"Metallic Materials"

am 02.09.2013

Name:

Matrikelnummer:

Aufgabe	Maximale Punkte	Erreichte Punktzahl	Einsicht: (nur neue Teilpunkte angeben, **nicht** neue Gesamtpunktzahl pro Aufgabe)
1	4,0		
2	10		
3	5,0		
4	3,0		
5	5,0		
6	5,0		
7	8,0		
8	6,5		
9	1,5		
10	2,0		
	Σ50		

Zum Bestehen der Klausur müssen mindestens 44% der Punkte erreicht werden.

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Aufgabe 1 Crystallography 4 Punkte

A hexagonal lattice is given.

a) Calculate the lattice constants a and c in dependence of the ball radius and also the optimal c/a ratio. Give also the volume ratio of the hexagonal lattice and compare the volume ratio of the unit cell to the one of the cubic unit cells. Why is the volume ratio of the hexagonal unit cell equal to the volume ratio of one of the cubic unit cells?

b) Please assign the following element if they are interstitial or substitutional solvable.
C Cr Cu Mn N Nb O P Si Ti V

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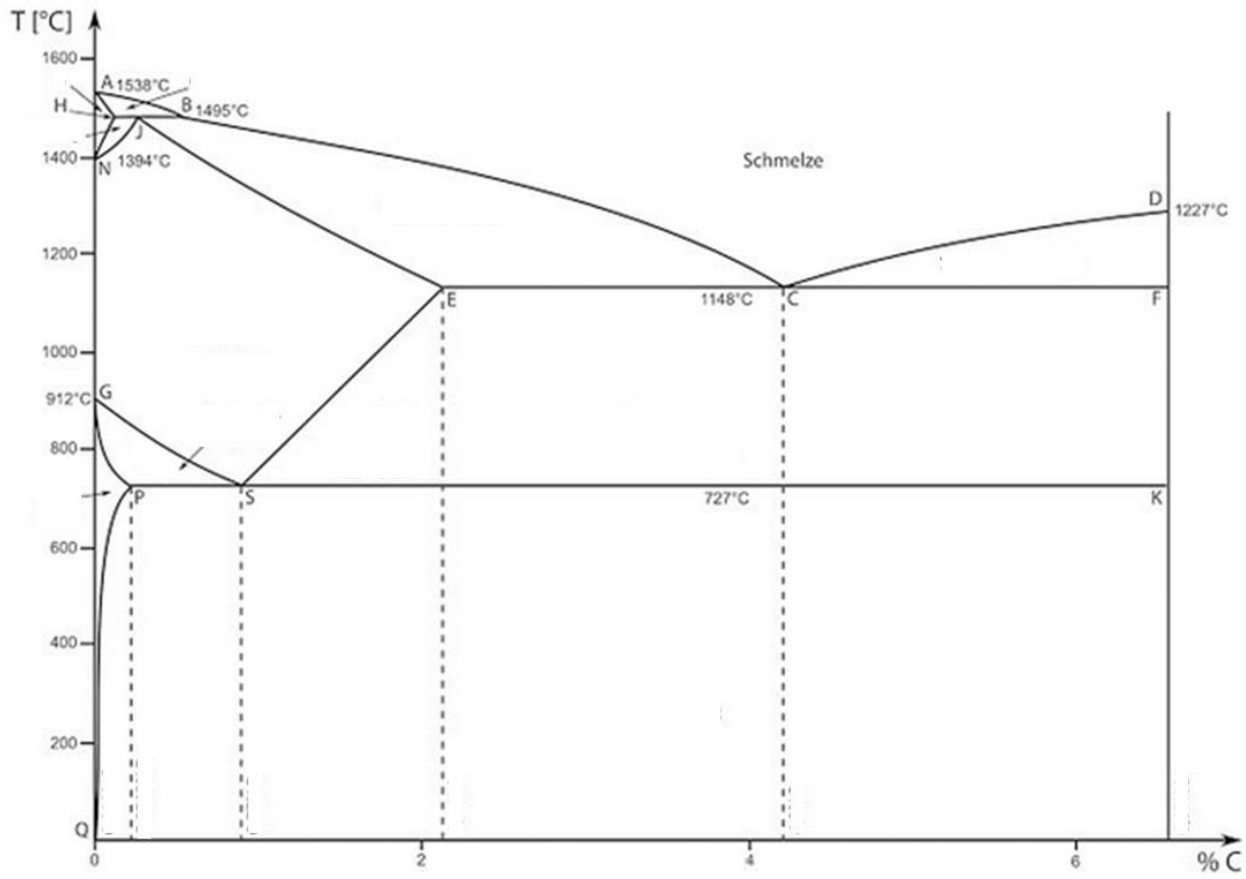
Aufgabe 2 Iron Alloys 10 Punkte

