



**NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY**

FACULTY OF ENGINEERING AND SPATIAL SCIENCES

DEPARTMENT OF MECHANICAL, MINING AND PROCESS ENGINEERING

QUALIFICATION: BACHELOR OF ENGINEERING IN METALLURGY	
QUALIFICATION CODE: 08BMET	LEVEL: 8
COURSE CODE: PNM710S	COURSE NAME: PYROMETALLURGY OF NON-FERROUS METALS
SESSION: JUNE 2023	PAPER: THEORY
DURATION: 3 HOURS	MARKS: 100

SUPPLEMENTARY QUESTION PAPER	
EXAMINER(S)	Prof. Godfrey Dzinomwa
MODERATOR:	Prof. Sofya Mitropolskaya

INSTRUCTIONS
<ol style="list-style-type: none">1. Answer all questions.2. Read all the questions carefully before answering.3. Marks for each questions are indicated at the end of each question.4. Please ensure that your writing is legible, neat and presentable.

PERMISSIBLE MATERIALS

1. Examination paper.

THIS QUESTION PAPER CONSISTS OF 5 PAGES (Including this front page)

Question 1

- (a) Explain the properties required for an effective furnace refractory **(5 marks)**
- (c) An oil-fired furnace is used to reheat metal 'x' stock from ambient to the working temperature before further treatment. Given the data below,

Operating temperature: 1350 °C

Exit flue gas temperature after preheater: 750 °C

Ambient temperature: 40 °C

Specific gravity of fuel oil: 0.89

Average fuel oil consumption: 400 liters / hr = 400 x 0.89 = 356 kg/hr

Calorific value of oil 10000 kCal/kg

Weight of stock: 6000 kg/hr

Specific heat of billet: 0.12 kCal/kg/°C

(Hint: $\text{Heat efficiency} = \frac{\text{Heat output (in billet stock)}}{\text{Heat input (from Fuel Oil used to reheat the stock)}} \times 100$)

Calculate

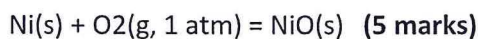
- (i) the heat content of metal 'x' as it comes out of the furnace **(5 marks)**
- (ii) the heat input into the furnace **(5 marks)**
- (iii) the efficiency of the furnace **(5 marks)**
- (b) Ideally, all heat added to the furnaces for smelting or other heating purposes should be used to heat the load or stock. In practice, however, a lot of heat is lost in several ways, resulting in typical thermal efficiencies below 50%. Discuss five (5) ways by which heat losses occur in the furnace **(5 marks)**.

Question 2

1. Given the following Ellingham diagram below,

(i) Explain the significance of Ellingham diagrams in Pyrometallurgy **(5 marks)**.

(ii) What is the free energy change at a temperature of 800°C for the reaction



(iii) Determine the Oxygen pressure in equilibrium with Ni and NiO at the temperature of 800°C **(5 marks)**.

(iii) Explain in terms of the C/CO line in the Ellingham diagram why metals such as Al were

considered to be unextractable with early age furnaces such as the blast furnace. (5 marks)

(iv) Explain why Carbon is arguably one of the most effective reducing agents for metal oxides and illustrate your answer using the C/CO, Mn/MnO reaction/s (5 marks).

