SCHOOL OF MINES

SECOND SEMESTER 2003-2004

1. GG 202	:	PHYSICAL GEOLOGY
2. GG 312	:	PETROLOGY (PAPER I – THEORY)
3. GG 312	:	PETROLOGY PAPER II PRACTICAL
4. GG 322	:	STRATIGRAPHY AND REMOTE SENSING (PAPER II PRACTICAL)
5. GG 332	:	STRATIGRAPHY AND REMOTE SENSING (PAPER I THOERY)
6. GG 335	:	STRUCTURAL GEOOGY (PAPER I – THEORY
7. GG 335	:	STRUCTURAL GEOLOGY (PAPER 1 PRACTICAL)
8. GG 402	:	GEOLOGY OF ZAMBIA
9. GG412	:	METAMORPHIC PETROLOGY PAPER 1 – THEORY)
10.GG 442	:	ECONOMIC GEOLOGY OF METALLIFEROUS MINERAL DEPOSITS (PAPER 1 THEORY
11. GG412	:	METAMORPHIC PETROLOGY (PAPER 11 PRACTICAL)
12. GG 472	:	APPLIED GEOCHEMISTRY (PAPER 1 THEORY)
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14. GG 542	:	ECONOMIC GEOLOGY OF NON- METALLLIC MINERAL DEPOSITES PAPER I - THEORY
15. GG 542	:	ECONOMIC GEOLOGY OF NON- METALIC MINERAL DEPOSITS PAPER II – PRACTICAL
16. GG 572	:	HYDROGEOLOGY
17. MG 319	:	INTRODUCTION TO COMPUTERS. PAPER I THEORY
18. MG 319	:	INTORDUCTION TO COMPUTERS PAPER II PRACTICALS
19. MI 322	:	STATISTICS AND COMPUTER APPLICATIONS
20. MI 435	:	SURFACE MINE DESIGN
21.MI 475	:	MINE ENVIRONMENT
22. 515	:	ROCK MECHANICS II
23. MI 535	:	COAL MINING METHODS
24. MI 562	:	INVESTMENT ANALYSIS
25. MM 205	:	INTORDUCTION TO METALLURGY I
26. MM 332	:	CHEMICAL THERMODYNAMICS II
27. MM 412	:	MINERAL PROCESSING II
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31. MM 542	:	FUELS, FURNACES AND REFRACTORIES
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UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS – JANUARY 2004

GG 202 – PHYSICAL GEOLOGY

STRUCTIONS: Answer any five questions using sketches wherever applicable.

ME: Three (3) Hours

1. (a) Define the following terms (10 marks).
   (i) Precipitation
   (ii) Stream
   (iii) Meander
   (iv) Discharge
   (v) Stream Capacity
   (vi) Stream Competence
   (vii) Saltation
   (viii) Dissolved Load
   (ix) Ox-Bow Lake
   (x) Sediment Sorting

   (b) Describe briefly how stream capacity is affected by stream velocity and discharge. (10 Marks)

Q2. (a) List five natural passageways that facilitate and state how each facilitates infiltration of water into the subsurface. (10 Marks)

   (b) What is infiltration capacity? (2 Marks)

   (c) What is storage capacity? (2 Marks)

   (d) Describe briefly two ways through which groundwater escapes to the atmosphere. (6 Marks)

Q3. (a) Describe and discuss four main things that could have lead to slope failure that occurred at Nchanga Open Pit in the year 2002. (12 Marks)

   (b) How do you think volcanism and earthquakes cause movement of earth materials (4 Marks)

   (c) What are focus and epicenter of an earthquake? (3 Marks)

   (d) In which country an earthquake measuring over 6 on the Rechter scale occurred about one and half weeks ago and killed over 40,000 people? (1 Mark)

Q4. (a) Describe three ways through which wind transports sediment and the type of sediment moved in each case. (9 Marks)

(b) What is wind? (1 mark)

(c) What is a dune? (2 Marks)

(d) How does a barchan dune migrate? (2 Marks)

(e) Explain how mountain ranges (e.g. Rockies of North America) and distance from oceans influence the formation of deserts. (6 Marks)

Q5. (a) Would you consider ice as a rock? Explain your answer. (2 Marks)

(b) How would you explain the presence of suspected till in Maamba area, Zambia? (3 Marks)

(c) Name and describe three landforms made by glaciers. (9 Marks)

(d) How would the continued global warming affect populations living close polar regions? (6 Marks)

Q6. (a) Define the following (6 Marks):

(i) Wavelength

(ii) Wave height

(iii) Period

(b) Give the equation that relates velocity of a wave to wavelength and period. (2 Marks)

(c) Calculate the velocity of a wave whose wavelength and period are 24 m and 8 seconds, respectively. (4 Marks)

(d) Differentiate spring tides from neap tides. (6 Marks)

(e) What is a beach? (2 Marks)

.....Good Luck!!!.....

THE UNIVERSITY OF ZAMBIA
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SECOND SEMESTER EXAMINATIONS - JANUARY 2004

GG 312 PETROLOGY

PAPER I – THEORY

INSTRUCTIONS: Answer six questions, two from each section. Illustrate your answers with diagrams wherever possible. All questions carry equal marks.

TIME: Three hours

SECTION A

Q1. What is the difference between magma and lava? Briefly outline the main mechanisms for differentiation of magma.

Q2. Summarize the main characteristics of the gabbro group of rocks.

Q3. Define the following terms:
(a) Porphyritic texture
(b) Amydaloidal texture
(c) Laccolith
(d) Batholith

SECTION B

Q4. Describe the main types of chemically formed sedimentary rocks paying attention to (i) type and size of their constituents, (ii) their depositional environment.

Q5. What properties are common in all sandstones regardless of texture? What features of sandstones indicate that it is not an igneous rock?

Q6. Give two classifications of sedimentary rocks in terms of mineralogical and chemical composition. To which sedimentary rock is the average continental igneous rock is most similar in chemical composition? Explain why this is so.

SECTION C

Q7. What is metamorphism? State the main agents of metamorphism and discuss two of them in details.

Q8. Discuss the main characteristics of regional metamorphism.

Q9. Explain the following:
(a) Schistosity
(b) Retrograde metamorphism
(c) Metasomatism

----------Good Luck!!!!----------

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SECOND SEMESTER EXAMINATIONS – JANUARY 2004

GG 312 PETROLOGY

PAPER II – PRACTICAL

INSTRUCTIONS: Answer all questions.

TIME: Three hours

Q1. Describe handspecimens A, B and C paying attention to their mineralogy, textures, and structure. Name the rocks.

Q2. Thin sections E, F and G are provided:

(a) Identify all the minerals present
(b) Discuss the textures observed
(c) Name the rocks

----------Good Luck!!!!----------

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – JANUARY 2004

GG322 - STRATIGRAPHY AND REMOTE SENSING

PAPER II - PRACTICAL

INSTRUCTIONS: Answer all questions. Neatly drawn sketches/diagrams recommended for a full mark

TIME: Three (3) Hours

Q1. (a) Zambia is in the process of putting in place a Remote Sensing Centre. Outline what you think would be the value of this Centre to Zambia. (10 marks)

(b) What is Spectral Response (Signature). (2 marks)

(c) What does the Word PIXEL stand for? (2 marks)

Q2. (a) Your company would like to purchase a Remote Sensing Image. The Company has approached you for advice as to which image format they can purchase. Outline 4 types of image formats available on the market today. (6 marks)

(b) Name three image processing software on the market. (3 marks)

(c) (i) What is Image Rectification? (2 marks)
(ii) What are the purposes of Image Rectification? (4 marks)
(iii) What steps would one take to do Image Rectification? (3 marks)

(d) What is the purpose of image classification and name two approaches to image classification? (3 marks)

Q3. (a) Outline briefly the 4 Resolution Concepts in Remote Sensing. (8 marks)

(b) Recognition elements are visual clues we can use in a systematic way to identify objects in an air photo or satellite image. List these elements. (10 marks)

(c) What does the acronym GIS stand for? (2 marks)

(d) List the 5 essential elements of GIS. (5 marks)

Q5. Your company has requested you to undertake a photogeological interpretation of the Maamba area in Southern Province. You are therefore required to:

(a) Provide a fully annotated photogeological interpretation on the central air photograph. (30 marks)

(b) Provide a short description of the photogeology of the annotated area. (10 marks)

----------GOOD LUCK!!----------

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – JANUARY 2004

GG332 - STRATIGRAPHY AND REMOTE SENSING

PAPER I - THEORY

INSTRUCTIONS: Answer any five questions. All questions carry equal marks. Use sketches where possible for a full mark.

TIME: Three (3) Hours

Q1. Define the following terms:
- (a) Stratigraphy
- (b) Species
- (c) Principle of Superposition
- (d) Aggradation
- (e) Lithofacies

Q2.
- (a) Give a formal definition of Remote Sensing.
- (b) What is the difference between a photograph and an image?
- (c) What were the historical landmarks in the development of Remote Sensing (Give examples in each case)?
- (d) Name five types of Remote Sensing.
- (e) To be good in Remote Sensing, a person has to have knowledge in the following. Name at least five.

Q3.
- (a) Explain, with aid of diagrams, the Law of the Correlation.
- (b) What do unconformities indicate?
- (c) Outline briefly how stratigraphic information can be organised and displayed i.e. so that it can be understood by other scientists.

Q4.
- (a) Differentiate between the following;
  - (i) Biostratigraphy and Lithostratigraphy
  - (ii) Transgression and regression
- (b) Briefly outline the processes responsible for the alteration of fossils in the stratigraphic record.
- (d) Give three reasons used in the recognition of unconformities.

Q5. (a) The appearance or disappearance of species in a particular area or a particular stratigraphic section can be attributed to environmental change and the migration of species as well as to evolution. If the environment in an area changes progressively through time, a number of results might be expected. Outline these results (Hint – there are five results).

(b) In Chronostratigraphy, in form of a table distinguish between TIME UNITS and TIME-ROCK UNITS in descending order of scale.

Q6. (a) Describe briefly 2 methods used in direct radiochronology of sedimentary rocks indicating their limitations.

(b) In sequence stratigraphy, outline two criterias for recognition of depositional sequences.

(c) Outline 3 principal aims of palaeontology.

----------**GOOD LUCK!!**.....

13th Jan 04

UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS – JANUARY 2004

GG335 - STRUCTURAL GEOLOGY

PAPER I - THEORY

INSTRUCTIONS: Answer any five questions. Illustrate your answers with diagrams
TIME: Three (3) Hours

Q1. Using sketches, briefly define the following terms:
(a) Strain marker
(b) Carinate structure
(c) Rodding
(d) Pinch and swell
(e) Nonconformity
(20 Marks)

Q2. The ten (10) sketches shown in Figures 1 and 2 show different types of structures. Answer the following with reference to Figures 1 and 2:
(a) Name the type of structure and indicate whether it is primary or secondary;
(b) Describe how the structure is formed; and
(c) Indicate the way-up.
(20 Marks)

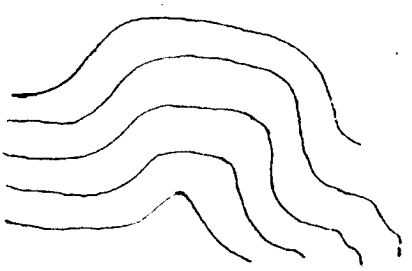
Q3. Describe five (5) types of foliations and elucidate their formation.
(20 Marks)

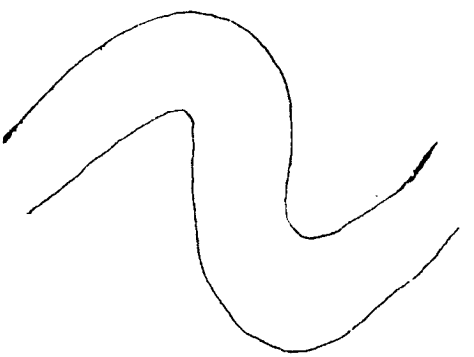
Q4. A fault plane strikes E-W and dips north 40°. σ_1 is oriented horizontal and equals 50mPa. σ_3 is vertical and equals 35mPa. Determine the normal and shear stress on the fault plane. Note: the angle between σ_3 and the fault plane is 90°-40°.
(20 Marks)

Q5. Describe Anderson's classification of faults using stresses. Calculate the strain undergone by a quartz rod initially 5 cm long deformed by stretching to 5.8 cm long.
(20 Marks)

Q6. (a) Define Hooke's Law. How is it applied in the deformation of rocks?
(b) What is creep?
(20 Marks)

----------Good Luck!!----------





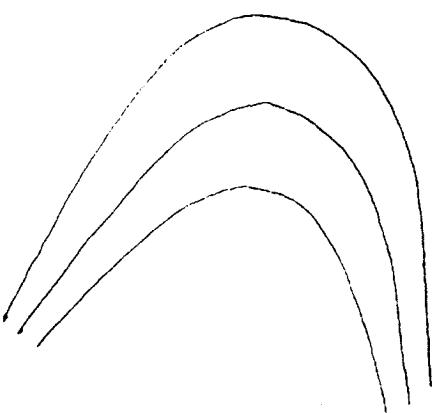
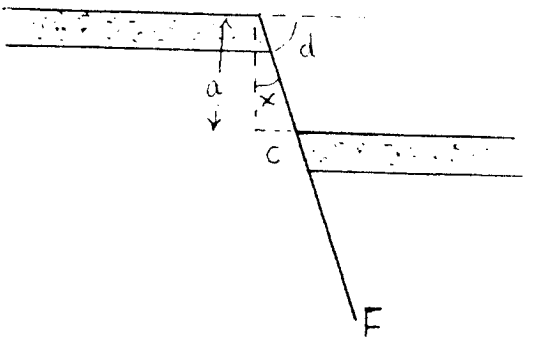
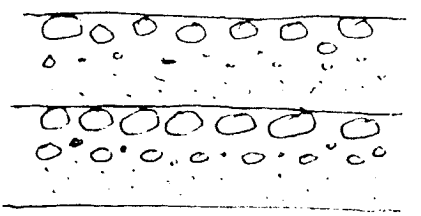
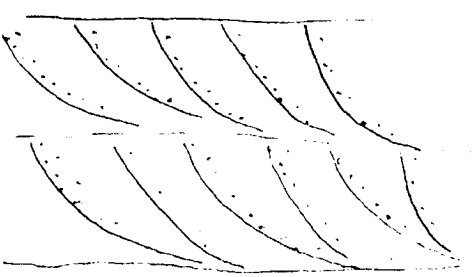


FIGURE 2







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SECOND SEMESTER EXAMINATIONS – JANUARY 2004

GG402 – GEOLOGY OF ZAMBIA

INSTRUCTIONS: Answer question one and any other four. Illustrate your answers wherever possible.

