National Exams May 2018

10-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 4 pages.

Question 1: (a) 2, (b) 2, (c) 2, (d) 2, (e) 2, (f) 2, (g) 2, (h) 2, (i) 2, (j) 2
Question 2: (a) 5, (b) 3, (c) 3, (d) 3, (e) 6
Question 3: (a) 4, (b) 4, (c) 4, (d) 4, (e) 4
Question 4: (a) 4, (b) 6, (c) 4, (d) 6
Question 5: (a) 3, (b) 3, (c) 2, (d) 2, (e) 6, (f) 4
Question 6: 20
Question 7: (a) 5, (b) 5, (c) 5, (d) 5

Problem No. 1 (20 marks): Mineral Processing

Explain the meaning of the following terms:

(a) Comminution (2 marks)
(b) Bond work index (2 marks)
(c) Dense media separation (2 marks)
(d) Direct flotation (2 marks)
(e) Reverse flotation (2 marks)
(f) Tailings (2 marks)
(g) Middling (2 marks)
(h) Concentrate (2 marks)
(i) Selective flocculation (2 marks)
(j) Hydrophobicity (2 marks)

Problem No. 2 (20 marks): Mass Balance

A copper ore has a grade of 2.0 % Cu. After a flotation test, a concentrate with 20 % Cu was produced. The weight of dry concentrate was 9.09 % 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 22.5 % solids pulp density? (6 marks)

Problem No. 3 (20 marks): Pyrometallurgical processes

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

a) Carbothermic reduction (4 marks)
b) Zinc fuming (4 marks)
c) Magnetizing roast (4 marks)
d) Sulfating roast (4 marks)
e) Chloridizing roast (4 marks)

Any appropriate reaction can be picked as an example.

Problem No. 4 (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. 5 (20 marks): Iron and steelmaking

(a) What are three major feed materials for the production of iron in a blast furnace? (3 marks)
(b) What is the function of coke in the production of iron in a blast furnace? (3 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. 6 (20 marks): Heat balance

A charge of 2 kg copper is placed in a furnace at 25 °C. Calculate the heat input required (in J) to raise the temperature of copper to 1100 °C assuming no heat losses. Following thermodynamic data is provided:

	Value	Unit
C_P of Cu (solid)	$22.64 + 6.28 \times 10^{-3} T$	$J\ K^{-1}\ mol^{-1}$
C_P of Cu (liquid)	31.38	$J\ K^{-1}\ mol^{-1}$
Latent heat of fusion of Cu at the melting point	13,000	$J\ mol^{-1}$
Melting point of Cu	1083	°C
Atomic weight of Cu	63.57	

Problem No. 7 (20 marks): Electrometallurgy

Consider a galvanic cell based on the following reaction:

$$Sn\ (s) + Pb^{2+}\ (aq) \longrightarrow Sn^{2+}\ (aq) + Pb\ (s) \qquad (1)$$

(a) Calculate the standard cell potential (E^o) at 25 °C (5 marks)

(b) Calculate the standard free energy (ΔG^o) 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 Pb^{2+} is 0.1 M and concentration of Sn^{2+} is 1.0 M. (5 marks)

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

$Sn^{2+} + 2\ e^- \longrightarrow Sn\ (s)$ -0.137 V

$Pb^{2+} + 2\ e^- \longrightarrow Pb\ (s)$ -0.125 V