

SCHOOL OF MINES
2014 ACADEMIC YEAR
FINAL EXAMINATIONS

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THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
UNIVERSITY EXAMINATIONS – JULY 2014
GG 312 – INTRODUCTION TO PETROLOGY
PAPER I - THEORY

**INSTRUCTIONS: ANSWER ANY FIVE QUESTIONS USING WELL LABELLED SKETCHES
WHEREVER POSSIBLE**

TIME: THREE (3) HOURS

- Q1 a) what are the major processes that are involved in the formation of sedimentary rocks?
b) Give a brief description of the textures of metamorphic rocks.
- Q2 a) Define metamorphism. What are the main factors that may control a metamorphic reaction?
b) What is contact metamorphism? Discuss the main rocks which can be formed as a result of regional metamorphism.
- Q3 a) What is the difference between magma and lava?
b) Give a brief description of the main textures of sedimentary rocks.
- Q4 a) Give a detailed description of the granite - rhyolite family.
b) Define the following:
i) Oolitic texture
ii) Foliation
iii) Marble
iv) Cross bedding
v) Arkose
- Q5 a) Define metamorphism. What are the main factors that may control a metamorphic reaction?
b) What is regional metamorphism? Discuss the main rocks which can be formed as a result of regional metamorphism.
- Q6 Compare and contrast between the following:
i) Marble and quartzite
ii) Schist and gneiss
iii) Shield volcano and composite volcano
iv) Arkose and grit
v) Peridotite and granodiorite
- Q7 a) Show how metamorphic rocks are classified.
b) Briefly describe the following shapes of igneous bodies:
i) Ring dyke
ii) Batholiths
iii) Sill
iv) Lopolith
v) Cone sheet

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

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS – JULY 2014
GG 421 – SEDIMENTOLOGY
PAPER II – PRACTICAL

INSTRUCTIONS: Answer both questions.

TIME: Three (3) Hours

Q1. An estate development company is seeking your expertise in interpreting the subsurface geology of an area where it wants to build a shopping mall that will include multi storey structures. Knowledge of the subsurface geology is critical. The only subsurface data available is in the form of lithological logs of two bore holes which were drilled many years ago. It is not clear who logged the bore holes and it is possible that in some cases, data may be missing. The bore holes were drilled 675 metres apart. You have been awarded the assignment and your terms of reference require you to carry out the following (70 marks):

- i) Make sedimentary logs of both cores, using the standard format available;
- ii) Interpret these cores in terms of processes of deposition and depositional (sub) environment basins, indicating how some facies are related to each other;
- iii) Correlate the two bore holes and comment, with good reasons, on whether their rocks were deposited in the same sub-basin or channel;

Log: B/H 1 (Bore hole collar = 965m above sea level)

0-2m	Very fine-grained mudstone, in places with shaly partings, desiccation cracks and root traces;
2-5m	Very fine- to medium-grained sandstone, horizontal bedding and locally massive;
5-10m	Coarse-grained to pebbly sandstone, trough cross-bedding alternating with planar x-beds;
10-16m	Matrix supported conglomerates, massive with crude bedding locally horizontal bedding;
16-19m	Clast-supported conglomerates, complex bed forms with tabular sheets;
19-21m	Pebbly sandstones, trough cross-bedding;
21- 24m	Very coarse grained sandstone, trough cross-bedded to parallel laminated;
24-25m	Medium-grained sandstone, ripple cross-laminated;
25-27m	Alternating mudstone and very fine-grained sandstone;
27-28.5m	Pebbly mudstone at base that is followed by mudstone, massive, followed by thinly laminated and then massive beds

Log: B/H 2 (Bore hole collar = 973m above sea level)

0-2m	Mudstone, in places with intraclasts, massive beds, desiccation cracks;
5-7m	Clast-supported conglomerates – mainly cobbles, complex bed forms with tabular sheets;
7-15m	Matrix supported conglomerates – mainly pebbles, massive with crude bedding locally horizontal bedding;
15-20m	Very fine-to medium-grained sandstone, horizontal bedding and locally massive;
20-23m	Mudstone, in places with shaly partings, thinly laminated overlain by massive beds; bioturbated with root traces;
23-24.5m	Schist

Q2. You are provided with four hand specimens marked A, B, C and D. You are required to do the following (30 marks):

- i) Describe the texture, composition and any observable structures of each specimen, and then name the rock;
- ii) Outline briefly, the depositional environment of each rock, suggesting the possible transportation mechanisms and distance from the source.

END OF EXAM AND GOOD LUCK

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS – JULY 2014
GGY 2001 – INTRODUCTION TO GEOLOGY
PAPER I – THEORY

INSTRUCTIONS: Answer any five questions. All the questions carry equal marks. Use diagrams and equations wherever it is necessary.

TIME: Three Hours

- Q1. Describe how you can use physical, chemical and optical properties to identify the following minerals.
(a) Amethyst
(b) Muscovite
(c) Magnetite
(d) Calcite
(e) Gold
(f) Galena
(g) K-feldspar
- Q2. Discuss the formation and classification of clastic sedimentary rocks.
- Q3. Describe the important elements of symmetry and crystallographic axes of each of the seven crystal systems.
- Q4. Write short notes on the following aspects of igneous rocks.
(a) Magmatic differentiation
(b) Classification of igneous rocks.
- Q5. Describe the primary and tectonic structures that are commonly associated with sedimentary and igneous rock units.
- Q6. Describe how the silica tetrahedral units are linked in the following minerals: biotite, pyroxene, olivine, quartz and amphibole.
- Q7. Describe the changes which take place during progressive regional metamorphism of limestones, sandstones and shales.

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

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS – JULY 2014
GGY 2001 – INTRODUCTION TO GEOLOGY
PAPER II – PRACTICAL

INSTRUCTIONS: Answer all the questions.

TIME: Three Hours

- Q1. Describe the elements of symmetry of the given crystal models and identify the crystal systems to which they belong. (16 %).
- Q2. Describe the physical and optical properties of the mineral specimens (M1, M2, M3, M4, M5, M6) and identify them by stating their name and the mineral group to which they belong. (30 %).
- Q3. Describe the mineralogical composition, texture and structure of the rock specimens (R1, R2, R3, R4, R5, R6) and use these features to identify them and establish the conditions under which they were formed. (54 %).

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

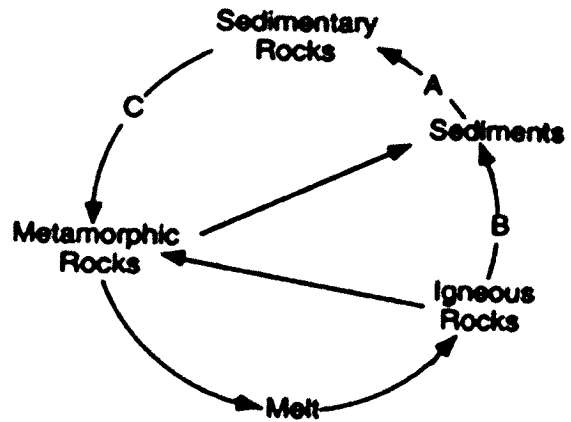
UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS – JULY 2014
GGY 2012 – EARTH RESOURCES AND ENVIRONMENT

TIME: THREE HOURS

SECTION A – MULTIPLE CHOICE: ANSWER ALL QUESTIONS

- 1 We breathe air every day, and it will always be available for us. Air is an example of a/an _____ resource; a) extinct; b) renewable; c) inexhaustible; d) nonrenewable
- 2 A resource that can be replaced in a human lifetime: a) conservative resource; b) nonrenewable resource; c) important resource; d) renewable resource
- 3 We need clean air and water to live. If we make our air and water dirty, we are _____ our resources: a) reusing; b) conserving; c) recycling; d) polluting
- 4 The desert is a very dry, hot place. People in the desert need to conserve their water because: a) there is a lot of rain in the desert; b) people get very thirsty there; c) the water in the desert is very dirty; d) The desert does not get much rain and has little water
- 5 To reuse a resource to make something new is to: a) renew; b) exhaust; c) replay; d) recycle
- 6 A material found in nature and used by living things is called a resource: a) False; b) True; c) Don't know
- 7 A resource that will be used up someday is called a: a) renewable resource; b) nonrenewable resource; c) extinct; d) inexhaustible resource
- 8 Which of the following resources is **NOT** a fossil fuel? a) uranium-235; b) hydrocarbons c) coal; d) oil shales; e) natural gas
- 9 The correct sequence of events during the process of coalification is: a) peat - bituminous coal – lignite - anthracite; b) peat-lignite - bituminous coal - anthracite; c) lignite - peat - bituminous coal - anthracite; d) anthracite-lignite-bituminous coal - peat; e) bituminous coal - lignite -anthracite-peat
- 10 Many of the Earth's resources are found under its surface. One way to get these resources is by: a) farming; b) clear-cutting; c) mining; d) using windmills
- 11 Plastic is made from which resource? a) coal; b) water; c) oil; d) plants
- 12 Oil will someday be all used up. Oil is a _____ resource; a) nonrenewable; b) renewable; c) exhausted; d) inexhaustible
- 13 Which resource can be recycled? a) natural gas; b) aluminum; c) wood; d) coal
- 14 Which of the following resources are inexhaustible? a) Oil; b) coal; c) sun; d) wood
- 15 Compared to felsic igneous rocks, mafic igneous rocks contain greater amounts of: a) aluminum; b) pink feldspar; c) white quartz; d) iron
- 16 What is the basic difference between ultraviolet, visible, and infrared radiation? a) wave velocity; b) half-life; c) temperature; d) wavelength
- 17 Which sedimentary rock is most likely to be changed to slate during regional metamorphism?
- 18 Turning off lights when they are not needed is a way we can _____ our resource at home: a) reserve; b) reuse; c) conserve; d) recycle
- 19 Which of the following resources is nonrenewable? a) groundwater; b) coal; c) wind; d) solar energy; e) wood
- 20 A **fossil fuel** forms from decayed organic matter. Which of the following resources is **NOT** a fossil fuel? a) peat; b) coal; c) oil; d) carbon dioxide; e) natural gas
- 21 Which of the following statements about nuclear power is **TRUE**? a) nuclear power is less efficient than oil for generating energy; b) nuclear power plants utilize uranium fission reactions to generate power; c) nuclear power is a renewable resource; d) nuclear power supplies about 50% of the world's energy needs; e) nuclear power is great because there are no environmental concerns

- 22 Which of the renewable energy resources listed below ultimately involves driving a turbine to generate electricity? a) nuclear; b) geothermal; c) tidal; d) hydroelectric; e) all of the above
- 23 Referring to the diagram below, path A is: a) cooling and crystallization; b) burial and lithification; c) weathering and deposition; d) cooling and uplift
- 24 Referring to the diagram below, path B is: a) deposition, heat and pressure, weathering; b) melting, crystallization, heat and pressure; c) deposition, heat and pressure, weathering; d) uplift, weathering and erosion, deposition; e) deposition, lithification and crystallization
- 25 Referring to the diagram, what factor(s) are responsible for path C? a) crystallization; b) heat and pressure; c) melting; d) burial and lithification



- 26 The life supporting gases such as O₂, CO₂ and N₂ are chiefly concentrated in the _____: a) troposphere; b) exosphere; c) hemisphere; d) stratosphere
- 27 The length of an Earth day is determined by the time required for approximately one: a) sun revolution; b) earth rotation; c) earth revolution; d) sun rotation
- 28 How are latitude and longitude lines drawn on a globe of the Earth? a) longitude lines are parallel and latitude lines meet at the equator; b) latitude lines are parallel and longitude lines meet at the equator; c) latitude lines are parallel and longitude lines meet at the poles; d) longitude lines are parallel and latitude lines meet at the poles

a) conglomerate; b) breccias; c) dolostone; d) shale

- 29 In general, the probability of flooding decreases when there is an increase in the amount of: a) runoff; b) precipitation; c) infiltration; d) snow melt

- 30 Many factors influence the proportion of water that infiltrates into the ground or runs off the land surface from a rainfall episode. Indicate with a tick, which situation in the diagram favours greater infiltration or greater runoff.

Surface has steep slope	Favors infiltration	Favors runoff
Soil is porous and sandy	Favors infiltration	Favors runoff
Rainfall is gentle	Favors infiltration	Favors runoff
Ground is nearly saturated	Favors infiltration	Favors runoff
Surface lacks vegetation and is barren	Favors infiltration	Favors runoff

- 31 Winter days in Cape Town are likely to be colder than summer days because in winter: a) the number of sunspots decreases; b) earth is farther from the sun; c) earth's southern axis is tilted away from the Sun; d) the sun gives off less energy
- 32 The motions of the three types of plate boundaries would be described as divergent, convergent, and transform: a) true; b) false
- 33 The apparent rising and setting of the Sun, as viewed from Earth, is caused by: a) the Sun's rotation; b) earth's revolution; c) the Sun's revolution; d) earth's rotation
- 34 The Andes Mountains of South America are a result of _____ plate boundary: a) divergent; b) transform; c) convergent; d) they are not related to a plate boundary
- 35 Features useful in defining plate boundaries include all except: a) distribution of mountain ranges; b) Shorelines between continents and oceans; c) distribution of volcanoes; d) distribution of earthquakes; e) all are correct
- 36 Which of these factors affects the rate of weathering? a) climate; b) surface area of the exposed rock; c) chemical composition of the exposed rock; d) all are correct

SECTION B – SHORT ESSAY QUESTIONS: ANSWER ANY TWO QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS

- 1 a) Describe the **two** types of weathering
- b) Which form of weathering promotes the other, and how?
- c) Describe three factors that affect the rate of weathering
- d) Name one climatic region in which each weathering type would predominate over the other, and why
- e) List **three factors** that influence the rate at which weathered material is eroded away.
- 2 a) Name and describe the **four** systems of the Earth
- b) Mention the number of compositional layers that the earth has, and also describe which of them is (i) the thinnest, and (ii) the heaviest, and why
- c) Briefly describe the **two** main sources of heat that warm the planet and sustain life
- 3 a) Describe briefly **six** components of the hydrologic cycle.
- b) Distinguish between porosity and permeability. State at least **two** factors that influence permeability of a geologic body.
- c) Distinguish a spring from an artesian well
- d) Why would you recommend against deforestation of a recharge area for an aquifer that serves your community?
- 4 a) what is the significance of the rock cycle?
- b) Describe the three major classes of rocks, and describe how they each originated
- c) List two common rocks in each of the three main classes

_____END OF THE EXAMINATION, AND GOOD LUCK!_____

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
UNIVERSITY EXAMINATIONS – JULY 2014
GGY3020 – INTRODUCTION TO MINERALOGY AND PETROLOGY
PAPER II – PRACTICAL**

INSTRUCTIONS: Answer both questions illustrating your answers wherever possible.

TIME: Two Hours

Q1. Given crystal A with x-axis, y-axis and z-axis being perpendicular to each other but z-axis is longer than the equal x-axis and y-axis and that z-axis goes through two opposite corners while x-axis and y-axis go through centres of two opposite prismatic faces, do the following: (60 marks)

- i) Sketch it and label all faces using Miller symbols and axes;
- ii) Plot its stereonet given that interfacial angle between any slanting face and prismatic face is 45° .
- iii) Ensure that all faces, axes of symmetry, crystallographic axes, planes of symmetry are plotted on the stereonet.
- iv) Using the stereonet determine the interfacial angle between any two slanting faces.

Q2 Give a full petrographic description of the six rock samples 1, 2, 3, 4, 5 and 6, emphasize on the following:

- a) Mineralogy
- b) Texture

Finally, name each rock

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

UNIVERSITY OF ZAMBIA EXAMINATIONS
JULY 2014 EXAMINATIONS

GGY 3020 – MINERALOGY AND PEROLOGY PAPER II

CRYSTAL MODEL A



**UNIVERSITY OF ZAMBIA
SCHOOL OF MINES**

UNIVERSITY EXAMINATIONS – JULY 2014

GGY3021 –CRYSTALLOGRAPHY AND OPTICAL MINERALOGY

PAPER I - THEORY

INSTRUCTIONS: ANSWER ANY FOUR QUESTIONS USING WELL LABELLED SKETCHES WHEREVER POSSIBLE

TIME: THREE (3) HOURS

- Q1. (i) Define the following terms: (a) Plane of symmetry; (b) Axis of symmetry; (c) Centre of symmetry; (d) Inversion axis.
- (ii) Describe briefly the following silicate structures giving at least one mineral example of each: (a) Single Chain Silicates; (b) Island Silicates; (c) Layer Silicates; (d) Framework Silicates
- (iii) Distinguish between ionic and covalent bonds. Give one mineral example of each type of bonds.

- Q2. (i) Determine the axial ratio $a:b:c$ for the following faces whose interfacial angles are provided in the table below and sketch the face relationship. Which system does this crystal belong to and why?

FACE	ρ	ϕ
(120)	90°	33°
(012)	69°	0°

- (ii) If the axial ratio $a:b:c$ is $1:1:2.567$, determine the ρ and ϕ angles for the faces (110) and (011). Draw the sketch first and step by step determine the angles.
- (iv) Intercepts that faces make with crystallographic axes are given below. Determine the Miller Indices and thus symbols of such faces.
Face A: $1/2, 3, 1/7$;
Face B: $\infty, 2/9, 1$;
Face C: $5/3, 2/3, 4$;
Face D: $2, \infty, 1/5$
- (v) Describe the following:
(a) Zone, (b) Zone Axis, (c) Zone Symbol and (d) Form.
- (vi) Prove if the following sets of faces lie in one zone using the zone symbol method:
(a) (100), (201), and (101);
(b) (01T1), ($11\bar{2}1$), and (10T0)

- Q4. (i) Sketch a tetragonal prism with the z-axis longer than the equal x-axis and y-axis and label the faces on it accordingly if the crystallographic axes intersect faces at right angles. Note that axes and Miller symbols of faces should be indicated on the sketch.
- (ii) Make a sketch of a stereogram that would result if the crystal in (i) was plotted in stereographic projection. On this stereogram indicate where a tetrad, the planes, the diads would plot if the stereogram is viewed with the positive side of the z-axis facing you.
- (iii) Define the following terms: (a) refractive index; (b) pleochroism; and (c) relief.
- Q5. (i) Define the following concepts in mineralogy: (a) isomorphism, (b) polymorphism, (c) solid solution, and (d) coupled substitution.
- (ii) Distinguish ore from ore mineral.
- (iii) Determine the concentration of: (a) Fe in magnetite and hematite; (b) Cu in chalcopyrite, bornite and chalcocite; (c) Zn in smithsonite; and (d) Ti in ilmenite.
- (iv) Is there any variation in concentration of Cu among the three ore minerals in (iii)(b)? What would be the cause of this variation?
- (v) Briefly explain why the concentration of a metal in ore concentrate is higher than in the ore.
- Q6. (i) Briefly explain the electrostatic valency principle.
- (ii) What is coordination number?
- (iii) Name and describe briefly three Goldschmidt rules that govern atomic substitution within a mineral.
- (iv) Under what conditions in terms of the rules described above do each of the following occur?: (a) element capture, (b) element admission and (c) element camouflage.

-----End of Exam

Good Luck!!!!-----

Useful Information

Magnetite – Fe_3O_4 ; Hematite – Fe_2O_3 ; Smithsonite – ZnCO_3 ; Chalcopyrite – CuFeS_2 ; Bornite – Cu_5FeS_4 ; Chalcocite – Cu_2S ; Ilmenite – FeTiO_3 ; Fe = 55.7; Cu = 63.6; Ti = 47.7; S = 32.0; C = 12.0; Zn = 65.3; O = 16.0

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – JULY 2014

GGY3021 – CRYSTALLOGRAPHY AND OPTICAL MINERALOGY

PAPER II - PRACTICAL

INSTRUCTIONS: Answer both questions illustrating your answers wherever possible.

TIME: One and Half Hours

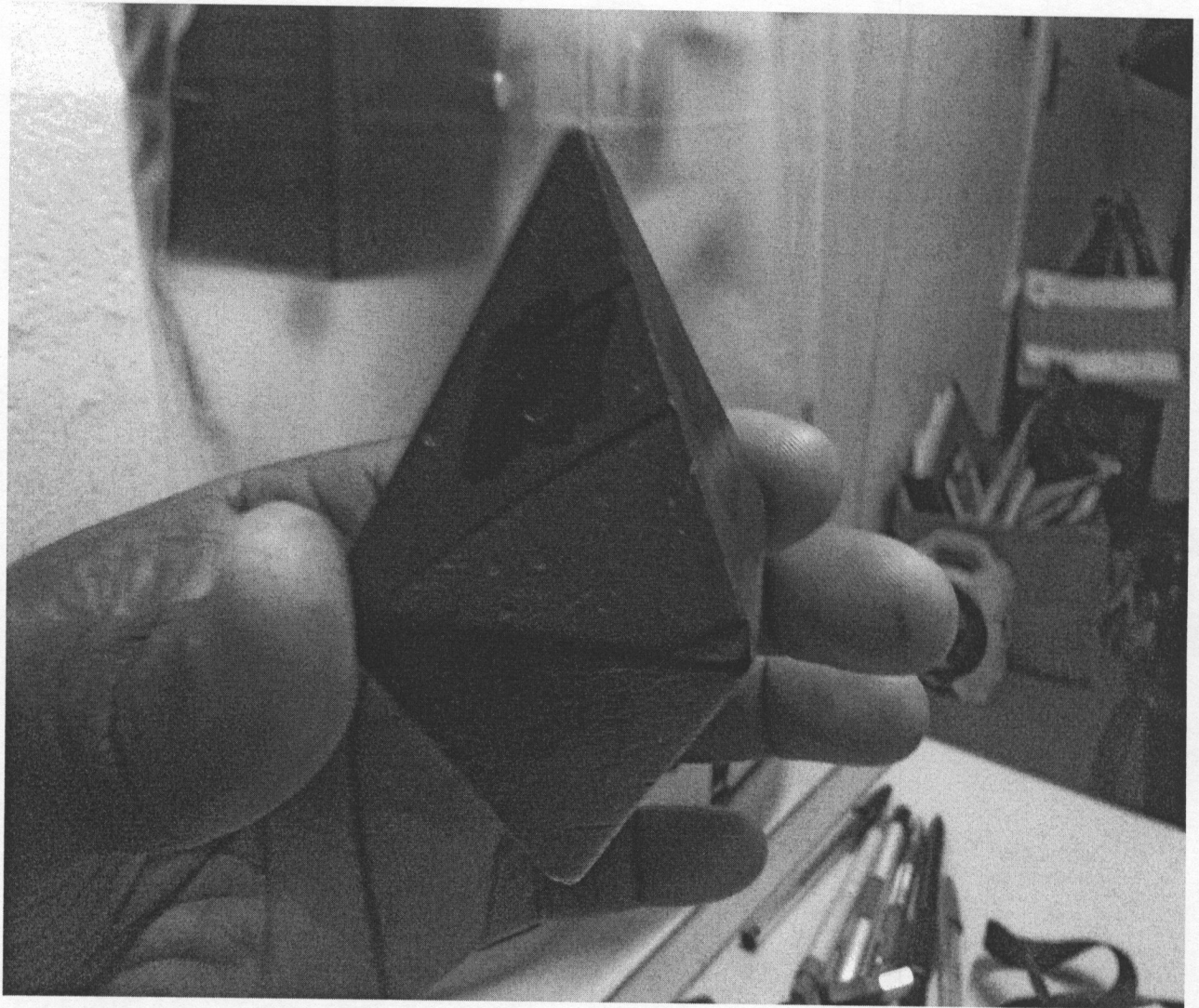
- Q1. Given crystal A with x-axis, y-axis and z-axis being perpendicular to each other but z-axis is longer than the equal x-axis and y-axis and that z-axis goes through two opposite corners while x-axis and y-axis go through centres of two opposite prismatic faces, do the following: (60 marks)
- (i) Sketch it and label all faces using Miller symbols and axes;
 - (ii) Plot its stereonet given that interfacial angle between any slanting face and prismatic face is 45° .
 - (iii) Ensure that all faces, axes of symmetry, crystallographic axes, planes of symmetry are plotted on the stereonet.
 - (iv) Using the stereonet determine the interfacial angle between any two slanting faces.
- Q2. Given thin section X determine the properties of the mineral and name it. (40 marks)

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

UNIVERSITY OF ZAMBIA
UNIVERSITY OF ZAMBIA EXAMINATIONS – JULY 2014

GGY3021 – CRYSTALLOGRAPHY AND OPTICAL MINERALOGY PAPER II

CRYSTAL MODEL A



UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS – JULY 2014
GGY 3030 – STRATIGRAPHY AND SEDIMENTOLOGY
PAPER I – THEORY

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

TIME: Three (3) Hours

Section A: Sedimentology

- Q1. (a) Briefly define the term Sedimentology with an illustration of the rock cycle.
(b) Briefly discuss (i) Siliciclastic sediments, and (ii) Non-siliciclastic sediments in terms of their origin, compositions, texture, particle size range and matrix. Give two examples of rocks formed in each of two types of sediments.
(c) Discuss the four main parameters of texture in sedimentary rocks.
(d) Briefly discuss three main ways of representing grain size distribution in a sediment.
- Q2. (a) Discuss the sedimentary processes and environments that would lead to the following in the a stratigraphy:
(i) fining upwards and, (ii) coarsening upwards.
(b). Write brief notes on the following which are related to cross stratification: (i) straight crested bed-forms and, (ii) sinuous bed-forms, (iii) co-sets and, (iv) heterolithic stratification.
(c) Discuss any two types of gravity flow deposits.
(d) Define the term facies and facies concept.
- Q3. (a) Discuss sediment maturity and how it provides evidence on the history of the sediment, paying particular attention to composition and texture, among others.
(b) Define the following: (i) Rudite, (ii) Arenite, (iii) Arkose, and (iv) Greywacke.
(c) Briefly discuss the two main ways in which carbonate rocks are formed.
(d) Briefly discuss what is meant by Sedimentary Basin Analysis
- Q4. (a) Discuss lateral and horizontal facies changes in rock record and the environmental processes that lead to the changes.
(b) Write brief notes on the following: (i) facies associations, and (ii) facies succession
(c) Write short notes on glacial depositional environments and give an example of a glacially deposited rock.
(d) Define glaciofluvial deposits?

