National Exams May 2015

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 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) 2, (d) 2, (e) 2, (f) 2, (g) 4
Question 4: (a) 6, (b) 4, (c) 6, (d) 4
Question 5: (a) 8, (b) 6, (c) 6
Question 6: (a) 4, (b) 6, (c) 4, (d) 6
Question 7: 20

Problem No. 1 (20 marks): Mineral Processing

Explain the meaning of the following terms:

a) Liberation (2 marks)
b) Concentration (2 marks)
c) Comminution (2 marks)
d) Gangue (2 marks)
e) Tailing (2 marks)
f) Middlings (2 marks)
g) Direct flotation (2 marks)
h) Reverse flotation (2 marks)
i) Flocculation (2 marks)
j) Thickening (2 marks)

Problem No. 2 (20 marks): Mass Balance

A copper ore has a grade of 2.1 % Cu. After a flotation test, a concentrate with 21 % Cu was produced. The weight of dry concentrate was 9.5 % 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 20 % solids pulp density? (6 marks)

Problem No. 3 (20 marks): Pyrometallurgical processes

Explain the following terms:

a) Low temperature Coking (4 marks)
b) High temperature Coking (4 marks)
c) Drying (2 marks)
d) Calcination (2 marks)
e) Roasting (2 marks)
f) Briquetting (2 marks)
g) Zinc fuming (4 marks)

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

(a) Describe the advantages of using oxygen instead of air in steelmaking. (6 marks)

(b) Which metals are used for deoxidation of steel and why? (4 marks)

(c) A Basic Oxygen Furnace (BOF) is treating a batch of 100 metric tonnes of pig iron (4 wt. % C, 1.5 wt. % Si, 0.75 wt. % Mn, rest Fe) by injecting pure oxygen gas. If all the impurities are removed and in addition 2.5 metric tonnes of iron is oxidized, how many kg of oxygen gas is required? Assume that half of carbon is oxidized to CO and half to CO_2. (6 marks)

(d) What is the composition of the slag in wt. % assuming all the FeO, MnO and SiO_2 report to the slag phase? (4 marks)

Atomic weights: Fe – 55.8; C – 12; O – 16; Mn – 54.9; Si – 28.1

Problem No. 5 (20 marks): Magnesium production

(a) Describe the silicothermic magnesium process (Pidgeon process) with the aid of chemical reactions. (8 marks)

(b) Describe the magnatherm process for the production of magnesium. (6 marks)

(c) Describe the electrolytic process for the production of magnesium. (6 marks)

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): Heat balance

A charge of 1 kg copper is placed in a furnace at 20 °C. Calculate the heat input required (in J) to raise the temperature of copper to 1200 °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	