a) Name all phases in the given metastable Fe-Fe3C diagram in a temperature range between 400 and 1600°C and within a range of the carbon content between 0 and 6,67 Mass-% C **(Attachment1)**. (*5 Punkte*).



Anlage1: Metastabile system Fe-Fe_3C

b) Which three different kinds of cementite can be defined? Please write down and label in the diagram, in what area of the phase diagram the different kinds of cementite can be found. (*1.5 Punkte*).

c) Please give the name of the temperature on which the magnetic properties are changing from ferro to paramagnetism of α-iron occurs. (*0,5 Punkte*)?

d) Calculate the phase composition of steel at a temperature of 800°C and with a carbon content of 0.3%. (3P.)

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Aufgabe 3 Phase transformation 5 Punkte

Quenching has the aim to create a martensitic microstructure. The martensitic transformation is mainly influenced by the C-content of the steel and the austenitizing conditions.

a) Add in **Figure 1** the martensite start temperature Ms and the martensite finish temperature Mf! (*1,0 Points*)

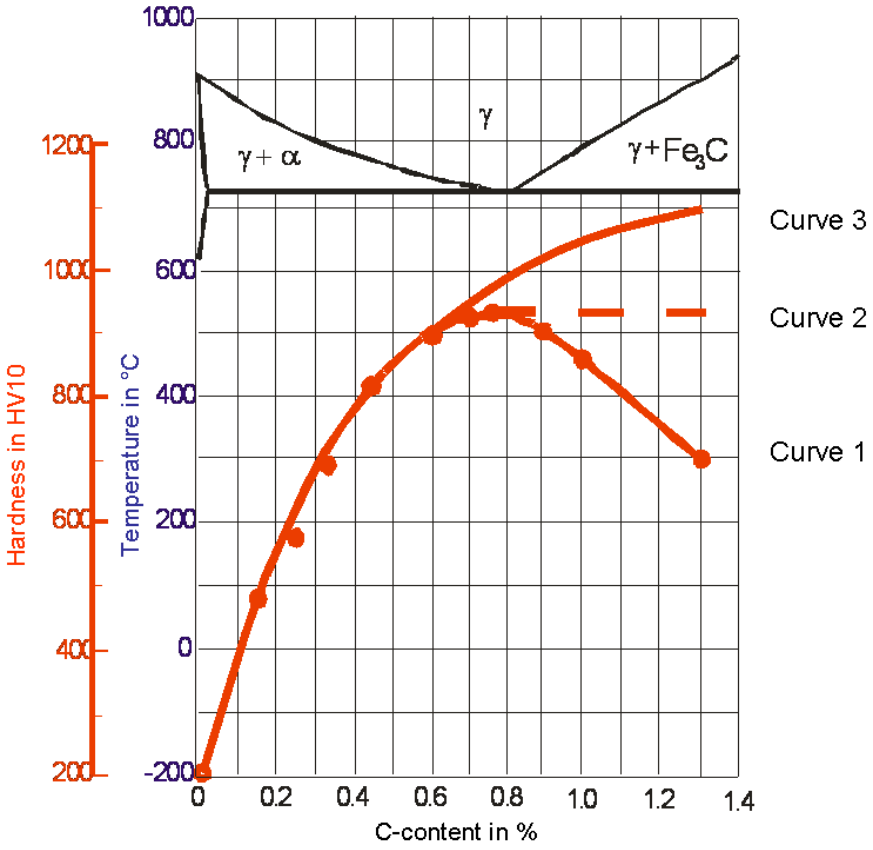

Figure 1

Beside the Ms-temperature the amount of retained austenite after quenching is strongly influenced by the C-content of the steel.