TIME: Three (3) Hours

1. a) Outline the stratigraphy of the Roan Supergroup on the Copperbelt of Zambia.
   b) Describe the sedimentological characteristics and depositional environment of the Kitwe Formation
   c) Discuss the two genetic models for the stratiform copper-cobalt mineralisation of the Copperbelt. Your answer should include evidence for and against each model.
   (32 Marks)

2. Describe the stratigraphy, sedimentology and depositional environment of the Muva Supergroup on the Bangweulu Block. (17 Marks)

3. Discuss the magmatic history of the Irumide Belt of northeastern Zambia. Your answer should include type of magmatism, petrography, geochemistry and tectonic significance. (17 Marks)

4. (a) What is meant by the following terms:
   (i) Formation
   (ii) Type Locality
   (b) In describing the Stratigraphy of an area, outline the main parameters or factors that have to be included in your description.
   (c) Name the formations that make-up the Karoo Supergroup in Zambia?
   (d) In Zambia, a number of basins contain the Karoo. Name them.
   (e) Name the type locality for the Kalahari Supergroup in Zambia and indicate the main rock type.
   (17 Marks)

5. (a) Decribe the Gwembe Coal Formation in terms of the following:
   i) Depositional environment
   ii) Economic significance and potential
   (b) Decribe briefly the tectonic setting of the Karoo Supergroup.
   (17 Marks)

6. With the aid of a table, give the stratigraphy of Zambia (17 Marks)

----------Good Luck!!----------

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SECOND SEMESTER EXAMINATIONS – JANUARY 2004

GG 412 METAMORPHIC PETROLOGY

PAPER I – THEORY

INSTRUCTIONS: Answer any five questions. Illustrate your answers with diagrams wherever possible.

TIME: Three hours

Q1. Briefly discuss the main factors that may affect a metamorphic reaction.

Q2. Define the following terms:
(a) Syntectonic crystallization
(b) Isochemical reaction
(c) Mylonite
(d) Polygonal granoblastic texture

Q3. Metamorphic rocks can be classified according to their main metamorphic agent, their geological setting and their plate tectonic setting. Discuss in details classifications of metamorphic rocks based on their plate tectonic setting.

Q4. What is a paired metamorphic belt? Explain how a paired metamorphic belt forms and give examples.

Q5. Discuss the tectonic significance of a preferred orientation of platy or elongated minerals in a metamorphic rock.

Q6. (a) Summarize the main characteristics of contact metamorphism.
(b) What is the difference between contact metamorphosed rocks of pelitic and quartzofeldspathic bulk composition?

----------Good Luck!!!!----------

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SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS – JANUARY 2004

GG 412 METAMORPHIC PETROLOGY

PAPER II – PRACTICAL

INSTRUCTIONS: Answer all questions.

TIME: Three hours

Q1. Thin sections A and B are provided:

(a) Identify all the minerals present
(b) Indicate the composition of the rock
(c) Describe the textures
(d) Discuss the metamorphic history

Q2. Give the petrographic description of the thins sections, C and D. Describe the textures and indicate the process/processes of their formation.

----------Good Luck!!!!----------

THE UNIVERSITY OF ZAMBIA
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SECOND SEMESTER EXAMINATIONS – JANUARY 2004

GG442 – ECONOMIC GEOLOGY OF METALLIFEROUS MINERAL DEPOSITS

PAPER I – THEORY

INSTRUCTIONS: Answer any five questions. All questions carry equal marks.

TIME: Three (3) Hours

Q1. (a) Define the following terms:
- (i) Ore Mineral
- (ii) Cut-off-grade
- (iii) Reflectance
- (iv) Reflectance Pleochroism
- (v) Scratch Hardness

(b) Recognition and interpretation of ore textures are important for three main reasons. What are these reasons?

(c) What is a stable isotope?

(d) Name three of the four stable isotopes important in investigations of ore deposits and state in each case the two isotopes used in the calculation of delta values.

(e) Distinguish between syngenesis and epigenesis.

(f) Classify the following deposit types into either syngenetic or epigenetic: Porphyry, Skarn, Vein, Volcanogeneic Massive Sulphide, Sedimentary Massive Sulphide, Magmatic and Placer.

Q2. (a) What is a skarn?

(b) Distinguish an exsoskarn from a endoskarn.

(c) Write short notes on the following:
- (i) Reaction Skarn
- (ii) Hornfels
- (iii) Skarnoid
- (iv) Metasomatism
- (v) Proximal skarn deposit

(d) Discuss briefly how the depth of formation of skarn affects the skarn size and alteration style.

(e) Why are minerals such as quartz, calcite and fluorite very useful in fluid inclusion studies of many ore deposits and not skarn deposits?

(f) What four geophysical methods would be useful in the exploration of skarn deposits and why?

Q3. (a) Define the term prophyritic.

(b) Porphyry deposits are important sources of three important metals. What are these metals?

(c) What two tectonic environments are porphyry deposits associated with?

(d) In Zambia there are several orogenic belts of Pan African age and yet we have not heard of any discovery of porphyry deposits. Why is this so?

(e) What mineralogy characterizes the following porphyry alteration zones:

(i) Propyllitic

(ii) Phyllic

(iii) Potassic

(f) Briefly discuss how porphyry deposits form.

Q4. (a) Briefly discuss the Zambian Copperbelt Deposits in terms of their tectonic setting, age, deformation and metamorphic features, the general, main host lithologies, main ore minerals and their zonation, and origin of both metals and sediments.

(b) Are the Zambian copper deposits strata-bound or stratiform? Why?

Q5. (a) What is a hydrothermal solution?

(b) Name the three main types of hydrothermal solutions and how each one of them is derived.

(c) Define the following terms:

(i) Epithermal Vein

(ii) Mesothermal Vein

(iii) Hypothermal Vein

(d) How in general terms do veins form?

(e) A vein deposit with copper mineralization has been discovered through exploration and needs to be evaluated. This vein deposit, containing quartz, pyrite and chalcopyrite, is vertical. Discuss the main features that the vein would acquire after oxidation has occurred and how these features are acquired.

Q6. (a) What is an environment?

(b) During the exploration stage of metalliferous mineral deposits the environment is negatively impacted. Discuss negative environmental impacts related to trenching/pitting and drilling and their remedial measures.

(c) Open pit mining on the Zambian Copperbelt has also negatively impacted on the environment despite the economic gain Zambia has derived from copper mining. Discuss the main environmental impacts that copper mining has had.

----------Good Luck!!!----------

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SECOND SEMESTER EXAMINATIONS – JANUARY 2004

GG442 – ECONOMIC GEOLOGY OF METALLIFEROUS MINERAL DEPOSITS

PAPER I – THEORY

INSTRUCTIONS: *Answer any five questions. All questions carry equal marks.*

TIME: Three (3) Hours

Q1. (a) Define the following terms:
- (i) Ore Mineral
- (ii) Cut-off-grade
- (iii) Reflectance
- (iv) Reflectance Pleochroism
- (v) Scratch Hardness

(b) Recognition and interpretation of ore textures are important for three main reasons. What are these reasons?

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(d) Discuss briefly how the depth of formation of skarn affects the skarn size and alteration style.

(e) Why are minerals such as quartz, calcite and fluorite very useful in fluid inclusion studies of many ore deposits and not skarn deposits?

(f) What four geophysical methods would be useful in the exploration of skarn deposits and why?

THE UNIVERSITY OF ZAMBIA
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SECOND SEMESTER EXAMINATIONS – JANUARY 2004

GG472 – APPLIED GEOCHEMISTRY

PAPER I – THEORY

INSTRUCTIONS: Answer any five questions. All questions carry equal marks.

TIME: Three (3) Hours

1. Define the following terms:
   a) Primary geochemical dispersion
   b) Syngenetic pattern
   c) Pathfinder element
   d) Epigenetic pattern
   e) Geochemical province

2. a) Discuss the fators that control the mobility of the chemical elements during chemical weathering.
   b) The weathering of silicate minerals is primarily by hydrolysis. Write the possible reactions of the hydrolysis of forsterite.

3. The solubility product of Galena is $10^{-27.5}$ and that of sphalerite is $10^{-24.7}$
   a) What is the ratio of (Pb^{2+}) to (Zn^{2+}) in equilibrium with both galena and sphalerite?
   b) If a solution containing 100 times more Zn^{2+} than Pb^{2+} percolates through a mixture of galena and sphalerite, which mineral would be replaced?
   c) Calculate the ratio of SO_4^{2-}/CO_3^{2-} in a solution at equilibrium with $CaSO_4$ and $CaCO_3$. $K_{CaCO3} = 4.5 \times 10^{-9}$; $K_{CaSO4} = 3.4 \times 10^{-5}$

4. a) Draw and describe a typical soil profile which you would expect to develop on granite in northwestern Zambia
   b) Discuss the main factors that affect soil formation
   c) State the optimum conditions for the formation of laterite

5. a) Use the thermodynamic data given below to construct an Eh-pH diagram for phase relations in the system U-O-H at 25°C and 1 bar pressure. Assume that the activity of dissolved U = 10^{-6}.

Species	$\Delta G^{o}f$
$UO_2(c)$	-246.62
$U_3O_8(c)$	-805.35
UO_2^{2+} (aq)	-227.66
H_2O	-56.69

b) Use the Eh-pH diagram to discuss briefly the mobility of U in the secondary environment.

6. The stream draining a copper mine area has a pH of 6.2 and a potential of 0.45V. Use the data given below and appropriate equations to determine the ratio Cu^{2+}/Cu^{+} and the activity of Cu^{2+}. Assume that Cu^{2+} is in equilibrium with tenorite.

Species	$\Delta G^{o}f$
Cu^{+}	+ 11.94
Cu^{2+}	+ 15.65
CuO	-31.00
H_2O	-56.69

----------Good Luck!!!----------

THE UNIVERSITY OF ZAMBIA
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SECOND SEMESTER EXAMINATIONS – JANUARY 2004

GG472 – APPLIED GEOCHEMISTRY

PAPER II – PRACTICAL

INSTRUCTIONS: Answer all questions.

TIME: Three (3) Hours

1. Discuss the rationale behind using stream sediments in geochemical exploration.

2. Discuss the basis of geobotanical and biogeochemical methods of exploration.

3. The data given below was obtained during an exploration programme for Copper in the Rufunsa area.

Table 1 Copper content (ppm) in stream sediment samples

32	138	160	950	50
32	68	165	1360	64
20	54	89	100	76
74	46	116	136	120
26	59	41	424	360
50	54	116	1020	480
152	66	91	820	100
80	62	100	240	350
58	33	89	1600	94
140	152	340	570	372
48	92	106	130	480
54	45	196	120	

a) Plot the data on a histogram and establish the background concentration.
b) How many populations are there in the data?
c) Which range of values occurs more frequently?
d) Calculate the sample standard deviation and determine the threshold value.

----------Good Luck!!!!----------

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS - JANUARY 2004

GG 542 ECONOMIC GEOLOGY OF NON-METALLIC MINERAL DEPOSITS

PAPER I – THEORY

INSTRUCTIONS: Answer any five questions

TIME: Three hours

1. Define the following terms giving examples of types, properties and uses of each.
   (a) Abrasives
   (b) Refractories

2. In the table below are given resources and parameters

Resource	Parameter
Sand and gravel China clay Gold Cement	Intrinsic value Place value Formation process of raw material Land demand Processing

   Describe each resource with respect to the parameters given

3. Industrial minerals represent a large group of rocks and minerals.
   (a) Why is there a need for their exploration?
   (b) Discuss the main technological characteristics which define their quality.

4. (a) What are fertilizer minerals?
   (b) State the main elements required for plant survival indicating their main sources.
   (c) Discuss the important market attributes of industrial minerals used in the chemical industry.

5. The gemstone sector of the Zambian mining industry could be a growth sector if properly managed. Outline the problems that this sector is facing and suggest possible solutions to such problems.

6. (a) Discuss the character of industrial minerals in relation to economic parameters.

(ii) Discuss environmental concerns associated with the exploitation of industrial minerals and how they can be mitigated.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS 2003

GG 542 ECONOMIC GEOLOGY OF NON-METALLIC MINERAL DEPOSITS

PAPER II – PRACTICAL

INSTRUCTIONS: Answer all questions.

TIME: Three hours

1. A cement factory has been presented with three raw materials named A, B and C. Using the chemical analyses given in the table below, determine which of the three is best for use based on the lime saturation factor.

Chemical composition	Raw material		
	A	B	C
Sio_2	12.0	21.1	12.5
Al_2o_3	5.0	7.9	3.3
Fe_2o_3	2.6	4,2	2.1
Cao	40.7	64.2	42.3
Mgo	1.1	1.8	0.6
Na_2o	0.2	0.2	0.3
K_2o	0.1	0.7	0.2
S	0.6	0.4	0.5
LOI	6.1	2.5	35.6

2. An area in Ngwerere of 400,000m^2 has on it a flat-lying formation of clay 20 m thick. The area has been converted into a brick works using these clay reserves. The clay has an average density of 1600 kg/m^3 and that the weight of an average unfired brick is 4 kg. The annual output of the brickworks is 16 million bricks.

   (a) What are the reserves of clay present in cubic meters?
   (b) How many cubic meters would be used up each year?
   (c) At the given rate of production, what would be the life expectancy of the brickworks?

3. Listed below are some properties of road aggregates. For each road layer, indicate the most desirable property giving reasons for your choice.

Property	Road layer			
	Subbase	**Road base**	**Base course**	**Wearing course**
High crushing strength Resistance to abrasion Resistance to polishing Ability to bond with bitumen High permeability				

----------Good Luck!!!!----------

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS 2003

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----------Good Luck!!!!----------

UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
GEOLOGY DEPARTMENT

SECOND SEMESTER EXAMINATIONS – JANUARY 2004

GG 572 - HYDROGEOLOGY

INSTRUCTIONS: Answer any five questions using sketches wherever applicable. Questions carry equal marks.

