Rheinisch-Westfälische Technische Hochschule Aachen

Mastercourse

Metallurgical Engineering

(Ferrous Process Metallurgy)

2010-01-15

Last name, first name: **Matrikel-Nr.:**

Signature:

Task	Points (max.)	Points	Signature	Approvaldate	Finalpoints (total)
1	5				
2	5				
3	5				
4	5				
5	5				
6	5				
7	5				
8	5				
9	5				
10	5				
Total:			**Total after approval:**		

For each correct partial answer: 0,5 points till the maximum reachable number of points

Mastercourse

Metallurgical Engineering

Univ. Prof. Dr.-Ing. Dieter Senk   **2010-01-15**

1. Task: Pelletizing und Sintering   **5 points**

a)

      1. Why can fine ore not be charged directly into the blast furnace?

      2. Name at least 2 kinds of fine ore agglomeration.

1,5 points

b) Name the axes and the zones marked with the numbers 1-5 in figure 1.

3,5 points

Ignition furnace

Red-heated surface

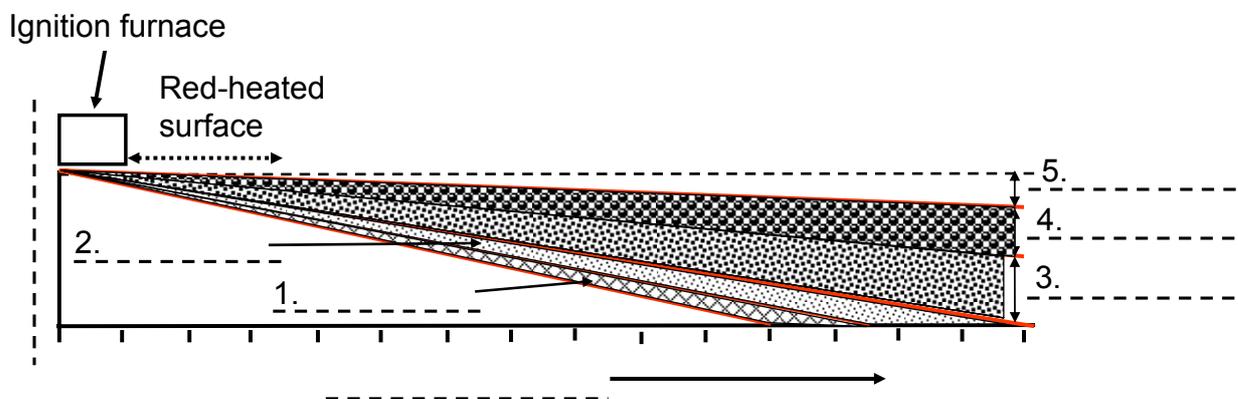2.

1.

5.

4.

3.

Figure 1

2. Task: Metallurgical Coke   5 points

a)

    1. Why is it necessary to cool down metallurgical coke after the coking process?

    2. Name and describe two ways to cool down metallurgical coke extensive.

2.5 points

b) What is the average process time of the coking process?

0,5 points

c) Give two "disadvantages" of using coke in the blast furnace.

1,0 points

d) There are several options to reduce the specific coke consumption in blast furnaces. Name at least two of these options.

1,0 points

3. Task: Blast Furnace   5 points

a) What are the functions of a blast furnace top charging system?

   What is the name of a charging system?

1,0 points

b) Explain in your own words the generation and feeding of hot blast into the blast
   furnace.

1,0 points

c)

    1.   Is it possible to operate a blast furnace with cold blast?

    2.   What is the main advantage of blast furnace operation with hot blast in
   comparison to cold blast?

1,0 points

d) Enclosed you find the Baur-Glaessner-Diagram for the reduction of ironoxides with CO/CO_2-gasmixtures.

