National Exams December 2014

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) 10, (b) 10
Question 3: (a) 4, (b) 4, (c) 4, (d) 4, (e) 4
Question 4: (a) 10, (b) 10
Question 5: (a) (i) 2, (ii) 2, (iii) 2, (iv) 2, (v) 2; (b) (i) 5, (ii) 5
Question 6: (a) 8, (b) 2, (c) 8, (d) 2
Question 7: (a) 4, (b) 6, (c) 10

Problem No. 1 (20 marks): Mineral Processing

Explain the meaning of the following terms:

a) Bond work index   (2 marks)
b) Classifying   (2 marks)
c) Direct flotation   (2 marks)
d) Reverse flotation   (2 marks)
e) Work of adhesion   (2 marks)
f) Hydrophobicity   (2 marks)
g) Coagulation   (2 marks)
h) Flocculation   (2 marks)
i) Selective flocculation   (2 marks)
j) Thickening   (2 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 100 t/h. The feed from ore bin contains 6 % moisture. The cyclone feed, underflow and overflow contain 30%, 75% and 15% solids respectively.

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

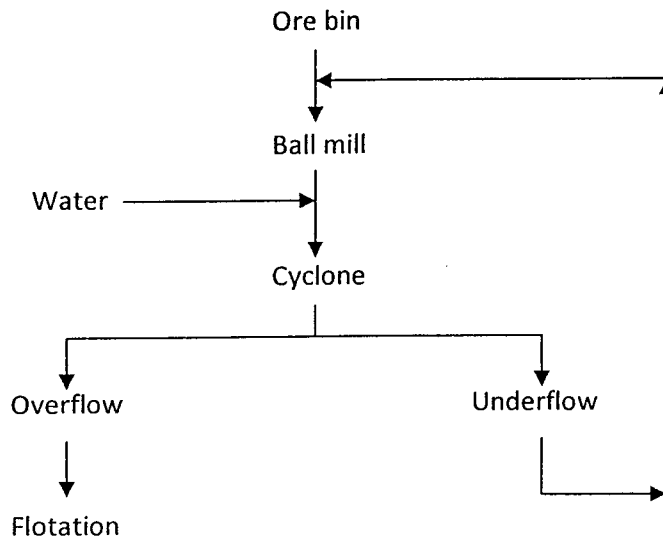(b) Calculate the amount of water required to dilute the ball mill discharge.   (10 marks)

Ore bin

Ball mill

Water

Cyclone

Overflow   Underflow

Flotation

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) 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): Pyrometallurgical processes/Refining

a) With the help of a phase diagram, explain the process of zone refining.   (10 marks)
b) With the help of appropriate chemical reactions and thermodynamic considerations, explain the process of vacuum refining.   (10 marks)

Problem No. 5 (20 marks): Hydrometallurgy/ solvent extraction

a) Explain the meaning of the following terms:

i) Extraction   (2 marks)
ii) Stripping   (2 marks)
iii) Phase ratio   (2 marks)
iv) Extractant   (2 marks)
v) Diluent   (2 marks)

b) A solution containing equal amounts of ions A and B is extracted by an organic solvent. Distribution ratio of A is 18, while distribution ratio of B is 3.
     i) Calculate the enrichment factor when aqueous to organic ratio is 2.   (5 marks)
     ii) Calculate the enrichment factor when aqueous to organic ratio is 12.   (5 marks)

Problem No. 6 (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. 7 (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)
$\Delta H^°_f$ (kJmol^{-1})	-945			-110.5	-804
C_P (JK^{-1}mol^{-1})	55.06	33.91	8.53	29.12	145.2

Assume that the heat capacities are independent of temperature.

    a) Write the balanced chemical equation for the reaction.   (4 marks)
    b) Calculate $\Delta H^°$ for the reaction at 25°C.   (6 marks)
    c) Calculate $\Delta H^°$ for the reaction at 130°C.   (10 marks)