Section B: Stratigraphy

Q1 Define the following:

- a) Member b) Group c) Unconformity d) Lithostratigraphy e) Allostratigraphy
f) Bed g) Supergroup h) Chronostratigraphy i) Biostratigraphy j) Ichnology

Q2

- a) Describe the following Steno's Laws:
i) Original horizontality
ii) Original continuity
iii) Superposition
- b) Describe the following Walter's Laws:
i) Transgression
ii) Regression

Q3

- a) What is a Stratigraphic Contact?
b) Name and describe two categories of stratigraphic contacts
c) Give two examples of each of the above contacts with diagrams

Q4 Taphonomy is a realm of paleontology dedicated to the study of the processes by which an organism becomes part of the fossil record.

- a) Describe four stages involved in an organism becoming a fossil
b) State six characteristics of a formation

END OF EXAM AND GOOD LUCK

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
UNIVERSITY EXAMINATIONS – JULY 2014
GGY3062 – REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEMS
PAPER I – THEORY

ANSWER: FIVE QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS

TIME: THREE (3) HOURS

Q1

- a) What is a GIS model?
- b) Describe four capabilities that make GIS special

Q2

Define the following:

- a) Raster data
- b) Vector Data
- c) Shape file
- d) Geodatabase
- e) Workspace

Q3

What is topology

List three common types of topology

Use diagrams to explain planar and non-planar topology

Q4

The process of remote sensing involves an interaction between electromagnetic radiation and the targets of interest. Briefly explain seven elements (stages) involved in this process.

Q5

State the spatial resolution, spectral resolution, temporal resolution and scene size for each of the following:

- a) Landsat 7 (ETM+)
- b) SPOT
- c) IRS - 1C
- d) IKONOS

Q6

Remote sensing and GIS can be used for applications in several different fields.

Name five fields and explain how remote sensing/GIS can be applied

Q7

Interpretation and identification of targets in remote sensing imagery is performed manually or visually. Describe five visual elements that aid in visual image interpretation.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
UNIVERSITY EXAMINATIONS – JULY 2014
GGY 4071 – IGNEOUS PETROLOGY
PAPER I – THEORY

ANSWER: Five Questions only. Illustrate your answer with figures, diagrams, etc. wherever possible. All questions carry equal marks

Time: 3 Hours

1. Define the following: (a) liquidus, (b) solidus, (c) solvus, (d) fractional crystallization (e) solid solution, (f) incongruently melting compound.
2. Draw examples of phase diagrams that show the following - be sure to label everything.
 - a) a phase diagram that has an intermediate compound that melts incongruently.
 - b) a phase diagram that shows complete solid solution between two end members.
 - c) a phase diagram that shows complete solid solution at high temperature and exsolution at low temperature.
3. Define the following: (a) ophiolite sequence, (b) ocean ridge, (c) oceanic island (d) Large Igneous Province.
4. Compare and contrast I-type, S-type, and A-type granitic rocks.
5. What are the most predominant basalt types found in continental flood basalt provinces and how do they differ from MORBs?
6. What is the difference between the calc-alkaline suite of rocks and the tholeiitic and alkaline suites?
7. Write short notes with diagrams and examples where possible, on the following:
 - a) Porphyritic texture
 - b) Lopolith
 - c) Solidus
 - d) Shield volcano
 - e) Congruent melting

End of exam

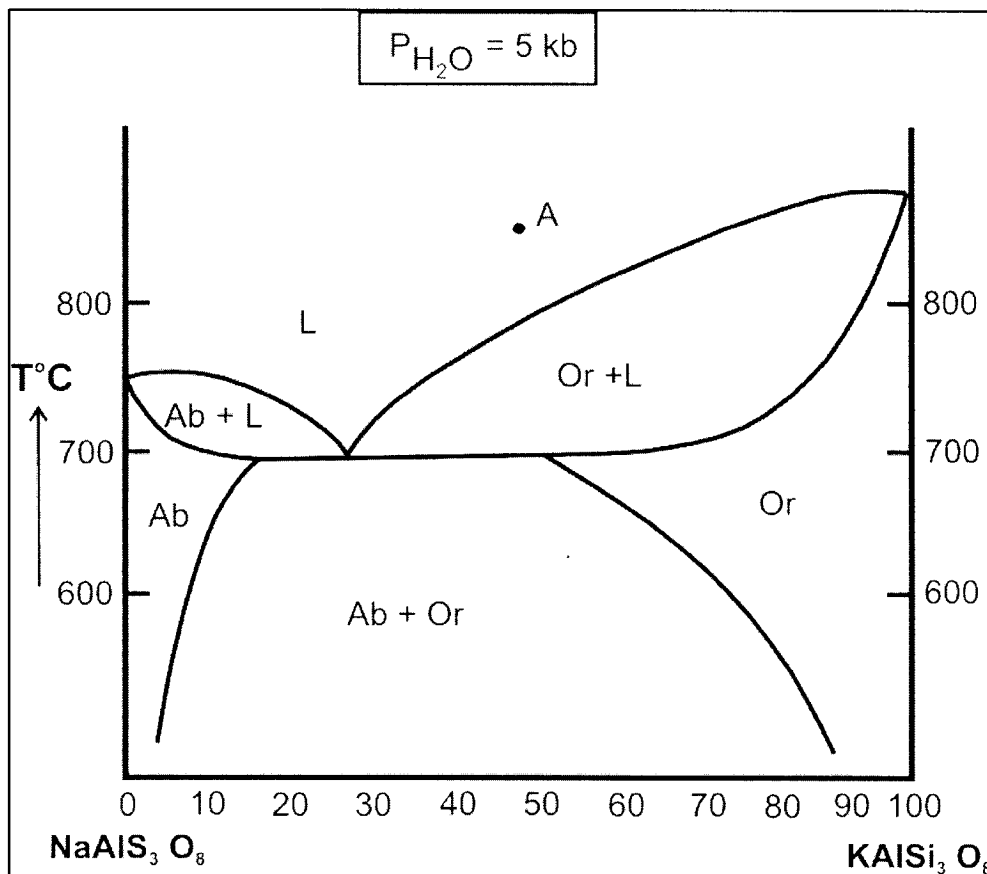
THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS – JULY 2014
GGY 4071 – IGNEOUS PETROLOGY
PAPER II – PRACTICAL

ANSWER: ALL QUESTIONS

TIME: TWO (2) HOURS

Q1. Fig. 1 is an illustration of the binary system Albite- Orthoclase (alkali feldspars at $P_{H_2O} = 5 \text{ Kb}$)

- Describe the crystallization of liquid A assuming equilibrium conditions. Pay also attention to the processes taking place at temperature below 700 oC
- How can the resulting rock be classified assuming that a third component Si_2O is present which produces 30% volume of quartz?
- What is the effect of an increase in the lithostatic pressure on the system?
- What would be the effect of a decrease in water pressure P_{H_2O} to 5 Kb on the crystallization of liquid A and on the mineralogy of the rock?



Q2. Give a complete petrographic description of thin sections A and B emphasizing on the following:

- Mineralogy
- Texture
- Is this rock a volcanic or plutonic? Why?
- Name the rock

End of examination

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
UNIVERSITY EXAMINATIONS – JULY 2014
GGY 4101 – GEOLOGY OF ZAMBIA**

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

TIME: Three (3) Hours

- Q1. Discuss the geology of greenstone belts with at least two examples of areas where they are found in southern Africa.
- Q2. Write an essay on the geological evolution of Africa.
- Q3. Discuss the Lufilian Orogeny and its economic significance to Zambia.
- Q4. Write brief notes on the Mozambican Belt.
- Q5. Write a short essay on the Katanga Super Group.
- Q6. Write an outline of the stratigraphy of Zambia and the economic significance of each major sequence.

END OF EXAM AND GOOD LUCK

**THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS – JULY 2014
GGY 4112 – METAMORPHIC PETROLOGY
PAPER I – THEORY**

**ANSWER: FIVE QUESTIONS ONLY. ILLUSTRATE YOUR ANSWER WITH FIGURES, DIAGRAMS ETC.
WHEREVER POSSIBLE. ALL QUESTIONS CARRY EQUAL MARKS**

Time: 3 HOURS

- Q1 Define and give an example of a dehydration reaction and a decarbonation reaction
- Q2 Starting with a shale, what textural changes would you expect as the metamorphic grade increased from surface conditions to granulite facies conditions under conditions of nonhydrostatic (differential) stress?
- Q3 Explain how metamorphic rocks are classified.
- Q4 Compare and contrast shock metamorphism and cataclastic metamorphism
- Q5 What is the crystalloblastic series?
- Q6 Define the following metamorphic rocks: (a) migmatite, (b) marble, (c) eclogite, (d) amphibolite, (e) gneiss, (f) mylonite
- Q7 Metamorphic rocks have different protolith, what are the main protolith of metamorphic rocks. Outline in detail, the main characteristics of each protolith.

*****End of exam*****

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
UNIVERSITY EXAMINATIONS – JULY 2014
GGY 4122 –HIGH TEMPERATURE GEOCHEMISTRY
PAPER I- THEORY

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

TIME: Three (3) Hours.

- Q1. Use Bowen's reaction series to discuss the distribution of Mg, Ni, Cr, Li, Ga, K, Hf, Rb, Be, B, Ba and REE during fractional crystallization of a parent magma of basaltic composition.
- Q2. Describe how you can use an Rb-Sr isochron and a concordia diagram to determine two independent dates of crystallization of a granodiorite.
- Q3. Discuss the use of isotope geochemistry in the determination of the following aspects of rock systems:
- Source of parent magmas of igneous rocks
 - Source of hydrothermal fluids
 - Temperature of crystallization of metamorphic mineral assemblages.
- Q4. Discuss the role of fractional crystallization in the development of deposits of chromium and beryllium.
- Q5. Discuss why dissolved silica, cation ratios (Na/K, Ca/Na, Mg/Li) and stable isotope ratios ($\Delta^{18}\text{O}$, $\Delta^{34}\text{S}$) are commonly used in the determination of reservoir temperatures of geothermal systems.
- Q6. Discuss the major types of chemical reactions that are likely to occur during progressive medium-pressure metamorphism of sedimentary rocks whose chemical data are given below.

Constituent	Rock unit 1	Rock unit 2	Rock unit 3	Rock unit 4
SiO ₂	5.14 %	59.93 %	99.4 %	0.01
TiO ₂	0.07	0.85	-	-
Al ₂ O ₃	0.4	16.62	-	-
Fe ₂ O ₃	0.49	3.03	-	-
FeO		3.18	-	-
MnO	0.14	-	-	-
MgO	7.79	2.63	-	0.02
CaO	42.3	2.18	-	55.9
Na ₂ O	0.03	1.73	-	-
K ₂ O	0.16	3.54	-	-
P ₂ O ₅	0.05	-	-	-
CO ₂	41.74	2.31	-	44.0
H ₂ O	1.05	4.34	0.5	0.1

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

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
UNIVERSITY EXAMINATIONS – JULY 2014
GGY 4122 –HIGH TEMPERATURE GEOCHEMISTRY
PAPER II - PRACTICAL.

INSTRUCTIONS: Answer all the questions. Use diagrams and equations where ever it is necessary.

TIME: Three (3) Hours.

Q1. The chemical composition of rock units which belong to a magmatic series are given below. Use these data to determine the major minerals in these rocks and to discuss how the trace elements Rb, Cs, U, Ni, Mn, Co, Cr, Be, REE and Sn are likely to be distributed in these rock units. (30 %).

Constituent	Rock unit 1	Rock unit 2	Rock unit 3	Rock unit 4
SiO ₂	43.05	48.47	60.89	71.36
TiO ₂	0.17	1.44	1.34	0.45
Al ₂ O ₃	1.22	21.22	15.42	13.10
Fe ₂ O ₃	7.30	1.25	2.42	1.16
FeO	1.49	7.31	5.12	2.64
MnO	0.148	0.09	0.11	0.05
MgO	43.47	6.70	1.44	0.31
CaO	0.86	9.05	4.05	1.47
Na ₂ O	0.28	3.41	3.78	2.71
K ₂ O	0.04	0.40	4.63	5.49
P ₂ O ₅	0.00	0.09	0.46	0.10

Q2. The data obtained during analyses of water from the hot springs in some areas of Zambia are given below. Use the geochemical geothermometer developed by Ellis and Mahon to determine the reservoir temperature of each geothermal system. (20 %)

Parameter	M sanzara Hot spring	Lochnivar Hot spring	Choma Hot spring	Chinyunyu Hot spring	Kariba Gorge Hot spring
KCl (ppm)	33.6	-	14	-	6.5
NaCl "	229.2	445	21	102	11
K ₂ SO ₄ "	-	58	-	-	-
CaSO ₄ "	778.9	136	-	-	9.5
Na ₂ SO ₄ "	934.3	1065	261	-	91.7
Na ₂ CO ₃ "	-	-	-	98	-
CaCO ₃	-	85	7	30.8	8

Atomic weights: K= 39, Cl = 35.5, Na =23, S=32, C= 12, O= 16.

$$T^{\circ}\text{C} = 1217/(\log(\text{Na}/\text{K})+1.483) - 273$$

$$T^{\circ}\text{C} = 1309/(5.19 - \log \text{Si}) - 273$$

Q3. Use the isotopic ratios given below and the mineral isochron method to determine the age of crystallization of the intrusive rock and the source of the parent magma. (35 %)

Mineral	⁸⁷ Rb/ ⁸⁶ Sr	⁸⁷ Sr/ ⁸⁶ Sr
Biotite	4.5	0.92
Muscovite	3.4	0.86
Microcline	2.1	0.79

$$\lambda^{87}\text{Rb} = 1.42 \times 10^{-11} \text{yr}^{-1}$$

Q4. During a Rock survey for mineralization associated with felsic rocks the data given below were obtained. Evaluate the potential of this area for the base metal (Ni, Cu, Co, Pb, Zn) and rare element (Sn, U, Nb) mineralization. (15 %)

Trace Element	Rock unit 1	Rock unit 2	Rock 3
Cr	10	8	19
Co	2	5	6
Ni	3	4	4
Cu	2	2	7
Zn	13	20	32
Rb	260	150	165
Sr	88	570	710
Ba	490	2550	2060
Y	25	11	20
Zr	42	113	200
Nb	15	8	21
Pb	77	33	18
U	3	2	3
Sn	4	2	1

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

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES**

UNIVERSITY EXAMINATIONS – JULY 2014

GGY 4132 – MINING GEOLOGY

INSTRUCTIONS: Answer any four questions. Illustrate your answers with sketches wherever possible.

TIME: Three (3) Hours

- Q1. Earlier exploration undertaken by a certain firm over an area of 70,000 km² in Mbala District revealed anomalies of Cu, Zn, Ni and Au in stream sediments. Further preliminary investigations showed that there were fragments of pentlandite, pyrrhotite, uraninite, gold and chalcopyrite among the stream sediments pointing to the possibility of sulphide vein mineralisation in an area of 70 km². This vein is assumed vertical. This area was sold to another firm because it was considered too small. From the many ground methods you know and with reasons select five that would effectively be useful and describe them briefly. (25 marks)
- Q2. (a) Distinguish a compressive body wave from a shear body wave. (4 marks)
(b) Why is it that body waves generally increase in velocity as they propagate from the Earth's crust into the mantle? (2 marks)
(c) Give two reasons why seismic would generally not be useful in mineral deposit exploration. (2 marks)
(d) Name two types of seismic methods, briefly describe each stating its limitations and where it would be applied. (8 marks)
(e) A compressive wave, generated via a controlled explosion, at point A, travels through a homogenous medium and is detected at point B, which is 200 km away. What would be its speed (in m/milli second) if it took 50 minutes to arrive? (6 marks)
(f) What would happen to the wave speed in (e) if at point B it propagates across a vertical fault into a medium of lower elasticity? (3 marks)
- Q3. (a) What is a Bouguer anomaly? (2 marks)
(b) Write short notes on the following gravity corrections: (i) Latitude, and (ii) Terrain (8 Marks)
(c) Sketch profiles resulting from gravity surveys in the following geological areas: (i) an area of an anticline of sedimentary rocks close to the earth's surface. This area is covered by a 4 m thick soil; (ii) an area in which, via a vertical fault, the left block is uplifted and the right block downthrown and the area is covered by a 5 m thick soil (10 Marks).

- Q4. (a) What is a geochemical anomaly and a false geochemical anomaly? (4 marks)
- (b) Briefly discuss two ways in which a false geochemical anomaly may be created. (4 marks)
- (c) A soil survey done in Chilengwaleza Area of Mazabuka District has produced chemical results for Ni and Cu given in Table 1. This area is known to be covered by a 5 m residue soil i.e. no rock crops out and flat. Using the results determine the mean, standard deviation and threshold for each metal. What do the statistics tell us about the potential for mineralisation in the area and what sort of mineralisation would it be and why? (17 marks)
- Q5. (a) What is surface mine mapping and what are its two key objectives? (3 marks)
- (b) During surface mine mapping state five geological features you would collect information for and why. (4 marks)
- (c) What geological features control slope stability in an open pit? Briefly explain the significance of describing in detail the attitude of such features. (5 marks)
- (d) Sketch, in cross section view, an open pit mine and label the four main parts. (4 marks)
- (e) In an open pit mine a fault surface is observed to be inclined in the same direction as the slope face and where the two intersect groundwater seeps out in form of a line of springs. Briefly discuss why this scenario may not be safe. (6 marks)
- (f) Distinguish a cross-section from a longitudinal-section. (3 marks)

Table 1: Soil geochemical results from Chilengwaleza Area, Mazabuka District

SAMPLE ID	Ni (ppm)	Cu (ppm)
ONS1	450.5	230.6
ONS2	256.2	130.3
ONS3	189.4	121.9
ONS4	320.1	175.5
ONS5	201.3	98.7
ONS6	123.8	75.6
ONS7	100.9	46.7
ONS8	89.4	38.9
ONS9	90.1	40.1
ONS10	105.7	68.2

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

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES**

UNIVERSITY OF ZAMBIA EXAMINATIONS – JULY 2014

**GGY 5171 – 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) Define the following terms: (8 marks)
- (i) Ore Mineral
 - (ii) Cut-off-grade
 - (iii) Reflectance
 - (iv) Reflectance Pleochroism
- (b) What is a stable isotope? (2 marks)
- (c) Distinguish between syngeneses and epigenesis. (4 marks)
- (d) Classify the following deposit types into either syngenetic or epigenetic and state why: Porphyry, Magmatic, Volcanogenic Massive Sulphide, BIFs, Residue and Placer. (6 marks)
- Q2. (a) Distinguish between stratabound and stratiform deposits. (6 marks)
- (b) 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. (7 marks)
- (c) Kupferschiefer is another example of stratiform deposits, describe briefly its characteristics. (7 marks)
- Q3. (a) What are the main differences between placer and residual deposits? (6 marks)
- (b) Discuss the factors that control the formation of placer deposits. (6 marks)
- (c) Name any four minerals that would form placer deposits. (2 marks)
- (d) Name and describe briefly two types of residual deposits. (6 marks)

- Q4. (a) What is a hydrothermal solution? (1 mark)
 (b) Name the three main types of hydrothermal solutions and how each one of them is derived. (6 marks)
 (c) Define the following terms: (6 marks)
 (i) Epithermal Vein
 (ii) Mesothermal Vein
 (iii) Hypothermal Vein
 (d) A vein deposit with copper mineralization has been discovered through exploration and needs to be evaluated. This vein deposit, containing quartz, pyrite and chalcopyrite, is vertical. Discuss the main features that the vein would acquire after oxidation has occurred and how these features are acquired. (7 marks)
- Q5. (a) Fractional crystallization and liquid immiscibility are two processes in the formation of magmatic mineral deposits. Describe the nature of these two processes and give one example deposit resulting from each deposit. (10 marks)
 (b) Distinguish between strombolian and podiform chromite deposits. (10 marks)
- Q6. Particles of quartz, pyrite and gold are contained in flowing water (at room temperature and 1 atm pressure) along a straight river channel. At these conditions water (with density of 910 kg/m^3 and viscosity of $0.982 \times 10^{-3} \text{ kg/s.m}$) flows at a speed of 50 m/s over a length of 200 m. Quartz, pyrite and gold have the following parameters.

PARTICLE	PARTICLE DIAMETER (mm)	PARTICLE DENSITY (kg/m^3)
Quartz	19	2000
Pyrite	7	5000
Gold	3	17000

- (i) $Re = UL\delta/\eta$
 (ii) $V = gd^2(\delta_p - \delta_f)/18\eta$
- (a) State what each of the equations given in (i) and (ii). (2 marks)
 (b) Determine the Reynolds Number and state whether the flow is laminar, transient or turbulent and why. (5 marks)
 (c) Determine the settling velocity for each one of the particles (quartz, pyrite and gold). (6 marks)
 (d) If the diameters were changed to 16 mm, 1 mm and 0.5 mm for quartz, pyrite and gold, respectively, determine the velocities of the particles assuming their densities are maintained and comment on the results. (7 marks)

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

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES**

UNIVERSITY EXAMINATIONS – JULY 2014

**GGY 5171 – ECONOMIC GEOLOGY OF METALLIFEROUS MINERAL
DEPOSITS**

PAPER II – PRACTICAL

INSTRUCTIONS: ANSWER ALL QUESTIONS

TIME: ONE AND HALF HOURS

You are provided with ~~three~~^{two} 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.

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

**UNIVERSITY OF ZAMBIA EXAMINATIONS
JULY 2014 EXAMINATIONS**

GGY5171 II PRACTICAL EXAMINATION

LIST OF POSSIBLE ORE MINERALS

Ilmenite
Rutile
Bornite
Carrollite
Pyrite
Chalcocite
Sphalerite
Galena
Magnetite
Chalcopyrite
Hematite
Cuprite
Pentlandite
Pyrrhotite
Smithsonite
Copper
Malachite
Azurite
Digenite
Tennantite

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
UNIVERSITY EXAMINATIONS – JULY 2014
GGY5192 – ECONOMIC GEOLOGY OF ENERGY AND INDUSTRIAL MINERAL DEPOSITS

ANSWER: ANY FIVE QUESTION. ALL QUESTIONS CARRY EQUAL MARKS

TIME: 3 HOURS

Q1

- a) Outline four raw materials for glass production
- b) Describe six types of float glass (name, main ingredients, properties, application)

Q2

- a) Name four forms in which asbestos occurs
- b) Describe four types of asbestos minerals
- c) What properties make asbestos exploitable?

Q3

- a) Describe five detailed uses of asbestos
- b) Explain five important uses of graphite

Q4

- a) Outline four environmental effects of coal exploitation
- b) Briefly explain six different ranks of coal indicating their carbon content

Q5

- a) List the physical properties of talc
- b) How does talc form?
- c) Describe two areas where talc is used commercially

Q6

- a) Contrast between primary and secondary kaolin
- b) Briefly describe uses of china and ball clays

Q7

- a) What is a ceramic product?
- b) Name three important raw material resources used in white ware and pottery.

END OF EXAMINATION.GOOD LUCK

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS – JULY 2014

GGY 5202 – MINERAL ECONOMICS AND MANAGEMENT
MET 5074 – ECONOMICS AND MANAGEMENT

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

TOTAL MARK: **100**
CLOSED BOOK

Question 1

- (i) Explain the difference between (a) accounting costs and (b) accounting and economic profit. **[4 Marks]**
- (ii) Define normal profit and explain the relationship between total profit, normal profit and economic profit. **[4 Marks]**
- (iii) Explain the relationship between (a) the average product and marginal product of a variable factor of production employed by a firm and (b) the firm's shortrun average cost and marginal cost. **[4 Marks]**
- (iv) Discuss economies and diseconomies of scale. **[4 Marks]**
- (v) (i) Explain the long average cost curves. **[2 Marks]**
(ii) Why a company should produce where the marginal cost is equal to marginal revenue. **[2 Marks]**

Question 2

In investment management

- (i) Discuss the major risks experienced. **[4 Marks]**
- (ii) The relationship between risk and return. **[3 Marks]**
- (iii) Explain the importance of minimum acceptable rate of return. **[3 Marks]**
- (iv) (a) Discuss the major investment alternative; **[3 Marks]**
(b) investment strategies; **[4 Marks]**
(c) useful investment characteristics to help you choose investments. **[4 Marks]**

Question 3

- (i) If in the economy the inflation rate is 6% and the bank rate is 9% over 10 years is an investment of K50,000 going to have its purchasing power protected. **[5 Marks]**
- (ii) If the income in (i) is taxed at 35% will the purchasing power be protected. **[5 Marks]**
- (iii) Discuss the decision criteria when choosing investment alternatives using the following methods:
- Rate of return **[2 Marks]**
 - Net present value **[1 Mark]**
 - Payback period **[1 Mark]**
 - Accounting rate of return **[1 Mark]**
- (iv) Discuss the advantages and disadvantages of using the following methods of choosing investment proposals: Pay back period accounting rate of return. **[5 Marks]**

Question 4

- (a) Given the following cash flows:
- | | | | | | | | |
|---|------------------|---|---|---|---|---|---|
| - | End of year 0 | 1 | 2 | 3 | 4 | 5 | |
| - | Cash flow (1000) | 3 | 6 | 4 | 1 | 7 | 5 |
- And an interest rate of 10%
- Calculate their (i) Present worth pw **[10 Marks]**
(ii) Future worth and **[10 Marks]**
- (b) Given the following cash flows at $i = 6\%$ and $i = 15\%$, calculate the rate of return and explain the results
- | | | | | | | |
|---|--------------------|----|----|----|----|----|
| - | End of Year | 0 | 1 | 2 | 5 | 4 |
| - | Cash flow (1000) – | 40 | 12 | 12 | 12 | 12 |
- [20 Marks]**

Question 5

A Mining company has taken 10 years to explore a deposit and has been spending 2 billion Kwacha per year, in year 11 and 12 it invested 20 billion per year in mining and metallurgical facilities after which it will earn 18 billion revenue between 13-25 years. What is the value of this project. **[20 Marks]**

END OF EXAMINATIONS

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
UNIVERSITY EXAMINATIONS – JULY 2014
GGY5212 – HYDROGEOLOGY**

ANSWER: ANY FIVE QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS

TIME: THREE (3) HOURS

1. Briefly explain the following:
 - (a) Aquifuge, giving an example
 - (b) Effective porosity
 - (c) Piezometric or potentiometric surface for a confined aquifer
 - (d) Intrinsic permeability
 - (e) General Partial Differential Equation for unsteady flow of groundwater in Cartesian coordinates
 - (f) Equilibrium or Thiem Equation for a confined aquifer
 - (g) Well Function
 - (h) Coliform Test
 - (i) Formation Loss Coefficient
 - (j) Specific capacity of a well

20 marks
2. (a) Describe the Hydrologic Cycle, with the aid of diagram 15 marks
(b) List the parameters, in the cycle, that will be absent in the dry season, at the School of Mines, UNZA. 5 marks
3. (a) Describe, with the aid of diagrams, the types of interstices and their relation to porosity, for the following rock categories:
 - (i) well sorted sedimentary deposit
 - (ii) poorly sorted sedimentary deposit
 - (iii) carbonate rocks
 - (iv) phyllites
 - (v) metamorphic rocks

15 marks

(b) Rank the following rocks in terms of quality of aquifer(s) from the best to the worst: Chunga Schists, Lusaka Dolomite, Cheta Schist, Cheta Dolomite, Alluvium. 5 marks
4. (a) Explain how a constant-head permeameter is used to measure hydraulic conductivities, in the laboratory 15 marks
(b) How reliable are laboratory tests compared to actual field hydraulic conductivities. Explain. 5 marks
5. (a) Describe the Cooper-Jacob Method of solution for unsteady radial flow in a confined aquifer 15 marks
(b) What assumptions are inherent in the application of the non equilibrium or Theis Equation. 5 marks
6. (a) Explain what is "Well Loss" 5 marks
(b) How is Well Loss evaluated? 5 marks
(c) Prepare a Table relating Well Loss Coefficient to Well condition 5 marks
(d) State the Rule of Thumb on Well Efficiency 5 marks
7. (a) (i) Explain public health significance of water quality related to physical Characteristics. 2 marks
(ii) List any three chemical contaminants, naming the health Effects, and in which local areas in Zambia are vulnerable to them. 8 marks
(b) Prepare a Table of Waterborne Diseases, Listing:
 - Waterborne disease
 - Causative Organism
 - Source of Organism in Water
 - Health Effect
 - Vulnerable Area in Zambia

10 Marks

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – JULY 2014

MET 2419 – INTRODUCTION TO MINERAL SCIENCES

TIME: THREE HOURS

ANSWER FIVE (5) QUESTIONS, AT LEAST ONE QUESTION FROM EACH SECTION IN SEPARATE ANSWER SCRIPTS

SECTION A

INTRODUCTION TO GEOLOGY.

1. (a) Define the following terms:
 - (i) Crystal
 - (ii) Unit cell
 - (iii) Primitive (P) lattice
 - (iv) Diad
 - (v) Mirror plane
- (b) Determine the Miller Indices for the crystal faces with the following intercepts: (Face A) $1/2, 3, 1/5$; (Face B) $\infty, 6, 2/7$; (Face C) $2/5, \infty, 3/8$; (Face D) $4/9, 7/8, 1/5$. Show all the steps involved.
- (c) Distinguish open from closed form.
 - (i)

[20]

2. (a) Distinguish rock from ore.
- (b) Briefly describe how plutonic igneous, clastic sedimentary and foliated metamorphic rocks form. Provide one example for each of the classes of the rocks named above.
- (c) What is the difference between ore and ore concentrate? Why would the grade of copper in the ore be lower than that in the concentrate?
- (d) Define the following terms:
 - (i) Lustre
 - (ii) Hardness
 - (iii) Cleavage
 - (iv) Fracture
- (e) What substance constitutes diamond and graphite? What are these two minerals called? List at least three characteristics of each of the minerals.

[20]

SECTION B

INTRODUCTION TO MINING ENGINEERING.

1. (a) Name the different mining methods used to extract minerals when
- (i) It is close to the surface
 - (ii) At a great depth
 - (iii) Under water [4]
- (b) What is known as novel mining methods, and name three of these methods and describe the principle of extraction of any one of those methods. Total marks [3]
- (c) Name three advantages of surface mining and three of underground mining. Total marks [3]
2. (a) Why is ore estimation important doing the mining of any ore and name the parameter need to carry out this purpose. Why is triangle method of sampling preferred over other methods [5]
- (b) Calculate
- (i) Cut off grade
 - (ii) the unit profit of copper deposit from the data given below
- Cost of production = \$ 7.5/tonne
Selling price of copper = \$ 1.60/kg
Percentage recovery = 96% of copper [5]
3. (a) Why do we apply the following in underground mining
- (i) Artificial supports
 - (ii) Ventilation [4]
- (b) Name the equipment for measuring the cooling power of air, the quantity of air flow in a particular section of a mines and the amount of sufficient oxygen present to support the lives of human beings. [3]
- (c) What will be the effect on the total amount of of air if the cross section area of the passage through which air is flowing doubled and the velocity of the air is reduced by half [3]

SECTION C

INTRODUCTION TO METALLURGY AND MINERAL PROCESSING.

ANSWER: TWO QUESTIONS

1.
 - a) Draw a simplified flow sheet of the production copper concentrates and tailing from it's mined ore right up to the concentration stage. Mention the appropriate equipment used at each stage. [8]
 - b) What do you understand by the terms grade and recovery of any processing method as applied to minerals and metals and state their relationship. [5]
 - c) What do you understand by the words, flotation, pre-flotation /concentration and reverse flotation? [3]
 - d) What do you understand by the words hydrophobicity and hydrophilicity. [4]
2. What role does the below mentioned reagents play in flotation and give some of their examples
 - i) Collectors [4]
 - ii) Frothers [3]
 - iii) Modifiers [4]
 - iv) Regulators [2]
 - b) What are Roughers, Scavengers and Cleaner circuits [4]
 - c) What do you understand by pre concentration and reverse flotation [3]
3. What do you understand by the following leaching methods:
 - In situ(underground or in placer leaching) [2]
 - Dump/heap leaching [2]
 - Pressure leaching [4]
 - Percolation or vat (tank) leaching [2]
 - Agitation leaching [2]
 - Counter current decantation [4]
 - Bacterial-aided leaching [4]

END OF MET 2419 EXAMINATION AND GOOD LUCK.

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – JULY 2014

MET 3430 - CHEMICAL THERMODYNAMICS

TIME : **THREE** hours

ANSWER: **THREE** questions from SECTION A
 TWO questions from SECTION B

The gas constant R = 0.08206 litre-atm/(mol)(K)
 = 8.314 J/(mol)(K)
1 litre-atm = 101.3 joules
1 atm pressure = 1.013×10^5 N/m²
 c_v for an ideal gas = 1.5R
 c_p for an ideal gas = 2.5R

Where applicable, all calculations are to be performed correct to three decimal places.

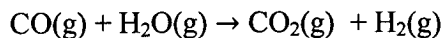
SECTION A

1. (a) Define the following:
- (i) A system and its surroundings
 - (ii) A closed system
 - (iii) An open system
 - (iv) Equilibrium
 - (v) A process and its path
- (7)
- (b) A certain mixture of carbon monoxide (CO) and carbon dioxide (CO₂) weighing 20 g occupies a volume of 15 litres at 25^oC and 1 atm pressure. Calculate the composition of the gas mixture in mole-percent assuming ideal gas behaviour. (Atomic weights: C, 12; O, 16.)
- (5)
- (d) One mole of an ideal gas at 25^oC is held in a cylinder by a piston at a pressure of 100 atm. The piston pressure is released in two stages: first to 50 atm; and then to 10 atm. Calculate the work done by the gas during these irreversible isothermal expansions and compare with the work done in an isothermal reversible expansion from 100 atm to 10 atm at 25^oC.
- (9)

2. (a) When tungsten carbide WC was burned with excess oxygen in a bomb calorimeter, it was found for the reaction
- $$\text{WC(s)} + \frac{5}{2} \text{O}_2 \rightarrow \text{WO}_3\text{(s)} + \text{CO}_2\text{(g)}$$
- that $\Delta U_{300}^0 = -1192 \text{ kJ}$.
 What is ΔH_f^0 at 300 K? What is the ΔH_f^0 of WC from its elements if the ΔH_c^0 for combustion of pure C and pure W at 300 K are -393.5 kJ and -837.5 kJ respectively?

(6)

- (b) Calculate the enthalpy change for the industrially important shift-conversion reaction as



at 1000K and at 1500 K.

Use the following additional information:

$$\Delta H_{f298}^0 \text{ for CO (g)} = -110.520 \text{ kJ mol}^{-1}$$

$$\Delta H_{f298}^0 \text{ for H}_2\text{O(g)} = -241.820 \text{ kJ mol}^{-1}$$

$$\Delta H_{f298}^0 \text{ for CO}_2\text{(g)} = -393.510 \text{ kJ mol}^{-1}$$

Heat capacity data at constant pressure for $c_p = a + bT + cT^2$ in $\text{J mol}^{-1} \text{K}^{-1}$

Component	a	$b \times 10^3$	$c \times 10^{-5}$
CO(g)	28.41	4.1	-0.46
H ₂ O(g)	30.54	10.29	0
CO ₂ (g)	44.22	8.79	-8.62
H ₂ (g)	27.28	3.26	0.5

(14)

3. (a) Prove that

$$c_p = - \left(\frac{\partial H}{\partial P} \right)_T \left(\frac{\partial P}{\partial T} \right)_H$$

(4)

- (b) In terms of entropy, state the Second Law of Thermodynamics.

(3)

- (c) You are given the data below. For the combustion of 1 mol of ethane to give CO₂(g) and H₂O(l) at a constant pressure and temperature of 1 bar and 25°C, calculate the energy that would be given to the surroundings in a free and unharnessed combustion. What is the maximum mechanical energy that could in principle be obtained from a reversible reaction?

Draw on a diagram the energy and entropy changes in the system, thermal and mechanical surroundings for the reversible reaction.

Component	ΔH_f^0 (kJ mol ⁻¹)	S^0 (J K ⁻¹ mol ⁻¹)
C ₂ H ₆ (g)	-84.68	229.60
O ₂ (g)	0	205.14
CO ₂ (g)	-393.51	213.74
H ₂ O(l)	-285.83	69.91

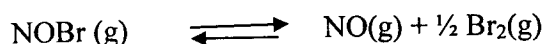
(13)

4. (a) An engine operates between 125°C and 40°C. What is the minimum amount of heat that must be withdrawn from the reservoir to obtain 1500 J of work? (3)

- (b) Derive the van't Hoff equation in the form

$$\frac{d \ln K_P}{dT} = \frac{\Delta H^0}{RT^2} \quad (5)$$

- (c) At 25°C the equilibrium



is rapidly established. When 1.10 g of NOBr is present in a 1.0-L vessel at 25°C, the total pressure is 0.35 atm. Calculate the equilibrium constant K_P and ΔG_{298}^0 for the reaction.

Atomic masses: N, 14; O, 16; Br, 80.

(12)

SECTION B

5. For the binary liquid system silver-lead, the following relative integral molar functions are listed for 727°C:

N_{pb}	0.1	0.3	0.5	0.7	0.9
ΔH (Cal)	300	775	1010	890	450
ΔS (Cal/K)	0.84	1.72	2.02	1.73	0.97

Calculate the relative integral molar Gibbs energy of mixing. (10)

Calculate the relative partial molar Gibbs energies for each component at the given mole fractions. (10)

2. (a) When salt is added to water it is established that its 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). (15)

- (b) 0.160 gm of Oxygen causes a lowering of the melting point of 100 gm of Silver by 10° C. The solubility of oxygen in solid Silver may be neglected. Calculate the heat of fusion of Silver. Atomic weights : Oxygen O = 16; Silver Ag, = 108, Melting point of pure Silver is 960°C, R = 8.31 J/mol.K. (5)

3. (a) What do you understand by terms given below and give specific examples

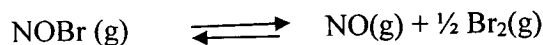
- (i) Extensive properties (2)
 (ii) Intensive Properties (2)
 (iii) Colligative properties (2)
 (iv) Variables (2)

4. (a) An engine operates between 125°C and 40°C . What is the minimum amount of heat that must be withdrawn from the reservoir to obtain 1500 J of work? (3)

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SECTION B

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3. (a) What do you understand by terms given below and give specific examples

- | | | |
|-------|------------------------|-----|
| (i) | Extensive properties | (2) |
| (ii) | Intensive Properties | (2) |
| (iii) | Colligative properties | (2) |
| (iv) | Variables | (2) |

- (v) Properties (2)
(vi) Phases (2)

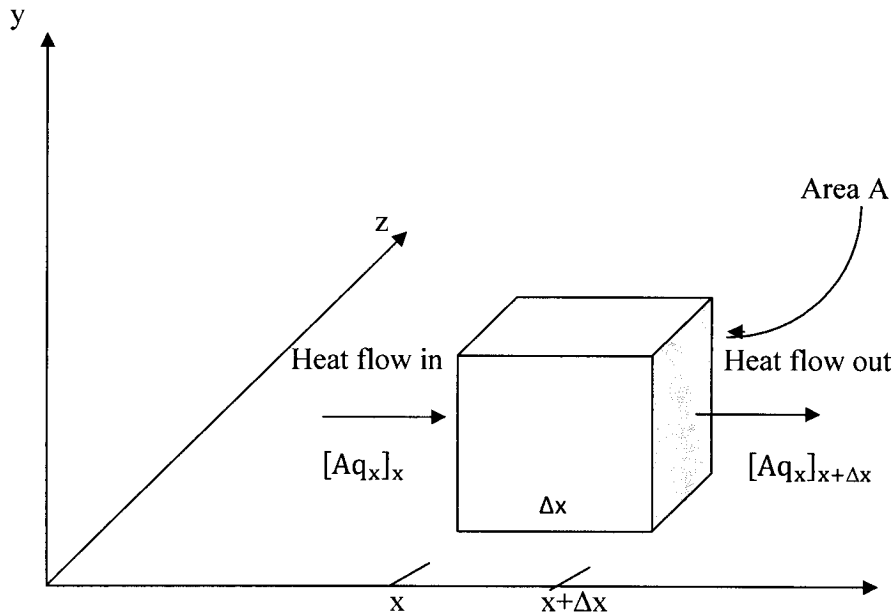
- (b) Derive the Gibbs-Duhem equation for a system of the properties involving two components such as A and B. Show how you could determine the partial molar quantity of one component when you know the other one. quantity of one component such as A when you know that of B. (8)

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
UNIVERSITY EXAMINATIONS – JULY 2014
MET 3449 Heat and Mass Transfer

TIME : 3 Hours

ANSWER: 5 Questions

1. Derive the one-dimensional heat conduction equation, we take a volume element of thickness Δx and having an area A normal to the coordinate axis x as illustrated in the figure below.



The word equation for the energy balance for the volume element is as follows:

$$\underbrace{\left(\begin{array}{l} \text{Net rate of} \\ \text{heat gain by} \\ \text{conduction} \end{array} \right)}_{\text{I}} + \underbrace{\left(\begin{array}{l} \text{rate of} \\ \text{energy} \\ \text{generation} \end{array} \right)}_{\text{II}} = \underbrace{\left(\begin{array}{l} \text{rate of} \\ \text{increase of} \\ \text{internal energy} \end{array} \right)}_{\text{III}} \quad [20]$$

2. (a) Using the **M, L** and **T** system of basic dimensions, derive the dimensional representation of each of the following physical variables:
- (i) Specific weight (weight per unit volume) [2]
 - (ii) Angular velocity [2]
 - (iii) Moment of a force [2]
 - (iv) Energy [2]
 - (v) Viscosity [2]
- (b) Using the **F, L** and **T** system of basic dimensions, derive the dimensional representation of each of the variables in part (a). [5]

(c) It is postulated that the period of oscillation P of a mass attached to a linear spring is a function of the mass m , the spring constant k and the gravity strength g . **Show** by dimensional analysis how these variables are related.

The relationship may be written as

$$P = f_1(m, k, g) \quad \text{The form of the function } f_1 \text{ is unknown.} \quad [5]$$

3. Consider a slab of thickness L and constant thermal conductivity k in which energy is generated at a constant rate of $G_0 \text{ W/m}^3$. The boundary surface at $x = 0$ is insulated (adiabatic) and the one at $x = L$ dissipates heat by convection with a heat transfer coefficient h into the fluid at a temperature T_∞ .

(i) Develop expressions for the temperature $T(x)$ and the heat flux $q(x)$. [5]

(ii) Calculate the temperatures at the surfaces $x = 0$ and $x = L$ under the following conditions: $L = 1 \text{ cm}$, $k = 20 \text{ W/(m}\cdot^\circ\text{C)}$, $G_0 = 8 \times 10^7 \text{ W/m}^3$, $h = 4000 \text{ W/(m}^2\cdot^\circ\text{C)}$ and $T_\infty = 100^\circ\text{C}$. [5]

4. Consider a solid cylinder of radius $r = b$ in which energy is generated at a rate of $G_0 \text{ W/m}^3$, while the boundary at $r = b$ is maintained at constant temperature T_2 .

Develop an expression for the one-dimensional, radial, steady state temperature distribution $T(r)$ and the heat flux $q(r)$. [10]

Calculate the centre temperature $T(0)$ and the heat flux at the boundary surface $r = b$ for $b = 1 \text{ cm}$, $G_0 = 2 \times 10^8 \text{ W/m}^3$, $k = 20 \text{ W/(m}\cdot^\circ\text{C)}$ and $T_2 = 100^\circ\text{C}$.

Mathematically, the problem is formulated as follows:

$$\frac{1}{r} \frac{d}{dr} \left(r \frac{dT}{dr} \right) + \frac{1}{k} G_0 = 0 \quad \text{in } 0 < r < b$$

$$\frac{dT(r)}{dr} = 0 \quad \text{at } r = 0$$

$$T(r) = T_2 \quad \text{at } r = b$$

5. What do you understand by the following terms

(i) Mass Transfer [5]

(ii) Equimolecular counter diffusion? Give a typical example. [5]

(iii) Fick's first law and equation [5]

(iv) Mass transfer coefficient [5]

6. (a) Explain why diffusion coefficients of gases are higher than that of liquids and solids. [5]

(b) Define the diffusion coefficient and name three properties on which it is dependant. [5]

- (c) Ammonia gas is diffusing through a uniform tube 0.10m long containing Nitrogen gas (B) at 1.0132×10^5 Pa and 25°C . This is a case of steady equi molar counter diffusion. At point 1, $P_{A1} = 1.013 \times 10^4$ Pa and point 2, $P_{A2} = 0.5 \times 10^4$ Pa. The diffusivity $D_{AB} = 0.230 \times 10^{-4}$ m²/s.

Calculate the flux N_A

- (i) at steady state [5]
(ii) Repeat for N_B (Show your working clearly) [5]

END OF EXAM IN MET 3449- GOOD LUCK

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES**

UNIVERSITY EXAMINATIONS – JULY 2014

MET 4112 – CONCENTRATION AND DEWATERING

ANSWER: Question 3 and any other four

TIME : 3 Hours

1.

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

- cobbing
- surfactant
- remanence
- differential flotation
- solids-handling capacity of the thickener
- surface active agent
- magnetic susceptibility
- electrical double-layer
- micelles
- physical adsorption

[20 marks]

2.

- a) Explain briefly, but clearly, why heavy medium separation in a gravitational vessel can be used only to separate relatively large particles, or minerals with a large difference in density, even though in theory any particle with a density larger than the medium density should sink, and any particle with a density lower than the medium should float. **[3 marks]**
- b) What are the main factors determining whether the feed particle is rejected, held in the bed, or passed down through in jigging? **[4 marks]**
- c) Outline the usual sequence of operation in the heavy media separation process. **[3 marks]**
- d) What are the main requirements for a medium to be used in heavy media separation?
Explain your answer briefly, but clearly. **[4 marks]**
- 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. **[6 marks]**

3.

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

The main reagents used in this flotation process are:

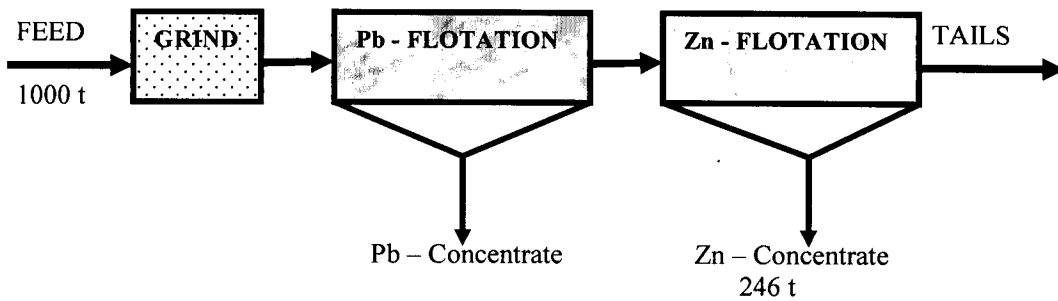
- copper sulphate
- lime
- sodium cyanide
- sodium di-chromate
- sodium iso-propyl xanthate
- tri-ethoxy butane

(i) State briefly what the function would be of each of the above reagents in this flotation process. [6 marks]

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

Indicate the principal mineral composition of each of the products, obtained with this flowsheet. [4 marks]

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



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

Complete the above metallurgical balance for one shift, during which 1000 tonnes of this ore were treated. [10 Marks]

4.

- a) Give an equation that expresses the 'area principle' in sedimentation, state what the symbols used in this expression represent, and explain this principle in a few words. **[4 marks]**
- b) Which operations and what equipment used in mineral processing are based upon this area principle? **[2 marks]**
- c) The main design parameters of a gravity thickener are its surface area and its depth. What quality is controlled by the surface area and what quality the depth controls? Explain your answers briefly. **[4 marks]**
- d) What are the functions of the rakes in a gravity thickener? What circumstances would necessitate raising of the rakes? **[4 marks]**
- e) What circumstances would necessitate re-circulation of the thickener underflow? Explain briefly for each case why this re-circulation is necessary. **[4 marks]**
- f) Describe briefly and in simple terms the differences between 'coagulation' and 'flocculation'. **[2 marks]**

5.

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

Illustrate with rough graphs of the intensity of magnetisation against the applied magnetic field for these three groups of substances.

What can you say about the magnetic susceptibility for these three groups of substances? **[5 marks]**

- b) What factors limit in practice the intensity of the applied magnetic field? **[3 marks]**
- c) Because of these limitations, what else is done in industrial practice to obtain a high magnetic force on the particles to be separated? **[2 marks]**
- d) Give a brief discussion on the separation of minerals by electrostatic separation and by electrodynamic (high-tension) separation.

Briefly describe the basic principles involved and the main types of equipment in use. Illustrate with rough diagrams. **[5 marks]**

- e) What is the characteristic difference in the size distribution in the products obtained by these two types of equipment? Explain briefly but clearly. **[3 marks]**
- f) Name two typical 'conducting' minerals and two 'non-conducting' minerals that are commonly separated by high-tension separation. **[2 marks]**

6.

- a) Briefly describe the steps, necessary for the attachment and adhesion of solid particles to air bubbles in a mineral pulp. **[3 marks]**
- b) Describe the concepts of a 'disjoining pressure', of a 'critical film thickness' and of an 'induction time' in flotation. **[3 marks]**
- c) What is the effect of the adsorption of a suitable collector upon the critical film thickness and the induction time? **[2 marks]**
- d) A zinc-lead sulphide ore, assaying 12.6 % PbS and 17.4 % ZnS, is treated by flotation.

With the assumption that the only minerals in the ore are galena, sphalerite and silicate gangue, calculate per 100 g of ore treated:

- (i) the theoretically possible recoveries of galena and of sphalerite after six minutes flotation; **[3 marks]**
- (ii) the theoretical concentrate grade of galena and sphalerite (% PbS and % ZnS) after two minutes flotation. **[6 marks]**
- (iii) the amount (in grams) of the silicate gangue contained in the concentrate after two minutes of flotation. **[3 marks]**

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

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

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

7.

Describe the three methods of tailings-dam construction with the aid of clearly labelled diagrams. Outline the advantages and disadvantage of each method. **[15 marks]**

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

[5 marks]

END OF EXAM IN MET 4112 – GOOD LUCK

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
UNIVERSITY EXAMINATIONS**

MET 4219 –PYROMETALLURGY EXAMINATION: 2014

ANSWER: ~~Question 7 and any other Four~~
TIME : 3 Hours

5 (five) Questions

1.

- a) Give four reasons why drying of concentrates before smelting is important. [4 marks]
- b) What condition is required for evaporation to take place in the process of drying the concentrates. [2 marks]
- c) Write down the equation used to determine the thermal efficiency and explain what each term stand for. [9 marks]
- d) Give three reasons why the magnitudes of thermal efficiencies in the process of drying are lower than 100%. [3 marks]
- e) Name two equipments used for the drying of concentrates. [2 marks]

2.

- a) What are the principal objectives of copper matte smelting? [2 marks]
- b) Give four required slag properties. [4 marks]
- c) Mention two problems caused by the presence of magnetite in matte smelting units and how could these problems be minimised? [4 marks]
- d) A copper concentrate has the following approximate analysis by weight:

Cu₂S - 20%
FeS₂ - 56%
SiO₂ - 24%

It is smelted in a reverberatory furnace using pure limestone as flux. The slag has 36% FeO and 21% CaO.

Calculate per 1000 kg of concentrate treated:

- i. the weight of limestone used as flux, [3 marks]
- ii. the weight of slag produced, and [2 marks]
- iii. the weight of matte produced. [5 marks]

3.

- a) What do you understand by calcination? [1 mark]
- b) Give three factors which affect the rate of calcination. [3 marks]
- c) What is the essential difference between calcining and roasting? [2 Marks]
- d) Mention the three types of equipment used in calcination and the type of material they can accept. [6 marks]
- e) Limestone with 56% CaO and 44% CO₂ is calcined in a rotary kiln giving a calcine of pure CaO. For each kg of limestone, 0.15 kg of fuel oil with 85% carbon and 15% hydrogen is used and volume of the combustion air is 2.1 Nm³. The fuel burns completely to CO₂ and H₂O which mix with the CO₂ evolved from limestone. Calculate the volume in Nm³ of the furnace gas as well as its wet composition.

Air can be regarded as containing 21% O₂ and 79% N₂. [10 marks]

4.

- a) Mention the two main routes into which, copper is lost from matte smelting operations. [2 Marks]
- b) How do temperature, matte grade and slag weight affect copper losses? [6 Marks]
- c) Describe the two main ways in which copper losses in slags occurs. [4 Marks]
- d) What methods are commonly used in the minimisation of copper-in-slag losses? [2 Marks]
- e) What is the purpose of fire-refining of copper? [2 Marks]
- f) Describe the two stages involved in the fire-refining of copper. [4 Marks]

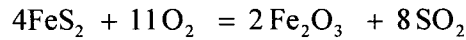
5.

