NATIONAL PROFESSIONAL EXAMINATIONS

DECEMBER 2010

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, i.e. in Problem 3.

(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 five (fill in blanks for Problem 6) and page six (plot for problem 4) with your examination booklet.

(7) The mark distribution is as follows:

Problem 1 Total 25 marks

Problem 2 Total 20 marks

Problem 3 Five Marks for each part, Total 30 marks

Problem 4 8 marks

Problem 5 7 marks

Problem 6 10 marks

Problem 1. (25 marks)

Assume that a copper deposit was discovered in northern Quebec. Exploration drilling delineated 8 million tonnes of ore with an average grade of 2 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 ($CuFeS_2$, 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 80 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 10 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/tonne).

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 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) Calculate the copper content of the mill tailings

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

Mining cost .....$ 50/tonne
Milling cost.....$ 10/tonne
Freight to Smelter.....$ 50/tonne
LME copper price.....$7000/tonne

(d) Calculate the percent economic efficiency.

(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)

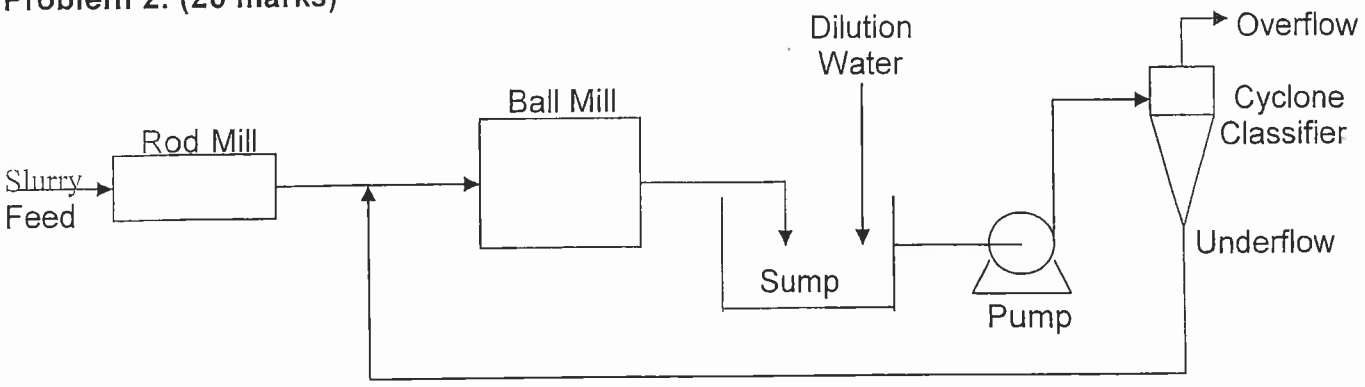

FIGURE 1. Layout of Grinding Circuit for Problem 2

A two-stage grinding circuit using a rod mill in open circuit with a ball mill in closed circuit with a cyclone classifier is used to grind 100 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:

	Percent - 200 mesh	Percent solids by weight	80 % passing Size Microns
Rod Mill Discharge	5	75	3600
Ball Mill Discharge	20	75	529
Cyclone Overflow	30	40	289
Cyclone Underflow	15	75	784

(a) Carry out a material balance and calculate the solids recirculating load (in %). **(8 marks)**

(b) Calculate the tons/hour of dilution water added to the sump. **(6 marks)**

(c) If the work index is 14, calculate the net power (kilowatts) required by the ball mill. **(4 marks)**
Bond's Equation:

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

(d) Calculate the specific gravity of the cyclone underflow slurry. **(2 marks)**

Problem 3. **(30 marks).**

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

- Gravitational dense medium separator
- Hydrocyclone classifier
- Spiral
- Zeta Potential
- Flotation Column
- Rod Mill
- Flocculation
- Frother
- Xanthate
- d_{50c}

Problem 4. (8 marks).
A sieve analysis was carried out on an ore and the results were as follows:

Size Microns	Weight g
+300	48
-300+150	43
-150+75	27
-75	42

Using the log-log graph paper provided on page six, plot the Cumulative Weight Percent Passing verses the Particle Size in microns. From the plot determine:

(a) the mass median size (50% passing size) in microns

(b) the estimated percentage of material in the –75+37 micron fraction

Problem 5 (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 6. **10 marks**

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From the list provided, choose the term which best describes the following statements:

(a) The main zinc-bearing ore mineral _____

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

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

(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 pf 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
Universal	Amine
Zincite	SMD
Cutpoint	Bond
Ratio of concentration	Copper sulphate
Contact angle	Galena
Middlings	Jig
MIBC	Blake
von Rittinger	Kick
Spiral	Tromp
Imperfection	Sphalerite
Ratio of enrichment	Dodge
Probable error	Separation efficiency
Degree of liberation	Ratio of reduction
Collector	Cyanide
Frother	SAG

Bonus Question (2 marks):

Name two metals produced in Canada which currently sell for less than $1.50 per pound.

