MSE 214 (Metals)
Exercise 9 — Phase Diagrams II
3rd December 2025

Question 1.

The kinetics of the austenite to pearlite transformation obey the Avrami relationship. Using the table given below, determine the total time required for 95% of the austenite to transform to pearlite:

Fraction transformed	Time (s)
0.2	280
0.6	425

Question 2.

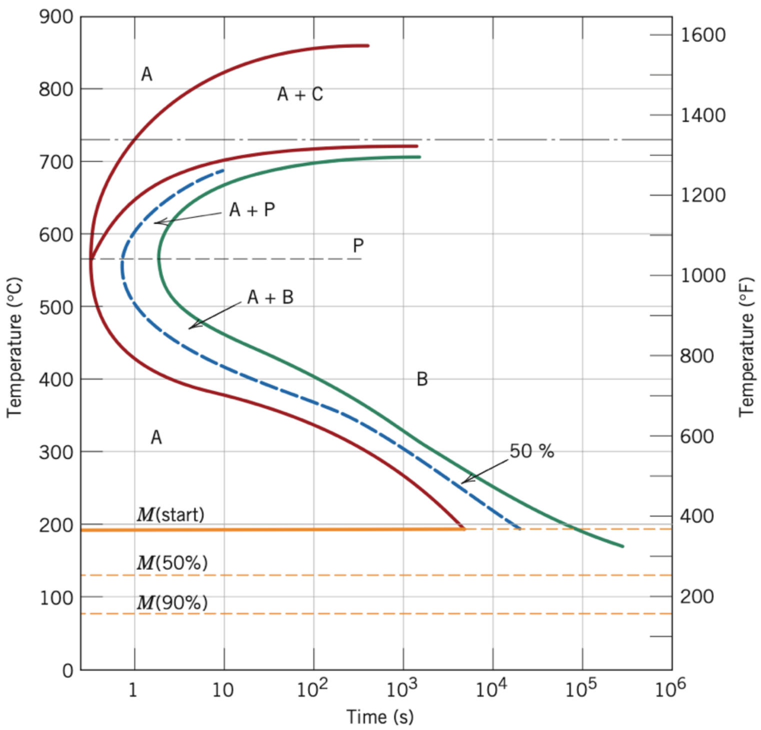
In terms of thermal processing and the development of microstructure, what are the two major limitations of phase diagrams?

Question 3.

The isothermal transformation diagram for a 1.13 wt% C steel alloy is shown below. Determine the final microstructure (in terms of just the microconstituents present) of a small specimen that has been subjected to the following time–temperature treatments.

In each case assume that the specimen begins at 920˚C and that it has been held at this temperature long enough to have achieved a complete and homogeneous austenitic structure.

Recap: Red lines are reaction starts, green lines are reaction ends.
Recap 2: Only A can transform into the other solid phases (P, B, and M)

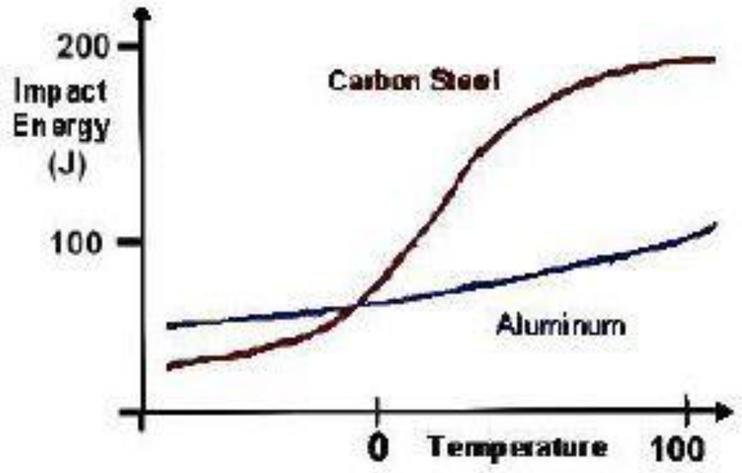


a) Rapidly cool to 775˚C, hold for 500s, then quench to room temperature

b) Rapidly cool to 625˚C, hold for 1s, then quench to room temperature

Question 4.

Impact tests were carried out for aluminum and carbon steel over a variety of temperatures (in ˚C). The results are shown below. For the purposes of this question, you can think of the impact energy here as the area under the stress-strain curve. It represents the energy absorbed by the metal before failing.



a) Based on these data, determine the crystal structures of the two materials. Explain your rationale.

b) Suggest which metal would be best as a shock absorber operating at 200˚C. Explain your rationale.

c) Suggest which metal would be best as a “break-before-bend” bar at 50˚C. Explain your rationale.

Question 5.

Give two reasons why martensite is so hard and brittle.

Question 6.

Welding is a process that involves joining two sections of a given metal by heating both sections to their melting point.

Improper welding of two steel plates often result in a higher brittle interface.

a) Why do you think this happens? Hint: What is the thermal conductivity of metals?

b) Suggest two ways we can modify the welding procedure to obtain steel plates without the brittle interface.