- a) Describe the operation of TWO of the following conventional matte smelting units outlining their advantages and disadvantages: [20 Marks]
- Electric furnace matte smelting
 - Flash furnace matte smelting
 - Reverberatory furnace matte smelting

6.

- a) What do you understand by roasting of concentrates? [1 mark]
- b) What do you understand by autogenous roasting? [1 mark]

- c) Give two reasons why roasting prior to smelting is important. [2 marks]
- d) Give two reasons why roasting sulphides prior to leaching is important. [2 marks]
- e) An iron pyrites concentrate contains 85% FeS₂ and 15% gangue. It is roasted with an amount of air 200% in excess of that stoichiometrically required for complete oxidation of FeS₂ in the reaction:



None of the gangue volatilizes and the calcine obtained after roasting contains 2% FeS₂ by weight. Using 100 kg of ore charged as the basis of calculation, determine:

- i. the extent of reaction; [4 Marks]
- ii. the composition of the furnace off-gas; [8 Marks]
- iii. the total volume of the furnace off-gas at 300 °C and 1 atmosphere. [2 Marks]

7.

- a) What is the primary purpose of converting in the copper smelting industry? [2 Marks]
- b) Describe the two stages of the copper converting process. [6 Marks]
- c) A copper converter blows to blister copper a charge of 20 tonnes matte containing 46% copper. The slag is to be with 29% SiO₂. Assume there are no losses of copper in the slag and the air blast is supplied at a rate of 90 Nm³ per minute. Only the stoichiometric air requirement is supplied. The flux comprises 4% Cu₂S, 16% FeS and 80% SiO₂.

Calculate:

- i. the weight of flux required; [2 Marks]
- ii. the volume of blast needed; [4 Marks]
- iii. the blowing time of each of the two stages. [6 Marks]

DATA

Atomic Weights

Fe = 55.845; S = 32.06; O = 15.999; Cu = 63.546; Ca = 40.078; Si = 28.086; C = 12.011

END OF EXAMS IN MET 4219 GOOD LUCK

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – JULY 2014

MET 4229 -HYDRO-ELECTROMETALLURGY.

TIME: THREE HOURS

ANSWER: FIVE QUESTIONS.

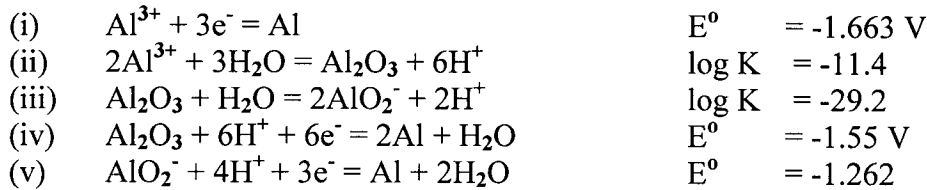
ALL QUESTION CARRY EQUAL MARKS

1. Explain the process flow sheet of materials in a Solvent extraction Plant incorporating electro winning with the help of a simplified diagram. (5)
 - (a) What do you understand by the term diluents and give it's most important properties required to be used as a diluents. (9)
 - (b) What do you understand by the term solvent and give it's most important properties required to be used as a solvent. (6)

2. What do understand is the difference between copper electro winning and electro refining and give the most appropriate equations involved? (6)
 - (i) Define the first and second faradays laws? (6)
 - (ii) An industrial Hall-Heroult cell working at 400,000 amps produces 275 kg of pure Aluminium per day. Calculate the current density and cathodic current efficiency. (4)
 - (iii) What do you understand by energy efficiency and what is this value in reference to (ii)? (4)

3. Under the following headings: (a) principle, (b) nature of suitable feed material (c) advantages and disadvantages of the method. Describe the following leaching methods very briefly but precise
 - (i) In situ(underground or in placer leaching) (2)
 - (ii) Dump/heap leaching (4)
 - (iii) Pressure leaching (4)
 - (iv) Percolation or vat (tank) leaching (2)
 - (v) Agitation leaching (2)
 - (vi) Counter current decantation (2)
 - (vii) Bacterial-aided leaching (4)

4. Construct the Al-H₂O Eh- pH diagram or Pourbaix Diagram at 25°C given the following information:



It will be assumed in the calculation that the aluminum ions in solution are each 10^{-3} m and that the activities of soluble species are equal to molal concentrations. (20)

5. A company wishes to extract valuables from an ore using a hydrometallurgical method. As an extractive metallurgist with the company, you are appointed to take charge of the development of a leaching process for the ore. Discuss fully, but concisely, what factors you would consider to obtain optimal results in the leaching of the ore. Note that apart from mentioning the factors, it is important to state clearly the parameters to optimise. (20)

6. (a) What are the steps which may be taken for material preparation prior to leaching? Briefly justify why those steps should be taken. (5)

(b) What do you understand by the following terms as used in hydrometallurgy in short notes but precise:

- | | | |
|-------|--------------------------|-----|
| (i) | Weight per volume | (1) |
| (ii) | Ppm or parts per million | (1) |
| (iii) | Ppb or parts per billion | (1) |
| (iv) | Molarity | (2) |
| (v) | Molality | (2) |
| (vi) | Normality | (2) |

(c) In a laboratory leaching experiment, 200 grams of a Zinc ore with 1.98% Zn is leached to give 600cm^3 of pregnant solution. The concentration of this solution is too high to be measured directly by atomic adsorption spectrophotometry (AAS). Hence 1 ml of the pregnant solution was pipette and made up to 250cm^3 of solution "P" using distilled water. 10 ml of "P" is pipette and made up to 100cm^3 with distilled water, to obtain a solution "Q". If "Q" is found by AAS to analyse 25 ppm Zn. What percent of Zn in the ore is leached in the experiment? (6)

END OF MET 4229 HYDRO AND ELECTROMETALLURGY EXAMINATION AND GOOD LUCK 2014.

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – JULY 2014

MET 4249 – FUELS, FURNACES AND REFRACTORIES

TIME: THREE HOURS

ANSWER: ANY FIVE QUESTIONS.

1. (a) Give a brief description of the following furnaces:
- (i) Hearth Furnaces [2]
 - (ii) Shaft Furnaces [2]
 - (iii) Converters [2]
- (b) The most important properties of refractory materials generally considered are
- (i) Refractoriness
 - (ii) Spalling resistance; and
 - (iii) Slag resistance
- Briefly describe the determination of these properties [9]
- (c) Outline the standard route followed in the manufacture of refractories, and show sketches of the firing furnaces used. [5]
2. (a) With the aid of a sketch, describe the important allotropic forms of silica [4]
- (b) Outline four properties of silica [4]
- (c) Draw the $\text{SiO}_2\text{-Al}_2\text{O}_3$ equilibrium diagram [4]
- (d) Casually made dolomite bricks “perish” and “dust”. What is the meaning of these two expressions in this context? And how can “perishing” and “dusting” be minimised in the manufacture of dolomite bricks? [4]
- (e) Give the common applications of dolomite bricks [4]

3. (a) What is a special refractory? Give examples of special refractories and their applications [4]
- (b) Distinguish between zircon and zirconia [4]
- (c) State the three advantages of slip-casting of refractories. [4]
- (d) With the aid of a diagram, describe "pressure sintering" [4]
- (f) State the four points used to assess whether insulation can be justified in pyrometallurgy [4]
4. (a) Draw two typical oil burners. [6]
- (b) State the factors that determine flame temperature in the combustion of a fuel. [3]
- (c) What are the assumptions made in calculating an ideal flame temperature? [3]
- (d) Calculate the ideal flame temperature for the combustion of methane by air preheated to 600 degrees C. [8]

The heat of combustion is given by:



Specific heats:

$$\text{Air} = 0.324 \text{ cal/l}^\circ\text{C}$$

$$\text{CO}_2 = 0.58 \text{ cal/l}^\circ\text{C}$$

$$\text{H}_2\text{O} = 0.46 \text{ cal/l}^\circ\text{C}$$

$$\text{N}_2 = 0.36 \text{ cal/l}^\circ\text{C}$$

1 mole of gas occupies 22.4 litres at STP

5. (a) State the various classifications of fuels [4]
- (b) What are the main chemical components of fossil fuels [1]
- (c) Define the calorific value of a fuel [1]
- (d) Calculate the net calorific value of a gas mixture containing 50% H₂, 40% CO, 5% CH₄, and 5% N₂. The heats of oxidation are -57 800, -67 623 and -191 800 cal/mol respectively. [6]

- (e) Calculate the volume of air required, and the composition of the flue gases when 1 kg of oil is burnt stoichiometrically, where the oil analysis is 85% C and 15% H. [8]
6. (a) The storage procedures for coal are designed for two purposes, what are they? [2]
- (b) There are several factors that can contribute to the spontaneous combustion of coal, what are they? [3]
- (c) What is meant by carbonisation of coal, and what are its main objectives? [3]
- (d) What are the conditions under which coal is carbonised to produce coke? [1]
- (e) The carbonisation of coal is done at two different temperature ranges, what are they and which of the two resulting coke components is used in pig iron manufacture? [2]
- (f) State the commonly used physical tests of coke. [3]
- (g) In the combustion of a solid fuel, draw sketches showing gas analysis and temperature distribution in coke beds of a very un-reactive fuel and a very reactive fuel. [6]

END OF EXAMINATION IN MET 4249

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – JULY 2014

MET4319 PHASE TRANSFORMATIONS

TIME: THREE HOURS

ANSWER: FIVE QUESTIONS

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

$\frac{\partial C_A}{\partial x}$ expressed as a partial derivative? (3)

- (b) Show, with the aid of appropriate sketches, why the presence of vacancies is essential for substitutional diffusion to occur. (5)

- (c) What would you expect to happen to the rate of substitutional diffusion at elevated temperatures and why? (3)

- (d) It has been stated that the equation $D = \frac{1}{6} \Gamma a^2$ applies to any diffusing species in any cubic metal.

Show that this is true for self-diffusion in a pure bcc metal for two adjacent {220} planes. (9)

2. (a) Why are vacancies important and what happens when they exist in metals and alloys? (4)

- (b) In class it was shown that the ratio of vacant to occupied sites (i.e. vacancy concentration) in a material can be expressed as

$$\frac{n_v}{n_o} = \exp - \frac{Q_f}{RT}$$

Using this expression, determine the vacancy concentration in copper at 1350K and when it is slowly cooled to 300K ($Q_f = 83,700$ J/mol and $R = 8.31$ J/mol K). (6)

- (c) From your answer to part (b), is there any significant difference in vacancy concentrations at 1350 and 300K? If so, what could have happened to the vacancies during slow cooling from 1350 to 300K? (6)

- (d) What would happen to the vacancy concentration in part (b) if the copper were quenched from 1350 to 300K? (4)

3. (a) Distinguish between a phase and a microconstituent. (2)

- (b) Figure 1a is the Hf-U phase diagram while Figure 1b is an enlargement of the U-rich end of the phase diagram. Uranium has three allotropes: a high temperature form (δ) which is orthorhombic, an intermediate temperature form (β) which is tetragonal and a low temperature form (ϵ) which is body centered cubic.

(i) Label the phase diagram and identify all the invariant reactions. (11)

(ii) For the Hf-20 wt.% U alloy, determine the compositions and relative amounts of the phases present at 1300°C. (4)

- (iii) Draw schematic free energy/composition curves at 1130°C. (3)
4. (a) What was the main reason that led to the proposal of dislocation theory? (4)
 (b) Using the vectors \mathbf{b} and $\boldsymbol{\xi}$, distinguish between an edge and a screw dislocation. (4)
 (c) Why is a jog on a stepped screw dislocation unable to move by glide? (4)
 (d) The total line length of the dislocations visible in a 4 cm by 4 cm transmission electron microscope (TEM) photograph of a metal foil, taken at a magnification of 20,000X is measured as 400 cm. The foil specimen imaged by this picture had a thickness of 300 nm. Determine the dislocation density in the specimen. (8)
5. (a) Describe how Time-Temperature-Transformation (TTT) curves for steel can be constructed. (4)
 (b) What are the M_s and M_f curves on the TTT curves? (2)
 (c) During quenching of a fully austenitic steel, what microconstituents would be expected if the M_s curve is crossed but the M_f curve is not? (2)
 (d) What microstructure result from each of the following treatments, taken independently, of a previously annealed 0.80 wt.% C steel (The Fe-Fe₃C phase diagram is shown in Figure 2).
 (i) heat to 730°C, water quench (3)
 (ii) heat to 815°C, air cool (3)
 (iii) heat to 150°C, water quench (3)
 (iv) heat to 760°C, furnace cool (3)
6. (a) With the aid of appropriate sketches, describe the mechanisms by which microconstituents form during slow-cooling of a hypereutectoid steel. (4)
 (b) 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 in the steel. (5)
 (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. (4)
 (iii) What would be the equilibrium structure of this steel if it were heated to 850°C? (5)
 (c) For the decomposition of austenite to pearlite, it can be shown that the fraction of austenite transformed ($f(t)$) is related to the nucleation rate (N) and the growth rate (G) by the following expression:

$$f(t) = 1 - \exp\left(-\frac{\pi N G^3 t^4}{3}\right)$$

If $N=1000 \text{ cm}^{-3}\text{s}^{-1}$ and $G=3 \times 10^{-5} \text{ cm s}^{-1}$, what is the time required to obtain 50% transformation? (2)

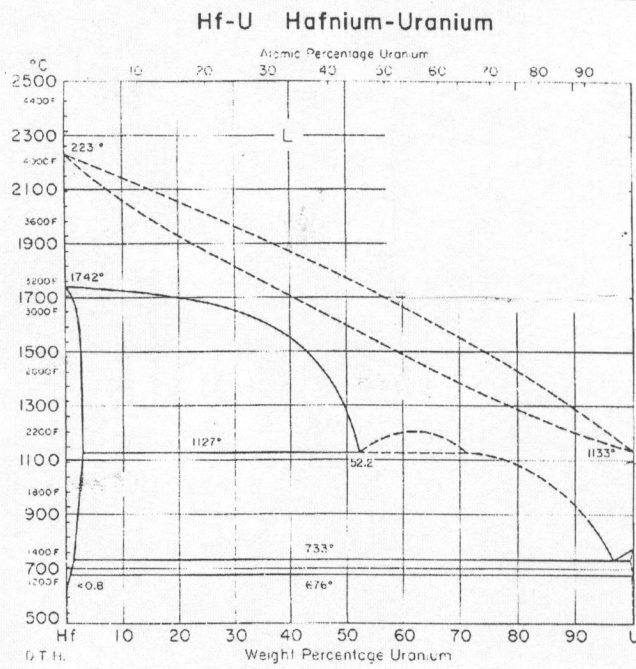


Figure 1a

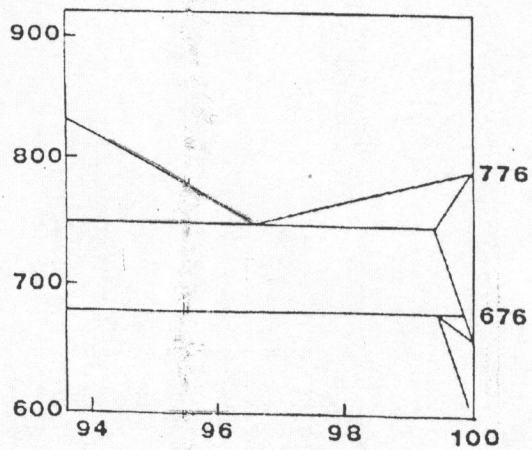
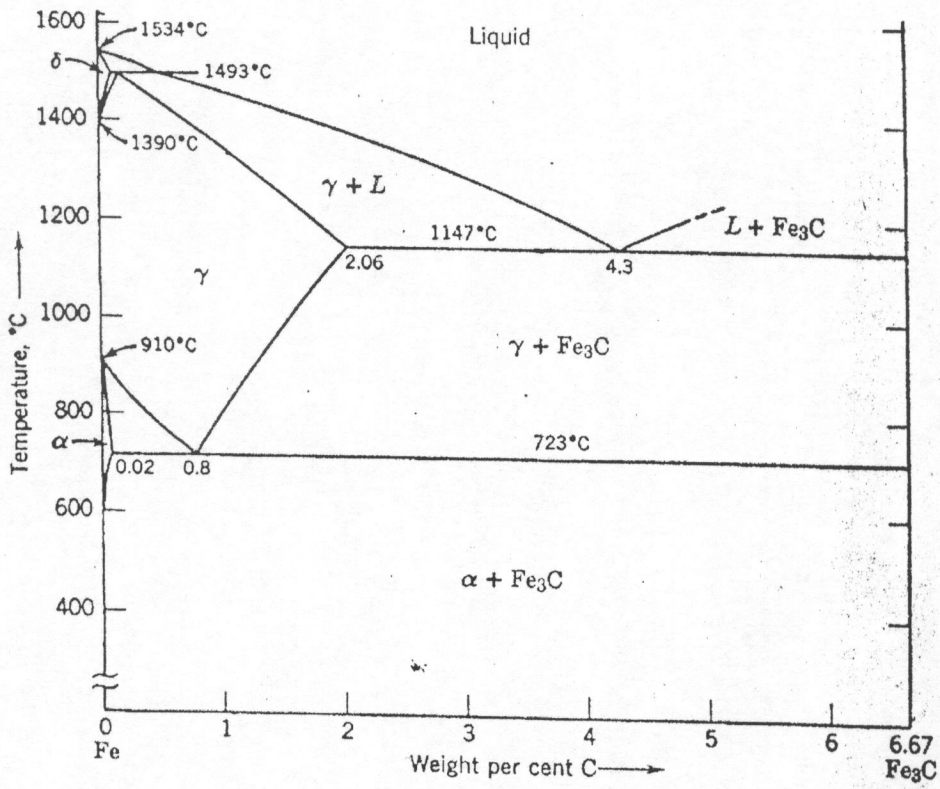


Figure 1b



Phase diagram for the system Fe-Fe₃C.

UNIVERSITY OF ZAMBIA

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UNIVERSITY EXAMINATIONS

JULY 2014

MET 4479: METALLURGY AND THE ENVIRONMENT

ANSWER: ALL FIVE QUESTIONS

TIME: 3 HOURS

1. (a) What is an Environmental Project Brief (EPB), and what are its objectives and contents? State five projects that fit in to the category of an EPB **(5 mark)**
 - (a) Clearly state the stages involved in undertaking an EPB from project identification to A Decision Letter being issued by the Zambia Environmental Management Agency (ZEMA) **(5 marks)**
 - (b) What is Environmental Impact Assessment (EIA), and what are its objectives and contents? What is the main difference between an EPB and an EIA? State five projects that fit in to the category of an EIA **(5 mark)**
 - (c) Clearly state the stages involved in undertaking an EIA, from project identification to A Decision Letter being issued by the Zambia Environmental Management Agency (ZEMA). What are the two main objectives for developing Terms of Reference for an EIA? **(5 marks)**
2. (a) What is an environmental Management System? What are the steps involved in the development of an environmental management system? **(5 Marks)**
 - (b) State the benefits of an environmental management system? **(2 Marks)**
 - (c) What are the key contents of an Environmental Policy? **(3 Marks)**
 - (d) Identify the piece of legislation in Zambia that elaborates the process of mining environmental auditing? What are the key objectives of this piece of legislation? What are the key contents of an environmental auditing report? **(5 Marks)**
 - (e) Compare the ISO14001 system to the Eco-Management and Audit System (EMAS), highlighting the main differences **(5 marks)**
3. (a) What is Cleaner Production? What are the benefits of Cleaner Production? Cleaner Production can be divided into five categories, what are they? **(3 Marks)**

- (b) Define Ecologically Sustainable Industrial Development (EISD) in the context of Cleaner Production. What are the three factors that industrial development must take into account in order to achieve EISD? Elaborate as to why this is important. **(3 Marks)**
- (c) Clearly elaborate why pollution prevention has evolved from: dilution to treatment to avoidance/cleaner production. **(5 Marks)**
- (d) The pay-back period for Cleaner Production techniques is short even when the investment costs are high. What are the savings of Cleaner Production accrued from? Energy is an input in industrial processes, what are the common options to reducing energy consumption? **(5 Marks)**
- (e) State four well known barriers to the introduction of Cleaner Production. There are four principle analytical tools which can assist in identifying opportunities for adopting Cleaner Production techniques, what are they? **(4 Marks)**
4. Due to the growing interests in environmental protection and increased awareness of the adverse impacts associated with manufacturing processes and consumption patterns, several methods/tools have been developed to better understand and reduce these impacts. Life Cycle Assessment (LCA) is one of these. What is the definition of LCA? Draw a diagram that illustrates the four elements of LCA and briefly summarise the principle consideration of each element. State the benefits and limitations of LCA. **(20 Marks)**
4. (a) There are six important reasons for cleaning gases and water from metallurgical processing. State three of them. **(3 Marks)**
- (b) Dust collection is done by a variety of methods, with the method chosen taking into account a number of considerations, state four of these considerations **(2 Marks)**
- (c) Particle sizes and types are broken into four categories for the purposes of removal of particulate matter from gases, state and define them. **(2 Marks)**
- (d) There are eight types of dust collectors in common usage, each of which has its best collector efficiency within a certain particles size range. Identify four dust collectors and give their respective efficiency ranges. **(4 Marks)**
- (e) What is a Settling Chamber, and what is the principle on which it works? Illustrate its operation by means of a sketch. Give the equation used to determine the efficiency of a horizontal settling chamber. Give the equation used to determine the minimum

particle diameter that can be collected at 100% efficiency in a horizontal chamber. State the mathematical expression that gives the relationship of the cross-sectional area of the flue and chamber relative to the velocity of the gas **(9 Marks)**.

END OF MET 4479 EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – JULY 2014

MET 4459: PROCESS INSTRUMENTATION AND CONTROL

TIME : THREE HOURS

ANSWER : FIVE questions

**Additional information is provided with the examination paper.
Where applicable, all calculations are to be done correct to three decimal places.**

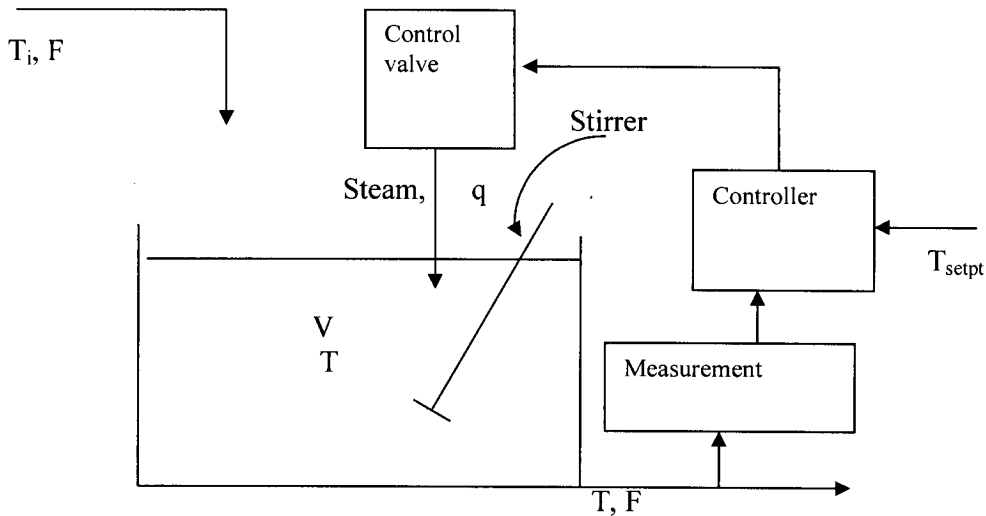
1. (a) What is the job we have to do in process control?

(3 marks)

(b) In the home, the geyser has a temperature setting, a thermostat to measure the actual temperature of the water together with the error and a heating element. Draw a block diagram of this feedback process indicating the signals in and out of each block.

(4 marks)

(c) Consider a stirred tank heater as shown below.



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

(3 marks)

(ii) Develop a feedback control configuration, in terms of a block diagram, to achieve your control objective.

(4 marks)

d) If C_1 and C_2 are arbitrary constants, find a differential equation of minimum order of which each of the following expressions is a general solution:

- (i) $y^2 = C_1(t + C_1)$ (3 marks)
(ii) $y = C_1e^{-t} + C_2e^{-5t}$ (3 marks)

2. (a) Consider the following dynamic equation:

$$t \frac{dy}{dt} + 2y = t^3 \quad \text{given that when } t = 1, y = 0.$$

Derive the expression for $y(t)$.

(6 marks)

(b) You are given the following dynamic equation:

$$\frac{d^2y}{dt^2} + 4 \frac{dy}{dt} + 4y = 2t + \sin t \quad y(0) = 1, y'(0) = -1$$

Derive the expression for $y(t)$ using the method that includes the complementary function. (14marks)

3. (a) Using Laplace transforms, solve the following equation for $y(t)$:

$$\frac{dy}{dt} = \int_0^t y(t) dt + 4U(t)$$

given that $y(0) = 1$

(10marks)

(b) A first-order system is represented by

$$\frac{1}{2} \frac{dy}{dt} + \frac{1}{2}y = \frac{1}{2} U(t - 1) - U(t - 4) \quad y(0) = 1$$

Develop an expression that shows how the output $y(t)$ changes in response to the inputs. Calculate y at $t=2$ and at $t=4$. What is the ultimate value of y ?

(10marks)

4. (a) What is feedback control?

(5 marks)

(b) A step change in $x'(t)$ of magnitude 4 is introduced into a system having the following relationship:

$$y'(s) = \frac{120}{s^2 + 12s + 120} x'(s)$$

Find the output $y'(t)$. What is the final value of $y'(t)$? Check using the final value theorem. (15marks)

(15marks)

5.. (a) Describe a Bode plot for a first order system..

(4 marks)

(b) Consider the storage tank in the figure below.

Suppose we want to control the liquid level in the tank at 1.5 m by manipulating the effluent flow rate F_2 according to the following proportional control law:

$$F_2 = -0.9(1.5 - h) + 0.03$$

(i) Develop the transfer function between h' and F_1' .

(5 marks)

(ii) Determine the time constant τ_{CL} and the process gain under control, K_{CL} .

