THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
2006 FIRST SEMESTER EXAMINATIONS

1.	GG	202	Physical geology
2.	GG	205	Principles of geology I
3.	GG	305	Principles of geology II
4.	GG	312	Petrology II – Practical
5.	GG	322	Stratigraphy and remote sensing paper I – theory
6.	GG	335	Structural geology paper II – practical
7.	GG	402	Geology of Zambia
8.	GG	412	Metamorphic petrology I (theory)
9.	GG	442	Economic geology of metalliferous ore deposits (paper II)
10.	GG	472	Applied geochemistry (paper I theory)
11.	GG	542	Economic geology of non-metallic deposits (paper I theory)
12.	GG	572	Hydrogeology
13.	MG	319	Computer technology I
14.	MI	455	Operations research
15.	MI	515	Rock mechanics (Paper I)
16.	MI	535	Coal mining methods
17.	MI	562	Investment analysis
18.	MI	595	Mineral production control
19.	MM	205	Introduction to metallurgy and mineral processing paper I theory
20.	MM	332	Chemical thermodynamics II
21.	MM	412	Mineral processing II
22.	MM	442	Hydrometallurgy
23.	MM	452	Process control and instrumentation
24.	MM	542	Fuels, finances and refractories
25.	MM	552	Process design
26.	MM	562	Foundry

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

FIRST SEMESTER EXAMINATIONS – JUNE 2006

GG201 – INTRODUCTION TO GEOLOGY

PAPER I – THEORY

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

1. (a) The atmosphere and hydrosphere form the outer parts of planet Earth. How do you think these two zones formed at the formative stages of the Earth and what are the main constituents of each of the zones? (5 marks)
   (b) How does the process of photosynthesis contribute to the sustenance of the atmosphere and life? (2 marks)
   (c) Continental drift (continents are in constant motion) is one of the concepts that contributed to the unifying theory of plate tectonics. State and discuss briefly two pieces of evidence supporting continental drift. (4 marks)
   (d) State the three types of plate boundaries and describe geological activities associated with each boundary (9 marks)

2. (a) Define the following (6 marks):
      (i) Proton
      (ii) Neutron
      (iii) Electron
      (iv) Atomic number
      (v) Atomic mass
      (vi) Isotope
   (b) Distinguish covalent bonds from ionic bonds (4 marks).
   (c) With two mineral examples for each describe isomorphism and polymorphism. (5 marks)
   (d) Why is colour not a diagnostic physical property of a mineral? Give two mineral examples in which colour is so variant. (3 marks)
   (f) Density (or specific gravity) of a mineral is a function of two parameters. State these two parameters. (2 marks)

3. (a) If a rock that contains quartz, K-feldspar, muscovite and biotite had to be melted, would you expect it to melt all at once or not and why? List the minerals in order of their melting. (3 marks)
   (b) If you were mapping an area with a series of lava flows, how would tell the top of one flow and bottom of the next younger flow? (2 marks)
   (c) Distinguish a sill from a dyke. (4 marks)
   (d) Describe the following briefly: (9 marks)
      (i) Cross-bedding
      (ii) Ripple marks
      (ii) Graded-bedding
   (e) What sedimentary interpretations can one draw from cross-bedding and ripple marks. (2 marks)

4. (a) State the principle of original horizontality and the principle of superposition. (4 marks)
   (b) What are fossils? (2 marks)
   (c) Describe and discuss how the following are used in relative dating of geological events: (6 marks)

(i) Layering
(ii) Unconformity
(iii) Cross cutting features

(d) Sate three of the four commonly used radiometric dating methods giving for each the parent and daughter isotopes. (3 marks)

(e) Give the limitations associated with radiometric dating methods. (5 marks)

5. (a) Describe briefly the following: (10 marks)
(i) Normal fault
(ii) Horst
(iii) Joint
(iv) Monocline
(v) Anticline

(b) What is 090/50°E in one word? State each of the three parts reflected in this word. (2.5 marks)

(c) What would you call a fault on which the following movements are evident: (1.5 marks)
(i) Horizontal
(ii) Vertical
(iii) Both vertical and horizontal

(d) Describe briefly the three steps involved up to just before the development of a mineral deposit. (6 marks)

6. (a) What do you think is a hydrothermal solution? (2 marks)

(b) State and describe three ways in which hydrothermal solutions are generated. (9 marks)

(c) Distinguish between vein and disseminated deposits. (4 marks)

(d) What is a placer deposit and how does it form? Give examples of minerals that would constitute such deposits and why? (5 marks)

7. (a) State any four negative impacts that copper/cobalt mining on the Zambian Copperbelt has imposed on the environment and indicate how each of these impacts may have been generated? (8 marks)

(b) Suggest ways in which each of the environmental impacts in (a) may be remedied. (8 marks)

(c) Stone crushers in Lusaka need to protect themselves against flying stone fragments, sharp stone edges and dust. Suggest three ways in which they may achieve this protection stating which parts of the body may need such protection. (3 marks)

(d) State one mining law and one environmental law applied in Zambia. (1 mark)

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

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

FIRST SEMESTER EXAMINATIONS – JUNE 2006

GG311 CRYSTALLOGRAPHY AND MINERALOGY
PAPER I – THEORY

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER ANY 5 QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.

Q1. (i) What are isotropic and anisotropic minerals?
(ii) Explain what happens to light when it enters an anisotropic mineral.

Q2. (i) What are allochromatic minerals? Illustrate your answer with examples.
(ii) What is pseudomorphism and in what way does it take place?

Q3. Describe the following terms:
(i) Relief
(ii) Pleochroism
(iii) Birefringence

Q4. (i) What are Miller Indices and how are they derived?
(ii) What forms are represented by the following Miller Indices?
(a) (001)
(b) (110)
(c) (111)

Q5. (i) What is a unit cell and why is it important in crystallography?
(ii) What are idiomatic minerals?

Q6. Describe the following terms:
(i) Diaphaneity
(ii) Fluorescence
(iii) Birefringence

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

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

FIRST SEMESTER EXAMINATIONS – JUNE 2006

GG411 - IGNEOUS PETROLOGY
PAPER 1 -THEORY

TIME: THREE HOURS
INSTRUCTIONS: ANSWER QUESTION ONE AND ANY OTHER FOUR QUESTIONS. ILLUSTRATE YOUR ANSWERS WITH FIGURES, DIAGRAMS WHEREVER POSSIBLE

Q1. Figure 1 is an illustration of the binary system albite- orthoclase alkali feldspar at P H_20 =5Kb (40 marks):

(a) Describe the crystallization of liquid A assuming equilibrium conditions. Also pay attention to the process taking place at temperature below 700°C.
(b) How can the resulting rock be classified assuming that a third component SiO_2 is present which produces 30% volume of quartz?
(c) What is the effect of an increase in the lithostatic pressure on the system?
(d) What would be the effect of a decrease in the water pressure P H_20 to 2 Kb on the crystallization of liquid A and on the mineralogy of the resulting rock?

Q2. Summarize the main characteristics of Skaergaard basic intrusion, and name a similar intrusion in Africa. (15 marks)

Q3. What are the main mechanisms which can account for the development of symplectitic intergrowth texture in plutonic rocks? Describe the most important ones. (15 marks)

Q4. Magmatic rocks can be divided into alkalic and subalkalic type according to their plate tectonic setting. What are the chemical, mineralogical and environment of formation of the two types? (15 marks)

Q5. Name the different types of occurrences of basalts and describe one type from Africa in detail. (15 marks)

Q6. Give a brief account of the followings (15 marks):
(a) Ophiolitic complex
(b) The phase rule
(c) Laccolith and lopolith

Q7. On the basis of field occurrences a distinction has been made between anatectic granites and magmatic granites, explain these differences in detail. (15 marks)

----------End of Examination----------

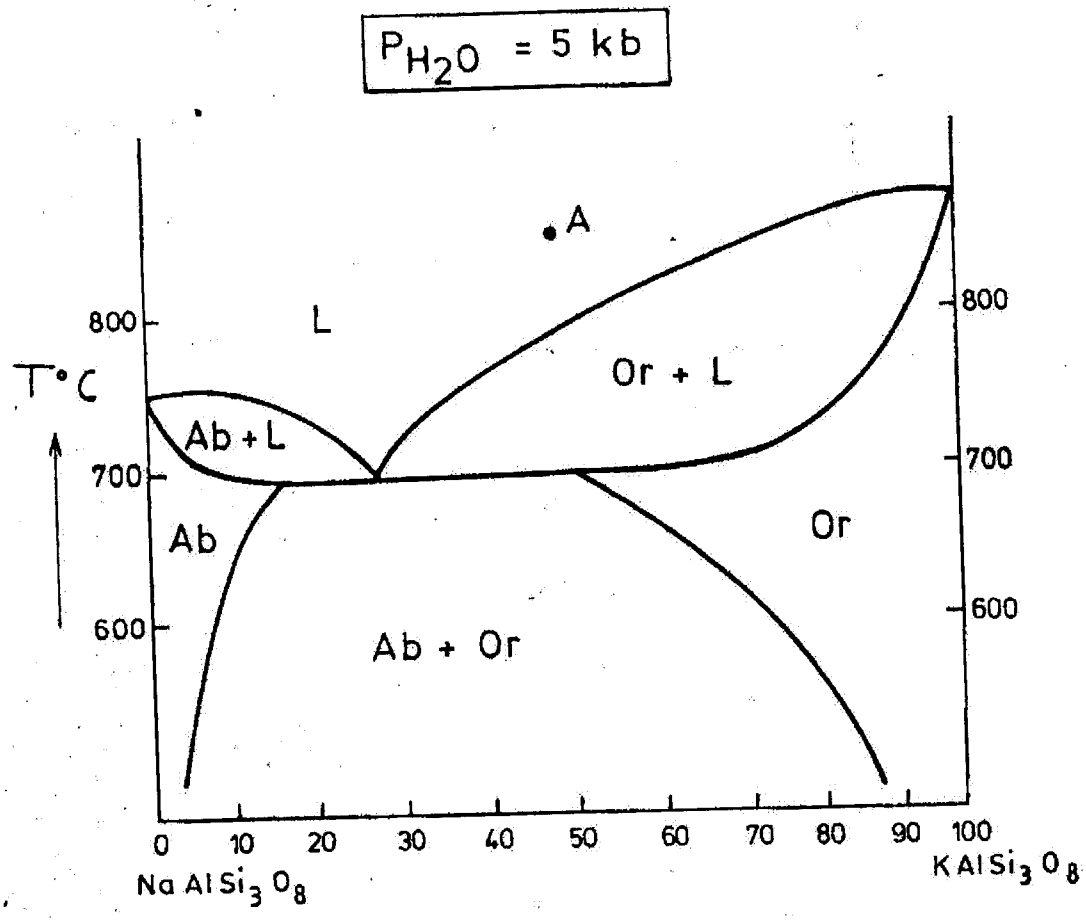
P_{H_2O} = 5 kb
A
L
Or + L
Ab + L
Ab
Or
Ab + Or
T°C
800
700
600
800
700
600
0
10
20
30
40
50
60
70
80
90
100
Na AlSi$_3$O$_8$
KAlSi$_3$O$_8$

Figure 1

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

FIRST SEMESTER EXAMINATIONS – JUNE 2006

GG421: SEDIMENTOLOGY
PAPER I – THEORY

TIME: THREE (3) HOURS

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

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1. Distinguish between the following:
   (a) Compositional and Textural maturity
   (b) Sheet sands and Dune sands
   (c) Sediment and Sedimentation
   (d) Glaciofluvial and Glaciomarine
   (e) Desiccation cracks and Syneresis cracks

2. (a) Depositional environment is a particular geomorphic setting in which a particular set of physical, chemical and biological processes operates to generate a certain kind of sedimentary deposit characterized by specific texture, structural and compositional properties. Outline the following:
   (i) Elements characteristic of the physical environment.
   (ii) Elements characteristic of the chemical environment.
   (iii) Elements characteristic of the biological environment.
   (b) On what basis can you define Facies? Explain briefly.
   (c) Briefly outline the basic tools for environmental analysis.

3. Contrast with the aid of diagrams or tables where applicable between the following:
   (a) Braided and Meandering river systems
   (b) Wackestone and Packstone
   (c) Fining and Coarsening upwards
   (d) Proximal and distal trends in alluvial systems
   (e) Trough and Planar cross-bedding

4. (a) Give the classification of Sedimentary Basins.
   (b) In carrying out a Basin Analysis study, what are the major concerns?
   (c) Choose any two techniques used in Basin Analysis and describe them.

5. (a) Classify the deltaic system.
   (b) Draw a plan view of a delta and label its components. Briefly describe the principal categories of the delta facies indicated on your plan.
   (c) Sketch the components of a Beach. Use Oregon beaches as an example.

6. (a) The geological record is characterized by several major episodes in which large reef structures and smaller reef mounds were formed and intervening periods when only the smaller reef mounds were formed. In table form, name the major reef builders in the geological record indicating the periods in which they were active.
   (b) Distinguish between Isolated Platform and Reef Mound.
   (d) Outline the stages of Reef Growth (vertical zonation) indicating the resulting carbonate rock types at each stage.

7. Write short notes on the following:
   (i) Deposits in an Ocean Basin
   (ii) Anastomosing rivers
   (iii) Mudrocks
   (iv) Significance of sedimentary structures
   (v) Facies Models

GOOD LUCK END OF EXAM

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

FIRST SEMESTER UNIVERSITY EXAMINATIONS - JUNE 2006

GG435 - STRUCTURAL GEOLOGY AND PLATE TECTONICS
PAPER II - PRACTICAL

INSTRUCTIONS:	**Answer all questions.** Hand in all relevant sketches.
TIME:	**Three (3) Hours**

Q 1. What does Fig 1 represent? Name and describe as far as possible features (a) to (e). (10 marks)

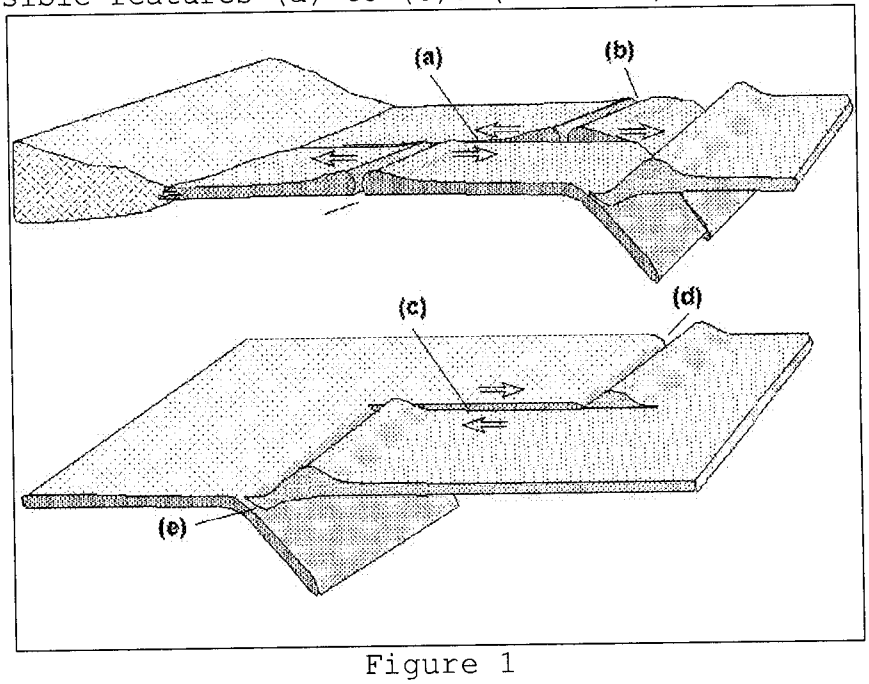


Figure 1

Q2. (a) Name the convergent plate boundary shown in Fig 2.
(b) Name features (a) to (c).
(c) What happens during this type of plate movement?
(15 marks)

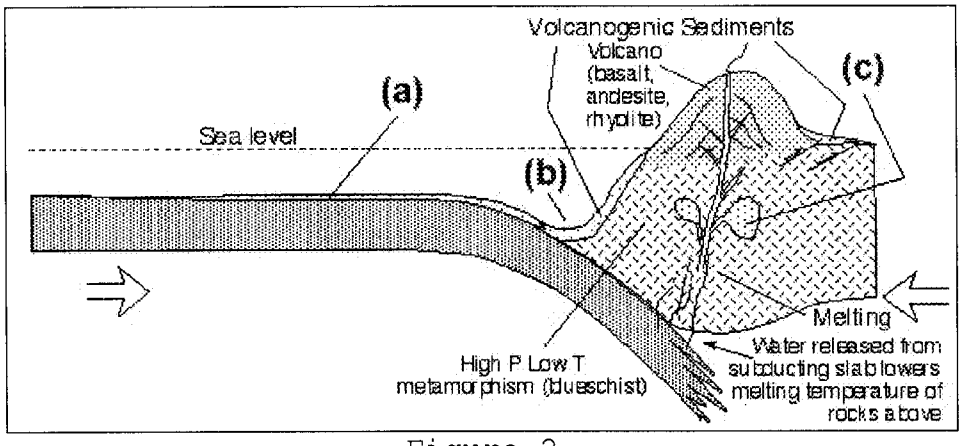


Figure 2

Q3. Find the angle between a line trending 124, plunging 40°, and a second line trending 038, plunging 50° by plotting on a stereonet. Determine the attitude of the surface on which the two lines lie. Plot the surface. If this surface was a fault and the two lines represented slickenside, make a 3 dimension oriented sketch to show the relationship between the fault and the lines. (25 marks)

Q4. (a) Plot the two planes and find their line of intersection:
(i) Strike 012 degrees, Dip 60 degrees SE
(ii) Strike 107 degrees, Dip 41 degrees SSW

(b) Plot poles to the two planes above and determine the following:
(i) The acute and obtuse angles between the planes
(ii) The acute bisector and plot the bisector plane on which the acute bisector and the intersection point lie
(iii) The attitude of the bisector plane

(30 marks)

Q5 Measurements presented in the table below are from belemnite observed in rock exposure. From these data determine the longitudinal strain (e) values and comment on each of the results obtained. (20 marks)

Original length of belemnite (Lo) (cm)	Length of belemnite after deformation (L1) (mm)
3.2	15
11.5	193
6.4	64
9.2	78
20.3	321

End of Exam *Good luck!*

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

FIRST SEMESTER EXAMINATIONS – JUNE 2006

GG471 APPLIED GEOCHEMISTRY
PAPER I – THEORY

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER QUESTION 1 AND ANY OTHER 3 QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.

Q1. Use the data in Table 1 to discuss the origin of the rocks in the magmatic series and the major factors that controlled the distribution of the major and trace elements in the rock units.

Table 1 Composition of a series of igneous rocks

Weight %	Picrite basalt	Olivine basalt	Trachy-basalt	Trachy-andesite	Trachyte	Aegirine-augite trachyte
SiO_2	46.8	47.7	51.1	56.3	59.5	61.5
TiO_2	1.9	3.2	2.8	1.8	0.9	0.3
$AI20_3$	8.2	15.2	17.6	17.8	19.4	18.3
Fe_20_3	1.2	2.3	2.8	2.9	1.7	2.6
FeO	9.8	8.7	6.8	4.7	3.6	2.8
MgO	19.8	9.7	4.8	2.3 .	1.0	0.2
CaO	9.5	8.9	6.9	4.7	2.0	1.5
Na_2O	1.6	2.7	4.0	4.8	5.2	7.0
K_2O	1.2	1.6	3.2	4.7	6.7	5.8
Minerals (%)						
Orthoclase	7.2	9.5	18.9	27.8	39.5	34.5
Albite	9.8	21.9	28.3	38.4	39.1	48.9
Anorthite	11.4	24.5	20.5	13.3	9.7	1.1
Nepheline	2.0	0.6	3.1	1.1	2.6	5.6
Diopside	28.6	15.8	11.0	8.1	0.3	5.5
Olivine	35.5	18.4	8.7	3.6	4.5	0.1
Ilmenite	3.6	6.1	5.3	3.5	1.7	0.6
Magnetite	1.9	3.2	4.2	4.2	2.6	3.7
Trace elements (ppm)						
Ni	465	210	52	5	3	3
Co	100	34	29	7	-	-
Cr	1,250	245	51	2	-	-
Zr	100	123	196	323	335	1,000
Rb	30	65	80	200	100	307
Y	10	16	21	28	50	43
La	-	20	42	62	85	150
Ba	340	850	1,020	350	625	-
Sr	450	725	1,010	933	275	15
Ga	5	18	20	18	20	27
Li	3	16	5	13	8	33
V	100	160	128	70	-	-

Q2. Use Figure 1 to discuss and account for the regularities in the relative abundances of the elements in the cosmos.

