Chalmers
Industrial and Materials Science

Kursnr.: MMK073

Exam in Materialteknik-Z, October 30th, 2019

Examiner: Uta Klement (772 1264)
After the exam, the answers will be posted on the course webpage (Canvas).
The results of the exam will be available electronically.

Checking (*granskning*) of the corrected exams on Wednesday, November 27th and on Thursday, November 28th between 12:00 and 13:00 at the Department of Industrial and Materials Science (Rännvägen 2A, second floor; contact Uta Klement). Written requests for revision of the correction must be handed in no later than December 15th, 2019.

Questions:
First, please read all questions! Don't write long answers but always motivate them.
Please, give back all the pages, even this front page!

1. Atomic structure, bonding, and Miller indices	6 P
2. Mechanical properties	7 P
3. Phase diagrams	7 P
4. Phase transformations	6 P
5. Defects and diffusion	7 P
6. Electrical and thermal properties	6 P
7. Environment	5 P
8. Joining	4 P
9. Helicopter lab	2 P
Σ :	**50 P**

Ranking:
3 ≥ 40 % (20 P)
4 ≥ 60 % (30 P)
5 ≥ 75 % (38 P)

Notice: During the exam a **calculator** (*typgodkänd räknare*) and an **English-Swedish dictionary (or the wordlist)** is allowed. The periodic system and 1 page with equations and formulas are included in the exam handout **- nothing else is needed!**

Gothenburg, October 28th, 2019

Good luck !! **Uta**

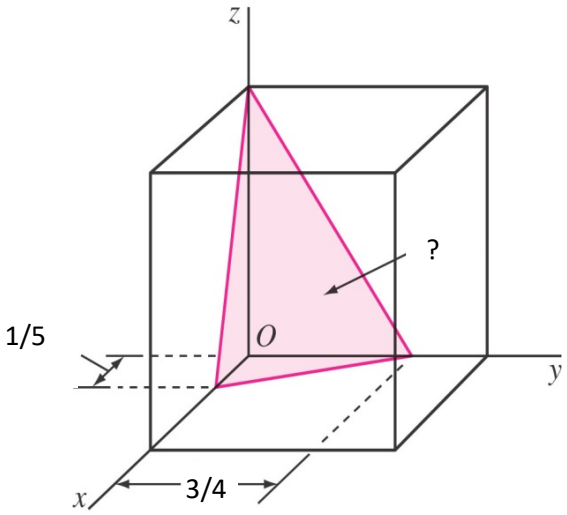
1. Interatomic bonding and Miller indices (6 P)

a) Describe briefly the type of bonding for ceramics, and semiconductors. (2 P)

b) Dealing with Miller indices, give the correct brackets for

(i) a specific crystallographic plane
(ii) a specific crystallographic direction
(iii) a family of planes
(iv) a family of directions (1 P)

c) Give the Miller indices of the plane sketched below: (1 P)



d) Make a sketch of the potential energy-versus-interatomic separation curve for a strongly **and** a weakly bonded material. (2 P)

2. Mechanical properties (7 P)

a) Name and explain the 4 strengthening mechanisms for metals! (2 P)

b) You are supposed to deform both, Copper (Cu) and Magnesium oxide (MgO). How are dislocations moving in these materials and what type of problem may you encounter (especially in MgO)? Describe in words or make a sketch for illustration. (2 P)

c) Draw a stress-strain curve of a metal and mark in the curve
- the yield strength
- where to obtain ductility
- the ultimate tensile strength
- regime where necking occurs (2 P)

d) Explain in which regime of the stress-strain curve you should deform/shape a metal! (1 P)

3. Phase diagrams (6 P)

a) Make sketches f the cooling curves of an single-component system and a binary component system! (1 P)

