Summer 2020

MATERIAL SCIENCE AND ENGINEERING

Time : Three hours

Maximum Marks: 100

Answer FIVE *Questions, taking* ANY TWO *from* **Group A,**
ANY TWO *from* **GROUP B** and ALL *from* **GROUP C.**

All parts of a question (a, b, etc.) should be answered at one place

Answer should be brief and to-the-point and be supplemented with neat sketches.

Unnecessary long answer may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

GROUP A

1. (a) Write the differences between crystalline and non-crystalline materials, defining both of them. 5
(b) Draw the crystal cell diagram and classify the crystal system. 5
(c) What are the differences between metals and alloys? Give two examples each for metals and alloys. 5
(d) What are the differences between ceramics and polymers? Give two examples each for ceramics and polymers. 5

2. (a) Write names of important point defects and describe about each of them. 8
(b) Draw the diagram and explain about edge dislocation. 8
(c) Explain diffusion in solids with examples. 4

3. (a) Draw the binary phase diagram with specific notations. 5
(b) Describe Gibb's phase rule. 5
(c) Draw a neat diagram of tensile stress-stain curve showing the relevant points. 5
(d) Explain viscoelastic properties and creep. 5

4. (a) Explain ductile fracture and Griffith theory. 6
(b) What are the effects of heat treatment and temperature on properties of metals? 6
(c) Explain Bauchinger's effect. Describe the deformation in polycrystalline materials. Explain cold and hot working with suitable diagrams. 8

GROUP B

5. (a) Why heat treatment of steel is done? Explain two main important stages of heat treatment. 6
(b) Describe annealing, normalizing, hardening and tempering processes of heat treatment. 8
(c) Explain austempering and carburizing of steel. What are the advantages? 6

6. (a) Define specific heat, thermal conductivity and thermal expansion. 6
(b) Explain crystalline and noncrystalline ceramics with suitable examples. 4
(c) What are the types of refractories? Describe main uses of refractory materials. 5
(d) What are the electrical properties of ceramic phases? Differentiate rocks and building stones. 5

7. (a) What are the structural properties of (i) Polymer, (ii) Thermoplastics (iii) Thermosets and (iv) Elastomer. 8
(b) Explain polymerization mechanism. 4

(c) Describe main properties of glass. What is polymerism fraction in glass? Explain with examples. 8

8. (a) Explain magnetism, diamagnetism, paramagnetism, and ferromagnetism. 8
(b) What is cryogenics? Explain polymerization mechanismwith suitable application. 6
(c) Explain magnetic energy. Define insulators. 6

GROUP C

9. Answer *all* questions. 2 × 10

(i) Magnetic moment.
(ii) Grain growth
(iii) Age hardening
(iv) Critical cooling rate.
(v) Iron-carbon system.
(vi) Work hardening recovery.
(vii) Season cracking
(viii) Yield strength.
(ix) Nanomaterial
(x) Susceptibility of paramagnetic magnetic material.

Winter 2019

MATERIAL SCIENCE AND ENGINEERING

Time : Three hours

Maximum Marks: 100

Answer FIVE *Questions, taking* ANY TWO *from* **Group A,**
ANY TWO *from* **GROUP B** and ALL *from* **GROUP C.**

All parts of a question (a, b, etc.) should be answered at one place

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answer may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicates full marks.

GROUP A

1. (a) Classify the different groups of Engineering Materials. Mention the areas in which they are used. 5
   (b) Distinguish between thermoplastics and thermosets, using any three of their characteristics 5
   (c) On the basis of their structure, describe how elastomers are different from the other long-chain polymers 5
   (d) What is the weight of sulphur that is required to fully cross link 68 kg of polyisoprene (ebonite) starting from natural rubber? 5

2. (a) What is crystal imperfections? What are the crystalline imperfections? 5
   (b) What are the points of imperfections in an elemental crystal? 5
   (c) Differentiate Frenkel defect between Schottky defect with suitable sketches 10

3. Explain with suitable examples the following: 5*4
   (i) The phase rule
   (ii) Binary phase diagrams
   (iii) The level rule
   (iv) Fick's laws of diffusion

4. (a) Draw a neat diagram of tensile stress-strain curve mentioning important points 5
   (b) Explain plastic deformation by slip with suitable sketches. 5
   (c) Explain the effect of grain size on dislocation motion 4
   (d) Define creep. What are the mechanisms of creep? 6

GROUP B

5. (a) What is heat treatment of steel? 2
   (b) Define annealing, normalizing, hardening and tempering with suitable examples 8
   (c) What is the difference age hardening and surface hardening? 4
   (d) Explain the process of case carburizing of a steel component. 6

6. (a) Explain with sketches-Ductile Fracture and Brittle Fracture 12
   (b) A sample of glass has a crack of half length 2μm.TheYoung's modulus of the glass is 70 GN m^{-2} and specific surface energy is 1 Jm^{-2} .Estimate its fracture strength and compare it with its Young's modulus 8

7. (a) Define specific heat ,thermal conductivity and thermal expansion with examples. 6
   (b) What are the thermal properties of metal? What are the advantages of high temperature of Materials? 10

8. (a) What are the difference between ceramic materials and polymers ? 2
(b) Define thermoplastics, thermosets and elastomer with examples 8
(c) Define magnetism, dimagnetism, paramagnetism and ferromagnetism 8
(d)What is nano material? Give an example. 2

GROUP C

9. Answer in brief the following: 2*10

(i) Define semiconducting materials with examples.
(ii) Diffusion in solids
(iii) Binary systems
(iv) Viscoelastic properties
(v) Bauchinger's effect
(vi) Cold and hot working
(vii) Silicone structures
(viii) Time scale for phase changes
(ix) Decarburization of steel
(x) Long chain polymers

Summer 2019

MATERIAL SCIENCE AND ENGINEERING

Time : Three hours

Maximum Marks: 100

Answer FIVE *Questions, taking* ANY TWO *from* **Group A,**
ANY TWO *from* **GROUP B** and ALL *from* **GROUP C.**
All parts of a question (a, b, etc.) should be answered at one place
Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answer may result in loss of marks.
Any missing or wrong data may be assumed suitably giving proper justification.
Figures on the right-hand side margin indicates full marks.

Group A

1. (a) What is the difference between crystalline and amorphous materials ? What is atomic packing factor ? Show that the atomic packing factor for FCC crystal strucure is 0.74. 10
   (b) Define a unit cell? Write the difference between space lattice and bravais lattice. 5
   (c) Distinguish between metals,ceramics and polymers with respect to bonding. 5

2. (a) Schematically represent the Frenkel and Schottky Imperfection. 6
   (b) Distinguish between the direction of the dislocation lines,the Burgers vector and the direction of motion for both edge and screw dislocation, differentiating between positive and negative types. 8
   (c) Find the equilibrium concentration of vaccancies in aluminium at 300 K and 900 K. Given AHr = 68 kJ/mol. 6
3. (a) State ficks laws of diffusion. 8
   (b) Explain Gibhs phase rule. 4
   (c) Deduce an expression for engineering strain and true strain. 4
   (d) Explain the significance of the secondary stage of an idealized creep curve. 4
4. (a) Distinguish between : 5 x 3
   (i) Cold and hot working
   (ii) Slip and twinning
   (iii)Recovery and recrystallisation
   (b) Deduce an expression for critical resolved shearstress(CRSS) for a polycrstalline metal. 5

Group B

5. (a) Compare between: 5 x 2
   (i) Austempering and martempering
   (ii) Gas carburising and carbonitriding
   (b) Define hardenability. Enumerate the factors affecting the hardenability of the steel. 5
   (c) What is age hardening ? what are the main requirements for an alloy to depict size hardening? 5
6. (a) Breifly explain why the thermal conductivities are higher for crystalline non crstalline ceramics. 6
   (b) Cite the measures to be undertaken to reduce the likelyhood of thermal stock of accarmic specimam. 4
   (c) Discuss different types of refractories with suitable examples. 7
   (d) Mention two desirable characteristics of glasses. 3
7. (a) Cite the primary differences between addition and condensation polymerization techniques. 6
   (b) What are clastomers? List the molecular characteristics that are essential for clastomers. 4

(c) What is the distinction between macris and dispersed phases in a composite material?contrast the mechanical characteristics of matrix and dispersed phases for fiber-reinforced composites. 6

(d) Mention the general differencein strengthening mechanism between large particle and dispersion strengthened particle- reinforced composites. 4

8. (a) Explain diamagnetism,paramagnetism and ferromagnetism in magnetic materials. 6

(b) Enumerate the differences between hard and soft magnetic materials with respect to magnetization curves. 4

(c) Mention the reasons for the difference in electrical conductivity between metals,semiconductors, and insulators in terms of electron energy band structure. 6

(d) At room temperature the electrical conductivity of Pbs is 25 (Ω -m)-1,whereas the electron and hole mobilities are 0.06 and 0.02m2/V-s respectively. Compute the intrinsic carrier concentration for PbS at room temperature. 4

Group C 2 x 10

9. Answer in brief the following:

(i) What is the angle between the directions [001] and [111] of cubic crystal?

(ii) What is the degree of freedom of a system of two components when the number of phases in two?

(iii) What is congruent transformation?

(iv) Define devitrification.

(v) What is mobility?

(vi) Write the expressions for permeability and suscep tibilty of a magnetic materials.

(vii) Define the term Tg.

(viii)What is vulcanization?

(ix) Write the invariant reactions: (a) monotecic (b) syntectic.

(x) State the Griffith criterion for the propagation of a crack.

Winter 2018

MATERIAL SCIENCE AND ENGINEERING

Time: Three hours

Maximum marks: 100

Group A

1. (a) What are the differences between crystalline and non-crystalline materials? Draw the unit cell diagram indicating α,β and γ and a,b,c and classify the seven crystal systems based on the relation between a,b,c and α, β, γ. (8)

   (b) What are the differences between metals and alloys? Give at least one example for metals and alloys. (6)

   (c) What are important characteristics properties of polymers and give a few applications. (6)

2. (a) Write the names of important point defects and write about each one of them. (8)

   (b) Draw the diagram and explain about edge dislocation. (6)

   (c) Calculate number of vacancies in one mole nickel (Ni) at a temperature of 500 K. Enthalpy of formation of vacancies in Nickel $= 168 \times 10^{3}$ joules/ mole, Avogadro number $N = 6.02 \times 10^{23}$ atoms per mole, $R = 8.314\,\text{J mol}^{-1}\text{K}^{-1}$ (6)

3. (a) Draw the $Al_2O_3 - Cr_2O_3$ binary phase diagram, and write the phase rule for this system and explain meanings of liquidus and solidus. In the two phase region, what are degrees of freedom? (8)

   (b) In mechanical properties of solids, explain on *(1)* Elastic deformation, *(ii)* ordinary elasticity and *(iii)* rubber like elasticity. (6)

   (c) Draw the load vs elongation curve for a metal and explain (i) Engineering stress, (ii) Engineering strain and ultimate tensile strength. (6)

4. (a) What is plastic deformation? Explain (i) slip, (ii) Twinning. Usually at what temperatures, slipping and twinning occurs and explain. (8)

(b) Explain how dislocations are multiplied during deformation. Draw the diagram and explain the successive stages in the operation of a Frank-Read source. (6)

(c) In case of Copper (Cu), its work hardened to a stage where slip occurs at a shear stress of 45 MNm^{-2}. The shear modulus of Copper is 45 GMm^{-2}. The burgers vector of dislocations in copper=2.55A°. Calculate the length of dislocation, line between two pinning points in Copper. (6)

Group B

5. (a) Why steels are widely used in industries? Give at least four properties of steel with its wide use. (8)

   (b) Write any two important principles of heat treatment of metals and purpose. (6)

   (c) Explain two main important stages of heat treatment. (6)

6. (a) Define annealing. What are the main objectives of annealing? (10)

   (b) When temperature difference is maintained name the type of the carriers and how they are able to carry the energy from high temperature regions to low temperature regions to low temperature regions in the metals. (5)

   (c) What are the types of refractories? Write about important use of refractory materials. (5)

7. (a) What is glass? Write about its main important constituents. If suitable chemicals are added to the sand, what happens to its fusion temperature? Name the chemicals required to decrease fusion temperature. (9)

   (b) Write about its key important properties of glass. (6)

   (c) What is polymer? Give one example of it. Write the differences between thermosets and thermoplasts. Give name of two thermosetting polymers. (5)

8. (a) What is cryogenics? Write about characteristics of low temperature materials. (10)

(b) What are composite materials? Give important characteristics of composites and give examples. (5)

(c) A very small size iron particle of cubic shape has volume **v** = $(2.87)^3 x 10^{-30} m^3$. It has two atoms. The saturation magnetisation of particle is 170000A/m. calculate net magnetic moment per atom. (5)

Group C

9. Answer all questions: 2 x 10

(i) Which of the following has higher energy band gap and explain why?
   (a) Metals
   (b) Ceramics

(ii) A copper sheet is in contact with aluminium sheet and is heated to 600ºC. pre exponential constant. Do Cu $_{in\ Al}$=0.25 x $10^{-4} m^2 S^{-1}$. Activation energy Q $_{Cu\ in\ Al}$ = 121 x 1000 J mol^{-1}. Calculate diffusion coefficient of Cu in Al at 600ºC, R=8.314J $mol^{-1} K^{-1}$.

(iii) In binary phase diagram, the number of components is two (2). In certain region of phase diagram, number of phases are '2'. The pressure is kept constant all the time. Calculate the number of degrees of freedom.

(iv) In case of mechanical properties of materials, define true stress and true strain and mention the meanings of symbols used.

(v) Draw the tensile load versus elongation curve of a metal and define yield point. Show yield point in the diagram.

(vi) Define recrystallization in poly crystalline materials.

(vii) Define spontaneous magnetisation in ferromagnetic materials.

(viii) When a semi-conductor is heated to higher temperature what happens to its resistance? Explain.

(ix) What are the carriers of thermal conductivity in ceramics when temperature difference is maintained between its two ends? Explain.

(x) Define susceptibility of paramagnetic magnetic material. Is it positive or negative. What is its approximate magnitude?

Summer 2018

MATERIAL SCIENCE AND ENGINEERING

Time: Three hours

Maximum Marks: 100

Group A

1. (a) What is the difference between space lattice and bravais lattice? Mention different types of Bravais lattices. Show that the atomic packing factor for BCC crystal structure is 0.68. (8)

   (b) State Fick's laws of diffusion. (7)

   (c) Differentiate between Frenkel and Schottky defect. (5)

2. (a) Discuss the rules that led to the formulation of conditions which favour the extensive substitutional solid solubility, state the difference between random and ordered solid solution. (8)

   (b) What are the difference between the state of phase equilibrium and metastability? (4)

   (c) Explain why cross-slip occurs in BCC and FCC metals, but not in HCP metals. Define Burgers vector. Distinguish between the direction of the dislocation line, the Burgers vector and the direction of motion for both edge and screw dislocations. (8)

3. (a) Discuss the role of (i) grain boundaries and (ii) precipitate particles in strengthening crystalline materials against plastic yield (6)

(b) Why creep is considered to be a high temperature property? Enumerate the metallurgical variables affecting the creep behavior of a material. Explain the effect of grain size on the creep strength of a material. (8)

(c) Distinguish between the ductile and brittle fracture. (6)

4. (a) Explain the Schmid's law. (5)

(b) Briefly differentiate the following: (5 × 3)

(i) Hot and cold working

(ii) Slip and twinning

(iii) Recovery and recrystallization.

GROUP B

5. (a) Compare the following :

(i) Cyaniding and Carbo- nitriding (5)

(ii) Martempering and austempering (5)

(b) What are the main requirements for an alloy to be age-hardenable? What is the driving force for age hardening? (6)

(c) Mention the objective of stress-relieving annealing process. (4)

6. (a) Cite three characteristics that improve and two characteristics that are adversely affected by increasing the porosity for refractory ceramics. (5)

(b) Why are the borosilicate glass and fused silica resistant to thermal shock? (5)

(c) What is devitrification? Mention the desirable characteristics of glass – ceramics (5)

(d) Briefly explain how the degree of crystallinity affects the thermal conductivity of polymeric materials and why? (5)

7. (a) State the difference between addition polymerization and condensation polymerization. (6)

(b) Briefly explain how molecular weight and degree of crystallinity, influences the tensile strength and tensile modulus of a semi- crystalline polymer. (5)

(c) For a polymer-matrix fiber –reinforced composite, (i) compare the desired mechanical characteristics of matrix and fibre phases and (ii) mention reasons why there must be strong bond between fibre and matrix at their interface (5)

(d) What are the general differences in strengthening mechanism between large-particle and dispersion strengthened particle – reinforced composites? (4)

8. (a) Explain briefly the phenomenon of magnetic hysteresis and why it occurs for ferromagnetic and ferromagnetic materials? (6)

(b) Why the magnitude of the saturation magnetization decreases with increasing temperature for ferromagnetic materials? (4)

(c) In terms of electron band structure, discuss reasons for the difference in electrical conductivity between metals and semiconductors. (5)

(d) Calculate the electrical conductivity of intrinsic silicon at 150 °C ;the intrinsic carrier concentration is $5\times 10^{19} m^{-3}$, the electron and hole mobilities are $0.07 m^2$/V-s and $0.023 m^2$/V-s, respectively. (5)

GROUP C

9. Answer the following in brief: (2× 10)

(i) Define a Burger Vector.

(ii) How modulus of elasticity and bulk modulus is related?

(iii) What is synthetic and monotectic reaction?

(iv) What is a laminar composite?

(v) What is S-N curve?

(vi) Define the terms (a) susceptibility and (b) permeability of a material .

(vii) How electron mobility and drift velocity is related?

(viii) What is jominy end – quench test?

(x) What is stress corrosion cracking?

Winter 2017
MATERIAL SCIENCE AND ENGINEERING

Time: Three hours
Maximum marks: 100

Group A

1. (a) What is the crystal structure? Mention different types of crystal systems. Show That the packing efficiency for FCC crystal structure is 0.74. 7
(b) State laws of steady state and non-steady state diffusion process. 7
(c) Differentiate between two types of zero-dimensional defects. 6
2. (a) Discuss the Hume-Rothery rules that govern the extension substitutional solid Solubility. 6
(b) What is phase rule? Mention the number of phases, components and degree of Freedom at the peritectic temperature of a binary phase diagram. 6
(c) Define Burgers vector. Distinguish between edge and screw dislocations. 8
3. (a) Explain briefly the main strengthening methods against plastic yield at low Temperatures. 6
(b) Discuss the various mechanisms of creep process. 6
(c) Mention the salient features of Cup and Cone type of fracture. 4
(d) Deduce a relationship between engineering strain and natural strain. 4
4. (a) Explain the critical resolved shear stress (CRSS) of polycrystalline materials. 6
(b) Discuss the process of recovery, recrystallization and grain growth. 7
(c) Differentiate between two models of plastic deformation. 7

Group B

5. (a) Briefly explain the surface hardening treatments: (i) Case hardening (ii) Cyaniding, (iii) Carbonitriding. 9
(b) Discuss the precipitation sequence inA1-4.5% Cu alloy. 7
(c) Mention the objective of tempering process 4
6. (a) Briefly explain why the thermal conductivity is higher for crystalline than non Crystalline ceramics. Why porosity decreases the thermal conductivity of ceramic Materials? 6
(b) Define thermal stress. Briefly explain why thermal stress may be introduced in to a Structure by rapid heating or cooling . 5
(c) Briefly explain the different types of refractories with suitable examples. 6
(d) metals are typically better thermal conductors than ceramics explain. 3
7. (a) What are the difference between chain reaction polymerization and step reaction Polymerization and step reaction polymerization? 6
(b) compare between thermoplastic and thermosetting polymers (i) on the basis of Mechanical characteristics structures. 5
(c) What is distinction between matrix and dispersed phases in a composite material? Contrast the mechanical characteristics of matrix and dispersed phases for fiber Reinforced composites. Mention the general differences in strengthening mechanism Between large particle and dispersion-strengthened particle reinforced composites? 9
8.(a) Explain the differences between diamagnetism paramagnetism and ferromagnetism 6
(b) Why does the conductivity of semiconductor change with impurity content? Compare this with the behaviour of metallic conductors. 4
(c) State the differences between hard and soft magnetic materials in terms of both Hysteresis behaviour and typical application’s 5
(d) calculate the electrical conductivity of intrinsic silicon at 250 ºC; the intrinsic carrier concentration is 4×10^{19} m^{-3} , the electron and hole motilities are 0.06 m^2/V-s,

respectively . 5

Group C

9. Answer the following in brief : 2 x 10
   i. Define a Burger vector.
   ii. Shear modulus , G (kN/mm^2). Obeys proportionality with elastic modulus, E (kN/mm^2). If E=100 kN/mm^2 and Poisson ratio, 0-0.25, calculate the value of G
   iii. Define an elasticity and viscoelasticity.
   iv. State Griffith theory .
   v. What is fatigue limit of a material?
   vi. Define the term (a) Curie temperature and (b) remanence of material
   vii. What is meant by mobility?
   viii. Define hardenability? State the factors affecting the hardenability.
   ix. What is TD nickel?
   x. What is vulcanization of rubber?

SUMMER 2017

MATERIAL SCIENCE AND ENGINEERING

Time : Three hours

Maximum marks : 100

Answer five questions, taking any two from Group A, any two from Group B and all from Group C.

Group A

1. (a) Mention the types of Bravais lattices possible in crystalline materials. Show that the atomic packing factor for BCC crystal structure is 0.68. 7
   (b) State Fick's laws of diffusion. 7
   (c) Difference between Frenkel and Schottky defects. 6
2. (a) Explain Hume Rothery rules that govern the formation of substitutional solid solutions. 6

   (b) State Gibb's phase rule. Mention the number of variables and the degree of freedom at the eutectic temperature of a binary phase diagram. 6
   (c) Distinguish between the direction of the dislocation line, the Berger's vector and the direction of motion for both edge and screw dislocations, differentiating between positive and negative types. 8
3. (a) Discuss the role of (i) grain boundaries and (ii) precipitate in strengthening metallic alloys w.r.t yielding. 6
   (b) Explain the significance of secondary stage of a creep curve, what will be the effect of increasing temperature and stress on the creep rate? 6
   (c) Mention the essential difference between shear fracture and cleavage fracture 4
   (d) Establish a relationship between engineering strain and true strain. 4
4. (a) Differentiate between: 5x3
   (i) Slip and twinning
   (ii) Two types of mechanical working process
   (iii) Recovery and recrystallization.
   (b) Explain the Schmid's law 5

Group B

5. (a) What is tempering? Differentiate between austempering and martempering process. 6
   (b) Explain in brief the following surface hardening treatments: 6
   (i) Carburising (ii) Nitriding
   (c) Mention the basic requirements for an alloy to behave as age-hardenable. Discuss the stages of age-hardening process. 8
6. (a) Explain the fabrication of a glass-ceramics. State the most important desirable characteristics of glass-ceramics. 6

(b) What is devitrification? State the merits and demerits of devitrification process. 5

(c) Briefly explain the types of refractories with suitable examples. 5

(d) “Residual thermal stresses may be introduced into a structure by rapid heating or cooling”. Explain the statement. 4

7. (a) State the difference between chain reaction and step reaction polymerization. 6

(b) Mention the advantages of polymer matrices over metal matrices for composite materials. 6

(c) What is the distinction between continuous phase and dispersed phases in a composite material? State the difference between particle reinforced and fibre reinforced composites. 8

8. (a) explain the magnetic materials with suitable examples. 5

(b) Cite the major similarities and difference between ferromagnetic and ferromagnetic materials. 6

(c) Calculate the electrical conductivity of intrinsic silicon at 423 K. Given, intrinsic carrier concentration for Si at 423 K is $4x10^{19}m^{-3}$, intrinsic electron and hole mobilities are 0.06 m^2/V-s and 0.022 m^2/V-s respectively. 4

(d) How does the electron structure of an isolated atom differ from that of a solid material? 5

Group C

9. Answer the following in brief: 2x10

(i) What is hardenability?

(ii) Define glass transition temperature?

(iii) A cylindrical specimen of steel having an original diameter of 12.8 mm is tensile tested to fracture and found to have cross- sectional diameter at fracture as 10.7 mm, determine percent reduction in area.

(iv) Shear modulus, G (GPa), obeys proportionality with elastic modulus E (GPa). If E = 45 GPa and Poisson’s ratio v = 0.31, calculate the value of G.

(v) A pure aluminium wire has been drawn at temperature of 250 ^{0} C is it hot or cold working by relevant parameter?

(vi) What is peritectic reaction?

(vii) Write the stacking sequence in BCC and FCC crystal systems.

(viii) Why surface pits lower the fatigue strength of materials?

(ix) What is stress corrosion cracking?

(x) Define:

(a) Fatigue life and

(b) Endurance limit.

Winter 2016
MATERIAL SCIENCE AND ENGINEERING

Time: Three hours
Maximum Marks : 100

Group A

1. (a) Classify engineering material from various view point. Differentiate between steel and iron, alloys and composite and ceramics and polymers. (5)
   (b) What are different types of ceramics? Name any five ceramics and write their properties and application. (5)
   (c) (i) There is 5% probability for an electron to occupy an energy state which is 0.4eV above the Fermi energy. Estimate the temperature at which this can happen. (7)
   (ii) The dielectric strength of a natural rubber is 40000 V/mm at 60 Hz. Calculate the thickness of insulation on a wire carrying 33 kV to sustain the breakdown. (3)

2. (a) What is slip plane ? How it is related to dislocation ? Explain with the help of a diagram, the slip plane and slip plane and slip direction in FCC,BCC and HCC and HCP crystals. (5)
   (b) Describe the process of decomposition of austenite to the following: 2.5*4
   (i) Pearlite
   (ii) Ferrite
   (iii) Bainite
   (iv) Retained Austenite
   (c) Explain the working of TTT diagrams and what information in supplied by them ? (5)

3. (a) What is the necessity of knowledge true stress-strain diagram ? What are the utilities of these curves in tension, while the opposite is correct in compression – why ? (10)
   (b) Explain the mechanisms involved in creep occurrence. Suggest material to prevent or minimize creep in metals and non metals. (5)
   (c) Justify with reason whether ball bearing should be oil hardened or water quenched. (5)

4. (a) Write a short note on the Bauschinger effect. What is strain hardening and state the effect of strain hardening. (10)
   (b) Explain mechanism of dislocation in plastic deformation with neat sketches. (5)
   (c) Explain the yield point phenomenon in material in term of dislocation. (5)

5. (a) Use Fick's first law to derive an expression for growth rate of pearlite nodule. (6)
   (b) A piece of steel which was quenched after prolonged holding at 700^c was found to have ferrite martensite structure. Explain when would you except this to happen? (6)
   (c) Explain why thicker section are more susceptible to cracking during hardening heat treatment. (4)
   (d) Hardness of a quenched and tempered steel is reported to be RC 35. What additional test will you recommend to know that it has indeed been given this heat treatment? (4)

6. (a) For the MgO-Al2O3 system, what is the maximum temperature that is possible without the formation of a liquid phase ? At what composition or over what range of compositions will this maximum temperature be achieved ? (5)
   (b) Explain why residual thermal stresses are introduced in to a glass piece when it is cooled. (5)

   (c) Explain how density, firing distortion, strength, corrosion resistance and thermal conductivity are affected by the extent of vitrification. (5)

(d) Compare the manner in which the aggregate particles become bonded together In clay-based mixtures during firing and in cements during setting. (5)

7. (a) Briefly explain how each of the following influences the tensile modulus of a semi-Crystalline polymer and why:
   (i) Molecular weight
   (ii) Degree of crystallinity
   (iii) Deformation by drawing
   (iv) Annealing of an undeformed material
   (v) Annealing of a draw material. (6)

(b) Write an essay on polymeric materials that are used in the packaging of food products and drinks. Include a list of the general requisite characteristics of materials that are used for these applications. Now cite a specific material that is utilized for each of three different container types and the rationale for each choice. (4)

(c) List several advantages and disadvantages of using transparent polymeric materials for eyeglass lenses. Cite four factors that determine what fabrication technique is used to form polymeric materials. (5)

(d) A continuous and aligned glass fiber-reinforced composite consists of 40 volume % of glass fibres having a modulus of elasticity of 69 GPa and 60 volume % of a polyester resin that when hardened, display a modulus of 3.4 GPa.

   (i) Compute the modulus of elasticity of this composite in the longitudinal direction.
   (ii) If the cross-sectional area is 250mm and a stress of 50 MPa is applied in this longitudinal direction, compute the magnitude of the load carried by each of the fiber and matrix phases.
   (iii) Determine the strain that is sustained by each phases when the stress in part(ii) Is applied. (5)

8. (a) Estimate the maximum and minimum thermal conductivity values for a cement that Contains 90 volume % titanium carbide(TiC) particles in a nickel matrix,Assume Thermal conductivity of 27 and 67 W/m-K for TiC and Ni, respectively. (5)

(b) Write an expression for the modulus of elasticity for a hybrid composite in which all fibres of both types are oriented in the same direction. (5)

(c) Briefly explain why the magnitude of the saturation magneitization decreases with increasing temperature for ferromagnetic materials and why ferromagnetic behavior ceases above the Curiet temperature. (5)

(d) Calculate the(i) saturation magnetization and (ii) saturation flux density for nickel, which has a density of 8.90g/cm3.

Group C

9. Answer the following in brief:

(i) Obtain the miller indicies of a direction which is common to the planes(110) and (120) inside a cubic unit cell. (2)

(ii) Determine the interplaner spacing between (200),(220) and (111) planes in a FCC Crystal. The atomic radius is 1.246 A. (2)

(iii) Write short notes on: 2*5
   (a) Magnetization
   (b) Susceptibility
   (c) Bohr magneton
   (d) Curie constant
   (e) Neel temperature

SUMMER 2016
MATERIALS SCIENCE AND ENGINEERING
Group A

1. (a) Draw the unit cell diagram and classify seven crystal systems in terms of a, b, c and α, β, γ. Mention one material which possesses cubic crystal structure. (6M)

(b) Calculate the effective number of atoms per unit cell in BCC. (4M)

(c) What is the main difference between Schottky and Frenkel defects? (4M)

(d) Describe Fick's law of diffusion. (6M)

2. (a) Discuss the different mechanisms of strengthening in metals in brief. (6M)

(b) Explain the cup and cone fracture. (5M)

(c) State Griffith theory of brittle fracture. (3M)

(d) Describe in brief three stages of an ideal creep curve. (6M)

3. (a) Draw a neat diagram and explain behaviour of specimens under brittle and ductile fractures. (6M)

(b) Explain, with examples why materials for machine parts and structural components used at elevated temperatures must be creep-resistant. (6M)

(c) Explain, by giving spring and dashpot models, visco-elastic behaviour of materials. (8M)

4. (a) What is Gibb's phase rule? Draw the lead-tin phase diagram and explain eutectic and eutectoid reactions in it. (8M)

(b) What is Bauschinger effect in materials? Explain. (4M)

(c) What is slipping? Explain characteristic properties of slip lines and planes in materials. (8M)

Group B

5. (a) In the annealing of materials, explain on recovery, recrystallization and grain growth. (8M)

(b) What is tempering? Explain how it affects the properties of steel. (6M)

(c) What is the difference between hardness and hardenability? Explain the factors affecting hardenability. (6M)

6. (a) How much heat is required for 250g of tungsten to raise its temperature from 25ºC to 650ºC? Specific heat of tungsten is 0.032 cal/g.K. (6M)

(b) Explain the mechanism of how thermal expansion takes place. Why lead has larger thermal expansion coefficient than tungsten? (6M)

(c) What is ceramic material? Point out the mechanism of electrical conductivity in conductive ceramics like Indium Tin Oxide (ITO). (8M)

7. (a) For components of automotive and gas turbine engines, some ceramics are preferred than traditional metals and alloys - why? Name at least one material. (5M)

(b) Mention important steps in the preparation of ceramics and explain briefly about each step. (10M)

(c) What are plastics? Mention the types of additives used for enhancing their properties. (5M)

8. (a) Mention important characteristics of thermoplastics. Point out whether they can be processed into different required shapes at elevated temperatures or low temperatures. (7M)

(b) What is thermosetting polymer? Explain and mention name of one material of this type. (6M)

(c) Classify different types of composites and explain their properties. Name one or two materials which are natural composites. (7M)

Group C

9. Answer the following in brief: (2M each)

(i) Define short range order? Name one or two examples of materials which have short range order.
(ii) An aluminium rod of length 375 cm is extended by applying a load. Calculate the strain produced in the material.
(iii) What is offset yield strength? Point out how it is determined practically.
(iv) State Fick's second law of diffusion.
(v) Mention why creep is high in lead at room temperature under its own weight.
(vi) Mention four simple heat treatment steps and their purpose.
(vii) What is the important characteristic property of material used for Surgeon's glove?
(viii) What is apparent porosity? Write the formula for apparent porosity of a ceramic.
(ix) Draw the typical susceptibility vs temperature of paramagnetic specimen and Curie's law formula.
(x) What is Curie temperature of a ferromagnetic specimen? Write the Curie-Weiss formula for ferromagnetic, property of a material.

