Lab #1 – Laboratory Calculations

Name: ________________________________ Grade: ____________ Feedback:

Group Name:
____

Pledge: "On my honor as a Virginia Tech student, I have neither given nor received unauthorized assistance on this assignment." Initial_____

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If you answer yes to any questions in the Hokie Health survey (questions can be posted in the syllabus), you must not attend class in person. Notify me by email and contact Schiffert Health Center for testing and quarantine protocol.

Introduction

In the mineral processing laboratory, several types of calculations are frequently used in both methods development and data analysis. The purpose of this laboratory exercise is reacquaint you with these types of calculations.

Mineral Speciation

For most mineral processing operations, the physical separation is based on distinction in the mineral species (e.g. sphalerite vs. chalcopyrite); however, assays are often reported on an elemental basis (e.g. Zn vs. Cu). As a result, one must be able to easily convert between mineral and elemental analyzes depending on the situation. This conversion can be accomplished by using the ratio of molar mass values in the mineral component, according to the formula in the table below. This ratio then serves as a "conversion factor" that can be used to convert between elemental and mineral assays.

Metallurgical Balances

A flowsheet describes the sequence of unit operations that are performed in a mineral processing plant. The flowsheet (or any part of the flowsheet) can be represented using a series of nodes and streams. A node represents a unit operation as either a junction (streams which combine to form a single stream) or separator (one stream that is separated in two or more streams). A series of material balance expressions can be constructed for each node in the flowsheet. For example, consider the following expressions for a simple separator:

$$F = C + T$$
$$Ff = Cc + Tt$$

where F, C and T are the respective mass flow rates of the feed, concentrate and tailings streams and f, c and t are the respective assays which represent the content of a given component in these streams. These balances can then be used to derive an expression for concentrate yield (Y), as given by the two-product formula (shown in the table below). The two-product formula is particularly useful as it describes the mass distribution (i.e. C, F, and T) of material around a unit using only assay data (c, f, and t). Since assays are much easier to measure than mass flow rates, this expression is very useful for plant personnel. To help remember this equation, operators often refer to this expression as the "fat cat" formula. Two other useful measures of separation performance are recovery (R) and rejection (J), which are also defined in the table below.

Slurry Calculations

In both the plant and laboratory settings, process engineers are often called upon to perform calculations involving slurry. In the process plant, slurry characteristics play a significant role in how well various unit operations perform, as most units are designed to operate within a narrow range certain percent solids concentrations. In the laboratory, engineers and technicians are often asked to perform dilutions to produce slurries with prescribed characteristics. All slurry calculations are governed a simple mass (m) and volume (v) balance between the solid, liquid, and slurry (subscripts s, l, and sl, respectively) components. These equations can often be solved simultaneously by using standard density (ρ) relationships. Slurries are often denoted by the percent solids values. The governing equations are given below:

Helpful Equations

Fraction of Element in Mineral	$\% \, Element = 100\left(\frac{(Atomic\, Wt\ of\ \ Element)\times(moles\ of\ \ Element)}{Atomic\, Wt\ of\ \ Mineral}\right)$		
Two Product Formula	$Y = 100\frac{(f-t)}{(c-t)}$		
Recovery	$R = 100\frac{Cc}{Ff} = (100Y)\frac{c}{f}$		
Rejection	$J = 100\frac{Tt}{Ff} = (100-Y)\frac{t}{f}$		
Slurry Balances	$m_{sl} = m_S + m_l$	$V_{sl} = V_S + V_l$	$\frac{m_{sl}}{\rho_{sl}} = \frac{m_s}{\rho_s} + \frac{m_l}{\rho_l}$
Slurry Densities	$\rho_s = \frac{m_s}{V_s}$	$\rho_{sl} = \frac{m_{sl}}{V_{sl}}$	$\rho_l = \frac{m_l}{V_l}; often = 1.0g/cc$
% Solids	$Mass\%Solids = \frac{m_s}{m_{sl}} \times 100$	$Volume\%Solids = \frac{V_s}{V_{sl}} \times 100$	

Procedure

Complete the following calculations and questions. Feel free to work with your group members and ask the instructor if you have any questions. When you are finished submit your work to the laboratory instructor.

