UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

DEPARTMENT OF GEOLOGY

2017-2018 ACADEMIC YEAR

GGY 2012 EARTH RESOURCES AND DEVELOPMENT

GGY 3020 MINERALOGY AND PETROLOGY

GGY 3025 CRYSTALLOGRAPHY AND OPTICAL MINERALOGY

GGY 3030 STRATIGRAPHY AND SEDIMENTOLOGY

GGY 3049 STRUCTURAL GEOLOGYGGY

GGY 3051 ENGINEERING GEOLOGY

GGY 3069 REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM

GGY 4070 IGNEOUS AND METAMORPHIC PETROLOGY

GGY 4089 STRUCTURAL GEOLOGY AND PLATE TECTONICS

GGY 4090 GEOCHEMISTRY

GGY 4101 GEOLOGY OF ZAMBIA

GGY 4119 MINING GEOLOGY

GGY 4125 COMPUTER TECHNIQUES

MET 2419 INTRODUCTION TO MINERAL SCIENCES

MET 3430 CHEMICAL THERMODYNAMICS

MET 3449 HEAT AND MASS TRANSFER

MET 4111 COMMUNICATION AND CLASSIFICATION

MET 4122 CONCENTRATION AND DEWATERING

MET 4229 HYDROMETALLURGY

MET 4249 FUELS, FURNACES AND REFRACTORIES

MET 4319 PHASE TRANSFORMATIONS

MET 4459 PROCESS INSTRUMENTATION AND CONTROL

MIN 2019 INTRODUCTION TO MINING

MIN 3019 INTRODUCTION TO GEMOLOGY

MIN 3029 BASIC ROCK MECHANICS

MIN 3059 INTRODUCTION TO MINERAL ECONOMICS

MIN 4015 DRILLING AND BLASTING

MIN 4045 UNDERGROUND MINING

MIN 4075 MATERIAL HANDLING

MIN 4085 MINE VENTILATION

UNIVERSITY OF ZAMBIA

UNIVERSITY OF ZAMBIA EXAMINATIONS: NOVEMBER – DECEMBER, 2018

GGY2012 – EARTH RESOURCES AND ENVIRONMENT

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

Time 3 hours
Full Marks: 100

1. a) Briefly explain the:
   i) Association between tectonic plate boundaries and volcanism
   ii) Three types of tectonic plate boundaries
   iii) Relationship between convection currents in the mantle and plate tectonics
   iv) Areas at which crust is generated and destroyed
   b) Briefly describe:
   i) Types of faults associated with each tectonic plate boundary.
   ii) Two pieces of evidence, which would suggest that Pangaea ever existed

2. a) Distinguish between a resource and a reserve
   b) Give three examples of resources and how they are used
   c) Explain, what renewable and non-renewable resources are, and provide two examples of each
   d) Describe three positive and negative aspects of using any two forms of renewable energy sources
   e) Describe at least **two**:
   i) Human activities that would affect the hydrosphere
   ii) Parameters that would contribute to sustainable resource development

3. a) What is groundwater?
   b) Define:
   i) An aquifer
   ii) Cone of depression
   c) Distinguish between
   i) Porosity and permeability.
   ii) Zone of aeration and zone of saturation

d) What would be one negative impact of deforestation in a recharge area for an aquifer that serves your community? What recommendation would you make to decision-makers to reduce on this impact?

4. a) What is the significance of the rock cycle?

   b) Describe the three major classes of rocks on the basis of their origin, and give **three** common rocks in each of the main rock classes.

   c) Rocks that originate from solidification of magma occur either as **volcanic** or **plutonic** bodies. Explain:

      i) Their modes of occurrence.

      ii) How and why textures of these two groups of rocks differ, and give three examples of plutonic rocks and their volcanic equivalents.

5. a) Describe:

   ~~i) The **four** integrated parts of the Earth~~

   ii) The flow of energy and matter in the biosphere

   iii) Why the troposphere is one of the most important layers of the atmosphere

   b) Write short notes on six components of the hydrologic cycle

   c) Using some component(s) of the hydrologic cycle, explain a situation that would lead to flooding of an area.

   d) Describe the **two main** types of aquifers

   e) Define permeability and state any **two** factors that influence it in a geologic body.

   f) Distinguish a spring from an artesian well.

6. Describe the:

   a) **four** integrated systems of the Earth.

   b) flow of energy and matter in the biosphere

   c) Importance of the troposphere

   d) Briefly describe two earth's cycles, and how they arise.

7. Briefly describe

   a) Explain at least three factors that determine the economic potential of a mine

   b) Write a shot account of two environmental problems associated with resource exploitation.

   c) Explain the meaning of Sustainable Resource Development.

   ~~d) This is when.~~

   e) Discuss at least **two** ways of minimising impacts of mining on the environment.

********** **END OF EXAMINATION, GOOD LUCK!** **********

THE UNIVERSITY OF ZAMBIA

UNIVERSITY OF ZAMBIA EXAMINATIONS – NOVEMBER 2018

GGY3020 – MINERALOGY AND PETROLOGY

PAPER I

INSTRUCTIONS: **Answer at least two questions from each section and any other one question illustrating your answers wherever possible. Use a separate answer book for each section.**

Time: Three (3) Hours
Full Marks: 100

SECTION A – MINERALOGY

Q1. (a) Determine axial ratios a/b and c/b for the following faces whose interfacial angles are provided and draw well labelled sketches showing face relationships. **(6 marks)**

FACE	p	ϕ
(210)	90°	33°
(021)	69°	0°

(b) Using the zone symbol method prove if the following set of faces lies in the same zone: (01T1), (21bar31) and (10T0). **(6 marks)**

(c) If the axial ratio a:b:c is 1:1:2.560 determine interfacial angles ϕ (in the x-y plane) and ρ (in the z-y plane) given faces (110) and (011). **(2 marks)**

(d) Determine the unit cell volume (cm^3) and density (g/cm^3) of the mineral hypersthene [a pyroxene; $(Mg,Fe)_2Si_2O_6$], which belongs to the monoclinic system. Unit cell parameters are as follows: a = 18.20Å, b = 8.83Å, c = 5.20Å; $\alpha = 90°$, $\beta = 90.45°$, $\gamma = 90°$; Z = 8. **(6 marks)**

(20 marks)

Q2. (a) Write short notes on the following terms. **(8 marks)**
(i) Coupled Substitution
(ii) Polymorphism
(iii) Refractive Index
(iv) Cleavage

(b) Distinguish contact twin from penetration twin. **(4 marks)**

(c) Explain how refractive index affects the passage of rays of light in the mineral. **(4 marks)**

(d) Under what conditions in terms of the rules described above does each of the following occur?
(i) element camaflouge, and (ii) element admission. **(4 marks)**

(20 marks)

Q3. (a) Calculate the mineral formulae for the minerals whose Electron Microprobe Analysis (EPMA)
analytical results provided. Write down the mineral formular using up to 3 decimals. **(12 marks)**

Forsterite Mg_2SiO_4

Oxide	Wt. % Oxide
SiO2	40.30
FeO	8.85
MgO	49.58
CaO	0.07
MnO	0.13
NiO	0.42
TOTAL	99.35

(b) Describe briefly the following silicate structures giving at least one mineral example of each:
(i) Single Chain Silicates and (ii) Island Silicates. **(6 marks)**

(c) Given that the unit cell interplanar distance [$d_{(110)}$] for fluorite is 3.863 Å. Using the Bragg equation, determine 2Θ for fluorite if the CuKα wavelength (λ) for the analysis was 1.5405 Å and n = 1. **(2 marks)**

(20 marks)

SECTION B – PETROLOGY

Q 4 (i) Give brief account of the followings:-

a) Aphanitic texture
b) Oolitic texture
c) Cone sheet
d) Amphibolite
e) Arkose

(ii) Briefly give the main characteristics of the gabbro family

(iii) Define metamorphism. Give brief account of the main agents of metamorphism. State briefly the different types of metamorphism.

(20 marks)

Q5 (i) Explain the classification of chemical rocks in terms of origin, texture and composition.

(ii) Describe the main textures of foliated rocks.

(iii) Define the following:

1- Porphrytic texture
2- Slaty cleavage
3- Phyllite
4- Met conglomerate
5- Coral limestone

(20 marks)

Q6 (i) Compare and contrast igneous rocks and sedimentary rocks with regards to:
(a) Origin
(b) Composition
(c) Texture

(ii) What is the difference between magma and lava?

(iii) Give a brief description of the main textures of metamorphic rocks.

(20 marks)

Q7. (i) Explain the classification of detrital rocks in terms of origin, texture and composition.
(ii) Define the following:

a) Vesicular texture
b) Graded bedding
c) Migmatite
(d) grit
(e) Oolitic limestone

(20 marks)

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

THE UNIVERSITY OF ZAMBIA

UNIVERSITY OF ZAMBIA EXAMINATIONS – NOVEMBER 2018

GGY3020 – MINERALOGY AND PETROLOGY

PAPER II

INSTRUCTIONS: **Answer all questions illustrating your answers wherever possible. Use separate answer books for each section.**

TIME: Two (3) hours

FULL MARKS: 70

SECTION A – MINERALOGY (1.5 hours)

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

Q.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 of 60° between (001) & (101) and angle between y-axis and (110) of 45°, do the following:

(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.
(a) Determine, using the stereonet, the interfacial angle between faces (110) and (bar110).

(20 marks)

SECTION B – PETROLOGY (1.5 hours)

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

a) Mineralogy
b) Texture
c) Name the rock

(35 Marks)

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

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – NOVEMBER 2018

GGY 3025 – CRYSTALLOGRAPHY AND OPTICAL MINERALOGY

PAPER I

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

TIME: Three (3) Hours
Full Marks: 100

Q.1. (a) Define the following: (i) Diad, (ii) Centre of symmetry, (iii) Unit Cell, & (iv) Crystal. **(8 marks)**

(b) Write short notes on pedion and prism. **(4 marks)**

(c) What is the interfacial angle between faces X and Y and faces Y and R if angles between faces X and Y, and between faces Y and R are 121° and 137°, respectively. Sketch the arrangement of faces. **(5 marks)**

(d) Determine the Miller Indices of the faces given in the table below. **(8 marks)**

Face	Intercepts		
A	1/3a	5b	1/5c
B	∞a	1/3b	1/7c
C	1/2a	∞b	1/4c
D	∞a	∞b	1/8c

(25 marks)

Q.2. (a) Given the information below determine a/b and c/b and axial ratio a:b:c. Sketch the arrangement of faces and show the calculations in full. **(8 marks)**

Face	p	ϕ
(130)	90°	65°
(012)	42°	0°

(b) Using the zone symbol method prove if the following set of faces lie in one zone: (100), (201), (102) and (011). **(3 marks)**

(c) A crystal having 6 faces belongs to the tetragonal system. Axes X and Y are equal in length and lie in the same plane, which is perpendicular to the Z axis. Axes X and Y are shorter than Z. Axes X and Y pass through centers of opposite faces while Z axis passes through centers of faces constituting a pinacoid.

Determine the elements of symmetry present on the crystal. Sketch the crystal labelling all faces using Miller Indices, indicating the crystallographic axes, the characteristic element of symmetry and also sketch a stereonet labelling all elements of symmetry. **(14 marks)**

(25 marks)

Q.3. (a) Write short notes on the following terms and concepts: (i) isomorphism, (ii) polymorphism, (iii) solid solution, (iv) pleochroism. **(8 marks)**

(b) Provide chemical formulae for magnetite and chalcopyrite. Determine the % of Fe in pyrite and of Cu in chalcopyrite. **(5 marks)**

(c) State the Law of Constancy of Interfacial angles. **(4 marks)**

(d) Name and describe briefly two of the three Goldschmidt rules that govern atomic substitution within a mineral. **(8 marks)**

(25 marks)

Q.4. (a) Distinguish coordination number from radius ratio. (4 marks)

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

(c) How do temperature and pressure affect the coordination number? **(4 marks)**

(d) Under what conditions in terms of the rules described above does each of the following occur? (i) capture, and (ii) admission. **(6 marks)**

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

(f) State two values of minerals and brief describe each of them. **(4 marks)**

(25 marks)

Q.5. (a) Distinguish between ionic and covalent bonds. Give one mineral example of each type of bonds.
(8 marks)

(b) State the chemical formulae of chalcopyrite and pyrite and determine the concentrations of copper and iron, respectively. **(5 marks)**

(c) Write short notes on the following silicate structures giving at least one mineral example of each: (i) Double Chain Silicates; (ii) Ring Silicates; (iii) Sheet Silicates; and (iv) Framework Silicates. **(12 marks)**

(25 marks)

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

(b) Write short notes on coordination number and radius ratio. **(4 marks)**

(c) Describe the following: (a) Zone, (b) Zone Axis, and (c) Zone Symbol. **(6 marks)**

(d) Determine the refractive index if the angles of incidence and refraction to a ray of light are 62° and 30°, respectively. **(3 marks)**

(e) If the angle of incidence is 52° and the refractive index is 1.4 determine the angle of refraction. **(3 marks)**

(e) Explain how, under a microscope, you would tell if a mineral has polysynthetic twinning. **(3 marks)**

(25 marks)

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

PERIODIC TABLE

1 H 1.00794																	2 He 4.002602
3 Li 6.941	4 Be 9.012182											5 B 10.811	6 C 12.0107	7 N 14.00674	8 O 15.9994	9 F 18.9984032	10 Ne 20.1797
11 Na 22.989770	12 Mg 24.3050											13 Al 26.581538	14 Si 28.0855	15 P 30.973761	16 S 32.066	17 Cl 35.4527	18 Ar 39.948
19 K 39.0983	20 Ca 40.078	21 Sc 44.955910	22 Ti 47.867	23 V 50.9415	24 Cr 51.9961	25 Mn 54.938049	26 Fe 55.845	27 Co 58.933200	28 Ni 58.6534	29 Cu 63.545	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.92160	34 Se 78.96	35 Br 79.504	36 Kr 83.80
37 Rb 85.4678	38 Sr 87.62	39 Y 88.90585	40 Zr 91.224	41 Nb 92.90638	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.90550	46 Pd 106.42	47 Ag 196.56655	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.760	52 Te 127.60	53 I 126.90447	54 Xe 131.29
55 Cs 132.90545	56 Ba 137.327	57 La 138.9055	72 Hf 178.49	73 Ta 180.94.79	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.217	78 Pt 195.078	79 Au 196.56655	80 Hg 200.59	81 Tl 204.3833	82 Pb 207.2	83 Bi 208.58038	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 (269)	111 (272)	112 (277)		114 (289) (287)		116 (289)		118 (293)

58 Ce 140.116	59 Pr 140.50765	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.964	64 Gd 157.25	65 Tb 158.92534	66 Dy 162.50	67 Ho 164.93032	68 Er 167.26	69 Tm 168.93421	70 Yb 173.04	71 Lu 174.967
90 Th 232.0381	91 Pa 231.035888	92 U 238.0289	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)

PERIODIC TABLE

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55 Cs 132.90545	56 Ba 137.327	57 La 138.9055	72 Hf 178.49	73 Ta 180.94.79	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.217	78 Pt 195.078	79 Au 196.56655	80 Hg 200.59	81 Tl 204.3833	82 Pb 207.2	83 Bi 208.58038	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 (269)	111 (272)	112 (277)		114 (289) (287)		116 (289)		118 (293)

58 Ce 140.116	59 Pr 140.50765	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.964	64 Gd 157.25	65 Tb 158.92534	66 Dy 162.50	67 Ho 164.93032	68 Er 167.26	69 Tm 168.93421	70 Yb 173.04	71 Lu 174.967
90 Th 232.0381	91 Pa 231.035888	92 U 238.0289	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)

THE UNIVERSITY OF ZAMBIA

UNIVERSITY OF ZAMBIA EXAMINATIONS: NOVEMBER-DECEMBER 2018

GGY 3025 – CRYSTALLOGRAPHY AND OPTICAL MINERALOGY

PAPER II

INSTRUCTIONS: Answer all questions illustrating your answers wherever possible.

TIME: Two (2) Hours
Full Marks: 40

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1. Study the V and W and using physical properties (colour, streak, lustre, hardness, cleavage, reaction to dilute hydrochloric acid and reaction to a magnet), identify the mineral samples. **(10 marks)**

2. Study the mineral X under the microscope and using optical properties identify the mineral. **(10 marks)**

2. Crystal model 5 is provided. X and Y are of equal length and lie in the same plane which is perpendicular to Z-axis, which is longer than axes X and Y. X and Y axes go through centres of two opposite prism faces while Z-axis goes through two opposite pyramidal corners. The interfacial angle between one of the slanting faces and one of the prism faces is 60°. Do the following:

   (a) Sketch the crystal model and label the axes and all faces using Miller Indices;
   (b) Determine all the elements of symmetry and classify the crystal into a system;
   (c) Identify and name the two open forms present on the crystal and faces that belong to each of the forms;
   (d) Determine the zone symbols for the zones represented by axes parallel to the three crystallographic axes X, Y and Z;
   (e) 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.

   (20 marks)

End of Exam

THE UNIVERSITY OF ZAMBIA

UNIVERSITY OF ZAMBIA EXAMINATIONS – NOVEMBER 2018

GGY 3025 – CRYSTALLOGRAPHY AND OPTICAL MINERALOGY

PAPER II – PRACTICAL

LIST OF POSSIBLE MINERALS

SPECULARITE

HEMATITE

PYRITE

HALITE

FLOURITE

CALCITE

PYRRHOTITE

MAGNETITE

CHALCOPYRITE

BIOTITE

QUARTZ

FELDSPAR

PLAGIOCLASE

GARNET

OPAQUE MINERAL

MUSCOVITE

UNIVERSITY OF ZAMBIA

UNIVERSITY OF ZAMBIA EXAMINATIONS: NOVEMBER – DECEMBER, 2018

GGY 3030: STRATIGRAPHY AND SEDIMENTOLOGY

PAPER I

INSTRUCTIONS: Answer questions 1 and 2. Choose any 3 questions from the rest.. Well – labelled sketches & diagrams are required for a full mark Each question carries equal marks

TIME: THREE (3) HOURS
Full Marks: 100

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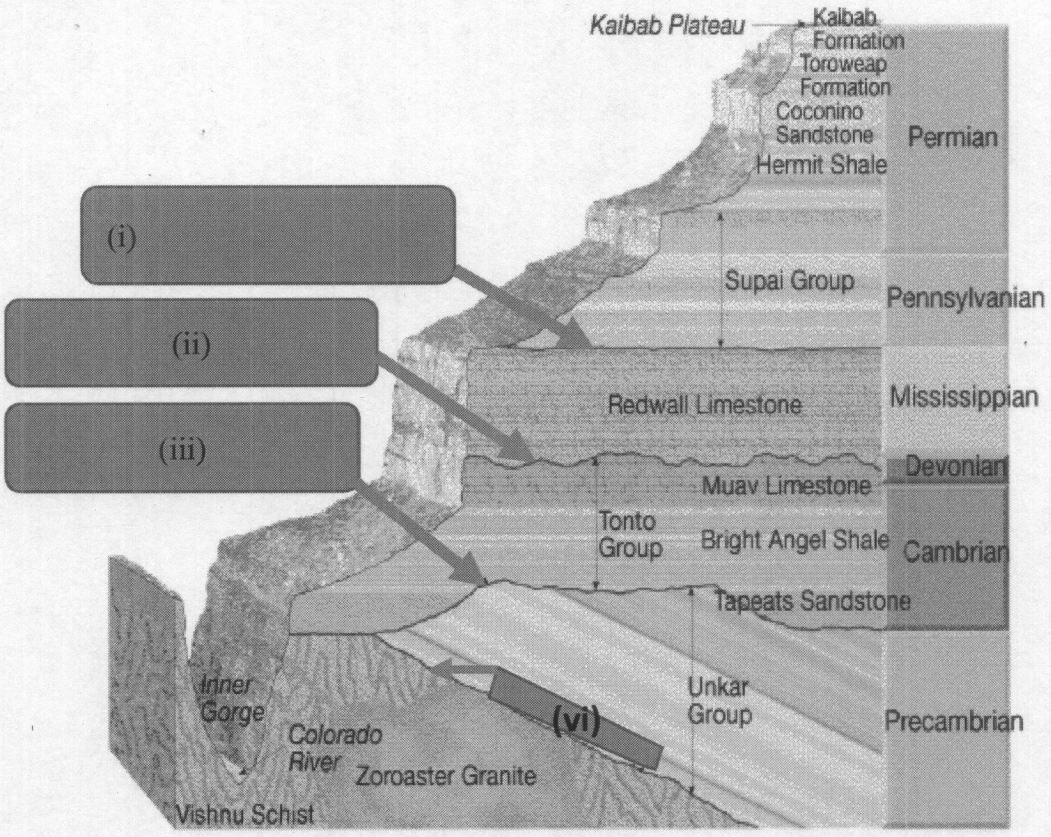
1. (a) Define the Term Strata?
   (b) Outline the functions of a Stratigrapher
   (c) What is an Unconformity?
   (d) Define Four Types of Unconformity.
   (e) In the diagrams below, Name the following unconformities as pointed.



