THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

2005 FIRST SEMESTER EXAMINATIONS

COURSE/CODE		COURES /TITLE
GG	201	Introduction to geology Paper II (Practical)
GG	301	Principles of geology – Paper I Theory
GG	301	Principles of geology paper II Practical
GG	311	Crystallography and Optical mineralogy Paper I Theory
GG	311	Crystallography and optical mineralogy Paper II Practical
GG	361	Engineering geology - Paper I Theory
GG	361	Engineering geology - Paper II practical
GG	411	Igneous petrology - Paper I Theory
GG	411	Igneous Petrology Paper II Practical
GG	421	Sedimentology Paper I Theory
GG	421	Sedimentology Paper II Practical
GG	435	Structural geology and plate tectonics Paper I Theory
GG	471	Geochemistry Paper I Theory
GG	471	Geochemistry Paper II Practical
GG	551	Exploration mining geology and management
GG	561	Engineering geology and rock mechanics
GG	581	Applied geophysics
MG	319	Computer techniques
MI	209	Introductory mining engineering
MI	315	Rock Mechanics I
MI	411	Drilling and blasting
MI	431	Underground mine design
MI	453	Operations research
MI	465	Mineral economics
MI	545	Mine Management
MI	555	Geostatistics

MI	585	Materials Handling
MM	321	Physical Metallurgy I
MM	331	Chemical Thermodynamics I
MM	411	Mineral Processing I
MM	441	Pyrometallurgy
MM	451	Transport Phenomena
MM	481	Ferrous Metallurgy
MM	515	Special topics in Mineral Processing
MM	525	Mechanical Metallurgy
MM	545	Special topics in Extractive Metallurgy
MM	571	Mine Management and Economics

UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
FIRST SEMESTER UNIVERSITY EXAMINATIONS – JUNE 2005

GG 201 – INTRODUCTION TO GEOLOGY
PAPER I - THEORY

INTRUCTIONS: **ANSWER ANY FIVE QUESTIONS USING SKETCHES WHEREVER POSSIBLE**
TIME: **3 HOURS**

Q1.

(i) Name the most accepted theory on the origin of and describe this theory in not more than 5 lines. (3 marks)
(ii) Armageddon, a movie by Bruce Willis, tells story about a possible collision between and an outerspace fragment. Where do you think would be the origin of such a fragment? (1 mark)
(iii) On what bases is the solar system divided into two groups? (2 marks)
(iv) What is a meteorite? (1 mark)
(v) Name three sources of material which have been dated to indicate the age of the solar system and state its age. (3 marks)
(vi) Name the three structures of planet Earth and in what state they area. How was this structure established? (3 marks)
(vi) Name and the process involved in the formation of the Earth's structure (4 marks)
(vi) State for each of the three main structures two dominant constituent elements and why. (3 marks)

Q2

(i) Distinguish an atom from an ion. (2 marks)
(ii) What is coordination number and how does this influence packing of atoms (3 marks)
(iii) How many neutrons & electrons are contained in and what are the atomic numbers and atomic masses of the following isotopes whose protons are 6: (a) Carbon-12, (b) Carbon-13, (c) Carbon-14? (3 marks)
(iv) What do you think happens to the sizes & charges of Na and Cl when they lose and gain electrons, respectively and why? (4 marks)
(v) Distinguish between ionic and covalent bonds giving one example compound for each type. (6 marks)
(iv) Suppose you were given a solid substance that is oval shaped. Would you consider such a substance a crystal? Why or why not (2 marks)
(vii) Define the following: (i) pedion, (ii) dome, (iii) prism, and (iv) pyramid (2 marks)

Q3

(i) What is a mineral and how does it form? (4 marks)
(ii) Why is it that sometimes a mineral may have perfect cleavage in one direction while in another it would fracture? (2 marks)
(iii) Define a polymorph. What are the two polymorphs of carbon? (3 marks)
(iv) Describe the simplest way to determine specific gravity of an unknown irregularly shape mineral. (2 marks)
(v) Name 4 groups of minerals, other native elements and silicates, based on their chemical composition. Give one mineral example of each of the 4 groups. (4 marks)
(vi) Pure quartz (colourless), amethyst (purple) and rose quartz (pink) all belong to a family of minerals called quartz. Why is it that they are different in colour. (3 marks)
(vii) Diamonds are forever. Why? (3 marks)
(viii) Distinguish polymorphism from isomorphism. (5 marks)

Q4

(i) Using a sketch, describe the rock cycle. (5 marks)

(ii) What is the difference between lava from magma? Give two examples of volcanic rocks and theircoarse-grained equivalents. (4 marks)

(iii) Igneous rocks are classified using a number of schemes, including colours. If you were given two igneous rocks, one dark in colour and another light coloured. Classify these on the basis of colour and indicate the minerals that are expected in each of the rocks. (6 marks)

(iv) Make a list of the following minerals in terms of which would melt first and which would melt last: olivine, biotite, amphibole and pyroxene and why? (3 marks)

(iv) Name and describe the four processes involved in the formation of sedimentary rocks. (8 marks)

(v) What sort of information can we draw from the presence of cross bedding and or ripple marks in sedimentary rocks? (4 marks)

(vi) What sort of sedimentary rocks would result from gravel and sand particles? (2 marks)

(vii) Name and describe briefly the three main types of metamorphism. (9 marks)

(viii) What is foliation and how does it form? (3 marks)

(ix) Give two examples of unfoliated rocks. (2 marks)

Q5

(i) Describe very briefly the following structures (12 marks)

(a) Syncline
(b) Ancline
(c) Joint
(d) Normal fault
(e) Reverse fault
(f) Oblique fault

(ii) How do you think a rift valley forms and what two landscapes result from rifting? (5 marks)

Q6

(i) Distinguish eon from era giving an example of each. (3 marks)

(ii) Date relatively the rocks units and structures reflected in Fig 1 and write a brief geological history of the area. (12 marks)

(iii) What are fossils and state two geological aspects in which they are important? (3 marks)

(iv) State the principle of faunal succession and the principle of crosscutting. (4 marks)

Q7

(i) Give the general stratigraphy of Zambia. (3 marks)

(ii) A number of structural provinces traverse the Zambian terrane. Name four of these and state at least one mineral deposit associated with each of the structural provinces. (8 marks)

(iii) What is a hydrothermal solution and name three ways in which hydrothermal solutions are produced? (4 marks)

----------End of Exam ----------Good Luck----------

UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
FIRST SEMESTER UNIVERSITY EXAMINATIONS – JUNE 2005

GG 201 – INTRODUCTION TO GEOLOGY
PAPER II - PRACTICAL

INTRUCTIONS: **ANSWER ALL QUESTIONS**
TIME: **3 HOURS**

Q1. Determine the elements of symmetry present on the crystal models provided A, and B. Classify the models into systems using the characteristics elements of symmetry. Sketch the models and indicate on the sketches the characteristic elements of symmetry.

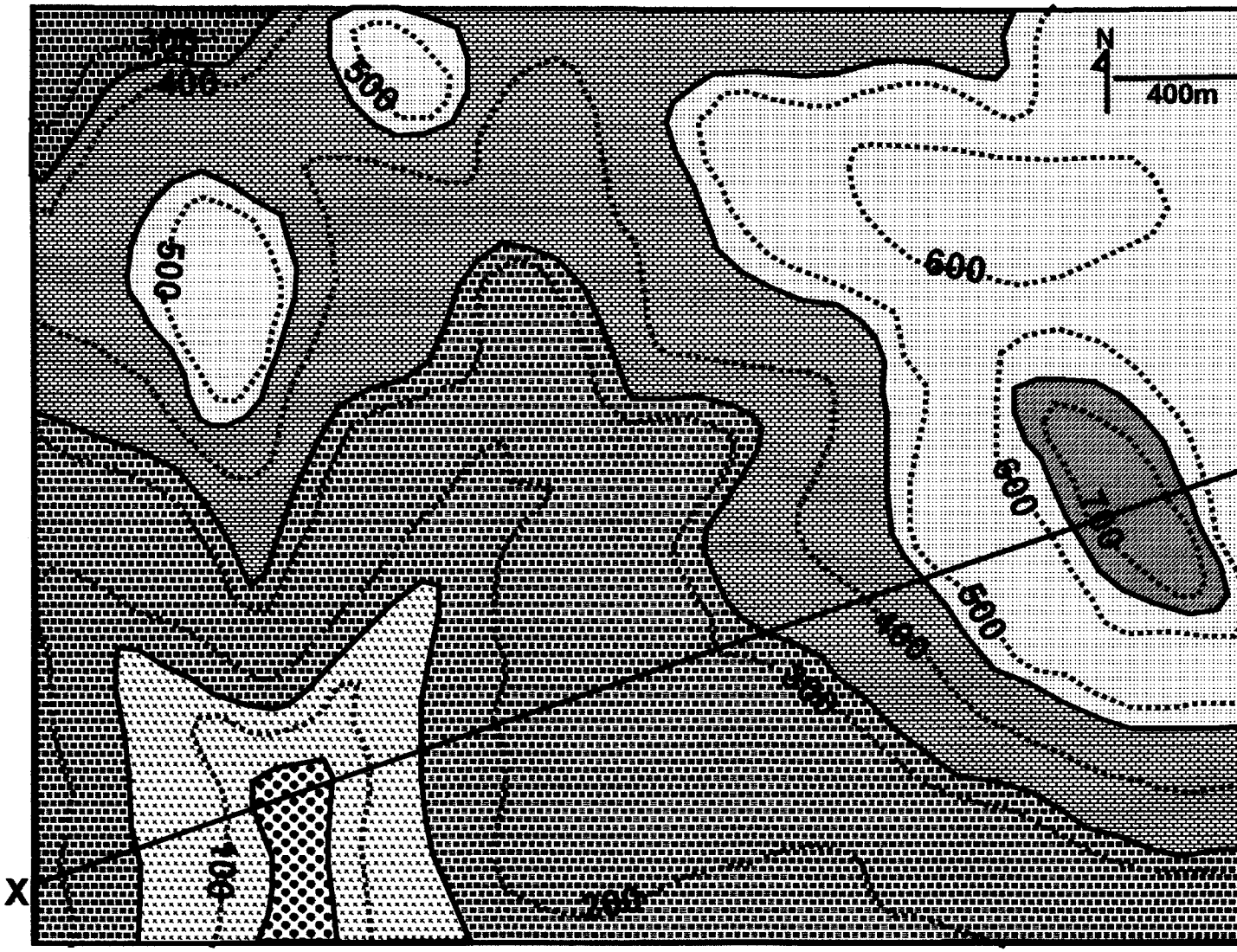
Q2. Identify the following minerals samples provided D, E and F using the following physical properties colour, streak, lustre, hardness, cleavage, reaction to acid, and magnetism.

Q3. You are provided with rock samples H, I and J. Using the following properties colour, texture, crystallinity, mineralogy, sorting and roundness, and reaction to acid name the rocks. With reason(s) state if the rock is igneous, metamorphic or sedimentary.

Q4. Using the geological map (Figure 1) provided do the following:

(i) Determine with reason(s) if the strata are horizontal, inclined or vertical.
(ii) Draw a geological section along line X-Y.
(iii) Determine the true thickness of each of the layers.
(iv) Give a geological history of the area

----------End of Exam ----------Good Luck----------



Conglomerate

Sandstone

Siltstone

Limestone

Calcareous Sandstone

Basaltic lava flow

Figure 1

THE UNIVERSITY OF ZAMBIA
FIRST SEMESTER EXAMINATION- JUNE 2005.
GG301- PRINCIPLES OF GEOLOGY
PAPER I: THEORY

TIME: 3 HOURS

ANSWER: FOUR (4) Questions, 3 from ~~section~~ A and 1 from ~~section~~ B.

Part A:

Q1. a) i) What is a Flinn diagram?

ii) What is the significance of the value K in the Flinn diagram?

iii) What is the main difference between the Logarithmic Flinn diagram and the ordinary Flinn diagram?

b) The following strain measurements were made on deformed cobbles in a meta-conglomerate: X=6cm, Y=3cm and Z=2cm.

i) Plot the strain on a Flinn diagram

ii) Calculate the value of K

iii) What type of strain is this?

iv) Did the strain involve volume loss or gain? Explain your answer

c) Name and illustrate Andersonian faults with the aid of block diagrams, indicating the following:

i) Orientation of principal stresses

ii) Dip of the fault planes

iii) Sense of displacement

d) Distinguish between:

i) Irrotational and coaxial strain

ii) Rotational and noncoaxial strain **[25 marks]**

Q2. a) Illustrate with the aid of block diagrams the following faults:

i) A reverse slip fault

ii) Reverse sinistral slip fault

iii) Sinistral strike slip fault

iv) Normal sinistral slip fault

v) Thrust slip fault

b) Illustrate with the aid of sketches the following kinematic indicators:

i) Dextral Riedel Shear (R)

ii) Sinistral En echelon tensional gashes

iii) Sinistral drag folds

iv) Sinistral imbricate steps

c) Distinguish between continuous and disjunctive cleavage as seen in hand specimens.

d) Draw sketches of outcrop patterns on a flat surface of the following fold structures:

i) Upright plunging antiform

ii) Upright horizontal synform

iii) Inclined plunging synform

iv) Inclined horizontal antiform **[25 marks]**

Q3. a) Derive the principal stress equations **EITHER** from the first principles **OR** from the Mohr diagram.

b) Given a general state of stress, find the orientation and values of the principal stresses: σ_x=20 Pa, σ_y=12 Pa and τ_{xy}=8 Pa.

c) A fluid pressure of 10 Pa is introduced, what are the new values of the principal stresses in (b)?

d) Illustrate the following state of stresses with the aid of a Mohr diagram:

i) Uniaxial tension
ii) Biaxial stress
iii) Triaxial stress
iv) Hydrostatic stress **[25 marks]**

Q4. a) Define

i) Asperite
ii) Boudin
iii) Plane strain
iv) Deviotoric stress

b) Describe and illustrate with a sketch

i) Two types of crenulation cleavages
ii) Spaced foliation

c) Distinguish between ductile and brittle deformation, and give one example each of the structures that form under these conditions.

d) Give three examples of overprinting relations during deformation of rocks at elevated temperatures, pore fluid pressure and pressure. **[25 marks]**

Part B:

Q5. a) Define

i) Ore
ii) Gangue
iii) Cut-off grade
iv) Reserves

b) Name and describe the three classes of Ore reserves.

c) Give a general stratigraphy of the Geology of Zambia

d) Name the mineral resources that are associated with each of the structural units in Zambia. **[25 marks]**

Q6. a) State the conditions that must be met for oil to form and be persevered.

b) Explain the processes involved in the formation of coal

c) Why is it that the Zambian Maamba coal is second grade, whereas the Zimbabwean Hwange coal is of first grade?

e) What do you understand by the term placer deposits? Give six examples of the placer deposits. **[25 marks]**

-GOOD LUCK AND ENJOY YOUR VACATION-

THE UNIVERSITY OF ZAMBIA
FIRST SEMESTER EXAMINATION- JUNE 2005.
GG301- PRINCIPLES OF GEOLOGY
PAPER II: PRACTICAL

TIME: 3 HOURS
ANSWER: ALL QUESTIONS

Q1. Refer to Map 1:

a) Mark the plane of unconformity with a heavy line
b) What is the attitude of the Carboniferous series of beds?
c) What is the attitude of the Silurian series of beds?
d) Is there evidence for the presence of overlap?
e) Determine the true and vertical thickness of each map unit.
f) Draw a section to natural scale from L to M.
g) Give a brief description of the geological history of the area.

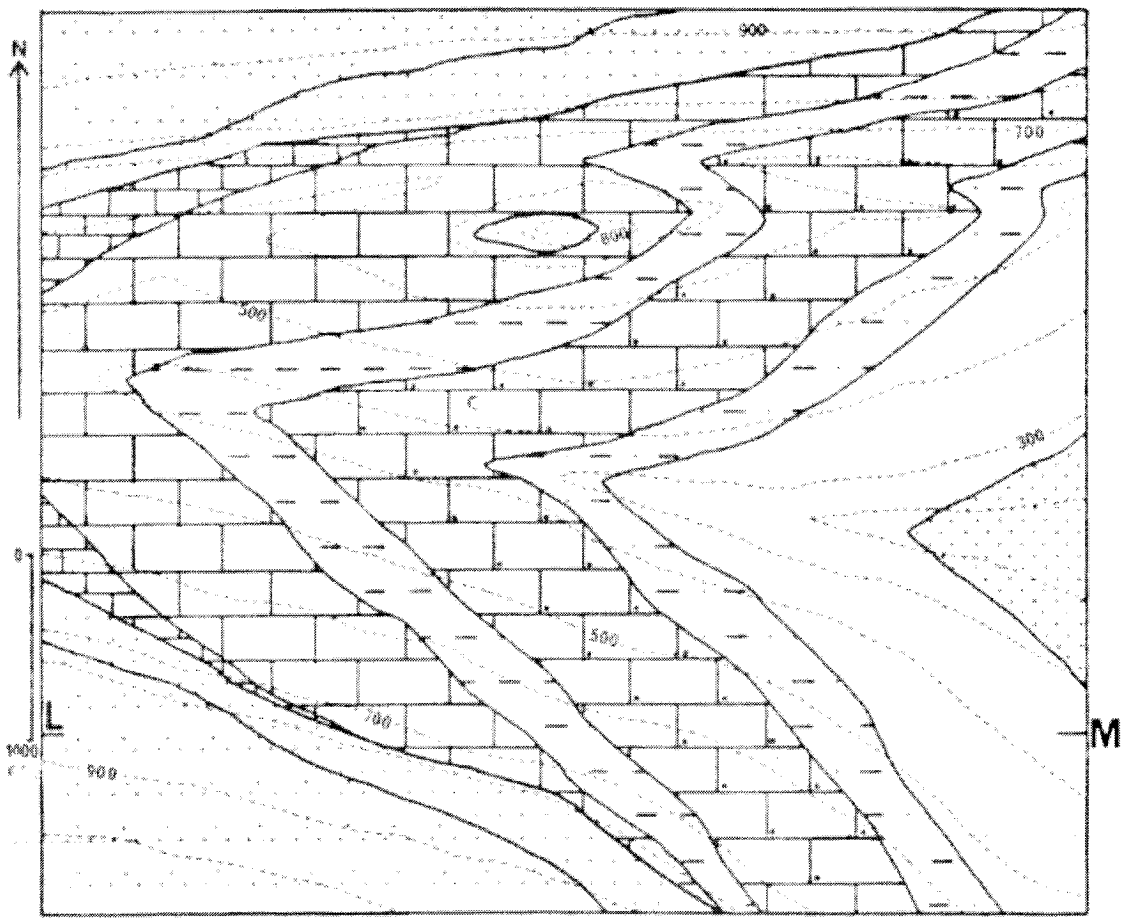
Q2. Refer to Map 2:

The lines indicated with K on the map represent part of the outcrop of a Carboniferous coal seam. The coal seam has a constant dip and strike. The line TT forms part of the outcrop of a Triassic sandstone, also with a constant dip and strike. In point A the coal seam has been cut off by the sandstone.

a) Complete the geological map.
b) Determine the dip and dip direction of the coal seam and the sandstone
c) Shade the area where coal can be mined
d) Draw cross section X-Y.

-GOOD LUCK-

MAP 1


N
900
700
600
500
300
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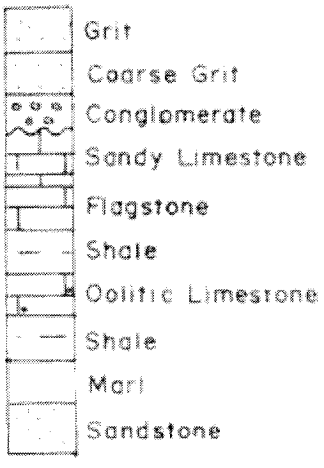
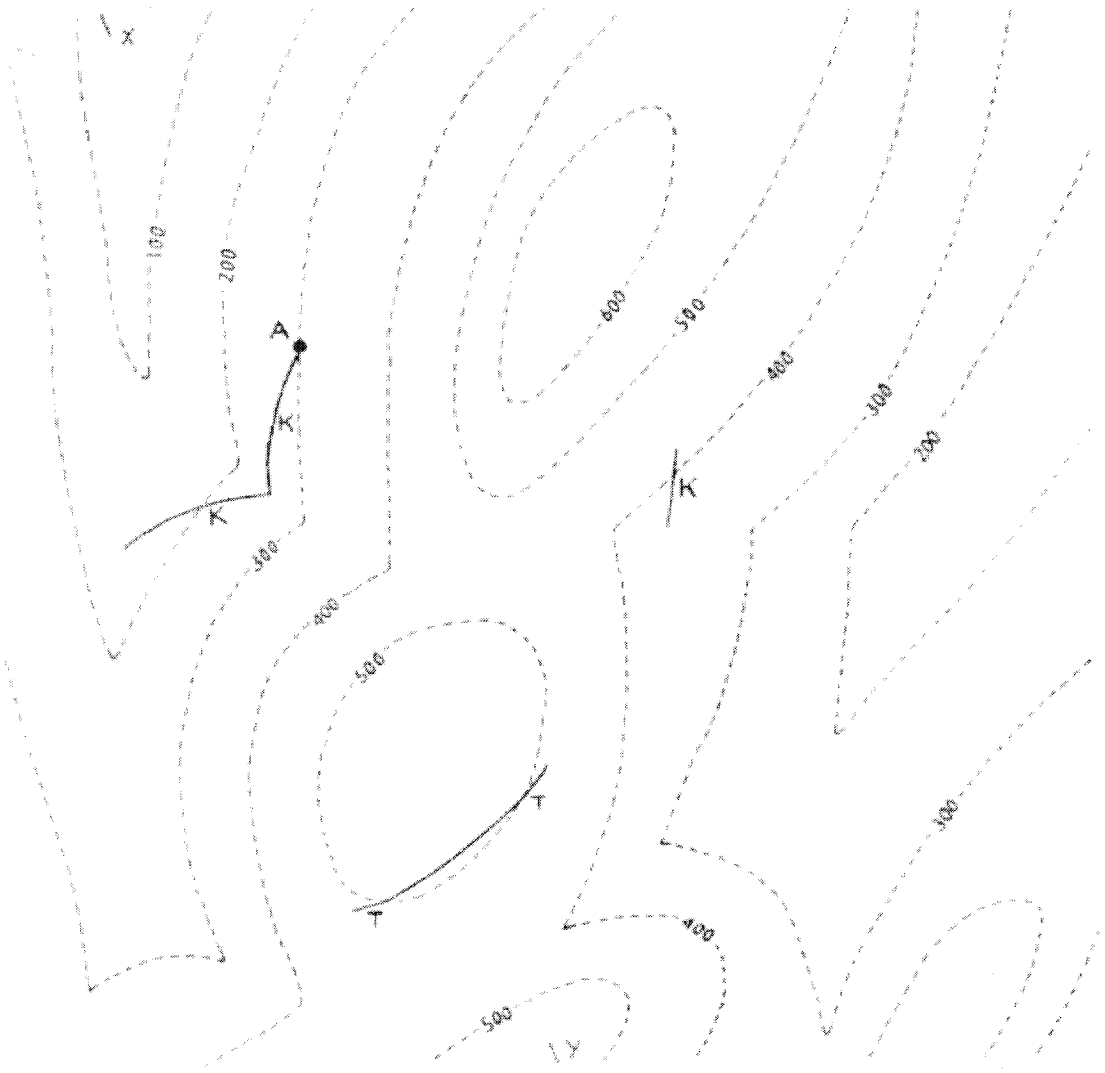
1000
L
M


Grit
Coarse Grit
Conglomerate
Sandy Limestone
Flagstone
Shale
Oolitic Limestone
Shale
Marl
Sandstone

MAP 2



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UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
FIRST SEMESTER UNIVERSITY EXAMINATIONS – JUNE 2005

GG311 –CRYSTALLOGRAPHY AND OPTICAL MINERALOGY

PAPER I - THEORY

INSTRUCTIONS: **ANSWER ANY FOUR QUESTIONS USING WELL LABELLED SKETCHES WHEREVER POSSIBLE**
TIME: **THREE (3) HOURS**

Q1. (i) Define the following terms: (a) Plane of symmetry; (b) Axis of symmetry; (c) Centre of symmetry; (d) Inversion axis.

(ii) Describe briefly the following silicate structures giving at least one mineral example of each: (a) Single Chain Silicates; (b) Island Silicates; (c) Layer Silicates; (d) Framework Silicates

(iii) Distinguish between ionic and covalent bonds. Give one mineral example of each type of bonds.

Q2. (i) What is a crystal face?

(ii) What is interfacial angle? If interfacial angles between faces A and B and B and C are 50° and 38°, respectively. Determine the interfacial angle between faces A and C.

(iii) If the angle between two adjacent faces (001) and (101) on a crystal of the tetragonal system is 40°, make a sketch and determine the angle between faces (100) and (101) and axial ratios a/c, b/c and a/b.

(iv) Intercepts that faces make with crystallographic axes are given below. Determine the Miller Indices and thus symbols of such faces. Face A: 1/2, 3, 1/7; B: Infinite, 2/9, 1; C: 5/3, 2/3, 4; D: 2, infinite, 1/5

(iv) Describe the following: (a) Zone, (b) Zone Axis, (c) Zone Symbol and (d) Form.