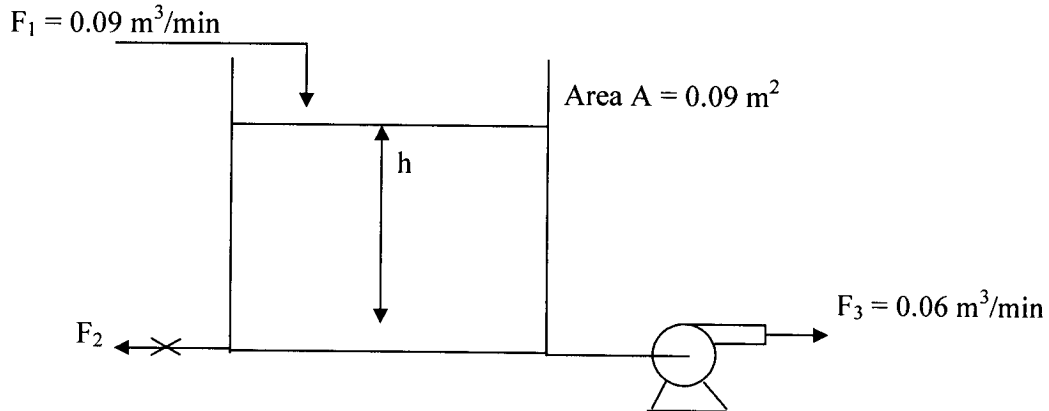
(2 marks)

(iii) Compute the dynamic response of the liquid level to a step change in F_1 of magnitude $0.03 \text{ m}^3/\text{min}$.

(5 marks)

(iv) Compute the new steady state value of the liquid level and the offset.
What is F_2 at this new steady state?

(4 marks)



6. (a) Comment on the stability of a system. Use a second order as an example.

(3 marks)

(b) Given that

$$y(s) = \frac{e^{-5s}}{s(5s+1)}$$

Determine $y(t)$ at $t = 10$ or $y(10)$.

(4 marks)

(c) We have the following relationship between the deviation in T , $T'(t)$ and the deviation in T_i , $T'_i(t)$ in the Laplace domain:

$$T'(s) = \frac{20s+1}{(3s+1)(15s+1)} T'_i(t)$$

(i) Find $T'(t)$ for a unit step change in $T'_i(t)$.

(10marks)

(ii) What is the ultimate value $T'(\infty)$. Check with the final value theorem.

(3 marks)

END OF EXAMINATION IN MET 4459

Here is the additional information.

The first-order ODE is as follows:

$$\tau \frac{dy}{dt} + y(t) = K x(t) \quad y(t_0) = y_0$$

The solution is

$$y(t) = y_0 e^{-(t-t_0)/\tau} + \frac{K}{\tau} e^{-t/\tau} \int_{t_0}^t e^{t/\tau} x(t) dt$$

Table of Laplace Transforms

$\frac{f(t)}{U(t)}$	$\frac{f(s)}{\frac{1}{s}}$	$\frac{f(t)}{tU(t)}$	$\frac{f(s)}{\frac{1}{s^2}}$
$t^n U(t)$	$\frac{n!}{s^{n+1}}$	$e^{-at} U(t)$	$\frac{1}{s+a}$
$t^n e^{-at} U(t)$	$\frac{n!}{(s+a)^{n+1}}$	$\sin kt U(t)$	$\frac{k}{s^2 + k^2}$
$\cos kt U(t)$	$\frac{s}{s^2 + k^2}$	$\cosh kt U(t)$	$\frac{s}{s^2 - k^2}$
$\sinh kt U(t)$	$\frac{k}{s^2 - k^2}$	$e^{-at} \cos kt U(t)$	$\frac{s+a}{(s+a)^2 + k^2}$
$e^{-at} \sin kt U(t)$	$\frac{k}{(s+a)^2 + k^2}$	$(1 - e^{-t/\tau}) U(t)$	$\frac{1}{s(\tau s + 1)}$
$(1 + \frac{1}{\tau_2 - \tau_1} (\tau_1 e^{-t/\tau_1} - \tau_2 e^{-t/\tau_2})) U(t)$		$\frac{1}{s(\tau_1 s + 1)(\tau_2 s + 1)}$	
$(\frac{1}{\tau^n (n-1)!} e^{n-1} e^{-t/\tau}) U(t)$		$\frac{1}{(\tau s + 1)^n}$	
$(\frac{1}{\tau_1} \frac{\tau_1 - \tau_3}{\tau_1 - \tau_2} e^{-t/\tau_1} + \frac{1}{\tau_2} \frac{\tau_2 - \tau_3}{\tau_2 - \tau_1} e^{-t/\tau_2}) U(t)$		$\frac{\tau_3 s + 1}{s(\tau_1 s + 1)(\tau_2 s + 1)}$	

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

$$2e^{-kt} (a_1 \cos kt + b_1 \sin kt)$$

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

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

**UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
UNIVERSITY EXAMINATION – JULY 2014**

METALLURGY AND MINERAL PROCESSING DEPARTMENT

MET 5239 – IRON AND STEEL MAKING.

Time : THREE hours
 Answer: ALL FIVE QUESTIONS
All questions carry equal marks

1

(a) A pig iron Blast Furnace produces 6 000 tonnes per working day consuming 1.5 tonnes sinter per tonne pig iron produced. 10% of the sinter delivered to the Blast Furnace plant is returned after sieving in the Blast Furnace Charge section. Within the Sinter Plant 6 sintering strands each of 175m² surface area are present, and only 5 of them are in operation at a time, with the 6th one on standby. If the Sinter Plant, where you are the Plant Metallurgist, operates 20 hours per working day, calculate:

- (i) The productivity of each sintering machine per hour **(5 marks)**
- (ii) The vertical velocity of a sintering machine in this plant **(4 marks)**
- (iii) The length of the sintering strands used in the plant **(5 marks)**

In the above calculations make the following assumptions:

- Productivity factor = 65%
- Bulk density of sinter = 1.5 tonnes per m³
- Height of material in pallet = 350 mm
- Speed of sintering strand = 2m per min

- (b) Why is it not possible to charge fine concentrates to the Iron Blast Furnace **(1 marks)**
- (c) In preparing iron ore concentrate for charging to the Blast Furnace, two agglomeration processes are used namely, pelletising and sintering. With the aid of a sketch, describe the four distinct process stages in pellesiting. **(5 marks)**

2

An Iron Blast Furnace is charged with the following materials while the pig iron product is also as shown:

Ore	Coke	Flux	Pig Iron
Fe ₂ O ₃ = 75%	C = 95%	CaCO ₃ = 97%	Fe = 94%
SiO ₂ = 13.2 %	SiO ₂ = 5%	SiO ₂ = 3%	C = 3.1%
MnO = 2.5%			Si = 2.1%
Al ₂ O ₃ = 7.3%			P = 0.4%
P ₂ O ₅ = 2.0%			Mn = 0.4%

Calculate:

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

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

3

- (a) Describe the coking process during the production of metallurgical coke (5 marks)
- (b) Outline six properties of metallurgical coke that are required (3 marks)
- (c) What are the other three fuels that are used in the Blast Furnace? (2 marks)
- (d) Using a diagram describe the five main operating parts of the Blast Furnace (5 marks)
- (e) Describe the reactions in the Blast Furnace that take place using the following routes:
 - (i) Gaseous reduction (2 marks)
 - (ii) Reduction by solid carbon, and (1 mark)
 - (iii) High temperature reactions (2 marks)

4

- (a) With the aid of a diagram, describe the five internal zones of a Blast Furnace (5 marks)
- (b) One disadvantage of introducing the Bessemer (Acid) process for steel making in 1856 was that sulphur and phosphorus could not be removed from steel. Why? (2 marks)
- (c) Draw a sketch showing metal composition changes during the blowing of an acid Bessemer Converter (4 marks)
- (d) The Basic Bessemer or Thomas steelmaking process introduced in 1877 made it possible for the removal of phosphorus. Why? (2 marks)
- (e) Draw a sketch showing metal composition changes during the blowing of a basic Thomas Converter (4 marks)
- (f) What are the three advantages of a Bottom Blown Process (3 marks)

5

- (a) Give three general requirements of steel for continuous casting (3 marks)
- (b) With the aid of a sketch, describe the progress of solidification in the mould during continuous casting (6 marks)
- (c) Describe the requirements that cause the interposition of a tundish between the ladle and casting mould. (4 marks)
- (d) Why is it necessary to protect steel from reoxidation during casting? (1 mark)
- (e) Give four objectives for lubricating the mould in Open Stream casting. (6 marks)

END OF EXAM IN MET 5239 - GOOD LUCK!

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
UNIVERSITY EXAMINATION**

MET 5259 – Special Topics in Extractive Metallurgy

TIME: 3 Hours

ANSWER: Question 6 and any other four.

1

Describe the various types of scrap used in steel making. What is the importance of metal recycling? Describe the methods of recycling of the following metals:

- (i) Copper
- (ii) lead and
- (iii) zinc

[20%]

2

- a) Mention three main sources from which precious metals could be recovered.
- b) Mention three main ways into which precious metals are lost.
- c) What is electronic scrap?
- d) Describe the steps involved in the preliminary processing of electronic scrap.
- e) In a converter steel making process about 30% of steel scrap may be used. What are the three functions of the added steel scrap?
- f) What are the main problems of using scrap in steel making process?

[20%]

3

The proximate analysis of copper concentrate (wt. %) is as follows:

20% Cu₂S, 49% FeS₂, 26% SiO₂, 5% Al₂O₃.

The concentrate is smelted in a furnace in the presence of iron ore and limestone. The analysis of iron ore is 81% Fe₂O₃ and 19% SiO₂, and that of limestone is 93% CaCO₃ and 7% SiO₂. The grade of matte is 45% and the ratio of SiO₂:FeO:CaO in slag is 45:40:15. The oil amounts to 12% of the charge and analyses 85% Carbon and 15% Hydrogen. The air used is 10% excess than theoretically required for smelting.

Calculate per 2one of concentrate treated:

- a) the weight each flux;
- b) the weight of slag and;
- c) the volume of air and % composition of gases.

[20%]

4

- (a) Describe in general the solvent extraction (SX) process as applied in the recovery of copper from its ores.
- (b) Describe the following leaching systems:
 - (i) sulphuric acid leaching
 - (ii) ammonia leaching
 - (iii) concentrated chloride leaching
- (c) What properties should a successful copper extractant have?
- (d) Give a comparison of properties for reagents based on ketoximes, modified aldoximes and ketoxime/aldoxime mixture.
- (e) What is crud? What variables affect its formation?

[20%]

5

- (a) Discuss with the help of neat flowsheets the production of H_2SO_4 and elemental sulphur from smelter flue gases.
- (b) Describe with diagrams how the following gas cleaning equipments operate:
 - (i) electrostatic precipitators,
 - (ii) scrubbers, and
 - (iii) Bag Houses

[20%]

6

(a) Convert the following parameters into numerical values for their equivalent blast furnace model variables:

Operating parameters	Model variable
(i) Ore charge: hematite, Fe ₂ O ₃	$\left(\frac{O}{Fe}\right)^x$
(ii) Blast: 1200 Nm ³ dry air per tonne of product Fe	n_O^B
(iii) Pig iron: 5 % C	$\left(\frac{C}{Fe}\right)^m$
(iv) Total carbon in charge: 460 kg dry coke (90 % C) and 50 kg oil (85 % C) per tonne of Fe.	$n_c^i = n_c^o$
(v) Active carbon from (iii) and (iv)	n_C^A
(vi) Carbon in top gas from (v)	n_C^g
(vii) Top gas composition: 23.9 Vol. % CO, 20.5 % CO ₂ , 55.6 % N ₂	$\left(\frac{O}{C}\right)^g$
(viii) Quantity of CO and CO ₂ in top gas from (vi) and (vii)	$n_{CO}^g, n_{CO_2}^g$

(b) The heat demand, D of a hematite-charged blast furnace is 560 000 kJ per kg mole of product Fe. The total carbon in charge is 600 kg per tonne of product Fe. The pig iron product contains 5 % C. Calculate:

- (i) The volume of blast air (Nm³ per tonne Fe) which is required to keep this furnace operating at a steady state.
- (ii) Composition of the top gas.

[20%]

7

Calculate top gas composition for an ideal gas blast furnace operating with a mixture of Fe₂O₃ and coke. Coke is 90% C and is consumed at the rate 475 kg/ton of iron. Oxygen is introduced at the rate of 350 kg/1000kg iron. Hot metal has 4.5% C.

[20%]

Given:

$$n_{\text{O}}^{\text{B}} + \left(\frac{\text{O}}{\text{Fe}}\right)^{\text{X}} = n_{\text{C}}^{\text{A}} \left(\frac{\text{O}}{\text{C}}\right)^{\text{g}}$$

$$n_{\text{O}}^{\text{B}} + \left(\frac{\text{O}}{\text{Fe}}\right)^{\text{X}} - \frac{\text{D}}{283000} = n_{\text{C}}^{\text{A}} \frac{172000}{283000}$$

$$X_{\text{CO}_2}^{\text{g}} = \left(\frac{\text{O}}{\text{C}}\right)^{\text{g}} - 1 \quad \text{and} \quad X_{\text{CO}}^{\text{g}} = 2 - \left(\frac{\text{O}}{\text{C}}\right)^{\text{g}}$$

END OF EXAM IN MET 5259

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – JULY 2014

MET 5339 METAL FORMING

TIME: THREE HOURS

ANSWER: FIVE QUESTIONS

1. (a) In class, it was stated that the force (or pressure) P required for metal fabrication has three components and can be expressed as

$$P = f(\sigma_0) + f(\mu) + f(C)$$

where σ_0 = yield strength, μ = coefficient of friction and C = geometric factor that is characteristic of the particular mode of working. Explain how each one of these components affects the overall force (or pressure) requirements during metalworking. (4)

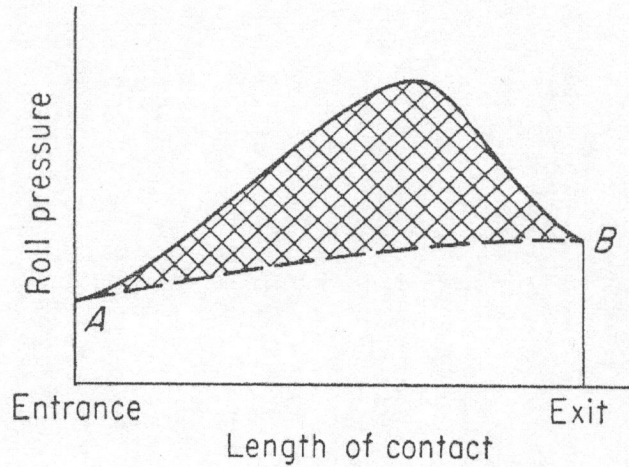
- (b) Justify why during most metal working processes it is essential to subject the stock material to stress levels that will cause it to yield. (3)
- (c) State three effects of friction on metal working processes. (3)
- (d) Show that the work for plastic deformation during metal working is

$$W_{pl} = \frac{VK\varepsilon^{m+1}}{m+1}$$

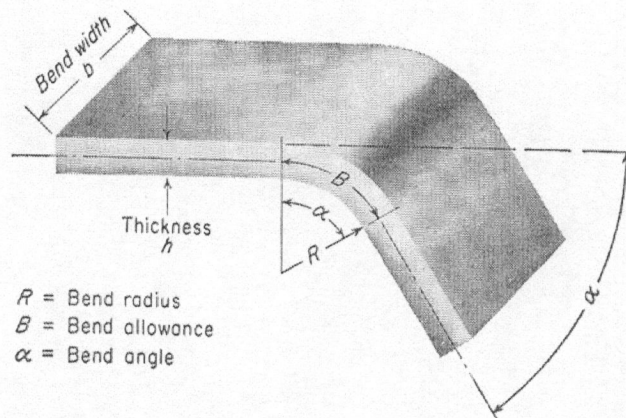
- (10)
2. (a) How would you determine the presence of redundant work during extrusion? (4)
- (b) Show that in the extrusion of a metal, the work/unit volume is numerically equal to the extrusion pressure. (10)
- (c) A 40 mm long, 30 mm diameter billet is used in a direct extrusion press. When its length has been reduced to 20 mm, the extrusion pressure was found to have decreased by 30%. Use this information to estimate the coefficient of friction for the process. (6)
3. (a) Describe the advantages and disadvantages of drawing tube with a fixed mandrel, and floating plug. (5)
- (b) What limits the maximum reduction per draw in tube and wire drawing? (3)
- (c) Calculate the drawing load required to achieve 30% reduction in area on a 10 mm diameter copper wire, given that the yield stress of the metal is 235 N/mm². (6)
- (d) If the wire is passing through the die at 2.25 m/s, calculate the power of the electric motor assuming 100% efficiency. (6)

$$\frac{P'}{A_2} = \bar{\sigma}_0 \ln \frac{A_1}{A_2}$$

4. (a) State two ways in which power supplied to the rolling mill is expended. (2)
 (b) What are the main variables controlling the rolling process? (3)
 (c) The figure below shows the friction hill during rolling.



- (i) What does the shaded area represent? (4)
 (ii) What does the area under line AB represent? (4)
 (iii) Why is there a friction hill in the overall roll pressure? (4)
 (d) With the aid of an appropriate sketch, describe how a pipe develops during extrusion. (3)
5. (a) What products can be made by sheet metal bending? (4)
 (b) The figure below shows the bending of a sheet metal.



In this case,

$$\frac{R_{min}}{h} = \frac{1}{2q} - 1 \quad \text{for } q < 0.2$$

where q = reduction in area measured in a tension test.

- (i) What is the significance of the minimum bend radius R_{\min} ? (4)
- (ii) In the middle of the thickness of this sheet (h) is a neutral axis. What would happen to the neutral axis during plastic bending? (5)
- (iii) What happens to the outside and inside fibres during bending? (5)
- (c) State two problems that may be encountered in products of sheet metal bending. (2)

6. (a) What is the unique characteristic of forged parts as compared to those manufactured by other metal working processes? (4)
- (b) Describe the common defects found in forged products. (5)
- (c) In upsetting a cylinder, the equations below have been developed for homogeneous compression with coulomb friction. Suppose a 15 cm high, 5 cm diameter, cylinder were compressed to half-height for a material with a flow stress of 70 MPa under conditions where the coefficient of friction is 0.15,
- (i) from a consideration of the friction hill, where does the maximum pressure occur and what is its value?

$$p = \sigma_o' \exp \frac{2\mu}{h} (a - x)$$

since $\sigma_o' = \frac{2}{\sqrt{3}} \sigma_o$

$$p = 1.15 \sigma_o \exp \frac{2\mu}{h} (a - x) \quad (8)$$

- (ii) what is the maximum force required?

$$\bar{p} = \frac{\sigma_o}{2} \left(\frac{h}{\mu a} \right)^2 \left[\exp \frac{2\mu a}{h} - \frac{2\mu a}{h} - 1 \right] \quad (3)$$

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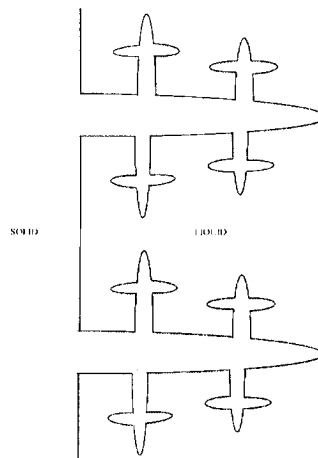
UNIVERSITY EXAMINATIONS – JULY 2014

MET5349 FOUNDRY TECHNOLOGY

TIME: THREE HOURS

ANSWER: FIVE QUESTIONS

1. (a) Discuss the concept of undercooling. (7)
- (b) The figure below shows a solid with primary, secondary and tertiary dendrite arms. Describe in detail how these dendrite arms develop during solidification. (7)



- (c) The dendrite arm spacing (DAS) is dependent on the cooling rate, ϵ , by an equation of the form

$$DAS = k\epsilon^{-n}$$

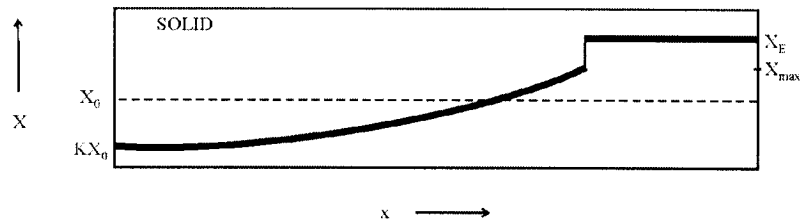
where k = constant. Suppose for Al-4.9% Cu, DAS was measured as 100 and 10 μm at the cooling rates of 0.1 and 60 K/s, respectively.

- (i) Determine k and n for the alloy (3)
- (ii) What cooling rate is necessary to reduce the arm spacing to 1 μm ? (3)
2. (a) During solidification

$$K = \frac{X_S}{X_L}$$

- (i) How does solute composition of the solid and remaining liquid vary during solidification when $K < 1$? (2)
- (ii) How does solute composition of the solid and remaining liquid vary during solidification when $K > 1$? (2)

- (b) The composition profile at T_E (eutectic temperature) and below during solidification in a single phase alloy, of initial composition X_0 , with no diffusion in the solid but perfect mixing in the liquid is shown below.



- (i) Discuss how this composition profile develops. (6)
 (ii) If the solute balance is

$$(X_L - X_S)df_S = (1 - f_S)dX_L$$

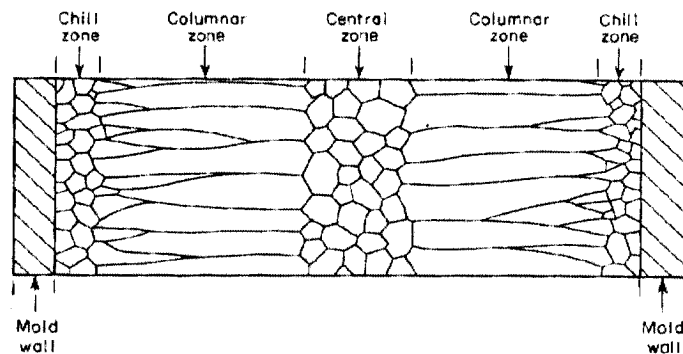
Show that

$$X_S = KX_0(1 - f_S)^{(K-1)}$$

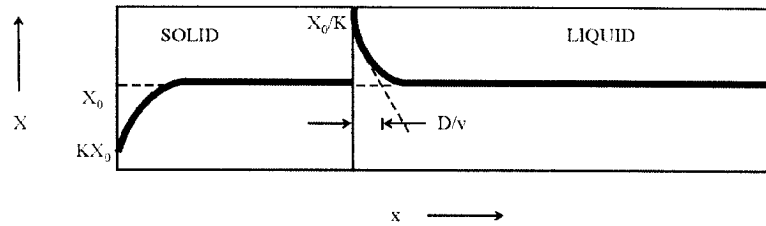
$$X_L = X_0 f_L^{(K-1)}$$

(10)

3. (a) Distinguish between a normal, and an anomalous eutectic structure; use appropriate sketches. (4)
 (b) What are off-eutectic alloys and which microconstituents would be expected in them? (4)
 (c) Solidification zones in ingots and castings are depicted below.



- (i) Describe in detail the factors leading to the development of each one of these zones. (7)
 (ii) By examining the central and columnar zones, which one is likely to have anisotropic properties? Why? (5)
4. (a) Describe how the difference in composition between the solid and remaining liquid during solidification has been utilized in purifying semi-conductor materials. (5)
 (b) For the case of no diffusion in the solid and only diffusional mixing in the liquid (but no convection), the following composition profile may exist above the eutectic temperature for an alloy of initial composition X_0 .



$$X_L = X_0 \left\{ 1 + \frac{1-K}{K} \exp - \left[\frac{x'}{D_L/v} \right] \right\}$$

- (i) Show why the initial solid composition is KX_0 and state why this eventually increases to X_0 . (5)
- (ii) Show why the liquid composition at the interface is X_0/K and why this eventually decreases to X_0 . (5)
- (iii) What is D_L/v and what is its significance? (5)
5. (a) Explain the usage of the following foundry materials when making sand moulds. (2)
- (i) Sand (2)
- (ii) Binder (2)
- (iii) Water (2)
- (b) What materials are used for pattern making? (3)
- (c) What is die casting? (3)
- (d) Describe, with the aid of appropriate sketches, how a sand mould is made. (8)
6. (a) What is the primary function of a riser? (3)
- (b) What are the three distinct volume reductions accompanying the transformation from liquid to solid? (3)
- (c) State three conditions that a riser must fulfil for it to be effective. (3)
- (d) List four comparative advantages of a blind riser. (4)
- (e) An equation due to Chvorinov is used to estimate the relative solidification of riser and casting

$$t_s = K \frac{V_c^2}{A_c^2} = KM_c^2$$

- (i) What are the various parameters in this equation? (2)
- (ii) On the basis of this equation, what is the optimum riser shape? (3)
- (iii) Why is the optimum shape in part (ii) not utilized in casting? (2)

**THE UNIVERSITY OF ZAMBIA
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UNIVERSITY EXAMINATION

JULY 2014

MET 5469: PROCESS DESIGN

TIME : THREE HOURS

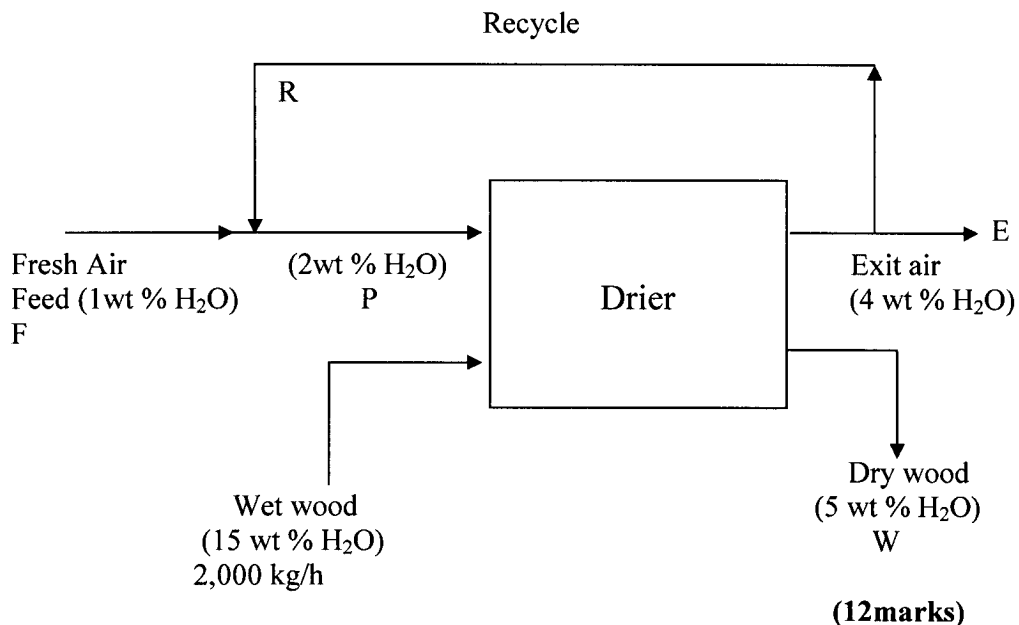
ANSWER : 5 QUESTIONS

Additional information is provided with the examination paper.

