UNIVERSITY OF JOHANNESBURG

PROGRAM	:	BACHELOR OF ENGINEERING TECHNOLOGY EXTRACTION METALLURGY
SUBJECT	:	**MINERAL PROCESSING 2B**
CODE	:	**MPRMTB2**
DATE	:	SUMMER EXAMINATION 23 November 2019
DURATION	:	(SESSION 1) 08:30– 11:30
WEIGHT	:	40:60
FULL MARKS	:	100
TOTAL MARKS	:	100

EXAMINER	:	Prof W. NHETA
MODERATOR	:	DR E. MATINDE
NUMBER OF PAGES	:	3

INSTRUCTIONS TO STUDENTS:

ANSWER ALL QUESTIONS.
PUT YOUR FINAL ANSWERS ON THE ANSWER SHEETS PROVIDED.
INCLUDE YOUR WORKING IN THE SCRIPT. IF NO WORKING IS SHOWN IN THE SCRIPT, NO MARKS WILL BE AWARDED
ENSURE THE ANSWER SHEETS HAVE YOUR NAME AND STUDENT NUMBER ON THEM.

Question 1

An ore consisting of chromite ($FeCr_2O_4$), Magnetite (Fe_3O_4) and Quartz (SiO_2) is fed to a magnetic separation circuit at the rate of 100t/hr solids. The first stage is a low intensity magnetic separator (LIMS) and the magnetics fraction from this unit is fed to secondary stage LIMS unit for further upgrading. The non-magnetics from both LIMS units are combined and fed to a wet high intensity magnetic separator (WHIMS).

Based on the following information:

Mass of chromite in the feed is twice the mass of magnetite in the feed.
Grade of Cr in the feed is 9.28% Cr
% magnetite recovery to LIMS 1 magnetics – 98%
% Fe recovery to LIMS 1 magnetics – 60.2%
Mass of LIMS 1 magnetic fraction – 12.2 tons /hour
% Chromite recovery to LIMS 2 magnetics – 50%
% Magnettite recovery to LIMS 2 magnetics – 98%
% Magnetite in LIMS 2 non-magnetics - 11.56%
% Chrome recovery to WHIMS magnetite – 95%
% Magnetite in WHIMS magnetic fraction – 1.03
Tons Fe in WHIMS non-magnetic Fraction – 0.387

Calculate:

1.1 The % Quartz in the LIMS 1 magnetic fraction. (5)

1.2 The % Cr in the LIMS 1 non-magnetic fraction (4)

1.3 The % Fe in the LIMS 2 Feed (3)

1.4 The % Chromite in the LIMS 2 non-magnetic fraction (4)

1.5 The % Fe in the WHIMS feed (7)

1.6 The % Cr in the WHIMS magnetic fraction (7)

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Fe – 56 Cr – 52 O - 16

Question 2

An ore containing Galena (PbS), Quartz (SiO_2) and Silver (Ag) is fed to a flotation plant. Some of the silver is free and some is locked in Galena. All of the silver has been liberated from the Quartz. The ore contains 6.928% Galena. The concentrate has a mass of 30t/hr and a grade of 24% Pb. The tails grade is 1.5% Pb and 2g/t Ag. Of the free Silver in the tailings, 25% is free. The free silver recovery to the concentrate is 90%.

2.1 Calculate the mass of the feed to the concentration plant (3)

2.2 Calculate the % Pb Recovery to the concentrate (2)

2.3 What is the Total Ag grade of the feed (7)

2.4 What is the silver grade of the Galena (8)

[20]

Pb – 207.2 S – 32.1

Question 3

3.1 In froth flotation, what are the two methods by which collectors coat mineral surfaces? (2)

3.2 Discuss how one works for oxides and silicates. (2)

3.3 Discuss how one works for sulphide minerals (2)

3.4 Discuss two methods by which sulphides can be collected using Xanthate (Include the formulae for the resections) (9)

3.5 Why does sphalerite not float with Xanthates? (2)

3.6 How can it be activated to float? (Include the reactions) (4)

[21]

Question 4

4.1 Discuss the five desirable properties of the solid medium used in Dense Medium Separation (DMS) apart from low cost. (14)

4.2 Explain why the bath density should be set for the floats rather than the sinks in DMS separations. (6)

[20]

Question 5

5.1 As a young Metallurgist working on a Gold mine, you are given a task to choose a suitable site for a tailings dam. Discuss five environmental factors that you should take into consideration and why? (9)

[9]

