SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

SRM Nagar, Kattankulathur – 603 203

DEPARTMENT OF PHYSICS

QUESTION BANK

II SEMESTER

PH3225 – Materials Science

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SUBJECT : PH3255 – Materials Science
SEM / YEAR: II SEM / 2024-2025

UNIT-I: INTERATOMIC FORCES AND IMPERFECTION IN SOLIDS

Introduction - forces between atoms - interatomic bonding - Ionic, covalent and metallic bonding - Intermolecular bonding - dispersion, dipole and hydrogen bonding. Imperfections - point, line, surface and volume - plastic deformation mechanisms - slip and twinning - role of dislocations in slip - strengthening methods - Hall-petch relation- strain hardening - refinement of the grain size - solid solution strengthening - precipitation hardening

PART – A

Q.No	Questions	BTL	Competence
1.	How is ionic bond formed?	BTL2	Understanding
2.	Write about the properties of covalent bond.	BTL1	Remembering
3.	Calculate the maximum number of covalent bonds that an atom can form.	BTL2	Understanding
4.	Outline the properties of metallic bond.	BTL2	Understanding
5.	What is meant by Vanderwaals force?	BTL1	Remembering
6.	What are imperfections?	BTL1	Remembering
7.	What are point defects?	BTL1	Remembering
8.	Name the types of point defects.	BTL2	Understanding
9.	What are Schottky defect?	BTL1	Remembering
10.	What is Frenkel defect?	BTL1	Remembering
11.	What is meant by dislocation?	BTL1	Remembering
12.	What is edge dislocation?	BTL1	Remembering
13.	What is screw dislocation?	BTL1	Remembering
14.	What is meant by stacking fault?	BTL1	Remembering
15.	Define twin boundary.	BTL2	Understanding
16.	Name the plastic deformation mechanism in metals.	BTL2	Understanding
17.	Define plastic deformation by slip.	BTL1	Remembering
18.	Define twinning.	BTL2	Understanding
19.	Differentiate slip and twinning.	BTL2	Understanding
20.	Name the four strengthening methods.	BTL2	Understanding
21.	Give the Hall-Petch equation and explain the terms involved in it.	BTL2	Understanding

22.	Define strain hardening.	BTL1	Remembering
23.	What is solid solution strengthening?	BTL1	Remembering
24.	What is meant by precipitation hardening?	BTL1	Remembering
	PART-B		
1.	Analyze the type of bonding that occurs in ionic crystals along with its properties. (16)	BTL4	Analyzing
2.	Discuss in detail about the bonding that involves the complete transfer of electrons from one atom to another so that each atom acquires a stable electronic configuration similar to the nearest inert gas atoms. (16)	BTL4	Analyzing
3.	With Schematic representation illustrate the formation of bonding involved in CH_4 – methane molecule. (16)	BTL3	Applying
4.	Illustrate the formation of bonding which involves the mutual sharing of electrons between adjacent atoms each having incomplete outermost shells. (16)	BTL3	Applying
5.	Describe the band formation that occurs with the help of delocalized electrons. Also mention the properties of the bond formed. (16)	BTL3	Applying
6.	Explain in detail about how metallic bond is formed by partial sharing of valence electrons by the neighbouring atoms. (16)	BTL4	Analyzing
7.	Briefly categorize the main differences between ionic, covalent and metallic bonding. (16)	BTL4	Analyzing
8.	With a neat sketch explain the bonding forces that arises from atomic or molecular dipoles. (16)	BTL4	Analyzing
9.	Explain the various types of one dimensional defects with neat diagram. (16)	BTL4	Analyzing
10.	Discuss in brief about point defects. How these defects affect the properties of materials? (16)	BTL4	Analyzing
11.	With a neat diagram analyze the defects that occurs due to dislocation or distortion of atoms in a line. (16)	BTL4	Analyzing
12.	Explain in detail the form of different types of dislocations in a crystal and significance of it in determining the properties of the material. (16)	BTL4	Analyzing
13.	Analyze and explain about the various types of interfacial defects occurring in a crystal. (16)	BTL4	Analyzing
14.	Explain in detail about the various surface defects and its influence in determining the mechanical and physical properties of materials. (16)	BTL4	Analyzing
15.	Discuss in detail about the two significant mechanisms of plastic deformation in metals. (16)	BTL3	Applying
16.	Elaborate the four main strengthening methods against plastic yield. (16)	BTL3	Applying
17.	Explain the strengthening methods which are used to restrict the dislocation motion. (16)	BTL4	Analyzing

UNIT-II: PHASE DIAGRAMS

Solid solutions - Hume Rothery's rules - the phase rule - single component system - one-component system of iron - binary phase diagrams - isomorphous systems - the tie-line rule - the lever rule - application to isomorphous system - eutectic phase diagram - peritectic phase diagram - other invariant reactions - free energy composition curves for binary systems - microstructural change during cooling.