Data Records & Calculations

Mineral Speciation

1. A mineralogical assessment has been performed on a rougher concentrate from a large copper mine. The data show that the copper exists as chalcopyrite, bornite, and chalcocite (chemical formulas give below), while all of the gangue exists as silica. Use molar mass ratios to determine the copper content (%Cu) in each of these pure mineral fractions.

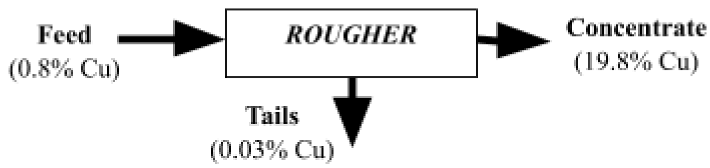
   Recall the following molar mass values (all in g/mol):
   Cu = 63.5 Fe = 55.8 S = 32.1 Si = 28.1 O = 16.0

Mineral	**Formula**	**%Cu**
Chalcopyrite	$CuFeS_2$	
Bornite	Cu_5FeS_4	
Chalcocite	Cu_2S	
Silica	SiO_2	

2. The mineralogical data also shows the relative concentration of each mineral species. In this sample, chalcopyrite = 48%, bornite = 5.0%, chalcocite = 2.0%, and silica = 45%. Given that data, what is the expected overall copper assay (%Cu) of the sample?

Metallurgical Balances

1. Using the two-product formula, please determine the mass rate of copper concentrate, the recycle mass rate and the reject mass rate for the flotation unit shown below. You may assume the circuit is fed 1,000 tons per hour (TPH). Also, you should assume that the copper ore is chalcopyrite ($CuFeS_2$) contained in a silica gangue matrix, and $CuFeS_2$ and SiO_2 are the only mineral species present.



Concentrate Mass Rate	= __________ TPH		Mass Rate of Tails	= __________ TPH	
Cu Recovery	= __________ %		Cu Rejection	= __________ %	
$CuFeS_2$ Recovery	= __________ %		SiO_2 Rejection	= __________ %	

Slurry Calculations

1. A particular laboratory protocol asks for 100 g of slurry containing very fine ferrosilicon (ρ_s = 6.7 g/cc). Determine the mass AND volume percent solids of ferrosilicon needed to produce a slurry density of 2.50 g/cc in tap water?

2. In a separate experiment, you are asked to create one liter of slurry containing 10% solids by weight. The ore for this experiment has a dry density of 2.65 g/cc. What volume of water (in liters) and what mass of ore (in grams) must you mix together to create this slurry?

Discussion Questions

1. What is the difference between yield, recovery and rejection?

2. Which of the assays in the circuit shown above do you think would be more important to measure accurately?

Conclusions

1. What was the objective of this laboratory exercise?

2. What important fundamental concepts did you learn from the exercise?

3. List your group name as well as the other members of your group.

Final Problem

The following problem encompasses many of the skills which will be learned throughout the duration of this class. In the space below, make your best effort, but don't worry if you can't complete it successfully. We will return to this question at the end of the semester. Circle all the words you don't currently understand.

You have been asked optimize the reagent dosage and residence time for a sphalerite flotation operation. The client has provided you a bulk sample (approximately 50 lbs.) of minus 1" run-of-mine material and has indicated that the current feed to the flotation circuit is approximately 80% minus 100 mesh. Unfortunately, the client has provided no other information on the current flotation parameters.

Create a detailed list of the steps needed to complete the request. Describe what data is needed, how that data would be collected, and how the data would be analyzed to meet the client's objectives. Don't forget steps involving sample preparation, sample characterization, experimental trials, sample assays, data analysis, and reporting. Estimate how much time would be needed to complete all tasks, and describe the supplies and equipment which must be used.