Where applicable, all calculations are to be done correct to three decimal places.

1. (a) Distinguish between external and internal constraints in process design. Comment on one of each. **(4 marks)**
 (b) Deduce the number of design variables and how they may be utilized for a stream separator, assuming all streams being liquid. **(4 marks)**
 (c) An annealing furnace uses a fuel oil containing 12.0 wt% H and 88.0 wt% C. It is proposed to fire this furnace with 25% excess air. If 10 wt% of the total carbon burns to CO only, calculate the flue gas analysis in mole %. Take 1 kg of fuel as a basis.
 Atomic masses: H, 1; C, 12; O, 16; N, 14. **(12marks)**

2. (a) Comment on the concept of design variables in process design. **(4 marks)**
 (b) Deduce the number of design variables for a cooler and show how they may be utilized. **(4 marks)**
 (c) In a wood drier, the hot air must contain at least 2 weight per cent water to prevent the wood from drying too rapidly and splitting. The original fresh air fed contains 1wt % water. Wood is dried from 15 wt % water to 5 wt % water. The air leaving the drier contains 4 weight percent water. Calculate the amount of wet air that must be returned to the drier if two tonnes (2000 kg) per hour of wet wood is dried. The flow diagram is as below:



3. (a) Briefly comment on regenerative heat exchangers.

(3 marks)

(b) For a system with a combination of n inlets and outlets, a general statement of the First Law is

$$dE' = \delta q - \delta w + \sum_{i=1}^n \delta m_i (u_i + P_i v_i + \bar{v}_i^2 / 2 + g z_i)$$

From the above equation, derive the equation $dH' = \delta q$, for a closed system.

(4 marks)

(c) An electric melting furnace is used to melt copper scrap. The scrap is at an initial temperature of 25°C. It is claimed that the overall average power consumption of the furnace is 280 kWh per ton of copper melted. Calculate the amount of heat required assuming that the copper is not only melted but also heated to a final temperature of 1200°C. Estimate the thermal efficiency of this furnace in percent.

Melting point of copper: 1083°C

Heat of fusion of copper: 12,970 J/mol

C_p for Cu(l) = 22.64 + 6.28x10⁻³T J/mol.K

C_p for Cu(s) = 31.38 J/mole.K

Atomic weight of Cu : 63.55

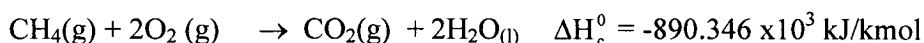
1 Wh : 3600 J

(13marks)

4. (a) Illustrate, with sketches, the temperature profiles of the fluids as a function of the distance along the flow path for a *parallel flow exchanger*, *counterflow exchanger*, an *evaporator* and a *condenser*. The hot fluid in each case is on the shell side.

(5 marks)

(b) A gas stream of 500 kmol/h of CH₄ at 101.32 kPa and 373 K is burned in a furnace using air at 313 K. The combustion is complete and 50% excess air is used. The stack gas leaves the furnace at 700 K. **Calculate the heat removed in the furnace.** The combustion reaction for CH₄ at 298 K is as follows:



Latent heat of vaporisation of water at 100°C and 760 mm Hg is 40,683 kJ/kmol. The specific heat capacity of liquid water is 75.2 kJ/kg.K; the mean specific heat capacity of air is 29.1 kJ/kmol.K

The mean specific heat capacity data are as follows:

Gas	c_p (in kJ/kmol.K)
CO ₂	44.4
H ₂ O	35.1
O ₂	31.2
N ₂	29.9

(15marks)

5. (a) Illustrate with sketches the flow path arrangements for a single-shell pass two-tube pass counterflow and a two-shell pass four-tube pass counterflow.

(3 marks)

(b) The design heat load for an oil cooler is $q = 500 \text{ kW}$. Calculate the heat transfer area, A , required if the inlet and outlet temperature differences are 40°C and 15°C respectively. The average value of the heat transfer coefficient is $U_m = 500 \text{ W}/(\text{m}^2 \cdot ^\circ\text{C})$.

(4 marks)

(c) It is desired to warm oil of specific heat $2.0 \text{ kJ}/\text{kg} \cdot \text{K}$ from 300 K to 325 K by passing it through a tubular heat exchanger with metal tubes of inner diameter 10 mm . Along the outside of the tubes flows water of specific heat $4.2 \text{ kJ}/\text{kg} \cdot \text{K}$, inlet temperature 372 K and outlet temperature 361 K . The overall heat transfer coefficient from water to oil, based on the inside area of the tubes, may be assumed constant at $230 \text{ W}/\text{m}^2\text{K}$ and 75 g/s of oil is passed through each tube.

The oil is to make two passes through the heater. The water makes one pass along the outside of the tubes. Calculate the length of the tubes required.

(9 marks)

(d) A shell-and-tube heat exchanger, of area 25 m^2 , is to cool 6 kg/s of oil [$c_p = 2.0 \text{ kJ}/\text{kg} \cdot ^\circ\text{C}$] from 65°C to 35°C by using 10 kg/s of water [$c_p = 4.2 \text{ kJ}/\text{kg} \cdot ^\circ\text{C}$] at an inlet temperature of 20°C . The average heat transfer coefficient is $U_m = 600 \text{ W}/(\text{m}^2 \cdot ^\circ\text{C})$. Calculate the effectiveness and the exit temperatures of the fluids for a counterflow heat exchanger.

(4 marks)

6. (a) Data for the filtration of CaCO_3 in water at 298 K and a constant pressure of $46.2 \text{ kN}/\text{m}^2$ are presented in the table. The area of the plate-and-frame press was 0.044 m^2 . Calculate the constant R_m . Data are given as $t_f =$ time in seconds and $V_f =$ volume of filtrate collected in m^3 . The viscosity of the water at 298 K is $0.89 \times 10^{-3} \text{ Pa} \cdot \text{s}$.

$V_f \times 10^3$	t_f	$V_f \times 10^3$	t_f	$V_f \times 10^3$	t_f
0.5	17.3	1.0	41.3	1.5	72.0
2.0	108.3	2.5	152	3.0	201.7

Use the following additional information:

$$P = (K_1 V + K_2) q$$

where $K_1 = \frac{s\rho\mu\alpha_{av}}{(1-ms)A^2}$ and $K_2 = \frac{R_m\mu}{A}$

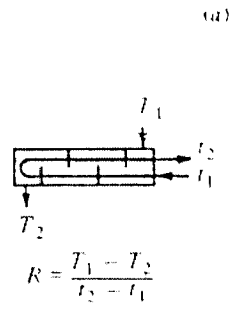
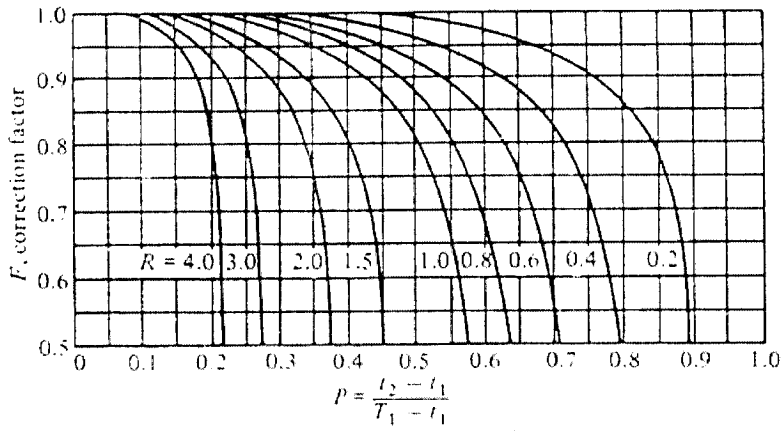
(12 marks)

(b) The slurry in part (a) is to be filtered in a plate-and-frame press having an area of 26 m^2 . The same pressure of $46.2 \text{ kN}/\text{m}^2$ will be used in constant pressure filtration. Assuming the same filter properties and filter cloth, calculate the time to recover 2.26 m^3 of filtrate.

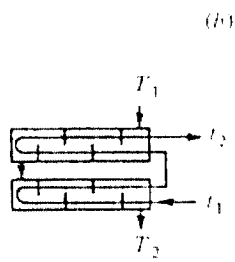
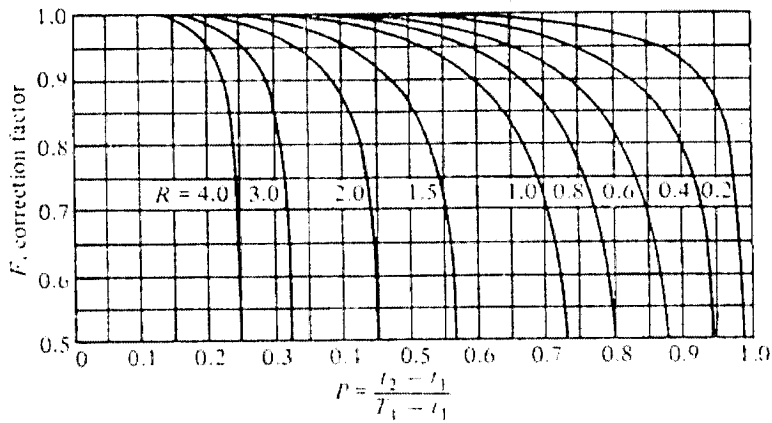
$$K_1 = \frac{K_3}{A^2} \quad \text{and} \quad K_2 = \frac{K_4}{A}$$

(8 marks)

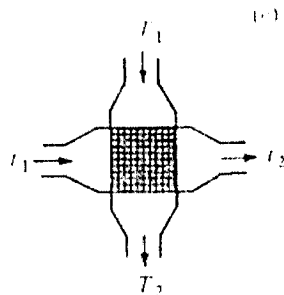
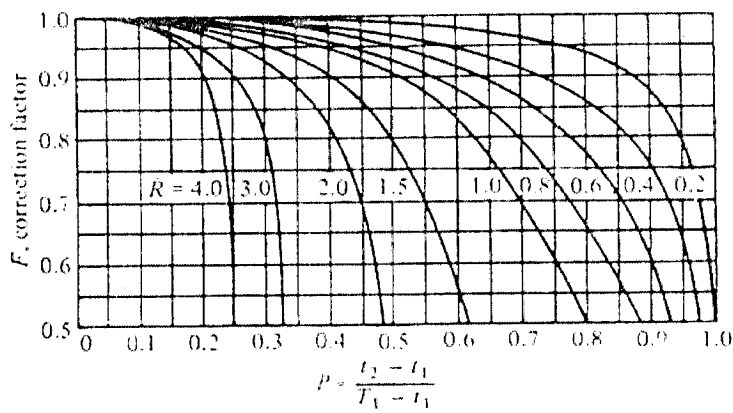
END OF EXAMINATION IN MET 5469



$$R = \frac{T_1 - T_2}{t_2 - t_1}$$



$$R = \frac{T_1 - T_2}{t_2 - t_1}$$



$$R = \frac{T_1 - T_2}{t_2 - t_1}$$

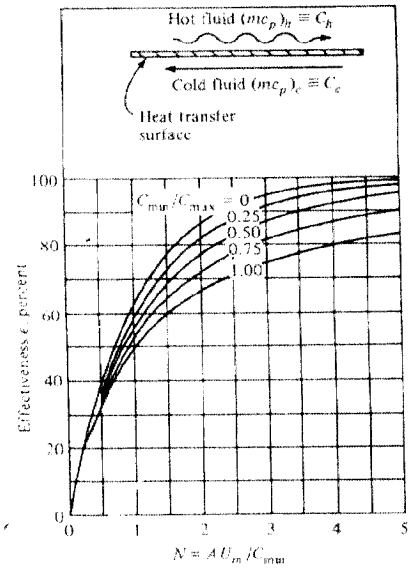


Figure 11-18 Effectiveness for a counterflow heat exchanger. (From Kays and London [10].)

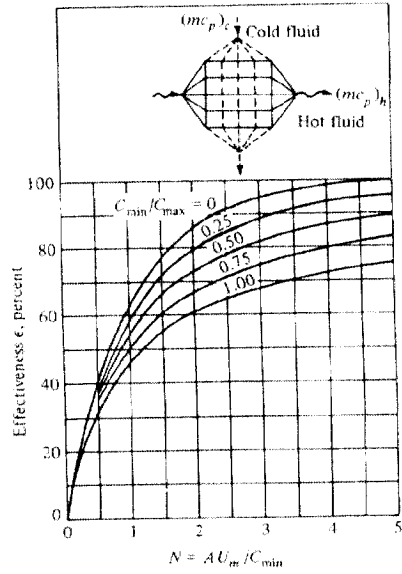


Figure 11-19 Effectiveness for a cross-flow heat exchanger, both fluids unmixed. (From Kays and London [10].)

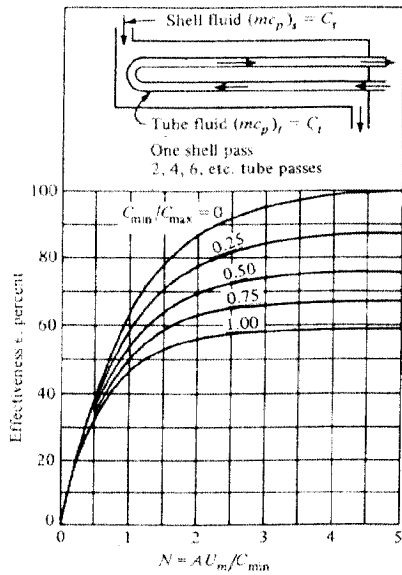


Figure 11-20 Effectiveness for a single shell pass heat exchanger with two, four, six, etc. tube passes. (From Kays and London [10].)

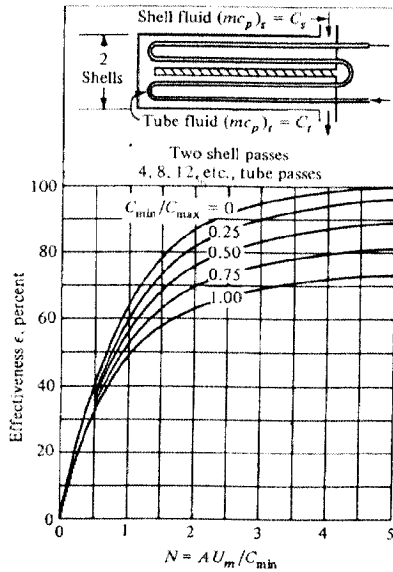
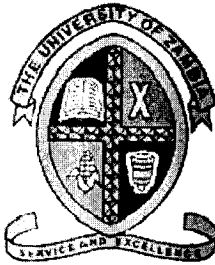


Figure 11-21 Effectiveness of a two shell pass heat exchanger with four, eight, twelve, etc. tube passes. (From Kays and London [10].)



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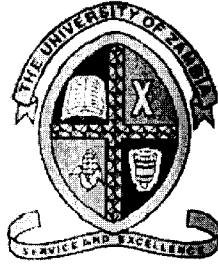
END OF YEAR - FINAL EXAMINATION

COMPUTER TECHNIQUES
MG 319

Date: 28TH JULY, 2014
Time: 09:00hrs – 12:00hrs
Duration: 3 Hours

Instructions

1. There are **TWO** sections in this paper;
 - a) Answer **ALL** the questions in **Section A**
 - b) Answer **ANY THREE (3)** questions from **Section B**



THE UNIVERSITY OF ZAMBIA
School of Mines

END OF YEAR - FINAL EXAMINATION

COMPUTER TECHNIQUES
MG 319

Date: 28TH JULY, 2014
Time: 09:00hrs – 12:00hrs
Duration: 3 Hours

Instructions

1. There are **TWO** sections in this paper;
 - a) Answer **ALL** the questions in **Section A**
 - b) Answer **ANY THREE (3)** questions from **Section B**

SECTION A: Multiple Choice – 40 Marks

1. What is the output of executing this code?

```
int i;  
for(i = 0; i<5; i++){  
  
}  
System.out.println(i);
```

- a. 12345
 - b. 5
 - c. 0
 - d. None of the above.
2. In Java which of the following is not a reserved word?
- a. while
 - b. For
 - c. int
 - d. double
3. Which of the following is not a legal identifier?
- a. _test
 - b. 7UP
 - c. \$100
 - d. Dmz
4. In which method ~~is~~ does the execution of a program start?
- a. println method
 - b. static method
 - c. void method
 - d. main method
5. What ~~is~~ the correct signature or heading of the main method;
- a. public static void main(string[] args)
 - b. public static void Main(String[] args)
 - c. public void main(String[] args)
 - d. public static void main(String[] args)
6. By convention, Java class names..
- a. must start with an uppercase letter
 - b. must start with a lowercase letter

- c. can start with a number
 - d. can include a '+' symbol
7. Which method do you use to print something and immediately take the cursor to the next line?
- a. Print()
 - b. Println()
 - c. printf()
 - d. println()
8. What is the correct order of increasing number of bits used by the following integral types in Java?
- a. byte, short, long, int
 - b. short, byte, int, long
 - c. byte, int, short, long
 - d. byte, short, int, long
9. By convention, Java method names..
- a. must start with an uppercase letter
 - b. must start with a lowercase letter
 - c. can start with a number
 - d. can include a '+' symbol
10. What is the effect of the '\t' character?
- a. It is a carriage return
 - b. Has the same effect as the enter key
 - c. Has the same effect as a tab key
 - d. Has the same effect as a space key
11. What effect has the '\n' character?
- a. Has the same effect as the enter key
 - b. Has the same effect as a tab key
 - c. Has the same effect as a space key
 - d. It is not recognised in Java.
12. What is the output of running the code below?

```
int i = 5;
int j = 10;
int temp = i;
i = j;
j = temp;
System.out.println("i = "+i+" j is "+j);
```

- a. i is 10
j is 5
- b. i is 10 j is 5
- c. j is 5 i is 10
- d. i is 5 j is 10

13. Suppose the `int temp = i;` and `j = temp;` statements are omitted from the code above, what will be the output

- a. Same as above
- b. i is 5 j is 5
- c. j is 5 i is 10
- d. i is 10 j is 10

14. Suppose the program is stored in the correct file. What command do you use to compile it?

```
public class MG319 {
    public static void method1(){
        System.out.println("Java is good!");
    }
}
```

- a. `Javac MG319`
- b. `Javac MG319.java`
- c. `Java MG319`
- d. `Java MG319.java`

For the next five questions, select the correct output of the pieces of code given.

15.

```
System.out.print("Mandela\n");
System.out.println("Nelson");
```

- a. Mandela Nelson.
- b. Mandela Nelson
- c. MandelaNelson
- d. Mandela
Nelson

```
System.out.println("Obama");
```

16.

```
System.out.print("Barak");
```

- a. ObamaBarak
- b. Barak Obama
- c. Obama Barak
- d. Obama
Barak

```
System.out.print("I\nlove");
```

17.

```
System.out.print("Java");
```

- a. I
Love Java
- b. I LoveJava
- c. I love
Java
- d. I
loveJava

```
System.out.print("Garvey");
```

```
System.out.print("\nMarcus");
```

18.

- a. Garvey\nMarcus
- b. Garvey Marcus
- c. Garvey
\nMarcus
- d. Garvey
Marcus

```
boolean print = true;
```

```
int x = 1;
```

```
do{
```

```
    System.out.print(x);
```

```
    x = x*10;
```

```
    if (x == 100) print = false;
```

```
}
```

19.

```
while(print==false);
```

- a. xx10
- b. 110100

- c. 1 10 100
- d. False

```
public class CircularQueue{  
    public void mysteryMethod() {  
        System.out.print("test");  
    }  
}
```

20.

- a. CircularQueue
- b. mysteryMethod
- c. test
- d. none of the above

SECTION B: Choose three out of four questions

1.

- i. Draw a labeled diagram illustrating how the various hardware components of the computer are interconnected and how the flow of communication goes
- ii. Define What an Operating System is?
- iii. List the five functions of Operating Systems?
- iv. Give three examples of Operating System.

2.

- i. What is Software? [4 Marks]
- ii. Differentiate between the following giving examples if possible.
- iii. Systems software and application Software.
- iv. General purpose software and Specialised software.

3.

- i. What are the five methods of acquiring software?
- ii. What is an Operating system?
- iii. Draw a labeled diagram illustrating the components of an Operating System
- iv. Describe the two modes of interface that operating systems offer the users for interacting with the computer, giving examples.
- v. Give two examples of popular Operating Systems.

4.

- i. Define what a spreadsheet is?
- ii. Give four common features of a spreadsheet
- iii. What is a Database Management System (DBMS)
- iv. Give four functions of a DBMS

UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATION – JULY 2014

MIN 2019 INTRODUCTION TO MINING

INSTRUCTIONS: **ANSWER QUESTION 1 AND ANY FIVE (5)** TOTAL MARK: 100
TIME: **3 HOURS** CLOSED BOOK

- Q1.** (a) There are sequences of activities involved in modern mining which is known as stages in the life of a mine. Name these stages and explain briefly the purpose and procedure involved in each stages. **(10 marks)**
- (b) What are the major factors need to be considered in estimating (i) the height of the head gear, (ii) diameter of a circular shaft, (iii) depth of the shaft and (iv) size of the cage for the purpose of hoisting and lowering men and material? **(10 marks)**
- Q2.** The entire methods of mining currently in use are grouped in four major classes. These are surface mining, underground mining, novel methods of mining and solution mining. Name all the subdivisions under each method. **(16 marks)**
- Q3.** Although surface mining has several advantages over underground mining, still underground mining is recommended under certain situation. Write the situation and give three advantages of underground mining and three disadvantages of surface mining. **(16 marks)**
- Q4.** It is intended to access a mineral deposit lying at a depth of 800m from the surface using a circular shaft. Write clearly;
- (i) the details of explosives of explosive you would recommend, type of detonators, amount of explosive in each blast hole
- (ii) the drill method for drilling blast holes
- (iii) how would you to ensure that the shaft being sink is truly vertical
- (iv) Arrangement of blast holes assuming the finished diameter of the hole is equal to 6.0m. **(2.5x4=10 marks)**
- Q5.** Explain with the help of a neat diagram what is meant by “pressure arch dome” and its significance in mining. How the total load of loose and broken rocks enclosed in this dome is estimated? **(16 marks)**

- Q6.** (a) What is the purpose of (i) artificial ventilation and (ii) artificial support in underground mines? **(7 marks)**
- (b) How would you ensure that every person present in underground are:
- (i) Getting cool and fresh air in which oxygen content is not less than 19%.
 - (ii) Air does not contain dust more than the prescribed limit as required by Mine Regulation.
 - (iii) Temperature of air is comfortable. **(3x3=9 marks)**
- Q7.** For safe, efficient and economic running of a mine it is necessary to have an organization chart having different responsibilities assigned to them. Draw a standard chart for a modern mine for mining and processing plant personals. **(16 marks)**

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS – JULY 2014

MIN 3029 - BASIC ROCK MECHANICS

TIME: **THREE (3) HOURS**

Total Marks: **100**

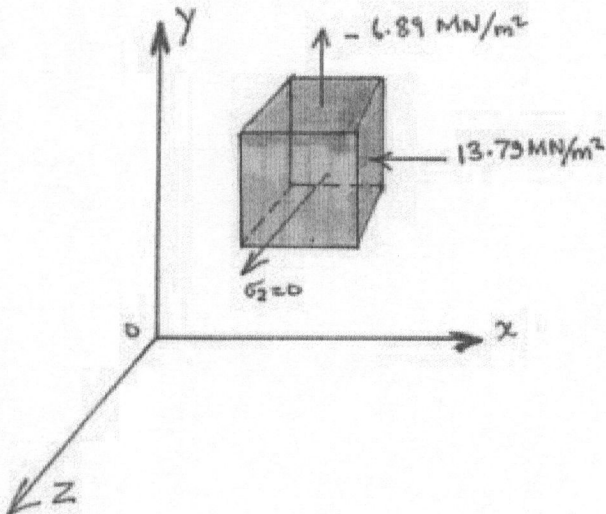
INSTRUCTIONS: **ANSWER FIVE QUESTIONS.**

CLOSED BOOK

CALCULATORS AND DRAFTING EQUIPMENT ALLOWED

Question One

At a point in a rock mass, the major principal stress in the X-direction is 13.79 MN/m^2 , the minor principal stress in the Y-direction is -6.89 MN/m^2 i.e tension, and the intermediate principal stress in the Z-direction is equal to zero;



Given that: Young's Modulus $E = 34.50 \text{ GN/m}^2$
Poissons Ratio $\mu = 0.2$

- (a) Calculate the strains in the X, Y and Z directions **(9 Marks)**
- (b) Would you expect with a biaxial stress condition that there would be a biaxial strain condition? Explain your answer. **(3 Marks)**
- (c) What would you mean by a plane strain condition? **(2 Marks)**
- (d) Plot the stresses acting on the XY, YZ and ZX planes on a Mohr diagram. **(6 Marks)**

(Total Marks 20)

Question Two

The application of a force to a surface of a body produces deformations in the body and as a result, the surface on which the force acts moves as the force is applied. Thus a certain amount of work is done on the body. For perfectly elastic materials, this work is converted to potential energy of strain.