TIME: Three (3) Hours

Q1. Define the following quantities as applied in hydrogeology (20 marks).
- (a) Specific Storage
- (b) Phreatic Aquifer
- (c) Piezometric Head
- (d) DOC
- (e) Turbidity
- (f) Well Function
- (g) Base flow
- (h) Aquiclude
- (i) Aquitard
- (j) Radius of influence

Q2. Derive the Non Steady State Equation $\nabla^2 \mathbf{h} = \mathbf{(S/T)}\delta\mathbf{h}/\delta\mathbf{t}$. (20 marks)

Q3. Describe a field procedure to determine S and T, for a confined aquifer, using one pumping borehole and one observation borehole. (20 marks)

Q4. A borehole which was pumping at a uniform rate of 2500 cubic meters per day was shut down after 240 minutes; Thereafter, measurements of residual drawdown **s´** and recovery time **t´** were made, as given below. (20 marks)

Plot the data and determine the Transimissivity T, and explain why recovery tests should be carried out at all.

Recovery Test Date
(Pump shut down at t = 240 minutes)

Recovery Time (t′, min)	Residual Drawdown (s′, m)
1.0	0.89
2.0	0.81
3.0	0.76
5	0.68
7	0.64
10	0.56
15	0.49
20	0.45
30	0.38
40	0.34
60	0.28
80	0.24
100	0.21
140	0.17
180	0.14

Q5. (a) Prepare a Table of waterborne diseases, indicating type of waterborne disease, organism causing the disease, source of the organism in water and symptoms of the disease. (10 marks)

(b) Describe briefly UNZA′s human faecal waste disposal system. (10 marks)

Q6. Coliform Bacteria are used as INDICATOR ORGANISMS to examine water quality. Summarize in form of a flow-chart the "Multiple–tube Fermentation Method " of analysis. (20 marks)

.....Good Luck!!!.....

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS – JANUARY 2004

MG 319 - INTRODUCTION TO COMPUTERS

PAPER I - THEORY

INSTRUCTIONS: Answer any five questions. All questions carry equal marks.

TIME: Three hours

Q1. (a) Describe in detail, two different "START-UP" (BOOT-UP) processes.

(b) To protect vital components of your computer system, you should follow a set of rules. Describe all important rules related to file management and directory structure.

Q2. Disks and Directories are important in managing your data within your computer. Describe the following in detail:

(a) All important Disk-related commands

(b) All essential Directory-related commands

Q3. (a) There are four basic mouse operations you will often work with. Describe them, giving clear examples of each operation.

(c) The Programme Manager is the window in which you start your applications. It organizes programs into groups. Describe the standard programme groups.

Q4. (a) In working with a word processor, there are considerations to be made. State the initial steps involved, distinguishing all safety procedures related to processing word documents.

(b) A spreadsheet program offers the user ways of entering data. Describe three major operators used.

Q5. Define the following terms:

(a) BIOS
(b) Clipboard
(c) Download
(d) Motherboard
(e) Mainframe
(f) Network
(g) Path name

Q6. (a) Different computer generations are characterized by different internal memory and processing facilities and by different external memory carriers. Describe the internal components and external memory carriers for the four computer generations.

(b) List eight precautions to take in order to extend the life span of a computer.

(c) All classes of computers have two characteristics in common. State the two characteristics.

(d) Discuss two fundamental advantages of WINDOWS over MS-DOS.

----------Good Luck!!----------

THE UNIVERSITY OF ZAMBIA
School of Mines
Mining Engineering Department

MI322 - STATISTICS AND COMPUTER APPLICATIONS

Semester Two Final Examination - January 2004

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

INSTRUCTION: ANSWER ALL QUESTIONS

1(a) Define statistics ***[2 marks]***

(b) Describe the three sources of difficulty typically confronting the investigator. ***[6 mks]***

(c) With clear definition of the variables involved, what formulae are used in the following circumstances?

(i) To estimate the sample variance when the population mean η is known.

(ii) To estimate the statistic in a normal distribution if the standard deviation σ is not known.

(iii) To estimate the statistic for which we believe, say, that two sets of 10 yields obtained with methods A and B could be treated as *random samples from appropriate populations* of yields with approximately the same form; in particular, that they have the same variance σ^2

(iv) To estimate the statistic if the only evidence about σ is from the $n_A = x$ runs made with method **A** and $n_B = x$ runs made with method **B**.

[12 marks]

2(a) For a random variable having a normal distribution with mean η = 6, and standard deviation σ = 2, what is the probability that an individual observation selected at random will be between 5 and 7? *Illustrate your answer in a diagram.* ***[8 marks]***

(b) For observations with a normal distribution with mean 123.4 and variance 25, what is the chance that a single randomly chosen observation will be less than 120.0? *Illustrate your answer in a diagram.* ***[8 marks]***

(c) A mining engineer measured performance ***y***, Km/hr, of a sample of loaders all of the same make and age: 27, 8, 24.3, 22.8, 26.0, 24.2. For the variance of ***y*** calculate (1) the statistic $\hat{s}^2$, assuming that the mean performance for this type of loader is known to be η = 25. ***[4 marks]***

3(a) Prove that a LEAST SQUARE LINE always passes through the point $(\bar{x}, \bar{y})$.

[6 marks]

(b) A young mining engineer was given a task to carryout a test on exotic drilling using a high-powered projectile gun. He did this by varying distances between the source of projectiles and the target rock position, and noting the cavities created in the target object. Results obtained are shown in Table 3.1.

(i) Fit a least square line to the data, and ***[10 marks]***

(ii) Graph the line obtained. ***[4 marks]***

Table 3.1

Distance between projectile source and target (m), x	1	3	4	6	8	9	11	14
Length of cavity created (m), y	1	2	4	4	5	7	8	9

4. Three different loaders were tested for their performance. The allocation of drivers and loading times were random. The average tonnage pulled per hour was then recorded, as shown in Table 4.1. In clear steps, determine if there is a difference in the performance of the loaders.

Table 4.1

A	B	C
48	47	49
49	49	51
50	48	50
49	48	50

[20 marks]

5 Given the data in Table 5.1 from a randomized paired design to test two different drill bits;

Table 5.1

A	B	A	B	B	A	A	B	B	A
3	5	8	12	11	4	2	10	9	6

(a) Calculate the ***t*** statistic for testing the hypotheses $\delta = 0$ and the probability associated with two-sided significance test (interpolate graphically in the ***t*** table). ***[12 marks]***

(b) For the data given in Table 5.1, compute 80 % confidence limits for the mean difference δ. ***[8 marks]***

END OF EXAMINATIONS

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
UNIVERSITY END SEMESTER II EXAMINATIONS – JANUARY 2004

MI 435 – SURFACE MINE DESIGN

TIME: 3 HOURS FULL MARKS: 100

INSTRUCTIONS: Answer FIVE QUESTIONS only. For questions 4(b) and 7(a) ensure you enter your computer number on the answer sheets provided.

1. (a) Show the relationship between capital equipment build-up or scale-down in an open pit life-of-mine plan and three major stripping ratio-driven mining strategies. **[10 marks]**

   (b) Illustrate step by step the bottom-up bench and ramp design method of pit design. **[10 marks]**

2. (a) Explain the ore reserve and resource methodology employed in ex ZCCM Copperbelt open pit copper ore reserve systems, specifically define:
   i Fully developed reserves; **[3 marks]**
   ii Partly developed reserves; and **[3 marks]**
   iii Undeveloped reserves. **[3 marks]**

   (b) Demonstrate how the ultimate pit limits for an open pit are done manually. **[11 marks]**

3. (a) Illustrate the relationship between the progression of HIV/AIDS and its economic impact on the design and operation of surface mines. **[8 marks]**

   (b) Relate the major surface mining methods with the orebody characteristics favourable for surface mine design. **[12 marks]**

4. (a) Briefly describe the positive moving cone open pit optimisation technique. **[8 marks]**

   (b) Compute block column economic values, M_{ij}, and profit values, P_{ij}, from the ZMK net revenue values per block as provided in Table 1(a), and determine a Lerchs Grossman ultimate pit for a 1:1 slope. Positive net revenue values in this case also coincide with ore above cutoff

grade. Use Tables 1(b), (c) and (d), as may be necessary, for your calculations. **[12 marks]**

5. (a) Discuss open pit drainage and dewatering under the sub-headings:
   i Perimeter drainage; **[3 marks]**
   ii In-pit drainage and sump dewatering; and **[3 marks]**
   iii Strata groundwater control. **[3 marks]**

   (b) Demonstrate the computation of the number of trucks required for an open pit, making your own reasonable assumptions for various factors involved in the computation. **[11 marks]**

6. (a) Fig 1, appended, is a picture of Navachab Open Pit in Namibia. Identify three types of equipment shown in the picture, and describe their operating mechanisms. **[10 marks]**

   (b) Describe, as best as you can, the operations in progress from the details shown in the picture in Fig 1, and comment on the operational efficiency posture of the hauling equipment. **[10 marks]**

7. (a) Fig 2, appended, is a picture of Nchanga Open Pit at Chingola, Zambia. Label each feature of open pit geometry or equipment indicated by the ten arrows on that picture. **[10 marks]**

   (b) Explain the terminology used for each feature of open pit geometry and equipment labelled by the ten arrows in Fig 2. **[10 marks]**

Computer Number:.....

Table 1 (a): ZMK Net Revenue Values for 1:1 slope

				-10	-10	-10	10	50	-10	-10	-10	-10				
				-10	-10	-10	10	50	75	-10	-10	-10				
				-10	-10	-10	75	-10	200	-10	-10	-10				
				-10	-10	-10	150	-10	100	-10	-10	-10				
				-10	-10	-10	-10	-10	25	-10	-10	-10				

Table 1 (b)

Table 1 (c)

APPENDICES CONTINUED ON NEXT PAGE

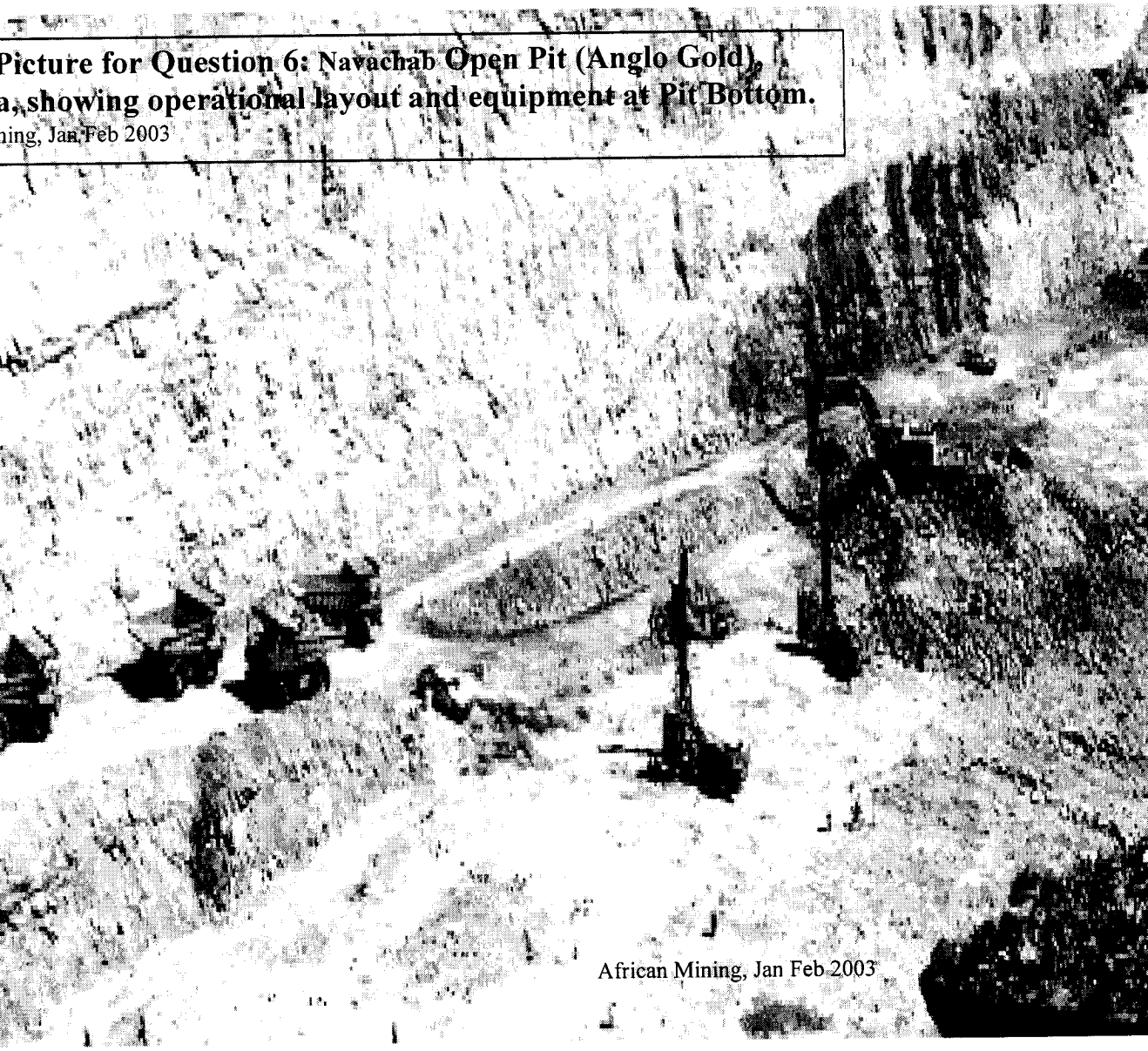
Computer number:.....

Table 1 (d)

APPENDICES CONTINUED ON NEXT PAGE

Picture for Question 6: Navachab Open Pit (Anglo Gold), a, showing operational layout and equipment at Pit Bottom.

ning, Jan Feb 2003



African Mining, Jan Feb 2003

Computer Number:.....

Fig 2 - Nchanga Open Pit, Chingola, Zambia – Pit 20 – North Wall – Mid 2003

END OF EXAMINATIONS – GOOD LUCK!

UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

END OF SEMESTER II EXAMINATIONS - JANUARY 2004

MI 475 - MINE ENVIRONMENT

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

ANSWER: FIVE (05) QUESTIONS, ALL THREE (03) QUESTIONS FROM SECTION A AND ANY TWO (02) FROM SECTION B.