Characterise the fields in which Hematite, Magnetite, Wustite and metallic Iron are stable.
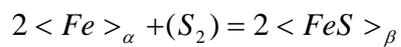
2,0 points
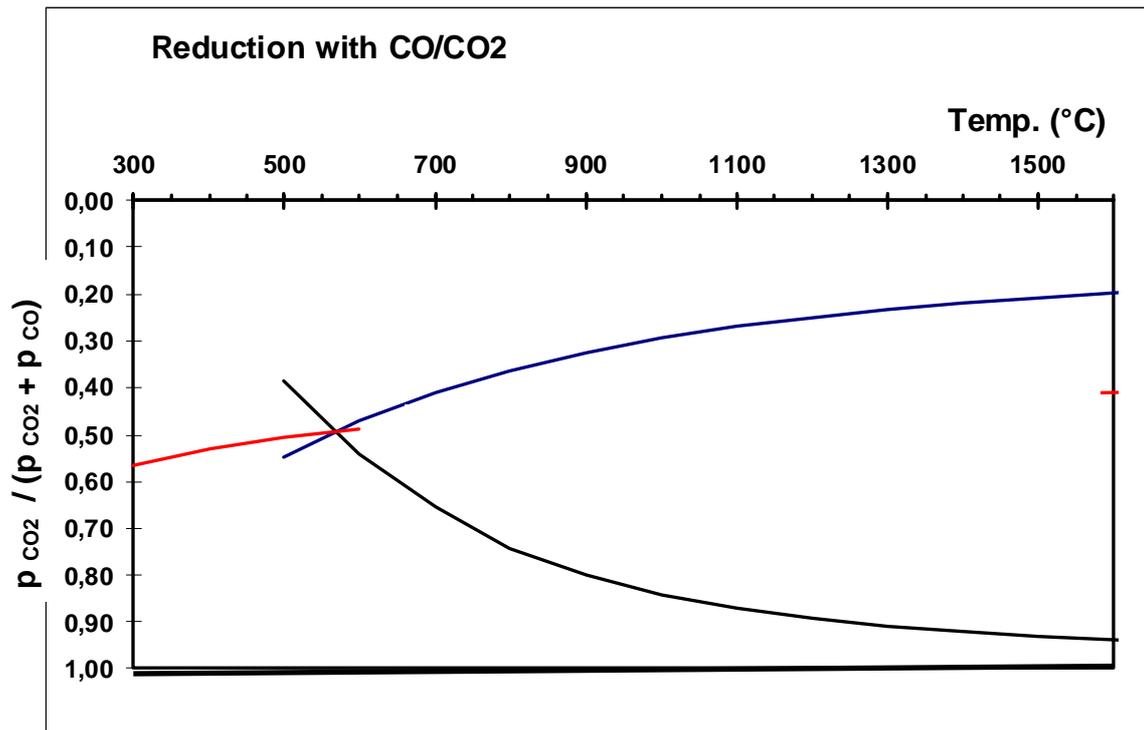
4. Task: Thermodynamics   5 points

a) What does the law of Heß say?

1,0 points

b) Calculate the equilibrium temperature of the reaction:

$$2 <Fe>_\alpha + (S_2) = 2 <FeS>_\beta$$

when the equilibrium partial pressure of sulphur amounts to $p_{s_2} = 10^{-10}$
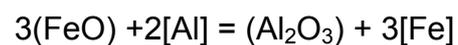
Given:

$$R = 8,3143 \; J/mol \; K$$

$$\Delta G^0 = (-300495 + 105,10T)\frac{J}{mol}$$

3,0 points

c) Write down the formular of the equilibrium constant for the reaction:

$$3(FeO) + 2[Al] = (Al_2O_3) + 3[Fe]$$
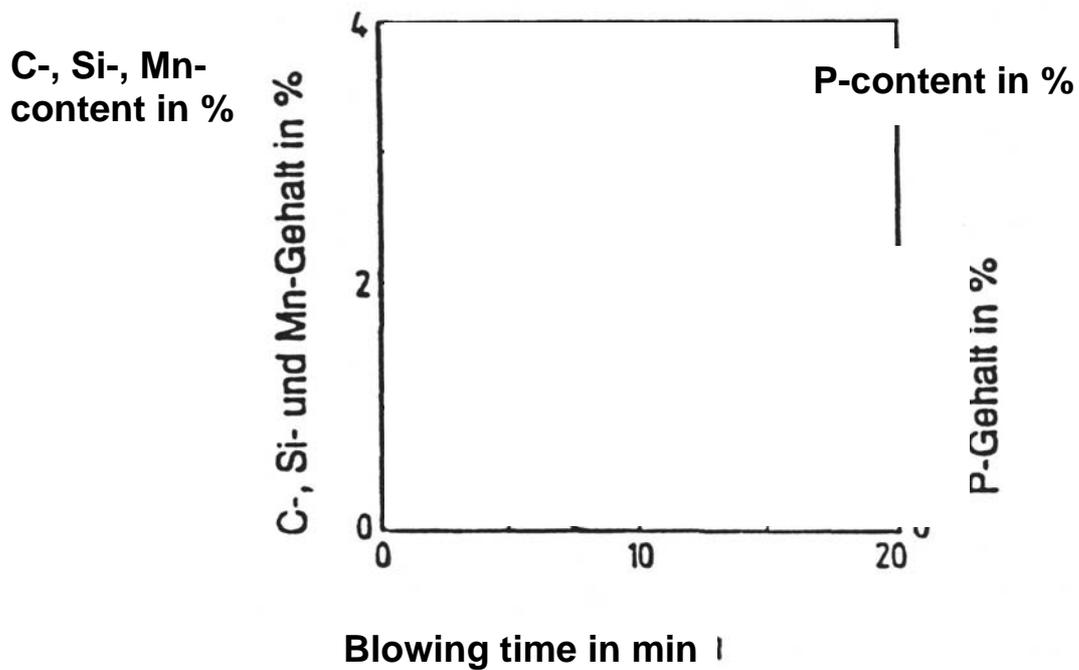
1,0 points

