UNIVERSITY OF JOHANNESBURG

PROGRAM	:	NATIONAL DIPLOMA *ENGINEERING METALLURGY*
SUBJECT	:	**PRODUCTION OF IRON AND STEEL**
CODE	:	**PRS21-1**
DATE	:	WINTER SSA EXAMINATION 2015 15 JULY 2015
DURATION	:	(SESSION 2) 11:30 - 14:30
WEIGHT	:	40 : 60
TOTAL MARKS	:	100

EXAMINER	:	DR S BHERO	
MODERATOR	:	DR N NAUDE	5063
NUMBER OF PAGES	:	4 PAGES	

INSTRUCTIONS	:	ANSWER ALL QUESTIONS
REQUIREMENTS	:	CALCULATOR

QUESTION 1 (40 marks)

The performance of the blast furnace can be inferred from the analysis of products coming out of the furnace. Table 1 shows analysis of top gas, slag and hot metal.

Table 1: Analysis of products of the blast furnace

Top gas	20% CO	20% CO_2	4% H_2	4% H_2O	50% N
Slag	29% SiO_2	11% Al_2O_3	34% CaO	11% MgO	3% S
Hot Metal	3.7% C	1.3% Si	1% Mn	0.09% P	0.03% S

1.1 Comment on the reasons for the following differences pertaining to top gases:

1.1.1 The efficiency of the reduction process. (2)

1.1.2 Which one was the main reducing agent in the upper zone and why. (2)

1.1.3 Why is N so high and what is its effect in blast furnace gas as a fuel used to fire the stoves? (2)

1.1.4 Why is oxygen not in the top gases and what is will give rise to some oxygen in top gases? (2)

1.1.5 Why does carbon deposition reaction reduce the calorific value of top gases? (2)

1.1.6 What may cause a top gas temperature of 700°C and how this problem be corrected? (2)

1.2 With reference to slag analysis:

1.2.1 Calculate the basicity ratio of the slag and comment on its suitability. (3)

1.2.2 What are the origins of the constituents of slag? (3)

1.2.3 Why is S content high in blast furnace slag while P is low? (3)

1.2.4 From [FeS] + (CaO) = (FeO) + (CaS), explain why tapping has to be a batch process. Use the partitioning of sulphur in slag and metal to show why CaO must be high but FeO low in slag. (3)

1.3 With reference to hot metal analysis:

1.3.1 What do the high Si and low S contents indicate about furnace temperature and why? (3)

1.3.2 What are the benefits of high silicon iron for steel making? (3)

1.3.3 What are the disadvantages of high silicon iron for steel making? (3)

1.3.4 What would you do to meet a customer of 0.02 P and 0.002% S steel grade? (3)

1.4 How is the cost of producing iron reduced by:

1.4.1 Tuyere injections? (2)

1.4.2 Increasing sinter charge? (2)

[40]

QUESTION 2 (40 marks)

Table 1: Analysis of slags from Vanderbijlpark amd New Castle

Slag wt%	CaO	SiO_2	MgO	Al_2O_3	MnO	Fe_2O_3	FeO	Fe	S	P
Vanderbijlpark LD	36	12	10	4	4.8	15.3	12.1	3.9	0.25	2
New Castle LD	35	36	10	13					0.2	0.5

Use Table 1 to answer Questions 2.1 – 2.4

2.1 Using the data in the Table 1 above

2.1.1 Calculate basicity ratios of LD slag Vanderbijlpark (VBP) and New Castle. (4)

2.1.2 Comment on the basicity ratios and their suitability in steel making. (2)

2.2 In view of the basicity ratios in 2.1and the slag analysis in Table 1:

2.2.1 Explain why the phosphorus contents is slags are different. (2)

2.2.2 Explain why there was high Fe_2O_3 and FeO in the VBP slag but none in New Castle slag? (2)

2.2.3 Sulphur content was low in both slags. (2)

2.3 What could have caused the following?

2.3.1 LD slag at Vanderbijlpark contains more silica than at New Castle. (2)

2.3.2 LD slag at New Castle contains more Al_2O_3 than at Vanderbijlpark (2)

2.3.3 LD slag at Vanderbijlpark contains more Fe than at New Castle (2)

2.3.4 Vanderbijlpark slag contains MnO while New Castle does not. (2)

2.4 Comment on the following:

2.4.1 The effect slag at New Castle and Vanderbijlpark on the refractory of LD. (2)

2.4.2 The type of refractory lining you would recommend for the two plants. (2)

Table 2: Analysis of blast furnace metal and LD blown metal

Constituent	Hot metal	Blown metal
C	3.8%	0.05%
Mn	1.2%	0.25%
Si	0.6%	0.001%
P	0.09%	0.02%
S	0.08%	0.02%

Use Table 2 to answer Questions 2.5 - 2.6

2.5 Pertaining to hot metal analysis;

2.5.1 What shows that the LD turn -down temperatures would be low and how is it corrected? (2)

2.5.2 What shows that desulphurisation of hot metal was carried out before LD process? (2)

2.5.3 What shows that the iron making process was inefficient? (2)

2.5.4 Was the carbon catch procedure possible? Give reasons for your answer. (2)

2.6 Pertaining to blown metal analysis, what shows that?

2.6.1 The LD process was efficient (2)

2.6.2 SiO_2 is more stable than MnO on the Ellingham diagram. (2)

2.6.3 How can low carbon contents of 0.01% be achieved in steel? (2)

2.6.4 Why is the melting point of blown metal much higher than the melting point of hot metal? (2)

[40]

QUESTION 3 (10 marks)

3.1 From of the carbon boil equation; [C] + [O] = CO_g.

3.1.1 Derive the expression of K and find the [C] as a function of other variables (2)

3.1.2 Use your expression in 3.1.1 to derive the conditions for the carbon boil. (2)

3.1.3 Explain how the principle of carbon boil in VOD and AOD. (2)

3.2 Apart from decarburisation what are the other benefits of VOD and AOD? (2)

3.3 Explain how elements such as silicon and manganese in steel affect the carbon boil. (2)

[10]

QUESTION 4 (10 marks)

The reaction; $Fe_3O_4 + C = 3Fe + 4CO$ occurs in the blast furnace. (4)

4.1 Calculate the temperature range for this reaction

4.2 In which blast furnace zone does the reaction occur and which other tow reactions occur there? (2)

4.3 Explain ways of reducing coke rate and thereby increase productivity of the furnace: (4)

[10]

Thermodynamic data

$3Fe + 2O_2 = Fe_3O_4$ $\Delta G^o = -1091060 + 312.8T$

$C + \frac{1}{2}O_2 = 2CO_{(g)}$ $\Delta G^o = -111700 - 88T$

$C + O_2 = CO_{2(g)}$ $\Delta G^o = -394100 - 0.8T$