WINTER 2015
MATERIALS SCIENCE AND ENGINEERING
Group A

1. (a) Distinguish between crystal structure and crystal system. Show that the packing efficiency of a BCC crystal is 0.68. (6M)
(b) What is the difference in the stacking sequence of close packed layers in BCC and FCC structures? (4M)
(c) Explain Fick's law of diffusion. (6M)
(d) Differentiate between Frenkel and Schottky imperfection. (4M)

2. (a) Explain the Hume Rothery's rules for primary substitutional solid solubility (6M)
(b) What is Gibb's phase rule? Define a phase, a component and degree of freedom. (4M)
(c) What are equilibrium diagrams? What are their advantages and limitations? (5M)
(d) Mention the difference between edge and screw dislocations. (5M)

3. (a) Deduce the relationship between (i) Engineering stress and true stress and (ii) Engineering strain and true strain (8M)
(b) Differentiate between the following: (6M)
(i) Elastic and anelastic deformation
(ii) Plastic deformation and creep.
(iii) Zero-gauge length elongation and uniform elongation
(c) Briefly explain the two modes of plastic deformation. (6M)

4. (a) Define recrystallisation temperature and state the factors on which it depends (5M)
(b) What is the effect of cold work in tensile strength, ductility, electrical conductivity and why? (5M)
(c) Explain the Schmid law. The critical resolved shear stress of perfect copper crystal is 4 x 10^5 N/m^2. Determine the amount of stress to be applied in tension along $[1\ \bar{1}\ 0]$ axis of the copper crystal to make it slip on $[1\ \bar{1}\ \bar{1}]$ $[0\ \bar{1}\ \bar{1}]$ slip system. (10M)

Group B

5. (a) Define hardenability. What is the severity of quench? What is impact on hardenability? (6M)
(b) Compare different stages of tempering of plain carbon steel based on (i) main transformation (ii) change in volume and (iii) change in hardness (6M)
(c) Distinguish between gas carburizing and carbo-nitriding. (4M)
(d) What is age–hardening? What is the driving force for age hardening? (4M)

6. (a) Cite two desirable characteristics of glasses. Define devitrification. Mention two properties that may be improved by devitrification and two that may be impaired. (5M)
(b) What happens as a glass piece is thermally tempered? (5M)
(c) Differentiate between polymorphism and isomerism. (5M)

(d) Explain briefly why the tendency of a polymer to crystallize decreases with increasing molecular weight. (5M)

7. (a) State the differences between addition and condensation polymerization. (6M)

(b) Briefly explain how each of the following influences the tensile or yield strength of a semi crystalline polymer and why; (6M)

(i) Degree of crystallinity
(ii) Molecular weight
(iii) Deformation by drawing

(c) State the general difference in strengthening mechanism between large-particle and dispersion strengthened particle reinforced composites. (5M)

(d) What are hybrid composites? (3M)

8. (a) Differentiate between hard and soft magnetic materials with examples (6M)

(b) What is the difference between electronic and ionic conduction? (5M)

(c) What is meant by the drift velocity and mobility of a free electron? How are they related? (4M)

(d) The resistivity of pure silicon at room temperature is 3000 Ω-Cm. Calculate the intrinsic carrier density. Given the electron and hole mobilities are 0.14 m^2/V-s and 0.05 m^2/V-s, respectively. (5M)

Group C

9. Answer the following in brief: (2M each)

(i) Calculate the angles between following directions of cubic crystal;
(a) Between [001] and [011]
(b) Between [011] and [101]

(ii) Find the equilibrium concentration of vacancies in nickel at 3000K. Given: ΔH for nickel = 168 kJ/mol.

(iii) State Griffith criterion for crack propagation in brittle solids.

(iv) Define (a) fatigue strength and (b) fatigue life.

(v) What are magnetic permeability and susceptibility?

(vi) What is vulcanization?

(vii) Define the term Burger's vector

(viii) What is Bauschinger effect?

(ix) The yield strength of high strength steel is 1.46 GPa and K_{IC} of 98 MPa $\sqrt{m}$. Find the size of surface crack that will cause sudden failure at half its yield strength.

(x) What is corrosion fatigue?

SUMMER 2015

MATERIAL SCIENCE AND ENGINEERING

Group A

1. (a) What is the difference between a space lattice and Bravais lattice ?Determine the radius of an iridium atom, given that Ir has FCC structure, a density of 22.4 g/cm3 and an atomic weight of 192.2 g/mol. 4 + 4

(b). Find the equilibrium concentration of vacancies in aluminium at -273^{0}C and 27^{0}C . Given $E_f = 68 \times 10^3 J / mol$. 5

(c) Compare interstitial and vacancy atomic mechanism for diffusion. Cite two reasons why interstitial diffusion is normally more rapid than vacancy diffusion. 7

2. (a) Explain the rules that led to the formulation of conditions which favour extensive substitutional solid solubility . What is the difference between random and ordered solid solution? 7

(b) What is the difference between equilibrium diagram and phase diagram? State the Gibbs phase rule. 6

(c) What is the relation between energy of a dislocation and Burgers Vector? Why can cross slip occurs in BCC and FCC metals, but cannot occur in HCP metals? Explain why dislocations have Burgers vector as small as possible. 7

3. (a) Explain why creep is considered to be a high temperature property . Mention the metallurgical variables affecting creep behaviour of a material. Describe the effect of grain size on the creep strength of a material. 7

(b) What are the essential differences between ductile and brittle fracture? 5

(c) Explain the Griffith's theory of fracture. A glass contains a surface crack $1\,\mu m$ deep and inner crack of $1.6\,\mu m$ length. Determine which crack will propagate first and at what stress, if both the cracks are normal to the tensile axis? Given: E = 65 GPa and $\gamma = 0.5 Jm^{-2}$ 8

4. (a) Distinguish between (i) recrystallisation and secondary recrystallisation based on driving force and (ii) recovery and dynamic recovery. 4 + 4

(b) Discuss the changes in internal structures of crystals by cold working. 5

(c) Explain the difference between resolved shear stress and critical resolved shear stress. What are the factors which affect the critical resolved shear stress. 7

Group B

5. (a) What are the aims of stress-relieving annealing ? 4

(b) Compare the following 5 + 5

(i) Age hardening and tempering

(ii) Martempering and austempering

(c) Define cyaniding .What are the aims of cyaniding? 6

6. (a) For refractory ceramic materials, cite three characteristics that improve with and two characteristics that are adversely affected by increasing porosity . 5

(b) Why are borosilicate glasses and fused silica resistant to thermal shock? 5

(c) Briefly explain why the thermal conductivity is higher for crystalline than non-crystalline ceramics. 5

(d) Briefly explain how the degree of crystallanity affects the thermal conductivity of polymeric materials and why? 5

7. (a) Cite the primary differences between chain reaction polymerization and step reaction polymerization .4

(b) Briefly explain how molecular weight and degree of crystallanity influences the tensile strength and tensile modulus of a semi-crystalline polymer. 6

(c) For fibre-reinforced composite, (i) compare the desired mechanical characteristics of matrix and fibre phases and (ii) cite two reasons why there must be a strong bond between fibre and matrix at their interface . 6

(d) What are disperson-strengthened composites? 4

8. (a) Briefly describe the phenomenon of magnetic hysteresis and why it occurs for ferromagnetic and ferromagnetic materials ? 6

(b) Why the magnitude of saturation magnetization decreases with increasing temperature for ferromagnetic materials? 4

(c) In terms of electron energy band structure discuss reason for the difference in electrical conductivity between metals and semiconductors. 5

(d) For intrinsic In Sb, the room-temperature electrical conductivity is $2 \times 10^4 (\Omega m)^{-1}$: the electron and hole mobilities are respectively 7.7 and 0.07 m^2/Vs. Compute the intrinsic carrier concentration at room temperature. 5

Group C

9. Answer the following in brief : 10×2

(i) The distance between (1 1 1) planes in FCC crystal structure is 2 $\overset{0}{A}$. Find the lattice parameter and atomic diameter.

(ii) A 45 kN force was applied on a Cu-Ni alloy tensile specimen having 12.5 mm diameter and 50 mm gauge length . Determine whether the specimen will undergo necking . Given $\sigma_{UTS} = 420$ MPa and $\sigma y = 250$ MPa.

(iii) What is S-N curve?

(iv) State Fick's first law of diffusion .

(v) What is peritectoid and monotectic reaction?

(vi) What is Jominy end-quench test?

(vii) Define (a) Tg and (b) Degree of polymerization.

(viii) Define (a) Curie temperature (Tc) and remanence of a magnetic material .

(ix) What is stress corrosion cracking?

(x) A steel has tensile strength of 1.6 GPa . A large tensile piece of such a steel has crack of length 7 mm in the interior and fractures at 0.6 GPa. Calculate its fracture toughness.

WINTER 2014

MATERIAL SCIENCE AND ENGINEERING

Time: Three hours

Maximum Marks: 100

Group A

1. (a) What is the difference between a crystal structure and a crystal system? Calculate the radius of a vanadium atom, given that v has a bcc crystal structure ,density of 5.96 g/cm^3 and an atomic weight of 50.9g/mol. (4+4)

(b) Calculate the equilibrium number of vacancies per cubic meter for copper at 1000^0 C. The energy for vacancy formation is 0.9 eV/atom; the atomic weight and density (at 1000 ^{0}C) for copper are 63.g/mol and 8.4 g/cm^3,respectively. (6)

(c) Briefly state Fick's laws of diffusion. (6)

2. (a) Differentiate between edge and screw dislocation based on the (i) Burger' vector and (ii) Direction of movement of atoms with dislocation movement. (5)

(b) What is Phase rule? One solid phase, on heating through an invariant temperature, becomes two solid phases. Name the invariant reactions. Sketch the phase boundaries near the invariant line? (5)

(c) What is the difference between substitutional and interstitial solid solutions? Explain the Hume Rothery's rules. (7)

(d)Why copper-nickel form extended solid solutions? (3)

3. (a) Explain the significance of secondary stage of a creep curve .What is the relationship between creep rate of secondary stage and temperature.? What will be the effect of increasing stress on this creep rate? (6)

(b) Deduce the relationship between (i) Engineering stress and true stress (ii) Engineering strain and true strain. (5)

(c) What is the essential difference between shear fracture and cleavage fracture? (5)

(d) What is the Griffith theory of fracture ? State the Griffith equation? (5)

4 (a) Explain Schmid's law .Mention factors which affect the critical resolved shear stress (CRSS)? (5)

(b) Distinguish between two modes of plastic deformation? (5)

(c) Differentiate between recovery and re crystallization based on micro structural changes?. (5)

(d) State and explain the effects of cold work on tensile strength, ductility and electrical conductivity? (5)

GROUP B

5. (a) Define tempering. What are the main aims of tempering? What is the driving force for tempering? (4)

(b) Explain why recrystallisation annealing is prefer over full annealing in some cases.? (4)

(c) Compare (i) Gas carburizing and carbonnitriding and flame and induction hardening. (6)

(d) State the factors that must be satisfied in order to obtain age hardening in an alloy. Discuss the steps in the process of age hardening? (6)

6. (a) Define devitrification. Cite two properties that may be improved by devitrification and two that may be impaired. (5)

(b) Explain why residual thermal stresses are introduced into a glass piece when it is cooled. (4)

(c) Briefly explain the different types of refractories with suitable examples. (3)

(d) Metals are typically better thermal conductors than ceramics – explain. (3)

7. (a) State the primary difference between addition and condensation polymerization techniques. (5)

(b) Compare between thermoplastic and thermosetting polymers

(i) on the basis of mechanical characteristics upon heating and

(ii) according to possible molecular structures. (5)

(c) What is the distinction between matrix and dispersed phases in a composite material? Contrast the mechanical characteristics of matrix and dispersed phase for fibre-reinforced composites. (5)

(d) Explain large-particle and disperson-strengthened composites with suitable example. (5)

8. (a) State the difference between hard and soft magnetic materials in terms of both hysteresis behaviour and typical applications. (5)

(b) Explain the major similarities and differences between ferromagnetic and ferrimagnetic materials. (5)

(c) Compare the temperature dependence of the conductivity for metals and intrinsic semiconductors. Briefly explain the differences in the behaviour. (5)

(d) Calculate the electrical conductivity of the intrinsic silicon at 150^0C; the intrinsic carrier concentration is 4×10^{19} m^{-3}, the electron and hole mobilities are 0.06 m^2/V-s and 0.022 m^2/V-s, respectively. (5)

Group C

9. Answer the following in brief: (10x2)

(i) Define Burger vector.

(ii) ‘Tensile strength is used as design criterion for brittle materials’. Justify the statement.

(iii) What is the magnitude of the maximum stress that exists at the tip of a surface crack having a radius of curvature 0.264 nm and crack length of 1 μm, when a tensile stress of 57 MPa is applied ?

(iv) Define (a) fatigue life and (b) endurance ration.

(v) Define hardenability ? State the factors affecting the hardenability.

(vi) What is TD nickel?

(vii) How are drift velocity and mobility of free electron related ?

(viii) What is thermal transformer?

(ix) What is vulcanization of rubber?

(x) Define the terms (a) permeability and (b) susceptibility of a magnetic material.

Summer 2014

MATERIAL SCIENCE AND ENGINEERING

Time: Three hours

Maximum Marks : 100

Answer FIVE questions, taking ANY TWO from Group A, ANY TWO from Group B and ALL from Group C.

Group A

1. (a) What is the difference between atomic structure and crystal structure? Calculate the radius of an iridium atom, given that it has an FCC crystal structure, a density of 22.4 gm / cm ^{3,} and an atomic weight of 192.2 g/mol (4+4)

(b) Briefly state Fick's law of diffusion. A plate of iron is exposed to a carburizing atmosphere on one side and a decarburizing atmosphere on the other at 700 ^{0} C . If a condition of steady state is achieved, calculate the diffusion flux of carbon through the plate, if the concentrations of carbon at position of 5 mm and 10 mm beneath the carburizing surface are 1.2 kg / m ^{3} and 0.8 kg / m ^{3} respectively. Assume a diffusion coefficient of $3x10^{-11}$ m^2/s at this temperature . (3 + 3)

(c) What are point defects? Explain types of defects (6)

2 (a) Mention the primary conditions that favor the extensive substitutional solubility of an alloy system (5)

(b) Distinguish between the direction of the dislocation line , the Burger's vector and the direction of motion for both edge and screw dislocations . (5)

(c) State Gibb ' s phase rule , at atmospheric pressure { chosen arbitrarily , a material of unknown composition shows four phases in equilibrium at 987 k . what is the minimum number of components in the system . (3+3)

(d) What are the difference between the state of phase equilibrium and metastability (4)

3 (a) Discuss the role of gain boundaries and precipitate particles in strengthening crystalline materials against yield. (6)

(b) Describe briefly the mechanism of creep (6)

(c) Distinguish between ductile and brittle fracture (6)

(d) A sample of glass has a crack of half length 2 micro meter. The Young's modulus of glass is 70 GM $^{-2}$ and the specific surface energy is Jm^{-2} . Estimate its fracture strength. (3)

4 (a) Explain the critical resolved shear stress [CRSS } (5)

(b) Differentiate between the following;

(i) Two types of metal working process

(ii) Slip and twinning

(iii) Recovery and dynamic recovery

Group B

5 (a) Compare between austempering and martempering [6]

(b) Define carbonitriding. What are the advantages if carbonitriding over carburizing? 5

(c) What is the severity of quench? What is impact on hardenability ? (4)

(d) What are the main requirements for an alloy to be age hardenable ? What is the driving force for age hardening? (5)

6. (a) Briefly explain why the thermal conductivity is higher for crystalline than non crystalline ceramics . Why porosity decreases the thermal conductivity of ceramic materials? 5

(b) Define thermal stress. Briefly explain why thermal stresses may be introduced in to a structure by rapid heating or cooling 5

(c) What is devitrification ? Mention the desirable characteristics of glass ceramics? 4

(d) For refractory ceramic materials, cite three characteristics that improve and two characteristics that are adversely affected by increasing porosity? (6)

7. (a) How the polymers can be classified based on the molecular structure ? Give suitable schematic representation (6)
(b) What are the difference between chain reaction polymerization and step reaction polymerization (6)
(c) What are the general difference in strengthening mechanism between large particle and dispersion –strengthened particle-reinforced composite? (3)
(d) For a polymer – matrix fiber reinforced composite , (i) compare the desired mechanical characteristics of matrix and fiber phases and ii) mention two reasons why there must be strong bond between fiber and matrix at their interface (5)

8 (a) Explain the practical importance of hysteresis curve for ferromagnetic materials? (5}
(b) Explain the difference between diamagnetism, paramagnetism and ferromagnetism (6)
(c) Why does the conductivity of a semiconductor changes with impurity content? Compare this with the behavior of metallic conductors. 5
(d) For intrinsic gallium arsenide, the room temperature electrical conductivity is 10^{-6} $(\text{ohm-m})^{-1}$; the electron and hole motilities are respectively 0.85 and 0.04 m^2/V-s. Compute the intrinsic carrier concentration at room temperature? (4)

Group C

9. Answer following in brief; 10 x2
(i) Define a burger circuit
(ii) Shear modulus, G KN/$mm^{2,}$ obeys proportionality with elastic modulus E (KN /mm^2) if E = 100 KN/mm^2 and poisson ratio v = 0.25 , calculate the value of G
(iii) Define anelasticity and viscoelasticity
(iv) State Griffith theory
(v) What is fatigue limit of a material?
(vi) Why a polymer that is in the rubbery state has a T_g below room temperature ?
(vii) Define the terms a) curie temperature and b) remanence of a magnetic material
(viii) What is corrosion fatigue?
(ix) What is meant by mobility
(x) What is cermet give examples

WINTER 2013

MATERIAL SCIENCE AND ENGINEERING

Time: Three hours

Maximum Marks : 100

Group A

1. (a) What is atomic packing factor of a crystal structure? Show that the atomic packing factor for the FCC crystal structure is 0.74. 2+4

(b) Describe Fick's laws of diffusion. 6
(c) Differentiate between Frenkel and Schottky defects. 5
(d) Find the equilibrium concentration of vacancies in aluminium at 300K. Enthalpy of formation of vacancies in aluminium, ΔH_f =68 $KJmol^{-1}$; R = 8.314 $Jmol^{-1} K^{-1}$. 3

2. (a) Explain Gibb's phase rule. Determine the degree of freedom for an Isomorphous alloy system when both the phases co-exist at equilibrium. 3+2
(b) State the Hume-Rothery rules that favour extensive substitutional solid solubility. 5

(c) Differentiate between edge and screw dislocations. 5

(d) What thermodynamic condition must be met for a state of equilibrium to exist? One solid phase on heating through an invariant temperature becomes two solid phases. What is the invariant reaction? What is the difference between the states of phase equilibrium and metastability? 1+1+3

3. (a) Discuss briefly three stages of an ideal creep curve. 6
   (b) Discuss in brief various mechanisms of strengthening in metals and Alloys. 6
   (c) Establish the relationship between true strain and engineering Strain. 4
   (d) Briefly explain the stages in ductile fracture 4

4. (a) Explain the Schmid's law. 5
   (b) Distinguish between the following; 5+5
   (i) Recovery and recrystallization processes
   (ii) Hot working and cold working

   (c) A relatively large plate of a glass is subjected to a tensile stress of 40 MPa. If the specific surface energy and modulus of elasticity for this Glass are $0.3 J/m^2$ and 69 GPa, respectively, determine the maximum length of a surface flow that is possible without fracture. 5

Group B

5. (a) Briefly explain the following surface hardening treatments:
   (i) Carburising, (ii) nitriding, and (iii) Carbo-nitriding. 9

   (b) Define hardenability of metals. Discuss the factors which affect Hardenability. 8
   (c) What are the steps in the age-hardening process? 3

6. (a) What is thermal stress? Discuss stresses due to restrained thermal Expansion and contraction and as a result of temperature gradients. 2+5
   (b) Explain why ceramics have low coefficient of thermal expansion. What measures may be taken to reduce the likelihood of thermal Shock of a ceramic piece? 5

   (c) What are glass ceramics? Glass ceramics are stronger than ordinary glass articles- explain. 4
   (d) What are refractories? Mention different types of refractories. 4

7. (a) Differentiate between thermoplastics and thermosetting polymers with examples. 6
   (b) What are the primary differences between addition and condensation polymerization techniques? 6
   (c) Define the term 'composites', what are the advantages of composite material over engineering alloys? Clearly state the difference between particle reinforced and fibre-reinforced composites. 8

8. (a) Describe the major similarities and dissimilarities between Ferromagnetic and ferrimagnetic materials. 6
   (b) State, with examples, the difference between hard and soft magnetic materials in terms of hysteresis behaviour. 6
   (c) In terms of electron energy band structure, discuss the difference in Electrical conductivity between metals, semiconductors and insulators. 5

(d) Calculate the electrical conductivity of intrinsic silicon at 150^0C , the intrinsic carrier concentration for Si at 150^0C is $4x10^{19}$ m^{-3} and the electron and hole mobilities are respectively 0.06^{m2} / Vs and 0.022^{m2}/Vs. 5

Group C

9. Answer the following in brief: 10 x 2
   - (i) What is the angle between [100] and [101] direction of cubic crystal?
   - (ii) Shear modulus, G (GPa), obeys proportionality with elastic modulus, E (GPa). If E = 18 GPa for a metal and Poisson's ratio, μ = 0.33, calculate the value of G for the metal.
   - (iii) Define isomorphous system with examples.
   - (iv) Define Burger's vector.
   - (v) Define the terms (a) susceptibility, and (b) permeability of a magnetic material.
   - (vi) Why thoria dispersed nickel retains very good mechanical strength up to 0.9 T_m. where T_m is its melting point?
   - (vii) Two samples A and B of a brittle material have crack length in the ratio 3:1. What will be ratio of tensile strengths of A and B?
   - (viii) What is stress corrosion cracking (SCC)?
   - (ix) What are superalloys? Give examples.
   - (x) Define glass transition temperature (T_g).

SUMMER 2013

MATERIALS SCIENCE AND ENGINEERING

Time: 3 hours

Maximum Marks: 100

Group A

1. (a) What is the difference between a crystal structure and a crystal system? Show that the Atomic packing factor for BCC is 0.68. 2+4
   (b) Compare interstitial and vacancy atomic mechanisms for diffusion. 6
   (c) Compute the diffusion coefficient for magnesium in aluminum at 550°C. Given :

   D_o= 1.2 $x10^{-4}$ m^2/s and Q_d= 131KJ/mol. 3
   (d) Calculate the radius of a vanadium atom, given that V has a BCC crystal structure, a density of 5.96g/cm^3, and an atomic weight of 50.9g/mol. 5

2. (a) State Hume Rothery rules that govern the formation of substitutional solid solutions 5
   (b) Explain Gibb's phase rule. Derive the degrees of freedom for a system, which has equal number of components and phases. 5
   (c) Differentiate between edge and screw dislocations. 6
   (d) What is the difference between equilibrium diagram and phase diagram ? One solid phase on heating through an invariant temperature becomes two solid phases. What is the invariant reaction? 4

3. (a) How can metal alloys be strengthened? 6
   (b) Distinguish between ductile and brittle fracture. 5
   (c) Explain the significance of secondary stage in an ideal creep curve. 4
   (d) State Griffith criterion for the propagation of a pre-existing crack in a brittle material. When a sodium silicate glass is immersed in a lithium nitrate bath at 260°C for a few minutes, cracks develop on the surface. Why? 5

4. (a) Explain the critical resolved shear stress of a polycrystalline material.

(b) Briefly write the difference between recovery and recrystallization processes. 5
(c) Explain the major differences in grain structure for a metal that has been cold worked and one that has been cold worked and then recrystallized. 5
(d) State the major differences between slip and twinning deformation mechanism. 5

Group B

5. (a) What do you mean by hardenability? Mention the factors affecting hardenability. 1+4
(b) Explain briefly the surface hanrdening treatments. 5
(c) Explain the process of austempering and martempering. 6
(d) Describe the steps in the age – hardening process. 4

6. (a) What are glass ceramics? How are they formed? What are desirable characteristics of glass ceramics? 6

(b) What is tempered glass and how can it be produced? 4
(c) For refractory ceramic materials, cite three characteristics that improve with and two characteristics that are adversely affected by increasing porosity. 6
(d) Define thermal stresses. Explain why residual thermal stresses are introduced into a glass piece when it is cooled. 4

7. (a) Distinguish between addition and condensation polymerization. 5
(b) Why are some polymers recyclable? Mention the properties of elastomers. 6
(c) Briefly classify the composite materials. Cite the importance of composite materials over other engineering alloys. Clearly state the difference between particle reinforced and fibre reinforced composites. 9

8. (a) Distinguish between hard and soft magnetic materials with examples. 5
(b) Explain briefly diamagnetism, paramagnetism and ferromagnetism. 6
(c) Compare the temperature dependence of the conductivity for metals and intrinsic semiconductors. Briefly explain the differences in behaviour. 5
(d) For intrinsic gallium arsenide, the room temperature electrical conductivity is 10^{-6} $(\Omega - m)^{-1}$; the electron and hole mobilities are respectively 0.85 m^2/V-s and 0.04 m^2/Vs. Compute the intrinsic carrier concentration at room temperature. 4

Group C

9. Answer the following in brief: 10 x 2
(I) Shear modulus, G (GPa), obeys proportionality with elastic modulus, E (GPa). If G = 45GPa for a metal and Poisson's ratio, ν = 0.31, Calculate the value of E for the metal.
(II) Stainless steels (an alloy of iron, a = 0.2867nm) always can contain huge amount of chromium. (a = 0.2885 nm)-Explain.
(III) Define isomorphous system with examples.
(IV) A pure copper wire has been drawn at temperature of 750^{o}C. Is it hot or cold working by relevant parameter?
(V) Define peritectic reaction.
(VI) Define (a) remanence and (b) coercivity
(VII) What is the angle between [101] and [011] direction of a cubic crystal?
(VIII) What are superalloys? Give suitable examples.
(IX) Define the glass transition temperature (T_g).
(X) What is TD nickel?.

WINTER 2012
MATERIALS SCIENCE AND ENGINEERING
Time: Three Hours
Maximum marks:100

Group A

1. (a) Mention different type of Bravais lattices possible in crystalline materials. Compute the theoretical density of copper with an atomic radius of 1.28 Å and an atomic weight of 63.5g/mol. 2+4
(b) Describe Fick's laws of diffusion. 6
(c) Differentiate between Frenkel and Schottky defect. 5
(d) Calculate the equilibrium concentration of vacancies in nikel at 300K.
Enthalpy of formation of vacancies in nickel, Hf=168 kJ/mol, R=8.314 J/mol 5

2. (a) Define phase. State the conditions for unlimited solid solubility for an alloy system. 1+4
(b) Explain Gibb's phase rule. 4
(c) Mention the differences between edge and screw dislocations. 5
(d) For a 99.65 wt% Fe-0.35wt% C alloy at a temperature just below the eutectoid, determine the following 3+3
(i) Fractions of total ferrite and cementite phases.
(ii) Fractions of the proeutectoid ferrite and pearlite.

3. (a) Discuss the different mechanisms of strengthening in metals in brief. 6
(b) Explain the cup and cone fracture. 5
(c) Discuss briefly three stages of an ideal creep curve. 6
(d) State Griffith theory of brittle fracture. 3

4. (a) Drive the expression for critical resolved shear stress (CRSS) of a polycrystalline material. 6
(b) Deduce the relationship between true strain and engineering strain 4
(c) Differentiate between the following: 5+5
(i) Hot and cold working
(ii) Slip and twinning

Group B

5. (a) Define hardenability. Mention the factors affecting hardenbility 1+4
(b) Explain carburising and nitriding treatment for surface hardening 5
(c) What is tempering? Suggest whether tempering should be done at higher or lower temperature with reasons. 2+3
(d) Define age-hardening. What are the main steps in the process of age hardening 1+4

6. (a) What are glass ceramic? How are they formed? What are desirable characteristics of glass ceramics. 2+2+2
(b) What is tempered glass and how can it be produced? 2+2
(c) What are refractories? How acid refractories differ from basic refractories? 2+3
(d) Define thermal stresses. What measures may be taken to reduce the likelihood a ceramic piece? 1+4

7. (a) Why are some polymers recyclable? What are elastomers and their special property? 3+3
(b) Describe how addition polymerization is different from condensation polymerization. 6
(c) What are composites? What are the advantages of composite materials over other engineering alloys? Clearly distinguish between particle reinforced and fibre reinforced composites.
2+3+3

8. (a) Differentiate between hard and soft magnetic materials with examples. 5

(b) Mention the major similarities and differences between ferromagnetic and ferrimagnetic material. 5

(c) In terms of electron energy band structure, discuss reasons for the difference in electrical conductivity between metals, semiconductors and insulators. 5

(d) To high-purity silicon is added 10^{23} m^{-3} arsenic atoms.

(i) Is this materials n-type or p-type? 2

(ii) Calculate the room temperature and electrical conductivity of this material. Given the electron mobility $=0.07 m^2/V\text{-}s$. 3

Group c

9. Answer the following in brief: 10X2

(i) Shear modulus, G (GPa), obeys proportionality with elasitic modulus, E (GPa) if E=117 for a metal and Poisson's ratio, V=0.31, find the value of G for the metal.

(ii) Calculate the radius of tungsten atom at room temperature with a =0.3165nm.

(iii) Stainless steel (an alloy of iron, a=0.2867nm) always can contain huge amount of chromium. (a =0.2885nm).

(iv) Define isomorphus system with examples.

(v) A pure aluminium wire has been drawn at temperature of $250^{o}C$. Is it hot or cold working by relevant parameter?

(vi) What is a peritectic reaction?

(vii) Define *(a)* magnetic susceptibility, and *(b)* Curie temperature.

*(viii)*What is the angle between [101]and [011] directions of a crystal

(ix) Define the glass transition temperature (Tg).

(x) What are superalloys? Give examples.

SUMMER 2012

MATERIALS SCIENCE AND ENGINEERING

Time: Three Hours

Maximum marks:100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,**

Group A

1. (a) What is the angle between [0 0 1] and [1 1 1] directions of cubic crystal? Show that packing efficiency of a BCC crystal is 0.68. (2 + 4)

(b) Find the equilibrium concentration of vacancies in aluminium at 300 K and 900 K. Enthalpy of formation of vacancies in aluminium, $\Delta H_f = 68$ kJ/mol, R = 8.314 J/mol K. (4)

(c) Distinguish between Frenkel and Schottky defects. (5)

(d) The diffusion coefficients for iron in nickel are given at following two temperatures.

T (K)	D (m^2/s)
1273	9.4×10^{-16}
1473	2.4×10^{-14}

Determine the values of Do and the activation energy Qd (5)

2. (a) Explain Gibb's phase rule . Find the degree of freedom when FCC and BCC iron co-exist in equilibrium. (5)

(b) Differentiate between edge and screw dislocations (5)

(c) In the Pb-Sn system, calculate the alloy composition at which the fraction of total α is 3 times the fraction of β phase at eutectic temperature,182^0C, Pb with 19% Sn dissolved in it. Sc with 2.5% Pb dissolved in it , and liquid is in equilibrium. (5)

(d) What is zone refining? Discuss how is it done practically? (5)

3. (a) Explain in brief strengthening mechanisms in metals and alloys. (5)
   (b) State briefly the significance of secondary stage in an ideal creep curve. (4)
   (c) State the Griffith criterion for crack propagation in brittle solid. A sodium silicate glass has no surface defects as etching has removed them, but has cracks inside from 2 μm to 5 μm in length. Calculate the surface energy of glass, if fracture strength = 100 MN /m^2 and Young's modulus = 70 MN/m^2 . (2+4)
   (d) What is the essential difference between brittle fracture and ductile fracture? (5)
4. (a) Deduce the relationship between true stress and engineering stress. (5)
   (b) Differentiate between the following: 5+ 5
      (i) Hot and cold working
      (ii) Recovery and re-crystallisation.
   (c) Explain Schmid's law (5)

Group B

5. (a) Discuss briefly the following case hardening methods: (i) Nitriding, and (ii) Cyaniding. (3+2)
   (b) Define hardenability and severity of quench. Mention the factors which affect hardenability. (2+3)
   (c) Define tempering. What are the main aims of tempering? (1+3)
   (d) What is age-hardening? What are the main requirements for an alloy to depict age-hardening? Mention the steps in the process of age-hardening. (1+2+3)

6. (a) Define thermal stress. Briefly explain why thermal stress may be introduced into a structure by rapid heating or cooling. (1+4)
   (b) A brass rod is to be used in an application requiring its ends to be held rigid. If the rod is stress-free at 20^0C, what is the maximum temperature to which the rod may be heated without exceeding a compressive stress of 172 MPa? Assume a modulus of elasticity of 100 GPa for brass . The magnitude of linear coefficient of thermal expansion is $20.0 \times 10^{-6} /^0 C$ (5)
   (c) Briefly explain why porosity decreases the thermal conductivity of ceramic materials. What may be the measures taken to reduce the likelihood of thermal shock of a ceramic materials? (3+3)
   (d) What are glass ceramics? What are the desirable characteristics of glass ceramics? (2+2)
7. (a) Differentiate between thermoplastics and thermosetting polymers with suitable examples. (6)
   (b) Distinguish between chain reaction and step reaction polymerizations. (6)
   (c) Define 'composites'. How can composite materials be classified? Write the advantages of composite materials over traditional engineering alloys. (2+3+3)

8. (a) Differentiate between hard and soft magnetic materials with suitable examples. (5)
   (b) Briefly explain diamagnetism, paramagnetism and ferromagnetism. (6)
   (c) Why does the conductivity of a semiconductor change with impurity content? Compare this with the behaviour of metallic conductor. (5)

(d) The resistivity of pure silicon at room temperature is $3000\Omega m$. Calculate the intrinsic carriers concentration .Given the electron and hole nobilities are 0.14 m^2/Vs, and 0.05 m^2/Vs respectively. (4)

Group C

9. Answer the following in brief: (10×2)

(i) The distance between (1 1 1) planes in FCC crystal structure is 2 $\overset{0}{A}$. Find the lattice parameter and atomic diameter.