2. Distinguish between the following:
   (a) Sorting and Roundness
   (b) Shallowing-upwards and Coarsening-upwards
   (c) Reynolds and Froude Number
   (d) Glaciofluvial and Glaciomarine
   (e) Loess and Volcanic ash

3. Contrast with an aid of diagrams or table where applicable between the following:
   (a) Braided and Meandering river systems
   (b) In-channel processes and overbank processes in meandering rivers
   (c) Lateral accretion deposits and vertical accretion deposits
   (d) Proximal and distal trends in alluvial systems
   (e) Trough and Planar cross-bedding

4. (a) Outline the characteristic features that typify lacustrine deposits when contrasted with marine deposits.
   (b) Briefly describe the characteristics features (diagnostic) of glacial deposits.
   (c) Briefly describe the characteristics features (diagnostic) of eolian deposits.

5. (a) Outline the components of Carbonate Rocks indicating various types within each component and where possible their sizes and content.
   (b) Using the Wentworth Classification list the four main groups of limestone and dolostones.
   (c) Using well-labeled diagrams, explain Dunham (1962) classification of carbonates.

6. (a) Zambian Copperbelt Copper deposits show evidence of deposition in PERITIDAL Systems. Outline the Common Elements to this Peritidal Model.
   (b) Distinguish between Isolated Platform and Rimmed Shelf.
   (d) With an aid of a sketch, outline the characteristic reef profile (lateral zonation) indicating the resulting carbonate rock types at each section.

7. (a) Define texture including the 5 grain properties, which are in the texture definition
   (b) Differentiate between the following:
      i. Biostratigraphy and lithostratigraphy; and
      ii. Transgression and regression.
   (c) Briefly outline the processes responsible for the alteration of fossils in the stratigraphic record.
   (d) In Chronostratigraphy, in form of a table distinguish between TIME UNITS and TIME-ROCK UNITS in descending order of scale.

GOOD LUCK END OF EXAM

UNIVERSITY OF ZAMBIA

UNIVERSITY OF ZAMBIA EXAMINATIONS: NOVEMBER – DECEMBER, 2018

GGY 3030: STRATIGRAPHY AND SEDIMENTOLOGY

PAPER II

INSTRUCTIONS: Answer all questions. Sketches and diagrams are important for a full mark

TIME: Three (3) Hours
Full Marks: 100

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1. You now a qualified sedimentologist who was assigned to map and interpret an outcrop in Chief Makasa's area in Mbala. Whilst you were in the field, you put together a Graphic Log of the area (Table below) and back at your work place you undertook a thin-section study whose data is also given below.

GRAPHIC LOG

Unit No.	Thick -ness	Upper Contact	Lithology	Primary Sedimentary Structures	Samples / Palaeo-Current (°)
7	3m	Sharp depositional	Siltstone, very fine- to medium-grained sandstone	Ripple-laminated siltstone towards top of unit; Horizontal bedding and locally massive in the sandstones	
6	5m	Sharp depositional	Coarse-grained to pebbly sandstone	Trough cross-bedding alternating with planar x-beds	(°) 95; 80; 95; 50; 45; 90; 115; 85; 75; 100;
5	6m	Sharp erosional	Matrix supported conglomerates – isolated boulders are observed in places Intercalations of sandstones observed	Massive with crude bedding locally horizontal bedding	**A (Sample & Thin Section)**
4	3m	Sharp depositional	Clast-supported conglomerates up to coble size	Complex bed forms with tabular sheets	
3	2m	Sharp depositional	Pebbly sandstones	Trough cross-bedding	(°) 190; 185; 170; 205; 270; 295; 175; 195; 200, 195.
2	3m	Gradational	Fine-grained sandstone up 1m, then medium-grained to 2m and then coarse- to very coarse-grained sandstone.	Parallel laminated in the fine-grained, planer in the medium grained, changing to trough cross-bedded sandstone	**B (Sample & Thin Section)**

1	2m	Sharp	Reddish brown, mudstone turning to siltstones towards top	Massive mudstone, which in places desiccation cracks are evident. Laminated siltstones with ripple marks	
		Sharp contact	Gneisses and schists	Foliated	

You are now required to do the following:

(a) Make a Detailed Stratigraphic Section of the outcrop.....**40 Marks**

(b) To describe the two hand specimens (A and B to be given during Exam) providing full mineralogy, structures, features and provenance..... **15 Marks**

(c) Your thin section study of A and B revealed the following modal composition. **A** – Othorclase (10%); Microcline (15%); Albite (5%); Plagioclase (6%); Quartz (50%); Biotite (1%); Muscovite (2%); Sericite (2%); Granite (2%); Slate (2%); Shale (2%) and Quartzite (3%) and **B** - Microcline (5%) Orthoclase (10%); Albite (2%) Plagioclase (5%); Quartz (65%); Muscovite (2%); Sericite (3%); Quartzite (2%); Rutile (2%); hematite (3%) and Calcite (1%). Classify the rocks in (c) using appropriate classification procedures.....**20 Marks**

(d) Construct rose diagram for each Unit where the palaeocurrent was measured to represent the palaeocurrent distribution and indicate the result on the Stratigraphic Section in (a).....**10 Marks**

(e) Describe fully the Sequence resulting from the section in (a) indicating possible Depositional Sub-environments and bedforms that could have given the sedimentary structures including the distribution of the palaeocurrent...**10 Marks**

(f) Comment on the overall appearance (nature) of the Sequence and arguing your case for possible types of environments in which such an overall sequence would occur..... **5 Marks**

GOOD LUCK **END OF EXAM**

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS: NOVEMBER - DECEMBER 2018

GGY 3049: STRUCTURAL GEOLOGY

PAPER 1

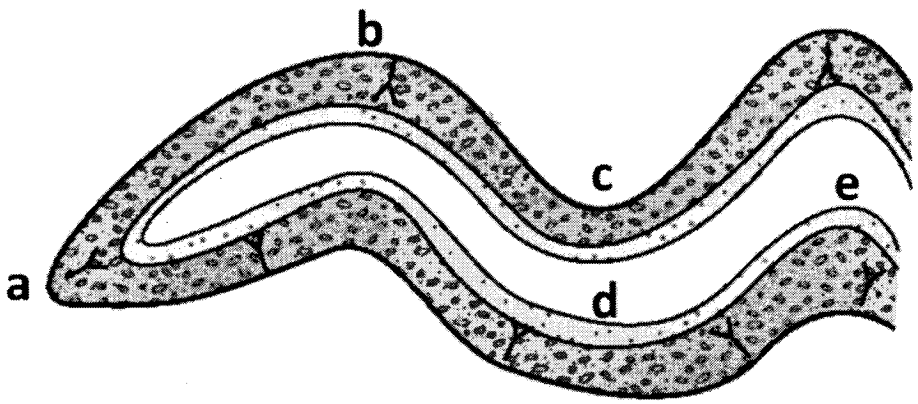
INSTRUCTIONS: Answer any five (5) questions. Neatly drawn sketches/ diagrams recommended for a full mark. All questions carry equal marks.

TIME: Three (3) Hours
Full Marks 100

Q.1. a) Illustrate with the aid of labeled block diagrams the following faults: **[15 marks]**

i) Sinistral strike slip fault
ii) Oblique reverse-slip fault
iii) Oblique dextral strike-slip fault
iv) Oblique normal fault
v) Thrust fault

b) Name the structures labeled A, B, C, D and E in the sketch below. Arrows indicate the younging direction. **[5 marks]**



(20 marks)

Q.2. a) Draw sketches to depict the following structures: **[10 Marks]**
(i) Box fold (ii) Similar fold (iii) Isoclinal fold (iv) Kink fold (v) Recumbent fold

b) Distinguish between ductile and brittle deformation, and give one example each of the structures that form under these conditions. **[10 Marks]**

(20 marks)

Q.3. a) Use neat diagrams to show outcrop patterns on a flat surface of the following fold structures: **[12 Marks]**

(i) Upright plunging antiform (ii) Upright plunging synform (iii) Structural Dome
(iv) Structural Basin

b) Explain what each symbol below represents **[8 Marks]**

i) 

ii) 

iii) 

iv) 

v) 

vi) 

vii) 

viii) 

(20 marks)

Q.4. Define the following terms.

i) Compressive stress
ii) Tensile stress
iii) Shear Stress
iv) Strain
v) Elastic Response
vi) Ductile Response
vii) Brittle Response
viii) Fault
ix) Strike
x) Dip

(20 marks)

Q5. a) Explain the following parts of a fold. **[16 Marks]**

i) Hinge
ii) Hinge point
iii) Hinge line
iv) Axial surface
v) Axial trace
vi) Inflection point
vii) Inter limb angle
viii) Wavelength

b) Bending occurs when forces act across a layer at high angle. List four examples of bending. **[4 Marks]**

(20 marks)

