Time : Three hours
Maximum Marks: 100

Summer 2019
MATERIAL SCIENCE AND ENGINEERING

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 is 68 x 10^{3} joules/ mole, Avogadro number N=602 x 10^{23} atoms per mole, R=8.314 $Jmol^{-1}K^{-1}$ (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=2.55Aº. 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 $\mathbf{v} = (2.87)^3 \times 10^{-30} m^3$. 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 $Cu_{in\ Al} = 0.25 \times 10^{-4} m^2 S^{-1}$. Activation energy $Q_{Cu\ in\ Al} = 121 \times 1000\ J\ mol^{-1}$. Calculate diffusion coefficient of Cu in Al at 600ºC, $R = 8.314\ J\ mol^{-1} K^{-1}$.

(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 ℃ ;the intrinsic carrier concentration is 5×10^{19}翮 $^{-3}$, the electron and hole mobilities are 0.07m^2/V-s and 0.023m^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 , , . 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 a
(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 -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: H 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 $E_f = 68 \cdot 10^3 J/mol$. 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

© Explain the Griffith's theory of fracture. A glass contains a surface crack 1 μm deep and inner crack of 1.6 μm 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 y $= 0.5 Jm^{-2}$ 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 $2 \cdot 10^4 (\Omega m)^{-1}$: 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 : $10 \cdot 2$

(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 3 x10 $^{-11}$ 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} $(ohm\text{-}m)^{-1}$; the electron and hole motilities are respectively 0.85 and 0.04 $m^2/V\text{-}s$. Compute the intrinsic carrier concentration at room temperature? (4)

Group C

9. Answer following in brief;
   (i) Define a burger circuit 10 x2
   (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