THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

SECOND SEMESTER 2012/2013 ACADEMIC YEARS

1. GG 202 -Earth resources and environment
2. GG 219 –Introduction to Geology(Theory)
3. GG 219 -Introduction to Geology (paper II) Practical
4. GG 312 –Introduction to petrology
5. GG 312-Introduction to petrology Practical
6. G G 319 –Crystallography and Optical Mineral mineralogy(Theory)
7. GG 319 –Crystallography and Optical Mineralogy (Practical)
8. GG 322 –Stratigraphy and paleontology (Theory)
9. GG 322 –Stratigraphy and paleontology (Practical)
10. GG 332 – Theory
11. GG 332 –Practical
12. GG 361 –Engineering Geology(Theory)
13. GG 361 –Engineering Geology (Practical)
14. GG 402 –Geology of Zambia
15. GG 412 –Metamorphic Petrology (Theory)
16. GG 412 –Metamorphic Petrology (Practical)
17. GG 442 –Economic Geology of Metalliferous mineral deposits and petroleum (Theory)
18. GG 442 –Economic Geology of Metalliferous mineral deposits and petroleum (Practical)
19. GG 472 – Applied Geochemistry (Theory)
20. GG 472 – Applied Geochemistry (Practical)
21. GG 542 –
22. GG 569 –Engineering Geology and rock mechanics
23. GG 572 –Hydrogeology

24. MI 311 –Drilling
25. MI 331 –Underground Mining
26. MI 335 – Surface Mining
27. MI 515 –Rock Mechanics II
28. MI 542 –Mine Finance and Administration
29. MI 545 –Mine Management
30. MI 565 –Mineral Economics
31. MM 205 –Introduction to mineral science
32. MM 332 –Chemical Thermodynamics II
33. MM 352 –Heat and Mass Transfer
34. MM 412 –Concentration and Dewatering
35. MM415 –Mineral processing for Mining Engineers
36. MM 422 –Materials performance
37. MM442 –pyrometallurgy
38. MM452 -process Instrumentation and Control
39. MM 502 –Metallurgy and the Environment
40. MM 552 –process Design
41. MM 562 –Foundry –Technology

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – AUGUST 2013

GG 202 – EARTH RESOURCES AND ENVIRONMENT

PAPER I – THEORY

INSTRUCTIONS: Answer any four questions. Use diagrams to illustrate your answers where ever it is necessary. All the questions carry equal marks.

TIME: Three (3) Hours

Q1. Discuss the theory of plate tectonics and its negative impacts on the communities that are adjacent to plate boundaries.

Q2. With reference to Gulf of Mexico and the atmosphere in large cities discuss the negative impacts of extraction and consumption of fossil fuels on the quality of the natural environment.

Q3. Discuss the impact of mining and processing of copper minerals in Zambia on the economy and the quality of the environments in which these operations are carried out.

Q4. Describe the hydrologic cycle and how the quality of the water in the different reservoirs has been affected by anthropogenic activities.

Q5. (a) Discuss the role which parent materials, organisms, climate, topography and time play in the development of thick nutrient rich soil profiles.

(b) Discuss the extent to which mining activities in Kabwe led to the pollution of soils in Kabwe district

Q6. Discuss the role of industrial minerals and fossil fuels in the development of Zambia

Q7. (a) Describe the exogenic cycle of N and the processes that are involved in the this cycle.

(b) Discuss how the exogenic cycle of nitrogen may be disturbed locally by the excessive application of nitrogenous fertilizers, large number of pit latrines, and deforestation.

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

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – AUGUST 2013

GG 219- INTRODUCTION TO GEOLOGY

PAPER I – THEORY

INSTRUCTIONS: Answer any four questions. Use diagrams to illustrate your answers where ever it is necessary. All the questions carry equal marks.

TIME: Three (3) Hours

Q1. Describe the geometrical properties of the seven crystal systems and state the basic elements of symmetry which well developed crystals of minerals belonging to these systems may posses.

Q2. (a) Write short notes on the classification of minerals.

(b) Describe the major characteristic properties which you can use to distinguish minerals in the following pairs.

(i) Galena/sphalerite
(ii) Graphite/Diamond
(iii) Pyrite/Gold
(iv) Magnetite/hematite
(v) Halite/Calcite
(vi) Talc/Gypsum
(vii) K-feldspar/Quartz
(viii) Muscovite/Biotite

Q3. (a) Arrange minerals in increasing order of hardness using Mohs' scale of hardness.

(b) Describe how the silicate tetrahedral units (SiO_4^{4-}) are linked in the following minerals:

(i) Forsterite

(ii) Quartz

(iii) Pyroxenes

(iv) Amphiboles

(v) Biotite

Q4. Write notes on the formation and classification of sedimentary rocks.

Q5. (a) Describe how igneous rocks are classified.

(b) Discuss the processes that are involved in the differentiation of basaltic magmas.

Q6. (a) Discuss the processes that will lead to the transformation of the following rock units during regional metamorphism.

(i) Sandstone
(ii) Dolomite
(iii) Granite
(iv) Shale
(v) Coal

(b) Write short notes on the following aspects:

(i) Regional and contact metarmorphism

(ii) Fabrics of metamorphic rocks

(iii) Grade of metarmorphism of schists

(iv) The stability of andalusite, kyanite and sillimanite in the P-T space.

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

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – AUGUST 2013

GG 219 - INTRODUCTION TO GEOLOGY

PAPER II – PRACTICAL

INSTRUCTIONS: Answer all the questions. Use diagrams to illustrate your answers where ever it is necessary.

TIME: Three (3) Hours

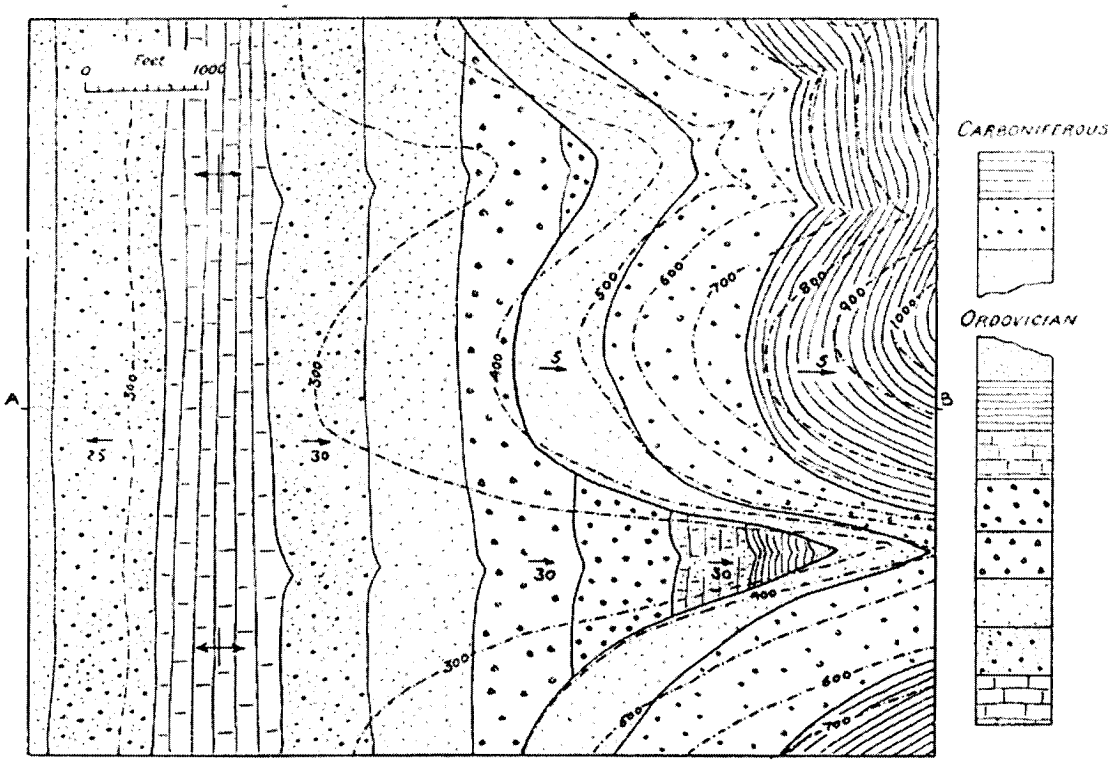
Q1. Describe the elements of symmetry which the given crystal models posses and use these features to classify them. (10 %)

Q2. Describe the properties of the given mineral specimens and use these to identify them. (30%)

Q3. Describe the texture and mineralogical composition of the given rock specimens and use these features to identify the rock units from which the specimens were collected. (40 %)

Q4. Describe the geological structures of the area shown on the given map illustrating your answer by a section drawn below it along the line A-B. (20 %)

----------END OF EXAMINATION----------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THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – AUGUST 2013

GG312 – INTRODUCTION TO PETROLOGY

PAPER I - THEORY

INSTRUCTIONS:	Answer any FIVE questions illustrating your answers with sketches wherever possible.
TIME:	Three (3) Hours

Q1. (a) What are the main factors which control the textures of igneous rocks? In detail describe the main textures of igneous 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 regional 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 gabbro- basalt family.

(b) Define the following:

(i) Porphrytic texture
(ii) Foliation
(iii)Phyllite
(iv)Met conglomerate
(v) Oolitic limestone

Q5. (a) What are the main factors which influence the viscosity of magma?

(b) Briefly describe the main clastic rocks.

Q6. Compare and contrast the following:

(a) Marble and quartzite
(b) Schist and gneiss
(c) Shield volcano and composite volcano
(d) Arkose and grit
(e) Preidotite and granodoirite

Q7. (a) Show how metamorphic rocks are classified.

(b) Briefly describe the following shapes of igneous bodies:
(a) Ring dyke
(b) Batholiths
(c) Sill
(d) Lopolith
(e) Cone sheet

End of Exam

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – AUGUST 2013

GG312 – INTRODUCTION TO PETROLOGY

PAPER II - PRACTICAL

INSTRUCTIONS:	Answer all questions illustrating your answers wherever possible.
TIME:	TWO HOURS

Q1. Give a full petrographic description of the ~~four~~ three thin sections 1, 2 and3, emphasize on the following:

a) Mineralogy
b) Texture
c) Name the rock

Q2. Give a full descriptions of samples A,B,C, D, E and F, and name the rocks.

----------End of Exam----------

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UNIVERSITY EXAMINATIONS – AUGUST 2013

GG319 – CRYSTALLOGRAPHY AND OPTICAL MINERALOGY

PAPER I - THEORY

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

TIME: Three (3) Hours

Q1. (i) Define the following: (12 marks)
- (i) Unit cell
- (ii) Crystal Lattice
- (iii) Plane of symmetry
- (iv) Rotational axis
- (v) Inversion axis
- (vi) Centre of symmetry

(ii) State the Law of Constancy of Interfacial Angles. (3 marks)

(iii) Determine the Miller indices and symbol for a face that lies between (003) and (100). (3 marks)

(iv) A crystal in a hexagonal system has 13 faces with the z-axis going through Center of a pedion and the opposite corner where 6 faces converge, while x-axis through centres of two opposite vertical faces, y-axis through centers of two opposite vertical faces and u-axis through centres of two opposite vertical faces. Sketch the crystal and label all faces and axes, name the three forms on the crystal and their faces. (7 marks)

Q2. (i) An orthorhombic crystal has 12 faces and three unequal orthogonal axes (z is longer than x and y). Axes pass through centers of opposite faces. Given the following angles between poles to faces determine axial ratios a/b, c/a and c/b: pole to (110) and pole to (100) = 45°, pole to (011) and pole to (010) = 45° and pole to pole to (001) and pole to (101) = 45°. (9 marks).

(ii) Sketch the whole crystal showing the three axes and all the 12 faces. Indicate the planes of symmetry on the sketch. (9 marks)

(iii) Using the zone symbol method prove if the following sets of faces lie in one zone: (100), (201), (102) and (011); (01bar11), (21bar31) and (10bar10). (7 marks)

Q3. (a) Write short notes on the following terms and concepts. (12 marks)
(i) Isomorphism
(ii) Polymorphism
(iii) Electronegativity
(iv) Pleochroism
(v) Zone axis
(vi) Interfacial angle

(b) Distinguish contact twin from penetration twin. (6 marks)

(c) Explain how density affects the refractive index of a mineral. (4 marks)

(d) If the latitude is 60^{o} what would be the co-latitude? Illustrate this in a sketch. (3 marks)

Q4. (i) What is coupled substitution? Why does this occur? (4 marks)

(ii) Calcium fluoride (CaF_2) is an (8, 4) coordinated structure, what does it mean? (3 marks)

(iii) Name and describe briefly two of the three Goldsmidt rules that govern atomic substitution within a mineral. (6 marks)

(iv) Under what conditions in terms of the rules described above does each of the following occur? (a) element capture, and (b) element admission. (4 marks)

(v) What mineral does beryl transform into when chromium is present in trace amounts and why? (4 marks)

Q5. (a) Distinguish between ionic and covalent bonds. Give one mineral example of each type of bonds. (8 marks)

(b) Describe briefly the following silicate structures giving one mineral example of each: (i) Single Chain Silicates; (ii) Island Silicates; (iii) Layer Silicates; and (iv) Ring Silicates. (14 marks)

(c) State two minerals for each of the following polymorphs: carbon, aluminosilicates and calcium carbonate. (3 marks)

Q6. (a) State situations when a mineral would appear isotropic under a microscope and explain why. (6 marks)

(b) What is visible light? (4 marks)

(c) State the BREWSTER'S Law. (4 marks)

(d) What is the effect of density on refractive index of a mineral? (4 marks)

(e) Sketch interference figures for a uniaxial positive mineral and a biaxial negative mineral. (4 marks)

(f) What is lustre responsible for in gemstones? (3 marks)

----------End of Exam----------

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – AUGUST 2013

GG319 – CRYSTALLOGRAPHY AND OPTICAL MINERALOGY

PAPER II - PRACTICAL

INSTRUCTIONS:	Answer all questions illustrating your answers wherever possible.
TIME:	One and Half Hours

1. Study the mineral Y under the microscope and using optical properties identify the mineral. (15 marks)

2. Using the provided crystal model 10 and assuming that z-axis goes through centres of 2 opposite six-sided faces, x-axis through centres of 2 opposite vertical edges and y-axis through centres of 2 opposite horizontal edges and interfacial angle (or co-latitude angle) of 60° between (001) & (011) and angle between y-axis and (110) of 45°, do the following: (25 marks)

   (a) Sketch the model and label all faces, crystallographic axes, characteristic elements of symmetry.
   (b) Identify and name the type of forms present on the crystal and faces that belong to each type.
   (c) Plot a stereogram for the crystal model ensuring that all the crystallographic axes, all the faces, and elements of symmetry (i.e. rotational axes of symmetry and planes of symmetry) are clearly labeled.
   (d) Determine the interfacial angle between (001) and (110) using the stereonet.

----------End of Exam----------

UNIVERSITY OF ZAMBIA

UNIVERSITY OF ZAMBIA EXAMINATIONS – AUGUST 2013

GG319 – CRYSTALLOGRAPHY AND OPTICAL MINERALOGY

POSSIBLE MINERALS

Quartz

Plagioclase Feldspar

Biotite

Tourmaline

Orthoclase

Fluorite

Halite

Chlorite

Phlogopite

Calcite

Dr. O.N. Sikazwe
LECTURER

20-08-13

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS – 2013

GG322 – STRATIGRAPHY AND PALEONTOLOGY

PAPER I – THEORY

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

TIME: Three (3) Hours

Q1. (a) In Biostratigraphy, discuss three possible reasons for the disappearance of species in a particular stratigraphic section.
(b) Write short notes on why a sedimentary unit that may extend over a very wide region would not be useful in chronostratigraphic correlation.
(c) A direct environmental relationship exists between lateral facies and vertically stacked sequence. Discuss.

Q2. (a) Discuss the effect on sediment pile and fossil record of a slow and progressive change in the environment of deposition of an area.
(b) Write short notes on transgression and regression and their impact on coastal sediments pile.
(c) Discuss the term paleoecology and its significance in stratigraphy and why it is considered not to be a complete science.

Q3. (a) Discuss the term Accommodation, in sequence stratigraphy, and how it affects the sediment pile.
(b) Explain what a composite bed set is and what it represents in terms of environment of deposition.
(c)Discuss clearly the type of rocks and features that would be ideal for accurate age dating and correlation.

Q4. (a) Discuss the term **Type Section** as applied in stratigraphy.
(b) Write short notes different types of sea level changes, their causes and impact on coastal sediment pile.
(d) Briefly explain the application biofacies in paleo-basin analysis.

Q5. (a) Discuss the different types of contacts between vertical and lateral adjacent beds indicating the depositional activities that would lead to each one of them.
(b) Write clear notes on lithostratigraphy.
(c) Discuss chronostratigraphy and its application in the development of the World Geological Time Scale.

Q6. (a) Describe briefly the terms: (i) biozone, (ii) hiatus.
(b) Describe how fossil record of same species appearing in rocks of adjacent areas may not represent correct age correlation.
(c) Discuss the evolution of a basin that would lead to dichronous deposition of a particular lithological unit.

Q7. (a) Write short notes that would explain the principles of Paleontology.
(b) Discuss any three modes of preservation of soft parts of fossils.
(c) Explain the organisms that are believed to represent the oldest life on Earth, where they are found and how old they are estimated to be?

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

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS – 2013

GG322 – STRATIGRAPHY AND PALEONTOLOGY

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

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS – 2013

GG322 – STRATIGRAPHY AND PALEONTOLOGY

PAPER I – THEORY

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

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS – 2013

GG322 – STRATIGRAPHY AND PALEAONTOLOGY

PAPER II – PRACTICAL

INSTRUCTIONS:	Answer all questions.
TIME:	Three (3) Hours

Study the logging information of two bore holes, MR1 and MR2, which were drilled 750 meters apart for geotechnical studies. You are asked to do the following:

(1) Make stratigraphic logs of both cores, using the standard format available; (30 marks)

(2) Draw a neat and clear cross section that represents the sub-surface geology of the area that lies between the two bore holes; (30 marks)

(3) Discuss, with good reasons, the possible depositional environment of the rocks intersected by the bore holes; (25 marks) and

(4) Comment on the possible reasons for the absence of mudstone at the base of bore hole MR1. (15 marks)

Log: MR1, collar elevation: 1257m above sea level

0-2m	Very fine-grained mudstone, in places with shaly partings, desication 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 with an erosional contact at the base with an undifferentiated rock;

Log: MR2, collar elevation: 1245m above sea level

0-2m	Mudstone, in places with intraclasts, massive beds, desication cracks;
2-5m	Medium to coarse grained sandstone, horizontal bedding;
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	Migmatite.

END OF EXAM AND GOOD LUCK

REFERENCE:

SCALE	LITHOLOGY	LIMESTONES: mud, wacke, pack, grain, rud &, bound MUD: clay, silt SAND: vf, f, m, c, vc GRAVEL: gran, peb, cob, boul	TEXTURE Grain size and other notes (structures, palaeocurrents, fossils, colour)	PROCESS INTERPRETATION	ENVIRONMENT INTERPRETATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS – 2013

GG 332

PAPER I – THEORY

INSTRUCTIONS: ANSWER ANY FOUR (4) QUESTIONS

ALL QUESTIONS CARRY EQUAL MARKS

TIME: THREE (3) HOURS

Q1. (a)Define GIS

(b)Explain capabilities that make GIS special

Q2. (a)What is Remote Sensing?

(b)Describe four (4) fields in which Remote Sensing and GIS are applied.

Q3. (a)Explain two methods used to capture data into a GIS.

(b)Describe two data models handled by the GIS

Q4. Aerial photographs and Satellite images have been used for decades by geologists to extract data. Describe five types of geological datasets that can be extracted.

Q5. Briefly explain the following terms:

(i) Transmissivity
(ii) Absorption band
(iii) Atmospheric window
(iv) Radiant energy
(v) Spectral resolution

Q6. Image enhancement is concerned with the modification of images to make them more suited to the capabilities of human vision.

Describe three (3) three types of enhancements carried out on an image.

END

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SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS – 2013

GG 332

PAPER II – PRACTICAL

INSTRUCTIONS: ATEMPT ALL THE STEPS IN THE QUESTION.