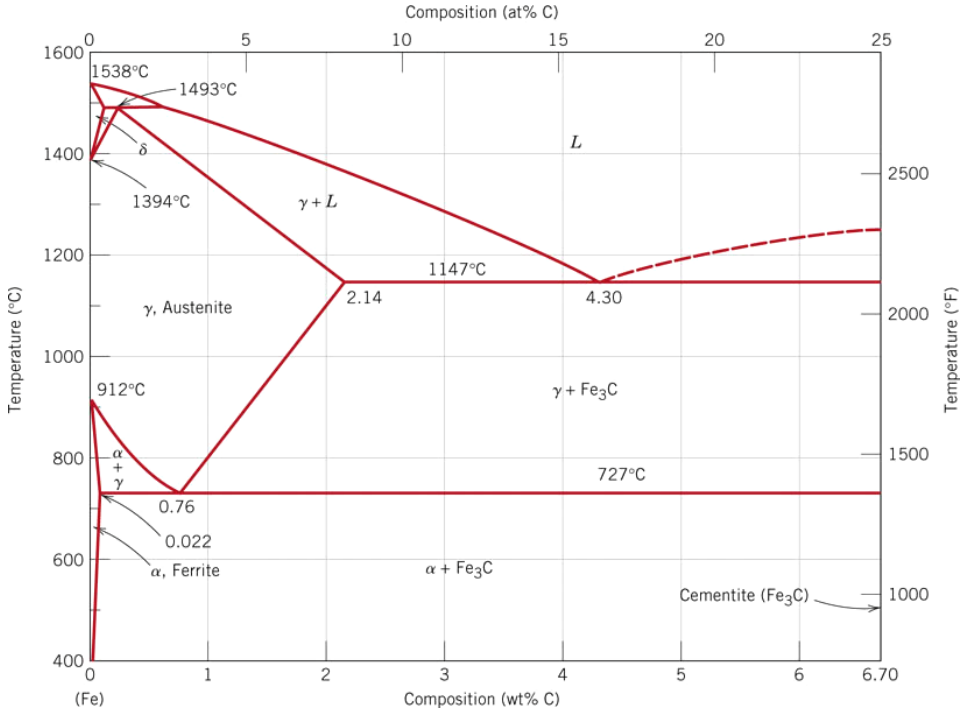
b) Describe the reactions that occur (equation with arrow) for
- Eutectic reaction
- Peritectic reaction
- Eutectoid reaction
- Congruent reaction (1P)

Below, the Fe-C phase diagram is given.

c) For Fe-4.3wt.% C provide sketches of the microstructure at 1100°C **and** 720°C. (1 P)

d) For Fe-0.5 wt.% C at 728°C determine
(i) the phases present and their composition (0.5 P)
(ii) their phase amounts (1 P)
(iii) Make also a sketch of the microstructure. (0.5 P)

e) What is the difference between a eutectic and a eutectoid reaction? Explain **and** give examples for both reactions. (1 P)



4. Phase transformations (7 P)

a) Upon transformation from austenite, coarse and fine pearlite can be formed. Explain which type of pearlite is formed when **and** why! (2 P)

b) How does the microstructure of a casting commonly look like? Make a sketch **and** describe the different parts! (2 P)

c) What is meant with "TTT" and what are the essential parts of a TTT diagram? Make a sketch! (2 P)

d) What is the difference between recovery and recrystallization? Explain briefly! (1 P)

5. Defects and diffusion (7 P)

a) Explain vacancy diffusion and interstitial diffusion! Which one is faster **and** why? (2 P)

b) How is temperature affecting interstitial and substitutional diffusion? Explain! (2 P)

c) Explain why complete solubility is not possible in an interstitial solid solution. (1 P)

d) Make sketches of (i) an interstitial, (ii) a substitute atom. (1 P)

e) What is the difference between a high angle and a low angle grain boundary? Explain! (1 P)

6. Electrical and thermal properties (6 P)

a) Make sketches of the electron energy band structure of a p-type and an n-type semiconductor (incl. defect level) and briefly explain for both cases how conductivity can be achieved. (2 P)

b) The curves below illustrate the variation of electrical conductivity with temperature of metals and of silicon. Explain the differences for the two types of materials. (2 P)

