Birla Institute of Technology & Science (BITS), Pilani
First Semester 2022-2023
Comprehensive Exam – Regular

Course No. : ME/MF F216
Course Title : MATERIAL SCIENCE AND ENGINEERING
Nature of Exam : CLOSED BOOK
Weightage : 15% of 200 Marks [= 30 Marks]
Duration : 60 minutes
Date of Exam : Tuesday, 27/12/2022 (FN)

No. of Pages = 6
No. of Questions = 30

Note:

1. **Negative Marks**: For each correct and incorrect answers **+1** and **-0.25** will be awarded
2. Read the questions carefully
3. Avoid random guesses
4. Avoid answering at the last minute
5. Don't do any rough work in this sheet. Use the last page of Part-B answer sheet for the rough work

Part A: Objective

Name:

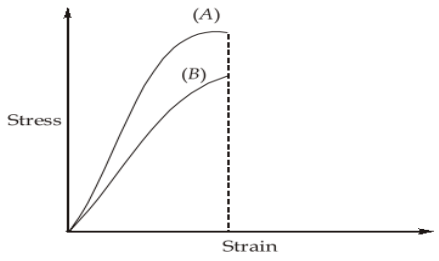
Id:

Branch:

Room No:

Signature of the student:

Sl. No	Question	Answer
1	At eutectic temperature for Lead (Pb) and Tin (Sn) mixture, the reaction occurring is a) Liquid => Solid α + Solid β b) Solid α => Liquid + Solid β c) Liquid => Solid α + Liquid d) Solid β => Solid α + Liquid	
2	Creep occurs only at high temperatures a) True b) False c) Can't say d) There exists no relation between creep phenomena and temperature	

3	The Atomic Packing fraction, APF of crystal structure follows the order a) B.C.C > F.C.C > H.C.P b) H.C.P > F.C.C > B.C.C c) F.C.C > H.C.P = B.C.C d) F.C.C = H.C.P > B.C.C e) None of the above	
4	For a fibre-matrix composite loaded in the ongitudinal direction, which is an incorrect statement? a) Stresses will be the different in fibre and matrix b) Strain will be the same in fibre and matrix c) Stresses will be finite d) Strain will be finite e) None of the above	
5	Ceramic materials are used in making a) Pneumatic types b) Bulletproof jacket c) Grinding wheels d) Air-conditioning valve e) Cement	
6	Rule of mixture is used to find a) Elastic modulus of composite b) Electrical conductivity of composite c) Thermal conductivity of composite d) All of the above e) None of the above	
7	Calculate the number of vacancies per cubic meter at 1000°C for a metal that has an energy for vacancy formation of 1.22 eV/atom, a density of 6.25 g/cm3, and an atomic weight of 37.4 g/mol.(k= 8.62 x10-5 eV/K) a) 1.49 × 1018 m−3 b)7.18 × 1022 m−3 c) 1.49 × 1024 m−3 d)2.57 × 1024 m−3	
8	The stress-strain curve for two materials A and B up to the yield point is shown below  a) Material A b) Material B c) Both have equal ductility d) Data insufficient	

9	Young's modulus of Ceramics is measured using a) Tensile test b) Torsion test c) 3-Point bend test d) Impact test e) None of the above	
10	Which of the following is not a desired property of a Matrix? a) Increased moisture absorption b) Low shrinkage c) Dimensional stability d) Low-temperature capability	
11	For a fiber-matrix composite, the strength of composites will be a) More than the strength of fibre b) More than the strength of matrix c) Twice the strength of fibre d) Half of the strength of matrix e) None of the above	
12	For a fibre-matrix composite, what will happen if the fibre volume fraction is 100% a) Composite will have zero strength in the longitudinal direction b) Composite will have zero strength in the transverse direction c) Composite will have infinite strength in the longitudinal direction d) Composite will have infinite strength in the transverse direction e) It is not a composite material at all	
13	If Hb and Hh are the thermal conductivities of the Base and the Handle of a pressure cooker. As a design engineer what will you choose? a) High, Hb and low, Hh b) Low, Hb and High, Hh c) High, Hb and High, Hh d) Low, Hb and Low, Hh e) None of the above	
14	If the energy for Frenkel defect formation in Silver Chloride is 1.1 eV, the number of Frenkel defects at 350°C will be (density of AgCl is 5.50 g/cm3, atomic masses of Ag & Cl are 107.87 g/mol & 35.45 g/mol, respectively) K=8.62 × 10-5 eV/K) a)6.56 × 1023 /m3 b) 6.56× 1023/m3 c) 8.24 × 1023 /m3 d) 8.24× 1023 /cm3	

