THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - 1999
FIRST SEMESTER EXAMINATIONS
SCHOOL OF MINES

1.	GG 201	-	Introduction to Geology Paper I - Theory
2.	GG 201	-	Introduction to Geology Paper II - Practical
3.	GG 301	-	Principles of Geology Paper II - Practical
4.	GG 311	-	Crystallography And Mineralogy Paper I- Practical
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 402	-	Geology of Zambia
9.	GG 411	-	Igneous Petrology Paper I - Theory
10.	GG 411	-	Igneous Petrology Paper II - Practical
11.	GG 431	-	Structural Geology Paper I - Theory
12.	GG 431	-	Structural Geology Paper II - Theory
13.	GG 471	-	Geochemistry Paper I - Theory
14.	GG 471	-	Geochemistry Papery II - Practicals
15.	GG 551	-	Exploration, Mining Geology And Management Paper I - Theory
16.	GG 551	-	Exploration, Mining Geology And Management Paper II - Practical
17.	GG 561	-	Engineering Geology - Theory
18.	MG 319	-	Computer Techniques - Paper I - Theory
19.	MG 319	-	Computer Techniques Paper II - Practicals

20.	MI 209	-	Introduction to Mine Development
21.	MI 315	-	Rock Mechanics
22.	MI 411	-	Drilling And Blasting
23.	MI 431	-	Underground Mine Design
24.	MI 465/MM/571		Mineral Economics/management and Economics
25.	MI 535	-	Coal Mining Methods
26.	MI 585	-	Materials Handling
27.	MM 321	-	Physical Metallurgy I
28.	MM 331	-	Chemical Thermodynamics
29.	MM 411	-	Mineral Processing I
30.	MM 441	-	Pyrometallurgy
31.	MM 451	-	Transport Phenomena
32.	MM 481	-	Ferrous Metallurgy
33.	MM 515	-	Special Topics in Mineral Processing
34.	MM 525	-	Mechanical Metallurgy
35.	MM 545	-	Special Topics in Extractive Metallurgy.

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UNIVERSITY FIRST SEMESTER EXAMINATIONS – MAY 1999

GG 201 – INTRODUCTION TO GEOLOGY
PAPER I – THEORY

TIME: **Three (3) Hours**
MARKS: **All Questions Carry Equal Marks**
ANSWER: **Five (5) Questions**

QUESTION 1

(a) What important concept does the rock cycle describe?
(b) Describe and explain each of the three processes that melt rock to form magma.
(c) What do the terms felsic, intermediate, mafic, ultramafic mean?
(d) Describe the mineralogy and texture of the following types of igneous rocks: granite, rhyolite, basalt, gabbro, andesite, and peridotite.

QUESTION 2

(a) Discuss the factors that control the response of rocks to stress.
(b) Name the three main types of structures produced when rocks deform. Explain the type of behaviour that each type of structure reflects.
(c) In what tectonic environment (s) would you expect to find each of the structures?

QUESTION 3

(a) How are minerals distinguished from other substances?
(b) List and explain the physical properties of minerals most useful for identification.
(c) List the rock-forming mineral groups. Why are they called "rock forming"?
(d) If you were given a crystal of diamond and another of quartz, how would you tell which is diamond?

QUESTION 4

(a) List the four factors that cause and drive metamorphism.
(b) Describe the two general kinds of changes that a rock undergoes during metamorphism.
(c) Describe and name the succession of metamorphic rocks that form as shale experiences progressively higher grades of regional dynamothermal metamorphism.
(d) What is a metamorphic facies?

QUESTION 5

(a) List the five stages in the formation of sedimentary rocks.
(b) In what ways are clastic sediments modified during transport?
(c) Describe how loose clastic sediment becomes lithified to form hard rock.

(d) How do shale, sandstone, and limestone differ from one another?

QUESTION 6

(a) Name the two categories of geological resources.
(b) Explain the importance of source rock, reservoir rock, cap rock and oil traps in the formation of petroleum and gas reserves.
(c) How are hydrothermal ore deposits formed?
(d) Explain the mechanism of formation of cumulate magmatic ore deposits

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS – MAY 1999

GG 201 – INTRODUCTION TO GEOLOGY

PAPER I I– PRACTICAL

TIME: **Two (2) Hours**

MARKS: **All Questions Carry Equal Marks**

ANSWER: **All Questions**

1. Identify the five mineral specimens provided on the basis of their physical properties and the standards provided.

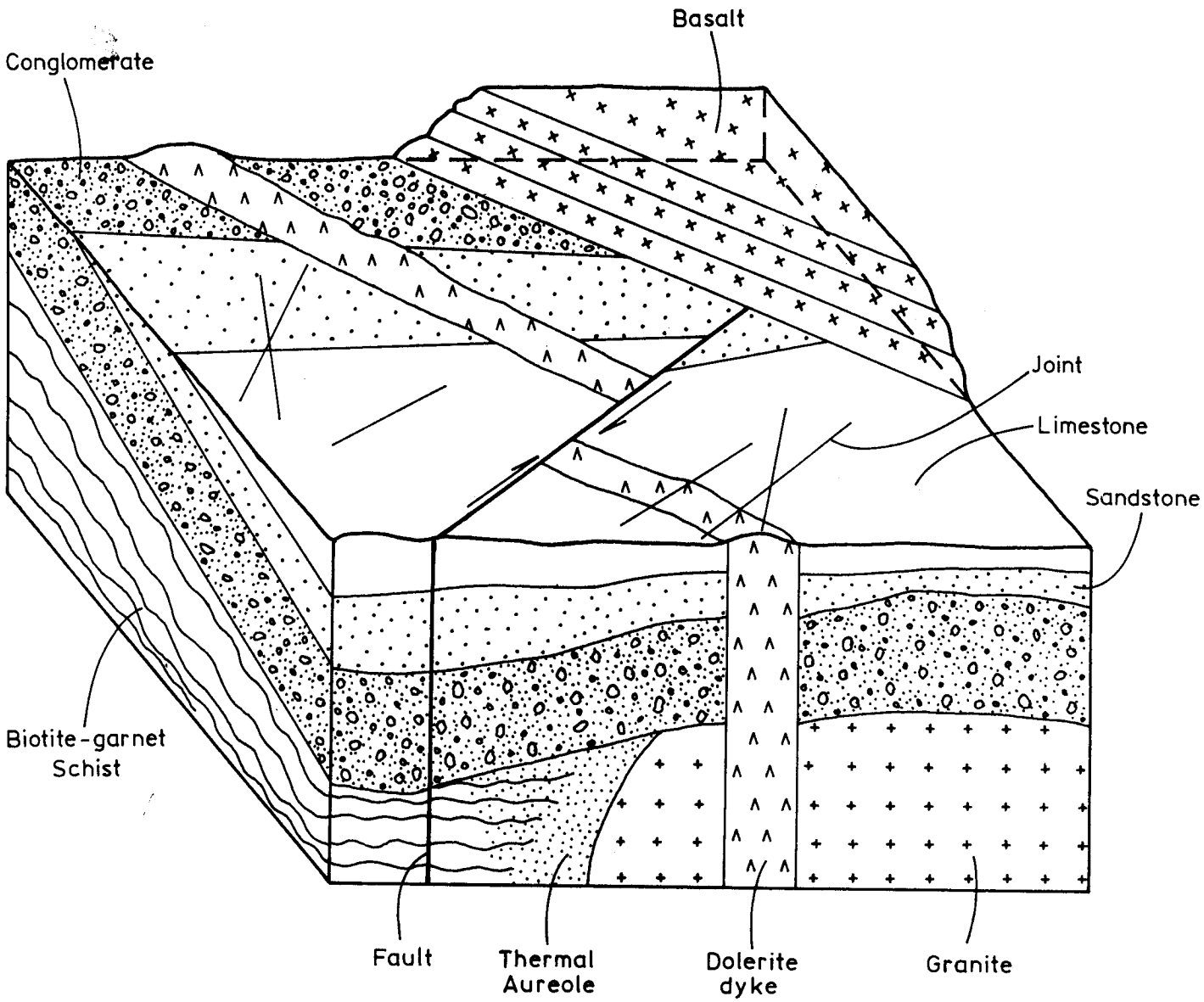
2. Identify and classify the five rock samples provided. List the main minerals in each rock.

3. Figure 1 is a block diagram of the geology of an area south of Kafue Town.

   a) Classify the rocks on the basis of their origin
   b) Write a brief geological history of the area, giving reasons for placing the events in such an order.

END OF EXAMINATIONS

Figure 1


Basalt
Conglomerate
Joint
Limestone
Sandstone
Biotite-garnet Schist
Fault
Thermal Aureole
Dolerite dyke
Granite

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UNIVERSITY FIRST SEMESTER EXAMINATIONS - MAY 1999

GG 301 - PRINCIPLES OF GEOLOGY

PAPER II PRACTICAL

TIME: **Three (3) Hours**
ANSWER: **All Questions**

1. Use Figure 1 to draw a geological cross section along line X-Y.

(75 %)

2. Discuss the mineralisation potential of the area given in Figure 2 in terms of the following types of deposits

   (a) Rare metal deposits (Be, Sn, Ta).

   (b) Chromite and magnetite deposits.

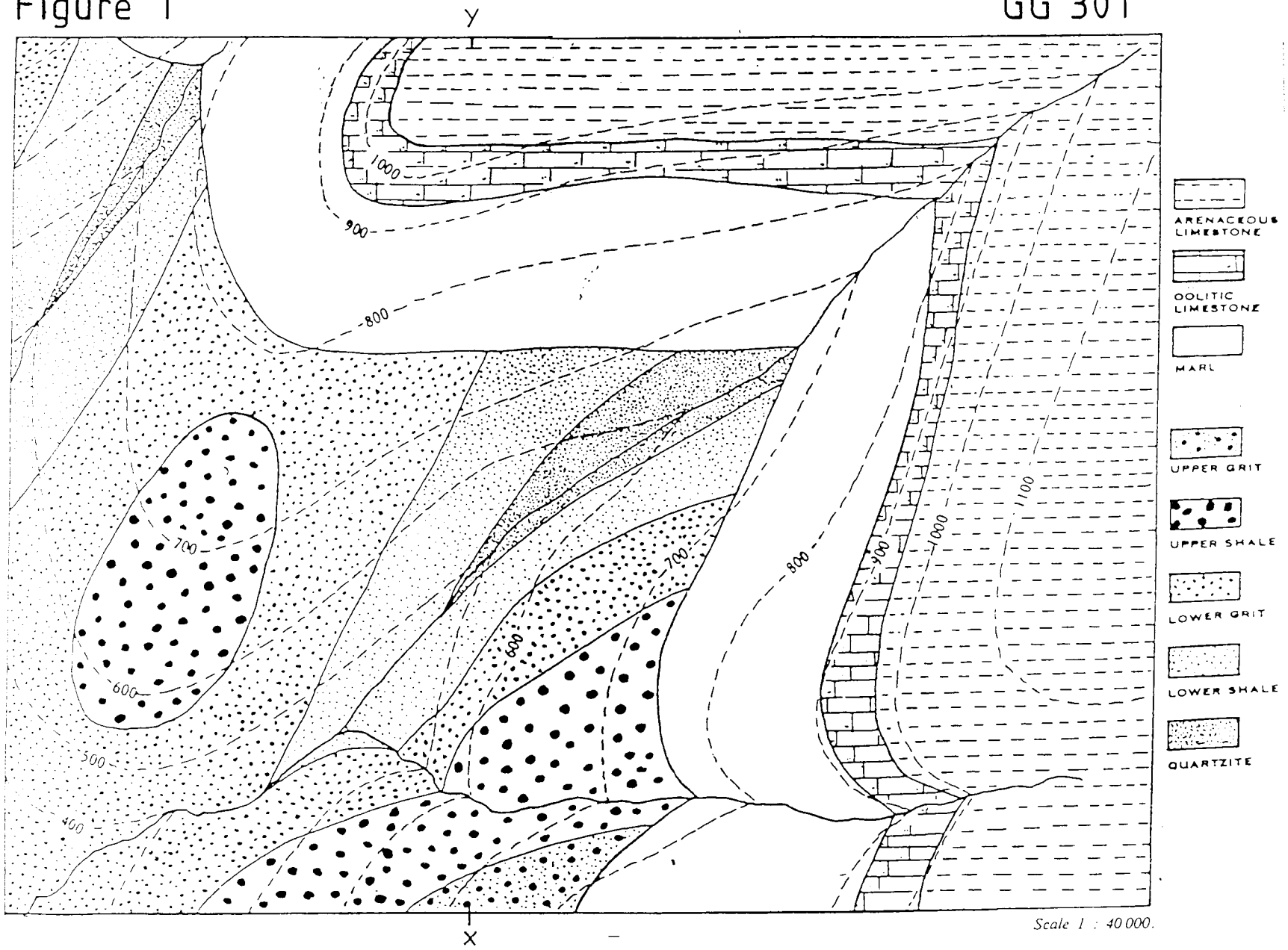
   (c) Industrial minerals (calcite, dolomite)

(25 %)

END OF EXAMINATION

Figure 1

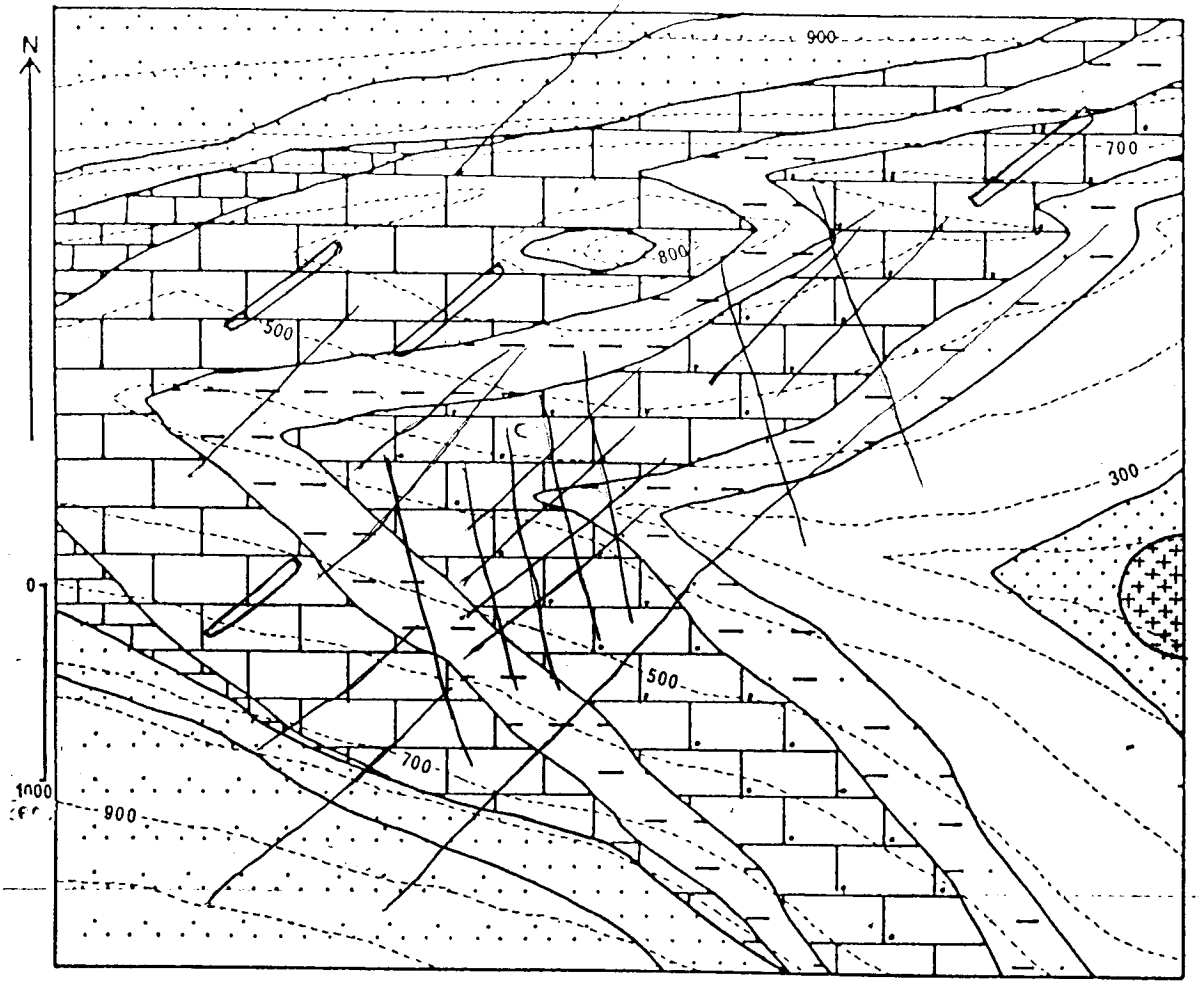
GG 301



Scale 1 : 40 000.

Figure 2

GG 301



Fracture

Grit

Coarse Grit

Conglomerate

Sandy Limestone

Flagstone

Shale

Oolitic Limestone

Shale

Marl

Sandstone

Granite

Pegmatite

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UNIVERSITY FIRST SEMESTER EXAMINATIONS – MAY 1999

GG 311 – CRYSTALLOGRAPHY AND MINERALOGY
PAPER I – THEORY

TIME: **Three (3) Hours**
ANSWER: **Any five (5) questions**
MARKS: **All questions carry equal marks**

QUESTION 1

(a) Discuss the chemical classification of pyroxenes. Illustrate your answer diagrammatically.

(b) Name the common SiO_2 polymorphs. Indicate their phase relationships on a P – T diagram and note their occurrence.

QUESTION 2

(a) How are faces of a crystal indexed? Explain the procedure followed in indexing and give an example accompanied by a sketch.

(b) Explain the difference between a crystal and a crystal form.

QUESTION 3

Write brief notes on the following:

(a) Streak
(b) Lustre
(c) Luminescence
(d) Pseudomorphism

QUESTION 4

(a) What happens when a beam of polarised light enters a mineral?
(b) What is an optic axis?

QUESTION 5

(a) Name and describe the main elements of symmetry.
(b) Name the seven crystal systems giving the characteristic symmetry element for each.

QUESTION 6

On the basis of their temperature of formation, mineral associations or paragenesis can be divided into three groups. Name and describe the groups.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS – MAY 1999

GG 311 – CRYSTALLOGRAPHY AND MINERALOGY

PAPER II – PRACTICAL

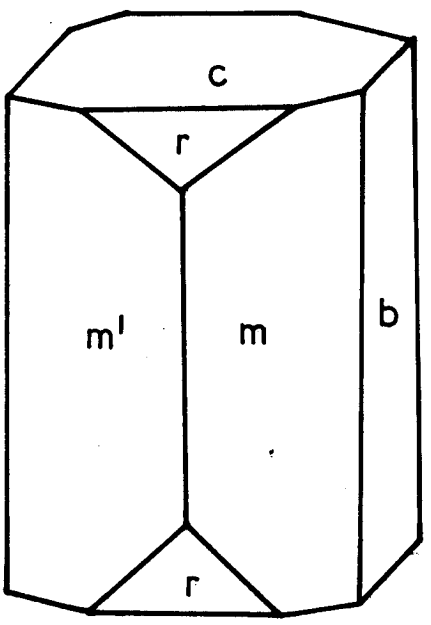
TIME: **Three (3) Hours**

ANSWER: **All Questions**

1. A crystal of zircon is composed of the forms {100}, {101} and {301}. The angle (100) $\wedge$ (101) is 47°51′.

   (a) Determine the axial ratio a:c.
   (b) Draw the crystal and index the faces.
   (c) Determine the angle between (301) $\wedge$ (001).

2. The diagram below shows a crystal of staurolite. Given that the axial ratio for staurolite is a:b:c = 0.471:1:0.340 and that the angles m $\wedge$ m′ = 50°26′ and r $\wedge$ c = 55°17′



Determine:

(a) What crystal system staurolite belongs to.
(b) The miller indices of the faces shown.

3. For each hand specimen (Nos 1 – 5):

(a) Give a systematic mineral description and identify the mineral.
(b) Identify each on the basis of chemistry i.e., native, sulphide, etc.
(c) To what crystal system does each belong
(d) Give a brief account on the origin of the mineral.

END OF EXAMINATIONS

UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS – MAY 1999

GG 361 ENGINEERING GEOLOGY
PAPER I - THEORY

ANSWER: ALL QUESTIONS
TIME: THREE HOURS

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1 (a) What is Magma? Describe the general chemical composition of most magmas.

(b) How would you distinguish a plutonic rock from a volcanic rock?

(c) What is the difference between gabbro and granite?

(d) Explain the difference between a sill and a dyke.

2 Define metamorphism.

(a) Describe the main factors that cause and control metamorphism.

(b) How does contact metamorphism differ from regional metamorphism?

(c) What is the difference between marble and schist?

3 (a) Name the three major processes of Chemical weathering, indicating any reactions that may be involved in each case.

(b) Define Lithification.

(c) Name and define at least two processes by which sediments are transformed into rocks.

(d) List any six features of sedimentary rocks.

(e) Why is bedding referred to as a primary structure while foliation, faults, joints and folds are called secondary structures?

4. Site investigations are usually carried out in stages, with each stage building up enough information to allow execution of the next. Mention two aims of a site investigation and the various stages involved.

5 Describe the following:

(i) Anticline and Syncline and how they are formed.

(ii) The three types of fold orientations.

(iii) The three types of fold shapes.

6 (i) Describe the components of precipitation, intercept, evaporation, overflow and infiltration in the hydrologic cycle.

(ii) Using some component(s) of the hydrologic cycle, describe a situation that would lead to flooding of an area.

(iii) Define permeability and state three features that influence the permeability of a geologic body.

END OF EXAMINATION. GOOD LUCK

UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS – MAY 1999

GG 361 ENGINEERING GEOLOGY
PAPER II - PRACTICAL

ANSWER: **ALL QUESTIONS**
TIME: **THREE HOURS**

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1 Examine the two rock samples provided and

(a) Describe the texture
(b) Identify the minerals present
(c) Name the rock

2 Map 1 shows the outcrop pattern of rocks in a prospective construction site

(a) Label the structure (strike) lines.
(b) Draw a section along A – B.
(c) What type of folds do the rocks display? Explain your answer.

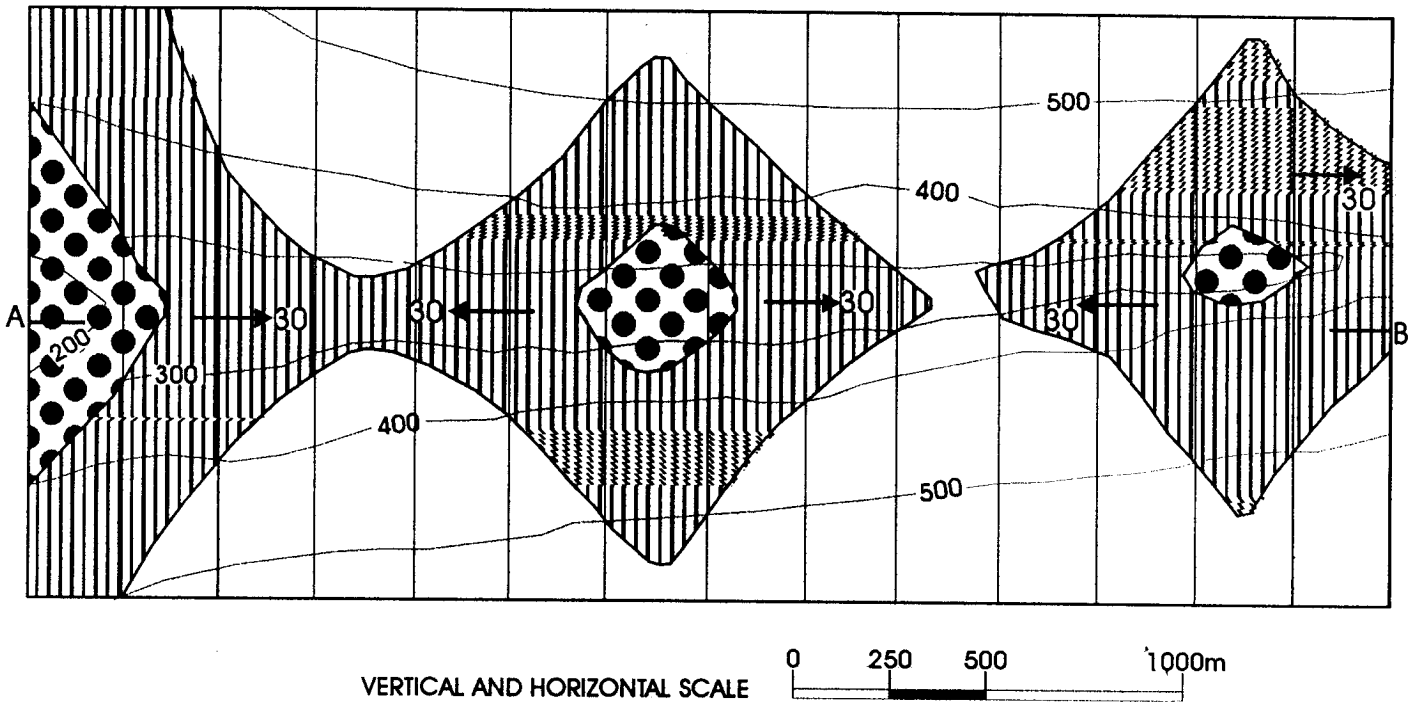
3 The area in map 2 is underlain by a granite sill. Minestone would like to use this granite as a source of aggregate for its construction activities in the vicinity of this area.

The granite sill outcrops at A, B, and C. Assuming the sill is planar and has a constant dip:

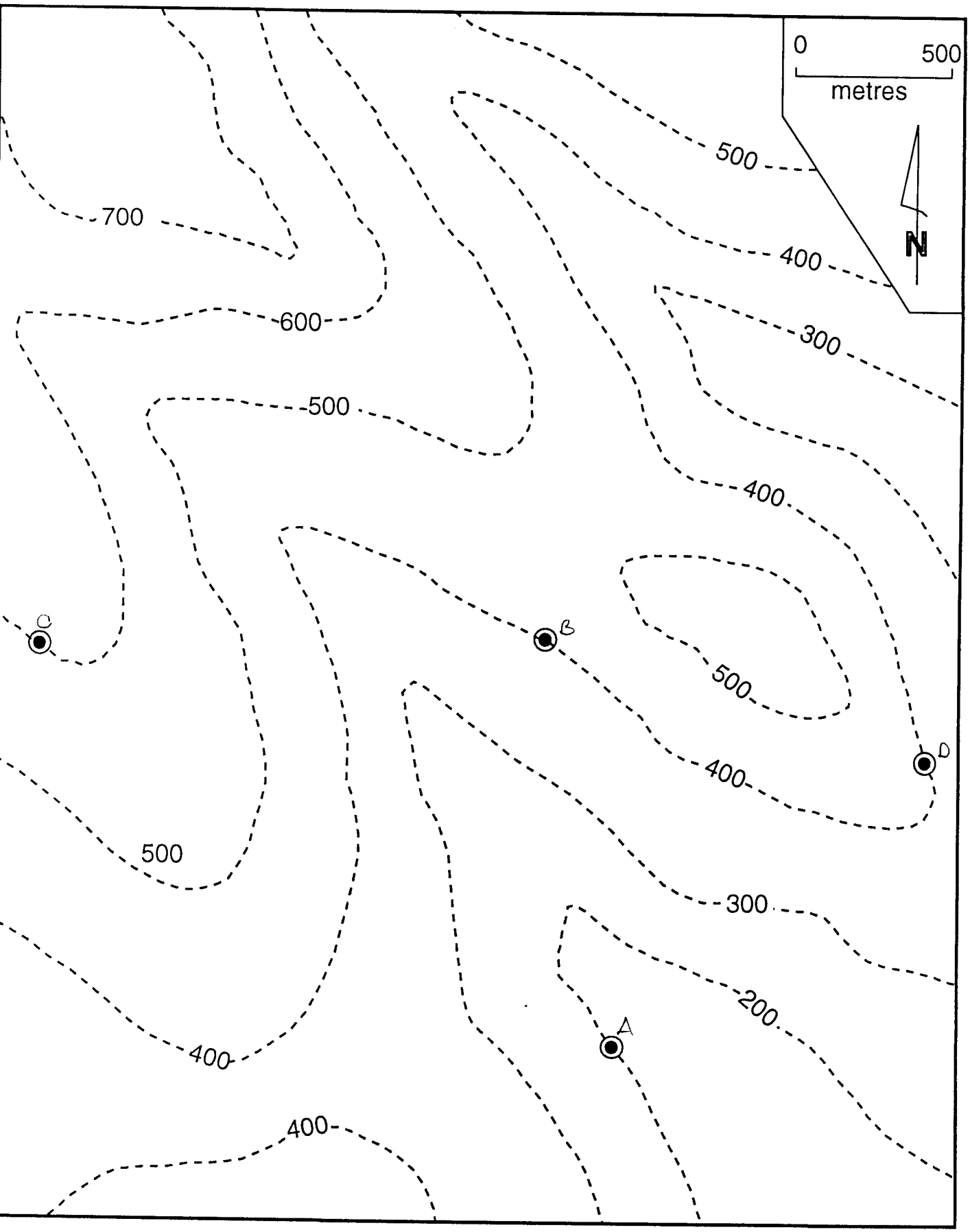
(a) Determine its strike and dip.
(b) Draw on the map the possible outcrop pattern of the sill
(c) Shade the area underlain by the sill.
(d) At what depth would the granite sill be encountered in a borehole sunk at D ?

END OF EXAMINATION. GOOD LUCK!

Map 1 for Gg361 Practical Examination



VERTICAL AND HORIZONTAL SCALE 0 250 500 1000m


0
500
metres
N
700
600
500
500
400
300
400
500
400
300
200
400
400
A
B
C
D

MAP 2

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UNIVERSITY FIRST SEMESTER EXAMINATIONS – MAY 1999

GG 402 – GEOLOGY OF ZAMBIA

TIME: **Three (3) Hours**
MARKS: **All Questions Carry Equal Marks**
ANSWER: **Both Questions from Section A and Two (2) from Section B**

SECTION A

1. Discuss the geological evolution of the Irumide belt with respect to the following:
   i) areal extent
   ii) sedimentation and stratigraphy
   iii) magmatism
   iv) deformation and metamorphism

2. This year's geological mapping will be in the Siavonga area, mid-Zambezi Valley. Some of the rocks exposed belong to the Karoo Supergroup. You are required to answer the following questions.

   a) Give the age of the Karoo Supergroup
   b) Name the formations of the Karoo Supergroup
   c) Outline the main differences in the formations of the Lower Karoo Group that could help you position yourself in the field
   d) select one of the formations named in (c) above and write short notes on its:

      i) stratigraphy
      ii) economic mineral potential
      iii) environment of deposition

SECTION B

3. Outline and describe briefly the procedures used when establishing a new, or re-naming a formation. Use a known formation to illustrate your answer.

4. Discuss the evidence that indicates that plate-tectonics operated during the Archean eon in Southern Africa.

5. Describe the main features which indicate that the Zambezi belt rocks were formed in a rift environment.

6. (a) Briefly describe the main features which characterize the Bangweulu Block as a craton.

(b) What role did the Ubendian shearing play in the evolution of the Bangweulu Block?

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS - MAY 1999

GG411 - IGNEOUS PETROLOGY

PAPER I - THEORY

TIME: **Three (3) Hours**
MARKS: **All Questions Carry Equal Marks**
ANSWER: **All Questions (illustrate your answers with figures, diagrams, etc, wherever possible)**

SECTION A

1. Disscuss the effects of lithostatic pressure (P_{load}) and fluid pressure (P_{H2O}) on the crystallization of magma. (20 %)

2. Figure 1 is an illustration of the binary system $M_gO - SiO_2$ at P = 1 atm.

   (a) Describe the crystallization of liquid A assuming equilibrium conditions. What is the mineralogy of the resulting rock A? (12%)

   (b) Discuss the mineralogical and chemical differences that would result from the removal of olivine from liquid A during its crystallization. (16%)

   (c) Define with the aid of the diagram the following terms.

   (i) liquid immiscibility
   (ii) incompatible minerals
   (iii) eutatic crystallization (12%)

SECTION B

ANSWER TWO QUESTIONS ONLY:-

3. What is the difference between anatectic granites and magmatic granites? (20%)

4. Briefly discribe the tectonic settings in which basalts are formed. (20%)

5. What are the most important simplectictic intergrowth textures? (20%)

6. Describe the main differences between a shield volcano and a composite volcano. (20%)

END OF EXAMINATION

GG 411 Paper I Reading
Igneous Petrology

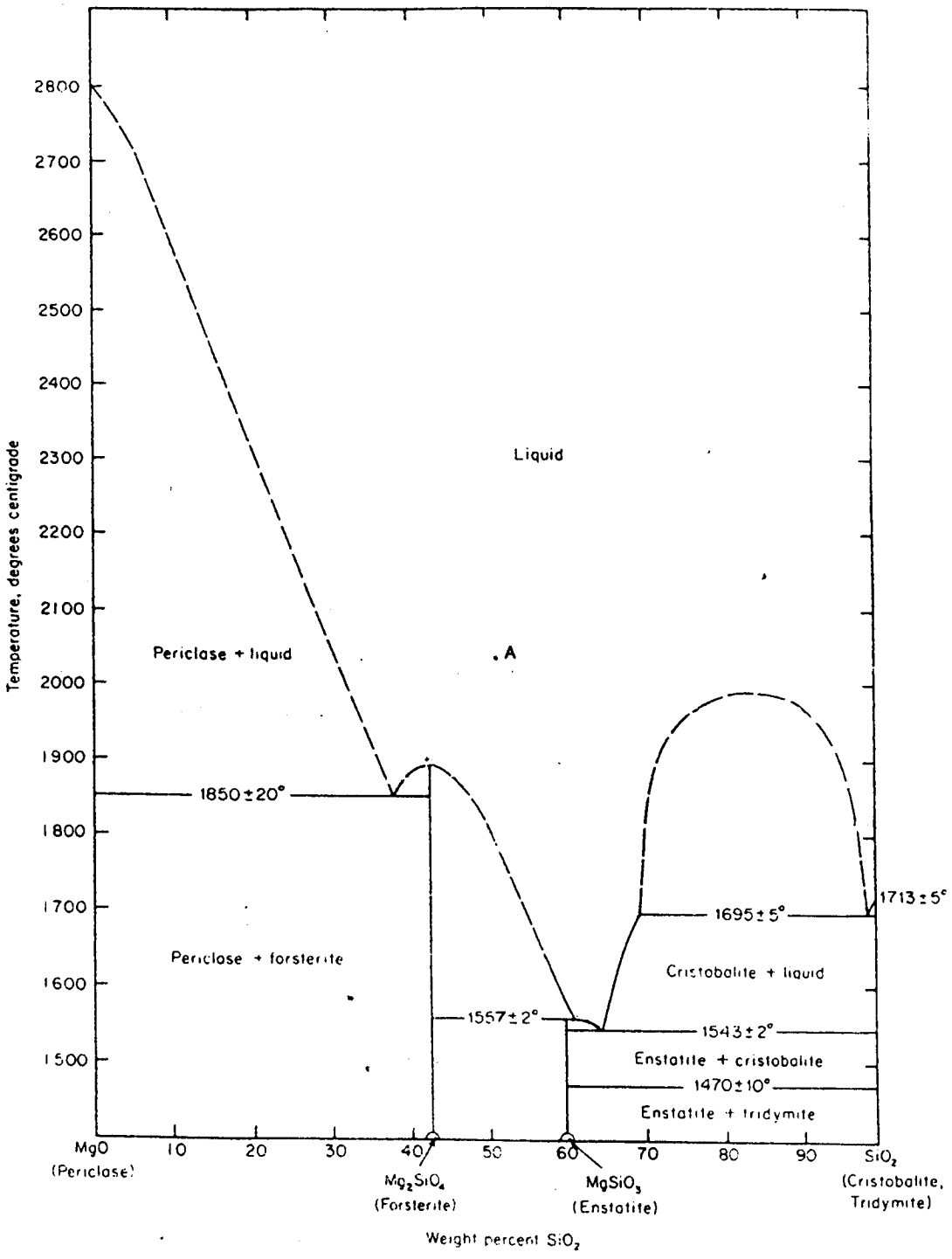


FIGURE 1

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS – MAY 1999

GG 411 - IGNEOUS PETROLOGY
PAPER II – PRACTICAL

TIME: **Three (3) Hours**
MARKS: **All Questions Carry Equal Marks**
ANSWER: ~~**Five (5)**~~ **Four (4) Questions**

1. Thin Section I

   (a) Identify all the minerals present.

   (b) Describe the texture of the rock.

   (c) Is this a volcanic or a plutonic rock.

   (d) Name the rock. (20%)

2. Thin Section 2

   (a) Determine on the basis of textural characteristics, the order of crystallization of the constituent minerals.

   (b) Determine the anorthite content of plagioclase. (30%)

3. Thin Section 3

   (a) Fully describe all minerals on the description form.

   (b) Estimate the modal composition.

