THE UNIVERSITY OF ZAMBIA
FIRST SEMESTER EXAM PAPER 2002/2003
SCHOOL OF MINES

1. GG 201	-	Introduction to Geology – (Theory)
2. GG 201	-	Introduction to Geology – (Practical)
3. GG 301	-	Principles of Geology II – (Paper I)
4. GG 311	-	Crystallography and Mineralogy (Paper I - Theory)
5. GG 311	-	Crystallography and Mineralogy (Paper II – Practical)
6. GG 361	-	Engineering Geology (Paper I Theory)
7. GG 361	-	Engineering Geology (Paper II – Practical)
8. GG 411	-	Igneous Petrology Paper I - Theory)
9. GG 411	-	Igneous Petrology
10. GG 421	-	Sedimentology (Paper I Theory)
11. GG 421	-	Sedimentology (Paper II Practical)
12. GG 435	-	Structural Geology (Paper I - Practical)
13. GG 435	-	Structural Geology Paper II – Practical)
14. GG 471	-	Introduction to Geochemistry (Paper I – Theory)
15. GG 561	-	Engineering Geology
16. GG 581	-	Applied Geophysics
17. MI 315	-	Introduction to Mining
18. MI 315	-	Rock Mechanics I
19. MI 411	-	Drilling and Blasting
20. MI 431	-	Underground Mine Design
21. MI 455	-	Operations Research
22. MI 465	-	Mineral Economics
23. MI 535	-	Coal Mining Methods
24. MI 545	-	Mine Management
25. MI 585	-	Materials Handling
26. MG 319	-	Computer Techniques (Practical)
27. MM 321	-	Physical Metallurgy I
28. MM 331	-	Chemical Thermodynamics I
29. MM 331	-	Mineral Processing I
30. MM 451	-	Transport Phenomena
31. MM 481	-	Ferrous Metallurgy
32. MM 515	-	Special Topics in Mineral Processing
33. MM 525	-	Mechanical Metallurgy
34. MM 545	-	Special Topics in Extractive Metallurgy

SHORT LOAN COLLECTION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – AUGUST 2003

GG 361 - ENGINEERING GEOLOGY

PAPER II - PRACTICAL

TIME: THREE HOURS

ANSWER: ALL QUESTIONS

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1. During a site investigation for a prospective construction site, the Geology Department provided you with a map showing different geological formations as shown in Map 1. For this Map:
   a) Determine the dip of the strata
   b) Draw a topographic profile and geologic section along the line AB to get an idea of the relationships of the different lithologies.

2. The Lusaka Water and sewerage Company has contracted you to explore for new sources of water to augment supply to the city of Lusaka. A map of part of the city indicates springs issuing out at A, Band C. for this area:
   i) Indicate the probable location of the remainder of the aquifer outcrop on the map.
   ii) Shade the area underlain by the aquifer, which you would recommend to for further drilling and exploitation

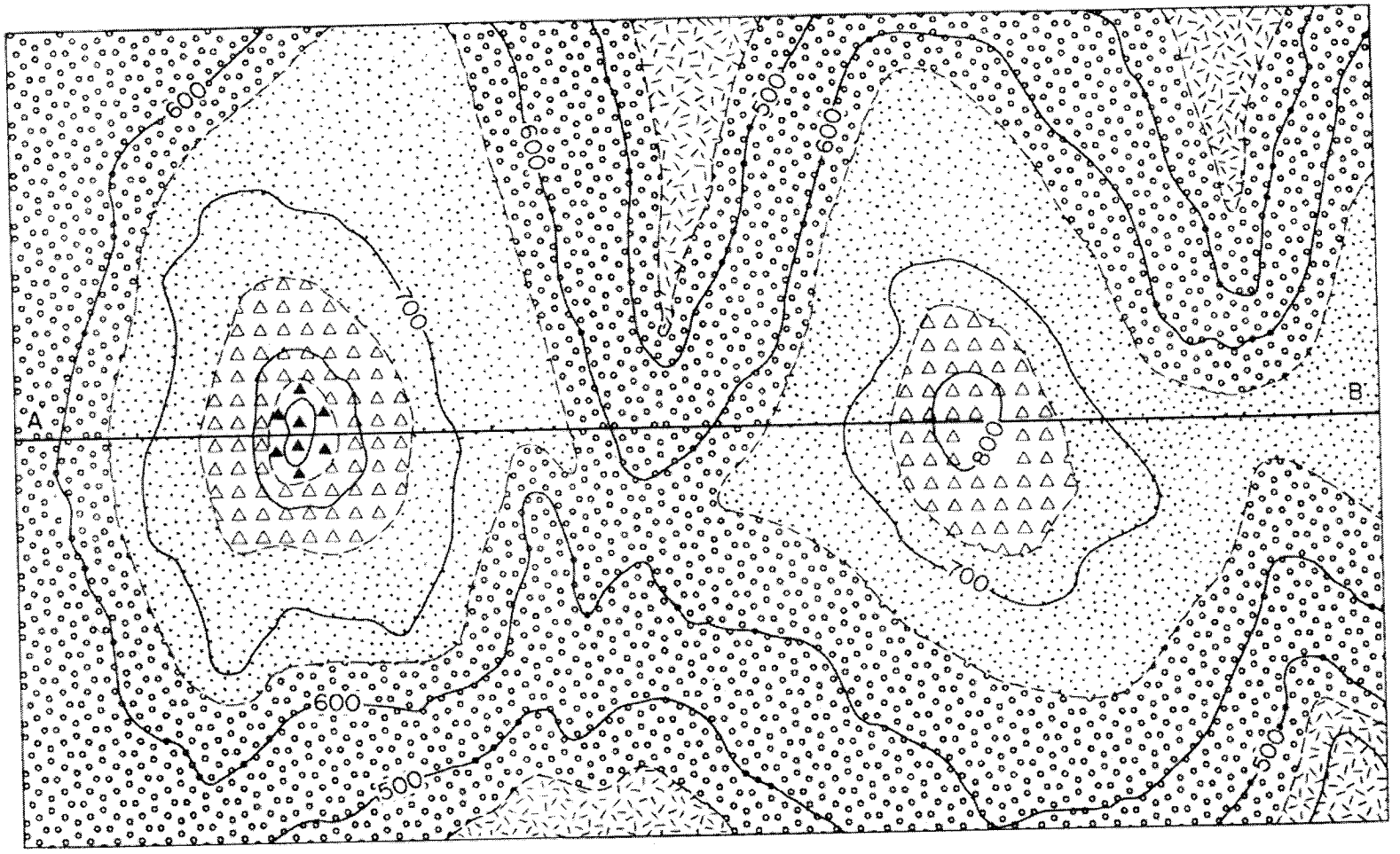
3. Map 3 depicts a land surface contoured at 5 m intervals from which Minestone would like to win sandstone and limestone for construction purposes. Outcrop locations of these beds' boundaries and of a mudstone are marked on the map, where the base of a sandstone outcrops at A, the base of a limestone outcrops at B, and the base of a mudstone at C. Assuming that between A and B only sandstone is present, between Band C only limestone is present and that only mudstone is present in the succession above C:
   i) Complete the outcrops of the bed boundaries.
   ii) Shade the lithologies as appropriate.
   iii) Indicate the depths at which sandstone and limestone would be intersected at point C.

   Note The rate of true dip of the beds is 1 in 10 on a bearing of 210°

END OF EXAMINATION. GOOD L UCK!!!

SHORT LOAN COLLECTION

Map 1



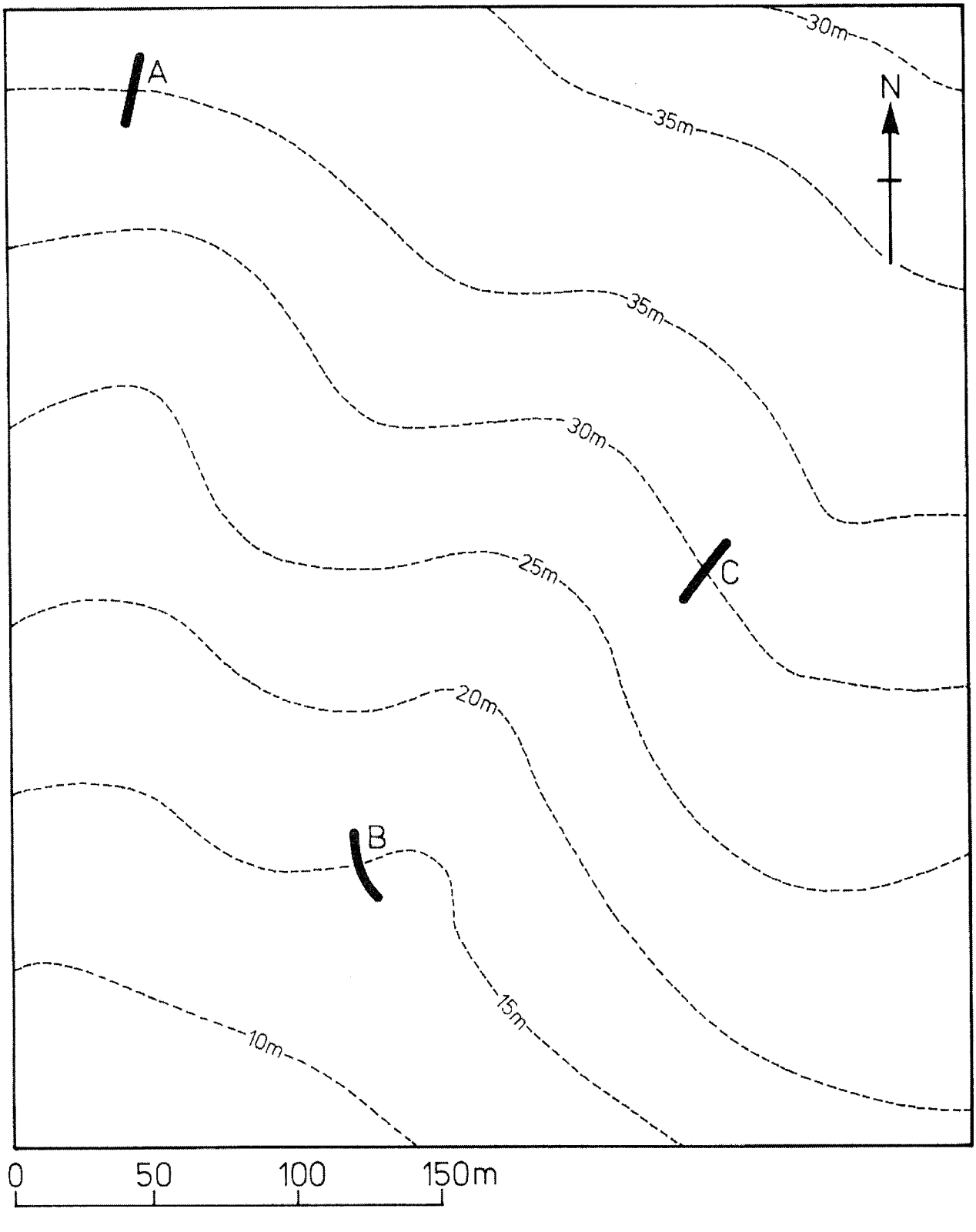
700 Topographic contours in Metres

Geologic contacts

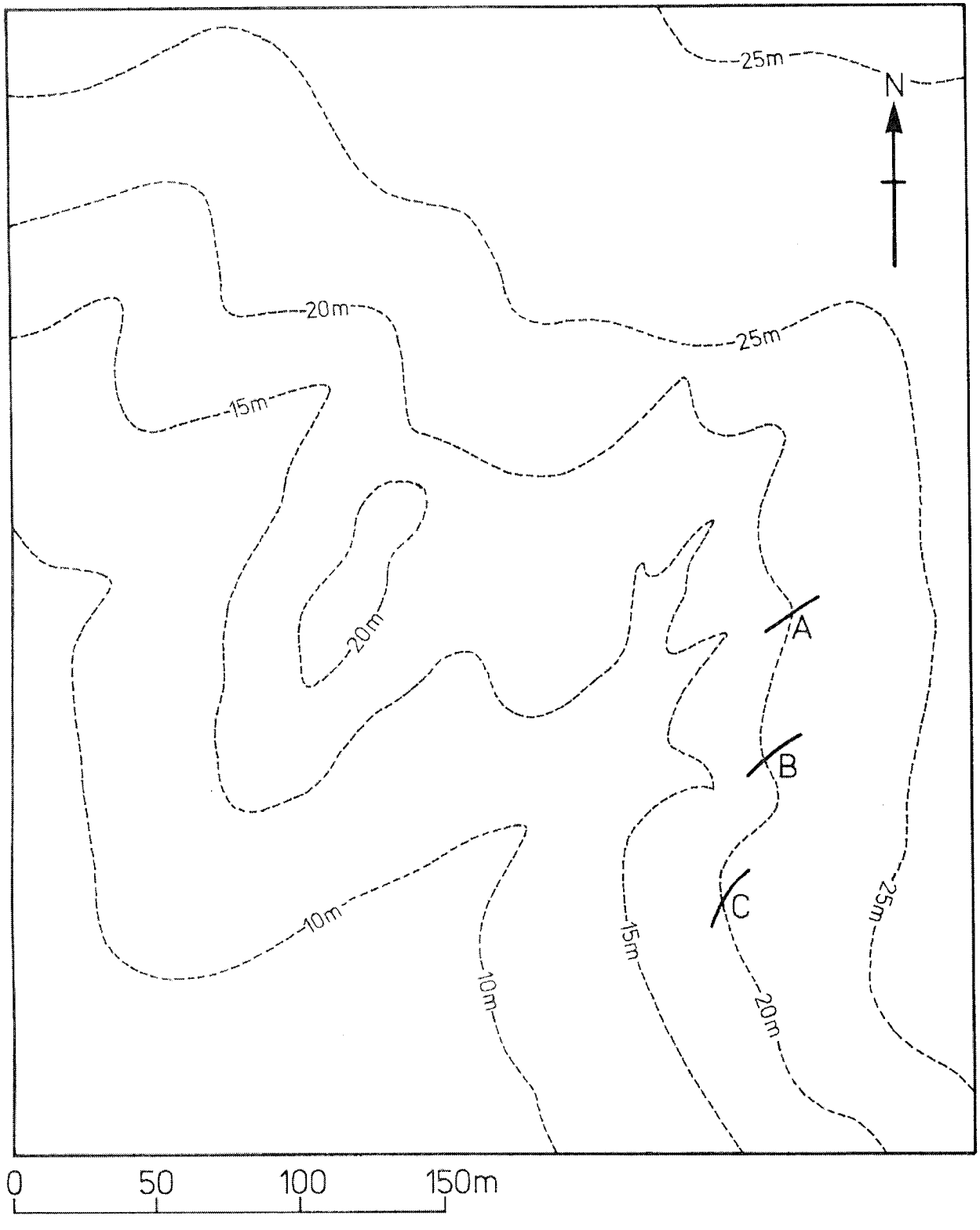
0 500

Scale in Metres

Map 2



Map 3



THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
FIRST SEMESTER UNIVERSITY EXAMINATIONS – AUGUST 2003

GG 411 – IGNEOUS PETROLOGY
PAPER II - PRACTICAL

TRUCTIONS: ANSWER ALL QUESTIONS.
ME: THREE HOURS

Give a complete petrographic description of thin section A. Estimate the modal percentage of its composition and classify it according to the IUGS system.

