

## National Exams December 2012

### 98-Met-A3. Metal Extraction Processes

3 hours duration

#### NOTES:

1. Answer only **five** questions. Any five questions (out of seven) constitute a complete paper. Only the first five questions as they appear in your answer book will be marked.
2. All questions are of equal value (20 marks each out of 100).
3. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper a clear statement of any assumptions made.
4. Candidates may use one of two calculators, the Casio or Sharp approved models. This is a closed book exam.
5. The exam consists of 3 pages.

Question 1: (a) 5, (b) 3, (c) 3, (d) 3, (e) 6

Question 2: (a) 4, (b) 4, (c) 4, (d) 4, (e) 4

Question 3: (a) 2, (b) 4, (c) 2, (d) 2, (e) 6, (f) 4

Question 4: (a) 4, (b) 6, (c) 4, (d) 6

Question 5: (a) 4, (b) 4, (c) 4, (d) 4, (e) 4

Question 6: (a) 4, (b) 6, (c) 4, (d) 6

Question 7: (a) 5, (b) 5, (c) 5, (d) 5

**Problem No. 1 (20 marks): Flotation**

A copper ore has a grade of 1.93 % Cu. After a flotation test, a concentrate with 19.3 % Cu was produced. The weight of dry concentrate was 9 % of the feed weight.

- (a) What is the percentage Cu content of the tailings? (5 marks)
- (b) What is the % copper recovery in the concentrate? (3 marks)
- (c) What is the % copper loss in the tailings? (3 marks)
- (d) What is the enrichment ratio? (3 marks)
- (e) If the copper ore has a specific gravity of 2.8, what will be the specific gravity of pulp, if the flotation test is run at 25 % solids pulp density? (6 marks)

**Problem No. 2 (20 marks): Pyrometallurgical processes**

With the help of appropriate chemical reactions and examples, explain the process of:

- a) Calcination (4 marks)
- b) Partial oxidation (4 marks)
- c) Dead roasting (4 marks)
- d) Sulfating roasting (4 marks)
- e) Chloridizing roasting (4 marks)

**Problem No. 3 (20 marks): Iron and steelmaking**

- (a) What are three major feed materials for the production of iron in a blast furnace? (2 marks)
- (b) What is the function of coke in the production of iron in a blast furnace? (4 marks)
- (c) What is the function of limestone in the production of iron in a blast furnace? (2 marks)
- (d) What are the products in the production of iron in a blast furnace? (2 marks)
- (e) Describe the advantages of using oxygen instead of air in steelmaking. (6 marks)
- (f) Which metals are used for deoxidation of steel and why? (4 marks)

**Problem No. 4 (20 marks): Copper production**

- (a) Draw a process flow sheet for the production of copper from sulfide ores. (4 marks)
- (b) Describe the process for production of copper from sulfide ores using the process flow sheet drawn in part (a). (6 marks)
- (c) Draw a process flow sheet for the production of copper from oxide ores. (4 marks)
- (d) Describe the process for production of copper from oxide ores using the process flow sheet drawn in part (c). (6 marks)

**Problem No. 5 (20 marks): Mass balance**

A copper concentrate contains 17.6 % Cu, 35.5 % Fe and 29.2 % S by weight. The concentrate is fed into a flash smelter. Air is blown in the smelter to produce a matte containing 45 % Cu. The slag produced by smelting contains 50 % FeO by weight with the rest being silica. Assume that the matte contains only  $\text{Cu}_2\text{S}$  and  $\text{FeS}$ . Neglect any copper loss in slag.

- (a) Calculate the percentage composition of  $\text{Cu}_2\text{S}$  and  $\text{FeS}$  in the matte. (4 marks)
- (b) What is the amount of matte produced per ton of concentrate? (4 marks)
- (c) What is the amount of slag produced per ton of concentrate? (4 marks)
- (d) What is the amount of  $\text{SO}_2$  produced per ton of concentrate? (4 marks)
- (e) What is the amount of  $\text{O}_2$  needed per ton of concentrate assuming 100 % efficiency? (4 marks)

Given: Atomic weights: Cu – 63.57, Fe – 55.85, O – 16, S – 32

**Problem No. 6 (20 marks): Zinc production**

- (a) Draw a process flow sheet for the pyrometallurgical production of zinc. (4 marks)
- (b) Describe the process for the pyrometallurgical production of zinc using the process flow sheet drawn in part (a). (6 marks)
- (c) Draw a process flow sheet for the hydrometallurgical production of zinc. (4 marks)
- (d) Describe the process for the hydrometallurgical production of zinc using the process flow sheet drawn in part (c). (6 marks)

**Problem No. 7 (20 marks): Electrometallurgy**

Consider a galvanic cell based on the following reaction:



- (a) Calculate the standard cell potential ( $E^\circ$ ) at 25 °C. (5 marks)
- (b) Calculate the standard free energy ( $\Delta G^\circ$ ) for the cell at 25 °C. (5 marks)
- (c) Calculate the equilibrium constant for the redox reaction at 25 °C. (5 marks)
- (d) Calculate the cell potential (E) at 25 °C if concentration of  $\text{Cu}^{2+}$  is 0.5 M and concentration of  $\text{Fe}^{2+}$  is 1.5 M. (5 marks)

Given: Standard reduction potentials at 25 °C for half reactions:

