THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
SECOND SEMESTER EXAMINATIONS
DECEMBER 2004

GG 202	-	PHYSICAL GEOLOGY
GG 312	-	PRINCIPLES OF PETROLOGY (PAPER I THEORY)
GG 312	-	PRINCIPLES OF PETROLOGY (PAPER II PRACTICAL)
GG 322	-	STRATIGRAPHY AND REMOTE SENSING PAPER II PRACTICAL)
GG 335	-	STRUCTURAL GEOLOGY II (PRACTICAL II)
GG 402	-	GEOLOGY OF ZAMBIA
GG 412	-	METAMORPHIC PETROLOGY (PAPER I - PRACTICAL)
GG 442	-	ECONOMIC GEOLOGY OF METALLIFEROUS MINERAL DEPOSITS (PAPER I THEORY)
GG 442	-	ECONOMIC GEOLOGY OF METALLIFEROUS MINERAL DEPOSITS (PAPER II PRACTICAL)
GG 472	-	APPLIED GEOCHEMISTRY (PAPER I THEORY)
GG 542	-	ECONOMIC GEOLOGY OF NON METALLIFEROUS MINERAL DEPOSITS
GG 572	-	HYDROGEOLOGY
MG 319	-	COMPUTER TECHNIQUES (PAPER I- THEORY)
MG 319	-	COMPUTER TECHNIQUES (PAPER II - PRACTICAL)
MI 322	-	STATISTICS AND COMPUTER APPLICATIONS
MI 465	-	MINERAL ECONOMICS
MI 475	-	MINE ENVIRONMENT
MI 515	-	ROCK MECHANICS II
MI 535	-	COAL MINING METHODS
MI 562	-	INVESTMENT ANALYSIS
MM 205	-	INTRODUCTION TO METALLURGY (PAPER I-THEORY)
MM 205	-	INTRODUCTION TO METALLURGY (PAPER II-PRACTICAL)
MM 332	-	CHEMICAL THERMODYNAMICS II
MM 412	-	MINERAL PROCESSING II
MM 415	-	MINERAL PROCESSING FOR MINING ENGINEERS
MM 422	-	PHYSICAL METALLURGY II
MM 442	-	HYDROMETALLURGY
MM 452	-	PROCESS CONTROL AND INSTRUMENTATION
MM 542	-	FUELS, FURNACES AND REFRACTIONS
MM 562	-	FOUNDRY

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS – DECEMBER 2004

GG 202 – PHYSICAL GEOLOGY

TIME: THREE HOURS

ANSWER: ANY **FIVE** QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS

---

1. a) Briefly describe any **THREE** types of mass movements.
   b) How do the following factors affect mass movement?
      i) Water
      ii) Slope angle
      iii) Earthquakes
   c) Distinguish between mechanical and chemical weathering. Describe and discuss how mechanical weathering would promote chemical weathering.
   d) You may have heard about the slope failure that occurred at the Nchanga Open Pits in 2002. Discuss any two factors that could have been responsible for this failure.

2. a) Define the following terms:
      i) Stream discharge
      ii) Stream capacity
      iii) Saltation
      iv) Dissolved load
      v) Sediment sorting
   b) Describe three ways in which streams carry their load.
   c) Suppose a stream channel is 35 m wide and 5.5 m. If water in the stream flows at a rate of 6 m sec^{-1}, determine its discharge.
   d) Distinguish between **influent** and **effluent** streams.
   e) Name the oceans to which the following Rivers flow: - Luapula, Luangwa, Kafue, Chambeshi and Zambezi.

3. a) Describe how stream velocity influences the capacity, competence and discharge of a stream.
   b) Describe the following:
      i) Delta
      ii) Alluvial fan
      iii) Dendritic drainage pattern
      iv) Trellis drainage pattern
   c) Describe the formation of (i) channel deposits, (ii) Alluvial fan, (iii) Flood plain deposits.
   d) Describe **three** factors that control current velocity of a stream

4. a) Why would you recommend against deforestation of a recharge area for an aquifer that serves your community?
   b) If a river flows through a vein of gold mineralisation into a flood plain downstream, which areas of the channel would you go panning for gold and why?
   c) Describe how tides are generated.
   d) In what ways do waves erode the coastlines?
   e) In the Maamba area of Zambia, tillite has been recognised at the base of the Lower Karoo. What does this signify about past climate?

5. a) List any **four** components of the hydrologic cycle.
   b) List **four** natural passageways of infiltration into the subsurface.
   c) Describe two ways by which groundwater escapes to the atmosphere.
   d) Distinguish between aquifer and aquitard.
   e) Distinguish between aeration/vadose zone and saturated zone.
   f) What features characterise karst topography in soluble rocks?

6. a) How are valley glaciers distinguished from continental glaciers?
   b) What are the main mechanisms of glacier flow?
   c) How do glaciers erode bedrock?
   d) Describe **three** kinds of glacial sediments.
   e) Name and describe three types of landforms created by glaciers.
   f) Global warming has resulted in a rise in temperatures. Discuss any possible environmental problems that may arise from continued rise in global temperatures.

7. a) Describe the main features of wind erosion.
   b) Name **three** types of sand dunes and show how each relates to wind direction and the availability of sand.
   c) Describe the main difference between the way wind transports dust and the way it transports sand,
   d) Loess is recognised as very fertile soil. Describe how it is formed.
   e) What evidence may you look for in ancient sandstones that would point to their aeolian origin?

----------END OF EXAMINATION – GOOD LUCK! ----------

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS – DECEMBER 2004

GG312 – PRICIPLES OF PETROLOGY

PAPER I – THEORY

INSTRUCTIONS: Answer six questions, two from each section using sketches wherever possible. All questions carry equal marks.

TIME: Three (3) Hours

SECTION A

Q1. (a) What geologic events are implied if a granite body is found exposed at surface?

(b) What are the differences between a sill, a dyke and a volcanic flow?

Q2. (a) Give the origin of vesicles in a basalt.

(b) Why is oceanic crust predominantly basalt, whereas continental crust is mainly of granite composition?

SECTOIN B

Q3. List and briefly discuss the five stages involved in the formation of sedimentary rocks.

Q4. (a) How do clastic sedimentary rocks differ from the chemical sedimentary rocks?.

(b) In what ways are clastic sediments modified during transportation?

(c) What is the difference between breccia and conglomerate?

Q5. (a) How do limestones.form? What is a bioclastic limestone?

(b) What does cross-bedding in a sandstone tell and mud cracks in a mudstone tell us about the depositional environment?

Q6. (a) Describe how loose clastic sediments become lithified to form hard rock?

(b) What is pore space in a clastic sediment? How is it modified during lithification?

(c) Describe the process of formation of coal.

SECTION C

Q7. (a) What are the main changes that a rock undergoes during metamorphism?

(b) Define metamorphism. What are the main agents or factors that control the formation of metamorphic rocks?

Q8. (a) What is the difference between contact metamorphism and regional metamorphism?

(b) Describe and explain how foliation texture is formed in metamorphic rocks?

(c) What is the effect of contact metamorphism on shale?

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

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS – DECEMBER 2004

GG312 – PRICIPLES OF PETROLOGY

PAPER II – PRACTICAL

INSTRUCTIONS: Answer all questions.

TIME: Three (3) Hours

Q1. Identify the seven (7) mineral specimens A, B, C, D, E, F and G. Indicate the characteristic physical properties of each mineral.

Q2. Give a petrographic description of the six (6) rock specimens 1, 2, 3, 4, 5 and 6. Name the rocks.

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

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – DECEMBER 2004

GG322 - STRATIGRAPHY AND REMOTE SENSING

PAPER I - THEORY

Answer: Any five questions using sketches wherever possible for a full mark. All questions carry equal marks.

Time: Three (3) Hours

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

Q2. (a) Name the Historical Landmarks that led to the development of Remote Sensing.
- (b) With a sketch illustrate the Electromagnetic Spectrum, indicating the various blinds and windows and the various sensors.

Q3. (a) Describe Walter's Law of facies of 1894. Use diagrams to illustrate some of your explanations.
- (b) Outline the five major stages in the evolution of life in the Phanerozoic

Q4. (a) Name the three types of fossils.
- (b) Outline the reasons why fossils are not preserved.
- (c) Describe the processes that may lead to the alterations of fossils.

Q5. (a) Charles Darwin (1859) provided a key with his explanation of organic evolution -- the origin of species by natural selection. Outline Darwin's observations (Hint: He observed 4 things)
- (b) Differentiate between the following:
  - (i) Relative and Absolute Ages.
  - (ii) Seismic Stratigraphy and Magneto-Stratigraphy
  - (iii) Chronostratigraphy and Biostratigraphy

Q6. (a) What is the name given to the surface that separates unconformable strata?
- (b) Decsribe the four main types of the surface you named in (a). Use sketches to illustrate your answer.

(c) Fill in the missing words (remember to give examples in brackets)

TIME UNITS	TIME-ROCK UNITS
(a) ----------	Eonothem (e.g. Phanerozoic Eonothem)
Era (e.g. Paleozoic Era)	(b) ----------
(c) ----------	System (e.g. Ordovician System)
Epoch (e.g. Late Ordovician)	(d) ----------
(e) ----------	Stage (e.g. Ashgillian Stage)
Chron	(f) ----------

Q7. (a) Define the term lithostratigraphy.
(b) Outline the main elements of lithostratigraphic units.
(c) What do you call a mappable unit that can be shown on a Map. How is this linked to other units such as a Supergroup. Draw a sketch or diagram to illustrate this.

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

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – DECEMBER 2004

GG322 - STRATIGRAPHY AND REMOTE SENSING

PAPER II - PRACTICAL

Answer:	All questions using neatly drawn sketches/diagrams wherever possible for a full mark.
Time:	Three (3) Hours

Q1 (a) What is Geographic Information System? (2 marks)
(b) Differentiate between the following:
(i) Photograph and an image (2 marks)
(ii) Spectral response and spectral signature. (2 marks)

(c) You have just been hired to work for the Ministry of Science and Technology. The Government would like to introduce Remote Sensing in Zambia. List what you consider to be the value of Remote Sensing in Zambia so as to convince the Minister to buy in this emerging technology.(7 marks)

(d) In order to understand Remote Sensing, what areas (or fields of specialization) should you have knowledge of. (6 marks)

(e) Define the term Spectral Band? How many spectral bands does Landsat 7 have? (8 marks)

Q2. (a) List the sensor systems known today. (5 marks)

(b) What does a Digital Image Data File consists of? (5 marks)

(c) List the known Image Formats that you can use to save your images on your computer. (7 marks)

(d) Outline the anatomy of a GIS. (6 marks)

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

3. As a Lecturer at the University of Zambia, you have been assigned to undertake a research study in the Southern Part of Zambia. In your preparation to undertake such a study, do the following:

   (a) List the items you will need to carry with you to the field.

   (b) You decide to select 3 aerial photos so that you can undertake an initial photo-geological interpretation. You are therefore required to:

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

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

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

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS – DECEMBER 2004

GG335 – STRUCTURAL GEOLOGY I

PAPER I – THEORY

INSTRUCTIONS: Answer any five questions using sketches wherever possible. All questions carry equal marks.

TIME: Three (3) Hours

Q1. (a) What is a primary structure?
(b) What is the significance of structural geology to oil formation?
(c) State the principle of Stratigraphic superposition.
(d) Define the following:
  (i) Bedding
  (ii) Cross bedding
  (iii) Graded bedding
  (iv) Ripple mark
  (v) Mud crack
(e) What interpretation can you draw from cross bedding, graded bedding and ripple marks?

Q2. (a) How do pillow lavas form?
(b) What are vesicles and how are they used in distinguishing various lava flows?
(c) What is an unconformity and what does it represent?
(d) Write short notes on the following:
  (i) Angular unconformity
  (ii) Nonconformity
  (iii) Disconformity
(e) Name four ways in which unconformities can be identified on an outcrop.

Q3. (a) Define the following:
  (i) Fold limb
  (ii) Fold wavelength
  (iii) Fold amplitude
  (iv) Fold height
  (v) Fold crest
  (vi) Fold trough
  (vii) Axial plane
  (viii) Hinge
  (ix) Dome

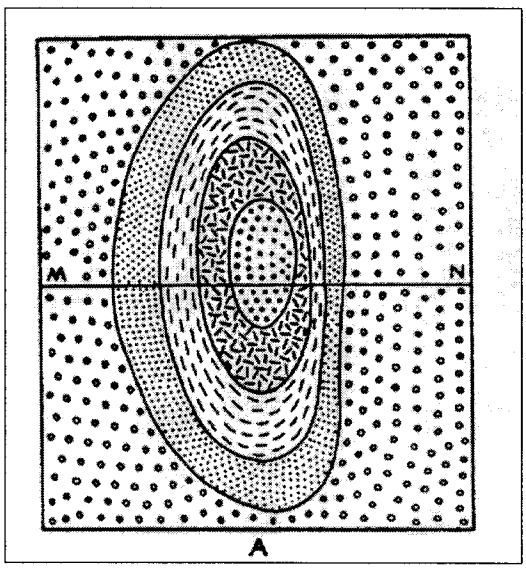
(b) Name and briefly describe three types of folds on the basis of the orientation of a hinge line.
(c) Name and describe briefly four types of folds on the basis of the orientation of an axial plane.

Q4. (a) Distinguish between:
  (i) Anticline and syncline
  (ii) Symmetrical folds and asymmetrical folds
(b) Define the following:
  (i) Parallel folds
  (ii) Similar folds

(iii) Concentric folds
(iv) Angular folds

(c) For the following interlimb angles name the corresponding fold types: (i) 180-120°, (ii) 120-70°, (iii) 70-30°, (iv) 30-0°, (v) 0°

(d) A map is given in the figure below in which age relations among the rocks and the attitudes are unknown. Draw four possible sections along line M-N.



Q5. (a) Distinguish between a fault and a joint.

(b) Define the following:
(i) Fault Plane
(ii) Hangingwall
(iii) Footwall
(iv) Dip
(v) Strike

(c) Write brief notes on the following:
(i) Normal fault
(ii) Reverse fault
(iii) Left handed strike slip fault
(iv) Oblique slip fault
(v) Rotational fault

(d) Describe the following:
(i) Throw
(ii) Heave

Q6. Define the following terms
(a) Force
(b) Stress
(c) Principal plane of stress
(d) Critical shear strength
(e) Cohesive strength
(f) Coulomb coefficient

Q7. The table below shows results of a fracture experiment carried out by a geologist on one identical rock type.

Experiment No.	Confining Stress σ_3 (MPa)	Axial Stress σ_1 (MPa)
1	14	87
2	42	164
3	70	242
4	99	321

(a) Draw Mohr circles for each experiment and construct the failure envelope
(b) Determine the Coulomb coefficient for this rock
(c) Determine the angle ϕ the fracture plane is likely to make with σ_3 direction when the rock fractures.

