"Metallic Materials"

am 25.02.2014

Name:

Matrikelnumber:

Task	Max. Points	Reached score	Review: (added points)
1	4.5		
2	4.0		
3	7.0		
4	5.0		
5	6.0		
6	4.0		
7	2.5		
8	5.0		
9	4.5		
10	4.5		
11	3.0		
Total score	Σ50		

To pass the exam 44% of the total score has to be reached.

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Task 1 Crystallography 4.5 Points

There are three different atomic structures for metallic materials.

a) Complete the given table *(3 Points)*!

Atomic structure	atoms/ unit cell	Volume ratio [%]	Number of octahedron gaps/unit cell	Number of tetrahedron gaps/EZ	Metalls
krz					
kfz					
hex					

b) Make a sketch of each unit cell! (1,5P)

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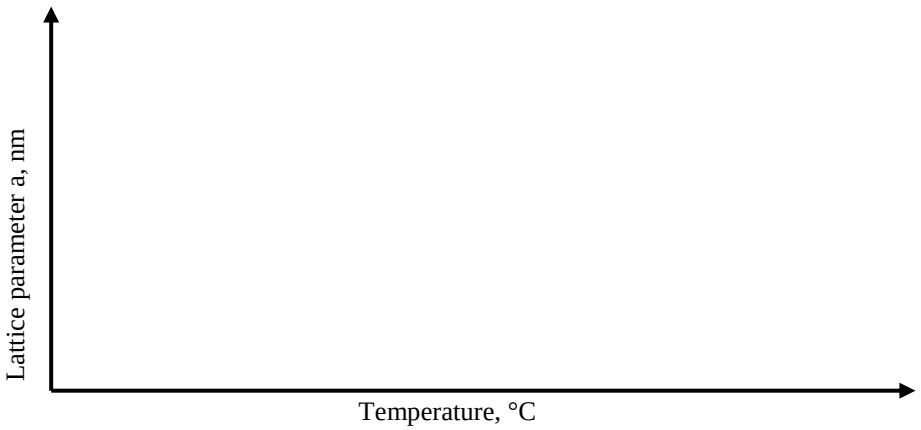
Task 2 Thermal properties 4 Points

The lattice parameter of pure iron changes in dependency of the temperature.

a) Sketch schematically the course of the lattice parameter in the temperature range from 400°C to 1500°C in **figure 1**. Label the characteristic regions and temperatures (*3.0 Points*).

Figure 1:



b) Which phenomenon is responsible for this material behavior (*1.0 Points*)?