- (a) A bar of length L m, and area of cross section A m² and Young's Modulus E N/m², is stretched by a force of T Newtons applied at each end. Derive expressions for the strain energy density W and the total strain energy stored in the bar. **(10 Marks)**
- (b) Find the greatest amount of strain energy per unit volume that can be stored in a rock specimen subjected to uniaxial compressive stress without producing permanent deformation. Take the elastic limit to be 100Mpa and Young's Modulus as 70Gpa. The cylindrical specimen has a diameter of 5.5cm and length 11.0cm. **(10 Marks)**

(Total Marks 20)

Question Three

The stress components at a point P in a stressed body are given with respect to the XYZ coordinate system by the matrix:

$$\begin{matrix} 14 & 7 & -7 \\ 7 & 21 & 0 \\ -7 & 0 & 35 \end{matrix} \text{ MPa}$$

- (a) Determine the magnitudes of the normal stress component and the shear stress acting on the plane whose normal has direction cosines:

$$\left(\frac{1}{3}^{1/2} \quad \frac{1}{3}^{1/2} \quad \frac{1}{3}^{1/2} \right) \quad \text{(10 Marks)}$$

- (b) Define the following terms using diagrams where appropriate:

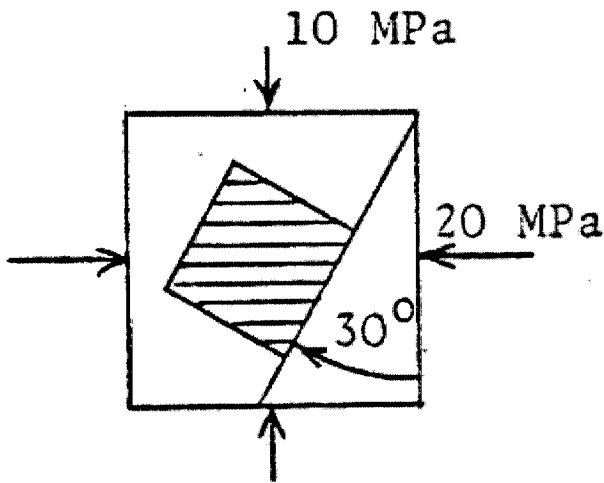
- (i) Field Stress
- (ii) Isostasy
- (iii) A Kelvin Material
- (iv) Anisotropy
- (v) Effective Stress
- (vi) Pure Shear

(10 Marks)

(Total Marks 20)

Question Four

Given below is a rock specimen under loading as shown:

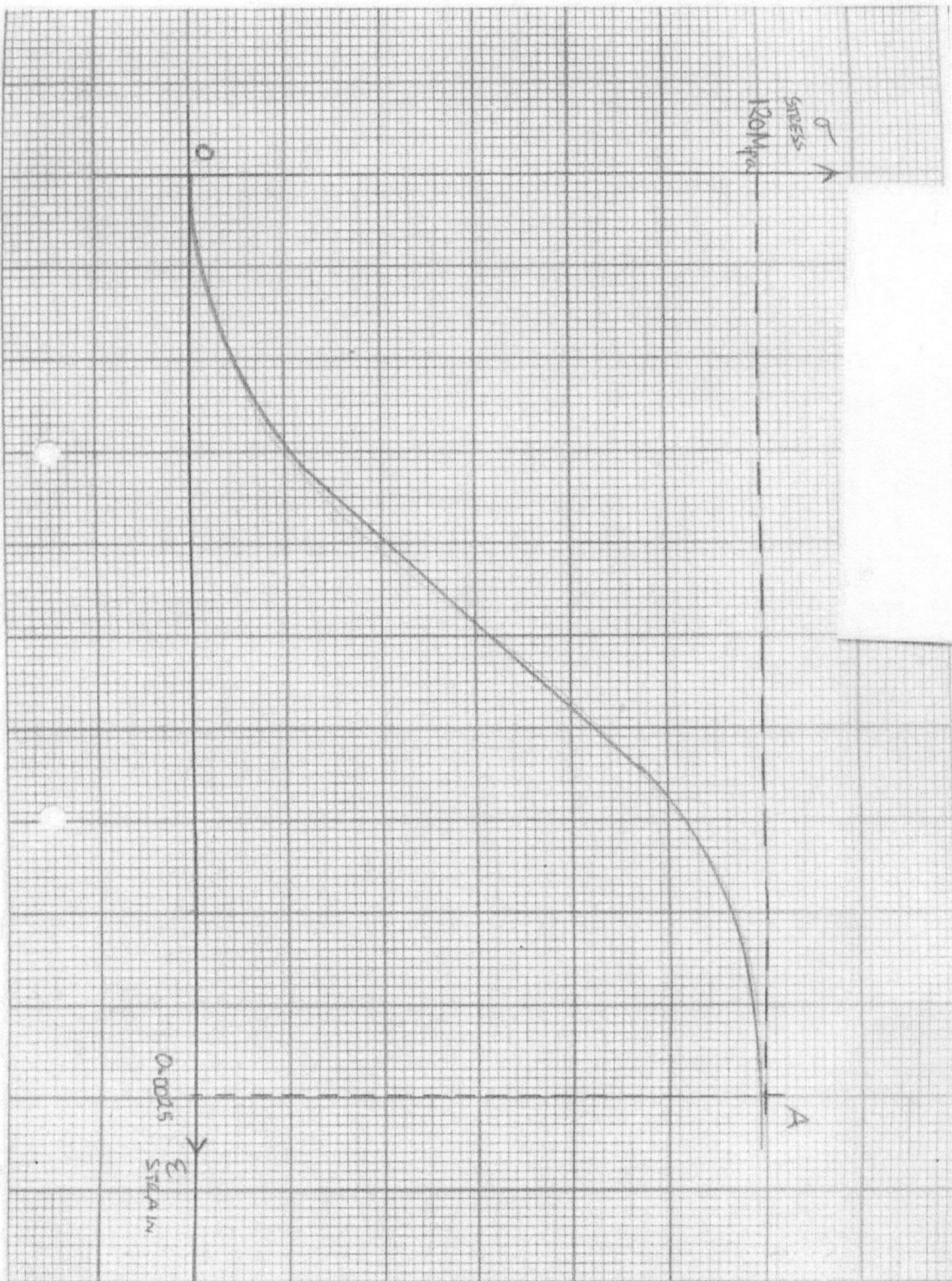


- (i) Calculate and sketch the stresses on the element inclined 30° to the principal stresses as shown. **(14 Marks)**
 - (ii) Use Mohr Circle (Graphical solution) to determine the stresses in (i) of question Four above. **(6 Marks)**
- (Total 20 Marks)**

Question Five

- (i) Using sketches and/or appropriate diagrams, describe the three most common ways of specifying Young's Modulus highlighting the situations where they find their best application. **(10 Marks)**
- (ii) Given the graph attached, depicting non-elastic rock behaviour of a rock under uniaxial compression, calculate the various moduli that would be associated with this deformation curve. **(10 Marks)**

(Total Marks 20)



END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS – JULY 2014

MIN 3059 – MINERAL ECONOMICS

INSTRUCTIONS:	ANSWER <u>ALL</u> QUESTIONS	TOTAL MARK: 100
TIME:	3 HOURS	CLOSED BOOK

Question 1

- (i) Explain the difference between (a) accounting costs and (b) accounting and economic profit. [4 Marks]
- (ii) Define normal profit and explain the relationship between total profit, normal profit and economic profit. [4 Marks]
- (iii) Explain the relationship between (a) the average product and marginal product of a variable factor of production employed by a firm and (b) the firm's shortrun average cost and marginal cost. [4 Marks]
- (iv) Discuss economies and diseconomies of scale. [4 Marks]
- (v) (i) Explain the long average cost curves. [2 Marks]
(ii) Why a company should produce where the marginal cost is equal to marginal revenue. [2 Marks]

Question 2

- (i) Use a diagram to show that perfectly competitive firms are price takers. How are prices determined in the perfectly competitive markets? [6 Marks]
- (ii) Why should a firm increase the quantity of its output even though the marginal cost is increasing. [7 Marks]
- (iii) Explain the relationship under perfect competition between
 - (a) total revenue and marginal revenue. [3.5 Marks]
 - (b) total revenue and average revenue. [3.5 Marks]

Question 3

- (i) Discuss the meaning of market structure. [6 Marks]
- (ii) Summarise the main features of market structure of main types of markets: Perfect competition, monopolistic competition, oligopoly and monopoly. [8 Marks]
- (iii) Discuss the main barriers to market entry. [6 Marks]

Question 4

- (i) What do you understand by price discrimination? [6 Marks]
- (ii) Discuss first degree, second degree and third degree price discrimination. [6 Marks]
- (iii) Discuss the main features of natural monopolies. [8 Marks]

Question 5

- (i) Discuss the major features of oligopolies. [8 Marks]
- (ii) Why do cartels normally fail? [6 Marks]
- (iii) Why do cartels advertise and diversify? [6 Marks]

END OF EXAMINATIONS

**THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS – JULY 2014**

MIN 5019 – GEOTECHNICAL ENGINEERING

TIME: **THREE (3) HOURS**

Total Marks **100**

INSTRUCTIONS: **ANSWER ALL QUESTIONS**

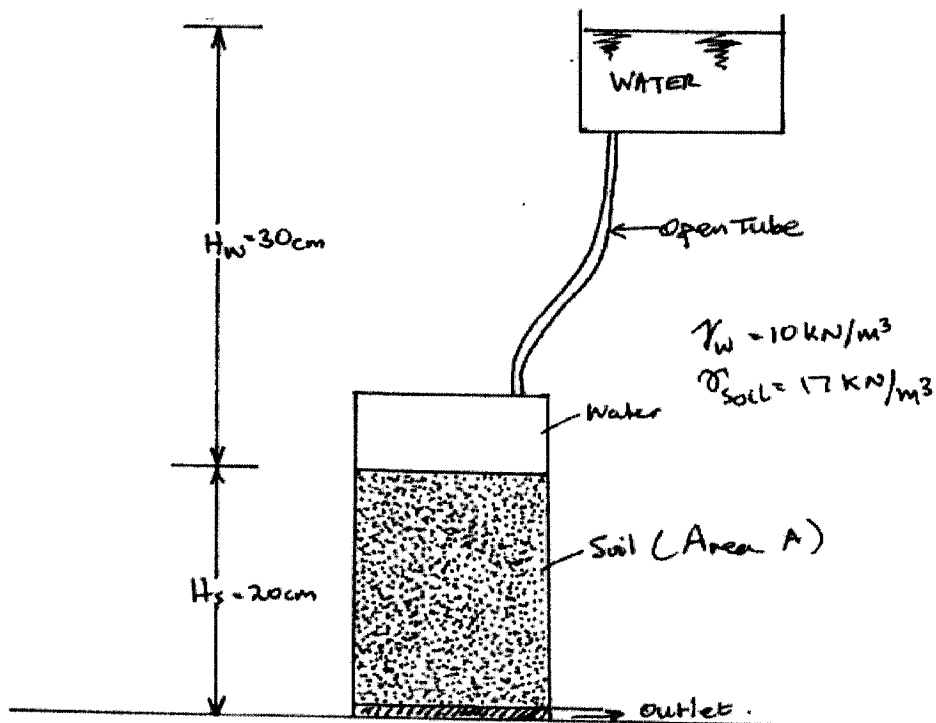
CLOSED BOOK

Question One

A laboratory constant head permeability test is shown in diagram 1. The sample area A is 80cm^2 .

- (a) If the quantity of flow l through the sample is given as $4 \times 10^{-6} \text{ m}^3/\text{sec.}$, calculate the coefficient of permeability K .
- (b) Calculate the effective vertical stress in the soil just above the filter as $\sigma^1 = \sigma_v - \mu$, and as $\sigma^1 = zy + iz\gamma_w$

If these are not numerically identical, explain why. **(20 marks)**
(Refer to Sketch below)



Constant head permeability Test.

Question Two

- (a) Discuss the modes of failure of slopes in case of open cut mining pit consists of weathered, weak rock and soil. How can such failures be controlled? **(10 marks)**
- (b) An open pit bank consists of soil and weakened rock has been analyzed by slip circle technique and expected to have base failure. Calculate the factor of safety (a) during the dry condition and (b) during the rainy season when soil is saturated.

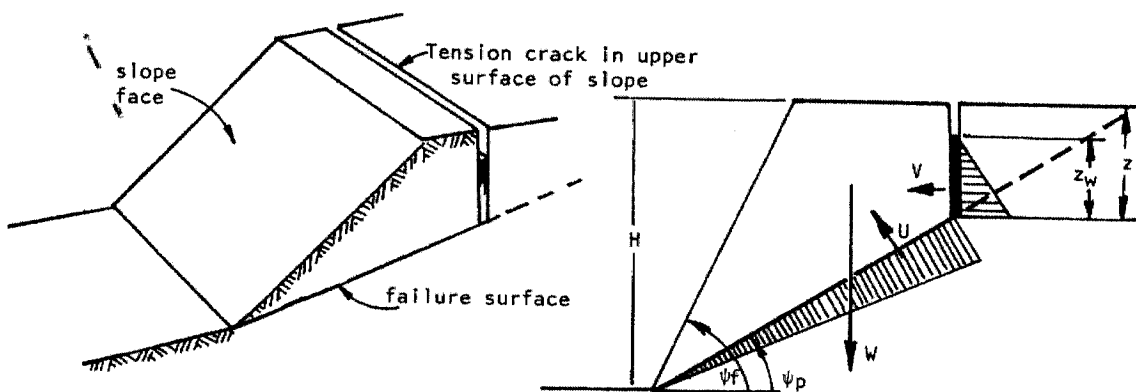
Rock soil property and the dimensions of the bank is given below.

- Rock-soil specific weight = 16.8kNm⁻³
- Rock-soil cohesion = 5.36kPa
- Rock-soil internal friction angle = 15°
- Pit slope = 32°
- Bank height = 24m
- Depth rock ledge = 36m

(10 marks)

Question Three

A 50m high slope with a face angle of 60° is found to have a bedding plane running through it at a dip of 30°. A tension crack occurs 15m behind the crest of the slope and from an accurately drawn cross section of the slope, the tension crack is found to be a depth of 20m.



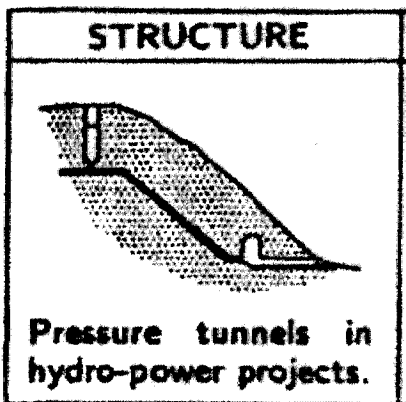
The unit weight of the rock is $\gamma = 30\text{KN/m}^3$ and that of the water $\gamma_w = 9.81\text{KN/m}^3$. Assuming that the cohesive strength of the bedding plane $C = 50.50\text{KN/m}^2$ and the friction angle $\phi = 30^\circ$.

- (a) Find the influence of the water level Z_w upon the Factor of Safety of the slope.
- (b) Find the Factor of Safety of the slope graphically if the tension crack is only half full of water.
- (c) Make general comments/observations on your findings.

(20 Marks)

Question Four

Pressure tunnels are extremely important structures when it comes to the development of hydroelectricity for economic development hydro power is considered clean energy due to its minimum pollution of the environment apart from its potential to sterilise large expanses of land.



Discuss the following in relation to the construction of pressure tunnels in Hydro-Power projects.

- (i) Typical problems
- (ii) Critical parameters
- (iii) Methods of analysis
- (iv) Acceptability criteria

(20 Marks)

Question Five

Water has potentially disastrous effects when present in rock slopes and mayn other earth works including other natural earth structures.

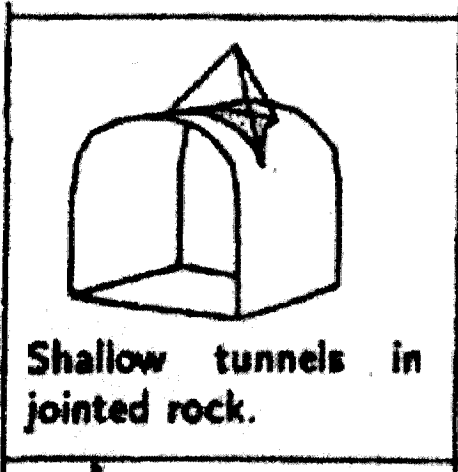
Write short notes on the following in as far as the influence of rain and ground on stability of earth works is concerned:

- (i) Dry Slopes
- (ii) Water in slope tension crack
- (iii) Water in tension crack only
- (iv) Water in tension crack and on sliding surface
- (v) Saturated slope with heavy re-charge.

(20 Marks)

Question SIX

Shallow tunnels find common use in transportation systems for crossings, rail transport, water reticulation systems and a hoist of other uses.

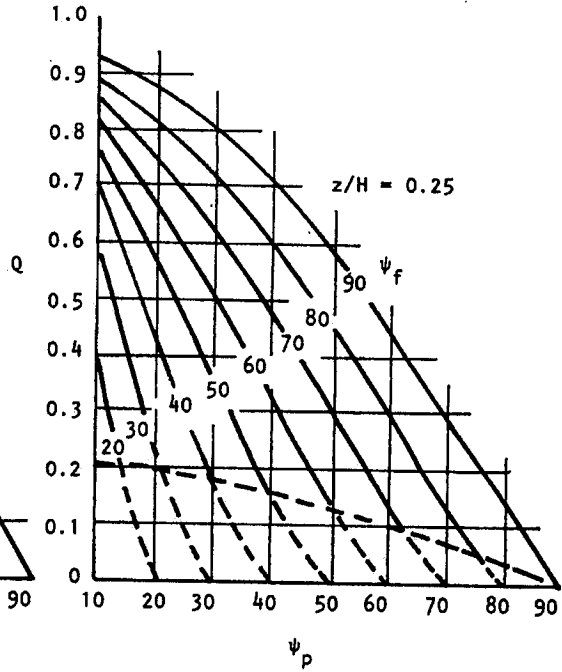
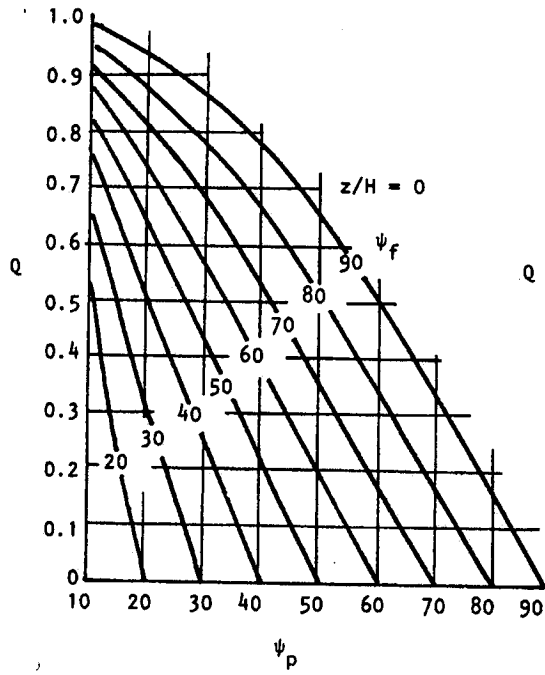


Discuss the use of shallow tunnels in jointed rock under topics given below:

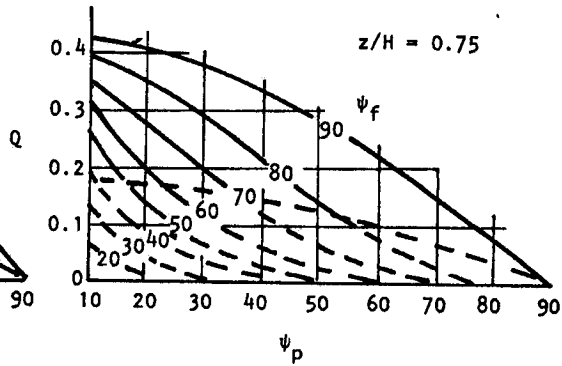
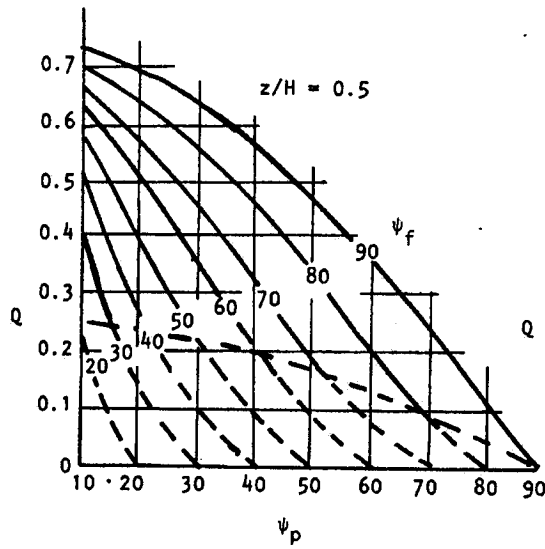
- (i) Typical problems
- (ii) Critical parameters
- (iii) Methods of analysis
- (iv) Acceptability criteria

(20 marks)

END OF EXAMINATION



Note:
Dashed lines refer to tension crack
in slope face.



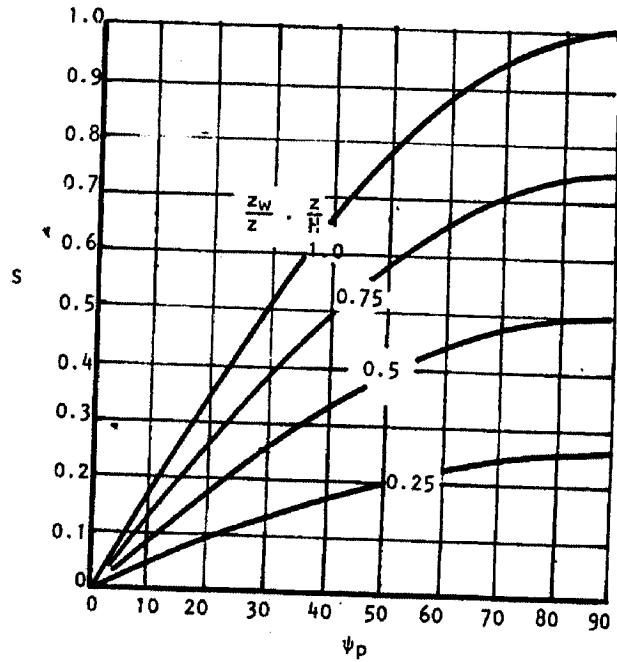
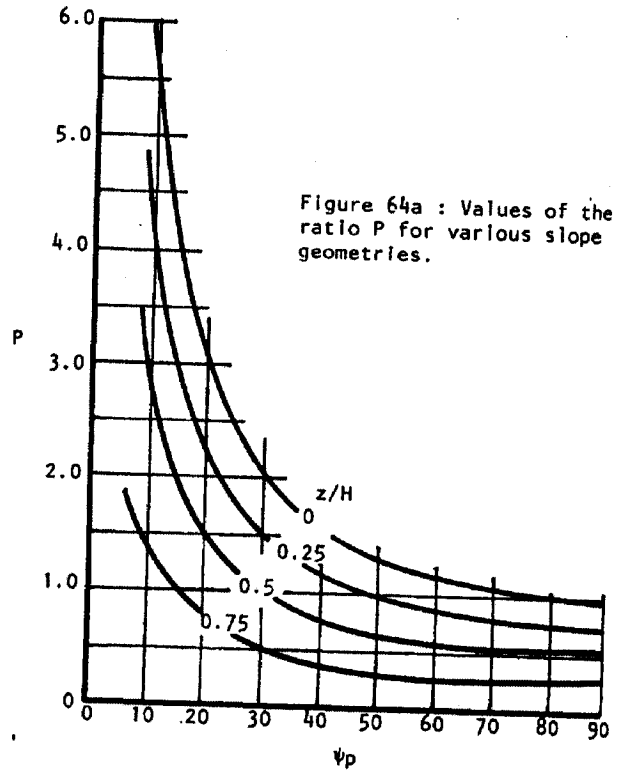
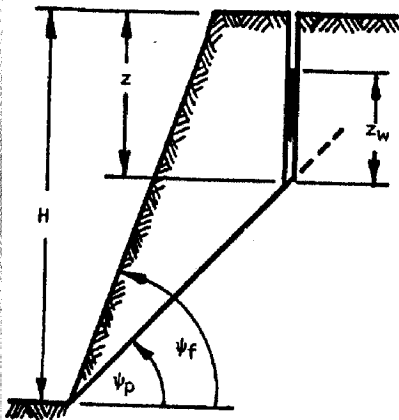


Figure 64b: Values of the ratio S for various geometries

MIN 5019 Geotechnical Engineering

Some Equations

$$F.S = \frac{C.A + (W \cdot \cos \psi_p - U - V \cdot \sin \psi_p) \tan \theta}{W \cdot \sin \psi_p + V \cdot \cos \psi_p}$$

$$W \cdot \sin \psi_p + V \cdot \cos \psi_p$$

$$P = (1 - z/H) \cdot \operatorname{Cosec} \psi_p$$

$$Q = [(1 - (z/H)^2) \cot \psi_p - \cot \psi_f] \sin \psi_p$$

$$Q = [(1 - z/H)^2 \cos \psi_p (\cot \psi_p \cdot \tan \psi_f - 1)]$$

$$R = \gamma_w / \gamma \cdot Z_w / Z \cdot Z / H$$

$$S = Z_w / Z \cdot Z / H \sin \psi_p$$

$$A = (H - Z) \cdot \operatorname{Cosec} \psi_p$$

$$U = 1/2 \gamma_w \cdot Z_w \cdot (H - Z) \cdot \operatorname{Cosec} \psi_p$$

$$V = 1/2 \gamma_w \cdot Z_w^2$$

$$F = \frac{2C / \gamma H \cdot \rho + (Q \cdot \cot \psi_p - R(P + S)) \tan \Phi}{Q + R \cdot S \cot \psi_p}$$

$$Q + R \cdot S \cot \psi_p$$

UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATION – JULY 2014

MIN 5029 – COAL MINING METHODS

INSTRUCTIONS: **ANSWER QUESTION 1 AND ANY FIVE (5) TOTAL MARK: 100**
TIME: **3 HOURS** **CLOSED BOOK**

- Q1 (i) What is the purpose of coal analysis? **(2 marks)**
- (ii) Explain the difference between the proximate analysis and ultimate analysis of coal and write what its significance of these two tests in mining industry? In how many ways the results obtained by proximate analysis can be reported? **(8 marks)**
- (iii) What are the impurities generally present in Run-of-mine (ROM) coal? Describe with the help of a neat diagram how these impurities can be removed? **(8 marks)**
- (iv) What harm can be expected if the coal is marketed unclean? **(2marks)**
- Q2. (a) Explain why is there is variation in the thickness, angle of dip and quality of coal? **(8 marks)**
- (b) There are several geological intrusions generally found in the coal mine. Name three of them and describe briefly their occurrences with the help of diagrams. Also write their detrimental effect on coal and method of working. **(8 marks)**
- Q3. (a) The production capacity of a mine depends on how mine cars (or tubes) are handled at the surface and underground. Write the factors that you would consider to design an ideal surface layout. **(8 marks)**
- (b) Draw a surface layout with run-round arrangement and write the advantage of the system. **(8 marks)**
- Q4. (a) It is universally accepted that the hydraulic mining is the practice of a mine where coal and dust explosions are expected, fire and health hazard is expected. Write at least eight special features of hydraulic mining and its limitations, if any. **(8 marks)**
- (b) Calculate hydraulic energy (E) required and from the data given below.
- Protohydyakowo hardness Index hardness of coal (f) = 2.0
 - Hydraulic energy to break 1 tonne as coal (fissured coal) d = 5kWh
 - Water pressure at the MONITOR (f) = 100kPa
- (8 marks)**

Q5. (a) Explain the difference between a longwall advance and longwall retreat method and write the situation in which they are most suited. **(8 marks)**

(b) Estimate the length of a longwall face to give an annual output of one million tonne from the data given below:

- Height of the seam is 3.5 m but 0.5m is left in the roof due to weak shale.
- Web of DERD shearer = 0.65m
- Assume DERD can cut coal from one end to other three times/shift.
- Number of production shifts = 3/day
- Specific gravity of coal = 1.27 **(6 marks)**

Write the purpose of the stage loader and give its approximate length, the width of the pan generally used at the longwall face **(2 marks)**

Q6. (a) Convergence in longwall roadways is due to the load of overlying strata and the gravitational pull. Explain which causes less convergence between a longwall advance and longwall method of mining. **(8 marks)**

(b) It is possible to predict convergence in underground coal mines. Write the parameters on which this phenomena depends.