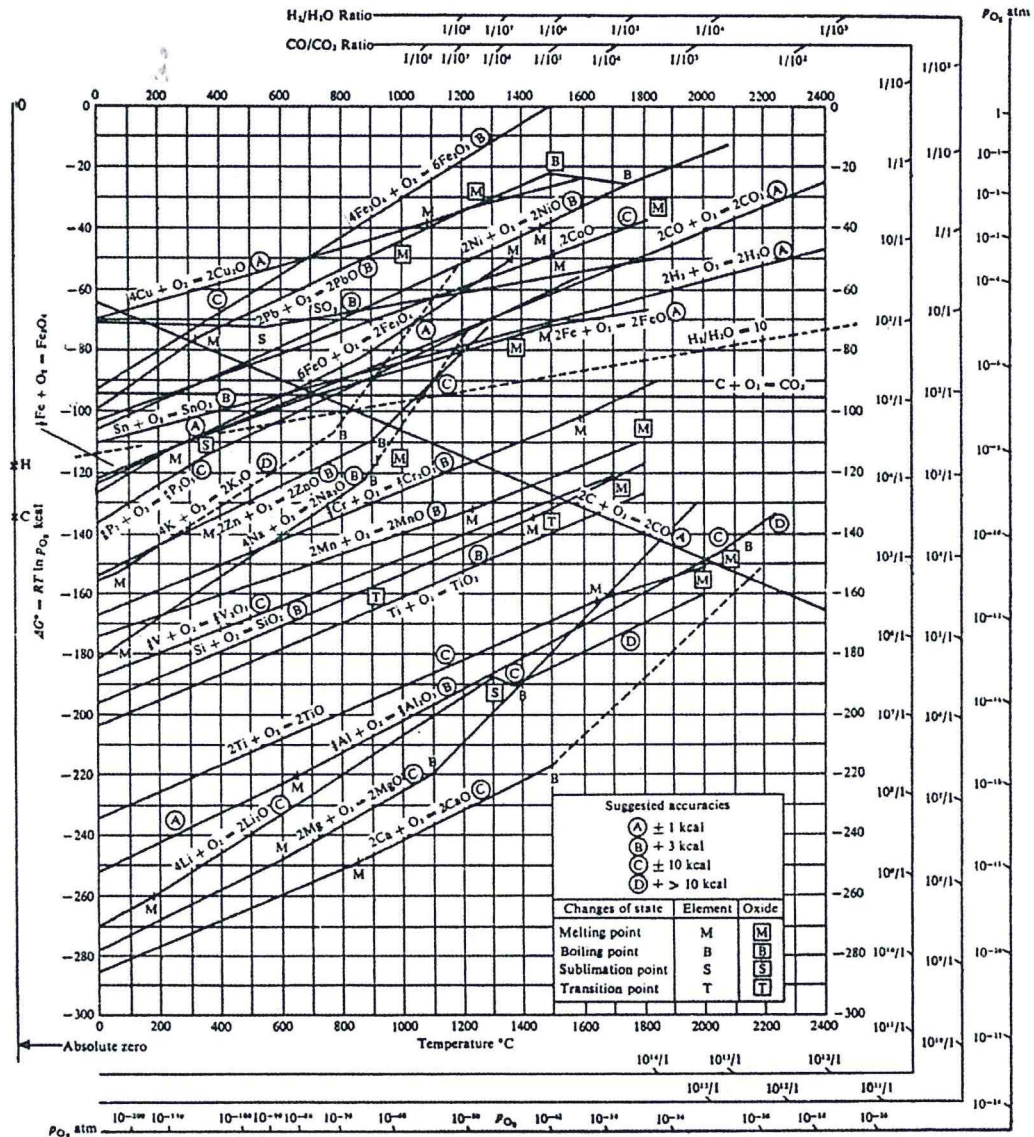


Fig. 1 Standard Free Energy Diagram for Oxides.

Question 3

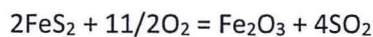
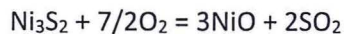
(a) Explain the mechanism by which roasting is achieved. How would you increase the kinetics of roasting and hence the production rate" (5 marks)

(b) In one roasting unit, 2000 kg of an ore concentrate of the composition given below is roasted using excess air.

Ni ₃ S ₂	25%
FeS ₂	37%
SiO ₂	30%
H ₂ O	8%

The roasting unit is heated by oil of composition 85% C and 15% H, the amount of oil is 6.5% of the weight of the ore.

The gases from combustion and roasting mix together and are carried through as flue gases. S is converted to SO₂. The roasted product consists of NiO, Fe₂O₃ and SiO₂ and the roasting reactions are given as;



Calculate:

- Weight of roasted product **(10 marks)**
- Volume of the fuel oil used given that its density is 0.89 g/cm³ **(5 marks)**
- Volume of SO₂ in m³ **(5 marks)**

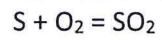
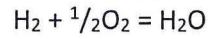
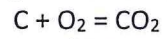
(Note: Atomic weights are Ni = 59, Fe = 56, S = 32, O = 16, H = 1)

Question 4

- Discuss the factors that you would consider in order to set up an Aluminium smelter in a given location. What measures could be taken for Namibia to be a favourable destination for such an investment **(5 marks)**.
- As Group Metallurgist of Smelters, you find that the electrostatic precipitator and the rest of the off-gas treatment plant of Smelter D (Ni-S) has not been operating for a month and the Smelter D Manager seems to be accepting the position, mainly because of reduced electricity bill due to the offline units. Explain to the Manager the disadvantages posed to the Company by this situation **(5 marks)**
- Coal amounting to 2500kg is to be used to dry some mineral concentrate. The composition by weight of the coal is given as;

C - 85%
H - 5%
N - 2%
S - 3%
O - 5%

Using stoichiometric balances, calculate the volume of air required for complete combustion of the coal to produce flue gases (mixture of SO₂, CO₂, H₂O and N₂) according to the reactions below **(10 marks)** ;



- (i)** If 5% excess air is blown, what is the total volume of air blown? **(5 marks)**

-----**End**-----