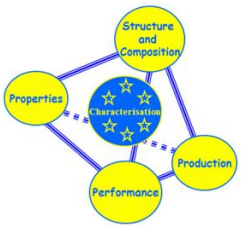
MLZ 462 / 2024-2025 SPRING / QUESTIONS



Question 1 Three-dimensional Bravais lattices and structures, and structure-property relationship

(a) Please draw the family of lowest and densest planes and directions in FCC and BCC structures.
(b) Explain the relationship between structure and mechanical properties (e.g. Fe or Carbon Nanotube).
(c) Explain the relationship between structure and electrical properties in semiconductors (e.g. Si or Ge or VO_2).
(d) Explain the magneto-crystalline anisotropy (relationship between structure and magnetic properties) in Fe, Ni and Co.

Question 2 Electrical, thermal and magnetic properties

(a) Write the general electrical conductivity equation and explain each term. How can we classify materials based on their electrical conductivity? Please, explain your answer by using electronic band structures.
(b) Please explain dielectricity and superconductivity. Are dielectric materials conductor, insulator or semiconductor? Why?
(c) How can we classify materials according to their magnetic susceptibility? Please, explain your answer by using atomic dipole configurations with or without magnetic field for each group of material.
(d) Please, draw the flux density vs. magnetic field strength curves for each material group and explain the graph.
(e) Please explain the mechanisms of the thermal conduction for ceramics, metals, and polymers.
(f) Please write the equation for the thermal shock resistance of a ceramic material and explain each term.

Question 3 Production of ceramic materials

Discuss the effects of powder properties (primary particles and granules) on the production and final properties of advanced ceramics.

Question 4 Mechanical properties

Please explain and discuss the differences on the mechanical behaviours of metals, ceramics, polymers and composite materials by drawing figures.

Question 5 Oxidation and corrosion

Although, under oxidizing conditions, a protective surface layer is formed on the surface of some metals (for example Al) it does not form in others (for example Fe). Explain this phenomenon. Also explain the effect of macro and micro properties of the oxide layer as a function of

temperature on the propagation rate of it by referring to thermodynamic, kinetic, transport, and diffusion aspects.

Question 6 Amorphous materials

a) In order to produce a glass what should be considered and then done from the very beginning of the process towards the end? Why is viscosity such an important factor from the viewpoint of crystallisation and bubble removal? Explain.

b) Differentiate between glass and glass ceramics. Some of our modern kitchen stove top is made of glass- ceramic materials. List at least three important characteristics required of a material to be used for this application. On the basis of this comparison, select the material most suitable for the stove top.

Question 7 Phase Diagrams and production relationship

Equilibrium phase formation is not common in a sintering system because of two main reasons. First of all, sintering is not an equilibrium process since heating profiles are usually determined by considering only densification. Secondly, homogeneous mixtures of system components, which would yield the equilibrium phase, cannot be obtained in a real green compact. Despite these facts, sintering process requires a deep understanding of phase diagrams for a given system.

Please discuss how phase diagrams can be used to understand densification and microstructural development during sintering. Constrain your research with solute drag and pinning mechanisms for microstructural development and liquid phase sintering for densification.

Question 8 Characterization

What are the interactions and resulting mechanisms between

(i) light and solid,

(ii) electron and solid,

(iii) ion and solid,

(iv) laser and solid and

(v) x-ray and solid

and how do we use these interactions in Materials Science and Engineering?

Question 9 Production of polymeric materials

Discuss the interrelationship between the four components (performance, properties, processing and structure) of the discipline of the materials science and engineering with respect to polymer matrix composite materials in **automobile industry**.

Question 10 Production of metallic materials

Discuss the interrelationship between the four components (performance, properties, processing and structure) of the discipline of the materials science and engineering **with respect to rails** used **for high-speed train transportation**.

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Question 11 **Sustainability**

How can you, as a citizen and as a materials scientist, reduce your carbon and water footprint?

What is expected from you given below?

i. The question must be addressed with a powerpoint presentation.
ii. You must address all the important words (at least 10) for “Sustainability”
iii. You must calculate personal carbon foot print (CFP) and water foot print (WFP) by using calculation programmes and explain how you can reduce it as a person and recalculate with your ideas how much you reduced your footprints. Please give a reference for the calculation programme
iv. Please choose a metal, ceramic, polymer or a composite production factory and find a report of that factory CFP and WFP and compare with the previous report and evaluate how they reduced the CFP and WFP
v. Please PUT FORWARD your IDEA about how to reduce it as a material scientist.