15	Cynidising is the process of a) Adding cyanide to the steel inner surface b) Process of extraction of cyanide from potassium cyanide c) Adding carbon and nitrogen into steel by heat treatment to increase its surface hardness d) Adding carbon and nitrogen into steel by heat treatment to increase its core hardness	
16	Dislocation in a material refers to a) Point defect b) Line defect c) Plane defect d) Volumetric defect	
17	The purpose of heat treatment is to a) Relieve the stresses set up in the material after hot or cold working b) Modify the structure of the material c) Change grain size d) All of the above e) None of the above	
18	The first material and metal/alloy are known to be used by man a) Cotton and Iron b) Wood and Copper c) Leather and Iron d) Stone and Bronze e) None of the above	
19	In which mode does the fracture surface appear bright and granular? a) Dynamic mode b) Static mode c) Ductile mode d) Brittle mode (e) None of the above	
20	The critical length of fibre to be used in composite doesn't depend on a) Fiber strength in tension b) Diameter of fibre c) Shear strength of the fibre-matrix interface d) Elastic modulus of the composite e) None of the above	

21	Which of the following may alter the mechanical properties of reinforced composites? a) Constituent properties b) Fiber length c) Fiber orientation d) All of the mentioned	
22	The process of shot peening increases the fatigue life of steel springs mainly because it results in a) surface hardening b) increased stiffness of the material c) structural changes in the material d) residual compression at the surface	
23	The relationship between the magnitude of compressive stress to the tensile stress on the fatigue test specimen is a) Equal to 1 b) Greater than 1 c) Lesser than 1 d) depends on yield stress of material	
24	The Burgers vector in iron is of the 1/2 <111> type. The shear modulus of iron is 80.2 GN m^{-2}. The line energy of dislocations in BCC iron is a) 2.49 X 10^{-9} J m^{-1} b) 3.49 X 10^{-9} J m^{-1} c) 1.86 X 10^{-9} J m^{-1} d) 3.42 X 10^{-9} J m-1	
25	What is meant by resilience in the stress-strain curve? a) Area in the plastic region b) Area in the elastic region c) Area in the elastic and plastic region d) None of the above	
26	Amorphous material is one a) In which atoms align themselves in a geometric pattern upon solidification b) In which there is no definite atomic structure and atoms exist in a random pattern just as in a liquid c) Which is not attacked by phosphorous d) Which emits fumes on melting	

27	Frenkel defect belongs to which of the following classes? a) Point defect b) Linear dislocation c) Interfacial defect d) Bulk defect	
28	Consider an FCC copper. If bond energy per atom is 5.62×10^{-19} J, and its atomic radius is 0.128 nm, the surface energy for (100) plane will be a) 1.5 J/m^2 b) 2.9 J/m^2 c) 4.5 J/m^2 d) 8.2 J/m^2	
29	A continuous and aligned glass fiber-reinforced composite consists of 40 vol% of glass fibers having a modulus of elasticity of 69 GPa and 60 vol% of a polyester resin displays a modulus of 3.4 GPa. Using the upper limit method, the modulus of elasticity of the composite is a) 26.46 GPa b) 29.64 GPa c) 28.74 GPa d) 26.74 GPa	
30	The ratio of lengths of two rods A and B of the same material is 1: 2 and the ratio of their radii are 2: 1, then the ratio of modulus of rigidity of A and B will be. a) 1:4 b) 1:1 c) 4:1 d) 1:1.1	