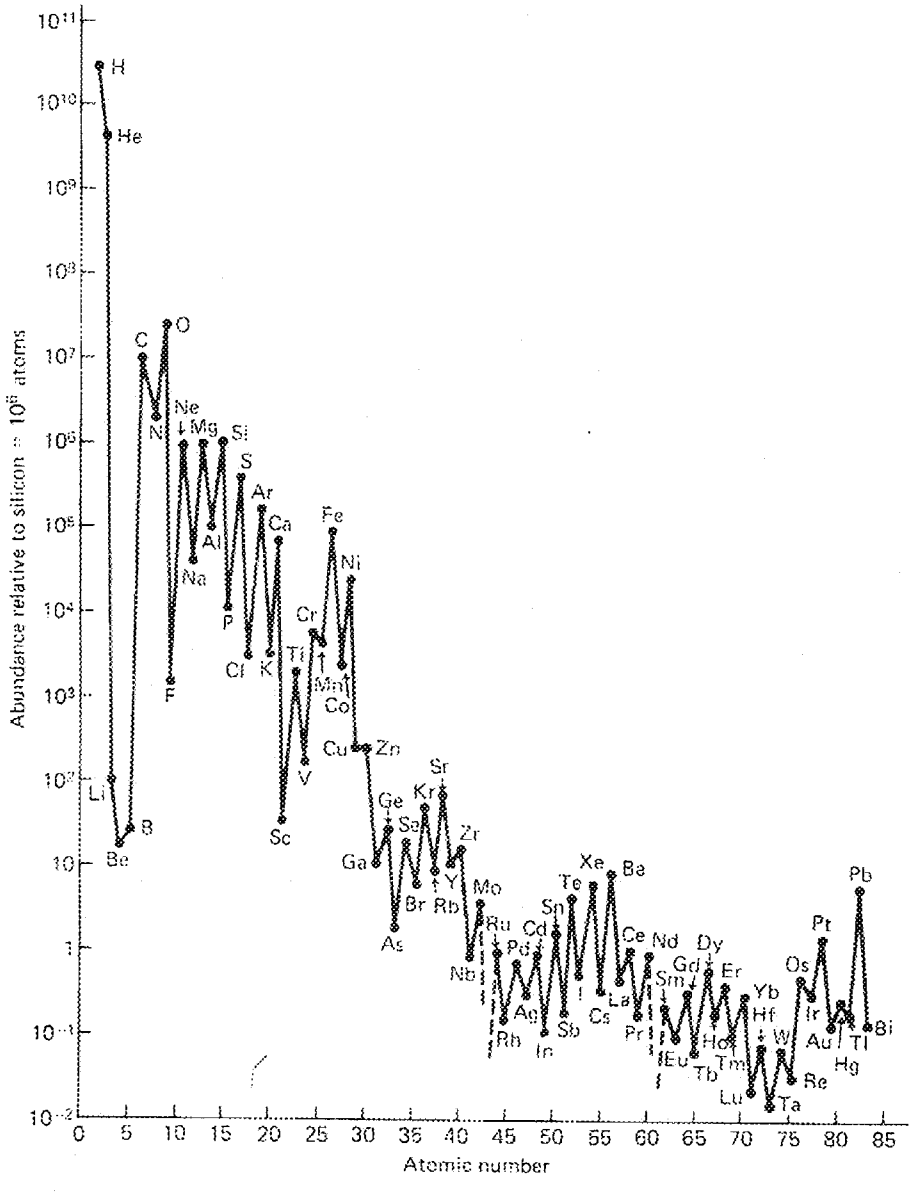


Figure 1. Abundance of elements in the cosmos.

Q3. (a) Describe the geochemical classification of the chemical elements.

(b) Describe briefly the chemical composition of the three distinct layers of the earth crust.

(c) Discuss briefly the major methods that have been used to estimate the abundance of the chemical elements in the earth's crust.

Q4. (a) Describe briefly the chemical classification of the meteorites.

(b) Discuss the role of the study of meteorites in the determination of the age of the earth and its chemical composition.

Q5. (a) Describe the major modes of decay of radioactive nuclides.

(b) Derive the general equation that is commonly used in isotopic dating of rocks and minerals.

(c) Discuss the following aspects of five radioactive systems that are commonly used in dating of igneous and metarmorphic rocks.

(i) Parent and daughter nuclides
(ii) Type of decay
(iii) Effective age range
(iv) Typical materials that are dated
(v) Sources of error in age determination

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

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

FIRST SEMESTER EXAMINATIONS – JUNE 2006

GG551 – EXPLORATION, MINING GEOLOGY AND MANAGEMENT

INSTRUCTIONS: Answer any four questions. All questions carry equal marks. Illustrate your answers wherever possible.

TIME: Three (3) Hours

Q1. Earlier exploration undertaken by a certain firm over an area of 70,000 km^2 in Mwinilunga District revealed anomalies of Cu, Zn, Ni and Au in stream sediments. Further preliminary investigations showed that there were fragments of pentlandite, pyrrhotite, uraninite, gold and chalcopyrite among the stream sediments pointing to the possibility of vein mineralisation in an area of 70 km^2. This area was sold to another firm because it was considered too small. From the many ground methods you know and with reasons select five that would effectively be useful and describe them briefly. (25 marks)

Q2 (a) What is a Bouguer anomaly? (3 marks)

(b) Write short notes on the following gravity corrections: (i) Latitude, (ii) Elevation, (iii) Terrain (12 Marks)

(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 (10 Marks).

Q3. (a) Briefly explain what bias sampling is. (2 marks)

(b) Briefly describe the following: (12 marks)

(i) Channel sampling
(ii) Grab sampling
(iii) Placer sampling
(iv) Bulk sampling

(c) Discuss the advantages and disadvantages of drill core and drill cuttings sampling methods. (6 marks)

(d) What is the importance of keeping sampling records? (5 marks)

Q4. (a) Define the terms grade and tonnage. (4 marks)

(b) An orebody has been channel sampled and assay values determined as presented in the table below. Calculate the unweighted arithmetic average grade and the width weighted average grade for both Cu and Co. If the orebody contains chalcopyrite (SG = 4.30), cobaltite (SG = 6.20), and quartz (SG =

2.70), determine the modified average assay. Show clearly how you get to the values and comment on the three results. (15 marks)

Channel Sample No.	Width (m)	Cu (%)	Co (%)
1	0.5	2.1	0.84
2	0.7	4.8	1.11
3	1.2	3.7	0.78
4	0.8	2.6	1.03
5	0.5	4.2	0.93
6	0.9	3.5	1.12
7	1.1	2.9	0.71
8	1.0	3.1	1.10
9	0.6	4.5	0.90
10	0.7	3.8	0.91

(c) If an orebody is tabular and inclined at 30° and two holes are drilled perpendicular to intersect this orebody. The first hole is located just east of the outcropping part of the orebody while the second is located 150 m further east from the first hole but along the same line of section. Sketch a section showing the arrangement, determine the inclination of the holes and the intersection distance between the two holes along the top surface of the orebody. (6 marks)

Q5. Describe the following:

(a) General Stratigraphy of the Zambian Copperbelt indicating location of the Orebodies on the Stratigraphy (15 marks).

(b) The duties of a mining geologist (10 marks).

Q6. (a) Mining has been taking place on the Zambian Copperbelt for over 75 years now. Various literature has blamed mining as the major source of environmental impacts. Describe the sources of pollution on the Copperbelt (13 marks).

(b) In a recent study by the Czech Geological Survey, Geological Survey of Zambia and University of Zambia, chromium and nickel were found to be enriched in sub-surface soils but very low in top soils whereas copper and cobalt show the reverse. Explain why this is so? (6 marks).

(c) In the same study cassava and sweet potato leaves were found to have higher concentrations of copper and cobalt than their roots (bulbs). Explain. (6 marks)

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

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – JUNE 2006

GG561 ENGINEERING GEOLOGYAND ROCK MECHANICS

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

1 a) The production Manager of the quarry mining construction materials along the Great East Road is seeki advice from an engineering geologist in the choice of a slope angle that would give maximum stability in t overlying groundmass. Triaxial cell tests performed on a sample from this groundmass gave the followi results:

Vertical pressure (kN m^{-2})	150	450
Lateral pressure (kN m^{-2})	400	1000

What angle would you recommend to him? Give reasons for your answer.

b) During the actual excavation of the quarry, a plane P was seen ***day-lighting*** into the cut slope. Triaxial c tests performed on soil filling this discontinuity produced the following results:

σ_2 (kN m^{-2})	1	5	9.5	15
σ_1 (k Nm^{-2})	9.2	28	48.7	74

Available data also revealed the following:
Cut slope angle is 60^0; Dip of the plane P is 50^0; the weight of the potential sliding mass is 400kN; Tc contact area is 200 m^2. Determine:

i) The total force resisting sliding
ii) The factor of safety of the block against sliding
iii) The magnitude of the force of a rock bolt installed perpendicular to the plane that would raise the factor safety of the block to 2.5

2 a) Write short notes on the following

i) Rock Quality Designation (RQD)
ii) Rock Mass Quality
iii) Influence of Rock Quality on seismic velocities

b) Describe the significance of the following characteristics of discontinuities in engineering practice

i) Orientation
ii) Spacing
iii) Separation and filling

c) Shear box testing carried out on one of the discontinuities gave the following results:

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

If the discontinuity experiences shear and normal stresses of 250 kN m^{-2} and 230 kN m^{-2}, respectively, desc its stability under these conditions.

3 a) In one prospective construction 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 the first refractor surface, which represents rock-head.

b) A soil sample of 12 cm collected from the site in (a) was subjected to a vertical load of 30kN. At failure, th sample experienced a 1 mm and 0.5 mm changes in length and diameter, respectively. Calculate;

i) The sample's longitudinal and diametric strains
ii) The modulus of elasticity (also called Young's modulus)
iii) Poisson's ratio *(Diameter of sample is 4 cm*

c) A seismic survey carried out at the same site as in (a) gave the following wave velocities:

Compressional waves = $10\ KM\ s^{-1}$
Transverse waves = $6\ KM\ s^{-1}$

Determine the Poisson's ratio for this groundmass. Give two possible reasons for the difference in value wi that determined in (b).

4 a) The University of Zambia intends to heed to public outcry to honour the late Professor Lameck Goma for h outstanding contribution to the life of the University by erecting his statue in front of the Administration Bloc The Statue is proposed to be supported by a square footing 2 m wide at a depth of 0.5 m. If the unit weight the soil at the site is 17 kN m^{-3}, and shear box tests performed on three specimens of this soil gave th following results:

Normal pressure (kN m^{-2})	35	70	105
Shear pressure (kN m^{-2})	29	58	87

Calculate the maximum safe bearing capacity, which can be imposed on this ground if the factor of safe against shear failure of the underlying soil has been determined to be 2.

b) A fine soil fraction obtained from the same site was used in an Atterberg limits test to determine its wat holding capacity. The following results were obtained:

Number of Blows	6	8	12	26	28	31
% Water Content	55.6	52.8	48.3	39.6	38.8	38

Determine for this soil:

ii) Its liquid limit
iii) Its plastic limit if its plasticity index is 20 %

c) After construction of the Goma statue in (a), it was discovered that it overlay a discontinuity inclined at 3(Further, it was determined that the statue imposed vertical (σ_1) and horizontal (σ_3) stresses of 700 kN m^{-2} a 300 kN m^{-2}, respectively, on the discontinuity. **Determine** the ensuing Normal and Shear stresses impos on the discontinuity surface as a result of these stresses.

5 a) Give the empirical formula of Coulumb's Law and describe all quantities involved.

b) Geologic masses can be categorised into three main classes based on their shear strength paramete Illustrate these main categories with the aid of diagrams.

c) In the location of a suitable dumpsite, a detailed site investigation is required.

i) Give three objectives of such an investigation?

ii) Describe the various stages of such an investigation in this kind of engineering practice.

d) To ascertain the suitability of the site, permeability tests were also carried out in the laboratory on a samp 0.15 m long with a diameter of 75 mm. During the test, the head in the standpipe, with a diameter of 1.5 c decreased from 1.3 m to 80 cm in 2.25 minutes. Calculate the coefficient of permeability of the sample mm/s. Comment on the representativeness of this result to the permeability of the groundmass.

********** END OF EXAMINATION. GOOD LUCK! **********

Bearing capacity factors

ϕ (Degrees)	N_c	N_q	N_γ
0	5.14	1	0
5	6.5	1.6	0.5
10	8.3	2.5	1.2
15	11	3.9	2.6
20	14.8	6.4	5.4
25	20.7	10.7	10.8
30	30.1	18.4	22.4
32	35.5	23.2	30.2
34	42.2	29.4	41.1
36	50.6	37.7	56.3
38	61.4	48.9	78
40	75.3	64.2	109.4
42	93.7	85.4	155.6
44	118.4	115.3	224.6
46	152.1	158.5	330.4
48	199.3	222.3	496
50	266.9	319.1	762.9

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

FIRST SEMESTER EXAMINATION- JUNE 2006
GG581-APPLIED GEOPHYSICS

INSTRUCTIONS: **ANSWER ANY FOUR QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS**

TIME: **THREE (3) HOURS**

1. (a) Prepare a Table showing Geophysical Methods and their main applications

10 marks

(b) Explain the importance of "Identification of Target" in the Geophysical Exploration Design. 15 marks

2. Give a brief description of geophysical exploration programmes for hard minerals that are currently going on in Zambia. This should include:

(i) type of mineral(s) being explored
(ii) possible geophysical methods employed
(iii) possible limitations of the methods in (ii)
(iv) areas where the explorations are being conducted
(v) potential economic benefits to Zambia as a country

25 marks

3. (a) Derive the Geometric Factor, K, for the Schlumberger Array

15 marks

(b) Calculate the resistance of a long conductor 2 kilometres long, having a cross-sectional radius of 1 millimetre and with a resistivity of one micro-Ohmmetre

10 marks

4. (a) Describe the term "Spatial Aliasing"? 10 marks

(b) Explain with the aid of sketches how Spatial Aliasing can be minimized.
15 marks

5. (a) Two bodies with masses of 100 Kg and 1000 Kg are separated by a distance of 10 cm. Calculate the force per unit mass on the 100 Kg body.
10 marks

(b) Compare and contrast gravity methods to magnetic techniques.

15 marks

6. (a) Describe the Proton Precession Magnetometer 20 marks

(b) List the temporal corrections normally carried out on magnetic data
5 marks

END OF EXAM

UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
UNIVERSITY EXAMINATIONS – JULY 2006

END SEMESTER 1 FINAL EXAMINATION
MI 209 INTRODUCTION TO MINE DEVELOPMENT

Time: **3 hours** **Total Mark:** **100**
Answer: **Question 1 and any other Five (05); Total questions to be answered are six (06)**

---

1. (a) Discuss the dynamics of mineral resources based on technology demand and price. **(5 marks)**
   (b) Discuss the differences between three mineral resource / reserve classification systems you know (Mcdvitt, McKelveys and Unified Department of interior classification system) **(7 marks)**
   (c) Mineral and energy industries have unique characteristic from other industries. Discuss these major unique characteristics. **(8 marks)**

2. (a) What are the purposes of PROSPECTING, EXPLORATION, Development and EXPLOITATION in the context of mining? How much approx Time and Cost they may take for each operation? **(8 marks)**

   (b) What are the major considerations in ore sampling? Discuss. **(4 marks)**
   (c) Calculate the cutoff grade (in %) for an iron deposit from the data given below:

   Iron ore price = $82.00 /tonne
   Production cost = $ 25.00/tonne
   Recover = 95 %

   (4 marks)

3. (a) Explain the penetration action of Rotary drills an Percussive drills. State the circumstances in which they are recommended for use. **(8 marks)**
   (b) State the applications of drill holes in mining. **(4 marks)**
   (c) Find the (i) the % recovery and (ii) RQD for the cylindrical rock cores obtained from a two metres drill barrel for the values given below: All values given in mm.

   110, 120 130, 140, 200, 250, 260, 90, 150, 75, 200, 80, 290 **(4 marks)**

4. (a) Explain using neat diagrams the difference in supporting action of Conventional type of supports and Strata reinforcement using steel bolts. **(8 marks)**

(b) A roadway of rectangular shape, of 6.0 m span and 4.0 m height to be supported using steel bolts. Estimate the LENGTH of the bolt and their SPACING in such a road way. **(4 marks)**

(c) How would you ensure the effectiveness of the bolts installed in the road way. **(4 marks)**

5 (a). What are the important considerations in the selection of a site for a mine shaft? **(8 marks)**

(b) In the Figure appearing at the end of the question paper label the names of the parts shown there and write their application in not exceeding one sentence. **(8 marks)**

6 (a) Describe the working principle of a high explosive. Why some of them are known as PERMITTED explosives? **(8 marks)**

(b) With the help of a neat diagram describe a Low Tension Detonator stating its composition and approx dimension. **(4 marks)**

(c) Write the chemical composition of ANFO, EMULSION and SLURRY EXPLOSIVES **(4 marks)**

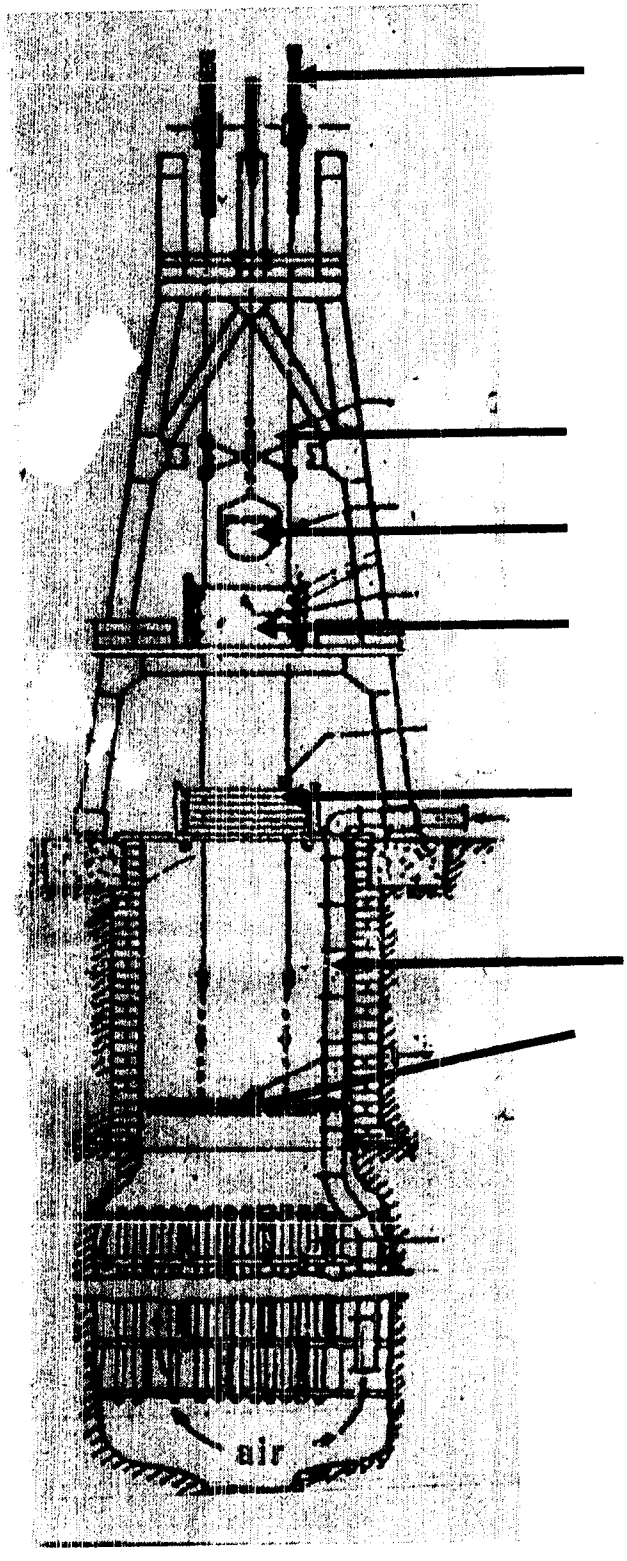
7. (a) Explain how the size of a pillar in Room and Pillar methods of working is decided? Mention three disadvantages of this method compared to the Longwall method. **(8 marks)**

(b) What is meant by caving height in context of underground mining? Is there any use of knowing this value? **(4 marks)**

(c) Calculate the caving height likely to be if the extraction height of a seam is 4.0m and the bulk factor of the overlying rock is 1.6? **(4 marks)**

Figure 5 (b)

Name: ___ ___ ___ Computer No. _____



UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
UNIVERSITY EXAMINATIONS – JUNE 2006

SEMESTER 1 FINAL EXAMINATION

MI 315 ROCK MECHANICS

Answer 5 out of 6 questions. All Questions carry equal Marks. Time: 3 hours

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Q1. Define the following terms using diagrams/sketches where appropriate:

(a) Plane Strain
(b) Bulk Modulus
(c) Isotropy
(d) Pure Shear
(e) Virgin Stress
(f) Porosity
(g) Durability
(h) Effective Stress
(i) Viscous
(j) Modulus of Deformation

Q2. (i) Why should extreme care be exercised in the preparation of rock specimens for laboratory tests?