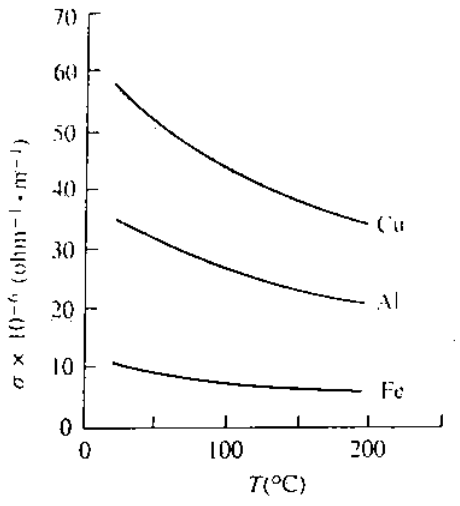


FIGURE 2 *Variation in electrical conductivity with temperature for some metals.*

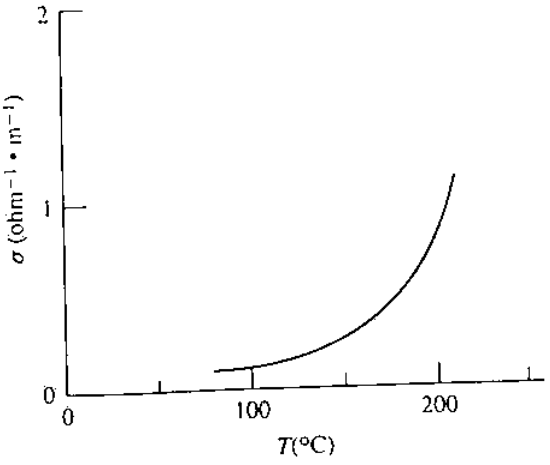
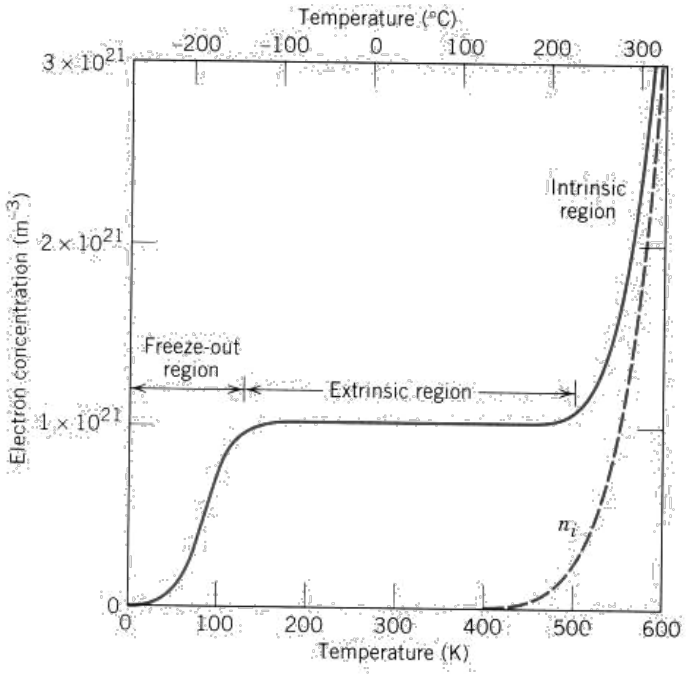


FIGURE 3 *Variation in electrical conductivity with temperature for semiconductor silicon.*

c) Briefly explain the figure below and describe what it means for the use of intrinsic/extrinsic semiconductors in our computers. (2 P)



6. Environment (5 P)

a) What is meant by the CO_2 footprint and why do we use it? (2 P)

b) What is meant with environmental stressors? (1 P)

c) Give total energy use of a truck and of a mobile phone! Motivate your answer! (2 P)

8. Joining (4 P)

a) Describe ball bonding and name the wire used. (2 P)

b) Explain electromigration (what is happening and what are the consequences)? (2 P)

9. Helicopter lab – points from report (2 P)