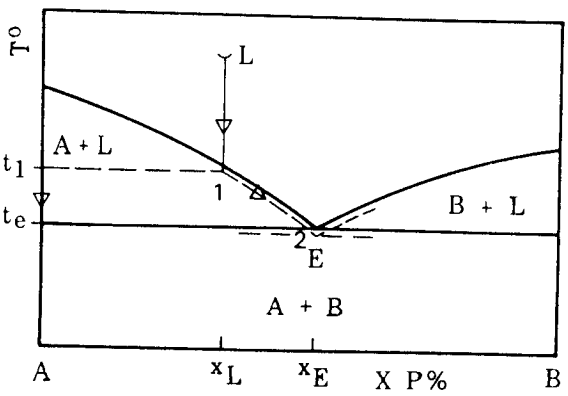
   (c) Give a general description of the texture.

   (d) Classify the rock according to the IUGS system. (30%)

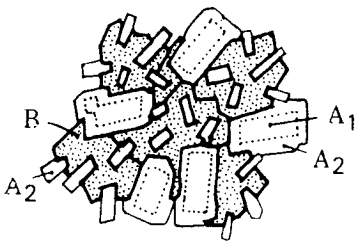
4. Figure I
   Indicate the order of crystallization in liquids subjected to eutectic crystallization in Figure A and B. (20%)

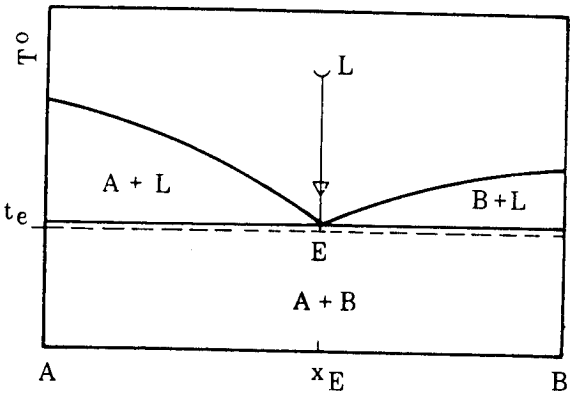
END OF EXAMINATION

GG 411 [illegible]
Igneous Petrology

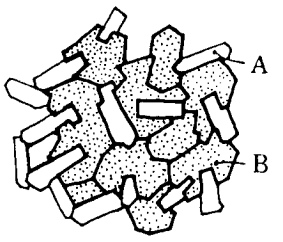


A





B



411 paper II Practical, Igneous Petrology

GEOLOGY DEPARTMENT

STUDY COLLECTION PETROLOGY

Rock Name			Coll. nr.	Collection:
			Orig. nr.	Location:
			Nr. of Slides:	Handsample:
Microscopic Description				
Mineralogy	Name	%	Description	
	Accessory			
	Secondary			
Texture				
Classification				

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS - MAY 1999

GG 431 – STRUCTURAL GEOLOGY

PAPER I – THEORY

TIME: **Three (3) Hours**

ANSWER: **Any Four Questions**

MARKS: **All questions carry equal marks**

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1. a) i) Name four lines of evidence supporting continental drift (2)
   ii) Briefly describe how the evidence given above demonstrates Continental drift (8)

   b) i) The most definitive evidence of sea-floor spreading comes from magnetic anomalies. Explain with sketches how magnetic anomalies demonstrate sea-floor spreading. (15)

2. a) Define the following terms (1 mark each)
   i) Ophiolite
   ii) Crustal province
   iii) Beniof zone
   iv) Melange
   v) Thin-skined tectonics

   b) i) State and illustrate the Wilson Cycle (10)
   ii) Describe the main characteristics of an orogenic belt and give two examples of Pan-African orogenic belts (5)

   c) Name three types of plate boundaries and describe their structural characteristics and magmatic associations (5)

3. a) i) Name three types of crystal lattice defects and give examples of each (3)
   ii) Distinguish between an edge dislocation and a screw dislocation (2)

   b) Sketch a simplified deformation map showing the different fields of deformation mechanism classes (5).

c) What are the characteristics of the following microstructures in thin section (2 mark each):
   i) Core and mantle texture
   ii) Mechanical twinning
   iii) Annealing
   iv) Grain boundary granulation
   v) Kinking

4. Briefly describe the following (5 marks each)
   i) Sub-grain rotation recrystallisation
   ii) Cobble creep
   iii) Strain hardening
   iv) Cataclastic flow
   v) Transposition of layering

5. a) i) Define a shear zone (2)
   ii) Name for types of shear zones (4)
   iii) State how grain size reduction is achieved in cataclasites and mylonites in a shear zone (2)
   iv) What features distinguish coaxial from non-coaxial Deformation (2)

   b) Describe the shear sense observation plane (2)

   c) Illustrate with sketches (2 marks each)
   i) En echelon veins indicating dextral sense of shear
   ii) σ-type (sigma) porphyroclast indicating sinistral sense of shear
   iii) Riedal shears indicating dextral sense of shear
   iv) S-C fabrics indicating sinistral sense of shear.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY FIRST SEMESTER EXAMINATIONS - MAY 1999

GG 471 - GEOCHEMISTRY
PAPER I – THEORY

TIME: **Three (3) Hours**
ANSWER: **Questions 1 and four others**

1. a. The Norwegian geochemist V. M. Goldschmidt formulated a set of rules to explain the entry of trace elements in minerals crystallizing from magma.

   i) state these rules and give examples of element pairs which behave according to the rules
   ii) discuss the factors which lead to the limited applicability of these rules in natural systems

   b. In olivine (Mg, Fe) SiO_4, the optimum size for the cation site is a radius of 0.77angstrom. Among the trace elements that may occupy this site are Ni, Mn, Co and Sc. Assuming size to be the only factor controlling the entry of these trace elements into olivine,

   i) list the elements that would enter olivine more readily than Mg
   ii) list the elements that would enter olivine more readily than Fe

   c. Discuss the changes in the order of entry of the trace elements that may result when electronegativity and charge are taken into account.

   i) relatively among the trace elements
   ii) relative to Mg
   iii) relative to Fe

   d. If olivine is the only mineral crystallising from a basaltic melt how would this affect the following ratios in the residual liquid: Ni/Co, Co/Mn, Mn/Sc, Ni/Mg, Sc/Fe, Co/Fe, Fe/Mg, Mn/Fe.

   (40 marks)

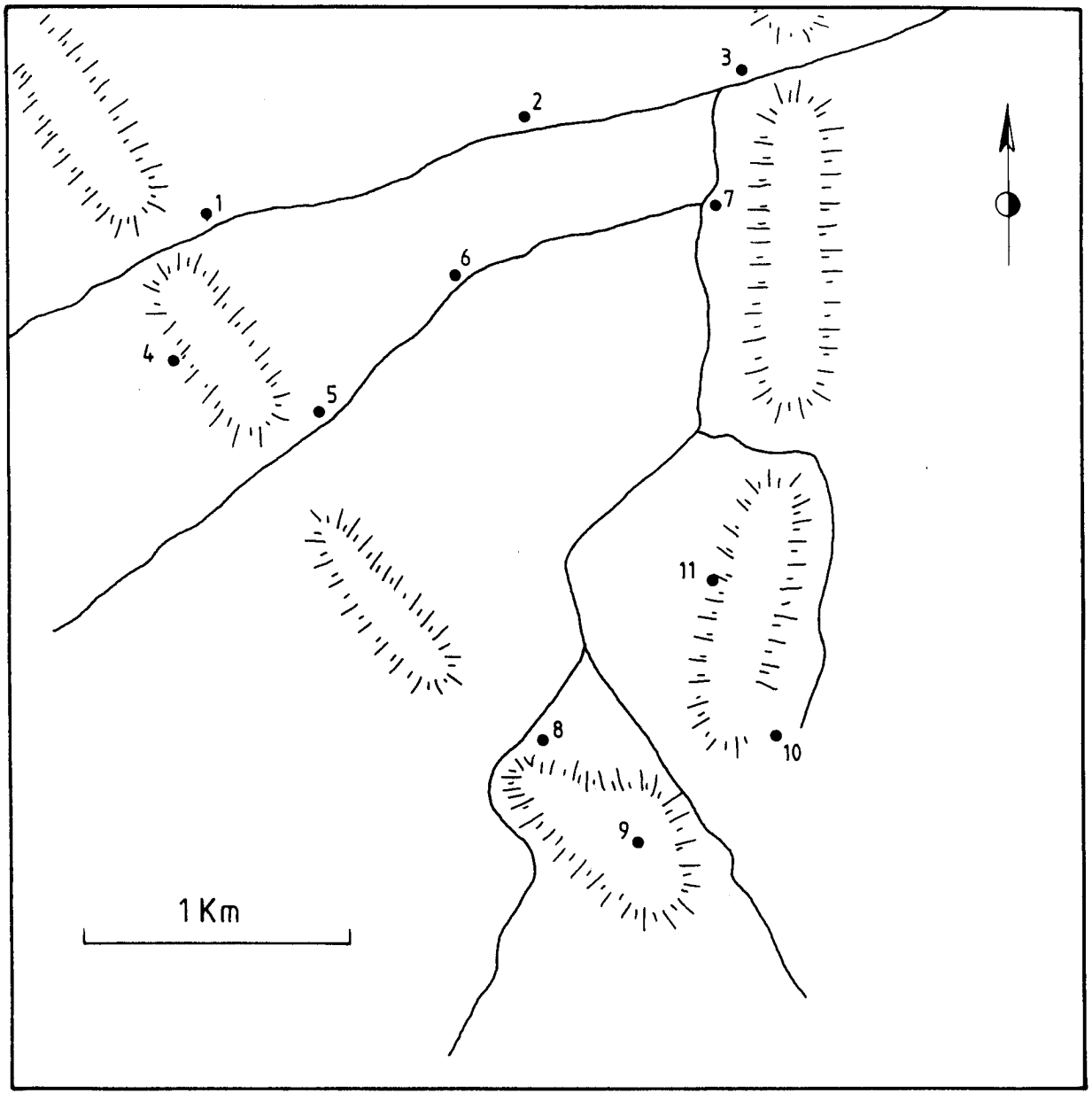
2. One of the main objectives of geochemistry is the estimation of the abundances of the chemical elements in the solar system. Explain ,

   a) How solar element abundances are estimated.
   b) How element abundances of the core, mantle and crust are estimated.
   c) Why crustal element abundances do not reflect solar abundances.

   (15marks)

GG 431 II

Map 2



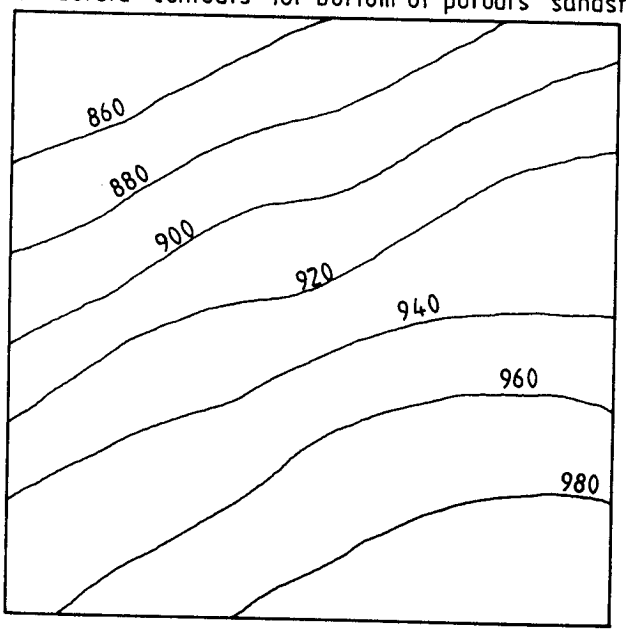
Quartzite ridges and hills

● 1 – 11 : Location numbers

GG 431 II

Map 1a

Structure contours for bottom of porours sandstone



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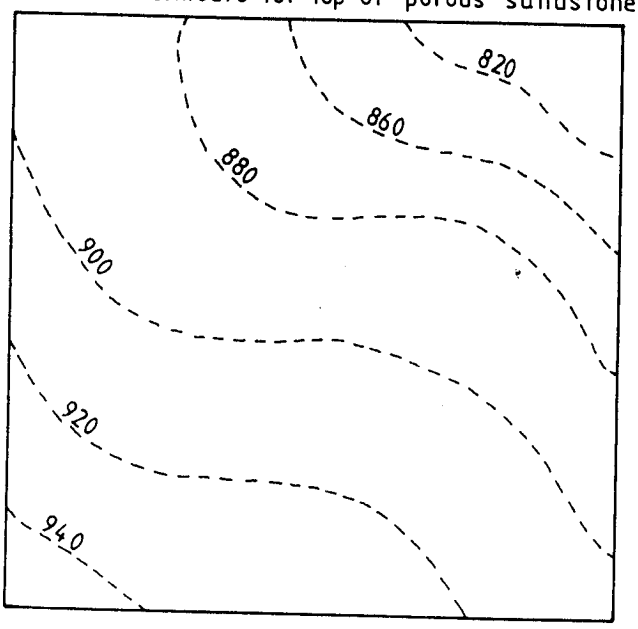
Map 1b

Structure contours for top of porous sandstone



1: 20 000

c) Given a dominantly left-slip fault with an attitude of 030°/70° W and a slip direction, which pitches 15° N, locate the principal stresses. (10 marks)

3. Refer to Map 2 (60 marks)

Map2 shows an area of generally poor exposure. Quartzites, which are poorly bedded and indistinctly foliated, form a series of low ridges and hill. Argillites, which are apparently conformable on quartzites are cut by a pervasive slaty cleavage, are restricted in occurrence to ground with low relief. Field notes from eleven locations, marked on the map, are provided below.

With these data use structural analysis techniques to solve the following problems:

a) Describe the structure of the area as complete as possible, indicating which evidence you used to draw your conclusions.
b) Add appropriate structural symbols to the map to make the structure clear.
c) Sketch a geological cross section along a convenient section line.
d) Construct a profile view of the fold.

Field notes for location 1-11

Abbreviations: Q= quartzite; A= argillite; S_0= bedding or primary lamination; S_1= slaty cleavage; L_1= intersection of S_1 and S_0; either within argillite or at quartzite/argillite contact.

1. Q/A contact; S_0: N335°/28°NE; S_0 subparallel to S_1; S_1 slightly shallower in dip
2. A; S_1: N347°E/26°NE
3. Q/A contact; S_0 N350°E/22°NE; S_0 subparallel to S_1; seems slightly steeper in dip
4. Q/A contact; S_0: N328°E/38°NE
5. Q/A contact; S_0: N322°/38°NE; indistinct graded bedding 'youngs' upstream
6. A; S_1; N343°E/28°NE
7. A; S_0 ? (apparent primary lamination); N000°E/62°NE; L_1: 18°/113°
8. Q/A contact; S_0: N307°E/62°NE; L_1:22°/116°
9. Q; S_0: N295°E/90°
10. Q/A contact; S_0: N015°E/22°NE
11. Q/A contact; S_0 N025°E/20°SE

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS - MAY 1999

GG 431 - STRUCTURAL GEOLOGY

PAPER II - PRACTICAL

TIME: THREE HOURS

ANSWER: ALL QUESTIONS

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1. Refer to Maps 1a and 1b (10 marks)

   Maps 1a and 1b show structure contour maps of the top and bottom of a porous sandstone on the basis of drill-hole information.

   a) Construct an isopachyte map for the sandstone on the tracing paper provided
   b) Indicate on the map where you would propose to drill for oil and explain why.
   c) Illustrate your answer with a suitable cross section.

2. Use the Wulff net and tracing paper provided

   a) Ripple marks are found pitching 80°SW in the west limb of a plunging fold. The bedding in this limb strikes N050°E and dips 65° NW. The fold axes plunges 30° towards N036°E direction. What was the original orientation of the ripple marks? (10 marks)

   b) Three diamond drill holes were drilled in a mining area where formations are known to have a uniform dip.

      Borehole A was drilled in the N220°E direction with a plunge of 55°. The angle measured between the core axis and the bedding-normal is 30°.

      Borehole B plunges 60° in the N110°E and the measured bedding normal-core axis angle is 40°.

      Borehole C was drilled plunging 60° due north. The measured angle between the bedding normal and the core axis is 75°.

      What is the attitude of the bedding? (10 marks)

3. The different ways of interatomic linkage are classified into four bond types.

a) Name the four types of bonds and give characteristics of each type.
b) Explain the significance of Si – O bonding for the viscosity of magmas. Which chemical components tend to disrupt the Si – O bonds? (15marks)

4. Define and discuss briefly:

a) geochemical cycle
b) compatible element
c) large ion lithophile element
d) distribution coefficient
e) coordination number
f) fractionation factor (15marks)

5. (a) Define an isotope and explain why the chemical properties of isotopes of the same element are the same
(b) Briefly describe the main applications of stable isotopes in geology
c) Describe the different modes of radioactive decay
d) Using Rb – Sr isotopes, briefly describe the principles behind absolute age dating of rocks and minerals. (15marks)

6. a) What are the characteristic features of the four meteorite types?
b) Describe the textural and chemical contrasts between carbonaceous chondrite and other types of chondrites.
c) What kinds of change would be involved in developing ordinary chondrites from carbonaceous types?
e) how has the abundance of hydrogen in the universe changed since the „ Big Bang"? (15marks)

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY FIRST SEMESTER EXAMINATIONS - MAY 1999

GG 471 - GEOCHEMISTRY
PAPER II – PRACTICALS

TIME: **Three (3) Hours**
ANSWER: **All Questions**

1. Atomic absorption spectrometry relies on two principles or processes for the generation and measurement of radiation.

   i) name and describe these two processes
   ii) where or how are they employed in the instrument (10 marks)

2. Briefly describe the following terms:

   a) sensitivity
   b) detection limit
   c) fluorescence
   d) ground state
   e) resonance line (25 marks)

3. Describe the types of errors encountered in analytical geochemistry. How can these errors be compensated for during an analysis? What parameters are used to measure the reliability of an analysis? (25 marks)

4. Five rocks from a lava field have given the following trace element results:

	1	2	3	4	5	
Rb (ppm)	6	23	16	34	100	
Ba (ppm)	400	1250	950	3200	642	
Sr (ppm)	200	540	390	1200	310	
Ni(ppm)	350	2	12	1	64	

   i) use the data to test whether all or some of the rocks can be related by fractional crystallisation
   ii) list the elements in order of increasing bulk distribution coefficient
   iii) calculate the three largest distribution coefficients on the assumption that the fourth is zero
   iv) calculate the degree of fractional crystallisation that is required to account for the chemical variation of the rocks considered to be related by this process.