Calculate the convergence in a roadway from the data given below:

- Depth of mine = 300m
- Pace index = 6 (weak roof rock)
- Floor index = 2 (wood chocks are used)
- Seam height = 3.0m (under extraction)

Q7. (a) Write the situation in which **the false roof mining method and the horizon method** of mining is most suited. **(7 marks)**

(b) Explain with the help of simple diagrams the concept of extraction of the above two methods. **(7 marks)**

(c) What percentage of coal would you expect to lose by using these two methods? **(2 marks)**

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATION – JULY 2014

MIN 5049 – APPLICATION OF SOFTWARES IN MINING

INSTRUCTIONS: ANSWER ALL QUESTIONS
TIME: 3 HOURS

TOTAL MARK: 100
CLOSED BOOK

SECTION A (THEORY) - 30 Marks

Question 1

Write short notes on the following;

- (i) Segment [2 marks]
- (ii) Digital Terrain Model (DTM) [2 marks]
- (iii) Visualiser [2 marks]
- (iv) Attributes [2 marks]
- (v) Digitizing [2 marks]

Question 2

The Figure 1 below shows a Surpac window which can be classified into 10 different areas / interfaces. Name the 10 areas / interfaces shown. [5 marks]

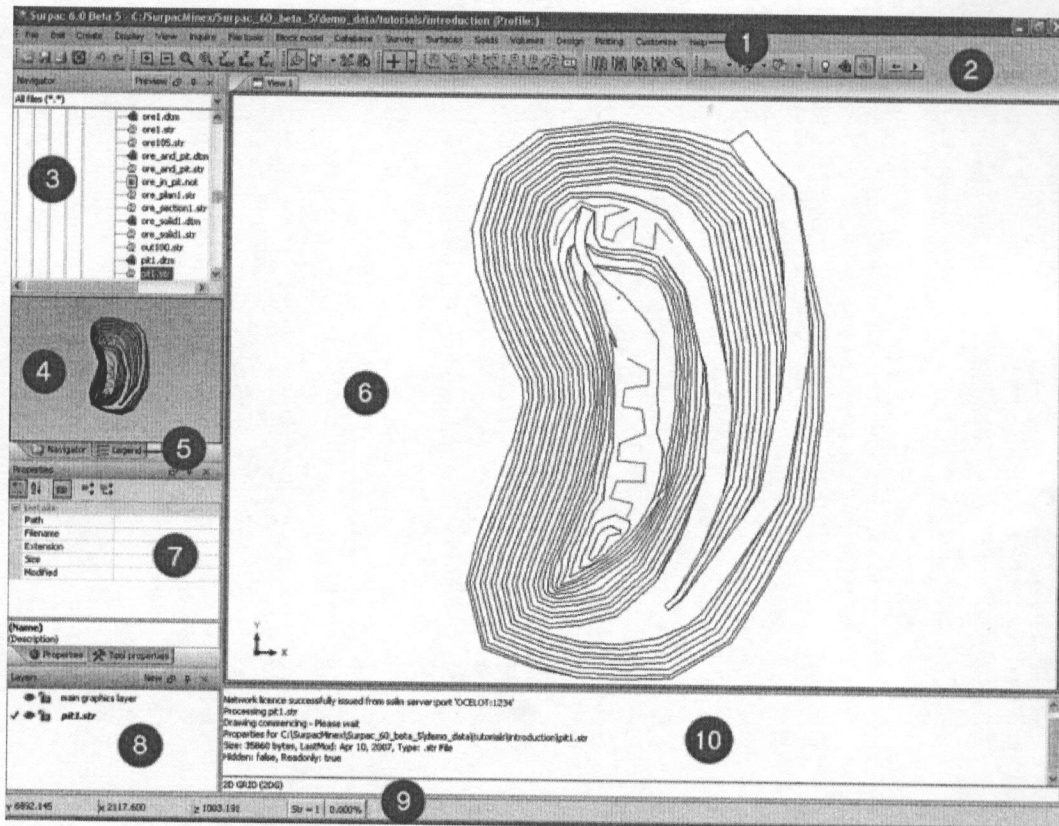


Figure 1: Surpac window

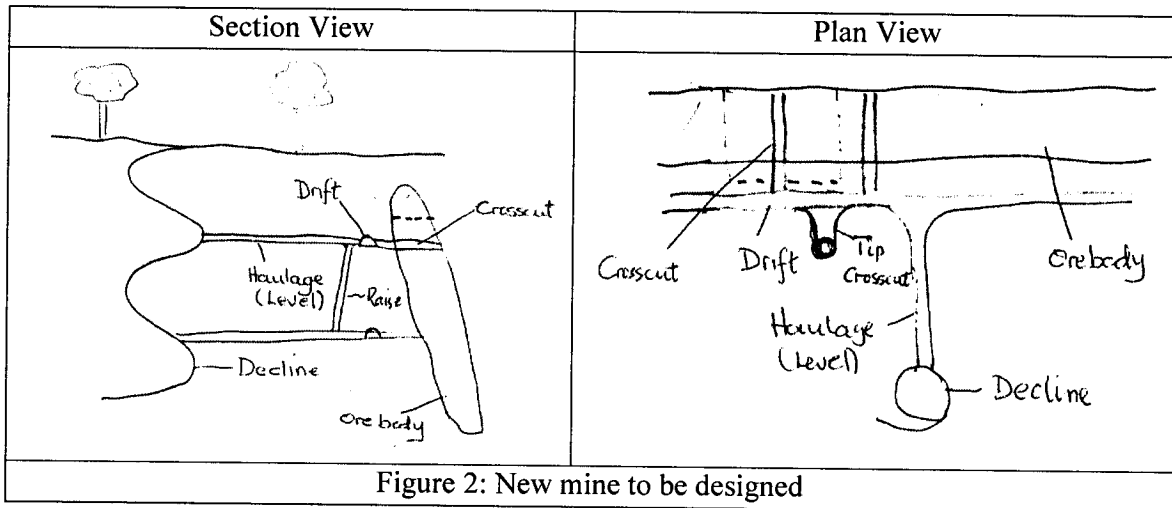
Question 3

- (i) Data in a string file is classified into 3 categories. Name the three categories. [3 marks]
- (ii) In open pit haul road design, why is it important to begin designing the road from the surface? [2 marks]
- (iii) What is the difference between a block model and a geological model? [5 marks]
- (iv) What is meant by "triangulation?" [5 marks]

SECTION B (PRACTICAL) - 70 Marks

Question 4

Figure 2 below shows a new mine to be designed. The mine is to be an underground mine with one level. As a Mine Planning Engineer working at this mine, you have been asked to;



- (a) In 3D, design the mine using Surpac Mine Software as it can be seen in the model; (Use files provided)
 - (i) Use decline to access the deposit; [5 marks]
 - (ii) Create two levels; [5 marks]
 - (iii) Design two drifts along the ore body on each level; [5 marks]
 - (iv) Design at least two cross cuts on each level; [5 marks]
 - (v) Design a tip cross cut **on the upper level**; [5 marks]
 - (vi) Design a tip (raise) from the upper level to the lower level [5 marks]
- (b) Using your design; determine the following;
 - (i) Total volume of material to be moved from the decline, levels, drifts and cross cuts, tip crosscut and the raise (show surpac calculations); [5 marks]
 - (ii) What is the total development meters (show surpac calculations); [5 marks]

(iii) If the total cost of primary developments is US\$3000/meter and US\$2500 for secondary developments, what is the total cost of developing the designed mine in terms of;

- Decline [5 marks]
- 2 Levels [5 marks]
- 2 Drifts [5 marks]
- Cross cuts on each level [5 marks]
- Tip cross cut [5 marks]
- Raise [5 marks]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS – JULY 2014

MIN 5059 – MINE MANAGEMENT

INSTRUCTIONS:	ANSWER <u>ALL</u> QUESTIONS	TOTAL MARK: 100
TIME:	3 HOURS	CLOSED BOOK

Question 1

To be able to study human behaviour you need to understand certain concepts and issues discuss the following:

- (i) Influences of human behaviour in organisations. [5 Marks]
- (ii) Major social discipline and their subsystems. [5 Marks]
- (iii) Perception and the major distortions in perception. [5 Marks]
- (iv) Psychological contract. [5 Marks]

Question 2

Write notes on the following approaches to the study of management.

- (i) Classical management and
 - (a) the work of Taylor [3 Marks]
 - (b) The work of Weber [3 Marks]

- (ii) Human Relations and its subgroups studied by:
 - (a) Tavistock Institute on coaling. [3 Marks]
 - (b) Maslow [3 Marks]
 - (c) Herzberg [3 Marks]
 - (d) Research undertaken at Western Electric Company of America [5 Marks]

Question 3

- (i) What is common in all organisations? [5 Marks]
- (ii) Write about the main components of organisation. [5 Marks]
- (iii) Discuss delegation or decentralization and its advantages and disadvantages in management. [5 Marks]
- (iv) Write short notes on four ways of how organisations react to change. [5 Marks]

Question 4

Discuss critical success factors of leadership.

[20 Mark]

Question 5

- (i) Write on shortcomings on each of the following leadership theories:
- (a) Trait theory [2 Marks]
 - (b) Situational approach [2 Marks]
 - (c) Functional theory [2 Marks]
- (ii) What helps to determine how leaders look at the needs of their subordinates? [4 Marks]
- (iii) As business develops in its life cycle what type of managers do you need? [4 Marks]
- (iv) Write extensively about management by objective and why it is extensively used in the mining industry. [5 Marks]
-

UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATION – JULY 2014

MIN 5069 – SAFETY, HEALTH AND ENVIRONMENT

INSTRUCTIONS:	ANSWER <u>ALL</u> QUESTIONS	TOTAL MARK:	100
TIME:	3 HOURS	CLOSED BOOK	

Question 1

- (a) Old existing mines and those which have been closed may cause difficult environmental problems. Write at least five (5) anticipated problems. **[5 marks]**
- (b) Discuss how each of the five (5) environmental problem mentioned in (a) above can be controlled. **[5 marks]**
- (c) What is the purpose of conducting Environmental Impact Assessment (EIA)? **[5 marks]**
- (d) What is Environmental Management Systems (EMS) and what are the benefits of implementing an EMS at a mine site? **[5 marks]**

Question 2

- (a) Distinguish between **risk** and **hazard**? **[5 marks]**
- (b) Explain the importance of hazard identification in hazard control process. **[5 marks]**
- (c) Discuss briefly the objectives of the Human Error Analysis (HEA). **[5 marks]**
- (d) What are the basic steps of the Human Error Analysis process? **[5 marks]**

Question 3

- (a) Discuss the Hierarchy of Control Measures that can be used to control or minimize mining hazards or risks at a work place? **[10 marks]**
- (b) There are a number of reasons for an operator to search for alternative hazard control measures at a work place. Discuss the reasons why an operator should search for alternative hazard control measures. **[5 marks]**
- (c) What problems may arise in this situation if ventilation alone is used for dust control? **[5 marks]**

Question 6

- (a)
 - (i) What is acid mine drainage (AMD) **[5 marks]**
 - (ii) Describe the mechanism of its formation **[10 marks]**

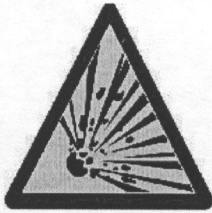
- (b) One of the ailments from which some categories of mine workers may suffer is the ailment of the ear. Write the sources of high level noise producing machines used in the mines and suggest some control measures to combat this ailment [5 marks]

Question 4

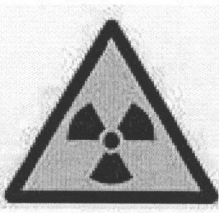
- (a) Effective safety communication is the cornerstone of a healthy organizational safety culture in most mines. Discuss the essence of safety communication at a mine site. [5 marks]
- (b) Safety signs provide information about situations affecting health and safety at a work place. Discuss five (5) classifications (types) of signs used in the mines. [5 marks]
- (c) Discuss ten (5) **causes of poor safety communication** at a workplace [5 marks]
- (d) Explain briefly what each of the signs below mean. [5 marks]



A



B



C



D



E

Question 5

- (a) What is the difference between respirable and total dust content of air? [5 marks]
- (b) Give brief answers to the following questions;
- (i) Identify five potential sources of fuel for mine fires? [2 marks]
- (ii) Explain the effects of fire on the underground mine environment? [3 marks]
- (c) Explain briefly the effects of Uranium waste on human health. [5 marks]
- (d) Discuss briefly the importance or objectives of mine rehabilitation. [5 marks]

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
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MIN 5079 ROCK MECHANICS 11 (ROCK ENGINEERING)

INSTRUCTIONS: **ANSWER QUESTION 1 AND ANY FIVE (5) TOTAL MARK: 100**
TIME: **3 HOURS** **CLOSED BOOK**

- Q1. (a) You have been approached by a civil engineering firm to advise them on the suitability of site where erection of a headgear, 40 m tall, and some other structures (such as workshop, a few double stories for offices, lamp rooms) etc. where mining is about to begin. . Write the investigations you will make for this purpose giving reasons for the properties you would investigate **(12 marks)**
- (b) Calculate the bearing capacity of the floor of a mine section in which cohesion (c) of floor rock /soil is 48 MPa and the angle of internal friction (ϕ) equal to 18 degrees. (The above values were obtained by triaxial test on a rock sample collected from the site). **(8 marks)**
- Q2. (a) One of the major reasons of catastrophic failure of water dam is pore-water water pressure. Briefly explain the phenomena of causing rupture in the rock mass and describe a method to measure pore-water pressure. **(6 marks)**
- (b) It is intended to construct a water reservoir and supply water to a hydro station for generating electricity to a close by mine and the township. The rock sample tested for the site of reservoir (limestone) tested by triaxial test yielded the following values:
- $\sigma_3 = 10\text{Mpa}$ and
 $\sigma_1 = 35\text{Mpa}$
- What value of pore-water pressure will cause rupture of the water reservoir?
- Suggest the way how this could have been prevented. **(10 marks)**
- Q3 (a) Prediction of stability of rock/soil slope is a tedious work and involves elaborate arrangement. Of late, some quick evaluation method for checking stability for massive slope failure is in use. Explain briefly the parameters which may be used for this purpose. **(10 marks)**
- (b) The analysis of a slope site has yielded the following values by geotechnical studies of the site rock/soil samples:
- Rock modules of elasticity $E = 50\text{Gpa}$
 - Poison's ratio (ν) = 0.25

- Value of ($\sigma_1, \sigma_2, \sigma_3$) (confining pressure) are 30 Mpa, 15Mpa and 10 Mpa respectively.

Calculate the critical strain (ϵ) produced from the above values and comment on the stability of the slope. **(6 marks)**

Q4. (a) (i) What is known as paste technology and how does this differ from the other support systems used in mines? **(5 marks)**

(ii) Currently, there are several types of steel bolts available for strata reinforcement. Describe with the help of diagram which type of a steel board is very popular for underground support? **(06 marks)**

(b) In a section of a mine having a weak zone is 4.0m height, the unit weight of the rock to be supported is 25kNm^{-3} and the working load of rock of 10 tones, find

(i) The spacing between two bolts; and, **(5 marks)**

(ii) The approximate length of the bolt you would recommend for this purpose. **(5 marks)**

Q5. (a) (i) explain the difference between toughness and hardness of a rock and write the properties on which the toughness depends. **(6 marks)**

(ii) What is the application of property toughness in mines? **(4 marks)**

(b) Name two methods of determining toughness and describe one of them.

A rock sample of 50mm diameter and 25mm thickness was tested diametrically and peak failure load was recorded equal to 5.0kN. Calculate the fracture toughness **(6 marks)**

Q6. (a) You are required to recommend a surface miner for cutting of coal. The coal cutting index based on rockmass cuttability classification is given below.

No.	Parameters	Rating based on values obtained
1	Point load index	15
2	Volumetric Joint Count	15
3	Abrasivity	9
4	Direction of Cutting with respect to major joint direction	9
5	Power of machine (kW)	12

Comment on the possibility of cutting the coal. **(10 marks)**

- (b) Find the uniaxial compressive strength of a rock sample if the protodyknov harness index is equal to 2.0. Also, estimate the approximate value of tensile and shear strength from the above value of a rock sample. **(8 marks)**
- Q7. (a) “Rock Engineering offers a balanced, comprehensive approach to the fundamentals of applied geology and rock behaviour as well as present the practical tools available to the engineer.” Comment on the above statement. **(8 marks)**
- (b) A rock sample of cube shape has a volume equal to 216 cm^3 gave a failure stress under compression testing machine equal to 75kN. What diameter of a cylindrical rock core would given the same value? **(8 marks)**

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
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MIN 5089 – MINE PLANNING AND DESIGN

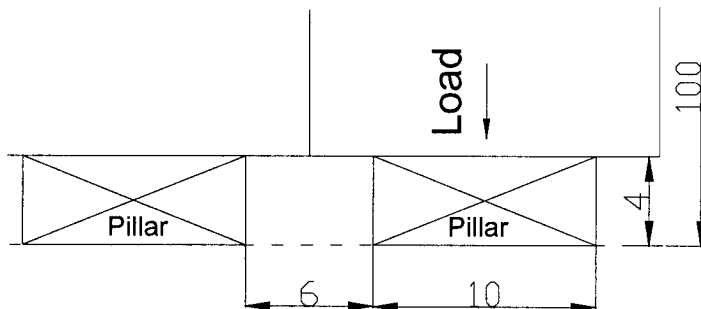
INSTRUCTIONS: **ANSWER ALL QUESTIONS**
TIME: **3 HOURS**

TOTAL MARK: **100**
CLOSED BOOK

Question 1

A coal seam is 4m thick at a depth of the coal floor below surface of 100m. Bord and pillar mining is to be done.

1. Will this pillar size be sufficient to ensure a safety factor of 1.6? [10 marks]
2. What will the centre to centre distance be? [5 marks]
3. What will be the percentage extraction? [5 marks]



Hints:

Safety factor = strength / load

$$\text{Strength} = 7176 \frac{W^{0.46}}{h^{0.66}}$$

$$\text{Load} = \frac{25HC^2}{W^2}$$

$$\% \text{ extraction } e = 1 - \frac{W^2}{C^2}$$

Question 2

- (a) Discuss the main process / procedure involved in mine planning and design [5 marks]
- (b) Explain briefly the factors that influence the choice of a mining method; [5 marks]
- (c) Choose **ONE** mining method below and discuss in detail the development and operations of the chosen method. Use a clear and well labelled diagram to illustrate your answer where possible. [10 marks]

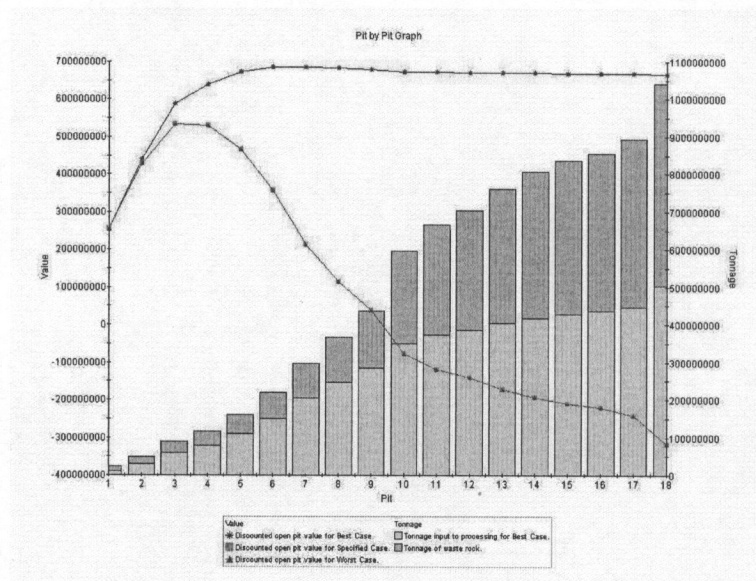
- (i) Vertical Crater Retreat (VCR)
- (ii) Sublevel open stoping
- (iii) Block caving
- (iv) Cut and Fill

Question 3

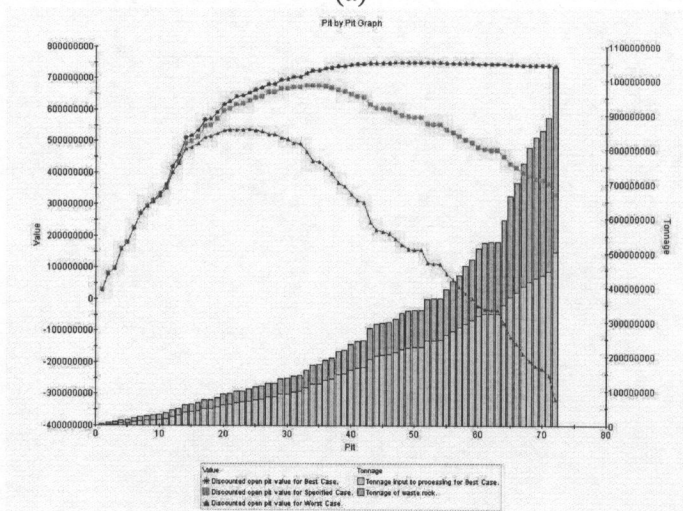
(a) Explain the following terms as they relate to Whittle Optimization;

- (i) Block Model; [2 marks]
- (ii) Revenue Factor; [2 marks]
- (iii) Pushback (cutback) in open pit mining; [2 marks]
- (iv) Mining CAF; [2 marks]
- (v) Worst Case Scenario in Whittle software; [2 marks]

(b) The figures below show the Pit-by-Pit graph from Whittle optimization software;



(a)



- (i) Discuss the difference between Graph (a) and Graph (b) [2 marks]
- (ii) Explain briefly the meaning of “Specified Case” in Whittle; [4 marks]
- (iii) Discuss the process of selecting pushbacks from pit shells using Whittle; [4 marks]

Question 4

Given the following information of the block model, answer the questions below;

- % Recovery through mill and smelter = 90 %
- Value of recovered copper = \$4000/ton
- Stripping and haulage to dump (level 1) = \$2.5/ton
- Mining and transportation to plant level = \$3/ton
- Haulage costs increase \$0.50/ton per bench.
- Processing, smelting, and refining = \$5/ton
- General overhead, administration, etc., (chargeable only to ore block) = \$2/ton
- Assume mill will not process material containing less than 1 % Cu.
- Ultimate pit slope = 1:1
- Round all the values to nearest \$.

0.00	1.15	0.08	0.05	0.00	0.00	0.05
	0.00	1.25	1.15	1.13	0.00	
		1.13	1.15	0.50		

- (i) Calculate the net profit or loss of each block. [14 marks]
- (ii) If each block contains 10,000 tonnes, give the mineable tonnage of ore and waste by bench. [4 marks]
- (iii) Determine the Overall Stripping ratio. [2 marks]

Question 5

- (a) What are the main objectives of production scheduling? [5 marks]
- (b) Fort Jameson is a small shallow open pit mine with a mine life of 15 months. The mine engineer has developed the production schedule as shown in the Table below. Some quantities are missing. Complete the Table below (production schedule). The stripping ratio is expressed in BCM waste per BCM ore. Round all values to one decimal place. Plot graphs to show the waste and ore movement over the life of the mine. [15 marks]

Table: Production Schedule for a gold mine

Parameter	May 02	June 02	July 02	Aug 02	Sept 02	Oct 02	Nov 02	Dec 02	Jan 03	Feb 03	Mar 03	Apr 03	May 03	June 03	July 03
Excavator total BCM/hr	480	470	460	450	450	450	450	430	430	430	420	420	420	450	450
Hours/shift	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Shifts/day	2.25	3	3	4	4	2	2	2	2	2	2	1	1	1	1
Days/month	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
BCM/shift															
BCM/day															
Total (BCM x '000)															
Waste (BCM x '000)	259.0	337.6	329.6	428.4	426.9	213.4	213.6	204.4	204.3	202.6	196.1	97.2	96.0	100.6	23.5
Ore (BCM x '000)															
Ore (tonnes)	0.5	1.6	3.4	7.6	10.8	5.6	5.4	4.9	5.5	10.4	14.7	9.8	12.8	20.0	10.0
Ore grade (g/t)	3.32	2.84	2.65	2.70	3.06	3.71	3.99	4.55	6.88	11.67	14.80	16.38	17.23	18.06	19.13
Stripping ratio	1079	449	206	118	84	83	89	101	98	53	36	27	20	14	6

END OF EXAMINATION