Q.6. a) Briefly explain the following: **[8 Marks]**

i) Simple shear
ii) Pure shear

b) Describe Class 1A, B and C of Ramsay's (1967) classification of folds. **[12 marks]**

(20 marks)

Q7. What is salt tectonics? **(5)** Describe the salt properties that influence its behavior during deformation, and explain what is density inversion? **(5).** With a neat sketch describe various salt diapir geometries **(10).**

(20 marks)

End of exam

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS: NOVEMBER - DECEMBER 2018

GGY 3049: STRUCTURAL GEOLOGY

PAPER II

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

TIME: Three (3) Hours
Full marks: 40

Q.1. (a) Cleavage in an area is oriented 110°/43°SW. A mineral lineation on the cleavage plane trends 160^0.

i) Plot the line representing this lineation on the stereogram of the plane.
ii) Determine the plunge of the lineation.
iii) Measure the rake of the line in the plane. **(5 marks)**

Q.2. A sandstone bed is exposed on a highway road cut. At one end of the cut, the apparent dip of the bed is 32°/256°. Around a bend in the road, the apparent dip of the same bed is 27°/125°. Determine the true dip of the bed. **(5 marks)**

Q.3. One limb (labeled A) of a chevron fold is oriented 020°/60°SE and the other limb (labeled B) is oriented 060°/40°NW. What is the plunge and bearing of the fold hinge? Assume that the fold hinge is the line of intersection between the two limbs. **(5 marks)**

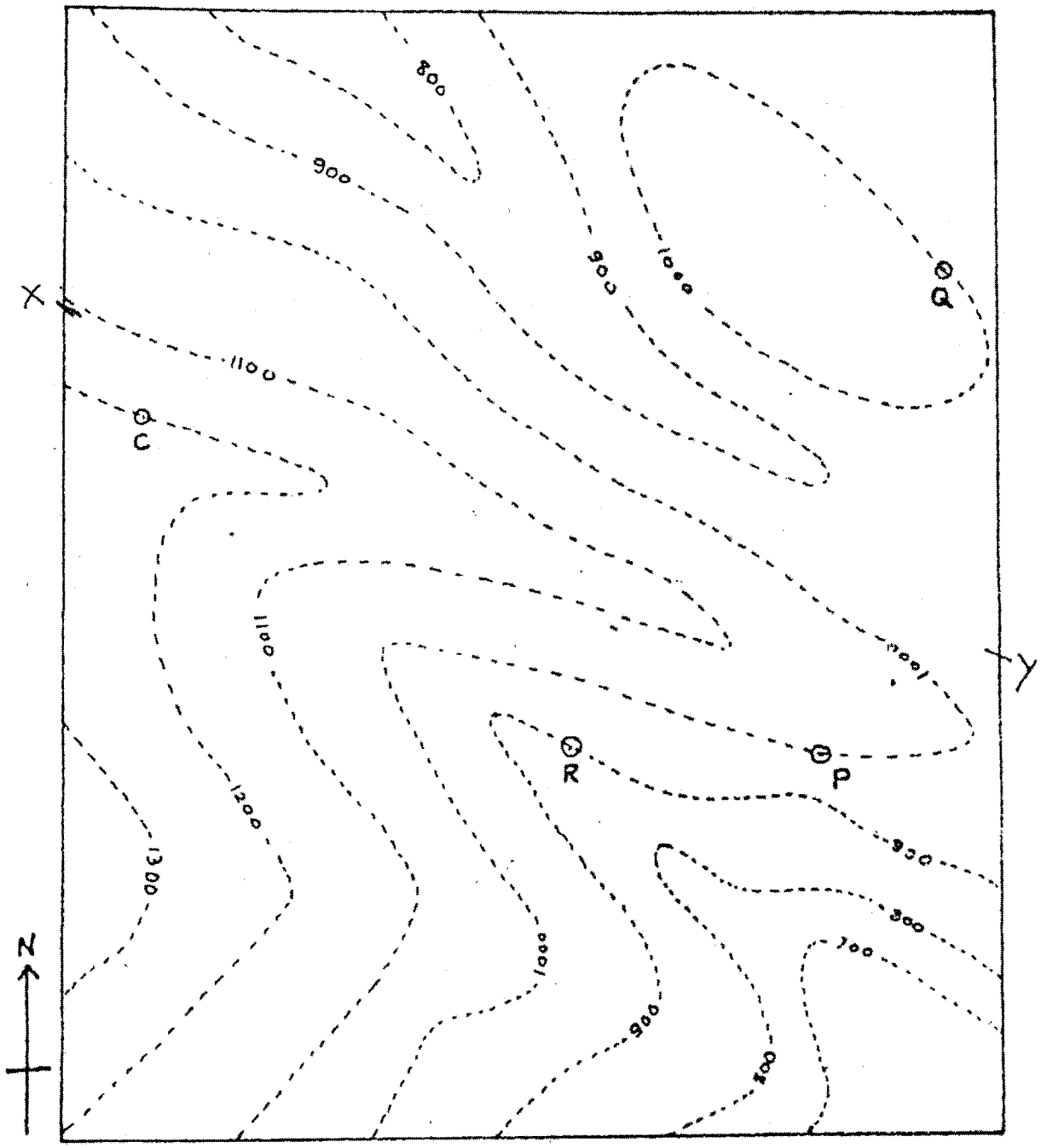
Q.3. Complete the rock outcrops on the given geologic map. **(10 marks)**

Q.4. Interpret the given geological map and give the stratigraphy and thickness of beds, and describe the structures **(5).** Construct a neat geological cross section along the given line. **(10 marks)**

(15 marks)

End of Exam

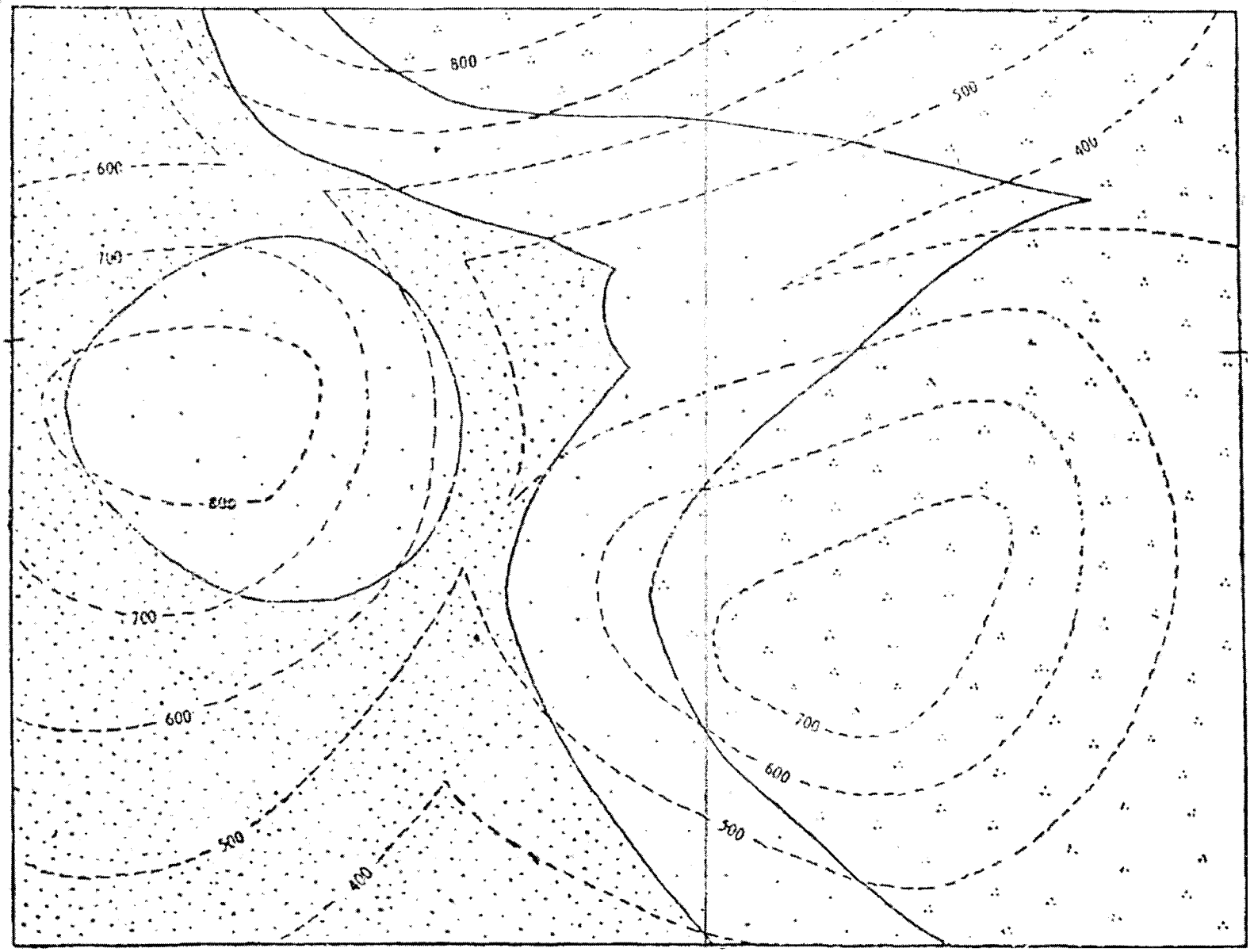
DEPARTMET OF GEOLOGY
School of Mines, University of Zambia



Problem: The lower trace of a grit bed outcrops at P, Q and R. Its upper trace is met with at C at a depth of 300 ft. The grit bed forms a part of a conformable series with conglomerate at the base, and sandstone 200 ft thick, underlying the youngest limestone bed of the series. Determine the dip and the thickness of the grit bed and complete the outcrop.

DEPARTMENT OF GEOLOGY
School of Mines, University of Zambia

Structural Geology Lab
III Year



Legend

Grit

mestone

hale

Problem: Describe the geology of the area with a suitable cross section.