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

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – DECEMBER 2004

GG335 – STRUCTURAL GEOLOGY I

PAPER II - PRACTICAL

Answer:	All questions.
Time:	Three (3) Hours

Q1 You are provided with Fig 1, do the following (35 marks):

(a) State with a reason whether the strata are horizontal, vertical or inclined

(b) Draw strike lines of the geological boundariesAB, BC, CD, EF and label them.

(c) What is the strike, dip and dip direction of the beds? Dip should be determined by both graphical and calculation methods.

(d) Draw to scale a cross section along line Y-Z

(e) Determine the true thicknesses of beds B, C, D and E.

Q2. Map (Fig 2) is a three point problem of a coal seam that is seen to outcrop at points A, B and C. Using this map do the following (35 marks):

(a) Draw strike lines

(b) Map in the coal seem

(c) Determine the strike, dip (both graphically and by calculation) and dip direction

(d) Draw to scale a cross section along line X-Y

(e) At what depth would a drill hole located at point D intersect the coal seam?

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

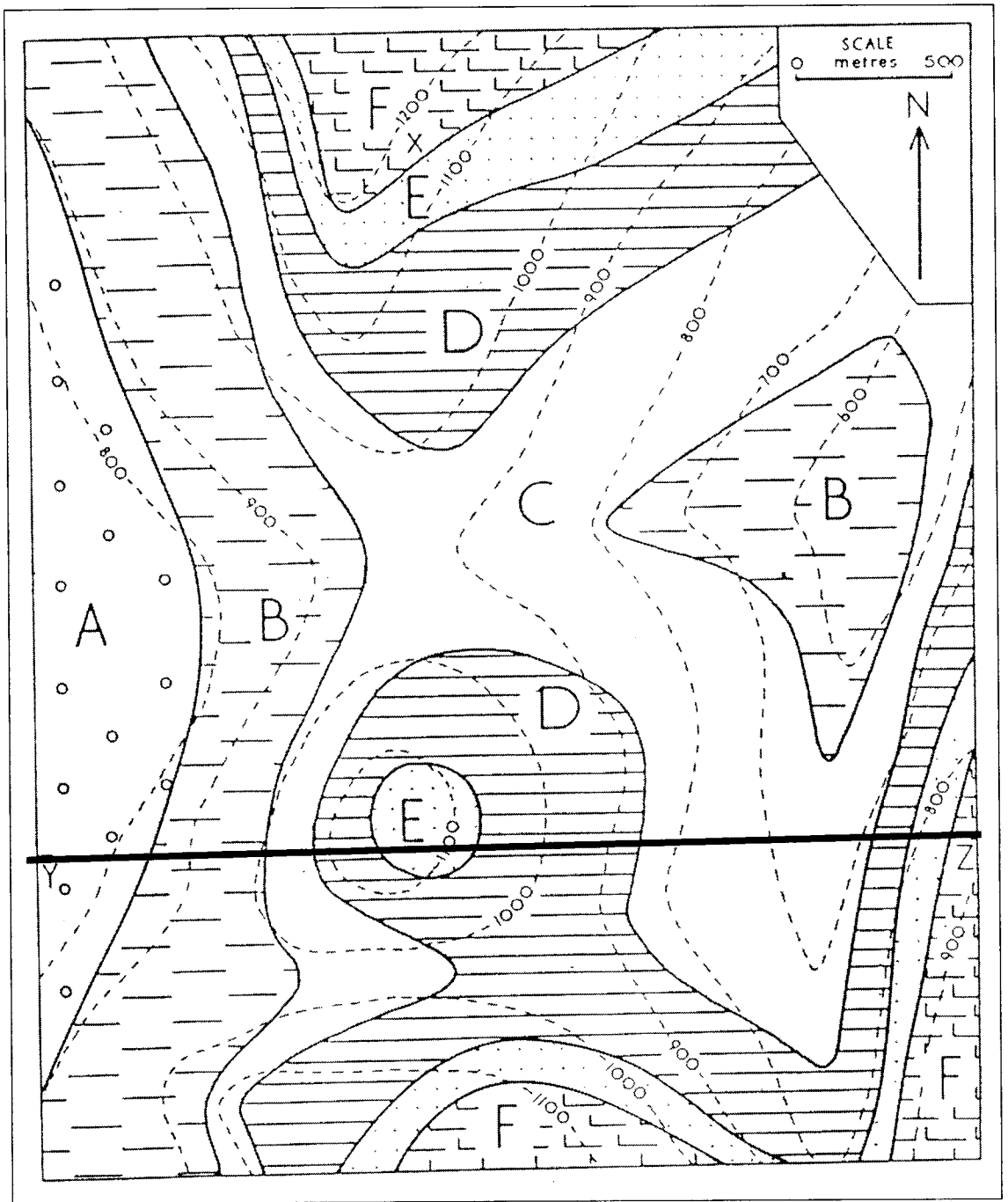


Fig. 1 Geological Map for GG335 II Exam Paper Second Semester 2004. This map is meant for question 1. Cross section should be drawn along Line Y-Z.

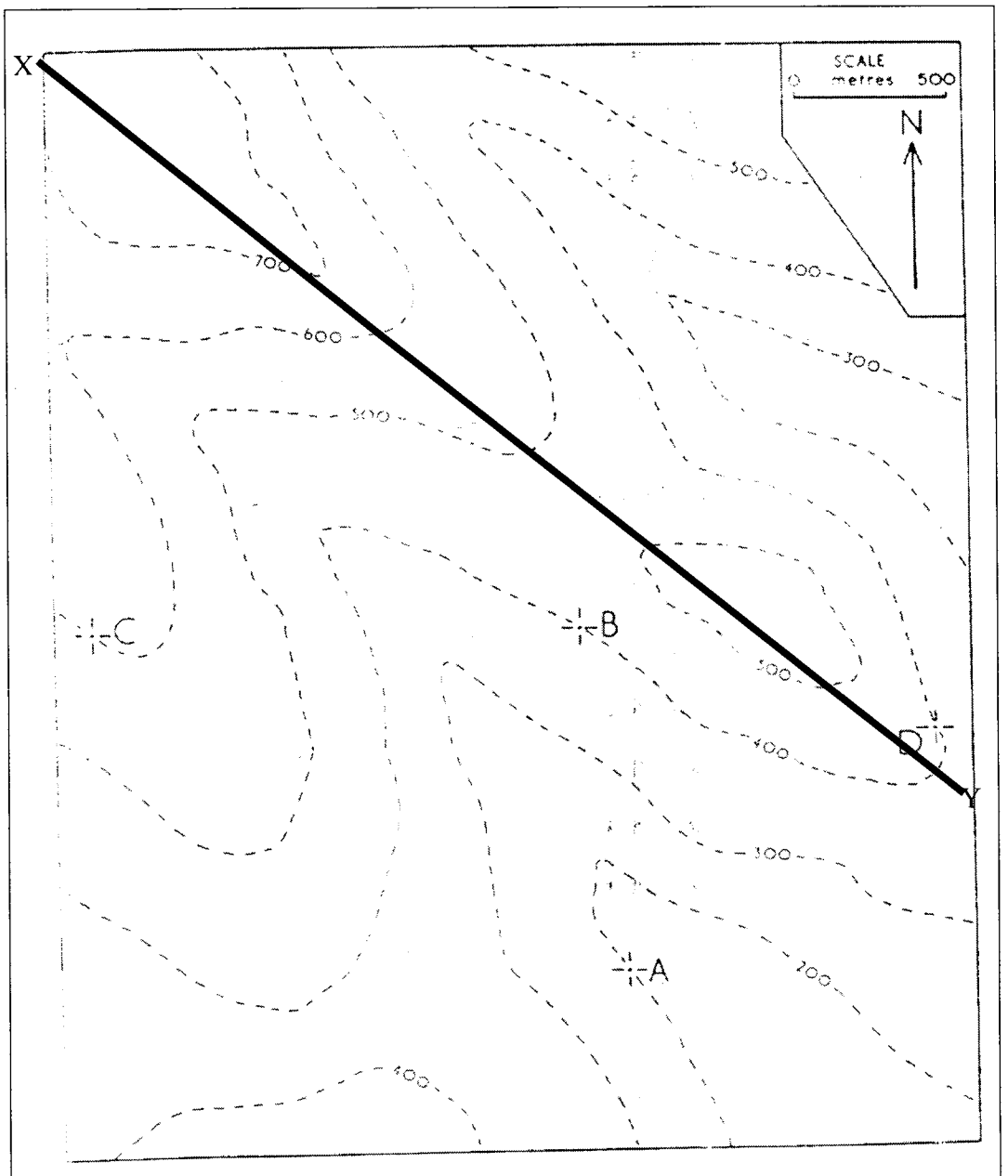


Fig 2 A map showing three points where a coal seam is seen to outcrop. This map is for question 2. Cross section should be drawn along Line X-Y.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS – DECEMBER 2004

GG402 – GEOLOGY OF ZAMBIA

INSTRUCTIONS: Answer any five questions using sketches wherever possible. All questions carry equal marks.

TIME: Three (3) Hours

Q1. The Lufilian fold belt is an example of a Neoproterozoic orogenic belt which has been interpreted using either the ensialic or modern-day plate tectonics.
(a) What do you understand by the term orogenic belt and how does it differ from mobile belt?
(b) Describe the main features that suggest that the Katangan sedimentary rocks were formed in a rift setting.
(c) Discuss the main evidence which has been used to postulate large-scale thrusting in the Lufilian belt and briefly discuss why the identification of these thrust units is of importance.

Q2. The Bangweulu Block is one of the major geotectonic units in Zambia.
(a) During which geological time period did the Bangweulu Block form?
(b) Discuss the geological evolution of the Bangweulu Block using the geological age data of rock units given below.

ROCK UNIT	AGE (Ma)	86Sr/87Sr INITIAL RATIO
Mambwe granodiorite	1869±40	0.7072
Mansa volcanics	1838±86	0.7016
Luchewe ganite	1833±18	0.7033
Mansa granite	1816±22	0.7063
Lusenga syenite	1134±8	0.7042
Lwakwa granite	1108±43	0.7085
Mambwe dolerite	709±12	--
Songwe syenite	671±62	0.7058

(c) How does the Bangweulu Block differ from a typical Archean craton?

Q3. The Archeaneon is characterized by distinctive rock associations which are rare or absent elsewhere in the geological record.
(a) Name these rock associations
(b) Why are these rocks mainly restricted to the Archean?
(c) Discuss two models Archean crustal development

Q4. (a) Describe the lithostratigraphy of the Katanga Supergroup in Zambia.
(b) Discuss the minerization in the Katangan orogen.

Q5. Discuss the geological evolution of the Irumide Belt in terms of stratigraphy, sedimentation, deformation and magmatism.

Q6. (a) Outline in form of a table the stratigraphy of the Phanerozoic in Zambia.
(b) Describe the geological setting of the Lower Karoo Group indicating its possible depositional environment and economic potential.

Q7. (a) Name the formations of the Sinakumbe Group.
(b) Describe the oldest formation in (a) including its (i) stratigraphy and (ii) possible depositional environment.

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

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS – DECEMBER 2004

GG412 – METAMORPHIC PETROLOGY

PAPER I – THEORY

INSTRUCTIONS: Answer any five questions using sketches wherever possible. All questions carry equal marks.

TIME: Three (3) Hours

Q1. Discuss the main features that may give rise to foliation in a metamorphic rock.

Q2. Define and state the usefulness of the following:
(a) Index mineral
(b) Granoblastic texture
(c) Geothermal gradient
(d) Mylonite

Q3. What is metamorphism? Explain the role of the six main factors in metamorphism.

Q4. (a) Describe a metamorphic protolith. What are the chemical and mineralogical characteristics of a metamorphic protolith?
(b) What is the role of crystalloblastic series in metamorphic textures?

Q5 The study of metamorphism is a key to crustal evolution. Discuss.

Q6. Consider the reaction: pyx + pl + H_2O = pl + ho + alm

(a) What is the chemical type of rocks in which this reaction may occur?
(b) Is this a continuous or a discontinuous reaction, why?
(c) What are the physical and chemical variables that may influence the reaction temperature? Explain your answer.
(d) Draw your conclusions about the metamorphic grade.

pyx – pyroxene; pl – plagioclase; ho – hornblende; alm - almandine

Q7. Discuss the classification of the main metamorphic types.

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

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS – DECEMBER 2004

GG412 – METAMORPHIC PETROLOGY

PAPER II – PRACTICAL

INSTRUCTIONS: Answer all questions.

TIME: Three (3) Hours

Q1. Give a complete petrographic description of thin sections A and B and name the rocks accordingly. (30 marks)

Q2. Provided with thin section C, do the following (30 marks):
- (a) Identify the minerals present
- (b) Describe the texture of the rock
- (c) What is the chemical type of the rock
- (d) Name the rock

Q3. Give a full petrographic description of thin section D, emphasize on the following (40 marks):
- (a) Mineralogy
- (b) Metamorphic history
- (c) Metamorphic grade
- (d) Name the rock

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

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS – DECEMBER 2004

GG442 – ECONOMIC GEOLOGY OF METALLIFEROUS MINERAL DEPOSITS

PAPER I – THEORY

INSTRUCTIONS: Answer any four questions using sketches wherever possible. All questions carry equal marks.

TIME: Three (3) Hours

Q1. (a) Discuss in general the importance of mineral resources to an economy such as the Zambian one.

(b) Discuss the eight factors controlling the availability of mineral resources?

Q2. (a) Distinguish between stratabound and stratiform deposits.

(b) The Zambian Copperbelt Deposits are believed to be stratiform why?

(c) Discuss briefly how the Zambian Copperbelt Deposits are believed to have formed paying attention to the source of the so much copper in the sediments, how this copper was transported and how it got deposited.

(d) If you did a mass balance of the copper in the sediments and that in the basement, would you conclude that two are the same? Why or why not?

(e) Kupferscieffer is another example of stratiform deposits, describe briefly its characteristics.

Q3. (a) What are the main differences between placer and residual deposits?

(b) Discuss the factors that control the formation of placer deposits.

(c) Name five minerals that would form placer deposits.

(d) Name and describe briefly the four types of placer deposits.

(e) Under what conditions do residual deposits form?

(f) Name and describe briefly two types of residual deposits.

Q4. (a) Describe and discuss characteristic features of skarns that form at depth and those that form near the Earth's surface.

(b) What sort of tectonic environment would you expect skarn deposits to form and why?

(c) Distinguish between reaction skarn and skarnoid and between endoskarn and exoskarn.