SECTION A

QUESTION 1

a) Describe briefly 5 sources of heat in underground mines including its mode of transfer to mine air. Where appropriate explain with the help of equations.
[10 marks]

b) The diagrams show the vapor refrigeration system (Fig.1) and a modified vapor cycle for cooling mine air (Fig. 2).

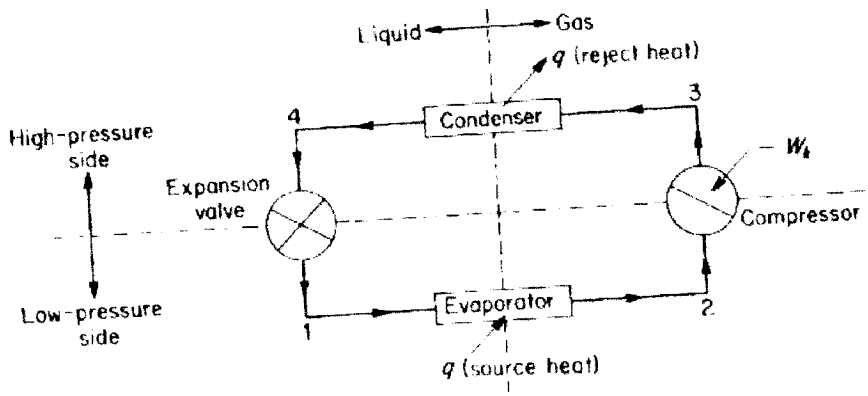


Fig.1. Schematic and block diagram of vapor refrigeration system using vapor cycle.

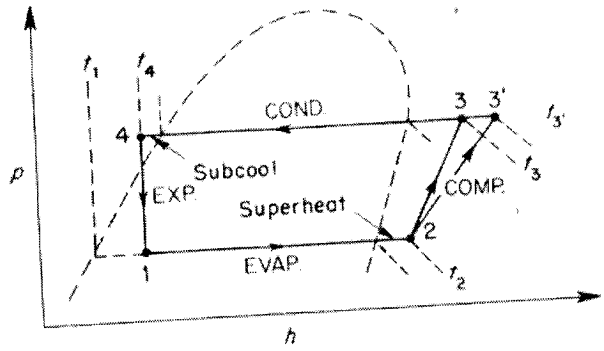


Fig. 2: Modified vapor cycle

(i) With reference to Fig.1, explain all the four (04) mechanisms of heat transfer taking place in a complete refrigeration cycle.

[8 marks]

(ii) Explain the purpose of allowing the refrigerant in the modified vapor cycle (Fig.2) to change slightly before undergoing pressure change.

[2 marks]

QUESTION 3

Fig.3 shows the performance characteristics of two fans connected in parallel on one shaft and the mine characteristics of three different air ways **A, B** and **C.**

a) With the help of a pencil or pen complete the graph by drawing the combined performance characteristic of the two fans.

[5 marks]

b) Show the operating points of each fan and indicate which region(s) will be economical for operating the two fans.

[5 marks]

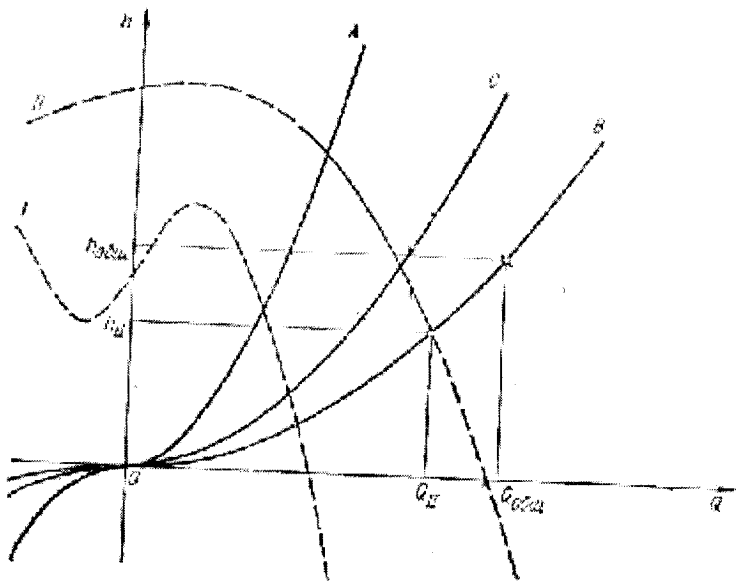


Fig. 3. Performance characteristics of two fans located on one shaft

c) Suppose the two fans are located in parallel on two different shafts as shown in diagram (Fig. 4) with mine characteristic **A≠B.** Explain with the help of a diagram how you would get the combined characteristic of the two fans.

[10 marks]

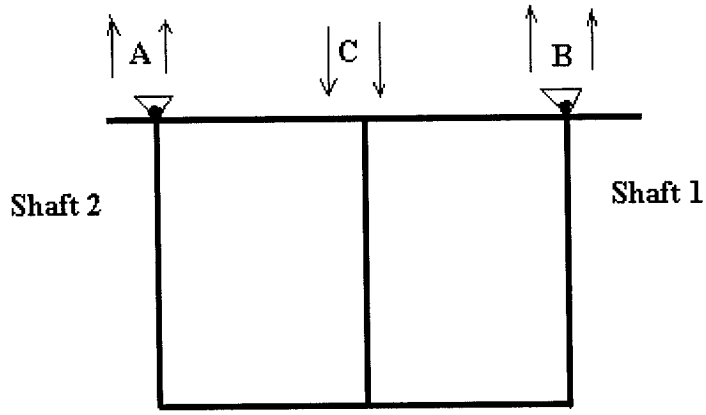


Fig 4. Location of two fans on two different shafts

QUESTION 3

Fig. 5. shows a typical mining ventilation system practiced at one of the mines in Europe.

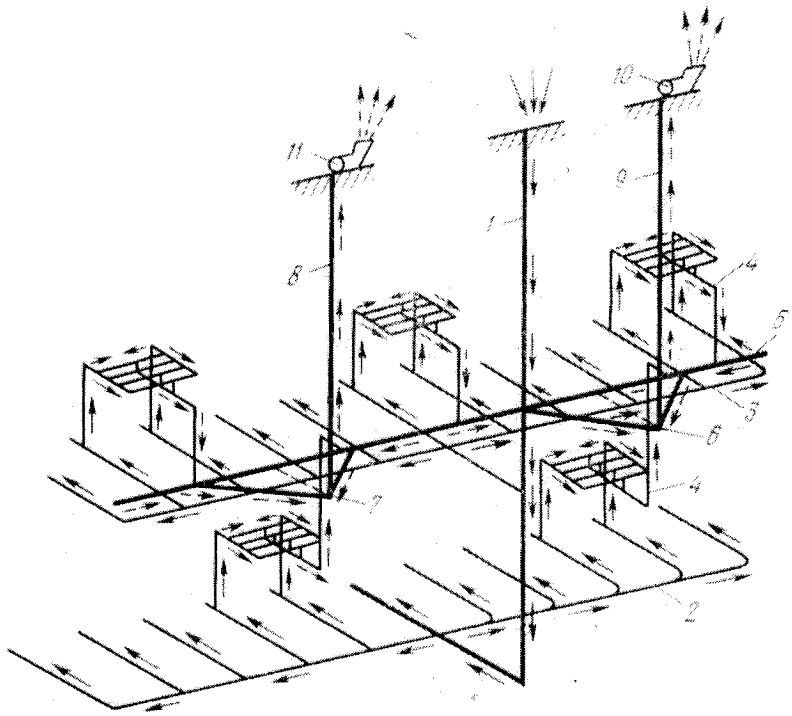


Fig.5. Mine ventilation system

a) Explain the advantages and disadvantages of using this type of mining ventilation system shown in Fig. 5.

[10 marks]

b) Give reasons why it is difficult to reverse air in this type of mine ventilation system.

[5 marks]

c) How would you handle fire accident happening in cross- cut No. 5 assuming that people are working in drift No. 4.

[5 marks]

SECTION B

QUESTION 1

(a) Distinguish between:

(i) Pollution and Pollutant **[3 marks]**
(ii) Rehabilitation and Restoration **[3 marks]**
(iii) Environmental Monitoring and Environmental Performance **[3 marks]**

(b) Why is it important to carry out an Environmental Impact Assessment (EIA) before commencement of mining operations? **[5 marks]**

(c) Discuss the basic elements of an Environmental Impact Assessment (EIA) document. **[6 marks]**

QUESTION 2

(a) Rehabilitation is an important phase during the life of a mine. Discuss the major rehabilitation procedures as applied to mining operations. **[8 marks]**

(b) Discuss the major factors to consider in mine planning taking into account environmental protection. **[6 marks]**

(c) Environmental monitoring and assessment is an important part in environmental protection. Discuss the importance of environmental monitoring in environmental protection. **[6 marks]**

QUESTION 3

(a) You are the general manager of a mining company called J&W in the Copperbelt and would like to carry out an environmental audit in your company. Discuss the approach you would take in conducting an environmental audit. **[8 marks]**

(b) At every stage during the life of a mine, the processes involved affect the environment quite extensively. Discuss the impacts on the environment of the following operations;

(i) Exploration **[3 marks]**
(ii) Mine site development **[3 marks]**
(iii) Ore extraction **[3 marks]**
(iv) Mineral dressing **[3 marks]**
(v) Metallurgical processing and refining **[3 marks]**
(vi) Mine closure **[3 marks]**

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
UNIVERSITY END SEMESTER II EXAMINATIONS – JANUARY 2004
MI 515 – ROCK MECHANICS II

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

INSTRUCTIONS:

(i) Answer question no. 1 and any other five; total questions to be answered six (06).
(ii) Neatly drawn and well labelled diagrams will get credit.

Q1.(a) Describe finite element modelling as used in mining, and comment briefly on the meaning of finite element major principal stress output below, for 'finger raises' at Nchanga block caving mine. (Figure attached) **(10 marks)**

(b) As the subject of rock mechanics has matured, there is a tendency to use instrumentation as a part of overall design and contruction control package. Under this background, describe the objectives of underground instrumentation before, during and after mining operations have ceased. **(10 marks)**

Q2. (a) (i) Explain what causes in-situ stress underground. Also, explain its significance for the underground excavation engineer. **(04 marks)**

(ii) Describe, with the help of diagrams, a method for the measurement of in-situ stress. **(04 marks)**

(b) A rectangular opening, 2.0 m high by 6.0 m wide in a bi-axial stress field is at 600 m depth. The uniaxial compressive strength and tensile strength of the rock in which the opening driven is 100 MPa and 10 MPa respectively. If the Stress Concentration Factor (S.C.F.) is 1.7 in compression and 0.7 in tension, and taking the average unit weight of rock equal to 26 kN/m^3, calculate the factor of safety for the opening and ~~component~~ comment on its stability. **(08 marks)**

Q3. Compute tangential, radial and shear stresses around a 6 m-diameter circular excavation 750 m below surface in a continuous homogenous isotropic linear elastic material at a point 9 m from the centre of the excavation, with an inclination of 45° to the major applied stress and a principal stress ratio of 0.6, using the Kirsch (1898) equations. **(16 marks)**

Q4. (a) What causes energy changes accompanying underground mining? Explain the consequences of such energy changes if any on mining. **(08 marks)**

(b) A 3.0 m horizontal orebody is located at a depth of 85 m with a rock cover having an average unit weight of 27 kN/m^3. It has been planned to mine with 6.0 m rooms and 8.0 m square pillars over the lower 2.5 m section.

Determine the factor of safety of the pillars against the compression failure. **(08 marks)**

Q5. (a) For the improvement of rock properties 'shortcrete' and 'rock reinforcement' techniques are gaining popularity. Explain clearly

(i) their supporting principles and
(ii) the situations under which they are most suited. **(4x2= 8 marks)**

(b) It has been decided to control movement of a section hillock using twenty five rockbolts. The specification of the section to be reinforced are given below:

- Volume of the rock block to be stabilized = 7,500 m^3
- Average density of rock = 25 kNm^{-3}
- Cohesive strength of the sliding surface (C) = 0.052 MPa
- Dip of sliding surface (ψ) = 47°
- Frictional angle of the sliding surface (Φ) = 22°
- Angle between the plunge of the bolt and normal to the sliding surface (θ) = 68°
- Recommended Factor of Safety = 1.60

Area of rock = 216 m^2

Determine ~~stress~~ tensim(T) on each rock bolt for the above situation. **(08 marks)**

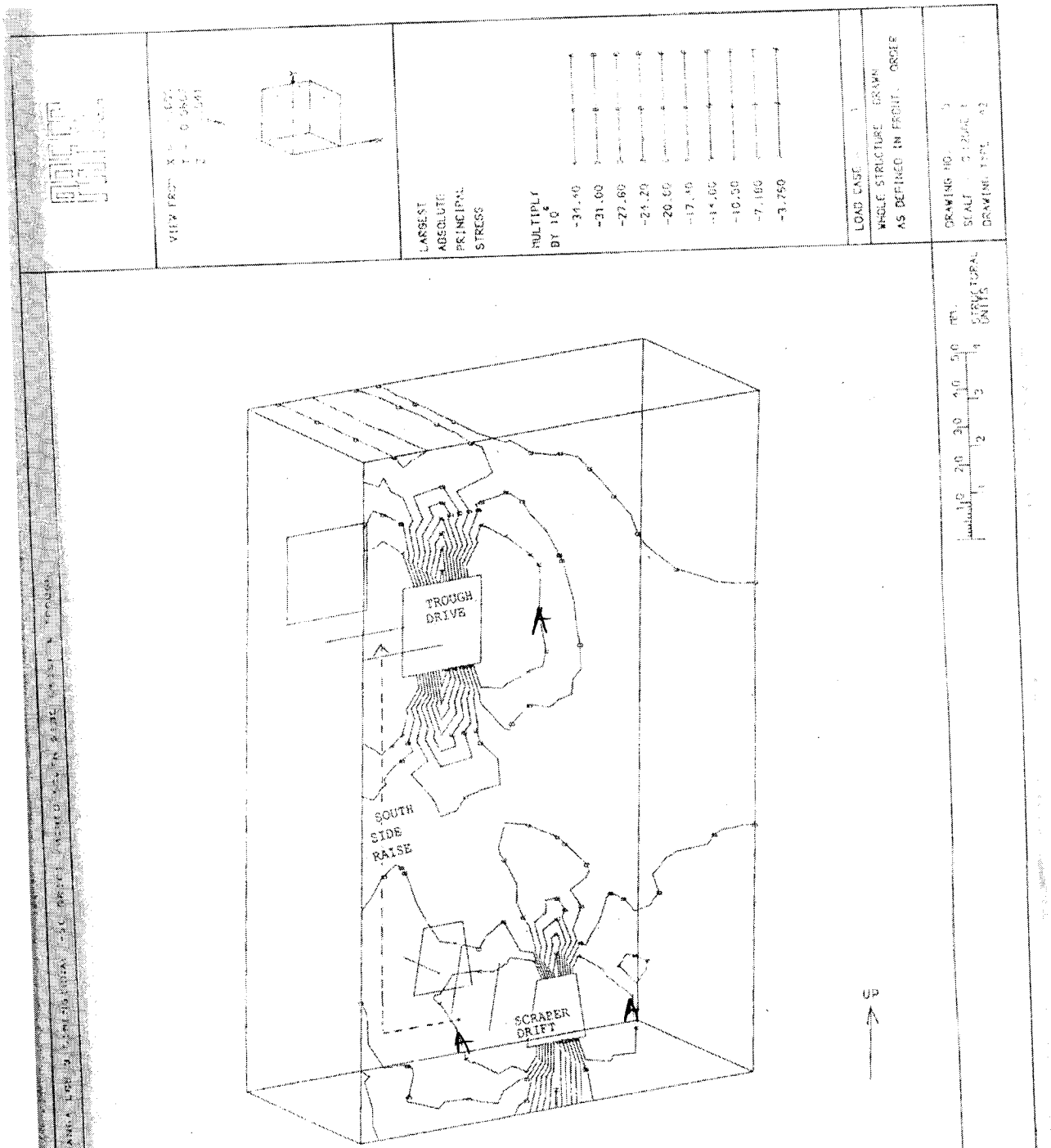
Q6.(a) Discuss mining induced subsidence with respect to type and development mechanism. **(08 marks)**