(Element distribution during fractional crystallisation is governed by the equation: $C_l = C_o (F^{(D-1)})$

where: Cl = concentration of element in residual liquid
Co = concentration of element in parent magma
F = fraction of residual liquid
D = bulk distribution coefficient (40marks)

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY FIRST SEMESTER EXAMINATION – MAY 1999

GG 551 – EXPLORATION, MINING GEOLOGY AND MANAGEMENT
PAPER I – THEORY

TIME: **Three (3) Hours**
ANSWER: **Any five (5) questions**
MARKS: **All questions carry equal marks**

1. A promising orebody has been located by a mining company in which you are employed as Exploration Geologist. How would you determine whether or not it can be worked economically in the prevailing circumstances. Discuss.

2. Discuss why a phased approach to mineral exploration is essential.

3. (a) Explain the induced polarisation (IP) geophysical method of search for disseminated sulphides, in Frequency Domain.

   (b) In an IP Survey for disseminated sulphides, resistivity change of 10 ohmetres takes place in a host rock mass whose resistivity is 2000 ohmetres. Calculate the Frequency Effect (FE).

   (c) Calculate the metal factor (MF) given the following quantities:

   $\rho dc = 3000$ ohmetres
   $\rho ac = 2500$ ohmetres

4. (a) Define the following terms:

   (i) Ore
   (ii) Reserves
   (iii) Grade
   (iv) Cut-off-grade
   (v) Minimum mining grade

   (b) Describe the three main categories for ore reserves classification used by ZCCM on the Copperbelt.

5. (a) What is Management?

   (b) State and briefly explain the elements of management.

6. Diagramatically show the following

(a) Functional organisation structure
(b) Product based structure
(c) Matrix organisation structure

END OF EXAMINATION

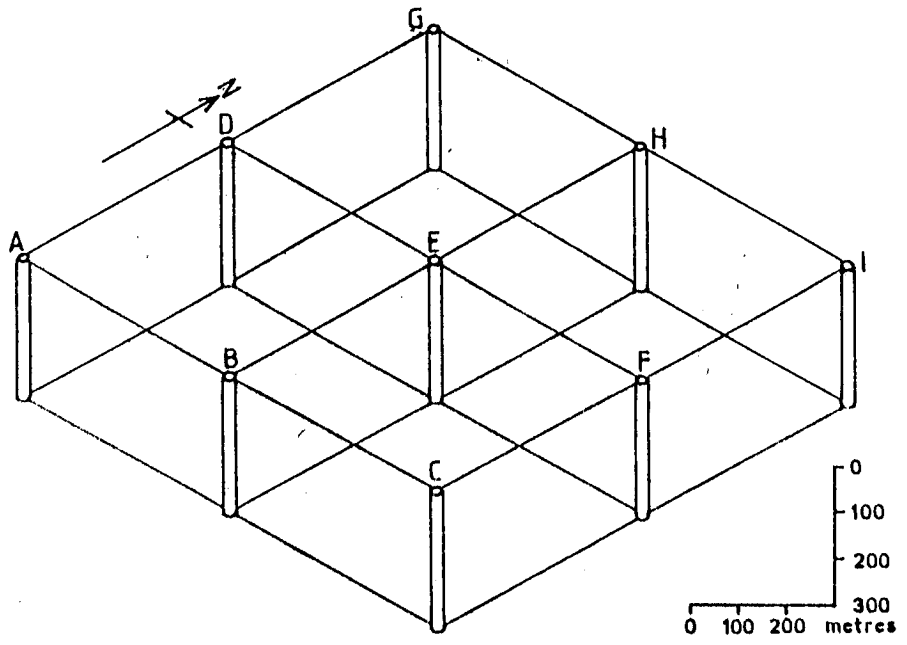
THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS – MAY 1999

GG 551 – EXPLORATION, MINING GEOLOGY AND MANAGEMENT
PAPER I I – PRACTICAL

TIME: **Three (3) Hours**
ANSWER: **All Questions**

QUESTION 1.
Figure 1 below shows a hypothetical array of boreholes in which the horizontal and vertical scales are equal.



The results of the borehole core logging with depths and grades of ore encountered are given in the Table below.

Hole	Depth of Ore	Grade %
A	No Ore	-
B	100 – 250	0.8
C	100 – 200	3.0
D	50 – 100	0.1
E	50 – 150	0.4
F	50 - 70	0.7
G	0 - 30	0.01
H	0 – 100	0.2
I	No Ore	-

(a) Use the borehole data to build a picture of the shape of the orebody.
(b) What is the overall shape of the orebody?
(c) Where would you most profitably carry out further evaluation drilliing and why?
(d) What volume of ore is contained in block between drill holes B,C,E and F?
(e) Determine the assay value of the orebody on the basis of the nine boreholes.

QUESTION 2

The Table below represents a geologist's record of an intersected ore horizon that has been sampled at Chibuluma Mine.

	Base									Top
%CO	0.2	0.6	0.3	1.0	0.9	0.05	0.6	0.05	0.3	0.2
%Cu	0.1	1.8	2.2	6.5	4.0	1.2	2.8	1.0	2.0	0.9
Thickness (m)	1.2	1.0	0.8	0.5	0.5	1.0	1.6	1.2	1.0	0.8

Answer the following questions:

(a) What is the likely mineral that contains the CO at the base and top of the drill-hole?
(b) What cobalt mineral is associated with rich copper grades in the drill hole?
(c) Calculate the weighted grade for both copper and cobalt.
(d) Find the average over the interval using statistics.

QUESTION 3

Exploration programmes have no universal pattern but they have some common features that are generalised. Name the stages, outlining for each stage, the activities involved.

END OF EXAMINATIONS

UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
UNIVERSITY FIRST SEMESTER EXAMINATIONS – MAY 1999
GG 561 ENGINEERING GEOLOGY
THEORY

ANSWER: ANY FOUR QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.
TIME: THREE HOURS

1 (a) Define the following terms:
(i) Differential settlement
(ii) Ultimate bearing capacity; and
(iii) The maximum safe bearing capacity.

(b) Site investigations are usually carried out in stages, with each stage building up enough information to allow the execution of the next stage. Mention two aims of a site investigation and describe its various stages.

2 An excavation is planned for a road embankment to be constructed between the Schools of Mines and Engineering. Available data reveal that if the slope is cut at the engineer's design angle of 60^{O}, a plane P would *'daylight'* into the slope face. Triaxial cell tests carried cut on this discontinuity set produced the following results:

Test Number	1	2	3	4
σ_2 (kNm^{-2})	1	5	9.5	15
σ_1 (kNm^{-2})	9.2	28	48.7	74

If the dip of plane P is 50^{0}, and the weight of a potential sliding mass on this plane, with a contact area of 200 m^2 is 400 kN, determine:
(i) The total force resisting sliding
(ii) The factor of safety of the block against sliding
(iii) The magnitude of the force of a rock bolt installed horizontally that would raise the factor of safety of the block to 2.0

3 (a) The ultimate bearing capacity for a strip foundation according to Terzaghi is given by the formula:

$$Q_f = c * N_c + \gamma * D * N_q + 0.5 * \gamma * B * N_\gamma$$

Explain all the symbols used in the equation.

(b) A statue of a prominent final year geology student is planned to be erected in front of the School of Mines. The structure is proposed to be supported on a square pad 2 m long and cast at a depth of 2.5 m. If the unit weight of the soil mass underlying the pad is 17 kNm^{-3}, and triaxial tests performed on samples of this soil gave the following results:

σ_2 (kNm^{-2})	90	173	345
σ_1 (kNm^{-2})	207	415	813

Determine the maximum safe bearing capacity of this soil against shear failure of the statue for a factor of safety of 2.

N_c (rectangle) = N_c {strip * (1 + 0.3 * B/L)
N_q (rectangle) = N_q {strip} * (1 - 0.2 * B/L)

N_γ (rectangle) = N_γ {strip}

4 (a) After the construction of the statue in Question 3, it was discovered that that there was a discontinuity inclined at 45^0 underlying the structure. It was determined that the structure imposed a vertical stress (σ_1) of 480 kNm^{-2}. If, as a result of this stress, the structure induced a horizontal stress (σ_2) of 210 kNm^{-2}, determine the normal and shear stresses on the discontinuity.

(b) Shear box testing carried out on the discontinuity in 4 (a) gave the following results:

Normal stress, σ_n (kNm^{-2})	50	100	200	300
Shear stress, σ_τ (kNm^{-2})	36	80	154	235

From the shear and normal stresses determined in 4 (a), would failure occur on the discontinuity plane? Explain your answer.

5 (a) Give the empirical formula of Coulomb's law and describe the quantities involved
(b) Illustrate, with the aid of diagrams, the three main categories of geologic materials based on their shear strength parameters.
(c) What is the difference between the properties of materials and the properties of mass with regard to both soils and rocks? Why is there a difference? Why is this difference of importance in engineering geology?

6 Tests performed on a soil sample in a proposed engineering construction site gave the following results:

Grain size (mm)	37.5	20	10	5	2	1.18	0.6	0.3	0.2	0.15	0.063	0.02	0.006	0.002	<0.002
Mass retained (g)	0	26	31	11	18	24	21	41	32	16	15	8	4	2	1

(i) Plot the grain size distribution curve
(ii) Calculate the uniformity coefficient
(iii) What are the percentages of clay, silt, sand and gravel fractions in the soil?
(iv) Name the soil.

END OF EXAMINATION. GOOD LUCK!

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS – MAY 1999

MG 319 – COMPUTER TECHNIQUES
PAPER I – THEORY

TIME: **Three (3) Hours**
MARKS: **Indicated for each question**
ANSWER: **All Questions**

1. Define the following computer terminology:

   (a) File conversion
   (b) Root directory
   (c) Multi-tasking
   (d) Screensaver
   (e) BUS
   (f) Laptop Computer
   (g) Internet
   (h) Print Manager
   (i) OS
   (j) Login

   10 MARKS

2. What is the role of a declaration part in any programming language (VAR, TYPE, CONST, USES, etc... in TP). In other words, what does the compiler do with that part that is of vital importance for running the program. 2 MARKS

3. Fill in the truth table for the following expression (with A, B and C binary numbers):

   $\neg C \vee (A \wedge B) = \text{RESULT}$ 3 MARKS

4. Suppose that you have just purchased a brand new computer, with only an operating system (e.g. Windows 95) installed. What actions do you have to take to:

   (a) Avoid any virus protection as you start using the computer
   (b) Prepare yourself to be able to clean the system if and when it would get infected in the future.

   Give ALL possible sources of virus infections, and methodology to follow to avoid infection through them. 10 MARKS

5. Calculate the value of Z (the base is in subscript):

$X_{10} = 7145_8 + 4233_5$

$Y_{10} = B325C_{16} - 55221_6$

$Z_{16} = 2 * (X_{10} + Y_{10})$ 5 MARKS

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FIRST SEMESTER EXAMINATIONS – MAY 1999

MG 319 – COMPUTER TECHNIQUES
PAPER II - PRACTICAL

TIME: **Three (3) Hours**
ANSWER: **The Following Question**

Write the program code for a Turbo Pascal program doing the following (variables and/or constant names are in *Italics).*

(i) Show a menu with the following choices:

(a) Enter structural measurements
(b) Recalculate structural measurements according to right-hand rule.

(ii) According to the choice on that menu:

For choice (a), write a module that can:

Read in *n* real values of *strike* (allowed values range between 0 and 360 degrees), *dip* (allowed values range between 0 and 90 degrees) and string [2] values of *dip_direction* (allowed values are "NE'', "NW'', "SE'', "SW'').

For Choice (b) write a module that does the following:

Check the value for *dip_direction.*

If *dip_direction* is either "NW'' or "NE'' then the *strike* should be between 180 and 360; if that is not the case, add 180 degrees to *strike*.

If *dip_direction* is either "SW'' or "SE'', the *strike* should be in the range 0 to 180; if that is not the case, subtract 180 degrees from *strike.*

After checking and adapting *strike* show all values of *strike, dip* and *dip-direction* on the screen. 30 marks

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

MINING ENGINEERING DEPARTMENT

FIRST SEMESTER UNIVERSITY EXAMINATIONS, MAY, 1999.

MI 209 - INTRODUCTION TO MINE DEVELOPMENT

TIME: 3 HOURS

INSTRUCTIONS: ANSWER QUESTION 1 AND ANY OTHER FOUR.

Q1. The process of locating a mineral up to its final preparation into a salable product is often referred to as mineral production process. Describe the sequential stages involved in this process giving the general scope of work involved in each stage. (20 marks)

Q2. The techniques used in prospecting and exploration are similar except that the latter tends to be more ground based. Explain these techniques and show how they are used to achieve objectives of mineral prospecting/exploration. (20 marks)

Q3. (a) Define the following mining terms:

(i) Rock penetration (ii) Dilution

(iii) Recovery (iv) Mining (4 marks)

(b) Products from Mining Industry have and continue to play a very important role in technological development. However, some of the effects of mining on the "environment" are very undesirable.

Classify and explain these negative impacts illustrating your answers with one example of each. (16 marks)

Q4. Discuss conventional shaft sinking under the following headings:

(a) Classification of sinking methods. (2 marks)

(b) Muck removal (4 marks)

(c) Dumping (4 marks)

(d) Drilling (4 marks)

(e) Blasting (2 marks)

(f) Ventilation (4 marks)

Q5. (a) Discuss the classification of surface mining methods citing one example of mining method in each group. (8 marks)

(b) What are the types of drilling machines used in mining applications. Explain the general principles behind each group of machinery. (12 marks)

Q6. Write short notes on the following:

(a) Functional components of drilling machines (6 marks)

(b) Drilling machines used in surface mining (14 marks)

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

END OF SEMESTER EXAMINATIONS, MAY, 1999

ROCK MECHANICS MI 315

Full Marks: 100 **Time: 3 hours**

INSTRUCTIONS FOR STUDENTS

- Answer **Question No. 1** and **any other 5. In total six questions**
- Neat presentation will get credit

Q1 (a) As a rock mechanics consultant you want to advertise the facilities you have in your rock mechanics laboratory. List the facilities and their applications for the safe and efficient operations of mines that you would like to advertise. **(12 marks).**

(b) How Poisson's ratio of rock may be determined in the laboratory? Give approximate value of Poisson's ratio for (i) rock (ii) Wood and iii) Glass **(4 marks).**

Q2 (a) Name three measuring devices for in-situ stress measurements in rock mass. Briefly describe their working principles. **(12 marks).**

(b) Calculate the 'flexural strength' of rock from the following data:

- Length of rock sample = 150 mm
- Diameter = 50 mm
- Failure load = 1000 KN
- Distance between two loads reactions (fulcrum) = 100 mm **(4 marks)**

Express your answer in MP_a

Q3 (a) Explain what is meant by Morh's criteria of rock failure. **(4 marks).**

(b) Below are the result of triaxial compression tests on rock samples.

Q5 (a) Describe the working principle of 'Flat Jack Method for measuring in-SiM stress in rock mass. (8 marks)

(b) What would be the value of horizontal stress in a rock in a gold mine at a depth of 2.5 km if the av. Unit weight of rock is 25 Knm^{-3} and Poisson's ratio is 0.25. Express your answer in Mpa. **(8 marks)**

Q6 (a) What is the basic mechanics of slope failure in rock? Suggest with the help of diagrams how the rock slope failure may be prevented. **(8 marks)**

(b) At what angle a block of granite, $1m^3$ having a mass of 2.5 tonne will begin to slide over the other grante block (which is stable, not moving) if the coefficient of friction between two grante blocks 0.8. (Take Value of $g = 10m/S^2$). **(8 marks)**

Q7 (a) Discuss the probable damagelikely to be caused by surface subsidence due to mining. Suggest method of control for above subsidence taking place. **(8 marks)**

(b) How surface subsidence due to mining can be monitored? Explain with the help of diagrams. **(8 marks).**

END OF EXAMINATIONS

Test	σ_3(MPa)	σ_1(MPa)	Failure angle (degree)
1	0	30	46
2	10	50	48
3	15	75	47

From the above values determine the:

(i) values of Si and ϕ **(8 marks)**
(ii) Uniaxial Compressive strength **(2 marks)**
(iii) Approx. value of tensile strength. **(2 marks)**

Q4 (a) What is known as Bieniawski's geomechanics classification? **(8 marks)**

(b) A tunnel to bedriven into igneous rock. From the values given below determine the Rock Mass Rating (RMR) and comment on the description of rock. Use Bieniawski's geomechanics Table (given).