(d) Name and describe briefly the main ground geophysical methods would be useful in exploring skarn deposits and why.

Q5. (a) Several theories have been advanced in the last 100 years or so to explain the origin of ore deposits. In terms of magmatic segregation two processes have been postulated to explain the origin of chromite and Cu-Ni orebodies. These are fractional crastallization and liquid immiscibility,

respectively. Describe the nature of these two processes and give one example deposit resulting from each deposit.

(b) Distinguish between startiform and podiform chromite deposits.

Q6 Describe and discuss in general vein mineral deposits in terms of their genesis, structures that control their location, shapes, mineral associations (both ores and gangue) and whether or not they are syngenetic or epigenetic.

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

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS – DECEMBER 2004

GG442 – ECONOMIC GEOLOGY OF METALLIFEROUS MINERAL DEPOSITS

PAPER II – PRACTICAL

INSTRUCTIONS: ANSWER ALL QUESTIONS

TIME: THREE (3) HOURS

Q1. Identify and describe ore minerals A, B, C, D, ~~and E~~ using their physical properties. (25 marks)

Q2. You are provided with three polished sections. Using the reflected light microscope identify the ore minerals present and describe the observed textures. Discuss the possible origin of the observed textures. (75 marks)

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

UNIVERSITY OF ZAMBIA

EXAMINATIONS –DECEMBER 2004

GG 472 - APPLIED GEOCHEMISTRY

PAPER I - THEORY

TIME: THREE HOURS
INSTRUCTIONS : ANSWER ANY FOUR QUESTIONS

1. The Eh-pH diagram for the system Se-O-H is given in Figure 1. Write balanced chemical equations for all the lines in the Eh-pH space and discuss the role of Eh and pH in the mobility of selenium in the secondary environment.

2. Discuss the major factors and processes that control the formation of bauxite deposits in the secondary environment.

3. The chemical composition of dolerite and the overlying laterite is given in Table 1. Use this data to answer the following questions.
   a) Arrange the elements in increasing order of mobility.
   b) Assuming that the proportion of Al that has been lost from the site is insignificant calculate the mass of rock material that has been lost per 100 g of soil that has been produced.
   c) Discuss briefly the processes that have produced the laterite.

Table 1

Constituent	Content in dolerite (%)	Content in laterite (%)
SiO_2	50.4	0.7
Al_2O_3	22.2	50.5
Fe_2O_3	9.9	23.4
FeO	3.6	--
MgO	1.5	--
CaO	8.4	--
Na_2O	0.9	--
K_2O	1.8	--
H_2O	0.9	25.0
TiO_2	0.9	0.4
Total	**100.5**	**100.0**

4 The chemical composition of the groundwater draining a base metal sulphide ore deposit and stream water that has been affected by drainage from a coal mine are given in Table 2.

   a) Discuss briefly the major processes and factors that are controlling the chemical composition of the two water bodies.
   b) Discuss briefly the quality of both the ground and stream water and its suitability for human consumption.

Table 2. Chemical composition of water

	Content in Water (mg/l)	
Constituent	**Groundwater**	**Stream**
Ca	68	-
Mg	41	68
Na	23	17
K	20	16
SiO2	56	21
Al	433	29
Fe	2178	143
Cu	312	0.1
Zn	200	1
SO4	6600	817
Cl	0.1	3.7
Salinity	9990	1260
pH	2.0	3.0

5. The chemical composition of a stream is given in Table 3. Use this data and the thermodynamic data provided below to predict the fate of calcite crystals that are in contact with the water in the stream

Table 3.

Constituent	Concentration Mol/kg
HCO_3^-	1.90×10^{-3}
SO_4^{2-}	2.65×10^{-4}
CL-	2.9×10^{-4}
NO3-	4.3×10^{-5}
Ca^{2+}	8.5×10^{-4}
Mg^{2+}	3.7×10^{-4}
Na^+	5.17×10^{-4}
K^+	4.9×10^{-5}
Fe^{2+}	2.5×10^{-6}
pH	7.0

$-\log \gamma = AZ^2 I^{0.5}$ $\quad A = 0.5085$

Ksp $CaCO_3 = 10^{-8.35}$

Dissociation constant for $HCO_3^- = 10^{-10.3}$

6. In a survey for Arsenic-rich Au bearing quartz veins the data given in Figure 2 was obtained. Contour the data and assess the potential of this area for gold mineralization. Give some reasons why the use of As as a pathfinder element is strongly recommended in the soil surveys for hydrothermal gold deposits.

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

Fig. 1 Eh-pH diagram for the system Se-O-H

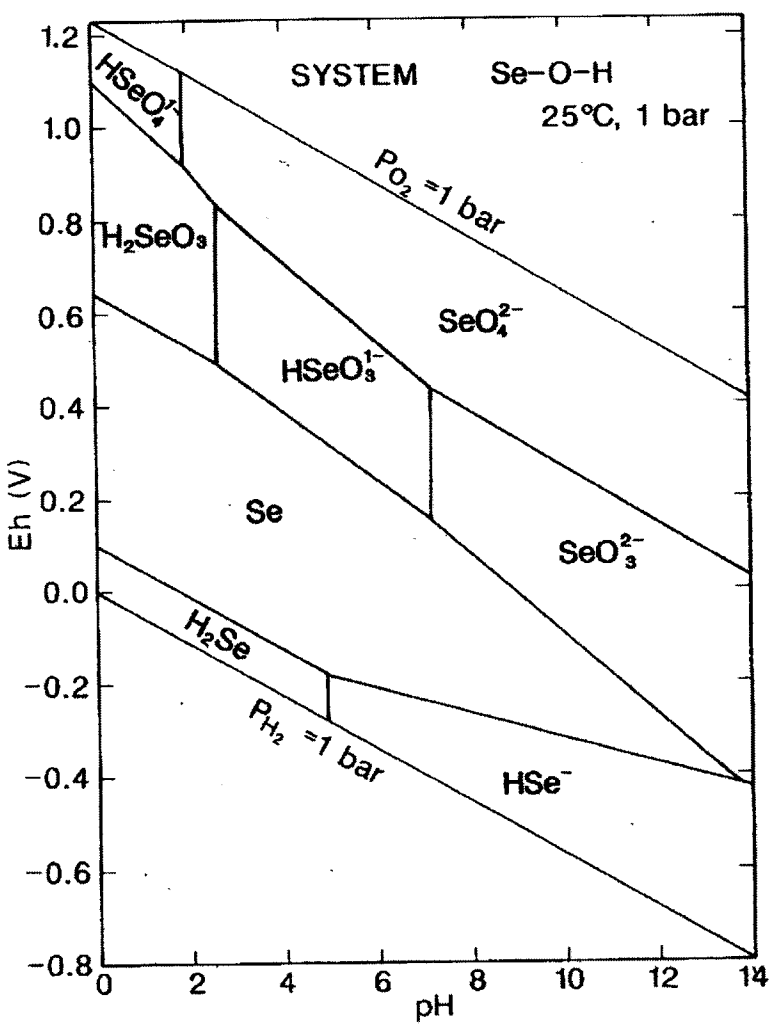
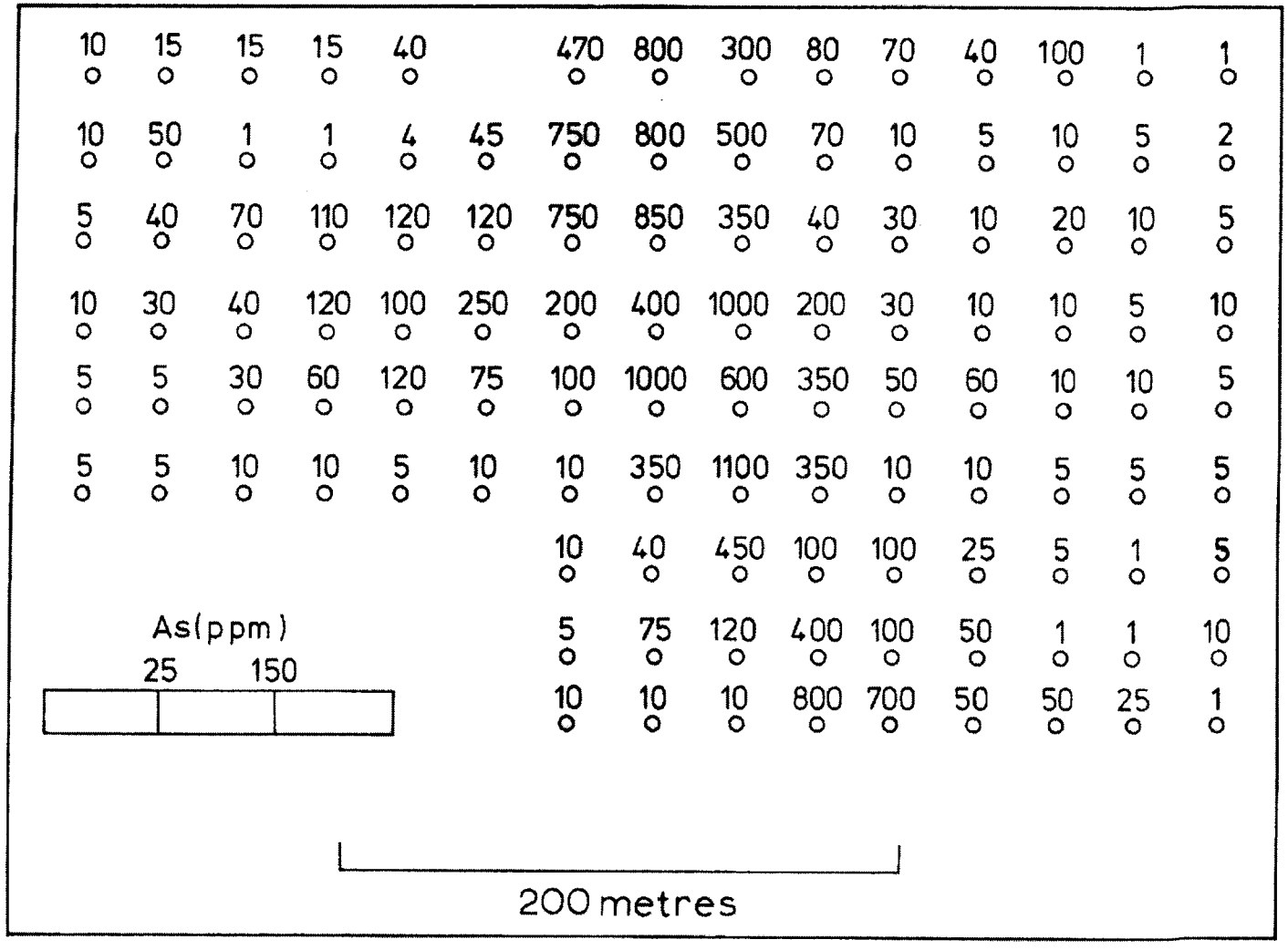


Fig. 2


10 15 15 15 40 470 800 300 80 70 40 100 1 1
10 50 1 1 4 45 750 800 500 70 10 5 10 5 2
5 40 70 110 120 120 750 850 350 40 30 10 20 10 5
10 30 40 120 100 250 200 400 1000 200 30 10 10 5 10
5 5 30 60 120 75 100 1000 600 350 50 60 10 10 5
5 5 10 10 5 10 10 350 1100 350 10 10 5 5 5
10 40 450 100 100 25 5 1 5
As(ppm)
25 150
5 75 120 400 100 50 1 1 10
10 10 10 800 700 50 50 25 1
200 metres

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS – DECEMBER 2004

GG542 – ECONOMIC GEOLOGY OF NONMETALLIFEROUS MINERAL DEPOSITS

INSTRUCTIONS: Answer any four questions using sketches wherever possible. All questions carry equal marks.

TIME: Three (3) Hours

Q1. (a) UNZA has to replace the asphalt used to line roofs of student hostels to stop leaking, a costly exercise. What causes the asphalt to be replaced time and again? Discuss how and why roofing granules can be used together with asphalt to stop its frequent replacement.
(b) What sort of rocks would be suitable for use as granules and why?
(c) How are roofing granules manufactured?

Q2. (a) What is kaolinite and describe how it is naturally generated.
(b) Kaolinite is used in the manufacture of many products that are useful to industry. State any 8 of these products and discuss discuss in each case which properties make kaolinite a useful raw material.

Q3. (a) On the Zambian Copperbelt gypsum is artifially produced, how?
(b) What is Plaster of Paris?
(c) Name and describe briefly the three stages involved in the production of wallboards.
(d) Give five reasons why gypsum is a useful material in agriculture.

Q4. (a) What are abrasives?
(b) State five minerals that may be used as abrassives.
(c) State and discuss five most important physical properties that would make a material qualify as an abrasive.
(d) Distinguish between a strong-shaped grain abrasive and a weak-shaped grain abrasive. State the purposes that each of the shaped grain abrassives.

Q5. The Great East road like any other road is composed of a 4 layered structure:
(a) Name the 4 layers
(b) What is the use of each of the layers?
(c) Describe the type and nature of aggregate used in each layer and why.
(d) What is meant by well-graded road aggregate?

Q6. Chilanga cement produces Mpanvu Cement.

(a) What is cement?

(b) Name the 4 raw materials of cement.and give two examples of where from each of the raw materials are derived

(c) State two main stages involved in cement production and briefly describe these stages

(d) Name two common products of cement and how these are these produced.

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

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS – DECEMBER 2004

GG572 – HYDROGEOLOGY

INSTRUCTIONS: Answer any five questions using sketches wherever possible.

TIME: Three (3) Hours

Q1. (a) Draw the hydrologic cycle. (10 marks)
(b) Rank in order of magnitude (biggest to smallest) the various parameters in the cycle for Lusaka for the month of September. (10 marks)

Q2. From your geological knowledge of Zambia, describe, in each Province, the rock formations that constitute groundwater aquifers. (20 marks)

Q3. (a) Describe how to construct a Piezometric surface from water level data. (10 marks)
(b) What groundwater information can be derived from the study of the Piezometric surface? (10 marks)

Q4. A step-drawdown pumping test was carried out. The following data were obtained (20 marks):

Specific Capacity ($x10^{-3}$ m^3/day)	Well Discharge (m^3/day)
2	500
3	1000
5	2000
6	2500
7	2750

(a) Determine the aquifer and well loss parameters for n = 2.
(b) From the results in (a), is the well properly designed and developed, or not? Explain your answer.