(b) Identify and describe the main factors in the composite mechanical strength behaviour of discontinuous rockmasses. **(08 marks)**

Q7.(a) Define and describe creep behaviour in isotropic rock, and comment on how this affects underground pillars. **(08 marks)**

(b) Illustrate the role of confining stress in attainment of brittle ductile transition, and comment on the significance of this process in underground support. **(08 marks)**

****** END OF EXAMINATION ******



(a) Major principal stress.

Fig.6.55 Nchanga:Mined 4.5m length scraper drift section, trough and south side raise, three dimensional-stress contours.

(ii)

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
UNIVERSITY END SEMESTER II EXAMINATIONS – JANUARY 2004
MI 535 – COAL MINING METHODS

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

INSTRUCTIONS:

Answer question no. 1 and any other five. Total questions to be answered six (06)

Q1. (a) Discuss, keeping in mind the requirements of the statute, what is meant by 'adequate ventilation'? **[8 marks]**

(b) There are certain preventive safety measures recommended in coal mining against danger from

(i) methane gas
(ii) coal dust and
(iii) water inundation in underground coal mining.

Discuss the above using diagrams where necessary. **[4x3=12 marks]**

Q2. Surface coal mining presupposes the existence of an accurately delineated coal formation and coal reserves on which to base mine design and determination of equipment type, sizes and layout for both overburden removal and coal extraction. Based on the above, write notes on the following methods of coal reserves estimation and 'stripping ratio' determination clearly stating and describing the various steps and information required:

a) Tonnes per Hectare Method **[4 marks]**
b) Isopach Maps **[4 marks]**
c) Computer Methods **[4 marks]**
d) Comment on the impacts of the Economic Stripping Ratio, Equipment Limitations and Mining or Barrier losses on the final minable reserves estimate. **[8 marks]**

Q3. With the aid of clear and illustrative sketches, write notes on the three methods of opening-up and development of a surface coal mine:

a) Area/Dragline Method **[5 marks]**
b) Modified Open Pit/Shovel-Truck Method **[5 marks]**
c) Block Area/Dozer-Scraper Method **[4 marks]**
d) State and explain the impacts of the following on the Area/Dragline Method:

i) Pit Length **[2 marks]**
ii) Pit Width **[2 marks]**
iii) Pit Orientation **[2 marks]**

Q4. Based on the following sub-headings, write brief notes on the two Continuous Surface Coal Mining Systems laying special emphasis on the differences in their mode of application and operation:

a) The two types of Continuous Surface Coal Mining Systems **[4 marks]**
b) Operation and performance determination of a Bucket Wheel Excavator (BWE) System **[6 marks]**
c) Merits and demerits of Continuous Surface Coal Mining Systems as Compared to Cyclic Surface Coal Mining Systems **[6 marks]**
d) Factors affecting the productivity of Continuous Surface Coal Mining Systems. **[4 marks]**

Q5. (a) A 3 m thick seam, free from dirt band and not known for spontaneous heating, lying at a depth of 200 m is to be mined. Above the deposit some important structures need to be protected from the serious damage due to mining subsidence if any. Describe a method for the extraction of such a deposit and show the arrangements to transport coal from the face to the surface. **[8 marks]**

(b) A coal seam 3.5 m thick over a plan area of 150 m x 150 m, at a depth of 300 m to be mined by room and pillar mining. Given that the strength of coal pillar equal to 20 MPa, unit weight of the overlying rock is 26 kN/m^3, the number of square shaped pillars equal to 12, compute the size of the pillar for a factor of safety 1.2 so that the pillar remains stable until the mining is over. **[8 marks]**

Q6. (a) (i) Describe the circumstances in which you would recommend the application of a longwall retreat system of mining.

(ii) A Double Ended Ranging Drum (DERD) shearer has been recommended for use on a longwall retreat face. Draw a layout showing arrangements of the equipment to extract coal. **[4x2 = 8 marks]**

(b) Calculate the monthly output (assuming 20 working days in a month) from a shearer face given:

- Length of the coal face = 250 m

- Web of shearer = 0.75 m
- Average cutting speed of the shearer = 2.5 m/min
- Number of coal cutting shifts/day = 3
- The time available for cutting coal is 60% of the 8 hour shift
- Specific gravity = 1.25

Express the answer in million tonnes. **[8 marks]**

Q7. (a) (i) A 10 m thick coal seam is to be mined using the 'false roof' system. Explain with the help of diagrams how such a seam can be mined. **[6 marks]**

(ii) Explain the difficulties and dangers associated with mining such a thick seam. **[2 marks]**

(b) What is known as 'horizon' method of mining? Explain briefly, using a simple layout (both in plan and section), for a seam 3 m thick dipping approximately at 20 degrees. **[8 marks]**

***** END OF EXAMINATION *****

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - JANUARY 2004

MM 332

CHEMICAL THERMODYNAMICS II

TIME: THREE HOURS

ANSWER: FIVE QUESTIONS

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1. At 2000 °K solid MgO which is a major source elemental Magnesium dissociates into gases products according to the reaction:

$$MgO\ (s) \quad \Leftrightarrow \quad Mg\ (g) + {}^{1}/_{2}\ O_2\ (g)$$

(a) Assuming that the system is initially composed of pure Mg0 [s] only, calculate the Partial pressure of Mg (g) and O_2 (g) at equilibrium at 2000°K.

(b) Find the partial pressure of 0_2 at equilibrium at 2000 °K if the system initially contains in addition to pure MgO (g), Mg (g) at 0.4 atmosphere. pressure.

$\Delta G^0 diss = 320{,}942$ J at 2000 °K

2. (a) Derive the expression for the lowering of the freezing point of a solvent due to the addition of a small amount of a non-volatile solute B. Assume that, there is no solid - solid solubility

(b) 0.320 gm of Oxygen causes a lowering of the melting point of 200 gm of Silver by 10° C. The solubility of oxygen in solid Silver may be neglected. Calculate the heat of fusion of Silver. Atomic weights : 0xygen O = 16; Silver Ag, = 108 gm, Melting point of pure Silver is 960 °C.
R= 8.31 J/mol.K

3. (a) For an ideal solution derive ΔV mix, Δ H mix, ΔS mix and ΔG mix.

(b) A solute obeys the following relation in dilute solutions; $f_B = kN_B^{\frac{3}{2}}$

Where N_B is the mole fraction of the solute. Derive the expression for the fugacity of the solvent f_A. Assume a binary solution.

4. A Container measuring V litres in Volume is divided into three unequal compartments that contain 1 g mole Helium gas, 2 g moles of Neon gas and 3 g moles of Argon gas. The initial temperature of the gases is 25^0C and 1.2 atmospheres. The gases are allowed to mix using the ideal principle under isothermal conditions. Calculate the following:

   (a) the Volume of the Container
   (b) the mole fraction of each gas in the mixture
   (c) the partial pressure of each gas in the mixture
   (d) the change in the Gibbs Energy of mixing G^M
   (e) the change in Entropy of mixing S^M sustained by the system.

5. The activity co-efficient of Zinc (Solute or component B) in Mercury (Solvent or Component A) was investigated at 25°C and was found to be represented by the following relation:

$$\gamma_B = 1 - 3.92N_B$$

   a. Derive the relationship for the activity coefficient γ_A for Mercury in this solution at 25°C .
   b. Everett et al investigated the activity of Zinc in liquid Copper - Zinc alloy in the temperature rang 1069-1303 ^{0}K. They found that the activity co- efficient for Zinc can be expressed as follows:

      $RT\ln\gamma_{Zn} = -31{,}630\ N^2_{Cu}$

      where R = 8.3143 J/mole. ^{o}K.

      Calculate the partial pressure of Zinc, P_{Zn} over a solution having the composition N_{Zn} = 0.4 and 0.6 at 1300° K. The vapour pressure of pure liquid Zinc is given as

      Log P^O_{Zn} = -6620/T - (1.255LogT) - 12.34 mm Hg.

   c. Using question (b), derive the expression for the relationship for the activity coefficient of Copper, in the Copper - Zinc alloy at 1300 ° K.

6. The emf of the cell Cd(l) | Cd^{2+} [in melt] | Cd – Pb (l, X_{Cd} = 0.128) is found to be 37.14 mV at 500^{0}C. The temperature coefficient of the cell emf is 99.1μ mV/^{0}K

   a. Find the G^M_{Cd} (= G_{Cd} - G^0_{Cd}) and S^M_{Cd} (= S_{Cd} - S^0_{Cd}) at 500 ^{0}C

   b. Determine the value of a_{Cd} in the alloy, relative to pure liquid Cd as the standard state.

   c. Calculate the vapour pressure over the Cd – Pb alloy given that the vapour pressure of pure liquid Cd is 13.5 Torr at 500 ^{0}C and ascertain whether the Cd – Pb system at X_{Cd} = 0.128 exhibit a positive or negative deviation from Raoult's law.

d. In electrolysis of primary products, the amount of material W in grams produce in passing a current of I amperes in a period of t seconds for a substance with atomic weight A and valence n is given by

$W = ItA/nF$

An important parameter this process is the so called current efficiency which is defined as the percentage of the total quantity of electricity passing through the cell that is actually utilized in the production of the electrolyte. Thi is designed as CE = Actual weight of material produced divided by the theoretical amounts estimated. In the industrial production of Alumnium using the Hall-Heroult cell working at 40,000 amps, 275 kg of pure Aluminium is produced per day. Calculate the Current Efficiency CE.

The half reaction is given as $\mathbf{2Al_2O_3 \Leftrightarrow 2\ Al^{3+} + 2\ AlO^{-3}}$

7..a. Discuss the role of following on the velocity of a chemical reaction.

i. The nature of reactants and products

ii. Temperature of the reaction

iii. Concentration of both reactants and products

iv. Presence of catalysts

b. Explain in detail, how the **collision theory** differs from the **theory of absolute rates.**

c. The concentration of Sulphur in pig iron after desulphurisation with basic slag at 1470^0 C at various intervals of time is a follows below as :

Time [Min]	0	9	20	40	64
Concs of Sulphur Kg/m^2	87.1	57.4	30.2	10.0	2.75

Show that the desulphurisation is a first order reaction and determine the half-life for this process.

END OF EXAMINATION IN MM332

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – JANUARY 2004

MM 412

MINERAL PROCESSING II

TIME: 3 HOURS

ANSWER: **Question 3** and any **other 4**, but keep your answers brief. Relative weight of each question indicated in brackets.

Question 1

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

- the wash ratio in filter cake washing
- surfactant
- pulp dilution
- differential flotation
- solids-handling capacity of the thickener
- surface active agent
- magnetic susceptibility
- electrical double-layer
- micelles
- physical adsorption

[20 %]

Question 2

(a) Explain briefly, but clearly, why heavy medium separation in a gravitational vessel can be used only to separate relatively large particles, or minerals with a large difference in density, even though in theory any particle with a density larger than the medium density should sink, and any particle with a density lower than the medium should float.

(b) What are the main factors determining whether the feed particle is rejected, held in the bed, or passed down through in jigging?

(c) Outline the usual sequence of operation in the heavy media separation process.

(d) What are the main requirements for a medium to be used in heavy media separation?

Explain your answer briefly, but clearly.

(e) Draw a simplified flowsheet of a heavy media separation plant, using a cone separator and ferrosilicon as medium, and show how the medium is recovered.

Explain your flowsheet in a few words.

(f) What are the main applications of heavy media separation? **[20 %]**

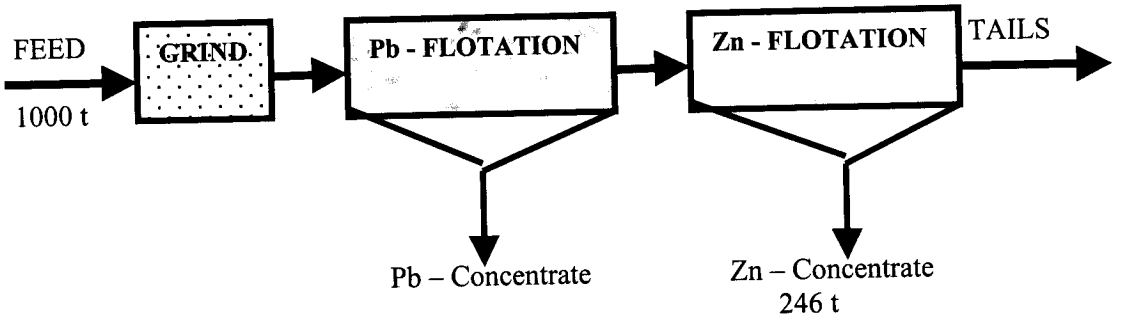
Question 3

(a) Describe the operation of a column flotation cell with the aid of a clearly labelled diagram indicating the various zones that can be distinguished.