PART – A			
Q.No	**Questions**	**BT**	**Competence**
1.	What is a solid solution?	BTL1	Remembering
2.	Differentiate substitutional and interstitial solid solutions with an example.	BTL2	Understanding
3.	Give the Hume Rothery's rules for formation of solid solution.	BTL1	Remembering
4.	What is the effect of crystal structure and atomic radii on formation of solid solution between two metallic elements?	BTL2	Understanding
5.	What happens when the electro negativities of atoms differ?	BTL2	Understanding
6.	Define the term Phase.	BTL1	Remembering
7.	Define degrees of freedom.	BTL1	Remembering
8.	What is a phase diagram?	BTL1	Remembering
9.	Mention the significance of phase diagram.	BTL2	Understanding
10.	Define Gibb's Phase rule.	BTL1	Remembering
11.	What is a single component or unary system?	BTL1	Remembering
12.	What is meant by tie-line rule?	BTL1	Remembering
13.	State lever rule.	BTL1	Remembering
14.	Mention the use of tie-line rule and lever rule in the binary phase diagram.	BTL2	Understanding
15.	Define isomorphous system. Give two examples	BTL1	Remembering
16.	What are liquidus, solidus and solvus line in a phase diagram?	BTL2	Understanding
17.	Define invariant reaction.	BTL1	Remembering
18.	What is Eutectic Reaction?	BTL1	Remembering
19.	What is Peritectic Reaction?	BTL1	Remembering
20.	What is meant by peritectoid reaction?	BTL1	Remembering
21.	Define eutectoid phase reaction	BTL2	Understanding
22.	What is meant by syntectic reaction?	BTL1	Remembering
23.	State the monotectic reaction.	BTL1	Remembering
24.	Give the difference between hypoeutectic alloy and hypereutectic alloy.	BTL2	Understanding
PART – B			
1.	(i) Discuss the Hume Rothery's rule for forming a solid solution. (10) (ii)Write short notes on substitutional and interstitial solid solution. (6)	BTL3 BTL4	Applying Analyzing
2.	(i) How are solid solutions classified? Give example for each. (6) (ii) Discuss the Hume –Rothery rules for the solid solubility of one element in another. (10)	BTL4 BTL3	Analyzing Applying

3.	With neat diagram explain the Unary phase diagram of pure iron. (16)	BTL4	Analyzing
4.	Explain unary phase diagram of iron and explain different phases formed with increase in temperature. (16)	BTL4	Analyzing
5.	Explain in detail about binary Isomorphous system and the region present in it. (16)	BTL4	Analyzing
6.	(i) Draw a typical equilibrium diagram for an isomorphous system. (12) (ii) Explain tie line rule and lever rule and apply the same for an isomorphous system. (4)	BTL4 BTL3	Analyzing Applying
7.	Draw a typical equilibrium diagram for a eutectic type of system with limited solid solubility and explain its important features. (16)	BTL4	Analyzing
8.	Explain the phase diagram of a system whose solubility is limited and the melting points of the components are comparable. (16)	BTL4	Analyzing
9.	Cu and Ag have limited solid solubility. The melting point of Cu is 1085°C and Ag is 779°C and both the elements have FCC structure. Identify and explain the phase diagram in detail. (16)	BTL3	Applying
10.	Draw a typical equilibrium diagram for a peritectic type of system with limited solid solubility and explain its important features. (16)	BTL3	Applying
11.	Explain the phase diagram of a system whose solubility is limited and the melting points of the components are vastly different. (16)	BTL4	Analyzing
12.	Discuss about the invariant reaction in which a solid phase and liquid phase will together form a second solid phase at a particular temperature and composition upon cooling. (16)	BTL3	Applying
13.	What do you mean by free energy curves? Explain the construction of phase diagram of completely soluble components from Gibb's energy curves with suitable sketch. (16)	BTL4	Analyzing
14.	Explain about Eutectoid, peritectoid, monotectic and syntectic invariant reactions with an example. (16)	BTL4	Analyzing
15.	Explain in detail about the changes in microstructure due to equilibrium cooling with a neat diagram. (16)	BTL4	Analyzing
16.	Discuss in detail the microstructural changes that takes place in a eutectic system. (16)	BTL3	Applying
17.	Discuss the microstructural changes for any alloy that occur on cooling in the binary isomorphous system. (16)	BTL3	Applying

UNIT-III: FERROUS ALLOYS

The iron-carbon equilibrium diagram - phases, invariant reactions - microstructure of slowly cooled steels - eutectoid steel, hypo and hypereutectoid steels - diffusion in solids - Fick's laws - phase transformations - TTT-diagram for eutectoid steel - pearlitic, bainitic and martensitic transformations - tempering of martensite - steels - stainless steels - cast irons.

