

Ph.D. Qualifying Examination

Materials Science

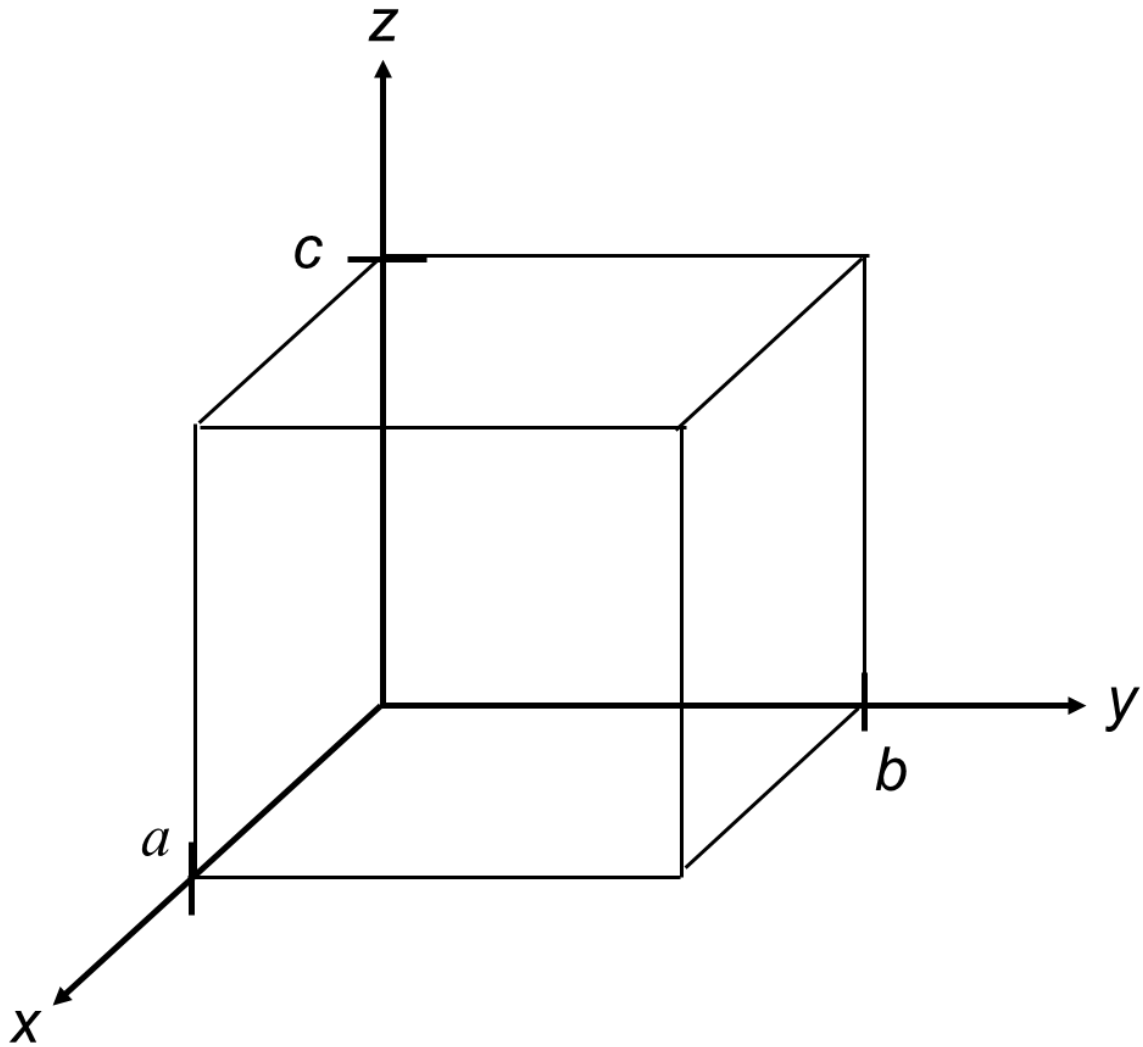
Summer 2024

Notes:

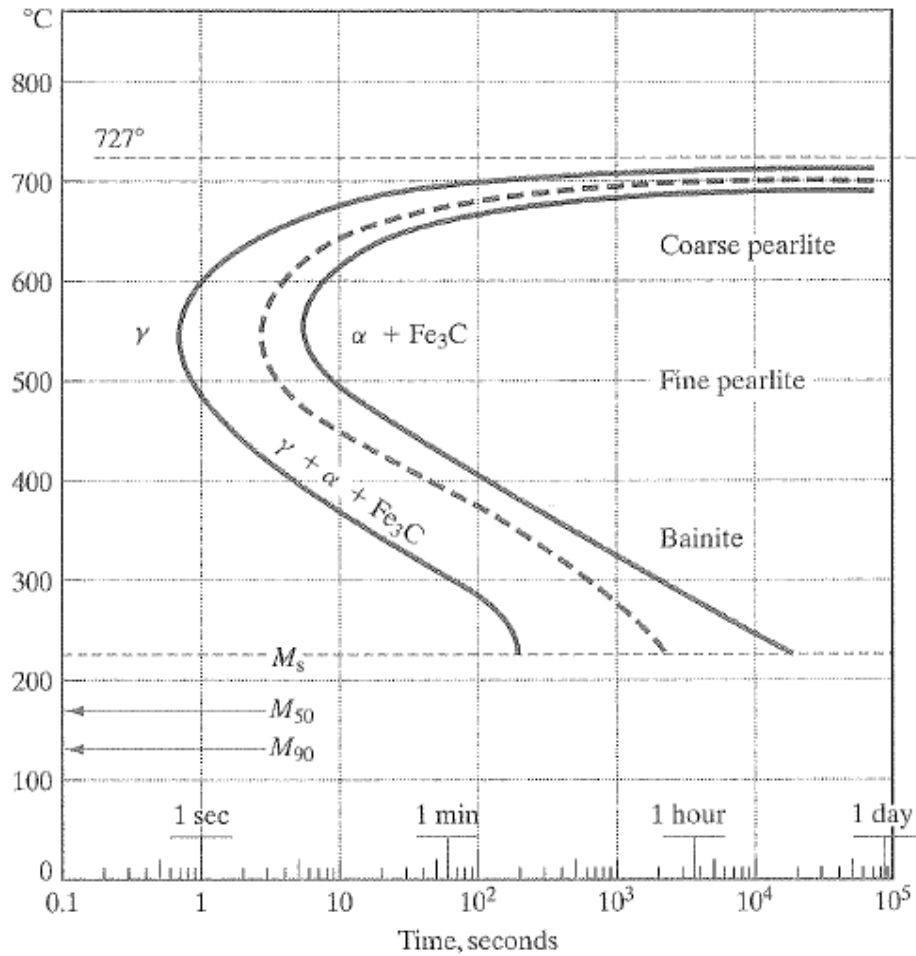
- There are a total of 4 problems.
- Time allowed: 2.5 hours.
- Exam is closed book and closed-notes (one double-sided sheet of formulas is allowed).
- Problems count 25 points each (total=100 points).
- Show your work on these exam sheets. (Add additional sheets, if needed.)
- You may use a calculator.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

1. Explain the stress-strain behavior of a ductile material. How will it be different than the brittle material's stress-strain curve? Briefly explain why the stress increases, goes through a maximum and is reduced with strain in the ductile materials.

2. Sketch (001) , $(\bar{1}\bar{1}\bar{1})$ and $(10\bar{2})$ planes within the following cubic unit cell.



3. Consider the following TTT diagram for the eutectoid steel.



Three different eutectoid steel samples are given the following heat treatments:

(a) instantaneously quenched to 600°C, held for 2 minutes, then cooled to room temperature;

(b) instantaneously quenched to 400°C, held for 2 minutes, then cooled to room temperature;

(c) instantaneously quenched to 100°C, held for 2 minutes, then cooled to room temperature.

List these heat treatments in order of decreasing hardness of the final product. Briefly explain your answer.

4. (a) What is "recrystallization temperature"? (b) In general, do you expect a higher or lower recrystallization temperature when impurities are added into a metal? Why?