Q5. Define the following terms as they relate to water quality (20 marks):
(a) MCL
(b) pH
(c) Very hard water (in terms of CaCO3)
(d) Ec
(e) Turnover
(f) Coliform Group
(g) Thermocline
(h) DOC
(i) DO
(j) Physical characteristics of water

Q6 Prepare a Table showing the following (20 marks):

Column 1	Waterborne Disease
Column 2	Causative Organism
Column 3	Source of the organism in water
Column 4	Health Effect on humans

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

UNIVERSITY OF ZAMBIA
UNVERSITY EXAMINATIONS – SECOND SEMESTER, DECEMBER 2004

MG319 - COMPUTER TECHNIQUES

PAPER I - THEORY

TIME: 3Hrs

INSTRUCTIONS: Answer ALL Questions.

Question 1: Terminology and Definitions **[25 marks]**

a. What is Hardware and Software?
b. What is a high-level language and low-level language? Give examples.
c. What is BIOS and what is its function?
d. Define what a flow chart is, and where it can be applied.
e. Define a pull-down (drop down) menu.

Question 2: File Management **[25 marks]**

a. Distinguish between Program files and Data Files
b. What are file extensions? Give an example of some of the various file extensions.
c. What is a File Manager?
d. Briefly can you explain how files are organised on disk?
e. What do you understand by the word **desktop**; what is normally contained on it.

Question 3: Windows **[25 marks]**

a. Describe the operations of a mouse.
b. Describe two types of windows.
c. Define what an icon is and describe its use.
d. Explain what features you expect to see when you open a file manager.
e. What is a scroll bar, and is it used for?

Question 4: Computer and Software **[25 marks]**

a. Contrast between **DOS** and **Windows** Operating systems.
b. What are the advantages of using a Computer?
c. Describe the classification of Computers stating their origin and characteristics.
d. Which files in **Windows** and **DOS** are used to configure and customise the system?
e. What is application software?

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
UNVERSITY EXAMINATIONS – SECOND SEMESTER, DECEMBER 2004

MG319 - COMPUTER TECHNIQUES

PAPER II - PRACTICAL

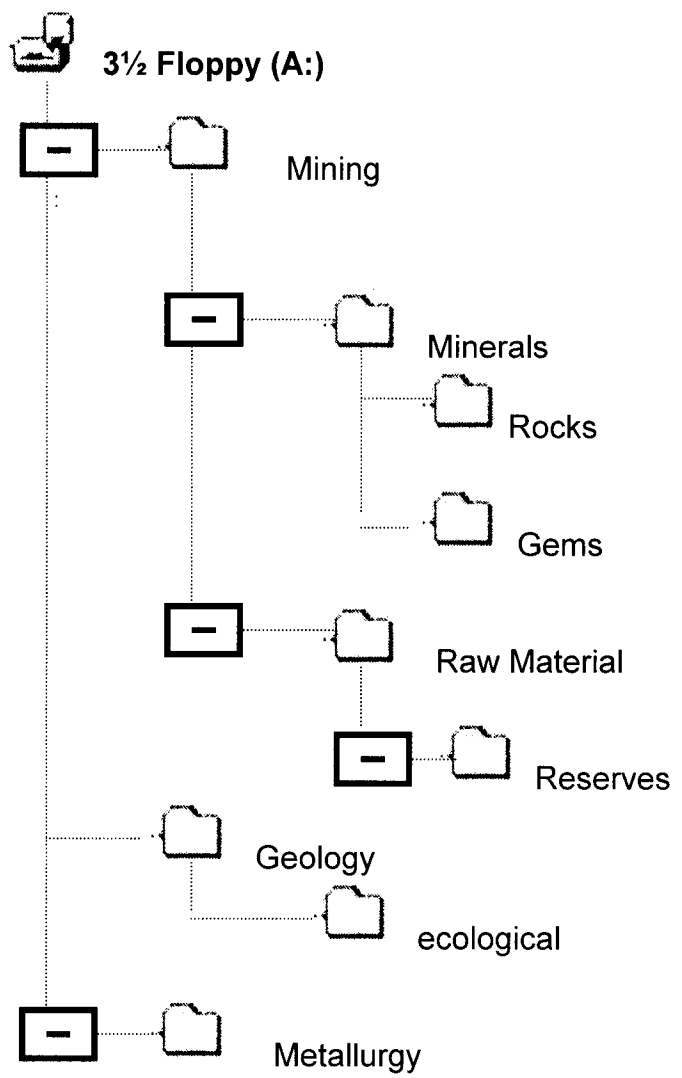
TIME: 3Hrs

INSTRUCTIONS: Answer ALL Questions. Use formulas where applicable

---

Question 1: File Management

Study the directory tree structure given below and create a similar tree structure on your floppy disk.



[30 marks]

Question 2: Microsoft word

Open Microsoft Word document called ***minerals&rocks***.doc from Directory ***mg319geo2004*** and do the following:

- Change the ***font type*** of all the sub titles to either ***Bookman Old Style*** or ***Lucinda Console*** or ***Impact*** and of the ***Font size*** of **16** and ***Bold***
- Change font ***size*** of the rest of the text to ***11***
- Insert pictures from the ***crystals&minerals.doc*** saved in the Directory ***mg319geo2004*** and place them on top of selected paragraph headings.
- Centre the pictures
- Insert page Numbers
- Save the changes on to the Floppy Disk.

[35 marks]

Question 3: Microsoft Excel

Open the Microsoft Excel Spread sheet document ***Shoprite Budget*** from ***mg319geo2004*** Directory.

There are Four (4) quarters in the ***Shoprite area Budget***. And you are required to do as follows:

- Calculate totals for **Inside Sales, Outside Sales, Government Sales.**
- On each quarter, calculate the total revenue.
- Calculate 21% of the **Cost of Goods Sold**
- Calculate the **Gross Margin** by subtracting **Cost of goods sold** from **Total revenue** on all quarters
- Calculate the **selling expenses** by multiplying **total revenue** by 12% on all quarters
- Calculate the **overhead** by multiplying **total revenue** by 11% on all quarters
- Calculate the **Total Expenses** by summing, **Selling Expenses** and **Overheads**
- Calculate the **Netprofit** by subtracting **Total Expenses** from **Gross Margin**
- Save all the changes on to a floppy disk

N.B. All Work must Served on a Floppy Disk unless where difficulties are experienced, then save on hard disk but this should be specified.

[35 marks]

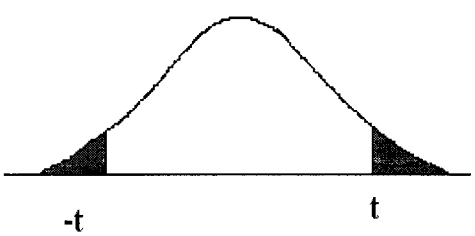
END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SHOOL OF MINES
END OF SECOND SEMESTER EXAMINATIONS- 2004
MI 322 STATISTICS AND COMPUTER APPLICATIONS

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

INSTRUCTION: Answer any 5 questions.

1. Graph 1 shows the student-distribution with 9 degrees of freedom. Find the value of **t**, for which
   a) The shaded area on the right = 0.05 **[5 Marks]**
   b) The total shaded area = 0.05 **[5 Marks]**
   c) The total unshaded area= 0.99 **[5 Marks]**
   d) The shaded are on the right=0.01
   e) The area to the left of **t**, is 0.90 **[5 Marks]**



Graph 1. Student t – distribution with 9 degrees of freedom.

2. 500 drill bits have a mean weight of 5,05 kg and a standard deviation 0f 0.3 kg. Find the probability that a random sample of 100 drill bits chosen from this group will have a combined weight of :
   a) between 496 and 500 kg **[10 Marks]**
   b) More than 510 kg **[10 Marks]**

3. The distribution of heights among KCM plc Miners aged between 18 and 24 is approximately normally distributed with a mean of 1.65 m.
   Using the empirical rule: $\sigma = 0.2$m
   a) Find the range of heights falling within 68, 95 and 99.7 %. **[10 Marks]**
   b) What percentage of these miners is taller than 1.70 m? **[5Marks]**
   c) Find the mean height of miners falling with 95 %. **[5 Marks]**

4. Table 1 shows a randomized drilling experiment used in the comparison of standard and modified drill bits in meters. The driller arrived at this random arrangement by taking 11 playing cards, 5 blue corresponding to bit **A** and 6 red corresponding to bit **B.**

Position	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Bit	**A**	**B**	**B**	**A**	**A**	**B**	**B**	**B**	**A**	**A**	**B**
Penetration	**25**	**12**	**26**	**23**	**21**	**24.2**	**14**	**16**	**17**	**21**	**20**

Find:

a) The difference in average, pooled variance and standard error of average difference. **[15 Marks]**

b) Calculate the value of $\mathbf{t_0}$ **(from** student t distribution) using the hypothesis η_B-$\eta A=0$

[5 Marks]

5. Weight amounts of zinc were dissolved in 100 ml portions of diluted acid and the solution presented to a chemist for analysis, yielding the following data.

Mg Zinc dissolved , X	0.102	0.213	0.306	0.407	0.511	0.602
Mg Zinc found γ	0.097	0.207	0.300	0.93	0.502	0.613

Find a) The model

$y_u = BX_u + \varepsilon_u$, to the data using methods of least squares.

[20 Marks]

6. Six temperature readings (^{0}F) were taken on a patient at 5- minute intervals, three before and three after taking the drug. The results recorded as 10 (T-98.0, were as follows: before the drug 4,3,7; after the drug 10,6,8. The same patient when not on the drug gave the following successive results at 5 – minute intervals:
5,5,9,7,3,4,5,5,9, 12, 14, 89,11 14, 9, 10
10,6,5,4,2,3,3,3,8,2,3,4,6,5,3,2,4,6,4

a) Construct an external reference distribution for the difference between adjacent averages of three. **[5 Marks]**

b) Using "nearly independent" differences, construct a reference distribution. Use data in five sets of six, leaving a gap of one between sets.) Based on these two reference distributions, what is the significance level for the null hypothesis η_B-$\eta A=0$ when the alternative is $\eta_B \geq \eta A$?

[15 Marks]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
UNIVERSITY SEMESTER II EXAMINATIONS – DECEMBER 2004

MI 465 MINERAL ECONOMICS

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

ANSWER ANY 5 QUESTIONS

---

1. What do you understand by the term "National Mineral Policy"? Discuss the typical objectives of mineral resource policies in developing countries. **(20 marks)**

2. Discuss how the following factors can affect the demand for copper:

   i) The price of copper **(4 marks)**
   ii) Prices of copper substitutes **(4 marks)**
   iii) Prices of complimentary metal products **(3 marks)**
   iv) Society's per capital incomes **(3 marks)**
   v) Size of the population **(3 marks)**
   vi) Changes in technology **(3 marks)**

3. i) Discuss the various types of mineral taxes that may be levied on a mine enterprise. **(8 marks)**

   ii) Which of these taxes can be considered more acceptable from an investor's point of view and why? **(6 marks)**

   iii) What are the unique factors that must be considered important in mineral taxation? **(6 marks)**

4. Small-scale mine that produces cut marble has a capacity of 100 slabs per month, with fixed costs of $15,000 per month. It finds that its unit variable costs are $320.

   i) At what output must it operate if it can sell cut slabs at $500 each and break even? **(8 marks)**

   ii) Because of seasonal variations in sales, the company would like to have a break-even point of not greater than 60% of capacity. What reduction in fixed costs would be required in order to make this possible? **(6 marks)**

iii) What reduction in unit variable costs would be required in order to achieve the same results (with fixed costs remaining at unchanged at $15,000)? **(6 marks)**

5. Describe in detail the various forms of market structures. Give mineral commodity examples where possible. **(20 marks)**

6. The major objectives of a mining firm may be listed as profit maximisation, survival and growth. How do these factors affect the overall company corporate strategy? **(20 marks)**

GOOD LUCK!

UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS – DECEMBER 2004
SEMESTER II EXAMINATIONS

MI 475 MINE ENVIRONMENT

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

ANSWER: ANY FIVE (05) QUESTIONS

1.(a) Environmental auditing is essential to the achievement of Environmental Management goals and the continual improvement in environmental performance.

(i). Discuss the benefits that can be derived from the environmental audit process when audit findings are implemented. **[10 marks]**

(ii). Each audit has specific objectives and areas of emphasis, depending on the facilities and areas of specific environmental concern. However, there are common elements to all audits. Discuss these common elements to environmental audit. **[5 marks]**

(b) Discuss the methods of environmental monitoring assessment in the mining industry.

[5 marks]

2. (a) Figure 1 shows the schematic diagram of mine ventilation system with quantities assigned and head losses calculated. Determine the mine quantity and static head.

[10 Marks]

(b) Assuming that air quantities are split naturally in the same figure 1 and that no air quantities are assigned, derive equations for analysis of the same network (schematic diagram).

[10 Marks]

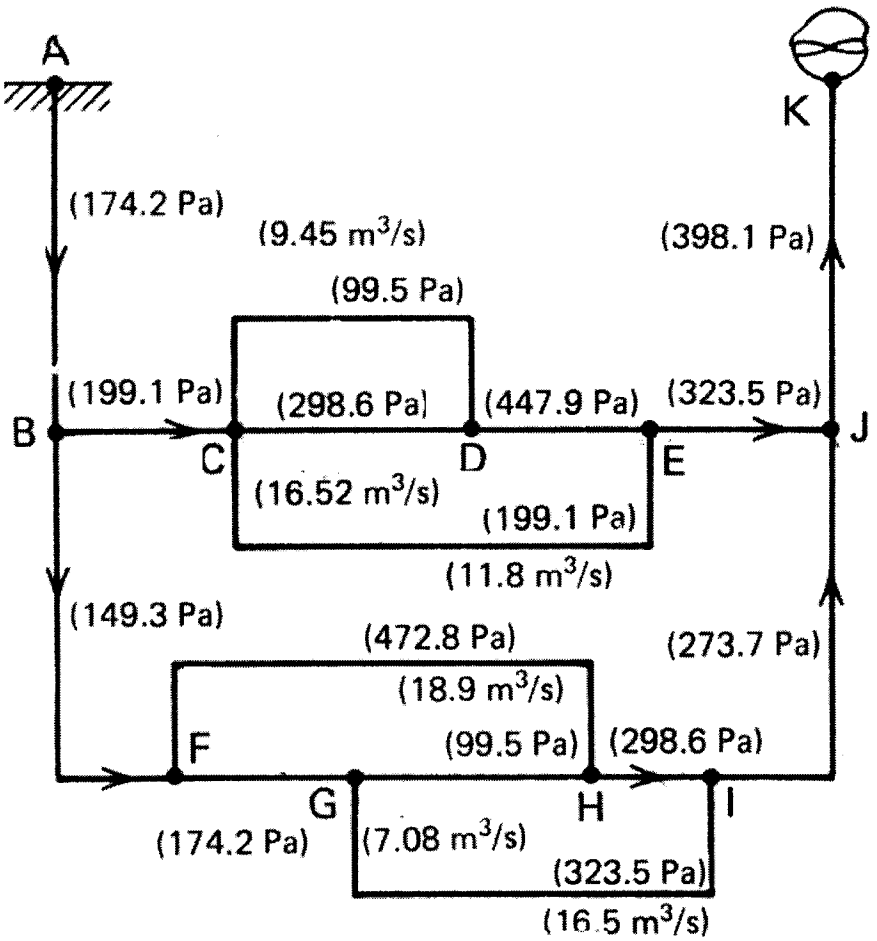


Figure1. Schematic diagram of Mine Ventilation

3. (a) Discuss the importance of conducting an Environmental Impact Assessment (EIA).