- Uniaxial comprest in which tunnel is driven = 200 MP_a
- Drill Core Quality RQD(%) = 70%
- Joint spacing = 0.3 m
- Conditions of joints = Joints open >5 mm,
- Groundwater general condition = severe water problem

(8 marks)

(a) Classification parameters and their ratings

Parameter		Ranges of values						
1 strength of intact rock material	point-load strength index (MPa)	>8	4–8	2–4	1–2	for this low range, uniaxial compression test is preferred		
	uniaxial compressive strength (MPa)	>200	100–200	50–100	25–50	10–25	3–10	1–3
rating		15	12	7	4	2	1	0
2 drill core quality RQD (%)		90–100	75–90	50–75	25–50	<25		
rating		20	17	13	8	3		
3 joint spacing (m)		>3	1–3	0.3–1	0.05–0.3	<0.05		
rating		30	25	20	10	5		
4 condition of joints		very rough surfaces, not continuous, no separation, hard joint wall rock	slightly rough surfaces, separation <1 mm, hard joint wall rock	slightly rough surfaces, separation <1 mm, soft joint wall rock	slickensided surfaces or gouge <5 mm thick or joints open 1–5 mm, continuous joints	soft gouge >5 mm thick or joints open >5 mm, continuous joints		
rating		25	20	12	6	0		
5 groundwater	inflow per 10 m tunnel length (l min^{-1})	none		<25	25–125	>125		
	or joint water pressure	0		0.0–0.2	0.2–0.5	>0.5		
	or major principal stress							
	or general conditions	completely dry		moist only (interstitial water)	water under moderate pressure	severe water problems		
rating		10		7	4	0		

THE UNIVERSITY OF ZAMBIA
School of Mines
Mining Engineering Department

MI411 – DRILLING AND BLASTING

ANSWER QUESTION 1 AS COMPULSORY, AND ANY OTHER 4 QUESTIONS, 2 FROM EACH SECTION

(THREE Hours)

COMPULSORY QUESTION

Q1(i)a. Mention at least <u>two</u> main functions of THRUST in percussive drilling

b. What are the <u>four</u> main FLUSHING MEDIA for hole drilling in rock are and what are the conditions in which they are applied ?

c. For a nearly circular drill hole with a radius of 10 m length and diameter of 105 mm, determine the deviation at which a reflector inserted into such a hole would cease to be seen.

c. Due to problems of fatigue, the impact velocity of the piston in actual drilling is limited to (Choose the only correct answer):

(i) 4 – 7 m/s, (ii) 9 – 11 m/s, (iii) 0.7 – 1.2 m/s, (iv) 15 – 18 m/s

[10 points]

Q1(ii) A total of 200 electric detonators of resistance 2.2 Ω/detonator, are connected in a series-parallel circuit using 60 m of bus wire, 60 m of connecting wire and 200 m of firing cable. The resistances of these wires per 100 m are 3.3 Ω, 4.0 Ω and 1.0 Ω respectively. If a 440 v ac power line is used to detonate the circuit,

(a) Show a labelled sketch for the circuit assuming reverse hook-up between firing cable and bus wire (4 marks)

Calculate

(b) The optimum number of series (2 marks)

(c) The current delivered to each series (2 marks)

(d) The total power requirement of the circuit (1 mark)

(e) What is the advantage of reverse hook up? (1 mark)

SECTION ONE

Q2(i) When calculating hole trajectory deviations from data obtained by photo- or tv-camera, state the fundamental assumptions made. **[6 points]**

(ii) From the data provided in Table 1, determine trajectory hole deviation at hole survey station number 3, illustrated in Figure 1. **[14 points]**

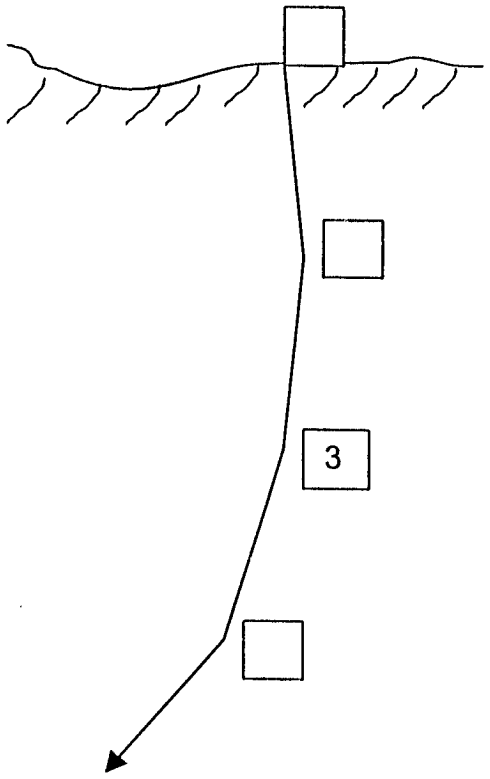


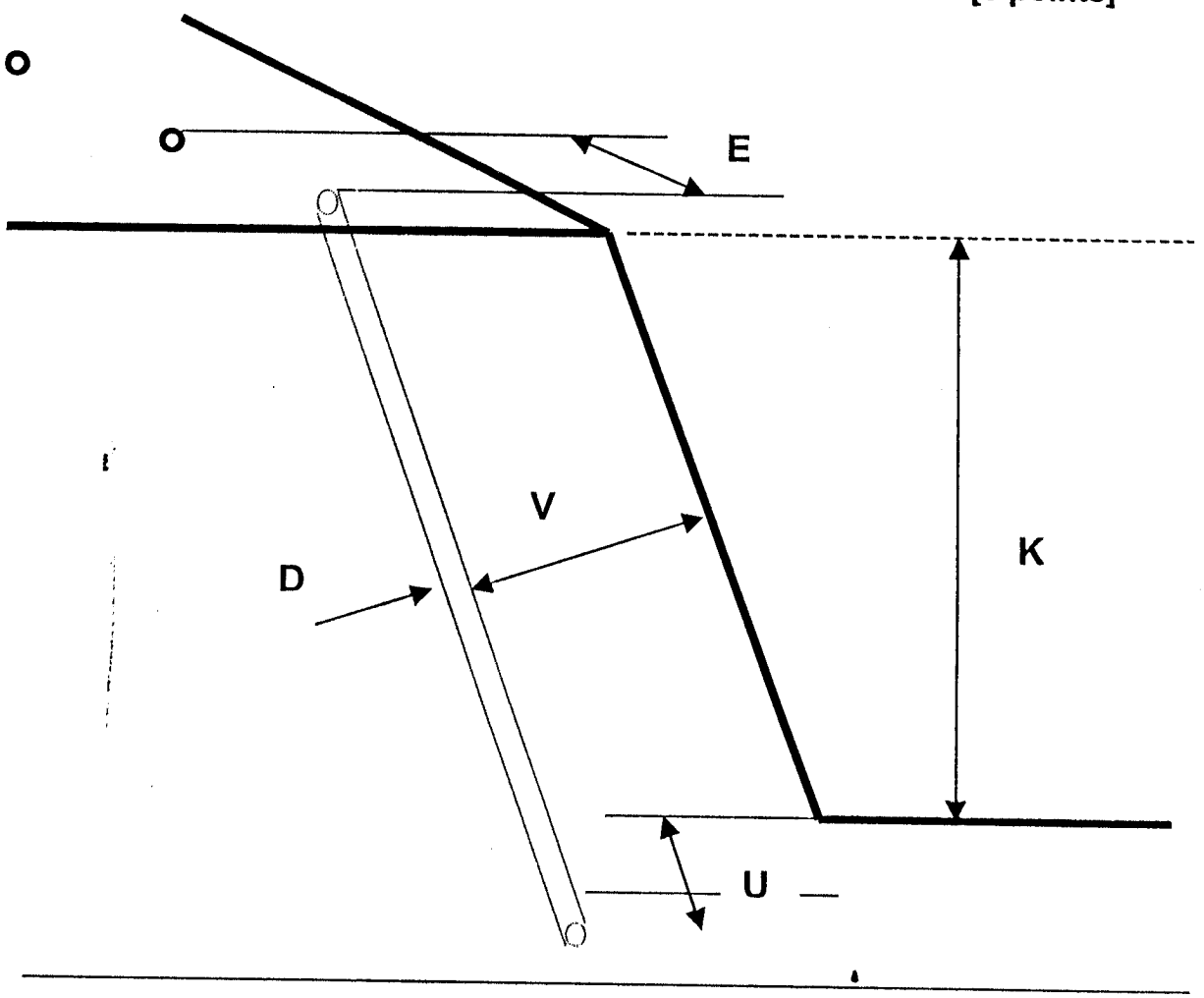
Figure 1. *Partial sketch showing a hole path*

Table 1 An example output of digitized data from measurements by tv-camera.

Survey Station	Hole Length (m)	X(m)	Y (m)	Z (m)	DIP (gons)
1	0.0	6223.31	3957.69	570.20	-87.54
2	0.7	6223.44	3957.65	569.51	-87.54
3	2.2	6223.73	3957.67	568.04	-87.15
4	3.7	6224.03	3957.70	566.57	-86.72
5	5.2	6224.34	3957.72	565.10	-86.37
6	6.7	6224.66	3957.73	563.63	- 86.20

Q3(i). In the bench illustrated in Figure 2, give relationships for K, E, V and U.

[8 points]



Figures 2. *A diagram showing parameters for bench drilling, where **D** = hole diameter, **K** = bench height, **E** = spacing between holes, **V** = distance between roles of holes in a bench and **U** = under drilling (planned **over drilling**).*

3(ii) With the help of Tables 2 an3 and Figures 2 to 4, complete the remaining slots in Table 2.

[12 points]

Table 2. Parameters for bench drilling

CONDITIONS	EXAMPLE
Rock type	Limestone
Density, (t/m^3)	2.6
Annual production, (tons)	1,000,000
Annual production, (m^3)	1,000,000 / 2.6 = 385,000
Normal hole diameters for benching, 76 – 152 mm	Selected: 102
V, (m)	
E, (m)	
U, (m)	
K, (m)	
H, (m)	
Q, (m^3)	
q_h, (m^3)	
B	
ADM	

Fugure 3. Relationship Between Bench Burden and Hole Diameter

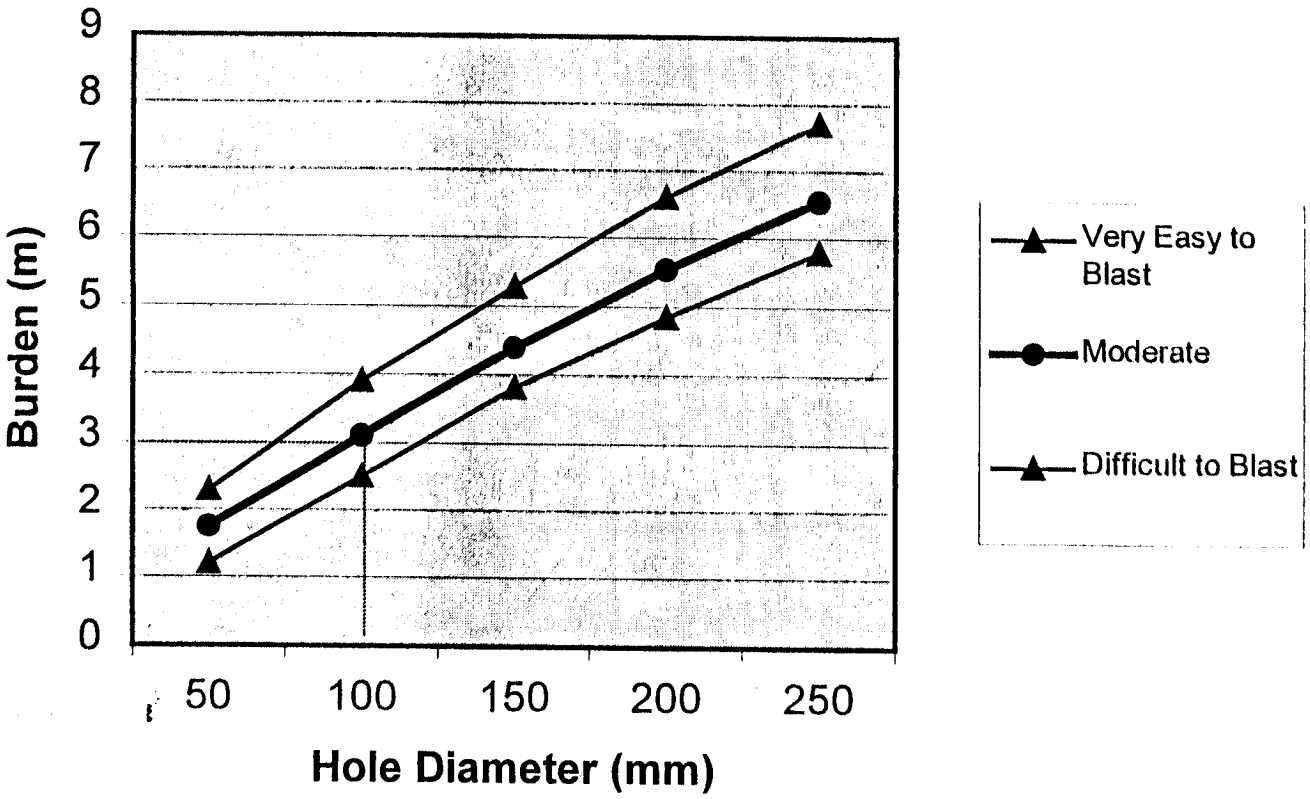


Figure 4. Inclination Factor for Determining Hole Length

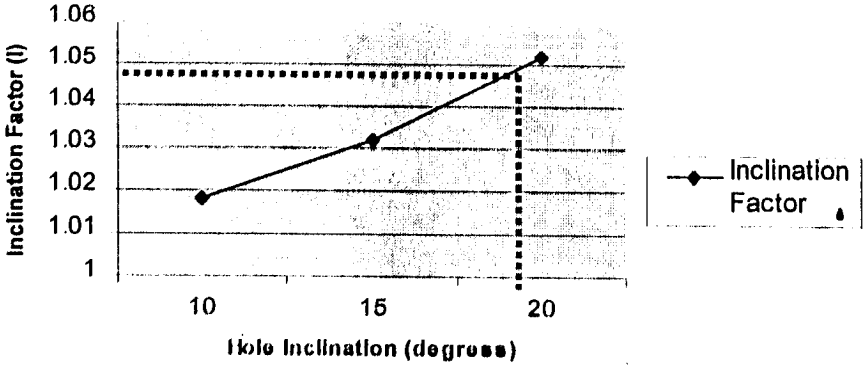


Table 3. Inclination factor used for estimating hole length

Inclination factor (I)	Hole inclination (°)
1.05	3:1 = 19.5
1.03	4:1 = 14.5
1.02	5:1 = 11.5
1.01	10:1 = 6

Q4.(i) Briefly explain the influence of rock *hardness and structure* on drilling.

[4 points]

(ii) Compare the hydraulics and compressed air as energy media in terms of *compliance, percussion energy transmission and working environment*

[6 points]

(iii) Using a sketch, clearly illustrate the principle of thrust transmission in mechanized drilling feeds. What are the functions of *the fixed and travelling* centralizers ?

[10 points]

SECTION B: BLASTING

5a. Describe the chain reaction sequence of blasting charges of NG based explosives such as Ammon Gelgnites. (10 marks

5b. What are the main ingredients of industrial explosives? Explain the role of each component. (10 marks

6a. State and explain the detonation properties of explosives. Indicate the influence of each property on selection of explosives for a given mining operation. (14 marks

6b. Explain the following terms in relation to explosives classification giving one example of each.

(I) primary explosives (2 marks)
(ii) secondary explosives (2 marks)
(iii) low explosives (2 marks)

7. Describe the following initiation devices indicating their general construction, areas of application and explain how detonation is achieved.

(a) Delay electric detonator (10 marks)
(b) Noncl detonator (10 marks)

END OF EXAMINATION.

GOOD LUCK!

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

MINING ENGINEERING DEPARTMENT

UNIVERSITY FIRST SEMESTER EXAMINATION - MAY 1999

MI 431 : UNDERGROUND MINE DESIGN

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER QUESTION 1 AND ANY OTHER FOUR.

Q1. An ore body is mined by sub-level stoping. It has a dip of 80%, thickness of 14 metres and a specific gravity of 3. A typical panel has a length of ~~10~~ 40 metres and height of 100 metres. The level and sublevel intervals are 80 metres and 20 metres respectively. The rib pillar width is 10 metres and the crown pillar is 20 metres thick. The cut through is developed on the footwall side.

The table below is a summary of the development required for a panel.

Development end	Quantity	Cross-Sectional dimension (mxm)	Length	
			in ore (m)	in waste (m)
Main (Haulage) level drive	2	4.0 x 4.0	-	40
Loading crosscuts	2	3.7 x 3.7	-	14
Coning (chamber) drive	1	3.7 x 3.7	40	-
Service raises	2	1.4m diameter	-	60
Sublevel drilling drives	3(1 per sublevel)	3.7 x 3.7	40	-
Sublevel drives	3 (1 per sublevel)	3.7 x 3.7	-	40
Slot raise	1	1.8m diameter	65	-

(i)Show the layout of the panel indicating the cut through, rib pillar, crown pillar, the sublevels, levels, crosscuts, coning drives, sill pillar and the draw points.

(10 marks)

Q6. (a) Decribe in detail, the polygon and triangular methods of estimating ore reserves, illustrate your answer with clearly labelled diagrams.

(10 marks)

(b) Describe in detail two of the techniques used in selecting a mining method; based on physical and geological characteristics of the ore body as well as the ground conditions of the hanging wall, ore zone and footwall. (10 marks)

END OF EXAMINATION **GOOD LUCK**

THE UNIVERSITY OF ZAMBIA
UNIVERSITY FIRST SEMESTER EXAMINATIONS 1999

MI 455

OPERATIONS RESEARCH

TIME: THREE HOURS

ANSWER: ALL QUESTIONS

Q1. A mine has two production shafts A and B. The production statistics for each shaft are as follows:

	Shaft A	Shaft B
Hoisting capacity, t/day	4,000	3,000
Mining output, t/manshift	20	28
Haulage performance, t/unit/shift	300	190

The underground force operates on a two shifts per day basis. Production miners are restricted to 120 per day.

Haulage fleet in the mine consists of 10 units. However, since the shafts are close together, a unit can work a portion of a shift at another shaft without loss of production. Mill capacity including surface bin is limited to 5,000 tonnes per day. The profit per tonne averages $2.00 for poduction from Shaft A and $3.00 for output from Shaft B.

If the objective is to maximize profit find:

(i) Formulate a linear program model for this problem (5 points)
(ii) The maximum daily profit (5 points)
(iii) The number of tonnes to mine daily from each shaft (5 points)
(iv) The best allocation of resources for each shaft (5 points)

Q2. 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 the following table

(ii) Calculate

(a) the gross tonnage in the panel (2 marks)

(b) the total development ore tonnes (2 marks)

(c) the net tonnage of the panel (2 marks)

(d) the specific development per tonne of fully developed reserve of a panel (2 marks)

(e) if the ring design requires drilling of holes to cover ore to the sublevel above, calculate the tonnage produced from one ring given a ring burden of 1.2m (2 marks)

Q2. The following is a description of an ore deposit:

- Thickness - 20 metres
- Dip - 65%
- Footwall - hard and firm
- Ore zone is of medium hardness
- It is bedlike in shape with irregular contours
- Depth of cover: 400m
- Ore is of moderate to rich value
- Reserves: 4 million tonnes
- High produ ction rate is desired.

(a) Suggest s suitable mining method, defending your choice. (10 marks)

(b) Show the typical layout of the mining method on an appropriate view. (5 marks)

(c) Describe the stoping sequence of the chosen mining method (5 marks)

Q3. Sublevel stoping is a massive underground mining method. Describe this mining method under the following headings:

(a) General definition of mining method (1 mark)

(b) Suitable ore body and country rock (3 marks)

(c) Stope development (4 marks)

(d) Stoping sequence (6 marks)

(e) Typical layout of the method. (6 marks)

Q4. (a) Mining methods can be distinguished on the basis of displacements induced in the country rock and the energy redistribution which accompanies mining. Explain the objectives and mining requirement in terms of above criteria for following category of mining techniques.

(i) mining with support (for supported and unsupported mining methods) (5 marks)

(ii) caving mining (5 marks)

(b) The following table represents information on a block of ore between two levels 30 metres apart between sections 00^E and 250^E separated by a sublevel. The block is composed of 5 panels, with each panel divided into two equal portions.

(c) one above and the other below the sublevel.