(ii) Describe two (2) tests you would conduct to determine the tensile strength of a rock sample, mentioning possible sources of error and how these could be eliminated.

(iii) Calculate the tensile strength in (ii) above if tests were conducted using as specimens, cylindrical rock samples 6cm long and 7cm^2 cross sectional area, subjected to a force of 100 KN. Comment on your results.

(iv) The elastic and shear modulus of a rock specimen are found to be E = 70 Gpa and G = 29Gpa. Determine Poissons ratio ν and the Bulk Modulus K of the rock specimen.

(v) Given the σ–ε curve as indicated in the figure attached, labeled question 2(v), calculate the Initial Tangent and Secant Modulus. Briefly mention how these Moduli are applied in practice. (Assume the rock is elastic up to point A)

Q3. The Mohr's envelope of failure for a rock material is given in the following form:

$$\tau^2 = 45\ (\sigma + 5)\ \text{Mpa}$$

Plot the envelope on the σ–τ plane and establish which of the following states of stress would result in failure:

(a) σ =60 Mpa τ = 50 Mpa

(b) σ_1 =125 Mpa σ_2 = 40 Mpa σ_3 = 20 Mpa

(c) σ_1 =110 Mpa σ_2 = 30Mpa σ_3 = -10 Mpa

Q4. The following strains are measured at a point on the free surface of a solid body:

Direction	Angle	Strain ε
A	0^0	0.002
B	120^0	0.002
C	240^0	-0.001

(i) Draw the Mohr's circle for the state of strain specificied above

(ii) From the Mohr's circle, determine the maximum shear strain value

(iii) Mark on the Mohr's circle the following corresponding strain components:

$$\varepsilon = 2.6 \times 10^{-3} \qquad \gamma = -2.4 \times 10^{-3}$$

(iv) What is the magnitude of the strain components ε and γ when $\theta = -30^0$ measured from the direction of the major principle strain?

Q5. A vertical cut is expected to be made in a closely jointed and completely dry rock mass as shown in the figure below. The joints strike parallel to that of the vertical cut.

Slide would take place on the joint surfaces when $\tau = 30 + 0.58\ \sigma$ Kpa, where τ is the shear stress along the dip and σ is the stress normal to the joint plane.

The mass density of the rock is 2700kg/m^3.

Considering a unit length of the cut:

(i) Determine the factor of safety of the rock structure when the height was 6m.
(ii) Calculate the height at which failure would take place.
(iii) Mention ways in which you would increase the factor of safety (F.S) against sliding explaining precisely how the mechanism(s) work.

Q6. Two gauge marks 3cm apart are made along the axis of a cylindrical specimen 6cm long and 7cm2 cross- sectional area. The specimen is then subjected to a compressive force of 100KN.

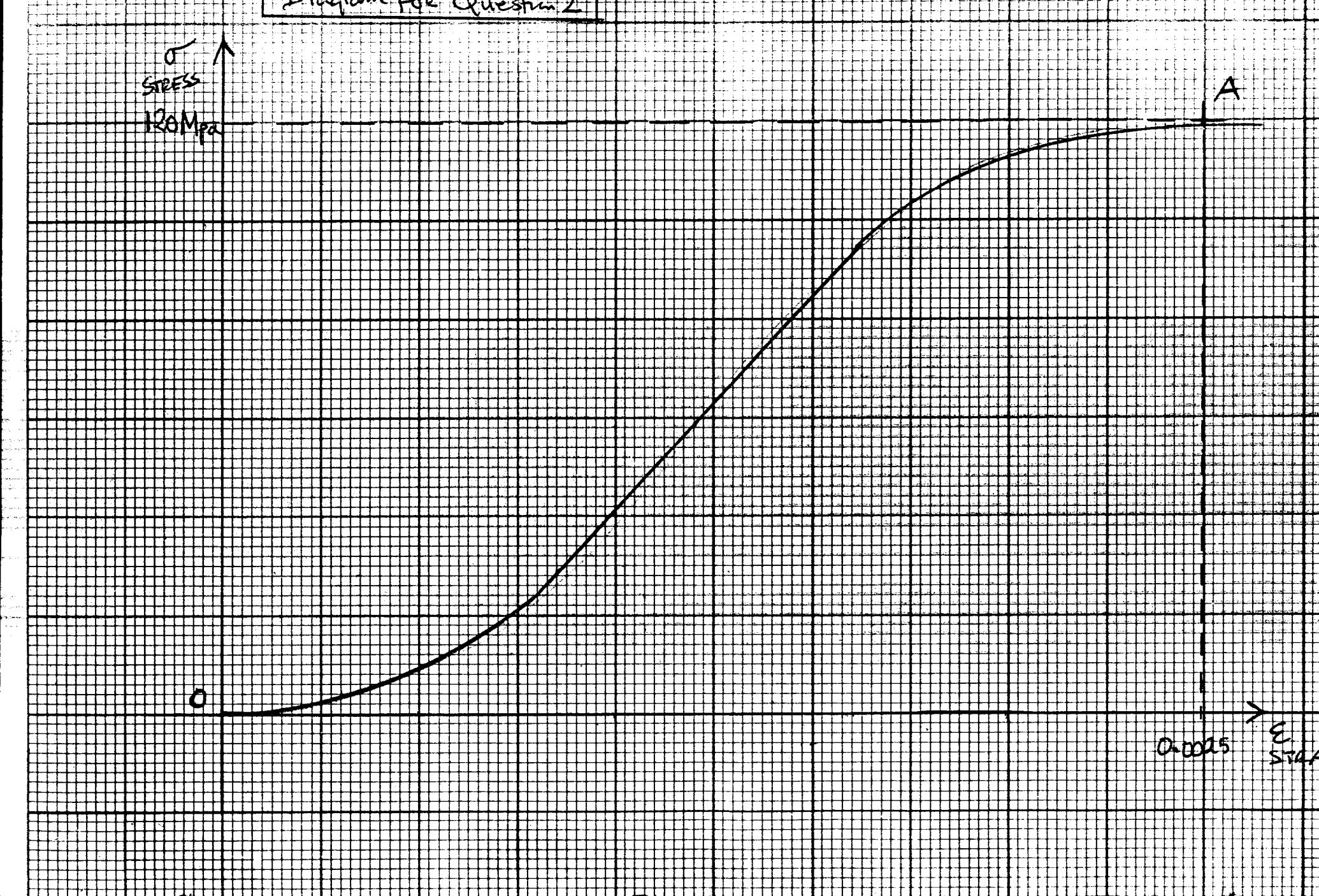
Find

(a) The strain
(b) The Stress
(c) Contraction between the gauge marks
(d) Total contraction of the specimen
(e) The total change in volume of the specimen
(f) The change in the cross-sectional area of the specimen

Take E= 60 Gpa and $\nu = 0.3$

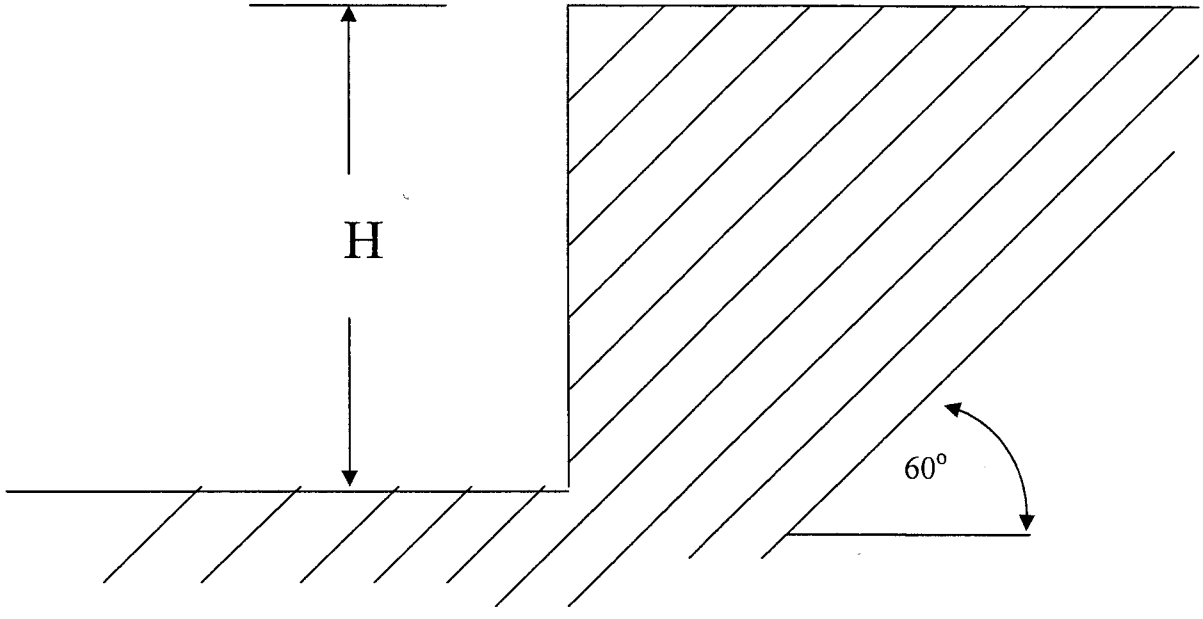
0ooooo End of Examination ooooo0

Diagram for Question 2



UNIVERSITY EXAMINATIONS – JUNE 2006

DIAGRAM FOR QUESTION 5



UNIVERSITY OF ZAMBIA
School of Mines
UNIVERSITY EXAMINATIONS – June 2006

SEMESTER 1 EXAMINATIONS

MI 411: DRILLING AND BLASTING

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

ANSWER ALL QUESTIONS

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1 If we measure the stress in the drill steel for pistons 2 and 3 (Figure 1.1) we get the diagram shown in Figure 1.2

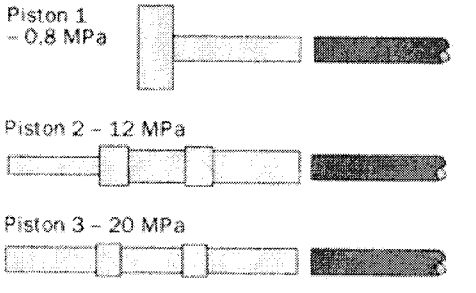


Figure 1.1

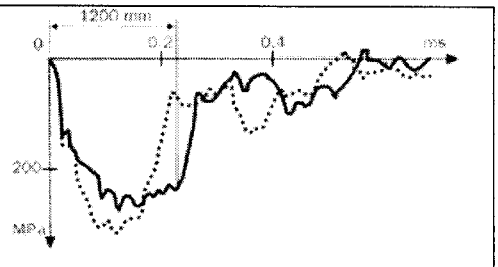


Figure 1.2

From this diagram we see that the stress in the drill steel is 250-300 MPa (25-30 kg/mm^2) and that the primary shock wave has a length of about 1,200 mm (which is the speed of sound in steel 5,200 m/s multiplied by 0.23 millisecond).

Given that an extension rod with a diameter of 38 mm has a cross-sectional area of about 975 mm^2, ***how much force (in tonnes)*** is produced at 25 kg/mm^2 stress for transmission to the rock via the drill steel and bit? ***[5 marks]***

2 With the help of a diagram for a tunnel face, clearly label the *(a) floor holes, (b) cut holes, (c) wall holes, (d) stoping holes, and (e) roof holes.*

[5 marks]

3 Mention the four main FLUSHING MEDIA for hole drilling in rock. What are the respective drilling conditions in which such flushing media are mainly applied ? ***[20 marks]***

4 Derive formulae for conversion of raw data in 3-dimensions to trajectory hole deviations for a Maxibor measurement technique. ***[20 marks]***

5 MI411 Monk Consulting Ltd has just been awarded a project of 1500 m long road tunnel with a cross section area of $88m^2$. A blasthole diameter of 38 mm is chosen as the tunnel contour is to be smooth blasted. The drilling equipment is an electro hydraulic jumbo with 4.3 m steel length and feed travel of 3.9m. The expected advance is over 90 % of the blasthole depth.

The explosive is Emulite 150 in 29 and 25 mm cartridges for the cut, stoping and floor. Gurit 17 x 500 mm in plastic cartridges is to be used for the contour while Nonel GT/T is to be used for initiation.

To attain an advance of more than 90 % of the 3.9m blasthole depth, Monk Consulting Ltd has chosen to use a large hole diameter of 127mm and has assigned you to do the job.

Design a **4-square** large hole cut. ***[20 marks]***

6 Given the conditions shown in Table 6.1, and with the help of Table 6.2; in clear steps and clearly labelled diagram(s), **design the blast** for the bench. ***[20 marks]***

Table 6.1 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 cut and dropped into the hole
Charging condition:	Dry holes

Table 6.2 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	-	-

7 With the help of Figure 7.1 in the Appendix, fill-in the *missing information and/or bracketed label numbers* in the passages which partially describe working principles of a drifter. (**NOTE!! Submit the appendix page)** ***[10 marks]***

APPENDIX (For Question 7)

(NOTE!! SUBMIT THIS PAGE)

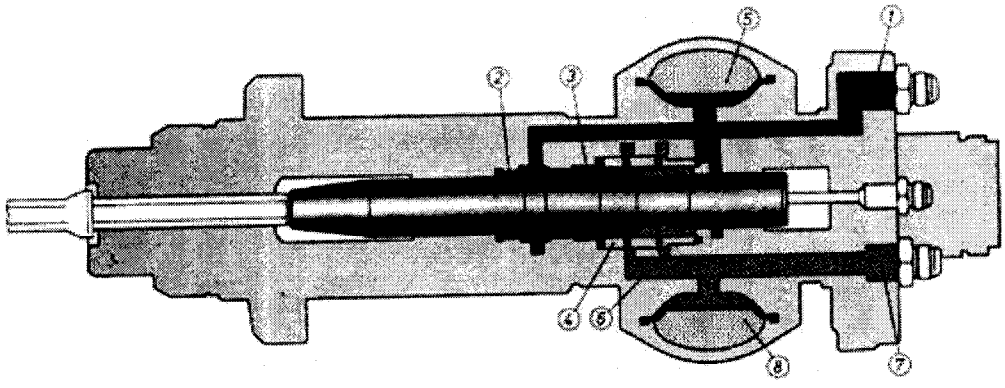


Figure 7.1

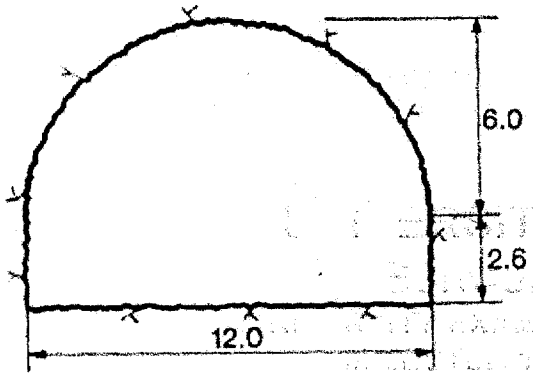
The diagram in Figure 7.1 indicates a _____ drifter. The piston is shown at the end of its stroke. The hydraulic oil enters the drifter through the _____ (1) and flows into the front part of the cylinder ( ). It forces the piston _____ and at the same time enters the distributor chamber (3) pushing the _____ (4) to the rear position. A part of the oil delivery enters the high pressure accumulator ( ) compressing its nitrogen and thus accumulating _____. In this position the oil in the rear part of the cylinder escapes through port 6 to the return port ( ). The _____ ( ) functions similarly to prevent shock loads in the return hoses.

YOUR COMPUTER NUMBER: _____

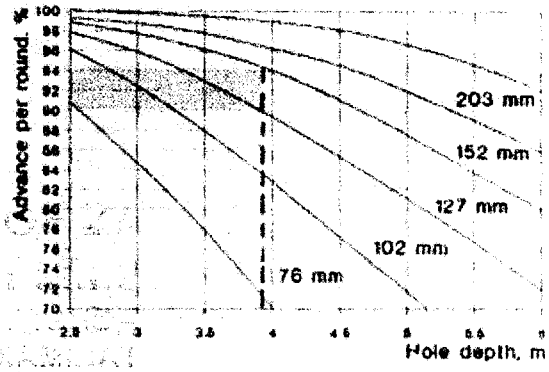
=== END OF EXAM ===

UNIVERSITY OF ZAMBIA
School of Mines
UNIVERSITY EXAMINATIONS – June 2006
SEMESTER 1 EXAMINATIONS
MI 411: DRILLING AND BLASTING

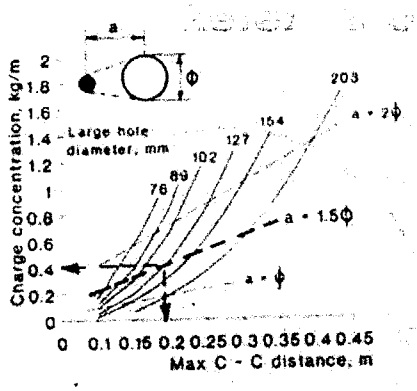
Reference Figures for Question 5



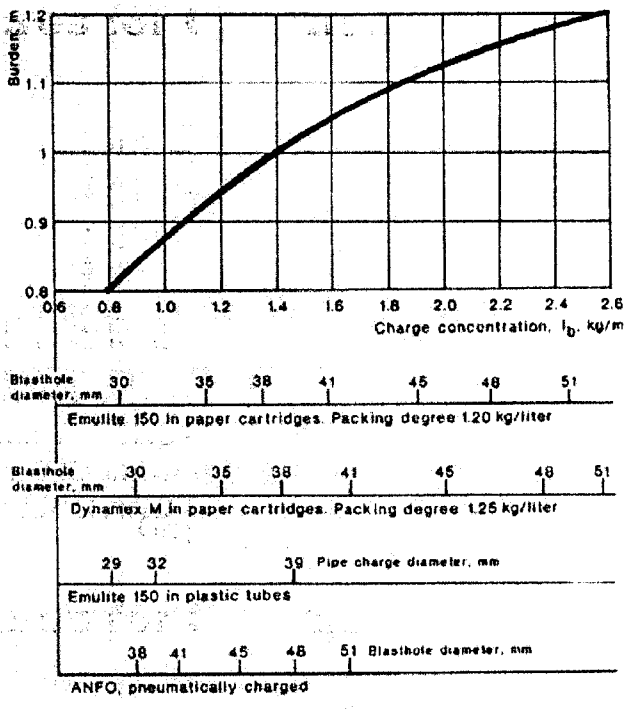
Tunnel dimensions



Graph of hole length vs advance



Charge concentration vs maximum C-C distance (m)



C-C distance

UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
1ST SEMESTER EXAMINATIONS – JUNE 2006

MI 431 – UNDERGROUND MINE DESIGN

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

ANSWER: ANY FIVE (05) QUESTIONS

Question 1

Draw any variant of sublevel caving method and briefly explain under the following headings:

I. Main characteristic features **[5 Marks]**
II. Sphere of application **[5 Marks]**
III. Development and extraction procedures **[5 Marks]**
IV. Advantages and disadvantages of mining method **[5 Marks]**

Question 2

Explain with the help of graphs and equations methods employed in:

i) Determining optimum height of level and factors influencing level sequencing in the mine: **[10 Marks]**
ii) Calculating economically feasible (optimal) annual productivity of a mine. **[10 Marks]**

Question 3

Briefly explain with the help of diagram(s):

i) jenelid/Kvapil concept of gravity ore- flow in caving methods and factors influencing its flow in the stope. **[10 Marks]**
ii) Discuss various kinds of fill materials applied in cut and fill mining method and conditions under which they can be used **[5 Marks]**
iii) Explain the development and extraction process in cut and fill mining method **[5 Marks]**

Question 4

i) Explain the basis for classifying *ore losses* and their negative effects on mining operations. **[10 Marks]**
ii) Fig. 2 shows a portion of panel in room and pillar coal mine. All opening are 6 m in width, and the mining height is regular. Rooms are driven on 18 m centers and cross cuts on 24 m centers. Calculate the percentage recovery in the panel (1) without pillar

recovery and (2) with recovery of chain pillars. Disregard the effects of barrier pillars, and calculate for the smallest repetitive dimensions in the panel.