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b) Sketch in Figure 2 the amount of retained austenite after quenching to room temperature in dependence of the C-content! (*1,0 Points*)

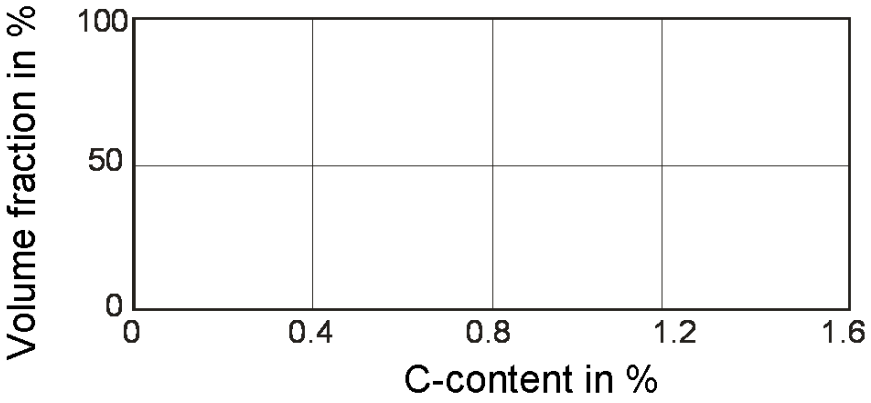

Figure 2

For a scientific publication you do a series of quenching experiments. For the same C-content different austenitiszing and quenching conditions have been chosen:

1) Austenitizing in the γ-phase field + quenching in water
2) Austenitizing in the γ-phase field + quenching in fluid nitrogen
3) Austenitizing in two-phase field γ/Fe_3C+ quenching in water

The results of the subsequent hardness measurements are shown as curves 1, 2 and 3 in **Figure 1**.

a) Assign the different quenching experiments to the curves 1, 2 and 3! (*1,5 Points*)

- Experiment 1 → Curve…
- Experiment 2 → Curve…
- Experiment 3 → Curve…

b) Explain the different curve shapes in note form! (*3,0 Points*)

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Aufgabe 4 Ageing 3 Punkte

Ageing of steel is directly connected to the grain nucleation, grain growth and grain coarsening. Please write down the function which describes the nucleus growth. Explain all parameters of the function and the influence of the precipitation coefficient by a sketch of the precipitated amount of grains and the precipitation time. Give also two parameters which affecting the precipitation kinetics.