Scale 1" = 1000 ft

N

THE UNIVERSITY OF ZAMBIA

UNIVERSITY DEFERRED EXAMINATIONS – DECEMBER 2018

GGY 3051 - ENGINEERING GEOLOGY

PAPER II – PRACTICAL

INSTRUCTIONS: Answer ALL Questions.
TIME: Three (3) Hours
Full Marks: 100

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1. During a site investigation for a prospective construction site, the Geology Department provided you with a map showing different geological formations as shown in Map 1. For this Map:
   a) Determine the dip of the strata
   b) Draw a topographic profile and geologic section along the line AB to get an idea of the relationships of the different lithologies.
   c) Arrange the rocks in order of their age starting with the oldest, at the bottom, andthe youngest, at the top. **(30 Marks)**

2. You have been contracted by the Lusaka Water and sewerage Companyto locate new sources of water to augment supply to the city of Lusaka. The area of interest is shown in Map 2, in which water springs occur at A, B and C. you are required to do the following for this area:
   i) Indicate the probable remainder of the aquifer outcrop on the map.
   ii) Shade the area underlain by the aquifer, which you would recommend for further drilling and exploitation **(30 Marks)**

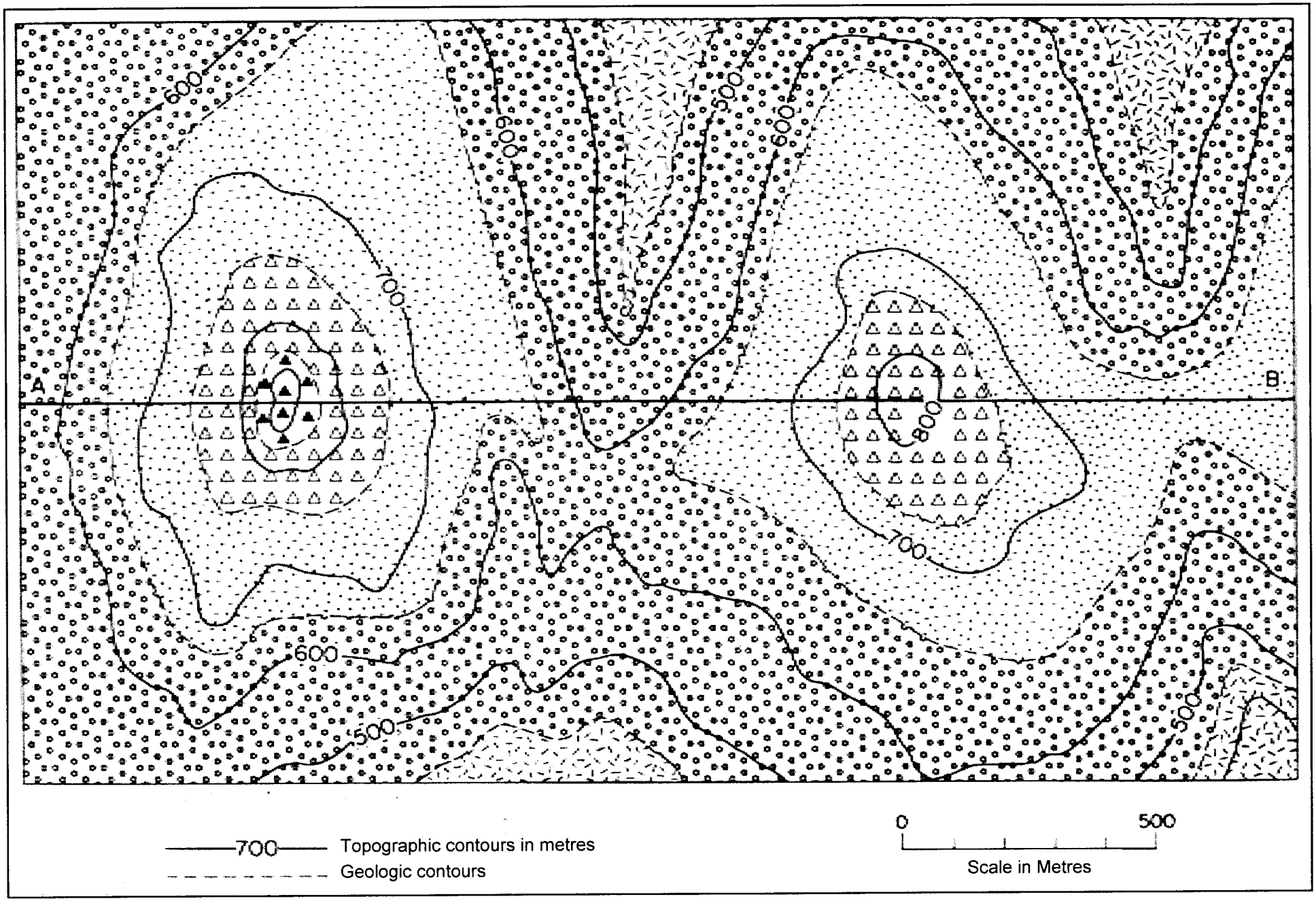
3. A construction company would like to win sandstone and limestone materials for a new construction site at the East Park Mall. Outcrop locations of these beds' boundaries are marked on Map3, with a land surface contoured at 5 m intervals.The base of the sandstone outcrops at A; the base of the limestone outcrops at B; and the base of the mudstone, at C. Assuming that between A and B only sandstone is present, between Band C only limestone is present and that only mudstone is present in the succession above C:
   i) Complete the outcrop patters of the bed boundaries.
   ii) Shade the lithologies as appropriate.
   iii) Indicate the depths at which sandstone and limestone would be intersected at point C.

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

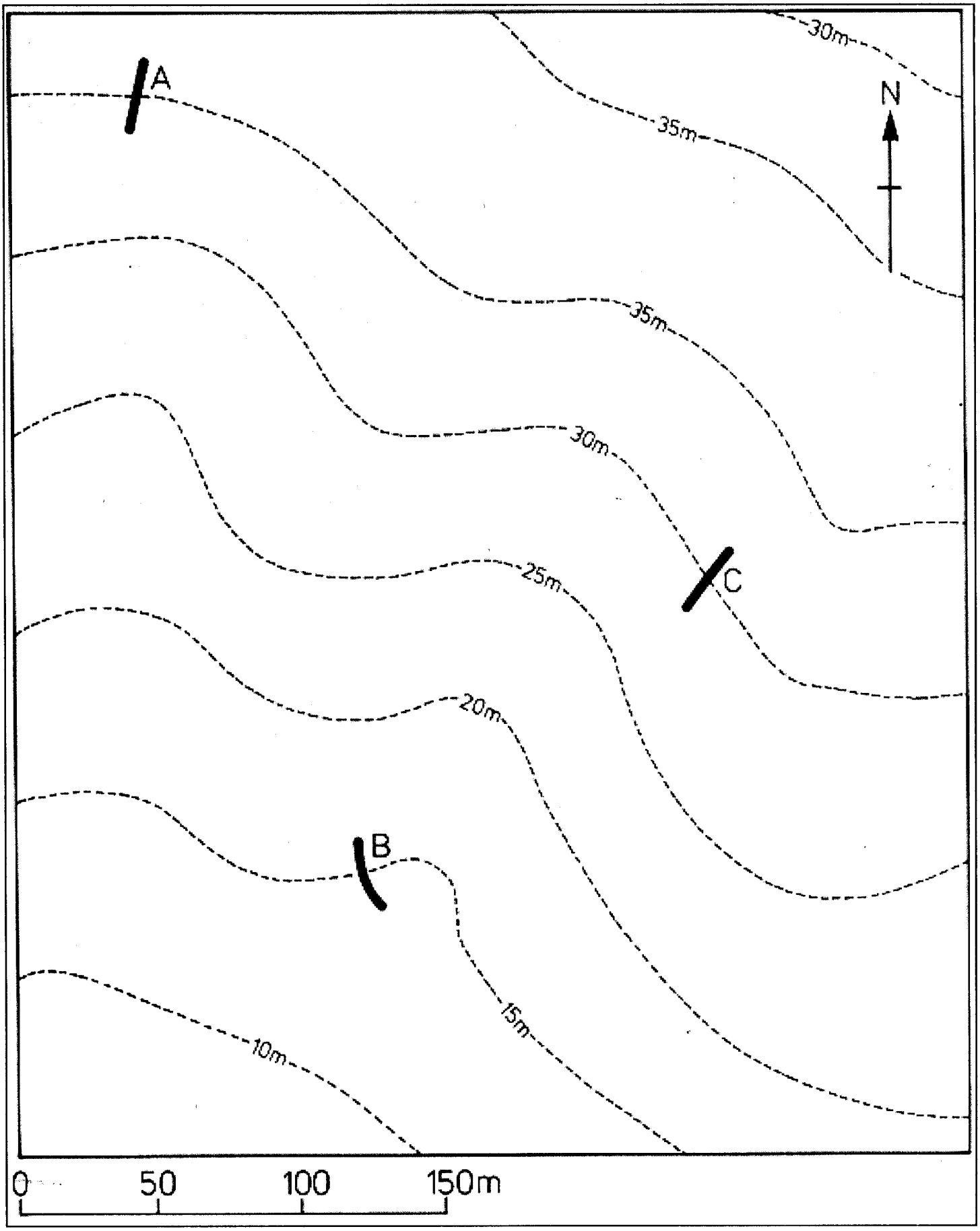
   (40 Marks)