(v) Prove if the following sets of faces lie in one zone: (100), (201), (101), (102) and (011); (01bar11), (11bar21), (21bar31) and (10bar10) using the zone symbol method.

Q4. (i) What is stereographic projection?

(ii) Sketch a cube and label the faces on it accordingly if the crystallographic axes are assumed to intersect faces at right angles. Note that axes and Miller symbols of faces should be indicated on the sketch.

(iii) Make a sketch of a stereogram that would result if the crystal in (ii) was plotted in stereographic projection; On this stereogram indicate where a tetrad, the diads would plot if the steregram is viewed with the positive side of the c-axis facing you.

(iv) Define the following terms: (a) refractive index; (b) polarisation; and (c) optic axis.

(iv) Briefly explain the relationship between refractive index and density.

(v) Name two light rays that would result from polarization.

(vi) In which type of minerals would you expect light to be polarized, isotropic or anisotropic? Why?

Q5. (i) Is it true that the refractive index is the same as the radius of an indicatrix?

(ii) Sketch interference figures for the following: (a) uniaxial positive minerals; (b) Uniaxial negative minerals; (c) biaxial positive minerals; (d) biaxial negative minerals.

(iii) Why do sections cut perpendicular to the optic axis in hexagonal, trigonal and tetragonal minerals behave isotropic.

(iv) Why do minerals belonging to the orthorhombic, monoclinic and triclinic have two optic axis?

(v) What is 2V?

(vi) What is the name given to the indicatrix resulting from the following: (a) When 2V is acute, (b) When 2V is obtuse

Q6. (i) What is coupled substitution? Why does this occur?

(vi) Write two equations illustrating coupled substitution, one in alkali feldspars and another in plagioclase feldspar

(vii) What is coordination number?

(viii) Name and describe briefly three Goldsmidt rules that govern atomic substitution within a mineral.

(ix) Under what conditions in terms of the rules described above do each of the following occur?: (a) element capture, (b) element admission and (c) element camouflage

----------End of Exam Good Luck!!!!!----------

UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
FIRST SEMESTER UNIVERSITY EXAMINATIONS – JUNE 2005

GG311 –CRYSTALLOGRAPHY AND OPTICAL MINERALOGY

PAPER II - PRACTICAL

INSTRUCTIONS: ANSWER ALL QUESTIONS
TIME: THREE (3) HOURS

Q1. Determine the interfacial angles on the crystal models A, B, and C provided and plot the stereogram for each of the models. On the stereogram plotted for each model show all the faces and the axes of symmetry.

Q2. Identify the minerals in thin sections X, and Y using plane polarized properties and crossed polarized properties. Sketch the sections indicating the magnification.

----------End of Exam Good Luck!!!!!----------

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - JUNE/JULY 2005

GG 361 - ENGINEERING GEOLOGY

PAPER I - THEORY

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

1. a) Describe the components of the hydrologic cycle.
   b) Using some component(s) of the hydrologic cycle, describe a situation that would lead to flooding of an area.
   c) Define permeability and state three features that influence the permeability of a geologic body.
   d) Permeability in the laboratory is determined by the use of permeameters. On such permeameter in the Department of Civil and Environmental Engineering has a diameter of 75 mm and is 0.15 m long. The diameter of the stand-pipe is 1.5 cm. During the test, the head decreases from 1.3 m to 80 cm in 2.25 minutes. Calculate the coefficient of permeability of the sample in mm/s.

2. a) During an in-situ test to determine deformation characteristics of a foundation ground, a rock mass with a circular cross-sectional area, with a diameter of 1.5 m, was subjected to a load of 30 kN. If the mass experienced a change of 15 cm in its original length of 3 m and 7.5 cm in its diameter, calculate:
      i) Longitudinal and diametral strains
      ii) Poisson's ratio
      iii) Modulus of elasticity
   b) After constructing a statue for the Pontiff-General in the Monk Square, it was discovered that there was a discontinuity inclined at 30° underlying the structure. It was determined that the statue imposed a stress (σ_1) of 700 kNm^{-2}. If, as a result of this stress, the discontinuity experiences a horizontal stress (σ_3) of 300 kNm^{-2}, **determine** the normal and Shear stresses that acted on the discontinuity surface.

3. a) Describe the two main modes of occurrence of igneous rocks and explain how and why textures of these two groups of rocks differ.
      i) Explain the difference and similarities between Gabbro and Granite.
      ~~ii) What geologic events are implied if a granite body is found exposed at the surface?~~
   b) Geologic materials may be classified into three main groups on the basis of their shear strength parameters. Illustrate, with the aid of diagrams, these three main categories of geologic materials.
   c) Give the empirical formula of Coulomb's law and describe the quantities involved.

d) 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 the difference of importance in engineering geology?

4. Write short notes on the following:

a) Anticline and Syncline and how they are formed

b) The three types of fold shapes

c) Three major types of discontinuities and their significance in engineering practice.

d) What geologic events are implied if a granite body is found exposed at the surface?

e) Why there are so many silicate minerals in the Earth's crust.

5. a) i) Describe the three major classes of rocks.

(ii) What criteria are used to categorise them into these three classes.

(iii) List two common rock types in each of the three main classes of rocks

b) Site investigations are usually carried out in stages, with each stage building up enough information to allow execution of the next.

i) Mention two aims of a site investigation.

ii) Briefly describe the different stages involved

6. The following results were obtained from a shear box test on specimens of a sand soil compacted to in-situ density:

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

i) Determine the shear strength parameters.

ii) Would failure occur on a plane within a mass of this sand at a point where shear stress is 122 kNm^{-2} and normal stress of 246 kNm^{-2}? Give reason(s) for your answer.

----------End of Examination----------Good Luck----------

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – JUNE / JULY 2005

GG 361 - ENGINEERING GEOLOGY

PAPER II - PRACTICAL

TIME: THREE HOURS

ANSWER: **ALL** QUESTIONS

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1. The Lusaka Water and sewerage Company has contracted you to explore for new sources of water to augment supply to the city of Lusaka. Map 1 shows part of the aquifer in with springs occurring at A, B and C. For this area:
   i) Indicate the probable location of the remainder of the aquifer outcrop on the map.
   ii) Shade the area underlain by the aquifer, which you would recommend for further drilling and exploitation

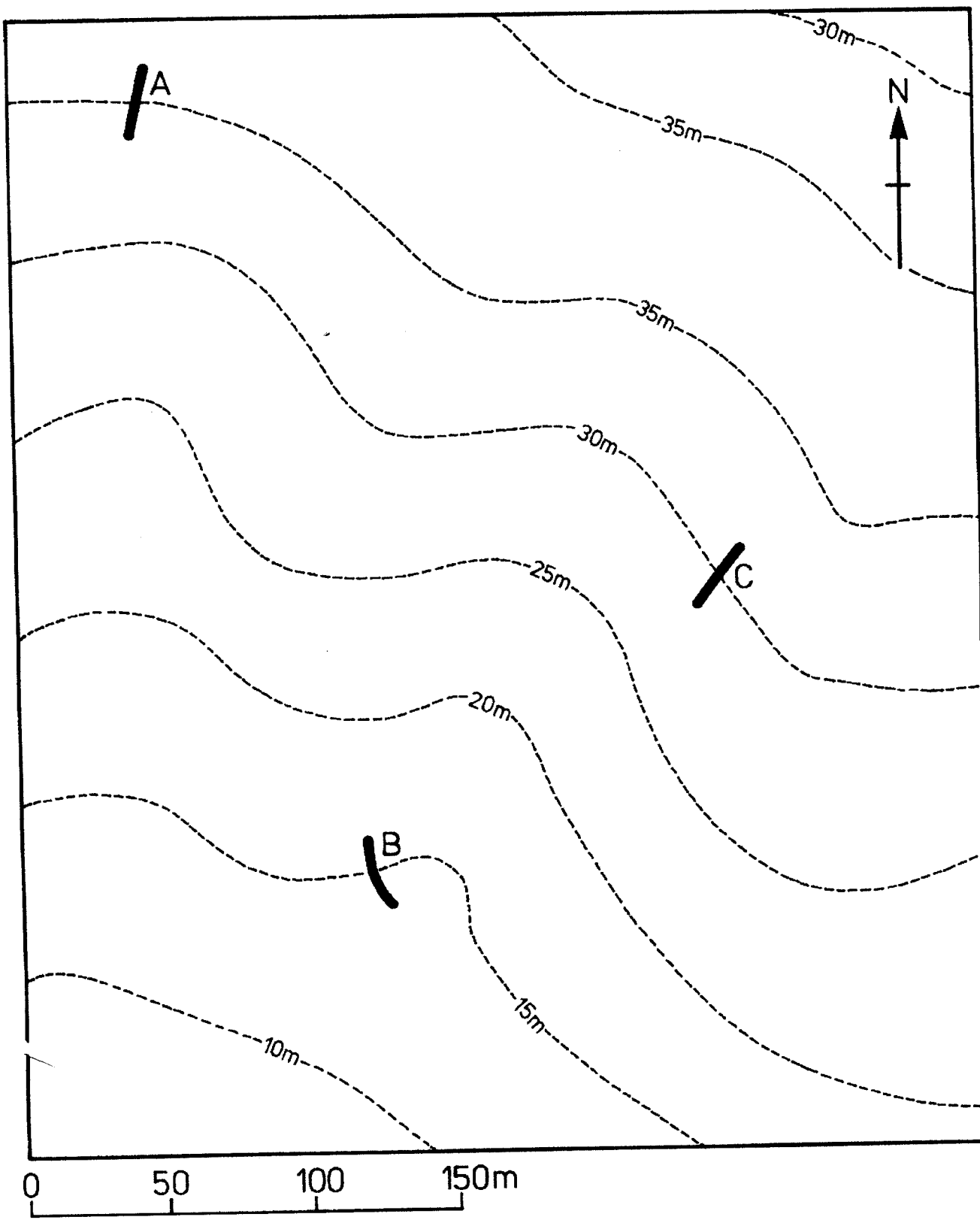
2. Map 2 depicts a land surface contoured at 5 m intervals. ZMCK Engineering Consultants would like to win sandstone and limestone for construction purposes. Outcrop locations boundaries of these beds and a mudstone are marked on the map in which the base of a sandstone outcrops at A, the base of a limestone outcrops at B, and the base of a mudstone at C. Assuming that between A and B only sandstone is present, between Band C only limestone is present and that only mudstone is present in the succession above C:
   i) Complete the outcrops of the bed boundaries.
   ii) Shade the lithologies as appropriate.
   iii) Indicate the depths at which sandstone and limestone would be intersected at point C.

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

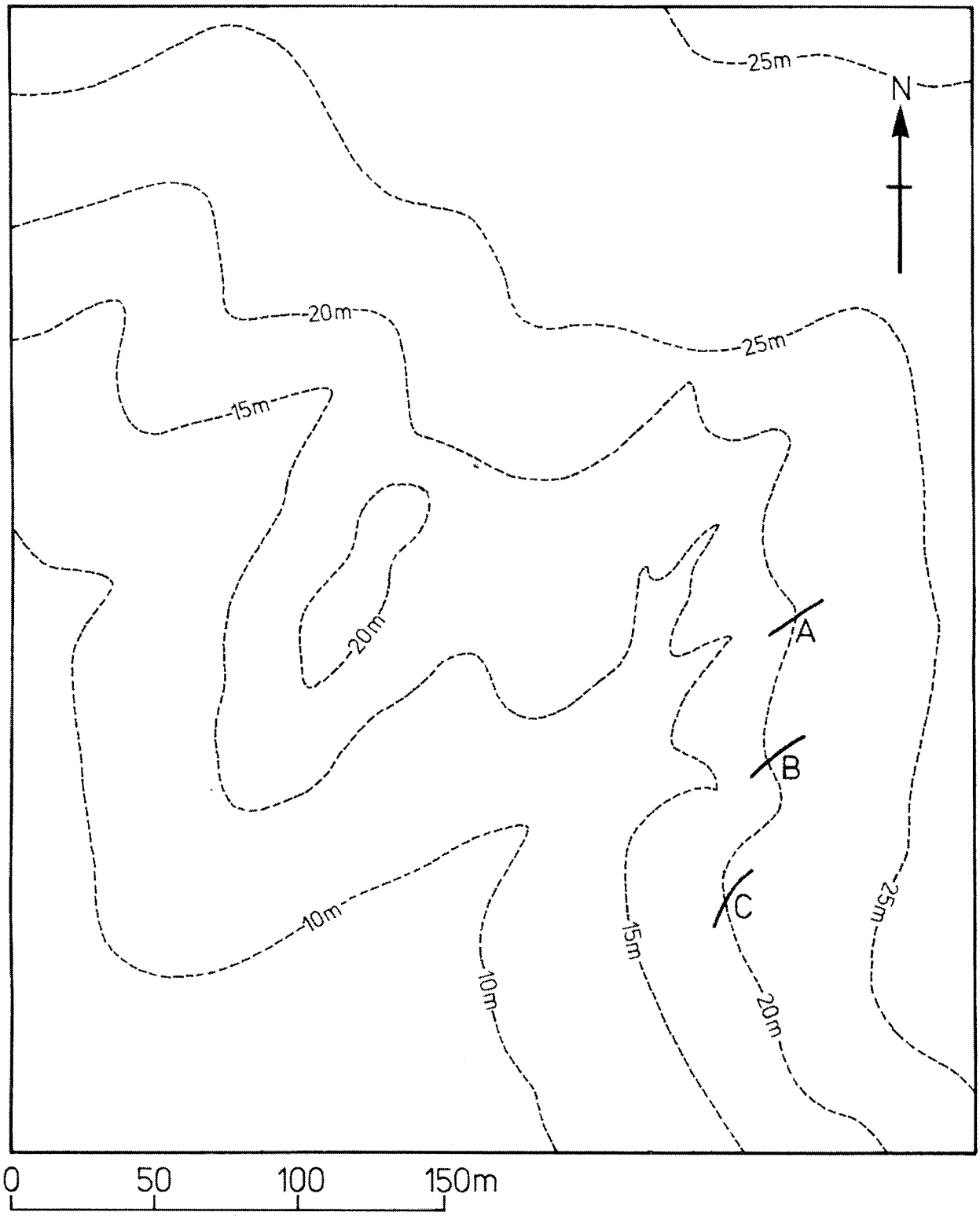
3. During a site investigation for a prospective construction site, the Geology Department provided you with a map showing different geological formations as shown in Map 3. For this Map:
   b) Determine the dip of the strata
   c) Draw a topographic profile and geologic section along the line AB to get an idea of the relationships of the different lithologies.

END OF EXAMINATION. GOOD L UCK!!!

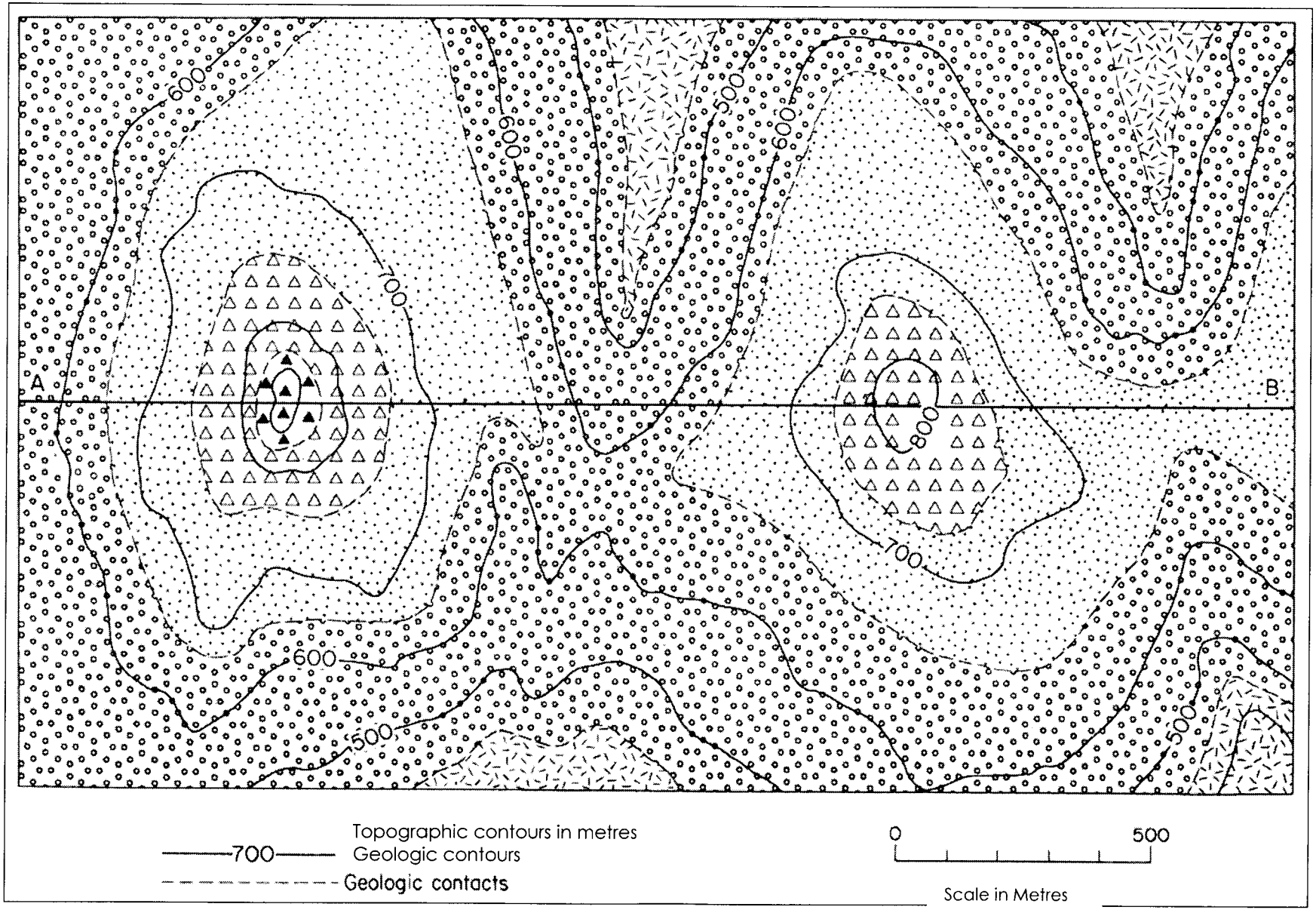
Map 1



Map 2



Map 3


600
600
500
600
600
700
A
B
800
700
600
500
500
Topographic contours in metres
700
Geologic contours
Geologic contacts
0
500
Scale in Metres

THE UNIVERSITY OF ZAMBIA
UNIVERSITY FIRST SEMESTER EXAMINATIONS – JUNE 2005

GG 411 I IGNEOUS PETROLOGY
PAPER 1 THEORY

TIME: THREE (3) HOURS
INSTRUCTIONS: ANSWER ANY FIVE QUESTIONS

Q1. Contrast the different types of anorthites, focusing on chemistry,mineralogy, field ocurrences and age.

Q2. What is a mafic igneous layered intrusion? Give a brief description with regard to its petrologic and process of formation. What is its likely genetic relationship to continental flood basalt?

Q3. Name the different types of converget plate tectonic margin. Briefly discuss the different igneous activities which are associated with each type.

Q4. Suppose you are a field geologist mapping a deformed terrane in an orogenic belt. With an aid of a lablled figure describe the petrologic characterstics you would use to recognise an ophiolite suite. What does the presence of an ophiolite suite tell you about the tectonic process?

Q5. (a) Viscosity is one of the most important physical properties of magma. What physical and chemical factors are most important in controlling viscosity?
(b) How do you differniate between sills and lava flows in the field?

Q6. Describe the following:

(a) Pyroclastic deposits
(b) Eutetic crystallization
(c) Solidus line
(d) Phase chemistry

Q7. (a) What are main factors are considered in the classification and nomenclature of igneous rocks according to the International Union of Geological Science (IUGS)?

(b) The composition of a phaneritic igneous rock is given below. Plot the rock composition on the IUGS classification diagram and give it an appropriate name.

Qtz 0 30%; Kfsp = 40%; Plag $_{An\,(4)}$ = 15%; Aegerine = 15%

END OF EXAM GOOD LUCK

THE UNIVERSITY OF ZAMBIA
UNIVERSITY FIRST SEMESTER EXAMINATIONS – JUNE 2005

GG 411 IGNEOUS PETROLOGY
PAPER II PRACTICAL

TIME: THREE (3) HOURS
INSTRUCTIONS: ANSWER ALL QUESTIONS

Q1. THIN SECTIONS (A) AND (B)

Identify the minerals. Describe their texures in details and explain their possile processes of formation. Name the rocks.

Q2. THIN SECTION (C)

Give a detailled petrographic description and comment on its chemistery using the above informations. Is this a volcanic or a plutonic rock? Why? Name the rock.

Q3. THIN SECTION (D) IS FROM A PLUTONIC IGNEOUS ROCK

(a) Identify the minerals.

(b) Estimate their modal percntae.

(c) Describe the texture

(d) Name the rock according to the IUGS system

END OF EAM GOOD LUCK

THE UNIVERSITY OF ZAMBIA
UNIVERSITY FIRST SEMESTER EXAMINATIONS – JUNE 2005

GG421: SEDIMENTOLOGY
PAPER I – THEORY

TIME: THREE (3) HOURS
INSTRUCTIONS: ANSWER ANY 5 QUESTIONS. EACH QUESTION CARRY EQUAL MARKS. WELL – LABELLED SKETCHES & DIAGRAMS ARE REQUIRED FOR A FULL MARK

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1. Distinguish between the following:
   (a) Sorting and Roundness
   (b) Shallowing-upwards and Coarsening-upwards
   (c) Reynolds and Froude Number
   (d) Glaciofluvial and Glaciomarine
   (e) Loess and Volcanic ash

2. (a) Outline the components of Carbonate Rocks indicating various types within each component and where possible their sizes and content.
   (b) Using the Wentworth Classification list the four main groups of limestone and dolostones.
   (c) Using well-labeled diagrams, explain Dunham (1962) classification of carbonates.

3. Compare and contrast with the aid of diagrams or table where applicable between the following:
   (a) Braided and Meandering river systems
   (b) In-channel processes and overbank processes in meandering rivers
   (c) Lateral accretion deposits and vertical accretion deposits
   (d) Proximal and distal trends in alluvial systems
   (e) Trough and Planar cross-bedding

4. (a) What are the typical features of lacustrine deposits and distinguish them from those of marine deposits.
   (b) Briefly describe the characteristics features (diagnostic) of glacial deposits.
   (c) Briefly describe the characteristics features (diagnostic) of eolian deposits.

5. (a) Discuss the various factors that influence the formation of deltaic systems.
   (b) Describe the various types of Facies Models. How are these models constructed, their use, and what external controls should be taken into account when constructing them?

6. (a) Zambian Copperbelt Copper deposits show evidence of deposition in PERITIDAL Systems. Outline the Common Elements to this Peritidal Model.
   (b) Distinguish between Isolated Platform and Rimmed Shelf in carbonate systems.

(d) With an aid of a sketch, outline the characteristic reef profile (lateral zonation) indicating the resulting carbonate rock types at each section.

7. Define the following terms:
   (i) Texture including the 5 grain properties, which are in the texture definition
   (ii) Anastomosing rivers
   (iii) Beach and Barrier Island Systems
   (iv) Hemipelagic and Pelagic

END OF EXAM GOOD LUCK

THE UNIVERSITY OF ZAMBIA
UNIVERSITY FIRST SEMESTER EXAMINATION – JUNE 2005
GG421: SEDIMENTOLOGY
PAPER II – PRACTICAL

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

1. You have just returned from mapping an outcrop in the Chileleka region and put down a GRAPHIC LOG as in the Table below.