PART – A

Q. No	Questions	BT	Competence
1.	What is meant by ferrous alloy?	BTL1	Remembering
2.	Name the micro-constituents of iron-carbon alloys.	BTL2	Understanding

3.	Define cementite.	BTL1	Remembering
4.	Why carbon solubility is more in an austenite?	BTL2	Understanding
5.	Calculate the amount of ferrite and cementite present in pearlite.	BTL2	Understanding
6.	What feature in the iron-carbide diagram is used to distinguish between steels and cast irons?	BTL2	Understanding
7.	Distinguish hypo eutectoid steel and hypereutectoid steels.	BTL2	Understanding
8.	Differentiate between Martensite and Bainite.	BTL2	Understanding
9.	What is meant by pearlite?	BTL1	Remembering
10.	Write the microstructure of Eutectoid steel.	BTL1	Remembering
11.	Define the term diffusion.	BTL1	Remembering
12.	State Fick's first law of diffusion.	BTL1	Remembering
13.	State Fick's second law.	BTL1	Remembering
14.	What is phase transformation? Give examples.	BTL1	Remembering
15.	What is tempering of matensite?	BTL2	Understanding
16.	What is meant by TTT diagram?	BTL2	Understanding
17.	List the possible classifications of stainless steel based on their microstructure.	BTL2	Understanding
18.	What is low Carbon steel?	BTL2	Understanding
19.	Why are steels stainless?	BTL3	Understanding
20.	Differentiate low, medium and high carbon steels.	BTL2	Understanding
21.	How do cast irons differ from steels in terms of carbon content?	BTL2	Understanding
22.	Mention the types of cast irons.	BTL1	Remembering
23.	What is gray cast iron?	BTL1	Remembering
24.	List out the various morphologies of graphite in cast iron.	BTL2	Understanding
	PART-B		
1.	Draw the iron- carbon equilibrium diagram and list the invariant reactions in it. (16)	BTL3	Applying
2.	Explain iron-carbon phase diagram and explain different phases formed with respect to change in composition and temperature. (16)	BTL4	Analyzing
3.	Explain the various invariant reactions involved in the system with the help of the Fe-C equilibrium diagram. (16)	BTL4	Analyzing
4.	Explain the microstructural development for slowly cooled steels. (16)	BTL4	Analyzing
5.	Describe the structural changes that take place in hypo and hyper Eutectoid with neat diagrams. (16)	BTL3	Applying
6.	Explain in detail the microstructural changes that occur in steel with composition less than 0.76 wt% C and greater than 0.76 wt% C. (16)	BTL4	Analyzing
7.	Derive Fick's first and second law of diffusion equation with necessary diagrams. (16)	BTL3	Applying
8.	Briefly explain the concepts of steady state diffusion and non-steady state diffusion on the basis of Fick's law. (16)	BTL4	Analyzing

9.	With the help of temperature- time- transformation (TTT) diagram of eutectoid steel, brief on the microstructure and properties of the following heat treatment process: annealing, normalizing, quench hardening and tempering. (16)	BTL3	Applying
10.	Describe the various transformations involving the decomposition of austenite with the help of a TTT diagram of eutectoid Steel. (16)	BTL3	Applying
11.	With the help of Isothermal Transformation Diagram explain the transformation of austenite to pearlite, bainite and martensitic. (16)	BTL3	Applying
12.	What are the main characteristics of stainless steels? Name different types of stainless steels and their applications. (16)	BTL4	Analyzing
13.	State different types of steel based on carbon content and explain each one of them in detail. (16)	BTL4	Analyzing
14.	Write short notes about the following materials in terms of composition, properties and applications. (i) Austenite stainless steel (ii) Ferrite Stainless steel and (ii) Martensite stainless steel (16)	BTL4	Analyzing
15.	Explain the classification of cast iron in detail. (16)	BTL4	Analyzing
16.	Explain the properties and applications of different types of cast iron. (16)	BTL4	Analyzing
17.	Draw the microstructure of any four types of cast irons and give one application for each. (16)	BTL3	Applying

UNIT-IV: MECHANICAL PROPERTIES

Tensile test - creep resistance - creep curves - mechanisms of creep - fracture - the Griffith criterion - critical stress intensity factor and its determination - fatigue failure - fatigue tests - methods of increasing fatigue life - hardness - Rockwell and Brinell hardness - Knoop and Vickers microhardness - Nanoindentation.

