NATIONAL PROFESSIONAL EXAMINATIONS

MAY 2010

98-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 Total 25

Problem 2 (a) 2, (b) 3, (c) 10, (d) 5 Total 20 marks

Problem 3 (a) 4 (b) 2 Total 6 marks

Problem 4 (a) 4 (b) 3 Total 7 marks

Problem 5 Six marks each Total 30 marks

Problem 6 Two marks each total 12 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.

Problem 2. (20 marks)

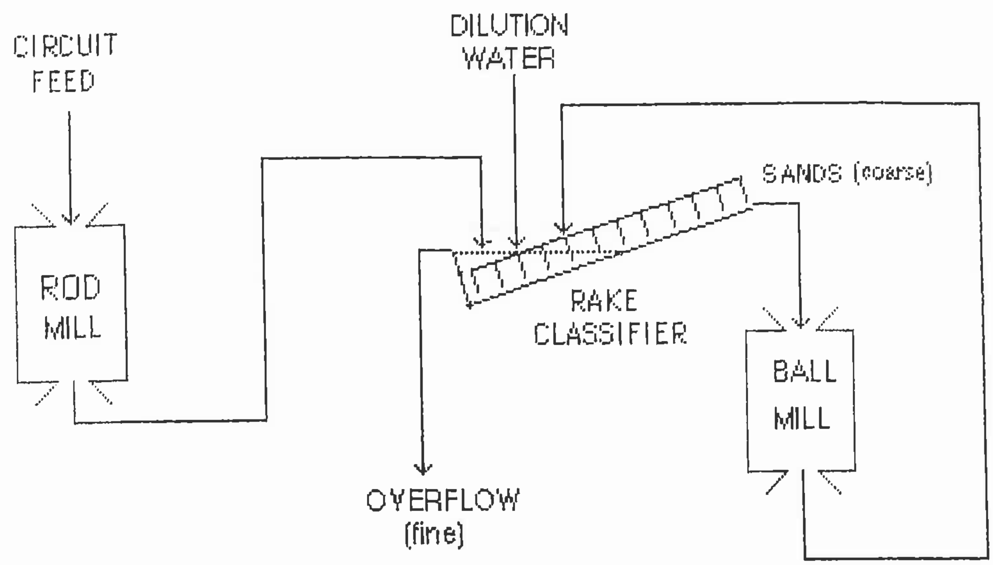

FIGURE 1. Layout of Grinding Circuit for Problem 2

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 40 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. (7 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%

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. (7 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 1.4) which would settle in water at the same rate 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)

Explain the similarities and differences between the following terms as they are related to mineral processing. Use sketches in your answers. **Only answer any five (5).**

(i) Coagulation/flocculation

(ii) Dense medium/classification cyclone

(iii) Upstream/downstream tailings dam

(iv) Frother/collector

(v) Gyratory/cone crusher

(vi) Merrill-Crowe/carbon-in-pulp process

(vii) Separation/economic efficiency

(viii) Mechanical/column flotation cell

(ix) d_{50}/d_{50c}

(x) Cataracting/cascading medium.

Problem 6. Short answer questions. (Total 12 marks)

(a) Explain the difference between 'ore' and 'mineral'.

(b) List two particle size analysis techniques other than sieving.

(c) Why is the heap leaching of gold usually more economical than leaching in stirred tanks?

(d) List two limitations of Stokes Law (see Problem 5).

(e) With the aid of a sketch, explain the concept of contact angle.

(f) What are the two most abundant metals present in the earth's crust?

Bonus Question (2 marks):

In 2008 the top 10 non-petroleum mineral commodities produced in Canada in terms of value of production (in alphabetical order) were:
Copper, Coal, Diamonds, Gold, Iron Ore, Nickel, Potash, Sulphur, Uranium, & Zinc.

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