GRAPHIC LOG

Unit No.	Thick-ness	Upper Contact	Lithology	Primary Sedimentary Structures	Samples/ Palaeo-Current (°)
1	2m	Surface	Very fine-grained mudstone, in places with shaly partings	Thinly laminated overlain by massive beds	
2	3m	Sharp depositional	Very fine- to medium-grained sandstone	Horizontal bedding and locally massive	
3	5m	Sharp depositional	Coarse-grained to pebbly sandstone	Trough cross-bedding alternating with planar x-beds	50; 90; 100; 45; 09; 90; 112; 80; 73; 65; 75; 150
4	6m	Sharp erosional	Matrix supported conglomerates	Massive with crude bedding locally horizontal bedding	**A (Sample & Thin Section)**
5	3m	Sharp depositional	Clast-supported conglomerates	Complex bed forms with tabular sheets	
6	2m	Sharp depositional	Pebbly sandstones	Trough cross-bedding	195; 182; 175; 200; 275; 290; 176; 197; 205
7	3m	Gradational	Alternating very coarse grained sandstone and medium-grained sandstone	Trough cross-bedded to parallel laminated and ripple cross-laminated in the medium-grained sandstone	**B (Sample & Thin Section)** 123; 125; 80; 75; 165; 122; 185; 65; 120; 155; 165; 175
8	2m	Gradational	Alternating mudstone /siltstone and very fine-grained sandstone	Massive sandstone with desiccation cracks and root traces in mudstones	**C (Sample & Thin Section)**

You are now required to do the following:

(a) Make a Detailed Stratigraphic section of the outcrop.....25 marks
(b) To describe the three hand specimens (A – C) and thin sections (A – C) providing full mineralogy, structures, features & provenance.....30 marks

(c) Classify the rocks in (b) using appropriate classification procedures.....5 marks
(d) Construct rose diagram for each Unit where the palaeocurrent was measured to represent the palaeocurrent distribution and indicate the result on the Stratigraphic Section in (a).....15 marks
(e) Describe fully the Sequence resulting from the section in (a) indicating possible Depositional Sub-environments and bedforms that could have given the sedimentary structures including the distribution of the palaeocurrent....10 marks
(f) Comment on the overall appearance (nature) of the Sequence and arguing your case for possible types of environments in which such an overall sequence would occur..... 5 marks

END OF EXAM GOOD LUCK

THE UNIVERSITY OF ZAMBIA
UNIVERSITY FIRST SEMESTER EXAMINATION – JUNE 2005

GG435 STRUCTURAL GEOLOGY AND PLATE TECTONICS
PAPER I - THOERY

TIME: THREE (3) HOURS
INSTRUCTIONS: ANSWER ANY FIVE QUESTIONS

Q1. Using Figure 1, answer following questions:

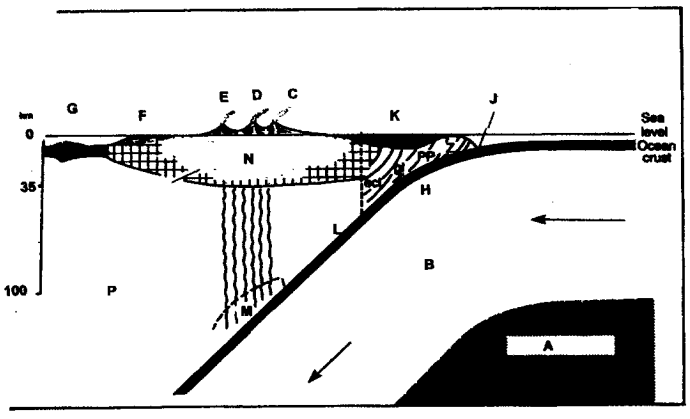


Figure 1

(a) Explain in detail, In terms of plate tectonics what the figure is all about?
(b) Define the letter **A to M**
(c) What do the letters **ecl, gl, pp** and **z** stand for?
(d) What processes occur at positions **J** and **M**?
(e) Give two examples of where you can expect to see the situation in figure 1.

Q2. Explain with sketches the following terms:
(a) Subduction zone
(b) Wilson cyle
(c) Mid-ocean ridge
(d) Sinistral transform fault
(e) Slaty cleavage

Q3. What do you understand by the Vine-Matthews hypothesis? Give paleoclimatological, geological, and paleomagnetic evidence that support the theory.

Q4. Determine the plaeostresses given the following:

(a) Shear zone A 80/068 (dip/dip direction)
Shear zone B 70/208 (dip/dip direction)

(b) Plane 1 (N54° 78°SE)
Plane 2 (N24° 42°NW)

Q5. Describe in detail (with sketches) the structure of constructive plate boundaries.

Q6. Calculate the amount of crustal shortening when a 1178 km fold belt is thrusted to 83 km. In the same area a 475 km thick sedimentary package was reduced to 240 km. What is **e**?. What is **λ** in both cases?

Q7. Explain in detail and mathematically the structures formed due to the process of boudinage.

END OF EXAM GOOD LUCK

THE UNIVERSITY OF ZAMBIA
UNIVERSITY FIRST SEMESTER EXAMINATIONS – JUNE 2005

GG435 STRUCTURAL GEOLOGY AND PLATE TECTONICS
PAPER II - PRACTICAL

TIME: THREE (3) HOURS
INSTRUCTIONS: ANSWER ANY FOUR QUESTIONS

Q1. Using Figures 1 to 5, do the following:

(a) Name the type of fold structure represented in the stereo-plot
(b) Describe the formation of structures.

Q2.

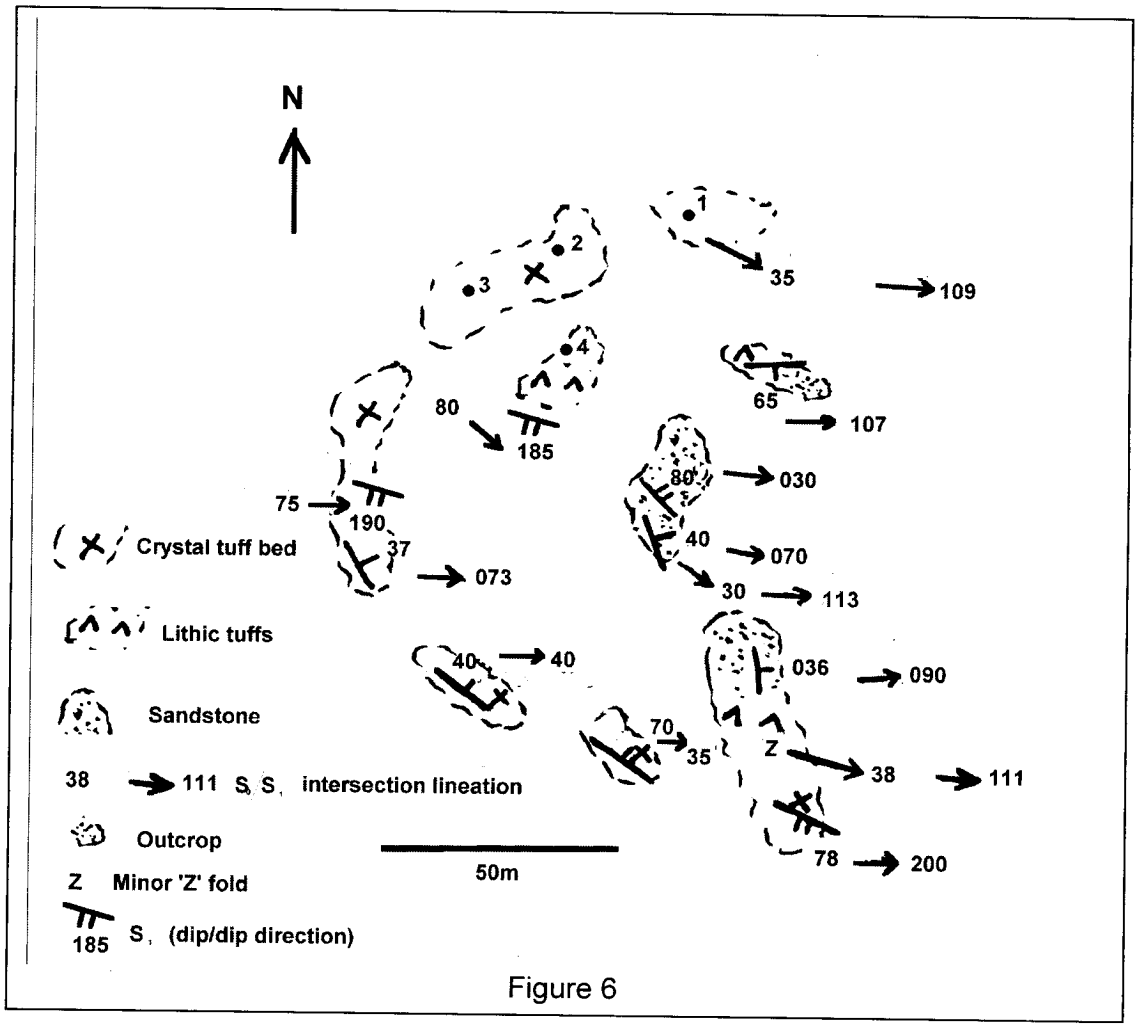


Figure 6

S_o attitude: 70° → 182° ; S_o attitude: 37° → 146°; S_o /S_1 intersection attitude: 37° → 108°; S_o attitude: 25° → 131°

Use the structural data given above and Figure 5 to do the following:
(i) Draw in the lithological traces (contacts)
(ii) Draw the axial trace
(iii) Find the fold axis

Q3. Use stereographic projection to determine the fold axis, given:

Dip Direction	Dip of limb
015°	40°
015°	38°
012°	45°
018°	35
100°	49° overturned
080°	44° overturned
075°	50°
080°	60°

Q4. Find the plane containing L_1 (S78°W plunge 40°), L_2 (N42° plunge 62°)

Q5. Find σ_1, σ_2, and σ_3, given fault plane 1 N54°W 78°E and fault plane 2 N24° 42°SW.

END OF EXAM GOOD LUCK

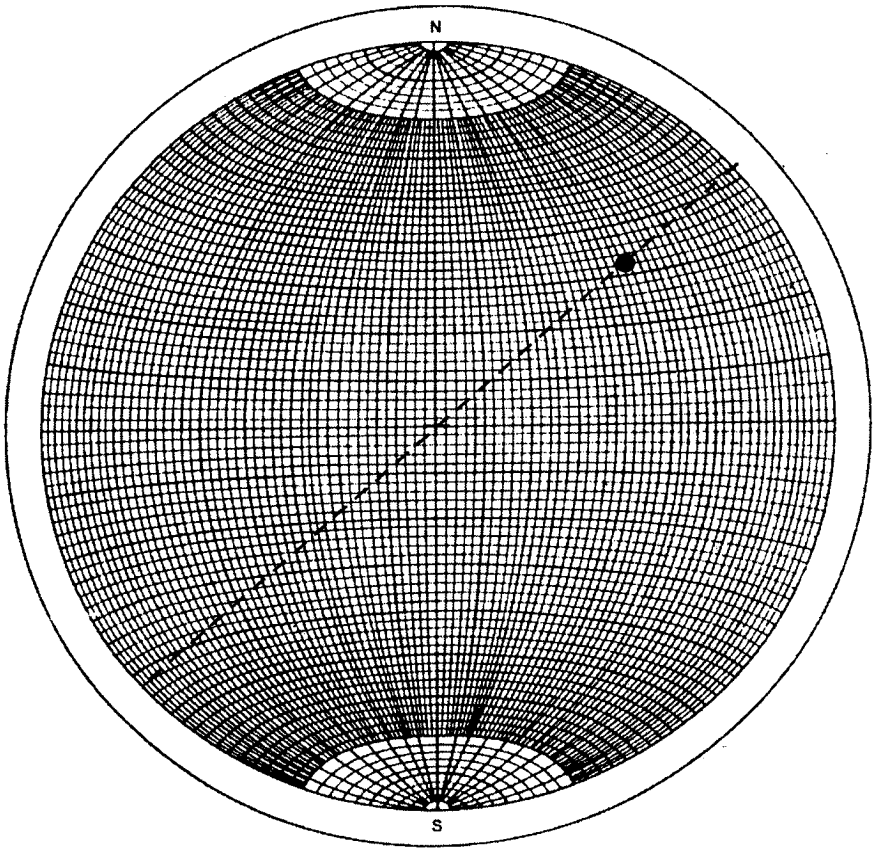


FIGURE 1

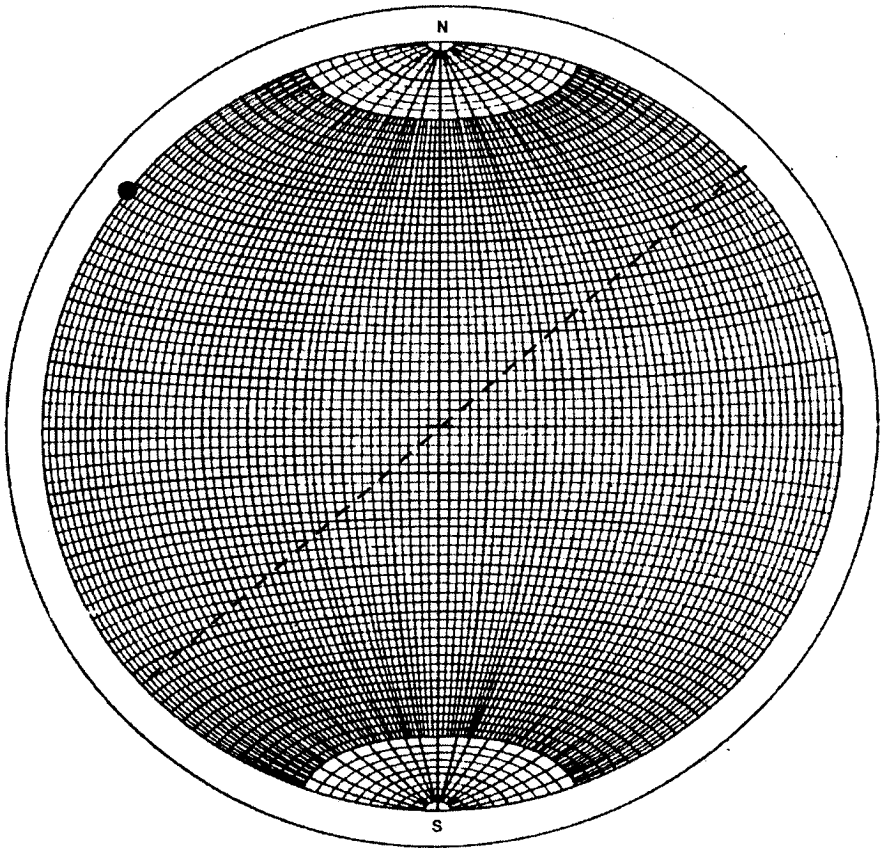


FIGURE 2

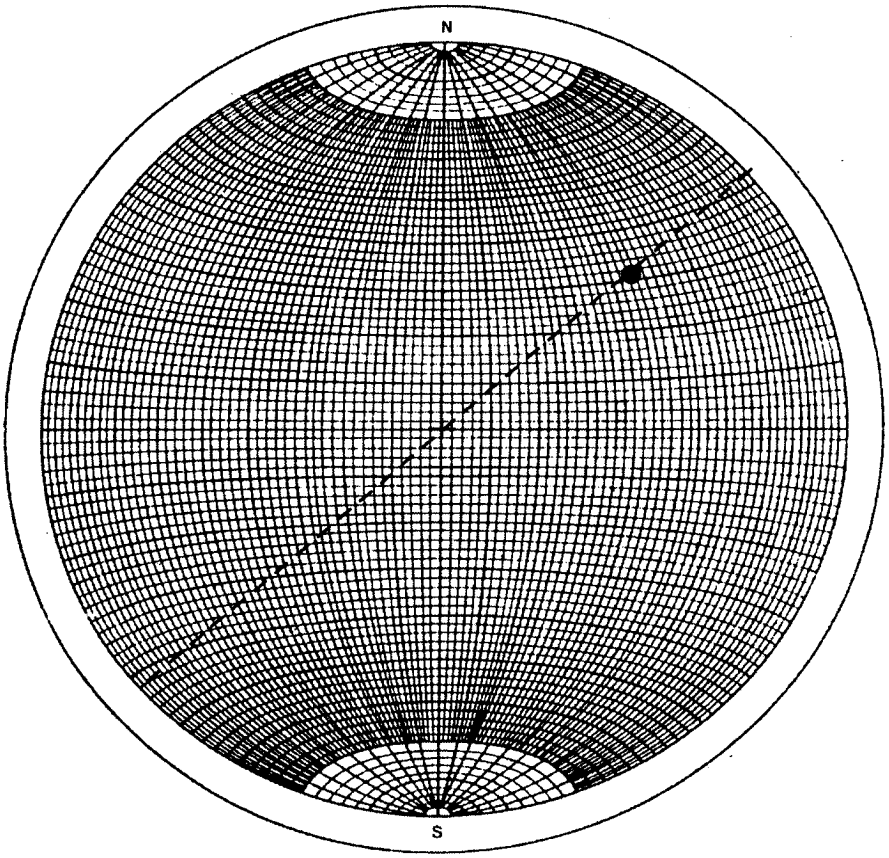


FIGURE 3

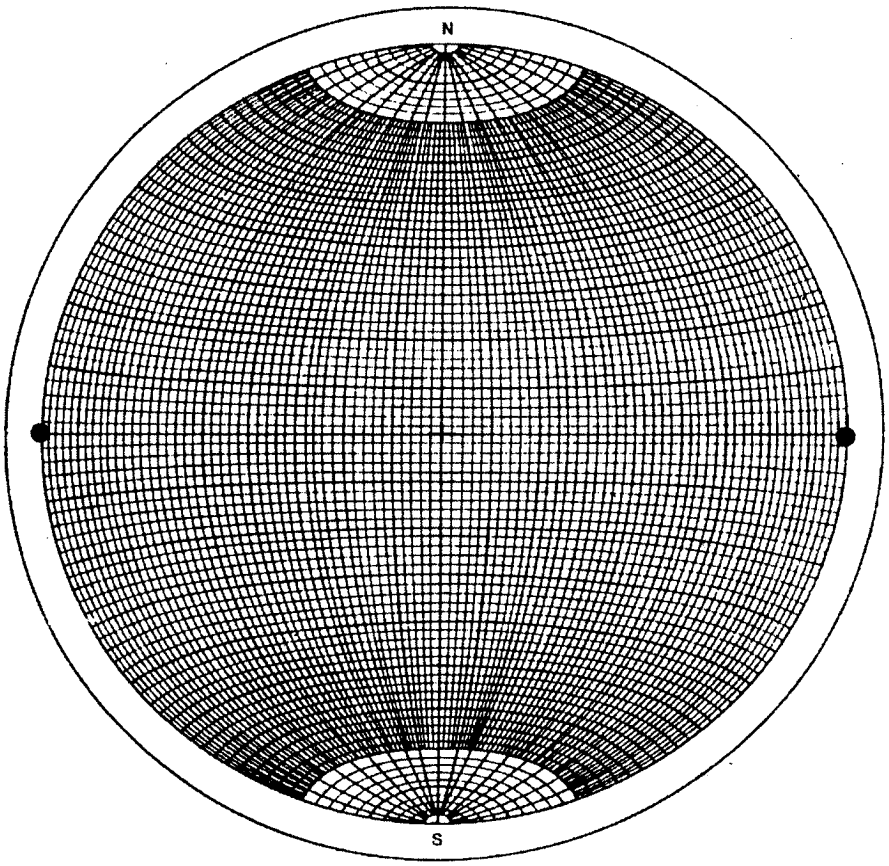


FIGURE 4

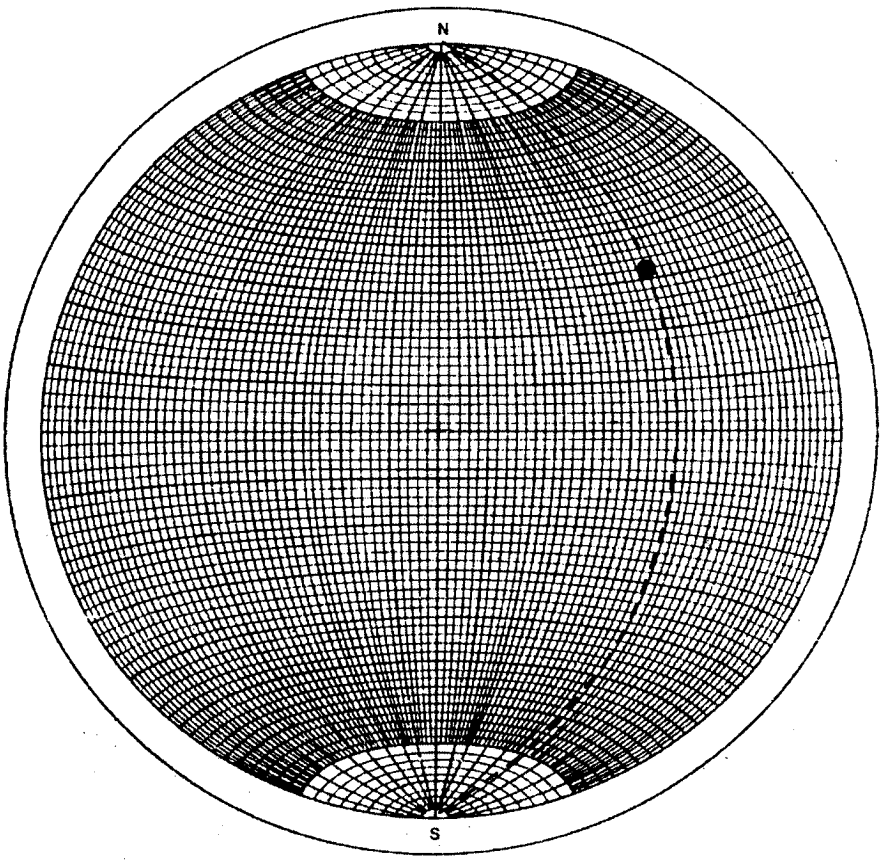


FIGURE 5

THE UNIVERSITY OF ZAMBIA
UNIVERSITY FIRST SEMESTER EXAMINATION
GG 471 GEOCHEMISTRY
PAPER I - THEORY

INSTRUCTIONS: **Answer any four questions. Use diagrams and chemical equations where ever it is necessary**

TIME: **THREE (3) HOURS**

Q1. (a) Discuss briefly the role of gravitational contraction and thermal nuclear reactions in the production of nuclides of the following elements during stellar evolution.
(i) Helium
(ii) Carbon
(iii) Oxygen
(iv) Magnesium
(v) Silicon
(b) Describe briefly the composition of each of the major types of meteorites.
(c) Discuss briefly the role of the study of meteorites in the determination of the composition and the age of the solar system.

Q2. (a) List the ten most abundant elements in the whole earth.
(b) Discuss briefly the major methods that have been used to determine the composition of the earth's crust.
(c) Discuss briefly how the changes in P-T conditions may lead to major transformations in the mineralogical composition of the pyrolite in the sub-shells of the earth's mantle.

Q3. (a) Describe briefly six radioactive systems that are used in geochronology in terms of:
(i) parent and daughter nuclides.
(ii) mathematical equations
(iii) type of decay
(iv) effective time range.
(v) typical materials that are dated
(b) Discuss briefly the major source of errors in dating of geological materials.
(c) Use the following data from analyses of minerals and rocks to determine the age of crystallisation of the rock unit and its initial strontium ratio. What is the most likely source of the parent magma. Use a decay constant of 1.42×10^{-11} a^{-1} for ^{87}Rb.

Sample	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$
1	2.098	0.8245
2	0.198	0.7096
3	1.173	0.7668
4	2.033	0.8191
5	1.364	0.7791
6	0.319	0.7163

Q4. Discuss briefly the role of the following factors on atomic substitution and the distribution of the trace elements (Ni, Rb, Ba, Ga, Sr, Cr, Cs, Li, B, Zr) during fractional crystallisation of the basaltic magma whose composition is given in Table 1.
(a) temperature
(b) atomic radii and atomic charge
(c) ionic potential
(d) crystal field stabilisation energy

(e) water content

Table 1 Composition of a magma on dry weight basis

SiO2	48.1
Al2O3	17.2
Fe2O3	1.3
FeO	8.4
MgO	8.6
CaO	11.4
Na2O	2.37
K2O	0.25
TiO2	1.17
P2O5	0.10
MnO	0.16

Q5. Evaluate the rare metal mineralisation potential of the rock units whose representative analyses are given in Table 2.

Table 2 Composition of plutonic rock units

	Rock Unit A	**Rock Unit B**	**Rock Unit C**
SiO2	73.38	72.70	70.56
Al2O3	13.97	14.08	14.14
Fe2O3	0.8	0.48	0.72
FeO	1.1	1.35	1.2
MgO	0.47	0.55	0.6
CaO	0.75	1.04	1.35
Na2O	3.2	3.22	4.92
K2O	4.69	4.84	5.59
TiO2	0.16	0.24	0.33
P2O5	0.04	0.07	0.14
MnO	0.03	0.04	0.05
Ta	5	0.3	0.13
Rb	450	190	162
Ba	320	450	2061
Sr	60	175	710
W	8	0.15	0.8
Sn	40	6	2
Li	50	20	15

Q6. (a) Discuss briefly the variation of delta ^{34}S values in sulfide minerals of the meteorites, igneous rocks, sedimentary rocks and ore deposits.

(b) In a fluid inclusion geothermometric study of a basemetal sulfide deposit the following data was obtained:

Sample number	Mean Homogenisation temperature (° C)
1	210
2	230
3	190
4	220
5	200

Use the above data and sulfur isotope fractionation equations for the following mineral-pairs to establish if isotopic equilibrium was achieved during crystallisation of the ore mineral assemblage.

Pyrite-galena

$10^3 \ln \alpha = (1.1 \times 10^6)/T^2 = 4.8$

Pyrite-sphalerite

$10^3 \ln \alpha = (3.0 \times 10^5)/T^2 = 1.3$

Pyrite-chalcopyrite

$10^3 \ln \alpha = (4.5 \times 10^5)/T^2 = 2.0$

Chalcopyrite-galena

$10^3 \ln \alpha = (6.5 \times 10^5)/T^2 = 2.7$

Sphalerite-chalcopyrite

$10^3 \ln \alpha = (1.5 \times 10^5)/T^2 = 0.6$

==========END OF EAXAMINATION==========

THE UNIVERSITY OF ZAMBIA
UNIVERSITY FIRST SEMESTER EXAMINATION
GG 471 GEOCHEMISTRY
PAPER II - PRACTICAL

INSTRUCTIONS: **Answer any three (3) questions. Use diagrams and chemical equations where ever it is necessary**

TIME: **THREE (3) HOURS**

Q1. (a) Discuss briefly the variation of delta ^{18}Ovalues in igneous rocks and meteoric water.