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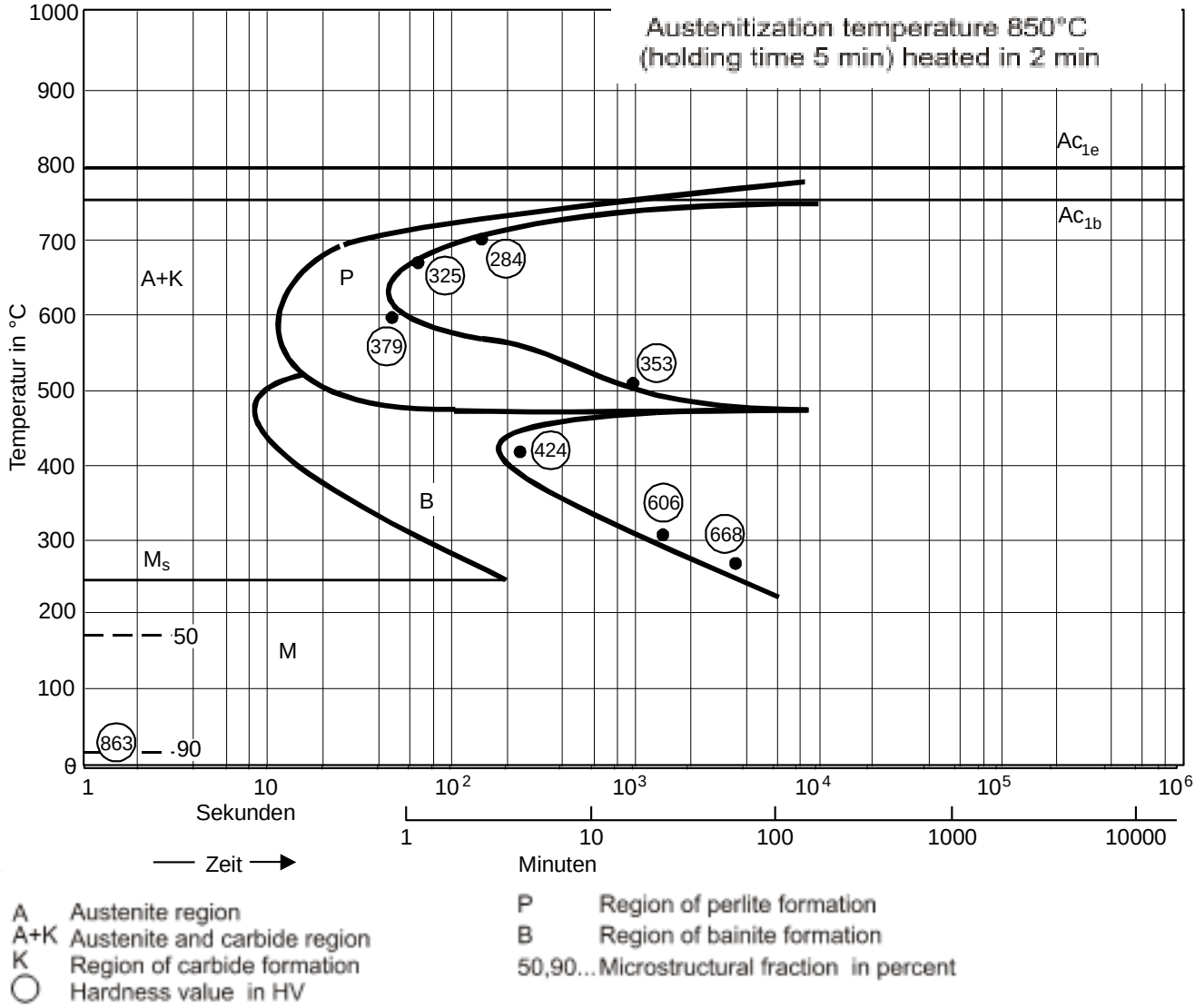
Aufgabe 5 Technical Heat Treatment I 5 Punkte

a) What kind of diagram can be seen in picture 1? 0.5P

b) Explain why such diagrams are used and how they are created! 2P

c) Make a sketch of the complete heat cycle to reach a perlitic steel with a hardness of 379HV10. Use table 1 to fix the important parameters. 2.5P

Chemische Zusammen-	C	Si	Mn	P	S	Cr	Cu	Mo	Ni	V
setzung in %	1,04	0,26	0,33	0,023	0,006	1,53	0,20	<0,01	0,31	<0,01



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Heating period	
1. Holding time	
Austenising temperature	
Holding temperature	
2. Holding time	

