UNIVERSITY OF JOHANNESBURG

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| **PROGRAM** | : | NATIONAL DIPLOMA<br>*ENGINEERING METALLURGY* |
| **SUBJECT** | : | **PRODUCTION OF IRON AND STEEL** |
| **CODE** | : | **PRS21-1** |
| **DATE** | : | WINTER SSA EXAMINATION 2016<br>25 JULY 2016 |
| **DURATION** | : | (SESSION 1) 08:00 – 11:00 |
| **WEIGHT** | : | 40 : 60 |
| **TOTAL MARKS** | : | 100 |

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

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| **INSTRUCTIONS** | : | ANSWER ALL QUESTIONS |
| **REQUIREMENTS** | : | CALCULATOR |

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**QUESTION 1 (40 MARKS)**

Pertaining to preparation for iron making:

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

1.1.1 Explain why crushing and screening of blast furnace input materials are undertaken. (2)

1.1.2 Why is blending of iron ore from various mines necessary? (2)

1.1.3 Why is coke and not coal charged into the furnace? (2)

1.1.4 Why is limestone and not lime charged into the furnace? (2)

1.1.5 Why -6mm particles screened off the blast furnace charge? (2)

1.2 Pertaining to blast furnace process:

1.2.1 What is the purpose of tuyere injections? (2)

1.2.2 Why is steam sometimes injected into the blast and what other benefit does steam bring? (2)

1.2.3 Why should top gases not allowed to escape to the atmosphere? (2)

1.2.4 What is the importance of the first reaction $C + O_2 = CO_2$? (2)

1.2.5 Why is particle size and particle size distribution critical for the blast furnace burden? (2)

1.3 Pertaining to the blast furnace products:

1.3.1 What does the analysis of top gases show? (2)

1.3.2 What is the problem with slag basicity of less than 1? (2)

1.3.3 What are the disadvantages of high silicon iron for steel making? (2)

1.3.4 Why is high temperature recommended for good quality iron? (2)

1.3.5 What happens when blast furnace temperatures are too high? (2)

1.4 Pertaining to blast furnace equipment:

1.4.1 Why are tuyeres made of copper and why are they water cooled? (2

1.4.2 Why should temperatures of top gases be controlled? (2)

1.4.3 Why are different parts of the blast furnace lined with different refractories? (2)

1.4.4 Why is so much water used at the blast furnace? (2)

1.4.5 What are the reasons for the shape of different parts of the blast furnace? (2)

**[40]**

**QUESTION 2 (40 MARKS)**

2.1 Pertaining to LD charge:

2.1.1 Why is slag from the blast furnace unsuitable for the LD process? (2)

2.1.2 Why is it better to desuphurise before the LD process rather than after? (2)

2.1.3 What is the purpose of charging scrap into the LD vessel? (2)

2.1.4 Why is lime charged at the beginning of the blow while iron ore is charged towards the end? (2)

2.1.5 Why is it advisable to charge hot metal first before scrap into the LD vessel? (2)

2.2 Pertaining to the LD process:

2.2.1 Why is oxygen blown into the LD vessel? (2)

2.2.2 Derive an expression and deduce conditions for decarburisation in the LD vessel? (2)

2.2.3 Derive an expression and deduce conditions for desulphurisation. (2)

2.2.4 Why does sulphur content remain virtually unchanged despite blowing oxygen? (2)

2.2.5 Explain the motivation of the carbon catch process. (2)

2.3 Pertaining to the products of the LD process:

2.3.1 Why to top gases contain more $O_2$ than $N_2$ and more CO than $CO_2$? (2)

2.3.2 Why is the LD slag basicity $\approx 3$ and $Fe_2O_3$ content also high? (2)

2.3.3 Do you think LD slag is suitable for sinter making? Give reason for your answer. (2)

2.3.4 Does fluorspar enhance separation of metal and slag? (2)

2.3.5 With blown metal of 0.05% C, how can you meet customer requirements of 0.002% C? (2)

2.4 How do the following reduce the productivity at steel making?

2.4.1 High sulphur iron. (2)

2.4.2 Too low silicon iron. (2)

2.4.3 Too high silicon iron. (2)

2.4.4 Poor quality lime. (2)

2.4.5 Overfilling the LD vessel. (2)

**[40]**

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**QUESTION 3 (20 MARKS)**

3.1 Make calculations to determine temperature ranges for the following reactions:

3.1.1 $SiO_2 + C = Si + CO$ (3)

3.1.2 $FeO + C = Fe + CO$ (3)

3.1.3 $FeO + CO = Fe + CO_2$ (3)

3.1.4 Determine in which zone of the blast furnace the above reactions occur (1)

3.2 Calculate free energies for the following reactions at 1327°C (1600K)?

3.2.1 $Si + O_2 = SiO_2$ (2)

3.2.2 $Mn + O = MnO$ (2)

3.2.3 $C + ½O_2 = 2CO_{(g)}$ (2)

3.2.4 $Fe + O_2 = FeO$ (2)

3.2.5 Determine the order of the above reactions in the LD vessel at start of blowing at 1327°C. (2)

**[20]**

**Thermodynamic data**

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| $C + ½O_2 = 2CO_{(g)}$ | $\Delta G^o = -111700 - 88T$ |
| $C + O_2 = CO_{2(g)}$ | $\Delta G^o = -394100 – 0.8T$ |
| $Mn + ½O_2 = MnO$ | $\Delta G^o = -403000 + 90T$ |
| $Si + O_2 = SiO_2$ | $\Delta G^o = -941000 + 190T$ |
| $2Fe + {}^3/_2O_2 = Fe_2O_3$ | $\Delta G^o = -810520 + 254T$ |