NATIONAL PROFESSIONAL EXAMINATIONS

MAY 2003

98-MMP-A3 - Mineral Processing

DURATION : 3 hours

NOTES: (1) No notes or text books permitted.

(2)Candidates may use one of the approved Casio or Sharp calculators.

(3) Answer all questions.

(4) Show all calculations.

(5) The mark distribution is as follows:

Problem 1 (a) 10, (b) 4, (c) 3, (d) 4, (e) 5, (f) 5, (g), 5 (h) 4, Total 40

Problem 2 (a) 2, (b) 4, (c) 10, (d) 4 Total 20 marks

Problem 3 (a) 5,(b) 5, (c) 5, (d) 5 Total 20 marks

Problem 4 10 marks

Problem 5 10 marks

Bonus Question 2 marks

Problem 1. (40 marks)

Assume that a copper deposit was discovered in northern Ontario. Exploration drilling delineated 8 million tonnes of ore with an average grade of 5 percent copper. The deposit is located between 1000 and 1300 metres below the surface which will be extracted by underground mining.

The main copper-bearing mineral is chalcopyrite ($CuFeS_2$) with minor amounts of chalcocite and bornite. The gangue minerals are pyrite and silicates. The ore specific gravity is 3.0. Metallurgical test work found that the ore can be concentrated by standard milling methods to produce a 27 percent copper concentrate at a recovery of 80 percent.

The proposed 1500 tonne/day mine/mill will use an underground primary crusher followed by two stages of crushing to produce a minus 1/2-cm product. The ore will be ground to 20 percent plus 65 mesh (210 microns) using a rod mill followed by a ball mill operating in closed circuit with hydrocyclone classifiers. Grinding tests showed that the ore has a Work Index of 12 (kw-hr/short ton).

The flotation circuit will employ two stages of cleaning. A second small ball mill will be employed to regrind the cleaner tails and the scavenger concentrate. The regrind ball mill will operate in open circuit with the discharge returned to the conditioner. The concentrate will be thickened, filtered and dried prior to shipment by rail to the smelter. The concentrate will be sold to the smelter according to the following schedule:

(i) treatment charge, \$60/ tonne of concentrate
(ii) pay for 90 % of contained copper at the prevailing London Metal Exchange price

(a) Draw a flowsheet of the mill circuit showing the main flowstreams through the various operations as per the above description and your knowledge of mineral processing.

(b) If electrical power is available a 8¢/ Kw-hr, using Bond's equation estimate the power cost (in \$/day) required for comminution of the ore. List the assumptions made in your calculation.

Bond's Equation:

$$W = \frac{10W_i}{\sqrt{P}} - \frac{10W_i}{\sqrt{F}}$$

(c)Calculate the % copper in pure chalcopyrite. Given atomic weights:
Copper.....63.5
Iron.....55.9
Sulphur....32.0

(d) Calculate the copper content of the mill tailings

(e) Using the following economic factors, calculate the net operating profit (in $/day) of the operation (i.e. income minus operating costs)

Mining cost $40/tonne
Milling cost.....$ 5/tonne
Freight to Smelter.....$30/tonne
LME copper price.....$2500/tonne

(f) Calculate the percent economic efficiency.

(g) Using the Gy equation calculate the required size of sample of the grinding circuit feed (i.e. fine ore bin discharge) required to obtain a copper assay that is accurate to within 0.1% Cu, 95 times out of 100. Assume a value of C of 0.6 g/cm^3 .

Gy Equation :

$$M = \frac{C\, d^3}{s^2}$$

(h) What flotation reagents would you recommend be used in the flotation circuit for this ore.

Problem 2. (20 marks)

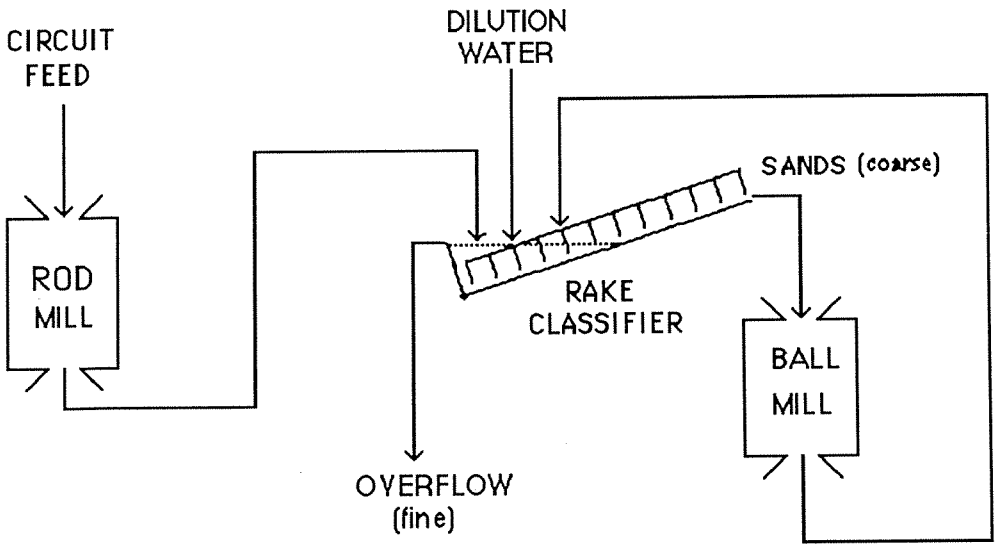

FIGURE 1. Layout of Grinding Circuit for Problem 2

A two-stage grinding circuit using a rod mill in open circuit with a ball mill in closed circuit with a rake classifier is used to grind 50 tonnes per hour of ore (SG 3.0). The circuit layout is illustrated in Figure 1 above. Assume that the circuit was sampled and the results were as follows:

Stream	%solids by wt	% - 100 microns
Circuit (Rod Mill) Feed	80	5
Rod Mill Discharge	80	20
Classifier Sands (Ball Mill Feed)	75	20
Classifier Overflow	33.3	75
Ball Mill Discharge	75	47.5

Using the above data carry out a material balance and calculate the following:

(a) the tonnes/hour of solids in the classifier overflow.

(b) the tonnes/hour of dilution water added to the rake classifier

(c) the percent circulating load in the ball mill circuit.

(d) the specific gravity of the ball mill discharge slurry.

Problem 3. (20 marks).

Describe using sketches the following unit operations. Explain the principles of operation and applications to mineral processing.

(a) Gravitational dense medium separator

(b) Hydrocyclone classifier

(c) Autogenous grinding mill

(d) Shaking table

Problem 4 (10 marks)

Describe in some detail using sketches the action of a flocculant and a coagulant.

Problem 5 (10 marks)

Describe in some detail using sketches the carbon-in-pulp gold leaching process and explain how it differs from the standard Merrill Crowe process.

Bonus Question (2 marks):

In 2002 the top non-petroleum mineral commodities produced in Canada In terms of value of production were:

Cement, Copper, Coal, Diamonds, Gold, Iron Ore, Nickel, Potash, Sand & Gravel, Uranium, & Zinc.

Which two of these commodities is Canada the world's leading producer?