NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

FACULTY OF ENGINEERING AND THE BUILT ENVIRONMENT

DEPARTMENT OF CIVL, MINING AND PROCESS ENGINEERING

QUALIFICATION : BACHELORS OF ENGINEERING IN MINING ENGINEERING	
QUALIFICATION CODE: 08BMEG	**LEVEL: 8**
COURSE CODE: FFR820S	**COURSE NAME: FUELS FURNACES AND REFRACTORIES**
SESSION: JUNE 2023	**PAPER: THEORY**
DURATION: 3 HOURS	**MARKS: 60**

FIRST OPPORTUNITY QUESTIONS	
EXAMINER(S)	**Maweja Kasonde**
MODERATOR:	**Prof. Vusumuzi Sibanda**

INSTRUCTIONS
1. Answer all questions. 2. Read all the questions carefully before answering. 3. Marks for each question are indicated at the end of each question. 4. Please ensure that your writing is legible, neat and presentable.

PERMISSIBLE MATERIALS

1. Examination paper.
2. Calculator

THIS QUESTION PAPER CONSISTS OF 4 PAGES (Including this front page)

Question 1 **(max 5)**

Considering typical losses from furnaces.

How do you improve the thermal efficiency of high temperature furnaces. Use examples of a kiln furnace, a reverberatory furnace and a blast furnace.

Why do you limit air excess in high temperatures furnaces operating above 1000°C?

Question 2 **(max 5)**

Explain the effect of fuel choice on the following operation conditions of a metallurgical furnace.

a. Heat transfer and performance
b. Furnace atmosphere
c. Refractory life

Question 3 **(max 5)**

Consider the physics of combustion.

a. Explain the importance of jet recirculation in a furnace heated up by a combustion flame.
b. How will you design the burner in a furnace where the flame is not restricted by the walls?

Question 4 **(max 5)**

In a 3-phase electric arc furnace, how do you adjust the voltage drop through the arcs?

How do you protect the power supply system from large surges during the melting step?

Question 5 **(max 5)**

Explain the working principle and technical advantage of the Outokumpu furnace for matte smelting copper sulphide concentrates.

Question 6 **(max 5)**

During the operation of a reverberatory furnace, the analysis reveals that the flue gas contain some amount of carbon monoxide CO, which infers an incomplete combustion of the hydrocarbon liquid fuel used to generate the heating flame.

a. What is the cause of incomplete combustion? How would you proceed to safely adjust the operation parameters?
b. Describe the safe procedure to avoid an explosion during furnace start-up.

Question 7 **(max 5)**

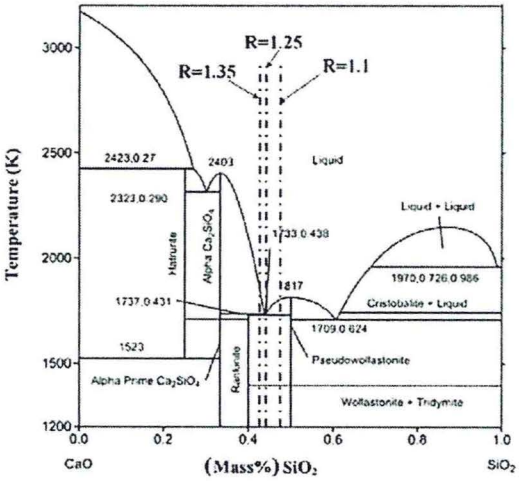
The true way to prevent crack growth due to thermal shock in refractories is described by the parameter:

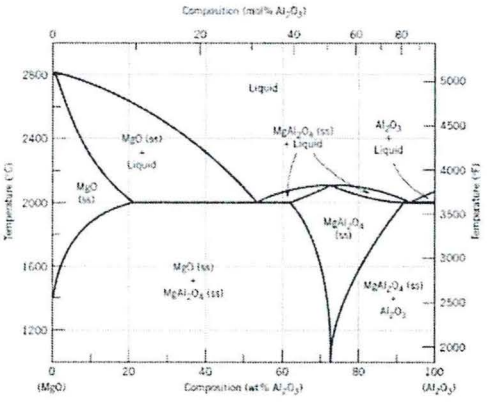
$$R^m = \frac{E\,\gamma_{fract}}{\sigma_f{}^2(1-\mu)}$$

How do you implement this behaviour in practice to improve the refractory life?

Question 8 **(max 7)**

The phase diagrams of two refractory material systems ($CaO - SiO_2$) and ($MgO - Al_2O_3$) are given. Motivate your choice of the bricks for constructing a furnace operating at 1600°C.





Question 9 **(max 8)**

A new furnace was designed to work with a burner of manufactured Lean Reformer Gas LRG. The traditional supplier of LRG gas is temporarily unable to meet your order quantities and schedules. Considering the properties in the table below, would you consider the blast furnace off-gas, Commercial propane LPG or Coke Oven Gas as substitute in the meantime? Note: Changing the burner would lead to months long downtime of the furnace.

Property	Blast furnace	Coke oven	Lean Reformer Gas	Commercial Propane
CH_4 (%)	-	28	22.7	-
C_2H_6 (%)	-	-	5.0	1.5
C_3H_8 (%)	-	-	-	91
Higher C_xH_y (%)	-	2	0.4	7.5
CO (%)	24	7.4	2.2	-
H_2	2.5	54	53.7	-
N_2 (%)	56	5.6	-	-
CO_2 (%)	17.5	2	16.0	-
O_2 (%)		0.4	-	-
Relative density/air	1.04	0.38	0.593	1.523
Calorific value CV [MJ/m³]	3.18	19.89	18.92	93.87
Air required [m³/m³]	0.631	4.572	4.398	23.762

Question 10 **(max 10)**

Fuel oil with the following ultimate composition (w%/w) is burnt with a 10% excess air in a furnace. Carbon 82%, Hydrogen 18%.

Assuming air composition is 76.7 w% Nitrogen and 23.3 w% Oxygen. Considering complete combustion, determine:

(i) The mass of air required to burn 1kg fuel oil
(ii) The mass of flue gas formed from the combustion of 1kg fuel oil
(iii) The volume of flue gas formed at (300°C, 1atm) from 1kg oil

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