NATIONAL PROFESSIONAL EXAMINATIONS

DECEMBER 2016

10-Met-B1 - Mineral Processing

DURATION: 3 hours

NOTES:

(1) This is a CLOSED BOOK EXAM. No notes or textbooks permitted.

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

(3) Answer all questions except where otherwise noted i.e. Problem 5.

(4) Show all calculations.

(5) 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.

(6) Hand in page 5 with your examination booklet

(7) The mark distribution is as follows:

Problem 1 (a) 10, (b) 5 (c) 5 (d) 5 (e) 5 Total 30

Problem 2 (a) 2 (b) 8 (c) 6 (d) 4 20 marks

Problem 3 5 marks

Problem 4 5 marks

Problem 5 Five marks each Total 30 marks

Problem 6 One mark each total 10 marks

Bonus Question 2 marks

Problem 1. (30 marks)

Assume that a copper deposit was discovered in northern Quebec. Exploration drilling delineated 8 million tonnes of ore with an average grade of 1 percent copper. The deposit is located between 300 and 500 metres below the surface which will be extracted by underground mining.

The main copper-bearing mineral is chalcopyrite ($CuFeS_2$, 34.6 % Copper) 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 95 percent.

The proposed 1500 tonne/day mine/mill will use an underground primary jaw crusher followed by two stages of crushing to produce a minus 1.5-cm (15,000 microns) product. The ore will be ground to 95 percent minus 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/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 a smelter according to the following schedule:

(i) treatment charge, $100/ tonne of concentrate

(ii)pay for 90 % of contained copper at the prevailing London Metal Exchange price

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

(b) Calculate the copper content of the mill tailings.

(c) If electrical power is available a 20¢/ 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:

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

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

Mining cost .....$ 30/ton
Milling cost.....$ 6/ton
Freight to Smelter.....$ 50/ton
LME copper price.....$7000/ton

(e) 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 1.0 g/cm^3 .

Gy Equation :

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

Problem 2. (20 marks)

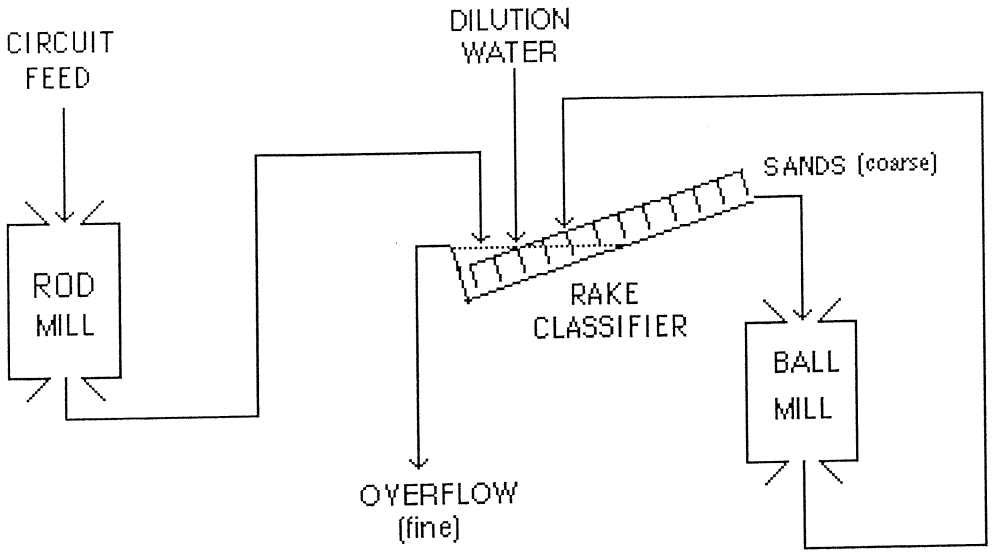

FIGURE 1. Layout of Grinding Circuit for Problem 2

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 30 tons 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 solids in the classier sands (coarse product).

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

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

Problem 3. (5 marks).

A flotation kinetics test was carried out on an oil sands sample. The results were as follows:

Flotation Time Minutes	Bitumen Recovery
1	60%
12	90%
15	90%

Assuming that the flotation follows the following first order rate equation:

$$R = RI\,[1 - \exp(-kt)]$$

(a) Using the available data determine the parameters RI and k.
(b) Determine the flotation time required to achieve an 80% recovery.

Problem 4. (5 marks)

$$V = \frac{g\ d^2\ (D_s - D_f)}{18\ \mu}$$

(a) Using Stokes' equation (given above) calculate the diameter of a coal particle (Specific gravity 1.3) which would settle in water at the same velocity as a 40-micron diameter quartz (Specific gravity 2.65) particle settling in water.

(b) Repeat the calculation in part (a) for both particles settling in air.

Problem 5. **(30 marks).**

Using sketches describe the following terms as they relate to mineral processing. Answer any **SIX** of the following ten topics.

Gravitational dense medium separator
Hydrocyclone classifier
Tabling
Zeta Potential
Flotation Column
Tailings dams
Flocculation
Frother
Xanthate
Thickener

HAND IN THIS PAGE WITH YOUR EXAMINATION BOOKLET. Answer in the spaces provided.

Problem 6. **10 marks**

HAND IN THIS PAGE WITH YOUR EXAM BOOKLET

From the list provided, choose the word(s) which best describes the following statements:

(a) The main lead-bearing ore mineral _____

(b) The percentage of mineral occurring as free particles._____

(c) Ratio of concentrate grade to the feed grade _____

(d) The energy consumed in size reduction is proportional to the area of the new surface produced _____

(e) Jaw crusher pivoted at the top _____

(f) An autogenous tumbling mill that utilizes steel balls in addition to the natural grinding media_____

(g) $\frac{d_{75} - d_{25}}{2d_{50}}$ _____

(h) Flotation reagent that alters the chemical nature of mineral surfaces so that they become hydrophobic due to the action of the collector_____

(i) Common flotation depressant for sulphide minerals _____

(j) A gravity concentration unit operation that uses a pulsating current of water to separate minerals_____

Table	Activator	Quebracho
Universal	Amine	Pulsator
Plombite	Hutch	Gaudin
Cutpoint	Bond	Zeta Potential
Ratio of concentration	Copper sulphate	Centrifuge
Flowing film concentrator	Galena	Contact angle
Middlings	Jig	von Rittinger
MIBC	Blake	Frother
Gangue	Kick	Humphreys spiral
Spiral	Tromp	Partition parameter
Imperfection	Sphalerite	SAG
Ratio of enrichment	Dodge	Fatty acid
Probable error	Separation efficiency	Cyanide
Degree of liberation	Ratio of reduction	Collector
Cerussite	High tension	Tromp

Bonus Question (2 marks)

Two metal commodities which currently sell for less than $3/kg

_____ and _____.