NATIONAL PROFESSIONAL EXAMINATIONS

MAY 2013

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. problem 3.

(4) Show all calculations.

(5)Pages 5 and 6 are to be handed in with the examination booklet

(6) 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.

(7) The mark distribution is as follows:

Problem 1 (i) 7, (ii) 5, (iii) 4, (iv) 1, (v) 2, (vi, a) 6 , (vi, b) 3, (vii) 4 Total 32

Problem 2 (i) 7, (ii) 5, (iii) 4, (d) 2 Total marks 18

Problem 3 5 marks each Total 30 marks

Problem 4 Plot 5, (i) 2, (ii) 3 Total 10 marks

Problem 5 One mark each Total 10 marks

Bonus Question 2 marks

1. The publication *Milling in Canada* contains the following description of the copper flotation circuit at the Gibraltar Mine located in central British Columbia:

> The three grinding circuits each feed an individual flotation bank of 16 Denver 600H flotation cells. Rougher flotation is carried out at 42% to 44% solids and is operated at a pH of 9.6 to 10.2, with lime addition to the rod mill. Sodium isopropyl xanthate is added to the cyclone overflow as a flotation collector; Orform F-2 is added to the cyclone overflow as a frother.
>
> Concentrate from all three flotation cell banks are combined and pumped to a regrind circuit. The bulk regrind mill is 9.5 ft diam. by 14 ft long ball mill powered by a 670 hp motor in closed circuit with one 20 in. horizontal Krebs cyclone.
>
> The bulk regrind cyclone overflow flows by gravity to a column surge tank. A 10 in. by 8 in. SRL pump on the column surge tank pumps to one of two 7 ft by 40 ft high column flotation cells. The two column flotation cells operate in series with the tail of the first feeding the second column. The concentrate from the two columns grading 28% copper is combined and pumped to the concentrate thickener. The tails of the second column is pumped to a bank of sixteen 300H Denver flotation cells. The concentrate from the column scavenger flotation cells flows by gravity to the column feed surge tank where it combines with the regrind cyclone overflow. The tails of the column scavenger flotation cells flows by gravity to the final tailings box.

(i) Sketch the flow sheet of the flotation circuit described above. **(7 marks)**

(ii) If the feed grade is 0.31 % Cu and the copper recovery is 80% calculate the grade of the tailings (% Cu). **(5 marks)**

(iii) If the mill processes 30,000 tonnes per day of ore, calculate the tonnes of concentrate produced each day. **(4 marks)**

(iv) Calculate the % copper in pure chalcopyrite ($CuFeS_2$). **(1 mark)**

Given atomic weights:
Copper.....63.5
Iron.....55.8
Sulphur.....32.1

(v) If the only copper-bearing mineral in the ore is chalcopyrite, calculate the percentage of chalcopyrite in the copper concentrate.**(2 marks)**

(vi) If the economic factors for the mining and milling operation are:

mining cost $3.00/tonne of ore
milling cost $4.00/tonne of ore
concentrate freight $150/tonne
smelting charges...$250/tonne
operating days per year.....350

and payment is received for the copper contained in the concentrate at the rate of $7/kilogram, calculate

(a) the economic efficiency (in %) **(6 marks)**

(b) the net operating profit (i.e. revenues minus costs) in $ million/year **(3 marks)**

(vii) If the ore is ground to 95% passing 200 microns, using Gy's equation calculate the weight of sample required to maintain the sampling error to within ± 0.01% Cu, 95% of the time.

Gy's Equation $M = \frac{C\,d^3}{s^2}$ assume C = 60 g/cm^3 **(4 marks)**

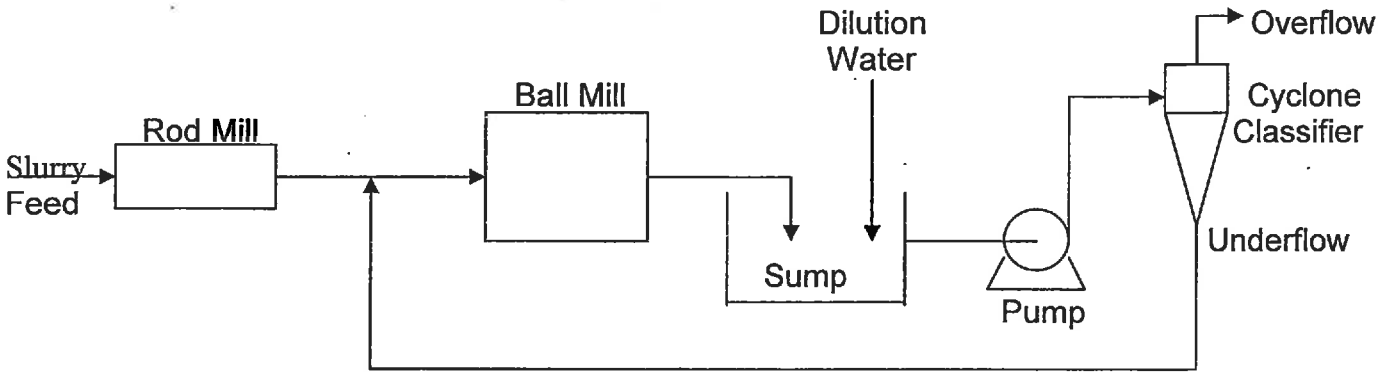

FIGURE 1. Layout of Grinding Circuit for Problem 2

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

(i) Carry out a material balance and calculate the solids circulating load (in %). **(7 marks)**