ALL DATA REQUIRED FOR THIS EXAM IS STORED ON YOUR PC's G: DRIVE IN THE FOLDER CALLED "GG332_II_EXAM"

TIME: THREE (3) HOURS

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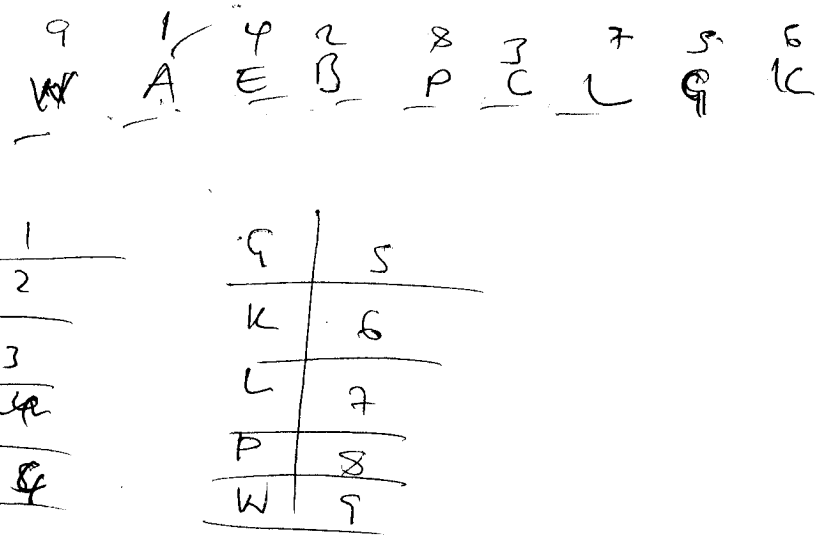
1. Start ArcView 3.2
2. Create a new project and save it as your full names in the folder given below:

   G:\GG332_II_EXAM

3. Add a new View
4. Name the new view as "Geological Map"
5. Add theme, browse to the folder given above and select the given scanned geological map called "geology_image" and load it in your view
6. Create a new (polygon) theme, call it "geology_poly" and save it in the folder given above
7. Start editing the "geology_poly" theme
8. Digitise the whole map
9. Open the theme attribute table.
10. Add a field (Column) and name it as "CODE" and change "number" to "String"
11. In your newly added field, type the codes for each geology polygon as indicated on the map.

12. Double-click the "geology_poly" theme on your view and edit the legend to reflect the new codes.
13. Change the geology colours to match the original map
14. Go to theme menu and auto-label your geology
15. Use display tools (zoom, pan, re-size window etc.) to make your map fit accurately in your view
16. Save your project and all the edits
17. Go to File menu and export the map as "Geology_poly_map" in jpeg format. Save it in the given folder above
18. Leave your ArcView Project open. DO NOT close the program.

END



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THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – AUGUST/SEPTEMBER 2013

GG 361 - ENGINEERING GEOLOGY

PAPER I – THEORY

TIME: 3 HOURS

ANSWER: ALL QUESTIONS FROM SECTION 1, AND ANY **THREE** QUESTIONS SECTION 2. **ALL** QUESTIONS IN SECTION 2 CARRY EQUAL MARKS

SECTION 1: MULTIPLE CHOICE QUESTIONS

1. Which of the following is NOT a silicate mineral? a) fluorite b) quartz c) olivine d) amphibole
2. The most common element in the earth's crust is: a) oxygen b) silicon c) carbon d) aluminium
3. Which of the following is the LEAST valuable property for mineral identification? a) colour b) crystal form c) cleavage d) hardness
4. The two formulas Mg_2SiO4 and Fe_2SiO4 represent: a) two chemical compounds b) two minerals that have related physical properties, c) two nonrelated minerals d) variations of the mineral olivine
5. The silicate mineral group contains all but which of the following minerals: a) quartz b) olivine c) dolomite d) plagioclase
6. Kaolinite and other clay minerals fall into which of the silicate mineral groups? a) framework or 3-D b) sheet c) single chains d) double chains
7. Quartz and feldspar are members of the: a) framework or 3-D silicates b) sheet silicates c) single-chain silicates, d) double-chain silicates
8. The smaller crystals in a porphyry are called: a) phenocrysts b) groundmass c) xenoliths d) aphanites
9. The fact that different minerals crystallize at different temperature best explains differences in the: a) grain-size of igneous rocks b) size of igneous rock masses, c) compositions of igneous rocks d) amount of xenoliths
10. The grain size of an igneous rock is controlled mainly by: a) rate of cooling b) kind of minerals c) Bowen's reaction series d) pressure

11 ~~14~~. The large crystals in a porphyry are called: a) phenocrysts b) groundmass c) xenoliths d) aphanites

12 ~~15~~. Igneous rocks that cool very rapidly may have any but which of the following textures? a) phaneritic b) aphanitic c) glassy d) porphyritic

13 ~~16~~. The main difference between conglomerate and breccia is in: a) particle size b) mineralogy c) particle roundness d) particle orientation.

14 ~~17~~. With increasing distance of stream transport, which of the following changes does sediment undergo? a) percent of stable minerals decreases b) grain roundness increases c) sorting decreases

15 ~~18~~. Which of the following metamorphic rocks display FOLIATION? a) quartzite b) marble c) slate d) hornfels

16 ~~19~~. The rock cycle allows igneous rocks to become metamorphic rocks without going through the sedimentary rock stage. a) true b) false

17 ~~20~~. Which of the following has the LARGEST crystals? a) phyllite b) shale c) gneiss d) schist

18 ~~21~~. A fault with a low angle of dip in which the hanging wall has moved up relative to the foot wall is called: a) normal b) reverse c) thrust d) strike slip e) no way to determine

19 ~~22~~. If a rock layer strikes northeast-southwest, its dip will be: a) northwest b) southeast c) northwest or southeast d) northeast or southwest

20 ~~23~~. Dip and strike may be measured for: a) rock layers b) joint planes c) foliation planes d) any of the above

21 ~~24~~. If a rock layer dips due east, its strike is: a) north-south b) east-west c) north d) south e) can't tell from this information

22 ~~25~~. A steeply dipping fault in which the hanging wall has moved up relative to the footwall is called: a) normal fault b) thrust fault c) strike-slip fault d) reverse fault.

SECTION 2: ESSAY-TYPE QUESTIONS.ANSWER ANY **THREE** QUESTIONS

1. a) Geologic materials may be classified into **three** main groups on the basis of their shear strength parameters. With the aid of diagrams, illustrate these main categories.

   b) Give the empirical formula of Coulomb's law and describe the quantities involved.

   c) Describe the two main modes of occurrence of igneous rocks and explain how and why textures of these two groups of rocks differ.

      i) Explain the difference and similarities between Gabbro and Granite.

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

   d) What is the difference between the properties of materials and the properties of mass with regard to both soils and rocks? Why is there a difference? Why is the difference of importance in engineering geology?

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

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

   i) Determine the shear strength parameters.

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

3. a) During an in-situ test to determine deformation characteristics of a foundation ground, a rock mass with a circular cross-sectional area, with a diameter of 1.5 m, was subjected to a load of 30 kN. If the mass experienced a change of 15 cm in its original length of 3 m and 7.5 cm in its diameter, calculate:

      i) Longitudinal and diametric strains

      ii) Poisson's ratio

      iii) Modulus of elasticity

   b) After constructing a statue of the late Professor Lameck Goma near the main entrance of the University of Zambia, it was discovered that there was a discontinuity, inclined at 30°, underlying the structure. If the statue imposed a stress (σ_1) of 700 kNm^{-2}, which in turn, induced a horizontal stress (σ_3) of 300 kNm^{-2}, **determine** the Normal and Shear stresses that acted on the discontinuity surface.

4. a) Give three reasons, why joints are important in engineering practice

   b) What physical factors determine the shear strength of soils?

   c) Describe four characteristics of discontinuities, which affect the deformability and strength of rock masses when loaded by an engineering process?

   d) Whenever a project is conceived, the site must be subjected to an investigation. These investigations are usually carried out in stages, with each stage building up enough information to allow execution of the next stage.

      i) Mention four objectives for carrying out a site investigation.

      ii) Briefly describe the different stages involved

5. a) Describe **four** components of the hydrologic cycle

   b) Using some component(s) of the hydrologic cycle, describe a situation that would lead to frequent flooding as experienced in Lusaka after a heavy down-pour.

   c) Define permeability and state **three** features that influence it in different geologic bodies.

   d) Permeability of a soil sample collected from the construction site of the planned UNZA shopping complex was determined using a permeameter in the Department of Civil and Environmental Engineering laboratory. The soil sample had a diameter of 75 mm and was 0.15 m long, while the diameter of the stand-pipe was 1.5 cm. During the test, the water level in the standpipe decreased from 1.3 m to 80 cm in 2.25 minutes. Calculate the coefficient of permeability of the sample in mm/s.

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

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS – AUGUST/SEPTEMBER 2013
GG 361 - ENGINEERING GEOLOGY
PAPER II - PRACTICAL

TIME: THREE HOURS
ANSWER: ALL QUESTIONS

1. In Map 1, a vertical borehole was drilled on a site located at point C, with an elevation of 170 m above sea level. The borehole intersected shale between 0 and 25 metres; limestone between 20 and 50 metres; sandstone between 50 and 80 metres; and conglomerate between 80 and 170 metres. All the bedding and foliation planes encountered in the borehole display a horizontal attitude.

   For this map:

   i) Complete the geological map of the area
   ii) Draw a geological cross-section along the line A – B and mark on it the Formations intersected by the borehole. (***Note:*** The solid geology is obscured by alluvium below the 60 m contour).

2. Map 2 depicts an area north of Lusaka contoured at 5 m intervals, on which three rock boundaries of a granite sill, schist and sandstone are marked. The base of a granite sill outcrops at A, the base of a schist outcrops at B, and the base of a sandstone at C. Assuming that between A and B only granite sill is present, between B and C only schist is present and that only sandstone is present in the succession above C:

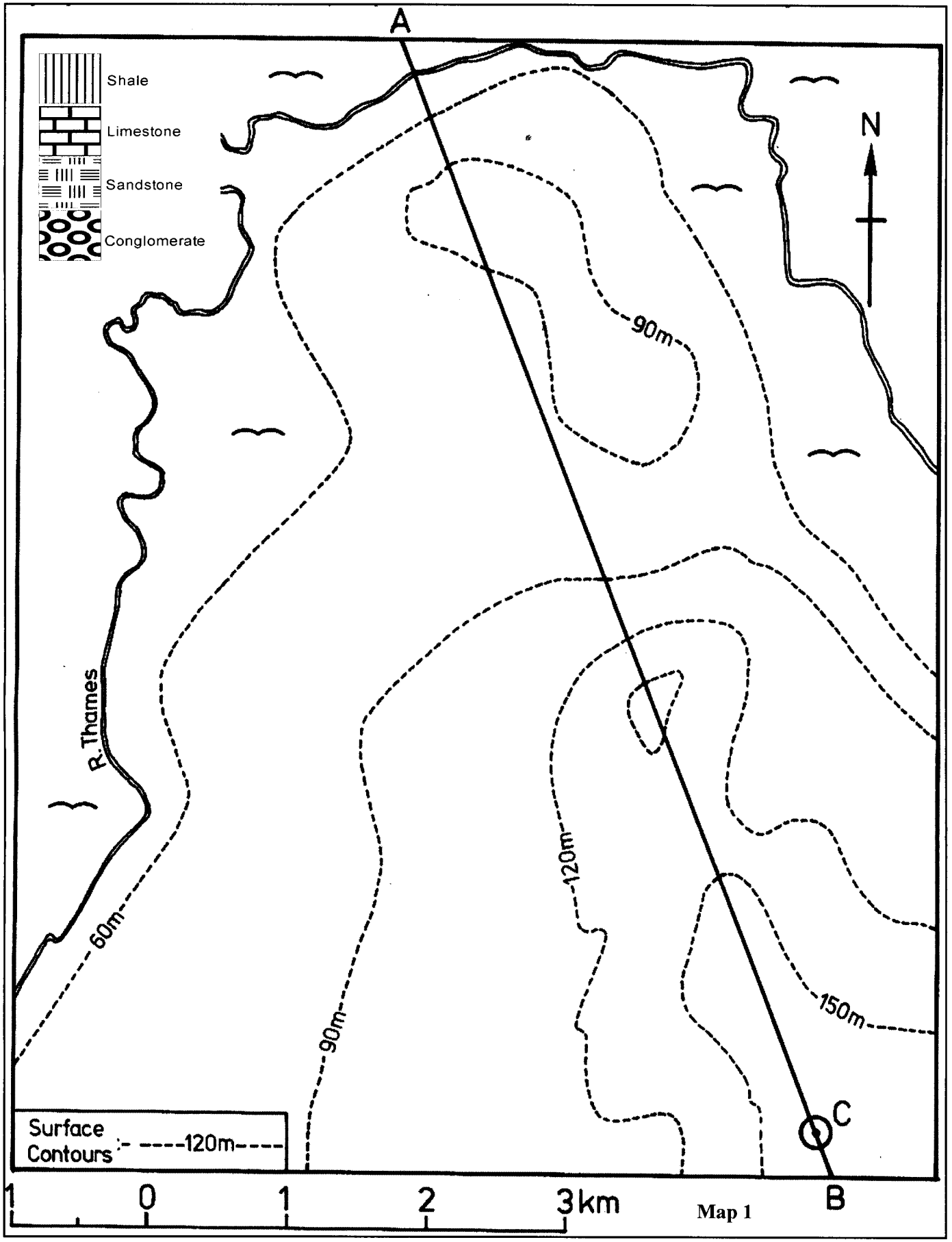
   a) Complete the outcrops of the bed boundaries.
   b) Shade the lithologies as appropriate.
   c) Indicate the depths at which the bases of schist and granite sill would be intersected in a vertical borehole drilled at C.
   d) Determine the true thicknesses of schist and granite sill.

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

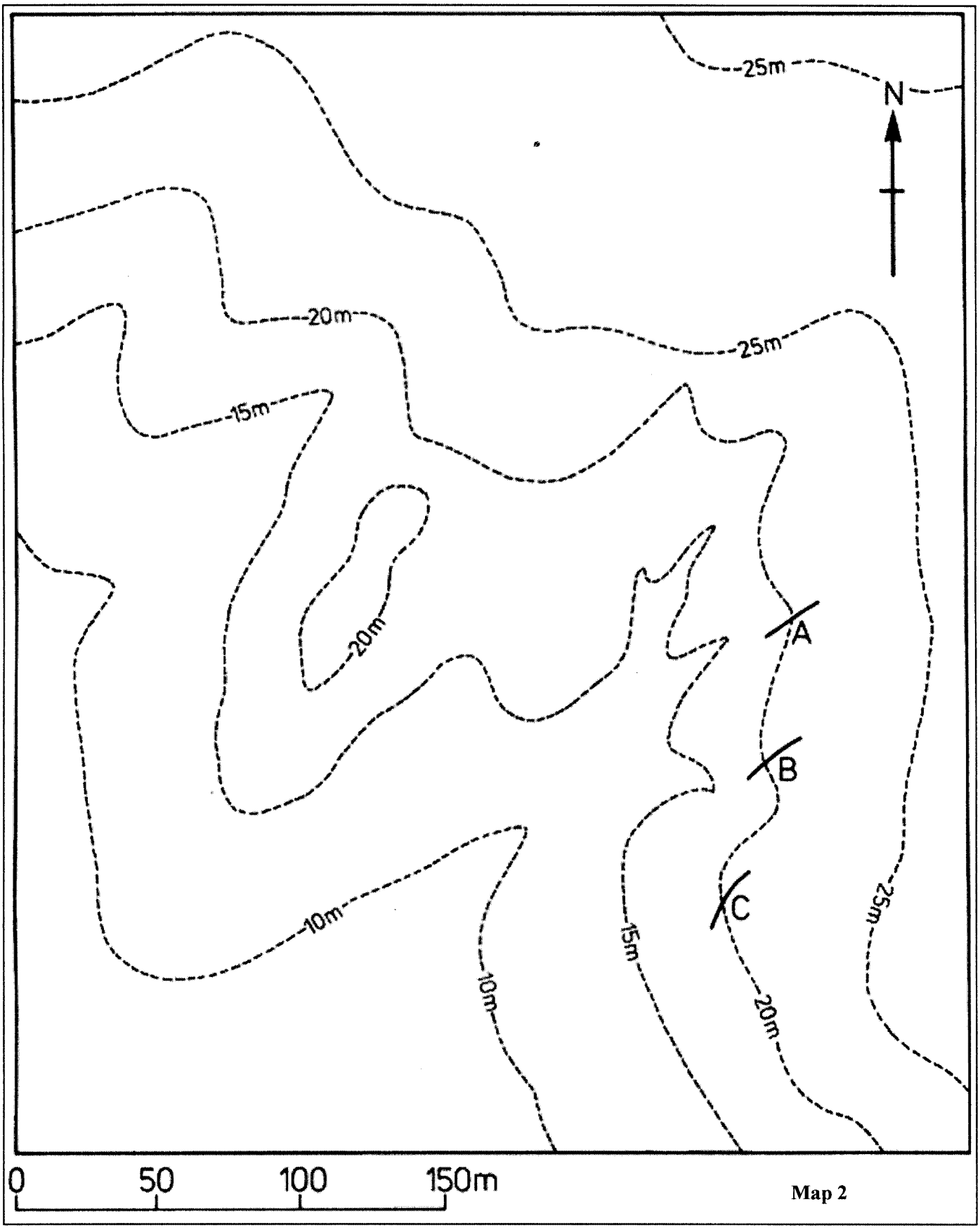
3. The continuous lines on Map 3 are geological boundaries separating the outcrops of dipping strata, beds P, Q, R, S, T and U.

   a) Draw structure contours for each geological boundary and calculate the amount and direction of dip.
   b) Draw the section P-Q
   c) Determine the true thickness of each bed (Contours in metres)

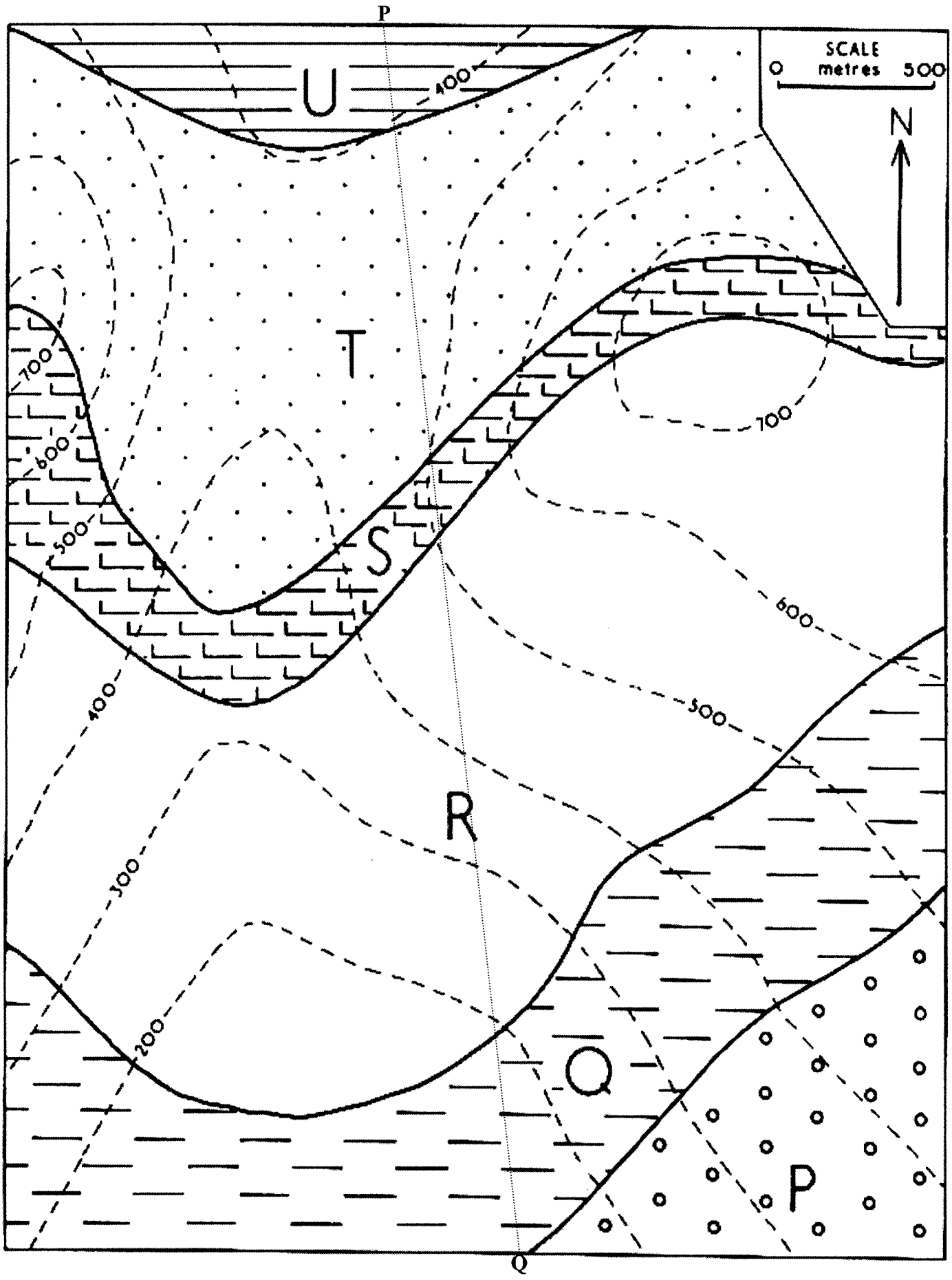
..... END OF EXAINATION. GOOD LUCK!! .....