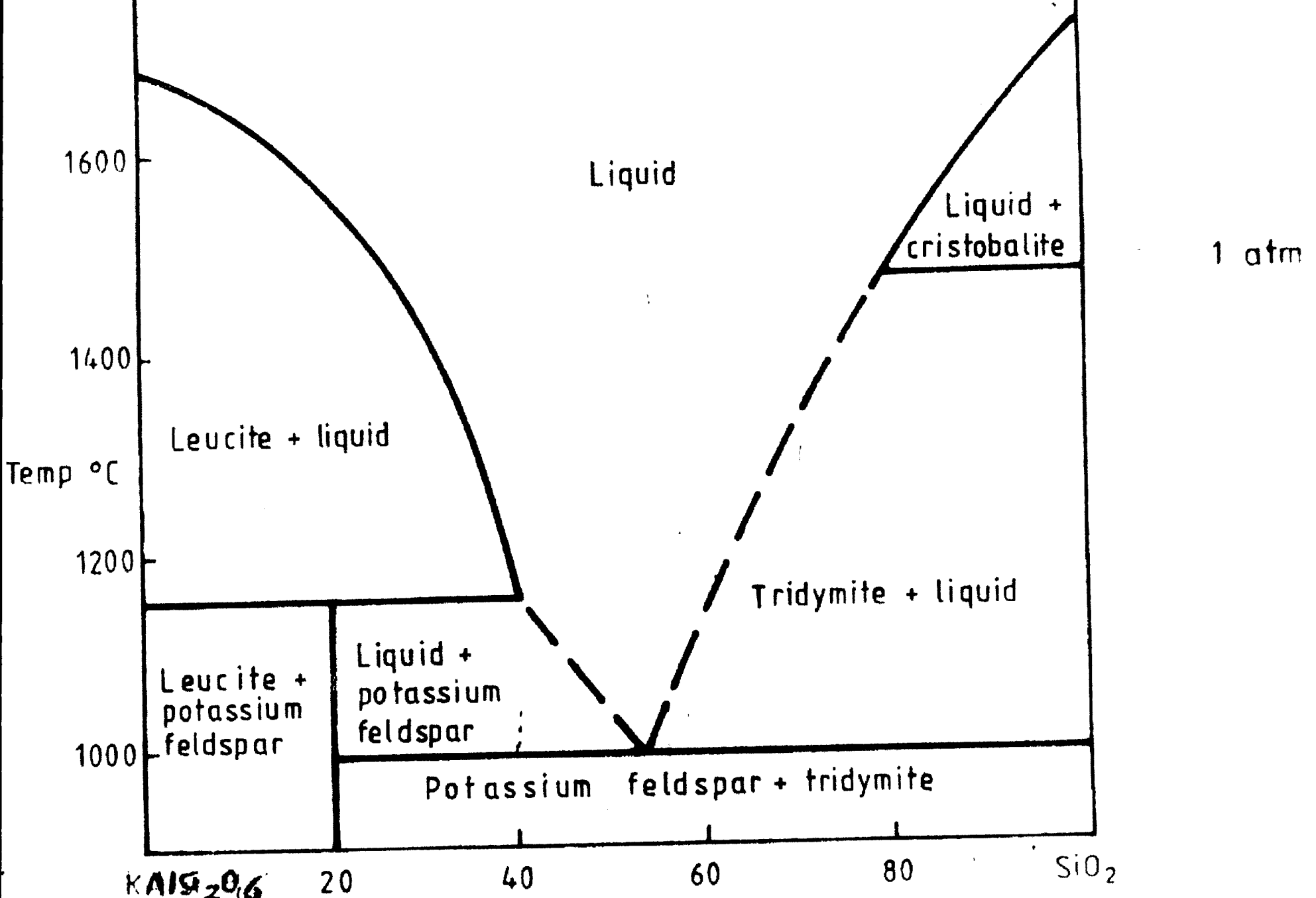
You are provided with thin section B. Do the following:

(a) Identify the minerals
(b) Describe the texture of the rock
(c) Is this a volcanic or a plutonic rock? Why?
(d) Name the rock

A leucite-silica binary system in given in Figure 1. Using this system do the following:

(a) Describe the crystallisation path of a liquid of composition 30% silica, 70% leucite. At what temperature is crystallization complete?
(b) Calculate the amount of liquid, which is present before the peritectic reaction starts and after it is finished.
(c) What is the mineralogy of the resulting rock and what are the mineral percentages?

GOOD LUCK!!!!


Liquid
Liquid + cristobalite
1 atm
1600
1400
1200
1000
Temp °C
Leucite + liquid
Tridymite + liquid
Leucite + potassium feldspar
Liquid + potassium feldspar
Potassium feldspar + tridymite
KAlSi2O6
20
40
60
80
SiO2

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
FIRST SEMESTER UNIVERSITY EXAMINATIONS – AUGUST 2003

GG 411 – IGNEOUS PETROLOGY
PAPER I - THEORY

INSTRUCTIONS: ANSWER ANY FIVE QUESTIONS ILLUSTRATING YOUR ANSWERS WITH FIGURES AND DIAGRAMS WHEREVER POSSIBLE.

TIME: THREE HOURS

Q1. Summarize the main characteristics of a layered igneous complex and give an example of an ore deposit which can be associated with the complex.

Q2. Various processes can account for the crystallization of rocks that may be derived from one single magma. Describe these processes and indicate their relative importance.

Q3. Explain the difference between hypersolvus and subsolvus granites.

Q4. Explain with the aid of diagrams the following terms:

(a) Incongruent melting
(b) Liquid immiscibility
(c) Incompatible minerals

Q5. Summarize the main geological environment or environments in which basalts are likely to occur and give their petrographic composition.

Q6. What are the main characteristics of Kimberlites? Indicate their usual plate tectonic setting.

Q7. Give three possible explanations for the formation of symplectic intergrowth in igneous rocks. Give examples.

GOOD LUCK!!!!

UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

UNIVERSITY FIRST SEMESTER EXAMINATION – AUGUST 2003
GG421 - SEDIMENTOLOGY
PAPER II – PRACTICAL

INSTRUCTIONS: ANSWER ALL QUESTIONS. SKETCHES AND DIAGRAMS ARE IMPORTANT FOR A FULL MARK.
TIME: THREE (3) HOURS

1. (a) What are the main components of siliciclastic rocks? – (3 marks)
   (b) Name four chemical cements in terrigeneous clastic sedimentary rocks. – (4 marks)
   (c) Give grain size limits of silt, sand and gravel. - (6 marks)
   (d) Outline the significance of grain size in sedimentological studies. – (6 marks)

2. (a) In undertaking your field studies, you were requested by your supervisor to provide grain-size analysis for sediments used in the construction of the Lusaka – Chirundu road. You were further requested to provide the significance of the following parameters you used in the grain-size analysis
   i) Sorting (3 factors) – (3 marks)
   ii) Skewness (1 factor) and give 4 deposit examples indicating the type of skewness showed by each deposit type. – (5 marks)
   (b) Outline Dunham (1962) classification of Carbonate Rocks using well-labeled diagrams. – (8 marks)

3. You have been mapping a horizontal sedimentary sequence in the Senga Hill area, north of Kasama Town, Northern Province in which you put together a graphic log (Table 1) including data pertaining to thin section study and palaeocurrents.

   You are now required to do the following:
   i) Draw a Detailed Stratigraphic Section of the outcrop – (20 marks)
   ii) The following modal composition of a Sandstone in Unit 7 was recorded.

Quartz	- 70%
Orthoclase	- 10%
Biotite	- 3%
Plagioclase	- 2%
Muscovite	- 3%
Granite grains	- 5%
Schist grains	- 2%
Quartzite grains	- 3%

   Classify the Sandstone from this thin section study using the provided Triangular Diagram (10 marks)

   iii) The following palaeocurrent data was recorded in Units 3 and 6 in your graphic log.

Unit 3 (O°)	Unit 6 (O°)
75	180
65	175

UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

UNIVERSITY FIRST SEMESTER EXAMINATION – AUGUST 2003
GG421 - SEDIMENTOLOGY
PAPER II – PRACTICAL

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   (b) Name four chemical cements in terrigeneous clastic sedimentary rocks. – (4 marks)
   (c) Give grain size limits of silt, sand and gravel. - (6 marks)
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   Classify the Sandstone from this thin section study using the provided Triangular Diagram (10 marks)

   iii) The following palaeocurrent data was recorded in Units 3 and 6 in your graphic log.

Unit 3 (O°)	Unit 6 (O°)
75	180
65	175
95	200
120	225
130	185
125	195
123	175
140	165
76	185
120	110

Calculate the palaeocurrent direction for these two units and comment on the distribution of the palaeocurrents indicating possible depositional environment(s) that could have given rise to the palaeocurrents- (15 marks)

iv) (a) Describe the resulting Stratigraphic Section indicating possible depositional sub-environments and bedforms that could have produced the sedimentary structures. – (10 marks)
(b) Comment on the overall appearance (nature) of the Sequence and arguing your case for possible types of environments in which such an overall sequence would occur. - (10 marks)

Table 1 GRAPHIC LOG for the Senga Hill area

Unit No.	Thickness	Upper Contact	Lithology	Primary Sedimentary Structures
1	2m	Surface of outcrop	Very fine-grained mudstone, in places with shaly partings	Thinly laminated overlain by massive beds
2	3m	Sharp depositional	Very fine- to medium-grained sandstone	Horizontal bedding and locally massive
3	5m	Sharp depositional	Coarse-grained to pebbly sandstone	Trough cross-bedding alternating with planar x-beds. **Unit 3 - Palaeocurrents**
4	6m	Sharp erosional	Matrix supported conglomerates	Massive with crude bedding locally horizontal bedding
5	3m	Sharp depositional	Clast-supported conglomerates	Complex bed forms with tabular sheets
6	2m	Sharp depositional	Pebbly to very coarse-grained sandstones	Trough cross-bedding **Unit 6 - Palaeocurrents**
7	1 m	Gradational	Medium-grained to very fine-grained sandstone	Ripple cross-laminated **Modal composition of Unit 7 given**
8	1 m	Sharp depositional	Alternating siltstones and mudstone	Laminated siltstone and massive mudstones with desiccation cracks and root traces

END OF EXAM **GOOD LUCK**

UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

UNIVERSITY FIRST SEMESTER EXAMINATIONS – AUGUST 2003

GG421 - SEDIMENTOLOGY
PAPER I – THEORY

NSTRUCTIONS: ANSWER ANY 5 QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS. WELL – LABELLED SKETCHES & DIAGRAMS ARE REQUIRED FOR A FULL MARK.

IME: **THREE (3) HOURS**

Distinguish between the following:

(a) Bindstone and Framestone.

(b) Matrix and cement in carbonate rocks.

(c) Glaciolacustrine and glaciomarine

(d) Planar cross-bedding and Trough cross-bedding

(e) Bed load and Suspended load

(a) With the aid of a neatly labeled sketch, describe the ideal turbidite (Bouma) sequence.

(b) Outline the four (4) functions which Facies Models should fulfill.

(c) With the aid of a table, differentiate between terrigenous clastic and carbonate sediments

(d) Describe briefly the characteristic (diagonostic) features of glacial deposits.

(a) Briefly outline two methods by which sedimentary structures are classified indicating their limitations.

(b) Outline the characteristics features of eolian deposits.

(c) Explain how lakes are created.

(a) Differentiate between proximal and distal trends of an alluvial fan setting.

(b) In the study of depositional environments, modeling of depositional systems is important. Outline the common elements you would consider in developing a model of a braided river system.