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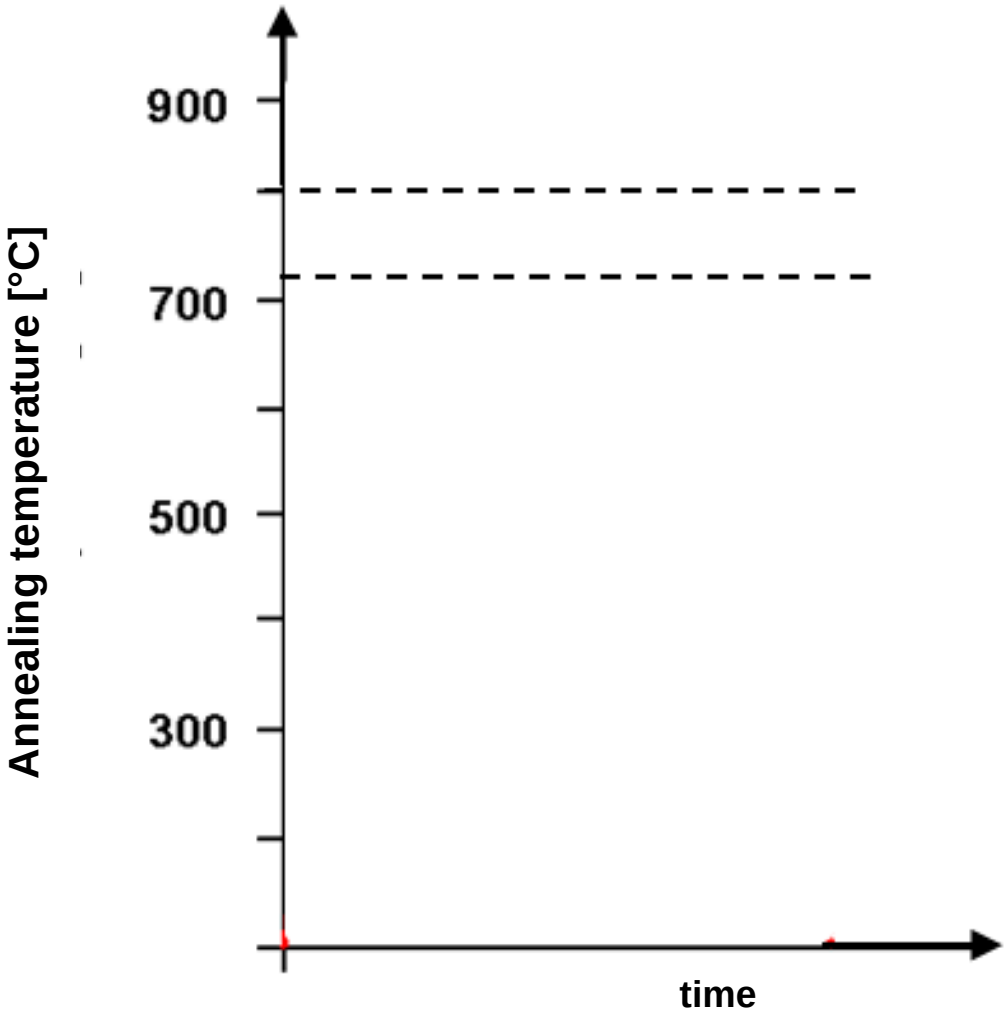
Aufgabe 6 **Technical Heat Treatment II** **5 Punkte**

Normalizing is one of the most used heat treatments for steel and cast iron.

a) What kind of benefit can be reached by normalizing these materials? (je 0,5 → 1,5 Punkte)

b) Make a sketch of the heat cyle for this heat treatment. Give also information about the annealing time and annealing temperature for hypo- and hyper- eutectoid steels. Why is it necessary to respect the annealing time. (2,5 P)



c) Give two examples what happens if a steel will be normalized (1,0 P).