Usually, the column is operated at a positive bias. What does this mean?

What advantages flotation columns appear to have over the conventional cells?

(b) Given below, is the flotation circuit of a lead-zinc ore, which produces a lead concentrate, a zinc concentrate and a zinc tailings as follows:



Product	Weight (t)	Assay (%)		Weight (t)		Recovery (%)	
		Pb	Zn	Pb	Zn	Pb	Zn
Feed	1000	10.0	12.8	-	-		
Pb-cons	-	50.0	-	-	-	-	-
Zn-cons	246	1.6	26.0	-	-	-	-
Zn-tailing	-	1.0	5.6	-	-	-	-

Complete the above metallurgical balance for one shift, during which 1000 tonnes of this ore were treated.

[20 %]

Question 4

(a) It is given that a complex sulphide ore contains pyrite, galena, sphalerite, bornite and chalcopyrite, and that its treatment by froth flotation yields three concentrates: a lead concentrate, a zinc concentrate and a copper concentrate.

The main reagents used in this flotation process are:

- copper sulphate
- lime
- sodium cyanide
- sodium di-chromate
- sodium iso-propyl xanthate
- tri-ethoxy butane

(i) State briefly what the function would be of each of the above reagents in this flotation process.

(ii) Draw a simplified flowsheet for this flotation process, showing its main stages, and indicate in the flowsheet where you would add each of the above reagents (some reagents may be added at more than one addition point).

Indicate the principal mineral composition of each of the products, obtained with this flowsheet.

(b) Describe the down stream method of tailings-dam construction with the aid of a clearly labelled diagram. Outline the advantages and disadvantage of this method.

What are the most serious problems associated with the disposal of tailings and how are they minimised?

[20 %]

Question 5

(a) Give an equation that expresses the 'area principle' in sedimentation, state what the symbols used in this expression represent, and explain this principle in a few a words.

(b) Which operations and what equipment used in mineral processing are based upon this area principle?

(c) The main design parameters of a gravity thickener are its surface area and its depth. What quality is controlled by the surface area and what quality the depth controls? Explain your answers briefly.

(d) What are the functions of the rakes in a gravity thickener? What circumstances would necessitate raising of the rakes?

(e) What circumstances would necessitate re-circulation of the thickener underflow? Explain briefly for each case why this re-circulation is necessary.

(f) Describe briefly and in simple terms the differences between 'coagulation' and 'flocculation'.

(g) Discuss, very briefly the effects of (i) solid concentration (ii) pulp temperature and (iii) flocculant doserate, upon coagulation and flocculation.

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Question 6

(a) Give a brief discussion on the separation of minerals by electrostatic separation and by electrodynamic (high-tension) separation.

Briefly describe the basic principles involved and the main types of equipment in use. Illustrate with rough diagrams.

(b) What is the characteristic difference in the size distribution in the products obtained by these two types of equipment? Explain briefly but clearly.

(c) Name two typical 'conducting' minerals and two 'non-conducting' minerals that are commonly separated by high-tension separation.

(d) A zinc-lead sulphide ore, assaying 12.6 % PbS and 17.4 % ZnS, is treated by flotation.

With the assumption that the only minerals in the ore are galena, sphalerite and silicate gangue, calculate:

(i) the theoretically possible recoveries of gn and of sl after six minutes flotation;

(ii) the theoretical concentrate grade (% PbS and % ZnS) and after two minutes flotation.

The specific rates of flotation under the conditions chosen were found to be:

galena	0.6 min^{-1}
sphalerite	0.1 min^{-1}
water	0.05 min^{-1}
silicates	0.02 min^{-1}

You may assume flotation to be first-order and these flotation rates to remain constant during the flotation times considered. You may also assume all the gn and sl to be floatable under the conditions chosen.

[20 %]

- END OF MM 412 EXAMINATION –
GOOD LUCK !

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[20 %]

- END OF MM 412 EXAMINATION –
GOOD LUCK !

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - JANUARY 2004

MM 415

MINERAL PROCESSING

TIME : THREE HOURS

ANSWER: FIVE QUESTIONS **(QUESTIONS 2 AND 6 ARE COMPULSARY)**

---

1. Define the following terminologies as used in Mineral Processing:

- Minerals
- Run – of – Mine [ROM] Ore
- Ratio of concentration
- Middlings fraction
- Reverse flotation
- Liberation
- 80% passing reduction ratio
- Pulp density
- Hindered settling

2 a. Give the definition **of Bond's Work Index.**

b. Show mathematically how Bond's hypotheses on energy consumption during crushing or grinding of an ore are related to the hypotheses of Kick and von Rittinger.

c. A feed of 80% passing 1600μm. This size reduction required 3kwh per tonne feed. What is the work index of this operation? What would be the energy required to reduce this material from a feed size of 1600μm to a product size of 75μm in the same mill.

3 a. Write short but clear notes of reasonable length on:

i. Jaw Crusher

ii. Gyratory Crusher

iii. Cone Crusher

What are the main differences of these crushers in terms of operation, construction and capacity?

b. What are mill liners, and what are their main functions?

a. Draw a circle representing a cross – section through a ball mill in operation, and indicate in which zone grinding is effected mainly by **abrasion** and in which zone is affected mainly by **impact**. Indicate the direction of rotation of the mill. Describe how grinding in a ball will take place and explain the effect of mill speed upon the sizing of the product.

b. What do you understand by open – and closed circuit grinding. Show this by simple flowsheets.

c. What are the main advantages of hydrocyclones over mechanical Classifiers? Briefly describe the efficiency of a cydone.

d. What is jigging and what are its main applications? Name and describe some that are in use.

e. What are the main requirements of the solid particles to be used as a medium in heavy media cyclones? Explain briefly.

5. a. What is flotation? Briefly describe the uses of the following reagents in flotation:

i. collectors
ii. frothers
iii. regulators

b. What do you understand by **scavenger circuit** and **cleaner circuit?**
c. What do you understand by "reverse" flotation?

d. Describe the process of flolation of oxidized copper ores as originally practised at Nchanga Copper Mine. Draw a flowsheet.

6. a. The cydone overflow line is instrumented with a magnetic flow meter and a nuclear density gauge, and the mass of dry ore fed to flolation is 30 t/h. The feed from the fine ore bin is sampled, and is found to contain 7% moisture. The cyclone feed contain 35% solids, cyclone underflow 60% solids, and the overflow 20% solids

Calculate.

i. the circulating load in the circuit,

ii. the amount of water required to dilute the ball mill discharge and

iii. show the operating flowsheet

b. Describe the three dewatering methods used in mineral processing to reduce the quantity of water in the concentrate. Give advantage of each method.

c. Briefly describe the construction of tailing dumps by the upstream and downstream methods. Give advantages of each method.

END OF EXAMINATION IN MM 415

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - JANUARY 2004

MM422

PHYSICAL METALLURGY II

ME: THREE HOURS

NSWER: ALL THE QUESTIONS

Discuss the validity of the following statements, in each case explaining your reasoning.

(a) An electron diffraction pattern is a reciprocal lattice in reciprocal space representation of a real lattice in real space.
(b) Steels with fine grain sizes tend to have lower ductile-brittle transition temperatures
(c) Mechanisms of creep are always detrimental.
(d) Martensitic transformations can occur in non-ferrous materials as well.
(e) During stress corrosion cracking, there is very little overall corrosion.

(a) Why is annealing such an important process?
(b) Briefly, describe the processes taking place during annealing.
(c) Why are Al-Cu alloys capable of being strengthened by precipitation hardening? Your answer should include Orowan's model for fine particle strengthening.
(d) During precipitation hardening it is essential that after solutioning, an alloy is quenched before ageing. Describe why quenching is so crucial in this case.

(a) Why is it crucial for structures to be designed in such a way that the stress intensity factor K_I is below K_{IC}?
(b) How would you use K_{IC} to determine the crack size that a particular structure would tolerate without fracture?
(c) An aluminium alloy plate has a Young's modulus of 70 GPa and a centrally located through thickness crack of length 10 mm. If the plane strain fracture toughness of the alloy is 63 MPa $m^{½}$ and Poisson's ratio is 0.33, determine
  (i) The critical stress at which the crack starts to grow when the plate is thick enough to fail by plane strain.
  (ii) The critical stress at which the crack will grow when the plate is thin and fails under plane stress.
  (iii) The crack extension force for plane strain failure.
  (iv) The crack extension force for plane stress failure.

$$K_I = \sigma\sqrt{\pi a} = \sqrt{GE}$$

$$K_I = \sqrt{\frac{GE}{1-\upsilon^2}}$$

(a) List five types of information that can be obtained from electron diffraction patterns.
(b) Specimens for electron diffraction studies are usually only 1000-5000Å thick. Why do you think it is so important for these specimens to have a very low thickness? In your opinion, what limitation does such a low specimen thickness impose on the observation of some microstructural features?
(c) A diffraction pattern from a non-primitive cubic material is shown in Figure1.
    (i) Index the pattern.
    (ii) What is the crystal structure of the material?
    (iii) What is the beam direction?

(a) Why are alloying elements added to steels?
(b) State four ways by which alloying elements are utilised when added to steel.
(c) For an fcc→hcp martensitic transformation in cobalt, the following orientation relationship has been reported

$$(111)_\gamma \parallel (0001)_{\alpha'}$$

$$\left[\bar{1}10\right]_\gamma \parallel \left[11\bar{2}0\right]_{\alpha'}$$

where α' designates martensite. What does this orientation relationship indicate about the martensitic transformation in cobalt?

(d) Two Jominy curves, for steels A and B, are given in Figure 2. With an explanation of your reasoning, indicate:
    (i) which steel has a higher hardenability, A or B?
    (ii) which would probably be better for use in knife blades?
    (iii) which has more uniform strength?

END OF EXAMINATION IN MM422

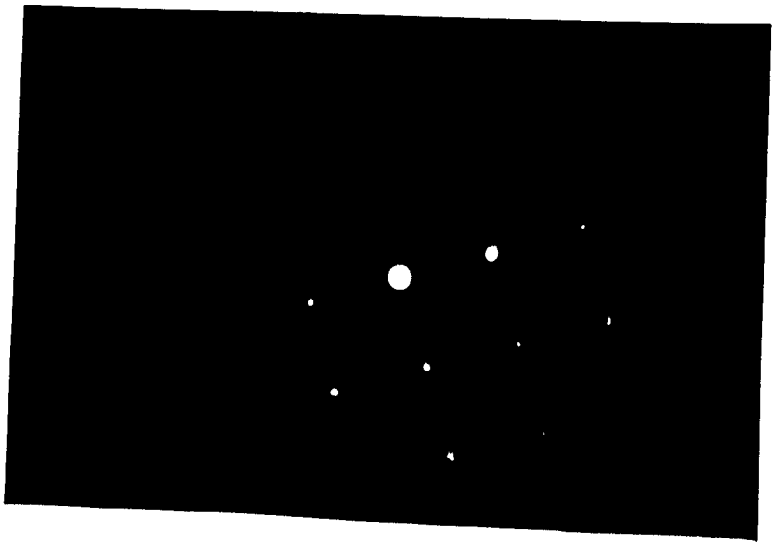
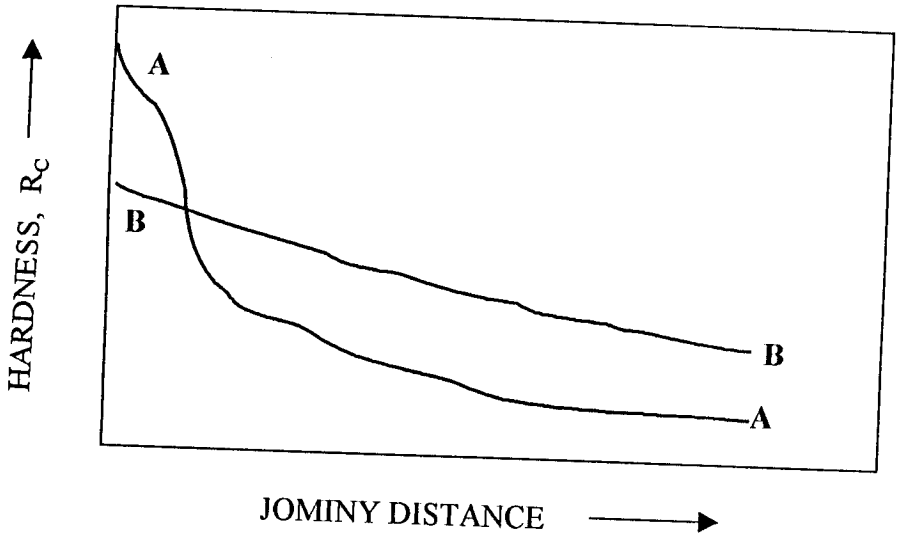


Figure 1



Angles between crystallographic planes (and between crystallographic directions) in crystals of the cubic system [After Barrett (1971)]

{*hkl*}	Values of angles between *HKL* and *hkl* planes (or directions)						
100	0°	90°					
110	45°	90°					
111	54°44′						
210	26°34′	63°26′	90°				
211	35°16′	65°54′					
221	48°11′	70°32′					
310	18°26′	71°34′	90°				
311	25°14′	72°27′					
320	33°41′	56°19′	90°				
321	36°42′	57°41′	74°30′				
110	0°	60°	90°				
111	35°16′	90°					
210	18°26′	50°46′	71°34′				
211	30°	54°44′	73°13′	90°			
221	19°28′	45°	76°22′	90°			
310	26°34′	47°52′	63°26′	77°5			
311	31°29′	64°46′	90°				
320	11°19′	53°58′	66°54′	78°41′			
321	19°6′	40°54′	55°28′	67°48′	79°6′		
111	0°	70°32′					
210	39°14′	75°2′					
211	19°28′	61°52′	90°				
221	15°48′	54°44′	78°54′				
310	43°6′	68°35′					
311	29°30′	58°31′	79°59′				
320	36°49′	80°47′					
321	22°12′	51°53′	72°1′	90°			
210	0°	36°52′	53°8′	66°25′	78°28′	90°	
211	24°6′	43°5′	56°47′	79°29′	90°		
221	26°34′	41°49′	53°24′	63°26′	72°39′	90°	
310	8°8′	31°57′	45°	64°54′	73°34′	81°52′	
311	19°17′	47°36′	66°8′	82°15′			
320	7°7′	29°45′	41°55′	60°15′	68°9′	75°38′	82°53′
321	17°1′	33°13′	53°18′	61°26′	68°59′	83°8′	90°
211	0°	33°33′	48°11′	60°	70°32′	80°24′	
221	17°43′	35°16′	47°7′	65°54′	74°12′	82°12′	
310	25°21′	49°48′	58°55′	75°2′	82°35′		
311	10°1′	42°24′	60°30′	75°45′	90°		
320	25°4′	37°37′	55°33′	63°5′	83°30′		
321	10°54′	29°12′	40°12′	49°6′	56°56′		
	70°54′	77°24′	83°44′	90°			
221	0°	27°16′	38°57′	63°37′	83°37′	90°	
310	32°31′	42°27′	58°12′	65°4′	83°57′		
311	25°14′	45°17′	59°50′	72°27′	84°14′		
320	22°24′	42°18′	49°40′	68°18′	79°21′	84°42′	
321	11°29′	27°1′	36°42′	57°41′	63°33′	74°30′	
	79°44′	84°53′					