(c) In Meandering River systems, in-channel deposits are very common. A good example is a point bar sequence. Describe an "ideal" point bar sequence with the aid of a sketch.

(a) The Zambian Copperbelt Lower Roan Group is interpreted as being deposited in a shallow marine environment. One such sub-environment is the peritidal system which includes tide dominated lagoons and tidal flats. Outline the common elements of the peritidal system model.

(b) Describe the factors that influence the development of delta systems and their importance.

(c) Briefly outline the characteristic features of ocean basins.

6 (a) How are carbonate minerals formed?

(b) With the aid of a sketch, show the zonation of a marginal Reef.

(c) Outline the stages of reef growth.

(d) Throughout the geological time scale Reef builders have been recognised. List three such builders and indicate which one (s) where active during the deposition of the Lower Roan Group of the Zambian Copperbelt.

7 (a) List the five common evaporite minerals.

(b) Briefly explain the four Common Techniques used in Basin Analysis.

(c) Basin Analysis is an important tool in the study of any sedimentary basin. Briefly describe two applications of basin analysis giving Zambian examples in each case.

GOOD LUCK **END OF EXAM**

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

FIRST SEMESTER UNIVERSITY EXAMINATIONS – AUGUST 2003
GG435 - STRUCTURAL GEOLOGY
PAPER II - PRACTICAL

INTRUCTIONS:	ANSWER ALL QUESTIONS
TIME:	THREE HOURS

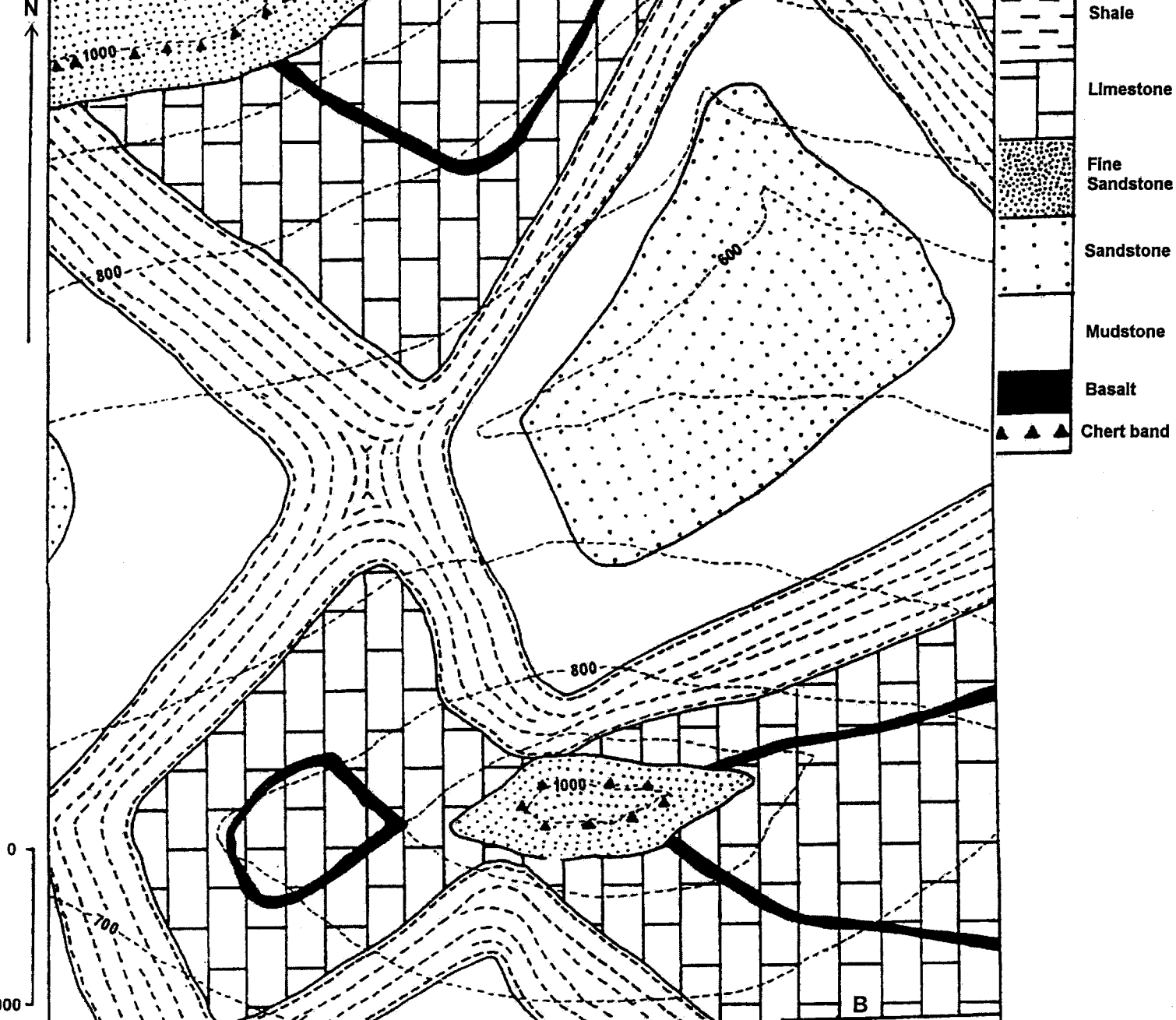
PART A (60 marks) Using Map One, do the following:

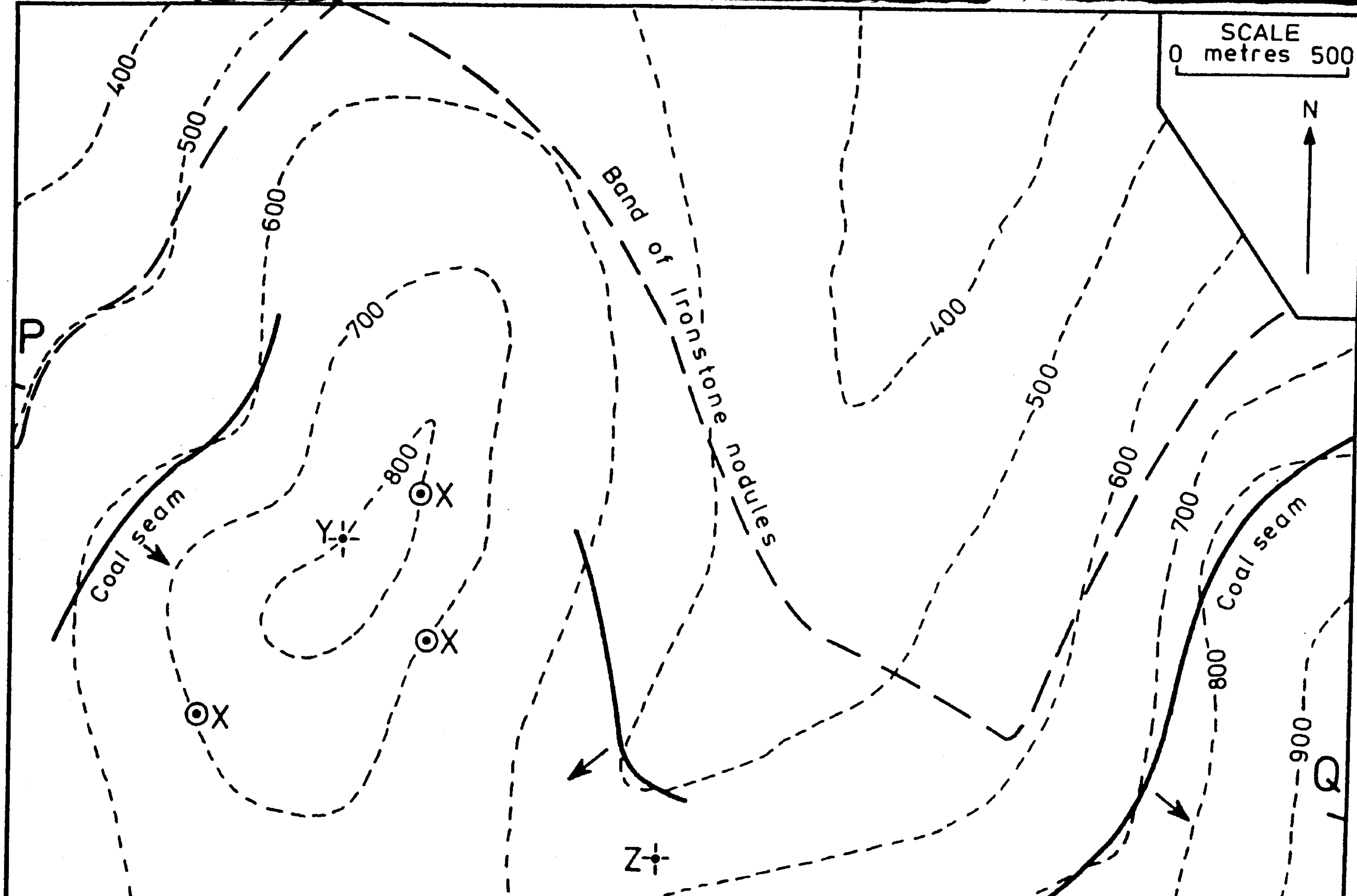
1. Draw in the strike lines
2. Determine the attitude of each bed
3. Draw cross-section A - B
4. Determine the type of structures present.
5. Briefly explain the formation of the structures.
6. Determine the thickness of each bed.
7. Determine the maximum depth at which you expect the basalt in the valley underlain by sandstone
8. Where would you place at least three vertical drill holes (DDH1, DDH2, and DDH3), within the limestone, to intersect a horizontal coal seam outcropping at 600m elevation?
9. Draw the stratigraphic table
10. Describe the structural history of the map area

PART B (40 marks) Using Map Two, do the following:

1. Complete the outcrop of the coal seam
2. Determine the depth at which the coal seam will be intersected in drill holes Y and Z.
3. Determine the amount of plunge of the fold axes? Draw the axial traces.
4. Draw cross-section along line P-Q

GOOD LUCK!!!!!


N
1000
800
600
800
1000
700
0
1000
B
Shale
Limestone
Fine Sandstone
Sandstone
Mudstone
Basalt
Chert band


SCALE
0 metres 500
N
400
500
600
700
800
900
Band of Ironstone nodules
Coal seam
Coal seam
P
Q
X
X
X
X
Y
Z

UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – FIRST SEMESTER, AUGUST 2003

MG 319: COMPUTER TECHNIQUES

PRACTICAL

TIME: 3 Hrs

INSTRUCTIONS: Answer ALL questions. Use formulas where necessary
Practical Part All Answers must be saved on a floppy Disk.

Question 1

1. Open the file named "mg319tst.doc". From Directory MG319 on the Hard Drive.

2. Highlight the first five paragraphs and use the Lower Formatting Toolbar to change its font to Britannic, its font size to 18, and its alignment to center.

3. Highlight the phrases 6-8 inclusive and change the font to Desdemona or Bushscript if Desdemona is not found, 18, Bold. Highlight the last five lines of the document, and then use a button to add bullets to the beginning of those items. Make the highlighting disappear.

4. Use the Replace facility in the Edit Menu, to replace the word 'data' with information every time it appears in the document.

5. Change the spacing of the document from Single to 1.5 Lines. Make the highlighting disappear.

7. Save this document on your floppy drive using the File Menu.

8. Close this document.

[35 marks]

Question 2

- Open Exeltst1.xls from MG319 Directory on the hard-drive.
- Find the difference between the Assets and liabilities of 1995 and 1994 and give resulting column the heading, "DIFF".
- Sum up the total Assets and liabilities for 1994 and 1995.
- Change the heading "Balance Sheet" to Impact font of size 18.
- Change Assets and liabilities Headings to Courier New of size 16.
- Name the cells for total assets and liabilities to "Total-Assets" and "Tot-liability", Using the name facility.
- Use Bar Chart to construct a graph for the two years.

[35 marks]

Question 3

Produce the following on your floppy drive.

In the file Manager Create Three (3) Directories Namely:

i) Assignments
ii) Projects
iii) Exams

Under Assignments directory, create sub-directories:
i) Written
ii) Lab

Under Projects directory, create sub-directory

i) Finalyear

[30 marks]

END OF EXAMINATION IN MG 319

UNIVERSITY OF ZAMBIA

SCHOOOL OF MINES
MINING ENGINEERING DEPARTMENT
UNIVERSITY EXAMINATIONS – AUGUST 2003

END OF SEMESTER ONE EXAMINATION

INSTRUCTIONS: Answer all questions from section **A** and any three from section **B**

TIME: 3 Hours **Full Marks : 100**

MI 209 – INTRODUCTION TO MINING

SECTION A

1. (a) Name two major ore reserve and resource classification systems, and state the definitions of ore resources and reserves associated with one;

[5 marks]

(b) Discuss common computational methodologies for mine ore reserves and resources, including their associated rationale and algorithms.

[15 marks]

2. Mining methods are characterised by different operating techniques such as ore- mobilisation, extraction and transportation which are as a result of geometric, geomechanical and geologic properties of the ore- body.

i) Explain in detail how the above properties influence the choice of a mining method.

[15 Marks]

ii) State five major technological demands that should be met by any mining method during extraction of ore-deposits.

[5 Marks]

SECTION B

3 (a) Identify two major open pit optimisation routines commonly used in the mining industry, and briefly explain the objectives of open pit optimisation;

[5 marks]

(b) Differentiate between the terms 'open cast' and 'open pit', and illustrate open pit geometry and associated terminology.

