

ORDRE DES INGÉNIEURS DU QUÉBEC

NOVEMBER 2016 SESSION

Open-book examination
Calculators: only authorized models
Duration: 3 hours

14-MT-A4 Structure of Materials

- *Note : the exam contains 75 points, and will be converted to 100 points.*
- *Please, answer all questions.*

Question 1. (5 points) - In a low carbon steel, yield strength can be varied through the grain size by controlling the hot rolling process. For two rolling schedules, the following grain size / yield strength results were obtained: (7 μ m, 640 MPa) and (10 μ m, 550 MPa). What grain size would be required to generate a yield strength of 1000MPa?

Question 2. (5 points) - Aluminum and silicon are side by side in the periodic table. Which one would you expect to have the higher modulus of elasticity? Explain.

Question 3. (5 points) - Suppose an element has a valence of 2 and an atomic number of 27. Based only on the quantum numbers, how many electrons must be present in the 3d energy level?

Question 4. (5 points) - A single crystal of a BCC metal is oriented so that the [001] direction is parallel to the applied stress. If the critical resolved shear stress required for slip is 83 MPa, calculate the magnitude of the applied stress required to cause slip to begin in the [1-11] direction on the (110), (011) and (10-1) slip planes.

Question 5. (5 points) - The number of vacancies in a material is related to temperature by an arrhenius equation. If the fraction of lattice points containing vacancies is 8×10^{-5} @ 600C, determine the fraction at 1000C.

Question 6. (5 points) - A force of 20 000N will cause a 1cm² bar of Mg to stretch from 10 to 10.045 cm. Calculate the modulus of elasticity of this bar.

Question 7. (5 points) - A steel part can be made by powder metallurgy or by machining from a solid steel block. Which part is expected to have the higher toughness? Explain.

Question 8. (5 points) - Amorphous polymers are more permeable to CO₂ than their crystalline counterparts. Explain why.

Question 9. (5 points) - You are tasked to separate polymers, aluminum and steel residues during a recycling operation. Describe the possible methods/avenues that can be employed to separate the material mixture.

Question 10. (5 points) - Using the data provided in the following Table, determine the solidification time to be imposed to obtain a material possessing a secondary dendrite arm spacing (SDAS) of 30 microns.

Solidification time (s)	SDAS (cm)	Solidification time (s)	SDAS (cm)
156	0.0176	606	0.0282
282	0.0216	1356	0.0374

Question 11. (5 points) - What is the angle between the direction [110] and [101] in a cubic unit cell?

Question 12. (10 points) - Based in Hume-Rothery's conditions, which of the following systems would be expected to display unlimited solid solubility?

A) Au-Ag B) Al-Cu C) Al-Au D) Mo-Ta E) Nb-W

	Al	Au	Cu	Mo	Nb	Ta	W
Structure	FCC	FCC	FCC	BCC	BCC	BCC	BCC
Atomic radius	1.432	1.442	1.278	1.363	1.426	1.43	1.371
Valence	+3	+1	+1	+4	+4	+5	+4

Question 13. (5 points) - Would you expect a 6061-T9 aluminum alloy to be stronger or weaker than a 6061-T6 alloy?

Question 14. (5 points) - Demonstrate that the atomic packing factor of the body centered cubic unit cell is 0.68.