Mineral Processing 2B
MPRMTB2
Examination 2019
<u>Memorandum</u>

Question 1

	Feed	LIMS 1 Mags	LIMS 1 Non-mags	LIMS 2 Mags	LIMS 2 Non-mags	WHIMS Feed	WHIMS Mags	WHIMS Non-mags
Mass	**100**	**12.2**	87.8	10.51	1.696	89.5	19.22	
% Chromite							97.37	
% Magnetite					**11.56**		1.03	
% Cr	**9.28**		9.989				44.73	
Tons Chromite	20	1.096	18.90	$^{0.5}$0.548	0.548	19.45	$^{0.95}$18.48	
Tons Cr	9.28		8.770				8.575	
Tons Magnetite	10	$^{0.98}$9.8	0.2	$^{0.98}$9.604	0.196	0.396	0.198	
Tons Fe in Chromite	5.0	0.274				4.863	4.62	
Tons Fe in Magnetite	7.24	7.095				0.287	0.143	
Total Tons Fe	12.24	$^{0.602}$7.369				5.15	4.763	**0.387**
% Fe		60.40				5.754		
Tons Quartz		1.304	68.7		0.952	69.65		
% Quartz		10.69						

Fe_3O_4
Fe 168 0.724
O 64
232

$FeCr_2O_4$
Fe 56 0.250
Cr 104 0.464
O 64
224

FEED
t/hr Cr = 100 x 9.28/100 = 9.28
t/hr Chromite = 9.28/0.464 = 20
t/hr Magnetite = 10
t/hr Fe in Chromite = 20 x 0.25 = 5.0
t/hr Fe in Magnetite = 10 x 0.724 = 7.24
t/hr Total Fe = 5 + 7.14 = 12.24

LIMS 1 MAGS
t/hr Magnetite = 10 x 0.98 = 9.8
t/hr Fe in Magnetite = 9.8 x 0.724 = 7.095
t/hr Total Fe = 0.602 x 12.24 = 7.369
t/hr Fe in Chromite = 7.369 – 7.095 = 0.274
t/hr Chromite = 0.274/0.25 = 1.096
t/hr Quartz = 12.20 – 1.096 – 9.80 = 1.304
% Quartz = 100 x 1.304/12.20 = **10.69** (5)

LIMS 1 NON-MAGS (by difference)
t/hr Mass = 100 – 12.20 = 87.80
t/hr Chromite = 20 – 1.096 = 18.90
t/hr Cr = 18.90 x 0.464 = 8.770
% Cr = 8.770/87.80 x 100 = **9.989%** (4)
t/hr Magnetite = 10 – 9.8 = 0.2
t/hr Quartz = 67.80 – 18.90 – 0.2 = 68.70

LIMS 2 FEED = LIMS 1 MAGS
% Fe = 7.369/12.20 x 100 = 60.40%

LIMS 2 MAGS
t/hr Chromite = 1.096 x 0.5 = 0.548
t/hr Magnetite = 9.8 x 0.98 = 9.604

LIMS 2 NON-MAGS
t/hr Chromite by difference = 1.096 – 0.548 = 0.548
% Chromite = 0.548/1.696 x 100 = **32.31%** (4)
t/hr Magnetite by difference = 9.8 – 9.604 = 0.196
t/hr Mass = 0.196/11.56 x 100 = 1.696
t/hr Quartz = 1.696 – 0.548 – 0.196 = 0.952

FEED TO WHIMS
Addition of LIMS 1 and LIMS 2 Non-Magnetics
t/hr Mass = 1.696 + 87.80 = 89.50
t/hr Chromite = 0.548 + 18.90 = 19.45
t/hr Magnetite = 0.196 + 0.20 = 0.396
t/hr Fe in Chromite = 19.45 x 0.25 = 4.863
t/hr Fe in Magnetite = 0.396 x 0.724 = 0.287
t/hr Total Fe = 4.863 + 0.287 = 5.15
% Fe = 5.15/89.50 x 100 = **5.754** (7)
t/hr Quartz = 68.70 + 0.952 = 69.65

WHIMS MAGS

t/hr Chromite = 19.45 x 0.95 = 18.48
t/hr Cr = 18.48 x 0.464 = 8.575
t/hr Fe in Chromite = 18.48 x 0.250 = 4.620
t/hr Total Fe = 5.15 – 0.387 = 4.763
t/hr Fe in Magnetite = 4.763 – 4.62 = 0.143
t/hr Magnetite = 0.143/0.724 = 0.198
t/hr Mass = 0.198/1.03 x 100 = 19.22
% Cr = 100 x 8.575/19.22 = **44.61%** (7)

1.1 % Quartz – 10.69 (5)
1.2 % Cr – 9.89 (4)
1.3 % Fe – 60.40 (3)
1.4 % Chromite – 32.31 (4)
1.5 % Fe – 5.754 (7)
1.6 % Cr – 44.61 (7)
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Question 2

	Mass t/hr	% Galena	% Pb	Pb t/hr	Galena t/hr	Total Ag g/hr	Ag in Galena g/hr	Ag Free g/hr	Total Ag g/t
Cons	**30**		**24**	7.2					
Tails	120		**1.5**			240	180	60	**2.0**
Feed	150	**6.928**	6.0	9.0	10.39	1500	900	600	10

