KATHMANDU UNIVERSITY
End Semester Examination
July/August 2024

Level : B.E.
Year : II
Time : 2 hrs. 30mins.

06 AUG 2024

Course : MEEG 213
Semester : I
F. M. : 40

SECTION "B"
[40 marks]

Attempt *ALL* questions. *Assume suitable data if necessary.*

1.
a. Explain Material Science and Engineering tetrahedron with illustration. [1]
b. Titanium (Ti-6Al-4V) implant, Heat resistant refractories, HDPE shampoo bottle and Glass Fiber Reinforced Polymer (GFRP) represent four different categories of materials. State four major types of materials and classify above materials with two additional examples for each type of the materials. [3]
c. Carbon in diamond is crystalline whereas carbon in graphite is amorphous. Explain the differences between diamond form of carbon and graphite form of carbon [2]

2.
a. Nickel has an FCC metal structure with an atom radius of 0.124 nm. Given molar mass of Ni = 58.69 g/mol.
i) Derive the relationship between atomic radius and lattice parameter for Ni. [1.5]
ii) Calculate the theoretical density of Ni. [1.5]
b. Explain the procedure to identify Miller indices of crystallographic direction. Indicate direction [121] in cubic unit cell. [2]
c. Explain with illustrations all the types of line defect (dislocation) in crystalline solids. Discuss the significance of Burger's vector in these line defects. [3]

3.
a. Draw a representative stress – strain curve for steel material with elastic – plastic material behavior. With respect to the stress – strain curve, indicate and explain how to obtain elastic modulus (E), yield strength (σ_y), ultimate tensile strength (UTS) and percentage elongation of the steel material. [5]
b. Define hardness of material. Explain basic principles of hardness measurement using different hardness scale. [3]
c. Explain the fracture mechanisms commonly observed in composite materials [2]

4.
a. State three phase transformation process observed in Iron – Iron Carbide phase diagram with transformation equation. [1.5]
b. Explain different types of annealing heat treatment process of eutectoid steels along with their purpose and effect on the steel material. [2.5]
c. The Time-Temperature-Transformation (TTT) diagram has a characteristic C-shape curve. Explain the reasons behind characteristic C-shape of the TTT diagram. [2]
d. Write short notes on: [2×1=2]
i) Surface treatment processes
ii) Dendritic growth mechanism

P.T.O.

5.

a. Define critical radius (r^*) in terms of free energy per unit volume (ΔG_v) and surface free energy (σ_{sl}) associated with solidification/phase transformation process. [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 1270 °C. [3]

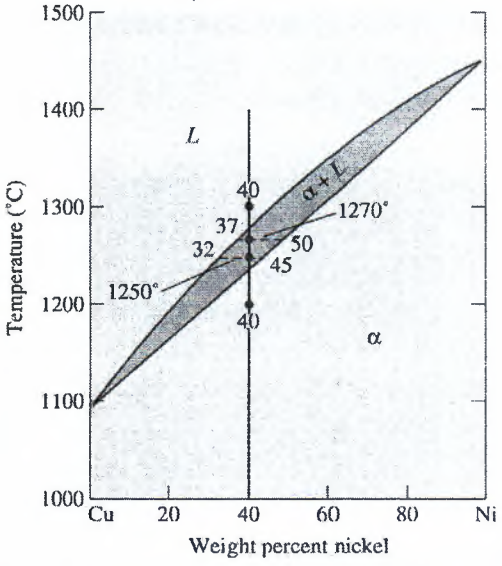

Figure 1: Copper – Nickel phase diagram

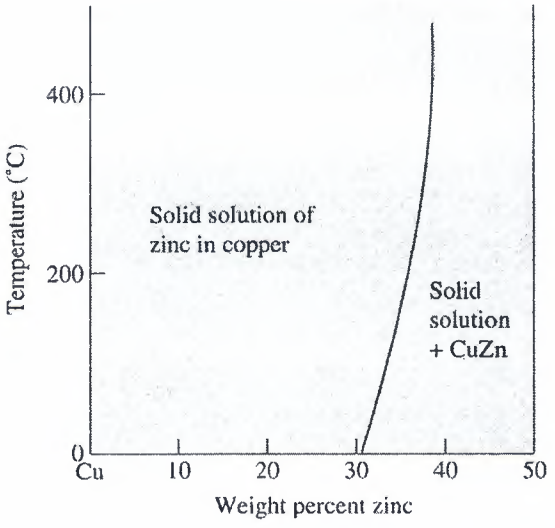

Figure 2: Solubility of Zn in Copper

c. Figure 2 above shows the solubility of Zn in copper. The maximum solubility limit of Zn in Cu metal is 30 % at RT. Addition of higher amount of Zn in Cu will result into ionic compound CuZn. If 50% Zn is added to Cu metal, discuss different strengthening mechanisms observed in the new Cu-Zn alloy. Explain the effect of temperature on the solubility limit of Zn in Cu. [3]

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Marks Scored:

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Exam Roll No. :

Time: 30 mins.