A
Shale
Limestone
Sandstone
Conglomerate
N
90m
R. Thames
60m
120m
90m
150m
C
B
Surface Contours :- ----120m----
1 0 1 2 3km

Map 1



Map 2


P
Q
U
T
S
R
Q
P
400
700
600
500
400
300
200
700
600
500
SCALE
metres 500
N

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS – 2013

GG 402 – GEOLOGY OF ZAMBIA

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

TIME: Three (3) Hours

Q1. Write an essay on the geological evolution of Africa.

Q2. Write an outline of the stratigraphy of Zambia and the economic significance of each major sequence.

Q3. Discuss orogenic cycles that shaped Africa.

Q4. Write brief notes on the Ubendian Belt.

Q5. Write a short essay on the Irumide Belt.

Q6. Discuss the geology of greenstone belts with at least two examples of areas in southern Africa.

END OF EXAM AND GOOD LUCK

UNIVERSITY OF ZAMBIA

SECOND SEMESTER UNIVERSITY EXAMINATIONS – AUGUST 2013

GG 412 – METAMORPHIC PETROLOGY

PAPER I – THEORY

INSTRUCTIONS: ANSWER ANY FIVE (5) QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS

TIME: THREE (3) HOURS

Q1. Metamorphic rocks have different protolith, what are the main protolith of metamorphic rocks. Outline in detail, the main characteristics of each protolith.

Q2. Differentiate between the following:

a) Gneiss and schist
b) Burial metamorphism and shock metamorphism
c) Metamorphic grade and metamorphic zone
d) Marble and quartzite

Q3. Nomenclature of metamorphic rocks differ from igneous rocks and sedimentary rocks. Discuss in detail, the main criteria for naming metamorphic rocks.

Q4 Compare and contrast igneous rocks and metamorphic rocks with regards to:
(a) Origin
(b) Composition
(c) Texture

Q5 Define the following:
a) Polygonal-granoblastic texture
b) Geothermal gradient
c) Index mineral
d) Migmatites

Q6 Define metamorphism. Discuss all the physical and chemical factors that may control a metamorphic reaction.

Q7 What is a metamorphic facies? Briefly discuss the facies of regional metamorphism.

****End of exam****

UNIVERSITY OF ZAMBIA

SECOND SEMESTER UNIVERSITY EXAMINATIONS – AUGUST 2013

GG 412 – METAMORPHIC PETROLOGY

PAPER II – PRACTICAL

INSTRUCTIONS : ANSWER ALL QUESTIONS. ILLUSTRATE YOUR ANSWERS WITH SKETCHES, FIGURES WHEREVER POSSIBLE

TIME : THREE (3) HOURS

Q1. Figure 1 is a geological map showing the distribution of mineral assemblages (represented by open symbols) of politic lithologies in a regionally metamorphosed sequence in Nyimba District. Do the following:

(a) Demarcate metamorphic zones
(b) Name the metamorphic zones
(c) Show the distribution of high grade metamorphism

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

(a) Mineralogy
(b) Texture
(c) Chemical type
(d) Metamorphic grade
(e) Name the rock

****End of exam****

Q2. Figure below shows a map of Rufunsa in which an intensely folded sequency of schists, gneisses and amphibolites is overlain by gently folded series of pelites and quartzites.

(a) On the basis of the key minerals given, demarcate metamorphic zones in the gneiss complex. Name each zone.

(b) What is the metamorphic or structural or tectonic significance of rock type F?

F Mylonite

E Quartzite

D Phyllite & Schist

Quartzite-Pelite Formation

C Calcsilicate gneiss

B Amphibolite gneiss

A Biotite gneiss

Gneiss Complex

Chlorite
Epidote
Sericite/Muscovite
Biotite
Garnet
Kyanite
Sillimanite
Actinolite/Tremolite
Hornblende
Diopside

Thrust Fault

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – AUGUST 2013

GG442 – ECONOMIC GEOLOGY OF METALLIFEROUS MINERAL DEPOSITS AND PETROLEUM

PAPER I – THEORY

INSTRUCTIONS: Answer three questions from Section A and one question from Section B. All questions carry equal marks. Use separate scripts for Sections A and B.

TIME: Three (3) Hours

SECTION A – METALLIFEROUS DEPOSITS

Q1. (a) Define the following terms: (10 marks)
- (i) Ore Mineral
- (ii) Cut-off-grade
- (iii) Reflectance
- (iv) Reflectance Pleochroism
- (v) Scratch Hardness

(b) What is a stable isotope? (2 marks)

(c) Name three of the four stable isotopes important in investigations of ore deposits and state in each case the two isotopes used in the calculation of delta values. (6 marks)

(d) Distinguish between syngenesis and epigenesis.(4 marks)

(e) Classify the following deposit types into either syngenetic or epigenetic: Porphyry, Magmatic and Placer. (3 marks)

Q2. (a) What is a skarn? (2 marks)

(b) Distinguish an exsoskarn from a endoskarn.(4 marks)

(c) Write short notes on the following: (10 marks)
- (i) Reaction Skarn
- (ii) Hornfels
- (iii) Skarnoid
- (iv) Metasomatism
- (v) Proximal skarn deposit

(d) Discuss briefly how the depth of formation of skarn affects the skarn size and alteration style. (5 marks)

(e) What four geophysical methods would be useful in the exploration of skarn deposits and why? (4 marks)

Q3. (a) Define the term prophyritic.(2 marks)
(b) What two tectonic environments are porphyry deposits associated with and why? (3 marks)
(c) In Zambia there are several orogenic belts of Pan African age and yet we have not heard of any discovery of porphyry deposits. Why is this so? (4 marks)
(d) What mineralogy characterizes the following porphyry alteration zones: (9 marks)
(i) Propyllitic
(ii) Phyllic
(iii) Potassic
(e) Briefly discuss how porphyry deposits form. (5 marks)

Q4. (a) What is a hydrothermal solution? (2 marks)
(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) How in general terms do veins form? (4 marks)
(e) A vein deposit with copper mineralization has been discovered through exploration and needs to be evaluated. This vein deposit, containing quartz, pyrite and chalcopyrite, is vertical. Discuss the main features that the vein would acquire after oxidation has occurred and how these features are acquired. (7 marks)

Q5. (a) Several theories have been advanced in the last 100 years or so to explain the origin of ore deposits. In terms of magmatic segregation two processes have been postulated to explain the origin of chromite and Cu-Ni orebodies. These are fractional crastallization and liquid immiscibility, respectively. Describe the nature of these two processes and give one example deposit resulting from each deposit. (15 marks)
(b) Distinguish between startiform and podiform chromite deposits.(10 marks)

SECTION B – PETROLEUM

Q6 Discuss clearly the generation and accumulation of petroleum in the sub-surface.

Q7 W rite short but clear notes on the possibility of oil accumulations in Zambia.

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

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – AUGUST 2013

GG442 – ECONOMIC GEOLOGY OF METALLIFEROUS MINERAL DEPOSITS AND PETROLEUM

PAPER II – PRACTICAL

INSTRUCTIONS: ANSWER ALL QUESTIONS

TIME: ONE AND HALF HOURS

You are provided with 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. (75 marks)

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

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - AUGUST 2013

GG 472 – APPLIED GEOCHEMISTRY

PAPER I – THEORY

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

TIME: Three Hours

Q1. (a) Calculate the Rb-Sr isochron age and initial $^{87}Sr/^{86}Sr$ ratio of a suite of whole rock samples based on the following data.

Sample	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$
1	2.098	0.8245
2	1.173	0.7668
3	0.319	0.7163

(b) Calculate a K-Ar date for a sample of biotite based on the following data.

K_2O = 9.00%, ^{40}Ar = 2.424 μg/g, $\lambda_e = 0.581 \times 10^{-10}\ a^{-1}$, $\lambda = 5.543 \times 10^{-10}\ a^{-1}$

Isotopic abundance of ^{40}K = 0.01167%; Atomic weights :

K= 39.098, O= 15.999, ^{40}Ar = 39.96

Q2. (a) Discuss the processes that cause high degrees of fractionation of stable isotopes of oxygen and sulfur in meteoric precipitation and sedimentary environments respectively.

(b) Discuss the role which stable isotope studies play in the establishment of the following aspects of sulfide mineral deposits:

(i) Source of ore forming fluids.
(ii) Temperature of formation of mineral assemblages

(c) Describe the fractionation of isotopes of oxygen in a comagmatic series formed by fractional crystallization of a basaltic magma.

Q3. Describe a single dating system that you can employ to establish the following aspects of a metamorphosed igneous intrusion:

(a) Source of the magma
(b) Age of crystallization of magma.
(c) Age of metamorphism

Q4. (a) Discuss how the following factors may control the distribution of trace elements during fractional crystallization of basaltic magmas.

(i) Ionic charge and radius
(ii) Magma temperature
(iii) Ionic potential
(iv) Crystal field stabilization energy

(b) Discuss the relationship between the chemical composition of the magma and its viscosity.

Q5. Use appropriate diagrams to discuss the metarmorphic reactions that are likely to take place during medium pressure regional metarmorphism of a siliceous dolomitic limestone.

Q6. (a) Discuss the four major types of reactions that occur during metarmorphism.
(b) Describe how polymorphic changes in the Al_2SiO_5 system may be used to determine P-T conditions in Al-rich systems.
(c) Discuss the mobility of the following chemical components during metarmorphism: CaO, K_2O, Al_2O_3, SiO_2, Na_2O, CO_2, H_2O.

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

UNIVERITY EXAMINATIONS - AUGUST 2013

GG 472 – APPLIED GEOCHEMISTRY

PAPER II – PRACTICAL

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

TIME: Three Hours

Q1. Use the thermodynamic data given below to construct stability fields of Al_2SiO_5 minerals In the P-T space

Name	$\Delta_f H(1,298)$ kJ	S(1, 298) kJK^{-1}	V(1, 298) kJ $kbar^{-1}$
Kyanite	-2592	0.0853	4.409
Andalusite	-2589.0	0.0932	5.147
Sillimanite	-2582.7	0.0993	4.984

(25 %)

Q2. (a) Use equations 1 and 2 to derive equation 3

$\alpha_{a\text{-}b} = R_a/R_b$ (1)

$\delta = (R_a - R_{std}) \times 1000/R_{std}$ ‰ (2)

$\alpha_{a\text{-}b} = (\delta_a + 1000)/(\delta_b + 1000)$ (3)

(b) The sulfur isotopes geothermometer for the mineral pair sphalerite- galena is: $1000Ln\alpha_{sphalerite\text{-}galena} = 7.0 \times 10^5/T^2$. If the Δ value for this mineral pair is 3.4 determine The temperature of formation of the hydrothermal mineral deposit in which the minerals occur.

(20 %)

Q3. Use the geochemical data in table 1 to answer the following questions.

(a) Describe the mineralogical composition of the given rock units
(b) Identify the rock units
(c) Evaluate the degree of evolution of the rock units
(d) Discuss the mineralization potential of the rock units
(e) Discuss how Zr, Co, U, Rb, Be, Li and Cr are likely to be distributed in these rocks. (40 %)

Q4. Use the data in table 2 to discuss the type of chemical reactions and migration of chemical components which have occurred during metarmorphism of rock unit A (shale) to rock unit B (schist). (15%)

Table 1 Distribution of major elements (%) and trace elements (ppm) in the igneous intrusions

Constituent	R1	R2	R3
SiO_2	50.4	74.7	73.75
TiO_2	0.9	0.05	0.0
Al_2O_3	22.2	13.96	15.47
Fe_2O_3	9.9	0.29	0.14
FeO	3.6	0.13	0.06
CaO	8.4	0.81	0.0
MgO	1.5	0.09	0.0
Na_2O	0.9	4.79	0.34
K_2O	1.8	5.3	4.48
H_2O	0.9	0.7	2.72
Rb	15	202	2810
Ba	76	782	60
Sr	1300	160	1
Ni	410	2	0
Sn	1	5	2000
Ta	0	0.5	350

Table 2 Distribution of major elements (%) in some rock units

Constituent	A (shale)	B (Schist)
SiO_2	59.93	63.51
TiO_2	0.85	0.79
Al_2O_3	16.62	17.35
Fe_2O_3	3.03	2.00
FeO	3.18	4.71
CaO	2.18	1.24
MgO	2.63	2.31
Na_2O	1.73	1.96
K_2O	3.54	3.35
H_2O	4.34	2.42
CO_2	2.31	0.22

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

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS – 2013

GG 542

INSTRUCTIONS : ANSWER ANY FIVE (5) QUESTIONS

ALL QUESTIONS CARRY EQUAL MARKS

TIME : THREE (3) HOURS

Q1. Describe any two (2) common types of glasses in terms of name, ingredients, properties and application

Q2. (a)List ten (10) steps involved in the manufacture of float glass

(b)Outline Portland cement Row Materials.

Q3. Describe the two (2) types of sand and gravel deposits. Give examples of where they occur in Zambia

Q4. Explain five (5) uses of Coal

Q5. (a) Sheet mica free from defects can be punched/stumped into required shapes and classified into blocks, films or splittings. Briefly describe four (4) types of mica made from these classes.

(b) Explain four (4) detailed uses of mica

Q6. (a) Define Kaolin and state its composition.

(b) There are two broad classes in the genesis of Kaolin. Name the classes and describe their genesis.

Q7. (a) What is a pegmatite?

(b) How are pegmatites formed?

(c)List four industrial minerals exploited from pegmatites.

*****Good luck*****

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – AUGUST/SEPTEMBER 2013

GG 569 – ENGINEERING GEOLOGYAND ROCK MECHANICS

TIME: 3 HOURS

ANSWER: ALL QUESTIONS FROM SECTION 1 AND ANY **THREE** QUESTIONS FROM SECTION 2. **ALL** QUESTIONS IN SECTION 2 CARRY EQUAL MARKS

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1 In stress-strain test, rocks that exhibit a significant amount of plastic response before failure are said to be: a) plastic b) ductile c) elastic d) brittle

2 Which of the following is NOT a common triggering mechanism of slope failure?: a) sudden increase of water, b) changes in slope c) earthquakes d) actually, all of these are common triggering mechanisms

3 POROSITY is found by dividing the volume of voids by the: a) volume of solids b) volume of water c) total volume of the sample

4 Which of the following is likely to have the greatest hydraulic conductivity? a) clay b) sandstone c) sand d) gravel

5 Groundwater that is in direct vertical contact with the atmosphere through open pores of an aquifer is called, a) confined, b) unconfined, c) perched, d) artesian

6 A CONE OF DEPRESSION in the water table results from a) excess rate of pumping b) excess volume of pumping c) any significant amount of pumping d) defective pump

7 If the liquid limit is 40% and the plastic limit is 25%, the PLASTICITY INDEX is: a) 60% b) 65% c) 15% d) 32.5%

8 The strength of intact rock specimens tested in the lab are almost always greater than that of the overall rock mass in the field, because: a) lab testing is more accurate, b) discontinuities weaken the rock mass, c) the weight of the overlying rocks weakens the rocks in the field, d) rocks in the field have been exposed to weathering

9 In a direct-shear apparatus, when the normal force is 100 N a shear force of 60 N is required to cause failure. What is the angle of internal friction? a) 31^0 b) 22^0 c) 37^0 d) 53^0

10 The plastic limit and the liquid limit, together, are referred to as the: a) Atterberg limits b) Mohr-Coulomb limits c) Wegener limits

11 A particle-size distribution characterized by roughly equal proportions of all particle sizes would be called: a) poorly graded b. well sorted c. poorly sorted d. ductile

12 The geological term WELL SORTED corresponds to the engineering term: a) well graded b) poorly graded c) highly porous d) highly plastic

13 The capacity of a rock to transmit water is called: a) porosity b) void ratio c) permeability

14 A rock or sediment that both stores and transmits a significant amount of water is called an: a) aquifer, b) aquiclude, c) aquitard

15 In its simplest form, Darcy's law relates mean velocity to: a) cross-sectional area x hydraulic gradient, b) hydraulic conductivity x head, c) hydraulic conductivity x hydraulic gradient

16 If the water in a piezometer tapping an aquifer stands above ground level the aquifer is said to be: a) equipotential b) artesian c) confined d) perched

17 Slabs of rock parallel to cliff face that tilt and then fall forward are best termed: a) translational slides b) rock falls c) topples

18 A factor of safety less than 1.0 means that the hillslope is: a) unstable b) marginally stable c) stable

19 The shear strength a material possesses, when the effective normal stress = 0 is called the: a) internal friction b) friction between particles c) cohesion d) interlocking of particles

20 Which of the following classifications in the Unified Soil Classification System has the highest strength? a) well graded gravel b) clayey gravel c) silty sand d) silt e) silty clay

21 The soil mechanics test that involves rolling moist soil into thin threads is the: a) Atterberg limit b) liquid limit c) plastic limit

22 The liquid limit minus the plastic limit gives the: a) sensitivity b) soil activity c) plasticity index d) solid limit

23 Coherent movements that occur along curved failure surfaces are called: a) translational slides b) slumps c) earth flows

24 Which of the following is NOT included as part of internal friction? a) friction between particles b) interlocking of particles c) cohesion between particles

25 Linear features in the landscape as seen on Landsat images may assist in finding groundwater supplies because: a) they show topographic lows b) they show zones of layered sedimentary rock, c) they show faults or other fractured zones that may have locally enhanced the permeability.

SECTION 2: ESSAY-TYPE QUESTIONS

1 A tunnel excavation for an underground parking lot was excavated at the UNZA Shopping Mall. During this excavation, a plane P was seen ***day-lighting*** into the slope. Triaxial cell tests performed on soil filling along this discontinuity produced the following results:

σ_2 (kNm^{-2})	1	5	9.5	15
σ_1 (kNm^{-2})	9.2	28	48.7	74

Available data also revealed the following:
Angle of the cut slope of 60^0; Dip of the day-lighting plane P of 45^0; Weight of the potential sliding mass of 600kN; Total contact area is 300 m^2. Determine:

i) The total force resisting sliding
ii) The factor of safety of the block against sliding
iii) The magnitude of the force of a rock bolt installed perpendicular to the plane that would raise the factor of safety of the block to 3.

2 a) To determine the average depth to suitable foundation ground under the UNZA Shopping Mall, a seismic refraction survey was undertaken, which gave the following results:

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

Assumption: Layers in the prospective site are horizontal. In this case, calculate:

i) The wave velocities in each layer
ii) The depth to the first refractor surface, which would be assumed to represent rock-head. (20 Marks)

b) The seismic survey carried out in (a) gave Compressional and Transverse wave velocities of 10 KM s^{-1} and 6 KM s^{-1}, respectively. Determine for this groundmass its Poisson's ratio. What would be the difference, if at all, between the value of Poisson's ratio from this test and one obtained from vertical loading of a sample of the same material in the Lab? Give one possible reason for such a difference.

3 a) what are the three main categories into which Geologic masses can be sub-divided? Illustrate these with the aid of diagrams.

b) Lusaka City Council (LCC) is planning a new dumpsite to serve a part of the City of Lusaka, for which a detailed site investigation is required.
   i) Give <u>three</u> objectives of such an investigation?
   ii) Describe the various stages of such an investigation.