(ii) Calculate the tons/hour of dilution water added to the sump. **(5 marks)**

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

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

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

3. Explain the similarities and differences between the following terms as they are related to mineral processing. Use sketches in your answers. **Answer any six (6) (30 marks)**

(i) Coagulation/flocculation
(ii) Jig/shaking table
(iii) Mechanical/column flotation cell
(iv) Frother/collector
(v) Gyratory/cone crusher
(vi) Dense Medium/classification cyclone
(vii) Upstream/downstream tailings dam
(viii) Magnetic/high-tension separator
(ix) d_{50}/d_{50c}

Problem 4.
Given that a sieve analysis was carried out on an ore with the results as follows:

Size Microns	Weight g
+425	17
-425+300	31
-300+212	24
-212+150	19
-150+106	15
-106+75	12
-75	42

Using the log-log graph paper provided on page six, plot the Cumulative Weight Percent Passing versus the Particle Size in microns **(5 marks)**. From the plot determine:

(i) the mass median size (50% passing size) in microns. **(2 marks)**

(ii) the estimated percentage of material in the –75+37 micron fraction. **(3 marks)**

Problem 5. **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 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 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
Zincite	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

Bonus Question (2 marks):

List two mineral commodities produced in Canada that are routinely processed using Dense (Heavy) Medium Separation.

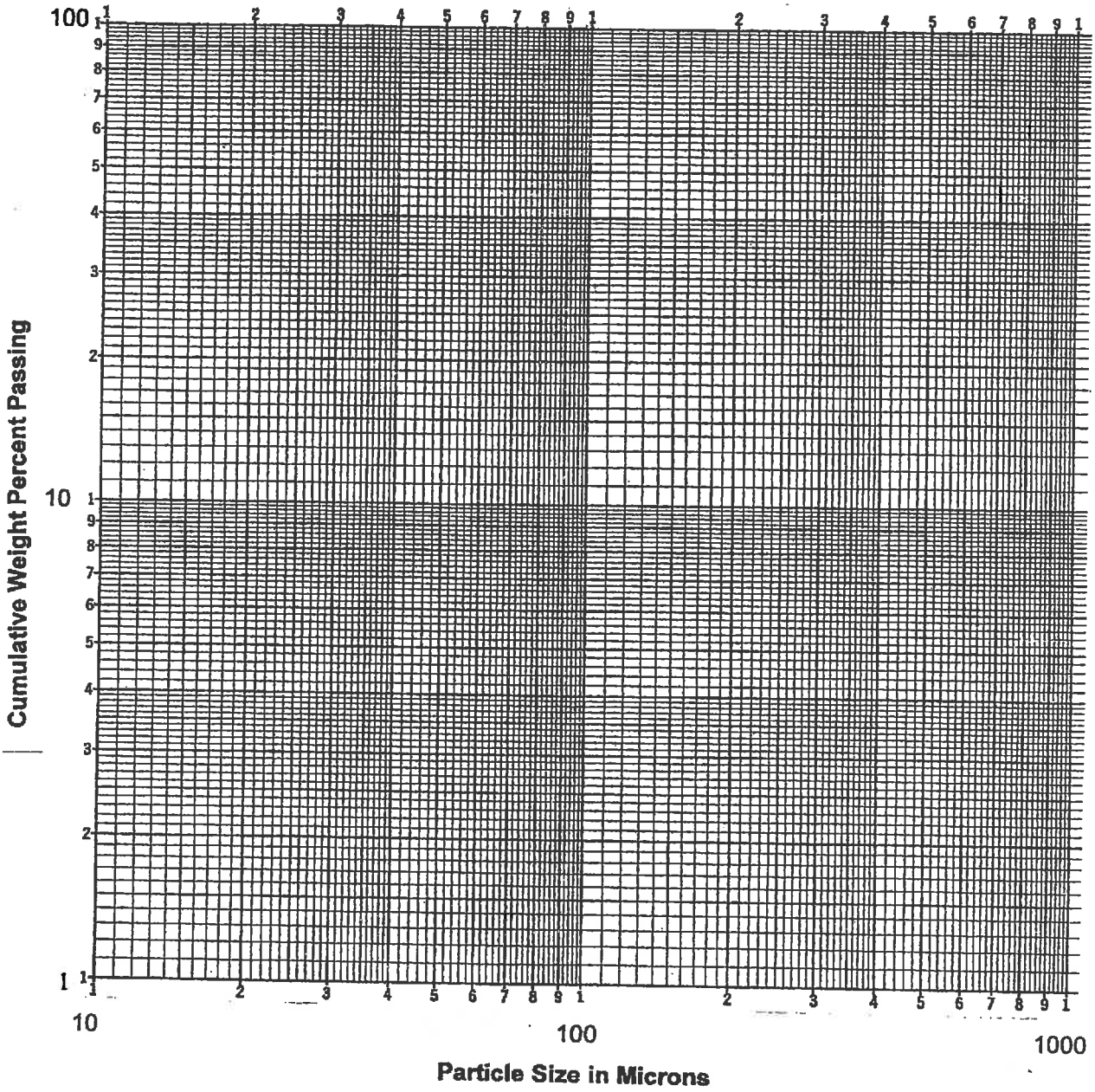

Figure 2. Size Analysis Graph for Problem 4