

Ph.D. Qualifying Examination

Materials Science

Summer 2022

Notes:

- There are a total of 4 problems.
- Time allowed: 2.5 hours.
- Exam is closed book and closed-notes.
- Problems count 25 points each (total=100 points).
- Show your work on these exam sheets. (Add additional sheets, if needed.)
- You may use a calculator.
- Laptops and cell phones are not allowed.

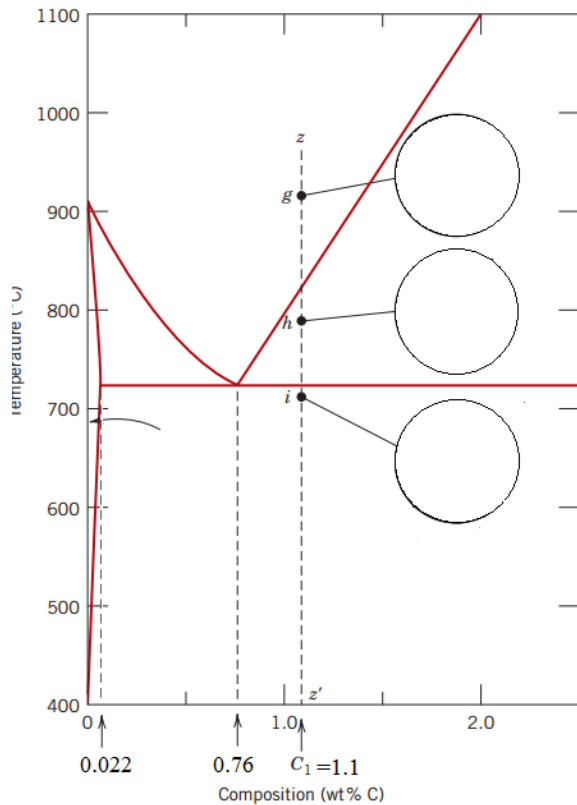
1. Show that the atomic packing factor for the BCC crystal structure is 0.68.

2. Define the typical characteristics of metal, ceramic and polymer materials. If someone gives you a material cube without mentioning the materials type, how would you identify if that block is metal, polymer or ceramic?

(Hint: what materials characterization techniques or tools will be used to identify the materials type of the cube. Justify your choice of characterization techniques)

3. The following represents the phase diagram for an iron-cementite alloy of hypereutectoid composition.

- On the schematic, write down the name of the present phases in the 5 regions and draw the microstructure for each of the three g, h, and i points.
- For point i (right below the eutectoid line), what are the weight fractions and carbon content in the pro-eutectoid and eutectoid phases; carbon concentration in cementite is 6.7 %.



4. A powder metallurgy (PM) manufactured Ti-6Al-4V alloy was subjected to a tensile test. The output from the test (displacement vs. force data) is given in the table below. The gauge was circular in shape with 6.42112 mm in gauge diameter and 20.54562 mm in gauge length. Find the following for PM Ti-6Al-4V alloy from the tensile data. **(Points: 25)**

- (i) Engineering stress-strain curve
- (ii) True stress-strain curve
- (iii) Yield strength (in MPa)
- (iv) Tensile strength (ultimate tensile strength) (in MPa)
- (v) True fracture stress (in MPa)

Force (kN)	Displacement (mm)
0.23	20.62
6.09	20.93
14.68	21.26
24.42	21.62
25.67	21.69
26.63	21.77
27.70	21.97
28.45	22.33
28.86	22.68
29.05	22.96
29.19	23.39
29.26	23.66
29.34	24.00
29.24	24.34
29.13	24.72
29.03	25.05
28.61	25.38
28.08	25.71
26.81	25.98