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

4 A hole drilled at the site of the new UNZA Shopping Mall along the Great East Road to ascertain ground conditions intersected nine metres of soil with the remainder being in rock. The portion that intersected rock gave the following drilled lengths in cms:

11.8	23	7	5.3	17	9	9.2	9	75.8	10.7	8	8.9	5.3
9.9	56	10.8	9	7.6	17.9	19.4	8.3	8.8	7.3	33.9	7.8	10.5
11	8.9	8.2	9	10.7	11	8.4	9.8	6.5	7.5	9.9	6.5	8.9
20	12.3	9.7	5.8	56	9.1	87.9	10.8	16	7.3	65	7.9	12.3
8.5	17	9.7	44.1	8.8	9.8	20	9	25	9	45	11.4	39.1

If the hole was 25 metres deep, determine its:

i) Rock Quality Designation (RQD)

ii) Total Core Recovery (TCR)

iii)Core Loss

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

5 a) Write brief notes on the following:

i) Ultimate bearing capacity

ii) The Maximum Safe Bearing Capacity

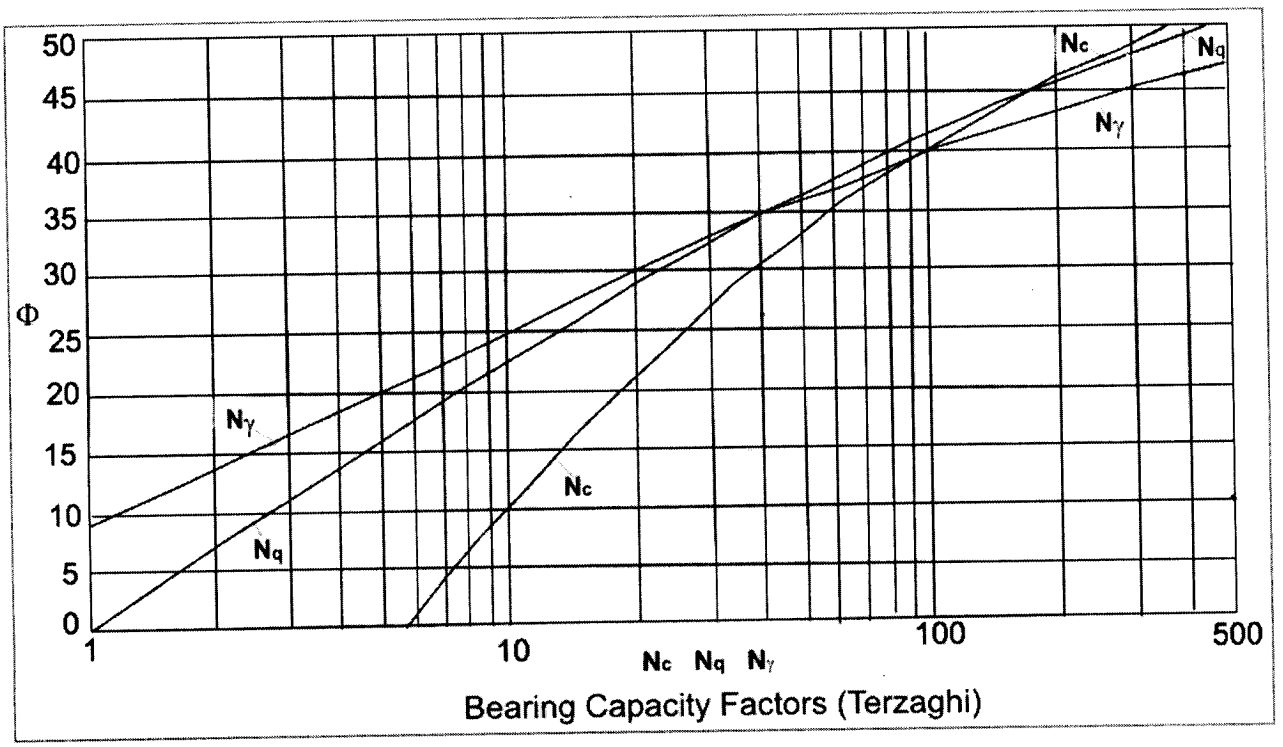
iii) Differential settlement

b) The Resident Engineer's Department is planning to build a new sports hall at one of UNZA's Goma Fields. It is designed to be supported by square (2m x 2m) footings founded at 1.5m below ground surface. If the unit weight of the foundation soil was determined to be 15 kN m^{-3}, and shear box tests performed on three specimens of this soil gave the following results:

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

Determine the ultimate bearing capacity of the soil under each footing.

$N_{c(rectangle)} = N_{c\{strip\}}*(1 + 0.3.B/L)$; $N_{q\ (rectangle)} = N_{q\ \{strip\}}$; $N_{\gamma\ (rectangle)} = N_{\gamma\ \{strip\}}*(1-0.2.B/L)$; bearing capacity factors are given at the end of the paper.



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UNIVERSITY OF ZAMBIA EXAMINATIONS

SCHOOL OF MINES

GG 572 HYDROGEOLOGY FINAL EXAMINATION, AUGUST 2013

ANSWER: FIVE (5) QUESTIONS

ALL QUESTIONS CARRY EQUAL MARKS

TIME: THREE (3) HOURS

---

1. Briefly explain the following:

   (a) Connate water
   (b) Aquiclude
   (c) Piezometric surface of a confined aquifer
   (d) Hydraulic conductivity written as a tensor
   (e) Cone of depression
   (f) Step-Drawdown Test
   (g) Specific capacity
   (h) Effect of excessive Nitrate (NO_3) on human health
   (i) Storage coefficient for a confined aquifer
   (j) Well function

   20 MARKS

2. (a) Describe with the aid of a diagram the hydrologic cycle

   10 MARKS

   (b) Explain what parameters of the hydrologic cycle have the potential to be affected (locally) with development taking place in the Lusaka South Economic Zone. What are the changes if any?

   10 MARKS

3. Describe with the aid of a diagram the vertical distribution of groundwater.

   20 MARKS

4. (a) Permeameters are usually employed to measure hydraulic conductivity of geologic samples in the laboratory. Describe how this is done using the constant head permeameter.

15 MARKS

(b) Suppose you are given a piezometric surface (water level) map of Lusaka and the sourrounding areas.

(i) Where would you expect contour lines to be close together, in schists and quartzites or in the carbonate rocks

2 MARKS

(ii) What does closeness of contours mean in terms of transmissivity.

3 MARKS

5. Describe how to conduct Cooper-Jacob method of pump test of the non equilibrium equation.

20 MARKS

6. (a) Explain how to carry out a groundwater survey employing Vertical Electrical Sounding (VES).

15 MARKS

(b) What advantages does Continuous Vertical Electrical Sounding (CVES) have over VES?

5 MARKS

7. (a) Prepare a table summarizing the more common waterborne diseases, listing:
- Waterborne disease
- Causative organism
- Source of organism in water
- Health effect

15 MARKS

(b) Explain why groundwater in John Laing is extremely vulnerable.

5 MARKS

UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS
SEMESTER 11 EXAMINATIONS

MI 311 – DRILLING

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

Question One

(a) What is known as wire line drilling? What are its special features which makes this system altogether different from others? Explain using a simple diagram. **[8 marks]**

(b) There are some special drill patterns which are used to create a free face particularly in case of driving a tunnel since the drill holes are filled parallel to the axis of the tunnel. Suggest with the help of neat diagrams at least TWO such drill patterns for the above purpose. **[8 marks]**

(c) The rock quality designation (R.Q.D.) values are accepted in dealing with rock mechanics problem only when some special conditions are met for drilling operations. Write those conditions **[2 marks]**

(d) If the RQD value of a section of a rock is 62%, comment on the type of rock. **[2 marks]**

Question Two

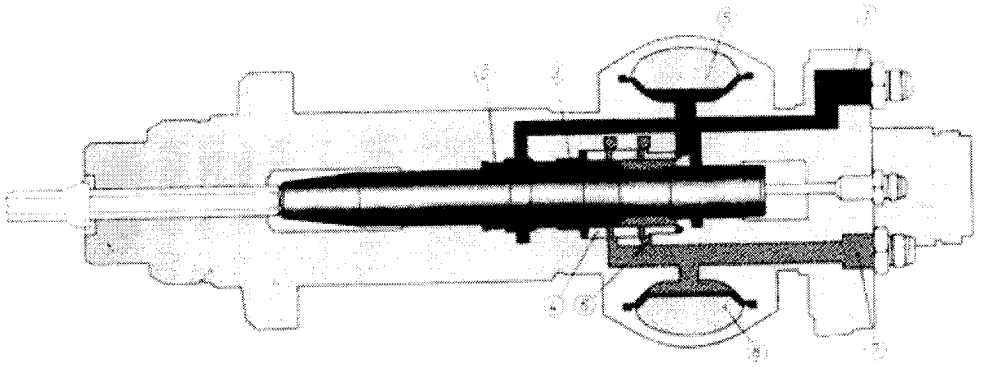
Describe the four primary rock breakage mechanisms, highlighting the situations where they derive the best applications. **[20 marks]**

Question Three

Given below is a cut-out section showing the various components of a hydraulic rock drill / drifter:

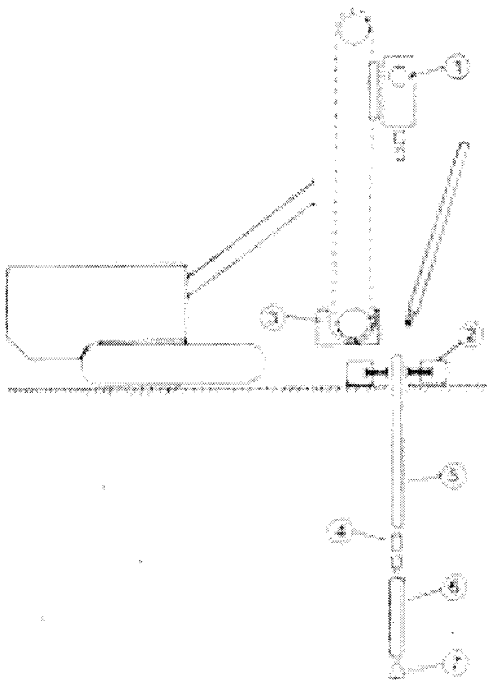
(a) Name the numbered components indicating their specific functions in the operation of the drill. **[10 marks]**

(b) If you were to improve the power and efficiency of the rock drill, which components would you modify? **[10 marks]**

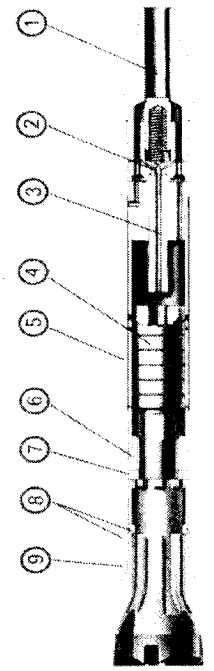


Question Four

Given on the following page are schematic diagrams of the components of the ITH Equipment and the assembled construction of the ITH hammer.



For question 4(a)



For question 4(b)

(a) Name the equipment components describing their functions in the operation of the machine **[10 marks]**

(b) Name the components in the construction of the ITH hammer highlighting how each component contributes to the drilling process. **[10 marks]**

Question Five

(a) Discuss the principles of percussive drilling. Use mathematical expressions to rend credence to to the properties that make percussion tenable. **[5 marks]**

(b) Feed and rotation may be referred to as the major ingredients in breaking rock by drilling: Discuss how feed and rotation affect the overall drill process. **[10 marks]**

(c) Why is flushing necessary in the drilling process? Mention the varios flushing media indicating where they derive their best application. **[5 marks]**

Question Six

(a) Describe the types and sources of hole deviations. **[15 marks]**
(b) How can hole deviations be corrected or minimized. **[5 marks]**

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATION
SEMESTER II EXAMINATIONS

MI 331 – UNDERGROUND MINING

INSTRUCTIONS:	**ANSWER ALL QUESTIONS**	TOTAL MARK:	**100**
TIME:	**3 HOURS**	CLOSED BOOK	

Question 1

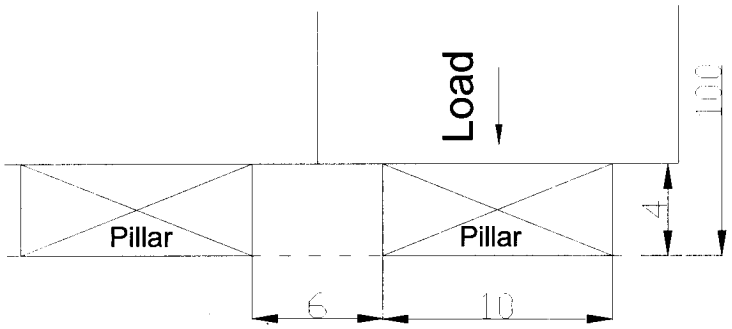
(a) Explain the following terms as applied in Room and Pillar mining method;

(i) Pillar Safety Factor; **[3 marks]**
(ii) Percentage of Extraction; **[3 marks]**
(iii) Pillar Strength; **[3 marks]**

(b) A coal seam is 4m thick at a depth of the coal floor below surface of 100m.

Room and pillar mining is to be done.

(i). Will this pillar size be sufficient to ensure a safety factor of 1.6? **[4 marks]**
(ii). What will the centre to centre distance be? **[4 marks]**
(iii). What will be the percentage extraction? **[3 marks]**



Question 2

(a) Mention **five** underground mining equipments and explain the **functions** of the mentioned equipment in underground mining. **[6 marks]**

(b) Explain in detail the systems of underground mine haulage. Your answer must cover the following systems: **[10 marks]**

(i) Face transport;
(ii) Subsidiary haulage;
(iii) Main Haulage;

(c) Discuss the factors influencing the choice of mine access. **[4 marks]**

Question 3

(a) Explain the main fundamental considerations when selecting an underground mining method. **[5 marks]**

(b) Explain briefly the factors that influence the choice of a mining method. **[5 marks]**

(c) Choose **<u>one</u>** mining method below and discuss in detail the **suitability, development and operations (production)** 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 caving;
(iii) Block caving;
(iv) Cut and Fill;

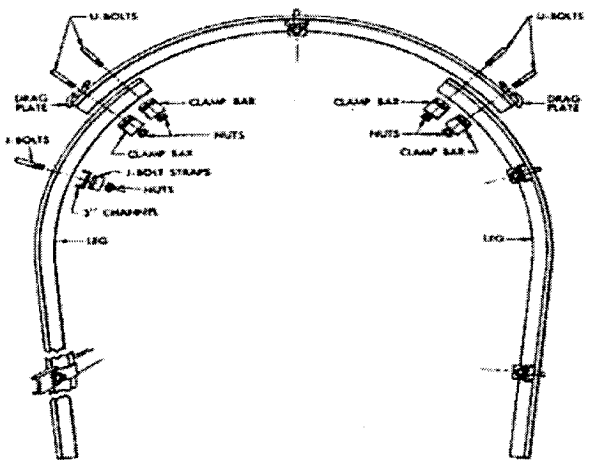
Question 4

(a) Explain the following terms;

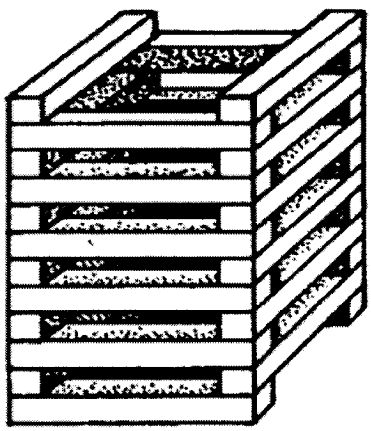
(i) Primary opening; **[2 marks]**
(ii) Secondary opening; **[2 marks]**
(iii) Rib Pillar; **[2 marks]**
(iv) Bleeder shaft; **[2 marks]**
(v) Crown Pillar; **[2 marks]**

(b) Discuss at least **four** ground control methods in underground mining operations. **[6 marks]**

(c) The figure below show two underground supports systems. Names the two supports systems. **[4 marks]**



A



B

Question 5

(a) Mention five (5) factors that are considered before a mine can be developed? **[4 marks]**

(b) Discuss the factors that influence the choice of the location of the shaft **[4 marks]**

(c) Briefly discuss at least 5 functions of the shaft **[4 marks]**

(d) Discuss briefly the following;

(i) The main objectives of scheduling in underground mining; **[4 marks]**

(ii) The importance of sequencing in underground mining. **[4 marks]**

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATION
SEMESTER II EXAMINATIONS

MI 335 – SURFACE MINING

INSTRUCTIONS:	**ANSWER ALL QUESTIONS**	TOTAL MARK:	**100**
TIME:	**3 HOURS**	CLOSED BOOK	

Question 1

(a) Explain the following

(i) Dead heading **[2 marks]**
(ii) Buffer Blasting **[2 marks]**
(iii) Factors to be considered in open pit mine design. **[4 marks]**
(iv) Methods of reinforcing and supporting pit slopes in open pit mining? **[6 marks]**

(b) Explain briefly the following open pit and explain their importance in an open pit mine (Explain using labelled diagram where possible);

(i) Open pit limit **[1 mark]**
(ii) Berm **[1 mark]**
(iii) Slope angle **[1 mark]**
(iv) Bench **[1 mark]**
(v) Bench Height **[1 mark]**
(vi) Toe **[1 mark]**

Question 2

(a) Answer the following questions;
(i) What determines haul roads width in an open pit mine? **[2 marks]**
(ii) What controls the pit limits? **[4 marks]**

(b) Discuss the importance of having correct "Pit wall Slope" in open pit mine? **[4 marks]**

(c) What are some of the advantages and disadvantages of strip mining? **[4 marks]**

(d) Discuss the main issues to be considered in haul road design. **[6 marks]**

Question 3

Consider the sketch of a small block model cross-section shown below. The Block Economic Values (BEVs) are written on the blocks. Blocks with BEV = 0 at the top of certain blocks refer to "air blocks", that is blocks located above the surface topography. Given that the maximum allowable slope angle on the section should be 1 block: 1 block both on the left and to the right, **determine the maximum valued pit outline on the section using Dynamic Programming.** **[20 marks]**

	1	2	3	4	5	6	7	8	9	10
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	-1	-1	-1	-1	-1	-1	-1
3	-1	-1	-1	-1	-1	3	4	4	-1	-1
4	-1	-1	-1	-1	4	5	5	-1	-1	-1
5	-1	-1	5	6	6	-1	-1	-1	-1	-1

Question 4

(a) What are the main objectives of scheduling in open pit mining? **[2 marks]**

(b) Discuss the main inputs for the open mine schedule. **[4 marks]**

(c) Explain what is meant by the following, as they relate to open pit scheduling;

(i) Production Schedules; **[2 marks]**

(ii) Development Schedule; **[2 marks]**

(iii) Production drilling schedule; **[2 marks]**

(iv) Equipment Schedule; **[2 marks]**

(d) Mention five open pit equipment and explain the functions of each equipment in open pit mining. **[6 marks]**

Question 5

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]**

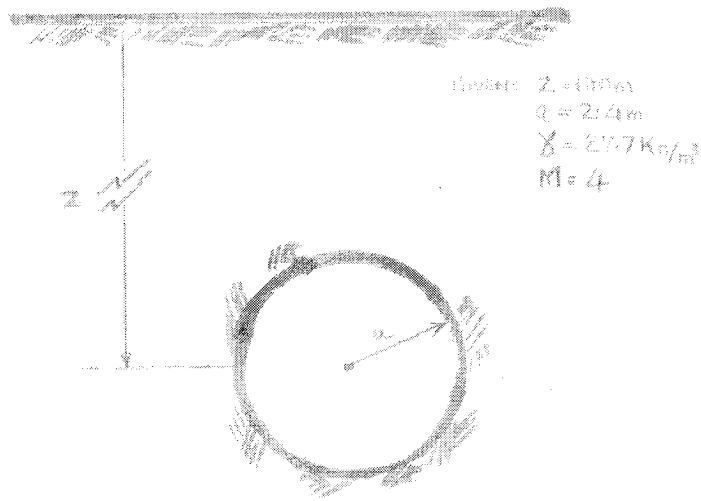
END OF EXAMINATION

UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS
SEMESTER II EXAMINATIONS

MI 515 – ROCK MECHANICS II

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

Q1



A circular unlined tunnel, 4.8m in diameter is driven at a depth of 610m; the density of the overburden is 27.7 KN/m^3; Poisson's Number is 4.

Assuming that the horizontal stress in the undisturbed ground is due only to the horizontal restraint of the overburden pressure, calculate using plate theory equations:

(a) The stress at the surface of the rock at the crown of the tunnel and plot on one Mohr diagram, the three (3) stress circles for the radial, tangential and horizontal planes. **[15 Marks]**

(b) What is the stress concentration factor in (a) above? **[5 Marks]**

Q 2 (i) What is the difference between Permeability, water content and porosity of the soil? **[6 Marks]**

(ii) Explain briefly, how water content and porosity can be determined of rock can be determined? State the units in which these are expressed. **[6 Marks]**

(iii) If 5,000 cc of water flow through mudstone in 121 seconds, the water difference in the two stand pipes used for testing permeability is 7.31 cm and the difference in water tapping tube is 10cm calculate the coefficient of permeability given the cross-section area of the mudstone sample is 81 cm^2. **[4 Marks]**

Q3. (a) One of the principal causes of water dam failure is the increase in pore water pressure in the rock which contains water. What this property means and how this is measured? **[6 Marks]**

(b) It is proposed to construct a water dam to supply water to a hydra station The values of COHESION and ANGLE OF INTERNAL FRICTION of the rock bed is 1.07 MPa and 40 degrees respectively when the value of σ_3 and σ_1 were 9.03 MPa and 34.5 MPa respectively.