[15 marks]

4. (a) Briefly, explain the terms 'yielding arch set', 'pillar', 'timbering', and 'subsidence';

[5 marks]

(b) Mention two types of underground rock-bolts, and explain their modes of operation and installation.

[15 marks]

5. With the help of clear diagrams , explain briefly three common methods involved in shaft sinking methods.

[20 Marks]

6. The drilling performance is mainly influenced by four groups of factors. Explain in detail how these factors influence rock penetration.

[20 Marks]

----------END OF EXAMINATION----------

GOOD LUCK

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
MINING ENGINEERING DEPARTMENT
END OF SEMESTER EXAMINATION – AUGUST 2003
MI 315 ROCK MECHANICS I

TIME: 3 HOURS **FULL MARKS 100**

INSTRUCTIONS FOR STUDENTS

- Answer question no. 1 and any other five. In total six(06) questions to be answered.
- Use the supplied graph paper for question no. 4(b)
- Calculations must be shown in full

1. (a) the knowledge of rock mechanics is considered very important before, during and even after for the safe and efficient operation of mines. Justify, this statement, citing mining examples where appropriate.

(10 marks)

(b) As a rock mechanics consultant you intend to set up a laboratory to provide services to both underground and surface mine operators. List the facilities you would like in such a laboratory stating clearly their purposes.

(6 marks)

(c) Give some ideas based on logistics on the price you would like to charge from your clients for different services offered.

(4 marks)

2. (a) What are known as 'physical' and 'mechanical' properties of rock? Name <u>three</u> under each property and state their usefulness in mining.

(10 marks)

(b) From the data given below calculate tensile strength of the rock:

- load at failure (diametrical loading) = 30 KN
- diameter of rock sample = 50mm
- Thickness = 25mm
- Data of loading = 200 N/s rate
- Void ratio = 10%

3. (a) Rocky classified based on their ORIGIN, STRENGTH (uniaxial compressive strength), <u>BEHAVIORAL</u> PROPERTIES, BIENIASKI AND N.G.I geomechanics classifications. Name all the parameters used under these classifications

(10 marks)

(b) (i) Calculate the R.M.R. of rock if the value of Q= for that rock is 3.

(4 marks)

(ii) What will be your comment for a rock type The its R.M.R. value is 30?

(2 marks)

4. (a) What is the difference between uniaxial and a triaxial strength of rock? Describe, briefly, how these tests are performed?

(10 marks)

(b) In a series of triaxial compression tests in a dolomite the following represent the stresses at peak load conditions.

TEST	σ_3 (MPa)	σ_1 (MPa)
1	1.0	9.2
2	5.0	28.0
3	9.5	48.7
4	15.0	74.0

Determine the value of (i) shear strength (ii) angle of internal friction and (iii) cohesion that best fit the data.

(06 marks)

5. (a) What causes in situ stress underground? Name <u>three</u> instruments that may be needed to measure this stress and describe anyone of them in detail.

(10 marks)

(b) Calculate the horizontal stress induced in a rock mass at a depth of 700m. Given that the average density of overlying rock is 2.6×10^3 N/m^3 and Poisson's ratio equal to 0.25

(6 marks)

6. (a) What are the different modes of failure of slopes in hard rock? Describe with the help of diagrams. Briefly describe the method of control of such slides.

(10 marks)

(b) At what angle a will block of rock begin to slide if its mass is 5 tonnes? The coefficient of friction between two rock surfaces is 0.7. Take value of g=10N/m^2. What will be the effect on the angle of slide if the mass of the rock is doubled

(6 marks)

7. (a) The nature of subsidence due to mining of bedded deposit (e.g. coal) varies drastically to mining from a vein deposits (e.g. copper, iron etc.). Describe with the help of diagrams the kind of subsidence you would expect from the above two cases.

(10 marks)

(b) List the factors which are responsible for subsidence due to mining. Suggest same measures that can be taken underground to minimize such subsidence.

(4 marks)

(c) Calculate the minimum extracted area in case of <u>mining bedded deposits</u> subsidence when the depth is 100m and 500m respectively.

(2 marks)

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

SCHOOOL OF MINES
MINING ENGINEERING DEPARTMENT
UNIVERSITY XAMINATIONS – AUGUST 2003

END OF SEMESTER ONE EXAMINATION

MI 431 – UNDERGROUND MINE DESIGN

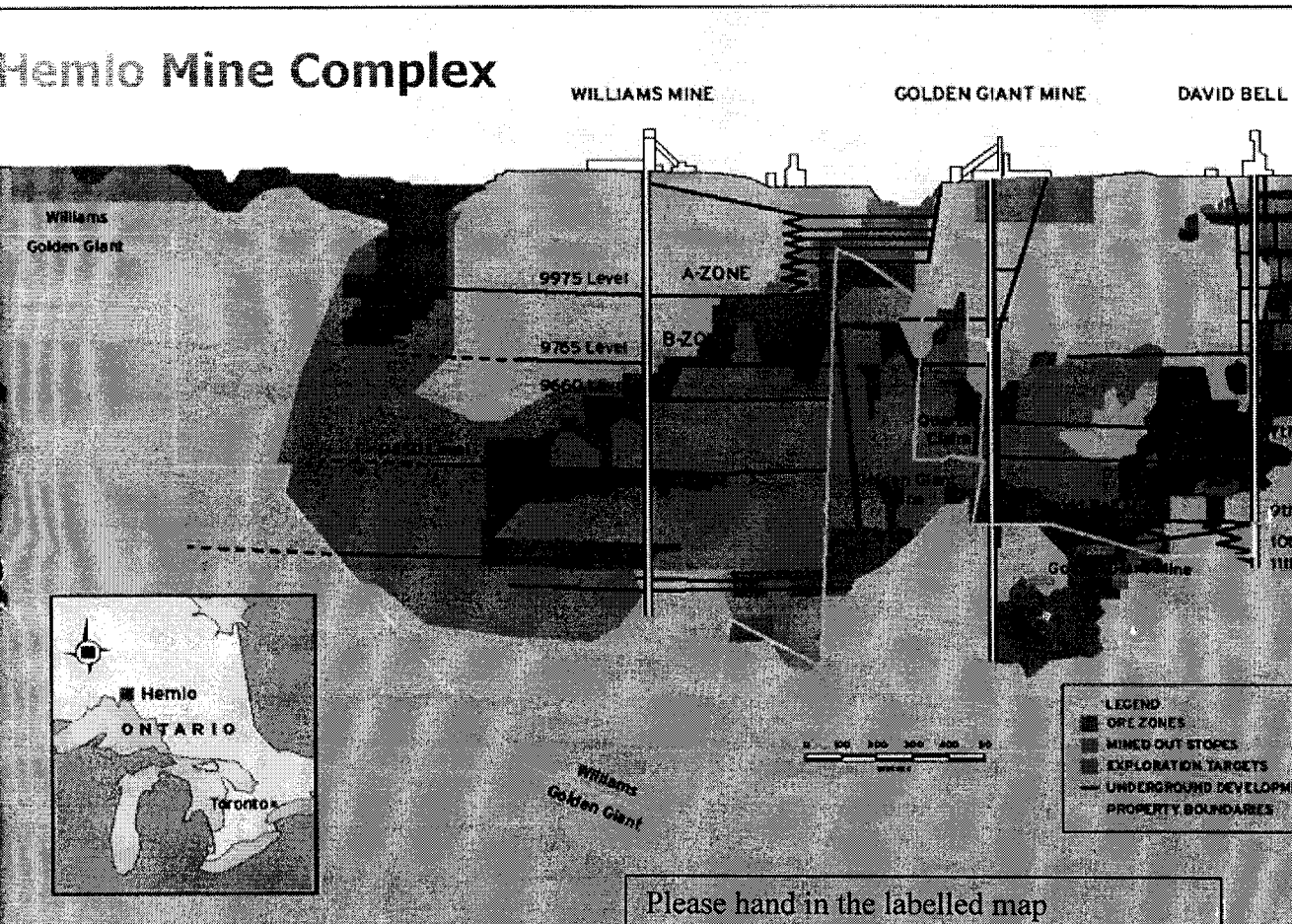
INSTRUCTIONS: Answer all questions from section A any three questions from section **B**
TIME: 3 hours

Section A

1. Figure 1 below (a small one superimposed on a big one) are of the Hemlo mine comple in Canada. Based on the illustrations, identify the types of plans or sections they migh be, and why and then hypothetically describe the layout and geology of the mine comple as completely as possible, citing any reservations and deficiencies you might have. Yo can label the infrastructure, excavations and ore zones on the illustrations attached, an add anything, as you may wish.

[20 marks]

Figure 1



Please hand in the labelled map

a) Show the relationship between mining costs and level spacing, and explain how this relationship can be used to select the optimum level spacing.

[5 marks]

b) Describe and illustrate the main structures and features of the block caving method based on the herringbone scraper drift system, including an explanation of the significance of the herringbone layout.

[15 marks]

SECTION B

(a) Examine the influence of the shape of a drawpoint in sublevel caving on draw point muck pile geometry and gravity flow of blasted ore and waste;

[5 marks]

(b) Describe and illustrate the basic principles and structure of the transverse sublevel caving method. **[15 marks]**

A portion of a panel in room and pillar mine is shown in figure 2 below. All openings are 6 m in width , and the mining height is regular. Rooms are driven on 18 m centres and cross cuts on 24 m centres.
Calculate the extraction ratio in the panel (a) without pillar recovery and (b) with recovery of chain pillars. Disregard the effect of barrier pillars, and calculate for the smallest repetitive dimensions in the panel.

[20 marks]

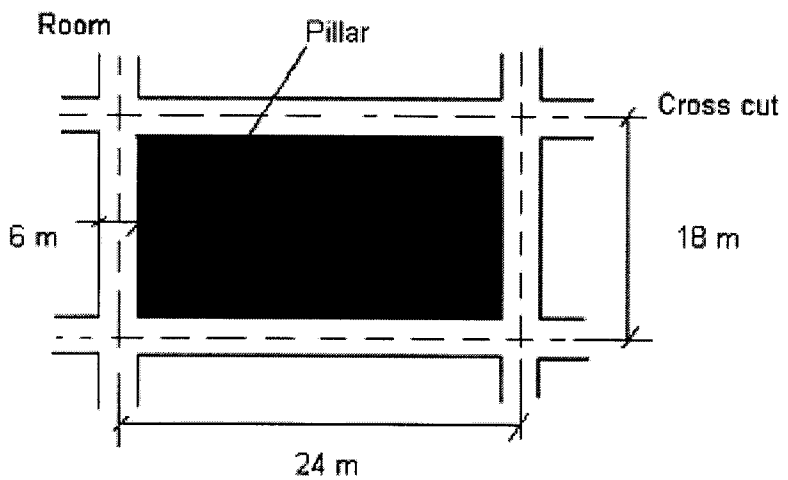


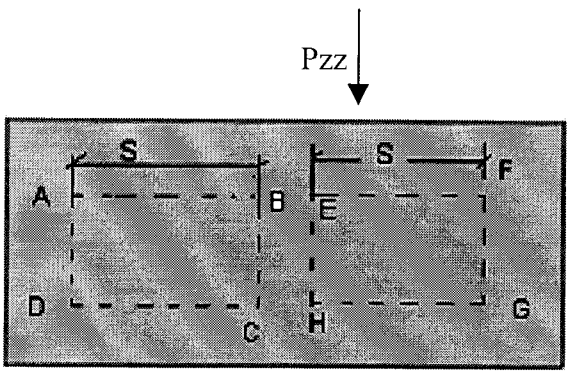
Figure 2. Portion of room and pillar mine

Figure 3 below shows a pre-mining state of loading around the rooms in a

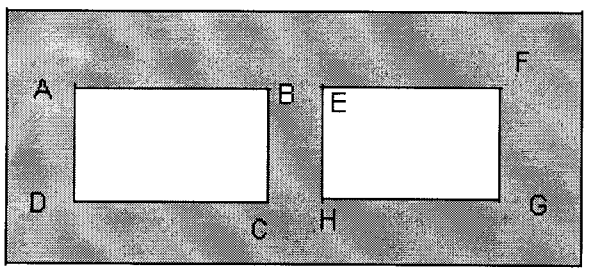
stratiform ore-body subject to a)uniaxial stress b) post excavation state and c) free – body diagram showing induced axial pillar load. Given that
Pzz – uniaxial vertical pre-mining stress field
Pz – induced axial pillar load and
S- pan of excavation.

a) Find the work done by the applied load on the pillar.

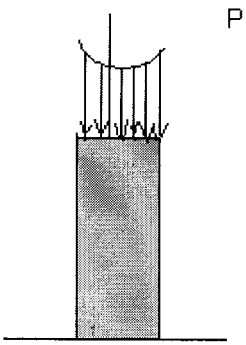
[5 Marks]



a)



b)



c)

b) What is the criterion used for the geomechanical classification of underground mining methods. Explain each category of mining methods and illustrate your answer by citing one mining method.

[15 Marks]

Explain briefly the main principles involved in selecting a mining method based on numerical approach.