[5 marks]

(b) In achieving best practice in environmental protection, mining companies and government agencies have developed common EIA methodologies i.e. early information collection and scoping and consultation. Discuss what is **involved in** and **the importance** of;

(i). Early information collection **[5 marks]**
(ii). Scoping and consultation **[5 marks]**

(c) Discuss the importance of conducting environmental monitoring in environmental protection. **[5 marks]**

4. With the help of clear diagrams or equations, explain briefly the following *methods of dust sampling:*

a) Thermal precipitation **[5 Marks]**
b) Electrical precipitation **[5 Marks]**
c) Gravimetrical method **[5 Marks]**
d) Optical method **[5 Marks]**

5. Figure 2 shows two fans connected in parallel on two shafts with different mine characteristics. The performance characteristics of the fans and corresponding mine air ways are shown in figure 3.

In relation figure 3, explain:

a) How the combined characteristic curve is plotted **[5 Marks]**
b) The meaning of corresponding points (numbers) **1, 2, 3, 4** and **5 .** **[5 Marks]**
c) The unstable working region of the fan and state what would happen if the fans continued working in this region. **[5 Marks]**

and 2

Explain what would happen to fans 1, if there was sudden increase in resistance in mine air way **AB.**

[5 Marks]

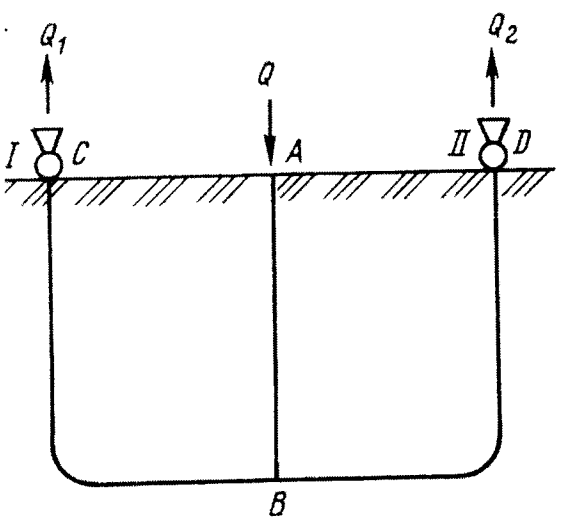


Figure 2. Parallel work of two fans

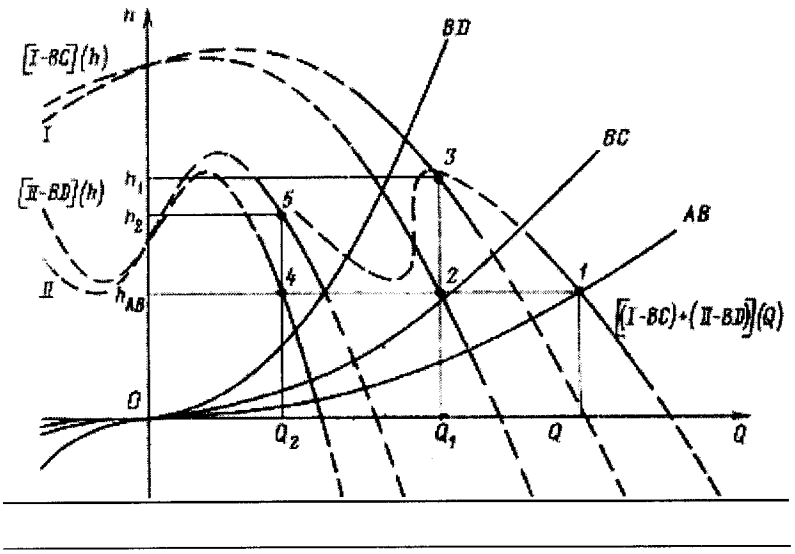


Figure 3. Graph for determining working regimes of fans connected in parallel on two different shafts.

6. Explain:

a) Main factors influencing design of mine ventilation systems.

[10 Marks]

b) Type of ventilation employed in development ends. Use diagrams to illustrate your explanation.

[10 Marks]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
UNIVERSITY SEMESTER II EXAMINATIONS – DECEMBER 2004

MI 515 ROCK MECHANICS II

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

INSTRUCTIONS:
(i) Answer ay six (06) questions
(ii) Four (04) marks for neatly drawn and well labeled diagrams

---

1. (a) Rock is classed in several ways amongst which CSIR and NGI classifications are of interest to Rock Mechanics Engineers. Name all the parameters that are used under these classifications.
[10 marks]

(b) A circular tunnel 4.0m diameter at a depth of 500m to be driven in gneiss. The rock mass classification of the tunnel site are given below:

RQD = 85% Jr = 3; Ja = 1
Jn = 3.5%: Ja = 3: SRF = 1

Calculate the value of Rock Mass Rating (RMR) and comment on the rock type.
[06 marks]

2. (a) Explain how it can be ensured that the dimensions of the pillar in the room and pillar mining are adequate in terms of its safety.
[10 marks]

(b) Find the average axial pillar stress on a rectangular pillar 6 m by 12 m plan area and room span 4.0m being mined at 600m depth. The unit weight of overburden rock is 27 kN^{-3}.

If the span of the room is increased in the above problem (keeping other factors same) what will be the effect on pillar's safety factor?
[06 marks]

3. (a) What are the possible types of discontinuous subsidence may occur due to underground mining?
[10 marks]

(b) A stratified mineral deposit 4.0m thick, lying at a depth of 400m is being extracted. The width of the extraction panel is 160m.

(i) calculated the value of maximum subsidence that way take place and show its location on the subside curve; given S/m = 0.85
[03 marks]

(ii) How far the effect of subsidence will reach from the edge of the excavation if the angle of draw is 27°?

[03 marks]

4. (a) Rockbolts supporting actions to that of conventional type of supports are altogether different. Describe with the help of diagrams the difference between the two methods of supported . How would you ensure that the bolts installed any where in the mine are effective?

[06 marks]

(b) A section of a rock hillock is to be stabilized to prevent its slide using steel bolts. If the number of bolts recommended for this purpose are 25, calculated the tension (in tones) on each bolt from the details given below:

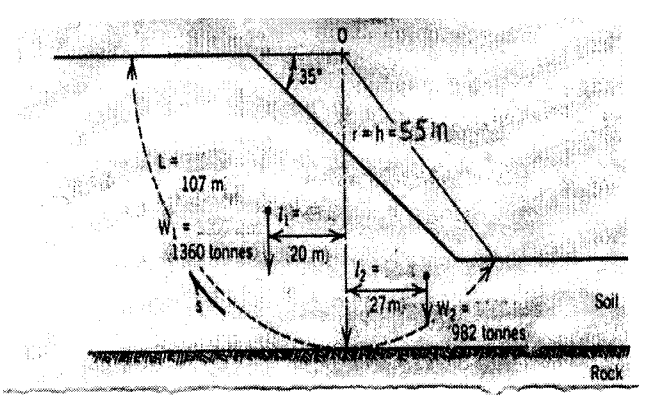
- Area of the wedger shaped block = 520 m^2
- Average thickness of rock strata = 15 m
- Average density of rock to be bolted = 25kNm^{-3}
- Cohesive strength (c) of sliding surface = 52kPa
- Dip (ψ) of the sliding surface = 47°
- Friction angle (ϕ) of the sliding surface = 23°
- Angle between the plunge of the bolt and normal to the sliding surface (θ) (find by calculations)
- Factor of safety expected not less than 1.60

[10 marks]

5. (a) What are the possible causes of a bank (made of mixed soil and weathered rock) failure resulting in a slide? Suggest some measures using diagrams to prevent such slides.

(b) Calculate the factor of safety and then comment on the stability of the slide of the bank shown in cross-section in figure below. Analyse for both DRY (slr = 55,000 m tones and SATURATED conditions (slr =0). Use slip circular technique for calculation.

[06 marks]



THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
UNIVERSITY SEMESTER II EXAMINATIONS – DECEMBER 2004

MI 535 COAL MINING METHODS

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

INSTRUCTIONS: ANSWER **QUESTION NO. 1** AND **ANY OTHER FIVE.**
TOTAL QUESTIONS TO BE ANSWERED SIX (06).

==========

1. (a) Discuss in detail why the method of mining coal generally differs to that of metalliferrous mining? [10 marks]

   (b) (i) Give in terms of percentage world the amount of coal for the following countries: CIS; USA; China; Canada and Africa [05 marks]

   (ii) There are over hundreds of applications of coal (apart from quite a few as industries in which coal is used by products) in the different industries. Name ten. [05 marks]

2. a) State and discuss the most evident impacts of surface Coal Mining on the environment. [06 marks]

   b) State and briefly discuss the main factors requiring consideration in Surface Coal Mine planning and feasibility studies. [10 marks]

3. With the aid of corresponding neat and clearly labeled sketches,

   a) Lay down and describe the various methods of opening-up and development of a surface coal mine as well as the factors that will influence the method selection [10 marks]

   b) Write brief notes on types of equipment employed in overburden removal and mining in surface coal mines. [06 marks]

4. With the aid of clearly drawn and labeled sketches, write brief notes on the Dragline as a stripping machine in surface coal mines under the following sub-headings:

   i. Description of the major components and operating parameters of a dragline (05 marks)
   ii. Operation of a dragline on stripping [05 marks]
   iii. Dragline performance estimation [02 marks]
   iv. Factors affecting dragline performance on stripping [04 marks]

5. (a) Describe the conditions in which you would recommend the use of shortwall method of mining. [08 marks]

(b) A coal seam 2.0 m thick lying at 400 m depth is to be mined using shortwall method of mining. Draw a layout of a face giving the details of workings, equipment in use and their locations at the face. [08 marks]

6. (a) A coal seam, 2.5 m thick lying at a depth of 600 m, highly prone to spontaneous combustion is to be mined. The floor of the seam is hard and not expected to give heaving problem. The management is not in a hurry for the quick return of capital.

Describe a suitable method for the above situation and justify the reasons for your choice. [08 marks]

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

- Length of the coal face = 220 m
- Thickness of the coal seam = 2.0 m
- Web of shearer = 0.75 m
- Average speed of the shearer on the face = 2.5 m/min
- Number of coal cutting shifts/day = 3
- Available time for shearer for cutting coal is 60% of the 8 hour shift
- Average specific gravity of coal = 1.25

Express the answer in million tones nearest to whole number. [08 marks]

7. (a) A coal seam 12 m thick at a depth of 400 m is to be mined.

Describe a method for the extraction of such deposit and explain the difficulties and dangers associated with mining such a thick seam. [08 marks]

(b) (i) Name four geological intrusion that may be encountered in a coal mine [02 marks]

(ii) Describe the effect of fault, fold and washout in mining coal from Underground. [06 marks]

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

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
UNIVERSITY SEMESTER II EXAMINATIONS – DEC. 2004
MI 562 INVESTMENT ANALYSIS

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

INSTRUCTIONS: ANSWER ANY FIVE QUESTIONS

---

1. (a) Discuss the following terms as used in project evaluation
   - (i) Payback period [2 marks]
   - (ii) Net present value [2 marks]
   - (iii) Internal rate of return [2 marks]

   What are their advantages and disadvantages when used as decision criteria? [2 marks]

   (b) You are looking into a long term chance of going into emerald mining. Your geological knowledge gives you confidence that if you spent K1,000,000.00 per year for five years, you would discover a deposit capable of being developed in two years at a cost of K3,000,000.00 per year. On inception of production your projected revenue will be K1,500,000.00 for 10 years and operating costs of K500,000.00 per year. The bank lending rate is at 10%.

   - (i) What is the expected equivalent annual value of your project?
   - (ii) At this cost of capital, what is the NPV?
   - (iii) Obtain your IRR for this project.
   - (iv) If your bank requires that such risky projects should pay off in 8 years, would it lend you money? What defence would you back your decision to go ahead?

   [12 marks]

2. As a Manager of an open pit you have a choice of an existing equipment or a new proposal.

	Existing Equipment (K)	Proposed New Equipment (K)
Capital expenditure	-	250 000
Annual operating hours	3 000	3 000
Hourly Operating And Mt. Costs		
Year 1	50	10
Year 2	60	20
Year 3	65	30
Year 4	80	50
Salvage Value		
New 0	50 000	-
End of Year 1	40 000	100 000
2	30 000	80 000
3	20 000	70 000
4	10 000	50 000

Which is the preferred alternative? [20 marks]

3. (a) What do you understand by the term economic rent as applied to mineral resources? What are some of the problems developing countries have in collecting this rent? [6 marks]

Describe three rent collecting systems you know. [6 marks]

(b) Detail the steps one would take to explore, prospect and mine in Zambia? [4 marks]

Comment on the privatization of the copper mining industry in Zambia. [4 marks]

4. (a) You are a father of a son born now who will need school fees amounting to K4000.00 per year for his engineering course lasting 5 years when he will be 15 years old. The bank rate is 15% compounded annually. How much money do you need to leave in a will if you were to die this year to cover his engineering course?

[10 marks]

(b) Your brother who is a taxi driver has come to seek advice regarding his operations. He has an old taxi which he can sell now for K10,000.00. He is thinking of replacing it with a new BMW costing K50,000.00. The old taxi has the following characteristics, operating cost increasing at K2,000.00 per year for the next five (5) years at which it needs to be scrapped.

The new taxi will need K10,000.00 to operate per year and can last 10 years before it is scrapped. If the cost of capital is 10%, tax rate is 50%, declining balance depreciation is allowed at 40%, what is the best choice for him between the old taxi and the new BMW?

[10 marks]

5. A Banana Republic which has been run by a clique of 25 old men has run of its reserves created out of smuggled emeralds. You are the Bank Governor of this Republic which is suggesting to decontrol prices of all foods, introduce fees for social services and sell all government owned companies to some deposed president now staying in an American colony. The little foreign currency earned from the remaining emeralds and capital from sell of companies will then be auctioned monthly. You know there are sufficient engineers and local millionaires in your republic. Provide a two page report to the President as to this course of action or alternative courses.