********** Best of luck **********

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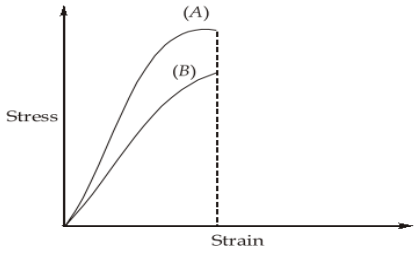
8	The stress-strain curve for two materials A and B up to the yield point is shown below  a) Data insufficient b) Material B c) Both have equal ductility d) Material A	

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13	If Hb and Hh are the thermal conductivities of the Base and the Handle of the pressure cooker. The worst engineer will you choose? a) High, Hb and low, Hh b) Low, Hb and High, Hh c) High, Hb and High, Hh d) Low, Hb and Low, Hh e) None of the above	
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Course No.	: ME/MF F216
Course Title	: MATERIAL SCIENCE AND ENGINEERING
Nature of Exam	: OPEN BOOK
Weightage	: 25% of 200 Marks [= 50 Marks]
Duration	: 120 minutes
Date of Exam	: Monday, 27/12/2022 (FN)

No. of Pages = 6
No. of Questions = 6

1. Read all the questions carefully
2. Each question has two options separated by "**OR**"
3. Attempt either of them completely
4. Don't attempt both options for any of the questions
5. Only one of the options will be evaluated if both the options are attempted partially or fully for any of the questions

Part B: Subjective

Q 1. On a hypothetical binary eutectic phase diagram as shown in Figure Q.1, a cooling curve is shown at 27% of B. Calculate the following quantities: **[12 Marks]**

a) The fraction of primary solid that forms under equilibrium cooling at the eutectic temperature.

b) The fraction of liquid with the eutectic composition that will transform into two solid phases below the eutectic isotherm.

c) The amount of α and β that will form from the liquid just below the eutectic isotherm.

d) The total amount of α phase in the alloy at a temperature just below the eutectic temperature.

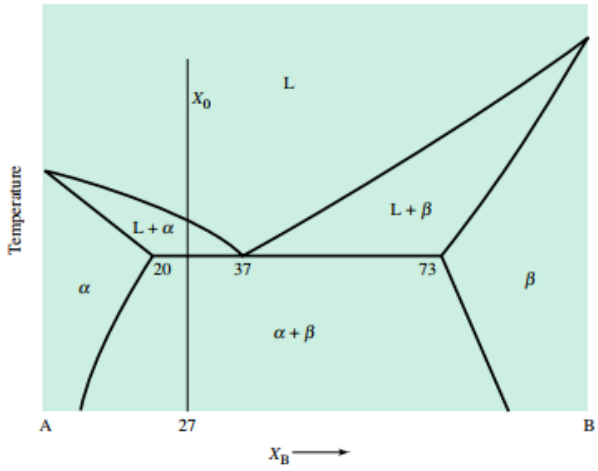

Figure Q.1

OR

Q 1. You need to produce a Cu-Ni alloy having a minimum yield strength of 20,000 psi, a minimum tensile strength of 60,000 psi, and a minimum % elongation of 20%. You have in your inventory a Cu-20% Ni alloy and pure nickel. Using Figure Q.2, Design a method for producing castings having the required properties. **[12 Marks]**