********** END OFEXAMINATION. GOOD L UCK! **********

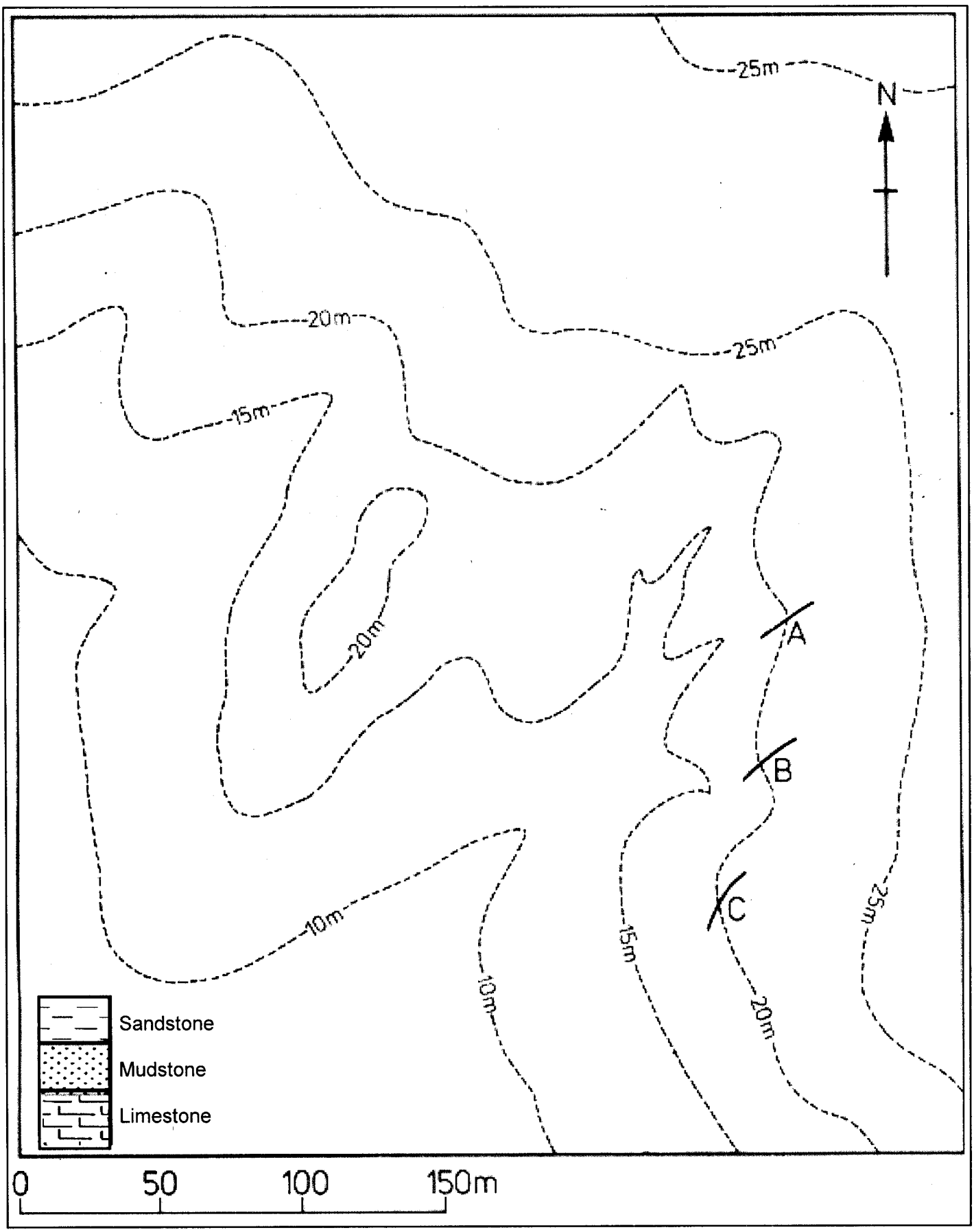
Map 1


600
600
500
600
700
A
B
800
700
600
500
500
700
Topographic contours in metres
Geologic contours
0
500
Scale in Metres

Map 2



Map 3


25m
N
20m
25m
15m
20m
A
B
C
10m
10m
15m
20m
25m
Sandstone
Mudstone
Limestone
0
50
100
150m

UNIVERSITY OF ZAMBIA

UNIVERSITY OF ZAMBIA EXAMINATIONS: NOVEMBER - DECEMBER 2018

GGY 3069 - REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM

PAPER I

INSTRUCTIONS: Answer any five questions. Draw figures wherever necessary. Neatly drawn sketches/diagrams recommended for al full mark.

All questions carry equal marks.

Time 3 hours
Full Marks: 100

Q1

a) What is a GIS model?
b) Briefly describe four characteristics of a model
c) Describe four capabilities that make GIS special

20 Marks

Q2 Define the following:

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

20 Marks

Q3

a) What is topology
b) List three common types of topology
c) Use well labeled diagrams to explain planar and non-planar topology

20 Marks

Q4 The process of remote sensing involves an interaction between electromagnetic radiation and the targets of interest. Briefly explain seven elements (stages) involved in this process.

20 Marks

Q5 State the spatial resolution, spectral resolution, temporal resolution and scene size for each of the following:

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

20 Marks

Q6 Remote sensing and GIS can be used for applications in several different fields. Name five fields and explain how remote sensing/GIS can be applied.

20 Marks

Q7 Interpretation and identification of targets in remote sensing imagery is performed manually or visually. Describe five visual elements that aid in visual image interpretation.

20 Marks

END – GOOD LUCK

UNIVERSITY OF ZAMBIA

UNIVERSITY OF ZAMBIA EXAMINATIONS: NOVEMBER - DECEMBER 2018

GGY 3069 - REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM PAPER II

INSTRUCTIONS: Answer all questions. Draw figures wherever necessary. Neatly drawn sketches/diagrams recommended for al full mark.

All questions carry equal marks.

Time 3 hours
Full Marks: 100

Q1. Georeferencing

1. Start Arc Map and create a blank Map.
2. Set the Coordinate System of the Dataframe to **Arc 1950 UTM Zone 35S**
3. Use catalog to connect to the folder on the C drive called **GGY_3069_II_2018**
4. Load the given topographic map called **RUFUNSA_TOPO**
5. Use the georeferencing Tool bar to georeference the **RUFUNSA_TOPO** using the four **GCPs** shown on the map
6. Use the following coordinates for the **GCPs**

Name	X	Y
GCP 1	780008	8329990
GCP 2	780001	8332985
GCP 3	787035	8332976
GCP 4	787026	8329988

7. Update Georeferencing
8. Add the shape file called **Buildings** to your ArcMap project to overlay on the **RUFUNSA_TOPO**
9. Save the ArcMap Project as **Q1_Georeferencing_CCCC** (where CCCC is your Computer Number) in the folder called **GGY_3069_II_2018**

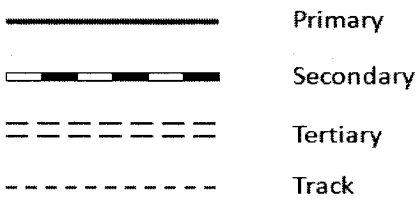
Q2. (Continue with the same ArcMap project from Q1 above)

1. Open the attribute table of the shape file called **Buildings**
2. Add a new field and call it **Name.** The type should be **Text**
3. **Start editing**
4. Enter the names of each building in the new field in the attribute table
5. **Save edits and stop editing**
6. **Label** the buildings using the Names *(Hint: right-click the layer>properties>labels>)*

7. Save the ArcMap Project as **Q2_Attributes_CCCC** (where CCCC is your Computer Number) in the folder called **GGY_3069_II_2018**

Q3. (Continue with the same ArcMap project from Q2 above)

1. Use the Catalog to create a new shapefile. *(Hint: right-click the background>new>shapefile>)*
2. The name should be **Roads,** the feature type should be **polyline**
3. Set the coordinate system (spatial reference) to **Arc 1950 UTM Zone 35S**
4. Create another new shapefile and call it **Rivers**
5. Start Editing *(Hint: right-click the layer>edit features>start editing)*
6. Use the Editor and Editing windows to create features (digitize) the roads and rivers from the RUFUNSA_TOPO
7. *(Caution: save edits frequently to avoid loss of work)*
8. When all features are digitized, open the attribute table of **Roads**
9. **Add a field** and call it **Name**
10. Enter the names of the roads as follows:



11. Change the appearance of the symbols based on the attributes above *(Hint: right-click the layer>properties>symbology)*
12. Save Edits and Stop Editing
13. Zoom to the entire Map (full extent)
14. Switch off the **RUFUNSA_TOPO**
15. Switch to Layout View *((Hint: View menu)*
16. Make a layout and insert Title as **Map of Rufunsa**
17. Insert **North Arrow, Scale Bar** and **Legend**
18. Save the ArcMap Project as **Q3_Digitizing_CCCC** (where CCCC is your Computer Number) in the folder called **GGY_3069_II_2018**
19. Go to **File menu**
20. Choose **Export Map**
21. Browse to the folder called **GGY_3069_II_2018**
22. Give File Name as **Q3_Digitizing_CCCC** (where CCCC is your Computer Number)
23. Save as type **PDF**
24. **Save**
25. **Close ArcMap**

END OF EXAM

UNIVERSITY OF ZAMBIA

UNIVERSITY OF ZAMBIA EXAMINATIONS: NOVEMBER – DECEMBER, 2018

GGY 4070 – IGNEOUS AND METAMORPHIC PETROLOGY

PAPER I

INSTRUCTIONS: Answer at least two questions from each section and any other one question illustrating your answers wherever possible.

TIME: Three (3) Hours
Full Marks: 100

SECTION A

Q.1 Differentiate between the following

(i) Eutectic point and coetectic points in geological phase diagrams.
(ii) Shallow granitic intrusions and deep-seated granitic intrusions
(iii) *Myrmekitic texture and* Intergranular texture

Q.2 Summarize the main characteristics of the Skaergaard Igneous Complex.

Q. 3 Identify and describe the followings textures. Give the possible interpretation of their formation

(a) Reaction Rim Texture
(b) Rapikivi Texture
(c) Amygdaloidal texture
(d) Graphic texture

SECTION B

Q4 (a) Define metamorphism
(b) What is foliation? Distinguish between rock cleavage and schistosity.

Q5 Outline in details the main characteristics of pyroclastic metamorphism with regard to:

a) General characteristics
b) Main rock types
c) Texture
d) Controlling factors

Q6. Define the following metamorphic rocks: (a) Migmatite (b) Augen gneiss (c) eclogite, (d) Mylonite

Q7 Differentiate between the following:

a) Hornfelse and Slate
b) Index mineral and isograd
c) Amphibolite and Migmatite
d) Schistosity and Slaty cleavage

Q8 Nomenclature of metamorphic rocks differs from igneous rocks and sedimentary rocks. Discuss in detail, the main criteria for naming metamorphic rocks.