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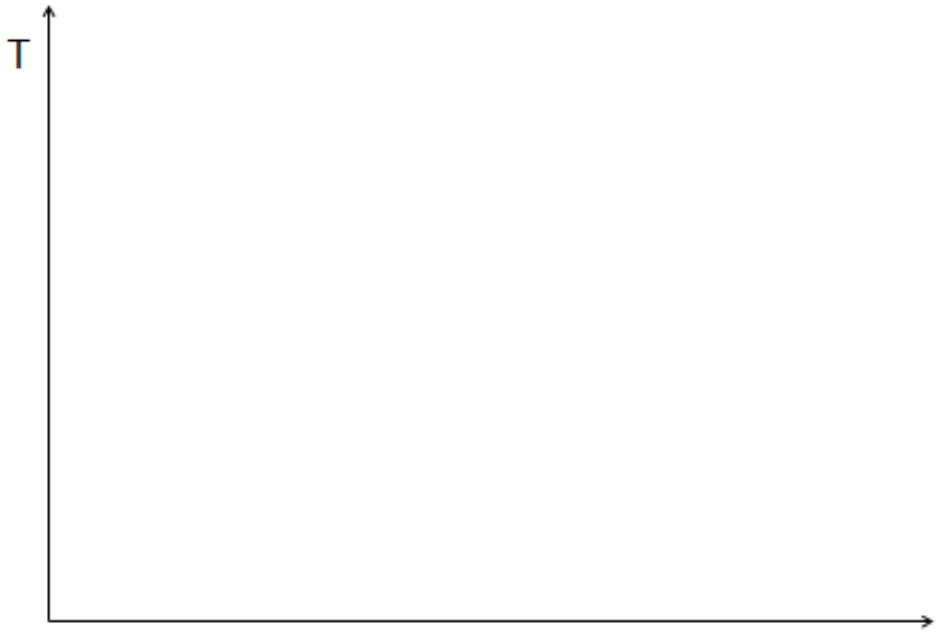
Aufgabe 7 Technical heat Treatment III 8 Punkte

Quenching and tempering is a combined heat treatment based on DIN EN 10052.

a) Name the process steps of the quenching and tempering and give a short explanation of these and make a sketch within the given time temperature diagram. (1,5 Punkte)

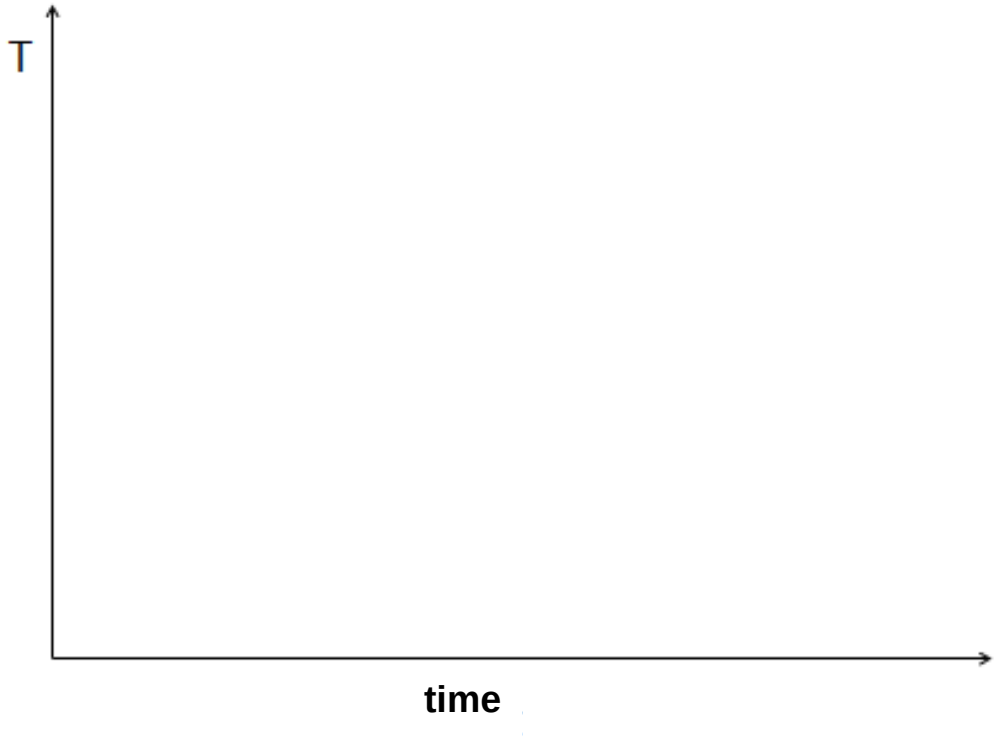


b) What kind of mechanical properties can be improved by this process? Name two examples! (1,0 Punkte)