[20 Marks]

END OF EXAMINATION

----------GOOD LUCK----------

UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – AUGUST 2003

1ST SEMESTER EXAMINATIONS

MI 455 - OPERATIONS RESEARCH

TIME: 3 HOURS

ANSWER: ANY FIVE (05) QUESTIONS FULL MARKS 100

CALCULATORS ALLOWED

Question 1

A local coal mining company operating an underground mine has eight production faces in operation. Data with respect to these faces are given in Table 1:

Table 1. Data with respect to the faces

Face	Coal Type	Maximum Production [t/d]	Sulphur Content [%]	Ash Content [%]	Fines [%]	Contribution [$/t]
1	Power	1000	1.2	10	10	30
2	Power	1500	1.7	12	10	25
3	Power	1000	1.1	8	15	20
4	Coking	2000	1.8	6	15	10
5	Power	1500	1.5	2	10	25
6	Coking	1000	1.2	6	10	10
7	Coking	2000	1.3	10	20	10
8	Coking	1000	1.1	10	20	15

Notes

- Faces 1, 2 and 3 supply coal to a common loading point which has a capacity of 3250 t/d (Three thousand two hundred and fifty).
- The main hoisting shaft has a capacity of 10000 t/d (Ten thousand)

- Maximum sulphur content in the ROM coking coal should be 1.4%.
- Maximum ash content in the ROM coking coal should be 7.8%.
- Maximum fines in the power coal should be 500 t/d (Five hundred).

(a) Describe the steps one should follow in formulating a linear programming model. **[5 marks]**

(b) Formulate an Optimization Model for a production plan to maximize the total daily contribution. Use $X_1, X_2, \ldots, X_8$ to represent the proposed coal tonnages to be produced from each of the eight production faces. **[15 marks]**

Question 2

Consider a project which has 8 events (event 1 = project start and event 8 = project finish). The three PERT time estimates (in days) are given in Table 2.

Table 2: PERT time estimates (in days)

Activity	Most optimistic	Most Likely	Most Pessimistic
1 2	3	4	6
1 3	1	2	3
2 4	3	5	6
2 5	3	4	6
3 7	5	6	7
4 6	1	3	4
5 6	1	3	5
5 7	1	2	3
6 7	3	5	7
6 8	1	2	4
7 8	2	3	4

[a] Construct an arrow diagram for the project. **[3 marks]**

[b] Using the PERT assumptions, find the mean and variance of the times for each activity. **[3 marks]**

[c] Find the critical path using the mean times in [b]. **[3 marks]**

[d] Assume the completion time for the total project can be approximated by a normal distribution with the following parameters;

$\Sigma \xi$ = Sum of means along the critical path
$\Sigma \sigma^2$ = Sum of variance along the critical path.

Determine these parameters. **[3 marks]**

[e] Find the probability that the project will be completed in 15 days or less. **[4 marks]**

[f] If you had to estimate a time for project completion, and wanted to be 85% confident of completion by this time, what would be your estimate? **[4 marks]**

Question 3

(a) Discuss the simplifying assumptions of the Economic Order Quantity (EOQ) Model? **[4 marks]**

(b) The demand for a certain brand of bit at Konkola Copper Mines (KCM) Plc is assumed to be 600 per month. KCM must pay the supplier \$8 for each bit, and it costs \$30 to set up each order. The storage cost per bit per month is \$0.40. Ordered goods arrive instantaneously. Assuming that no shortages are allowed, and that there are 24 working days per month, find:

(i) The economic order quantity (EOQ) to the nearest integer; **[4 marks]**
(ii) The approximate time between orders; **[4 marks]**
(iii) The total cost per year; **[4 marks]**
(iv) Maximum inventory level; **[4 marks]**

Question 4

(a) Discuss with examples the application of Operations Research Techniques in mining. **[12 marks]**

(b) Explain the following terms:

(i) Entering and leaving basic variables. **[4 marks]**
(ii) Basic and non-basic variables. **[4 marks]**

Question 5

(a) What is degeneracy in linear programming and how is it identified and remedied in simplex method? **[7 marks]**

(b) Explain what a penalty cost is? **[3 marks]**

(c) In an underground mine operations at Roan Antelope Mining Corporation of Zambia Plc (RAMCOZ), four Jackhammers are to be used to drill four ends. Table 3 below shows the four ends that must be driven and the Jackhammers that must be assigned to these ends. The matrix entries represent costs in dollars.

Table 3: Showing ends to be driven and the Jackhammers to be assigned to these ends

Jackhammer / Ends	1	2	3	4
2310 Tip Cross-cut	6	5	7	4
2350 Drilling drive	5	8	3	8
2350 Vent Raise	6	3	4	7
2350 Haulage	10	8	7	4

If you are the Mine Captain of this area, what assignment would you adopt in order to ensure that all 4 ends are completed at minimum cost? What is the total cost of the assignment. **[10 marks]**

Question 6

(a) How does a **stage** differ from **state** in Dynamic Programming? **[4 marks]**

(b) Discuss four characteristics that define a queuing system. **[4 marks]**

(c) At Mopani Copper Mines Plc, two mechanics work in an underground workshop in which loaders arrive randomly to refuel at an average rate of 10 per hour. Each loader takes, on average, nine minutes to serve, where the service time is assumed to follow an exponential distribution.

(a) Find the probability that both assistants are idle. **[4 marks]**
(b) Find the probability that at least one assistant is busy. **[4 marks]**
(c) Find the expected number of loaders in the system. **[4 marks]**
(d) Find the expected waiting time. **[4 marks]**

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
DEPARTMENT OF MINING ENGINEERING

END OF SEMESTER (SUPPLEMENTARY/DEFERRED) EXAMINATION, MARCH 2001

COALL MINING METHODS: MI 535

Time: 3 Hours Full Marks: 100

INSTRUCTIONS: Answer question no. 7 and any other five. Total number of questions to be answered six.

(a) Discuss briefly the geological information you would like to obtain prior to developing a coal mine. Explain the relevance of the information you mention.
(8 Marks)

(i) While coal reserves are widely distributed throughout the world, certain countries are fortunate than the others. Name three countries and their approximate reserves in terms of percentage which account for 90% world's coal depth.

(4 Marks)

(ii) List eight industrial applications of coal. What is the current annual production of coal in Zambia?

(4 Marks)

(a) Explain clearly, where would you recommend the hangwall mining and the room and pillar mining methods?

(8 Marks)

(b) Technically, mining of coal is easier than the metaliferrous mining. Discuss.
(8 Marks)

(a) State the advantages of mining coal in panels. What are the factors on which the size of such panels depend?

(8 Marks)

(b) A mine having room and pillar working has low production and low productivity. Suggests the measures separately, to improve upon both.

(5 Marks)

(a) A coal seam 4 m thick at a depth of 300 m to be mined by bord and pillar mining. Give the details, with the help of the diagrams, of development, depillaring and transport system to convey coal from the face to the surface.

(8 Marks)

(b) What is meant by 'non-cyclic' mining? State the advantages and disadvantages of this system.

(Marks)

5(a) A Double Ended Ranging Drum (DERD) sheer is to be used on a longwall retreat face. Give an arrangement for combination of the equipment to extract coal. The equipment shown must be clearly labelled.

(8 Marks)

(b) Calculate the daily output from a shearer face, given:

- Length of long face = 200 m
- Thickness of coal seam = 2.5 m
- Web of shearer = 0.6 m
- Av. Speed of shearer on the face = 2.5 m/min
- Number of coal cutting shifts/day = 3
- Duration of shift = 8 hours, but the actual time available for cutting coal = 60% of the 8 hour shift.
- Av. sp.gra. of coal = 1.25

Express you answer in million tonnes. (8 Marks)

6(a) State the circumstances most suitable for horizon mining. Discuss its advantages.

(b) Draw a suitable layout, both in plan and section, for mining by horizon mining and briefly describe the method for mining coal.

(8 Marks)

7(a) Describe the safety measures recommended (as per the statute) in a coal mining against the dangers from (i) methane explosion and (ii) water inundation.

(10 Marks)

(a) A coal seam 3 m thick, over a plan area 100 m x 100 m, at a depth of 350 m is to be minsed by 'room and pillar mining'. Given the strength of coal pillar equal to 10 Mpa, the safety, factor of the pillar be kept 1.2, and the av. Density of the overlying role is $27KNm^{-3}$.

Calculate the size of the pillars of SQUARE shape twelve (12) in numbers (within the above area) so that the pillars should remain stable until the mining is complete.

(10 Marks)

END

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
MINING ENGINEERING DEPARTMENT

END OF FIRST SEMESTER EXAMINATION- AUGUST 2003
MI 545 MINE MANAGEMENT

TIME: 3 HOURS **FULL MARKS 100**

ANSWER ALL QUESTIONS
Each question carries equal marks

1. Write short notes on the following:
   (a) Meaning of business management
   (b) Function of management
   (c) Vision statement of an organisation
   (d) Goals of an organisation
   (e) Objectives of an organisation

2. Consider one of the following companies operating in a "globalising" village.

   (a) A farming company in a "tropical jungle"
   (b) A Copper Mining Company in a "Banana" Republic
   (c) A diamond cutting monopoly in a "Jewish State"

   For the company chosen undertake a SWOT analysis for it and justify its future.

3. In as far as a corporation's strategy is concerned what environment and culture would suit.

   (a) Role Culture
   (b) Power Culture
   (c) Matrix culture
   (d) Cluster Culture

4. (a) What do you understand by the term "Motivation"
   (b) What are the key considerations and implication to management styles in the following theories.
      (i) Theory X
      (ii) Theory Y
      (iii) Theory Z

   (d) What are the key areas to consider when managing by objectives (MBO)
   (e) What do you understand by the phrase "competency models of management". Where is this model most suitable to apply.

5. (a) A company with current liabilities of K120,000, has the following current assets: Stocks K80,000, Debtors K60,000 cash K40,000

   i. What is its current ratio?
   ii. What is its acid test ratio?
   iii. What is its working capital?

   (b) What is the importance of ratio analysis in business assessment? Discuss all the common ratios in detail.

6. (a) When faced with problems of raising funds for your company what potential sources would you consider? Write briefly about disadvantages and advantages of each source.

   (b) In your consideration of structuring a loan proposal (Debt) what features should you consider

7. (a) What are the economic functions of a stocks exchange
   (b) How does it operate.
   (c) What economic indicators would short term stock and long term exchange indices reveal.

8. (a) Differentiate Criminal Law from Civil Law
   (b) List five factors which may affect the validity of a contract
   (c) Give an example of a contract which must be made by deed
   (d) Give three examples of contracts which must be in writing.

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – AUGUST 2003

MM 321 – PHYSICAL METALLURGY I

TIME: THREE HOURS

ANSWER ANY FIVE QUESTIONS

1. (a) Why are aluminium based alloys equally important in engineering manufacture as are iron based materials? What is the most important alloying element for aluminium casting alloys and explain why.

   (b) Why are small amounts of lead added to some Cu-Zn brasses? In what state is the lead distributed in brasses?

2. What is the main objective in metal heat treatment procedures and what condition (s) must be satisfied (indicate by making reference to a binary alloy) before an alloy is heat treatable?

   Briefly describe the following

   (i) Solution treatment

   (ii) Quenching

3. (a) Why is it important to evaluate/study crystallographic directions and planes in crystal systems as applicable to metals and metal processing.

   (b) What assists the process of heterogeneous nucleation to only require significantly lower under-coolings?

   (c) Explain why "coring" or solute re-distribution occurs during solidification of an alloy. Is coring avoidable in solidification?

4. (a) Show that the effective strain, ε, is equal to the strain hardening exponent, n, in a tensile loading procedure given that

$$\frac{d\sigma}{d\varepsilon} = \sigma \quad \text{and} \quad \sigma = k\,\varepsilon^n$$

How is the value of the strain hardening exponent, n, evaluated from the tensile test? (Hint: use the value of the logarithmic strain in relation to volume constancy rule).

(b) Distinguish between screw and edge dislocations and show the significance of the Burgers vector, b.

5. (a) What is strain hardening of a metal? Most metal working processes involve strain hardening, suggest a way in which the effects of strain hardening are minimized or removed from a metal.

(b) Illustrate the mechanism of shear in crystal structures showing the relative distances between planes of atoms and that between equilibrium positions. What is the theoretical strength of cubic iron whose shear modulus, G, is 550 MPa?

6. (a) For two screw dislocations, b_1 and b_2, and separated by distance r, the force generated as a result of the shear stress is;

$$F_S = \tau_{max.}\, b$$

Using the result from the model on shearing atomic planes and the resultant theoretical shear strength, $\tau_{max.}$, show that the force may be expressed as

$$F_S = \frac{Gb^2}{2\prod r}$$

(b) What is the importance of knowing the instantaneous cross-sectional area of the material under loading as in the tensile experiment above in evaluating characteristics such as ultimate tensile strength (UTS) and elongation (ductility).

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS – AUGUST 2003

SCHOOL OF MINES
DEPARTMENT OF METALLURGY AND MINERAL PROCESSING

MM 411 - MINERAL PROCESSING I

Answer questions 1 and any other four, but keep your answers brief and to the point.
Relative weight of each question indicated in brackets. **Time: 3 hours**

Question 1

Consider a grinding circuit, consisting of a rod mill in open circuit and a ball mill in closed circuit with a hydrocyclone, as in the attached diagram.

(a) Imagine that, as part of a survey of the above circuit, samples were taken of the rod mill and ball mill discharges and of the cyclone underflow and overflow, and that sieve analyses of composite samples of these products gave the following results:

Fraction	Weight Percentages Retained			
	RMD	BMD	CUF	COF
+ 212μm	35.1	24.4	34.9	3.6
+150μm	11.7	21.6	25.1	1.2
+106μm	5.8	25.0	22.5	13.3
+75μm	6.4	13.2	9.2	18.4
+53μm	7.4	10.4	3.9	26.9
-53μm	33.6	5.4	4.4	36.6

Calculate the circulating load over the ball mill / cyclone circuit as a percentage of new feed.

