Chalmers *Kursnr.: MMK 072*
Material och tillverkningsteknik

Exam in Material och tillverkningsteknik, June 1st, 2007

Karin Björkeborn (instead of Uta Klement) (772 1319) responsible for materials part
and Antal Boldizar (772 1314) responsible with respect to polymer materials
and Gustav Holmqvist (7725026) responsible for unconventional machining
and Anders Kinnander (772 5828) responsible for metal cutting
and Per Öhl (772 5771) responsible for metal forming

The answers will be posted on Thursday, June 7th, 2007.
The results of the exam will be posted on Monday, June 18th.
Checking (*granskning*) of the corrected exams: Wednesday, June 20th, between 13:00 and 14:00 h at the department.

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. Electron configuration and chemical bonding	4 P
2. Sb-Bi phase diagram	4 P
3. Joining techniques	5 P
4. Electrical properties	5 P
5. Mechanical properties	4 P
6. Metal Cutting economy	5 P
7. Metal cutting theory	2 P
8. Metal Forming	7 P
9. Unconventional machining methods: Laser cutting	3 P
10. Glass transition and melting point of polymers	3 P
11. Processing of polymers	3 P
12. Commodity plastics	2 P
13. Engineering plastics	3 P
	Σ : 50 P

Ranking :
3 ≥ 40 % (20 P)
4 ≥ 60 % (30 P)
5 ≥ 75 % (37,5 P)

Notice: During the exam a **type-approved calculator** (*typgodkänd räknare är tillåten*) and an English-Swedish dictionary (or the wordlist) is allowed. The periodic system and 4 pages with formulas are included in the exam handout **- nothing else is needed!**

Göteborg, May 28th, 2007

Good luck !! Uta, Anders, Antal, Gustav & Per

1. Electron configuration and chemical bonding (4 P)

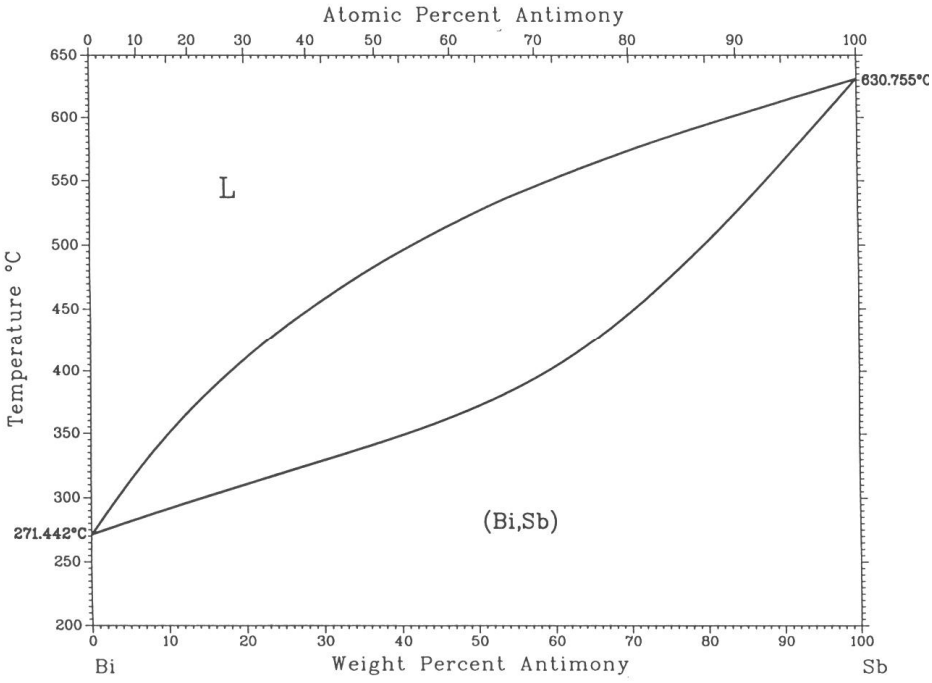
a) The atom is fully described by 4 quantum numbers. What do they describe and how are they related? (2 P)

b) Describe van der Waals bonding and covalent bonding! (2 P)

2. Bi-Sb phase diagram (4 P)

Consider a Bi - 50 wt% Sb alloy and determine the following:

(a) the liquidus and solidus temperatures of the alloy (1 P)
(b) the composition of the last liquid to solidify (0.5 P)
(c) the composition of the last solid to melt (0.5 P)
(d) the composition of the solid and liquid phases at 450ºC (1 P)
(e) the amounts of the solid and liquid phases at 450ºC. (1 P)

