National Exams May 2019

09-MMP-A3, Mineral Processing

3 hours duration

NOTES:

1. 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.

2. This is a CLOSED BOOK EXAM.

3. Approved Casio or Sharp calculator is permitted.

4. Three (3) questions constitute a complete exam paper.

5. Marking scheme:

Question 1.	(1) 6; (2) 6; (3) 4; (4) 2; (5) 2; (6i) 6; (6ii) 4. Total 30 marks.
Question 2.	(1) 8; (2) 6; (3) 10; (4) 2. Total 26 marks
Question 3.	4 marks each. Total 44 marks.
Grand Total	100 marks

QUESTION 1

The publication *Milling Practice 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.

(1) Sketch the flow sheet of the flotation circuit described above. **(6 marks)**
(2) If the feed grade is 0.31% Cu and the copper recovery is 80%, calculate the grade of the tailings. **(6 marks)**
(3) If the mill processes 30,000 tonnes per day of ore, calculate the tonnes of concentrate produced each day. **(4 marks)**
(4) Calculate the % copper in pure chalcopyrite ($CuFeS_2$). Atomic mass Cu 63.5, Fe 55.8, S 32. **(2 marks)**
(5) If the only copper-bearing mineral in the ore is chalcopyrite, calculate the percentage of chalcopyrite in the copper concentrate. **(2 marks)**
(6) 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

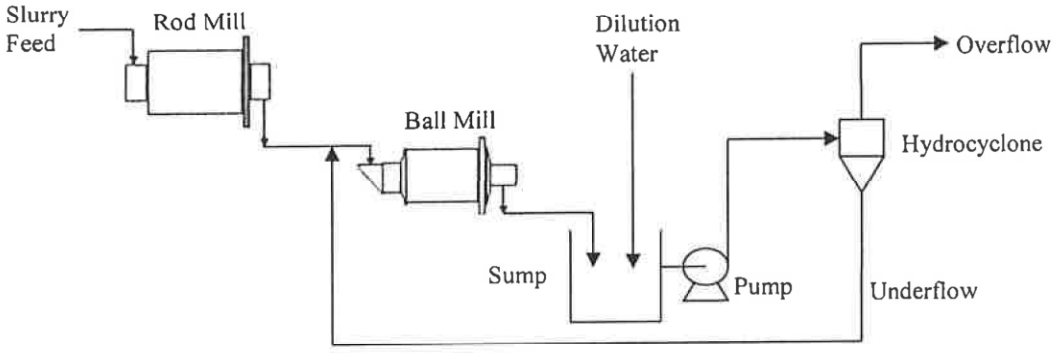
and payment is received for the copper contained in the concentrate at the rate of \$7/kg, calculate:

(i) the Economic Efficiency (in %). **(6 marks)**
(ii) the operating profit in million \$ / year. **(4 marks)**

QUESTION 2

A two-stage grinding circuit using a 3 m diameter, 5 m long rod mill in open circuit and a 3 m diameter, 3.5 m long ball mill in closed circuit with a hydrocyclone classifier is used to grind 100 tonnes/hour of ore . The circuit layout is shown in the figure below. At steady state, the circuit was sampled and the results were as follows:

	wt% solids	wt% passing 74 μm	80% passing size, μm
Rod mill feed	80	5	4000
Rod mill discharge	80	15	900
Ball mill discharge	77	40	121
Hydrocyclone overflow	35	75	81
Hydrocyclone underflow	75	25	400



(1) Calculate the solids circulation load for the ball mill (in %). **(8 marks)**

(2) Calculate the tonnes/hour dilution water added to the sump. **(6 marks)**

(3) If the Bond Work Index of the ore is 14 kWh/tonne, calculate the power rating of the ball mill (in kW). Bond equation is: $W = 10W_i\left[\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}}\right]$. **(10 marks)**

(4) Calculate the specific gravity of the cyclone underflow slurry. The specific gravity of the ore is 3.0. **(2 marks)**

QUESTION 3

Answer eleven (11) of the following 13 questions **(4 marks each)**

(1) With reference to QUESTION 2, if the circuit operator wishes to produce a finer product, i.e., cyclone overflow, list two appropriate control actions he/she might take.

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

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

(4) Stokes equation gives the terminal settling velocity of a particle in a fluid. This equation can be written as $v = \frac{d^2 g(D_s - D_f)}{18\eta}$. List two limitations of this equation.

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

(6) "The percentage of the mineral occurring as free particles in the ore in relation to the total content of the mineral." The above phrase is the definition of?

(7) In the equation $E_p = \frac{d_{75} - d_{25}}{2}$, what is E_p known as and what does it measure?

(8) Sketch the structural formula of sodium ethyl xanthate.

(9) Through BET surface area measurement, it is found that the specific surface area of a powder sample is 1.4 m^2/g and the density of the powder solids is 2.6 g/cm^3. What is the specific surface diameter (d_{SV}) of the sample?

(10) A sample of a hydrocyclone underflow slurry weighs 1,142 grams and measures 650 mL. If the density of solids is 2.6 g/cm^3, what is the concentration of the solids in wt%?

(11) In the above question (10), what is the concentration of the solids in vol%?

(12) In a fire assay, the final gold bead weighs 0.5 mg, what is the gold grade of the ore (g/t)? (In fire assay, one assay-ton is 29.17 g).

(13) In a standard Bond Grindability test on a -6 mesh ore sample with an 80% passing size of 2350 µm, when the circuit reached steady state with 250% circulation load, one revolution of the ball mill rotation generated 1.6 grams (net) of -105 µm material with an 80% passing size of 89 µm. What is the Bond Work Index of the ore?

$$W_i = \frac{44.5}{P_1^{0.23} G^{0.82} \left[\frac{10}{\sqrt{P_{80}}} - \frac{10}{\sqrt{F_{80}}} \right]}$$