(b) Calculate the delta ^{2}H value for meteoric water that has a delta ^{18}O value of -10 ‰.

(c) Use the data below to construct an alkali feldspar – water fractionation diagram for oxygen isotopes.

1000 ln α	$10^6 T^{-2}$ (K)
1.0	1.5
4.0	2.5

(d) An igneous rock unit that has been affected by interaction with groundwater experiences a decrease in delta ^{18}O value of k-feldspar from +9.1 to -8.5 ‰. If the water has a delta ^{18}O value of -11.5 ‰ use the diagram constructed above to estimate the temperature of the reaction.

Q2. (a) Use the equations below to compute and plot coordinates in the $^{206}Pb^*/^{238}U$ versus $^{207}Pb^*/^{235}U$ diagram that correspond to the Concordia curve for values of t from 3.0×10^9 to 3.7×10^9 a.
$T_{1/2}$ for $^{238}U = 4.468 \times 10^9$ a and $T_{1/2}$ for $^{235}U = 0.7038 \times 10^9$ a
$^{206}Pb^*/^{238}U = e^{\lambda_1 t} - 1$
$^{207}Pb^*/^{235}U = e^{\lambda_2 t} - 1$

(b) Determine the age of zircons from the biotitic gneiss by plotting the data given below on the diagram constructed above.

Sample	$^{206}Pb^*/^{238}U$	$^{207}Pb^*/^{235}U$
1	0.714	31.75
2	0.625	27.00
3	0.595	25.60
4	0.500	20.00

(c) Calculate the age of sphene from the rock unit given that $^{206}Pb/^{204}Pb = 140.8$, $^{207}Pb/^{204}Pb = 35.36$, $(^{206}Pb/^{204}Pb)_0 = 12.97$, $(^{207}Pb/^{204}Pb)_0 = 14.17$.

Q3. Describe briefly the analytical procedures (sampling, sample preparation, element analysis) that you would use to determine the content of a trace element in an igneous rock unit which is exposed in an area given in Fig. 1.

Q4. Account for the distribution of the trace elements in the different rocks of the Skaergaard intrusion whose analyses are given in Table 1.

Table 1 Composition of Rock Units in the Skaergaard layered Intrusion

	Lower Zone Rock Unit	Middle Zone Rock Unit	Upper Zone Rock Unit
SiO2	45.7	45.7	44.2
Al2O3	16.0	15.3	8.1
Fe2O3	1.8	3.3	4.2
FeO	10.2	13.3	25.4
MgO	9.3	6.7	0.3
CaO	10.7	10.2	8.8
Na2O	2.43	2.85	2.62
K2O	0.23	0.25	0.4
TiO2	0.88	2.95	2.28
P2O5	0.07	0.08	1.54
MnO	0.08	0.16	0.48
Ni	250	85	3
Co	80	95	5
Cr	175	0.1	0.1
Zr	50	60	200
Rb	2	2	20
Ba	20	30	150
Sr	140	175	190
W	0.17	0.15	0.4
Ga	20	25	30
Li	2	2	11

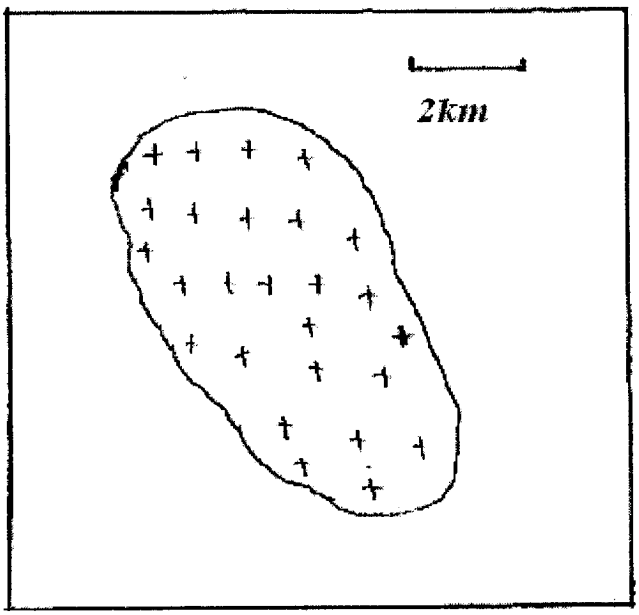


Figure1. A sketch map of an igneous intrusion.

Table 2 Data for estimation of Pb 207-206 dates

AGE	$e^{\lambda 238t} - 1$	$e^{\lambda 235t} - 1$	$^{207}Pb^*/^{206}*Pb$
1.0E+09	0.1678	1.6774	0.0725
1.1E+09	0.1861	1.9545	0.0762
1.2E+09	0.2046	2.2603	0.0801
1.3E+09	0.2234	2.5977	0.0843
1.4E+09	0.2426	2.9701	0.0888
1.5E+09	0.2620	3.3810	0.0936
1.6E+09	0.2817	3.8344	0.0987
1.7E+09	0.3018	4.3348	0.1042
1.8E+09	0.3221	4.8869	0.1100
1.9E+09	0.3428	5.4962	0.1163
2.0E+09	0.3638	6.1685	0.1230
2.1E+09	0.3851	6.9105	0.1302
2.2E+09	0.4067	7.7292	0.1378
2.3E+09	0.4287	8.6326	0.1460
2.4E+09	0.4511	9.6296	0.1548
2.5E+09	0.4738	10.7297	0.1643
2.6E+09	0.4968	11.9437	0.1744
2.7E+09	0.5202	13.2834	0.1852
2.8E+09	0.5440	14.7617	0.1968
2.9E+09	0.5681	16.3930	0.2093
3.0E+09	0.5926	18.1931	0.2227

==========END OF EXAMINATION==========

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

FIRST SEMESTER UNIVERSITY EXAMINATIONS – JUNE 2005

GG551 – EXPLORATION, MINING GEOLOGY AND MANAGEMENT

INSTRUCTIONS: Answer any four questions using well labeled sketches where possible.

TIME: Three (3) Hours

Q1 (a) What is a Bouguer anomaly?

(b) Write short notes on the following gravity corrections: (i) Latitude, (ii) Elevation, (iii) Terrain

(b) Sketch profiles resulting from gravity surveys in the following geological areas: (i) an area of an anticline of sedimentary rocks close to the earth's surface. This area is covered by a 4 m thick soil; (ii) an area in which via a vertical fault the left block is uplifted and the right block downthrown and the area is covered by a 5 m thick soil.

Q2. A stream sediment survey was conducted along the Mbita River and its tributaries for Cu as shown in Figure 1. It is believed that a copper sulphide mineralisation (probably a vein) lies in the vicinity.

(a) Explain how you would locate this vein using stream sediments

(b) Trace out the suspected vein mineralisation on Fig 1 and explain why this vein should be located in the area you have traced out and not others.

(c) Name and describe three ways in which false anomalies may be result

Q3. You have been provided with magnetic data (Table 1) from a magnetic survey conducted at Kerry Road in Northwest Scotland using a proton magnetometer. At Kerry Road the earth's (background) magnetic field is 49000 gammas. The survey was done along lines set at an interval of 50 m and these lines are 400E, 350E, and 300E. The measurement points along each of the lines is 25 m. From the data provided do the following:

(a) Determine the residual magnetic field

(b) Using a scale of 1 cm to 25 m construct the survey lines in such a way that they are arranged from 400E going eastwards to 300E.

(c) Using a contour interval of 100 gammas produce a magnetic contour map

(d) Generate for each survey line a profile

(e) Indicate on the contour map and profiles where the anomalies (if any) are and what could these anomalies be possibly be attributed to?

Q4. A small area (40 km^2) in Nyimba, Eastern Province, believed to be underlain by a gold-nickel bearing vein with associated pyrite, pyrrhotite, magnetite and uraninite, has been selected for further ground investigations. This vein, believed to be nearly vertical, has no showing on the surface as it is overlain by a 5 m thick soil and lies in a relatively flat area. State and describe briefly with reasons four geophysical methods and one geochemical method you would recommend.

Q5. Briefly describe the following:

(a) Sampling Methods including the factors that should be considered when selecting a particular method.

(b) Advantages of using geostatistical methods in ore reserve estimations and the errors that may emanate from such calculations.

(c) The Ore Reserve Classification on the Zambian Copperbelt

Q6. (a) Mining has been taking place on the Zambian Copperbelt for over 75 years now. Various support (geotechnical) systems are applied. Outline briefly the geotechnical properties of earth materials that should be considered when evaluating these materials to determine the type of support system should be applied.

(b) Name any five mines in Zambia including their owners. From our coverage of the Copperbelt mines, outline in form of a Table the general Stratigraphy of the Zambian Copperbelt indicating the Orebodies and Ore minerals

----------End of Exam.....Good Luck!!----------

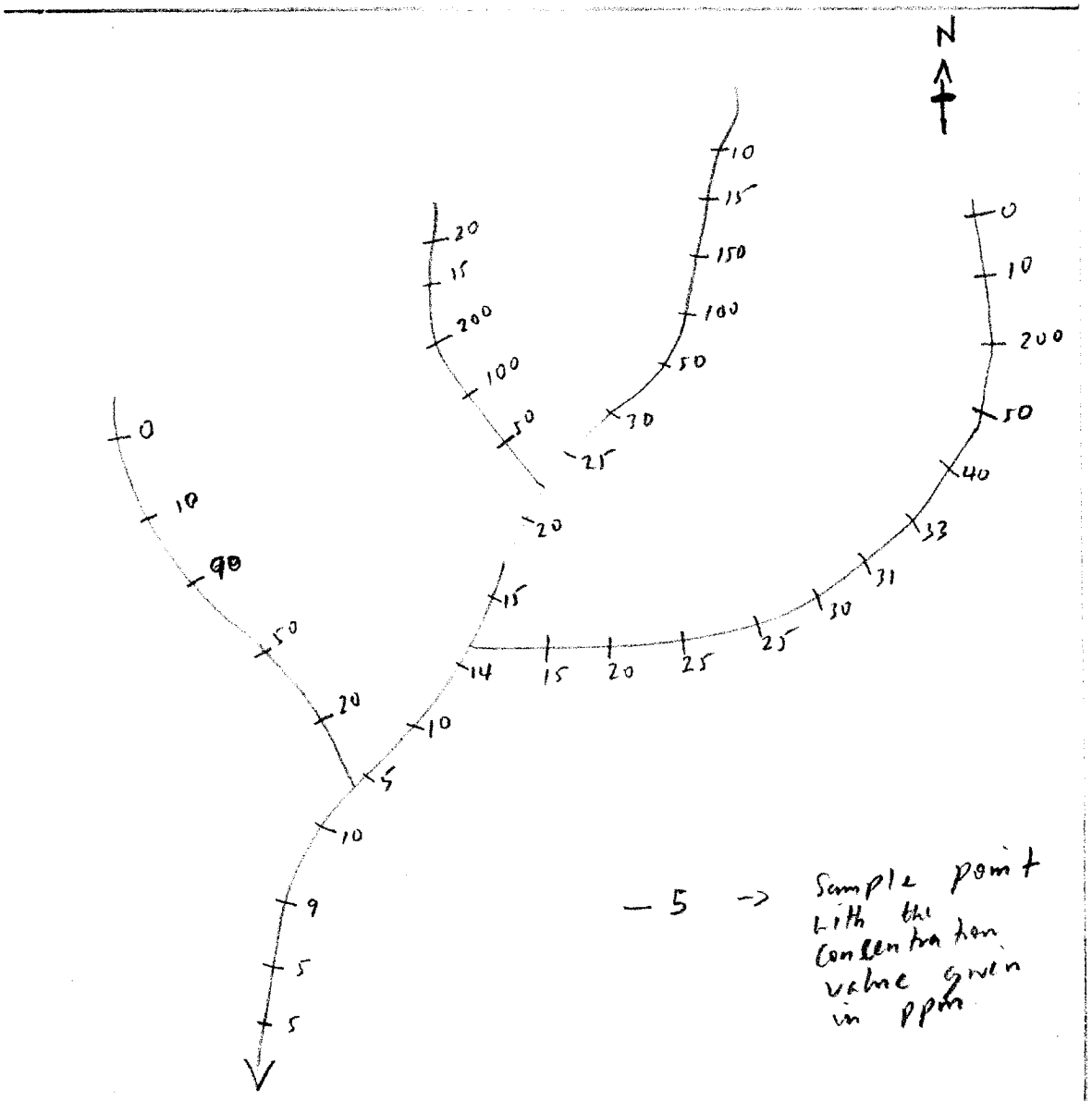


Figure 1 map of a stream sediment survey along Mbita River and its tributaries

Table 1 Magnetic data from a ground survey at Kerry Road in NW Scotland
Background magnetic field is 49000 gamma

LINE No.	STATION	MAGNETIC FIELD (gamma)	RESIDUE FIELD (gamma)
400E	425	49459	
	450	49326	
	475	49900	
	500	49474	
	525	49480	
	550	49482	
	575	49573	
	600	49773	
	625	49653	
	650	49398	
	675	49823	
350E	225	49502	
	250	49590	
	275	50462	
	300	49746	
	325	49402	
	350	49450	
	375	49515	
	400	49514	
	425	49675	
	450	51212	
	475	46600	
	500	49615	
	525	49513	
	550	49533	
	575	49602	
	600	49589	
	625	49536	
	650	49510	
300E	250	49511	
	275	49442	
	300	49653	
	325	49856	
	350	49501	
	375	49461	
	400	49090	
	425	49435	
	450	49434	
	475	49555	
	500	49525	
	525	49545	
	550	49533	
	575	49600	
	600	49500	

THE UNIVERSITY OF ZAMBIA
UNIVERSITY FIRST SEMESTER EXAMINATIONS – JUNE 2005
GG 561 ENGINEERING GEOLOGYAND ROCK MECHANICS

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

1 (a) (i) What role has refraction seismics in engineering geology?

(ii) What is the aim of a site investigation?

(iii) Describe in some detail, the various stages of such an investigation

(b) In one section of the site, a seismic refraction survey was done to determine the average depth to rock head and gave the following results:

Geophone distance (m)	10	15	20	25	30	35	40	45	50	55
Arrival times (ms)	3	4.5	6	7	7.8	8.5	9	10	10.6	11.5

Assuming that the layers are horizontal, calculate:

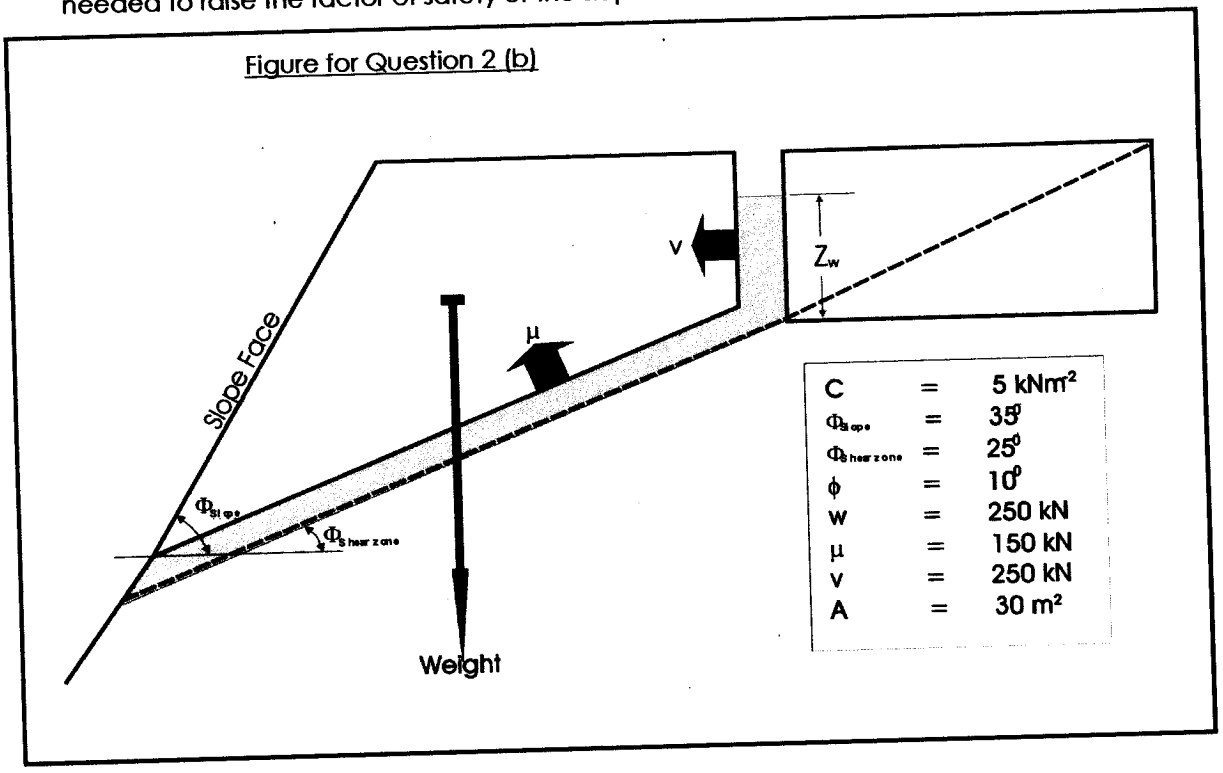
i) The wave velocities in each layer

ii) The depth to rock-head.

2 a) Discuss the geologic / geotechnical data required in the design of a surface excavation

b) There is a plan to construct a new soccer field in front of the Veterinary hostels. The soccer field will involve excavating the ground to some depth. A shear zone is envisaged to 'daylight' into the excavation. The data for the slope and shear zone are given in Figure 1. Write a short report stating, whether or not this scenario poses any cause for concern with regard to the stability of the slopes. Determine the amount of force in a rock-bolt installed horizontally that would be needed to raise the factor of safety of the slope to 3.

Figure for Question 2 (b)



3 a) The University Administration is concerned about the lack of parking space at the Institution and has plans to build an underground car park behind the Department of Biological Sciences. A 20 – metre borehole drilled at the site to ascertain ground conditions intersected nine metres of soil with the remainder being in rock. The portion that intersected rock gave the following drilled lengths:

11.8	1.3	3.0	5.3	17.0	3.8	2.5	9.0	95.3	5.0	5.0	2.8	5.3
8.0	36.0	10.8	110	3.3	5.0	19.4	2.3	3.3	7.3	10.3	7.8	10.5
3.0	4.3	8.2	53.1	7.0	11.0	59.0	8.0	6.5	7.5	5.5	6.5	7.0
20.0	12.3	2.8	5.8	13.8	3.0	87.9	10.8	16.0	7.3	10.5	7.9	12.3

Determine for this drill hole:

i) The core loss
ii) The Rock Quality Designation (RQD)
iii) Total Core Recovery (TCR)

How would you describe the quality of the rock intersected by the drill hole? Justify your answer.

4 (a) After construction of an underground parking space, it was discovered that that there was a discontinuity inclined at 30^0 underlying the parking platform. The total design vertical stress (σ_1) on the platform was determined to be 680 kNm^{-2}. If, as a result of this stress, a horizontal stress (σ_2) of 310 kNm^{-2} is induced on the discontinuity, determine the normal and shear stresses acting on the discontinuity as a result of the imposed stresses.

(b) Shear box testing carried out on the discontinuity in 5 (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 5 (a), would failure occur on the discontinuity plane? Explain your answer.

5 Given below is a list of engineering and natural processes that affect the behaviour of the ground:

(a) Dynamic loading
(b) Withdrawal of support by underground excavations
(c) Withdrawal of support by surface excavations
(d) Static loading
(e) Changes in fluid pressure

For the stability of Findeco House along Cairo Road, rank the processes in order of the most probable to the least probable causes of instability. Discuss your ranking.

6 a) The Belgian Government intends to donate the following laboratory equipment to the Geology Department:

i) Shear Box apparatus

ii) Triaxial Cell

iii) Casagrande Apparatus

Discuss, by means of diagrams, how and what you would use the equipment for in each case.

b) The Public Health Department at the Lusaka City Council is looking for a subsurface waste disposal site for hazardous and toxic waste. The site must be within fifteen kilometres from the town centre. From your knowledge of the geology and hydrogeology of Lusaka, where would you recommend this facility to be sited? Give reasons for your answer.

END OF EXAMINATION. GOOD LUCK!

THE UNIVERSITY OF ZAMBIA

FIRST SEMESTER UNIVERSITY EXAMINATIONS – JUNE 2005

GG581 – APPLIED GEOPHYSICS

INSTRUCTIONS: Answer any four questions using well labeled sketches where possible.

TIME: Three (3) Hours

Q1 Define the following geophysical terms:

(a) Potential method (3 marks)
(b) Bioelectric potential (3 marks)
(c) Magnetic Induction (3 marks)
(d) Diamagnetic material (3 marks)
(e) Nano Tesla (3 marks)
(f) Dielectric property (3 marks)
(g) Over-voltage (3 marks)
(h) Body wave (2 marks)
(i) Epicentral Distance (1 mark)
(j) Bulk Modulus (1 mark)

Q2. Describe how you would conduct a self potential (SP) survey for massive sulphides. (25 marks)

Q3. (a) Derive an exptression for the determination of a Geometric Factor (k) in four electrode array. (10 marks)

(b) Determine the value for k, for the Dipole-Dipole configuration for a = 30 metres and n = 2. (15 marks)

Q4. (a) Give a brief description of equipment used in Induced Polarisation survey in frequency domain. (15 marks)

(b) Calculate the Metal Factor given the following: (10 marks)

ρ_{dc} ~~δdc~~ = 100 ohm-metres

ρ_{ac} ~~δac~~ = 50 ohm-metres

Q5. Describe the regional geology of the Western Basin of Zambia with particular reference to basalts, and their effects on magnetic surveys for the determination of depth to Basement. How do you go around the problem, if any? (25 marks)

Q6. (a) In Magneto-telluric (MT) of exploration both magnetic (H) and electric (E) fields are measured, in order to obtain surface resistivities. Describe any method you would use to measure the E-field. (10 marks)

(b) In an MT survey for geothermal energy a voltage reading of 500 millivolts was obtained between points (x1, y1) = (0, 10 metres) and (x2, y2) = (0, 110 metres). Calculate Ey. (15 marks).

END OF EXAM GOOD LUCK

UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – FIRST SEMESTER, JUNE/JULY 2005

MG319 II

COMPUTER TECHNIQUES

PRACTICAL PAPER

TIME: **3 HOURS**

ANSWER: **ALL QUESTIONS. USE FORMULAS WHERE APPLICABLE**

QUESTION 1: MICROSOFT WORD

Open the Microsoft Word document **Copper Reserves**, saved on your Computer in the Directory **C:\met2005exam**. Edit and format it and save it on the **floppy Disk**. If you have any difficulties in saving on to the floppy, **Save** on hard disk in the same directory giving it a different file name and, ensure that you state this on your answer sheet.

[50 Marks]

Execute the following actions:

- Create enough space on top of page and Insert the mineral picture from the **met2005exam** directory provided.
- The Document contains Main Heading , sub-headings and text body and some valuable points at the end:
- Apply font style of **Times New Roman,** or **Albertus Medium** or **Book antiqua**; choose only **one**, which ever will be available and **NOT** all, to the **Main Heading** to Font Size of 36 of Bold type, and Centered
- Apply the bulleting style of your choice to the coloured text below the Title Heading and set the colour to **Automatic.**
- Insert a Picture in the Document from the Directory **C:\met2005exam** called metlogo and place it under the bulleted text.
- Apply the font style of **arial Unicode ms** to all sub-headings in the document.

- ❖ In the paragraph under the sub-heading 'Why Do We Need the Change in Energy Use ?' , apply the font of "Courier" of size 10.

- ❖ Replace the word 'fossil' with 'leftover' in the entire document.
- ❖ Change the text after the bulleted text into a tow column news paper style document

QUESTION 2: MICROSOFT EXCEL SPREAD SHEETS

Create the following Microsoft Excel Spread Sheet document called **fuels.xls** and save it on your floppy.

[50 Marks]

A	B	C	D	E
	ANNUAL FUEL CONSUMPTION			
Fuel Source	**2002 Cons**	**2003 Cons**	**2004 Cons**	**2005 Cons**
Oil	131	161	181	201
Coal	91	101	201	301
Natural Gas	75	85	95	105
Biomass	55	65	75	85
Hydro	24	34	44	54
Nuclear	22	32	42	52
TOTAL				

Enter the following Spreadsheet and carry out the following:

1. Centre the Title across the columns and Column Headings within the cells.

2. EMBOLDEN the title to give it emphasis
3. INCREASE the size of the Title to 20
4. Include Total Column in **F** and Calculate the Totals.
5. INCLUDE an **IF** .Statement to check if Consumption Column Totals are greater or Equal to 300.
6. Emphasise on the Highest Consumption and add a narrative about these same Consumption Details.
7. Do a pie chart on the Total consumption to all fuels.

END OF EXAMINATION IN MG 319, PRACTICAL

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

FIRST SEMESTER EXAMINATION

MI- 209 (INTRODUCTORY MINING ENGINEERING)

TIME: 3 Hours
INSTRUCTION: ANSWER ALL QUESTIONS IN SECTION A AND ANY FOUR QUESTIONS FROM SECTION B

SECTION A

QUESTION 1

Define and with the aid of examples, write brief notes on the purposes and methods used in:

a) Prospection for Minerals *(10 marks)*

b) Exploration for Minerals *(10 marks)*

QUESTION 2

a) With the aid of corresponding sketches, write short notes on the following Principles of Calculating Mineral Inventories:

i. The Rule of Gradual Changes or Law of Linear Functions *(04 marks)*

ii. The Rule of Nearest Points or Sphere of Equal Influence *(04 marks)*

iii. The Rule of Generalization *(02 marks)*

b) Write brief notes on:

i. Definition and Objectives of Development Drilling. *(05 marks)*

ii. The various drill patterns employed in development drilling, their merits and demerits *(05 marks)*

SECTION B

QUESTION 1

(a) What are the different methods of underground mining? Describe the situation under which these methods are recommended. *(08 marks)*

b) In a room and pillar mining, calculate percentage recovery during

i. Development stage and
ii. Depillaring for the data given below:

- Width of rooms = 4.0m
- Width of pillars = 20.0 m

(07 marks)

QUESTION 2

(a) (i) What are the purposes of artificial support in underground mining? ***(04 marks)***

(ii) What is meant by Pressure Arch Theory? Describe using a diagram. ***(04 marks)***

(b) (i) The supporting action of rockbolt is altogether different from the conventional type of support. Explain by means of diagrams. ***(04 marks)***

(ii) Find the expected caving height in the case of a coal seam having extraction height equal to 3 m and the bulk factor of the overlying rock is 1.2. ***(03 marks)***

QUESTION 3

a) State and describe the four methods employed in Surface Mining. ***(06 marks)***

b) With the aid of corresponding sketches where applicable, write brief notes on the opening-up and development of:

i. An Open Pit Mine ***(03 marks)***
ii. An Open Cast or Strip Mine ***(03 marks)***
iii. A Quarry ***(03 marks)***

QUESTION 4

(i). Using a clearly drawn diagram, illustrate the main parameters for percussive and rotary drilling techniques ***(4 points)***

(ii). Describe the main functions of *(a) percussion, (b) thrust, (c) rotation, (d) flushing* and *(e) coupling* in percussion drilling. ***(8 marks)***

(iii) Mention at least eight (areas) in the sequence of underground mining operations where drilling is applied. ***(3 marks)***

QUESTION 5

(i) What are the advantages of using large stopes? ***(6 markss)***

(ii) What are the principle limitations of using large stopes? ***(3 marks)***

(iii) Define hole deviation ***(3 marks)***

(iv) What are the main types of hole deviations? ***(3 marks)***

GOOD LUCK!!!

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
FIRST SEMESTER EXAMINATION – JUNE 2005

MI 315 – ROCK MECHANICS I

TIME: **3 HOURS** **FULL MARKS: 100**

INSTRUCTIONS

1. Answer all questions
2. Graph paper is supplied.

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1. (a) For the safe and efficient mining operations list the engineering properties of rock and give reasons for their importance. **[08 marks]**

   (b) Briefly describe factors influencing the insitu stress state. **[06 marks]**

   (c) A rock sample in the form of a cube, has a volume of 125 cm^3. If the force required to break that cube is 62.5 kN, calculate the compressive strength of the rock sample. From the value obtained, estimate the value of (i) tensile and (ii) shear strength.

   Express the answers in MPa. **[06 marks]**

2. (a) Explain, step by step, the method of determining Poisson's ratio of a rock sample. State the application of this property in mining. **[08 marks]**

   (b) Find the modulus of rupture of a rock sample 150 mm length, 50 mm diameter and the distance between the supporting fulcrum is 60 mm. The load at which the rock failed is 200 kN. **[08 marks]**

3. (a) Discuss the "tributary area method" of estimating average state of axial stress used in the design of mine pillars. **[08 marks]**

   (b) A flat orebody lying at a depth of 150 m below ground surface is planned for extraction using 6.0 m room spans, and pillars 7.0 square in plan. The thickness of the ore deposit to be mined is 3 m. The strength of square pillars of width of W_p and height h is given by $S = 7.5\, h^{-0.66} * W_p^{0.46}$ where S is in MPa, and h and W_p are in metre. The Unit weight of the overburden rock is 25 kN/m^3.

Determine the factor of safety against compressive failure of pillars in the planned area. **[08 marks]**

4. (a) (i) List the factors which are responsible for subsidence due to mining. **[04 marks]**

(ii) Explain with example, how the maximum possible subsidence for a particular mining can be predicted **[04 marks]**

(b) (i) Calculate the caving height if the extraction of coal seam is 3.0 m and the bulk factor of the overlying rock is 1.2. **[04 marks]**

(ii) Describe the measures that can be taken to minimize the damage of surface and sub-surface structures due to mining subsidence. **[04 marks]**

5. (a) What is known as liquefaction failure and in which case is it likely to occur?

How can the liquefaction failure be minimized? **[08 marks]**

(b) A sample of saturated clay weighed 1526 g in its natural state and 1053 g after drying. Determine:

(i) Void ratio and (ii) the porosity of the clay sample, given that the unit weight of the soil constituents is 2.70 g/cm^3. **[08 marks]**

6. (a) Describe :

(i) The different modes of failure of slopes in hard rock with the help of clear diagrams; **[04 marks]**

(ii) How these slides can be controlled? **[04 marks]**

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

If the mass of rock block is doubled, will it still slide at the same angle? **[08 marks]**

***** END OF EXAM *****

UNIVERSITY OF ZAMBIA
School of Mines
UNIVERSITY EXAMINATIONS – June/July 2005

SEMESTER 1 EXAMINATIONS

MI 411: DRILLING AND BLASTING

TIME: 3 Hours **FULL MARKS:** 100

ANSWER **ALL 5** QUESTIONS

1(i) With the help of a diagram, clearly label the *(a) burden, (b) hole spacing, (c) bench height, (d) sub-drilling, (e) stemming, (f) column charge,* and *(g) bottom charge* ***[7 marks]***

(ii) With the help of a clearly labelled diagram, describe *(a) collaring, (b) alignment,* and *(c) trajectory deviations.* ***[3 marks]***

(iii) With the help of a graph, explain the three stages of the blasthole expansion in relation to time. ***[10 marks]***

2(i) With the help of a diagram, illustrate at least three (3) types of waves experienced by a drill rod when impacted by a piston ***[3 marks]***

(ii) Distinguish between particle and sonic velocities. ***[4 marks]***

(iii) With well illustrated diagrams and appropriate definitions of variables, derive an equation for the particle velocity in a drill rod due to stress wave. ***[13 marks]***

3 Given the conditions shown in Table 3.1, and with the help of Tables 3.2 and 3.3; in clear 8 steps, calculate **specific drilling** ***[20 marks]***

Table 3.1 Bench blasting conditions.

Bench height:	K = 15 m
Width of the round:	w = 26 m
Blasthole diameter:	d = 76 mm
Rock constant	c = 0.4
Hole inclination:	3:1
Explosive:	Emulite 150 in 65 mm plastic hoses dropped into the hole
Charging condition:	Dry holes

Table 3.2 Charge concentration for different blasthole diameters and different explosives

Blasthole diameter (mm)	**51**	**64**	**76**	**89**	**102**	**127**	**152**
ANFO, kg/m	1.6	2.6	3.6	5.0	6.5	10.1	14.5
Emulite 150 (cut and Dropped into dry Blastholes), kg/m	2.3	3.7	5.0	7.1	9.3	-	-
Bulk emulite, kg/m	2.4	3.9	5.3	7.5	9.9	15.3	21.9
Dynamex M (Charged With pneumatic charging Machine and ROBOT), Kg/m	2.6	4.0	5.6	7.8	10.2	-	-

Table 3.3 Change concentration for drill series 11 and 12 - tamped explosives

Blasthole diameter, mm	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**
Em150	0.66	0.71	0.76	0.81	0.87	0.92	0.98	1.04	1.11	1.17	1.24	1.30	1.37
Dx M	0.69	0.74	0.79	0.85	0.91	0.96	1.03	1.09	1.16	1.22	1.29	1.36	1.43

4(i) Figure 4.1 is a diagrammatic description of underground mining. Accurate drilling is paramount in any of the operations. Select six (6) of the operations and outline the types of drill holes associated with them.

[6 marks]

(ii) Describe the major economic consequences that can arise due to poor drilling in SUB-LEVEL CAVING mining method, related to the following:

(a) rock breakage
(b) transportation
(c) rock stability
(d) drilling inputs

[8 marks]

(iii) What are the **three major obstacles** to developing large stopes in mining industry? ***[6 marks]***

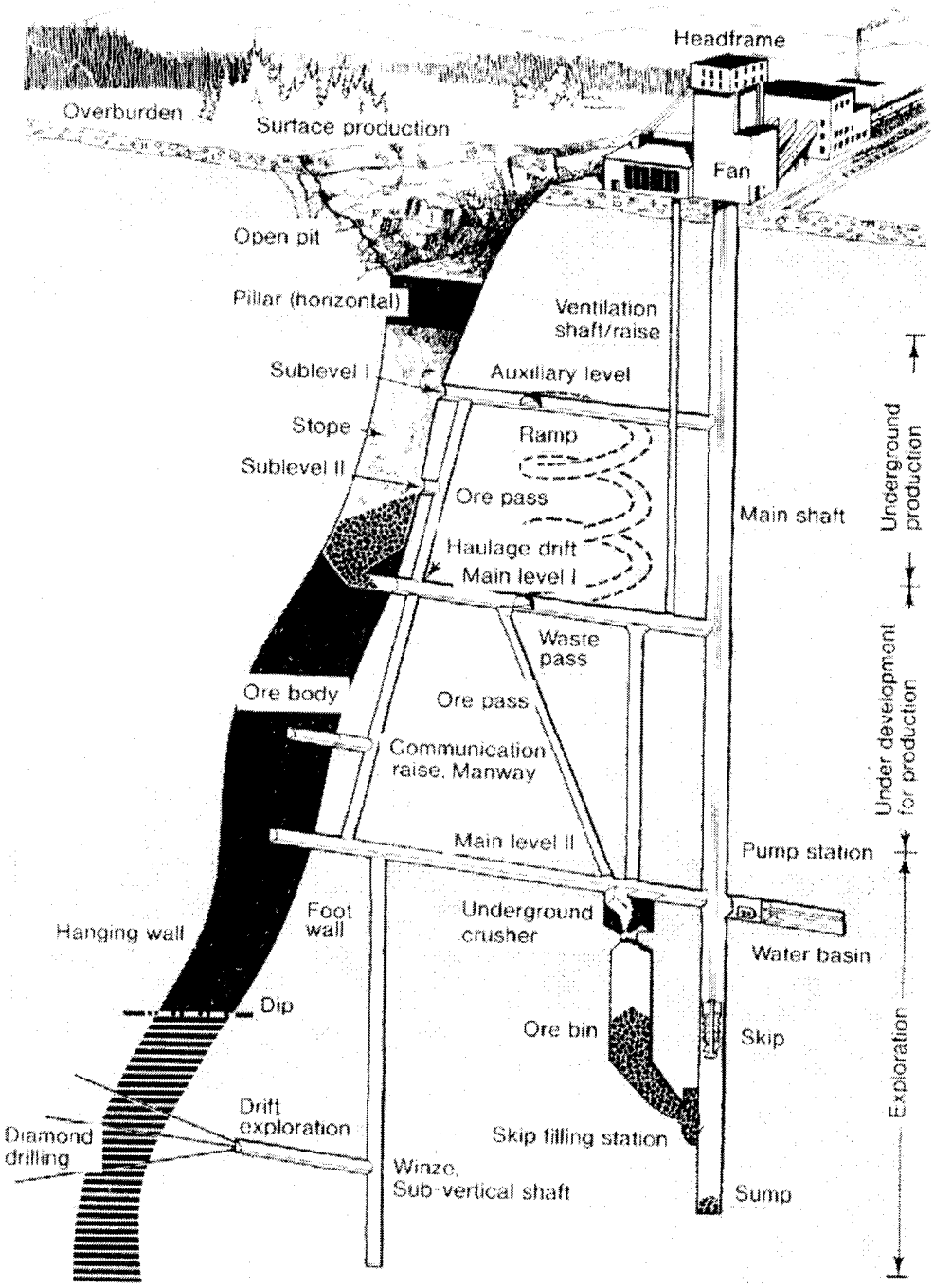


Figure 4.1 A sketch of underground mining

5(i) Using diagram 5.1, COPY on your answer sheet provided and label the five (5) types of holes indicated by lines in a tunnel face. ***[5 marks]***

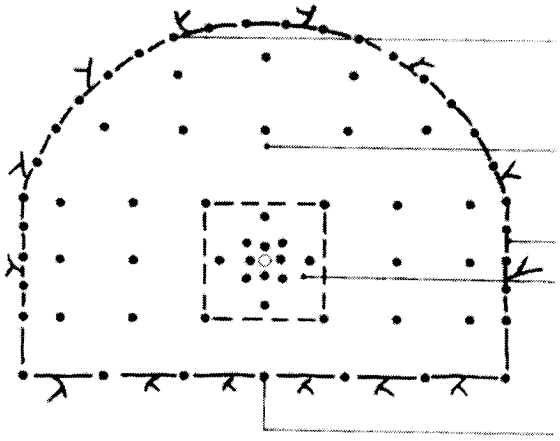


Figure 5.1 Sketch of a tunnel face

(ii) With the help of diagrams, illustrate (a) burn cut, (b) large hole cut, and (c) v-cut ***[9 marks]***

(iii) When designing a large hole cut, what are the four (4) parameters of importance for one to obtain a good result? Explain the equivalent diameter and write down its formula. ***[6 marks]***

=== END OF EXAM ===

UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
FIRST SEMESTER EXAMINATIONS – JUNE 2005
MI- 431 UNDERGROUND MINE DESIGN

INSTRUCTIONS : Answer any 5 questions **Full Marks**: 100
TIME : **3 Hours**

Question 1

Explain in detail stages involved in selection of a mining method based on "**Nicolas Method - Numerical Approach**"

[20 Marks]

Question 2

Fig.1 shows a massive mining method currently used for mining iron ore. Briefly describe the mining method under the following headings:

(i) Main characteristic features **[5 Marks]**
(ii) Development and stopping sequence **[5 Marks]**
(iii) Advantages and disadvantages of this mining method **[5 Marks]**
(iv) Formation of slot and drill pattern **[5 Marks]**

Question 3

Explain the criteria used for the geo-mechanical classification of underground mining methods. Illustrate your answer by citing each category of mining methods.

[20 Marks]

Question 4

Explain reasons for classification of ore losses and dilution at the mine and state their negative effects on the operations of the mine.

[20 Marks]

Question 5

With the help of *clear diagrams and equations* explain the process of ore-flow in caving methods using Janelid and Kvapil's gravity flow concept of material in bins.

[20 Marks]

Question 6

The following cost data (Table 1) for the unit operations and stages of mining and other production activities and charges have been determined at an underground copper mine; for simplicity's sake in these calculations, the unit operations costs have already been estimated.

Table 1

Operation/Activity	Unit cost $/tonne
Rock breakage	1.10
Materials handling	1.45
Auxiliary operations	0.30
Indirect charges	10%
Prospecting and exploitation	1.50
Development	2.65
Plant depreciation	1.85
Processing (Beneficiation, refining, smelting)	8.50
Transportation	6.30
Royalty	2.25
Income tax rate	30 %

The grade of ore is 2.2 % copper, estimated recovery is 85 %, and the prevailing market price is $1.40/lb. Determine all costs, the value of the ore, and gross and net profits.

[20 Marks]

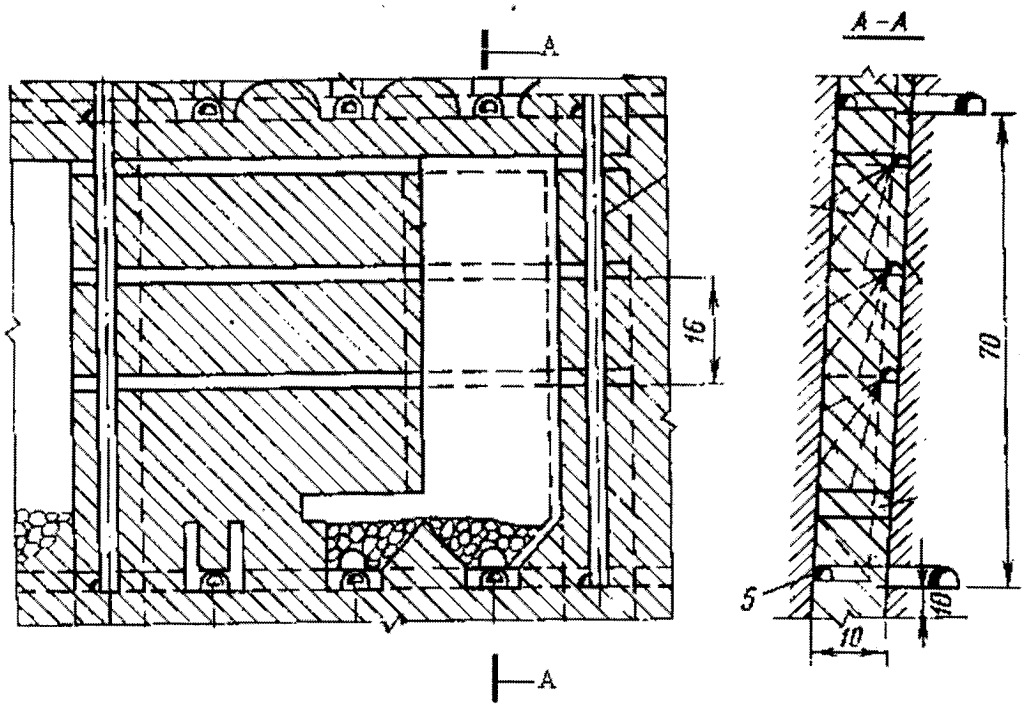


Fig .1 Mining method.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

FIRST SEMESTER EXAMINATIONS - JULY 2005

MI 455 OPERATIONS RESEARCH

TIME: THREE (03) HOURS **FULL MARKS 100**

INSTRUCTIONS: ANSWER ALL FIVE (05) QUESTIONS

QUESTION 1

(a) Write short notes on the following;

(i). Objective function **[3 marks]**
(ii). Model constraints **[3 marks]**
(iii). Decision variables **[3 marks]**

(b) Describe the steps followed in formulating a linear programming model. **[4 marks]**

(c) An mining company produces three grades of steel. The product hours and profit per unit are shown below. There are three operations involved in the manufacture of each grade as shown below.

Steel	Operations (Hours)			Profit
	I	II	III	
Grade 1	3	3	6	14
Grade 2	6	7	4	11
Grade 3	9	5	4	8

There is only a limited amount of operation time available for I, II and III this being 450, 380 and 500 hours respectively.

The firm would like to know how many units of each grade of steel to produce in order to maximize profit. Formulate the problem as a linear programming model.

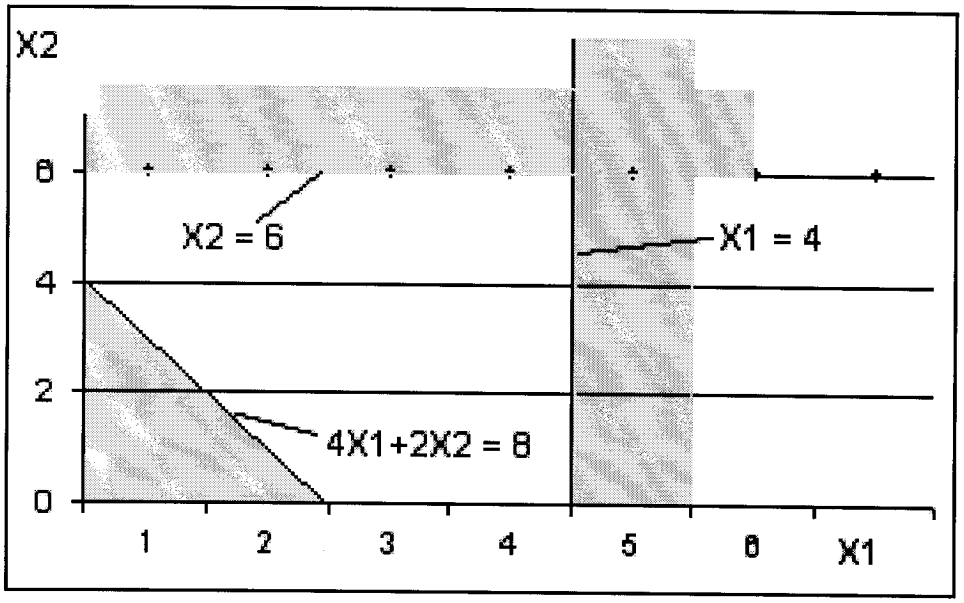
[7 marks]

QUESTION 2

(a) How are multiple optimal solutions identified in Simplex Method? **[4 marks]**

(b) Figure 2.1 below shows one of the problems in linear programming.

Figure 2.1: Graph of linear programming model.



(i) Name and discuss this type of problem **[3 marks]**
(ii) How is this type of problem identified in Simplex Method. **[3 marks]**

(c) Solve the following linear programming model using Simplex Method.

Minimize $Z = 6X_1 + 3X_2$
Subject to:

$$2X_1 + 4X_2 \geq 16$$
$$4X_1 + 3X_2 \geq 24$$
$$X_1, X_2 \geq 0$$

[10 marks]

QUESTION 3

(a) Briefly discuss the four characteristics that define a queuing system? **[4 marks]**

(b) Discuss at least five (5) applications of queuing theory in mining? **[4 marks]**

(c) An underground pump station has currently one (01) diesel pump. The diesel pump is used (by incoming and outgoing loaders) at a rate of 12 per hour. The average time of refueling is three (03) minutes.

(i) If the loader has to refuel, find the probability that the diesel pump is busy. **[4 marks]**
(ii) Find the expected waiting time before the loader refuels. **[4 marks]**
(iii) Find the average number of loaders (either incoming or outgoing) which are in the queue. **[4 marks]**

QUESTION 4

(a) Discuss the importance or Operations Research in solving mining problems? Give examples to demonstrate the application of operation research techniques in mining? **[5 marks]**

(b) What is the critical path and what is its importance in project planning? Discuss the various methods of determining the critical path in Network Analysis. **[4 marks]**

(c) Given the following PERT activity time estimates;

Activity	Most optimistic	Most Likely	Most Pessimistic
$1 \rightarrow 2$	5	8	17
$1 \rightarrow 3$	7	10	13
$2 \rightarrow 3$	3	5	7
$2 \rightarrow 4$	1	3	5
$3 \rightarrow 4$	4	6	8
$3 \rightarrow 5$	3	3	3
$4 \rightarrow 5$	3	4	5

(i) Construct an arrow diagram for the above network. **[2 marks]**
(ii) Determine the Critical path **[2 marks]**
(iii) Determine the expected project completion time and variance **[4 marks]**
(iv) Find the probability that the project will be completed in 28 days or less? **[3 marks]**

QUESTION 5

(a) What is degeneracy in transportation problem and how is it remedied? **[3 marks]**

(b) What is the purpose of performing the line test in the assignment solution method? **[3 marks]**

(c) Distinguish between a Transition and Recursive Return function as applied in Dynamic programming. **[3 marks]**

(d) Consider the following transportation tableau and solution.

To / From	A		B		C		Supply
1		12		10	600	6	**600**
2	400	4		15		3	**400**
3	300	9		7		M	**300**
4		11	500	8	300	6	**800**
Dummy	200	0		0		0	**200**
Demand	**900**		**500**		**900**		**2300**

(i) Is this a balanced or unbalanced transportation problem? Explain. **[3 marks]**

(ii) Is this solution degenerate? Explain. If it is degenerate, show how it would be put into proper form. **[4 marks]**

(iii) Is there a prohibited route in this problem? Explain. **[2 marks]**

(iv) Compute the total cost of this solution. **[1 mark]**

(v) What is the value of X_{2B} in this solution? **[1 mark]**

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
THE SCHOOL OF MINES
FIRST SEMESTER EXAMINATIONS - JUNE 2005

MI 465 MINERAL ECONOMICS

TIME: 3 HOURS

INSTRUCTIONS: ANSWER ANY FIVE QUESTIONS

1. What factors affect the following:

   (i) The demand for gemstones on international markets? **(10 marks)**

   (ii) The demand for Zambian cobalt? **(10 marks)**

2. International Precious Metals Plc has analyzed its past 5 year costs at different levels of silver production as indicated in the following Table below.

