GWANDA STATE UNIVERSITY

FACULTY OF ENGINEERING AND THE ENVIRONMENT

DEPARTMENT OF METALLURGICAL ENGINEERING

EMR 3203 PYROMETALLURGY – NON FERROUS

Part III Second Semester Examination Paper

MAY / JUNE 2023

This examination paper consists of 4 printed pages

Time Allowed: **3 hours**

Total Marks: **100**

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INSTRUCTIONS

1. Answer ALL questions in section A and any 2 from 3 in section B
2. Use of calculators is permissible.

Additional Requirements

MARK ALLOCATION

Section A	50 Marks
Section B	50 Marks
Part Questions	As shown in each part question
Total Attainable	100

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SECTION A (50 MARKS)

ANSWER ALL QUESTIONS

Question 1

A copper converting furnace blows to blister copper a charge of 20 tonnes of matte containing 46% copper. Ore carrying 4% Cu_2S, 16% FeS, 80% SiO_2 is used as flux, the desired slag is to 29% SiO_2. The air blast is supplied at 5436 m^3/hr at room conditions of temperature and pressure. 2% of the copper is lost to the slag with 1% as Cu_2S and 1% as CuO.

You are required to calculate:

a) The weight of flux necessary [6]
b) The volume of blast required for the entire blow [6]
c) The blowing time for each of the two stages of converting [10]
d) The heat generated in watts at each of the two stages of converting [10]
e) The percentage SO_2 in the flue gases at each of the two stages of converting [10]
f) Assuming all the flux is added at the start of the blowing process how many minutes will it take to have matte with copper composition of 60% [8]

One mole of gas occupies 24L at room temperature and pressure. Atomic Weights Are Cu – 63.546 g/mol, Fe – 55.845 g/mol, Ca – 40.078 g/mol, S – 32.065 g/mol, O – 15.999 g/mol, Si – 28.0855 g/mol

Reaction Enthalpy Changes

$2FeS + 3O_2 \rightleftharpoons 2FeO + 2SO_2$	ΔH = -940KJ/mol reaction
$FeO + 2SiO_2 \rightleftharpoons FeO.2SiO2$	ΔH =0.64KJ/kg of FeO
$Cu_2S + O_2 \rightleftharpoons 2Cu + SO_2$	ΔH = -217.3KJ/mol reaction
Cu_2S (l) + $2O_2$(g) $\rightleftharpoons$ 2CuO(l) + SO_2(g)	ΔH = -527.5KJ/mol reaction

SECTION B (50 MARKS)

ANSWER ANY TWO QUESTIONS

Question 2

Roasting of cobalt-copper sulphide concentrates is done to produce a soluble sulphate calcine. The roasting temperature is maintained between 695-705°C to avoid formation of insoluble oxide.

a. How many degrees of freedom does this cobalt-copper sulphide system have? [2]
b. What type of furnace can be used for this roasting? [2]
c. With your choice of furnace, you stated above in (b) how will the roasting residence time be varied? [2]

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d. With your choice of furnace, you stated above in (b) what will be the ideal feed particle size and justify your answer? [4]
e. State two effects to the roasting process of operating the furnace at a temperature lower than 500℃. [2]
f. What is the difference between drying, roasting and smelting? [3]
g. In what four ways can the temperature of the roasting furnace be regulated to stay within the 695-705℃ range? [8]
h. State two effects to the roasting process of operating the furnace at a temperature higher than 900℃. [2]

Question 3

Bindura Nickel Cooperation has a Nickel smelting plant. In smelting of sulphide ore a matte of base metals and sulphide soluble precious metals are also collected in the matte.

a. State and explain five different ways this smelting furnace can pollute the Bindura environment. [10]
b. For each of the ways of pollution stated above in (a) highlight the form/type of pollution it is. [5]
c. For each of the ways stated in (a) explain how the pollution can be minimised in furnace design and/or operation? [5]
d. State any three social benefits that comes with / were brought by, having a smelting plant in Bindura [3]
e. State any two social negatives that can be/were brought about by having a smelting furnace in Bindura. [2]

Question 4

Zimbabwe the world's fourth largest reserves of Platinum Group Metals (PGMs) and is the world's third largest producer after South Africa and Russia.

a. Describe the basic flow sheet for processing of ROM ore with PGMs associated with sulphide minerals to independent Platinum Group Metals. Highlight typical machinery you would use in each stage of the flowsheet. [6]
b. In PGM sulphide mineral separation from oxide materials how can recovery be improved if some of the PGMs occur as native metals in micro-particle sizes of 25µm sizes. [3]
c. Give four reasons why PGMs ores need to first be prepared into concentrates by mineral processing before feeding to the smelter furnace. [4]
d. What is the purpose of converting PGMs smelter matte before sending it to the refinery? [2]
e. Give two reasons why PGMs concentrate should the dried before being fed to the smelter. [2]

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f. Describe the drying process and equipment you would use to dry smelter feed that is transported as slurry to the smelter. [4]
g. What two factors limit the erection of a PGMs refinery plant in Zimbabwe. [2]
h. State any two uses of PGM materials. [2]

END OF QUESTION PAPER

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