(b) If the feed rate to the rod mill is 95 tph (dry weight), what is the feed rate to the ball mill, based upon your answer to question (c)?

(c) What is the size distribution in the cyclone feed, based upon the above data?

(d) From these data, calculate the recoveries to the cyclone underflow for the different size fractions and plot these against particle size on the graph paper.

(e) What is the separating size in this cyclone operation, based upon these data?

(f) What is the 'imperfection' in this cyclone operation, based upon these data?

[20 %]

Question 2

State briefly what you understand by the following terms, used in mineral processing:

- Percent suspension
- Bulk density
- Optimum mesh-of-grind
- Angle of nip
- Graded crushing
- Classification
- Stokes diameter

- Separating size of a cyclone
- Specific surface (volume basis) of a group of particles
- Permeability of a medium

[20%]

Question 3

(a) Discuss the classification mechanism of a hydrocyclone with the aid of a clearly labelled diagram.

What are the main design variables and operating parameters of this cyclone?

(b) Hydrocyclones have replaced mechanical classifiers in most modern grinding plants. What are the advantages of hydrocyclones over mechanical classifiers?

(c) The most modern mechanical classifier is the rake classifier.

(i) Describe the operation of this classifier with the aid of a clearly labelled diagram, showing the various zones that can be distinguished.

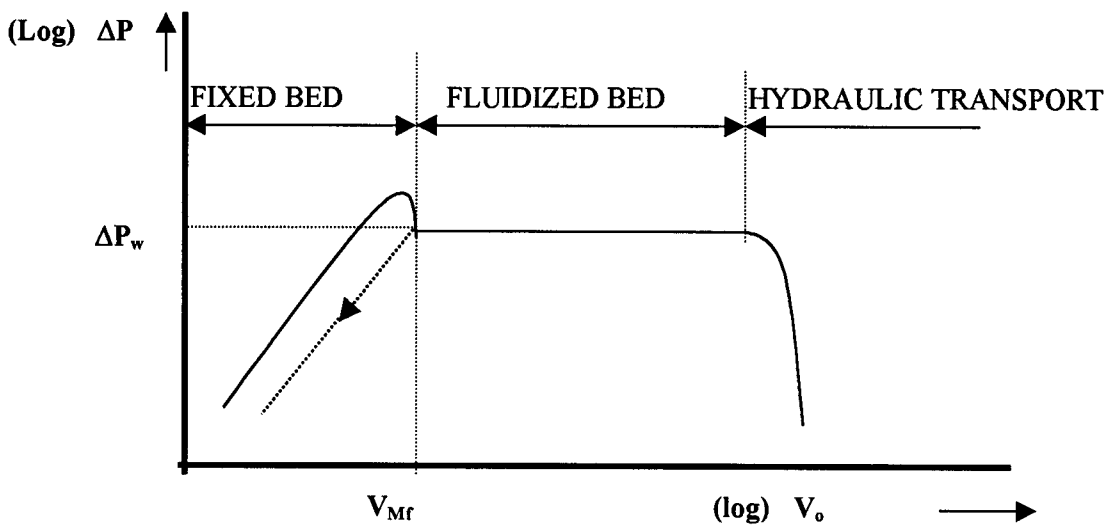
(ii) What operation controls can be used on this type of classifier and state briefly how these controls influence the separation size in this classifier?

(iii) Describe what happens to the separating size when the feed to the classifier is diluted below and beyond the critical dilution.

[20%]

Question 4

Ideal fluidisation can be represented graphically on a double-logarithmic plot as follows:



Ideal Fluidisation

(a) State what the following parameters stand for: ΔP, ΔP_w, V_o, and V_{mF}.

(b) When is the bed said to be in a state of incipient fluidisation and in a fluidised state?

(c) Ideal fluidisation, as represented by the fluidisation curve above, is not always realised. Two phenomena that often occur in practice are channelling and slugging. Explain the underlined terms.

(d) Liquid-solid systems generally exhibit particulate fluidisation where as gas-solid systems, on the other hand, usually shows aggregative fluidisation. What is particulate fluidisation and aggregative fluidisation? Explain why the two types of fluidisation are different.

(e) By which dimensionless groups can the type of fluidisation be characterised and what criterion is used in this?

[20%]

Question 5

(a) Describe the crushing action of a jaw crusher and a gyratory crusher with the aid of clearly labelled diagrams.

Describe the protection mechanisms of jaw crushers and gyratory crushers when an uncrushable material (e.g. tramp metal) enters the crushing cavity.

(b) What are the essential differences between the grinding action of the rod mill and the ball mill? What is the effect of these differences in the grinding action on the size distribution in the respective mill products?

(c) Describe the grinding action of a ball mill indicating the various zones that can be distinguished.

(d) Broken rock of 80% passing 2500μm is ground wet in a ball mill to a product of 80% passing 225μm. This size reduction required 8 kWh per tonne of feed.

(i) How much energy would be required per tonne to reduce this rock from the same feed size to 80% passing 100μm in the same ball mill?

(ii) If it would be required to mill 11000 t/day of this same rock from 2500μm to 100μm (80% passing sizes) in three (3) shift operation with an expected mill efficiency of 89%, how much energy would that require per 24 hour day?

(iii) What minimum horsepower should be installed in the grinding section based upon the above data?

1 hp = 0.75 kW

[20 %]

Question 6

(a) Impellers may be roughly divided into two broad classes: axial flow impellers and radial flow impellers. Describe the characteristics of each of these two impellers and give an example of each.

(b) Describe the three main flow patterns that can be achieved with rotating impellers in a cylindrical tank.

(c) If you are interested in an impeller with a large pumping capacity and a relatively low head, what size of an impeller would you chose and at what speed would you run it?

(d) The power requirements of an impeller are expressed by the power number P_o, defined as:

$$P_o = \frac{P}{\rho_l \, n^3 \, Da^5}$$

where in P = power drawn by the impeller.

Show that P_o is effectively a drag coefficient or a friction factor for the impeller.

) Particles (sphericity = 0.6) are dispersed in a settling tank. The relation between the various parameters in settling is determined by the drag coefficient (C_D) and the Reynolds number (Re):

$$C_D = \frac{4}{3} \frac{d(\rho_s - \rho_l) g}{\rho_l \, v_t^2} \qquad Re = \frac{\rho_l \, d \, v_t}{\eta}$$

) Given that d = 150 μm, ρ_s = 4 700 kg/m^3, ρ_l = 1000 kg/m^3, g = 10 m/s^2 and η = 1.8 cP, calculate the terminal velocity of a particle.

i) Given that v_t = 20 cm/s, ρ_s = 4700 kg/m^3, ρ_l = 1000 kg/m^3, g = 10 m/s^2 and η = 1.8 cP, calculate the size of the particle (d) in microns.

[20%]

END OF MM 411 EXAM
GOOD LUCK!

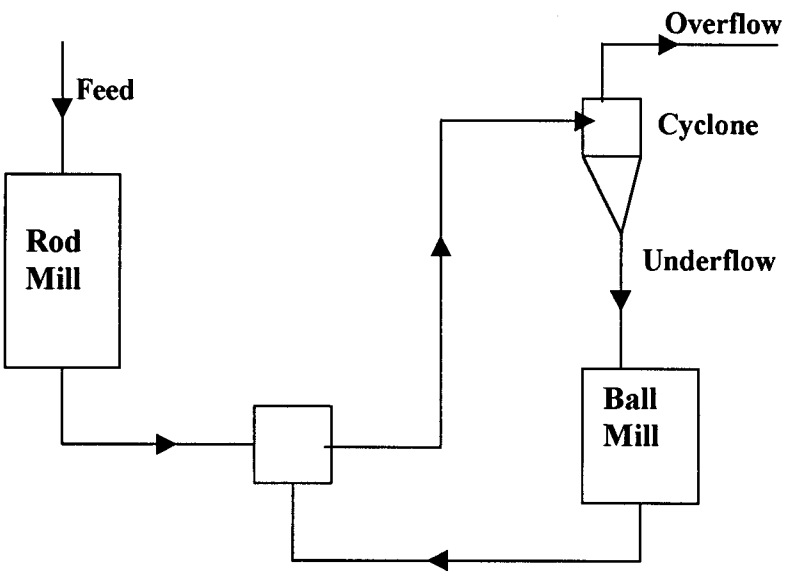


Diagram for question 1 - Rod mill – Ball mill – Cyclone circuit

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - FIRST SEMESTER, AUGUST, 2003

MM 441

PYROMETALLURGY

TIME: THREE HOURS.
ANSWER: ALL QUESTIONS. THE CREDIT FOR A FULL ANSWER IS SHOWN IN BRACKETS BESIDE EACH QUESTION.

1(a) Give a reasoned account of the origin of magnetite in matte smelting units and explain how its presence in the units may be minimized. (7%)

(b) Two copper sulphide concentrates, named X and Y, destined for matte smelting in an electric furnace are blended in a mass ratio of 3 parts X to 2 parts of Y. If the concentrates analyze (gangue oxide composition only) as shown below, calculate how much silica flux (with 80% SiO_2) needs to be added per tonne of the concentrate blend so that the normalized slag composition is: 59% SiO_2, 31% CaO, and 10% Al_2O_3. State any assumptions you make. (13%)

	Gangue oxide composition			
Concentrate	%Al_2O_3	%MgO	%SiO_2	%CaO
X	6.52	0.73	40.1	19.2
Y	8.50	12.81	28.1	13.95

2. With the aid of an appropriate industrial example, explain each of the following metallurgical processes:

(a) Liquation (5%)
(b) Poling (5%)
(c) The Harris process (5%)
(d) The Parkes process (5%)

3(a) Calculate the partial pressure ratio, CO_2/CO, prevailing in a furnace in which solid carbon is in equilibrium with a CO-CO_2 gas mixture at 1200 °C if the total pressure of CO and CO_2 is one atmosphere. (7%)

Data:

$C + 0.5O_2 = CO$

$\Delta G° = - 26700 - 20.95T$ cal/mol

$C + O_2 = CO_2$

$\Delta G° = - 94200 - 0.2T$ cal/mol

(b) Discuss the Imperial smelting process under the following headings: (13%)

(i) Feed to the process

(ii) Reactor used

(iii) Process chemistry

(iv) Products and product recovery

4(a) Copper converters are either top or side blown but never bottom blown. Explain why? (5%)

(b) In a copper converting industrial experiment, each converter is charged with an 8 tonne batch of matte containing 37% Cu. For blowing this matte, each converter is supplied with a constant air blast of 90 Nm^3/minute. Three blowing stages are used, as listed below, per batch of matte fed to each converter

Stage 1: A preliminary blow of 10 minutes duration in which no flux is added. This stage produces a protective magnetite coating on the refractories. The coating analyzes: 74.8% Fe_3O_4, 1.8% FeO, 5.1% CuO, and 18.3% un-oxidized constituents.

Stage 2: A slag blow in which the flux used has the composition: 2.4% Cu_2S, 28% FeS, and 53% SiO_2, with the remainder being other species. It can be assumed that by the end of the slag forming stage, the magnetite coating from the preliminary blow is entirely corroded. The converter slag produced comprises: 31.7% Fe_3O_4, 39.7% FeO, 15.8% SiO_2 and 5.0% CuO.

Stage 3: The copper blow in which blister copper (98.7% Cu and 0.3% S) is produced.

Assuming air (21% O_2 and 79% N_2) with a stoichiometric requirement of oxygen for all the three stages of converting is used, calculate (per converter batch) the following: (15%)

(i) The weight of the magnetite coating produced.
(ii) The weight of flux required.
(iii) The weight of slag made.
(iv) The weight of blister copper produced.
(v) The blowing time for the second stage.

Relative atomic weights: Cu=63.5; Fe=55.8; S=32.1; Si=28.1; O=16.0;

5(a) Why are concentrates with copper sulphide minerals sometimes roasted? (5%)

(b) Use the standard Gibbs energy data given below to construct three lines that would form part of the Mo-S-O predominance area diagram at 627 °C. (10%)

(c) Label appropriately the partial predominance area diagram drawn in Question 1(b). Hence deduce which molybdenum compound or compounds would be present in the calcine, assuming equilibrium is attained, if a molybdenite concentrate is roasted at atmospheric pressure at 627 °C in a furnace with a gas composition of 5% O_2 and 15% SO_2. (5%)

Data:

R = 1.986 cal/deg/mol

(i) $MoO_2 + 2SO_2 = MoS_2 + 3O_2$

$\Delta G^\circ_T = 218900 - 38.0T$ cal/mol

(ii) $MoS_2 + 3.5O_2 = MoO_3 + 2SO_2$

$\Delta G^\circ_T = -257600 + 57.5T$ cal/mol

(iii) $MoO_2 + 0.5O_2 = MoO_3$

$\Delta G^\circ_T = -38700 + 19.5T$ cal/mol

In the above equations, all substances other than O_2 and SO_2 can be considered pure solids at 627 °C.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
UNIVERSITY EXAMINATION - AUGUST 2003
MM 451
TRANSPORT PHENOMENA

Time : THREE hours
Answer: FIVE questions
All questions carry equal marks

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1. The pressure rise across a pump H (expressed as a head in metres) may be considered to be affected by the following variables:

Variable	Dimensions
ρ = fluid density	ML^{-3}
ω = angular velocity	T^{-1}
D = impeller diameter	L
Q = volumetric flow rate	L^3T^{-1}
μ = fluid viscosity	$ML^{-1}T^{-1}$

Find the pertinent dimensionless groups, choosing them so that H, Q and μ each appear in one group only. Find the pertinent power number if the pressure rise were replaced by the power input to the pump.