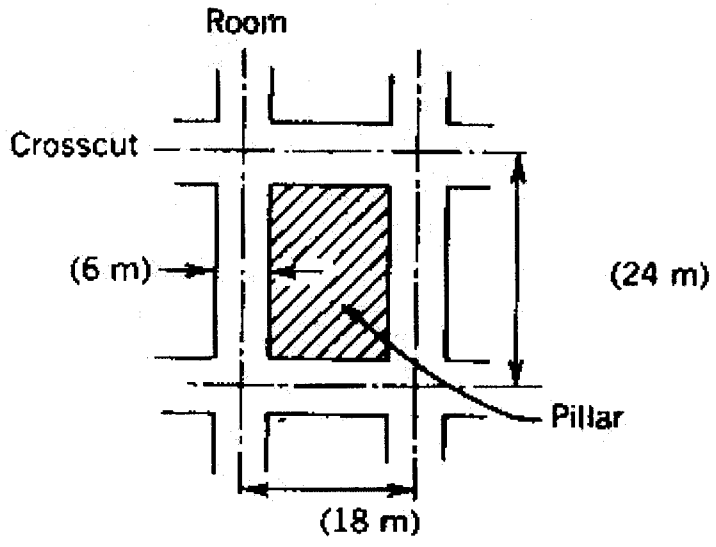


Fig. 2 Portion of panel in room and pillar coal mine

Question 5

i) Explain with the help of clear diagrams and/or formulae the following methods of calculating blasting parameters based on:

a) Physical and mechanical properties of rocks **[5 Marks]**
b) Direction of breaking ore in the stope **[5 Marks]**
c) Known powder factor **[5 Marks]**
d) Total length of holes per 1000 tonnes of broken ore **[5 Marks]**

Question 6

Fig. 2 shows a block diagram for VCR vertical crater retreat method used for mining an ore-body with average thickness of 20 meters. The block has the following parameters: length 50m, height 80 m. The density of ore $\rho = 2.5$ t/m^3 the height of the slice being blasted per round is 2.5 m.

i) Given that : Q=18, kg – amount of explosives (charge) per blast hole; E= 4 - coefficient of energy deformation ;Δ=0.45 – depth ratio
Calculate:

a) Optimum burden for placing the charge **[3 Marks]**
b) Powder factor **[2 Marks]**
c) Amount of broken ore from one crater **[5 Marks]**
d) Amount of broken ore per slice **[5 Marks]**

ii) Calculate the amount of dilution in the stop, assuming that 20 tones of waste is mixed and extracted together with clean ore in the process of extraction.

[5 Marks]

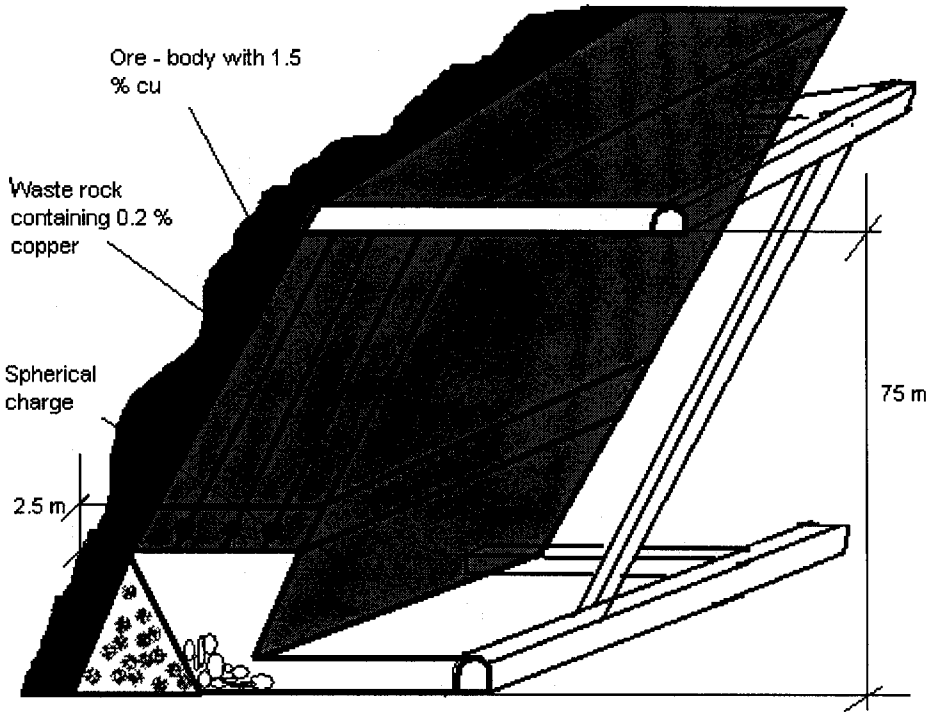


Figure 2. Block diagram of VCR Mining method

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

UNIVERSITY OF ZAMBIA
School of Mines
UNIVERSITY EXAMINATIONS – June 2006
SEMESTER 1 EXAMINATIONS

MI 435: SURFACE MINE DESIGN

TIME: THREE (03) HOURS
INSTRUCTIONS: ANSWER ALL QUESTIONS IN SECTION 1 AND ANY TWO QUESTIONS FROM SECTION 2

SECTION 1

Question 1.1

Explain the various Pit Design Information Model types and, with the aid of a clear diagram, show their linkages in Due Diligence Studies under the following sub-headlines:

a) Information Models (05 Points)
b) Information Time Bombs (05 Points)
c) Legalities in Due Diligence Studies (05 Points)
d) Information Models in Due Diligence Studies (05 Points)

Question 1.2

a) Write short notes on the application of the Positive Moving Cone Technique as a simulation algorithm for the determination of the maximum valued pit in surface mine design paying special attention to:

- How the algorithm works
- Its failure to design the true optimum pit
- Its failure to recognize the positive valued pit
- Its characteristics (10 Points)

b) Consider the sketch of a small 2-D block model given below. The BEV are written on the blocks. Blocks with BEV = 0 at the top of certain blocks refer to 'air' blocks. Given that the maximum allowable slope angle on the section should be 1 block:1 block both on the highwall and footwall, determine the maximum valued pit outline on the section using the Positive Moving Cone Technique. (10 Points)

0	0	0	0	0	-1	-1	-1	0	0
0	0	0	-2	-1	-1	-1	-1	-1	-2
-2	-1	-1	-1	+4	+5	+5	-1	-2	-3
-3	-2	-1	+5	+6	+6	-1	-2	-3	-4
-2	-1	+6	+7	+7	-1	-2	-3	-4	-5

Question 1.3

The sketch below is a 2-D cross section of the same small block model given in the preceding question with all its characteristics. The maximum allowable slope angle on the section should be 1 block:1 block both on the highwall and footwall.

0	0	0	0	0	-1	-1	-1	0	0
0	0	0	-2	-1	-1	-1	-1	-1	-2
-2	-1	-1	-1	+4	+5	+5	-1	-2	-3
-3	-2	-1	+5	+6	+6	-1	-2	-3	-4
-2	-1	+6	+7	+7	-1	-2	-3	-4	-5

Using the two blank templates herewith provided, determine <u>the two alternative maximum valued pit outlines</u> on the section using the Dynamic Programming algorithm. (20 Points)

<u>SECTION 2</u>

Question 2.1

With the aid of corresponding sketches, write notes on the following:

1. Requirements for the compilation of a Geological Model under the following sub-headings:

    a) Exploration Model (04 Points)
    b) Ore Genesis Model (04 Points)
    c) Data Acquisition for Ore Genesis and Exploration Models (04 Points)
2. Drill-Patterns and Hole Spacing for Exploration Models (08 Points)

Question 2.2

Chronologically State and briefly describe the various stages involved in the construction of an Orebody Model. (20 Points)

Question 2.3

Write short notes on open pit Productivity and Efficiency under the following sub-headings:

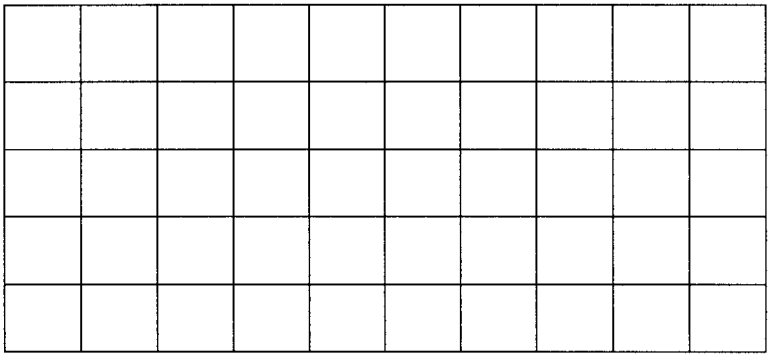
a) Complementation of Equipment and Equipment manufacturers (04 Points)
b) Costs, Pay, Shifts and Productivity (04 Points)
c) Scale of Operation, Truck Size and Cycle Times (04 Points)

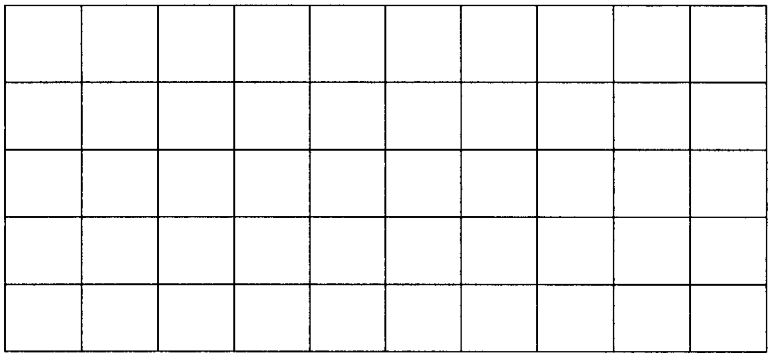
d) Energy Consumption – Diesel/Electricity versus Rock mines Cycle Times and Depth of Mining (04 Points)

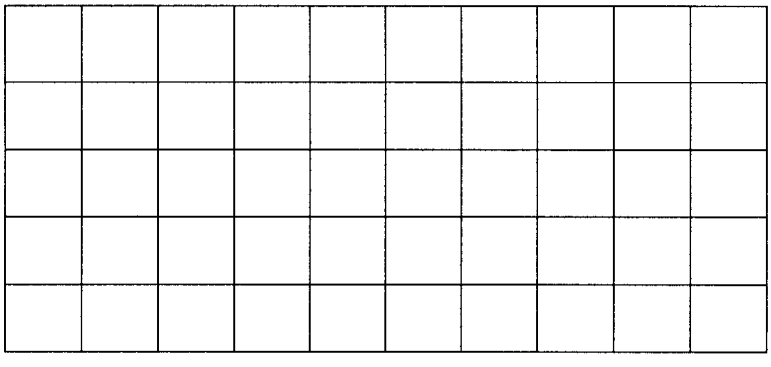
e) Equipment Availability, Utilization and Overall Efficiency (04 Points)

GOOD LUCK!!!

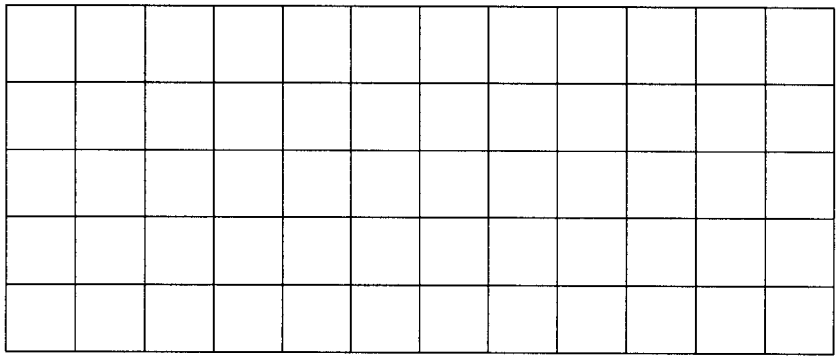
Question 1.3 DP-ALTERNATIVE 1

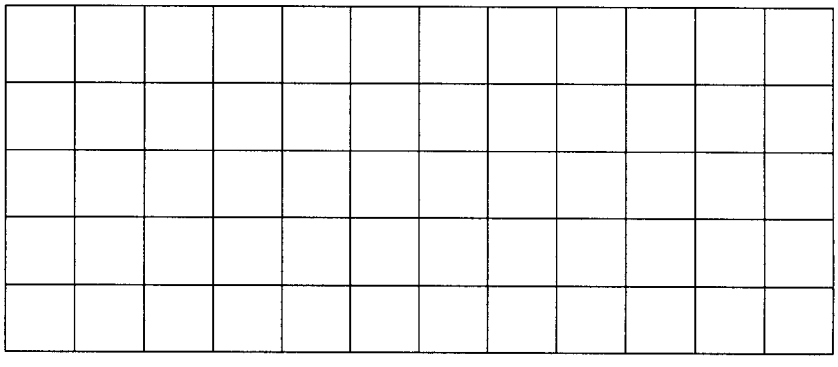


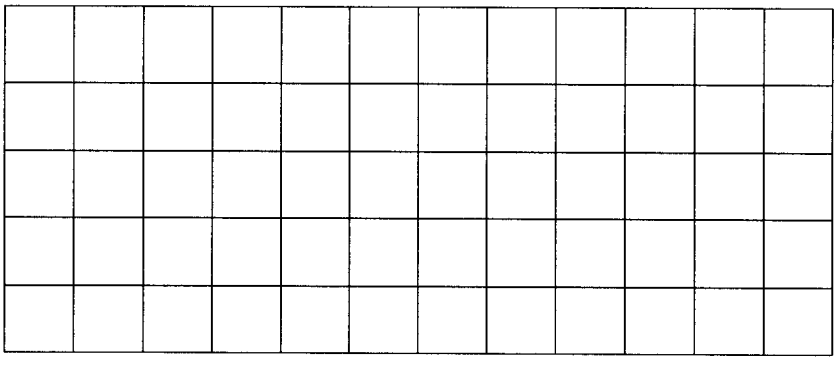




Question 1.3 DP-ALTERNATIVE 2







UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
UNIVERSITY EXAMINATIONS – JULY 2006
1st SEMESTER EXAMINATIONS

MI 465 – MINERAL ECONOMICS

TIME: 3 HOURS **FULL MARKS: 100**
INSTRUCTIONS: ANSWER ALL QUESTIONS
TABLES AND GRAPH PAPERS PROVIDED

QUESTION 1

(a) Define the following and explain the difference between them.

(i) Demand and quantity demanded; and **[3 marks]**
(ii) Supply and quantity supplied **[3 marks]**

(b) The demand and supply schedules for emerald have been established as follows;

Price per gram (US$)	Quantity Demanded (Lots/time period)	Quantity supplied (Lots/time period)
100	1000	25000
90	3000	21000
80	5000	19000
70	8000	15000
60	12000	12000
50	18000	9000
40	26000	6000

(i) Determine graphically the equilibrium level of price and quantity of emerald demanded. **[3 marks]**
(ii) Assume government controlled price is fixed at U$45 per gram. Will there be any excess supply or demand at this price? What will be the price eventually paid on the black market for emerald? **[4 marks]**
(iii) Assume that the government instead of controlling gemstone prices, the market is liberalized resulting in increased supply. The new supply curve is parallel to the old one. 23000 grams are now supplied when prices reach US$80 per gram. What will be the new equilibrium prices? **[4 marks]**
(iv) Assume that along with the increase in supply, extensive advertising by the Export Board is conducted resulting in increased demand. The new demand curve is parallel to the old one. At a price of US$80 per gram, 7000 grams are now demanded. Show graphically the new equilibrium price. **[3 marks]**

QUESTION 2

(a) Define the following terms giving examples in each case.

(i) Current liabilities **[3 marks]**
(ii) Long term liabilities **[3 marks]**
(iii) Fixed assets **[3 marks]**
(iv) Current assets **[3 marks]**

(b) Given the following accounting information for Monks Mining Limited for 2005 financial year, prepare a Balance Sheet as at 31 December 2005.

Capital as at 1st January 2005	47600
Profit for the year to 31 December 2005	8000
Freehold premises, net book value at 31 December 2005	50000
Motor Vehicles, net book value at 31 December 2005	9000
Fixtures and Fittings, net book value at 31 December 2005	8000
Long-term loan (mortgage)	25000
Bank Overdraft	2000
Goods held in stock	16000
Debtors	500
Cash in hand	100
Creditors	1200
Taxation payable	3500
Drawings	4000
Accrued costs of rent	600
Prepayment of insurance	300

[8 marks]

QUESTION 3

(a) Write short notes on the following;

(i) Net Present Value (NPV) **[3 marks]**
(ii) Payback Period (PP) **[3 marks]**
(iii) Rate–of–Return (ROR) **[3 marks]**

(b) Monks Mining Plc invested US$10 million on an Open Pit Project. This investment is expected to generate cash flows of US$1million per year for 5 years. If the cost of capital is 12%, determine;

(i) The expected Rate-of-Return **[4 marks]**
(ii) The Net Present Value **[4 marks]**
(iii) Present Value Ratio **[2 marks]**
(iv) Comment on the financial viability of this investment. **[1 marks]**

QUESTION 4

(a) Discuss the objectives of taxation in the mineral industry. What are the effects of taxes on the mineral resource development? **[10 marks]**

(b) MKB Mining Company purchased mining equipment at a cost of US$6000 each. The equipment is to be used during the removal of overburden material at an open pit mine. Past records indicate that the equipment have an economic life of 7 years and can be sold for an average of US$1000 each after its economic life. The company currently receives 10% interest on invested funds. Using **Declining-balance method**, determine:

(i) The book value at the end of year 3 **[4 marks]**
(ii) The depreciation charge during year 1 and 2 **[3 marks]**
(iii) The depreciation reserve accumulated by end of year 3. **[3 marks]**

QUESTION 5

(a) Discuss the factors which lead to replacement of an equipment or processes. **[8 marks]**

(b) An open-pit mine with a fleet of dump trucks makes pit-to-concentrator deliveries. Past records modified to account for recent price trends indicate a cost pattern over a 6-year period that is expected to apply to depreciation and maintenance for future truck acquisition. The purchase price per truck is US$30000.

Year	**1**	**2**	**3**	**4**	**5**	**6**
Operating cost (US$)	800	1000	1300	1600	2000	2500
Replace price (US$)	1600	1000	600	500	500	300

Assume a zero interest rate and that all the trucks are going to be replaced at one time, how many years should they be kept in service before replacement. Show your answer using a graph.

[12 marks]

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
1ST SEMESTER EXAMINATIONS – JUNE 2006

MI 475 - MINE ENVIRONMENT

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

ANSWER: ANY FIVE (05) QUESTIONS

Question 1

Figure 1 shows a mine ventilation circuit and corresponding net work diagram consisting of three meshes. Determine the distribution of air flow in the branches. Assume that the fan pressure remains constant at 2000 Pa and that there is no natural ventilation.

Question 2

Derive equations for calculating pressure drops for a fluid flowing in:

i) Cylindrical smooth walled pipes with uniform cross section area under laminar flow.

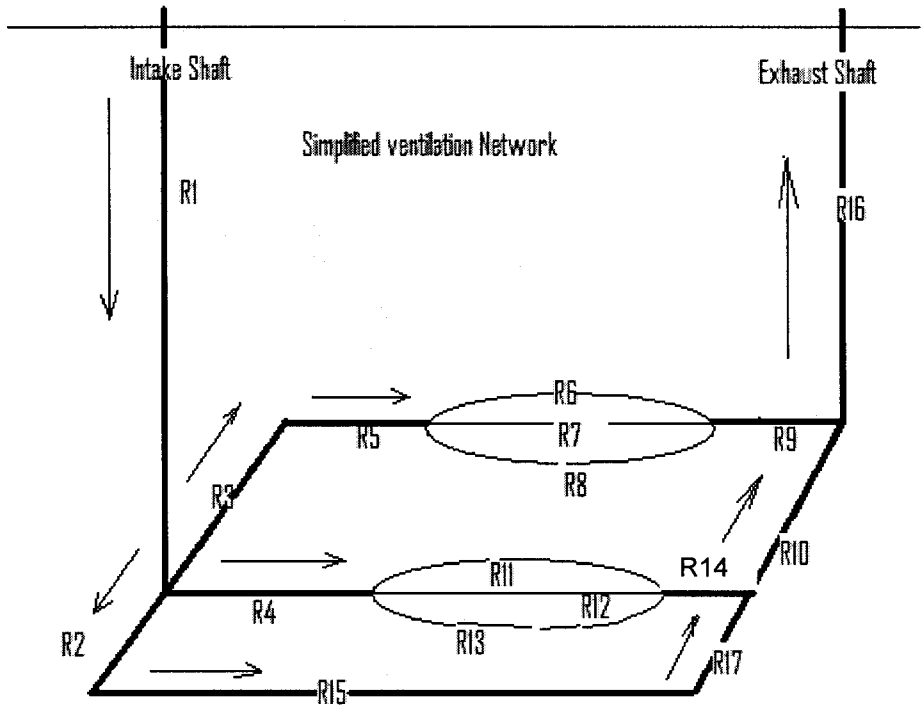
ii) Conduits of varied shapes

[20 Marks]

Question 3

The diagram below shows a simplified ventilation network of a newly developed Iron mine with the following values of R_i in $N.S^2/m^8$:

R1=0.05	R2=0.1342	R3=0.1132
R4=0.123	R5=0.123	R6=0.0235
R7=0.031	R8=0.0234	R9=0.12
R10=0.1132	R11=0.0165	R12=O.0174
R13=0.0155	R14=0.12	R15=0.1425
R16=0.12,	R17=0.11.	