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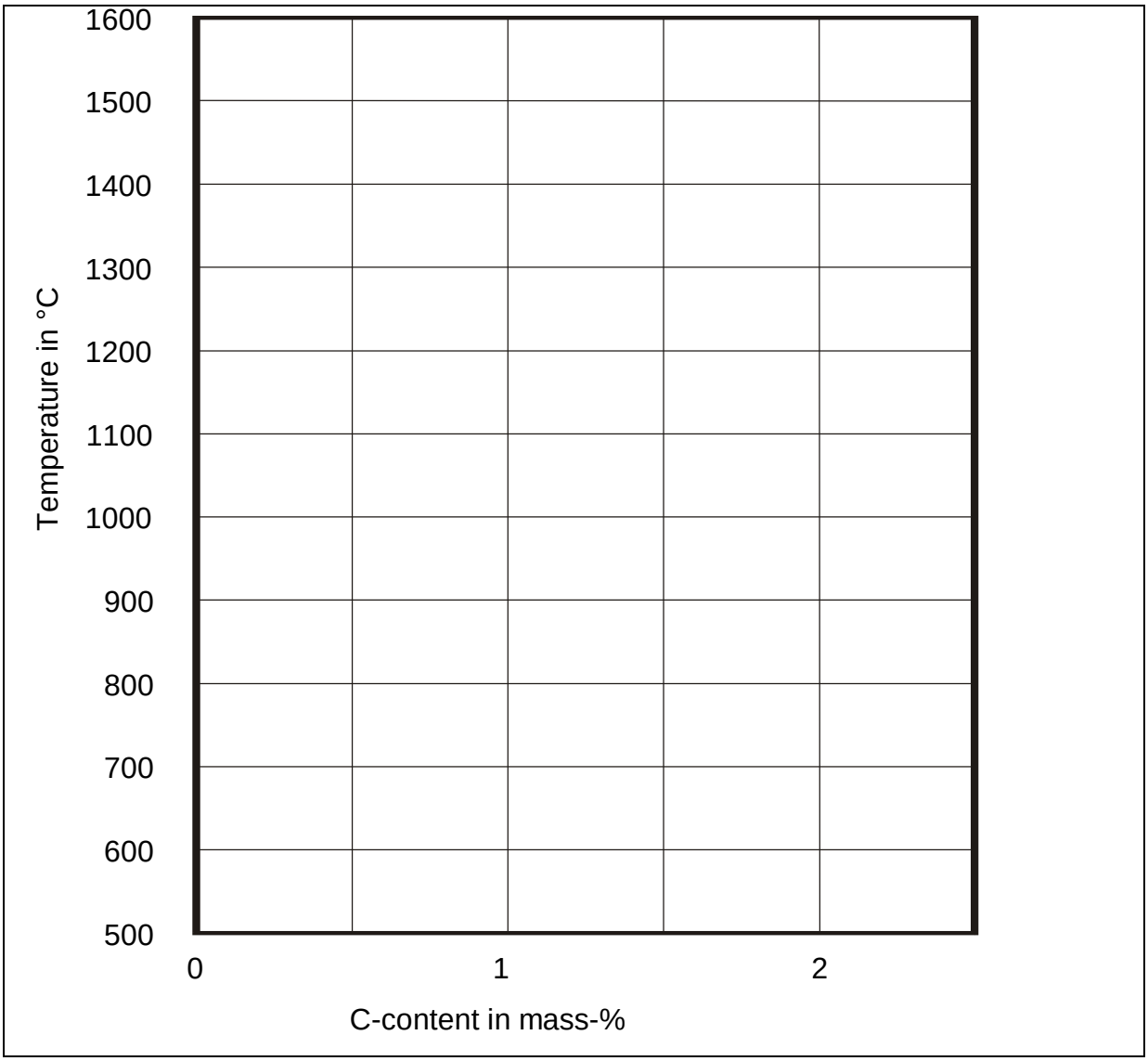
Task 3 **Iron alloys** **7 Points**

The metastable Fe-Fe_3C diagram is an important binary phase diagram in materials science. Please draw the diagram up to 2.5 mass.-% of carbon. Use **figure 1** for your drawing. Designate the phase fields with the correct names and inscribe characteristic temperatures as well as carbon contents (7 Points).

Figure 1:



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Task 4 Phase transformation I 5 Points

A non-alloyed steel with a carbon-content of 1.2 % C is heated to the following temperatures:

- above A_{ccm},
- between A_{c1} and A_{ccm} and
- just below A_{c1}

In all cases the steel is held just as long as full soaking of the material is guaranteed.

a) Which microstructures occur at the 3 given temperatures (2,5 points)?

b) How are the microstructures from a) affected when quenching in salt brine (2,5 points)?

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Task 5 Phase transformation II 6 Points

Pearlite is a lamellar microstructure consisting of ferrite and cementite.

a) Describe in key words the transformation process from austenite to pearlite. What are the characteristics of the pearlite-formation mechanism (*2.5 Points*)?

b) Explain the C-concentration during the growth of the pearlite's ferrite- and carbide-lamellae. Draw the C-distribution along the phase boundaries ferrite-austenite and carbide-austenite (*2 Points*).

c) Explain briefly why the lamellae-growth during pearlite formation does not come to a standstill (*1.5 Points*).