[20 marks]

6. A bus costing K30,000 is estimated to have the following operating and maintenance costs:-

YEAR	OPERATING & MAINTENANCE COSTS (K)	SALVAGE VALUES (K)
1	10,400	20,000
2	11,300	15,000
3	12,220	11,000
4	13,160	8,000
5	14,120	6,000
6	15,100	4,000
7	16,100	3,000
8	17,100	2,000
9	18,600	-
10	20,600	-

What is the optimum economic life of this tractor? [20 marks]

7. (a) Write short notes on the following:

(i) Inflation and its effect on operating costs and debt. [4 marks]

(ii) Why sensitivity analysis is usually undertaken in mineral project evaluation. [4 marks]

(iii) Why risk analysis is necessary before embarking on mine development. [4 marks]

(b) (i) Highlight the major components of costs. [4 marks]

(ii) Discuss the basic methods of cost estimation and when they are best used. [4 marks]

*** **END** ***

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – DECEMBER 2004

MM 205 – INTRODUCTION TO METALLURGY

PAPER I - THEORY

TIME: THREE HOURS

ANSWER: ANY FIVE QUESTIONS. USE SEPARATE ANSWER BOOKS FOR EACH SECTION

SECTION I: INTRODUCTION TO GEOLOGY

1. (a) Define the following terms:
   (i) Crystal
   (ii) Unit cell
   (iii) Primitive (P) lattice
   (iv) Axes of symmetry
   (v) Mirror plane
   (b) Classify the 4 crystals in the Table below into crystal systems using the characteristic elements of symmetry to be drawn from the data provided:

CRYSTA No.	AXES	PLANES	CENTRE
A	5 diads, 4 triads, 3 tetrads	5	Yes
B	6 diads, 1 hexad	6	Yes
C	3 diads, 3 triads, 4 tetrads	3	Yes
D	3 tetrads, 1 triad	3	Yes

   (c) Name and describe briefly the open forms you know.

2. (a) Define what physical properties are.
   (b) Distinguish between colour and streak.
   (c) Why is colour not a diagnostic physical property of minerals?
   (d) Distinguish between transparency and opacity.
   (e) Define the following terms:
      (i) Lustre
      (ii) Hardness
      (iii) Cleavage
      (iv) Fracture
   (f) Diamond and graphite are composed of the same substance and yet diamond is the hardest substance known to man and it is dense, while graphite is very soft and less dense. Why do you think this is so?

3. (a) What is a polymorph? Give two examples of sets of minerals that are considered polymorphs.

(b) Given the following axial intercepts determine the Miller Indices and give their face symbols:

FACE	INTERCEPTS
A	1/3, 5, 1/2
B	2, 1/7, ¼
C	3, 1, 1/6
D	2/3, ½, 3

Show the calculation.

(c) Define the following terms
- (i) Mineral
- (ii) Atom
- (iii) Isotope
- (iv) Proton
- (v) Electron

(d) How do cations and anions form?

(e) Distinguish between covalent and ionic chemical bonds.

SECTION II : INTRODUCTION TO METALLURGY AND MINERAL PROCESSING

4. (a) Why are lean ores not suited for direct smelting?

(b) How does ore concentration improve an ore's suitability for smelting? State the steps involved in concentration with a typical flowsheet.

(c) What is leaching? State two commercial examples of leaching of ores and explain their applicability.

5. (a) During the fire refining of blister copper, explain how the oxygen is removed as practiced at Nkana Smelter, Kitwe.

(b) What is involved in electro-winning and electro-refining of a metal? State in each case the main source of raw material in the electrolysis.

6. Give explanations on the following terms indicating their importance in mineral processing or treatment.

- (i) "Volume specific surface" and "mass specific surface"
- (ii) Give two definitions of equivalent diameters
- (iii) Size distribution and permeability

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – DECEMBER 2004

MM 205 – INTRODUCTION TO METALLURGY

PAPER II - PRACTICAL

TIME: THREE HOURS

ANSWER: BOTH QUESTIONS

---

1. You are provided with 8 wooden crystal models (2, 6, 5, 10, 14 & 18,). Using these models do the following:

   (a) Determine the number of faces, edges and corners on each of the crystals
   (b) Determine all the elements of symmetry present on each of the models
   (c) Using the characteristic elements of symmetry classify each of the models into a crystal system
   (d) Sketch each of the models showing the characteristic elements of symmetry

2. A, B, C, D and E are unknown mineral specimens provided to you. Determine the following physical properties on each of the minerals: Colour, Streak, Lustre, Hardness, Cleavage, Fracture, Reaction to acid, Reaction to a magnet and Touch. Name each of the minerals and state the mineral group to which each of the minerals belong.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - DECEMBER, 2004

MM 332

CHEMICAL THERMODYNAMICS II

TIME: THREE HOURS

ANSWER: FIVE(5) OUT OF SIX (6) QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.

1..a. What do you understand by the term chemical kinetics? Discuss the roles of following on the velocity of a chemical reaction.

i. The nature of reactants and products
ii. Temperature of the reaction
iii. Concentration of both reactants and products
iv. Presence of catalysts

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

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

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

Derive the equation for the first order reaction and show that the desulphurisation is a first order reaction and determine the half life for this process.

2. (a) When salt is added to water it is established that it's freezing point to ice decrease by a few degrees. Derive the expression for the depression of the freezing point of a Solvent A (Water) due to the addition of a small amount of non-volatile solute B (Salt).

(b) 0.160 gm of Oxygen causes a lowering of the melting point of 100 gm of Silver by 10^o C. The solubility of oxygen in solid Silver may be neglected. Calculate the heat of fusion of Silver. Atomic weights : 0xygen O = 16; Silver Ag, = 108, Melting point of pure Silver is $960\,^{O}$C.
R = 8.31 J/mol.K

3. (a) In the treatment of pig iron to produce steels, various elements are added in small proportions to it to improve on the properties of the steels. If an element B behave as a solute and obeys the henry's law following the relation in dilute solution as shown below

$$f_B = k N^{2/3}_B$$

Where N_B is the mole fraction of that particular solute. Derive the expression for the fugacity, f_A of the Iron behaving as a solvent A. Assume the melt formed is a binary solution.

(b) A container measuring V litres in volume is divided in three equal compartments that contain 1g.mole of Helium gas, 2g.mole of neon gas and 3g.mole of organ gas. The initial temperature and pressure for each gas are 25°C and 1.2 atm. The gases are allowed to mix. Calculate (a) the volume of the container, (b) the mole fraction of each gas in the mixture, and (c) the partial pressure of each gas in the mixture. Calculate (d) the change the Gibbs energy of the system after gases mixed G^M, and (e) the change in entropy S^M sustained by the system during the mixing process. Assume that the gases behave ideally.

4. (a) In multi- component systems, it is observed that at finite low concentration, the activity coefficient of a solute varies with the addition of other components. Show how Wayner used the Taylor expansion to represent the activity coefficient at infinite dilution and definite what are the interaction parameters.

(b) Calculate the oxygen content of liquid iron in a Bessemer top brown furnace containing 0.16 wt% silicon in equilibrium with solid silica at 1600°C. The following data are available:

$$Si_{(l)} + O_{2(g)} = SiO_{2(s)}; \qquad \Delta G^o_f = -946{,}348 + 197.643T \text{ J}$$

$$1/2O_{2(g)} = O_{(l,\,wt)}; \qquad \Delta G^o_{r\rightarrow wt} = -117{,}152 - 2.887T \text{ J}$$

Interaction coefficients:

$$e^{(o)}_o = -0.20 \qquad e^{(Si)}_o = -0.131$$

$$e^{(Si)}_{Si} = 0.32 \qquad e^{(o)}_{Si} = -0.24$$

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

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

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

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

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

W = ItA/nF

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

$$2Al_2O_3 \Leftrightarrow 2\ Al^{3+} + 2\ AlO^{-3}_3$$

The half anodic reaction is given as

$$2\ AlO^{-3}_3 \Leftrightarrow Al_2O_3 + 6e^- + 1.5O_2$$

The half cathodic reaction is given as

$$2\ Al^{3+} + 6e^- \Leftrightarrow 2\ Al$$

Overall reaction is

$$Al_2O_3 \Leftrightarrow 2\ Al^+ + 1.5O_2$$

6. The Henrian activity coefficient Υ^{o}_{Al} for Aluminium in liquid iron-Aluminium alloys is reported to be 0.063 at 1600°C. Calculate the standard free energy of formation of $Al_2O_3(s)$ at 1600° C for each of the following four standard states for Al:
   a) **$2Al(l, pure) + 3/2O_2(g) = Al_2O_3(s)$**
   b) **$2Al(l, h) + 3/2O_2(g) = Al_2O_3(s)$**
   c) **$2Al(l, wt) + 3/2O_2(g) = Al_2O_3(s)$**
   d) **$2Al(l, at) + 3/2O_2(g) = Al_2O_3(s)$**

$\Delta G^{o} = -1,682,927 + 323.239T$ J/mol.

Molecular weights if Al and Iron are **26.98** and **55.85** respectively.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - DECEMBER, 2004

MM 412

MINERAL PROCESSING II

TIME: THREE HOURS

ANSWER: FIVE QUESTIONS. KEEP YOUR ANSWERS BRIEF AND TO THE POINT. RELATIVE WEIGHT OF EACH QUESTION INDICATED IN BRACKETS.

Question 1

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

- the wash ratio in filter cake washing
- reslurry washing
- surfactant
- differential flotation
- consolidation trickling
- cobbing
- magnetic susceptibility
- remanence
- coagulation
- flocculation

[20 %]

Question 2

(a) What do you understand by the 'concentration criterion' in gravity separation?

State in a few words what use is made of this criterion in the separation of minerals by gravity methods.

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

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

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

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

Explain your flowsheet in a few words.

(f) What are the main applications of heavy media separation?

[20 %]

Question 3

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

(b) Explain the role played by the following reagents used in mineral flotation:

- collectors
- frothers
- modifiers

(c) As part of an investigation into the flotation of a copper ore, a series of laboratory batch flotation tests was carried out under different conditions. Each test was done in duplicate. The results of one set of duplicate tests are shown below.

Fraction	Time (min)	Batch flotation test 1		Duplicate test	
		wt (g)	%Cu	wt (g)	%Cu
C1	2	32.8	31.28	42.5	25.93
C2	5	33.0	18.42	37.4	16.17
C3	10	47.2	4.64	58.6	3.14
Tails	-	882.3	0.29	854.1	0.30

(i) From these test results, calculate the cumulative recoveries and plot these against cumulative flotation time.

(ii) What is the grade of the feed?

(iii) Assuming that all the copper minerals have the same specific rate of flotation, calculate the value of this specific flotation rate. (Assume flotation to be first order).

(iv) How much copper remains in the pulp after 3 minutes of flotation?

[20 %]

Question 4

(a) Briefly state the differences between diamagnetic, paramagnetic and ferromagnetic substances.

(b) What factors limit in practice the intensity of the applied magnetic field?

(c) Because of these limitations, what else is done in industrial practice to obtain a high magnetic force on the particles to be separated?

(d) Make a working diagram of a three-stage induced-roll magnetic separator in operation and briefly explain how such equipment functions.

(e) In industrial concentration of minerals by magnetic separation, flocculation, or agglomeration of particles occur, which entrain gangue and bridge the gaps between the poles. How can this flocculation and entrainment of gangue be minimised and if possible prevented?

(f) Explain briefly what you understand by high-tension separation with the help of a sketch. What sorts of particles are found in the non-conducting and conducting products?

What are the main avenues along which charge can be acquired by a particle?

[20 %]

Question 5

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

What do you understand by the 'solids-handling capacity' of the thickener?

(b) Draw a schematic diagram of a horizontal belt filter used in a countercurrent cake washing operation. Clearly indicate the routing of the various process streams in your diagram.

Referring to your diagram, briefly describe and explain this cake washing operation.

(c) Describe the upstream method of tailings-dam construction with the aid of a clearly labelled diagram.

Outline the advantages and disadvantages of this method.

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

[20 %]

Question 6

In a particular industrial process, a mineral suspension with an initial solids concentration (C_o) of 50 g l^{-1} has to be thickened to an underflow concentration (C_u) of 340 g l^{-1}.

A laboratory batch-settling test on this suspension gave the following results:

Time (min)	Mudline height (cm)	Time (min)	Mudline height (cm)
0	34.0	12	10.5
1	33.0	14	9.0
2	30.5	16	8.0
3	28.0	18	7.5
4	25.5	20	7.0
5	23.0	25	6.5
6	20.5	30	6.3
7	18.0	40	6.0
8	15.5	50	5.8
9	13.5	60	5.6
10	12.0	90	5.5

(a) Plot the batch sedimentation curve for this batch-settling test on the graph paper provided.

(b) What is the relationship between solids concentration and interface ('mudline') height, that was developed by Kynch and used by Talmage and Fitch in their methods for determining thickener areas required?

(c) Show briefly how this relationship can be used to apply the data from one batch settling test to the Coe and Clevenger method of determining required thickener areas.

(d) Using the 'simplified' method of Talmage and Fitch, determine the time (tu) required to reach the required underflow solids concentration, and the thickener unit area required from this batch settling curve.

Explain briefly how you determine the 'compression point'. **[20%]**

- END OF MM 412 EXAMINATION –
GOOD LUCK!

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – DECEMBER 2004

MM 415

MINERAL PROCESSING FOR MINING ENGINEERS

TIME : THREE HOURS

ANSWER: FIVE QUESTIONS, QUESTION 1 AND 3 ARE COMPULSORY

---

1. State briefly but clearly what you understand by the following terms used in mineral processing:

   - Metallic and non-metallic minerals
   - Contained values of the ore
   - Liberation
   - Critical speed of a tumbling mill
   - Middlings fraction
   - Angle of "nip"
   - 80% passing reduction ratio
   - reverse flotation
   - hindered settling ratio of two minerals
   - pulp density of a solid/liquid mixture

2. Write short but clear notes of reasonable length on:

   a) Jaw crusher
   b) Gyratory crusher
   c) Rod and ball mills
   d) Sedimentation and elutriation in particle analysis

3 (a) Give a simplified statement of the hypotheses on energy consumption in comminution as proposed respectively by Von Rittinger, Kick and Bond.

(b) Show also how each of these formulations can be derived as a special case from Walker's equation for the energy consumption in comminution.

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

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

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

(iii) What minimum horse power should be installed in the grinding section based upon the above data
(1 hp = 0.75 kW)

(d) Given the following data

Feed to the rod mill = 55 tonnes dry ore per hour
Rod mill discharge = 62% Solids
Cyclone feed = 48%
Cyclone overflow = 31%
Cyclone ~~feed~~ underflow = 74%

(i) Calculate the circulating load in the grinding circuit

(ii) Calculate the amount of water added to the mill and cyclone feed respectively

(iii) Draw the operating flow sheet. Is it open or closed circuit ?

