

NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
FACULTY OF INDUSTRIAL TECHNOLOGY
BACHELOR OF ENGINEERING (HONS) DEGREE
Part Five Examination December 2013

TCE 5107 Advanced Minerals Engineering IA
Duration of Examination 3 Hours

Instructions to Candidates:

1. Answer **ALL** questions in SECTION A and **THREE** questions in SECTION B.
 2. Show all your steps clearly in your calculation.
 3. Start the answers for each question on a new page.
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SECTION A - 40 MARKS

1. a) What are the sources of heat energy in pyrometallurgical processes? [3]

b) (i) What is the difference between pig iron and sponge iron? [4]
(ii) What is the purpose of flux material in blast furnace iron making? [3]

c) (i) Why is the chromium oxide ore referred to as an ore of the spinel type. [1]
(ii) Give the reaction sequence of Cr_2O_3 refining in the submerged arc furnace. [6]

d) What is the major use of platinum? [3]

2. a) Zinc concentrates of a location are composed of 60% zinc, present as ZnS , iron present as FeS and 7% SiO_2 . On roasting Zn oxidizes to ZnO , iron to Fe_2O_3 and S to SO_2 , 3% of ZnS however, remains unchanged. Coal equal to 20% of raw ore is used: the ashes from the coal do not mix with the ore, but the products of combustion pass through the furnace and into the flue mixed with the gases from the roasting.
The coal is composed of 72% C, 6% H, 8% O_2 , 2% S and 12% ash.
The flue gases carry 12% oxygen.
Calculate:

- (i) The weight of roasted ore, and the % of sulphur in the roasted ore. [6]
 - (ii) The theoretical volume of air used in roasting and for combustion of coal. [2]
 - (iii) The % composition of the flue gases and the % excess air used above the theoretical requirement for roasting and combustion. [4]
- b) (i) Nickel laterite ores are divided into three nickel-bearing layers, state these layers. [1]
- (ii) Explain why different extraction techniques are used for the extraction of nickel from each layer. [4]
- c) What are the products of the copper converting process? [3]

SECTION B - 60 MARKS

3. a) Briefly describe the unit operations in pyrometallurgy. [10]
- b) (i) Why is the agglomeration of ore fines an important step in modern iron making plants? [4]
- (ii) Sintering one of the methods that is used to agglomerate fine iron ore particles before charging them into the furnace. With the aid of a diagram describe and explain the different zones during progressive sintering of iron ore fines. [6]
4. a) Coke is a critical raw material in blast furnace iron making, what are its functions? [5]
- b) A sinter of iron ore consisting mainly of haematite is charged into the blast furnace. Give a full description of the reactions in each zone and the operating conditions. [10]
- c) The following furnaces are employed in the steelmaking industry i.e. Basic oxygen furnace and the Electric arc furnace. Describe

- the reactions that are involved in **one** of these furnaces, clearly distinguish the principal phases involved and how each element behaves. [5]
5. a) Describe Flash Smelting including a detailed chemistry of the process reactions. [10]
- b) Based on your analysis of the flash and submerged tuyere furnaces in copper smelting, recommend the ideal furnace for a modern copper making plant. [10]
6. a) Roasting of ZnS ore i.e. $(\text{ZnS} + 1.5\text{O}_2 = \text{ZnO} + \text{SO}_2)$ can be achieved by sintering the fine ore particles using a Dwight-Lloyd machine. State 5 conditions which are essential for down-draught sintering of ZnS ore and explain their effect on the process. [10]
- b) Give a detailed description of the Imperial Smelting Process, your description should include;
- (i) Clearly labeled diagram of the furnace. [3]
- (ii) Detailed description of the process operation [3]
- (iii) Reactions [3]
- (iv) Products [1]

TOTAL MARKS - 100 MARKS

END OF EXAM