

NON-FERROUS METALS SCIENCE AND ENGINEERING

Entrance exam for full-time second cycle studies

Questions for the 2019/2020 academic year

Guiding questions

1. Define the constants of elasticity, Young's modulus, shear modulus and Poisson's ratio for an isotropic body.
2. What conditions favour dendrite growth and what is dendritic segregation?
3. Describe the atomic diffusion mechanisms. Name the 1st and 2nd Fick's law and describe the rapid diffusion lengths.
4. What is hardness? Describe the Rockwell, Vickers and Birrell hardness tests, including the following details: what does the measurement consist in, used indenters, advantages/disadvantages, what materials are suitable for individual methods.
5. Describe the course of the ageing process in Al-Cu alloys. Characterize the phases which occur at individual stages and discuss their impact on the plastic and strength properties of the alloy.
6. Define the concept of carbon steel, alloy steel, cast iron and cast steel.
7. Characterize examples of diffusional and diffusionless transformation.
8. Characterize homogenous and heterogeneous nucleation during solidification.
9. Describe the processes of quenching and tempering steel alloys.
10. Homogenous and heterogenous plastic flow of deformed metals.
11. Structural testing methods, resolving power of the given method and types of microstructural elements which can be assessed/investigated using the given method.
12. The effect of dynamic recrystallization on the shape of the σ - ϵ curve and the structure of deformed material.
13. What is composite? Name and describe the division of composites.
14. Characterize interatomic bonds, provide examples.
15. Describe the solution hardening mechanisms for metal alloys. Name the rules of solid solution formation.
16. Define the notion of nanomaterial. Name the types of nanomaterials in terms of dimensions and application.
17. Derive the general form of deformation matrix and provide its specific form for a selected slip system.
18. Characterize an example of transformation with liquid phase and transformation in solid state (without liquid phase).
19. What is the purpose of microscopic examinations? Describe the observation method in bright and dark field.
20. Describe the processes of recovery and recrystallization of metals and metal alloys.
21. Name and application of an electron beam in material structure tests.
22. Discuss the impact of the grain size on the plastic and strength properties of metals.
23. The influence of temperature and deformation rate on the mechanical characteristics of deformed metals.
24. Name and describe the basic systems of phase equilibrium in binary alloys.

25. Draw charts of a tension curve for a material with a distinct yield point and for a material without a yield point. On one chart, draw the tension curve for pure copper in a recrystallized and strain-hardened state.
26. Describe the A1 structure type; name 3 crystallizing elements in this arrangement, draw a unit cell, name: space filling, coordination number, slip systems.
27. Describe the creep mechanisms in metals and metal alloys. How can one prevent the creep?
28. Based on your partial knowledge of the Cu-Zn equilibrium system, define the plastic working temperature of transient brasses ($\alpha + \beta$) and substantiate your choice.
29. Justify the concepts of dislocation and provide definitions of the Burgers vector for edge and screw dislocation.
30. Draw and describe a chart presenting the dependence between Gibbs free energy and temperature.
31. Draw a curve of a uniaxial tension of recrystallized material and determine the following on the chart: yield point, tensile strength, elongation. Based on the tension curve, draw a material hardening curve and, thereon, mark the specific work of the plastic strain.
32. What does "alloy hyperquenching" consist in? Name an example of an alloy subject to hyperquenching.
33. Types of solid solutions in metal alloys and conditions of forming continuous and limited solid solutions.
34. Name and characterize the types of crystalline lattice defects.
35. Characterize the mechanisms of plastic strain in metals.
36. Low- and high-temperature metal strain – name the division criteria.
37. List at least 3 types of intermetallic phases and describe their structural properties.
38. Structural processes occurring during ageing of aluminium alloys series 2000 (Al-Cu, Mg) and their effect on product properties.
39. What is a slide system. List slide systems in lattice A1, A2 and A3.
40. Give the general Hooke's law and reduce the number of spring constants for hexagonal crystals.
41. List and briefly describe the Bravais lattice types.
42. Describe the radiation spectrum of an X-ray lamp. Describe the formation mechanism of K-alpha emission lines.
43. Discuss the basic dislocations of RSC and RPZ cubic lattices and the HZ lattice.
44. Discuss the methods of metal and metal alloy casting.
45. Heat treatment of aluminium series 6000 (Al-Mg-Ai) – structural processes and their effect on product properties.
46. Discuss the ageing process (natural, artificial). Equilibrium system, with which the ageing process is possible or impossible.
47. List and discuss aluminium alloy series (casting alloy series and wrought alloy series). List and discuss the states of wrought alloys.
48. Characterize the processes of applying coatings from gaseous phase (PVD and CVD). Provide examples of coatings applied using these methods.
49. Morphology, properties and application of superficial layers.
50. Characterize ideal solutions, regular solutions, non-ideal solutions, ordered solutions.

Supplementary questions

1. Discuss the behaviour of an electrode in equilibrium conditions and in polarization conditions.
2. Discuss the notions of van Hoff's isotherm and isobar, present them graphically.
3. Explain Gibbs' phase rule and Le Chatelier's principle, provide examples using reactions,
4. List the methods of obtaining lead and discuss one of them in detail.
5. Discuss winning of aluminium oxide using the Bayer method in an $\text{Na}_2\text{O}-\text{Al}_2\text{O}_3-\text{H}_2\text{O}$ system.
6. Discuss obtaining of aluminium using the method of fused salts electrolysis, draw one of the types of electrolyzers.
7. Discuss the sulphide roasting theory and the process of roasting Zn concentrates in a fluidized bed.
8. Discuss the process of obtaining zinc using the IS method.
9. Characterize the process of obtaining copper in a fluidized-bed oven and shaft furnace, discuss the differences.
10. Describe the stages of converting copper matte, draw a convector.
11. List and discuss typical defects of products rolled from non-ferrous metals.
12. Using the example of the bell casting procedure, discuss and characterize the stages of the process of making casts in sand moulds.
13. Draw and discuss an example of a process of continuous casting of round ingots of non-ferrous metals. Sketch a continuous casting mould, including key structural elements.
14. List the basic processes of plastic working of metals; based on diagrams, briefly characterize each of them.
15. Draw the distribution of unit pressure along the length of the roll gap in cold and hot rolling. Discuss the factors affecting the magnitude of unit pressure.
16. Discuss the condition of metal being gripped by the rollers in the rolling process.
17. Name the methods of pipe drawing and discuss the types of used tools and devices.
18. Define the extrusion process and the material effective strain(s) in this process. Indicate the differences between direct and indirect extrusion.
19. List the basic processes of metal sheet forming, draw a diagram and describe the drawing process, discuss the phenomena which restrict this process.
20. Define the effective strains for the lengthening process, define the relation between the relative and true strain; demonstrate additivity of true strains.

The candidate is to provide a written answer to two directional and one supplementary question.