Hint: Input to the circuit = Output

4. (a) (i) Industrial screens are required to give a number of effects to the particles on the screens. These effects are mainly achieved by shaking or vibrating the screens. Name **THREE** most important requirements and explain why each of these effects is important.

(ii) The efficiency of screening can be expressed by the following equation

$$E = \frac{c - f}{c(1 - f)}$$

What do the symbols c and f stands for in this equation?

(iii) Name and discuss briefly the factors that effect screen performance

(b) What is classification as applied to a mixture of minerals in a fluid medium? Briefly describe the efficiency of a cyclone.

(c) What is jigging and what are its main applications?

5. (a) What is froth flotation: Describe the role of the following chemical Reagents in flotation

Collectors
Frothers
Regulators

Give examples in each case.

(a) What is the importance of Ph in froth flotation?

(b) What are " roughers", "scavengers" and " cleaners" cells in flotation circuits (Draw sketches)

6. (a) What are the main methods of dewatering? Briefly describe each of them.

(b) Describe briefly the construction of tailings dams by the upstream and down stream methods. What are the advantages of each method? (Illustrate with sketches.)

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNVERSITY EXAMINATIONS - DECEMBER, 2004

MM422

PHYSICAL METALLURGY II

TIME: THREE HOURS
INSTRUCTIONS: ANSWER ALL THE QUESTIONS

---

1. (a) On which principle are almost all strengthening mechanisms based?
   (b) How is strain hardening (cold working) accomplished?
   (c) Why is it essential to heat treat a metal or alloy after strain hardening?
   (d) Describe the processes involved in post-strain hardening heat treatment. Your description should include the role played by dislocations.

2. (a) Sketch and label a potential – log current density diagram which illustrates why an increase in the flow rate of oxygenated water across a steel surface may decrease rather than increase the corrosion rate.

   (b) A metal tube fabricated from alloyed steel that exhibits active-passive transition behaviour is used to transport oxygenated sulphuric acid from one vessel to another. During the transfer process the acid passes through the tube at a very high velocity whilst for shut down periods the acid is static. Using the data below, determine whether the alloyed steel is suitable for the purpose.

   i_{crit} = 100 μA cm^{-2}
   δ = 0.06 cm (when static)
   δ = 0.006 cm (when solution is flowing at high velocity)
   1 Faraday = 96500 C mol^{-1}
   D = 10^{-5} $cm^2 s^{-1}$
   Solubility of oxygen in the acid is 0.5 x 10^{-6} mol cm^{-3}

3. Use the data given below to construct a potential – pH diagram for the gallium – water system at 25°C and label the domains appropriately.

   Data at 25°C

   $$\frac{2.303\,RT}{F} = 0.0591\,\text{V}$$

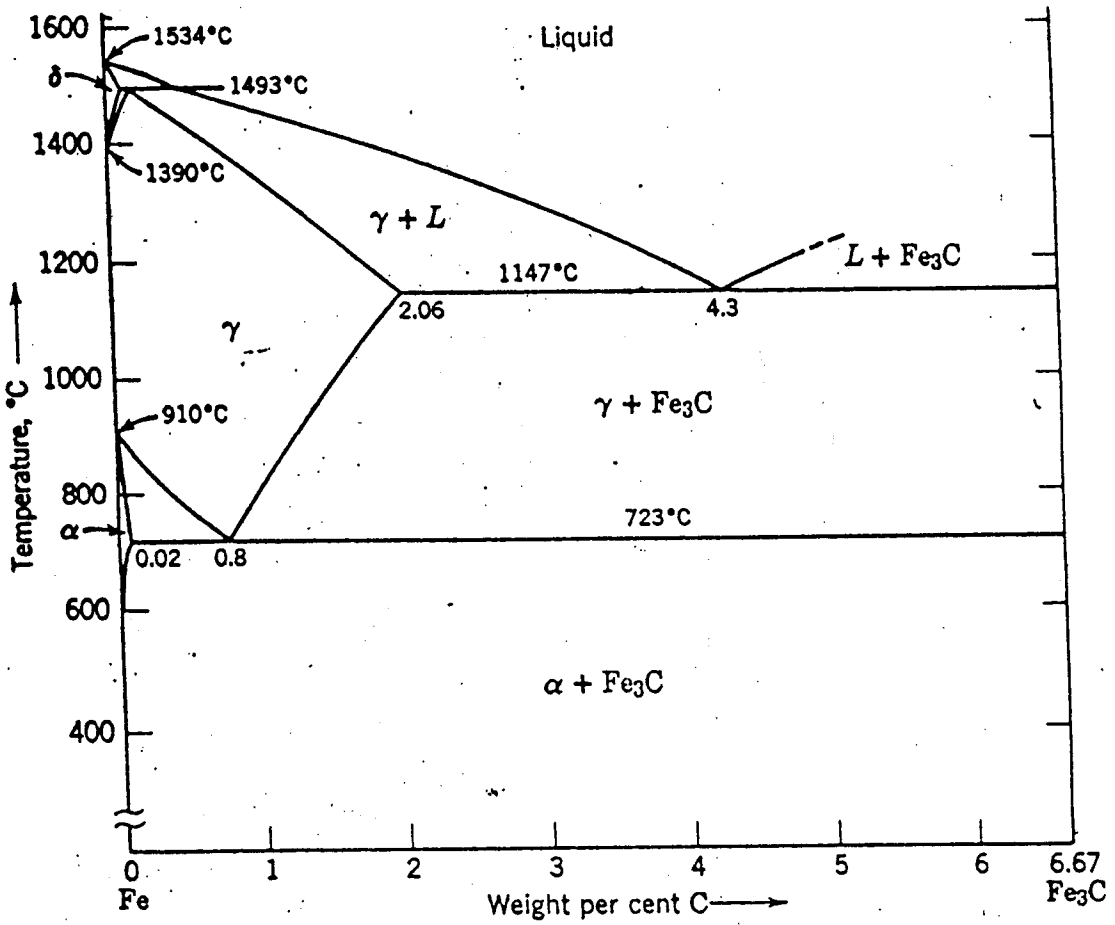
$Ga^{3+} + 3e^- = Ga$	E^o = -0.529 V
$2Ga^{3+} + 3H_2O = Ga_2O_3 + 6H^+$	$\log_{10} K$ = -4.46
$Ga_2O_3 + 3H_2O = 2GaO_3^{3-} + 6H^+$	$\log_{10} K$ = -81.62
$GaO_3^{3-} + 6H^+ + 6e^- = 2Ga + 3H_2O$	E^o = -0.485 V
$GaO_3^{3-} + 6H^+ + 3e^- = Ga + 3H_2O$	E^o = +0.319 V

$a_{Ga^{3+}} = a_{GaO_3^{3-}} = 10^{-6}$

4. (a) What is fatigue fracture and what are its main causes?
   (b) In class it was stated that for engineering components, the ASME has recommended that an S-N curve which is less than the experimental curve by two orders of magnitude for stress or twenty for number of cycles to failure should be used in design. Justify why this should be so.
   (c) Low-cycle fatigue failures occur at less than 10^4 cycles. Under what operating condition is this type of failure more likely to occur?
   (d) A fatigue specimen is cyclic loaded as follows: (1) The specimen is loaded in tension for 1 sec at 1,500 MPa/s, starting from a zero load; (2) it is then held at its maximum load for 1 sec; and (3) it is unloaded for 1 sec at –1,500 MPa/s. This cycle is then repeated over and over.
      i. Draw several cycles showing the cyclic loading pattern.
      ii. Determine the mean stress σ_m, alternating stress σ_a and stress ratio R.

5. (a) Why is the term "martensitic transformation" also applied to some non-ferrous materials?
   (b) What are the two features that distinguish martensite in ferrous materials from that in non-ferrous materials?
   (c) Why is martensite such a desirable constituent in tool steels?
   (d) After being slowly cooled from the austenite region, a hypoeutectoid steel exhibits a microstructure consisting of 40% pearlite and 60% ferrite.
      i. Estimate the carbon content of the steel.
      ii. Describe the equilibrium microstructure that would be obtained if the steel were heated to 730°C and held there for a long period of time.
      iii. What would be the equilibrium structure of this steel if it were heated to 850°C?
      iv. Make sketches of the microstructures in parts i-iii.

END OF EXAMINATION IN MM422



Phase diagram for the system Fe-Fe_3C.

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - DECEMBER, 2004

MM 442

HYDROMETALLURGY

TIME: THREE HOURS

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

1(a) Microbial leaching can assist in the leaching of a low grade surface deposit of chalcopyrite. Argue fully in support of this assertion. (8%)

(b) Given the data shown below, determine the pH defining the boundary between Co^{2+} and $Co(OH)_2$ on an Eh-pH diagram for the Co-H_2O system at 25 °C. Assume that the solids are pure and that cobalt in solution is at 0.2 M. Take the activity of cobalt as equal to its molar concentration. (10%)

Data:

Faraday constant = 96500 C/mol
Universal gas constant = 8.314 J/K/mol

$Co^{2+} + 2e^- = Co$ $\quad E° = - 0.28$ V

$Co(OH)_2 + 2e^- = Co + 2OH^-$ $\quad E° = - 0.73$ V

(c) What is the limiting residual cobalt ion activity for Co precipitation from an aqueous solution (pH = 6.6, temperature = 130 °C) with hydrogen gas at 50 atmospheres?(7%)

$Co^{2+} + 2\_ = Co$ $\quad E° = - 0.28$ V

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

2(a) As used in solvent extraction terminology, what is meant by "ion pair" and "chelating" extractants? Explain the extraction and stripping mechanisms of both types of extractants. (9%)

2(b) What is an equilibrium extraction isotherm? Explain how it is determined and used?(6%)

(c) A solvent with a chelating extractant has 9.2 g/l copper loaded in it. This organic phase is used to study cross flow stripping with a solute-free concentrated sulphuric acid solution. At each stage of stripping, 30 cm^3 of fresh strip solution is equilibrated with the organic phase. If in the first stage of stripping, 300 cm^3 of the loaded organic is used yielding at equilibrium an aqueous concentrate and a stripped organic with 62.0 g/l and 3.00 g/l copper, respectively, determine the least number of equilibrium stages required to yield a final stripped organic with not more than 0.08 g/l copper. Assume a constant stripping (distribution) coefficient of copper at each stage and that the organic and aqueous phases are immiscible. (10%)

3(a). How does contamination of crystals arise during precipitation processes? Explain the measures which could be used to minimize such contamination. (9%)

(b) Given that the solubility product of zinc carbonate is $1.00 * 10^{-10}$ at 25 °C, draw a zinc carbonate precipitation diagram at 25 °C. Take the overall dissociation constant of carbonic acid at 25 °C as $2.08 * 10^{-18}$ and that the equilibrium activity of H_2CO_3 in solution as 0.1. (10%)

(c) Outline the main features of the Goethite and Jarosite processes for the precipitation of iron from acid sulphate solutions. (6%)

4(a) During copper electrorefining, copper sulphate crystallization is sometimes observed. Explain the origin of such crystallization. What are the problems it causes and what remedial measures may be taken to forestall sulphate formation and to remove any sulphate already formed? (7%)

(b) In the electrolytic refining of nickel, the anode is a Cu-Ni alloy with 80 atom % Ni, whereas the cathode is pure nickel.

(i) Calculate the theoretical cell voltage for the electrorefining process at 45 °C when the alloy is assumed to be an ideal solid solution. (5%)

(ii) In practice, both Ni and Cu electrochemically corrode from the anode. The anolyte is withdrawn and Cu is removed by cementation as pure Cu on Ni powder. Calculate the equilibrium Cu/Ni mass ratio in the purified electrolyte at 45 °C, if Ni^{2+} and Cu^{2+} ionic activities are taken equal to their molarities. (7%)

(iii) In practice, during refining of the Ni-Cu alloy , the applied cell voltage is 2.0 V and the cathodic current efficiency is 95%. Calculate the electric energy consumption in kWh per kilogram of refined nickel. (6%)

Data:

R = 8.314 J/deg/mol

F = 96500 C/mol

Relative atomic weights: Ni = 58.7; Cu=63.5

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

$Cu^{2+} + 2e^- = Cu$ $\quad E° = 0.34$ V

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - DECEMBER 2004

MM 452

PROCESS CONTROL AND INSTRUMENTATION

TIME: THREE HOURS

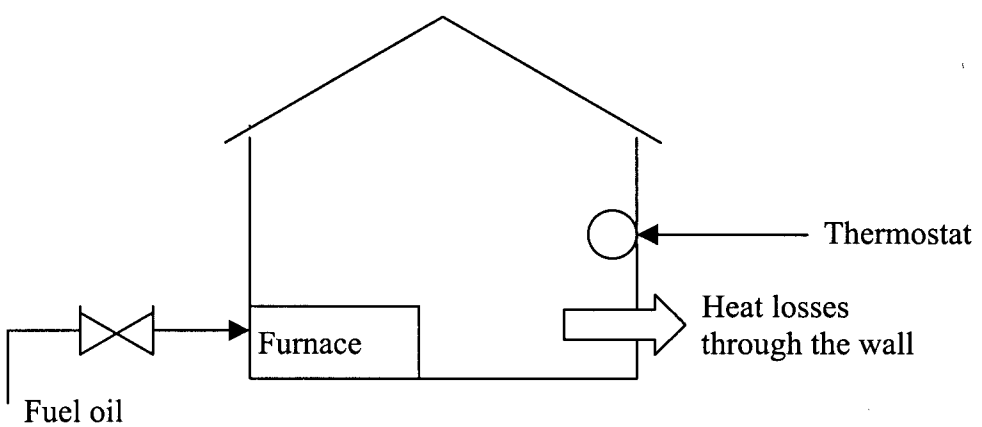
ANSWER: FIVE QUESTIONS. All additional data that the student will require are attached. All questions carry equal marks

---

1. (a) The student-teacher learning process is inherently a feedback process intended to reduce the system error to a minimum. The actual output is the knowledge being studied and the student may be considered the process. Construct a feedback block diagram of the learning process and identify each block in the system.

(b) Draw a schematic block diagram of a house hot-water geyser system. Identify the function of each element of the thermostatically controlled system.

(c) Consider the air-heating system used to regulate the temperature in a house as shown in the figure below. The heat is supplied from combustion of fuel oil.