Calculate the value of pore water pressure that will cause the failure of the water dam in the above situation. **[10 Marks]**

Q4 (a) Explain the difference between the rock bursts, gas out bursts, and the earth quake. **[6 Marks]**

(b) How rock bursts occurrence can be controlled ? Suggests some measures for its control. **[6 Marks]**

(c) Calculate the specific strain energy which will be developed from the data given below:

Poisson`s ratio of rocks =0.25; uniaxial compressive strength =120 MPa and modulus of rigidity = 60.5GPa **[4 Marks]**

Q5 (a) Briefly describe the the main reasons for failure of the bank. Suggests some control measures for this purpose. **[5 Marks]**

(b) To monitor the movement of the slope there are several methods which are in use these days. Name these methods and briefly describe their working principle. **[5 Marks]**

(c) If the base area of a hillock is 30x30m and the height of the hillock is 20 m. If the specific gravity of the material to be bolted is 2,500 kPa/ m^3, calculate the number of bolts you will recommend for this purpose (assuming each bolt can hold a load of 80 tonnes), spacing between the two bolts. **[6 Marks]**

Q6 (a) Use of models are very popular these days to solve intricate problems. Suggests whether the modelling can also be used in mines? Write the some mining problems which can be studied using models. **[6 Marks]**

(b) A building blocks making comp[any has approached you for developing blocks using limestone dust, sand and cement ranging between 40to 60MPa strength to be used for different purposes.

Suggest step by step, How can you develop the blocks of different strength as requested. Also, suggest how much money you will be charging from the company for this purpose. Justify the amount you will be charging. **[10 Marks]**

Q7 (a) What is chimney type of subsidence? Explain, using diagram how is it caused? **[5 Marks]**

(b) A rectangular panel for mining coal is in the process at a depth of 600 m. You are required to predict the nature of subsidence profile for the same. Suggest using diagram how would you do it? **[5 Marks]**

(c) If the extracted height of coal seam is 4.5m and the values for S/m and s/S are 0.08 and 0.02 obtained from NCB Subsidence Mining Engineers Hand book, calculate the amount of maximum subsidence that may occur. **[6 Marks]**

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SEMESTER II 2013 EXAMINATIONS

MI 542 MINE FINANCE AND ADMINISTRATION

TIME: 3 HOURS

INSTRUCTIONS: ANSWER ANY FIVE (5) QUESTIONS ONLY

1. Write short notes on the following business structures:

i)	Sole proprietor	**[4 marks]**
ii)	Corporation	**[4 marks]**
iii)	Limited company	**[4 marks]**
iv)	Cooperative	**[4 marks]**
v)	Joint venture	**[4 marks]**

2. Given the following company's Balance Sheet entries in Table 1, determine:

i)	The total current assets	**[4 marks]**
ii)	The total current liabilities	**[4 marks]**
iii)	The working capital. Comment on the value	**[4 marks]**
iv)	The current ratio	**[4 marks]**
v)	The equity position of the company	**[4 marks]**

Table 1. Balance sheet entries

Entry	Amount (US$)
Bank cash	1,450,000
Marketable securities at cost	1,850,000
Accounts payable	1,000,000
Accounts receivable	2,500,000
Inventories	700,000
Land	450,000
Buildings	3,800,000
Equipment and Machinery	4,950,000
Office equipment	100,000
Accumulated depreciation on fixed assets	3,500,000

Prepayments and deferred charges	100,000
Intangibles (goodwill, patent, trademarks)	100,000
Notes payable	850,000
Accrued expenses payable	330,000
Income tax payable	320,000
First mortgage bonds due 2020	5,700,000
Preferred stock	600,000
Capital surplus	700,000
Common stock	1,500,000
Accumulated retained earnings	1,700,000

3. Why is "SWOT" analysis important in project planning? Discuss the various aspects of this analysis. **[20 marks]**

4. What do you understand by the term "risk" in project management? Briefly discuss the various types of risks a project may encounter. **[20 marks]**

5. Write short notes on the following sources of funds in a mining project:

a)

i) Equity **[3 marks]**
ii) Retained earnings **[3 marks]**
iii) Mortgage bonds **[3 marks]**
iv) Debentures **[3 marks]**

b)

i) Comment on reasons why it is generally difficult to raise debt financing through financial institutions by small-scale miners. **[8 marks]**

6.

i) What are cost indices and how are they used in cost estimation? **[8 marks]**
ii) Give examples of three cost indices. **[4 marks]**
iii) An excavator was purchased for U$550,000 in 2010. What is the approximate cost of this unit today given Marshal & Swift indices as follows:

Year	Marshal & Swift Indices
2010	483
2013	761

[8 marks]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SEMESTER II 2013 EXAMINATIONS

MI 545 MINE MANAGEMENT

TIME: 3 HOURS

INSTRUCTIONS: ANSWER ALL QUESTIONS **TOTAL MARKS 100**

QUESTION 1

1 (a) Discuss the three social science disciplines used in the study of organizational behavioural and management and why? **(5 marks)**

(b) Discuss four factors which influence behavior in organizations **(5 marks)**

(c) Discuss the process of perception and its influence on managerial style and attitude towards subordinates **(5 marks)**

(d) What is a physiological contract and how does it impact on expectations of workers and employers **(5 marks)**

QUESTION 2

2 (a) List the eleven major approaches to the study of management **(8 marks)**

(b) Write short notes on

(i) Scientific management and Taylor **(3 marks)**

(ii) Burunercy and weber

(iii) The studies undertaken and fundings of experiment the western electric company of America **(3 marks)**

(c) Maslows hierarchy of need **(3 marks)**

(3) Hezerbergs two factor theory **(3 marks)**

QUESTION 3

3) (i) Discuss the desired attributes of a good director **(5 marks)**

(ii) Discuss Fayols principles of management **(6 marks)**

(iii) Write short notes on the following theories

(a) Theory X **(3 marks)**
(b) (b) Theory Y **(3 marks)**
(c) (c) Theory Z **(3 marks)**

QUESTION 4

(4) Organisations use the following concepts in managing institutions, Discuss why

(i) Vision (ii) Goals (iii) Objectives

(5 marks)

(d) Strategic planning is not about "leading armies" what is it? **(5 marks)**
(e) Leadership and management are different why? Discuss the main theories on leadership and your effective and understanding of management **(5 marks)**
(f) Business organization should attributes in their life cycle why? **(5 marks)**

QUESTION 5

a) All successful companies are planned. What happens when there is no planning? Discuss the steps involved in planning. **(10 marks)**

b) Controlling although the last function of management is important why? Discuss the variables controlled and tools for controlling. **(10 marks)**

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SEMESTER II 2013 EXAMINATIONS

MI 565 MINERAL ECONOMICS II

TIME: 3 HOURS

INSTRUCTIONS: ANSWER ALL QUESTIONS **TOTAL MARKS 100**

QUESTION 1

1 (a) Discuss the five objectives of economics in the management of a national economy **(4 marks)**

(b) Differentiate the three concepts of national income (GNP, GDP and NNP) **(4 marks)**

(c) State the main accounting relationships of national **income** **(4 marks)**

(d) Write short notes on the three methods of measuring national income **(4 marks)**

(e) Show how the five main sectors of the economy are interrelated **(4 marks)**

QUESTION 2

(a) Write short notes on the consumption functions and savings function **(6 marks)**

(b) Illustrate how the concept of investment multiplier is used in arriving at the determination of government expenditure **(5 marks)**

(c) Given that current level of national income is K10,000 million and the target for growth is 20% and mpc is 0.8 what could be the required investment in the economy **(5 marks)**

(d) Derive the following multipliers :

(i) Government expenditure multiplier **(1mark)**

(ii) Tax multiplier **(1mark)**

(iii) Balanced budget multiplier **(1mark)**

(iv) Foreign trade multiplier **(1mark)**

QUESTION 3

(a) In contemporary national growth economics why are the following concepts important?

(i) Capital formation

(ii) social and political factors

(iii) human capital

(iv) Technology and Techniques of production

(5 marks)

(b) Current economies are prone to economic instability. Discuss the main theories explaining the causes of cyclic instability

(i) Monetary over investment theory

(ii) Pure monetary theory
(iii) Sohumpeters innovation theory

(5 marks)

(c) Economic stabilization is based on good fiscal and monetary policies; write short notes

(i) Objectives of stabilization policies
(ii) Counter cyclical fiscal policy
(iii) Problems of counter cyclical fiscal policy **(5 marks)**

(d)Monetary policy is based on four main concepts write short notes on each of these concepts

(5 marks)

4) a) Taxes play two major functions, write about these functions **(4 marks)**

b) How do taxes influences individuals and corporations **(5 marks)**

c) Mining taxes should be used to fulfill needs of main claimants to economic rents identify the claimants and rent classification systems **(5 marks)**

d) Write short notes on

(i) Royalties **(2 marks)**

(ii) Profit based income taxes **(2 marks)**

(iii)Theories of **taxation** **(2 marks)**

5) Mineral marketing is based on understanding. Discuss (i, ii and iii)

(i) problems which producers and buyers face before commodity exchanges **(5 marks)**

(ii) forward contracts **(5 marks)**

(iii) futures contracts **(5 marks)**

(iv) Discuss the functionS of commodity exchanges **(5 marks)**

END OF EXAMINATION

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THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – AUGUST/SEPTEMBER 2013

MM 205 – INTRODUCTION TO MINERAL SCIENCES.

TIME:	THREE HOURS
ANSWER:	ANY FIVE QUESTIONS AND AT LEAST ONE FROM EACH SECTION. USE SEPARATE ANSWER BOOKS FOR EACH SECTION

SECTION A: INTRODUCTION TO GEOLOGY.

Q1. (a) Define the following terms:
(i) Crystal; (ii) Unit cell; (iii) Primitive (P) lattice; (iii) Axis of symmetry; (iv) Mirror plane **(12 marks)**

(b) Name and describe briefly any three open forms. **(6 marks)**

(c) Distinguish cation from anion. SIZE. **(4 marks)**

(d) Explain why a cation attains a smaller than the anion. **(3 marks)**

Q2. (a) Distinguish between colour and streak. **(4 marks)**

(b) Why is colour not a diagnostic physical property of minerals? **(3 marks)**

(c) Distinguish between transparency and opacity. **(4 marks)**

(d) Define the following terms: **(6 marks)**
(i) Lustre; (ii) Hardness; (iii) Cleavage

(f) Diamond and graphite are composed of the same substance and yet diamond is the hardest substance known to man and it is dense, while graphite is very soft and less dense. Why do you think this is so? **(4 marks)**

(g) Classify the following minerals into groups and state why. **(4 marks)**
(i) magnetite, and (ii) calcite.

Q3. (a) Distinguish ore from rock. **(3marks)**

(b) Describe the rock cycle and sketch it. **(3 marks)**

(c) Distinguish mechanical (or physical) weathering from chemical weathering. **(6 marks)**

(d) Briefly describe how igneous, sedimentary and metamorphic rocks form? **(9 marks)**

(e) Name and describe the process involved in the formation of rock salt (or halite). **(4 marks)**

SECTION B: INTRODUCTION TO MINING ENGINEERING.

1. (a) Write briefly the situation in which you would recommend surface mining and underground mining methods. **(02)**

Name the various methods used in surface mining and two names of the underground mining methods classed under;

(i) unsupported (ii) supported (iii) caving **(03)**

(b) Write three advantages of surface mining and two advantages of underground mining. Name some of the mining methods which are known as novel methods of mining. **(05)**

(c) Write the purpose of prospecting and exploration in mining. Explain briefly how they are done. **(05)**

(d) Estimation of ore reserve in mining is important before it is decided whether to go ahead or reject the project. Suggest a method for ore reserve calculation which are normally used.

A coal deposit spread over an area of 1.5 x 2.0 km having the thickness of 6m as reported by the drillers. It was also reported that the coal strata is dipping at an angle of 20 degrees from the horizon top. If the specific gravity of coal is 1.27, calculate the total quantity of coal.

Write the answer in whole number in nearest tonne. **(05)**

2. (a) What are the types of supports currently in use for underground mines? Explain the advantages of strata reinforcement using bolts over the other types. **(05)**

(b) Why is artificial ventilation necessary for underground mines? **(02)**

How would you ensure that a particular place in underground mine is getting adequate amount of air? **(03)**

(c) If the cross-section area of a circular passage through which air is flowing is doubled and the velocity is reduced by half, what would be the effect on the total quantity of air flowing through that passage? **(05)**

(d) What is an explosive? Name the ingredients for low explosive and for one high explosive. **(02)**

Sketch a Delay Action Detonator and show the different chemicals it contends **(03)**

SECTION C

INTRODUCTION TO METALLURGY AND MINERAL PROCESSING.

ANSWER: TWO QUESTIONS

Q1. 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]**

Q2 What role does the below mentioned reagents pray in flotation and give some of their examples

i) Collectors **[4]**
ii) Frothers **[3]**
iii) Modifiers **[4]**
iv) Regulators **[2]**

b) What are Roughers, Scavangers and Cleaner circuits **[4]**

c) What do you understand by pre concentration and reverse flotation **[3]**

Q3 a) What do you understand by terms Roasting, Smelting and fire refining and mention the equipment used? **[6]**
b) Explain how concentrates are prepared for leaching and smelting. **[2]**

b) Write brief notes but clearly what is involved in the extraction of copper by pyrometallurgical methods and the main products at each stage under the headings mentioned in (a) with the type of equipment used and possible reactions and temperature regime attained. **[12]**

END OF MM 205 SEMESTER II EXAMINATION AND GOOD LUCK.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

MM 332 - CHEMICAL THERMODYNAMICS II

UNIVERSITY EXAMINATIONS

SECOND SEMESTER AUGUST/SEPTEMBER 2013

TIME ALLOWED: THREE HOURS

ANSWER FIVE(5) OUT OF SIX (6) QUESTIONS, But remember that, all questions carry equal MARKS.

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1. The following thermodynamic data are available for the Cadmium - Lead liquid alloys at 773 K:

Npb	0.1	0.2	0.3	0.4	0.5
ΔG^{mix} (J/mole)	-1120	-1640	-1960	-2160	-2300

(a) How do you differentiate Partial and Integral molar quantities on one hand from relative partial and integral molar quantities. Plot ΔG^{mix} versus Ppb and obtain $(\bar{G}_{pb} - G^{o}_{pb})$ and $(\bar{G}_{Cd} - G^{o}_{cD})$ at Npb = 0.2 and 0.3. **[7]**

(b) Calculate G^{ex} at Npb = 0.2 and 0.3. **[6]**

(c) Explain the differences between ideal, real and regular solutions. For an ideal solution derive ΔV mix, ΔH mix, ΔS mix and ΔG mix. **[7]**

2. (a) Derive the expression for the lowering of the freezing point of a water, due to the addition of a small amount of salt, a non-volatile solute. Assume that, there is no solid - solid solubility, and that water and salt are components A and B forming a binary solution at room temperature. **[14]**

(b) The activity coefficient of chromium in iron at infinite dilution relative to pure solid chromium as the standard state is unity. Calculate the change in the Gibbs energy when solid chromium is dissolved in iron so as to form an infinitely dilute, weight percent solution of chromium in liquid iron at 2073 K from the following data:

Heat of fusion of Chromium L_f = 5,000 cal/mol (20,920 J/mol)
Melting point of Chromium T_f = 1830° C

Atomic weights of Fe and Cr are 55.85 and 52 respectively.
R =8.31 J/mol.K **[6]**

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

$$\gamma_B = 1 - 3.92 N_B$$

a. Derive the relationship for the activity coefficient γ_A for Mercury in this solution at 25°C . **[6]**

b. Everett et al investigated the activity of Zinc in liquid Copper - Zinc alloy in the temperature rang 1069-1303 ^{0}K. They found that the activity co-efficient for Zinc can be expressed as follows:

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

where R = 8.3143 J/mole. °K.

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

$$\log p^o_{Zn} = -\frac{6620}{T} - 1.255 \log T - 12.34 (mmHg)$$ **[6]**

c. Using the equation in (b), derive the expression for the relationship for the activity coefficient of Copper, in the Copper - Zinc alloy at 1300 ° K.**[8]**

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

a. Find the G^M_{Cd} (= G_{Cd} - G^0_{Cd}) and S^M_{Cd} (= S_{Cd} - S^0_{Cd}) at 500^{0}C **[6]**

b. Determine the value of a_{Cd} in the alloy, relative to pure liquid Cd as the standard state. **[4]**

c. Calculate the vapour pressure over the Cd – Pb alloy given that the vapour pressure of pure liquid Cd is 13.5 Torr at 500^{0}C and ascertain whether the Cd – Pb system at X_{Cd} = 0.128 exhibit a positive or negative deviation from Raoult's law. [4]

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

$$W = \frac{ItA}{nF}$$

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

The half reaction is given as $\mathbf{2Al_2O_3 \Leftrightarrow 2\ Al^{3+} + 2\ AlO^{-3}}$ **[6]**

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

i. The nature of reactants and products

ii. Temperature of the reaction

iii. Concentration of both reactants and products

iv. Presence of catalysts [6]

b. Explain in detail, how the **collision theory** differs from the **theory of absolute reaction rates.** **[8]**

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

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

Show that the desulphurisation is a first order reaction and determine the half life for this process. **[6]**

6. A container measuring V litres in volume is divided in three equal compartments that contain 1g.mole of Helium gas, 2g.mole of neon gas and 3g.mole of organ gas. The initial temperature and pressure for each gas are 25°C and 1.2 atm. The gases are allowed to mix.
Calculate :
(a) the volume of the container,

(b) the mole fraction of each gas in the mixture,
(c) the partial pressure of each gas in the mixture.

From the above obtained data Calculate:

(d) the change the Gibbs energy of the system after gases mixed G^M,
(e) the change in entropy S^M sustained by the system during the mixing process. Assume that the gases behave ideally.

[20]

END OF EXAMINATION IN MM 332

GOOD LUCK.

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THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

MM 352 – HEAT AND MASS TRANSFER

UNIVERSITY EXAMINATIONS

SECOND SEMESTER AUGUST/SEPTEMBER 2013

TIME ALLOWED: THREE HOURS

ANSWER FIVE (5) OUT OF SIX (6) QUESTIONS, But remember that, all questions carry equal MARKS.

1. (a) A thin metal plate 0.1 m by 0.1 m is placed in a large evacuated container whose walls are kept at 300 K. The bottom surface of the plate is insulated, and the top surface is maintained at 500 K as a result of electrical heating. If the emissivity of the surface of the plate is $\varepsilon = 0.8$, what is the rate of heat exchange in W between the plate and the walls of the container? Take $\sigma = 5.67 \times 10^{-8}$ W/(m^2.K^4) [10]

(b) A flat plate has one surface insulated and the other surface exposed to the sun. The exposed surface absorbs solar radiation at a rate of 800 W/m^2 and dissipates it by both convection and radiation into ambient air at 300 K. If the emissivity of the surface is $\varepsilon = 0.9$ and the convection heat transfer coefficient between the plate and the air is 12 W/(m^2.^{0}C), determine the temperature of the plate. [10]

2. (a) Define the following terms
(i) Conduction
(ii) Convection
(iii) Radiation
(iv) Thermal diffusivity [4]

(b) Explain the main mechanisms by which heat is conducted in solids.[4]

(c) The inside and outside surface temperature of a window glass are 20 and -12^o C respectively. If the glass which measures, 80 cm by 40 c, is 1.6 cm thick and has a thermal conductivity of 0.78 W/m^{o}C. Determine the heat loss through the glass over 3 hours. [8]

(d) Water at a temperature of 20^{0}C flows over a flat plate at 80^{0}C. If the heat transfer coefficient is 200 W/(m^2. ^{0}C), determine the heat transfer per square metre of the plate over 5h. [4]

3. (a) Write the heat conduction equation for one-dimensional steady-state flow in a solid having a constant k and a constant rate of energy generation G_0 W/m^3 within the medium for

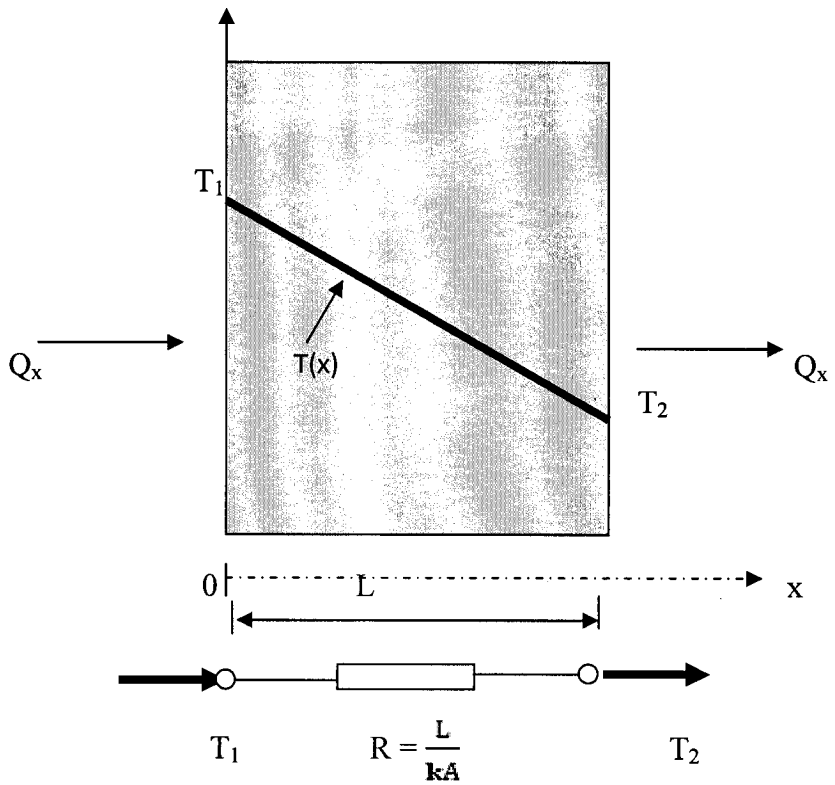
(a) a slab,(b) a cylinder and (c) a sphere.