Determine the equivalent resistance for the entire system and the mine static head, if the fan is exhausting air at the rate of 50 m^3/s.

[20 Marks]

Question 4

Explain briefly:

i. Various methods used in Mine air conditioning

[10 Marks]

ii. Methods of detecting Carbon monoxide and nitrous oxides in the mine and their physiological effects on man.

[10 Marks]

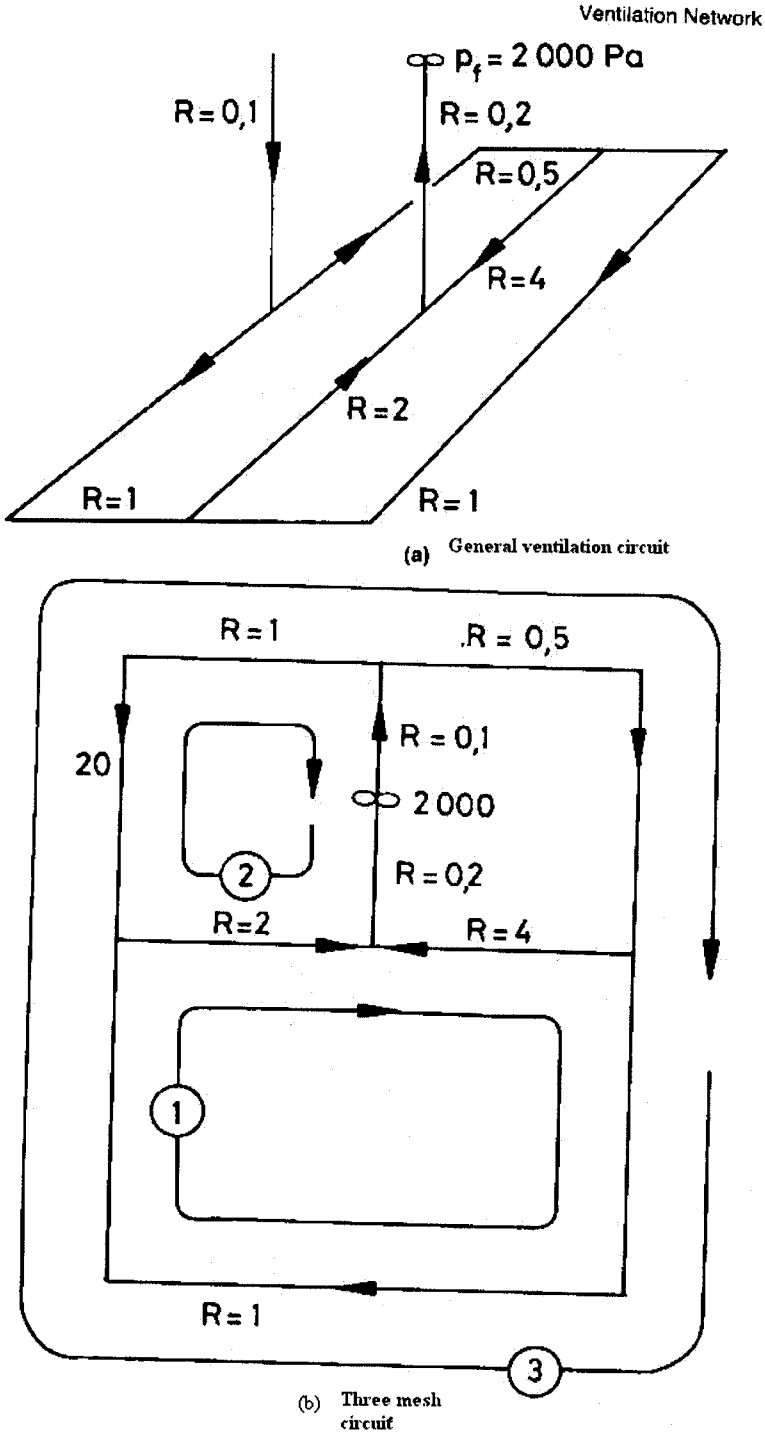


Figure 1. Mine ventilation circuit with three- mesh network

[20 Marks]

Question 5

You have just developed a shallow underground mine that will rely partly on Natural Ventilation Pressure (NPV) as shown in fig. 2.

i) What factors do you think are likely to affect NVP in your mine?

[5 Marks]

ii) In what ways would you aid NVP as a mine ventilation engineer?

[5Marks]

iii) Given the parameters reflected in the same figure calculate the NPV. Take the density of air to be 1.02 kg/m3. Neglect the effect of vapor pressures.

[10 Marks]

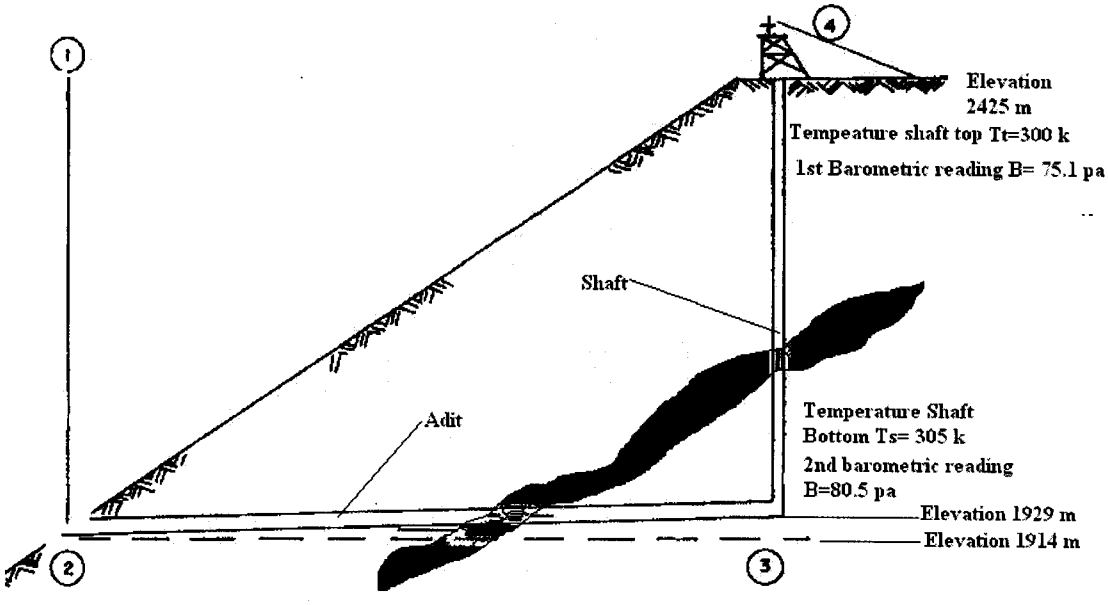


Fig. 2 Underground mine

Question six

Fig 3 shows performance characteristic curves s for two fans connected in parallel on two different shafts with corresponding mine air resistance curves.

i) Plot (not to scale) equivalent resistances of fans and corresponding air ways **[10 Marks]**

ii) Plot and determine combined characteristics points of the two fans **[5 Marks]**

iii) Determine and comment on the working regime points for both fans **[5 Marks]**

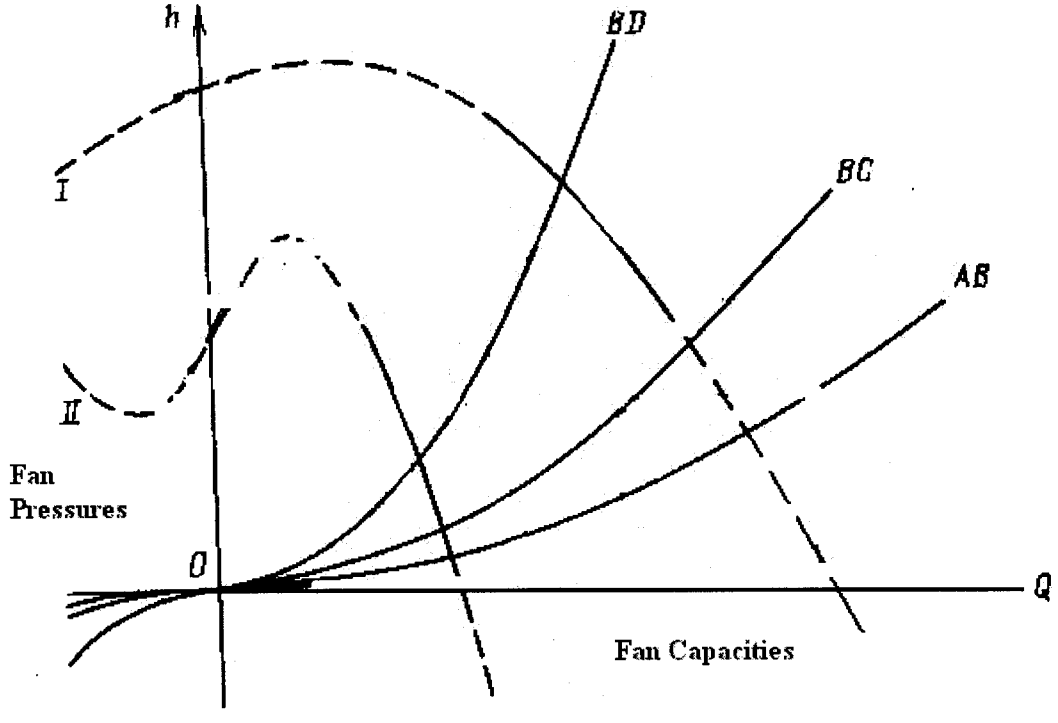


Fig. 3 Performance characteristic curves s for two fan located on two different shafts BC and BD with common air way AB.

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

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
UNIVERSITY EXAMINATIONS – JUNE/JULY 2006
1ST SEMESTER EXAMINATIONS
MI 545 – MINE MANAGEMENT

TIME: 3 HOURS **FULL MARKS: 100**
INSTRUCTIONS: ANSWER ANY FIVE QUESTIONS

1. Write short notes on the following:

   (i) Perception **[3 marks]**
   (ii) Physiological contract **[3 marks]**
   (iii) Machine theory model of management **[4 marks]**
   (iv) Vision, goals and objectives of business **[3 marks]**
   (v) Theories X, Y, and Z **[3 marks]**
   (vi) Major approaches to change based on culture of organisation. **[4 marks]**

2. (i) What do you understand by the term motivation? **[10 marks]**
   (ii) Discuss Alderfer's modified and hierarchy model of motivation and how it differs from Maslow's model of motivation? **[4 marks]**

3. (i) What are the differences between managers and leaders? **[4 marks]**
   (ii) How do you use the following models to manage people?

   (a) MBO **[6 marks]**
   (b) Competency model **[6 marks]**

   (iii) How do you measure managerial effectiveness and how managers should check their activities. **[6 marks]**

4. (i) Construct a statement of sources and application of funds in millions of kwacha given the following accounting items: **[20 marks]**

   (a) Increase in working capital

Stock	7
Debtors	6
Cash	4
Liabilities	2

   (b) Sources of funds

Profit before tax	20
Depreciation	10
Long term loans	13
Share capital	5

(c) Other uses of funds

Taxes paid	7
Dividends paid	5
Fixed assets purchased	17
Long term loans repaid	7

5. Given a working capital section of Chanshya Ltd as at 31st December 2002 as follows:

	Millions of Kwacha	
Current Assets		
Stocks	213	
Debtors	235	
Liquid resources	129	
		577
Current Liabilities		
Short term loan	32	
Creditors	186	
Taxes	54	
Dividends	23	
		295
Net current assets (working capital)		282
Sales		1195

Calculate the following ratios

(i) Current ratio **[4 marks]**
(ii) Acid test ratio **[4 marks]**
(iii) Working capital to sales **[4 marks]**
(iv) Day's sales in debtors **[4 marks]**
(v) Day's sales in stock **[4 marks]**

20

Comment on the adequacy of each ratio.

6. (i) What considerations should one take when considering borrowing? **[4 marks]**

(ii) What financial institution in a normal economy finance business? **[4 marks]**

(iii) Write short notes about interest rates **[4 marks]**
(iv) The role of Central Banks **[4 marks]**
(v) Role and procedures of equity markets **[4 marks]**

20

*** END ***

UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
1ST SEMESTER EXAMINATIONS – JUNE 2006

MI 555 – MINING GEOSTATISTICS

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

ANSWER: ANY FIVE (05) QUESTIONS

Question 1

A shallow reverse circulation (RC) drilling programme has recently taken place on a nickel deposit at Munali Albidon Mine. The nickel occurs in a regular gently dipping bed and has been adequately sampled over the test area by collecting and analyzing the chips and dust from the drill holes. The results from the 59 drill holes are listed below:

22.6	24.0	25.8	27.1	24.4	26.5	23.3
22.5	22.7	22.8	22.9	22.9	22.9	22.8
22.8	24.4	23.7	23.0	24.2	23.8	24.9
25.7	22.2	20.5	20.3	22.0	26.1	25.8
25.4	24.7	26.0	24.2	27.8	23.5	24.3
22.8	23.6	23.5	21.5	22.3	22.1	22.6
23.1	22.6	22.4	23.1	24.4	24.7	28.1
28.4	24.6	29.1	24.2	24.5	22.3	21.7
21.6	22.9	23.3				

a) Calculate the average (mean) nickel grade of the drilled deposit and the standard deviation of these data assuming normal distribution. Use your values of the mean and standard deviation to calculate the 95% confidence limits on this data set. What do 95% confidence limits mean, in practical terms, when related to this data set? (7 marks)

b) Construct a histogram of the nickel grade distribution using sensible class intervals. Does the shape of the grade distribution conform to the normal distribution you were asked to assume in part a) above and do you have any concerns over the values you calculated? (7 marks)

c) If the data set was log-normally distributed, what would the histogram shape look like? Describe the methods you might employ to normalize the data in this situation? What other estimator(s) of grade could be used rather than the arithmetic mean of a normalized dataset? (6 marks)

Question 2

a. What is meant by a global semi-variogram and why is its construction and modeling an important step in variography studies? (5 marks)

b. Indicator kriging is normally used in estimating resources at most mining companies. Describe the use of indicators in indicator kriging. (5 marks)

c. Briefly discuss the main similarities and differences between ordinary kriging and Indicator Kriging and the situations in which they might be used. (5 marks)

d. A combination of block modeling and kriging is often seen as the ideal means of estimating mineral resources and reserves. What are the particular advantages of these two techniques that make them so significant? (5 marks)

Question 3

a. Outline the basic geological conditions that must be met before variography can be undertaken. (5 marks)

b. Following the exploration programme at Kaleni Hills mine, the company decided that its resources were to be determined by a geostatistical estimation technique. As part of the data analysis to identify parameters for grade interpolation, the short range variability in copper grades is being investigated by downhole variography. Initial data for one of the boreholes under investigation is given below:

LAG DISTANCE	NUMBER OF PAIRS	TOTAL SQUARED DIFFERENCE
3.0	55	412.50
6.0	52	696.80
9.0	50	900.00
12.0	48	1004.16
15.0	46	1092.04
18.0	44	997.04
21.0	42	880.32
24.0	40	736.80
27.0	38	842.84
30.0	36	810.00
33.0	36	619.20
36.0	36	658.80
39.0	34	795.60

From the information provided, complete the calculations required to construct the semi-variogram for this borehole. Plot the experimental semi-variogram for this data and fit a model curve to it. State which variogram model type you have chosen and, if appropriate, indicate the nugget variance, sill and range values of the semi-variogram. (15 marks)

Question 4

A borehole through a zinc rich zone of a massive sulphide orebody has been sampled (%Zn) at 1.5m intervals. As part of the study into the best compositing interval to choose for this part of the deposit, the sample data has been composited into 3 different lengths, 4.5m, 3.0m and the original 1.5m sample interval, and variograms at each composite interval are to be prepared.

Sheet 1 shows the initial calculation sheet.

a. Complete the calculations required to construct the semi-variogram for the 1.5m composite. (5 marks)

b. Plot the semi-variograms for All the 3 composite intervals on the same graph paper provided based on the data supplied and your answer to (a). (5 marks)

c. Why do we need to composite sample data when constructing variograms? (4 marks)

d. Use your experimental semi-variograms to estimate the nugget, sill and range values for each composite interval. (6 marks)

Question 5

Eleven (11) channel samples were taken at 2m interval along an exploration crosscut in an underground nickel mine. The samples returned the assay results plotted on the plan of the crosscut as depicted in the figure below. One dimensional variogram values, γ (h), at selected lag distances, h, have been calculated and posted in the table below:

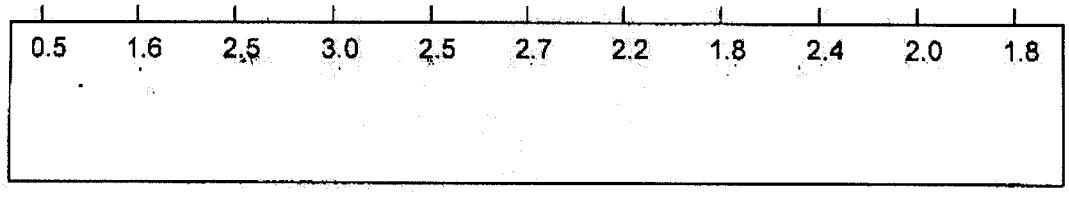


Figure showing nickel assay results from channel samples

h (m)	γ (h),	Number of pairs found at lag
2	0.35	
4	0.85	9
6	1.05	8
8	1.06	7
10		
12		
14		4
16		
18	1.15	2

Table showing variogram values for nickel assays

a) Compute and fill in the missing variogram values and sample pairs for the appropriate lag distance. (8 marks)

b) Plot and fit the spherical model to the experimental variogram. Infer the possible variogram parameters. (8 marks)

c) Briefly explain the effect, on the resultant variogram, of using a lag distance, (h), that is larger than the sampling interval. (4 marks)

Question 6

Figure below shows mid points of economic zinc intersections in boreholes (BH1, BH2, BH3, and BH4) plotted on a vertical longitudinal projection (VLP). Polygons (A1, A2, A3, and A4) are constructed around the boreholes purported to influence the block of ore outlined in the same figure. Details of the boreholes and polygons concerned are listed in Table below.