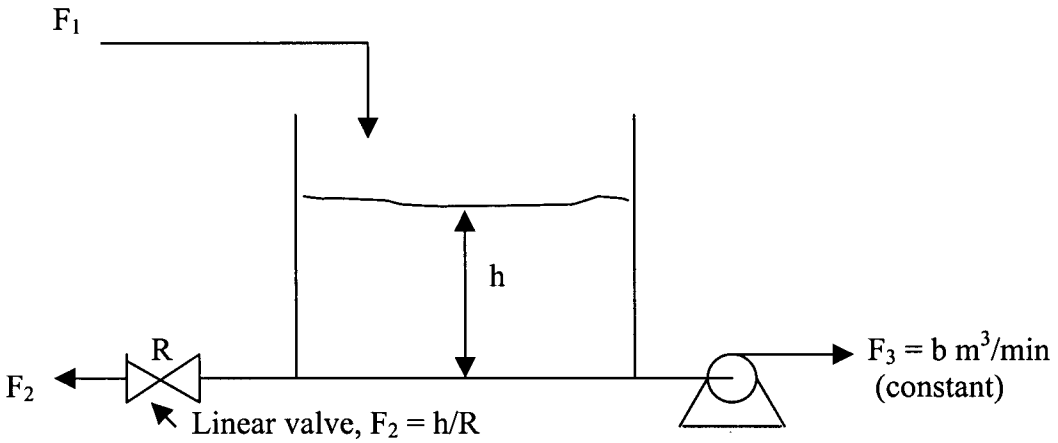
(i) Identify the control objective, the available measurements and the manipulated variable. What are the external disturbances for this system? Is this a SISO system?

(ii) Develop a feedback block diagram to achieve your control objective.

(iii) Identify the hard constraints.

(iv) Is a feedforward control configuration possible in this case? Briefly explain.

2. (a) Consider the system in the figure below.



Assume that the flow rate of the effluent fluid stream F_2 is proportional to the hydrostatic pressure that causes the liquid to flow. The cross-sectional area of the tank is A m^2. The flow rates F_1, F_2 and F_3 are in m^3/min.

(i) Develop a mathematical model for the system. What is the state variable and what balance have you used?

(ii) Develop an input-output model for the system including a pictorial representation.

(b) Linearise and convert to deviation variables the following singe-input single-output models:

(i) $\frac{dy}{dt} = ym - 2y + m^2$

(ii) $\frac{dy}{dt} = ym^2 + \sin \alpha m$ $\qquad$ α: constant

3. (a) Starting from the following equation yielding the Laplace transform of the derivative as

$$\int_0^t \frac{df(t)}{dt} e^{-st} dt = sf(s) - f(0)$$

prove the final value theorem. Using this theorem, find the final value of the following function as $t \rightarrow \infty$:

$$y(t) = 1 - 5e^{-0.5t} \sin (6t - 2)$$

(b) Solve the following differential equation using Laplace transforms:

$$\frac{d^2y}{dt^2} + \frac{dy}{dt} + y = 1 \qquad y(0) = y'(0) = 0$$

Work correct to three decimal places.

4. A cylindrical tank having a cross-sectional area of 0.2 m^2 is operating at steady state with an inlet flow rate of 10^{-3} m^3/s. Between the liquid heads h of 0.3 m and 0.09 m, the flow-head characteristics are given by the equation:

$$F_2 = 0.002h + 0.0006$$

where F_2 is the outlet flow rate. The inlet flow rate is given by F_1.

(a) Determine the transfer function relating inflow and liquid level,
(b) If the inflow increases from 10^{-3} m^3/s to 1.1×10^{-3} m^3/s according to a step change, calculate the liquid level 200 s after the change has occurred. What is the final value of the liquid level? Give the answer correct to three decimal places.

5. (a) A liquid-level system has a cross-sectional area of 0.3 m^2. The valve characteristics are

$$F_2 = 0.23\sqrt{h}$$

where F_2 = outlet flow rate, m^3/min
h = level above valve, m
Calculate the time constant when $h_s = 0.9$ m and also when $h_s = 2.7$ m. *Please linearise.*

(b) Given a system with the following transfer function:

$$\frac{Y(s)}{X(s)} = \frac{(T_1 s + 1)}{(T_2 s + 1)}$$

Find Y(t) when X(t) is a unit step change. For $\mathbf{T_1/T_2 = 5}$, show the numerical values of minimum, maximum and final values that may occur for Y(t). Check these using the initial value and final value theorems.

6. (a) The response of an underdamped second order system to a unit step change may be shown to be

$$y(t) = 1 - \frac{1}{\sqrt{1-\zeta^2}} e^{-\zeta t/\tau}\left[\zeta \sin \omega t + \sqrt{1-\zeta^2}\cos \omega t\right]$$

where $\omega = \dfrac{\sqrt{1-\zeta^2}}{\tau}$.

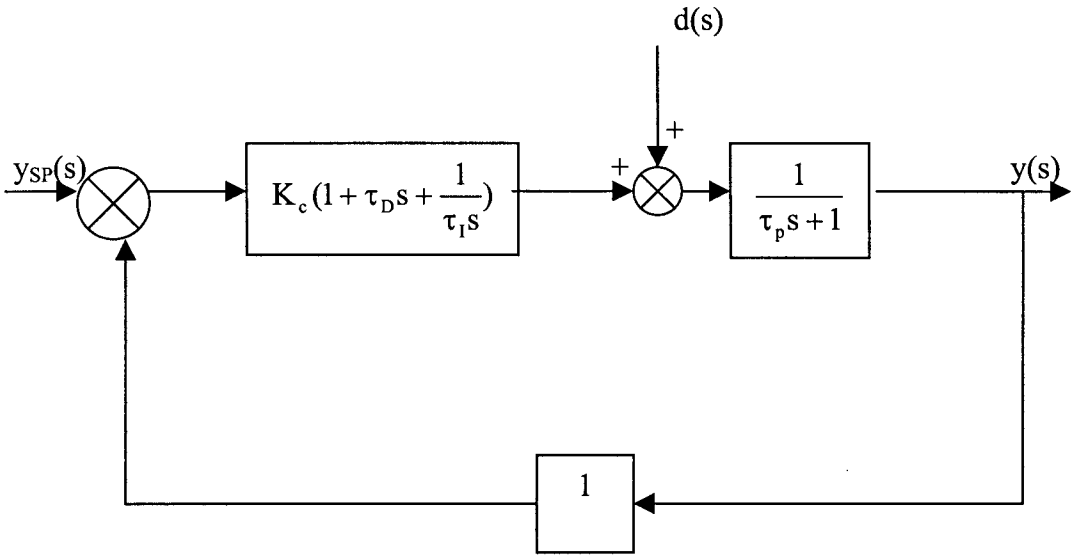
Prove that the overshoot for such a response is given by

$$e^{-\pi\zeta/\sqrt{1-\zeta^2}}$$

and that the decay ratio is equal to $(\text{overshoot})^2$.

(b) Suppose there is a second order system with $\tau = 0.5$ min and $\zeta = 0.5$. Using some of the information in part (a), calculate
(i) the maximum value of y(t),
(ii) the period of oscillation,
(iii) the rise time.

7. The control system shown in the figure below contains a three-mode (PID) controller.



(a) For the closedloop, develop formulas for the natural period of oscillation τ and the damping factor ζ in terms of the parameters K_c, τ_D, τ_I and τ_p. Use the expression for $G_L(s) = y(s)/d(s)$.

For the following parts, $\tau_D = \tau_I = 1$ and $\tau_p = 2$.

(b) Calculate ζ when $K_c = 0.5$ and also when $K_c = 2$.
(c) Do ζ and τ approach limiting values as K_c increases, and if so, what are these values?
(d) Determine the offset for a unit step change in the disturbance if $K_c = 2$.

END OF EXAMINATION IN MM 452

Additional information to assist the students in this examination is found on the next page.

Table of Laplace Transforms

f(t)	f(s)	f(t)	f(s)
u(t)	$\frac{1}{s}$	tu(t)	$\frac{1}{s^2}$
$t^n u(t)$	$\frac{n!}{s^{n+1}}$	$e^{-at}u(t)$	$\frac{1}{s+a}$
$t^n e^{-at}u(t)$	$\frac{n!}{(s+a)^{n+1}}$	sin kt u(t)	$\frac{k}{s^2+k^2}$
cos kt u(t)	$\frac{s}{s^2+k^2}$		

Inversion by partial fractions

METHOD 1

Suppose $L\{x(t)\} = x(s) = \frac{F(s)}{(s+k_1+jk_2)(s+k_1-jk_2)}$

where F(s) is some real function of s.

Let the function x(s) after partial fraction expansion become

$$x(s) = F_1(s) + \left(\frac{a_1+jb_1}{s+k_1+jk_2} + \frac{a_1-jb_1}{s+k_1-jk_2}\right)$$

where a_1 and b_1 are constants evaluated in the partial fraction expansion and $F_1(s)$ is a series of fractions arising from F(s).

Then the inverse transform arising from the complex root reduces to

$$2e^{-k_1 t}(a_1 \cos k_2 t + b_1 \sin k_2 t)$$

METHOD 2

Suppose x(s) after partial fraction expansion becomes

$$x(s) = F_1(s) + \frac{Bs+C}{(s+a)^2+k^2}$$

Then $$x(s) = F_1(s) + B\frac{s+a}{(s+a)^2+k^2} + \left(\frac{C-aB}{k}\right)\frac{k}{(s+a)^2+k^2}$$

The inverse transform arising from the above becomes

$$x(t) = F_1(t) + Be^{-at}\cos kt + \left(\frac{C-aB}{k}\right)e^{-at}\sin kt$$

The useful trigonometric identity is

$$p\cos A + q \sin A = r \sin(A+\phi)$$

where $r = \sqrt{p^2+q^2}$ and $\tan\phi = p/q$

THE UNIV ERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – DECEMBER, 2004

MM 542

FUELS, FURNACES AND REFRACTORIES

TIME: THREE HOURS

ANSWER: ALL QUESTIONS

---

1. (a) Distinguish between rank and grade of coal. [2%]

(b) Name four properties of coal that should be specified in the measure of grade of coal. [2%]

(c) The storage procedures of coal are designed for two purposes. Name them. [2%]

(d) In the combustion of a solid fuel, draw sketches showing gas analysis and temperature distribution on coke beds of very unreactive fuel and very reactive fuel. [4%]

(e) Describe four factors that affect the temperature attained in the combustion of a fuel. [4%]

(f) Describe how high temperatures are achieved when using pulverized fuel in a furnace. [4%]

(g) In heat exchangers, show the superiority of counter current flow to parallel flow using a diagram. [2%]

2. (a) Give a general description of furnaces. [4%]

(b) Give a description of the following furnaces, giving examples in each case:

(i) Hearth furnaces [2%]
(ii) Converters [2%]
(iii) Crucible furnaces [2%]

(c) Describe the process in which converters are used in copper smelting. [5%]

(d) The iron blast furnace is the most highly developed shaft furnace. Briefly describe the operation of the iron blast furnace showing the function of the main operating parts. [5%]

3. (a) Give a definition of special refractories. [2%]

(b) Some of the manufacturing methods of special refractories include slip casting, sintering and pressure sintering. Briefly describe these three manufacturing methods. [6%]

(c) Briefly describe the raw materials and manufacture of zirconia ware. What are the main applications of zirconia ware. [5%]

(d) Give a description of the manufacture of silicon carbide bricks and shapes. Mention two applications of silicon carbide material.[5%]

(e) How do insulation materials derive their low thermal conductivity? [2%]

4. (a) Distinguish between acid and basic refractories [2%]

(b) What are the three most important requirements the user of refractories looks for. [3%]

(c) Describe two methods used in the determination of slag resistance of a refractory. [4%]

(d) Describe the manufacture of carbon bricks with reference to the following

(i) Raw materials (Metallurgical coke, petroleum coke, anthracite and natural graphite) [4%]

(ii) Manufacture (mixing, moulding and firing) [5%]

(iii) Applications [2%]

5. (a) Using a diagram, describe the important allotropic forms of silica. [4%]

(b) What has been the two principle uses of silica bricks [2%]

(c) Why is it almost impossible to cool a furnace with silica brickwork below 300°C. [2%]

(d) Very briefly outline how magnesium oxide (MgO) may be produced from sea water. [3%]

(e) Outline the method of production of magnesite bricks and mention two of their uses. [5%]

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

END OF EXAMINATION IN MM 542

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – DECEMBER 2004

MM 562

FOUNDRY

TIME: THREE HOURS

ANSWER: ALL QUESTIONS

---

1. For a simple top gated casting, calculate the flow rate at an intermediate point situated 0.45 m from the surface in the downsprue given that the total height, ht, is 0.98 m and the diameter at the sprue outlet is 30 mm (where the velocity is a function of the total potential energy).

   From information above, calculate the mould filling time as well as its solidification time, t_s, with mould capacity of 900 cm^3 (assume cubic shape) and that the value of k is 150 secs/cm.

2. (a) Briefly discuss the operations of the crucible and induction furnaces in terms of the following;

   (i) Sources of heat and its transfer to the charge as well as relative efficiency and

   (ii) Types of alloys that may be treated by each of the furnaces.

   (b) What design features would you incorporate in a gating system in order to prevent;

   - Turbulence
   - Slag and other unwanted material from entering the mould cavity
   - Piping (shrinkage) and porosity of the casting

3. (a) Explain why processes such as sand, shell, plaster and investment casting can produce parts with greater shape complexity than others such as permanent mould, die and centrifugal casting.

   (b) Show how solidification in an alloy that has no solid diffusion but has perfect mixing in the liquid progresses

(c) During alloy solidification, the partition coefficient or ratio k, indicates solute distribution between the liquid and solid phases. If f_L and f_S are liquid and solid fractions respectively. Show the above as a material (mass) balance

If the Scheil equation is as follows $(C_L - C_S)\, df_S = (1 - f_S)\, dC_L$, set the boundary conditions for C_S and solve for C_L in the above equation.

4. For a rod of length *l* and mean flow stress of σ_m and that is being acted upon by a force F,

(a) Show that the work of homogeneous deformation W_H and for a constant volume V, between two strains ε_i and ε_f is given by $W_H = ln\,(A_i/A_f)$ where A_i and A_f are the initial and final cross-sectional areas.

(b) What does the work due to inhomogeneous deformation take into account?

(c) Given that $\sigma = 235\,\varepsilon^{0.28}$ for a material that is deformed from 15.2 mm to 10.8 mm, calculate the work done in achieving the deformation.

5. (a) A billet of an aluminium alloy is being hot extruded from a 101.6 mm diameter to a 25.4 mm in a single stroke. If the yield stress, σ_0, of the metal remains constant at 69 N/mm^2 (i.e. no work hardening) during the operation and the process efficiency, η, is 0.50. What is the magnitude of the pressure (stress) needed to perform the operation?

(b) Distinguish between direct and indirect extrusions by illustrating the tooling involved as well as the extrusion load-travel curves.

END OF EXAMINATION