject is to offer an overview over the fundamentals and basics of materials science, engineering materials, phase diagram, microstructure & characterization, various properties of engineering materials.

## Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
			ESE (E)	PA (M)	ESE (V)	PA (I)		
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	Ceramic crystal structures : Corundum , Wurtzite , Zinc blende , Rocksalt , Perovskite and Spinel structure etc.; Atomic Mobility : Diffusion & Diffusivity, Laws of Diffusion , Diffusion in solids , Controlling diffusivity . Nernst-Einstein equation. Temperature & impurity dependence of diffusion. Diffusion in crystalline oxides. Dislocation. Boundary & surface diffusion	08
2	Phase Transformations: Formal theory of transformation kinetics with examples. Spinodal decomposition. Thermodynamics & kinetics of nucleation & growth. Grain Growth, Sintering & Vitrification: Sintering - Single & multiphase. Study of sintering - Kinetics, mechanisms of mass transport, Sintering variables, Sintering aids .Recrystallisation & grain growth. Abnormal grain growth. Sintering vis-à-vis Vitrification. Sintering with a reactive liquid. Pressure sintering & hot pressing. Secondary phenomena. Firing shrinkage.	08
3	Microstructure & Characterisation: Features in microstructures. Microstructural observations - Optical & Electron Microscopy. Techniques of sample preparation. Ceramic Phase Equilibrium Diagrams: Techniques of determining phase diagrams. One - , two - , and three - components phase diagrams. Examples. Phase composition versus temperature. Non-equilibrium phases. Typical ceramic systems like zirconia - calcium oxide / magnesium oxide / ceria , calcia - silica , magnesia - silica ,soda - lime - silica , lime -	05



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	alumina - silica etc.	
4	Electrical Properties : Electrical conduction in materials, Electron mobility, Drift velocity, Relaxation time, Electrical resistivity, Energy band model : Insulators, Conductors, Semiconductors diagrams, Mechanism of electrical conduction in intrinsic and extrinsic semiconductors, Charge transport in pure silicon, Quantitative relationship of electrical conduction in intrinsic elemental semiconductors, Effect of temperature on intrinsic semiconductors, N - type and P - type semiconductors, Doping. Mass action law, Charge densities in intrinsic semiconductors. Electronic & Ionic conduction, Ceramic conductors like varistors, thermistors, resistors etc. Piezoelectricity, Ferroelectricity	09
5	Magnetic Properties: Diamagnetism, Paramagnetism , Pauli paramagnetism , Ferromagnetism , Antiferromagnetism & Ferrimagnetism - Ferrites .Soft & Hard magnetic materials- Ferrites, Mixed ferrites, Origin of interactions in ferromagnetic and anti ferromagnetic and anti ferrimagnetic materials, direct, super and double exchange interactions. Exchange energy, Magnetostatic energy, Magnetocrystalline anisotropy energy, Domain wall energy, Magnetostrictive energy. Properties & applications of ferrites	10
6	Optical Properties: Introduction. Light & electromagnetic spectrum, Electromagnetic waves in ceramics, Refractive index, Dispersion, Reflection and refraction. Transmission & reflection of light. Luminescence: Photo & Cathodes. Lasing action	05

### Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
19	36	13	11	11	10

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

### Reference Books:

1. Ceramic Whitewares – Dr. Sudhir Sen
2. Industrial Ceramics – Singer & Singer
3. Fine Ceramics – F.H. Norton.
4. The Technology of Ceramics and Refractories – P.P. Budnikov



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## Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	To express their technical knowledge over fundamentals of the subject.	30
CO-2	To be able to utilize their knowledge and skills for the preparation of other related highly technical subjects in the Glass & Ceramic Technology course curriculum	28
CO-3	To be able to apply this knowledge in their higher study, research work with related technical subjects	27
CO-4	To build a bridge between theoretical and practical concept used in industry.	5
CO-5	To strengthen the foundation of materials sciences	5
CO-6	To investigate deep into the research scope over the glass materials, their fabrication and various properties	5

## List of Experiments:

1. Preparation of Soda-Lime-Silica glass with different colouring oxides, e.g. CaO, FeO etc
2. Preparation of Boro-silicate glass with alkali & alkaline earth oxides.
3. Preparation of Opal glass with different opacifying agents -- Fluoride & Phosphate opal.
4. Preparation of low melting Phosphate glass in various systems.
5. Determination of Alkali resistance of glass
6. Determination of alkalinity of glass
7. Determination of density of glass
8. Thermal shock test on glass wares
9. Determination of strain in glass wares by polariscope
10. Demonstration of cord viewers

## List of OEPs :

1. Industrial practices for diffusion in solids
2. Industrial practices for sintering processes
3. Industrial practices for testing microscopy
4. Industrial practices for studying ferroelectric behaviour

## List of Open Source Software/learning website:

- 1) Literature available on internet
- 2) Glass & Ceramic dictionaries
- 3) Delnet
- 4) Literature available under R&D in Ceramic & Glass industry.
- 5) Ceramic & Glass journals