Given the following compact equation:

$$\frac{1}{r^n}\frac{\partial}{\partial r}\left(r^n k\frac{\partial T}{\partial r}\right) + G = \rho c_P \frac{\partial T(r,t)}{\partial t}$$

[6]

(b)



The figure above shows a one-dimensional steady state heat flow through a slab and the equivalent thermal resistance concept. For a constant thermal conductivity and an energy generation rate G(x) in W/m^3, the thermal energy balance reduces to

$$\frac{d^2T}{dx^2} + \frac{1}{k}G(x) = 0$$

Derive an expression for the temperature distribution T(x) in the slab and an expression for the rate of heat flow Q through an area A of the slab given the initial and final boundary conditions. [10]

(c) A small hot surface at temperature $T_1 = 430$ K having an emissivity $\varepsilon_1 = 0.8$ dissipates heat by radiation into a surrounding area at $T_2 = 400$ K. If this radiation transfer process is characterised by a radiation heat transfer coefficient, calculate the value of h_r. [4]

4. A hollow cylinder with inner radius r = a and outer radius r = b is heated at the inner surface at a rate of q_0 W/m^2 and dissipates heat by convection

from the outer surface into a fluid at a temperature T_∞ with a heat transfer coefficient h. There is no energy generation and the thermal conductivity of the solid is assumed constant.

Derive expressions for the determination of the temperature T_1 and T_2. [15]

Calculate the surface temperatures T_1 and T_2 for a = 3 cm, b = 5 cm, h = 400 $W(m^2.\ ^0C)$, $T_\infty = 100^0C$, k = 15 $W/(m.\ ^0C)$ and $q_0 = 10^5 W/m^2$. [5]

5. (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)
(ii) Angular velocity
(iii) Moment of a force
(iv) Energy
(v) Viscosity **[5]**

(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) Verify whether the following equation is dimensionally homogeneous:

$$a = \frac{2d}{t^2} - \frac{2V_0}{t}$$

where a = acceleration
d = distance
V_0 = velocity
t = time

Use the following symbolic notation: The symbol [=] will mean "has dimensions of". For example, a [=] $\mathbf{LT^{-2}}$ means "a" has dimensions of $\mathbf{LT^{-2}}$. We shall use the same symbol for units, where applicable, and hope that we know what is meant. [5]

(d) 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.[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 $D_{AB} = 0.230 \times 10^4\ m^2/s$.

(i) Calculate the flux N_A at steady state [5]
(ii) Repeat for N_B (Show your working clearly) [5]

END OF EXAMINATION IN MM 352

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS

MM 412 – CONCENTRATION AND DEWATERING

Answer: Five Questions
Time : Three 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:

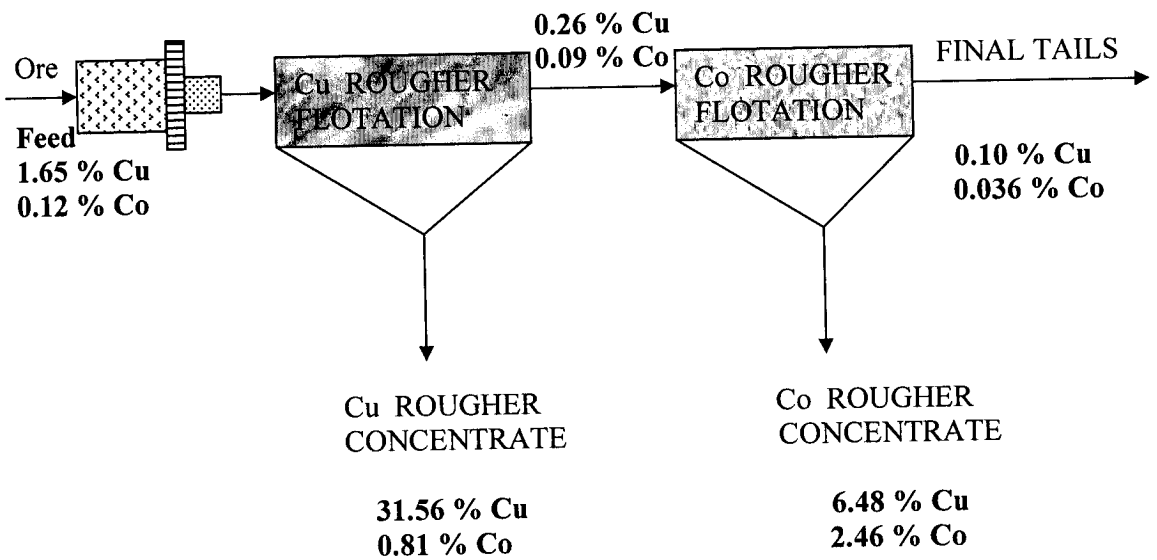
- copper sulphate
- lime
- sodium cyanide
- sodium di-chromate
- sodium iso-propyl xanthate
- tri-ethoxy butane

(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) A copper / cobalt sulphide ore at Nchanga Concentrator is treated in a differential flotation circuit to produce a copper concentrate and a cobalt concentrate in two stages, as shown in the diagram below. The average grades of the feed and products of this circuit are as indicated.



(i) Calculate the average recoveries of copper and of cobalt from the feed to the copper rougher concentrate and to the cobalt rougher concentrate. **[6 Marks]**

(ii) If the feed tonnage (F) is 18 000 tonnes (dry) per day, how much copper will be lost to the final tailings per day? **[4 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 a 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 two 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 MM 412 EXAMINATION –
GOOD LUCK !

UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
UNIVERSITY EXAMINATION

MM 415 – MINERAL PROCESSING FOR MINING ENGINEERS

Answer: Five Questions
Time : Three Hours

1.

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

- 80% passing reduction ratio
- ~~work index~~ bulk density
- grindability
- set of a crusher
- liberation
- middlings fraction
- angle of nip
- differential flotation
- work index
- comminution

[20 marks]

2.

a) Describe the crushing action of a jaw crusher with the aid of a clearly labelled diagram. Why do most modern jaw crushers use curved swing-jaw plates? **[7 marks]**

b) What is the purpose of a flywheel in a jaw crusher? **[3 marks]**

c) Describe the crushing action of a gyratory crusher with the aid of a clearly labelled diagram. **[7 marks]**

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

3.

a) Describe with a simple sketch the operation of the Symons standard cone crusher. What is the purpose of the parallel zone? **[7 marks]**

b) Describe the protection mechanism of the Symons standard cone crusher when an uncrushable material enters the crushing cavity. **[1 mark]**

c) What do you understand by the 'Set' of the Cone crusher and how could this be adjusted? **[3 marks]**

d) Primary crushers in particular can be operated in one of two distinct modes: "free crushing" and "choked crushing". Explain the underlined terms.**[4m arks]**

e) Describe the grinding action of a ball mill indicating the various zones that can be distinguished. **[5 marks]**

4.

a) Figure 1 below shows a conventional grinding circuit operation consisting of a rod mill and a ball mill in closed circuit with a hydrocyclone. From the following given data:

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

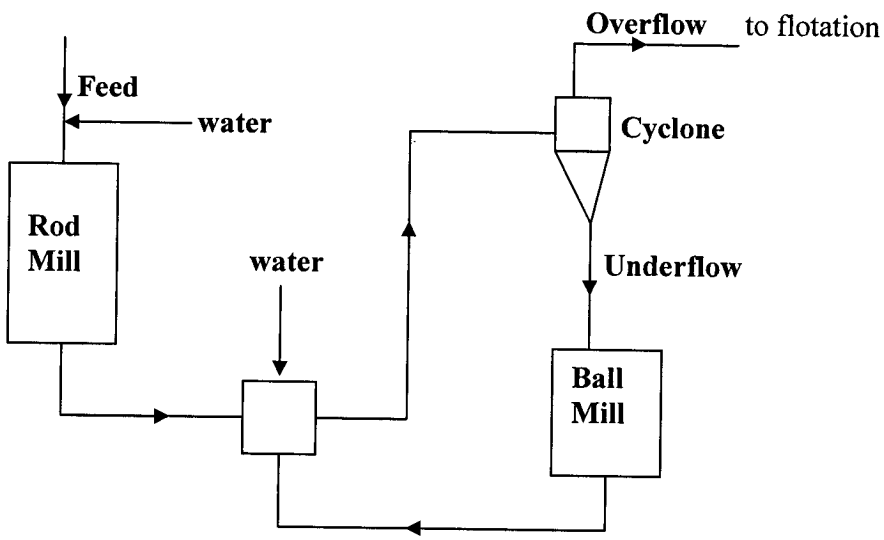


Figure 1: Rod mill – Ball mill – Cyclone circuit

Calculate:

i. the circulating load **[5 Marks]**
ii. the amount of water added to the rod mill and **[2 Marks]**
iii. the amount of water added to the cyclone feed. **[4 Marks]**

b) In a simple ball mill-classifier circuit shown below (Figure 2), the feed rate is ***F*** t/h and the circulating load (classifier underflow) is ***U*** t/h. The samples of ball mill discharge, circulating load and classifier overflow (circuit product) were taken and screen analysed, and the percentage passing 75 μm in the mill product, circulating load, and classifier overflow were ***b***, ***u*** and ***o*** respectively.

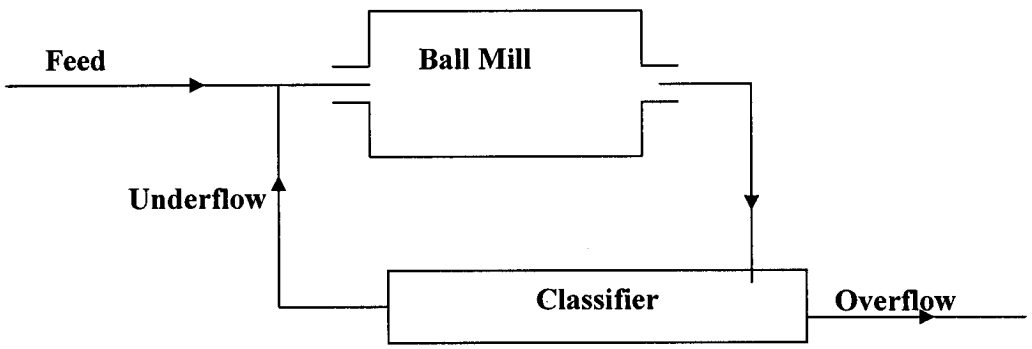


Figure 2: Ball Mill – Classifier Circuit

(i) Determine the expression of the circulating load as a percentage of new feed. **[5 marks]**

(ii) If F = 1000 t/h, b = 30%, u = 13% and o = 55%, calculate the circulating load as a percentage of new feed, and the ball mill discharge rate in t/h. **[4 marks]**

5.

a) Write Bond's third theory equation and state what each letter stands for. **[3 Marks]**

b) A mill has a 4,500 hp motor. For 80 percent power draw, what feed tonnage rate (t/h) can the mill treat if the 80 percent passing feed size is 0.5 inches and the desired product size is 80 percent passing 200 μm. Assume the Work Index of the ore is 14.8 kWh/t. **[6 marks]**

c) What are the two major function liners of tumbling mill perform? Give the three main groups into which mill liners can be classified. **[4 marks]**

d) Give and discuss three factors that affect the grinding of ores. **[3 marks]**

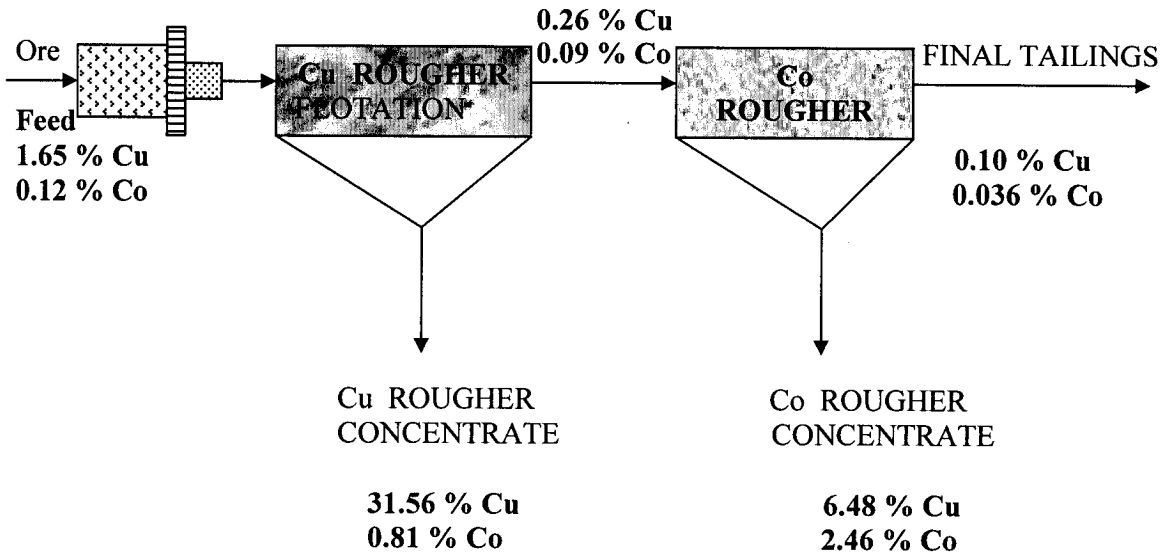
e) What are the essential differences between the grinding action of the rod mill and the ball mill? What is the effect of these differences in the grinding action on the size distribution in the respective mill products? **[4 marks]**

6.

a) What is froth flotation? Describe the role of the following chemical reagents in mineral flotation:

i. Collectors
ii. Frothers
iii. Depressants and activators **[9 Marks]**

b) A copper / cobalt sulphide ore is treated in a differential flotation circuit to produce a copper concentrate and a cobalt concentrate in two stages, as shown in the diagram below. The average grades of the feed and products of this circuit are as indicated.



(i) Calculate the average recoveries of copper and of cobalt from the feed to the copper rougher concentrate and to the cobalt rougher concentrate. **[6 marks]**

(ii) What is the ratio of concentration into the copper rougher concentrate? **[2 Marks]**

(iii) If the feed tonnage (F) is 18 000 tonnes (dry) per day, how much copper will be lost to the final tailings per day? **[3 Marks]**

7.

a) What are the main methods of dewatering? Briefly describe each of them. **[5 marks]**

b) Describe briefly the construction of tailing dams by the upstream, downstream and centre-line methods. What are the advantages of each method? Illustrate with sketches. **[15 marks]**

END OF MM 415 EXAM
GOOD LUCK!!

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

2012/13 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS

MM422: MATERIALS PERFORMANCE

TIME: THREE HOURS
ANSWER: ALL the Questions in Section A and THREE Questions in Section B

SECTION A

1. What materials would you select for the following applications and why?
   (a) Battery cap
   (b) Surgical implant
   (c) Cylinder head
   (d) Photographic equipment

2. Discuss the validity of the following statements, in each case explaining your reasoning.
   (a) Steels with fine grain sizes tend to have lower ductile – brittle transition temperatures.
   (b) Stainless steels may not always be resistant to corrosion.
   (c) Plane stress always does result in the generation of plain strain.
   (d) Yielding of materials may have some beneficial effects in metal fabrication.

SECTION B

3. (a) Why was the Griffith Criterion proposed?
   (b) Show, from first principles, that the theoretical strength of a material can be expressed as

$$\sigma_{max} = \sqrt{\frac{\gamma_S E}{d}}$$

   (c) Copper has a Young's modulus of 1.10×10^5 MPa, a surface energy of 1.725 J/m^2 and a lattice parameter of 3.1653 Å. Assuming that fracture occurs on a close-packed octahedral plane (i.e. (111)), compute the interplanar spacing.

$$d = \frac{a}{\sqrt{h^2 + k^2 + l^2}}$$

   (d) Determine the theoretical strength of Copper in MPa.

4. (a) Distinguish between true stress and engineering stress.
   (b) Examination of an engineering stress-strain curve reveals that fracture occurs at a stress level that is below the tensile strength of a material. Why is this so?
   (c) On a stress-strain curve, what is the significance of the elastic limit?
   (d) Derive the two conditions for the onset of plastic instability, i.e. necking, in materials

5. (a) Discuss why it is essential for structures to be designed to operate at stress levels below their yield strength.

(b) A uniaxial compressive load of 300,000 N causes yielding of a solid cube of side 100 mm. What load would be required to produce yielding if the other sides were constrained by compressive loads of 150,000 and 400,000 N, respectively. Assume that the Maximum-Shear-Stress Theory (Tresca theory) $\sigma_o = \sigma_1 - \sigma_3$ is applicable.

(c) An axial tensile force of 100 kN is applied to a steel rod 4 cm diameter and 50 cm long. Deduce the change in volume if E = 210,000 N/mm^2 and $\nu = 0.26$

$$Volumetic\ Strain = \varepsilon_x + \varepsilon_y + \varepsilon_z$$

The strain in the x-direction is

$$\varepsilon_x = \frac{1}{E}[\sigma_x - \nu(\sigma_y + \sigma_z)]$$

Similar expressions for the y and z-directions can be obtained.

6. (a) What is the Pilling-Bedworth rule?

(b) Describe, by using schematic diagrams, four mechanisms by which high temperature oxidation of a metal will take place. Clearly indicate the movement of the different species and the positions where oxide layer growth occurs.

(c) Draw curves indicating the linear, parabolic, logarithmic and inverse logarithmic growth laws for oxidation. Indicate the growth laws that would be desirable for an oxidation resistant alloy.

(d) The following crystallographic data refer to two metals and their oxides:

Material	Structure	No. of metal atoms in unit cell	Unit cell dimensions (Å)	
			a	c
Ca	fcc	-	5.582	-
Cd	hcp	-	2.979	5.618
CaO	cubic	4	4.78	-
CdO	cubic	4	4.68	-

For each metal calculate the percentage change in volume when the metal changes to oxide. On the basis of the Pilling-Bedworth rule, would these oxides be protective or non-protective against further oxidation?

$$V_{cubic} = a^3$$

$$V_{hcp} = 0.866\, a^2\, c$$

END OF EXAMINATION IN MM422

Question	1	2	3	4	5	6
Points	12	12	25	25	25	25

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS

MM 442 – PYROMETALLURGY

Answer: Five Questions
Time : Three Hours

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) Mention 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 three problems caused by the presence of magnetite in matte smelting units and how could these problems be minimised? **[6 marks]**

d) A copper concentrate has the following approximate analysis by weight:

Cu_2S - 20%
FeS_2 - 56%
SiO_2 - 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, **[2 marks]**
ii. the weight of slag produced, and **[3 marks]**
iii. the weight of matte produced. **[3 marks]**

3.

a) What do you understand by calcination? **[1 mark]**

b) Give three factors which affect the rate of calcination. **[3 marks]**

c) Mention the three types of equipment used in calcination and the type of material they can accept. **[6 marks]**

d) Limestone with 56% CaO and 44% CO_2 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 Nm^3. The fuel burns completely to CO_2 and H_2O which mix with the CO_2 evolved from limestone. Calculate the volume in Nm^3 of the furnace gas as well as its wet composition.