(ii) What is an eutectic reaction and eutectoid reaction?

(iii) Define an isomorphous system with examples.

(iv) Define the terms 'anelasticity' and 'viscoelasticity' .

(v) What is Bauchinger effect?

(vi) Define (a) Curie temperature, and (b) coercivity.

(vii) Define glass transitin temperature (Tg) .

(viii) What is tempered glass?

(ix) Calculate the room temperature electrical conductivity of silicon that has been doped with 10^{23} m^{-3} of arsenic atoms . The electron mobility $\mu e = 0.07$ $m^2/V.s$

(x) Define any one high temperature material with an example.

WINTER 2011

MATERIALS SCIENCE AND ENGINEERING

Time: Three Hours

Maximum marks:100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** *and* ALL *from* **Group C**.

Group A

1. (a) Mention different types of Bravais lattices possible in crystalline materials. Show that the atomic packing factor (APF) of FCC crystal structure is 0.74 2+4

(b) Describe Fick's first law of diffusion. A plate of iron is exposed to a carburizing atmosphere on one side and a decarburizing atmosphere on the other side at 700^0C . Under steady state conditions, calculate the diffusion flux of carbon through the plate, if the concentration of carbon at position of 5 mm and 10 mm beneath the carburizing surface are 1.2 kg/m^3 and 0.8 kg/m^3, respectively. Assume a diffusion coefficient of 3×10^{-11} m^2/s at this temperature 3+3

(c) Calculate the equilibrium concentration of vacancies in nickel at 300 K. Enthalpy of formation of vacancies in nickel, ΔH_f = 168 kJ/mol ; R = 8.314 J/mol-K^{-1} 3

(d) Differentiate between Frenkel and Schottky defects. 5

2. (a) Explain Gibb's phase rule. Determine the degree of freedom for an isomorphous alloy system when both the phases co-exist at equilibrium 3+2

(b) State Hume-Rothery rules that favour extensive substitutional solubility 5

(c) For a 99.65 wt.% Fe-0.35 wt% C alloy at a temperature just below the eutectoid temperature, determine the following : 2+2+ 2.

(i) Fractions of total ferrite and cementite phases.

(ii) Fractions of the proeutectoid ferrite and pearlite

(iii) Fractions of eutectoid ferrite.

(d) What thermodynamic condition must be met for a state of equilibrium to exist? What is the difference between the states of phase equilibrium and metastability ? 1+3

3. (a) Discuss in brief the different mechanisms of strengthening mechanisms in metals and alloys. 6
(b) Explain the cup-and –cone fracture 4
(c) Discuss briefly the three stages of an ideal creep curve. 6
(d) Deduce the relationship between true strain and engineering strain. 4

4. (a) Differentiate between the following : 5+5
(i) Slip and twinning
(ii) Hot working and cold working.
(b) Explain Schmid's law 5
(c) Briefly cite the difference between recovery and recrystallization processes. 5

Group B

5. (a) Define hardenability. Mention the factors which affect hardenability. 2+3
(b) Briefly explain the following surface hardening treatments : (i) Carburising, and (ii) Nitriding. 5
(c) Distinguish between martempering and austempering. What is the objective of tempering process? 5+2
(d) What are the basic requirements for an alloy to behave as age-hardenable ? 3

6. (a) Define thermal stress. Discuss stresses due to restrained thermal expansion and contraction and as a result of temperature gradients. 2+5
(b) 'Many ceramics that are used for thermal insulation are porous' Justify the statement. 3
(c) What are glass-ceramics? How are they formed? What are the desirable characteristics of glass-ceramics? 2+2+2
(d) What is tempered glass and how can it be produced? 2+2.

7. (a) Differentiate between thermoplastic and thermosetting polymers with examples. 6
(b) How is addition polymerisation reaction different from condensation polymerisation reaction? 6.
(c) Define 'Composites'. What are the advantages of composite materials over engineering alloys. Clearly distinguish between particle reinforced and fibre reinforced composite. 2+3+3.

8. (a) Explain briefly the following : Diamagnetism, (ii) Paramagnetism, and (iii) ferromagnetism. 3 × 2
(b) Cite with examples, the difference between hard and soft magnetic materials in terms of hysteresis behaviour. 4
(c) In terms of electron energy band structure, discuss reason for the difference in electrical conductivity between metals, semiconductors and insulators. 5
(d) Cite the differences between n-type and p-type extrinsic semiconductors. 5

Group C

9. Answer the following in brief 10 × 2
(i) What is the angle between [0 0 1] and [0 1 1] directions of cubic crystal
(ii) What is an isomorphous system? Give an example.
(iii) What is peritectic reaction?
(iv) Define Burgers vector.
(v) State the Griffith criterion for crack propagation in brittle solid.
(vi) What is Bauschinger effect?
(vii) Define the glass transition temperature (T_G).
(viii) Define (a) Magnetic susceptibility, and (b) magnetic permeability.
(ix) How can degree of polymerisation be expressed?
(x) What are refractories? Give examples.

SUMMER 2011

MATERIALS SCIENCE AND ENGINEERING

Time: Three hours

Maximum Marks: 100

Group A

1. (a) Draw schematics to show different types of Bravis lattices in crystalline materials. Calculate the atomic packing factor (APF) of FCC and BCC crystal structure. 6
   (b) Explain the types of defects in crystalline materials in brief. 4
   (c) Differentiate between the edge and screw dislocations in terms of Burger's vector. 5
   (d) Find the equilibrium concentration of vacancies in aluminium at 0K and 900 K. Enthalpy of formation of vacancies in aluminium, ΔH_f = 68 kJmol^{-1}'; R = 8.314 J mol^{-1}K^{-1} 5

2. (a) Mention and explain Nernst-Einstein relation in diffusion . 5
   (b) Describe Fick's second law of diffusion. The diffusion coefficients for copper in aluminium at 500°C and 600°C are 4.8 × 1014 m^2/s and 5.3 × 10.13 m^2/s, respectively. Calculate the time required at 500°C to produce diffusion depth equal to that at 600°C for 10 hr 5
   (c) Explain Gibbs phase rule. Find the degrees of freedom when FCC and BCC iron co-exist in equilibrium. 5
   (d) Draw an eutectic phase diagram and explain it. 5

3 (a) Draw and explain Fe Fe_3C phase diagram Indicate the carbon percentage range of steel. 8
   (b) Define peritectic reaction. Explain with a suitable phase diagram. 6
   (c) Explain the mechanism of working of zone refining process with the help of a diagram. 6

4. (a) Differentiate between true and engineering stress-strain curve. Indicate the elastic zone, plastic zone, and yield point in a stress strain curve of mild steel. 8
   (b) Describe visco-elastic behaviour of materials. Explain Maxwell elements and Voigt-Kelvin model 6
   (c) Explain Griffith's theory of brittle fracture. Why has silicate glass a relatively low fracture strength ? 6

Group B

5 (a) Discuss different methods of carburising, nitriding and carbo-nitriding. 8
   (b) Define hardenability of metals. Describe Jominy's hardenability test in brief. 6
   (c) Discuss different mechanisms of hardening in metals and alloys. 6

6 (a) Explain the working principle of a bimetallic strip thermostat in regulating temperature. 5
   (b) Define thermal stress. Discuss stresses due to restrained thermal expansion and contraction. 5
   (c) Define high temperature materials. Name some of the high temperature materials. 5
   (d) What are ceramics? What is the range of thermal expansion coefficients in ceramics? Explain why ceramics have low coefficient of thermal expansion. 5

7. (a) What are polymers? Describe briefly the terms 'saturated polymer' and 'unsaturated polymer'. 8
   (b) Differentiate between thermoplastic and thermosetting polymers 6
   (c) Define the term 'composites'. Describe briefly about different types of composites and their applications. 6

8. (a) What are nano materials? Mention important applications of nano materials 8
   (b) Define Curie temperature. What is spontaneous magnetisation? Write about characteristics of ferromagnetic materials 6
   (c) Discuss band theory of solids. Differentiate between metals, semiconductors, and insulators on the basis of band theory. 6

Group C

9. Answer the following in brief: l0 × 2

(i) At high temperature, the mechanical strength is high or low? Give answer with proper reasoning.

(ii) Draw the binary phase diagram of Al_2O_3— Cr_2O_3 clearly showing the tie line.

(iii) Why thoria dispersed nickel retains very good mechanical strength up to 0.9 T_m , where T_m is its melting point ?

(iv) Mention relative magnitudes of enthalpy of motion for the atoms moving on the surface along the boundary and within the lattice.

(v) Explain how surface cracks can be made ineffective.

(vi) Find the fractional amount of ferrite (α) and cementite (Fe_3C) using Lever's rule and placing the fulcrum at 0.8% carbon in iron—iron carbide phase diagram.

(vii) What is glass? Mention its important characteristics.

(viii) Explain the degree of polymerisation

(ix) Draw schematics of (a) linear, (b) branched, (c) cross-linked, and (d) networked polymer structures.

(x) Define (a) susceptibility, (b) permeability, and (c) magnetisation of a magnetic material..

WINTER 2010
MATERIALS SCIENCE AND ENGINEERING

Time: Three hours

Maximum marks: 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B,** *and* ALL *from* **Group C.**

Group A

1. (a) What are Bravai's lattices? Explain in brief the difference in stacking sequence of FCC and HCP crystal structure. 2+4

(b) Calculate the atomic packing factor (APF) for the FCC crystal structure. 4

(c) What are point defects and how are they created? Discuss different types of point defects in brief. 1+4

(d) Discuss major differences between edge and screw dislocations. 5

2. (a) What is Gibb's phase rule? Explain its application with reference to binary phase diagrams. 2+3

(b) Write the eutectoid reaction in Fe-Fe_3C system and find the amount of different phases at the eutectoid point (2+3)

(c) What is true stress? Deduce the relationship between engineering and true stress. 1+4

(d) What is meant by the toughness of a material? How is it measured and assessed? 2+3.

3. (a) Differentiate between ductile fracture and brittle fracture 5

(b) Explain the S-N curve with respect to ferrous and nonferrous material. 5

(c) Explain how deformation takes place by twinning. 5

(d) Differentiate between cold working and hot working. 5

4. Write notes on *any four* of the following 4×5

(a) Fick's law of diffusion

(b) Creep behaviour in metals

(c) Hume-Rothery's rule

(d) Deformation in polycrystalline material.

(e) Solid solution strengthening

(f) Recovery, recrystallization and grain growth.

Group B

5. (a) Draw the Iron-Iron Carbide phase diagram clearly indicating the phases present at different temperatures and carbon content. 14
(b) Explain in brief the time-temperature transformation (TTT) diagrams. 6
6. (a) Distinguish between thermal heat capacity and thermal heat content. 4
(b) Explain the types of magnetisms in brief. 6
(c) Differentiate between intrinsic and extrinsic semiconductors. 5
(d) Discuss the mechanism of sintering of ceramics materials. 5
7. (a) Discuss different mechanisms of polymerisation. 8
(b) What are the factors affecting mechanical properties of polymers. Discuss. 6
(c) What are composite materials? Briefly classify the composite materials. 2+ 4.
8. Write short notes on any four of the following 4×5
(a) Annealing and normalising.
(b) Thermoplastics and thermosets
(c) Surface hardening
(d) Basic refractories.
(e) Continuous cooling transformation (CCT) diagram.
(f) Zone theory of solids.

Group C

9. Give brief and précis answer to the following 10×2

1. Define hardenability.
2. what is an isomorphous system
3. State the Hall-Petch equation; explain the meaning of each symbol.
4. What is a peritectic reaction?
5. What is Bauchinger effect?
6. What is critical cooling rate
7. what are the main materials for cryogenic application.
8. what is glass transition temperature (t_g)
9. Define fracture toughness of a material.
10. What is superconductivity?

SUMMER 2010
MATERIALS SCIENCE AND ENGINEERING

Time: Three hours

Maximum marks: 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B,** *and* ALL *from* **Group C.**

Group A

1. (a) What are the Hume-Rothery rules? 4
(b) What are the differences between Frenkel and Schottky imperfections? 4
(c) 'Most dislocations in crystals are mixed dislocation type'- Explain. 4
(d) Why are the grain boundaries considered as high energy regions? 4
(e) What is stacking fault? 4

2. (a) Explain interstitial and vacancy diffusions. 4
(b) Explain Fick's law for non-steady state diffusions. 6
(c) From Gibb's phase rule, explain why a triple point is an invariant point. 4
(d) Why are cored structures developed during solidification? How are they Removed in case of an alloy? 6

3. (a) Describe changes in microstructures, with suitable sketches, when cooled slowly from austenite to room temperature, for (i) hypo-eutectoid plain carbon steels; (ii) Eutectoid plain carbon steels; and (iii) hyper-eutectoid plain carbon steels. 10

(b) A slowly cooled plain carbon steel shows pro-eutectoid ferrite to be 10% by we weight of the microstructure. What is the carbon percentage in the steel? 3

(c) Discuss the differences in shapes of tensile stress-strain curves for metals, ceramics and polymers. 7

4. (a) What are the differences between ductile and brittle fracture? 4

(b) What is a slip system? Discuss the slip systems of FCC, BCC AND HCP Crystals. 6

(c) Show a characteristics creep curve and describe three stages in creep deformation. 10

Group B

5. (a) What is the difference between hardness and hardenability? 4

(b) What are the difference between martempering and austempering? 4

(c) Describe different methods of carburizing. 7

(d) Discuss different stages of age-hardening treatment in aluminum alloys. 5

6. (a) What are the applications of thermal sensors? 4

(b) What are the super alloys? What are the applications of these alloys? 6

(c) Why are ceramic materials generally brittle? 4

(d) Discuss the stages of sintering of ceramic materials. 6

7. (a) What is glass transition temperature? 3

(b) What are the differences between thermoplasts and thermosets? 5

(c) What are the differences between chain growth and step growth polymerization? 5

(d) What is a composite material? Enumerate the difference between particle and fiber reinforced composite. 2-5

8. (a) What are the differences between conductors, semiconductors and insulators? Discuss in terms of energy band structure. 8

(b) What are the differences between intrinsic and extrinsic semiconductors? 4

(c) Write a short note on superconductivity. 5

(d) What are the benefits of polymer matrix composites? 3

Group C

9. Answer the following in brief: 10×2

(1) Draw the following crystallographic planes (221) and (101).
(2) What are the differences between annealing twins and deformation twins?
(3) What is the difference between impact toughness and fracture toughness?
(4) What is Schmid’s law?
(5) What are sessile and glissile dislocations?
(6) What is the measure of ductility?
(7) What is peritectic transformation?
(8) Why is glass tempered?
(9) What is the angle between the [011] and [101] directions in cubic systems?
(10) In a Vicker’s hardness test, if the average length of diagonals is reported as 1.5 mm, calculate the VHN for a 30 kg load.

Winter 2009

MATERIALS SCIENCE AND ENGINEERING

Time: Three hours

Maximum marks: 100

Answer FIVE *questions, taking* ANY TWO *from* Group A, ANY TWO *from* Group B *and* ALL *from* Group C.