_____ _____

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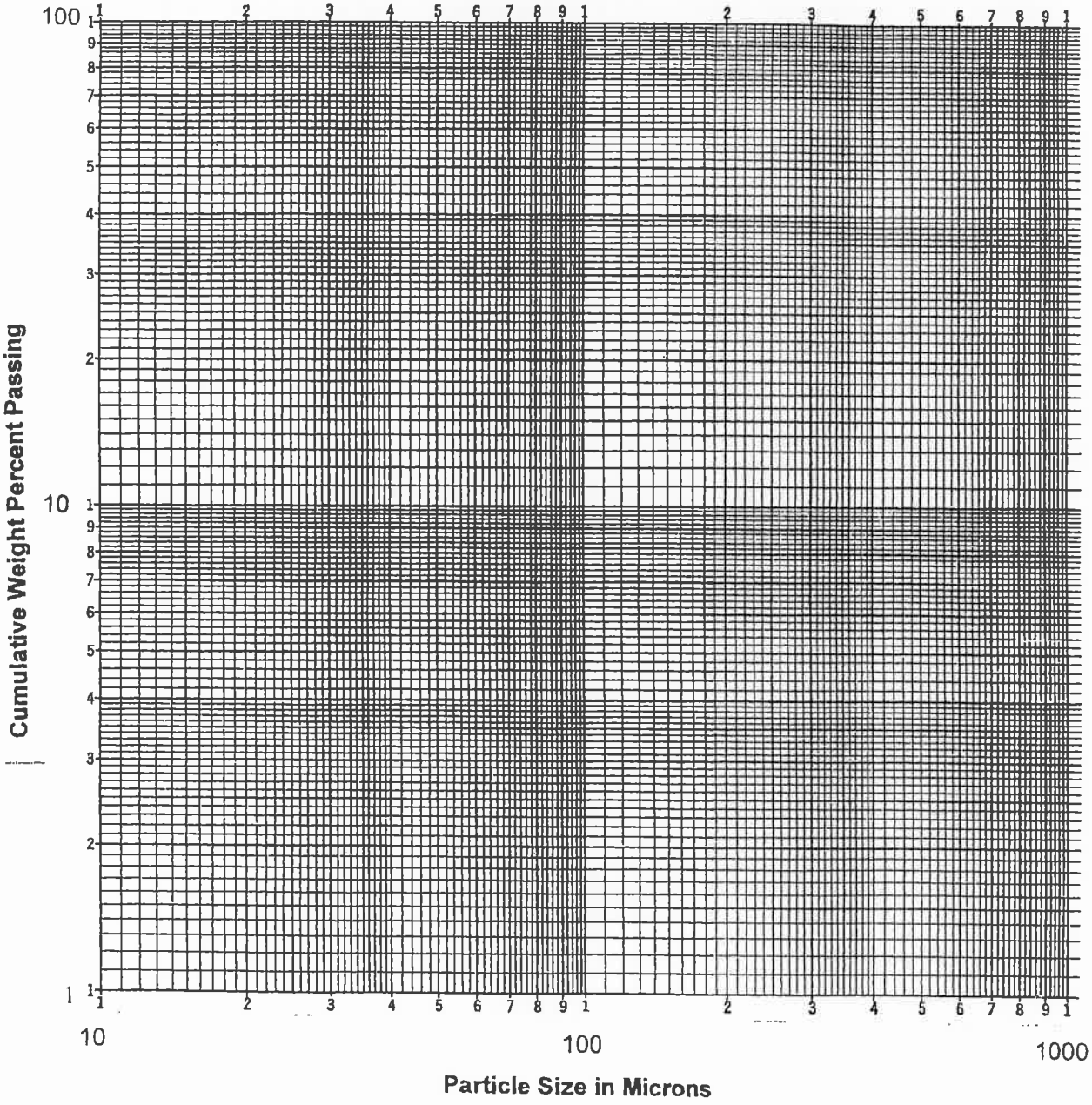

Figure 2. Size Analysis Graph for Problem 4