Air can be regarded as containing 21% O_2 and 79% N_2. **[10 marks]**

4.

a) What do you understand by roasting of concentrates? **[1 mark]**

b) What do you understand by autogenous roasting? **[1 mark]**

c) Describe four types of roasting. **[4 marks]**

d) Give four reasons why roasting prior to smelting is important. **[4 marks]**

e) Give two reasons why roasting sulphides prior to leaching is important. **[2 marks]**

f) Describe the two types of equipment used in roasting of concentrates and their advantages and disadvantages. **[8 marks]**

5.

a) Describe the operation of two of the following conventional matte smelting units outlining their advantages and disadvantages:

   a. Electric furnace matte smelting **[5 marks]**
   b. Flash furnace matte smelting **[5 marks]**
   c. Reverberatory furnace matte smelting **[5 marks]**

b) What is Isasmelt technology? What are the advantages of this new technology over the conventional methods/processes? Describe with a neat diagram the furnace used for smelting copper. **[10]**

6.

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 reduction 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]**

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 is charged with 100 tonnes of matte containing 55 wt% FeS, the remainder being Cu_2S. The sulphides are oxidised by blowing air into the converter.

$$FeS + 1.5O_2 \Rightarrow FeO + SO_2$$
$$Cu_2S + O_2 \Rightarrow 2Cu + SO_2$$

Determine:

(i) the volume of air required **[6 Marks]**
(ii) the volume of SO_2 formed, and **[4 Marks]**
(iii) the amount of copper formed. **[2 Marks]**

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THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
UNIVERSITY EXAMINATION **AUGUST 2013**

MM 452: 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.

The first-order ODE is as follows:

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

The solution is

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

---

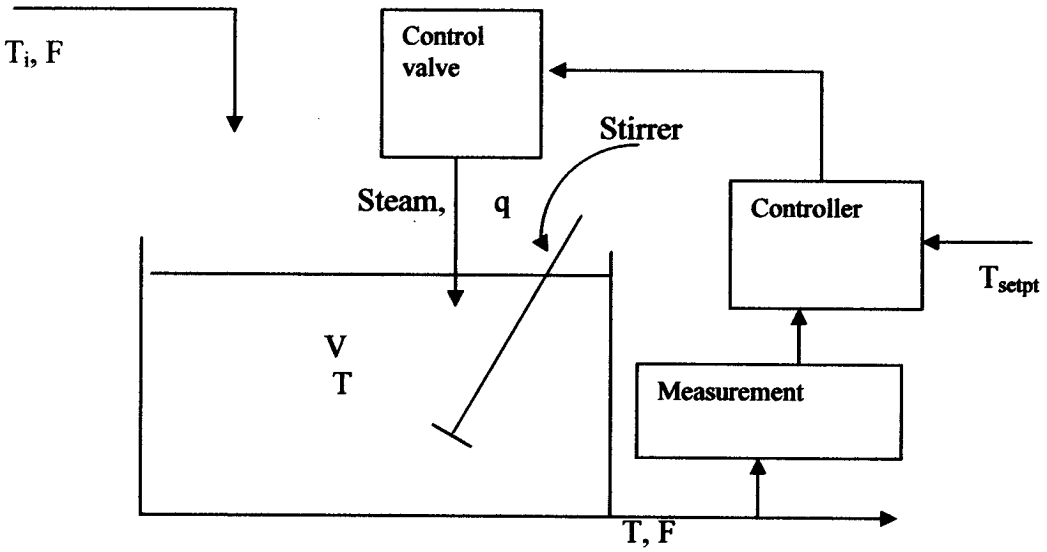
1. (a) What is the job we have to do in process control?

(3 marks)

(b) Draw a block diagram for the control system when a driver steers a vehicle in relation to the lane marking on the street. Indicate 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) $y^2 = C_1t^2 + C_2\,t$ **(3 marks)**

(ii) $y = C_1e^{-t} + C_2e^{2t}$

(3 marks)

2. (a) Consider the following dynamic equation:

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

Derive the expression for y(t).

(6 marks)

(b) You are given the following dynamic equation:

$$\frac{d^2y}{dt^2} - 3\frac{dy}{dt} + 2y = t + \sin t \qquad y(0) = 1,\ y'(0) = -1$$

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

3. (a) A first order system is

$$\frac{dy}{dt} = -\frac{y}{4} - \frac{x}{2} \qquad y(0) = 1$$

The input disturbance is initially zero. At t = 1, however, x undergoes a rectangular pulse of magnitude 3 and duration 3. Determine y and calculate its value at t =3.

(10marks)

(b) A first-order system is represented by

$$\frac{1}{2}\frac{dy}{dt} + \frac{1}{2}y = \frac{1}{2}\,U(t-1) - U(t-3) \qquad y(0) = 2$$

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 a system in Process Control?

(3 marks)

(b) Our blending tank under proportional control is represented by the following dynamic system model:

$$\tau_{CL}\frac{dC'_{Ao}}{dt} + C'_{Ao} = K_{CL}C'_{Ai} + K_{SP}C'_{Ao,setpt}$$

where $\tau_{CL} = \frac{\tau}{1+\frac{C_{Ac}K_c}{F}}$; $K_{CL} = \frac{1}{1+\frac{C_{Ac}K_c}{F}}$; $K_{SP} = \frac{\frac{C_{Ac}K_c}{F}}{1+\frac{C_{Ac}K_c}{F}}$

You are given the following parameter values:

$\tau = 300$ s ; $C_{Ac} = 400$ kg/m^3; $F = 0.02$ m^3/s ; $K_c = 0.0003$ m^6/kg s.

(i) Calculate the values of τ_{CL}, K_{CL} and K_{SP}.

Use the integrating factor method for what follows.

Suppose $C'_{Ai} = U(t - 50)$ kg/m^3,

(ii) calculate the value of C'_{Ao} at t = 150 s and t = 200 s. **(12marks)**

(iii) For the parameters given, determine the corresponding value of the offset and the value of $F'_c(\infty)$.

(5 marks)

5. (a) What do you understand by the Bode Diagram for a first order system?

(5 marks)

(b) A laser jet printer uses a laser beam to print copy rapidly for a computer. The laser is positioned by a control input, $x'(t)$, so that we have

$$y'(s) = \frac{500(s+100)}{s^2+60s+500} x'(t)$$

If $x'(t)$ is a unit step input, find the output $y'(t)$ What is the final value of $y'(t)$?

(9 marks)

(c) Determine $y(5)$ if $y(s) = \frac{e^{-3s}}{s(7s+1)}$

(6 marks)

6. For the two blending tanks in series, the transfer function is

$$C'_{A2}(s) = \frac{1}{(\tau_1 s+1)(\tau_2 s+1)} C'_{Ai}(s)$$

Suppose C'_{Ai} (t) = U(t – t_d).

(a) Derive a general expression for $C'_{A2}(t)$.

(8 marks)

(b) Suppose that in part (a) τ_1 = 5 minutes, τ_2 = 3 minutes and t_d = 5 minutes. Calculate the value of $C'_{A2}(t)$ at t = 15 minutes.

(5 marks)

(c) Suppose for the two-tank system $\tau_1 = \tau_2 = \tau$ and C'_{Ai}(t) = U(t). Derive the corresponding expression for $C'_{A2}(t)$. Is this system stable?

(7 marks)

END OF EXAMINATION IN MM 452 IN AUGUST 2013

Table of Laplace Transforms

f(t)	f(s)	f(t)	f(s)
U(t)	$\frac{1}{s}$	tU(t)	$\frac{1}{s^2}$
$t^nU(t)$	$\frac{n!}{s^{n+1}}$	$e^{-at}U(t)$	$\frac{1}{s+a}$
$t^ne^{-at}U(t)$	$\frac{n!}{(s+a)^{n+1}}$	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)	$\frac{k}{(s+a)^2+k^2}$		

Inversion by partial fractions

METHOD 1

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

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

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

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

where a_1 and b_1 are constants evaluated in the partial fraction expansion and $F_1(s)$ is a series of fractions arising from F(s).
Then the inverse transform arising from the complex root reduces to

$$2e^{-k_1t}(a_1\cos k_2t + b_1\sin k_2t)$$

METHOD 2

Suppose x(s) after partial fraction expansion becomes

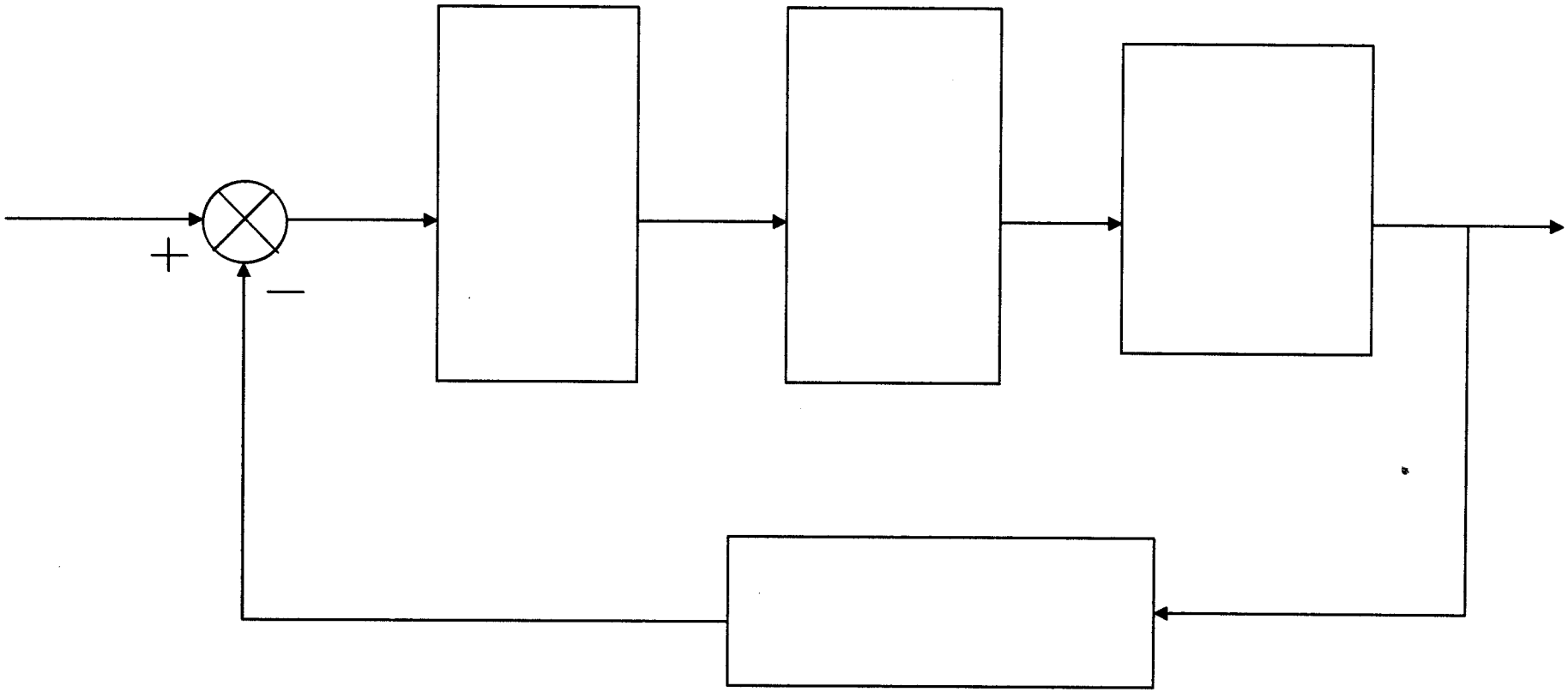
$$x(s) = F_1(s) + \frac{Bs+C}{(s+a)^2+k^2}$$

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

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

PROCESS CONTROL CL BLOCK DIAGRAM



UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

UNIVERSITY EXAMINATIONS SEPTEMBER 2013

MM 502: METALLURGY AND THE ENVIRONMENT

ANSWER: ALL FIVE QUESTIONS
TIME: 3 HOURS

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1. (a) What is an Environmental Project Brief (EPB), and what are its objectives and contents? State four 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 objective of a Terms of Reference 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). **(5 marks)**

2. (a) What is an Environmental Management System (EMS)? What are the distinct steps involved in the development of an environmental management system? **(5 Marks)**

   (b) What are the benefits of an environmental management system? **(2 Marks)**

   (c) What are the key contents of an Environmental Policy? **(3 Marks)**

   (d) What are the key provisions of the Mines and Minerals (Environmental) Regulations, also known as Statutory Instrument No 97 of 1997? 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? What are the five major life cycle stages of LCA? Draw the life cycle of a generic product system, and then briefly summarise the principle consideration of each life cycle stage. 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 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 five 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. State the collector and its efficiency range. **(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 MM 502 EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

UNIVERSITY EXAMINATION **AUGUST 2013**
MM 552: PROCESS DESIGN

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.

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1. (a) Briefly discuss the significance of degrees of freedom in process design.

(3 marks)

(b) Deduce the number of design variables for a stream divider that separates one stream into two streams of the same composition. How may the design variables be utilised?

(4 marks)

(c) A coal containing 81% total carbon and 6% unoxidised hydrogen is burned in dry air. The rest of the coal is solid inert. The amount of excess air is 30% and 10 wt % of the carbon is burned to CO. Calculate the number of kg of air per kg of coal and the molar composition of the stack gas.

Atomic weights: C,12; O,16; H,1; N, 14; *Air*, 29.

(13marks)

2. (a) In considering the anatomy of a manufacturing plant, two stages comprise product separation and product purification. Comment on these stages.

(4 marks)

(b) Chlorine Cl_2 and KOH react to form KCl, $KClO_3$ and H_2O. Balance the overall chemical equation.

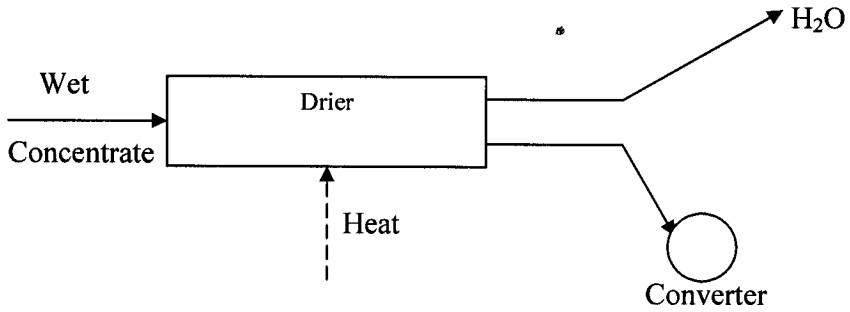
(3 marks)

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

(4 marks)

(d) In a process for copper smelting, the smelting furnace is bypassed and the concentrated ore is fed directly to the converter in a continuous stream where it is melted and blown with air to form blister copper in one operation. This concencntrate must, however, be dried, since moisture in contact with liquid metal can easily explode. Assuming that the feed rate is 20 metric tonnes/hour, on a wet basis with 7% moisture, and that the moisture after drying (before charging to the converter) is ½%, calculate the dry feed rate and the weight of moisture removed in metric tonnes per hour.

The flow diagram is as below:



Atomic weights: C,12; O,16; H,1; N, 14; *Air*, 29.

(9 marks)

3. (a) For a system with a combination of n inlets and outlets, a general statement of the First Law is $dE' = \delta q - \delta w + \sum_{i=1}^{n} \delta m_i \left(u_i + P_i v_i + \bar{v}_i^2/2 + g z_i\right)$.

Derive an equation for the heat balance on a closed system from the above equation.

(4 marks)

(b) A gas mixture containing 15% CO_2, 15% O_2 and 70% N_2 is to be cooled from 1650^{0}C (3000^{0}F) to 650^{0}C (1200^{0}F). How much heat must be removed from 100 moles of the mixture?

(6 marks)

(c) Hot gases leaving a gas recovery unit at a rate of 1600 moles/min at 200^{0}C (392^{0}F) and 1 atm pressure are passed through a heat recovery train. The gases contain 80% CO_2 and 20% H_2O. They leave the heat recovery train at 25^{0}C and essentially the same pressure. Since there has been some condensation, the gases now contain only 4% H_2O. Calculate the amount of heat removed in MJ per minute if the heat of vaporization of steam at 25^{0}C is 2.45 MJ/kg?

(10marks)

For this question, use the heat capacity data in the given figure. Remember 1 cal = 4.187 J.

4. (a) Heat is removed from a 20-m^3 reactor by feeding cooling through a jacket that surrounds the vessel. The heat removal rate is 3×10^3 kJ/h. The cooling water inlet and exit temperatures are 21^{0}C and 37^{0}C respectively. What is the water flow rate in gallons per minute (gpm)? Take the heat capacity of water as 4.19 kJ/kg.^{0}C and the density of water as 1000 kg/m^3. One gallon (UK) = 4.546×10^{-3} m^3.

(5 marks)

(b)In an oil cooler, 216 kg/h of hot oil enters a thin metal pipe of diameter 25 mm. An equal mass of cooling water flows through the annular space between the pipe and a larger concentric pipe; the oil and water moving in opposite directions. The oil enters at 420 K and is to be cooled to 320 K. If the water enters at 290 K, what length of pipe will be required? Take coefficients of 1.6 kW/m^2.K on the oil side and 3.6 kW/m^2.K on the water side. Take the specific heat of the oil as 2.0 kJ/kg.K and that of the water as 4.2 kJ/kg.K.

(5 marks)

(c) A heat exchanger is to be designed to cool 8.7 kg/s of ethyl alcohol solution [c_{ph} = 3.84 kJ/(kg. ^{0}C). This is to be done from 75^{0}C to 45^{0}C with cooling water [c_{pc} = 4.18 kJ/(kg. ^{0}C) entering the tube side at 15^{0}C with a flow rate of 9.6 kg/s. The overall heat

transfer coefficient based on the outer tube surface is U_o = 500 W/(m^2. ^{0}C). Calculate the heat transfer area for each of the following flow arrangements:

(i) Counterflow, shell and tube

(ii) Crossflow, both fluids unmixed.

(10marks)

$$U_o = \frac{1}{A_o\left[\frac{1}{A_o h_o} + \frac{1}{A_o h_{od}} + \frac{\ln(r_o/r_i)}{2\pi k_w L} + \frac{1}{A_i h_{id}} + \frac{1}{A_i h_i}\right]}$$

5. (a) It is desired to warm an oil of specific heat 2.0 kJ/(kg)(K) from 300 to 325 K by passing it through a tubular heat exchanger with metal tubes of inner diameter 10 mm. Water of specific heat 4.17 kJ/(kg)(K) flows along the outside of the tubes with inlet temperature 372 and outlet temperature 361 K.

The overall heat transfer coefficient from the water to oil, based on the inside area of the tubes, may be assumed constant at 230 W/(m^2)(K) and 75 g/s of oil is passed through each tube. The oil is to make two passes through the exchanger. The water makes one pass along the outside of the tubes.

Calculate

(i) the length of the tubes required,

(ii) the water flow rate in **kg/h**.

(12marks)

(b) A counterflow heat exchanger of heat transfer area A = 14.0 m^2 is to cool oil [c_{Ph} = 2000 J/kg.^{0}C] with water [c_{Pc} = 4170 J/kg.^{0}C]. The oil enters at 100^{0}C and the flow rate is 2 kg/s while the water enters at 20^{0}C with a flow rate of 0.48 kg/s. The overall heat transfer coefficient is 400 W/(m^2)(^{0}C). Calculate the exit temperature of the water and the heat load. **(8 marks)**

6. (a) In the filtration of a sludge, the initial period is effected at a constant rate with the feed pump at full capacity, until the pressure difference reaches 400 kN/m^2. The pressure is then maintained at this value for the remainder of the filtration. The constant rate operation requires 900s and one-third of the total filtrate is obtained during this period. Neglecting the resistance of the filter medium, determine the total filtration time and the filtration cycle for a downtime t_d of 1200 s.

(8 marks)

(b) An experimental filter press having an area of 0.0414 m^2 is used to filter aqueous $BaCO_3$ slurry at a constant pressure of 267 kPa. The filtration equation obtained is

$$\frac{t_f}{V_f} = 10.25\times10^6 V_f + 3.4\times10^3$$

where t_f is in seconds and V_f in m^3.

If the same slurry and conditions are used in a leaf filter press having an area of 6.97 m^2, how long will it take to obtain 1.00 m^3 of filtrate?