End of Exam

UNIVERSITY OF ZAMBIA

UNIVERSITY OF ZAMBIA EXAMINATIONS: NOVEMBER – DECEMBER, 2018

GGY 4070 – IGNEOUS AND METAMORPHIC PETROLOGY

PAPER II

INSTRUCTIONS: Answer all questions.

Time: Three (3) hours
Full Marks: 100

Q1. The model composition of four volcanic rocks is given below:

(i) Orthoclase 48%; Plagioclase (An_{26}) 39%; Quartz 3%; Augite 4%; Biotite 4%.

(ii) Quartz 30%; oligoclase 46%; Orthoclase 8%; Plagioclase (An_4) 4%; Hornblende 8%; Biotite 4%.

(iii) Orthoclase 35%; Quartz 33%; Plagioclase (An_4) 24%; Biotite 4%; Hornblende 4%.

(iv) Orthoclase 65%; Oligoclase 11%; Quartz 15%; Biotite 6%; Hornblende 3%.

(a) Plot the rocks on AQP diagram
(b) Name the rocks
(c) Name their plutonic equivalents (if any)

Q2. Give a complete petrographic description of thin section-A emphasizing on the following:
a) Mineralogy
b) Texture
c) Is this rock a volcanic or plutonic? Why?
d) Discuss the geotectonic setting/ settings in which the rock is found.
e) Name the rock

Q 3. Give a full petrographic description of thin sections-B paying more attention on the following:

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

Q4. Fig 1 shows discoveries of some of the index minerals in a group of metamorphosed pelites in a regionally metamorphosed sequence, Rufunsa District. Do the following:

a) Draw the **boundaries** between the metamorphic zones.
b) Name the metamorphic **zones**
c) Name the **isograds**
d) Shown the direction of high grade metamorphism

FIGURE 1

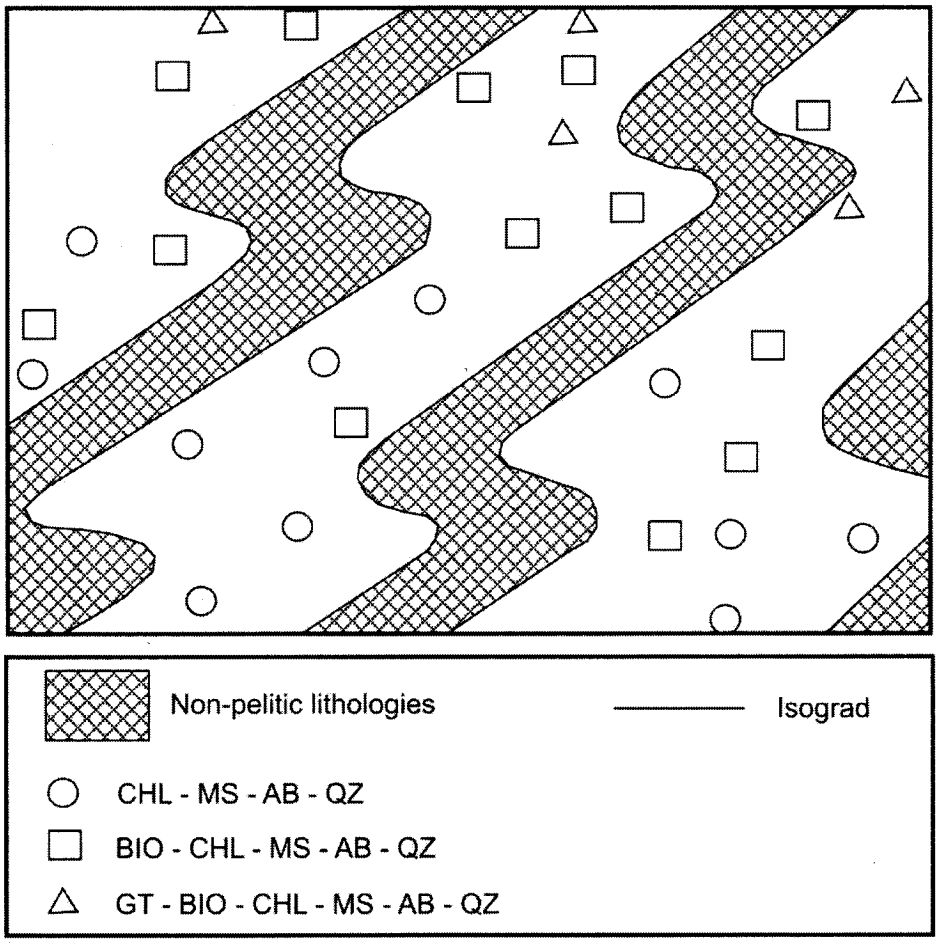
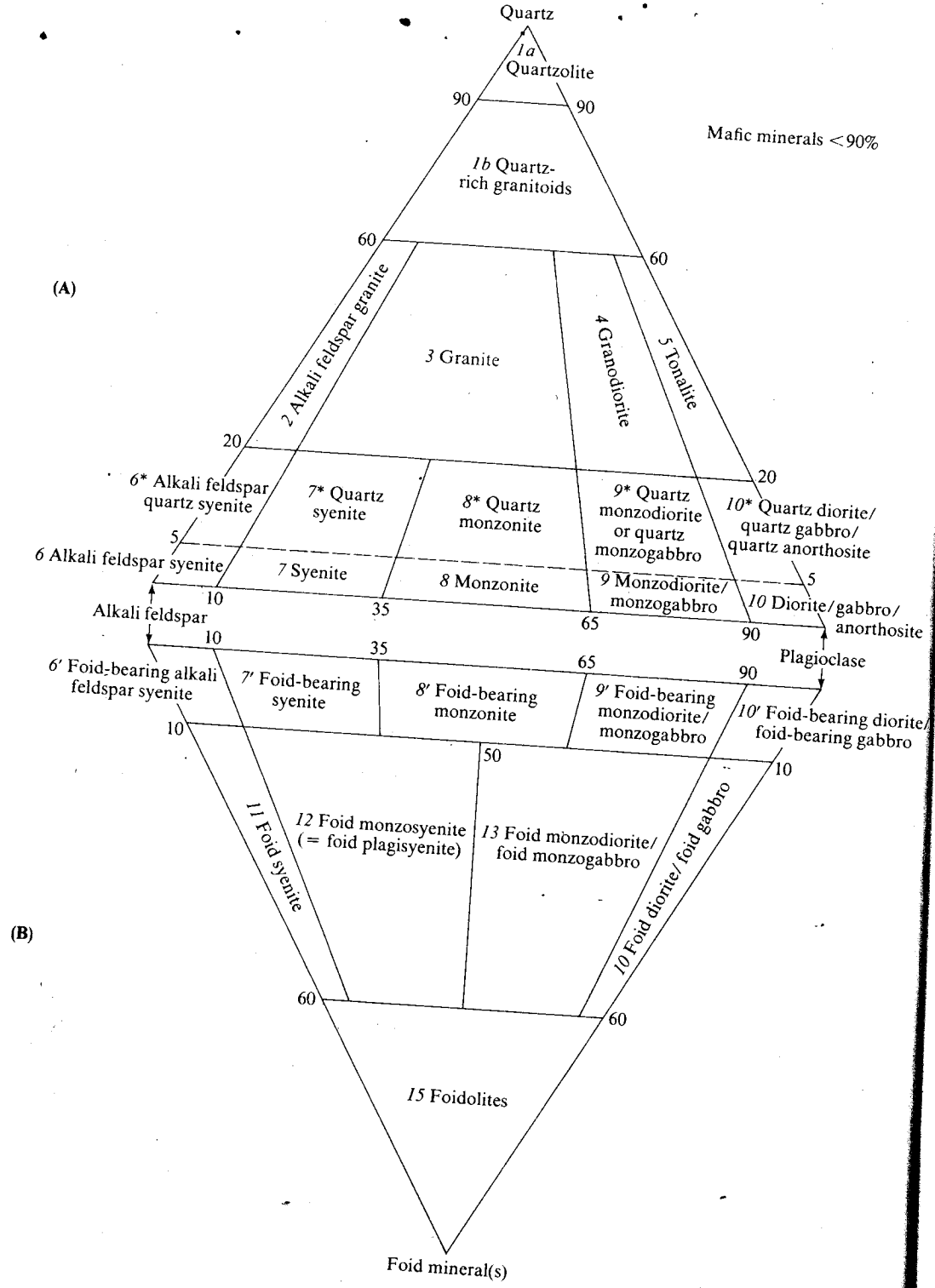


Fig1. Schematic map of Rufunsa illustrating the distribution of mineral assemblages (shown as symbols) of pelitic lithologies in a regional metamorphosed sequence.