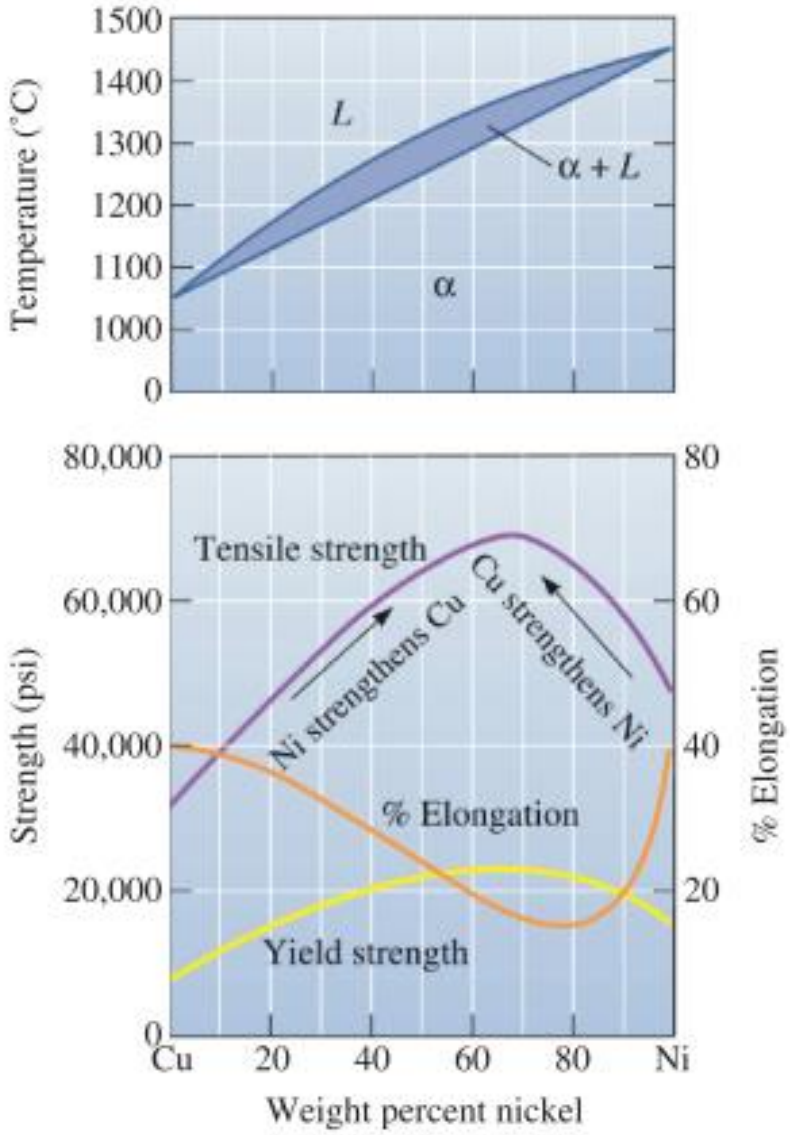

Figure Q.2

Q 2. Consider 2.0 kg of a 99.6 wt% Fe–0.4 wt% C alloy that is cooled to a temperature just below the eutectoid. **[10 Marks]**

a) How many kilograms of pro-eutectoid ferrite form?

b) How many kilograms of eutectoid ferrite form?

c) How many kilograms of cementite form?

OR

Q 2. For an Fe–0.35%C alloy, determine **[10 Marks]**

a) The temperature at which austenite first begins to transform on cooling

b) The primary micro constituent that forms

c) The composition and amount of each phase present at 728C

d) The composition and amount of each phase present at 726C

e) The composition and amount of each micro-constituent present at 726C

Q 3. The correlation between the endurance limit, σ_e, and ultimate tensile strength, σ_{uts}, for several materials follows the relation shown in Equation 3.1 **[8 Marks]**

$$0.25 < \frac{\sigma_e}{\sigma_{uts}} < 0.5 \qquad (3.1)$$

A structural component of cross-sectional area 5 cm^2 is fabricated from a plain carbon steel with the ultimate tensile strength, σ_{uts} = 800 MPa. Calculate the maximum permissible stress to which this component can be subjected if it must survive an infinite number of loading cycles. Repeat this calculation for a ductile aluminum alloy with the ultimate tensile strength σ_{uts} = 280 M

OR

Q 3. An Astroly jet engine blade will be used at 871^{o}C at a stress level of 200 MPa. Using the Larsen-Miller diagram shown in Figure 3 **[8 Marks]**

a) Determine the life of the blade, assuming C = 20

b) Estimate the maximum service temperature possible if a life of 500 hours is required

