NATIONAL PROFESSIONAL EXAMINATIONS

DECEMBER 2012

98-Met-B1 - 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 4.

(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 5 with your examination booklet

(7) The mark distribution is as follows:

Problem 1 (a) 10, (b) 10 (c) 4 (d) 2 (e) 4 (f) 2 Total 32

Problem 2 (a) 10 (b) 4 (c) 4 Total 18 marks

Problem 3 (a) 3 (b) 2 Total 5 marks

Problem 4 Six marks each Total 30 marks

Problem 5 one marks each over one Total 5 marks

Problem 6 One mark each total 10 marks

Bonus Question 2 marks

Unit conversions:

1 tonne (mt) = 1000kg = 2202.6 lb
1 ton (T) = 2000 lb
1 inch = 2.54 cm = 25,400 microns (μm)

Problem 1. (23 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, calculate 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.

(e) Using the Gy equation calculate the required size of sample of the zinc concentrate required to obtain a zinc assay that is accurate to within 0.1% Zn, 95 times out of 100. Assume a value of C of 5.0g/cm^3. Gy equation:

$$M = \frac{C\,d^3}{s^2}$$

(f) Assuming that the only minerals present in the ore are sphalerite (SG 4.0) and quartz (SG 2.65), calculate the specific gravity of the zinc concentrate.

Problem 2. (18 marks)

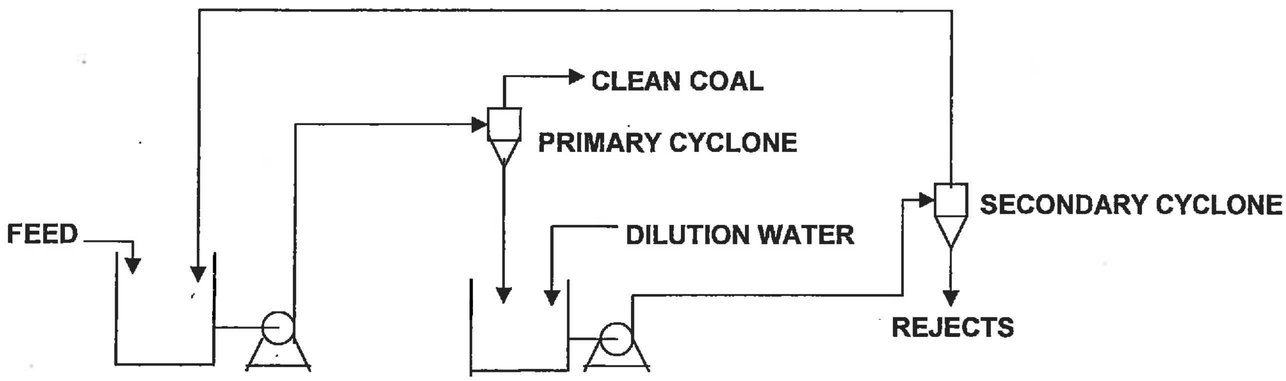

FIGURE 1. Layout of Coal Cleaning Circuit for Problem 2

A two-stage automedium (water only) cyclone circuit is used for cleaning 80 tonnes/hour of fine coal as illustrated in Figure 1. The circuit was sampled and the results were as follows:

	Percent Solids	Percent Ash
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. **(10 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. **(4 marks)**

Problem 3. (5 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%
15	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. (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) Magnetic/high tension separation

(vii) Jig/shaking table

(viii) Mechanical/column flotation cell

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

HAND IN THIS PAGE WITH YOUR EXAMINATION BOOKLET. Answer in the spaces provided.

5. Flotation collectors may be classified into four general categories:
   A. Dithiols (e.g. xanthates, aerofloats)
   B. Cationic (e.g. alkyl amines)
   C. Fatty acids & soaps (e.g. oleic acid, sulphonates
   D. Non-polar (e.g. kerosene, fuel oil)
   Beside each mineral indicate which type of collector (A, B, C, or D) would most likely be used to float that mineral.

______ Galena (PbS)	______ Quartz (SiO_2)
______ Sylvite (potash) (KCl)	______ Bituminous coal
______ Molybdenite (MoS_2)	______ Barite ($BaSO_4$)

(5 marks)

6. (i) Stokes' equation gives the terminal settling velocity of a particle in a fluid. This equation can be written as follows:

$$v = \frac{d^2 g\,(D_s - D_f)}{18\,\eta}$$

Define the following terms in Stokes' equation:

d ____

D_s ____

D_f ____

η ____

(ii) Two particle size analysis techniques other than sieving are

____________________________ and ____________________________

(iii) SAG is an acronym for ____.

(iv) "***The energy consumed in size reduction is proportional to the area of new surface produced***"
The above statement is attributed to: (choices are: Griffith, Von Rittinger, Kick or Bond)

____

(v)The most abundant metal in the earth's crust is (choices are: oxygen, iron, aluminum or magnesium)

______________________________.

(vi) $X = \frac{d_{75} - d_{25}}{2\,d_{50}}$ In this expression, X is known as ____________________

(10 marks)

Bonus Question (2 marks)

Two mineral commodities for which there is **no** mine production in Canada are

____________________________ and ____________________________.