National Exams December 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) 3, (f) 3, (g) 3, (h) 3
Question 2: (a) 10, (b) 10
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) 8, (b) 2, (c) 8, (d) 2
Question 6: (a) 4, (b) 6, (c) 10
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) Direct flotation (2 marks)
b) Reverse flotation (2 marks)
c) Work of adhesion (2 marks)
d) Hydrophobicity (2 marks)

Explain the role of following reagents in flotation:

e) Collector (3 marks)
f) Frother (3 marks)
g) Activator (3 marks)
h) Depressant (3 marks)

Problem No. 2 (20 marks): Mass Balance

The flowsheet shown in Figure 1 illustrates a conventional closed circuit grinding operation. The mass of dry ore fed to flotation is 10 t/h. The feed from ore bin contains 5 % moisture. The cyclone feed, underflow and overflow contain 25%, 80% and 12.5% solids respectively.

(a) Calculate the circulating load on the circuit in dry t/h. (10 marks)

(b) Calculate the amount of water required to dilute the ball mill discharge. (10 marks)

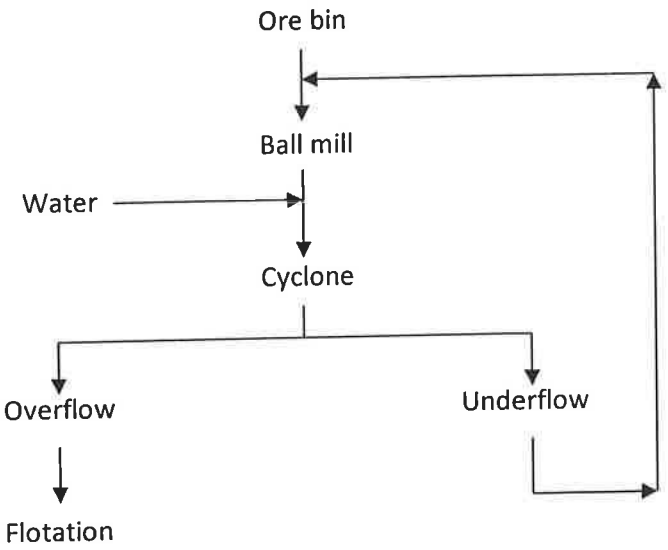

Figure 1: Closed circuit grinding flowsheet

Problem No. 3 (20 marks): Pyrometallurgical processes

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

a) Calcination (4 marks)
b) Oxidizing roast (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): Copper production

(a) Draw a process flow sheet for the production of copper from sulphide ores. (4 marks)
(b) Describe the process for production of copper from sulphide 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): Aluminum production

(a) Describe the Bayer process for the production of alumina. (8 marks)
(b) What is red mud? (2 marks)
(c) Describe the Hall-Heroult process for the production of aluminum? (8 marks)
(d) What is anode effect? (2 marks)

Problem No. 6 (20 marks): Heat balance

Titanium dioxide (solid) reacts with graphite and chlorine gas to form carbon monoxide gas and titanium tetrachloride (liquid). Following thermodynamic data is available at 25°C.

	TiO_2 (solid)	Cl_2 (g)	C (graphite)	CO (g)	$TiCl_4$ (l)
ΔH°_f ($kJmol^{-1}$)	-945			-110.5	-804
C_P ($JK^{-1}mol^{-1}$)	55.1	33.9	8.5	29.1	145.2

Assume that the heat capacities are independent of temperature.

a) Write the balanced chemical equation for the reaction. (4 marks)
b) Calculate ΔH° for the reaction at 25°C. (6 marks)
c) Calculate ΔH° for the reaction at 150°C. (10 marks)

Problem No. 7 (20 marks): Electrometallurgy

Consider a galvanic cell based on the following reaction:

$$Zn\ (s) + Cu^{2+}\ (aq) \longrightarrow Zn^{2+}\ (aq) + Cu\ (s)$$

(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 Cu^{2+} is 0.5 M and concentration of Zn^{2+} is 1.5 M. (5 marks)

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

$Zn^{2+} + 2\ e^- \longrightarrow Zn$	-0.76 V
$Cu^{2+} + 2\ e^- \longrightarrow Cu$	0.34 V