Cubic					Hexagonal	
	hkl					
$h^2+k^2+l^2$	Simple	Face-centered	Body-centered	Diamond	h^2+hk+k^2	hk
1	100				1	10
2	110	. . .	110		2	
3	111	111	. . .	111	3	11
4	200	200	200		4	20
5	210				5	
6	211	. . .	211		6	
7					7	21
8	220	220	220	220	8	
9	300, 221				9	30
10	310	. . .	310		10	
11	311	311	. . .	311	11	
12	222	222	222		12	22
13	320				13	31
14	321	. . .	321		14	
15					15	
16	400	400	400	400	16	40
17	410, 322				17	
18	411, 330	. . .	411, 330		18	
19	331	331	. . .	331	19	32
20	420	420	420		20	
21	421				21	41
22	332	. . .	332		22	
23					23	
24	422	422	422	422	24	
25	500, 430				25	50
26	510, 431	. . .	510, 431		26	
27	511, 333	511, 333	. . .	511, 333	27	33
28					28	42
29	520, 432				29	
30	521	. . .	521		30	
31					31	51
32	440	440	440	440	32	
33	522, 441				33	
34	530, 433	. . .	530, 433		34	
35	531	531	. . .	531	35	
36	600, 442	600, 442	600, 442		36	60
37	610				37	43
38	611, 532	. . .	611, 532		38	
39					39	52
40	620	620	620	620	40	
41	621, 540, 443				41	
42	541	. . .	541		42	
43	533	533	. . .	533	43	61
44	622	622	622		44	
45	630, 542				45	
46	631	. . .	631		46	
47					47	
48	444	444	444	444	48	44
49	700, 632				49	70, 53

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - JANUARY 2004

MM 442

HYDROMETALLURGY

TIME: THREE HOURS

ANSWER: ALL QUESTIONS

1(a) Use the data given below to draw a Pourbaix diagram (not necessarily to scale, but derive and indicate values of all important points) showing conditions for the thermodynamic stability and decomposition of water at 25 °C and 1 atmosphere pressure. (7%)

b) Derive and indicate on the same diagram the condition of neutrality of water from the oxidation-reduction point of view at 25 °C and hence label on the diagram, regions representing the following leachants: (7%)

(i) acidic and oxidizing, (ii) acidic and reducing, (iii) alkaline and oxidizing, and (iv) alkaline and reducing.

Data:

R = 8.314 J/K/mol; F = 96500 C/mol

$2H^+ + 2e^- = H_{2(g)}$ $E° = 0$ V

$O_{2(g)} + 4H^+ + 4e^- = 2H_2O$ $E° = 1.228$ V

c) Explain why the leaching of uranium ores uses acidic and oxidizing conditions, but not reductive or chemical dissolution in acidic media. (6%)

2(a) You are required to investigate the removal of some species from an aqueous solution using activated carbon, list the factors that you would consider that would have a possible effect on the effectiveness of the process. (4%)

b) Explain, briefly, how activated carbon adsorbs species from fluids. (5%)

c) In a pilot plant study to determine the feasibility of using ion exchange for nickel recovery from a dump leaching operation, a 6 m^3 column of the resin XF 4196 is used. After the resin in the column is substantially loaded, it is stripped with a solute-free regenerant. If the data obtained in the elution tests is as shown in the table below:

(i) Plot an elution curve for the process. (4%)

(ii) Estimate the mass of Ni eluted in the first 5 bed volumes of eluate. (7%)

Bed volumes eluate	1	2	4	6	7	8	9	10
g/l Ni in eluate	0.03	0.1	0.24	0.22	0.1	0.02	0	0

3(a) Distinguish the terms, "crystallization", "chemical precipitation", and "cementation". (6%)

b) In the hydrometallurgy of cobalt, copper, zinc, and nickel, iron is precipitated as ferric hydroxide and not as ferrous hydroxide. Why? (4%)

c) What is the limiting equilibrium residual nickel ion activity for Ni precipitation from aqueous solution (pH = 5.6, temperature = 250 °C) with hydrogen gas at 30 atmospheres? Keeping pH and temperature the same, what would be the effect of increasing the hydrogen gas pressure on residual nickel in solution? (10%)

$Ni^{2+} + 2e^- = Ni$ $\quad E° = -0.25$ V

$2H^+ + 2e^- = H_{2(g)}$ $\quad E° = 0$ V

4(a) As used in solvent extraction, what are tertiary amine extractants? (2%)

b) Using, as an example, the extraction of either cobalt in acid chloride solution or uranium in acid sulphate solution, explain how tertiary amine extractants accomplish metal extraction. (4%)

c) For a tertiary amine loaded with cobalt or uranium, explain how the amine would be regenerated. (4%)

d) A solvent with a chelating extractant has 3.48 g/l copper loaded in it. Portions of this organic phase are equilibrated with different volumes of a 180 g/l sulphuric acid solution. Data obtained pertaining to these equilibrium experiments is shown below.

Phase ratio, V_O/V_A	20/1	10/1	5/1	2/1	1/1	1/2	1/5	1/10
Stripped organic (g/l Cu)	1.88	1.48	1.21	1.01	0.92	0.91	0.84	0.83
Concentrated aqueous (g/l Cu)	57.0	45.7	37.3	30.0	27.3	26.6	25.6	25.4

(i) Construct an equilibrium stripping isotherm for the loaded solvent using the data given. (4%)

(ii) A continuous counter-current operation is to be used for stripping copper from loaded organic with the same composition as that used in the equilibration tests described above (i.e. with 3.48 g/l Cu). It is anticipated that a spent electrowinning electrolyte entering stripping will have 25.2 g/l Cu and 180 g/l H_2SO_4. Answer the following, assuming an organic to aqueous volumetric flowrate ratio of 10;

- What will be the copper content of the aqueous concentrate (advance electrolyte) produced? (2%)

- Predict the minimum number of ideal stages which will be required for such an operation for the final stripped organic to have less than 1.19 g/l Cu. (4%)

5(a) What is the function of the liberator circuit in a copper electrorefining tankhouse?(3%)

b) When copper electrorefining is done at a high current density of 400 A/m^2 (DC) some problems occur at the anodes and cathodes. When the same process is carried out with periodic current reversal, such problems do not arise. Explain why? (6%)

c) Starting sheets each with a submerged cross section of 95 cm X 95 cm are used in a copper electrolytic refining process. The potential drop between anodes and cathodes is maintained at 0.25 V while the average DC current density used is 200 A/m^2.

(i) At a current efficiency of 92%, calculate the time (in hours) required to deposit 100 kg of copper per starting sheet placed between two anodes. (7%)

(ii) Compute the energy required in kWh to electrorefine 1 kg of copper. (4%)

Data: Relative atomic weight of Cu = 63.5; F = 96500 C/mol

END OF EXAMINATION IN MM 442

THE UNIV ERSITY OF ZAMBIA

UNIVERSITY EXAMINATION – JANUARY, 2004

MM 542

FUELS, FURNACES AND REFRACTORIES

TIME: THREE HOURS

ANSWER: ALL QUESTIONS

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1. (a) What are the four factors that affect the temperature attained in the combustion of a fuel? [2%]

(b) Describe three assumptions considered in the determination of an ideal flame temperature of a fuel. [3%]

(c) Calculate the ideal flame temperature for the combustion of 1 m^3 of Producer gas at 20°C. The overall reaction is as follows expressed in litres. [6%]

$$120\ H_2 + 290\ CO + 25\ CH_4 + 4C_3H_8 + 272\ O_2 + 40CO_2 +$$

$$520N_2 = 186\ H_2O + 367\ CO_2 + 1554\ N_2$$

ΔH = 5,651 KJ/ m^3

Gas	**Specific heat (Cp) J/g °C**	**Molecular weights g/mol**
H_2	13.6	2
CO	1.21	28
CH_4	3.67	16
C_3H_8	3.77	44
H_2O	2.18	18
CO_2	1.42	44
N_2	1.19	28

1 mole of gas occupies 22.4 litres at STP.

(d) If in (c) above the gas had to be preheated to 800 °C, what would the adiabatic flame temperature be? [9%]

2. (a) Outline five sources of gaseous fuels. Describe the manufacture of producer and water gas. [6.5%]

(b) What is meant by 'carbonisation' of coal and what is the main objective of this process? [3.5%]

(c) Name two factors that contribute to spontaneous combustion of stored coal. How can coal be stored safely? [6%]

(d) Describe the four ingredients that are determined in 'proximate' analysis of coal. [4%]

3. (a) Name two faults that casually-made dolomite bricks suffer from. [4%]

(b) What are the three stabilization procedures associated with the manufacture of dolomite bricks. [6%]

(c) Why is lime (CaO) not used as a refractory? [2%]

(d) Write a reaction for the formation of doloma. [2%]

(e) Describe the manufacture of 'Fired stabilized dolomite bricks' [6%]

4. (a) Some of the important properties of refractory materials which directly determine their ability to withstand destructive factors during service are:

(i) Refractoriness [4%]
(ii) Thermal shock or spalling resistance and [4%]
(iii) Slag resistance [4%]

Describe how these are determined.

(b) Describe the Alumino-silicate refractories using the phase diagram shown in Figure 1 with reference to:

(i) Siliceous firebrick of 25% Al_2O_3 at 1545°C [2%]
(ii) Siliceous firebrick (25%) above 1545°C [2%]
(iii) Brick containing 45% Al_2O_3 at 1545°C [2%]
(iv) Mullite brick [2%]

5. (a) Describe the main factors that are considered in furnace construction [5%]

(b) Give a description and example of shaft furnaces. [5%]

(c) Converters are mainly used in the processing of copper and steel. Describe briefly the processes in which they are used in each case. [10%]

END OF EXAMINATION IN MM 542

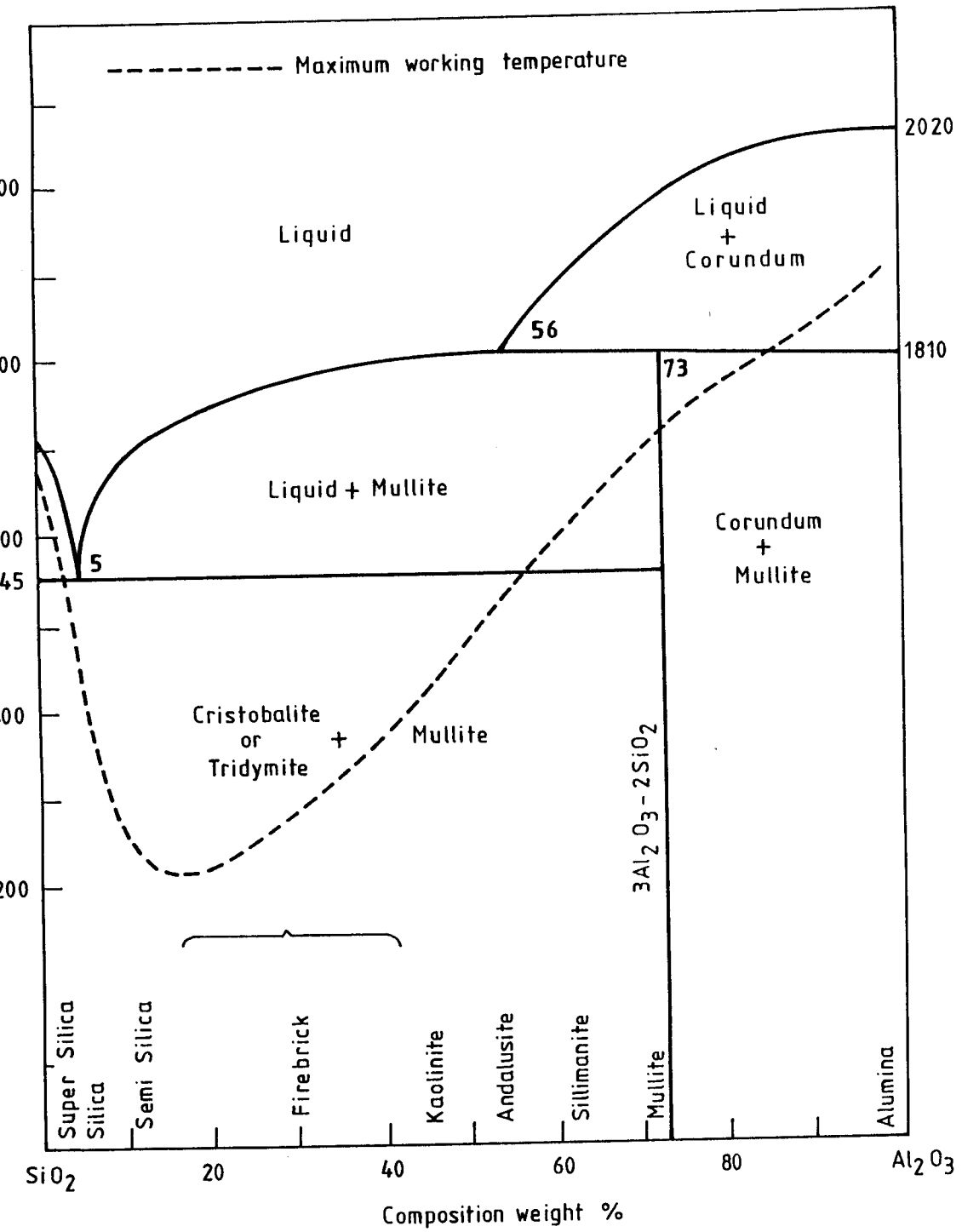

Fig. 1 The Al_2O_3 - SiO_2 equilibrium diagram (after Bowen and Greig) indicating the compositions of various kinds of brick based on the system, and their approximate maximum working temperatures which depend also on other aspects of composition

UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - JANUARY 2004

MM 552

PROCESS DESIGN

TIME : **THREE HOURS**

ANSWER: **FIVE QUESTIONS**
All additional data that the student will require are attached.
All questions carry equal marks

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1. (i) Comment briefly on the significance of design variables in process design.