(12marks)

$$P=(K_1V + K_2)q\ ;\quad K_1 = \frac{s\rho\mu\alpha_{av}}{(1-ms)A^2}\ ;\quad K_2 = \frac{R_m\mu}{A}$$

END OF EXAMINATION IN MM552 IN AUGUST 2013

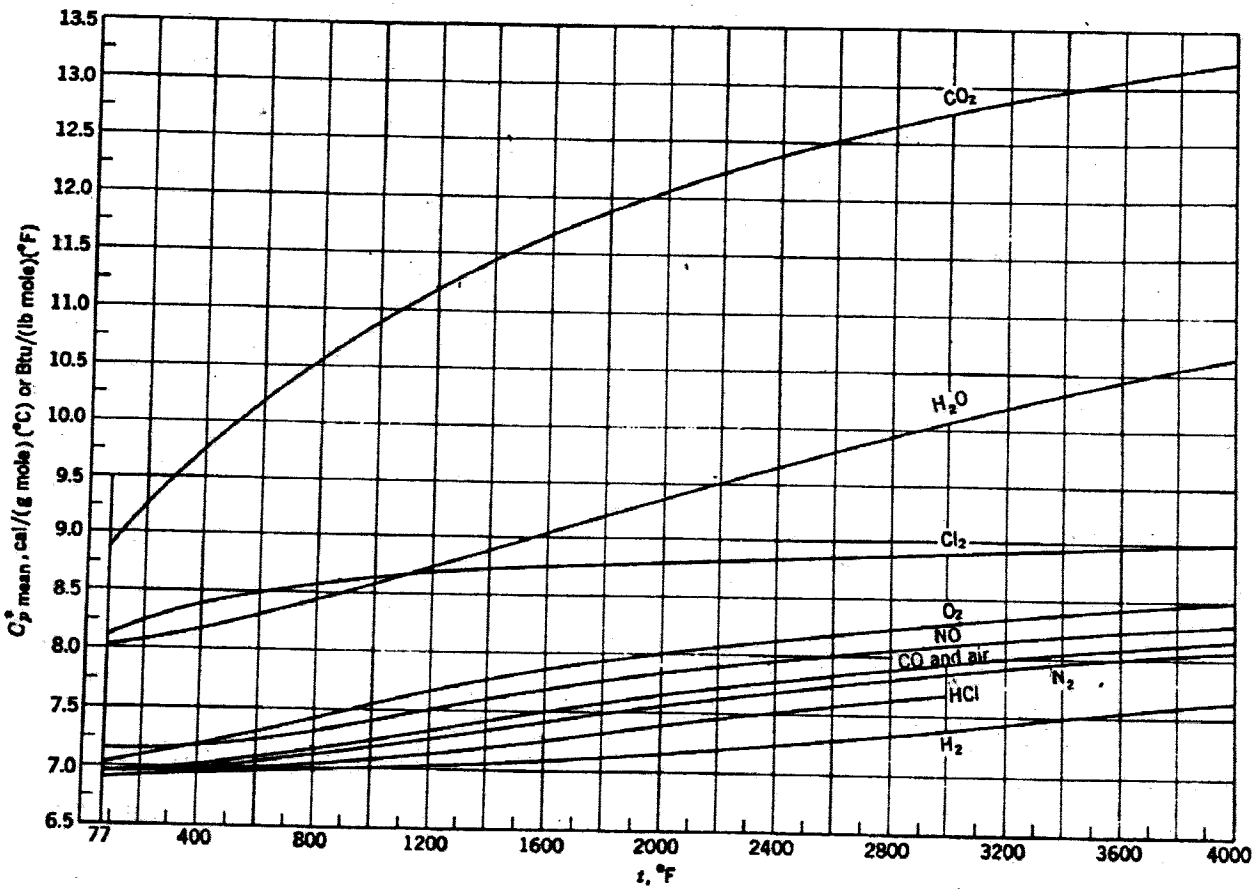
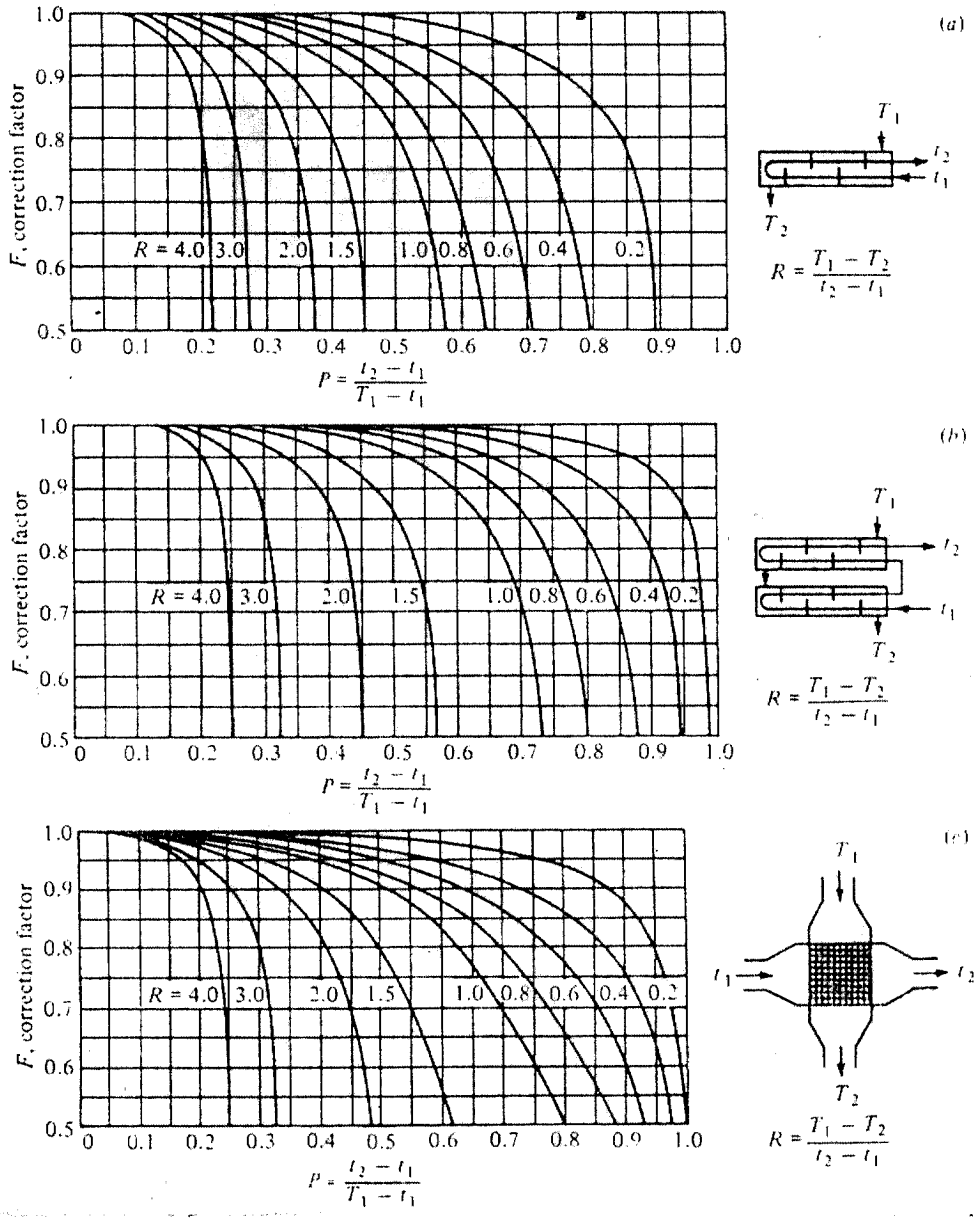


Figure 10–2 Mean molar heat capacities of gases in the ideal-gas state. Base temperature, 77°F. *Based mainly on data from D. D. Wagman (ed.)*, Selected Values of Chemical Thermodynamic Properties, *Natl. Bur. Stand. Circ.* 500, 1952. *From J. M. Smith and H. C. Van Ness,* Introduction to Chemical Engineering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


(a)
F, correction factor
1.0
0.9
0.8
0.7
0.6
0.5
R = 4.0 3.0 2.0 1.5 1.0 0.8 0.6 0.4 0.2
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
P = (t2 − t1)/(T1 − t1)
T1
t2
t1
T2
R = (T1 − T2)/(t2 − t1)
(b)
F, correction factor
R = 4.0 3.0 2.0 1.5 1.0 0.8 0.6 0.4 0.2
P = (t2 − t1)/(T1 − t1)
T1
t2
t1
T2
R = (T1 − T2)/(t2 − t1)
(c)
F, correction factor
R = 4.0 3.0 2.0 1.5 1.0 0.8 0.6 0.4 0.2
P = (t2 − t1)/(T1 − t1)
T1
t1
t2
T2
R = (T1 − T2)/(t2 − t1)

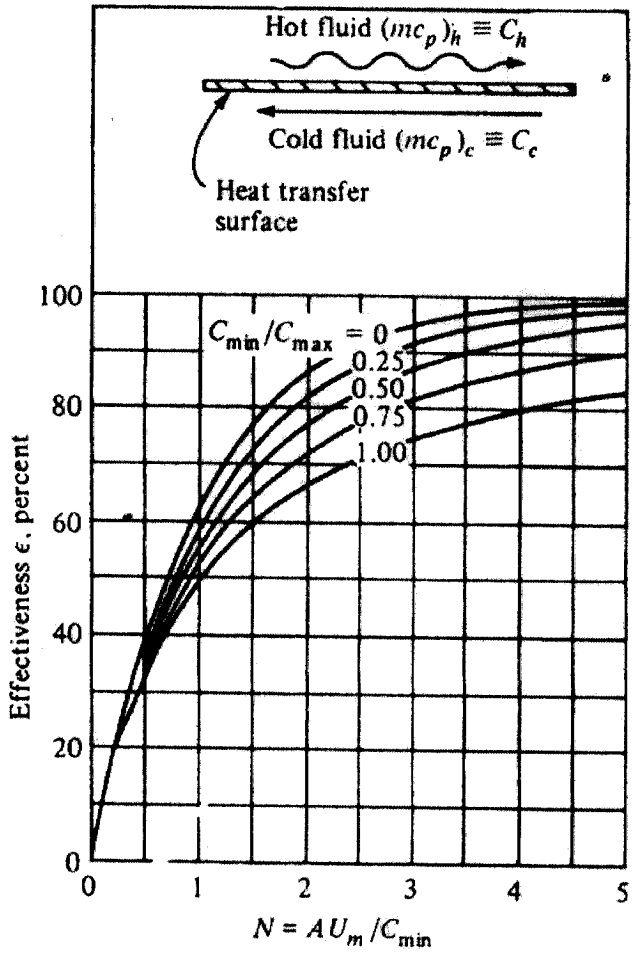


Figure 11-18 Effectiveness for a counterflow heat exchanger. (*From Kays and London* [*10*].)

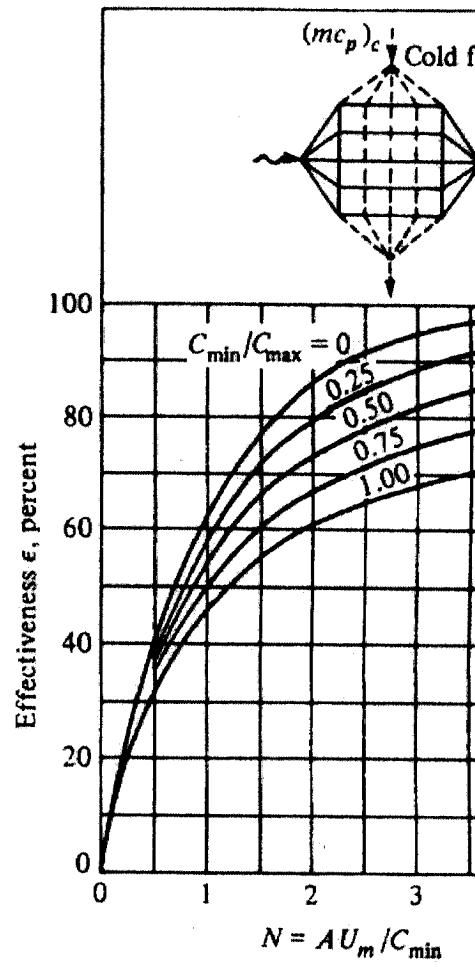


Figure 11-19 Effectiveness for a cro exchanger, both fluids unmixed. (*Fro London* [*10*].)

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THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

2012/13 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS

MM562 FOUNDRY TECHNOLOGY

TIME: THREE HOURS
ANSWER: ALL the Questions in Section A and THREE Questions in Section B

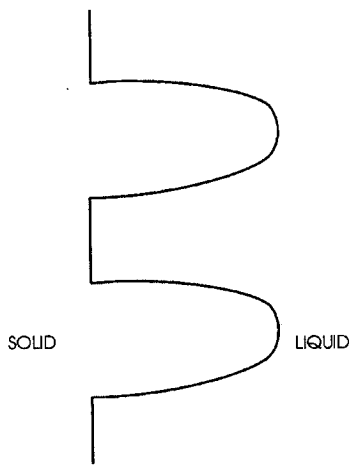
SECTION A

1. Write brief notes on the following:
   (a) Partition coefficient
   (b) Homogeneous nucleation
   (c) Nucleation energy barrier
   (d) Die casting

2. (a) Explain why moulding sands should have the following properties
   (i) Collapsibility
   (ii) Green strength
   (iii) Thermal stability
   (b) With the aid of appropriate sketches, outline the steps involved in the production of a sand mould

SECTION B

3. (a) A schematic illustration of two primary dendrite arms on an otherwise planar solid/liquid interface is shown below. With the aid of suitable diagrams, discuss why secondary and tertiary arms form.



   (b) The grain structure and hence the mechanical properties of a cast metal may be completely determined by the nucleation process
   (i) Explain the above statement
   (ii) What is the significance of the critical radius during nucleation?

(iii) Explain the effect of foreign particles, such as inclusions, on nucleation

4. (a) What is the primary function of a riser and what is its optimum shape?
   (b) Why is the optimum riser shape not employed in foundry practice?
   (c) How are the limitations in part (b) of the optimum riser shape accounted for in most risers?
   (d) Determine the dimensions of a riser (i.e. diameter and height) that can be used to produce a casting with length, width and thickness of 10, 5 and 2 in, respectively. The appropriate risering curves are shown in Figure 1.

5. (a) In most castings, what simple gases would you expect to find?
   (b) State Sievert's law. From this law, what is the most important factor which will influence the amount of gas going into solution in a metal?
   (c) Determine the maximum amount of nitrogen soluble at a pressure of 1 atm N_2 in a type 308 stainless steel containing 0.4 %C, 2.0 % Mn, 20 %Si, 20 %Cr and 10 %Ni at 1600°C. The appropriate data is shown in Figure 2. HINT: Determine log f_N for each element using Figure 2a; log f_N in Figure 2b is the sum.
   (d) What would happen if the amount of nitrogen in part (c) is exceeded?
   (e) What would happen if the amount of nitrogen in the melt is less than that in part (c)?

6. (a) For the phase transformation of liquid to solid

$$\Delta G_V = \frac{L\,\Delta T}{T_m}$$

Explain how the latent heat of fusion (L) and the undercooling (ΔT) influence solidification

(b) The number of crystal-like spherical clusters of radius r in a liquid is

$$n_r = n_0\, exp - \left[\frac{\Delta G_r}{RT}\right]$$

where n_0 = total number of atoms in the system and ΔG_r = excess free energy associated with the cluster and is given by

$$\Delta G_r = -\frac{4}{3}\pi r^3 \Delta G_V + 4\pi r^2 \gamma_{SL}$$

Estimate the number of crystal-like clusters in 1 mm^3 of copper at its melting point for "spherical" clusters containing

(i) 10 atoms

(ii) 100 atoms

The atomic volume of liquid copper = 1.6×10^{-29} m^3, γ_{SL} = 0.177 Jm^{-2}, K = 1.38×10^{-23} JK^{-1} and T_m = 1356 K.

HINT: at the melting point $\Delta G_v = 0$.

END OF EXAMINATION IN MM562

Question	1	2	3	4	5	6
Points	12	12	25	25	25	25

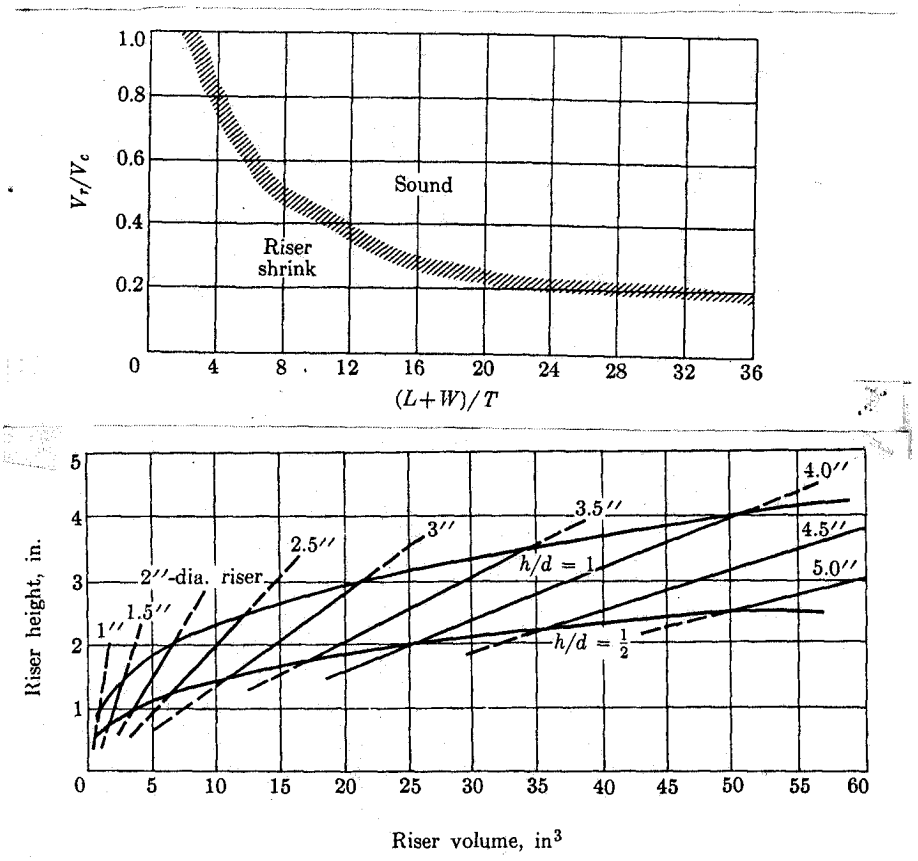
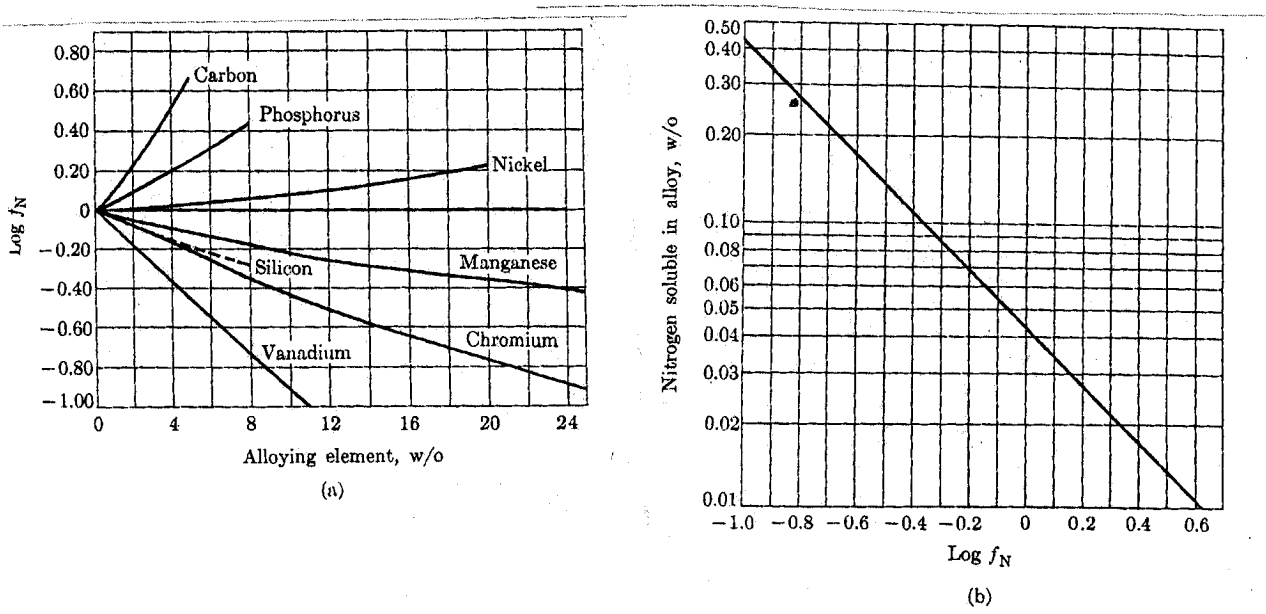


Figure 1



(a) Activity coefficients of nitrogen at 1600°C (2912°F) as a function of alloy content. Graph is used to compute log f_N in an alloy steel. (b) Chart for converting log f_N into w/o nitrogen soluble in an alloy at 1600°C (2912°F), under a pressure of 1 atm N. Log f_N was determined from Fig. 10-1.

Figure 2