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KATHMANDU UNIVERSITY
End Semester Examination
March, 2024

Marks Scored:

Level : B.E.
Year : II

Course : MEEG 213
Semester : I

Exam Roll No. :

Time: 30 mins.

F. M. : 10

Registration No.:

Date : 25 MAR 2025

SECTION "A"
[20Q. × 0.5 = 10 marks]

Choose the most appropriate answer and **mark [X]**.

1. Zirconia (ZrO_2) exhibits _____, meaning it can exist in three crystal structures: monoclinic (m-ZrO_2) at room temperature, tetragonal (t-ZrO_2) at intermediate temperatures, and cubic (c-ZrO_2) at high temperatures.
   [ ] allotropy [ ] polymorphism
   [ ] phase deposition [ ] phase transformation

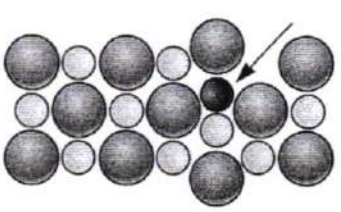
2. Silicon Carbide (SiC) used as an abrasive belongs to _____ material type.
   [ ] composites [ ] metals [ ] metallic glass [ ] ceramics

3. The correct order of coordination numbers for SC, BCC, FCC and HCP unit cells are:
   [ ] 6, 8, 12, 12 [ ] 8, 8, 12,12 [ ] 6, 6, 12, 12 [ ] 8, 12, 12, 12

4. Which of the following metals typically have a Body-Centered Cubic (BCC) crystal structure at room temperature?
   [ ] Aluminum and Copper [ ] Iron and Copper
   [ ] Iron and Chromium [ ] Nickel and Copper

5. Titanium above the temperature of 882 °C (β-phase) has BCC crystal structure. β-phase of titanium has a molar mass of 47.867 g/mol and atomic radius of 0.147 nanometers (nm). Calculate the theoretical density based on the above information.
   [ ] 2.7 g/cm^3 [ ] 4.06 g/cm^3 [ ] 5.56 g/cm^3 [ ] 7.2 g/cm^3

6. What type of point defect is illustrated in the figure?
   [ ] Substitutional defect
   [ ] Interstitial defect
   [ ] Frenkel defect
   [ ] Schottky defect



7. Formation of chevron pattern in the failed material indicates_____.
   [ ] ductile fracture [ ] brittle fracture [ ] fatigue fracture [ ] corrosion failure

8. The stress strain behavior of mild steel up to its proportional limit is represented by _____ behavior.
   [ ] linear elastic [ ] non-linear elastic [ ] elastic-plastic [ ] unpredictable

9. A cylindrical aluminum specimen has a diameter of 10 mm and a gauge length of 200 mm. Under a tensile load of 6 kN, it elongates by 0.25 mm. What is the elastic modulus (E) of aluminum?
[ ] 48.3 GPa [ ] 62.5 GPa [ ] 72.4 GPa [ ] 80.1 GPa

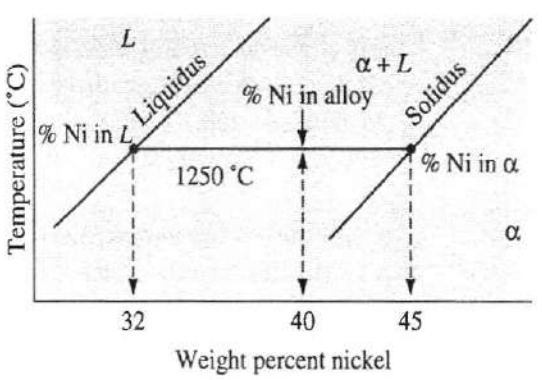
10. Failure of the material by repeated application of load below yield stress is known as _____.
[ ] fracture [ ] fatigue [ ] creep [ ] buckling

11. Which of the following is not true about dispersion strengthening?
[ ] dispersed phase particles should be round
[ ] hard dispersed phase should be continuous
[ ] dispersed phase particles should be small and numerous
[ ] Higher concentrations of the dispersed phase increase the strength

12. In the solidification process of metal casting, which type of crystals are formed near the mold face?
[ ] Big crystals systematic orientation [ ] Big crystals random orientation
[ ] Small crystals systematic orientation [ ] Small crystals random orientation

13. Which among the following three-phase invariant reaction represent cast irons in the iron-carbon phase diagram?
[ ] Peritectic [ ] Eutectic [ ] Peritectoid [ ] Eutectoid

14. Figure below shows part of Cu – Ni phase diagram. ***L*** represents liquid region and α represents solid region. The 40% Ni alloy (Cu – 40% Ni) at 1250°C is in $\alpha + L$ region. Determine the percentage of Ni present in the α phase in the two-phase composition.
[ ] 32 % Ni [ ] 40 % Ni
[ ] 45 % Ni [ ] 50 % Ni