Annual output (Oz/year)	Mining costs (US$)	Processing and refining costs (US$)	Marketing and other administrative Costs (US$)	Total costs (US$)
0	5,000	4,000	0	9,000
100	10,000	6,000	10,000	26,000
200	11,000	10,000	13,000	34,000
300	12,000	12,000	17,000	41,000
400	13,000	17,000	20,000	50,000
500	15,000	20,000	31,000	66,000

For all analyses assume costs vary linearly between data points.

Average exchange rate is £1 = US$1.8

Determine the breakeven production level if the sales prices is £83.33 per ounce.

ii) Determine the level of sales per month at £83.33 per ounce that will maximize total profit, and calculate the total profit at that level of production. **(5 marks)**

iii) Determine the level of operation that gives minimum total cost per unit. What is the profit at that level of operation for the £83.33 per ounce selling price? **(5 marks)**

iv) What is the total profit per month if 500 units per month are sold at £83.33 per ounce? **(5 marks)**

3. (i) Define the terms ***economies of scale and diseconomies of scale.*** **(10 marks)**

(ii) What factors lead to economies and diseconomies of scale? **(10 marks)**

4. (i) Describe the most common forms of mine taxes. **(10 marks)**

(ii) What are the most important considerations in mineral taxation? **(5 marks)**

(iii) From an investor point of view, which taxes are considered more acceptable and why? **(5 marks)**

5. (i) What is a mineral policy? **(4 marks)**

(ii) What are the principal objectives of mineral policies in developing countries? **(8 marks)**

(iii) Briefly discuss the key elements comprising a typical mineral policy in developing countries. **(8 marks)**

6. (i) Decision making theory for a mining company is about three key issues. Briefly describe the importance of these three objectives.

(a) Profit objective. **(5 points)**

(b) Growth **(10 points)**

(c) Diversification **(5 points)**

End of Examinations

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
FIRST SEMESTER EXAMINATIONS – JUNE 2005

MI 545 – MINE MANAGEMENT

TIME: 3 HOURS

INSTRUCTIONS: ANSWER FIVE QUESTIONS

1. (a) In understanding behaviour in organizations, what basic disciplines and systems are you using when you are:

   (i) Considering the behaviour of Kasai workers **[4 marks]**
   (ii) Prisoners **[4 marks]**
   (iii) Women workers **[4 marks]**

   (b) Write short notes on

   (i) Perception **[4 marks]**
   (ii) Stereotyping **[4 marks]**
   (iii) Physiological contract **[5 marks]**

2. (a) Categorise various theories or "schools" being used to study management science. **[10 marks]**

   (b) Why are Webers and Taylors theories so important? Provide a detailed discussion on their theories. **[15 marks]**

3. (a) You are thinking of investing in Eastern Congo, a region rich in gold. Provide an analysis of what faces you in this investment venture. **[10 marks]**

   (b) You are reorganizing your gemstone industry. What type of organizational culture and structure would you adopt? Discuss **[10 marks]**

   (c) In setting up a business, there are three issues you should consider to guide you. Write about them. (300 words each maximum). **[5 marks]**

4. (i) How are effective managers and leaders rated. **[10 marks]**

   (ii) Discuss Theories X, Y and Z and state under what situations can they be best used. **[15 marks]**

5. You are given a Balance Sheet and Profit and Loss Statement for a company as follows:

TABLE 8-1 Balance Sheet of General Business Corporation on December 31, 1986 and 1987

			1986	1987
Assets (uses of funds):				
(1) Cash			$ 11,009	$ 12,571
(2) Marketable securities			5,977	7,519
(3) Accounts receivable			33,581	31,053
(4) Inventories			59,443	56,521
(5) Other current assets			7,210	9,470
Total current assets			$117,220	$117,134
(6) Investments			$ 28,122	$ 29,818
(7) Property, plant, and equipment			511,486	523,283
(8) Total assets (TA)			$656,828	$670,235
Liabilities (sources of funds):				
(9) Accounts payable			$ 40,600	$ 44,343
(10) Other current liabilities			38,991	39,816
Accrued expenses	$17,800	$19,006		
Notes payable	20,090	19,610		
Income taxes payable	1,101	1,200		
Total current liabilities			$ 79,591	$ 84,159
(11) Long-term debt			$234,090	$212,717
(12) Deferred tax			39,119	46,840
Total long-term liabilities			$273,209	$259,557
(13) Shareholder equity (EQ)			304,028	326,519
Total liabilities and equity			$656,828	$670,235

TABLE 8-2 Income and Expense Statements for General Business Corporation for the Years Ending December 31, 1986 and 1987

	1986		1987	
(14) Sales (S)		$1,056,922		$1,130,439
(15) *Plus:* Other income		433		1,484
Equals: Total revenue		$1,057,355		$1,131,923
Expenses:				
(16) Cost of goods sold	694,329		728,861	
(17) Excise taxes	196,335		207,452	
(18) Marketing and administrative expenses	100,385		110,641	
Less: Total operating expenses	$ 991,049		$1,046,954	
Earnings before interest and taxes (EBIT)	$ 66,306		$ 84,969	
(19) Interest expense	17,443		14,526	
(20) Other expenses	334		9,528	
Less: Total expenses		$1,008,826		$1,071,008
(21) *Equals:* Earnings before taxes		48,529		60,915
(22) *Less:* Corporate income taxes		21,980		30,019
(23) *Equals:* Net income after taxes (NI)		$ 26,549		$ 30,896
(24) *Less:* Cash dividend payments (CD)		13,270		15,448
(25) *Equals:* Addition to retained earnings (RE)		$ 13,279		$ 15,448
Per share data for common stock:				
(26) Number of shares outstanding (NS)		19,310		19,310
(27) Market price per share of stock		$15.50		$19.00
(28) Earnings per share after tax (EPS)		$1.3748		$1.60
(29) Cash dividends per share (CDPS)		$.687		$.80
(30) Price-earnings ratio (P/E)		11.27 times		11.875 times

(i) Calculate the profitability ratios **[6 marks]**
(ii) Coverage ratios **[6 marks]**
(iii) Leverage ratios **[6 marks]**
(iv) Comment on the relevance of these ratios **[7 marks]**

6. (i) You are wiring a widow's house as an Engineer. What contract aspects should you consider? **[5 marks]**

(ii) What are the critical factors to consider in a contract? **[6 marks]**

(iii) (a) You are in a friendly relationship with a young lady, and the parents approach you, what type of liabilities do you face? **[7 marks]**

(b) The police approach you that you were violent and abuseful to the lady, what liabilities do you face? **[7 marks]**

*** **END OF EXAM** ***

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
FIRST SEMESTER EXAMINATIONS – JUNE 2005

MI 555 – GEOSTATISTICS

TIME: 3 HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS ONLY

1. (a) The mode of occurrence and morphology of a mineral deposit has an impact on the type and density of sampling and on the amount of material required. Discuss this with reference to

   (i) Phorphyry Copper –Molybdenum deposits **[6 marks]**

   (ii) Shear zone and epithermal gold deposits **[6 marks]**

   (iii) Stratiform deposits **[6 marks]**

   (b) For channel sampling, what information should be recorded for each sample line? **[7 marks]**

2. (a) Define the following terms

   (1) Regionalized variable **[3 marks]**
   (2) Estimation variance **[3 marks]**
   (3) Extension variance **[3 marks]**
   (4) Dispersion variance **[3 marks]**

   (b) Assuming second order stationarity is satisfied how are the semi variogram and covariogram related? **[3 marks]**

   (c) The semi variogram can be used for local estimation only if the intrinsic hypothesis is satisfied. What does this imply? **[3 marks]**

   (d) Give a formula for the semi variogram and illustrate how you practically can calculate it for

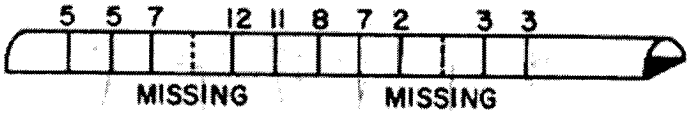
   (i) Channel samples on a line **[2 marks]**
   (ii) 2 D samples **[2 marks]**
   (iii) 3 D samples **[3 marks]**

3. (a) Write short notes on four (4) semi variogram models with sill values. **[12 marks]**

(b) What do you understand by the following terms

(i) Nugget effect **[4 marks]**
(ii) Anisotropy **[4 marks]**
(iii) Regularization **[5 marks]**

4. Calculate the semi variogram using the samples obtained along a drive shown in Figure 1. (Figure 3.4 – Rendu) **[25 marks]**



5. Assume a mining block of length 200 m and 250 m height with the following semi variogram parameters in isotrophe.

Co = 0.2
C = 2.0
a = 500 m

Assume the block has been sampled on four corners of the block

Calculate extension variance using auxiliary function. **[25 marks]**

6. Differentiate point Kriging from block Kriging and provide a mathematical basis for the two estimation methods. **[25 marks]**

***** END OF EXAM *****

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

FIRST SEMESTER EXAMINATIONS – JUNE 2005

MI 585 - MATERIALS HANDLING

TIME: 3 HOURS

INSTRUCTIONS: ANSWER ANY FIVE (05)

QUESTION 1

Write notes on and explain the Fundamentals of Equipment Selection under the following topics:

a) The eight (08) major factors that must be considered when selecting equipment for Materials Handling in mining *(05 marks)*

b) Supplementary five (05) factors that require consideration in the choice of equipment and machinery for Materials Handling; *(05 marks)*

c) The role, importance and impacts of Circular Analysis during mine optimization in relation to equipment selection. *(10 marks)*

QUESTION 2

a) List and write notes on the main Materials Handling operations giving examples of typical equipment deployed on each both in surface and underground hard-rock mining. *(10 marks)*

b) With the help of the notion of "Circular Analysis in Mine Optimization" state and explain the importance of the various optimization steps in relation to equipment selection. *(10 marks)*

QUESTION 3

a) Define and write notes on the various types of capacity estimations for excavating/loading equipment employed in materials handling laying special emphasis on the determinant characteristics/factors. *(10 marks)*

b) Describe the underground application and operation of a Front End Loader in Load Haul and Dump (LHD) as opposed to its application and operation as a pure FEL in surface mining, paying special attention to its operating dimensions, characteristics and factors. *(10 marks)*

QUESTION 4

a) Write notes on ripping as a material loosening operation in mining paying special emphasis on the following:

i. Various types of rippers *(02 marks)*

ii. Geometrical parameters of the ripper and their impact on the success in ripping *(03 marks)*

iii. Role and importance of the weight and power-rating (kW or Horsepower) on ripping output *(02 marks)*

iv. Ripping practice and techniques *(03 marks)*

b) Determine the ripping production and cost in the following situation:

- Machine.....D10R with Nr. 10 Single Shank Ripper
- Rip Spacing.....900 mm
- Ripping Speed (inclusive of slippage and stalls).....1.8 km/hr
- Ripper Penetration.....650 mm
- Rip Distance.....95 m
- Full time Ripping, no pushing or dozing;
- Manoeuvre Time (raise, pivot, turn and lower again)...0.25 minutes
- Assume 60 Minute-Hour
- Availability.....90%
- Utilization.....95%
- Seismic Velocity.....1 830 m/sec
- Owning and Operating (O&O) Costs for a D10-N = US $ 180.0/Hr (inclusive of US $15.00/Hr for the operator) *(10 marks)*

QUESTION 5

Given that a coal surface mine requires to pre-strip a total volume of 5 million bank cubic meters of mudstone for subsequent exposure of coal by a stripping dragline to satisfy the requirements of nearby located power station. You are required to determine and justify the loading and haulage equipment and fleet sizes, given the following:

(a) Materials Characteristics

Type of Material	Mudstone
SG – Loose	1.80 t/m^3
SG – Bank	2.40 t/ m^3

(b) Loading Equipment Alternatives

Type	Front-End-Loader	Hydraulic Shovel
Make	CAT 994	DEMAG H-185
Bucket Capacity (m^3)	16.0	16.0
Bucket Fill Factor (%)	90	95
Av. Cycle Time (sec)	40	30
Minutes per Hour (min)	50	50
Availability (%)	90	90
Utilization (%)	90	90

(c) Haulage Truck Alternatives

	Type 1 CAT-773D	Type 2 CAT-777D	Type 3 CAT-785C
Capacity (m^3)	35	60	78
Pay Load (tonnes)	53	96	144
Spot Time at loader (sec)	20	20	20
Waiting Time (sec)	10	10	10
Travel Distance (return)	6 000 (m)	6 000 (m)	6 000 (m)
Travel Speed – loaded	30km/hr	35km/hr	45km/hr
Travel Speed – empty	60km/hr	60km/hr	60km/hr
Spot Time at Dump (sec)	20	20	20
Manoeuvre/Dump Time (sec)	30	30	30

Knowing that the surface mine quarry operates 3 x 8 hr shifts per day and 260 days per year, you are required to:

i. Determine the maximum production achievable by each loading equipment type in BCM/Hr and Tonnes/Hr ***(04 marks)***

ii. Select and justify which loading equipment type and truck size combination you would deploy in the surface coal mine ***(04 marks)***

i. For the truck size selected, determine:

a) Number of passes to fill the truck ***(02 marks)***

b) Loading time per truck ***(02 marks)***

c) Loaded trucks per Hour ***(02 marks)***

d) Truck production in BCM and tonnes per hour ***(03 marks)***

e) Loading and haul equipment fleet sizes to be made available for the handling of the 5 million BCM per annum. ***(03 marks)***

QUESTION 6

With the aid of corresponding sketches, write notes on an underground skip and shaft hoisting system based on the following sub-topics:

a) Composition and associated equipment of a skip and shaft Hoisting System ***(10 marks)***

b) Factors to be considered in the determination of the number of Hoists required ***(10 marks)***

GOOD LUCK!!!

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – FIRST SEMESTER, JUNE/JULY 2005

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) Plumbing accessories
   (b) Automotive exhaust system
   (c) Automotive radiator
   (d) Textile machinery
   (e) Cutting tools

2. (a) Describe dislocation motion by glide.

   (b) Why is there no particular glide plane for a screw dislocation?

   (c) Explain, with the aid of appropriate sketches, how two edge dislocations with opposite Burgers vectors and under the action of a shear stress meet to form a row of vacancies or interstitials.

   (d) {110}, {112} and {123} planes have all been identified as slip planes in bcc materials. On how many slip planes does this imply that a single $\frac{a}{2}[111]$ dislocation might be able to move?

3. (a) Fick's first law of diffusion for species A is $J_A = -D_A \frac{\partial C_A}{\partial x}$. Why is the change in concentration $\frac{\partial C_A}{\partial x}$ expressed as a partial derivative?

   (b) Show, with the aid of appropriate sketches, why the presence of vacancies is essential for substitutional diffusion to occur.

   (c) What would you expect to happen to the rate of substitutional diffusion at elevated temperatures and why?

   (d) It has been stated that the equation $D = \frac{1}{6}\Gamma\alpha^2$ 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 {220} planes.

4. (a) Which one of the two types of nucleation, homogeneous and heterogeneous, is more common and why?

(b) The general equation of the free energy change for nucleation includes a strain energy (ΔG_ε) term as shown below. Why is this so?

$$\Delta G = v\Delta G_v^{'} + A\gamma \ + v\Delta G_\varepsilon$$

(c) Derive expressions for the critical nucleus size (r*) and activation energy barrier to nucleation (ΔG^*) for a spherical nucleus. What is the significance of these two parameters?

(d) Figure 1 is the diagram for a hypothetical embryo of silver growing against an arbitrary mould wall. With the aid of this diagram,

i. Compute the angle of contact, θ, of the embryo with the mould wall.

ii. Determine the magnitude of the factor that may be used to convert the homogeneous free energy needed to obtain a nucleus into that of the corresponding heterogeneous free energy.

5. (a) One version of the Phase Rule is $P + F = C + 1$. How can you use this rule to determine the factors involved in phase equilibria?

(b) State the Hume-Rothery rules that components A and B must satisfy in order to form a substitutional solid solution.

(c) The phase diagram for the Al-Co system is shown in Figure 2.

i. What are the chemical formulae (Al_xCo_y) of the β and δ phases?

ii. For an Al-30wt.%Co alloy, what are the phases present, their compositions and amounts at 950°C and 900°C?

iii. Draw a schematic cooling curve for an Al-60wt.%Co alloy.

END OF EXAMINATION IN MM321

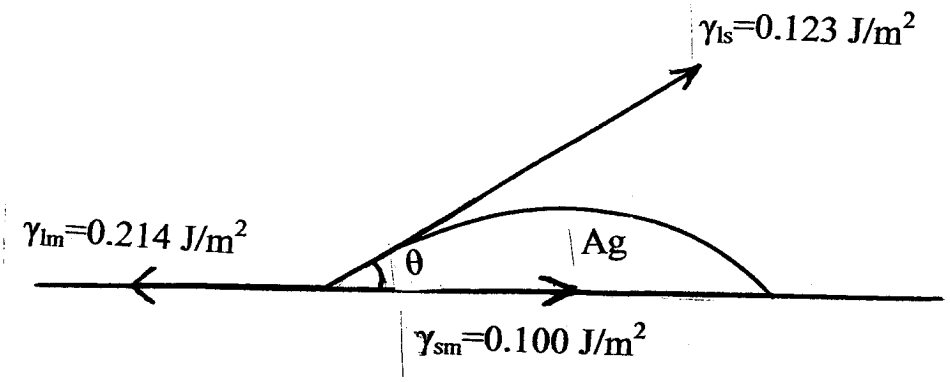
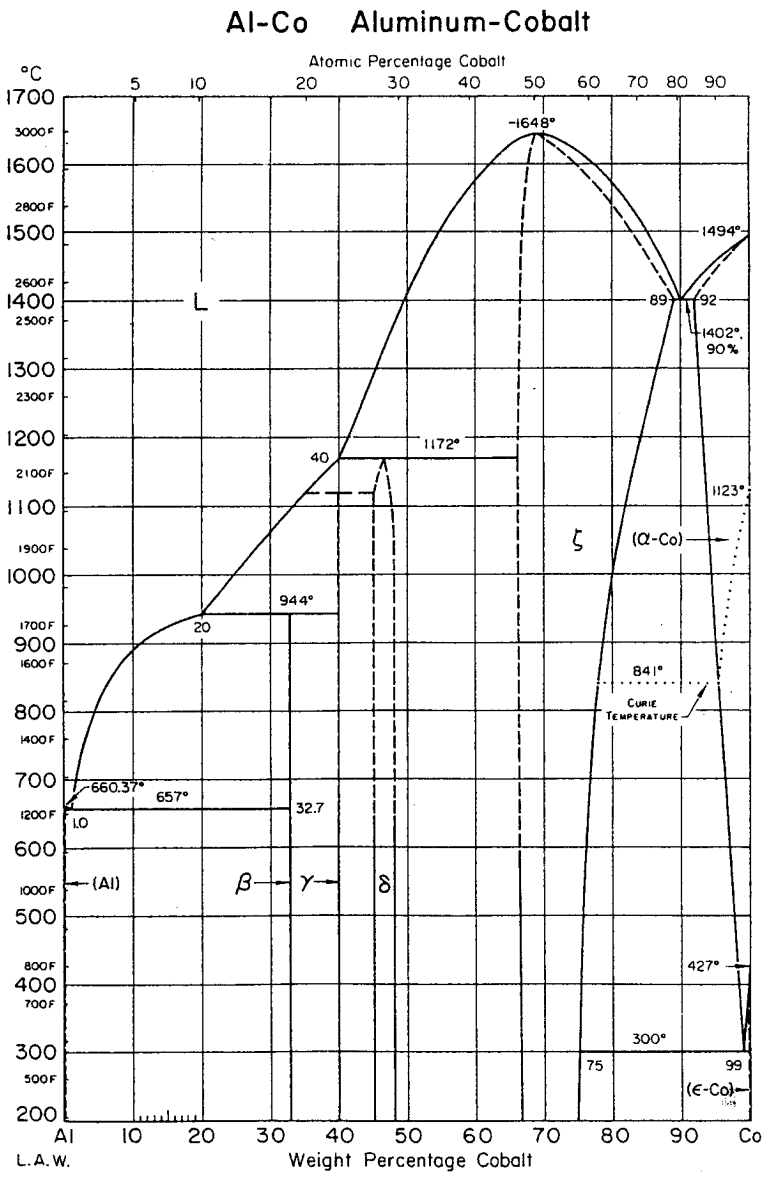


Figure 1

Figure 2



UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – FIRST SEMESTER JUNE/JULY, 2005

MM 331

CHEMICAL THERMODYNAMICS I

TIME: THREE HOURS

ANSWER: ALL QUESTIONS.

QUESTION 1

A quantity of an ideal gas occupies 10 litres at 10 atm and 100 **K**. If it undergoes a reversible adiabatic expansion to 1 atm, calculate:

(a) the final volume of the system,
(b) the work done by the system,
(c) the heat entering or leaving the system, and
(d) the internal energy and enthalpy changes in the system.

For the gas, the molar heat capacity $c_v = 1.5\ \boldsymbol{R}$.

[20%]

QUESTION 2

Calculate the average bond dissociation enthalpy of the Si-H bonds in SiH_4 from the following data. The molar enthalpy of combustion of SiH_4 (g) to SiO_2 (s) and H_2O (l) is $-1367\ kJ\ mol^{-1}$. The standard enthalpies of formation of SiO_2 and H_2O are $-858\ kJ\ mol^{-1}$ and $-286\ kJ\ mol^{-1}$ respectively. Also:

$$Si\ (s) \longrightarrow Si\ (g) \qquad \Delta H^{o}\ (298) = 368\ kJ\ mol^{-1}$$

$$\tfrac{1}{2}\ H_2\ (g) \longrightarrow H\ (g) \qquad \Delta H^{o}\ (298) = 218\ kJ\ mol^{-1}$$

[20%]

QUESTION 3

(a) Between 400 K and 500 K, the standard free energy change for the gas phase reaction

$$PCl_5\ (g) \longrightarrow PCl_3\ (g) + Cl_2\ (g)$$

is given by: $\Delta G^{o} = 83,680 - 14.52\ T \ln T - 72.26\ T \quad J/mol$

Calculate (a) ΔS^{o} , and (b) ΔH^{o} for the reaction at 450 K. Assuming all species to behave ideally.

(b) Consider the equilibrium

$$P_4\,(g) = 2P_2\,(g) \qquad \Delta G^{o} = 225,400 + 7.90T \ln T - 209.4\,T \text{ joules}$$

and calculate:

(i) The temperature at which $X_{P_4} = X_{P_2} = 0.5$ at a total pressure of 1 atm.

(ii) The total pressure at which $X_{P_4} = X_{P_2} = 0.5$ at 2000 K.

[20%]

QUESTION 4

At 298 K, the standard enthalpy of formation ($\Delta_f H^{o}$) of NH_3 (g) is - 46.11 kJ mol $^{-1}$. Assuming that the molar heat capacities can be represented by expressions of $C_p = A + BT$, with the coefficients A and B given below, calculate $\Delta_f H^{o}$ at 1000 K.

	N_2	H_2	NH_3
A / JK $^{-1}$ mol $^{-1}$	28.58	27.28	29.75
$10^{-3}\,B$ / JK $^{-1}$ mol $^{-1}$	3.77	3.26	25.1

[20%]

QUESTION 5

The virial equation for hydrogen is given as $PV = RT(1 + 6.4 \times 10^{-4} P)$. Using this virial equation for hydrogen gas at 298 K, calculate:

(a) The fugacity of hydrogen at 500 atm and 298 K

(b) The pressure at which the fugacity is twice the pressure

(c) The free energy change resulting from the compression of 1 mole of hydrogen at 298 K from 1 atm to 500 atm.

What is the magnitude of the contribution to (c) arising from the nonideality of hydrogen?

[20%]

END OF EXAMINATION IN MM 331

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS -FIRST SEMESTER JUNE/JULY 2005

MM 411

MINERAL PROCESSING I

TIME: 3 HOURS

ANSWER: ALL QUESTIONS

QUESTION 1

Consider a grinding circuit, consisting of a rod mill in open circuit and a ball mill in closed circuit with a hydrocyclone shown in Fig 1.

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

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

Calculate the circulating load over the ball mill / cyclone circuit as a percentage of new feed. **(2 %)**

(b) If the feed rate to the rod mill is 95 tph (dry weight), what is the feed rate to the ball mill, based upon your answer to question (c)? **(2 %)**

(c) What is the size distribution in the cyclone feed, based upon the above data? **(6 %)**

(d) From these data, calculate the recoveries to the cyclone underflow for the different size fractions and plot these against particle size on the graph paper. **(6 %)**

(e) What is the separating size in this cyclone operation, based upon these data? **(2 %)**

(f) What is the 'imperfection' in this cyclone operation, based upon these data? **(2 %)**

[20 %]

QUESTION 2

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

- Percent suspension
- Bulk density
- Optimum mesh-of-grind
- Angle of nip
- Graded crushing
- Classification
- Stokes diameter
- Separating size of a cyclone
- Specific surface (volume basis) of a group of particles
- Permeability of a medium **[20%]**

QUESTION 3

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

What are the main design variables and operating parameters of this cyclone? **(8 %)**

(b) Hydrocyclones have replaced mechanical classifiers in most modern grinding plants. What are the advantages of hydrocyclones over mechanical classifiers? **(2 %)**

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

(i) Describe the operation of this classifier with the aid of a clearly labelled diagram, showing the various zones that can be distinguished. **(4%)**

(ii) What operation controls can be used on this type of classifier and state briefly how these controls influence the separation size in this classifier? **(3 %)**

(iii) Describe what happens to the separating size when the feed to the classifier is diluted below and beyond the critical dilution. **(3 %)**

[20%]

QUESTION 4

The flowsheet shown in Figure 2 is that of a tin concentrator treating 30 dry tonnes per hour of ore.