2. (a) The velocity vector in a two-dimensional flow is given by the expression $\vec{v} = 10\vec{e}_x + 2x\vec{e}_y$ m/s when x is measured in metres. Determine the components (scalar and vector) of the velocity that make a -30^0 angle with the x axis at the point (2,2).

(b) A tank is filled to the edge with water. A cube 600 mm on edge and weighing 445 N is lowered slowly into the water until it floats. Determine the submerged height of the cube in mm and the mass (in kg) of water that flows over the edge of the tank? G = 9.807 m/s^2; density of water = 10^3 kg/m^3.

(c) Molten steel is teemed from a cylindrical ladle through a 0.05-m diameter nozzle at the bottom. If the initial volume of the molten steel is 1.5 m^3 and the velocity of discharge is 0.9 m per second, calculate the time in minutes required to empty the ladle. Density of molten steel is $7.8x10^3$ kg/m^3.

3. (a) A horizontal smooth fixed vane deflects a free jet of water having a velocity of 30.5 m/s and a diameter of $1.0x10^{-2}$ m. However, the vane is in the form of a U so that the exit jet travels in a direction exactly opposite to the entering jet. Calculate the force of the jet on the vane neglecting frictional effects.

(b) Water is flowing through a horizontal diffuser consisting of a section of pipe for which the ID (inside diameter) gradually increases from 0.05 m to 0.10m. The diffuser discharges into the atmosphere. The upstream pressure is 500 kPa absolute and the flow rate is 0.06 m^3/s. Calculate the force on the diffuser from the fluids in contact with it? What is the force of the air?

Density of water = 10^3 kg/m^3
Atmospheric pressure = 101.3 kPa

4. (a) For water flowing in a 0.25-cm diameter tube, the velocity profile is given as

$$v = v_{max}\left[1-\left(\frac{r}{R}\right)^2\right]$$

If the maximum velocity is 1.22 m/s, determine the magnitude of the shear stress at the tube wall.

Viscosity of water = $1.0\text{x}10^{-3}$ Pa.s.

(b) Water at 20^0C is pumped at 0.379 m^3/min from a reservoir through a system of piping into an open tank, the level of which is maintained constant at 5 metres above the level in the reservoir. The flow circuit comprises 8-cm diameter commercial steel pipe of a straight length of 50m containing a wide open gate valve and standard tee. Calculate the power consumption of the pump (in kW) if its efficiency is 70 percent.

Density of water	$= 10^3$ kg/m^3
Viscosity of water	$= 1.0\text{x}10^{-3}$ Pa.s
L_{eq}/D for the gate valve	= 9
L_{eq}/D for the standard tee	= 50
e/D for the steel pipe	= 0.0006
g	= 9.807 m/s^2

$$h_L = 2 f_f \frac{L}{D}\frac{v^2}{g}$$

5. An incompressible fluid flows steadily down a vertical surface as a thin film δ m thick in laminar flow in the vertical y direction. The fluid is at a large distance from the entrance.

(a) Using the Navier-Stokes equations, derive the equation of the velocity profile v_y as

$$v_y = \left(\frac{\rho g \delta^2}{2\mu}\right)\left[1-\left(\frac{x}{\delta}\right)^2\right]$$

where x is the distance from the liquid surface toward the wall.

(b) Derive expressions for the average velocity $v_{y\,avg}$ and the maximum velocity $v_{y\,max}$. What is the ratio of $v_{y\,avg}/\ v_{y\,max}$?

(c) What is the shear stress at the wall?

6. (a) In determining the thermal conductivity of an insulating material, the temperatures were measured on both sides of a flat slab of 25 mm of the material and were 318.4 K and 303.2 K. The heat flux was measured as 35.1 W/m^2. Calculate the thermal conductivity in W/m.K.

(b) Determine the heat transfer rate per m^2 of wall area for the case of a furnace with inside air at 1340 K. The furnace wall is composed of a 0.106-m layer of fireclay brick (k= 1.7 W/m.K) and a 0.635-**cm** thickness of mild steel (k = 34.0 W/m.K) on its outside surface. Heat transfer coefficients on inside and outside wall surfaces are 5110 $W/m^2.K$ and 45.0 $W/m^2.K$ respectively; outside air is at 295 K. Determine the temperature at each surface and at the brick-steel interface.

7. Equimolar counterdiffusion is occurring at steady state in a tube 0.11 m long containing N_2 and CO gases at a total pressure of 1.0 atm. The partial pressure of N_2 is 80 mm Hg at one end and 10 mm Hg at the other end. The diffusion coefficient D_{AB} is 2.05×10^{-5} m^2/s where N_2 is component A.

(a) Calculate the flux in $kmol/m^2.s$ at 298 K for N_2.
(b) Repeat part (a) at 473 K. Does the flux increase?
(c) Repeat at 298 K but for a total pressure of 3.0 atm absolute. The partial pressure of N_2 remains as in part (a). Does the flux change?

$R = 82.057 \times 10^{-3}$ $m^3.atm/kmol.K$
1 atm = 760 mm Hg
$D_{AB} \propto \frac{T^{1.75}}{P}$

This is the end of the examination in MM 451

TABLE 3.4–1

THE EQUATION OF CONTINUITY IN SEVERAL COORDINATE SYSTEMS

Rectangular coordinates (x, y, z):

$$\frac{\partial \rho}{\partial t} + \frac{\partial}{\partial x}(\rho v_x) + \frac{\partial}{\partial y}(\rho v_y) + \frac{\partial}{\partial z}(\rho v_z) = 0 \qquad (A)$$

Cylindrical coordinates (r, θ, z):

$$\frac{\partial \rho}{\partial t} + \frac{1}{r}\frac{\partial}{\partial r}(\rho r v_r) + \frac{1}{r}\frac{\partial}{\partial \theta}(\rho v_\theta) + \frac{\partial}{\partial z}(\rho v_z) = 0 \qquad (B)$$

Spherical coordinates (r, θ, ϕ):

$$\frac{\partial \rho}{\partial t} + \frac{1}{r^2}\frac{\partial}{\partial r}(\rho r^2 v_r) + \frac{1}{r \sin\theta}\frac{\partial}{\partial \theta}(\rho v_\theta \sin\theta) + \frac{1}{r \sin\theta}\frac{\partial}{\partial \phi}(\rho v_\phi) = 0 \qquad (C)$$

TABLE 3.4–6

COMPONENTS OF THE STRESS TENSOR FOR NEWTONIAN FLUIDS IN CYLINDRICAL COORDINATES (r, θ, z)

$$\tau_{rr} = -\mu\left[2\frac{\partial v_r}{\partial r} - \tfrac{2}{3}(\nabla \cdot v)\right] \qquad (A)$$

$$\tau_{\theta\theta} = -\mu\left[2\left(\frac{1}{r}\frac{\partial v_\theta}{\partial \theta} + \frac{v_r}{r}\right) - \tfrac{2}{3}(\nabla \cdot v)\right] \qquad (B)$$

$$\tau_{zz} = -\mu\left[2\frac{\partial v_z}{\partial z} - \tfrac{2}{3}(\nabla \cdot v)\right] \qquad (C)$$

$$\tau_{r\theta} = \tau_{\theta r} = -\mu\left[r\frac{\partial}{\partial r}\left(\frac{v_\theta}{r}\right) + \frac{1}{r}\frac{\partial v_r}{\partial \theta}\right] \qquad (D)$$

$$\tau_{\theta z} = \tau_{z\theta} = -\mu\left[\frac{\partial v_\theta}{\partial z} + \frac{1}{r}\frac{\partial v_z}{\partial \theta}\right] \qquad (E)$$

$$\tau_{zr} = \tau_{rz} = -\mu\left[\frac{\partial v_z}{\partial r} + \frac{\partial v_r}{\partial z}\right] \qquad (F)$$

$$(\nabla \cdot v) = \frac{1}{r}\frac{\partial}{\partial r}(r v_r) + \frac{1}{r}\frac{\partial v_\theta}{\partial \theta} + \frac{\partial v_z}{\partial z} \qquad (G)$$

APPENDIX E
THE NAVIER-STOKES EQUATIONS FOR CONSTANT ρ AND μ IN CARTESIAN, CYLINDRICAL, AND SPHERICAL COORDINATES

CARTESIAN COORDINATES

x direction

$$\rho\left(\frac{\partial v_x}{\partial t}+v_x\frac{\partial v_x}{\partial x}+v_y\frac{\partial v_x}{\partial y}+v_z\frac{\partial v_x}{\partial z}\right)=-\frac{\partial P}{\partial x}+\rho g_x+\mu\left(\frac{\partial^2 v_x}{\partial x^2}+\frac{\partial^2 v_x}{\partial y^2}+\frac{\partial^2 v_x}{\partial z^2}\right) \tag{E-1}$$

y direction

$$\rho\left(\frac{\partial v_y}{\partial t}+v_x\frac{\partial v_y}{\partial x}+v_y\frac{\partial v_y}{\partial y}+v_z\frac{\partial v_y}{\partial z}\right)=-\frac{\partial P}{\partial y}+\rho g_y+\mu\left(\frac{\partial^2 v_y}{\partial x^2}+\frac{\partial^2 v_y}{\partial y^2}+\frac{\partial^2 v_y}{\partial z^2}\right) \tag{E-2}$$

z direction

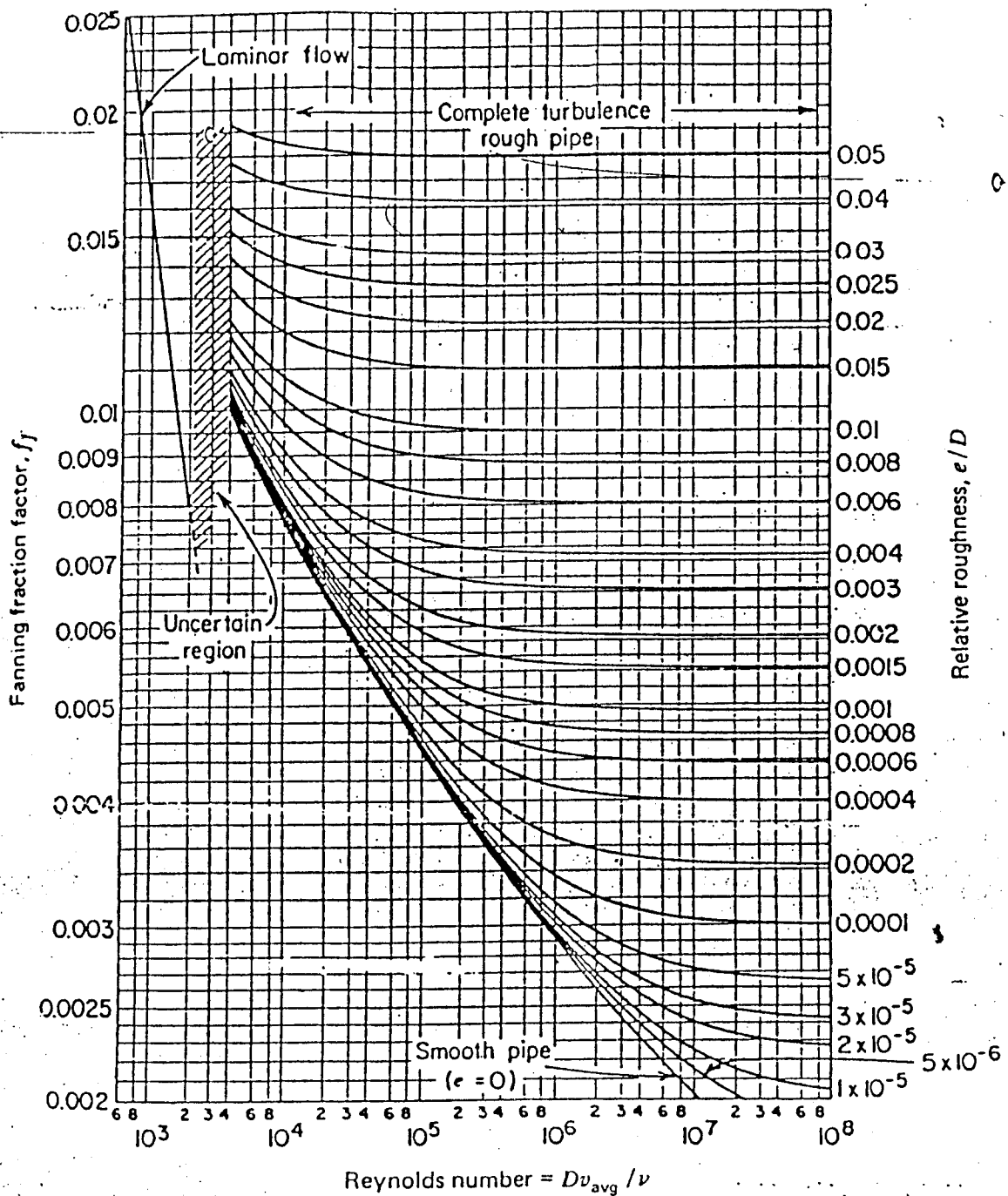
$$\rho\left(\frac{\partial v_z}{\partial t}+v_x\frac{\partial v_z}{\partial x}+v_y\frac{\partial v_z}{\partial y}+v_z\frac{\partial v_z}{\partial z}\right)=-\frac{\partial P}{\partial z}+\rho g_z+\mu\left(\frac{\partial^2 v_z}{\partial x^2}+\frac{\partial^2 v_z}{\partial y^2}+\frac{\partial^2 v_z}{\partial z^2}\right) \tag{E-3}$$

CYLINDRICAL COORDINATES

r direction

$$\rho\left(\frac{\partial v_r}{\partial t}+v_r\frac{\partial v_r}{\partial r}+\frac{v_\theta}{r}\frac{\partial v_r}{\partial \theta}-\frac{v_\theta^2}{r}+v_z\frac{\partial v_r}{\partial z}\right)$$

$$=-\frac{\partial P}{\partial r}+\rho g_r+\mu\left[\frac{\partial}{\partial r}\left(\frac{1}{r}\frac{\partial}{\partial r}(rv_r)\right)+\frac{1}{r^2}\frac{\partial^2 v_r}{\partial \theta^2}-\frac{2}{r^2}\frac{\partial v_\theta}{\partial \theta}+\frac{\partial^2 v_r}{\partial z^2}\right] \tag{E-4}$$


Laminar flow
Complete turbulence rough pipe
Uncertain region
Smooth pipe (e = 0)
Fanning friction factor, f_f
Relative roughness, e/D
Reynolds number = Dv_{avg}/ν
0.025
0.02
0.015
0.01
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.0025
0.002
0.05
0.04
0.03
0.025
0.02
0.015
0.01
0.008
0.006
0.004
0.003
0.002
0.0015
0.001
0.0008
0.0006
0.0004
0.0002
0.0001
5×10^{-5}
3×10^{-5}
2×10^{-5}
1×10^{-5}
5×10^{-6}
10^3
10^4
10^5
10^6
10^7
10^8

UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
UNIVERSITY EXAMINATION - AUGUST 2003

METALLURGY AND MINERAL PROCESSING DEPARTMENT

MM 515- SPECIAL TOPICS IN MINERAL PROCESSING.