PART – A

Q. No	Questions	BT	Competence
1.	Give the principle behind tensile test.	BTL1	Remembering
2.	Define yield point.	BTL1	Remembering
3.	What is meant by resilience?	BTL1	Remembering
4.	A steel specimen has a yield stress of 325.95 MPa and modulus of elasticity 2.1×10^{11} N/m^2. Calculate the modulus of resilience.	BTL2	Understanding
5.	An Aluminium rod of 12.5 mm diameter is subjected to fracture with a load of 50.5 kN. Calculate the fracture stress for the applied load.	BTL2	Understanding
6.	Define creep .	BTL1	Remembering
7.	Define creep resistance.	BTL1	Remembering
8.	Name few mechanisms whereby creep deformation occurs.	BTL2	Understanding
9.	List few methods to improve the creep resistance in alloys.	BTL2	Understanding
10.	Define fracture.	BTL1	Remembering
11.	Define brittle fracture.	BTL1	Remembering
12.	What is ductile fracture?	BTL1	Remembering
13.	Distinguish between ductile and brittle fracture.	BTL2	Understanding
14.	Why ductile fracture is more preferred than brittle fracture?	BTL2	Understanding
15.	Define critical stress intensity factor.	BTL1	Remembering

16.	A sample of glass has a crack of half-length 2 μm. The Young's modulus of the glass is 70 GN/m^2 and the specific surface energy is $1J/m^2$. Estimate its fracture strength.	BTL2	Understanding
17.	What is fatigue?	BTL1	Remembering
18.	List out the factors that lead to fatigue failure.	BTL2	Understanding
19.	List the steps of fatigue failure in metals.	BTL2	Understanding
20.	Define the term endurance limit in fatigue test.	BTL1	Remembering
21.	Mention methods of increasing fatigue life.	BTL2	Understanding
22.	Define hardness.	BTL1	Remembering
23.	What type of an indenter and range of load is used in Vickers and Knoop microhardness test?	BTL2	Understanding
24.	What is meant by Nanoindentation?	BTL1	Remembering

	PART-B		
1.	Discuss the tensile testing of materials. What are the important properties that can be obtained from the stress-strain curve? (16)	BTL3	Applying
2.	With a neat diagram explain the construction and working of tensile machine. Explain the various properties obtained from the tensile test. (16)	BTL4	Analyzing
3.	Draw the engineering stress – strain curve for mild steel. Discuss the tensile test and different mechanical properties obtained in tensile testing. (16)	BTL3	Applying
4.	(i) Write short note on the different stages in a creep curve. (12) (ii) Explain creep resistance materials with their properties. (4)	BTL4 BTL4	Analyzing Analyzing
5.	Draw a typical creep curve and brief on the various creep mechanism. (16)	BTL4	Analyzing
6.	Explain the different types of fracture. (16)	BTL4	Analyzing
7.	Write briefly about (i) Brittle fracture (8) (ii) Ductile fracture (8)	BTL4 BTL4	Analyzing Analyzing
8.	Explain Griffith's theory of fracture. (16)	BTL4	Analyzing
9.	Describe an experiment of fatigue test and also the methods of increasing fatigue life. (16)	BTL3	Applying
10.	Draw S-N curve for ferrous and non-ferrous metals and explain the procedure used to obtain S-N diagram. (16)	BTL4	Analyzing
11.	Describe fatigue testing and methods for improving fatigue strength of the components. Draw the S-N curve for Aluminium and tool steel. (16)	BTL3	Applying
12.	Explain the testing procedure for Rockwell hardness test and list the advantages and limitations. (16)	BTL4	Analyzing
13.	Explain the testing procedure for Brinell hardness test and list the advantages and limitations. (16)	BTL4	Analyzing
14.	Write in detail about the Vickers micro hardness test with its advantages and disadvantages. (16)	BTL4	Analyzing
15.	Discuss the Knoop micro hardness test with its advantages and disadvantages. (16)	BTL4	Analyzing

16.	Write in detail about the load, Intender, time duration and formula used in Rockwell, Brinell, Vicker and Knoop hardness. (16)	BTL4	Analyzing
17.	Explain how Nano indentation is used to investigate mechanical properties like hardness, elasticity of the material which gives ability to resist permanently, deformed when load is applied.	BTL3	Applying

UNIT-V: ADVANCED ENGINEERING MATERIALS

Metallic glasses: types - melt spinning process - properties and applications - Shape memory alloys - shape memory effect, pseudo elastic effect, properties of Ni-Ti alloy - applications: SMA blood clot filter - Ceramics - Super hard materials - Tungsten carbide and Boron nitrides - Graphene - Applications - Superplastic forming - Bulk nanostructured materials by Severe Plastic Deformation (SPD) - Nanomaterials - properties - Nanoparticle thin film coating for self-cleaning applications.