The ore, containing 10 % moisture, is fed into a rod mill, which discharges a pulp containing 65 % solids by weight. The rod mill discharge is diluted to 30 % solids before being pumped to cyclones. The cyclone overflows, at 15 % solids, are pumped to the slimes treatment plant.

The cyclone underflow, at 40 % solids, and containing 0.9 % tin, are fed to a gravity concentration circuit, which produces a tin concentrate containing 45 % tin, and a tailing containing 0.2 % tin.

The tailing slurry, containing 30 % solids by weight, is dewatered to 65 % solids in a thickener, the overflow being routed to the mill header tank, which supplies water to the rod mill feed and rod mill discharge.

Calculate:

(i) The flowrate of make-up water required for the header tank. **(9 %)**

(ii) The water addition needed to the rod mill feed. **(3 %)**

(iii) The water addition needed to the rod mill discharge. **(3 %)**

(iv) The recovery of Tin to the concentrate. **(5 %)**

[20 %]

QUESTION 5

(a) Describe the crushing action of a jaw crusher and a gyratory crusher with the aid of clearly labelled diagrams. **(6 %)**

Describe the protection mechanisms of jaw crushers and gyratory crushers when an uncrushable material (e.g. tramp metal) enters the crushing cavity. **(3 %)**

(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? **(3 %)**

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

(i) How much energy would be required per tonne to reduce this rock from the same feed size to 80% passing 100μm in the same ball mill? **(2 %)**

(ii) If it would be required to mill 11000 t/day of this same rock from 2500μm to 100μm (80% passing sizes) in three (3) shift operation with an expected mill efficiency of 89%, how much energy would that require per 24 hour day? **(4 %)**

(iii) What minimum horsepower should be installed in the grinding section based upon the above data? **(2 %)**

1 hp = 0.75 kW

[20 %]

END OF EXAMINATION IN MM 411

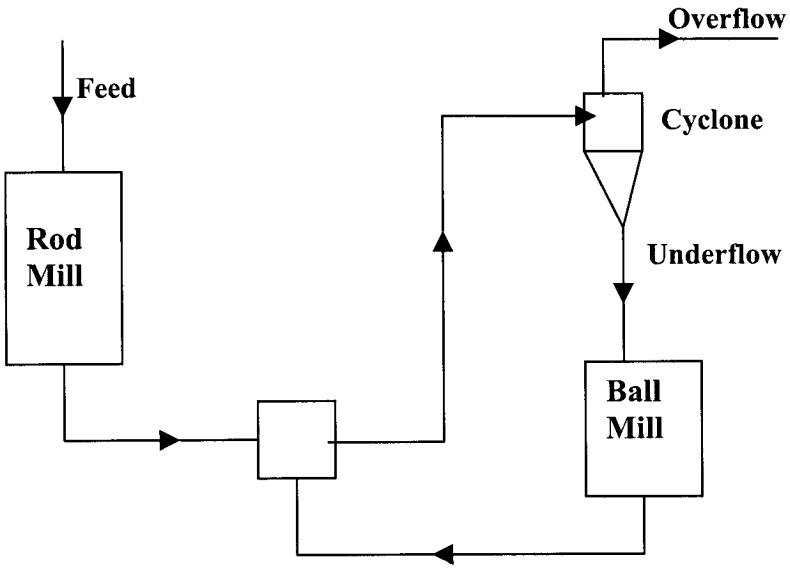


Figure 1: Rod mill – Ball mill – Cyclone circuit

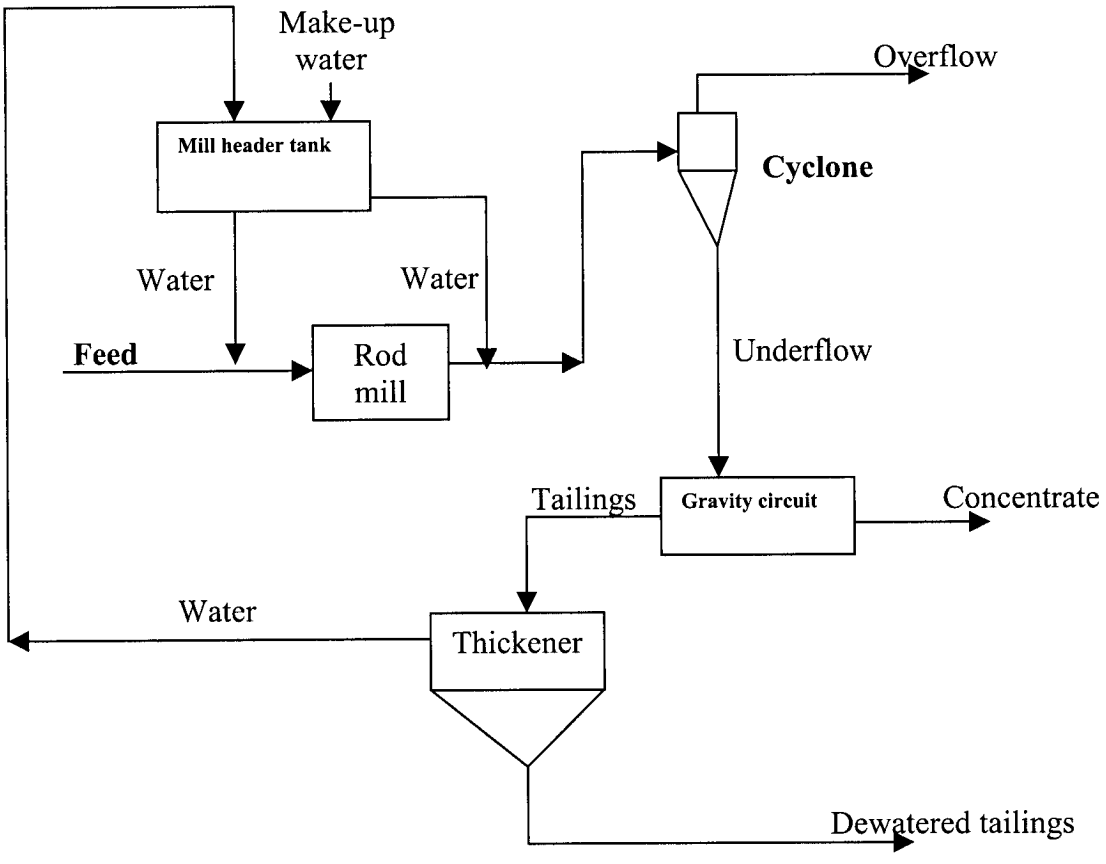


Figure 2: Tin concentrator circuit

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - FIRST SEMESTER, JUNE/JULY2005

MM 441

PYROMETALLURGY

TIME:: THREE HOURS.
ANSWER: ALL QUESTIONS.

QUESTION 1

Sphalerite which is to be assumed pure, is roasted completely at 900 ° C with an excess of air in a continuous process to yield a calcine with ZnO while SO_2 gas is given off. The roaster off-gas contains 5.5% SO_2 with the balance of the off-gas being O_2 and N_2.

(a) Calculate:

(i) the amount of air, in Nm^3, used per kilogram sphalerite roasted. (5%)

(ii) the off-gas composition in volume percent. (5%)

Assume air comprises 79% N_2 and 21% O_2 by volume. One kilomole of a gas occupies 22.41 Nm^3 and relative atomic weights are as follows: Zn = 65.4; S = 32.1; 0 = 16.0; N = 14.0.

(b) If heat losses amount to 20% of the exothermic heat of reaction, calculate per kilogram sphalerite roasted the heat deficit or surplus if sphalerite and air enter the roaster at 25 ° C. (15%)

The enthalpy of each substance shown in the table below is to be calculated using the formula:

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

Enthalpy Data

Substance	a	b * 10^3	c * 10^{-5}	d	H°_{298}
SO_2	10.38	2.54	-1.42	-2729	-70940
O_2	7.16	1.00	-0.40	-2044	-
N_2	6.66	1.02	-	-2030	-
ZnS	10.6	2.51	-	-3270	-22600
ZnO	30.09	9.91	-	-9407	-212000

QUESTION 2

(a) Assuming that Cu_2S and FeS behave ideally in a matte produced by smelting a copper sulphide concentrate at 1200 °C, and that the activity of FeO in the slag in equilibrium with the matte is 0.3, calculate the activity of Cu_2O in the slag if the matte has 60% Cu. (11%)

Data

$(Cu_2O) + [FeS] = [Cu_2S] + (FeO)$
$G^\circ = -15200 - 8.49T$ cal/mol

Relative atomic weights: Cu=63.5; Fe=55.8; S=32.1 and the universal gas constant = 1.986 cal/mol/K

(b) What are the relative advantages and disadvantages of flash and reverberatory furnace copper matte smelting? (6%)

(c) How can copper lost in smelter discard slags be minimized? (8%)

QUESTION 3

(a).(i) Given the data shown below, make a plot of $\log(CO_2/CO)$ against (1/T) in the temperature interval 150-1300 °C for the reactions: (10%)

$2CO = CO_2 + C$
$G^\circ = -40800 + 41.7T$ cal/mol

$SnO_2 + 2CO = Sn + 2CO_2$
$G^\circ = -273500 + 90.42T$ cal/mol

Assume that all condensed phases are pure and that the total CO plus CO_2 pressure is one atmosphere.

(ii) Using the constructed figure, state the minimum temperature (in °C) at which the

reduction of SnO_2 with CO in the presence of solid carbon is thermodynamically feasible. (3%)

(iii) In practice, carbothermic reduction of cassiterite concentrates to produce tin metal is carried out at a much higher temperature. Why? (3%)

(b) Account for the use of a two step smelting process, in the commercial production of tin metal by carbothermic reduction. How are these steps carried out? (9%)

QUESTION 4

(a) How does the Hoboken copper matte converter differ from the Peirce-Smith copper matte converter? (5%)

(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 analyzing 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.

Besides 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.

Based on 85 tonnes of matte fed, calculate:

(i) the wet weight of concentrate charged. (7%)
(ii) the weight of white metal produced. (5%)
(iii) the iron content (in %) of white metal. (5%)
(iv) the composition of the flue-gas. (3%)

One kilomole of a gas occupies 22.41 Nm^3 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. State any other assumptions you make in your calculations.

END OF EXAMINATION IN MM441

UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - FIRST SEMESTER, JUNE/JULY 2005

MM 451

TRANSPORT PHENOMENA

TIME : THREE HOURS

ANSWER: FIVE QUESTIONS. All additional data required by the student are attached. All questions carry equal marks.
Where applicable, all calculations are to be made correct to three decimal places.

---

1. (a) In dimensional analysis, what is meant by dimensional homogeneity?

(b) The shape of a hanging drop of liquid is expressible by the following formulation developed from photographic studies of the drop:

$$T = \frac{(\gamma - \gamma_0)(d_e)^2}{H}$$

where γ = specific weight of liquid drop, i.e. weight per unit volume
γ_0 = specific weight of vapour around it
d_e = diameter of drop at its equator
T = surface tension i.e. force per unit length
H = a function determined by experiment
For the equation above to be dimensionally homogeneous, what dimensions must H possess?

(c) The power P to drive a pump depends on the following variables:

Variable	Dimensions
Power,P	$\mathbf{ML^2T^{-3}}$
Density of fluid,ρ	$\mathbf{ML^{-3}}$
Angular rotation of rotor,N	$\mathbf{T^{-1}}$
Diameter of rotor, D	**L**
Head, H	**L**
Volumetric flow, Q	$\mathbf{L^3T^{-1}}$

Determine the pertinent dimensionless groups *choosing ρ, N and D as the repeating variables.*

2. (a) A vector $\vec{v}$ has components $v_x = 2$, $v_y = 4$, $v_z = -3$. Evaluate $(\vec{\delta}.\vec{v})$ and $[\vec{r}x\vec{v}]$ where $\vec{r}$ is the position vector.

(b) You are given the following stress field in kPa:

$$\tau_{xx} = 16x + 10 \qquad \tau_{zz} = \tau_{xz} = \tau_{yz} = 0$$
$$\tau_{yy} = 10y^2 + 6xy$$
$$\tau_{xy} = -5x^2$$

Express the pressure distribution P (x,y,z) as a scalar field. What is $\vec{\nabla} P$ at point (0, 10, 2) m and what is its component that makes a 60^0 angle with the positive x axis?

(c) If $\vec{r}$ is the position vector, show that $(\vec{\nabla} . \vec{r}) = 3$ and $[\vec{\nabla} \times \vec{r}] = 0$.

(d) A tank is filled to the edge with water. If a cube of material 600 mm on a side and weighing 445 N is lowered slowly into the tank until it floats, how much water in kg flows over the edge of the tank? What height of the cube in millimetres is submerged in the water?

3. (a) Molten steel is teemed from a ladle through a 5-cm diameter nozzle at its bottom. If the volume of molten steel in the beginning is 2.0 m^3 and the linear velocity is 100 cm per second, calculate the time required to empty the ladle.

(b) A well-stirred storage vessel contains 10,000 kg of a dilute solution of methyl alcohol in water (w_B = 0.05 weight fraction alcohol). A constant flow of 500 kg/min of pure water is suddenly introduced into the vessel and a constant withdrawal rate of 500 kg/min of solution is started. These two flows are continued and remain constant. Assume that the densities of the solutions are the same and that the total contents in the vessel remain constant at 10,000 kg of solution.

(i) How long will it take (in minutes) for the alcohol content to drop to 1.0 wt %?

(ii) How much time will elapse while the quantity of methyl alcohol in the vessel changes from 400 kg to 200kg?

4. (a) Water is flowing at a rate of 0.04 m^3/s through a horizontal nozzle attached to a pipe and discharges to the atmosphere at point 2. The nozzle is attached to the upstream end at point 1. The upstream inside diameter is 0.06 m and the gauge pressure is 1.1×10^6 N/m^2. The downstream diameter is 0.03 m and the pressure is 1.013×10^5 N/m^2. Calculate the resultant force of the fluids on the nozzle in newtons. The density of the water is 1000 kg/m^3.

(b) Water is flowing at steady state at 363 K (density of water = 965 kg/m^3) at a rate of 0.06 m^3/s through an upward 60^0 reducing bend ($\alpha_2 = 60^0$). The inlet pipe diameter is 0.10 m and the outlet diameter is 0.07 m. Neglect gravity forces. The inlet gauge pressure P_1 is 205.0 kN/m^2 and the exit gauge pressure is 111.5 kN/m^2. Calculate the **x-component** of the force of the fluids in newtons on the bend.

5. (a) In a vertical wetted-wall tower of width W m, the fluid flows down the wall as a thin film δ m thick in laminar flow in the vertical y direction. *Assume that the y direction is positive vertically downwards*. Derive the equation for the velocity profile v_y as a function of x, the distance **away** from the wall. The fluid has a density ρ, viscosity μ and the acceleration due to gravity is g. Also, derive expressions for v_{avg} (average velocity) and v_{max}. Use the Navier-Stokes equations in conjunction with the equation of continuity.

(b) The velocity profile for steady laminar flow through a horizontal circular tube is given as

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

where R is the inside radius of the tube. Show that $v_{avg} = v_{max}/2$. **Determine** the distance **a** from the centre of the pipe, in terms of R, at which the fluid will be moving at the average velocity? What is the shear stress at the wall of the tube?

6. (a) State four of the assumptions in the derivation of the Bernoulli equation.

(b) Water (density 1000 kg/m^3, viscosity 1x10^{-3} Pa.s) is pumped through a 50 mm diameter smooth pipeline at 4 kg/s and the pressure drop due to friction is 1x10^6 Pa. What is the length L of the pipe in metres?

$$h_L = \frac{\Delta P}{\rho g} = 2\, f_f \frac{L}{D}\frac{v^2}{g}$$

(c) Water with a density of 998 kg/m^3 is flowing at steady mass flow rate through a uniform-diameter pipe. The entrance absolute pressure of the fluid is 68.9 kPa in the pipe, which connects to a pump that actually supplies energy at 155.4 J/kg of the fluid flowing in the pipe. The exit pipe from the pump is the same diameter as the inlet pipe. The exit section of the pipe is 3.05 m higher than the entrance and the exit absolute pressure is 137.8 kN/m^2. Calculate the friction loss in the pipe system in J/kg flowing fluid. Assume that the flow is turbulent. Take g = 9.807 m/s^2.

7. (a) A furnace wall consists of 12.5 cm wide refractory brick (k_1 = 1.6 W/m.K) and 12.5 cm wide insulating brick (k_2 = 0.3 W/m.K). After the insulating brick, the wall is covered with an outside layer of 1.2 cm thick plaster (k_3 = 0.14 W/m.K). The inner surface of the furnace wall is at 1373 K and room temperature is 298 K. The heat transfer coefficient on the outside of wall surface is 17 W/m^2.K. Calculate the rate at which heat is lost per m^2 area of the wall surface. Also calculate the temperature of the outside wall surface.

(b) Hot air at a temperature of 330 K is flowing through a steel pipe of 100 mm diameter. The pipe is covered with a layer of insulating material of thickness 50 mm and its corresponding thermal conductivity is k_I = 0.23 W/m.K. The inside and outside heat transfer coefficients are 58 and 12 W/m^2.K respectively. The temperature of the atmosphere is 298 K. Find the heat loss from a 50 m length of pipe. *Neglect the resistance of the steel pipe.*

END OF THE EXAMINATION IN MM 451

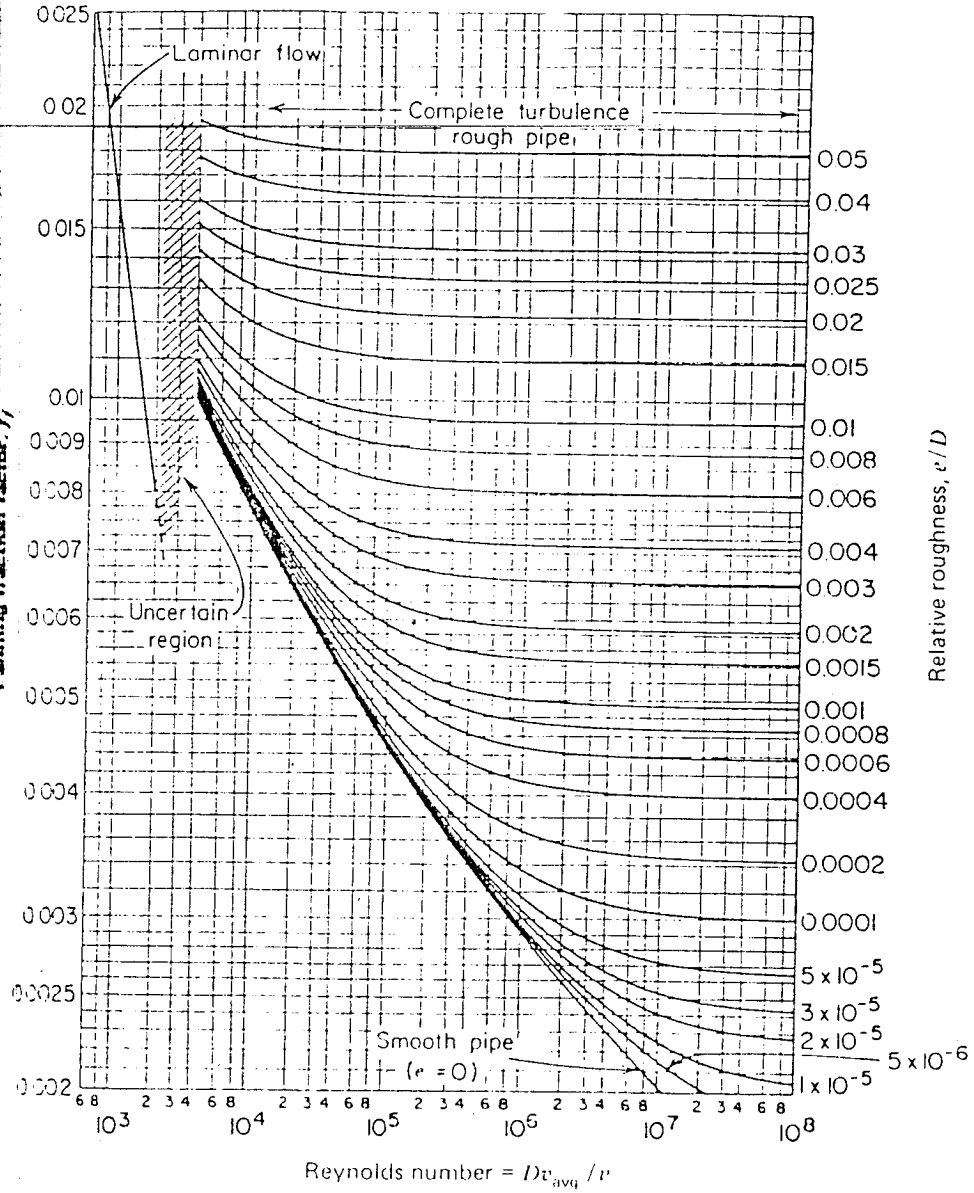


Figure 14.1 The Fanning friction factor as a function of Re and D/e.

§B.4 THE EQUATION OF CONTINUITY[a]

$$[\partial\rho/\partial t + (\nabla \cdot \rho\mathbf{v}) = 0]$$

Cartesian coordinates (x, y, z):

$$\frac{\partial\rho}{\partial t} + \frac{\partial}{\partial x}(\rho v_x) + \frac{\partial}{\partial y}(\rho v_y) + \frac{\partial}{\partial z}(\rho v_z) = 0 \tag{B.4-1}$$

Cylindrical coordinates (r, θ, z):

$$\frac{\partial\rho}{\partial t} + \frac{1}{r}\frac{\partial}{\partial r}(\rho r v_r) + \frac{1}{r}\frac{\partial}{\partial \theta}(\rho v_\theta) + \frac{\partial}{\partial z}(\rho v_z) = 0 \tag{B.4-2}$$

Spherical coordinates (r, θ, φ):

$$\frac{\partial\rho}{\partial t} + \frac{1}{r^2}\frac{\partial}{\partial r}(\rho r^2 v_r) + \frac{1}{r\sin\theta}\frac{\partial}{\partial \theta}(\rho v_\theta \sin\theta) + \frac{1}{r\sin\theta}\frac{\partial}{\partial \phi}(\rho v_\phi) = 0 \tag{B.4-3}$$

[a] When the fluid is assumed to have constant mass density ρ, the equation simplifies to $(\nabla \cdot \mathbf{v}) = 0$.

