December 2013

National Exams

-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) (i) 5, (a) (ii) 5, (b) (i) 5, (b) (ii) 5
Question 2: 20
Question 3: (a) 2, (b) 2, (c) 2, (d) 2, (e) 3, (f) 3, (g) 3, (h) 3
Question 4: (a) 2, (b) 4, (c) 2, (d) 2, (e) 2, (f) 8
Question 5: (a) 2, (b) 4, (c) 2, (d) 2, (e) 6, (f) 4
Question 6: (a) 8, (b) 6, (c) 6
Question 7: (a) 8, (b) 2, (c) 8, (d) 2

Problem No. 1 (20 marks): Mass Balance

(a) A slurry stream containing a solid ore is flowing at the rate of 5 m^3/h. The pulp density of the slurry is 1,350 kg/m^3. The density of solid ore is 2,500 kg/m^3.
(i) Calculate the % solids by weight. (5 marks)
(ii) Calculate the flow rate of solid within the slurry. (5 marks)

(b) A pump is fed by two slurry streams. First slurry stream is flowing at the rate of 10 m^3/h and contains 30 % solids. Second slurry stream is flowing at the rate of 20 m^3/h and contains 50 % solids. The density of solid ore in both streams is 2,750 kg/m^3.
(i) Calculate the % solids in the combined stream. (5 marks)
(ii) Calculate the tonnage of dry solids pumped per hour. (5 marks)

Problem No. 2 (20 marks): Heat balance

Given the following thermodynamic data, calculate the change in enthalpy when 1 kg of iron is heated from 100^{0}C to 1600^{0}C. (20 marks)

Solid α-Fe: $C_p = 17.5 + 24.8 \times 10^{-3}T$ J/(K mol)
α-β transformation at 760^{0}C: $\Delta H_{trf} = 2{,}760$ J/mol
Solid β-Fe: $C_p = 37.7$ J/(K mol)
β-γ transformation at 910^{0}C: $\Delta H_{trf} = 920$ J/mol
Solid γ-Fe: $C_p = 7.7 + 19.5 \times 10^{-3}T$ J/(K mol)
γ-δ transformation at 1400^{0}C: $\Delta H_{trf} = 1180$ J/mol
Solid δ-Fe: $C_p = 44$ J/(K mol)
Melting point at 1535^{0}C: $\Delta H_m = 15{,}680$ J/mol
Liquid Fe: $C_p = 42$ J/(K mol)

Problem No. 3 (20 marks): Flotation

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. 4 (20 marks): Pyrometallurgical processes

a) What is roasting? (2 marks)
b) Give two examples of roasting by writing balanced chemical reactions. (4 marks)
c) What is dead roasting? (2 marks)
d) What is chloridizing roasting? (2 marks)
e) Give an example of chloridizing roasting by writing a balanced chemical reaction. (2 marks)
f) ZnS is roasted with 25 % excess air. Calculate the composition of roast gas in volume %. (8 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? (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. 6 (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. 7 (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)