Group A

1. (*a*) State the atomic packing of a 'FCC and a 'HCP' crystal system. Write *two* examples of metals having the crystal structure in each system. 2+2 + 2

(*b*) How could Miller indices of crystallographic planes be derived in cubic unit cells? State the Miller indices of prism plane in a hexagonal unit cell. 4+2

(*c*) (*i*) Draw the phase diagram of pure Fe (from room temperature onwards). 2

(*ii*) Calculate the linear atomic density in [110] direction in atoms per meter in Cu-lattice (a_0 = 0.36nm). 4

(iii) What is the atomic percentage of Cu at 70 Cu 30 Zn brass. (Cu = 63.5, Zn = 65.4). 2

2. (*a*) Differentiate between the following with suitable example for each:

(i) Dislocation and partial dislocation. 4

(ii) Slip and cross slip. 4

(*iii*) Interstitial and substitutional solid solution. 4

(*b*) Explain octahedral and tetrahedral voids with an example of each. 4

(*c*) On quenching, high carbon steels get hardened but austenitic stainless steel do not—explain. 4

3. (*a*) Explain the following:

(*i*) ASTM grain fineness number 4

(*ii*) Arrhenius rate equation 4

(*iii*) Diffusivity. 4

(*b*) The diffusivity of silver atoms in solid silver metal is 1.0×10^{-17} m^2/s at 500 °C and 7.0×10^{-13} m^2/s at 1000°C. Calculate the activation energy (joules/mole) for the diffusion of Ag in Ag in the temperature range 500-1000°C. 4

(*c*) Define magnetic permeability of a magnetic material. What is relative permeability? 2+2

4. (*a*) Define (*i*) phase, (*ii*) degree of freedom, (*iii*) isomorphous system, and (*iv*)invariant reaction. 4×2

(*b*) Deduce relation between (*i*) engineering stress and true stress, and (*ii*) engineering strain and true strain. 4+4

(*c*) State the differences between (i) martensite and tempered martensite, and (*ii*) upper bainite and lower bainite. 2+2

Group B

5. Explain the following:

(a) On rise in temperature (*i*) why ceramics do increase the conductivity while metals do not, and (*ii*) ceramics show more stability than metals. 5

(b) Polymers cannot be used in construction of bridges while metals are used. 5

(c) For strengthening Al-Cu alloys, the precipitation between θ′ and θ" are favoured but not equilibrium precipitate. 5

(d) For boiler quality steels, coarse grain structures are favoured over fine grain structure. 5

6. (*a*) Describe with examples: (i) Half cell potential, (*ii*)galvanic corrosion, (*iii*) hydrogen over-voltage, and (*iv*) E_{corr} and I_{cott} 2+4+2+4

(*b*) What is passivation ? Why are mixed dilute acids more corrosive than concentrate acids? 4

(*c*) Deduce the expression for critical residual shear stress for deformation of metals. 4

7. (*a*) (*i*) Describe the basic property of a cryogenic material and its testing method. 2+4

(*ii*) Without phase change can you harden a metal? Give *two* common examples. 2+4

(*b*) (*i*) For better hardenability, alloy steels are favoured over plain carbon steels— explain. 4

(*ii*) Distinguish between martempering and austempering with necessary diagrams. 4

8. (*a*) (*i*) What is slip casting ? State its advantages. 4

(*ii*) Explain dielectric strength of a ceramics with examples. 4

(*iii*) What is piezoelectric effect? 2

(*iv*) Name *two* basic refractories commonly used in steelmaking furnaces. 2

(*b*) Distinguish between.(*i*) polymer and monomer, and (*ii*) thermoplastics and thermosets 2+2

(*c*) How can ductile fracture be identified from brittle fracture? Why are cast irons brittle but not steels? 2+2

Group C

9. Answer the following in brief: 10×2

(*i*) Lattice parameter of chromium is 286 pm (pico-meter). Calculate its atomic radius.

(*ii*) What will be the percentage of volume change take place during cooling of gamma iron (r_0= 0.127 nm) to alpha iron (r_0 = 0.124nm)?

(*iii*) Name the highest and lowest temperature points in copper-nickel equilibrium diagram.

(*iv*) How many atoms would be there in 5 moles of Neon gas?

(*v*) Whether iron (atomic radius = 0.1238 nm) and nitrogen (atomic radius = 0.07l nm) can form substitutional solid solution?

(*vi*) In a standard Brinell test (diameter of indenter = 10mm) for ferrous metals, if the diameter of indentation is 3.33 mm, what is the value of BHN?

(*iv*) Calculate the volume fraction of cementite (approximately) in ledeburite of Fe-C system.

(*viii*) In a Vickcr's hardness test, if the lengths of diagonals are reported as 1.51 mm and 1.49 mm, calculate the VHN for a 30 kg load?

(*ix*) Using Nernst equation, calculate the potential of the hydrogen electrode, E_H, at pH = 8.

(*x*) If a particular type of polyethylene has a molecular mass of 140,000 g/mol, what is the degree of polymerisation?

Summer 2009

MATERIAL SCIENCE AND ENGINEERING

Group A

1. (a) Explain in brief, why metals in general are ductile, whereas ceramics are brittle. 3

(b) Write the properties required for a material to with stand high temperatures. 3

(c) What is a polymer? How does the structure of a polymer differ from that of a metal? Explain. 7

(d) Define a crystalline substance. How does it differ from an amorphous material? 7

2. (a) What are point, line and surface defects? Explain each with examples and suitable sketch 7

(b) What is stacking sequence? Discuss stacking fault in FCC structure 6

(c) Explain steady state and non-steady state diffusion Derive Fick's law of diffusion 7

3. (a) Explain the mechanism of creep. 6

(b) Differentiate between ductile and brittle fracture 4

(c) State Gibb's phase rule. What is the minimum and maximum number of phases which could exists in a pure metal. 7

(d) The half-length of cracks in a steel is 2 μm. Taking E = 200 GNm^{-2}, estimate the brittle fracture strength at low temperature, if the true surface energy is $1.5Jm^{-2}$ 3

4. (a) Explain briefly plastic deformation by slip and twinning. 7

(b) What is Schmidt's law? Derive the expression of critical resolved shear strength. 6

(c) Differentiate between hot working and cold working. 3

(d) The yield strength of a polycrystalline material increases from 120MPa to 220 MPA on decreasing the grain diameter from 0.04 mm to 0.01 mm. Find the yield stress for a grain size of ASTM 9 4

Group B

5. (a) What are the different stages of age hardening treatment for aluminium alloys? 5

(b) What is hardenability? Why is it not so high in plain carbon steel? 5

(c) Discuss the heat transfer characteristics during normalising and its effect on mechanical properties 5

(d) Discuss the tempering process. 5

6. (a) What are refractories? Discuss their industrial applications 7

(b) What are nano materials? Discuss their engineering applications. 6

(c) What do you understand by silicon structures? Explain 7

7. (a) Arrange the following metals in order of their decreasing thermal conductivity : (*i*) Gold, (*ii*) Silver, (*iii*) Copper, and (*iv*) Aluminium. 4

(b) What are the benefits of composite materials? Discuss their properties. 6

(c) Discuss structural properties of polymers. 6

(d) Explain thermoplasts and thermosets. 4

8. (*a*) What are different engineering materials used for cryogenic application ? Discuss their properties. 5

(*b)* What are the difference between dimagnetism and ferromagnetism? 5

(*c*) What are intrinsic and extrinsic semiconductors? How can they be differentiated? 6

(*d*) What are Curie and Neal temperatures? 4

Group C

9. Answer the following in brief 10×2

(i) What is kirkendall effect?

(ii) What is Rauschinger effect?

(iii) State the advantages of normalising over annealing.

(iv) What is critical cooling rate?

(v) What are solid solutions?

(vi) Name *three e*lements which have high density.

(vii) What are *three* most common space lattice observed in matals?

(viii) Differentiate between elasticity and plasticity

(ix) Name *four* soft magnetic materials.

(x) What is the difference between toughness and resilience?

WINTER 2008 :

MATERIALS SCIENCE AND ENGINEERING

Group A

1. (a) State, with reasons, the group of materials in which the following belong: (i) Reinforced cement concrete, (ii) Flint glass, (iii) Wood, (iv) Brick, (v) Cast iron, (vi) Rubber. (6×2M)

   (b) Draw a burger's circuit to show Burger vector in a typical screw dislocation. (2 M)

   (c) Why the following phenomenon occurs? (3×2M)

   (i) Twin commonly occurs in FCC metals

   (ii) Edge dislocation moves faster than screw dislocations

   (iii) Copper can dissolve easily in gold.

2. (a) What is meant by the 'diffusivity'? What is steady state diffusion? How does it depend on temperature? (2+2+2)

   (b) State Fick's second law of diffusion. Describe how it affects heat treatment in carburization of low carbon steels. (2+4M)

   (c)You are given two pieces of steel samples: (i) 0.2% carbon steel, (ii) 0.8% carbon steel. Both are heated to austenite regions and then are quenched in water at room temperature. Describe what changes would occur to steels in every aspect. (4+4M)

3. (a) Draw the nature of a binary phase diagram having isomorphous system and label it. Find out the degrees of freedom, using Phase rule in all its regions. (3+3M)

   (b) Calculate the degree of freedom at peritectic point in Fe-C phase diagram, showing the peritectic region and labeling various phases. What is Curie point and show it in Fe-C phase diagram? (2 + 3 + 3 M)

   (c) Draw a continuous solid solution phase diagram and explain the lever rule. What is solvus line? (4 + 2 M)

4. (a) Distinguish between elastic and plastic deformation. Define yield point and toughness of a material. How does hardness differ from hardenability? (2+4+4M)

   (b) Deduce the relation: (2+4 M)

   (i) True strain, ε = In (1 + engineering strain, e)

   (ii) Critical resolved shear stress of deformation.

   (c) Describe Frank partial and Shockley partial dislocations. (4M)

Group B

5. (a) Explain the following: (i) Strain hardening, (ii) Recrystallization and grain growth, (iii) Hall-Petch equation, (iv) Frank-Read source. (4×3 M)

   (b) How does tempering become different from mar-tempering? What is Ms and Mf temperatures? Why is sub-zero cooling applied in some tool steels. (3×2M)

   (c) How can brittle fracture be identified from fracture surface? (2M)

6. (a) (i) State Griffith's law of fracture. What is critical stress intensity factor? (2+2M)

   (ii) How can brittle-to-ductile temperature be determined experimentally? (2M)

   (b) (i) State Fourier law of conduction of heat at steady state. (2M)

   (ii) What is R-value? (2M)

   (iii) How does thermal diffusivity differ from thermal conductivity? (2M)

   (c) What is Larson-Miller parameter? Enumerate the importance of superalloys, naming two of them. (2+4M)

7. (a) (i) What are semiconductors? (2 M)

   (ii) Classify semiconductors, explaining their types. (4M)

   (iii) What is p-n-p junction? (2M)

   (b) Name four ferromagnetic materials and state the reasons of their magnetism. (4+2M)

   (c) (i) What is fatigue strength of materials? (2M)

   (ii) Describe a method of carburizing of low carbon steels. (4M)

8. (a) (i) What is superconductivity? (2M)

(ii) Explain diamangnetism and paramagnetism. (2M)

(b) (i) How do glasses differ from ceramics? (3M)

(ii) What is sintering? Why are pure oxide refractiories popular? (3M)

(c) (i) Describe polymerization mechanism in producing polymers? (4M)

(ii) What are monomers and elastomers? (2M)

(iii) How do you measure hardness of polymers? (2M)

(iv) What are MMCs? (2M)

Group C

9. Answer the following in brief: (10×2)

(i) Draw the nature of engineering stress-strain curve of grey cast iron.

(ii) Calculate the Burger's vector, $\xrightarrow[b]{}$, of a FCC metal having lattice parameter a.

(iii) What is the percentage of carbon in cementite?

(iv) What is the critical cooling rate of steel, having austenite transformation at 720^{o}C, Ms at 20^{o}C and the nose of the T-T-T curve just have a gap of 5 sec.

(v) A tensile stress of 200MPa is applied by a metal having elastic modulus of 200 GPa. Find out the strain.

(vi) If a eutectoid point of plain carbon steel is assumed at 0.77% C, how much maximum pearlite can be obtained at 0.07% C-steel.

(vii) Why is cement concrete brittle?

(viii) Why does the conductivity of ceramics increase with temperatures?

(ix) Why are bridges on road not made with plastics even today?

(x) Why are motor shafts made highly polished?

SUMMER – 2008

MATERIALS SCIENCE AND ENGINEERING

Answer FIVE questions, taking ANY TWO From Group A.
ANY TWO from Group B and ALL from Group C
Figures in the bracket indicate full marks

Group A

1. (a) Show that true stress is related to engineering stress (σ_s) by the relation

$$\sigma = \sigma_s(1+\sigma_e)$$

where σ_e is the engineering strain. (8M)

(b) State the law used to calculate the critical resolved shear stress. Derive it (7M)

(c) 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 specific surface energy is 1J/m^2. Estimate its fracture strength (5M)

2. (a) How much proeutectoid ferrite is there in a slowly cooled 0.6% steel? How much eutectoid ferrite is there in the same steel? (5M)

(b) Differentiate between any three of the following: (3×3 M)

(i) Slip and twinning
(ii) Sessile and glissile dislocation
(iii) Ceramic and glass
(iv) Frenkel and Schottky defects.

(c) Justify the following statements with reasons: (3×2 M)

(i) Cold working increases hardness of materials.
(ii) Iron is less anisotropic than diamond.
(iii) Solar cells are semiconductors with p-n junction.

3. (a) What are the three regimes of a typical creep curve showing creep strain against time? Distinguish between the deformation mechanisms involved in three stages of creep.

(10M)

(b) What is a phase? What is the difference between α-iron and ferrite? Define an invariant reaction with an example (1+2+2 M)

(c) A steel bar of 13.146 mm diameter breaks with a load of 1500 N. Its final diameter is 8.146 mm. What is (i) true breaking strength, (ii) nominal breaking strength, and (iii) true fracture strain? (3+2M)

4. (a) Explain Bauschinger's effect and Maxwell model. (4+4 M)

(b) Find the equilibrium concentration of vacancies in aluminum and nickel at 0 K and 800K. (ΔH_fkJ/mol for aluminum is 68 and for nickel 168, and R= 8.314 J/mol/K) (4M)

(c) Explain why interstitial atoms such as C in Fe can diffuse more rapidly compared to vacancies (2M)

(d) Explain recovery, recrystallization and grain growth (3×2 M)

Group B

5. (a) What are cryogenic materials? Show how ductile to brittle transition zone takes place. Determine its applicability (5M)

(b) Distinguish between thermosetting and thermoplastics polymers (5 M)

(c) What are nanomaterials? How do they differ from conventional materials? (5M)

(d) Discuss the nitriding process. (5M)

6. (a) What are the purposes of hear treatment? Draw and label Fe-Fe3 C phase diagrams (10M)

(b) Differentiate between normalizing and full annealing (5M)

(c) A unidirectional fiber-epoxy composite contains 65% by volume fibers and 35% epoxy resin. Calculate the weight percentages of fiber and epoxy resin in composite material. If Young's modulus of the fiber is 400 GPa and that of epoxy resin matrix is 50 GPa, determine the Young's modulus of the composite. (5M)

7. (a) Explain magnetic hysteresis? (5M)

(b) What is the Fourier's law of hear conduction? (3M)

(c) What are the applications of thermal sensors? (4M)

(d) What is polymorphism and degree of polymerization? (4M)

(e) Explaiun Iaminates? (4M)

8. (a) Describe the application of following as engineering materials: (5+5M)

(i) Fiber reinforced composites

(ii) Elastomers

(b) Explain the following:

(i) Polymerism fraction in glass (3M)

(ii) Zone theory of solids. (4M)

(iii) Band model of conductivity. (3M)

Group C

9. (A) Choose the correct alternative for the following : (2×4 M)

(i) Relationship between modulus of elasticity (E), shear modulus (G) and Poisson's ratio(V is given by)

(a) E = V(1+2G) (b) G = 2E (1+V)

(c) G = 2V (1+E) (d) E = 2G (1+V)

(ii) Sintering of ceramic material is done for

(a) Solidification (b) reduction of compact porosity

(c) drying (d) reduction of strength.

(iii) The unit of magnetic permeability is

(a) Am^{-1} (b) Wbm^{-2}

(c) Hm^{-2} (d) $WbA^{-1}m^{-1}$.

(iv) Cup-and-cone fracture contour occurs in

(a) brittle fracture (b) ductile fracture

(c) cleavage fracture (d) None of the above

(B) Answer the following in brief: (2×6M)

(i) Name two soft magnetic materials

(ii) Give the scientific names of melamine and PET

(iii) Explain lever rule.

(iv) What is resilience?

(v) What are solvus and solidus line?

(vi) What is E-glass?

Winter 2007

MATERIALS SCIENCE AND ENGINEERING

Time : Three hours

Maximum Marks: 100

Answer FIVE questions, taking ANY TWO from Group A,
ANY TWO from Group B and ALL from Group C.

Group A

1. Two metals, X [melting point = 1300°C] and Y [melting point = 1000°C, are partially miscible. They from two solid solutions α and β. Under equilibrium conditions, maximum solubility values are given in the following table:

Temperature (°C)	0	200	400	600	800	900	950
Maximum solubility of Y in X [wt. %]	3	10	20	32	50	40	35
Maximum solubility of X in Y [wt. %]	2	2	3	5	10	5	3

A eutectic reaction occurs when the alloy contains 20 wt.% of X and producing both α and β phases.