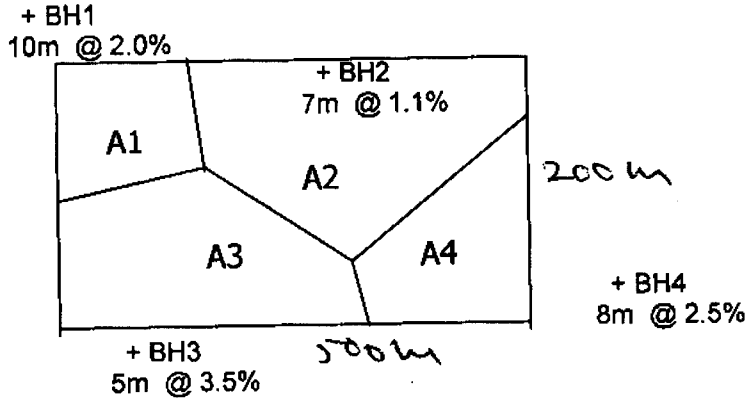


Figure showing VLP of economic zinc intersections

Table showing the Borehole information and associated polygons

POLYGON NUMBER	AREA OF INFLUENCE (m^2)	BOREHOLE NUMBER	INTERCEPT THICKNESS (m)	INTERCEPT GRADE (% Zn)
A1	5,000	BH1	10	2.00
A2	30,000	BH2	7	1.10
A3	20,000	BH3	5	3.50
A4	10,000	BH4	8	2.50
TOTAL/AVERAGE				

a. Use the information in Table above to evaluate the tonnage, grade and metal of zinc contained in the measuring 500m long and 200m high. Take the density of ore as $2.5t/m^3$. (5 marks)

b. What would be the grade of zinc in the same block if the arithmetic mean was used for the evaluation? Make a comment on the comparison of this value with that obtained using the polygon weighting method. (5 marks)

c. Outline the major drawbacks inherent in the statistical methods of estimation. How are the geostatistical methods superior in comparison? (5 marks)

d. What is a regionalized variable? Giving brief explanations where appropriate, list some of the basic assumptions of the theory of regionalized variables.
(5 marks)

Question 7

Briefly discuss the significance of the following in geostatistical analysis:

a) 'Zone of influence' in relation to a sampling programme (4 marks)

b) The statement "kriging is a BLUE" (4 marks)

c) Compositing of core samples (4 marks)

d) Directional variograms (4 marks)

e) Sampling density (4 marks)

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

SHEET No. 1: MINERAL RESOURCE ASSESSMENT

Distance Between samples (lag) m	4.5m Composite	3.0m Composite	1.5m Composite			
m	gamma/2 (γ/2)	gamma/2 (γ/2)	Number of Pairs	Total squared difference	Mean squared difference (gamma)	Gamma/2
1.5			58	154.28	2.66	1.33
3.0		2.67	56	346.08	6.18	3.09
4.5	3.4		54	543.24	10.06	5.03
6.0		6.08	52	696.8	13.4	6.7
7.5			51	842.52	16.52	8.26
9.0	5.91	8.32	50	900.0	18.0	9.0
10.5			49	947.66	19.34	9.67
12.0		9.5	48	1004.16	20.92	10.46
13.5	6.55		47	1075.36	22.88	11.44
15.0		11.01	46	1092.04	23.74	11.87
16.5			45	1025.1	22.78	11.39
18.0	6.68	10.32	44	997.04	22.66	11.33
19.5			43	939.98	21.86	10.93
21.0		9.18	42	880.32	20.96	10.48
22.5	5.71		41	800.32	19.52	9.76
24.0		8.75	40	736.8	18.42	9.21
25.5			39	723.06	18.54	9.27

27.0	7.21	10.62	37	820.66		
28.5			36	842.40		
30.0		10.1	36	810.0		
31.5	4.93		36	696.96		
33.0		7.8	36	619.2		
34.5			36	608.4		
36.0	4.28	8.12	36	658.8		
37.5			35	710.5		
39		11.55	34	795.6		
40.5	8.64		33	860.64		
42.0		13.18	32	897.92		
43.5			31	928.76		
45.0	10.01	14.18	30	942.0		

UNIVERSITY OF ZAMBIA
School of Mines
UNIVERSITY EXAMINATIONS – June 2006
SEMESTER 1 EXAMINATIONS

MI 585: MATERIALS HANDLING

TIME: THREE (03) HOURS

INSTRUCTIONS: ANSWER ALL QUESTIONS IN SECTION 1 AND ANY TWO QUESTIONS FROM SECTION 2

SECTION 1

Question 1.1

Write notes on and explain the Fundamentals of Equipment Selection under the following sub-headlines:

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

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

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

Question 1.2

Given the following:

(i) Rotary Blasthole Drill parameters

- Compressive strength of formation to be drilled = 25 x 20^3 psi.
- Pull down pressure of the drill rig = 85 x 10^3 lbs
- Revolutions per minute of drill string = 80 rpm
- Blasthole diameter = 12" (294mm)

(ii) Blast parameters

- Bench height = 12m
- Angle of highwall, $\propto = 75^0$
- Rock density, SG = 2, 45gm/cm^3
- Explosive density 0,85gm/cm^3
- Coefficient of spread, c = 1,5 to 2
- Number of rows per blast, n = 3 + delay sequencing

You are required to determine:

a)	The penetration rate of the rotary blasthole drill	(04 Points)
b)	Blast design parameters	(05 Points)
c)	Explosive consumption per hole	(03 Points)
d)	Rock broken per hole	(03 Points)
e)	Powder factor	(03 Points)
f)	Spread of the broken muck-pile	(02 Points)

Question 1.3

An electric rope shovel is equipped with a 15.5 m^3 dipper. The dipper fill factor is 0.9 when digging well-fragmented material and sinks to 0.8 in poorly fragmented material. The density (SG) of the material is 2.4 tonnes/BCM and the % swell is 25%.

a) If four (04) passes are required to load a haul truck, how many tonnes would be carried per truck for the two fragmentation conditions? (04 Points)

b) The open pit mine fleet consists of 85, 120, 170, 200 and 250 tonne haul units. Which of these truck sizes may be assigned to the shovel? (04 Points)

If the loading time is 3.5 minutes, loaded haul time is 12 minutes, spotting time at the dumpsite is 0.75 minutes, unloaded (empty) travel time is 8 minutes, spotting time at shovel is 0.5 minutes.

c) How many of the selected truck type should be assigned to the shovel, assuming a total effective shovel working time is 60 min/hr? (04 Points)

d) If, as is often the case in practice, the shovel works 50 minutes in an hour and trucks only work 45 minutes in an hour, how many trucks would you assign to the shovel? (04 Points)

e) If the hourly operating costs are $250.00/hr for the rope shovel and $ 150.00/hr for the truck, what is the penalty for poor fragmentation expressed in terms of additional loading and hauling costs ($/t)? (04 Points)

SECTION 2

Question 2.1

State, and with the aid of corresponding machine types, describe the four (04) major areas of machine application and working environment in mining indicating specific and typical examples of machines deployable on each of the unit operations in Materials Handling. (20 Points)

Question 2.2

Write brief notes on the Dragline as a stripping machine in large surface coal mining under the following sub-headings:

i. Description of the major components and operating parameters of a dragline (05 Points)
ii. Operation of a dragline on key-cutting and actual stripping (05 Points)
iii. Dragline performance estimation (05 points)
iii. Factors affecting dragline performance (05 Points)

Question 2.3

There exists three basic methods of estimating the capacity of excavating equipment i.e. Design, Technical and Effective Capacity.

a) You are required to define, explain and state the applicability and limitations of each of the three capacity estimate types. (12 Points)

b) Describe the application of FEL in surface mining as compared to its application in LHD-mode underground, paying special attention to its operating characteristics and limitations. (08 Points)

Question 2.4

As the trend to deeper mines and production from marginal orebodies continues, mine hoists and their associated equipment have become more and more sophisticated, complex, large and expensive. You are required to:

a) Write brief notes on Hoists stating their composition, classification and types (12 Points)

b) With the aid of corresponding sketches and formulae, discuss the design and operating criteria of a Friction or Koepe hoist (08 Points)

GOOD LUCK

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – JUNE/JULY 2006

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) automobile body sheet
   (b) food wrapping
   (c) domestic table knife
   (d) welding rod
   (e) electrical wires

2. (a) What is a stacking sequence?

   (b) Which of the following planes lie in the zone $[\bar{1}\bar{1}1]$?

   (111), (101), $(3\bar{1}\bar{1})$, $(2\bar{1}\bar{1})$ and $(12\bar{1})$

   (c) What is the zone axis for the following pairs of planes?

   $(\bar{1}10)$ *and* (331); $(2\bar{2}\bar{1})$ *and* $(\bar{1}\bar{1}1)$

   (d) Index the planes and directions in Figure 1.

3. (a) What is an invariant transformation?
   (b) On phase diagrams, why are the maximum and minimum points on the liquidus curves considered to be invariant points?
   (c) Label the Gold-Tin phase diagram in Figure 2.
   (d) Describe the equilibrium cooling behaviour of a Sn-70wt%Au alloy from 500 to 200°C.

4. (a) Show that vacancies must either be created or annihilated during climb of a pure edge dislocation in a direction perpendicular to its slip plane.
   (b) Describe the formation of a kink in edge, and screw dislocations.
   (c) In class, it was stated that the fcc structure has 12 slip systems whereas the bcc has 48. On the basis of the number of slip systems, it would be expected that the shearing stress in the bcc would be lower than that in the fcc. Why is this not the case?

(d) The energy of an edge dislocation per unit length is given by

$$E_e = \frac{Gb^2}{4\pi(1-\nu)} In\frac{R}{r_o}$$

Given that the parameter R is equivalent to the distance at which the strain field of the dislocation decreases to a value equal to that of neighbouring dislocations, i.e. R is approximately one half of the dislocation spacing:

i. Estimate the energy of a single dislocation if the dislocation density is 10^{10} lines/m^2.
ii. Estimate the energy of a single dislocation if the dislocation density is 10^{16} lines/m^2.

$G = 0.7 \times 10^{11}$ N/m^2 $\quad b \approx 3 \times 10^{-10}$ m $\quad r_o \approx 2b$ $\quad \nu \approx 0.3$

5. (a) Explain why the jump frequency of a substitutional impurity atom in a metal is appreciably less than the frequency with which the atom oscillates about its equilibrium site.
(b) Describe two major commercial applications of the solution to Fick's second law of diffusion.
(c) The diffusion coefficient of Pt in Ag in the temperature range 650-950°C can be expressed as

$$D_{Pt} = 6.0 \exp - \frac{136{,}000\, J/mol}{RT} \quad cm^2/\text{sec}$$

i. How long would it take for Pt to penetrate a distance of 3 mm at 700°C?
ii. What temperature would be required to treble the penetration distance in the same time as that in part (i)?
iii. Calculate the diffusion coefficients at 800 and 900°C. What can you say about the diffusion of Pt at 700, 800 and 900°C?

END OF EXAMINATION IN MM321

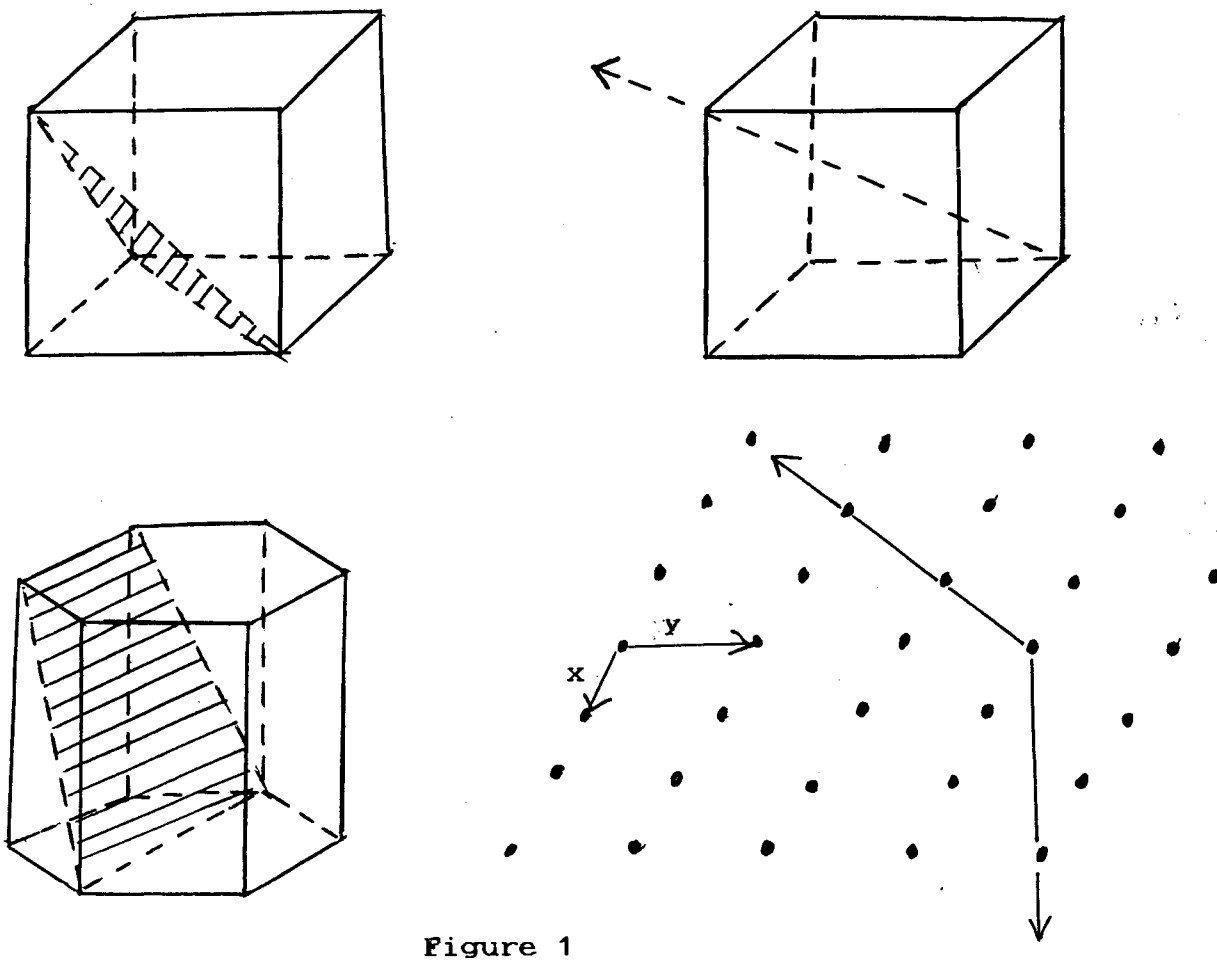
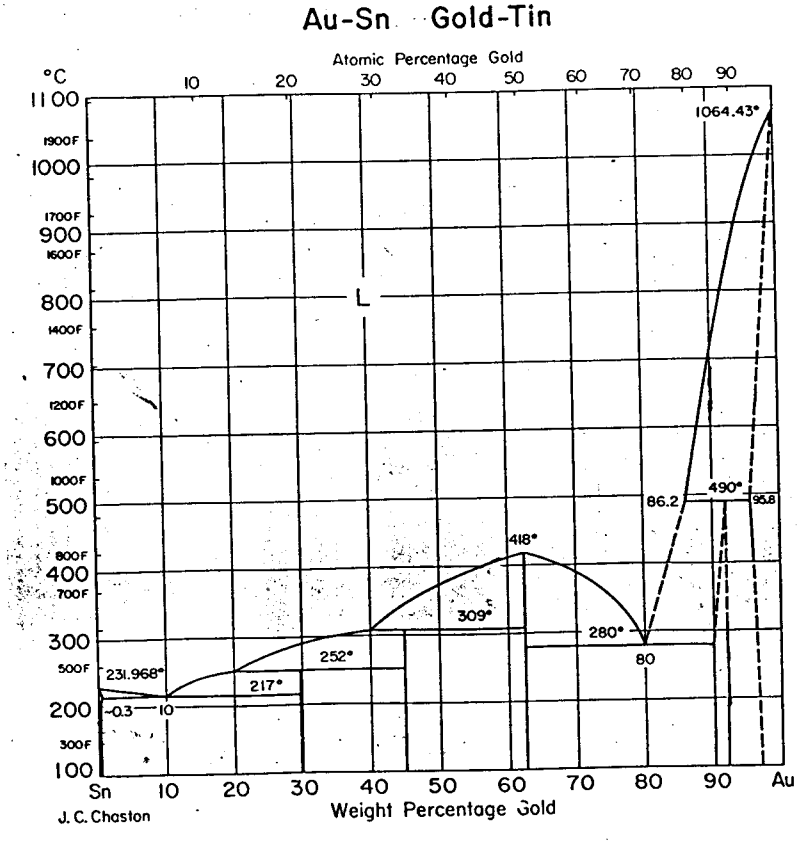


Figure 1

Figure 2



UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – JUNE, 2006

MM 331 - CHEMICAL THERMODYNAMICS I

TIME: THREE HOURS

ANSWER ANY FIVE 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:

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

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

[20%]

Question 4

At 298 K, the standard enthalpy of formation ($\Delta_f H^{\circ}$) 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 $\Delta_f H^{\circ}$ 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 4

(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: $\Delta G^o = 83,680 - 14.52\,T \ln T - 72.26\,T$ J /mol

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

(b) Calculate the entropy of 3 moles of CH_4 that is heated from 298 K to 1098 K at pressure of 1 atm, given that:

$$Cp\,(CH_4) / J\,K^{-1}mol^{-1} = 23.64 + 4.79 \times 10^{-2}\,T - 1.93 \times 10^{-5}\,T^2$$

(c) The entropy change of 2 moles of an ideal gas when it was expanded isothermally from V_A to V_B was found to be 5.595 J K^{-1}. Calculate the ratio V_B/V_A.

[20%]

Question 5

In the dead roasting of zinc sulphide, the reaction occurs as

$$2ZnS + 3O_2 = 2ZnO + 2SO_2.$$

With the help of the following data, find the standard heat of reaction at 25 °C (298 K) and 827 °C (1100 K):

For ZnS : $\Delta H^0_{298} = -48.2$ kcal /mole.

$$C_P = 12.16 + 1.24 \times 10^{-3}\,T - 1.36 \times 10^5\,T^{-2} \text{ cal/deg/mole}$$

For O_2 : $C_P = 7.16 + 1.0 \times 10^{-3}\,T - 0.4 \times 10^5\,T^{-2}$ cal/deg/mole

For ZnO : $\Delta H^0_{298} = -83.2$ kcal /mole.

$$C_P = 11.71 + 1.22 \times 10^{-3}\,T - 2.18 \times 10^5\,T^{-2} \text{ cal/deg/mole}$$

For SO_2 : $\Delta H^0_{298} = -70.95$ kcal /mole.

$$C_P = 10.38 + 2.54 \times 10^{-3}\,T - 1.42 \times 10^5\,T^{-2} \text{ cal/deg/mole}$$

[20%]

Question 6

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 EXAM IN MM 331
GOOD LUCK!

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – JUNE 2006

MM 411

MINERAL PROCESSING I

Answer: Questions 4 and any other four, but keep your answers brief and to the point.
Relative weight of each question indicated in brackets.

Time: 3 hours

Question 1

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

(a) Imagine that, as part of a survey of the above circuit, samples were taken of the ball mill discharge and cyclone feed 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			
	BMD	CF	CUF	COF
+ 212μm	24.4	27.1	34.9	3.6
+150μm	21.6	19.1	25.1	1.2
+106μm	25.0	20.2	22.5	13.3
+75μm	13.2	11.5	9.2	18.4
+53μm	10.4	9.7	3.9	26.9
-53μm	5.4	12.5	4.4	36.6

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

(b) Calculate the recoveries to the cyclone underflow for the different size fractions and plot these against particle size on the graph paper.

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

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

(e) If the discharge rate to the cyclone overflow is 95 tph (dry weight), what is the size distribution in the rod mill discharge?

[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

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

[20%]

Question 3

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

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

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

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

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

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

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

[20%]

Question 4

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.

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

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

(iv) How much water is contained in the cyclone overflow per hour?

[20 %]

Question 5

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

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

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

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

(d) Give and discuss three factors that affect the grinding of ores.

[20 %]

Question 6

(a) What is understood by the 'fall diameter' of a particle and what is understood by its 'quartz diameter'?

(b) What do you understand by the 'free settling ratio' of two minerals and what do you understand by their 'hindered settling ratio'?

(c) Explain briefly, but clearly, why hindered settling ratios are larger than the corresponding free settling ratios.

(d) The relationship of Richardson and Zaki is written as follows:

$$F_S = \frac{v_h}{v_t} = (1 - C_V)^n$$

(i) What do the various symbols, used in this equation, represent?

(ii) For what type of particles is this relationship valid?

(e) When a mixture of fine quartz and baryte has been separated into fractions by beaker decantation, what would you observe if you studied the resulting size fractions under a microscope? S.G of quartz and baryte are 2.65 and 4.5 respectively.

[20%]

END OF MM 411 EXAM
GOOD LUCK!