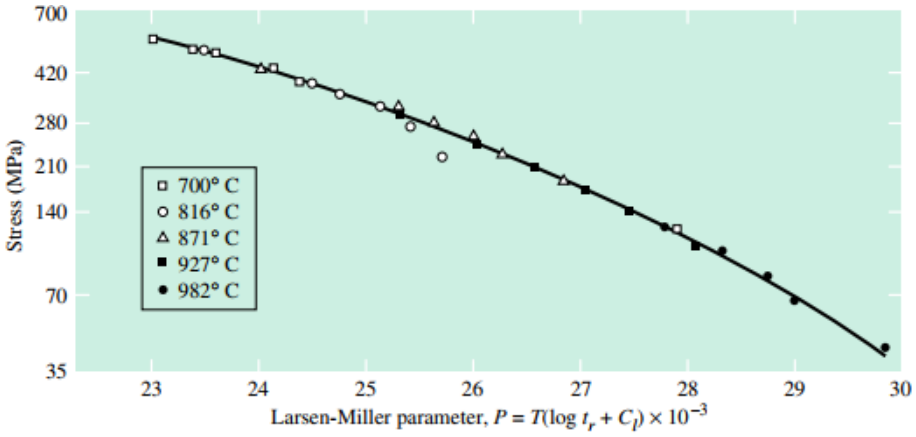

Figure Q.3

Q 4. a) An additively manufactured part as shown in Figure Q.4 needs finishing (machining) of its internal surfaces. The working temperature for the finishing operation is -30 °C. Discuss the following

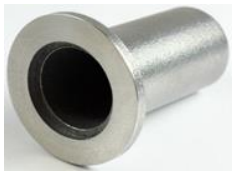

Figure Q.4

i. Which smart material can perform the intended operation? Why? **[2 Marks]**

ii. Discuss the mechanisms of finishing using the appropriate schematic diagram. **[3 Marks]**

b) Discuss the role of Curie temperature in the actuator/sensor response of a magnetostrictive material. **[2 Marks]**

c) How does inelastic deformation in a shape memory alloy offer a shape memory effect? **[3 Marks]**

OR

Q4. An electric field (2×1010 v/m) is applied to a piezoelectric material. The polarization of the material is a function of strain (ε) and varies as per the below Equation 4.1

$$P = \frac{1}{\varepsilon} \times log_e\, \varepsilon \qquad (4.1)$$

The term e (=2.71) is a mathematical constant. Find out

(a) the maximum possible electric displacement if $\varepsilon_0 = 8.854\times10^{-12}\ Fm^{-1}$. **[5 Marks]**

(b) the maximum electrostatic energy density **[2 Marks]**

(c) the stress in the material at 5% strain. **[3 Marks]**

Q 5. Calculate the longitudinal modulus and tensile strength of a unidirectional composite containing 55 % by volume of Sisal fibres in an epoxy matrix. The modulus and strength of fibre are 30 GPa and 600 MPa respectively and the same for the matrix is 3.5 GPa and 100 MPa respectively. Find the fraction of load taken by fibres in the composite**.** **[5 Marks]**

OR

Q 5. The modulus of elasticity of E-glass fiber is 72 GPa and that of epoxy resin is 3 GPa. Find the modulus of elasticity for a composite material consisting of 60% by volume of continuous E-glass fibre and 40 epoxy resin for the matrix, when it is stressed under iso-stress conditions **[5 Marks]**

Q 6. Three identical fatigue specimens (denoted A, B, and C) are fabricated from a nonferrous alloy. Each is subjected to one of the maximum-minimum stress cycles listed below; the frequency is the same for all three tests **[5 Marks]**

Specimen	σ_{max} *(MPa)*	σ_{min} *(MPa)*
A	*+450*	*−350*
B	*+400*	*−300*
C	*+340*	*−340*

(a) Rank the fatigue lifetimes of these three specimens from the longest to the shortest

(b) Now justify this ranking using a schematic S–N curve.

OR

Q 6. Steady-state creep rate data are given below for nickel at 1000°C (1273 K):

ε_s (s^{-1})	σ [MPa]
10^{-4}	15
10^{-6}	4.5

If it is known that the activation energy for creep is 272,000 J/mol, Compute the steady-state creep rate at a temperature of 850°C (1123 K) and a stress level of 25 MPa. **[5 Marks]**

########## Best of Luck ##########