Chalmers *Kursnr.: MMK073*
Material och tillverkningsteknik

Exam in Materialteknik-Z, October 26th, 2017

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

Checking (*granskning*) of the corrected exams: on Thursday, November 23nd and Tuesday November 28th, between 12:00 and 13:00 at the Department of Materials and Manufacturing Technology (Rännvägen 2A, second floor; contact Uta Klement). Written requests for revision of the correction must be handed in no later than December 15th 2017.

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. Crystal structure and crystal geometry	5 P
2. Mechanical properties	6 P
3. Defects and diffusion	9 P
4. Phase diagrams	4 P
5. Phase transformations	4 P
6. Environment	5 P
7. Electrical properties	7 P
8. Thermal properties	5 P
9. Joining and possible failures	5 P
Extra: Device report:	2 P
Σ :	**52 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, November 24th, 2017

Good luck !! **Uta**

1. Crystal structure and crystal geometry (5 P)

a) Sketch the fcc **and** bcc unit cell **and** give the amount of atoms in each unit cell. Which of the structures has the higher density? (1 P)

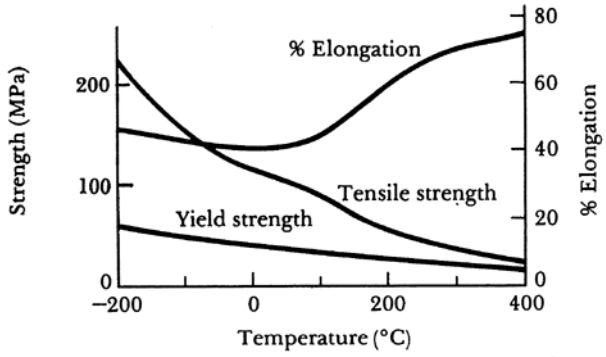
b) Make a sketch of the cubic crystal plane with Miller indices ($\bar{6}\bar{2}6$). (1 P)

c) Draw the following directions in a cubic unit cell: [$00\bar{1}$], [113], [$\bar{1}12$], [$\bar{5}2\bar{1}$]. (2 P)

d) Write down the Miller indices of all cubic face planes. (1 P)

2. Mechanical properties (6 P)

a) Below, you find a figure where strength and elongation of an Al alloy (melting temp. about 500ºC) is shown over temperature. Describe what is happening in the material? What is meant with %elongation **and** what is the yield strength? (3 P)



b) There are different methods to strengthen a metal. Name them! (2 P)

c) How can you strengthen a polymeric material? Name two possibilities! (1 P)

3. Defects and diffusion (9 P)

a) Make a sketch of an edge dislocation **and** explain/sketch how it is gliding! (1 P)

b) What is required/what are prerequisites for diffusion to happen? (1 P)

c) The diffusion coefficients for self-diffusion and carbon diffusion in α-iron at 500ºC are $3.0\ 10^{-21}$ m^2/sec and $2.4\ 10^{-12}$ m^2/sec, respectively. Explain the huge difference! (1 P)

d) What is happening during carburization **and** why is it used? Explain briefly! (2 P)

e) In order for two components to have complete solid solubility in each other, they usually have to follow certain conditions. Name them! (2 P)

f) Which hardening mechanisms (name all possible) can be achieved in an alloy with two elements that are totally soluble in each other? (2 P)

4. Phase diagram (4 P)

a) Draw cooling curves of a single component **and** a binary system! (2 P)

b) A Sn-Pb alloy of composition 30 wt.% Sn – 70 wt.% Pb is slowly heated from a temperature of 150ºC.

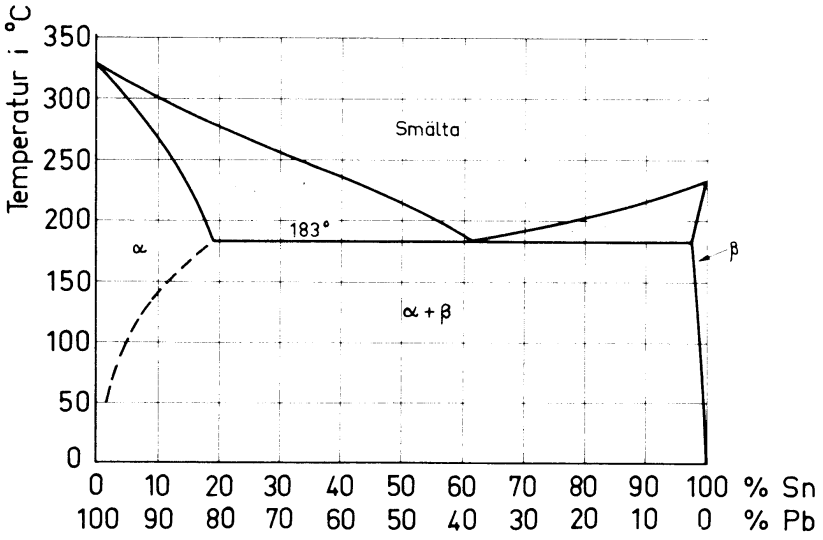
(i) How does the microstructure look like (at 150ºC)? Make a sketch! (1 P)

(ii) At what temperature does the first liquid form? (0.25 P)

(iii) What is the composition of this liquid phase? (0.25 P)

(iv) At what temperature does complete melting of the alloy occur? (0.25 P)

(v) What is the composition of the last solid remaining prior to complete melting? (0.25 P)



5. Phase transformations (4 P)

a) What is a martensitic transformation? Explain! Where to find martensite in the Fe-C phase diagram? (1 P)

b) Explain the difference between homogeneous and heterogeneous nucleation **and** state which one is more advantageous **and** why! (2 P)

c) You have a lamellar structure, for example pearlite. How can you determine if the microstructure was achieved at higher or at lower temperature? (1 P)

6. Environment (5 P)

a) Give estimates of the *used energy over life time* of a civil airplane **and** a vacuum cleaner. Motivate your answer! (2 P)

b) With respect to recyclability compare metals and polymers. Recyclability of which of the materials is more economic **and** why? For comparison, how would you rank fiber-reinforced polymers? Motivate! (3 P)

7. Electrical properties (7 P)

a) Explain – in words **and** with a sketch – the difference in electrical conductivity (or electron concentration) upon temperature of an intrinsic semiconductor **and** an extrinsic semiconductor. (2 P)

b) Sketch the electron energy band structure of a p-type semiconductor **and** explain how conductivity can be achieved. (1 P)

c) What are the major charge carriers in (i) an intrinsic semiconductor, (ii) an n-type semiconductor, (iii) a p-type semiconductor, **and** a (iv) metal? (1 P)

d) Ceramic are usually bad conductors or in fact insulators. Describe a case where ceramic material can be an excellent electrical conductor. What is required to achieve that? (1 P)

e) Matthiesen's rule describes what is affecting conductivity in metals? Name the effects! (2 P)

8. Thermal properties (5 P)

a) How is heat transported? Explain! (1 P)

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

c) Why don't you burn yourself at your steel sink when you are doing the dishes? Explain briefly! (1 P)

d) Why are ceramics sensitive to thermal shock? Explain (case to be chosen). (1 P)

9. Joining and possible failures (5 P)

a) Explain ball bonding **and** name the wire which has to be used! (2 P)

b) Explain what is meant with electromigration! (2 P)

c) What are direct **and** expanded contacts? Explain advantages! (1 P)