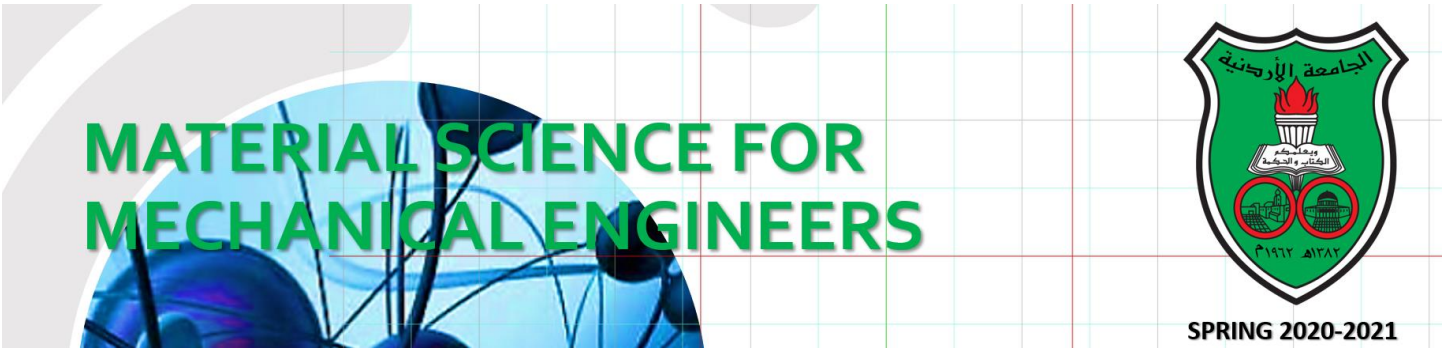

Midterm Exam

Time: ONE Hour

Date: April 11th, 2021

Instructions:

- Solve ALL six problems.
- Try to TYPE your answers when possible, otherwise use your clear and neat handwriting.
- Solve each problem on a *separate sheet*.
- Upload your answers as a PDF file, use the cover page and the correct file name: IDnumber_Midterm.pdf
- Maximum grade 25/25.
- Submit using the assignment section on MS Teams and make sure to turn in your work. Submissions sent by e-mail or the chat will be ignored.
- No late submission will be accepted.

Problem 1 (*3* Points)

Why should mechanical engineers be knowledgeable about composition, properties, and processing of materials? (a brief and straight forward reply, 100 to 300 words ONLY)

Problem 2 (*2* Points)

The electron configuration of a certain atom is given as: $[Ar]4s^2 3d^2$. What is that atom? Draw the energy level diagram for it showing the various shells and subshells using the wave-mechanical model. (Apply Pauli exclusion principle on the diagram)

Problem 3 (*6* Points)

What are the specific characteristics of primary interatomic bonds?

Problem 4 (*4* Points)

Sterling silver contains 92.5 wt% silver and 7.5 wt% copper. Copper is added to silver to make it stronger and more durable. What is the percent ionic character (%IC) of the bond between those two elements? Explain your answer.

Problem 5 (*4* Points)

Why are the activation energies for self-diffusion of nonmetals Si and C significantly higher than those of metals? Give a detailed explanation for your answer based on lecture notes covered in class.

Metal	Melting Point (°C)	Temperature Range Studied (°C)	Activation Energy kcal/mol
Zinc	419	240–418	21.9
Aluminum	660	400–610	39.5
Copper	1083	700–990	46.9
Nickel	1452	900–1200	70.1
α iron	1530	808–884	57.5
Molybdenum	2600	2155–2540	110
Silicon	1414	927–1377	115
Carbon	Diamond	1800–2100	156

Problem 6 (*6* Points)

Case-hardening is the process of hardening the surface of a metal object while allowing the metal deeper underneath to remain soft, thus forming a thin layer of harder metal at the surface. For iron or steel with low carbon content, which has poor to no hardenability of its own, the case-hardening process involves infusing additional carbon or nitrogen into the surface layer. This process can produce a component that will not fracture (because of the soft core that can absorb stresses without cracking), but also provides adequate wear resistance on the hardened surface. Consider a gear made of AISI1020 Steel, that needs case hardening at 927°C. Calculate the time in hours necessary to increase the carbon content to 0.40% at 0.50 mm below the surface. Assume that the carbon content at the surface is 0.93% and that the steel has a nominal carbon content of 0.18%. If the gear is kept at the same temperature for 7.23 hours, what will the carbon content be at 0.7 mm below the surface? The diffusion coefficient for AISI1020 Steel at this temperature can be taken as 1.42×10^{-11} m^2/s.