Panel identity	**1*	**2*	**3*	**4*	**5*	***1*	**82*	***3*	***4*	***5*
Average thickness [m]	3.5	4.0	5.0	4.0	5.0	4.0	6.0	5.0	3.0	3.0
Average grade [grams of silver per Kg of ore	5.0	7.0	10.0	8.0	7.0	8.5	9.0	8.0	6.0	5.0

*1 - The portion of first panel between level 1 and sublevel starting from 250^E cordinate

**1 - The portion of first panel between level 2 and the sublevel starting from 250^E cordinate

Given that the ore weighs 2.5 g/cm^3, and each panel is 50m by 50m (length and width) Calculate the total tonnage and Average Grade for the block. (10 marks)

Q5. The selection of a method of exploitation of an ore deposit is influenced mainly by technical and economic factors. Discuss these parameters indicating one influence of each factor on the mining method selection. (20 points)

THE UNIVERSITY OF ZAMBIA
UNIVERSITY FIRST SEMESTER EXAMINATIONS 1999

MI 465 / MM 571

MINERAL ECONOMICS/MANAGEMENT AND ECONOMICS

TIME: THREE HOURS

ANSWER: FIVE QUETIONS

Q1. (i) Discuss factors that influence the supply and demand for minerals. (10 points)

(ii) Why is a well structured mineral policy considered essential for the successful development of mineral resources in any given country? (5 points)

(iii) Discuss briefly the basic elements of a mineral policy. (5 points)

Q2. A small mining operation may be operated at 4 different levels of production, with costs and incomes given in the following table. Consider the investment life to be 10 years, without any salvage value at the end of life.

	Unit productio n/year	Initial Investment	Annual costs	Unit selling Price
Level 1	12,000	$100,000	$36,000	$5
Level 2	18,954	150,000	60,000	5
Level 3	23,116	185,000	80,000	5
Level 4	29,180	260,000	90,000	5

The minimum acceptable rate of return is 10%

NOTE that these production alternatives are mutually exclusive.

(a) What is the economically most attractive level of production on the basis of:

(i) the payback period (5 points)
(ii) the net present value (5 points)
(iii) the rate of return (5 points)

(b) What is the incremental net present value from level 1 to level 2? (5 points)

Q3. The demand and supply schedules for grade A amethyst have been established as follows:

Price per lot (US$)	Quantity demanded (lots/time period)	Quantity supplied (lots/time period)
100	1,000	25,000
90	3,000	21,000
80	5,000	19,000
70	8,000	15,000
60	12,000	12,000
50	18,000	9,000
40	26,000	6,000

(i) Determine graphically the equilibrium level of price and quantity of amethyst demanded. (5 points)

(ii) Assume a government controlled price fixed at $45 per lot. Will there be any excess supply or excess demand at this price? What will be the price eventually paid on the black market for amethyst? (5 points)

(iii) Assume that the government instead of controlling gemstone prices, the market is liberalized resulting in increased supply. The new supply curve is parallel to the old one. 23,000 units are now supplied when prices reach $80 per lot. What will be the new equilibrium price? (5 points)

(iv) Assume that along with the increase in supply, extensive advertising by the EXIM Bank is conducted resulting in increased demand. The new demand curve is parallel to the old one. At a price of $80 per unit, 7,000 units are now demanded. Show graphically the new equilibrium price. (5 points)

Q4. Minetech has identified three key variables in its operations as:

Sales quantity
Selling price
Total operating costs

A detailed study of these three variables was undertaken and resulted in the following probability estimates of levels of activity for the next year:

Sales quantity (Q)	Probability p(Q)	Sales price/unit	Probability p(p)	Total operating costs (OC)	Probability p(OC)
5,000	0.1	$20	0.1	$100,000	0.3
7,500	0.3	22	0.2	125,000	0.4
10,000	0.4	24	0.3	150,000	0.3
12,000	0.2	26	0.3		
		28	0.1		

(i) Determine the expected value of each of the above variables. (4 points)
(ii) Determine the expected value of the net profit (4 points)

Using Monte Carlo simulation technique and the following table of random numbers, determine the expected net profit and its associated variance from ten simulations. Why does this figure differ from the one obtained in (ii) above? (9 points)

RANDOM NUMBERS

Sales quantity	Sales price	Total cost
0.798	0.690	0.504
0.496	0.053	0.211
0.176	0.569	0.304
0.383	0.067	0.601
0.591	0.942	0.118
0.776	0.583	0.013
0.529	0.597	0.223
0.477	0.545	0.334
0.180	0.009	0.743
0.910	0.132	0.261

From the simulation (assuming each of the ten outcomes has an equal probability of occurrence), determine the probability of obtaining a greater than $90,000 profit. (3 points)

Q5. A mining company has purchased a screening cyclone at a cost of $900,000. It has a five-year depreciable life and an estimated $300,000 resale value at the end of 5 years.

(a) Taking into account the salvage value, determine using straight-line depreciation:
(i) Accumulated depreciation at end of 4 years (5 points)
(ii) The book value at end of 3 years (5 points)

If the sum-of-the years digit depreciation is applied, determine
(i) The accumulated depreciation at end of year 5 (5 points)
(ii) What rate of depreciation is charged at end of year 2? (5 points)

Q4. Give five examples to demonstrate the application of OR techniques in mining. (20 points)

Q5. New mining house would like to invest in Zambia. Earlier attempts aimed at acquiring controlling shares in ZCCM were unsuccessful. Bids to buy some divisions of ZCCM after ZPA's announcement to privatise the company's divisions were equally unsuccessful. The company has now decided to look elsewhere. It has two options to consider:

(i) Buy a recently revived gold mine prospect in Lusaka West at an advertised price of $5million. Preliminary available geological data indicates the prospect maybe fairy priced. The company expects to spend $100,000 on feasibility studies so that it can decide whether to develop the mine or not. Development and other costs to bring the mine into production are expected to be $500,000 and annual operating costs to be $200,000. Gold recovery by a recently developed method is expected to be 420 ounces with a probability of 0.2; 400 ounces with a probability of 0.5 and 390 ounces with a probability of 0.3. Gold price by contract with Ashanti has been agreed at $350 per ounce.

(ii) Approach the Ministry of Mines for a permit to develop a new emerald mine in Ndola rural. Once developed, the company hopes to sell cut stones internationally. Expected investment costs will be $950,000.Operating costs are expected to be $450,000 annually. 10,000 carats of cut stones will be produced annually. Emerald prices are extremely volatile. Three price scenarios with their corresponding probabilities have been investigated as follows:

Price $/carat	Probability of price
$2,000	0.1
1,900	0.4
1,500	0.5

(a) Construct the decision tree for the above problem. (10 points)

(b) If the company's objective is to maximise the expected value of contribution (i.e., profit), what is the company's best strategy? (10 points)

END OF EXAMINATION

Activity	a	m	B
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

(i) Construct an arrow diagram for the project. (3 points)

(ii) Using PERT assumptions, find the mean and variance of times of each activity (3 points).

(iii) Find the critical path using the mean times in (ii) above. (8 points).

(iii) Assume the completion time for the total project can be approximated by a normal distribution. Determine the project's completion time and its corresponding standard deviation. (3 points)

(iv) If you had to estimate a time for project completion, and wanted to be 95% sure of completion by this time, what would be your estimate? (3 points)

Q3. An exploration company buys core drills used in its exploration programs directly from South Africa. The company uses drills at a constant rate and requires 1,000 of them per month throughout the year (12,000 per year). If ordering costs are $25 per order, unit cost is $250 per drill, and annual inventory holding costs are charged at 20%, determine the following inventory decisions:

(i) What is the economic order quantity (EOQ) (10 points)
(ii) What is the length of cycle time in months between orders (5 points)
(iii) What are the total annual inventory holding and ordering costs associated with your EOQ? (5 points)

Q4 (a) What is horizon mining? What are the general considerations that govern the general layout in horizon mining? **(8 marks).**

(b) Show by means of diagrams a simple layout (both in plan and section) showing details of coal mining using horizon method of mining. The seam dips at 20°. **(8 marks).**

Q5 (a) What are the difficulties and dangers associated with mining a thick coal seam? **(8 marks).**

(b) A coal seam 12 m thick to be mined by 'False roof' (French method) system. Explain with the help of diagrams how such seam can be extracted. What % of coal can be extracted by this method. Give reasons for the figure you suggest. **(8 marks).**

Q6 (a) There are certain preventive safety measures must be taken against danger from:

(i) methane gas
(ii) coal dust and
(iii) water inundation in coal mining Discuss these factors under the above three headings clearly. **(8 marks).**

(b) What is known as "adequate ventilation" How can you ensure that the mine section of which you are in-charge is having adequate ventilation? **(8 marks).**

Q7 Give your views on the following:

(a) The prospect of coal mining industry in the next millennium. **(8 marks).**

(b) The need for teaching "coal mining methods" as a separate course (than the metal mining method). **(8 marks).**

END OF EXAMINATIONS

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
MINING ENGINEERING DEPARTMENT

End of Semester Examination

MI-585 MATERIALS HANDLING

Answer: ANY FIVE (05) QUESTIONS
TIME: THREE (03) HOURS

ALL QUESTIONS CARRY EQUAL MARKS

Question 1

a) Write brief notes on large truck haulage in surface mining under the following sub-headings:

i) History and developmental progression of surface mining rear dump truck capacities and power rating and current constraints towards further development

ii) Drive types and their merits/demerits

iii) Truck application in haulage, advantages and disadvantages (5)

b) Calculate the hourly output of a 316 tonne capacity dump truck given the following data:

Haulage Segment	A	B	C
Distance	1200m	1500m	2000m
Speed loaded haul (km/hr)	25	20	30
Speed empty haul (km/hr)	30	25	35
Loading time (minutes)	4.5		
Dumping Time (minutes)	1.5		
Spot time at dump (minutes)	0.5		
Availability (%)	90		
Utilisation (%)	95		

(10)

c) Calculate the truck fleet required if the production target is 2.5 million tonnes ore per year, knowing:

Stripping Ratio = 4:1
Hauling Shifts per day = 3
Shift Duration = 8 hours
Working days per year = 300 days (5)

Q6. The cost for Terex B25 dump truck is $300,000. According to performance data by the manufactures, they estimate the operating costs and salvage values for 8 years as follows:

PERFORMANCE DATA

Year	Operating cost ($)	Salvage values ($)
1	10,000	21,000
2	11,000	14,000
3	12,000	10,200
4	13,200	7,000
5	15,000	5,000
6	17,000	3,000
7	21,000	2,500
8	25,000	2,000

(i) If the tax rate is 50%, the discount rate is 10% and DBD rate is 30%, determine the optimum economic life of this dump truck. (10 points)

(ii) Give reasons for replacement of equipment and processes. (10 points).

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

END OF SEMESTER EXAMINATION MAY, 1999
COAL MINING METHODS MI535

Full Marks: 100 **Time: 3 hours**

- Answer ***any Six Questions***
- ***Neat presentation*** will ***get credit***

Q1 (a) Explain, what is meant by 'rank of coal? List the factors on which rank of coal depends upon. **(8 marks).**

(b) How Fault and washouts may affect working of a coal seam? Explain with the help of diagrams. **(8 marks).**

Q2 (a) Discuss the circumstances under which you would recommend bord and pillar method of working. **(8 marks).**

(b) A coal seam 5 m thick at a depth of 200 m is to be mined by bord and pillar method of mining. Describe with the help of diagrams the procedure of extraction of such coal seam. Give the details of development, depillaring and transport system to convey the coal from the face to the surface. **(8 marks).**

Q3 (a) What are the advantages of longwall retreat system of mining? Give also the disadvantage over the advancing system, if any. **(8 marks).**

(b) Give a layout of a longwall retreat face with a Double Ended Range Drum (DERD) Shearer. What daily output can reasonably be obtained by a DERD use if the face length is 210 m, the thickness of coal seam is 3 m and 'web' of shearer is 0.5? The average speed of DERD Shearer can be taken as 5.0^{m}/min. Assume other factors if necessary for making output calculation. Give the output in tonnes. **(8 marks).**

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - MAY 1999

MM321

PHYSICAL METALLURGY I

TIME: THREE HOURS

ANSWER: ALL THE QUESTIONS

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1. What materials would you select for the following applications and why?
   (a) a domestic table knife
   (b) an aircraft gas turbine
   (c) an automobile radiator
   (d) a filament of an incandescent light bulb

2. (a) In the early stages of this century, people doubted the existence of dislocations in materials. As a metallurgy student at the close of the century, what technique would you use to directly show the existence of dislocations in a material?

   (b) Is the following dislocation reaction possible?

$$\frac{a}{2}[10\bar{1}] \rightarrow \frac{a}{6}[21\bar{1}] + \frac{a}{6}[1\bar{1}\bar{2}]$$

   (c) The shear modulus for iron is about 69 GPa. Compute the theoretical shear strength for slip in this material. How many times larger is this than its observed shear stress for slip of 28 MPa? What does the answer you have obtained indicate about the strength of materials?

$$\tau_{max} = \frac{G}{2\pi}$$

3. (a) Find the zone axis for the following pairs of planes:

   (010) and $(3\bar{2}5)$; (103) and (112).

   (b) The hexagonal planes of the form $\{10\bar{1}0\}$ are called prism planes of the type 1. How many of them are there and what is their significance relative to the hexagonal unit cell?

(c) Show geometrically that in the hexagonal system $[\phi\phi\bar{1}2]$ is not perpendicular to $(\phi\phi\bar{1}2)$.

4. (a) Distinguish between the yield, and tensile strengths of a material.

(b) A metal with a Young's modulus of 138 GPa is subjected to a true tensile stress of 500 MPa. Calculate the true and nominal elastic strains.

(c) A tensile specimen, initially 1.50 cm in diameter, has a diameter at ultimate of 1.43 cm and a diameter at fracture of 0.95 cm. If the maximum load during the test is 70,000 N, find the load at fracture.

5. (a) Explain why the jump frequency of a substitutional impurity atom in a metal is appreciably less than the frequency with which the atom oscillates about its equilibrium site.

(b) State two major commercial applications of the solution to the non-steady state diffusion equation.

(c) The equation below applies to any diffusing species in any cubic metal. Show that this is true for self diffusion in a pure bcc metal for two adjacent {200} planes.

$$D = \frac{1}{6}\Gamma\alpha^2$$

END OF EXAMINATION IN MM321

UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

UNIVERSITY EXAMINATIONS - MAY, 1999

MM331 - CHEMICAL THERMODYNAMICS

Time: 3 Hours

Answer Five questions

All questions Carry Equal Marks

1. (a) Calculate the Thermal effect of the following reaction

$$Al_2O_{3\,(s)} + 3SO_{3\,(g)} = Al_2(SO_4)_{(s)} + \Delta H_{o_x}$$

Given: T = 298K and P = 1.013×10^5 N/m^2

Table 1.

Enthalpy of Reaction	Heat of Reaction 10^6 J/Kmol
$\Delta H°_1$	- 1675
$\Delta H°_2$	- 395.2
$\Delta H°_3$	- 3434.0

The standard enthalpies in Table 1 are obtained from the thermal effect between reactants to form products under standard conditions of temperature and pressure:

$$2Al_{(s)} + 3/2\ O_{2\,(g)} = \text{~~$Al_2(SO_4)$~~ } Al_2O_3{}_{(s)} + \Delta H_1^o$$

$$S_{(s)} + 3/2\ O_2 = SO_{3\,(g)} + \Delta H_2^o$$

$$2\,Al_{(s)} + 3S_{(s)} + 6O_{2\,(g)} = Al_2(SO_4)_{(s)} + \Delta H_3^o$$

Question 2

a) Write brief notes on main factors to be taken into account when selecting equipment for materials handling in mining. (5)

b) Write notes on types, principles and purposes of drilling in mining with emphasis on application and limitations of:

I. Percussive Drilling (5)
II. Rotary Drilling (5)
III. Roto-Percussive Drilling (5)

Question 3

a) What are the conditions that make stripping by Ripper and Scraper effective? (5)

b) Calculate unit production cost incurred in loosening rock for scraper loading with D 11N tractor with a single shank given the following situation:

Rip spacing = 1500 mm
Rip penetration = 2100 mm
Single pass = 750 m
Tractor rip speed = 1.75 km/hr
Turn time = 0.45 minutes per cycle
Hire cost of tractor (inclusive of fuel and lubricants) = K 650 000.00
Operator Cost K 30 000.00 per hour
Availability = 95%
Utilisation = 95% (7.5)

c) Estimate the hourly performance of a wheel tractor scraper given the following data:

Average haul distance 2500 m
Average travel speed (empty and loaded) = 15 km/hr
Scraping time = 1.5 minutes
Emptying and spreading time = 0.75 minutes
Weight haul unit – empty = 22 000 kg
Weight of haul unit – loaded = 57 000 kg
Material density = 2.45 t/bcm
Swell factor = 1.25
Time use factor = 85% (7.5)

Give answer in loose cubic metres.

Question 4

a) Write short notes and with the aid of appropriate sketches describe hoisting under the following sub-headings:
- Composition classification and types of hoisting systems
- Shaft types and tasks
- Headgear (Head-frames)
- Winding tower types (15)

b) With the aid of corresponding sketches, discuss the principles of operation and underlying design criteria of a Friction (Koepe) hoist. (5)

Question 5

a) Write brief notes on Belt Conveyor Selection and the characteristics that determine their selection as a transportation medium in mining. (10)

b) Given following belt specification for a belt conveyor, verify whether the installation will be capable of evacuating material from a Bucket Wheel Excavator rated at 7 million cubic metres (loose) per annum.

Belt width .....2 100 mm
Troughing angle.....30°
Material's angle of repose.....25°
SG of material.....1.75m^3/t
Belt speed.....2.5 m/s
Belt loading factor.....95%
Total working hours per day...18
Total working days per year....265
Time use factor.....95% (5)

c) If answer to (b) is NO, what conveyor belt design and operational alterations would you advocate for in order to accommodate the BWE production? (5)

Question 6

a) The following average figures are for:

i. Rotary Blast-hole drilling parameters

- Compressive strength.....35 x 10^3 psi
- Pull-down pressure on drill string.....120 x 10^3 psi.
- Drill string revolutions per minute.....90
- Blast hole diameter.....18 inches

ii Blasting parameters:

- Bench height.....H = 12 m
- Highwall angle..... 60°
- Rock Density.....2.5 g/cm^3
- Explosive density.....0.85 g/cm^3
- Coefficient of spread.....c = 1.5 to 2.0
- Number of rows per blast.....n = 3 + delay sequencing

You are required to calculate:

a) Penetration rate of the Rotary blast hole drill (4)
b) Blast design parameters (4)
c) Explosive consumption per hole (3)
d) Rock broken per hole (3)
e) Powder factor (3)
f) Spread of broken muck-pile (3)

Question 7

a) Define, give examples and describe the role and importance of auxiliary and ancillary equipment as employed in surface and underground mining. (10)

b) List and briefly describe the types and limitations in the application of equipment deployed to material handling in both surface and underground mining operations. (10)

END OF EXAMINATION

(b) Show that for constant pressure, the heat of any reaction:

$$bB + dD = gG + rR$$

Can be written as

$$\frac{d(\Delta H)}{dT} = \Delta C_p$$

2. (b) The molar heat capacities of lead at constant pressure per a range of temperatures, are given below.

Temp K	15	30	40	70	150	300
C_p,J/K/Mol	8.41	16.40	19.75	23.26	25.02	26.36

Calculate the standard entropy of lead at 25°C (298K) from the third law of thermodynamics. Assume that the entropy continuation below - 258°C (15K) follows Debye's equation.