F. M. : 10

Registration No.:

Date 06 AUG 2024

SECTION "A"
[20Q. × 0.5 = 10 marks]

Choose and mark [X] in the most appropriate option from each set of choices

1. The packing factor for SC, BCC and FCC unit cells can be arranged from smallest value to largest value in the following order:
   [ ] FCC < BCC < SC
   [ ] BCC < SC < FCC
   [ ] SC < BCC < FCC
   [ ] SC < FCC < BCC

2. The stress strain behavior of rubber is _____.
   [ ] linear elastic [ ] non-linear elastic [ ] plastic [ ] unpredictable

3. A crystallographic direction and family of direction are respectively represented by.
   [ ] (hkl), {hkl} [ ] (hkl), <hkl> [ ] [hkl], <hkl> [ ] [hkl], {hkl}

4. Molar mass of gold is 196.966 g/mol and Avogadro's number, Na = 6.023×10^{23} /mol. Calculate the number of atoms in 1 tola (11.66 g) of gold.
   [ ] 6.02×10^{22} atoms
   [ ] 3.565×10^{22} atoms
   [ ] 7.645×10^{22} atoms
   [ ] 5.58×10^{22} atoms

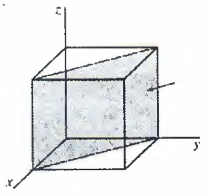
5. A material is known as allotropic if it _____.
   [ ] has fixed structure under all conditions
   [ ] exists in several crystal forms at different temperatures
   [ ] responds to heat treatment
   [ ] has its atoms distributed in a random pattern

6. Calculate the density of an Iridium atom, given that Iridium has an FCC crystal structure, atomic radius of 0.136 nm, and an atomic weight of 192.2 g/mol.
   [ ] 1.14 g/cm^3 [ ] 2.24 g/cm^3 [ ] 11.4 g/cm^3 [ ] 22.4 g/cm^3

7. Engineering stress-strain curve and True stress-strain curve are equal up to _____.
   [ ] elastic limit
   [ ] proportional limit
   [ ] yield point
   [ ] ultimate point

8. In phase nucleation process, the nucleated solid is _____ if its radius is less than the critical radius.
   [ ] a nucleus [ ] an embryo [ ] a tiny particle [ ] a molecule

9. In the given unit cell, the shaded plane is denoted by ____



[ ] (110)
[ ] (011)
[ ] (101)
[ ] (111)

10. The Hall-Petch equation for mild steel grade is given by, $\sigma_y = 100 + 600d^{-1/2}$. Calculate the required grain size to attend the yield strength of 375 MPa.
[ ] 5.9 μm [ ] 7 μm [ ] 4.76 μm [ ] 10.6 μm

11. The untreated Cu-20%Zn brass alloy is stronger than pure copper. If the solubility limit of Zn in Cu is 30%, which strengthening mechanism accounts for better strength of brass?
[ ] Solid-Solution strengthening [ ] Dispersion strengthening
[ ] Strain hardening strengthening [ ] Dislocation strengthening

12. _____ is a line (temperature) separating solid region from liquid + solid region below which its completely single phase solid.
[ ] Liquidus [ ] Solidus [ ] Solvus [ ] Isopleth

13. 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

14. Which of the following is an intermetallic phase in iron-carbon phase diagram?
[ ] Austenite [ ] Ferrite [ ] Cementite [ ] Graphite

15. Which of the following invariant phase transformation process is not observed in iron-carbon phase diagram?
[ ] Peritectic [ ] Peritectoid [ ] Eutectic [ ] Eutectoid

16. Among the following options, which one does not serve as a purpose of the heat treatment process?
[ ] Harden and Strengthen [ ] Soften
[ ] Improve machinability [ ] Improve smoothness

17. Arrange the microstructure phases from highest to lowest tensile strength: Austenite (A), Bainite (B), Course Pearlite (CP), Fine Pearlite (FP), Tempered Martensite (TM)
[ ] A, B, CP, FP, TM [ ] TM, B, CP, FP, A
[ ] TM, B, FP, CP, A [ ] TM, CP, FP, B, A

18. Which of the following statements is false about the tempering heat treatment process?
[ ] Tempering reduces the brittleness of hardened steel.
[ ] Tempering increases the hardness of the steel significantly.
[ ] Tempering is performed after quenching.
[ ] Tempering improves the toughness of the material.

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

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

20. Aluminum alloys with the addition of Cu element (Al-Cu alloys) are labeled as _____.

[ ] 2xxx series [ ] 3xxx series [ ] 4xxx series [ ] 5xxx series