(i) Based on the given information, construct an appropriate equilibrium phase diagram. Label each phase. 7+5

(ii) An alloy containing 60 wt.% of X is slowly cooled under equilibrium cooling conditions to room temperature from a temperature just above the melting point of X. Discuss the phase transformation which will take place and calculate the percentage of α at 200°C . 5

(iii) Outline the heat treatment you would recommend for the above alloy to obtain a very fine dispersion of β phase. 3

2. (i) Differentiate between coherent and non-coherent precipitation hardening 5

(ii) Give a brief account-of dislocation climb arid metallic creep interrelation 5

(iii) Suppose one Schottky defect occurred in every fifth unit cell of NaCl producing a lattice of 5-6 Å. Calculate the density of NaCl. What changes in the atomic arrangement will be necessary to maintain the charge neutrality if one Fe^{+2}ion is substituted for Na^{+}ion in NaCl? Given MW-Na = 23, Cl = 35-45 and $N_A = 6.02\times10^{23}$mol^{-1} 5 + 5

3. (i) Differentiate between polymorphism and isomerism. Explain with suitable examples. 5

(ii) With the help of a typical stress-strain curve for polyethylene terephthalate (PET), explain its behaviour on application of load.. Highlight the regions and points of interest to a materials engineer. Justify why polybutylene terephthalate is preferred over PET for making engineering parts. 10

(iii) The lattice parameter of. a material, having FCC structure, is 0.396 nm. Determine the length of the Burger's vector along [110] direction 5

4. (*i*) Distinguish between shape memory effect and superelasticity. 6

(ii) Explain why the phenomenon of creep of metals is so closely related to diffusion. Can you explain the creep behaviour of ceramics and polymers? Outline mechanistic dissimilarity, if any. 3 +3+3

(iii) Differentiate among stress concentration, stress intensity factor and fracture toughness. 2 + 2 + 1

Group B

5. (*i*) Glass fibers (diameter = 20 μm) provide longitudinal reinforcement for nylon subjected to tensile loading. If the volume fraction of the glass fiber used is 0.45, what fraction load will it carry? If the average stress in the composite is 14MPa, what will be the amount of stress in glass? Young's modulus of glass fiber and nylon are 70,000 MPa and 2800 MPa, respectively. 3+2

(*ii*) Show, if the melt viscosity of a thermoplastic is reduced by a factor of two, that the $\overline{H}_w$ will change by –18.5%. 5

(*iii*) Distinguish between the following (*any two*): 5 x 2

(a) Cement arid concrete.

(b) Glass and ceramics

(c) Nano-fillers and whiskers.

6. (i) What structural parameters influence the melting point of a polymer ? Explain with proper reasonings. 10

(*ii*) Briefly outline the nitriding process. Discuss it importance and advantage in steel industry. 5

(iii) ‘Duralumin’is analloy of alluminium containing 4 wt.% copper and is of considerable importance for aircraft structures. Outline the process and methodology you will adopt in order to improve its mechanical properties. 2+2+1

7. (*i*) What are the different methods of strengthening of glass ? Discuss their relative merits and demerits. 4+4

(*ii*) Explain the thermal anomalies exhibited by quartz and zirconia. 4

(*iii*) Schematically draw loop diagrams for hard and soft magnetic materials and outline the differences in their magnetic behaviours. 4 + 4

8. Plain carbon steel, containing ~0.6% carbon, is heated ~25°C above the upper critical temperature and heat treated separately as follows:

(a) Quenched in cold water

(*b*) Slowly cooled in the furnace

(c) Quenched in water and reheated at 250°C

(d) Quenched in water and reheated at 600°C

Describe the structure/morphology at room temperature which will be thus formed in each case with the help of appropriate diagrams. Explain the generalized properties (physical) of each form and justify the treatment you will prefer for making cutting tools and shock-resistant engineering components. 2×4 + 2 × 4 + 2 × 2

Group C

9. Justify the following statements in one or two sentences: 2×10

(*i*) Heterogeneous nucleation occurs more readily than homogeneous nucleation.

(*ii*) Multifunctional monomers lead to network structure

(*iii*) FCC metals are often recommended for use at low temperature.
(*iv*) N-type semiconductor is formed by doping of polyacetylene with rubidium.
(*v*) Clay looses its ability to make plastic dough with water on heating above 400 °C
(v*i*) Four octahedral sites are associated with one FCC unit cell.
(*vii)* Polyethylene undergoes significant deformation without fracture.
(*viii)* Single crystals are anisotropic.
(ix) Alumiuna has the higher modulus of elasticity than aluminum.
(x) Quenched plain carbon hyper-eutectoid steel has some retained 'austenite'.

Summer 2007
Materials Science and Engineering

Group A

1. (a). Why are ceramics brittle, while metals are ductile? Explain under what condition a ductile metal can become brittle? (1+3 M)
   (b) What is invariant reaction? Mention different invariant reactions present in the Fe-Fe3C diagram (1+3 M)
   (c). Differentiate between edge dislocation and screw dislocation with neat sketches (2+2 M)
   (c) A 13 mm diameter tensile specimen has a 50mm gage length. The load corresponding to the 0.2% offset is 6800 kg and the maximum load is 8400 kg. Fracture occurs at 7300 kg. the diameter after fracture is 8 mm and the gage length at fracture is 65 mm. calculate the (i)yield stress, (ii) tensile stress, (iii) breaking stress, (iv) elongation, and (v) reduction of area (1×5M)
   (e). Briefly discuss kirkendal effect with an example (3 M)

2. (a) State phase rule and definite its different terms (1+3 M)
   (b) Differentiate elastic, an elastic and viscoelastic behaviour of solid with an example in each case (3 M)
   (c) Discuss the differences in the microstructure of 0.5 and 1.1 weight % plain-carbon steel in annealed condition with the help of properly leveled schematic drawings. (4 M)
   (d). A reaction-bonded silicon nitride ceramic has strength of 300 Mpa and a fracture toughness of 3.6 MPa*yjM*. What is the largest-size internal crack that this material can support with S '07,out fracturing? Assume Y =1. (4 M)
   (e). Consider the gas carburizing of a gear of 1020 steel at 9270C. Calculate the time (in minutes) necessary to increase the carbon content to 0.40 wt% at 0.50 mm below the surface. Assume that the carbon content at the surface is 0.90 wt% and that the steel has a nominal carbon content of 0.20 wt% and that the steel has a nominal carbon content of 0.20 wt%. Given: Diffusivity of C in Fe (γ) at 9270C, D= 1.28 × 10 $-^{11}$ m2/s, if erf (Z) = 0.7143, Z= 0.755. (5M)

3. (a). Discuss allotropic transformation with an example? (4 M)
   (b). State the Hume-Rothery rules for subsitutional solid-solution formation (4 M)
   (c). $\frac{a}{2}\left[0\bar{1}1\right]=\frac{a}{6}\left[1\bar{2}1\right]+\frac{a}{6}\left[\overline{11}2\right]$. Prove that the above dislocation reaction is correct and spontaneous (2+2 M)
   (d). Discuss Griffith's theory for brittle fracture and derive the concerned equation for plane-stress condition (2+3 M)
   (e). Brinell indentation is taken in a steel sample using 10mm tungsten carbide ball at 500 kgf load. Calculate the Brinell harness value of the steel sample, if the average diameter of

indention is 2.5 mm (3 M)

4. (a). Briefly discuss the following (any two): (i) Climb, (ii) Cross slip, (iii) Twin (2 ½ ×2 M)
(b). Calculate the amount of (i) proeutectoid phase, (ii) total ferrite, and (iii) peartlite in the micro structure of slowly cooled 0.3 wt% C steel at temperature just below eutectoid temperature. (5)

(c). What is critical resolved shear stress? If aluminium deforms at an axial tension of 6.9 Mpa in direction [010] on (111) [110] slip system, what is its critical resolved shear stress? (1 +5M)
(d). What is toughness? Differentiate between fracture transition plastic (FTP) and nil ductility temperature (NDT) (1+3 M)

Group B

5. (a). Draw and properly level the T-T-T diagram of an eutectoid plain-carbon steel. State is utility and limitations. Define critical cooling rate (2+3+1 M)
(b). Explain why annealing and normalizing temperatures differ for hyper-eutectoid steel (3 M)
(c). What is superconductor? Give an example of superconductor and mention its application (2+2 M)
(d). Briefly discuss important microstructural considerations of a material for high-temperature application with examples. (3 M)
(e). A unidirectional continuous glass-fiber reinforced epoxy resin composite contains 60 volume % of E-glass fibers. The modulus of elasticity of glass-fiber and hardened epoxy resin is 72.4 and 3.1 GPa, respectively. Calculate the (i) modulus of elasticity and (ii) fraction of the load carried by the fiber for this composite under iso-strain condition assuming the rule of mixture to hold good. (2+2 M)

6. (a) What is creep? Draw a standard creep curve and explain its different sections (1+3 M)
(b). What is martensite? Distinguish between lath martensite and plate martensite. (4 M)
(c). What are nanomaterials? How does those differ from conventional materials. (2+2 M)
(d). Differentiate between thermoplastic and thermosetting polymers giving examples of both (5M)
(e). Explain why ceramic material is usually bad conductor (3 M)

7. (a). Define the terms: magnetic permeability, magnetic susceptibility, ferromagnetism, diamagnetism (1×4M)
(b).Define hardenability and mention its control factors (1+2M)
(c). Differentiate between intrinsic semiconductor and extrinsic semiconductor (2+2 M)
(d). Calculate and compare the atomic packing factors of the fcc and bcc unit cells. What role does the atomic packing factor have on creep strengths of fcc and bcc metals at same homologous temperature? (3+2 M)
(e). Predict the time to rupture for a S-590 iron component that is subjected to a stress of 140 Mpa at 800^0C. Assume the Larson-Miller parameter is 24.0×10^3 and C = 20. (4 M)

8. (a). Define: plastic, elastomers, monomer, copolymer. (1 × 4M)
(b). What is metallic glass? Give two unique properties of metallic glass explaining the causes (2+2M)
(c). State the important properties a material must have for cryogenic application, and name two such widely used materials (3+1 M)
(d). Define pearlite and differentiate it from Bainite. What is inter-lamellar spacing of pearlite? (1+2+1 M)
(e). How is a glass distinguished from other ceramic materials? (4 M)

Group C

1. Why electrical resistivity of metals and alloys increases with degree of cold working? (2 M)

2. Aluminium is FCC, and has an atomic radius of 0.143 nm. Calculate its lattice parameter. (2 M)

3. Draw and appropriately level the engineering stress-strain diagrams of mild steel. (2 M)

4.Why is a/6 [011] dislocation in FCC crystal strictly sessile in nature? (2 M)

5. Schematically show the variation of hardness with ageing time of a quenched Cu 4.5 wt% A1 alloy. Mention the under-peak-and over-aged regions along with the approximate positions of different precipitates. (2 M)
6. Draw a generalized strain-hardening curve for a FCC single crystal and mention the different regions with their names. (2 M)
7. Write Hall-Petch relationship and mention its significance. (2 M)
8. Draw hysteresis loops for soft and hard magnets and mention their differences. (2 M)
9. Define Curie temperature and glass transition temperature. (2 M)
10. Discuss the typical characteristics of fatigue fracture surface. (2 M)

WINTER -2006

MATERIALS SCIENCE AND ENGINEERING

Group A

1 (a) Define: Metallic bonding, covalent bonding; Orthorhombic and Tetragonal crystals structures with examples in each case. (4x1)

(b) What is the chemical formula of an intermetallic compound which consists of 49.2 wt% Cu and 50.8 wt% ? Cu=64, Au=197 (4)

(c) Copper has a FCC crystal structure and a unit cell with lattice constant of 0.361nm.What is the interplaner spacing of d111 planes? Show one prism plane $(10\bar{1}0)$ and $[2\bar{1}\bar{1}0]$ direction of HCP lattice. (2+2)

(d) Explain polymorphism and allotropy with example. (2+2)

(e) Using the zone theory, explain the mechanism for conductivity of copper. (4)

2 (a) Define phase, Isomorphous system, phase rule, Monotectic Reaction. (4x1)

(b) How do you explain the solubility of silver in gold? (4)

(c) Calculate the degree of freedom of the Peritectic reaction in Fe-C system. What is the degree of freedom at the gamma-loop? (2+2)

(d) For a 1-1 % carbon steel, why are annealing and normalizing temperatures different? Calculate the % of phases present at room temperature of the annealed 1-1% carbon steel. (2+2)

(e) What is Pearlite? What is the maximum solubility of ‘c’ in ferrite? How does it differ with Bainite? (2+2)

3 (a) Define hardness and hardenability, explaining their difference. (4)

(b) Why is hardenability of alloy steel better than C-steel? Distinguish between lath martensite & plate martensite. (2+2)

(c) What are Ms and Mf temperatures? Discuss the factors that determine the temperatures. (2+2)

(b) Distinguish between slip and twining, with examples. (4)

(e) Explain Hall-Petch equation and its relevance. (4)

4 (a) Define (any two): Cross slip, Frank-Read source, Bauschinger's effect, Lomer-Cottrel Barrier. (4)

(b) Derive the relationship between Engineering Strain and True Strain, Engineering Stress and True Stress. (6)

(c) Draw engineering Stress-strain curve for indicating Important points :(i) Grey Cast Iron, (ii)Mild Steel(only nature should be given). (4)

(d) Why are ceramics brittle in general? Distinguish between glass and ceramics. (3+3)

Group B

5 (a) Draw a standard creep curve and explain its sections. (4)

(b) Explain the development of fatigue crack growth mechanism. (4)

(c) What are cryogenic materials? Show how ductile to Brittle transition zone determines its applicability. (2+2)

(d) A copolymer consists of 15 wt% polyvinyl acetate (PVA) and 85 wt% polyvinyl chloride (PVC).Determine the mole fraction of each component. (4)

(e) Calculate the radius of the largest interstitial void in the FCC lattice, If it occurs at the (1/2, 0, 0) position. The Radius of the atom is to be taken as R. (4)

6 (a) Define: Homopolymer, Degree of Polymerization, Thermosetting Plastic, Elastomer. (4)

(b) Explain with applications: Nylon 6.6, PMMA, ABS, Neoprene. (4x2)

(c) A unidirectional fibre-epoxy composite contains 60% by volume fibres and 40% epoxy resin. The density of fibres is 1.48 mg/m^3 and that of the epoxy resin is 1.20 mg/m^3. Calculate the weight percentages of fibre and epoxy resin in the composite material . If the young's modules of the fibre is 400 GPa and that of epoxy resin matrix is 50 GPa, determine the young's modulus of the composite, assuming rule of mixtures to hold good. (4)

d). In a tension test, the engineering stress and engineering strain were found to be 500 MPa and 0.5 , respectively. Calculate the true stress and true strain. (4)

Q.7 (a) Define curie temperature, P-N junction, permeability, diamagnetism. (4)

b). Explain the hysteresis loop and its importance in regard to soft and hard magnets. (4)

c).What is metallic glass? Explain the cause for difference in its mechanism of deformation compared to that of metallic single crystals. (2+2)

d). what is strain hardening? Name one application where it is advantageous and one application where it is problematic. (4)

e). Derive the expression per the critical resolved shear stress for slip in a single crystal (4)

8 (a).Distinguish between octahedral interstitial sites and tetrahedral interstitial sites. (4)

b).What are nanomaterials? Give two unique properties of nanomaterials explaining the cause. (4)

c).Distinguish between thermosetting and thermoplastic polymers. (2+2)

d). State the properties promoting creep resistance and name two high temperature materials widely used. (2+2)

e). State the Griffith theory of fracture? What modifications is required for application to aluminum ? (4)

Group C

9 Answer the following questions. (10 x 2)

a). Find the atomic packing factor in case of FCC Crystals .

b). If the lattice parameter of alpha iron is 286 pm (Pico meter), what is its atomic radius.

c). Calculate the number of atoms per zinc crystal structure unit cell

d). Draw schematics stress and strain curve for perfectly elastics and visco-elastic solid.

e). Explain how point defect concentration of a metal depends on temperature?
f). Why does a composite having aluminum as matrix and SiC fibres as reinforcement differ in properties compared to that having same volume fraction of SiC particles .
g). What is difference between diamagnetism and ferromagnetism.
h). How is thermal shock resistance of materials related to thermal conductivity and co-efficient of thermal expansion.
i).Give two reasons for surface hardening of structural components
j). In a tension test, gauge diameter = 10mm, gauge length = 50mm and the maximum load reported as 3000 kgf. What will be ultimate tensile strength?