2. (b) Show how the Gibbs-Helmhotz equation is derived.

3. Calculate the activity of bismuth in a **Bi-Zn** alloy containing 70 atom % Zn at **600°C (873 K)** from the following data obtained from vapour pressure measurements:

X_{Zn}:	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
γ_{Zn}:	2.591	2.303	2.098	1.898	1.721	1.551	1.384	1.219	1.089

4. The excess partial molar free energy of zinc in liquid Cu-Zn alloys at **1027°C (1300 K)** can be represented as

$$\mathbf{G^{ex}_{Zn}\ (cal/mole) = -5150\ (1 - X_{Zn})^2.}$$

Calculate the activity of copper at **1027°C (1300 K)** in an equi-atomic solution.

5. Benzene and toluene form solutions that are almost ideal in behaviour. At 30°C pure benzene has a vapour pressure of 118.2 mm Hg and toluene has a vapour pressure of 36.7 mm Hg. Calculate the partial pressures and the total pressure over a solution composed of 300 grams of benzene and 600 grams of toluene. What would be the composition of a solution of benzene and toluene at 30°C if the vapour in equilibrium with it has a composition such that the mole fraction of the toluene is 0.35. Molecular weight of benzene is 78.14 and that of toluene is 92.14.

6. The partial pressures of A exerted by A-B alloys at 1000 K

X_A	1	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2
P_A 10^6	5	4.4	3.75	2.9	1.8	1.1	0.8	0.6	0.4

Determine (a) the composition range over which Henry's law is obeyed by the solution and (b) The value of Henry's law constant at 1000 K. If the temperature variation of the Henry's law constant is given as

$$\log K_A = -\frac{109.3}{T} - 0.2886$$

(c) Calculate ΔH_A^M in the composition range over which A obeys Henry's law

(d) Write an equation for the variation of ΔH^M with composition over the same composition range.

7(a) The excess partial molar free energy of zinc in liquid Cu-Zn alloys at 1027°C (1300 K) can be represented as

$$G^{xs}_{Zn} \text{ (cal/mole)} = -5150 (1 - x_{Zn})^2.$$

Calculate the activity of copper at 1027°C (1300 K) in an equi-atomic solution.

END OF EXAMINATION IN MM 331

THE UNIVERSITY OF ZAMBIA
UNIVERSITY OF ZAMBIA EXAMINATIONS
SCHOOL OF MINES

DEPARTMENT OF METALLURGY/MINERAL PROCESSING

MM 411 MINERAL PROCESSING I

Time : Three Hours
Answer: Questions 1 and any other 4.

1. Briefly explain what you understand by these terminologies used in mineral processing:

- Communition
- Mesh number
- Grindability of an ore
- Optimum mesh of grind
- Set of a crusher
- Terminal velocity of a particle
- Hindered settling
- Concentration criterion
- Consolidation trickling
- Cut point

2. (a) Discuss the operational principles with diagrams of three different Jaw Crushers and outline their suitability for use as primary crushers.

   (b) Draw a functional sketch of a gyratory crusher and explain the crushing mechanism.

   (c) On first sight, the cone crusher looks very much like the gyratory crusher. Outline the various features which distinguish the two.

   (d) How does an hydrocone fucntion?

3. (a) What can you say about the relationship between the energy input to a mill and the mill charge? Draw a simple sketch to illustrate this relationship.

   (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) What is the effect of the residence time on the size distribution of the product of the ball mill?

4.a. Of what benefit has the Waelz kiln process been to the lead and zinc industry? Describe the process under the following headings:
the feed, essential features of the plant, process chemistry, the products. (8%)

b. (i) Draw a clearly labelled block flow-diagram of the sequence of steps you would use to refine lead containing as impurities arsenic, silver, copper, and zinc. (2%)

(ii) Outline the principles involved in the removal of the above named impurities from lead. (5%)

5.a. Two copper sulphide concentrates, named X and Y, destined for matte smelting in a reverberatory furnace are blended in a mass ratio of 2 parts X to 1 part of Y. If the concentrates analyse (gangue oxide composition only) as shown below, calculate how much limerock flux (with 54.0% CaO) needs to be added per tonne of the concentrate blend so that the normalised slag composition is: 59% SiO_2, 31% CaO, and 10% Al_2O_3. State any assumptions made in your calculation. (10%)

	Gangue oxide composition			
Concentrate	$\%Al_2O_3$	%MgO	$\%SiO_2$	%CaO
X	4.43	1.96	17.5	1.05
Y	5.00	1.70	45.0	2.20

b. (i) Why is copper produced in converters refined prior to casting? (2%)

(ii) Refining of copper produced in converters is a two-stage process. What would be wrong with casting the copper after the first stage of refining? (2%)

(iii) Outline the principles involved in carrying out both stages of refining copper from converters. (6%)

END OF EXAMINATION

If in addition to the off-gas, the products of reaction are "white metal" with 75.2% Cu and 54.8 tonnes slag with 5.8% Cu, 45.5% Fe, and 25.4% SiO_2. Assume that there are no dust losses. State any other assumptions made.

Based on 85 tonnes of matte fed, calculate:

i. the wet weight of concentrate charged. (7%)
ii. the weight of white metal produced. (4%)
iii. the iron content (in %) of white metal. (5%)
iv. the composition of the flue-gas. In practice, the SO_2 content of the off-gas is less than that calculated. Why? (8%)

One kilomole of a gas occupies 22.41 Nm^{33} and relative atomic weights are as follows: Cu = 63.5; Fe = 55.8; S = 32.1; 0 = 16.0; N = 14.0; H = 1.0.

3.a. (i) Distinguish between roasting, drying, and calcination. (3%)
(ii) Why is drying an important metallurgical operation? (2%)

3.b. One tonne of an oxidised pyrite concentrate containing 80% FeS_2, 5% Fe_2O_3 and 15% moisture is to be dried by heating it to 250 °C. Assuming that any water lost leaves at 250 °C and that heat losses account for 50% of the heat supplied, estimate the thermal requirement (in kJ) for drying this material. (10%)

Thermodynamic Data

$H_2O_{(l)}$: $C_p = 18.03$ cal/deg/mol
H_2O : $L_v = 10520$ cal/mol
$H_2O_{(g)}$: $C_p = 7.17 + 2.56 * 10^{-3}T + 0.08 * 10^{5}T^{-2}$ cal/deg/mol

And the enthalpies for FeS_2 and Fe_2O_3 are to be calculated using the formula:

$H°_T - H°_{298} = aT + 0.5bT^2 + c/T + d$ cal/mol

Substance	a	b * 10^3	c * 10^{-5}	d
Fe_2O_3	23.49	18.6	-3.55	-6634
FeS_2	17.88	1.32	-3.05	-4363

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS - FIRST SEMESTER, 1999

MM 441
PYROMETALLURGY

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

1.a. The Gibbs energy change for the reduction of ZnO by CO to form zinc vapour by the reaction:

$$ZnO_{(s)} + CO_{(g)} = CO_{2(g)} + Zn_{(g)}$$

is given by:

$\Delta G^\circ = 46720 - 31.7T$ Cal

If T is in Kelvin and:

$$\log P^o_{Zn}(atm) = -\frac{6850}{T} - 1.255 \log T + 9.45$$

Calculate:

(i) the partial pressures of Zn, CO, and CO_2 in equilibrium with solid ZnO at 1300 °C for a total pressure of one atmosphere, and determine if liquid zinc can be produced at this temperature. (10%)

(ii) the value of the total pressure which will give liquid zinc at 1000 °C. (6%)

b. Answer the following about the Imperial Smelting Process:

i. What is "blue powder" and how can its formation be minimised? (2%)

ii. Why is the zinc content of the slag not less than 8%? (2%)

2.a. Using the headings shown below, briefly explain the operations of the Hoboken copper converter. (6%)

i. Converter feed (inputs)

ii. Process chemistry

ii. Converter products (outputs)

b. In the operation of a C.M.T. converter, for every 85 tonnes of matte with 50.9% Cu charged, 13.6 tonnes of flux analysing 4% Cu_2S, 16% FeS, and 80% SiO_2 is also fed. A concentrate with 7.3% H_2O and a dry analysis of 38.8% Cu and 29.9% sulphur is also charged. The minerals in the concentrate are bornite and pyrite while the gangue is SiO_2 only. Air required for the reactions is enriched to 32% O_2 and the supply is 20% in excess of stoichiometric needs.

(d) How many types of mills do you know and by using diagrams explain how they operate.

(e) Draw a detailed cross section of a tumbling mill showing its rotation direction.

4. Explain the principle of gravity concentration.

(a) Briefly describe the operation of pinched slices and illustrate your description with a rough sketch.

(b) Briefly describe the operation of Reichert Cone concentrator and illustrate your description with a rough diagram.

(c) Describe briefly how minerals can be separated on a shaking table by explaining the action of the flowing water over the inclined deck, the riffle and that of the shaking motion. Make a rough sketch of the deck of a shaking table and indicate where the various products should be collected.

5. (a) Draw a rough diagram of the cross section through a Harz jig, used in the concentration of cassiterite where the concentrates are collected on the screen. Describe the operation of this jig briefly.

(b) Draw a diagram of the cross section through a Denver jig, used in the concentration of cassiterite where the concentrates are collected on the screen. Describe the operation of this jig briefly.

(c) Briefly summarise the main differences between the Harz and Denver jigs.

6. (a) Draw a functional sketch of a rake classifier in operation, showing it's main parts and the various zones that can be distiquished. Describe this type of classifier functions. Indicate in your diagram where the feed enters and where the product leaves the classifier

(b) What operation controls can be used on this type of classifier and state briefly how these controls influences the separation size in this classifier.

(c) The efficiency of classification is expressed in terms of sharpness of particle size separation. In general hydraulic classifiers give sharper size separation than mechanical classifiers, which in turn give a higher efficiency of separation than hydrocyclone. In a few words, give the reasons why hydraulic classifiers generally give a sharper size separation than mechanical classifiers and the reason for the comparatively low separation efficiency in cyclones.

(d) In spite of the lower efficiency, hydrocyclones are usually preferred to mechanical classifiers . Give some reasons for this preference.

END OF EXAMINATION IN MINERAL PROCESSING I

3 (a) A smooth, horizontal U-shaped, fixed vane deflects a free jet having a velocity of 30.5 m/s and a diameter of 1.0×10^{-2} m. Calculate the force of the jet on the vane. Take the density of water as 1000 kg/m^3.

(b) Hot water in an open storage tank at 82.2 ^{0}C is being pumped at the rate of 6.7×10^{-3} m^3/s from the bottom of this storage tank. The line from the storage tank to the pump suction is 6.0 m of 50-mm smooth pipe and it contains three 90^0 elbows. The discharge line after the pump is 60 m of 50-mm smooth pipe and contains two 90^0 elbows. The water discharges to the atmosphere at a height of 6.0 m above the water level in the storage tank.

(i) Calculate the total friction losses in J/kg.
(ii) Calculate the kW power of the pump if its efficiency is 75 %.

Density of water = 970 kg/m^3
Viscosity of water $= 0.345 \times 10^{-3}$ Pa.s

$$F_f = 4f \frac{\Delta L}{D} \frac{v^2}{2}$$

$$h_c = 0.55\left(1 - \frac{A_2}{A_1}\right)\frac{v_2^{\,2}}{2\alpha}$$

L_e/D for each elbow = 35

4 (a) In a vertical wetted-wall film, the fluid flows down the inside as a thin film δ in steady laminar flow in the vertical z direction. Derive the equation for the velocity profile v_z as a function of x, the distance from the wall toward the liquid surface. Also derive the expression for $v_{z\,av}$.

(b) A long steel rod 0.305 m in diameter is initially at a temperature of 588 K. It is immersed in an oil bath maintained at 311 K. The surface convective coefficient is 125 W/m^2.K. Calculate the temperature at the centre of the rod after 1h. The average physical properties of the steel are k=38 W/m.K and $\alpha = 0.0381$ m^2/h.

5 (a) The walls of a furnace are built up to 150 mm thickness of a refractory of thermal conductivity 1.5 W/m.K . The surface temperatures of the inner and the outer faces of the refractory are 1400 K and 540 K respectively. Calculate the heat loss from the furnace in W/m^2.

(b) A layer of insulating material 25 mm thick of thermal conductivity 0.3 W/m.K is added to the wall of the furnace in part (a). The inner surface of the insulating material attains a temperature of 995 K assuming the inner surface of the furnace to remain at 1400 K. Calculate the coefficient of heat transfer from the outer surface of the insulation to the surroundings which are at 290 K. What will be the percent reduction in heat loss and the temperature of the outer surface of the insulation?

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
FIRST SEMESTER EXAMINATIONS – MAY 1999

MM 451
TRANSPORT PHENOMENA

Time: **THREE HOURS**
Answer: **FIVE QUESTIONS**
ALL QUESTIONS CARRY EQUAL MARKS

---

1 (a) A wet paper pulp contains 68 wt % water. After the pulp was dried, it was found that 55 % of the original water in the pulp was removed. Calculate the composition of the "dried" pulp and its weight for a feed of 1000 kg/min of wet pulp.

(b) Hot gases enter a heat recovery unit at a rate of 1000 moles per min at 498 K and a pressure of 1.0132×10^5 M/m^2. The gases contain 80 mol % CO_2 and 20 mole % H_2O. They leave the unit at 298 K and essentially the same pressure. Since there has been some condensation, the gases now contain only 5 mole % H_2O as water vapour.

Calculate the amount of heat in kJ/min which must be removed if the heat of vapourisation of H_2O at 298 K is 44 000 kJ/kg mol.

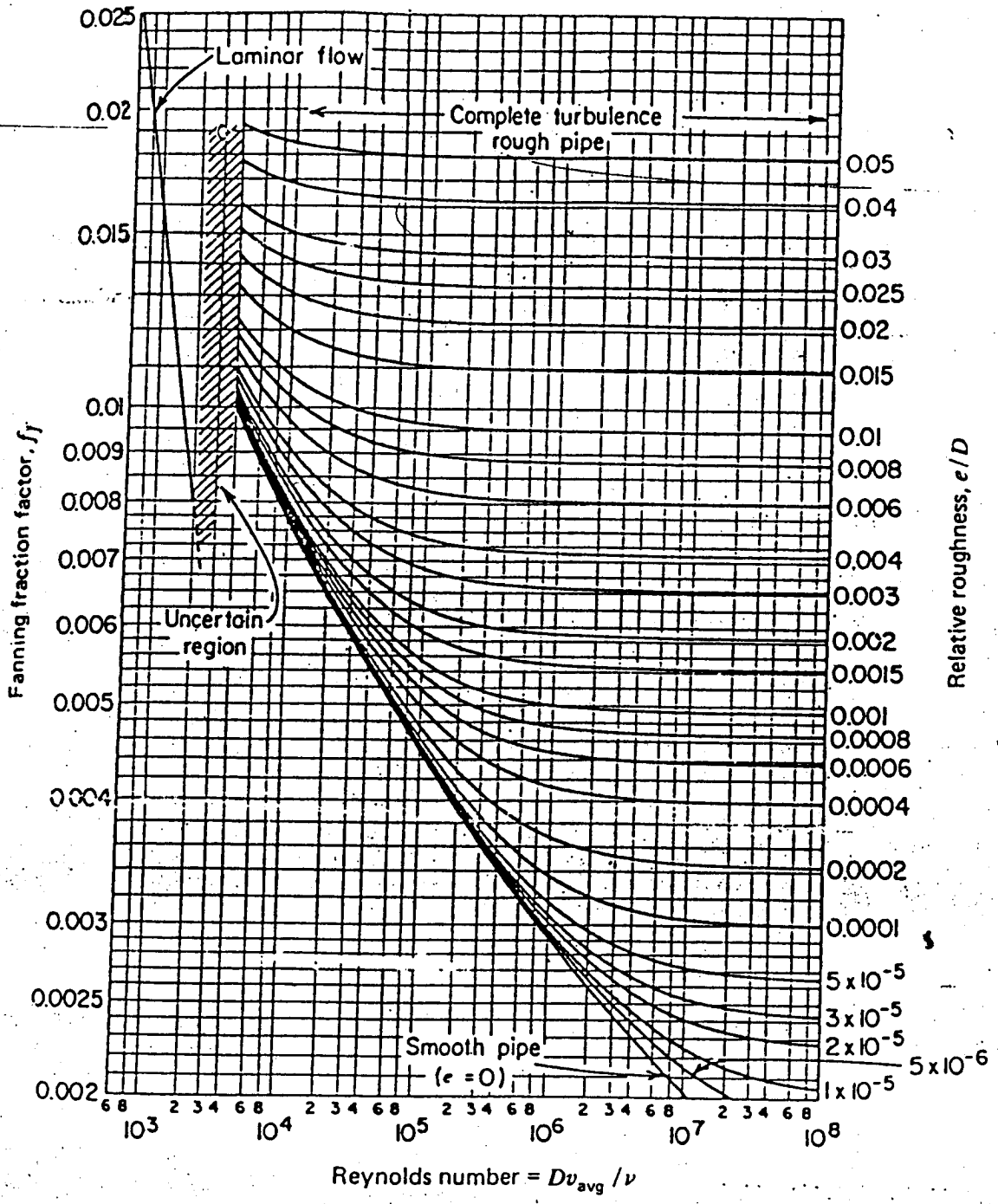
Heat capacity data:

Gas component	c_P (mean) J/mol. K
CO_2	41.0
H_2O	34.3

2 (a) A sea laboratory 5 m high is to be designed to withstand submersion to 100 m, measured from the sea level to the top of the sea laboratory. Calculate the gauge pressure in kN/m^2 on top of the sea laboratory and also the gauge pressure variation on the side of the container measured as the distance y in m from the top of the sea laboratory downward. The density of sea water is 1020 kg/m^3.

$g = 9.81$ m/s^2

(b) A well-mixed tank is fed water at 0.04 m^3/min and the water leaves the tank at the same rate via an overflow when the tank holds 0.4 m^3. At time zero a dye is added to the feed stream at a rate such that the feed to the tank contains 100 ppm (parts per million, mass) of dye. How long will it take for the dye to reach 99 ppm? Density of water is 1000 kg/m^3.


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

6 Calculate the rate of loss of heat from a 6.0 m long horizontal steam pipe of 50 mm internal diameter and 60 mm external diameter. It is carrying saturated steam at 800 kN/m^2 and 443 K. The temperature of the atmosphere and surroundings is 290 K. Neglect the inside resistance and that of the pipe wall.