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

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

θ direction

$$\rho\left(\frac{\partial v_\theta}{\partial t}+v_r\frac{\partial v_\theta}{\partial r}+\frac{v_\theta}{r}\frac{\partial v_\theta}{\partial \theta}+\frac{v_r v_\theta}{r}+v_z\frac{\partial v_\theta}{\partial z}\right)$$
$$=-\frac{1}{r}\frac{\partial P}{\partial \theta}+\rho g_\theta+\mu\left[\frac{\partial}{\partial r}\left(\frac{1}{r}\frac{\partial}{\partial r}(rv_\theta)\right)+\frac{1}{r^2}\frac{\partial^2 v_\theta}{\partial \theta^2}+\frac{2}{r^2}\frac{\partial v_r}{\partial \theta}+\frac{\partial^2 v_\theta}{\partial z^2}\right] \quad \text{(E-5)}$$

z direction

$$\rho\left(\frac{\partial v_z}{\partial t}+v_r\frac{\partial v_z}{\partial r}+\frac{v_\theta}{r}\frac{\partial v_z}{\partial \theta}+v_z\frac{\partial v_z}{\partial z}\right)$$
$$=-\frac{\partial P}{\partial z}+\rho g_z+\mu\left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial v_z}{\partial r}\right)+\frac{1}{r^2}\frac{\partial^2 v_z}{\partial \theta^2}+\frac{\partial^2 v_z}{\partial z^2}\right] \quad \text{(E-6)}$$

SPHERICAL COORDINATES*

r direction

$$\rho\left(\frac{\partial v_r}{\partial t}+v_r\frac{\partial v_r}{\partial r}+\frac{v_\theta}{r}\frac{\partial v_r}{\partial \theta}+\frac{v_\phi}{r\sin\theta}\frac{\partial v_r}{\partial \phi}-\frac{v_\phi^2}{r}-\frac{v_\theta^2}{r}\right)$$
$$=-\frac{\partial P}{\partial r}+\rho g_r+\mu\left[\nabla^2 v_r-\frac{2}{r^2}v_r-\frac{2}{r^2}\frac{\partial v_\theta}{\partial \theta}-\frac{2}{r^2}v_\theta\cot\theta-\frac{2}{r^2\sin\theta}\frac{\partial v_\phi}{\partial \phi}\right] \quad \text{(E-7)}$$

θ direction

$$\rho\left[\frac{\partial v_\theta}{\partial t}+v_r\frac{\partial v_\theta}{\partial r}+\frac{v_\theta}{r}\frac{\partial v_\theta}{\partial \theta}+\frac{v_\phi}{r\sin\theta}\frac{\partial v_\theta}{\partial \phi}+\frac{v_r v_\theta}{r}-\frac{v_\phi^2\cot\theta}{r}\right]$$
$$=-\frac{1}{r}\frac{\partial P}{\partial \theta}+\rho g_\theta+\mu\left[\nabla^2 v_\theta+\frac{2}{r^2}\frac{\partial v_r}{\partial \theta}-\frac{v_\theta}{r^2\sin^2\theta}-\frac{2\cos\theta}{r^2\sin^2\theta}\frac{\partial v_\phi}{\partial \phi}\right] \quad \text{(E-8)}$$

ϕ direction

$$\rho\left(\frac{\partial v_\phi}{\partial t}+v_r\frac{\partial v_\phi}{\partial r}+\frac{v_\theta}{r}\frac{\partial v_\phi}{\partial \theta}+\frac{v_\phi}{r\sin\theta}\frac{\partial v_\phi}{\partial \phi}+\frac{v_\phi v_r}{r}+\frac{v_\theta v_\phi}{r}\cot\theta\right)$$
$$=-\frac{1}{r\sin\theta}\frac{\partial P}{\partial \phi}+\rho g_\phi+\mu\left[\nabla^2 v_\phi-\frac{v_\phi}{r^2\sin^2\theta}+\frac{2}{r^2\sin\theta}\frac{\partial v_r}{\partial \phi}+\frac{2\cos\theta}{r^2\sin^2\theta}\frac{\partial v_\theta}{\partial \phi}\right] \quad \text{(E-9)}$$

* In the above equations,

$$\nabla^2=\frac{1}{r^2}\frac{\partial}{\partial r}\left(r\frac{\partial}{\partial r}\right)+\frac{1}{r^2\sin\theta}\frac{\partial}{\partial \theta}\left(\sin\theta\frac{\partial}{\partial \theta}\right)+\frac{1}{r^2\sin^2\theta}\frac{\partial^2}{\partial \phi^2}$$

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – FIRST SEMESTER, JUNE/JULY 2005

MM 481

FERROUS METALLURGY

TIME: THREE HOURS

ANSWER: ALL QUESTIONS (FIVE)

QUESTION ONE

(a) Why is it not possible to charge fine concentrates to the Iron Blast Furnace? (1%)

(b) In preparing iron ore concentrate for charging to the Blast Furnace, two agglomeration processes may be used, pelletising and sintering. With the aid of a sketch, describe the four distinct processing stages in pelletising. (5%)

(c) A pig-iron Blast Furnace plant produces 6,000 tonnes pig-iron per working day consuming 1.6 tonnes sinter per tonne pig iron produced. 12% of sinter delivered to the Blast Furnace plant is returned back after sieving in the Blast Furnace Charging section. Within the sintering plant, 5 sintering strands each of 175 m^2 surface area are present. Only 4 of them are in operation at a time. If the sintering plant, of which you are the shift metallurgist, operates 20 hours per working day, determine:

(i) the productivity of each sintering machine per hour (5%)

(ii) the vertical velocity of a sintering machine in this plant (4%)

(ii) the length of the sintering strand used in your plant (5%)

In determining the above, make the following assumptions:

Productivity factor = 60%
Bulk density of sinter = 1.5 tonnes/m^3
Height of material in pallet = 350 mm
Speed of sintering strand = 2 m/min

QUESTION TWO

An iron Blast Furnace in which you are a Shift Metallurgist is charged with the following materials:

Ore	Flux	Coke
Fe_2O_3 = 76%	$CaCO_3$ = 95%	C = 94%
SiO_2 = 14%	SiO_2 = 5%	SiO_2 = 6%
MnO = 1.7%		
Al_2O_3 = 5.0%		
P_2O_5 = 1.0%		
MgO = 2.3		

You need the product, pig iron, to have the following composition:

Pig Iron (PI)
Fe = 94%
C = 3.8%
Si = 1.4%
P = 0.4%
Mn = 0.4%

You want to keep the coke consumption rate at 780 kg/t pig iron and gases to carry 1 part CO to ½ part CO_2. You are also to assume that 98% of Fe put in the furnace will be produced as pig iron and the rest is to be slagged as FeO, and that the amount of flux is to 1/3 the amount of ore.

Determine:

(i) the weight of ore per tonne pig iron (5%)
(ii) the weight of slag per tonne pig iron and % composition (10%)
(iii) the oxygen required to the process (5%)

Atomic weights: Fe = 55.85, O = 16, Ca = 40.08, C = 12.01, Si = 28.09, Al = 26.98, Mn = 54.94, P = 31.0

QUESTION THREE

(a) With the aid of a diagram, describe the five internal zones of a Blast Furnace. (5%)

(b) One disadvantage of introducing the Bessemer (Acid) process for steelmaking in 1856 was that sulphur and phosphorus could not be removed from steel. Why? (2%)

(c) Draw a sketch showing metal composition changes during blowing of an acid Bessemer Converter. (4%)

(d) The Basic Bessemer or Thomas steelmaking process introduced in 1877 made it possible for removal of phosphorus. Why? (2%)

(e) Draw a sketch showing metal composition changes during blowing of a Basic Thomas Converter. (4%)

(f) What are the **three** disadvantages of a Top Blown Process? (3%)

QUESTION FOUR

(a) Distinguish between Basket and Bottom Pouring (4%)

(b) What is the advantage of Bottom Pouring (1%)

(c) Outline **five** disadvantages of Bottom Pouring (5%)

(d) In pouring pit practice, what is meant by Hot Top? (1%)

(e) Give **three** reasons why mould additions may be made during pouring (3%)

(f) Give three factors that govern the behaviour of steel in the mould and subsequent ingot structure. (3%)

(g) With the aid of a sketch describe the progress of solidification in the mould during continuous casting [3%]

QUESTION FIVE

(a) In vacuum refining, what is meant by stream and ladle degassing? (4%)

(b) What is the reason for better dephosphorisation in the bottom blown process in steelmaking? (1%)

(c) Draw a sketch comparing decarburisation levels with oxygen blown in both Top and Bottom blowing processes. (2%)

(d) Give **four** reasons for cleaning gases from metallurgical processing (4%)

(e) Describe the dust collection from metallurgical gases using a:

(i) Settling Chamber (3%)
(ii) Spray tower (2%)

(f) Describe **four** reasons that may lead to the release of gaseous compound to the atmosphere. (4%)

END OF EXAMINATION IN MM 481

UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – FIRST SEMESTER JUNE/JULY 2005

MM 515

SPECIAL TOPICS IN MINERAL PROCESSING.

TIME: THREE HOURS

ANSWER: FIVE QUESTIONS
(ALL QUESTIONS CARRY EQUAL MARKS)

QUESTION 1

First Quatum plc in Solwezi have just opened a Cu-Co mines with an ore containing 3% Cu in the form of chalcopyrite ($CuFeS_2$), 0.02% Co as Carrollite ($CoCu_2SO_4$) and the remainder being predominately siliceous gangue (s.g 2.7). The ore is stage crushed from ROM of about 2000mm to –12mm and sampled before being further treated. The output from the Gyratory crusher is fed to storage bins via a conveyor system at an average rate of 150 tonnes per hour. Assuming that the crushed material is thoroughly mixed, determine the :

a) the standard error of the mean
b) the 90% confidence limit of the error
c) the 95% confidence limit of the error
d) the 99% confidence limit of the error

in the Cu assay introduced by taking a 1kg sample from the conveyor at intervals of ¼ an hour. A test of the ore showed that the maximum Cu content of the largest piece in the sample is 10% Cu. The specific gravity of chalcopyrite is 4.2. Take the shape factor and size factor as 0.5 and 0.25 respectively. Discuss the most appropriate sampling method to be used.

QUESTION 2

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

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

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

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

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

QUESTION 3

(a) Explain the charging mechanism when minerals are put in a solution and how an electrical double layer may be formed on minerals particles using the Gouy-Chapman-Stern model.

(b) In electrokinetics, what do you understand by the following terms?

- Electrophoresis
- Streaming potential
- Electro osmosis
- Sedimentation Potential

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

(c) Briefly discuss various micro processes, which may take place simultaneously and successively in a flotation process. Illustrate these using a simplified kinetic equation describing the floatability of various minerals.

(d) In a simple first order flotations kinetic modeling exercise, show how the knowledge of the rate constant can be used to effect a separation of say four different minerals.

QUESTION 4

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

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

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

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

QUESTION 5

(a) Discuss the various methods, which can be used to measure the surface areas of powders. Outline the principle on which the BET is formulated to describe multiplayer adsorption of gases/solutions on mineral powders.

(b) The following data refer to the adsorption of n-butane at 273 K by a sample of tungsten powder which has a specific surface area (as determined from nitrogen adsorption measurements at 77 K) of 6.5 m^2g^{-1}:

Relative pressure (p/p_0)	0.04	010	0.16	0.25	0.30	0.37
Volume of gas adsorbed/ cm^3 (s.t.p.) g^{-1}	0.33	0.46	0.54	0.64	0.70	0.77

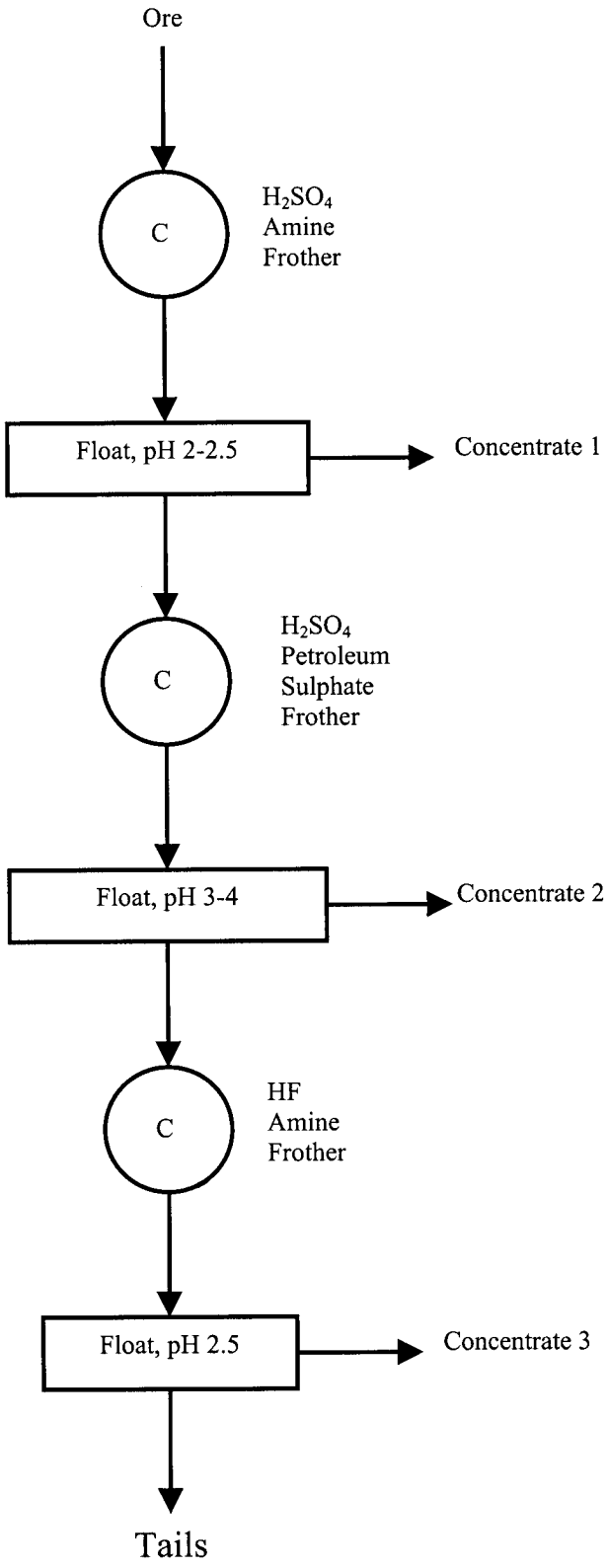
Use the BET equation to calculate a molecular area for the adsorbed butane at monolayer coverage and compare it with the value of 32.1 x $10^{-20}m^2$ estimated from the density of liquid butane. Explain the reasons for having two different values.

QUESTION 6

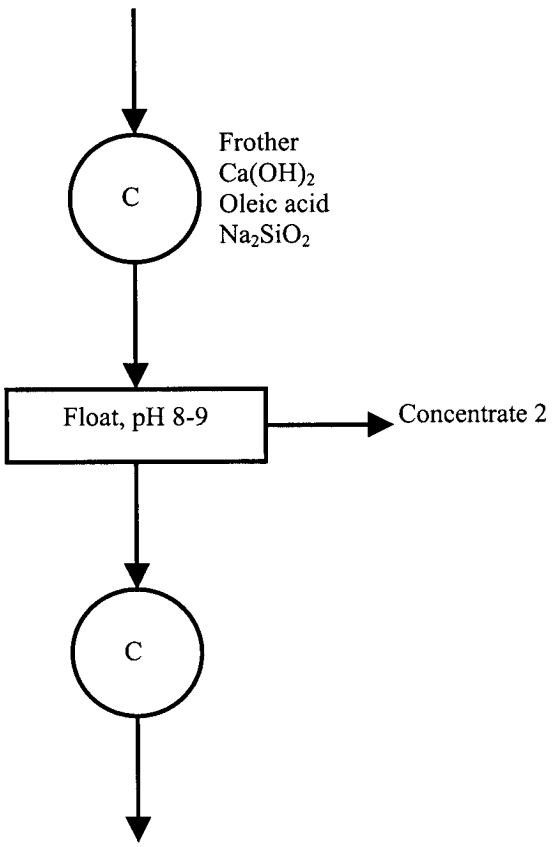
Study the attached flow sheets for the treatment of a pegmatite ore containing quartz, feldspar, mica and iron oxide. The intermediate flotation stage in (a) may be replaced by that outlined in (b). For the given combination of reagents in both (a) and (b), predict what minerals you would expect in the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

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

END OF EXAMINATION IN MM 515


Ore
C
H_2SO_4
Amine
Frother
Float, pH 2-2.5
Concentrate 1
C
H_2SO_4
Petroleum
Sulphate
Frother
Float, pH 3-4
Concentrate 2
C
HF
Amine
Frother
Float, pH 2.5
Concentrate 3
Tails

(a)


C
Frother
$Ca(OH)_2$
Oleic acid
Na_2SiO_2
Float, pH 8-9
Concentrate 2
C

(b)

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – FIRST SEMESTER JUNE/JULY 2005

MM 525

MECHANICAL METALLURGY

TIME: THREE HOURS

ANSWER: ANY FIVE QUESTIONS

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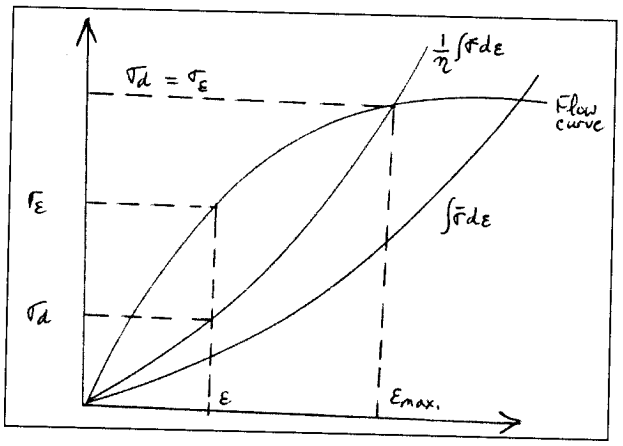
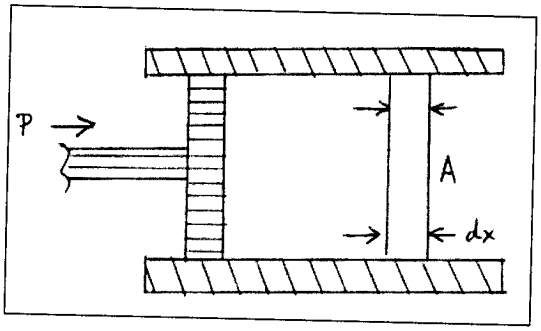
1. For a material that follows this power law hardening relationship, $\sigma_d = \underline{K \varepsilon^n}$
η
and given that the maximum strain possible in a single pass is $\varepsilon_{max.} = \eta(n+1)$, and that strain is also given as $\varepsilon = ln\,(A_o/A_1)$, show that the maximum reduction $r_{max.} = 1 - e^{-\eta(n+1)}$



2. (a) What are differences between direct and indirect extrusion and explain the role of friction in each case and its impact on the applied load.

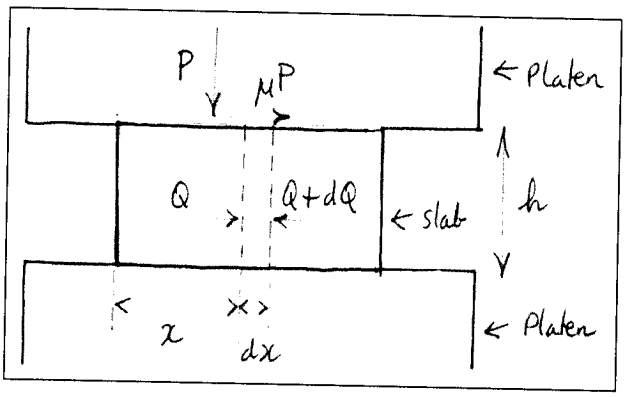
(b) Evaluate the expression for extrusion given that, $A \cdot dP = \prod D.dx \cdot \mu P$, gives an equilibrium between force on the ram and the frictional force acting on the cylindrical surface.



P = applied pressure
D = billet or container diameter
μ = coefficient of friction between billet and container.

3. (a) Show how the Von Mises yield criterion is used to correct the prediction of yielding as indicated in the Tresca's expression and explain what the final Von Mises condition means.

(b) Using the condition that $2\mu.P.\ \delta x = h.\delta Q$, where P and Q are vertical and transverse pressures acting on an element of a material in equilibrium as shown



Derive the expressions for maximum and average forging pressures utilising the Von Mises condition.

4. (a) Show schematically how the deep drawing operation is carried out on a circular sheet of a "blank material" and also indicating the various components or parts in the operation.

(b) How is the blank holder force estimated and if it is too low what happens to the drawn material?

(c) What would cause excessive thinning of the material being drawn?

5. (a) Evaluate the temperature rise resulting from deforming a high strength steel to a strain of 1.0. The following data apply;

$\rho = 7.87 \times 10^3$ kg/m^3 and σ (average) = 950 MPa over the strain interval, 0 to ε . The heat capacity of the steel, C, is 0.46×10^3 J/kg deg C.

(b) What is the effect of high stresses and strains during the working of a material such as the one above?

(c) What would result from localised heating during the above deformation as regards the structure of the material?

6. Discuss the effects of alloying elements in copper based alloys citing the special role of the following in metal forming

(i) Zinc
(ii) Nickel
(iii) Lead
(iv) Chromium

END OF EXAMINATION IN MM 525

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – FIRST SEMESTER JUNE/JULY, 2005

MM 545

SPECIAL TOPICS IN EXTRACTIVE METALLURGY

TIME: THREE HOURS

ANSWER: QUESTION 6 AND ANY OTHER FOUR

QUESTION 1

(a) Describe the various types of scrap used in steelmaking. What is the importance of metal recycling? Describe the methods of recycling copper, zinc and gold.

(b) Important developments in Pyrometallurgy took place only during the second half of the last century. What reasons can you give to account for this accelerated development?

(c) Metal consumption can be considered to be a measure of standard of living of the people. Can you elaborate on this statement? Take copper consumption as an example in this case.

QUESTION 2

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

(b) Describe in fair detail the thermochemistry of the converter process.

(c) Discuss the INCO and Outokumpu processes for the production of copper. What are the fundamental differences between the two processes?

QUESTION 3

(a) Describe the Warner process for the production of zinc from its ore. What are the peculiar features of this new technology?

(b) What is Aus-melt technology? What are its advantages over the conventional processes?

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

(i) lead – copper concentrates, and
(ii) nickel concentrates.
(iii) Has this technology any relevance to the Zambian Copperbelt industry? Give reasons.

QUESTION 4

(a) Show the kinetic mechanism of dissolution of gold and silver in cyanide solution.

(b) (i) The distribution ratio D is related to the pH of a solution according to the expression:

$$D = \frac{K' \times [R\,H]_0^2}{[H^{-1}]_{aq}^2} \quad \text{or}$$

$$\log D = \log K' + 2 \log [RH]_o + 2\, pH_{aq}$$

(ii) Construct a diagram showing the dependence of D to pH values.
(iii) Briefly describe the McCabe – Thiele diagram.
(iv) Describe solvent extraction (SX) process as applied in the recovery of uranium from its ores.
(v) What are the properties of good activated charcoal? In which area of metal extraction is it commonly used?

QUESTION 5

(a) With the help of Flowsheets describe the production of H_2SO_4 and elemental sulphur from smelter flue gases containing SO_2. What reasons dictate their recovery?
(b) Describe how each of the following equipment operates:

(i) Cyclones
(ii) Electrostatic precipitators, and
(iii) Scrubbers.

Show the limits of particles sizes in which each of these units operates effectively.

QUESTION 6

(a) The weight of the mixture charged per day is 600 tons of 2000 lb. In addition $CaCO_3$ is added as flux, sufficient to yield a slag of 20 % CaO. Assume that all the arsenic (As) enters the gases as As_2O_3. The gases contain no CO or free oxygen. Coke is used amounting to 8 % of the mixture. Its composition is 85 % C and 15 % SiO_2. The matte carries 40 % copper.

Required:

(i) The weight of matte produced, per day.
(ii) Weight of slag, per ton of ore.
(iii) Weight of $CaCO_3$ used, per ton of ore.
(iv) Volume of blast, per ton of ore.
(v) Volume and composition of the gases, per ton of ore.
(vi) Weight of As_2O_3 in the gases, per day.

(b) In the operation of a copper converter, the first charge is 30 tonnes of 42 % matte. The flux used is ore carrying Cu – 7 %, Fe – 16 %, S – 5 %, SiO_2 – 49 %. The slag carries 28 % SiO_2, 63 % FeO, 4 % CuO. After the first slag is poured, additional matte is charged of the same weight as the FeS, which has been oxidised from the first matte charge. The time of the blister-forming stage is 2 hours.

Required:

(i) The total weight of flux used, and the total weight of slag made.
(ii) Weight of blister copper formed, taking it as pure Cu.
(iii) Volume of blast used.
(iv) Total blowing time and volume of blast supplied per minute.

END OF EXAMINATION IN MM 545

THE UNIVERSITY OF ZAMBIA
THE SCHOOL OF MINES
FIRST SEMESTER EXAMINATIONS - JUNE 2005

MM 571 MINE MANAGEMENT AND ECONOMICS

IME: 3 HOURS

NSTRUCTIONS: ANSWER ONLY FIVE QUESTIONS

(a) In understanding behaviour in organizations, what basic disciplines and systems are you using when you are:

(i) Considering the behaviour of Kasai workers **[4 marks]**
(ii) Prisoners **[4 marks]**
(iii) Women workers **[4 marks]**

(b) Write short notes on

(i) Perception **[4 marks]**
(ii) Stereotyping **[4 marks]**
(iii) Physiological contract **[5 marks]**

(a) Categorise various theories or "schools" being used to study management science. **[10 marks]**

(b) Why are Webers and Taylors theories so important? Provide a detailed discussion on their theories. **[15 marks]**

(a) You are thinking of investing in Eastern Congo, a region rich in gold. Provide an analysis of what faces you in this investment venture. **[10 marks]**

(b) You are reorganizing your gemstone industry. What type of organizational culture and structure would you adopt? Discuss **[10 marks]**

(c) In setting up a business, there are three issues you should consider to guide you. Write about them. (300 words each maximum). **[5 marks]**

(i) How are effective managers and leaders rated. **[10 marks]**

(ii) Discuss Theories X, Y and Z and state under what situations can they be best used. **[15 marks]**

(i) What do you understand by the term "Cost of Capital" and how does it differ from the term "Capital Cost"? **(10 marks)**

(ii) Why is compounding of interest considered necessary? **(10 marks)**

(i) Two ore conveyor systems have the following cash flows as shown in the Table below.

Year	**System A (US$)**	**System B (US$)**
Initial investment (time 0)	200,000	500,000
1	10,000	15,000
2	12,000	18,000
3	15,000	20,000
4	18,000	22,000
5	18500	25,000
6	20,000	28,000
Salvage value at end year 6	5,000	20,000

If system A is overhauled at end of year 5 at a cost of $10,000 resulting in 20% reduction in operating costs in year 6, what will be the preferred alternative if the cost of capital is 10%?

(10 marks)

(ii) You invest K20 million in a bank offering you 20%. After 5 years you decide to withdraw a half of the money in the account and put it in a high interest account earning 25%. How much money are you going to have at the end of 7 years?

(10 marks)

End of Examination