# Mastercourse

**Metallurgical Engineering**  
*(Ferrous Process Metallurgy)*  
2010-10-29

<table>
<thead>
<tr>
<th>Task</th>
<th>Points (max.)</th>
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<th>Signature</th>
<th>Approvaldate</th>
<th>Finalpoints (total)</th>
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**Total:**

**Total after approval:**

For each correct partial answer: 0,5 points till the maximum reachable number of points
a) Several binding mechanisms occur during the hardening process of green pellets made from magnetite iron ore. Fill the binding-mechanism, the atmosphere and the temperature range into the table below.

<table>
<thead>
<tr>
<th>Type of binding-mechanism</th>
<th>Hematite</th>
<th>Magnetite</th>
<th>Slag</th>
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<tbody>
<tr>
<td>Oxidation to Hematite</td>
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<tr>
<td>Atmosphere</td>
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<tr>
<td>Temperature</td>
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<td>&gt; 900°C</td>
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</table>
2. Task: Metallurgical Coke  

a) Give a definition and the target of the coking process.  

1,0 points

b) Give the reason, why different cokes are mixed for the coking process.  

(at least 2 answers)  

1,0 points

c) What are the effects of charging qualitative bad coke on the blast furnace process? Name two examples.  

1,0 points

d) What are the qualitative effects of the following modifications on the specific coke consumption (kg coke/t HM) in blast furnaces?  

(For each question is only one answer (cross) allowed)

- a) Increasing of the blast temperature  
  - [ ] increasing specific coke rate  
  - [ ] decreasing specific coke rate  

- b) Increasing of the blast humidity  
  - [ ] increasing specific coke rate  
  - [ ] decreasing specific coke rate  

- c) Increasing the \( O_2 \)-content of the hot blast  
  - [ ] increasing specific coke rate  
  - [ ] decreasing specific coke rate  

1,5 points
e) Name one disadvantage for the use of coke in the blast furnace. 0.5 points
3. Task: Blast Furnace

In the Blast furnace, the reduction from Hematite to metallic Iron takes place.

a) Calculate the amount of oxygen in kg per tonne Hematite and the metallic Iron, which can be gained!

2,0 points

b) Give the coupled equations for direct reduction!

1,0 points

c) Calculate the amount of carbon in kg per tonne Hematite for 100 % direct reduction!

2,0 points
4. Task: Thermodynamics 5 points

a) Sketch the Iron-Carbon-Diagram including the most important data and mark the region of liquid pig iron in the diagram.

3.5 points
b) Calculate the oxygen partial pressure above pure iron oxide at 1500°C.

Given:

\[(\text{FeO}) = [\text{Fe}] + \frac{1}{2} \{\text{O}_2\}\]

\[\Delta G^0 = 63500 - 16.8 * T \text{ [cal/mole]}\]

1.5 points
5 Task: Basic Oxygen Furnace 

5 points

a) Write down four important exotherm oxidation reactions of the BOF refining process! Pay attention on the state of aggregation and present type of the reaction partners!

4 points

b) Call two reasons for the application of limestone during the blowing process.

1 point
6. Task: Direct and Smelting Reduction 5 points

a) Name and describe the reaction vessels of the existing smelting reduction processes. 2 points

b) What kind of process is the COREX-Process? 0.5 points

c) Name five basic metallurgical and process-specific parts of the MIDREX-process. 2.5 points
7. Task: Electric Steelmaking 5 points

a) Which ingredients are used in a modern electric arc furnace? 1 point

b) Which form of energy are used in electric arc furnaces? 2 points

c) Name four steps of development in the history of electric arc furnaces and point out the resulting advantages 2 points
a) A 250 tonne ladle of steel having an oxygen content of 450 ppm is to be Al-deoxidised at tap. Assuming an Al recovery rate of 60 % and an aim Al composition of 0,04 Mass-%, calculate the amount of 98 % Al alloy addition that is required.

\[ M_O = 16 \text{ g/mol} \]
\[ M_{Al} = 27 \text{ g/mol} \]
9. Task: Continuous Casting 5 points

a) Describe the solidification during the continuous casting process! 1 point

b) Describe in short terms the nucleation! 1 point

c) Name possible reasons for the contraction of the steel volume during Solidification! 1 point

d) Describe in short terms the procedure of segregation! 1 point

e) Name two types of continuous casting machines. 1 point
10. Task: Protection of Environment, Recycling 5 points

a) Give a definition of “Sustainable Development”. 1.0 points

b) Name at least 2 ways to prevent air pollution in the iron and steel industry. 1.0 points

c) Give at least 3 utilizations for iron and steel making slags. 1.5 points

d) Name at least 3 other (beside slags) residual or waste materials in iron and steel production, which are used as secondary raw materials. 1.5 points