What would be the percent reduction in heat loss by coating the pipe with a 50 mm thickness of 85 % magnesia lagging of thermal conductivity 0.07 W/m.K ? The emissivity of the surface of the bare pipe and also of the lagging may be taken as 0.85, and the coefficient h for the heat loss by natural convection can be calculated from the expression:

$$h = 1.32(\Delta T / D)^{0.25} \quad W/m^2.K$$

Where ΔT is the temperature difference in K. Take the Stefan-Boltzmann constant as 5.676×10^{-8} $W/m^2.K^4$. The surface temperature of the lagging is 305 K.

7 Ammonia gas is diffusing through N_2 under steady-state conditions with N_2 nondiffusing since it is insoluble in one boundary. The total pressure is 1.013×10^5 Pa and the temperature is 298 K. The partial pressure of NH_3 at one point is 1.333×10^4 Pa and at the other point 20 mm away it is 6.666×10^3 Pa. The D_{AB} for the mixture is 2.3×10^{-5} m^2/s and the gas constant R is 8314.34 m^3.Pa/kg mol.K.

(a) Calculate the flux of NH_3 in kg mol/s.m^2 .

(b) Do the same as (a) but assume N_2 also diffuses. In which case is the flux greater?

END OF 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):

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

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

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

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

THE UNIVERSITY OF ZAMBIA
UNIVERSITY OF ZAMBIA EXAMINATIONS
SCHOOL OF MINES

DEPARTMENT OF METALLURGY/MINERAL PROCESSING

MM 515 SPECIAL TOPICS IN MINERAL PROCESSING

Time : Three Hours
Answer: Five Questions.

1. 0.561g of a coal powder absorbed with the following amounts of nitrogen, n at 195°C and various pressures, P

n (milli moles)	0.439	0.534	0.623	0.693	0.754	0.84
p, (Cm, Hg)	2.5	6.30	11.4	16.3	20.8	25.8

(a) Calculate the specific surface area of the powder using the BET equation.

(b) The surface area of the powder as measured by election microscopy was $60m^2/g$. What can you say about the internal morphology of the powder?

BET Equation can be written as:-

$$\frac{p^1}{n(P_o - P)} = \frac{1}{n_m C} + \frac{(C-1)}{n_m C}\left(\frac{P}{P_o}\right)$$

The cross sectional area of a nitrogen molecule is 16.1×10^{-20} m^2.

2. (a) What do you understand by "particle size distribution functions" and what is their significance in practice? Give the general equation of these functions and define all the parameters.

(b) Mention the two commonly used function and define the ... meaning of all symbols. Show how meaningful interpretation can be made to check whether a set of data confirm a given function.

(c) Can you show how the two equation may be seen to be almost the same.

(d) A particle distribution of an ore is known to follow the G.S function with 90% and 50% of the particles being less than 1 mm and 0.5 mm respectively. What is the weight % between 10μm and 20μm?

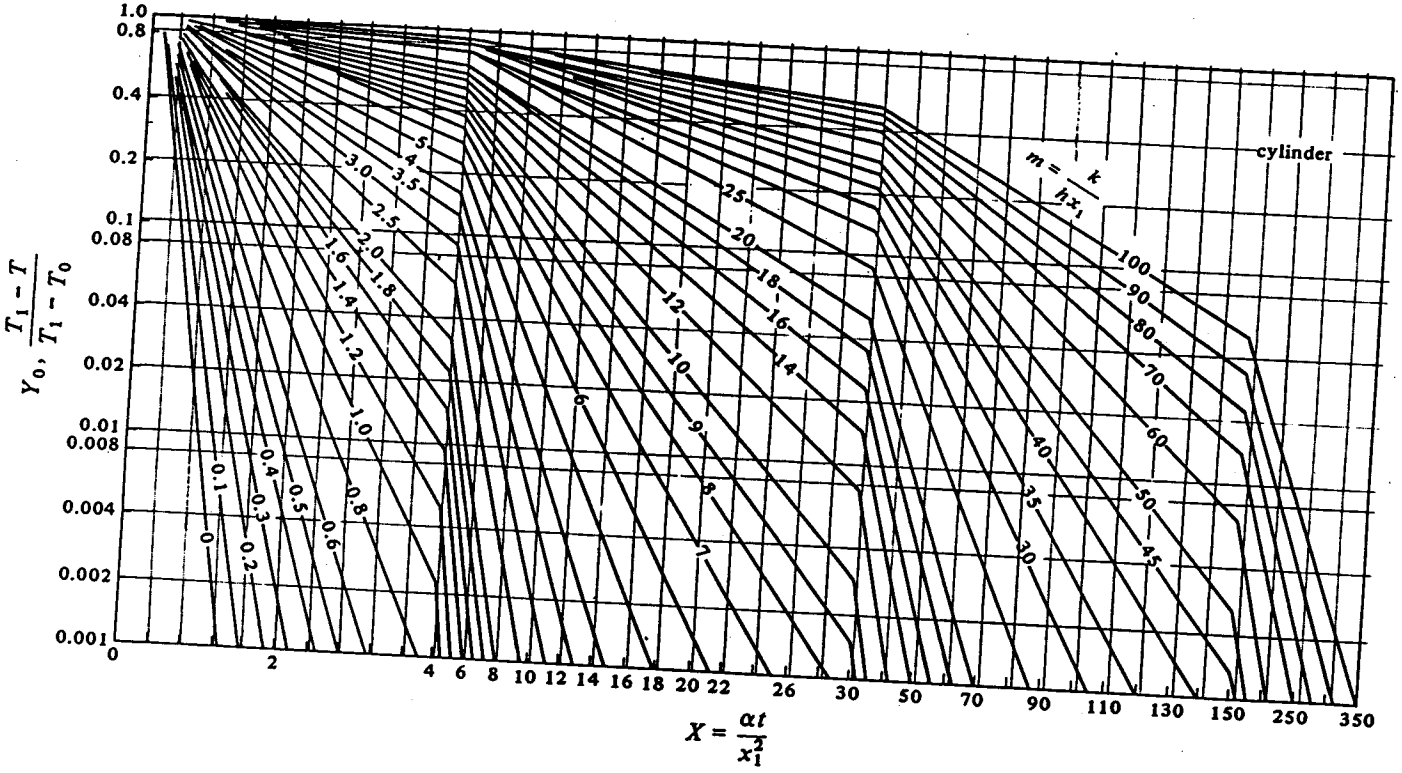
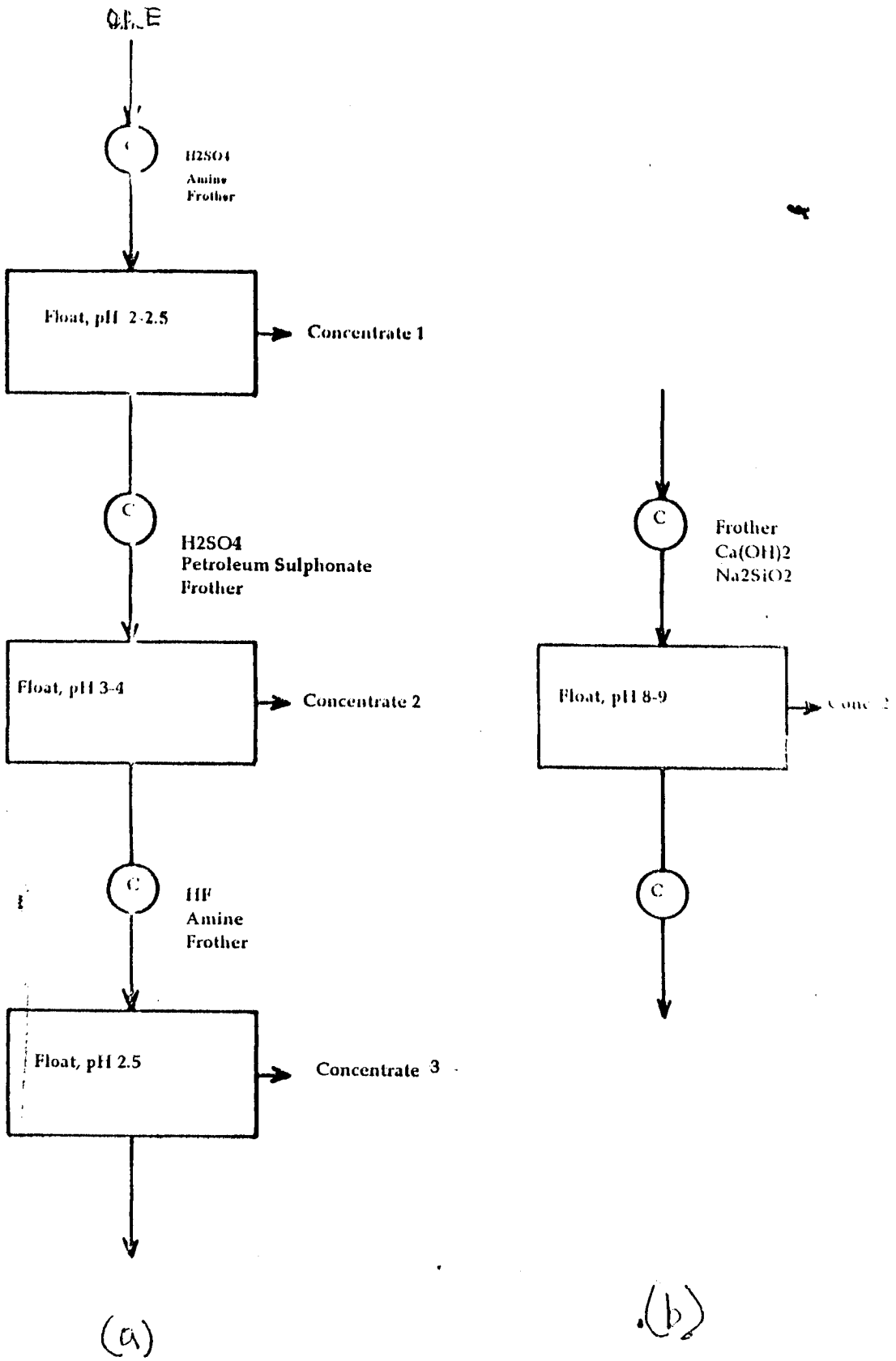


FIGURE 5.3-8. *Chart for determining temperature at the center of a long cylinder for unsteady-state heat conduction.* [*From H. P. Heisler, Trans. A.S.M.E., 69, 227 (1947). With permission.*]


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
Float, pH 8-9
C
(b)

(c) Briefly explain what is involved in particle micro-electrophoresis of surface charge determination. How is the information obtained useful in mineral beneficiation?

END OF EXAMINATION IN SPECIAL TOPICS IN MINERAL PROCESSING.

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

(i) the various definitions of "size".
(ii) application of these definitions size.

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

(c) Describe the Andreasen pipette and the interpretation/calculation of results.

(ii) What are the main disadvantages of this apparatus?

4. Study the attached flowsheets 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.

5. A quantity of ore containing chalcopyrite ($CuFeS_2$) is going to be used in flotation studies. The total amount of material available is 20kg. To determine the essay of the ore 200g is carefully removed and reduced to 100% pass 75μm before extracting a 2g sub-sample on which chemical analysis is to be performed. The ore is found to contain 3.41% Cu. Determine at the 95% confidence level the combined error limits on the head assay assuming the analytical error to be zero. The largest piece in the ore is 6.35mm and the richest piece is visually estimated to contain 75% chalcopyrite. The densities of the mineral and gauge are 4.2 and 2.7 g/cm^3 respectively.

6. (a) What do you understand by the electrokinetic phenomena at the solid-liquid interface in surface chemistry?

(b) Define the following:

(i) Electrophoresis
(ii) Electro osmosis
(iii) Streaming potential
(iv) Sedimentation potential

(b) Find the drawing load required to reduce copper wire by 40% reduction in area in a single pass to 1.5 mm if the average flow stress in the pass is 250 N/mm^2 and that 50% of the total workload is used in overcoming friction and redundant work.

6. (a) The plane strain flow stress, Y, of a metal is 206.9 N/mm^2. A sheet of this metal, 609.5 mm wide by 3.2 mm thick is to be cold rolled to 2.5 mm using rolls of 304.8 mm diameter, and the coefficient of friction is 0.075.

(i) Calculate the average pressure between the rolls and the sheet.

(ii) If a front tension of 68.9 N/mm^2 were applied, what would be the average pressure?

(b) Consider a sheet of metal of 127 mm width and 1.9 mm thickness. It is to be rolled to a thickness of 1.3 mm in one pass using a mill whose steel rolls are 203 mm in diameter. The value of μ in this case is 0.10 and the average plane strain flow stress of the metal sheet is 137.9 N/mm^2.

(i) Calculate the average roll pressure if roll flattening is ignored.

(ii) What is the effect of sticking friction on rolling?

(iii) Roll flattening is caused by tool elasticity and this results in energy loss due to elastic deformation. What other phenomenon arises from above and how is it taken care of.

END OF EXAMINATION IN MM525

(c) Discuss the pressure distribution over the face of the slab i.e. "friction hill."

3. (a) What do you understand by the term "ironing load" during deep drawing operations?

(b) What are the main defects found in deep drawn products?

(c) Consider a small volume of metal near the rim of a blank about to be deep drawn successfully into a cup. List and explain, individually, the sequence of deformations that would be encountered by the element during the drawing operation.

(d) Estimate the punch load for a deep-drawn cup with a 5 cm diameter and 1.5 cm wall if it is made from low-carbon steel with a yield strength of 210 MPa. The blank diameter is 10 cm and the overall coefficient of friction is 0.08 when the blank holder-pressure is 7 MPa.

$$L = 2\pi R_1 t\left[\sigma_o \ln\frac{R_1}{R_2} + \mu p\frac{R_1^2 - R_2^2}{R_1 t}\right]$$

4. (a) For a slab of width a and height h being forged under conditions of sticking friction, the balance of forces is simplified as;

$h.dQ = 2k.dx$ given that $2F = 2\mu.P = 2k = \sigma_0$

where k = critical shear stress.
σ_0 = flow stress of the material.

For the conditions $x = \pm a/2$, the values of Q and P are 0 and $2k = \sigma_0$ respectively. Derive the expression for forging pressure P, its maximum value P_{max}, and the average pressure P_{mean}.

(b) Calculate the average (mean) pressure during forging of a steel plate under conditions of sticking friction when the thickness is 175 mm and the width is 702 mm. Assume plane strain conditions exist and that the tensile yield stress is 450 MN/m^2.

5. (a) During heavy cold working of metal and without strain hardening and when the yield stress of the drawn metal wire σ_1 approaches its ultimate tensile stress Y, show that the maximum reduction in area possible is 63%.

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - MAY 1999

MM525

MECHANICAL METALLURGY

TIME: THREE HOURS

ANSWER: FIVE QUESTIONS

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1. (a) Distinguish between the yield criteria of Von Mises and Tresca.

(b) The Von Mises criterion is expressed as

$$(\sigma_1-\sigma_2)^2+(\sigma_2-\sigma_3)^2+(\sigma_3-\sigma_1)^2=2Y^2$$

Show algebraicailly what this equation reduces to if any two stresses in it are equal. What is the name of the equation which you have now arrived at?

(c) For what reasons are the stress conditions invariably complex in mechanical working processes? State briefly the practical implications of such complex stress systems.

2. By considering the equilibrium conditions for an element of material in a rectangular bar undergoing plane strain deformation, show that the stress required to produce yield varies across the breadth of the bar according to the equation.

$$P=1.15Y\exp\left(\frac{2\mu x}{h}\right)$$

whereY = yield strength in tension
μ = coefficient of friction
h = height of the bar
x = distance from the edge of the bar

(a) Discuss the limitations of this expression.

(b) Use this result to deduce the effect on pressure caused by:
(i) an increase in yield strength.
(ii) reduction in height of bar.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

DEPARTMENT OF METALLURGY/MINERAL PROCESSING

MM 545 SPECIAL TOPICS IN EXTRACTIVE METALLURGY

FIRST SEMESTER

Time: Three Hours **Attempt: All Five Questions**

1. Describe the various types of scrap used in iron and steelmaking. What is the importance of metal recycling? Describe the methods of recycling of copper, and gold in the relevant industries.

2. (a) Originally copper solvent extraction (SX) was envisaged only as a way to recover copper from low-grade copper dump leach solutions. Describe the state of the art of copper, (SX) as it is now.

   (b) Important developments in pyrometallurgy have only taken place in the last fifty years. What reasons can you give to account for this accelerated development?

3. (a) Write short but clear notes on the following processes/furnaces:

   (i) Mitsubishi continuous smelting process
   (ii) Inco oxygen smelting process
   (iii) Kivcet process

   (b) What is Aus-melt technology? What are the advantages of this new technology over the conventional methods/processes? Describe hypothetically (with neat sketches) the furnaces and possible flowsheets for smelting of copper and lead concentrates. Has this new technology any relevance to the Zambian copperbelt industry?

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

   (b) Describe the production of sulphuric acid - H_2SO_4 from smelter flue gases. What reasons dictate it's recovery?

   (c) Describe how the following gas cleaning equipment operate:

   (i) cyclones, and
   (ii) electrostatic precipitators.

5. From the data given in the accompanying Table calculate analytically and graphically the designated quantities, all per mole of product iron, Fe. Utilise the following equations:-

$$no^B + z.n^I + 1'06 = n_c^A (1'3) + y.n^I. (0'38) \quad \text{.....(1)}$$

$$D^{wrz} + n^I D^I = S^{wrz} = n_c^A \{19800\} + y.n^I. (95000) + E^B n_o^B \text{.....(2)}$$

Table

Item	Specification	Quantity		Model variable kg moles/kg mole product Fe
		Kg per tonne Fe	Kg moles per tonne Fe	
Fe	+	1000	?	
Input Iron Oxide	Fe_2O_3			$(o/Fe)^x =$
Iron Oxide entering wustite reduction zone	$Fe_{0.947}O$			$(o/Fe)^{xwrz} =$
Pig Iron	5%C	?	?	$(c/Fe)^m =$
Blast Temp.				T_B = 1400K
Blast Enthalpy				E_B=17000 KJ/Kg mole oxygen
Heat Demand of wrz				D^{wrz}=400,000kj /
Injectant heat Demand				D^I =7000kj/kg mole of injectant
Injectant	Pure oxygen enters furnace at blast temp. (1400K)	50 Nm^3	?	n^I = z = T_B = T
Oxygen from blast		?	?	n_O^B =
Dry air		(vol. air)	?	=
Active carbon		?		n_c^A
Total Carbon		?	?	n_c^i

- What is the effect of oxygen on carbon requirement?
- What is the effect of oxygen on the volume of gas being blown into the furnace and that going out of the furnace?
- What is the effect of oxygen on furnace productivity?
- What does the term E_B mean in the calculation you have just perfomed?
- The overall heat demand, D of the furnace, depends on other variables, what are these variables.
- Calculate the top - gas composition, $(o/c)^g$, i.e.

CO, CO_2 and N_2

END OF EXAMINATION

MM 545