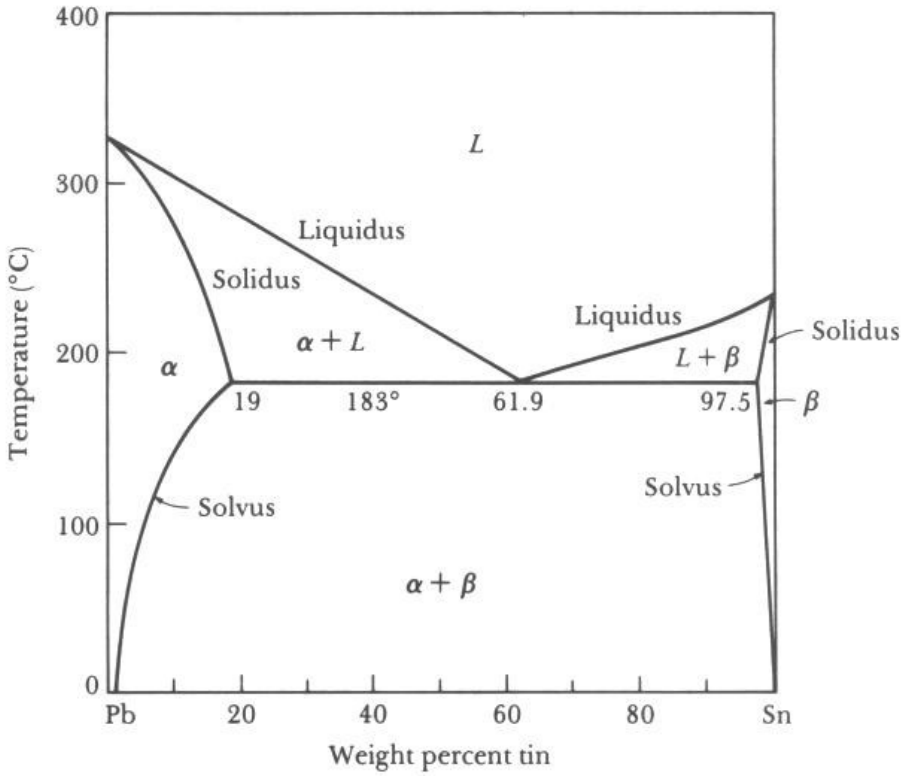


3. Joining techniques (5 P)

a) When discussing brazing and/or soldering wetting is an important issue. Describe briefly (sketch and text) the condition for (i) good wetting; (ii) bad wetting. (2 P)

b) (i) Pb-Sb is a common solder material. Which composition would be best suited as solder material? Motivate! (1 P)
(ii) Other compositions are used due to lower cost. Describe what consequences that has on the solidification. (1 P)

(iii) Makes sketches of the microstructures of the materials described in (i) and (ii)! (1 P)



4. Electrical properties (5 P)

a) Why do we need a band structure to describe solid materials and what is a band structure? (1 P)

b) Make a sketch of the electron band structure of a metal and an insulator and include the Fermi levels. (1 P)

c) What's the difference between the band structure of a semiconductor and an insulator? (0.5 P)

d) Describe briefly the difference in conductivity between metal and insulator with respect to their band structure! (0.5 P)

e) What is doping and what is an n- or p-type semiconductor? (1 P)

f) Make sketches of the band structure of an n-type and p-type semiconductor and include the defect levels. (1 P)

5. Mechanical properties (4 P)

a) Draw stress-strain curves for a materials with (i) high strength and low ductility, (ii) high strength and high ductility (iii) low strength and low ductility! What's the term being used to describe the combination of strength and ductility? (2 P)

b) How is temperature affecting strength and elongation/work hardening? Describe! (1 P)

c) There are 4 strengthening mechanisms for metals? Name them! (1 P)

6. Metal cutting economy (5 P)

Your company is going to do external turning (svarvning) of rings in cast iron. When the rings are delivered from the foundry, the diameter is 400 mm and the length 150 mm. The rings shall be turned (svarvade) in one cut (i ett snitt) to a diameter of 396 mm. The feed rate (matningshastigheten) is set to 0,3 mm/rev after a recommendation from the tool supplier. The relation between cutting speed and tool life is given in the table below.

v_c(m/min)	T_c(min)
235	48
282,5	16
330	6,0

Other information given is:

Cost/edge (Kv): 30 (sek/edge)
Machine cost: 400 (sek/h)
Time to change cutting edge: 75 s
Time to set up and take down rings: 20 s

Your task is:

a) Calculate the cutting speed (skärhastighet) for minimum cost and maximum production rate. (3 P)

b) Calculate the machining cost for the both cases in a). (2 P)

7. Metal cutting theory (2 P)

Which are the main methods for metal cutting? Characterize them also with respect to the chip formation. (2 P)

8. Metal forming (7 P)

a) The plasticity theory mainly uses four basic concepts/principles (fyra grundbegrepp).They can also been described as important and fundamental parameters that are especially and regularly used in plasticity calculations.

(i) Give the names of these four basic concepts. (2 P)

(ii) Deformation can occur in two complete different ways. How dose one use the von Mises yielding criterion (von Mises flytvillkor) when one wants to determine which of the two deformation types is present? (1 P)

b) Describe fully the neutral point (neutralpunkten vid valsning) and the conditions around it when flat rolling. (4 P)

9. Unconventional machining methods: Laser cutting (3 P)

Describe shortly the material removal process (avverkningsmekanismen) in laser cutting (laserskärning) of metals. Comment on the reason for the use of gas assistance (gastillförsel). Also comment on the properties of a laser cut surface as compared to an abrasive waterjet cut surface (vattenskuren yta) due the different material removal processes. (3 P)

10. Glass transition and melting point of polymers (3 P)

a) Describe what happens at the glass transition temperature and the melting point of a polymeric material! Guidance: Focus on what happens on a molecular level.

b) Draw a figure describing the specific volume of an amorphous polymer!

c) Give the names and make a simple sketch of the general crystal types that can be found in polymers!

11. Processing of polymers (3 P)

a) Give the names of four commonly used melt processing manufacturing techniques used for thermoplastics!

b) Describe the three basic steps, common for all melt-processing techniques! Guidance: relate to what happens with the material!

c) What are the main two difficulties, when melt processing of polymers. Guidance: Relate to two important physical properties, typical for polymers.

12. Commodity plastics (2 P)

a) Which polymers are referred to with commodity plastics? Give both names and the repeating unit in the polymer! (1 P)

b) Give four products or applications made of the commodity plastics! (1 P)

13. Engineering plastics (3 P)

a) Give names of 6 engineering plastics! (2 P)

b) What are the most important **better** properties of engineering plastics, compared to the commodity plastics? Give three examples! (1 P)