Pb 207.2 0.866
S 32.1
239.3

LEAD AND GALENA BALANCE
% Pb = 6.928 x 0.866 = 6.0
Let y = t/hr mass
6 x y = (30 x 24) + [(y – 30) x 1.5)]
y = 150
t/hr Mass = 150
t/hr Pb = 150 x 6/100 = 9

TAILS
t/hr Mass = 150 – 30 = 120

Cons
t/hr Pb = 30 x 24/100 = 7.2
% Pb Recovery = 100 x 7.2/9 = **80%**

SILVER BALANCE
g/hr total Ag in tails = 120 x 2 = 240
g/hr free Ag in tails = 240 x 25/100 = 60 = 10% of feed
g/hr free Ag in feed = 100/10 x 60 = 600
g/hr Ag associated with PbS in tails = 240 – 60 = 20% of feed (% of PbS in tails)
g/hr Ag associated with PbS in feed = 180 x 100/20 = 900
g/hr total Ag in feed = 600 + 900 = 1500
g/t total Ag in feed = 1500/150 = **10**
g/hr Ag associated with PbS in feed = 900
t/hr Galena = 150 x 6.928/100 = 10.39
g/t Ag associated with PbS = 900/10.39 = **86.62**

2.1 150	**(3)**
2.2 80%	**(2)**
2.3 10g/t	**(7)**
2.4 86.62 g/t	**(8)**
	[20]

Question 3
3.1 The two methods by which collectors coat minerals are Physiosorption and Chemisorption (2)
3.2. Physiosorption – Oxides and silicate minerals are chemically inert and surface -adsorption phenomena are dominated by the properties of the electrical double layer alone. (2)
3.3 Sulphide minerals are more chemically active and chemisorption is the dominant system (2)
3.4 Collection of metal sulphides by xanthates involves the precipitation of an insoluble compound on the metal surface, where it is held firmly by physical and chemical interaction with surface ions. (2)
The first means of collection requires that the conditions at the surface are sufficient oxidizing for the xanthate ions to be oxidized to dixanthogen X_2 (1)
Dixanthagen is insoluble and precipitates on the mineral surface, imparting hydrophobicity by virtue of its hydrocarbon tails. (1)
The surface reaction is as follows:

$$2X^- + 0.5O_2 + H_2O = X^2 + 2OH^- \quad (2)$$

If conditions are not sufficiently oxidizing, an insoluble metal xanthate must be precipitated on the mineral surface (1)
In the case of Galena (PbS), the surface reaction would be:

$$PbS + 2X^- = PbX_2 + S^{2-} \quad (2)$$

3.5 Sphalerite partially floats with xanthate because zinc xanthate is relatively soluble in water and therefore cannot form the hydrophobic film around the mineral. (2)

3.6 It can be activated by addition of Copper sulphate. Cu sulphide molecules will form at the Sphalerite mineral surface due to the fact that copper is more electro-negative than Zinc. (2)
It occurs according to the following reaction:\

$$ZnS + Cu^{2+} = CuS + Zn^{2+} \quad (1)$$

The mineral surface thus acts as though it were copper sulphide and reacts with the collector. (1)

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Question 4

4.1 The desirable properties of DMS medium are:

1. A high particulate density (SG) – This allows the fluid to have a high enough density to separate minerals whilst containing a minimum mass (volume) of the medium. This in turn leads to a maximum volume being available for the minerals being separated. (3)
2. Chemical inertness – This increases the resistance to corrosion. The liquid phase is water and any corrosion products would be colloidal. This will increase the viscosity of the fluid, reducing the rate at which the mineral components separate. (3)
3. It must be competent because if it breaks down:
    - The surface area increases and so the medium viscosity increases.
    - The efficiency of the recovery of the medium solids decreases with decreasing size
    - The corrosion rate increases. (3)
4. It must not adhere to the minerals because:
    - This would contaminate the product minerals
    - Represent a loss of the medium from circuit. (3)
5. The medium is expensive so there needs to be an effective way of recovering it at a high efficiency. (2)

4.2

1. Less solids will be required to produce the lower SG value. These are expensive (2)
2. The solids have to be recovered and resused to make the process economic. The higher the concentration, the higher the loss will be. (2)
3. The higher the solids concentration, the larger the recovery plant will have to be (2)

[20]

Question 5

1. The absence of wet or marshy area – Moisture can affect the dam and the presence of water indicates a link to the water table and thus the risk of ground water contamination (2)
2. Proximity to inhabited areas – because of the risk of pollution and safety eg Bafokeng, Mufulira and Merriespruit. (1)
3. The absence of rock on the surface of just below – Particularly where trenches may have to excavated because of the cost. (2)
4. The absence of the impermeable clay substrata – Because this will lead to instability and high seepage rates that can lead to pollution Hazards. (2)

5. Away from main roads, power lines, railways, rivers and streams – If there is a breakout from the dam can affect infrastructure. Leakage into rivers and streams will spread pollution quickly and widely. (2)

[9]