NATIONAL PROFESSIONAL EXAMINATIONS

MAY 2011

09-MMP-A3 - 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.

(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) The mark distribution is as follows:

Problem 1 (a) 10, (b) 8, (c) 4, (d) 3 (e) 5 Total 30

Problem 2 (a) 11 (b) 4, (c) 3, (d) 3 (e) 4 Total 25 marks

Problem 3 Part A or B Total 5 marks

Problem 4 Five marks each Total 30 marks

Problem 5 Total 10 Marks

Bonus Question 2 marks

Unit conversions:

1 tonne = 1000kg = 2202.6 lb
1 ton = 2000 lb
1 inch = 2.54 cm = 25,400 microns (μm)

Problem 1. (25 marks)

The publication *Canadian Milling Practice* **contains** the following description of the Nanisivik zinc mine which operated in the Canadian high arctic from 1976 to 2002.

> *The Nanisivik mill processes 2250 tonnes per day of ore. The economic mineralization of the ore is sphalerite (ZnS, 67.1% Zn).*
> *The plant has an operating availability of 95% with the balance consisting of planned maintenance shutdowns.*
> *The grinding section consists of a conventional circuit with primary grinding provided by a 2.9 m by 3.7 m rod mill and secondary grinding provided by a 3.2 m by 3.7 m ball mill. Classification is provided by three 38 cm cyclones with the flotation feed size of 60% -200 mesh (75 μm). The grinding index of the ore is 9 kWh per tonne milled. Grinding media consumption is 900 g/t split evenly between rods and balls.*
> *The flotation section consists of a rougher, scavenger and three cleaning stages. All flotation cells are Denver 30s. Rougher concentrates are reground in a 1.8 m by 2.7 m zinc concentrate regrind mill to a fineness of 80% - 75 μm. The flotation circuits are operated at a pH in the 12.2 range, which results in lime consumption in the order of 2300 g/t milled. The main collector is potassium amyl xanthate with consumptions totaling 150 g/t milled. Copper sulphate is added to the conditioning stage and represents 535 g/t milled in total consumption.*
> *The metallurgical performance is consistent with a concentrate grade of 57.5% zinc and a recovery of 96.5%.*
> *The dewatering section consists of conventional thickeners, vacuum disk filters and rotary dryers. The heat for the dryers is supplied from the power plant diesel exhaust gas. Concentrates are dried to 5% moisture and conveyed to the load out areas for haulage to the main storage facility capable of storing 125,000 t of concentrates.*

(a) Sketch the flow sheet of the milling circuit described above.

(b) If the feed grade is 6.91 % Zn,
(i) calculate the tonnes per year of zinc concentrate produced.
(ii) calculate the grade of the tailings (% Zn).

(c) Making reasonable assumptions, and using Bond's equation, calculates the net power (kilowatts) required for grinding of the ore. List the assumptions made.

Bond's Equation:

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

(d) Explain why copper sulphate is added to the flotation conditioner.

(e) Using the Gy equation calculate the required size of sample of the zinc concentrate required to obtain a zinc assay that is accurate to within 0.1% Zn, 95 times out of 100. Assume a value of C of 5.0 g/cm^3.

Gy Equation :

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

Problem 2. (25 marks)
A copper flotation circuit is used to concentrate 100 tonnes per hour of ore (valuable mineral is chalcopyrite (specific gravity 4.2, containing 34.6 % copper) with a siliceous gangue (specific gravity 2.6). The circuit layout is shown on the sketch below:

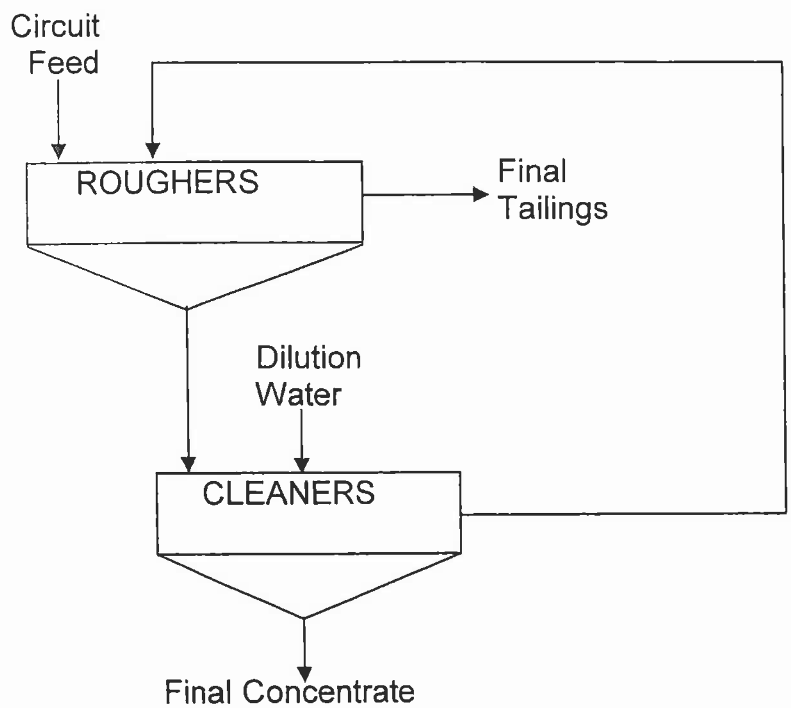

FIGURE 1. Layout of Flotation Circuit for Problem 2

Assume that the above circuit was sampled and the results were as follows:

Stream	%solids by wt	% Cu
Circuit Feed	33.3	0.5
Rougher concentrate	50	13.89
Final Concentrate	40	25
Cleaner Tailings	8.62	5
Final Tailings	31.2	0.1016

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

(a) the copper recovery in (i) the circuit
(ii) the cleaners
(iii) the roughers

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

(c) the tonnes/hour of final concentrate produced

(d) the tonnes/hour of solids recirculated back to the roughers i.e. the cleaner tailings.

(e) the specific gravity of the final concentrate solids

Problem 3. (5 marks).
ONLY ANSWER PART A OR PART B OF THIS QUESTION.
PART A
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:

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

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

PART B

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

(a) Using Stokes' equation (given above) calculate the diameter of a coal particle (Specific gravity 1.4) which would settle in water at the same velocity as a 30-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 4. (30 marks)
With the aid of sketches describe the operating principles and application of the following mineral processing unit operations. ANSWER ANY <u>**SIX**</u> OF THE FOLLOWING NINE TOPICS:

Dense (heavy) medium cyclone
Shaking table
Jig
Flotation column
Continuous thickener
High tension (electrostatic) separator
Jaw crusher
Spiral (Humphreys) concentrator
Rotary (Bradford) Coal Breaker

Problem 5. True False. (Total 10 marks)

Indicate whether the statement is true or false. If it is false, correct it to form a positive statement. For example if the statement was:

"Toronto is the capital of Canada."

You would declare the statement as being false and correct it by:

"Ottawa is the capital of Canada." OR "Toronto is the capital of Ontario."

But you could not correct it with a negative statement such as:

"Toronto is not the capital of Canada"

(i) Iron is the most abundant metal in the earth's crust.

(ii) Galena is the main lead-bearing ore mineral.

(iii) Kick's theory of comminution is that the energy consumed in size reduction is proportional to the area of new surface produced.

(iv) Separation Efficiency = R_m - R_g

where R_m = % recovery of the valuable mineral

R_g = % recovery of gangue into the concentrate

(v) $Imperfection = \frac{d_{75} - d_{25}}{2}$

(vi) A contact angle of zero means the solid surface is hydrophobic.

(vii) Zeta potential is the particle surface electrical charge relative to the surrounding aqueous medium.

Bonus Question (2 marks):

List two mineral commodities for which Canada has no mine production.