UNIVERSITY OF MINES AND TECHNOLOGY, TARKWA

SECOND SEMESTER EXAMINATIONS, MAY/JUNE, 2018

COURSE NO: MR 380
COURSE NAME: **FERROUS METALLURGY**
CLASS: BSc MR III TIME: 3 HRS

Name: _____ Index Number: _____

ATTEMPT ALL QUESTIONS

Q1. Calculate: i) the enthalpy change and ii) the free energy change for the calcination of limestone at 950°C using the data below:

$$CaCO_3 = CaO + CO_2$$

Component	ΔH_{298} (J mol^{-1})	S_{298} (J K^{-1} mol^{-1})	C_p (J K^{-1} mol^{-1})
CaO	-635,549.6	38	$41.84 + 20.125\times10^{-3}T - 4.519\times10^{5}\ T^{-2}$
CO_2	-393,296	214	$25.983 + 43.514\times10^{-3}T - 14.832\times10^{5}\ T^{-2}$
$CaCO_3$	-1,206,665.6	93	$82.843 + 49.748\times10^{-3}T - 12.912\times10^{5}\ T^{-2}$

[25 marks]

Q2. a) State the major similarities and differences between the electric arc furnace (EAF) and basic oxygen furnace (BOF) steelmaking processes **[7 marks]**

b) Outline the sequence of steps for the operation of an electric arc furnace steelmaking.

[8 marks]

c) List the components of the charge of an electric arc furnace. **[5 marks]**

d) The total energy input to an electric arc furnace is mainly from two sources; *electrical energy* and *chemical energy*. State the main sources of chemical energy input to the EAF

[5 marks]

Q3. You are the Metallurgist of ACeSMaRT Iron Resources with an iron ore concession consisting of siderite of grade 45% Fe_2O_3, 23% Fe_3O_4, 17% $Fe_{0.974}O$, 6.5% MgO, 5.5% CaO, 1.8% SiO_2 and 1.2 % LOI. It is intended to produce premium grade metallic iron nuggets from one tonne of ore through the rotary hearth furnace approach using polycarbonate -$(C_{16}H_{18}O_5)_n$- as reducing agent.

i) Determine the elemental reducing species in polycarbonate and their composition by weight. **[4 marks]**

ii) Outline the steps you will adopt to produce premium grade metallic iron from this concession. **[9 marks]**

iii) Calculate the maximum amount of metallic iron (in kg) that can be produced from the ore . **[5 marks]**

iv) Gas analysis of the offgas from thermal composition of polycarbonate using gas chromatographic analyser indicated that 5 mol $CO_{(g)}$, 1 mol $H_{2\,(g)}$, x mol $CH_{4\,(g)}$ are produced with y mol of solid C as the residue in the crucible. Using a simple material balance, write then the complete equation for the thermal decomposition of polycarbonate. Hence explain why polycarbonate could function as an excellent reductant, in spite of its oxygen content. **[7 marks]**

Q4 *Blast furnace iron making is still the most popular iron making process and globally it accounts for over 90% of all ironmaking processes.*

a) What are the major limitations of the Blast furnace? **[6 marks]**

b) What are the major functions of metallurgical coke in the blast furnace? **[6 marks]**

c) Part of the iron-oxygen-carbon phase diagram is shown below. It is required to produce metallic iron from iron oxide using a CO-CO_2 mixture as a reducing agent. Provide a brief account of the final products under each of the following conditions:

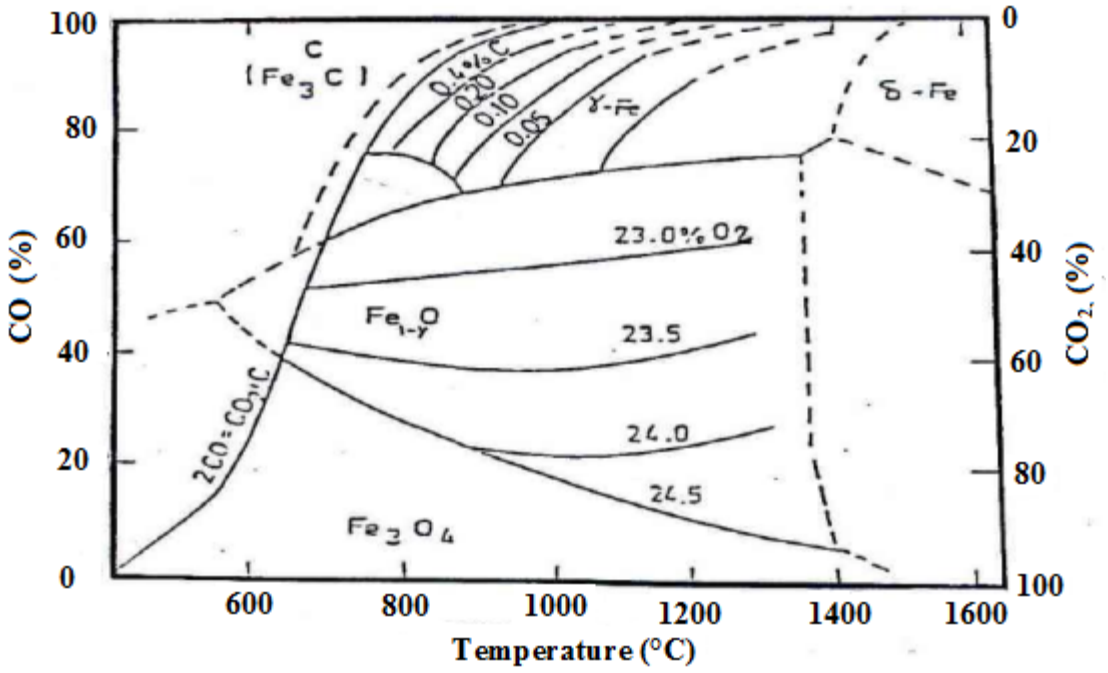
i) Temperature: 600 °C; Gas composition: 80% CO **[3 marks]**

ii) Temperature: 800 °C; Gas composition: 50% CO **[3 marks]**

iii) Temperature: 1000 °C; Gas composition: 60% CO **[3 marks]**

iv) Temperature: 1200 °C; Gas composition: 90% CO **[2 marks]**

v) Temperature: 1600 °C; Gas composition: 80% CO **[2 marks]**


C
(Fe3C)
0.4%C
0.20
0.10
0.05
γ-Fe
δ-Fe
23.0% O2
Fe1-yO
23.5
24.0
24.5
2CO=CO2+C
Fe3O4
CO (%)
CO2 (%)
Temperature (°C)
100
80
60
40
20
0
600
800
1000
1200
1400
1600

J.R. DANKWAH