

Name _____

1. Refer to the Fe-C phase diagram.
 - (a) Why is the solubility of carbon in iron higher at 1130°C than at 723°C?
 - (b) What are the solubility limits of carbon in iron at these two temperatures?

2. Wood has two bubbles on the stiffness versus density diagram from the text – how is this different or similar to the “uni-ply” and “laminates” bubbles for Carbon Fiber Reinforced Plastics (CFRP), Kevlar Fiber Reinforced Plastics (KFRP), Glass Fiber Reinforced Plastics (GFRP)? Note that each of these designations shows up two times in the engineering composites bubble.

3. The shear modulus (G) of aluminum is about 27 GPa. If a T4 hardening is performed followed by an H16 temper in a 6061 alloy, estimate the shear modulus of the material.

4. Discuss the process that aluminum undergoes to create a precipitate in hardening (such as the T6 alloy). Suggest at least two reasons an engineer who is not a material specialist should know about precipitation hardened alloys.

5. Define fracture toughness. Why should fracture toughness be considered when designing a travel mug?

6. Discuss the types of criteria that should be considered when selecting a material for use in a chisel. What issues other than cost are primary in the material selection?

7. A 7178-T6 aluminum alloy has a higher _____ than the 7178 alloy in the wrought condition. a) ductility b) yield c) modulus d) none of the above

8. On the Fe-C phase diagram γ is a FCC crystal that is stable at high temperatures. When γ is quenched (cooled quickly) a different structure is obtained at room temperature that is called Martensite. Is this structure shown on the attached Fe-C phase diagram? Indicate the Greek letter that represents Martensite or explain why it is not on the phase diagram.

Name _____

9. At 800°C an alloy of 0.45% C in Fe is at equilibrium. The α phase has(choose one)
- 0.0123% C in Fe
 - 0.53% C in Fe
 - 0.45% C in Fe
10. At 800°C an alloy of 0.45% C in Fe is at equilibrium. For a 100 gram sample the α phase is (choose one)
- 84.5 grams
 - 15.5 grams
 - 53.0 grams
 - 45.0 grams
11. An airplane propeller must sustain constant loading as it rotates. However, fracture toughness cannot be neglected because of the possibility of impact with a bird or other object while in flight. If the propeller is assumed to act like a brittle plate -- $\frac{K_{IC}^{1/2}}{r} = C$
- Select several possible candidate materials for building an airplane propeller from the given chart for light fracture resistant materials.
12. Aluminum as a pure material has very high formability. Explain why this is different for some of the precipitation hardened alloys? What changes in the material?
13. On the Fe-C phase diagram γ is a FCC crystal that is stable at high temperatures. When γ is quenched (cooled quickly) a different structure is obtained at room temperature that is called Martensite. Is this structure shown on the attached Fe-C phase diagram? Indicate the Greek letter that represents Martensite or explain why it is not on the phase diagram.
14. At 1450°F an alloy of 0.20% C in Fe is at equilibrium. The α phase has(choose one)
- 0.02% C in Fe
 - 0.52% C in Fe
 - 0.20% C in Fe

Name _____

15. At 1450°F an alloy of 0.45% C in Fe is at equilibrium. For a 100 gram sample the α phase is (choose one)
- 64.0 grams
 - 36.0 grams
 - 53.0 grams
 - 47.0 grams
16. In the Al-Si phase diagram describe the composition of the material when 10% by wt of silicon is added to Al and it is at equilibrium at 300 °C.
17. From the Al-Si phase diagram find the Greek letter that represents the precipitate that forms in a precipitation hardened alloy. Write that Greek letter here
- β _____
18. At 577°C an alloy of 0.10% Si in Al is at equilibrium. The α phase has _____% Si.
19. At 577°C an alloy of 0.10% Si in Al is at equilibrium. For a 100 gram sample the α phase is _____ grams.
20. As wood becomes scarcer and old growth wood becomes unavailable, the modulus of wood used in many applications decreases. Suggest a modification of the standard wood floor joist using composite materials to stiffen the beam.
21. It is possible to make a canoe paddle handle out of either aluminum or wood. If strength is the design parameter, write out the type of equation that would show how you include shape into your material selection. The exponent for a bar in bending is $2/3$ in the numerator and 1 in the denominator.
22. Name three strengthening mechanisms and write a short description of each.
23. What are the three primary and 2 secondary bonds we discussed in class. Give one example of each.

Name _____

24. How is the elastic modulus of a metal related to the graph of U , the interatomic potential, and r the interatomic spacing.
25. On the Fe-C phase diagram γ is a FCC crystal that is stable at high temperatures. When γ is quenched (cooled quickly) a different structure is obtained at room temperature that is called Martensite. Is this structure shown on the phase diagram?
26. Draw a stress strain curve for a linear, perfectly elastic material and for a ductile material with significant plastic deformation. Mark the yield strength, the modulus and the ultimate strength
27. Mark on a figure the plastic strain in a stress strain curve. Also mark the yield strength, the ultimate strength and the modulus.
28. At 1400°F (the left hand scale on the phase diagram), the equilibrium constitution for a 0.6 Wt% Carbon Iron Alloy has:
An overall composition of:
Number of phases:
Composition of each phase:
Proportion of each phase:
29. At what temperature does:
a) 2.0 Wt. % Carbon Iron Alloy melt?
b) 4.3 Wt. % Carbon Iron Alloy melt?
c) 0.8 Wt. % Carbon Iron Alloy form austenite, A FCC cubic structure?
30. At 1600°F (the left had temperature scale), the equilibrium constitution for a 0.8 Wt% Carbon Iron Alloy has:
The overall composition
Number of phases
Composition of each phase
Proportion of each phase

Name _____

Low density wood

Density 0.24-0.49 Mg/m³
Price 0.788-12.61 USD/kg
Compressive strength 14.8-46.6 MPa
Elastic Limit 16.2-45.1 MPa
Endurance limit 8-24.6 MPa
Fracture Toughness 0.6-3.6 MPa m^{0.5}
Young's Modulus 3.7-14.3 GPa

Tough Steels

Density 7.8-7.9 Mg/m³
Price 0.394-0.709 USD/kg
Failure strength 335-1155 MPa
Elastic Limit 335-1155 MPa
Endurance limit 281-606 MPa
Fracture Toughness 27-92 MPa m^{0.5}
Young's Modulus 200-215 GPa

Brass

Density 7.8 – 8.8 Mg/m³
Price 1.57-2.21 USD/kg
Compressive strength 70-500 Mpa
Elastic Limit 70-500 MPa
Endurance limit 105-300 MPa
Fracture Toughness 30-86 MPa m^{0.5}
Young's Modulus 90-120 GPa

Titanium

Density 4.36-4.84 Mg/m³
Price 23.64-63.04 USD/kg
Compressive strength 130-1395 Mpa
Elastic Limit 172-1245 MPa
Endurance limit 175-705 MPa
Fracture Toughness 14-120 MPa m^{0.5}
Young's Modulus 90-137 GPa

Epoxy-Glass Fiber Composite

Density 1.5-2.0 Mg/m³
Price 2.05-111.03 USD/kg
Compressive strength 240-880 MPa
Elastic Limit 150-1100 MPa
Endurance limit 128-765 MPa
Fracture Toughness 6-40 MPa m^{0.5}
Young's Modulus 15-45 GPa