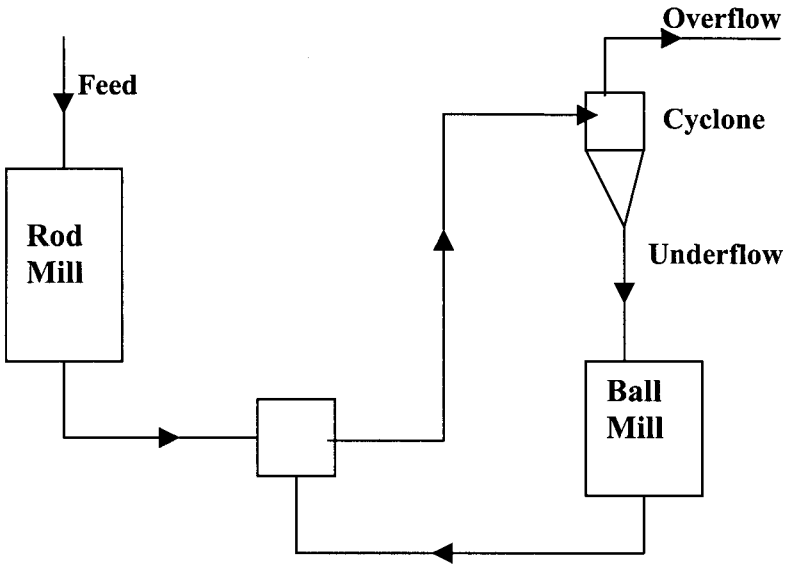


Figure 1: Rod mill – Ball mill – Cyclone circuit

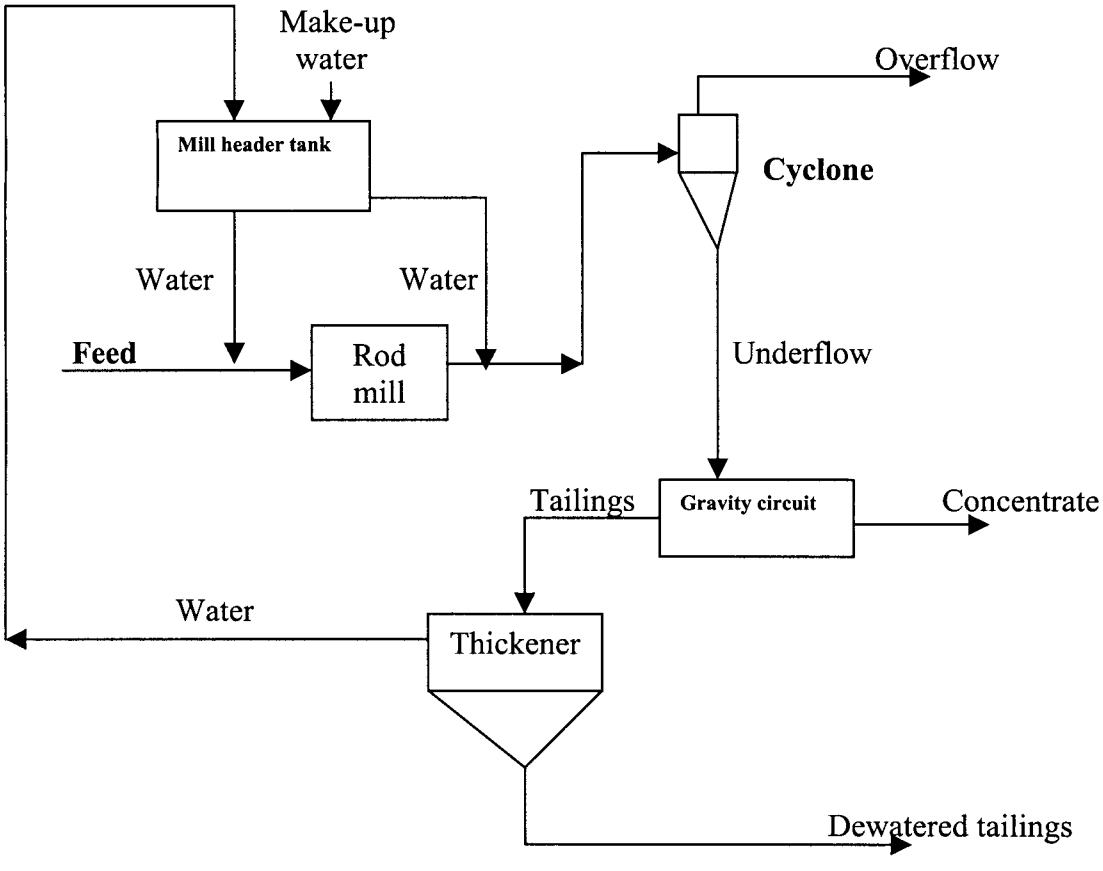


Figure 2: Tin concentrator circuit

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - JUNE, 2006

MM 441

PYROMETALLURGY

ANSWER: ALL QUESTIONS.

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

1(a) In a process to roast a pyrite concentrate to pyrite cinder, the calcine has some residual pyrite while the off-gas has 5% SO_2.

(i) How could the extent of pyrite roasting be increased? What would be the demerits of any measures you propose? (5%)

(ii) How could the SO_2 content of the off-gas be improved? State the disadvantages of any measures you cite. (5%)

(b) Use the thermodynamic data given below, to construct three lines that would form part of the Ni-S-O predominance area diagram at 527 °C. Assume that all solid phases are in their pure states. (10%)

(c) A nickel sulphide concentrate is roasted in a furnace in which the temperature has to be constant at 527 °C. If the furnace atmosphere is found to have an SO_2 partial pressure of 0.1 atm. and an O_2 partial pressure of 10^{-8} atm., state, assuming equilibrium is attained, what nickel phase or phases will be present in the roaster calcine. (5%)

Thermodynamic Data

Universal gas constant, R = 1.986 cal/(deg.mol)

(i) $3NiO + 3SO_2 = 3NiS + 4.5O_2$
$\Delta G^\circ = 292470 - 61.695T$ cal/mol

(ii) $NiSO_4 = NiS + 2O_2$
$\Delta G^\circ = 189805 - 89.70T$ cal/mol

(iii) $NiSO_4 = NiO + SO_2 + 0.5O_2$
$\Delta G^\circ = 92315 - 69.13T$ cal/mol

In the chemical equations above, all substances other than O_2 and SO_2 are pure solids at 527 °C.

2(a) Give a reasoned account of the origin of magnetite in matte smelting units and explain how its presence in the units may be minimized. (10%)

(b) Two copper sulphide concentrates, named X and Y, destined for matte smelting are blended in a mass ratio of 3 parts X to 2 parts of Y. If the concentrates analyze (gangue oxide composition only) as shown below, calculate how much silica flux (with 80% SiO_2) needs to be added per tonne of the concentrate blend so that the normalized slag composition is: 59% SiO_2, 31% CaO, and 10% Al_2O_3. State any assumptions you make. (15%)

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

3(a) A lead and zinc sulphide flotation concentrate has to be sintered prior to its carbothermic reduction in a shaft furnace. Outline, with reasons, the chemical and physical attributes that the sinter would be expected to possesss. (8%)

(b) In an Imperial Smelting Furnace, the sinter charged consists of 50% ZnO, 20% PbO, 20% FeO and 10% SiO_2. Coke which may be regarded as pure amorphous carbon is also charged. Preheated air (21% O_2, 79% N_2) is blown in through the tuyeres. In the furnace, all the coke charged reacts, and the carbon leaves the furnace only as CO and CO_2 of the top gas. All ZnO is reduced to vapour and PbO to liquid Pb, whereas FeO and SiO_2 form a molten slag. The gas after reduction, leaving as top gas, contains 7 volume percent Zn and its CO_2/CO ratio is 0.5. Calculate:

(i) the weight of coke required per 100 grams of sinter charged. (5%)

(ii) the composition of the top gas. (12%)

Relative atomic weights: C = 12.0, Pb = 207.2, Zn = 65.4, O = 16.0, N = 14.0

4(a) Under the headings given below, contrast 1st stage copper converting in a Peirce-Smith converter with the 1st stage of copper fire refining: (10%)

(i) Objectives
(ii) Furnace used
(iii) Process chemistry

(b) During the copper blow of the Peirce-Smith converter, white metal at 1200 °C is blown to copper using air enriched with oxygen to 25% O_2. The balance of the air can be taken as nitrogen. If the air blown into the converter enters at 25 °C, calculate the amount of copper scrap that has to be charged to the converter per tonne white metal in order for the converting temperature to remain constant at 1200 °C. Assume that the amount of air used is 30% in excess of stoichiometric requirements. Heat losses from the converter can be assumed to amount to 15.5% of the exothermic heat of reaction. (15%)

Thermochemical Data

Relative atomic weights: Cu = 63.5; S = 32.1

Heat capacities for copper:

$Cu_{(s)}$: $C_p = 5.41 + 1.50 \times 10^{-3}T$ cal/deg/mol (range: 298 K - m.p.)

$Cu_{(l)}$: $C_p = 7.50$ cal/deg/mol (range: m.p. - 1600 K)

Latent heat of fusion of copper at 1083 °C, $L_f = 3.12$ kcal/mol.

The enthalpy for the substances shown below is to be calculated using the formula:

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

Substance	a	b x 10^3	c x 10^{-5}	d	H°_{298}
Cu_2S	24.10	-	-	-7152	-19000
0_2	7.16	1.00	-0.40	-2044	-
N_2	6.66	1.02	-	-2030	-
Cu	7.50	-	-	-2235	-
SO_2	10.38	1.54	-1.42	-2729	-70940

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – FIRST SEMESTER, JUNE/JULY 2006

MM 451

TRANSPORT PHENOMENA

TIME : THREE HOURS

ANSWER : **FIVE QUESTIONS**. All additional data required by the student are attached.
Where applicable, all calculations are to be done correct to three decimal places.

---

1. (a) What is dimensional analysis? State two methods of performing dimensional analysis. **(3 marks)**

(b) Show that the frictional torque F Nm required to rotate a disc of diameter d m at an angular velocity ω s^{-1} in a fluid of viscosity μ kg/(m)(s) and density ρ kg/m^3 is given by

$$\frac{F}{d^5\omega^2\rho} = f\left(\frac{\rho d^2\omega}{\mu}\right)$$ **(7 marks)**

(c) The rate at which metallic ions are electroplated from a dilute electrolytic solution onto a rotating disk electrode is usually governed by the mass diffusion rate of ions to the disk. This process is believed to be controlled by the following variables:

Variable		*Dimensions*
Mass transfer coefficient	k	$\mathbf{LT^{-1}}$
Diffusion coefficient	D	$\mathbf{L^2T^{-1}}$
Disk diameter	d	**L**
Angular velocity	ω	$\mathbf{T^{-1}}$
Density	ρ	$\mathbf{ML^{-3}}$
Viscosity	μ	$\mathbf{ML^{-1}T^{-1}}$

Obtain a set of dimensionless groups for these variables, where k, μ and D are kept in separate groups. **(10 marks)**

2. (a) A vector $\vec{u}$ has components $u_1 = 2$, $u_2 = -2$, $u_3 = 1$. Evaluate $(\vec{\delta}_1 . \vec{u})$, $[\vec{\delta}_2 x \vec{u}]$, and the length of $\vec{u}$. **(3 marks)**

(b) Evaluate $[[\vec{\delta}_1\vec{\delta}_3.\vec{\delta}_3]]$ and $\{\vec{\delta}.\vec{\delta}\}$ **(3 marks)**

(c) A velocity field $\vec{v}$ has the following components:

$v_1 = bx_2$ $\quad v_2 = bx_1$ $\quad v_3 = 0$ where b is a constant.

Evaluate $(\vec{\nabla}.\vec{v})$, $\{\vec{\nabla}\vec{v}\}$, $[\vec{\nabla}x\vec{v}]$. Is the field irrotational? **(4 marks)**

(d) If $\phi = xy + 16t^2 + yz^3$, what is the vector field grad ϕ? What is the component of the vector grad ϕ in the direction $\vec{v} = 0.95\ \vec{\delta}_x + 0.32\ \vec{\delta}_y$ at position (0,3,2) when t = 0? **(5 marks)**

(e) An iceberg has a density of 920 kg/m^3 in ocean water, which has a density of 1020 kg/m^3. If we observe a volume of 2.8x10^3 m^3 of the iceberg protruding above the free surface, what is the volume of the iceberg below the free surface of the ocean? **(5 marks)**

3. (a) A thin layer of liquid, steadily draining from a plane inclined at an angle θ to the horizontal, has the following velocity profile:

$$v_x = v_{max}\left(\frac{2y}{\delta} - \frac{y^2}{\delta^2}\right)$$

where v_{max} is the surface velocity and δ is the thickness of the layer. If the plane has a width 0.1 m, determine the volume rate of flow in the film. Suppose that δ = 2 cm and the flow rate is 2 litres/min, estimate $v_{max.}$ Remember I litre = 1000 cm^3. **(8 marks)**

(b) A hold tank is installed in an aqueous effluent-treatment process to smooth out fluctuations in concentration in the effluent stream. The effluent feed to the tank normally contains no more than 100 ppm of acetone. The maximum allowable concentration of acetone in the tank is set at 200 ppm. The tank working capacity is 500 m^3 and is considered to be perfectly mixed. The effluent flow is 45,000 kg/h. If the acetone concentration in the feed is suddenly increased to 1000 ppm, due to a spill in the process plant, and stays at that level for half an hour, will the limit of 200 ppm in the effluent discharge be exceeded? **(12 marks)**

4. (a) A jet of water (density, 10^3 kg/m^3) issues from a nozzle at a speed of 6 m/s and strikes a stationary flat plate oriented normal to the jet. The exit area of the nozzle is 600 mm^2. What is the total horizontal force on the plate from the fluids in contact with it? **(5 marks)**

(b) Fluid flows between two parallel horizontal plates, a distance h apart. The upper plate moves at a velocity v_0 while the lower plate is stationary. For what value of pressure gradient will the shear stress at the lower plate be zero? Use the Navier-Stokes equations in conjunction with the equation of continuity. **(10 marks)**

(c) An oil having an absolute viscosity of 0.048 kg/(m)(s) flows through a 25 mm diameter pipe at a maximum velocity of 0.6 m/s. Caclaute the pressure drop(in kN/m^2) in 30 m of pipe and the velocity at a distance of 6 mm from the wall of the pipe.The velocity profile is:

$$v_x = \frac{(P_0 - P_L)R^2}{4\mu L}\left[1 - \left(\frac{r}{R}\right)^2\right]$$ **(5 marks)**

5. (a) Oil of specific gravity 0.8 and having a kinematic viscosity of 1.858X10^{-5} m^2/s is pumped through a 100 mm diameter smooth pipeline 3000 m in length. The discharge point, which is also at atmospheric pressure, is 10 m above the inlet. Find the power in kW required to pump 250 m^3/h.

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

Take g = 9.807 m/s^2. **(12 marks)**

(b) The inside surface of a brick wall L_1 = 10 cm thick (k_1 = 1 W/(m)(^{0}C) is at a temperature T_i =930 ^{0}C,and the outer surface is exposed to an ambient at T_a = 30 ^{0}C with a heat transfer coefficient h_0 = 20 W/(m^2)(^{0}C).

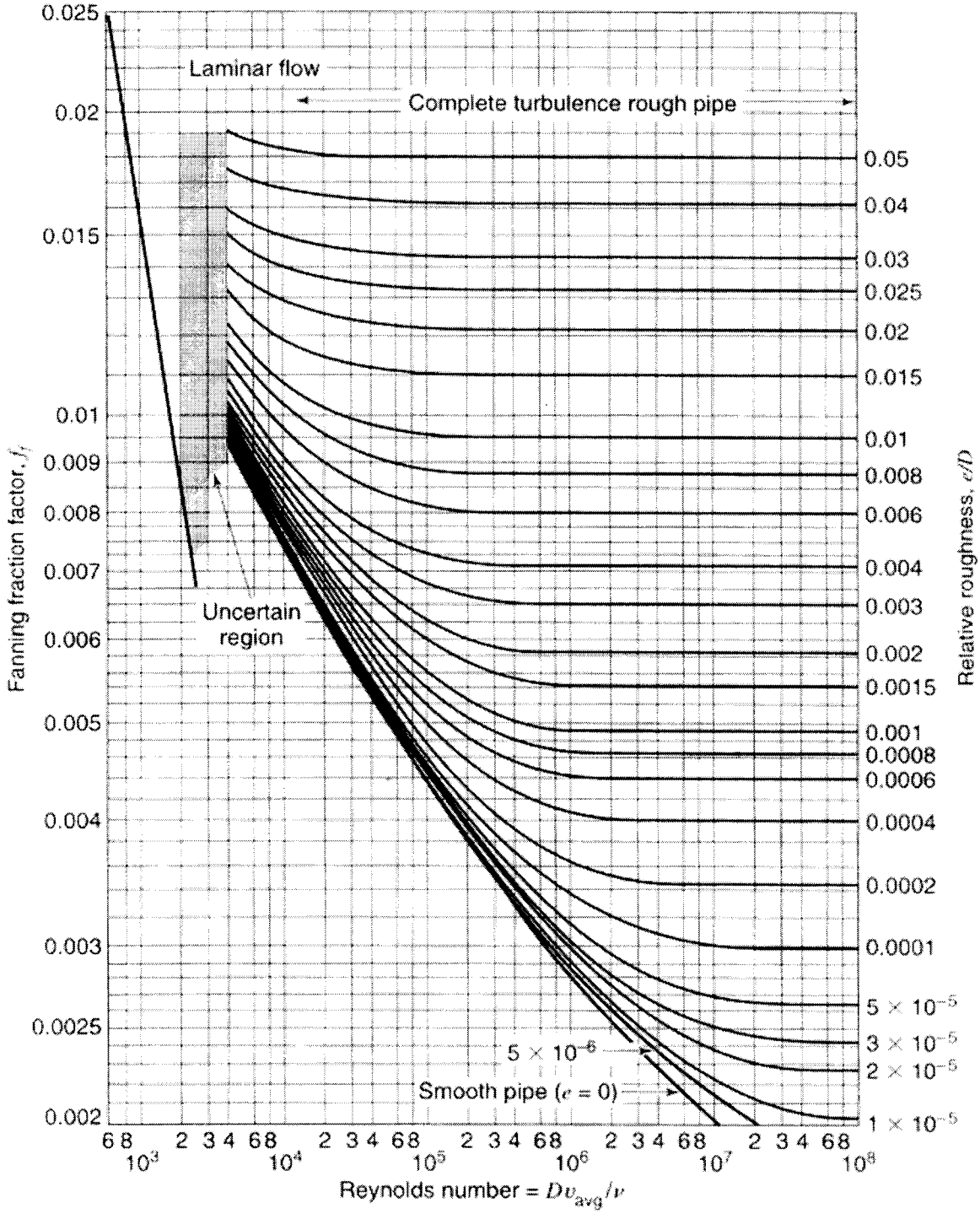
(i) What is temperature at the outer surface? **(4 marks)**

(ii) Calculate the thickness of the insulation layer in cm [k_2 = 0.1 W/(m)(^{0}C)] needed on the outer surface such that the surface layer exposed to air will not exceed 90 ^{0}C. **(4 marks)**

6. (a) A furnace wall consisting of 0.25 m fire clay brick [k_1 = 1.13 W/(m)(K)], 0.20 m of kaolin [k_2 = 0.09 W/(m)(K)] and a 0.10 m outer layer of masonry brick [k_3 = 0.66 W/(m)(K)] is exposed to furnace gas at 1370 K with air at 300 K adjacent to the outside wall. The inside and outside heat transfer coefficients are 115 and 23 W/(m^2)(K), respectively. Determine the heat loss per square metre of wall and the temperature of the outside wall surface under these conditions. **(10 marks)**

(b) Saturated steam at 403 K flows at 1.5 m/s through a steel [k_1 = 20.5 W/(m)(K)] pipe of 40 mm inside diameter and a wall thickness of 3.5 mm. The convective heat transfer coefficient by condensing steam on the inside surface may be taken as 8,500 W/(m^2)(K). The surrounding air is at 300 K, and the outside surface coefficient is 17 W/(m^2)(K). Determine the heat loss per 3 m of pipe insulated with 50 mm of 85 % magnesia [k_2 = 0.07 W/(m)(K)]. **(10 marks)**

END OF EXAMINATION IN MM 451


Laminar flow
Complete turbulence rough pipe
Uncertain region
Smooth pipe (e = 0)
5 × 10⁻⁶
Fanning friction factor, f
Reynolds number = Dv_avg/ν
Relative roughness, e/D
0.025
0.02
0.015
0.01
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.0025
0.002
0.05
0.04
0.03
0.025
0.02
0.015
0.01
0.008
0.006
0.004
0.003
0.002
0.0015
0.001
0.0008
0.0006
0.0004
0.0002
0.0001
5 × 10⁻⁵
3 × 10⁻⁵
2 × 10⁻⁵
1 × 10⁻⁵
6 8 10³ 2 3 4 6 8 10⁴ 2 3 4 6 8 10⁵ 2 3 4 6 8 10⁶ 2 3 4 6 8 10⁷ 2 3 4 6 8 10⁸

§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 $(\nabla \cdot \mathbf{v}) = 0$.