Time : THREE hours
Answer: Question 1 and any other four questions
All questions carry equal marks

Q1. An ore containing 3% Cu in the form of chalcopyrite ($CuFeS_2$), the remainder being predominately siliceous gangue (s.g 2.7). The ore is crushed to –12mm and sampled before being further treated. The output from the crusher is fed to storage bins via a conveyor system at an average rate of 100 tonnes per hour. Assuming that the crushed material is thoroughly mixed, determine the limit of error (at 99% confidence limited) in the Cu assay introduced by taking a 1kg sample from the conveyor at intervals of 30 minutes. A test of the ore showed that the maximum Cu content of any piece is 10% Cu. The specific gravity of chalcopyrite is 4.2. Take the shape factor and size factor as 0.5 and 0.25 respectively.

Q2. (a) What are the advantages of using particle size distribution functions over the other methods of presenting sizing data?

(b) What is the general equation of particle size distribution function. Outline the significance of the parameters with reference to the Guadin-Schulmann and Rosin–Rammler functions. Show the relationship between the two functions.

(c) A particle size distribution of the ore is known to follow the G.S. function with 90% and 50% of the particle being less than 1mm and 0.5mm respectively. What is the weight percent between $10\,\mu m$ *and* $20\,\mu m$?

Q3. (a) Explain how an electrical double layer may be formed when minerals are put in a solution:

(b) What do you understand by the following terms?

- Electrophoresis
- Streaming potential
- Electro osmosis
- Sedimentation Potential

How can you measure the first two and give detailed explanation of how Electrophoresis will lead to establishing the zeta potentials and explain how this may be use in the separation of different minerals.

Q4. What is the purpose of particle size reduction in mineral processing?

(i) Give the various definitions of "Reduction Ratio" and identify the most important definitions.

(ii) In Energy-Size reduction relationships as used in the design of comminution equipment, empirical "laws" are normally used. Name these laws and explain on which basis each one is used. Using a generalised equation derive each on of them.

(iii) What do you understand by the term "Bond index?

Q5. (a) "Only regular geometrical shapes can have their sizes conveniently qualified". Discuss the implications of this statement with regards to:

(i) The various definition of "size"
(ii) Applications of these definitions size.

(b) Discuss the principle involved in incremental methods and show how the data obtained may be useful.

(c) Describe the Andreassen pipette and the interpretation/calculation of results. What are the main disadvantages of this apparatus?

Q6. The following data refer to the adsorption of Nitrogen on 0.92 g of a sample of silica gel at 77 K being the pressure and V the Volume adsorbed:

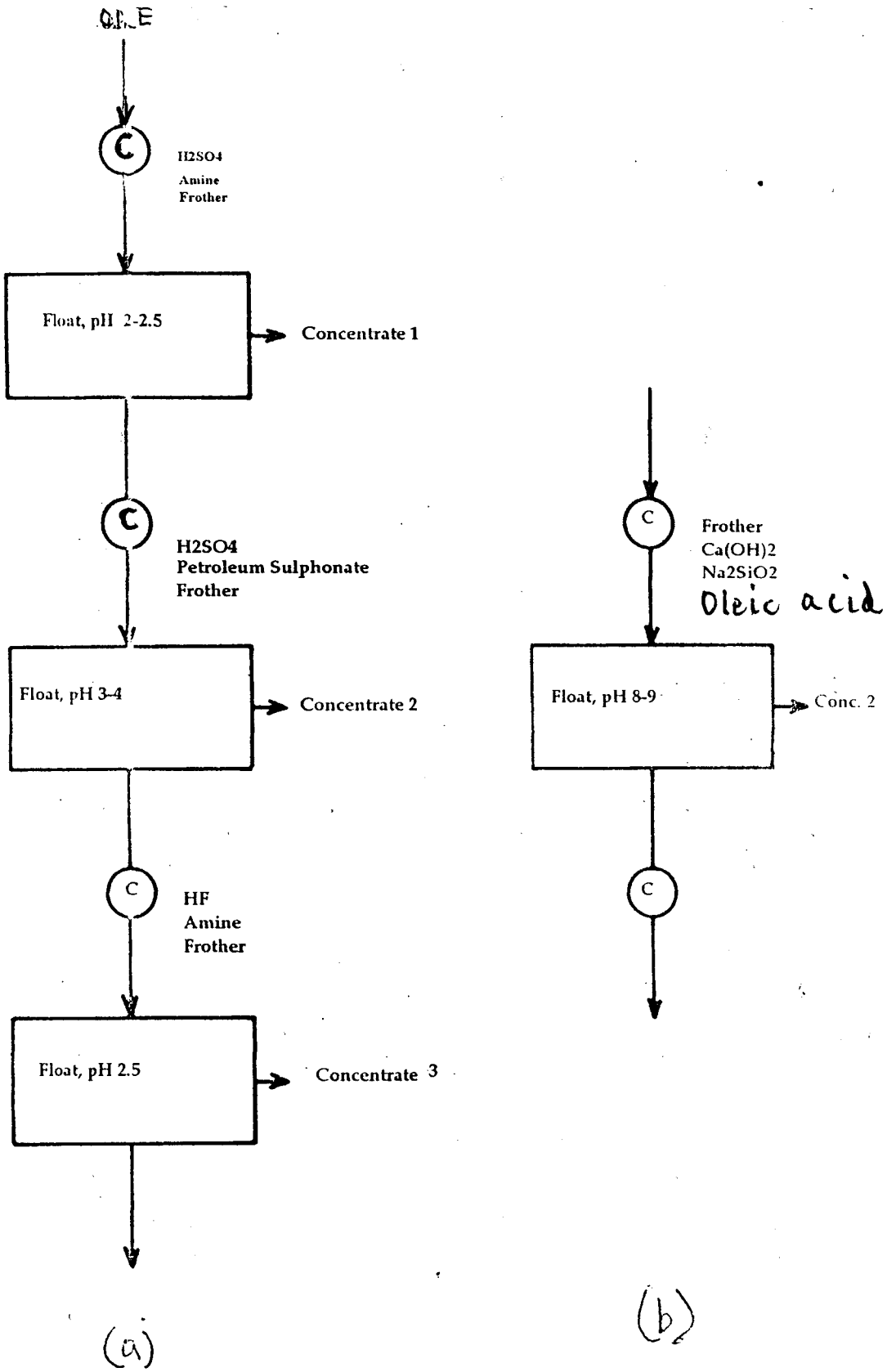
p/Kpa	3.7	8.5	15.2	23.6	31.5	38.2	46.1	54.8
Vol cm^3 (s.t.p.) g^-	82	106	124	142	157	173	196	227

Use the BET equation to calculate a specific surface area for silica gel sample taking the molecular surface area of the adsorbed Nitrogen at monolayer coverage as $16.2 \times 10^{-20} m^2$.

Q7. Study the attached flow sheets for the treatment of a pegmatite ore containing quartz, feldspar, mica and iron oxide. The intermediate flotation stage in (a) may be replaced by that outlined in (b). For the given combination of reagents in both (a) and (b), predict what minerals you would expect in the concentrates 1 to 3 and in the tailings.

Discuss critically the role of each reagent, outlining the theoretical basis for the separations you have predicted. The IEP's of the minerals occur at pH values of 1.5, 2.8, 2.8 and 6.2 for mica, quartz, feldspar and iron oxides respectively.

END OF EXAMINATION AND GOOD LUCK.


Q.F.E
C
H2SO4
Amine
Frother
Float, pH 2-2.5
Concentrate 1
C
H2SO4
Petroleum Sulphonate
Frother
Float, pH 3-4
Concentrate 2
C
HF
Amine
Frother
Float, pH 2.5
Concentrate 3
(a)
C
Frother
Ca(OH)2
Na2SiO2
Oleic acid
Float, pH 8-9
Conc. 2
C
(b)

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
DEPARTMENT OF METALLURGY AND MINERAL PROCESSING

UNIVERSITY EXAMINATIONS – AUGUST, 2003

MM545
Special Topics in Extractive Metallurgy

Answer Question 7 and any other four. **Time: Three Hours**

Question 1

(a) Describe the various types of scrap used in steelmaking. Briefly discuss the physical preparation and the chemical composition of such scrap. What are "tramp alloys", and what is the effect of such elements on the quality of steel.

(b) What is the importance of metal recycling? Describe the methods of recycling copper, zinc and gold.

Question 2

(a) Construct a stability or predominance equilibrium diagram for the roasting of chalcopyrite, $CuFeS_2$ at 1000 K. Discuss the sequence of reactions from A to D through B and C. Name the phases that form during the roasting operation.

(b) By the use of the predominance area diagram for the system Cu-Fe-S-O-SiO_2, describe the physico-chemical principles of matte smelting and converting. What is meant by magnetite fluxing and give appropriate chemical reactions.

(c) Discuss the role of silica in copper-iron oxysulphide melts during the converting of matte. Construct the ternary system FeO-FeS-SiO_2 at 1300 °C and one atmosphere pressure.

Question 3

(a) Discuss the Noranda and the Kivcet processes for the production of copper. What are the advantages and disadvantages of each process?

(b) What is the effect of oxygen enrichment and matte grade on the fuel ratio for all the autonomous smelting processes?

(c) What is the Warner process? What are the special characteristics of this new technology?

Question 4

(a) What is the Ausmelt technology? What are its advantages over conventional methods of metal production from their ores?

(b) Describe hypothetically (with neat sketches) the furnaces and the possible Flowsheets and reactions for the smelting of:

(i) copper concentrates, and
(ii) lead concentrates, both low and high grade.

(c) What relevance has this new technology for the Zambian Copperbelt Industry?

Question 5

(a) Describe the processes of producing:

(i) Sulphuric acid (H_2SO4),
(ii) Elemental sulphur (S) and
(iii) Calcium sulphite and calcium sulphate from smelter flue gases.
(iv) What reasons dictate the recovery of SO_2 in the above given forms?

(b) Describe how the following gas cleaning equipments operate:

(i) Cyclones
(ii) Electrostatic precipitators and scrubbers.

Show the limits of particle sizes in which these equipments work efficiently.

Question 6

(a) Describe in general the solvent extraction (SX) as applied in the recovery of copper from its ores.

(b) Describe the following leaching systems:

(i) Sulphuric acid leaching system,

(iii) Ammonia leaching system,

What are the advantages of each system?

(c) (i) What properties should a successful copper extractant have?

(iii) What is crud? Describe the various parameters which affect its formation, and how can it be suppressed in practice.

(iv) What are equilibrium modifiers, and what is their main function in leaching?

Question 7

From the Table give below, calculate the value of E^B at the blast temperature of 1400 K. Calculate also the values of the parameters given as model variables and their corresponding quantities as inputs to the blast furnace. What is the top gas composition?

END OF MM 545 EXAMINATION
GOOD LUCK!

Table for Question 7

Item	Specification	Quantity		Model variable
		Kg per tonne Fe	Kg moles per tonne Fe	
Fe		1000		
Iron oxide entering wustite reduction zone	$Fe_{0..947}O$			$\left(\frac{O}{Fe}\right)^{wrz} = ?$
Pig iron	5 % C			$\left(\frac{C}{Fe}\right)^{m} = ?$
Blast temperature				$T_B = 1400$ K
Oxygen from blast air				$n_O^B = ?$
Active carbon				$n_C^A = ?$
Total carbon				$n_C^i = ?$
Heat demand of wustite reduction zone				$D^{wrz} = 330\,000$ KJ/kg mole
Blast enthalpy				$E^B = ?$ (at 1400 K)

$$E^B = \frac{1}{2}\left\{\left[H_B^O - H_{1200}^0\right]_{O_2} + \frac{0.79}{0.21}\left[H_B^O - H_{1200}^0\right]_{N_2}\right\}$$

Hint: O_2: $36.2T - 13500$

N_2: $34.4T - 13000$