15. Which among the following is least ductile?
[ ] Bainite [ ] Fine pearlite [ ] Spheroidite [ ] Course pearlite

16. Annealing of steel is done to impart the following property in steel.
[ ] Ductility [ ] Strength [ ] Hardness [ ] None

17. Galvanization is done with as thin layer of _____.
[ ] copper [ ] tin [ ] zinc [ ] aluminum

18. Aluminum alloys with the addition of Mg and Si alloying element (Al-Mg-Si alloy) is labeled as _____.
[ ] 4xxx series [ ] 5xxx series [ ] 6xxx series [ ] 7xxx series

19. Oxides that, when added to a glass, help to extend the glassy network are _____.

[ ] glass formers [ ] intermediates [ ] modifiers [ ] silica glasses

20. Which of the following process would reveal microstructural details that would otherwise not be evident on the material sample?

[ ] Etching [ ] Grinding [ ] Polishing [ ] Sectioning

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SECTION "B"

Attempt ALL the questions. Assume suitable data if necessary.

1.

a. "*Materials science and engineering is an interdisciplinary field of science and engineering.*" Considering this statement explain how material science is different from material engineering? Define different length scales used in materials science and engineering. [1+1=2]

b. Polymers are one of the material types in the classification with its distinct properties. State four distinct properties of polymers as compared to other material types. Explain classification of polymers with two examples of each type of polymer. [2+2=4]

c. Write short notes on Metallic bond present in metals. [1]

2.

a. Titanium (Ti) exhibits two allotropic forms: at room temperature, it has a hexagonal close-packed (HCP) structure (α-phase), and above 882°C, it transforms to a body-centered cubic (BCC) structure (β-phase). The lattice parameters are given as follows.

α-phase of Ti (HCP)	**β-phase of Ti (BCC)**
a = b = 0.295 nm, c = 0.468 nm Vol. of Unit cell = $0.866a^2c$ Atoms per unit cell equivalent to 6 atoms	a = b = c = 0.332 nm

Determine:

i. Percentage change in volume as the crystal structure changes. [1.5]

ii. Derive the relationship between atomic radius and lattice parameter for β-phase of the titanium. [1.5]

iii. Packing factor for the β-phase of the titanium. [2]

b. What do you mean by perfectly aligned crystal structure? Explain the significance of crystal defects on the material properties. [2]

c. Describe any two types of line defects in crystalline materials with illustrations. [2]

3.

a. A cylindrical aluminum rod with an initial diameter of 12 mm and a gauge length of 200 mm is subjected to a tensile test. Under an applied load of 5 kN, the rod experiences an elongation of 0.30 mm within the gauge length. Assuming the material remains within the elastic limit, determine the elastic modulus (Young's modulus, E) of aluminum. [2]

b. Define material hardness. Explain Vickers hardness scales (HV). [2]

c. Explain the differences between ductile and brittle fracture of materials. [3]

d. Define impact toughness. Discuss how impact test is useful in determining ductile to brittle transition temperature. [2]

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4.

a. Explain nucleation of embryo in solidification process along with its types. [2]

b. State Lever rule for phase composition. Figure 1 below presents Copper – Nickel phase diagram, using Lever rule determine the amount of each phase in the Cu-40% Ni alloy at 1250 °C. [3]

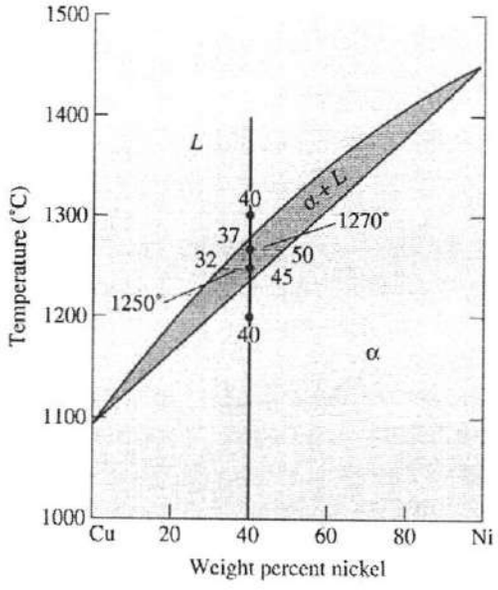

Figure 1: Copper – Nickel phase diagram

c. Explain shrinkage defect and gas porosity defect observed in solidification process.[2]

5.

a. Draw the iron-carbon phase diagram focusing on the cast iron region. Explain and illustrate the invariant phase transformation process represented in cast iron region of the phase diagram. [3]

b. Explain the differences between annealing and normalizing heat treatment processes with suitable illustration. [3]

c. Write short notes on: [2×1=2]

i. Austempering heat treatment process

ii. Carburizing surface treatment process