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Task 6 Phase transformation III 4 Points

You get the task to increase the profitability of a rail road line. This line of 500 km is designed of rails with a very coarse pearlitic steel of the grade 900. This line has a high abrasive wear, which demands a yearly exchange of the whole rail line.
In order to solve this problem you start with a benchmarking and investigate metallographic samples of rail materials of your business rivals.

a) Which material/microstructure might your business rivals be using in order to increase the wear resistance of the rails? (*1 Point*)

From an economical point of view you aim for a microstructure with a maximum wear resistance and an acceptable toughness. This microstructure should form directly from the austenite following the hot rolling.

b) Which desired microstructure should be accomplished? Which two sorts of this microstructure can occur in steel with a higher C-content? Explain -in note form- the metal physical mechanisms, which are responsible for this transformation! For that purpose take into consideration the temperature, diffusion, the role of carbon and the mechanism of transformation. (*3 Points*)

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Task 7 Technical heat Treatments I 2.5 Points

Bake-hardening steel grades are high strength steels used for car bodies.

a) Explain the advantage of Bake-Hardening steels in view of the production of car body parts (e.g.: fender or doors) (*1.0 Points*)?

b) Give the typical percentage range of the C-content in solid solution for BH-steels (*0.5 Points*)?

c) Is it possible that the absolute C-content in a BH-steel exceeds the stated value of exercise part b)? State a reason for your answer (*1 Point*).

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Task 8 Technical heat Treatment II 5 Points

In **appendix 1** a CCT-diagram of the steel grade 34Cr4 is given.

a) Draw a complete heat treatment in a temperature-time-diagram to gain a completely martensitic microstructure with minimum hardness. Which hardness can be expected for this heat treatment? (*2 Points*)

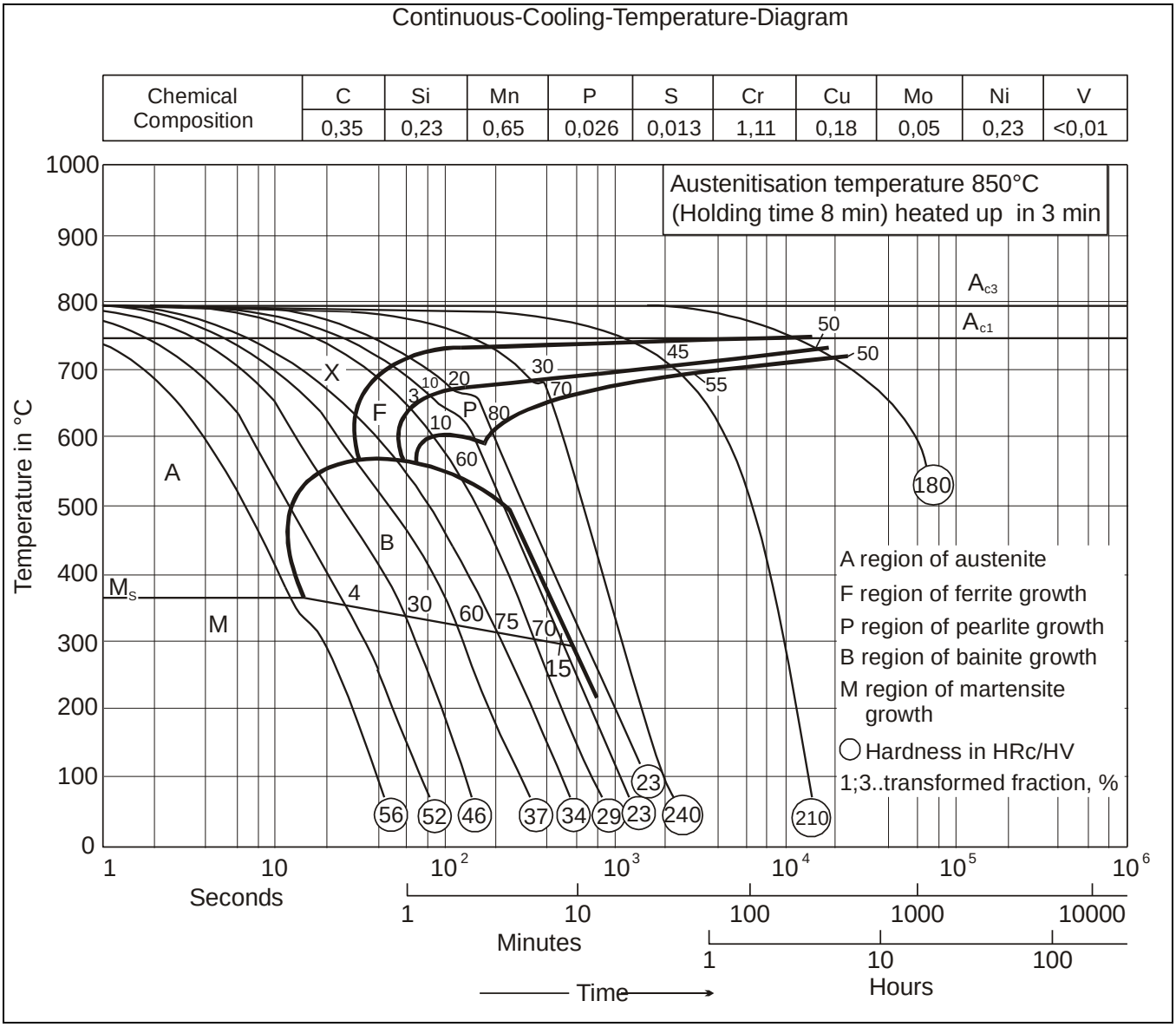
b) Especially in the pearlite region of the CCT-diagram, a delay of the cooling rate and even a rise in temperature can be found. How is this phenomenon called and which material behaviour is responsible for it (*1 Point*)?