SUMMER 2006

MATERIALS SCIENCE AND ENGINEERING

Answer FIVE questions, taking ANY TWO from ***Group A****,*
ANY TWO from ***Group B*** *and ALL from* ***Group C****.*
Figures in the bracket indicate full marks.

Group A

1) (a) Explain semiconductor, intrinsic and extrinsic semiconductors? (6M)
(b) Mention four strengthening mechanisms of metal and alloys temperature? (4M)
(c) Why are metals mostly ductile and ceramics brittle at room temperature? (10 M)

2) (a) What are the invariant points (degrees of freedom = 0) in a binary phase diagram with eutectic? (3M)
(b) Explain the terms isomorphous, eutectic, peritectic and eutectoid systems? (8M)
(c) Explain how will you determine the elastic and plastic and eutectoid systems? (3M)
(d) Define the following terms: (3×2M)
(i) Yield strength
(ii) Tensile strength
(iii) Poisson’s ratio.

3) (a) Explain the mechanism of creep? (8M)
(b) Distinguish between ductile and brittle fracture? (4M)
(c) What do you mean by normalizing and tempering, and indicate how those heat treatments affect the properties of steel? (4M)
(d) A sodium silicate glass has no surface defects as etching has removed them, but hhas cracks inside from 2 μm to 5 μm in length. Calculate the surface energy of glass if fracture strength = 100 MNm^{-2}; Young’s modulus = 70 GNm^{-2}. (4M)

4) (a) Write a note on viscoelastic properties of materials, showing schematic plots of variation of stress with strain and strain with time? (6M)
(b) Differentiate between edge and screw dislocation. (4M)
(c) Explain cold working, warm working and hot working. (6M)
(d) What is Bauschinger effect? (4M)

Group B

5) (a) Discuss mechanism of age hardening of Al alloys. (5M)
(b) How is hardenability test carried out? (5M)
(c) Discuss the heat transfer characteristics during quenching and its effect on mechanical properties. (5M)
(d) Discuss the nitriding process. (5M)

6) (a) What are the effects of high temperature on mechanical properties of materials? (3M)

(b) What will be your consideration for choice of an alloy for temperature applications (4M)

(c) A continuous and aligned glass fiber reinforced composite consists of 40 vol% of glass fibers having a modulus of elasticity 69 GPa and 60 vol% of a polyster resin that, when hardened, displays a modulus of 3.4 GPa. Calculate the modulus of elasticity of this composite in the longitudinal directions (7M)

d) Discuss zone theory of solids and explain zones in conductors and insulators. (6M)

7) (a) A transformer core is wound with a coil carrying an alternating current at a frequency of 50 Hz. Assuming the magnetization to be uniform throughout core volume of $0.02m^3$, calculate the hysteresis loss. The hysteresis loop has an area of 80,000 units, when the axes are drawn in units of 10^{-4} Wbm^{-2} and 10^{-2} Am-1 (6M)

(b) Distinguish between soft and hard magnets. (4M)

(c) Write the peritectic eutectic and eutectoid reaction of $Fe\text{-}Fe_3$ C phase diagram (5M)

(d) Discuss the cooling process of 0.6% C steel from 1500^0C to room temperature? (5M)

8) (a) Give some applications of polyethylene, nylons and polyester (4M)

(b) What is polymerization? With the help of suitable examples, compare and contrast the processes of addition polymerization and condensation polymerization (6M)

(c) Name two commonly used theomosetting polymers and their application, (5M)

(d) Why are fiber glass reinforced composites used extensively? (5M)

Group C

9) Answer the following questions (2×10 M)

a) What is Berger's vector?
b) State Fick's second law of diffusion
c) Differentiate between interstitial and vacancy diffusion?
d) What is work hardening?
e) Explain the reason for cracking of brass
f) How is marten site formed in steel?
g) If you subject a refractory lining to thermal gradient (hearting at one end and cooling at other), how will high or low coefficient of thermal expansion and thermal conductivity affect its longevity?
h) Give two examples of soft magnetic materials.
i) How do you determine the temperature for hot working of a metal?
j) Give two applications of nano materials?

WINTER 2005

MATERIALS SCIENCE AND ENGINEERING

Group A

1. (a) Calculate the volume of an FCC unit cell in terms of the atomic radius, *R*. Show that the atomic packing factor of FCC unit cell is more than that of BCC. (10)

(b) Differentiate between Frenkel pairs and Shottkey defects. 5

(c)Explain why interstitial atoms such as C in Fe, can diffuse more rapidly, compared to vacancies. (5)

2. (a) A tensile sample of polycryslalline copper has been loaded in tension to an arbitrary stress, σ exceeding the yield stress, σ_0 and then unloaded.

(i) With a schematic true stress-true strain curve representing the loading and unloading behaviour, show how elastic and plastic strains can be determined.

(ii) If the sample was a single crystal of copper, and subjected to compression right after unloading in tension, will the yield stress be equal to, more or less than σ_0. Explain. 10

(b) Assuming that the true stress-true strain curve follows the relation: σ = $\sigma_0 + K\varepsilon_p^n$ where σ is the true stress, σ_0 is the flow stress at plastic strain = 0, ε_p = true plastic strain, and n is the strain hardening exponent. Show that the rate of strain hardening, $d\sigma/d\varepsilon_p$ is a function of n, σ , σ_0 and ε_p . Estimate the value of $d\sigma/d\varepsilon_p$ where n = 0.3, σ = 300 MPa, σ_0 = 200MPa and ε_p = 0.05. (5)

(c) Draw schematic stress strain curves for ideally elastic, ideally plastic and viscoelastic solid. Explain how is the behaviour of viscoelastic solid different from those of other two. 5

3. (a) Explain why is twinning associated with homogeneous shear, though atoms are displaced by equal distance in slip ? (5)

(b) What are the three regimes of a typical creep curve, showing creep strain against time? Distinguish between the deformation mechanisms involved in the three stages of creep. 10

(*c)* What is the fundamental difference between stress-relaxation test and a creep test ? 5

4. *(a)* Explain on the basis of dislocation theory, why ceramics and intermetallic compounds are brittle, while metals are ductile ? 5

{b) Consider a single crystal of silver (fcc). The angle between normals to the planes (h_1 k_1 l_1) and (h_2 k_2 1_2) is

$$\cos^{-1}\{(h_1 h_2 + k_1 k_2 + l_1 1_2)/[(h_1^2 + k_1^2 + l_1^2)(h_2^2 + k_2^2 + l_2^2)]^{0.5}\}$$

If a tensile stress of 10.0MPa is applied along the [010] direction determine the resolved shear stress along the (111) plane and [110] direction. 5

(c) Mild steel samples *A, B* and *C* have been fractured by impact at liquid nitrogen temperature and in tension with a strain rate of 10^{-5} s^{-1} at 700 °C in air. Explain with reasons the differences in fracture surface morphology. 5

(d) What are the differences in grain structure and dislocation substructure do you expect after working different parts of same strip of copper through similar reduction at room temperature and 0.6 of its absolute melting point. 5

Group B

5.*(a)* What are the eutectoid and eutectic reactions in the Fe-C binary phase diagram ? 4

(b) If you carry out impact test on 0.4% C steel, subjected to heat treatments: (i) quenching in brine after soaking above the A_3, and *(ii)* tempering at 500°C for 1 h. Will the results vary? Explain. 4

(c) A plate of iron is exposed to a carburizing (carbon-rich) atmosphere on one side and a decarburizing (carbon-deficient) atmosphere on the other side at 700 °C. If a condition of steady-state is achieved, calculate the diffusion flux of carbon through the plate, if the concentrations of carbon at positions of 5 mm and 10 mm beneath the carburizing surface are 1.2 and 0.8kg/m^3. Assume a diffusion coefficient of 3×10^{-11} m^2/s at this temperature. How will you attempt the same problem, if non-steady state conditions exist? 6

(d) Differentiate between age hardening and dispersion hardening, emphasizing on how dislocations interact with the second phase and suitability for application of the materials strengthened by those methods at high temperatures. 6

6. (a) What are the two mechanisms responsible for thermal conductivity in materials? Why are amorphous ceramics or polymers less thermally conductive, compared to those, which are crystalline? 6

(b) Explain two different sources of thermal stresses in materials, which could be of any dimensions and used in different structural components. How is the thermal shock resistance dependent on thermal conductivity, coefficient of thermal expansion, elastic modulus, and anisotropy along crystallographic directions? 8

(c) How will you select and design materials to be used in (i) turbine blades of jet engines, operating at 1300 °C, *(ii)* propeller of a ship traveling in the Arctic ocean. Emphasize on requirements of microstructure, physical and mechanical properties. 6

7. *(a)* What do you mean by glass transition temperature ? How do the plots showing variation of specific volume with temperature for amorphous glass ceramic and a crystalline solid differ? 5

(*b)* Why are ionic ceramics used as dielectric in capacitors, and what does dielectric constant depend on? What is special in ferro-electric ceramics, and is it necessary for iron to be present? 6

(c) Distinguish between structure and properties of thermosetting and thermoplastic resins. 6

(d) Is substitutional solid solution of ceramics possible? What is the additional condition, which is not a requirement for metals? 3

8. (a) Distinguish between paramagnetism and ferromagnetism, explaining the mechanisms involving electron spins. 5

(b) Draw the magnetic hysteresis loop for hard and soft magnets, and explain the differences in behaviour in response to alternating field with emphasis on the magnetization parameters. 5

(c) Distinguish between addition and condensation polymerization, and state which of those are applied for processing polyethylene and polycarbonates. 5

(d) Using the character of electron distribution in different energy bands/explain the cause behind a material acting as conductor, and other acting as insulator. 5

Group C

9. Answer the following questions in *one* or *two* sentences: 2×10

(i) How many independent slip systems are required for plastic deformation in polycrystalline materials?

(ii) Why is the actual fracture strength of materials normally 10^{-1} - 10^{-3} times that of the theoretical cohesive strength ?

(iii) Which microstructural parameter of a material can be tailored to increase simultaneously the yield strength as well as the fracture toughness?

(iv) Under the application of an external stress, what is the direction of movement of edge and screw dislocation in a solid with respect to the Burgers vector?

(v) There are two alloys, one with a very high stacking fault energy compared to the other, which one is expected to demonstrate a higher rate of strain hardening?

(vi) Why does addition polymerization need a monomer with carbon-carbon double bond to begin with?

(vii) What are the two mechanisms of elastic deformation of elastomers such as rubber, which are absent in metals?

(viii) What is the cause of dielectric energy loss, when direction of an external electric field is alternated?

(ix) What is the principal difference in the elastic and physical properties of particle and fibre reinforced composites, which is important from the point of view of application?

(x) What modification was made in the expression of Griffith theory for universal application to all materials?

SUMMER 2005

MATERIAL SCIENCE AND ENGINEERING

Time : Three hours

Maximum marks : 100

Group A

1. (a) What is a Burger vector? Show it by drawing a Burger circuit? What is Frank-Read source? State its importance in plastic deformation. 2+2+2

(b) Distinguish between: (2x2)+ (2x2)

(i) Slip and Cross slip

(ii) Sessile dislocation and Glissile dislocation.

(c) What is Critical Resolved Shear Stress? Derive its formulae. 2+2

(d) Calculate the degree of freedom of ice and water kept in a beaker at 1 atmosphere pressure. 2

2. (a) State Fick's laws of Diffusion.

How can it help you m the problems of Case Carburising?

Given an activation energy, Q of 142 kJ/mol, for the diffusion of carbon in FCC iron and an initial temperature of 1000 K, find the temperature that will increase the diffusion coefficient by a factor 10. [R =8.314 J/(mol.K)]: Will you use a very high temperature? 2+2+(3+1)

(b) What is a Phase? What is the difference between α - iron and ferrite? Define an invariant reaction with an example. 2+2

(c) Differentiate between: (2x2)+ (2x2)

(i) Phase Rule and Phase Diagram,

(ii) Solvus Line and Solidus Line.

3. (a) Explain Lever Rule with a Tie Line.

Find the weight percentage of pro-eutectoid ferrite just above, the eutectoid temperature of a 0 3%C-steel. 2+2

(b) Derive the relationship between True Strain and Engineering Strain. What is Resilience? Why is it important for spring material? 2+(1 +1)

(c) Describe Yield Point Phenomenon. Draw the engineering stress-strain diagram of Glass. Why does necking occur during tension test of a ductile material 2+2+2

(d) Justify: 2x3

(i) Zinc is not as ductile as copper

(ii) Cold working increases hardness of materials

(iii) Steel is a brittle material at sub-zero atmosphere.

4. (a) Suggest one suitable material for each of the following purpose with justifications: 2x5

(i) File Cabinet

(ii) WaterTap

(iii) Manhole Cover

(iv) Garden Chair

(v) Glass Cutter.

(b) Explain with reasons: 2x5

(i) Ceramics are very hard

(ii) Solar cells are semiconductors with *p-n* junctions

(iii) High temperature creep is a diffusion controlled process

(iv) Brittle fracture commonly occurs in Grey Cast Iron

(v) Brass is always stronger than copper at room temperature.

Group B

5. (a) (i) Why has ferrite very low solubility of carbon, while austenite has high solubility of carbon ? 2

(ii) What is Hardenability ? Why is it not so high in plain carbon steels? ; 2+2

(iii) Draw the Peritectic reaction of Fe-C system. 2

(b) (i) State the advantages of Normalising over Annealing. 2

(ii) What is Critical Cooling Rate? Why is the shape of the T-T-T diagram in form of English letter *'C* ? 2+2

(iii) What is Tempering? Is it essential for high carbon steel after quenching? 2

(iv) Write the scientific names of following polymers with one of their typical use: Teflon, ABS. 2x2

6. (a) Explain a Chain Polymerisation, reaction. What is the Degree of Polymerisation? If a particular type of polyethylene has a molecular mass of 140,000 g/mol, what Is its degree of polymerisation? 2+2+2

(b) Distinguish between Homopolymer and Copolymer. 2x 2
State the basic structural units of PMMA and Nylon 6,6, elaborating their properties. (2x2) + (2xl)

(c) Define a Semiconductor and a Transistor. 2+2

7. (a) Differentiate between Ceramics and Glass, with examples. What is the Glass Transition Temperature? What type of glass is used in spectacle lenses? (2x2)+ 2

(*b*) Explain the reasons for the rising popularity of Pure Oxide Ceramics over traditional refractories. What is Magcarb? Where is it commonly being used? 2+2

(c) Draw the crystallographic unit of SiO_4^{4+} ion. What is Mullite? Explain Slip Casting. 2+(2+2)

(d) What is Alnico? Explain Patenting. 2+2

8. (a) (i) Why are monovalent metals like Silver or Copper so conductive? 2

(ii) Discuss Dielectric Constant and Dielectric Strength for ceramics. 2+2

(iii) Name two important ceramic insulators with their properties. 2

(b) (i) What is Hysteresis Loop? Explain its importance.

(ii) Distinguish between Diamagnetism and Paramagnetism. (2+2) +2

(c) What is E-glass? Where is it commonly used? 2+2

(d) By Energy Band Model explain the electrical conduction of an Intrinsic Semiconductor. 2

Group C

9. Answer the following: 2x10

(i) A tension test recorded ah engineering strain of 00046 against the engineering stress of 345 MPa of a material within its elastic range. Find out the elastic modulus of the material and the type of metallic alloy (like iron base, copper base etc)

(ii) The final thickness of a hard copper sheet is 1.0 mm. It was produced by cold working with 2.5% deformation. What was the starting thickness of the metal before cold working? To decrease the hardness what will you do?.

(iii) Atomic radii of two metal atoms are 0.128 nm and 0.133 nm respectively. Find out whether they form a solid solution, and if they form, state what type of solid solution it is.

(iv) Write down the Slip Plane and Slip Direction (one plane and one direction only) of Nickel (only Miller indices). How many slip systems are there in Nickel?

(v) Brass has a peritectic reaction at a temperature of 903^0C with 36.8% Zn (β-phase) in the middle and *32*-5% Zn at α-phase end and 37-5% Zn at liquidus end. Find out the percentages of liquid phase and α -phase present at the peritectic point.

(*vi)* Calculate the degree of freedom for eutectic reaction for an iron-carbon alloy and an iron-chromium-nickel alloy, under 1 atmosphere.

(*vii)* State the crystal structures of Cementite and Martensite.

(viii) The fracture toughness equation of a material is given by $K_{fc} = \sigma_f \sqrt{\pi a}$. If the material has a strength of 300 MPa, and a fracture toughness of 4 MPa$\sqrt{m}$, find out the largest internal crack in microns the material will support without cracking. σ_f = strength MPa, *a* = Crack size, m.

(ix) Name two soft magnetic materials.
(x) Write the scientific names of PET and Melamine.