

# NATIONAL PROFESSIONAL EXAMINATIONS

**MAY 2015**

**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 Problems 4 and 5.**
- (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) 5 (d) 4 (e) 7 Total 34 marks**

**Problem 2 (a) 3 (b) 4 Total 7 marks**

**Problem 3 (a) 8 (b) 5 (c) 4 Total 17 marks**

**Problem 4 Six marks for each part Total 30 marks**

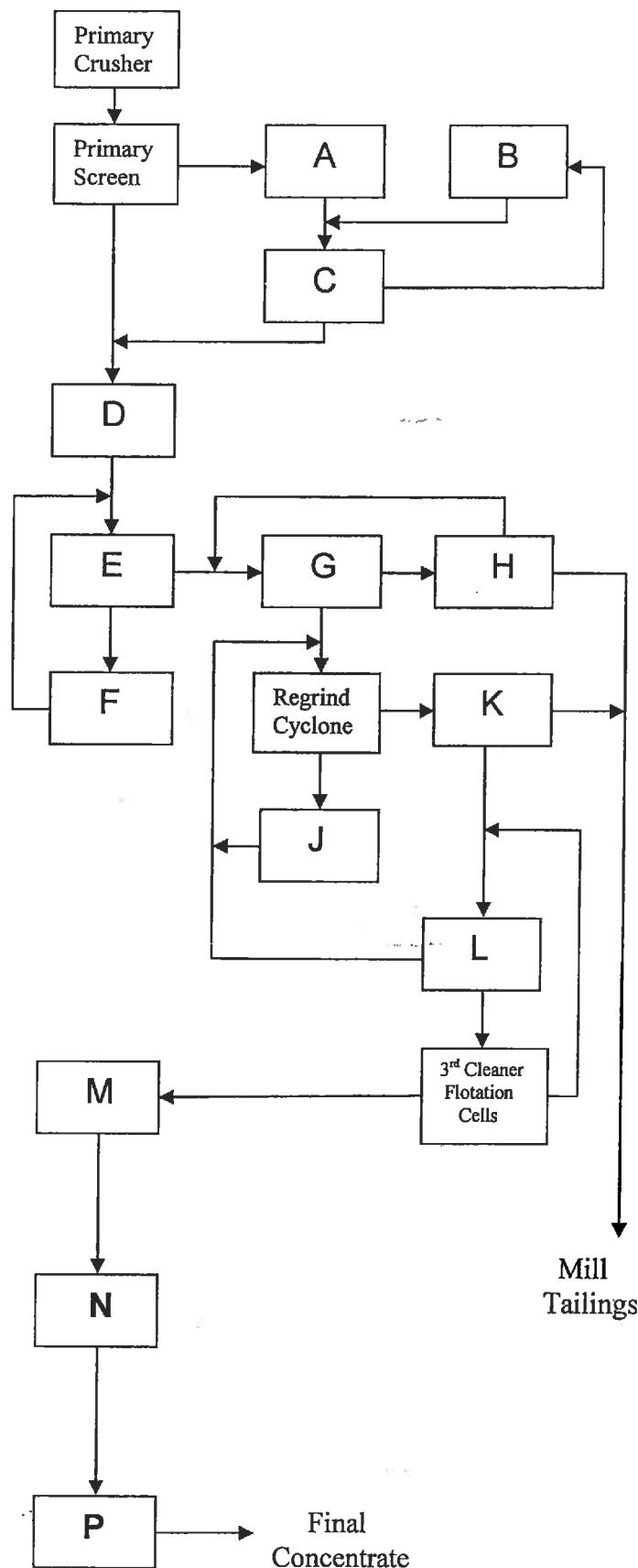
**Problem 5 Two marks each Total 12 marks**

**Bonus Question 2 marks**

**PROBLEM 1**

(a) Shown to the right is the flowsheet of the Bell concentrator which operated in central British Columbia from 1972 to 1992. The mill processed 12,000 tonnes/day of ore from an open pit mine to produce a copper concentrate. Identify the unit operations which best fit into the flowsheet at the appropriate locations from A to P. Select the unit operations from the list below: **(10 Marks)**

- thickener*
- secondary screen*
- scavenger flotation cells*
- ball mill*
- 1<sup>st</sup> stage cleaner flotation cells*
- tertiary crusher*
- hydrocyclones*
- regrind ball mill*
- dryer*
- rougher flotation cells*
- 2<sup>nd</sup> stage cleaner flotation cells*
- filter*
- secondary crusher*
- rod mill*



Problem 1 Continued

(b) If the copper content of the solid streams at the Bell concentrator were:

- Mill feed 0.5% Cu
- Tailings 0.04% Cu
- Concentrate 28.0 % Cu

Calculate the tpd of copper concentrate produced. **(8 Marks)**

(c) If electrical power was available a 6¢/ kw-hr, using Bond's equation and a Work Index of 16, estimate the power cost (in \$/day) required for comminution of the Bell ore. List the assumptions made in your calculation.