5. Task: Converter   5 points

a) Sketch the combustion lines in the given diagramme of the elements C, Si, P and
   Mn for a blowing time of 20 minutes.

1,0 points

C-, Si-, Mn-content in %

C-, Si- und Mn-Gehalt in %

4

2

0

P-content in %

P-Gehalt in %

0   10   20

Blowing time in min

b) Sketch schematically a LD-converter and the fluid flows during blowing.

2,5 points

c) Which element is oxidised fastest at the beginning of the refining process?   (Only one answer (cross) is allowed)Why? Please explain   **1,5 points**

- ☐ Iron
- ☐ Manganese
- ☐ Carbon
- ☐ Silicon
- ☐ Sulphur
- ☐ Phosphorus

6. Task: Direct and Smelting Reduction   5 points

a) The operator of a Midrex plant obtained a different kind of iron ore. The chemical analysis of the iron ore is given in the tabular below. Calculate the theoretical demand of reducing gas (STP) per ton of iron ore if conversion is complete. The reducing gas contains 80 % CO and H_2 and 20 % N_2.

5 points

Chemical composition of iron ore in wt-%

Fe_2O_3	SiO_2	Al_2O_3	CaO	MgO	P	S	Na_2O	K_2O	Mn	TiO_2	Other
92,68	6,3	0,31	0,07	0,06	0,02	0,01	0,01	0,01	0,02	0,24	0,27

7. Task: Electric Steelmaking   5 points

a) Sketch an AC and a DC electric arc furnace and name the most important furnace
    parts.

3,5 points

b) Explain the generation of foamy slag in Electric Arc Furnaces.

1,5 Punkte

8 Task: Secondary Metallurgy   5 Points

a) Calculate the content of aluminium and oxygene in g/t_{Steel} with the given data:

2 Points

[Al] =1,3 Mass. %:   [Al] = g/t_{Stahl}

   2,5 ppm [O]:   [O] = g/t_{Stahl}

b) Write down the chemical reaction for desulphurisation of steel!

0,5 Points

c) Name the two most important oxides for calculation of slag basicity!

1 Point

d) Give the 3 most important materials which are used for desoxdation of steel and arrange them by their efficiency!   **1,5 Points**

9. Task: Continuous Casting   5 points

a) Describe the solidification structure for continuous casting (CC).
   1) A characteristic value fort he solidification structure ist the secondary dendrite arm spacing (SDAS). The SDAS can be calculated for a Steel X after SDAS = 14,9 µm * $(\theta_f)^{0,36}$, mit $\theta_f = t_f$; $t_f = t_{liq} - t_{sol}$ (local solidification time), Calculate the colling rate to reach SDAS = 30 µm. ($T_{liq} - T_{sol}$ = 112 K)

1,5 Punkte

   2) Please draw directional and equi-axed dendrites and mark λ_1 and λ_2

1,5 Punkte

b) As alternative to the CC other continuous casting methods go on line.
   1) Please mention two methods for near net shape casting   **1 Punkt**
   2) Please mention one advantage and one disadvantage of these
      compared to the slab-CC   **1 Punkt**

10. Task: Protection of Environment, Recycling   5 points

a) Recycling is one of the key terms in sustainable development. The steel industry
    uses the recycling successfully in reclassification of scrap in the steel production.

    Name three different kinds of scrap and give a short description for each of them.

    1,5 points

b) Name 4 kinds of recycling/reuse of slags of the iron and steel industry.

    2,0 points

c) Name three methods to reduce air pollution.   **1,5 points**