c) What kind of microstructure can be found after the first process step? (1,0 Punkte)

d) Why is the carbon content of tempering steels in a range between 0,25 and 0,8 Mass% C? (1,0 Punkte)

e) The thermochemical treatment of case hardening offers the opportunity to improve the properties of the used steel. Please explain the process steps of case hardening in keywords. Please name also one variant of case hardening and give a sketch of the time-temperature process run. In addition to this explain what kind of effect has case hardening on the fatigue behavior of a steel (3.5 P.)



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Aufgabe 8 Phase transformation 6.5 Punkte

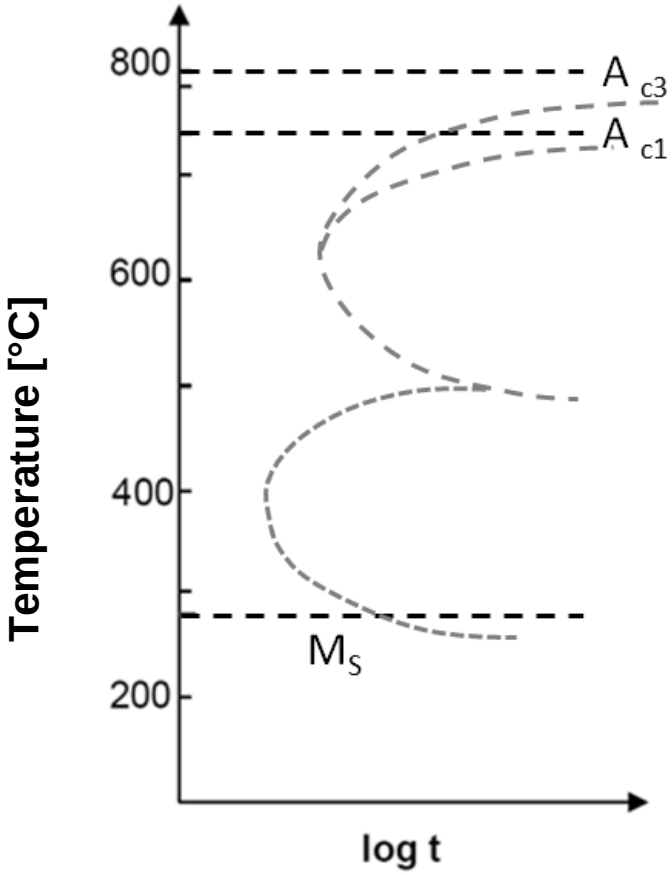
The isothermal transformation of undercooled austenite offers several possibilities to create different microstructures.

Die Isotherme Umwandlung des unterkühlten Austenits bietet unterschiedliche Möglichkeiten der Gefügeeinstellung.

a) Please complete the given diagram by labeling the phases and the area were microstructures of

- upper perlite
- lower perlite
- upper bainite und
- lower bainite

are created. Give also the typical carbide length of these microstructures and the reason for the different sizes. (3.5P.)



b) Draw a sketch of the schematic microstructure of the upper and lower bainite. (1 P)

c) Explain the influence of boron (B) on the phase transformation of a CMn – steel if it cools down in the area of the bainitic/martensitic phase boundary. Decide what change on the mechanical behavior (yield strength, impact energy Av) can be seen if you compare the unalloyed and alloyed steel.
(2P.)

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Aufgabe 9 Thermal properties 3.5 Punkte

Usually pure metals show a temperature dependency of their lattice and volume, as far as they show no polymorphy.

a) What is an “Invar-alloy” and what is its special property? Also name its approximate chemical composition! (1 *Point*)

b) Sketch the temperature dependency of the thermal expansion coefficient for an unalloyed steel and an Invar-alloy in one diagram. Explain the curves briefly (*2 Point*).

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