(ii) For the following, determine the number of design variables and how they may be utilised:
(a) a pump,
(b) a total condenser.

(iii) A pyrite ore is reduced with hydrogen. The ore contains 10 per cent w/w solid inerts (gangue). Twenty per cent excess H_2 is used, and the cinder (solid residue) remaining contains 5 per cent w/w FeS_2. The reduction reaction is

$$FeS_2 + 2H_2 \rightarrow Fe + 2H_2S$$

On the basis of 100 kg of ore charged, calculate the volume of furnace gases in m^3 at 400^0C and 101.325 kPa.
Atomic weights : Fe, 55.85; S, 32; H, 1.
The gas constant R = 8.314 kJ/kmol.K

2. (i) In the calcining of $CaCO_3$, find C (the number of components) to use in material balance calculations. How many independent balances would there be if all the CaO and CO_2 came from the decomposition of $CaCO_3$?

(ii) A bituminous coal contains:

Carbon	73.60 % w/w	Oxygen	10.00
Hydrogen	7.30	Moisture	0.60
Nitrogen	1.7	Ash	6.05
Sulphur	0.75		

It is powdered and blown into a cement kiln by a blast of air. For one kilogramme of the coal, calculate the volume of the products of combustion in m^3 using 25 % excess air at 200^0C and 101.325 kPa pressure. Determine the mole percentage composition of the products of combustion.
Atomic masses: C, 12; H, 1; N, 14; S, 32; O, 16.
The gas constant R = 8.314 kJ/kmol.K

3. In a sulphuric acid plant, the gas stream leaving the last converter stage goes to an absorption column in which 96 percent v/v of SO_3 is absorbed into 75 wt % H_2SO_4 to generate 98 wt % H_2SO_4 solution. Part of the concentrated H_2SO_4 is diluted with water (H_2O) to generate 75 weight percent H_2SO_4 which is recycled to the column. The absorption reaction is

$$SO_3 + H_2O \rightarrow H_2SO_4$$

The composition of the absorber feed gas is

SO_2	= 0.65 mole %
SO_3	= 7.52 mole %
O_2	= 2.02 mole %
N_2	= 89.81 mole %

For 1 ton per hour of 98 wt % H_2SO_4 produced, calculate

(i) the flow rate of 75 wt % H_2SO_4 to the absorber in kg/h,

(ii) the flow rate of 98 wt % H_2SO_4 from the absorber in kg/h,

(iii) the composition of the exit gases in mole percent. Assume these gases are dry.

A flow diagram of the process is provided with this examination paper.

Atomic weights: H, 1; O, 16; N, 14; S, 32.

Hint: Start with a basis of 100 moles of absorber feed gas.

4. A furnace burns a liquid coal tar for fuel derived from coke ovens. Calculate the heat transferred in the furnace in kJ/kg fuel, if the combustion gases leave the furnace at 1500K (2200^0F). The burners operate with 25 percent excess air with an average heat capacity of 28.9 kJ/kmol.K. Take the fuel supply temperature as 323K and the air inlet temperature as 288K. For the product gases, use the heat capacity data provided in the given figure with 1 cal = 4.184 J.

The properties of the fuel are:

Carbon	87.5 % w/w
Hydrogen	8.0
Oxygen	3.5
Nitrogen	1.0

Net calorific value	39,540 kJ/kg at 298K
Latent heat of vaporisation	350 kJ/kg at 298K
Heat capacity	1.6 kJ/kg.K

Atomic masses: C, 12; H, 1; O, 16; N, 14.

5. (i) Briefly discuss the discounted-cash-flow-rate of return and net present worth methods of profitability evaluation.

(ii) An engineer in charge of the design of a plant must choose either a batch or continuous system. The batch system offers a lower initial outlay but, owing to high labour requirements, exhibits a higher operating cost. The cash flows relevant to this problem have been estimated as follows in thousands of kwacha:

	Year		Discounted-cash-flow rate of return	Net present worth at 10%
	0	1-10		
Batch system	-20,000	5,600	25%	14,400
Continuous system	-30,000	7,650	22%	17,000

Check the values given for the discounted-cash-flow rate of return and net present worth. If the company requires a minimum rate of return of 10 percent, which system should be chosen and why?

Remember that for an annuity $P = R\left\{\frac{\left[(1+i)^n - 1\right]}{i(1+i)^n}\right\}$

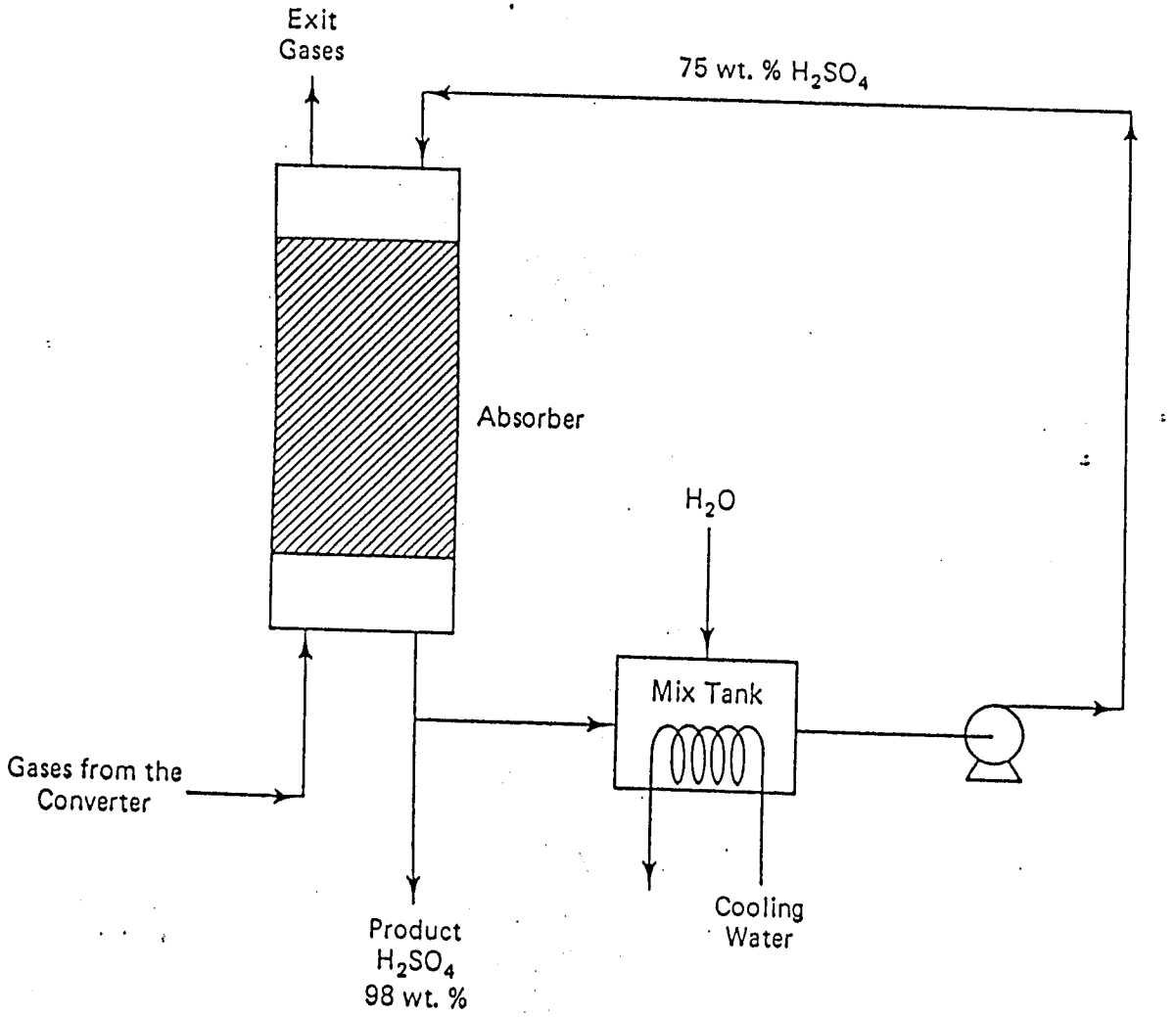
6. (i) Derive the following relationship for a counterflow heat exchanger:

$q = UA\Delta T_{lm}$

(ii) An air cooler for a lubrication system has to cool 1000 kg/h of oil(c_P = 2.09 kJ/kg.^{0}C) on the shell side from 80^{0}C to 40^{0}C by using a cooling water(c_P = 4.18 kJ/kg.^{0}C) flow of 1000 kg/h at 30^{0}C in countercurrent heat exchanger. Calculate the surface area of the heat exchanger, if the overall heat transfer coefficient is 24 W/m^2.^{0}C. Explain why this heat exchange cannot be accomplished in a cocurrent heat exchanger.

END OF EXAMINATION IN MM 552

A flow diagram of the process is as follows:



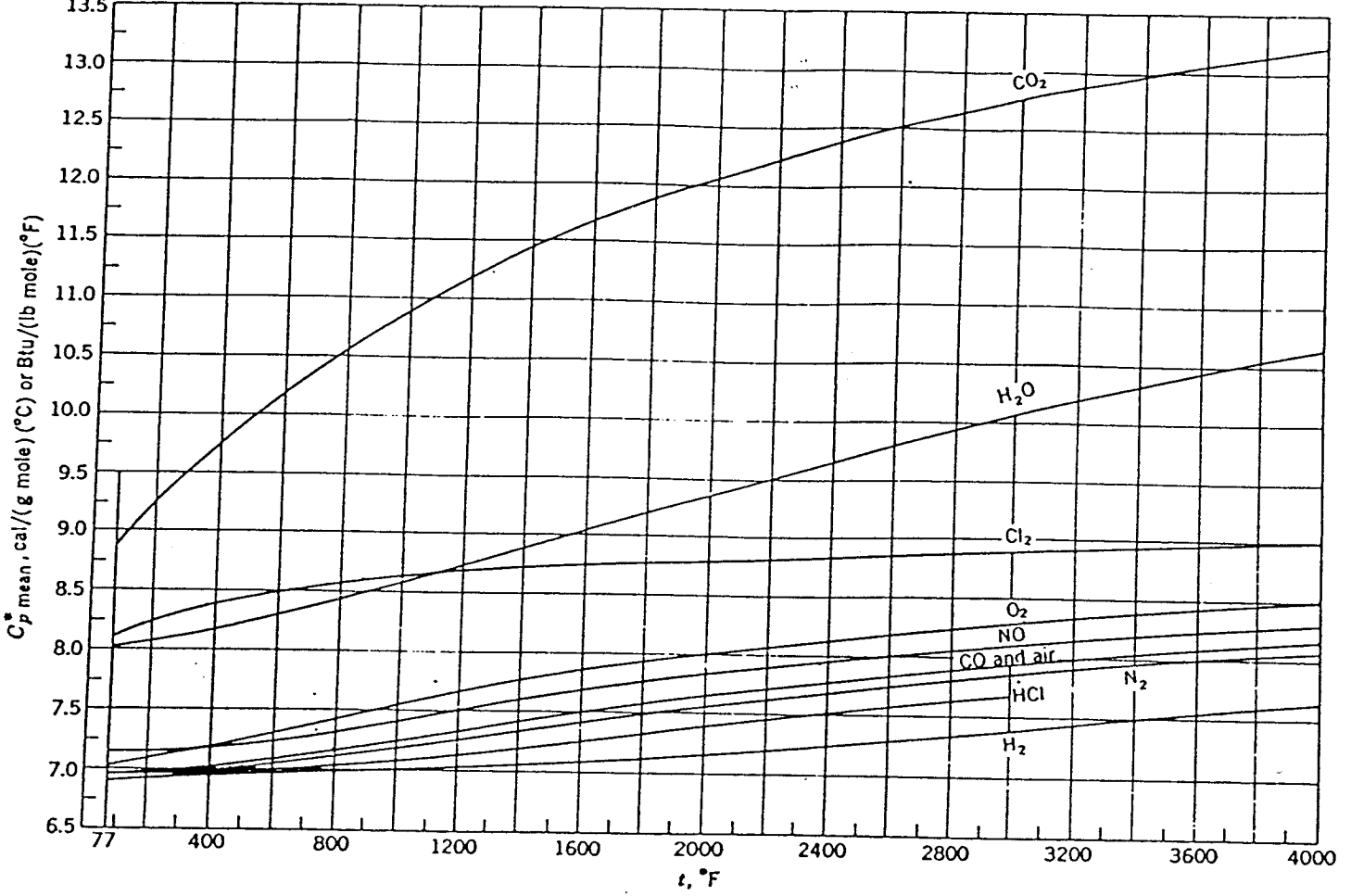


Figure 10–2 Mean molar heat capacities of gases in the ideal-gas state. Base temperature, 77°F. *Based mainly on data from D. D. Wagman (ed.)*, Selected Values of Chemical Thermodynamic Properties, *Natl. Bur. Stand. Circ.* 500, 1952. *From J. M. Smith and H. C. Van Ness*, Introduction to Chemical Engineering Thermodynamics, Second Edition. *Copyright 1959 McGraw-Hill Book Co. Reprinted by permission.*

3. Ammonia is removed from a stream of air by the absorption in water in a packed column. The air entering the column is at 760 mmHg pressure and 25^0C. The air contains 8.0 percent v/v ammonia. Only ammonia is absorbed in the column. If the flow rate of the ammonia-air mixture to the column is 200 m^3/s and the stream leaving the column contains 0.05percent v/v ammonia, calculate:

(i) the flowrate of gas leaving the column,

(ii) the mass of ammonia absorbed,

(iii) the flowrate of water to the column, if the exit water contains 1% w/w ammonia.