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

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

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

z direction

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

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

SPHERICAL COORDINATES*

r direction

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

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

θ direction

$$\rho\left[\frac{\partial v_\theta}{\partial t}+v_r\frac{\partial v_\theta}{\partial r}+\frac{v_\theta}{r}\frac{\partial v_\theta}{\partial \theta}+\frac{v_\phi}{r\sin\theta}\frac{\partial v_\theta}{\partial \phi}+\frac{v_r v_\theta}{r}-\frac{v_\phi^2\cot\theta}{r}\right]$$

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

ϕ direction

$$\rho\left(\frac{\partial v_\phi}{\partial t}+v_r\frac{\partial v_\phi}{\partial r}+\frac{v_\theta}{r}\frac{\partial v_\phi}{\partial \theta}+\frac{v_\phi}{r\sin\theta}\frac{\partial v_\phi}{\partial \phi}+\frac{v_\phi v_r}{r}+\frac{v_\theta v_\phi}{r}\cot\theta\right)$$

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

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – FIRST SEMESTER, JUNE 2006

MM 481

FERROUS METALLURGY

TIME: THREE HOURS

ANSWER: ALL QUESTIONS (FIVE)

QUESTION ONE

(a) Outline the operation of the Iron Blast Furnace under the following headings:

(i) raw materials (2%)
(ii) principles of reduction in the Blast Furnace (2%)
(iii) main operating parts of the Blast Furnace (3%)
(iv) Chemical reactions (3%)

(b) Describe two design solutions that reconcile the conflicting requirements of reduction and of heating the charge to satisfy the endothermic reactions in Direct Reduction of iron ores. (10%)

QUESTION TWO

(a) Write the formular for calculating the productivity of a sintering . Describe the meaning of the various factors in the formular. (5%)

(b) A Sintering Plant consisting of 6 sintering strands each of 175 m2 surface area has only 5 strands in operation at a time. The sintering operates for 20 hours per working day. If the productivity of one sintering machine is 155.5 t/hour, and that 10% of sinter delivered to the Blast Furnace is returned back after sieving. Calculate:

(i) the vertical velocity of a sintering machine in this plant (5%)

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

(i) the amount of pig iron produced by the Blast Furnace per working day, if it consumes 1.75 tonnes sinter per tonne of pig iron produced. (5%)

In determining the above, make the following assumptions:

Productivity factor = 60%
Bulk density of sinter = 1.6 tonnes/m^3
Height of material in pallet (H) = 400 mm
Speed of sintering strand = 2 m/min

QUESTION THREE

(a) Describe the five internal zones of an iron Blast Furnace. (5%)

(b) Why is external desulphurisation carried out? (1%)

(c) Name four factors on which the efficiency of desulphurisation depends? How can the desulphurisation operating practice be optimised? (6%)

(d) Magnesium can be used as a desulphuriser. Describe its action in desulphurisation. Outline three ways of controlling the action of magnesium. (4%)

(e) Describe the Corex Process in ironmaking. (4%)

QUESTION FOUR

(a) Name six reasons why the Top blown process replaced the Bessemer and Open Hearth processes. (6%)

(b) What were the three disadvantages of the Top Blown process. (3%)

(c) Draw a sketch showing the graphs of carbon content in steel against % oxygen blown for the Top and Bottom blown converters. Describe the difference in the graphs. (3%)

(d) What is the definition of 'Steel'? (2%)

(e) Carbon is known as 'the Chief controller of steel properties'. Describe the various steels containing different carbon contents and their application. (6%)

QUESTION FIVE

(a) Outline five benefits of vacuum degassing. (5%)

(b) Why is it possible to use cast iron, with a melting point much lower than that of steel for ingot moulds? (2%)

(c) In the solidification of a killed steel describe how an 'open top' forms. How can this be controlled. (5%)

(d) Describe the solidification process in semi killed steels and the resulting structure. (3%)

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

(i) Venturi Scrubber (3%)
(ii) Spray tower (2%)

END OF EXAMINATION IN MM 481

UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS– JUNE 2006

MM 515

SPECIAL TOPICS IN MINERAL PROCESSING.

Time : THREE hours

Answer: ANY FIVE questions
All questions carry equal marks

Q1. (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 flotation kinetic modeling exercise and show how the knowledge of the rate constant can be used to effect a separation of say four different minerals.

Q2. 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?

Q3. An ore containing 3% Cu in the form of chalcopyrite ($CuFeS_2$), the remainder being predominately siliceous gangue (s.g 2.7). The ore is crushed to –12mm and sampled before being further treated. The output from the crusher is fed to storage bins via a conveyor system at an average rate of 100 tonnes per hour. Assuming that the crushed material is thoroughly mixed, determine the limit of error (at 99% confidence limited) in the Cu assay introduced by taking a 1kg sample from the conveyor at intervals of 30 minutes. A test of the ore showed that the maximum Cu content of any piece is 10% Cu. The specific gravity of chalcopyrite is 4.2. Take the shape factor and size factor as 0.5 and 0.25 respectively.

Q4. (a) What are the advantages of using particle size distribution functions over the other methods of presenting sizing data?

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

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

Q5. The following data refer to the adsorption of Nitrogen at 195° C on a sample of 0.561 g of coal powder at various pressures in order to determine it's specific surface area:

n (milli moles)	0.439	0.534	0.623	0.693	0.754	0.84
P (cm (s.t.p.)Hg	2.5	6.30	11.4	16.3	20.8	25.8

(a) Using the BET equation, calculate the specific surface area of the powder.

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

BET equation may be written as:

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

The cross sectional area of Nitrogen is 16.1×10^{-20} m

Q6. 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 Iso-electric points (IEP) 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.

Q7 (a). Name two apparatus that can be used for ore characterisation in comminution.

b). Draw a schematic of the Hopkinson pressure bar and label clearly all the important components and Briefly describe the operation of the Hopkinson pressure bar with respect to ore characterisation tests.

You are in charge of the grinding section at Nkana concentrator. A new section is being mined at S.O.B and shaft is open and you start experiencing problems associated with grind. You request for drop weight tests to be performed on the ore. The technician performed the drop weight tests and then forgets to record the resulting size distribution for you. However, he gives you the energy at which the drop weight test was performed as 2.335 KW h/t which is in fact the specific comminution energy. Information from the breakage of S.O.B is provided in Figure 1 and historical information for the t_n - family of curves is given in Figure 2.

(i) Explain the steps you would take to estimate the size distribution resulting from breakage of the S.O.B rock using Figure 1 and Figure 2.

(c) Show the standard root 2 screen size with the 100% 90 mm as you top screen. Consider only screens above 1mm.

Using Figure 1 and Figure 2 when the ECS for the Drop weight breakage test was 2.355 KW h/t estimate and plot the size distribution for the S.O.B ore on the log – linear graph paper provide (log on the x-axis).

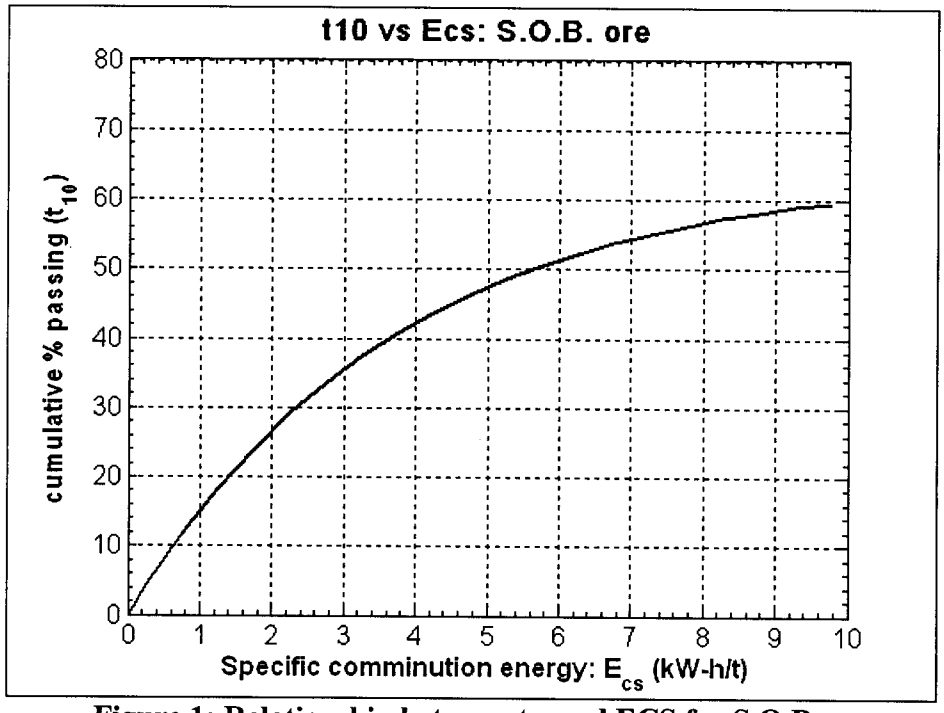


Figure 1: Relationship between t_{10} and ECS for S.O.B ore

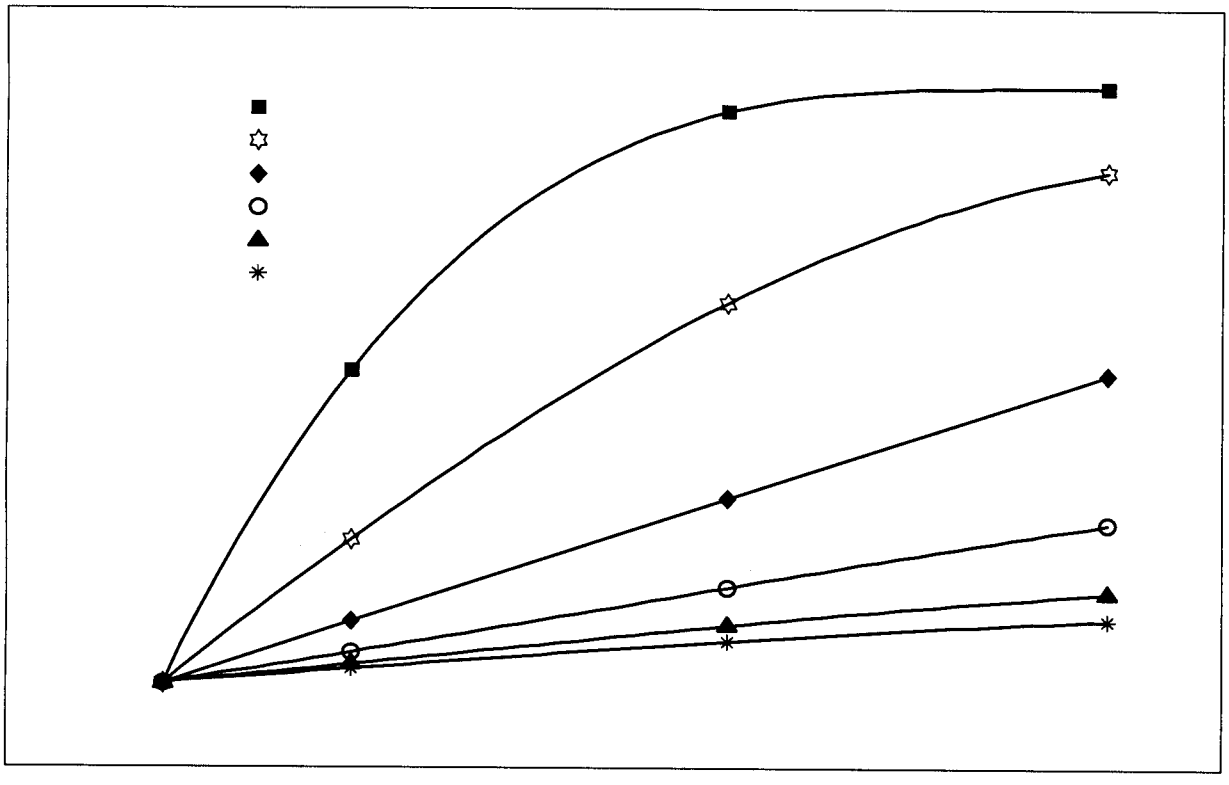


Figure 2: The standard t_n family of curves for the cu-co ores obtained from ore characterisation tests.

Q8. (a) Give four examples of different types classifiers used in the mineral processing industry.

(b) Name any two other types of hydrocyclones other than the conventional hydrocyclone and draw a schematic of the conventional hydrocyclone and label all the parts clearly.

Cyclone efficiency

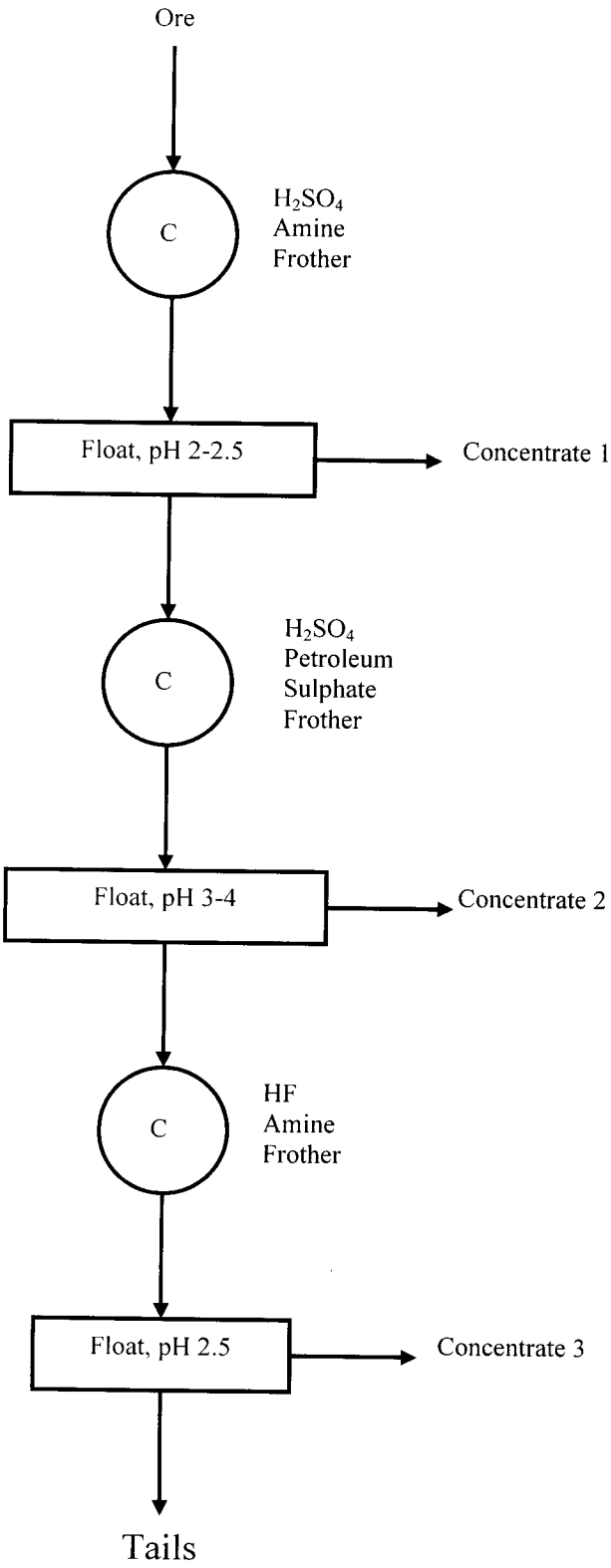
a) What is an efficiency curve? What are the differences between the actual efficiency curve, corrected efficiency curve, and reduced efficiency curve?
b) Using the data provided below and the log-linear graph paper provided draw an actual efficiency curve to the overflow of the hydrocyclone.

c) Using the water split to the overflow (show this value clearly), correct for the bypass and draw the corrected efficiency curve to the overflow on the same graph paper as part (a).
d) Showing the method clearly extract the actual cut size (d50), and the corrected cut size (d50c).
e) Briefly explain what the reduced efficiency curve is used for.

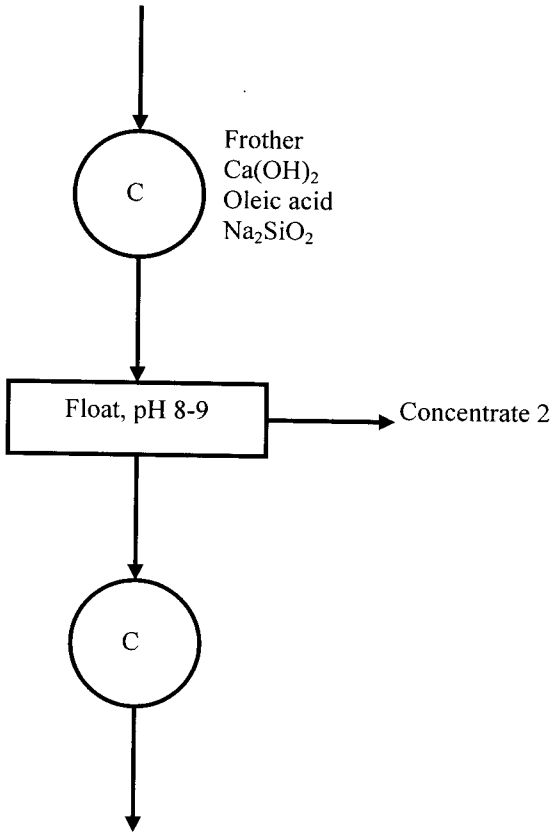
Table 1: Result from the sampling campaign help at Nkana concentrator

%solids		60.3	39.1	84.3
solids flow rate	tph	204.8	70.7	134.1
water flow rate	tph	135.1	109.5	25.5
%retained in each size	4750	10.2	0.0	15.7
	3360	3.0	0.0	4.5
	2370	2.7	0.0	4.1
	1680	3.0	0.0	4.5
	1190	3.6	0.0	5.5
	840	4.3	0.0	6.6
	600	5.7	0.0	8.7
	425	8.5	0.9	12.6
	300	7.9	3.6	10.0
	212	9.0	9.2	8.9
	150	7.2	10.7	5.5
	106	7.1	12.9	4.0
	75	4.5	9.2	2.3
	53	3.1	6.5	1.2
	38	20.3	47.0	5.7

END OF EXAMINATION AND GOOD LUCK.


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

SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – JUNE 2006

MM 545

SELECTED TOPICS IN EXTRACTIVE METALLURGY

TIME: THREE HOURS

ANSWER: QUESTION 5 AND ANY OTHER FOUR

QUESTION ONE

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

(b) Describe the physical and chemical methods of preparation of scrap for steel making. What are "tramp alloys" in iron and steelmaking? What effects do they have on steel products?

(c) Sketch a cupola furnace and describe how it operates. What are the charge materials and products of this furnace?

QUESTION TWO

(a) Describe in some detail the thermochemistry of the converter process. From the description of the converter process, draw the theoretical diagram for the mechanism of copper matte converting, showing the changes in the temperature and composition of the matte as a function of the processing time.

(b) Discuss the;

(i) INCO and

(ii) KIVCET

flashing smelting processes. What is the major disadvantage of the flash smelting process?

(c) Discuss the role of silica in a copper-iron oxysulphide melts (FeO-FeS-SiO_2) during the converting of matte. Draw the ternary system at $1300^{o}C$ and one atmosphere pressure.

QUESTION THREE

(a) What is Ausmelt technology? What are the advantages of this new technology over the conventional methods? Describe hypothetically and with neat sketches the furnaces and possible flowsheets for the smelting of ;

(i) copper concentrates, and

(ii) lead concentrates.

Has the technology any relevance to the Zambian Copperbelt industry? Give reasons.

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

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

QUESTION FOUR

(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) settling chamber, and

(ii) electrostatic precipitators.

QUESTION FIVE

(a) 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 %

SiO2 - 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 oxidized from the first matte charge. The time of blister forming stage is two hours.

Required:

(i) 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.

(b) Use the following equation:

$$n_o^B + \frac{(\underline{O})^X}{(Fe)} - \frac{D}{283000} = n_c^A \cdot \frac{172000}{283000}$$

to estimate the coke requirement and top gas analysis of a blast furnace which is operating according to the given table below;

Item	Specification	Kg/t Fe	Kg moles/t Fe	Kg moles/kg mole of product Fe
Fe		1000	17.9	
Iron oxide	Fe_2O_3			$\frac{(\underline{O})^X}{(Fe)} = ?$
Oxygen from blast air	1350 Nm^3 air per tonne of Fe	?	?	$n_o^B = ?$
Heat demand				D= 486000 kJ/kg mole of product Fe
Pig iron	5 % C	?	?	$\frac{(\underline{C})^m}{(Fe)} = ?$
Active carbon	?	?	?	$n_c^A = ?$
Input carbon from all sources	?	?	?	$n_c^i = \frac{(\underline{C})^m}{(Fe)} + n_c^A$

QUESTION SIX

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

(b) Describe the solvent extraction (SX) process as applied in the recovery of uranium from its ores.

(c) What are the properties of activated charcoal? In which area of metal extraction is it commonly used?

END OF EXAMINATION IN MM 545