Bond's Equation:

$$W = \frac{10W_i}{\sqrt{P}} - \frac{10W_i}{\sqrt{F}} \quad \text{(5 Marks)}$$

(d) Assuming that chalcopyrite (CuFeS<sub>2</sub>, 34.6% Cu, SG 4.2) and siliceous gangue (SG 2.7) are the only two mineral components present in the ore, calculate the specific gravity of the copper concentrate. **(4 Marks)**

(e) Assuming that the copper concentrate was sold to a smelter according to the following schedule:

- (i) Treatment charge, \$100/tonne of concentrate
- (ii) pay for 90% of copper at the London Metal Exchange (LME) price

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

- Mining cost .....\$4/tonne of ore
- Milling cost.....\$ 3/tonne of ore
- Freight to Smelter.....\$30/tonne
- LME copper price.....\$2500/tonne **(7 Marks)**

**Problem 2. (7 marks).**

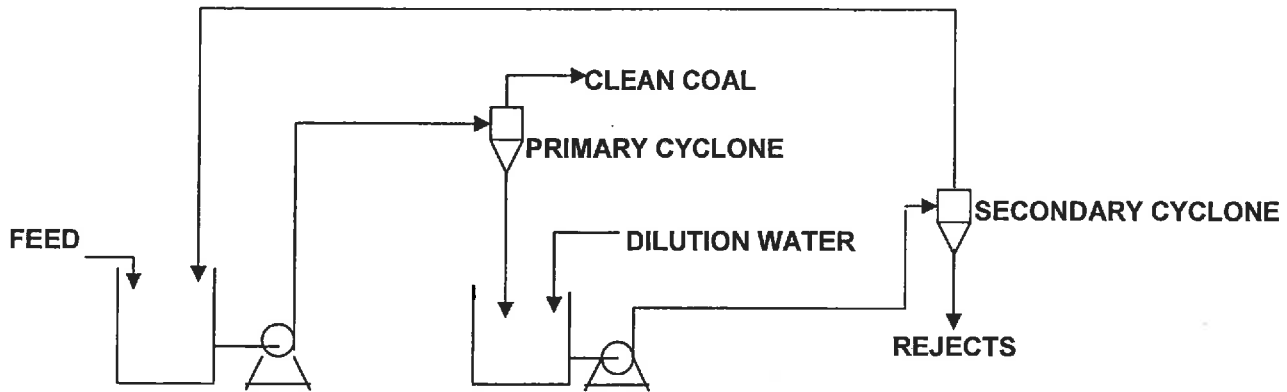
A laboratory flotation test was carried out on a sample of lead/zinc ore. The results were as follows.

	Weight g	Assay %	
		Pb	Zn
Pb Concentrate	40	65	7
Zn Concentrate	30	4	50
Tailing	430	0.5	1

(a) What is the calculated assay of the flotation feed i.e. % Pb & % Zn. **(3 Marks)**

(b) What is the distribution of lead and zinc to the concentrates and tailings. **(4 Marks)**

Problem 3



**FIGURE 1. Layout of Coal Cleaning Circuit for Problem 3**

A two-stage automedium (water only) cyclone circuit is used for cleaning 100 tonnes/hour of fine coal as illustrated in Figure 1. The circuit was sampled and the results were as follows:

	Percent <u>Solids</u>	Percent <u>Ash</u>
Circuit feed	12.5	25
Primary Cyclone Feed	13.16	25
Primary Cyclone Overflow (clean coal)	10.00	10
Primary Cyclone Underflow	25.00	47.5
Secondary Cyclone Overflow	16.67	25
Secondary Cyclone Underflow (rejects)	33.33	70

(a) Carry out a material balance and calculate the tonnes/hour of clean coal produced by the circuit. **(8 marks)**

(b) Calculate the tonnes/hour of dilution water added to the sump. **(4 marks)**

(c) Calculate the tonnes/hour of solids in the primary cyclone underflow. **(5 marks)**

4. Explain the similarities and differences between the following terms and explain how they are related to mineral processing. Use sketches in your answers.

**Answer any five (5) (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 5. Short answer questions. ONLY Answer any six (Total 12 marks)**

- (a) With regard to tumbling mills, what is the meaning of *critical speed*.
- (b) List two particle size analysis techniques other than sieving.
- (c) Gy's sampling equation is usually written as follows:  $M = C d^3 / s^2$   
Where  $M$  is the minimum weight of sample required.  
Define the meanings of  $d$  and  $s$ .
- (d) List two limitations of Stokes Equation (Law)
- (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?
- (g) The rate of flotation is usually described by the following equation:  
$$R = RI [1 - \exp(-kt)]$$
where  $R$  is the cumulative recovery of a given mineral species in time  $t$   
Define the meanings of  $k$  and  $RI$
- (h) List two naturally hydrophobic minerals.
- (i) Sketch the structural formula of sodium ethyl xanthate.

**Bonus Question**

Name two mineral commodities produced in Canada which are not concentrated by froth flotation (2 marks)