PART – A

Q.No	Questions	BT	Competence
1.	Define metallic glasses.	BTL1	Remembering
2.	What is meant by glass transition temperature?	BTL1	Remembering
3.	List the merits of metallic glasses as transformer core.	BTL2	Understanding
4.	State any four applications of metallic glasses.	BTL2	Understanding
5.	What is meant by shape memory effect?	BTL1	Remembering
6.	Specify two phases of shape memory alloys.	BTL1	Remembering
7.	State pseudo elasticity.	BTL1	Remembering
8.	Mention the advantages and disadvantages of shape memory alloys.	BTL2	Understanding
9.	List the applications of SMA in medical field.	BTL2	Understanding
10.	Define ceramic materials.	BTL1	Remembering
11.	Write the general mechanical properties of ceramics.	BTL1	Remembering
12.	Why are ceramics hard and brittle in nature?	BTL2	Understanding
13.	What is a cermet?	BTL1	Remembering
14.	Ceramics are stronger in compression than in tension. Reason out.	BTL2	Understanding
15.	What are Super hard materials?	BTL1	Remembering
16.	Mention the uses of Tungsten carbide and Boron nitrides.	BTL2	Understanding
17.	Mention the applications of graphene.	BTL2	Understanding
18.	Define Superplastic forming (SPF).	BTL1	Remembering
19.	What is meant by Severe Plastic Deformation (SPD)?	BTL1	Remembering
20.	What are nanomaterials?	BTL1	Remembering
21.	Mention some effects of size reduction of nano particles	BTL2	Understanding
22.	Write any four applications of nanoparticles.	BTL1	Remembering
23.	Define contact angle hysteresis.	BTL1	Remembering

24.	What is the lotus effect on glasses?	BTL2	Understanding

PART – B

Q.No	Questions	Level	Competency
1.	Discuss the preparation, Characteristics and uses of Metallic Glasses. (16)	BTL3	Applying
2.	Describe in detail the preparation, properties and applications of metallic glasses. (16)	BTL3	Applying
3.	How is metallic glass produced by melt spinning method? List out the properties and applications of metallic glasses. (16)	BTL4	Analyzing
4.	Describe the characteristics of Shape Memory Alloys and its applications. (16)	BTL4	Analyzing
5.	(i)Write in detail about Shape Memory Alloys. (10) (ii)List out the characteristics and applications of SMA. (6)	BTL4 BTL3	Analyzing Applying
6.	Discuss in detail about shape memory effect, pseudo elasticity and hysteresis effect of SMA. (16)	BTL3	Applying
7.	Describe the characteristics exhibited by Ni-Ti shape memory alloys and its applications. (16)	BTL4	Analyzing
8.	List out and explain the properties and applications of any four types of ceramics. (16)	BTL4	Analyzing
9.	i) Write a short note on glass ceramics. (8) ii) Give the properties and applications of different ceramics. (8)	BTL4 BTL3	Analyzing Applying
10.	Explain how ceramic materials can be classified in different ways. (16)	BTL4	Analyzing
11.	Explain super hard materials and their applications. (16)	BTL4	Analyzing
12.	Explain the properties and applications of Tungsten carbide and Boron nitrides. (16)	BTL4	Analyzing
13.	(i) Describe the phenomenon of Superplastic forming. (8) (ii) Explain bulk nanostructured materials by Severe Plastic Deformation (SPD). (8)	BTL4 BTL4	Analyzing Analyzing
14.	List and explain the properties and applications of graphene. (16)	BTL4	Analyzing
15.	Describe the mechanical, electrical properties and applications of graphene. (16)	BTL3	Applying
16.	What are nanomaterials? Explain the properties and applications of nanomaterials. (16)	BTL4	Analyzing
17.	Explain how Lotus Leaf-Inspired Nanotechnology is used in thin film coating for self-cleaning applications. (16)	BTL3	Applying