c) Explain the difference between a continuous and an isothermal TTT-Diagram! (2 *Points*)

Appendix 1:

Continuous-Cooling-Temperature-Diagram

Chemical Composition	C	Si	Mn	P	S	Cr	Cu	Mo	Ni	V
	0,35	0,23	0,65	0,026	0,013	1,11	0,18	0,05	0,23	<0,01



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Task 9 Technical Heat Treatment III 4.5 Points

Recrystallisation annealing enables the rearrangement or improvement of the forming properties after cold rolling.

a) What is the difference between recrystallization and recovery (*2 Points)*?

b) What are the two requirements for recrystallization *(1 Point)*?

The recrystallization behavior of a material is characterized by a special diagram, which uses simple measurable parameters.

c) Which parameters are used and what boundary condition has to be considered depending the annealing time. *(1,5 Point)*

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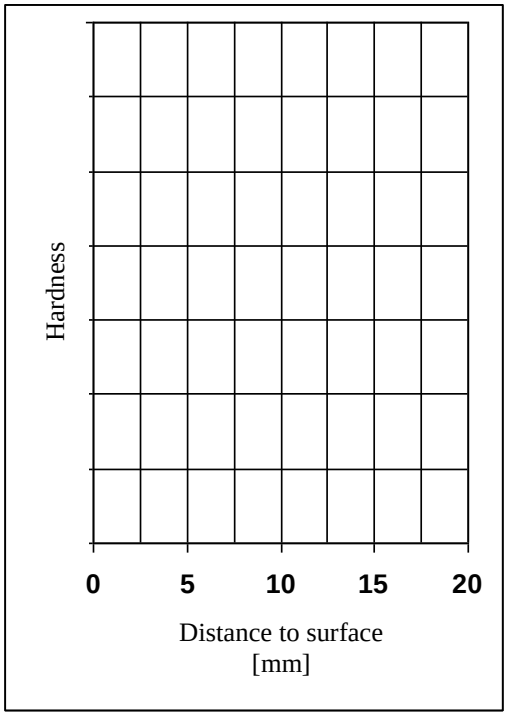
Task 10 Technical Heat Treatment IV 4.5 Points

To achieve mechanical properties a drive shaft with a diameter of 40 mm needs to be quenched and tempered. You can choose between these three kinds of steels:

- C 35
- 44Cr2
- 42CrV6

a) Sketch the Hardness in dependency to the distance of the surface for each material (quenched and tempered) in the given diagram *(3 Points).*



b) Explain the change in hardness using the words hardening capacity, hardness penetration and critical cooling rate (*1.5 Points*).

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Task 11 Phase Transformation IV 3 Points

Martensite formation is explained by a crystallographic model, which is separated into two sub-steps: the lattice-changing deformation and the lattice retaining deformation.

a) Explain the lattice- changing deformation by drawing a sketch of each single transformation step of this model. (*2 Points*)

b) Name two types of possible metal physical effects which compensate the lattice distortion (*1 Point*).

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