End of exam***

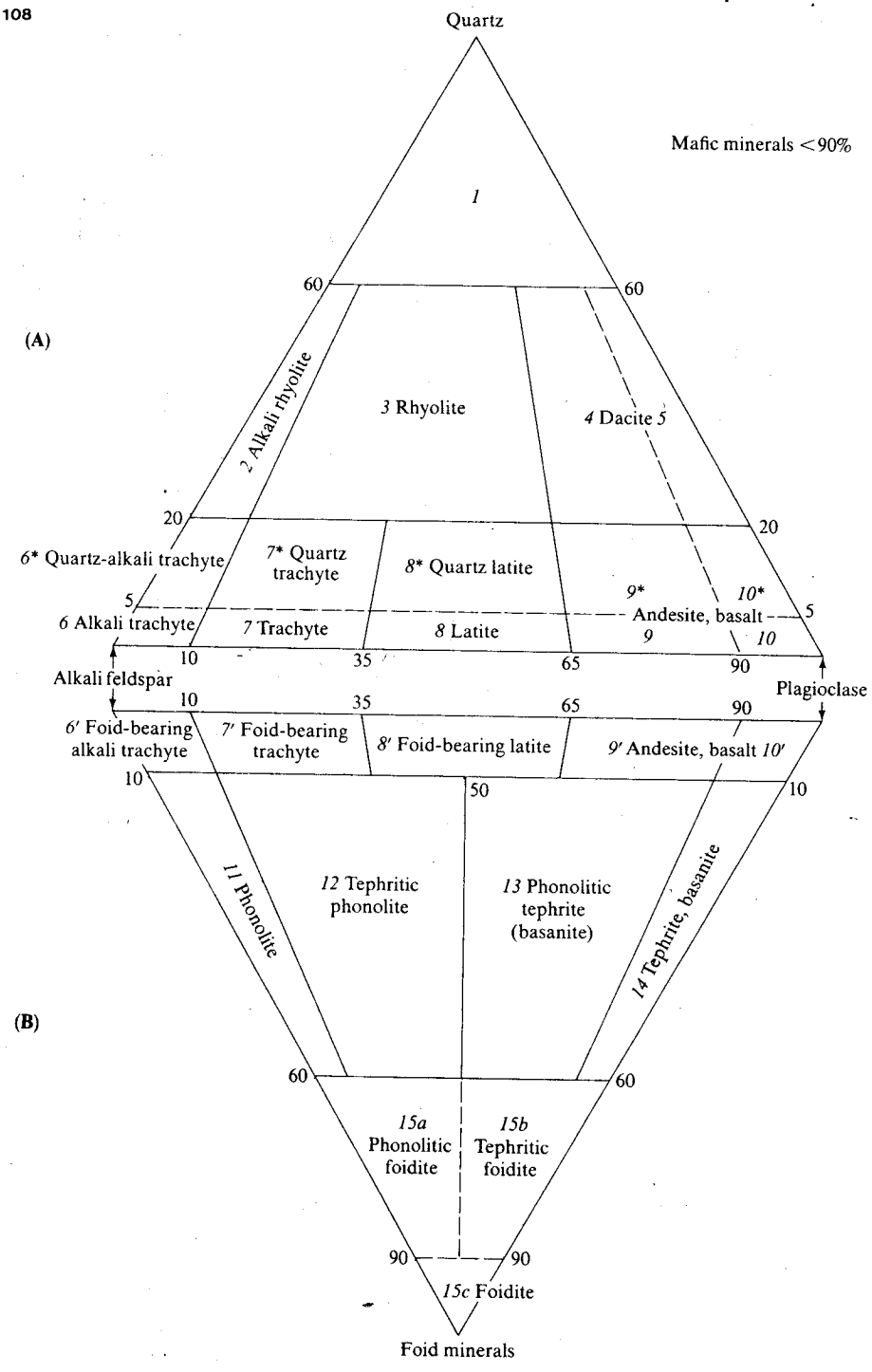


(C)

Figure 4–1
(A, B) The classification of
igneous rock must be phane
feldspar, and either quartz
these minerals are recalcula
technique shown in Figure
composition or distinctive t
percentages cannot be deter
"foid-bearing" should be us
1976, *Earth Sci. Rev., 12,*

(see Figure 4–1B). A roc
spathoid are chemically
pound (feldspar) of inter

The volcanic igneous r
ment (see Figure 4–3). D
basis of silica content (a
less than 52% SiO_2 is ba
composition (a rock with



A

(C)

Normative color index

(D)

Figure 4–3

(A, B) The classification of vol
triangles an igneous rock must
alkali feldspar, and either quar
minerals are recalculated to 10
Figure 4–2. Appropriate modif
distinctive texture. In the case
tentative classification can be b
group names (for field use). **(D**
index (volume percentage of ma
1979, *Geology, 7,* Figs. 1, 2; an

UNIVERSITY OF ZAMBIA

UNIVERSITY OF ZAMBIA EXAMINATIONS: NOVEMBER – DECEMBER, 2018

GGY 4089 - STRUCTURAL GEOLOGY AND PLATE TECTONICS

PAPER I

INSTRUCTIONS: Answer any five questions. Draw figures wherever necessary. All questions carry equal marks.

Time 3 hours
Full Marks: 100

Q.1. (a) Define force, stress and strain (**2 marks**).

Calculate the magnitude of the stress (in MPa) at a depth of 1000 m below the surface underlain by a granitic body of 1000 mx1000 m sides. (given: density of granite=2.7g/cc, g= 9.8 m/s^2. (**10 marks**)

(b) What is a Mohr Stress Diagram? Describe the method of construction of a Mohr Stress Diagram. **(8 marks)** **20**

Q.2 (a) With neat sketches describe rigid body and non-rigid body deformations, and homogeneous and inhomogeneous strains **(5 marks**).

Explain pure and simple shares. (**5 marks**)

(b) Give the equations for calculation of extension (*e*) and stretch (*s*). Also show the relation of stretch with extension. Within a body that has undergone homogeneous deformation, find the values of *e* and *s* in the direction of lengthening if during the deformation, a 5 cm long line has changed its final length to 8 cm. (**10 marks**) **20**

Q.3. (a) What is a shear zone? What are Mylonites and Cataclasities? Describe, illustrating with neat sketches, under what conditions are shear zones formed? **(10 marks)**

(b) List the Common shear-sense indicators and describe S-C fabrics. Draw figures as needed. (**10 marks**) **20**

Q.4. (a) List the five principal deformation mechanisms (**2 marks**). Describe dissolution creep. Illustrate your answers with neat sketches (**8 marks**)

(b) What is superposed folding? With a neat sketch show the main geometric elements of a refolded fold. Describe four basic patterns resulting from the superposition of folds. Illustrate with figures in each case. **(10 marks)** **20**

Q.5. (a) With a neat diagram show the crust, lithosphere and asthenosphere, and describe briefly their characteristics. **(10 Marks)**

(b) Discuss the driving mechanism for plate tectonics. On a neat diagram show all the forces acting on a subducting plate environment. (**10 marks**) **20**

Q.6. Describe various theories of origin of the first crust and early crustal composition and their mode of origin. **20**

Q.7. Write short notes on: (a) Accretionary prism, (b) Fore arc and back arc basins. **20**

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

UNIVERSITY OF ZAMBIA

UNIVERSITY OF ZAMBIA EXAMINATIONS: NOVEMBER – DECEMBER, 2018

GGY 4089 - STRUCTURAL GEOLOGY AND PLATE TECTONICS

PAPER II

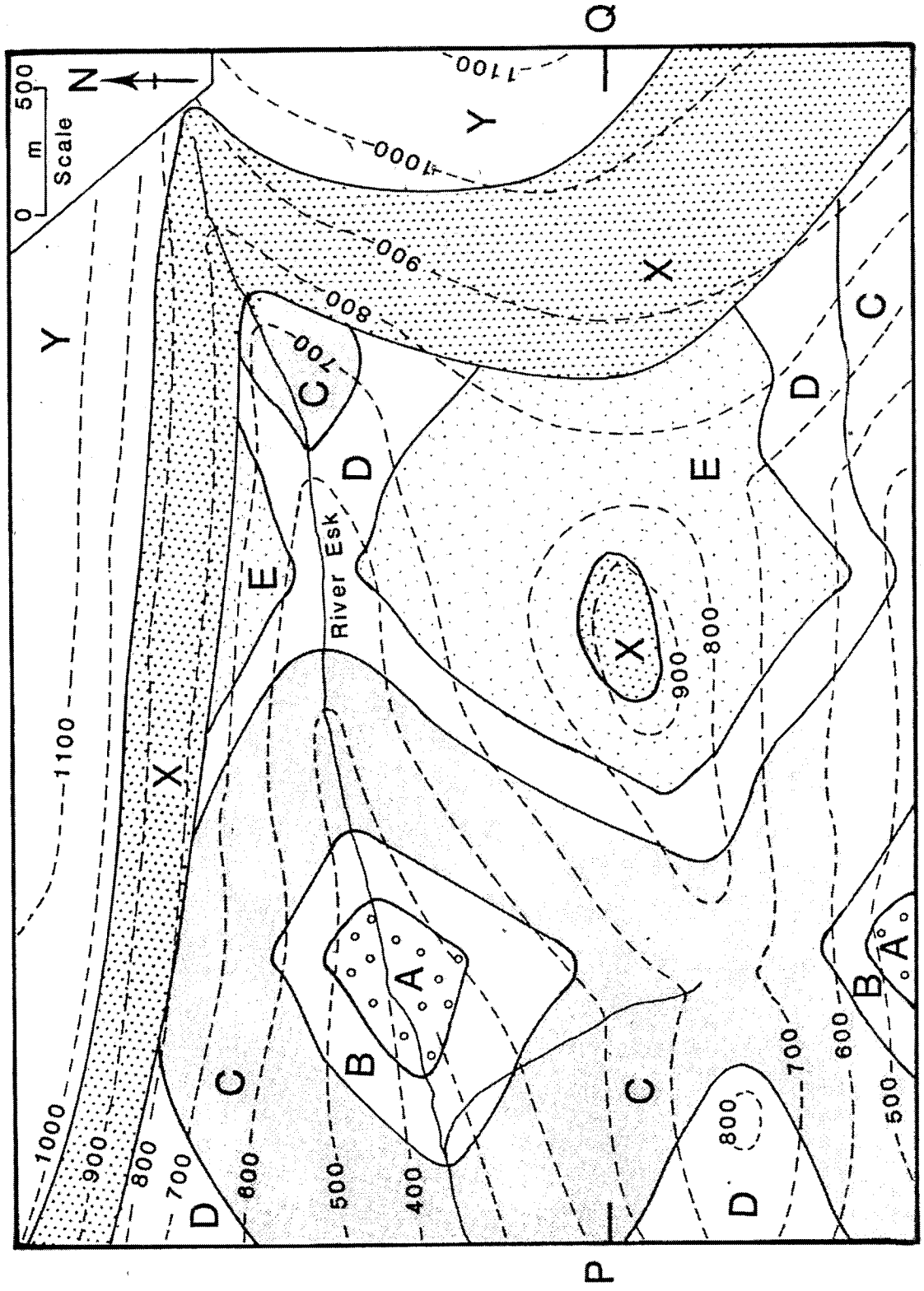
INSTRUCTIONS: Attempt all questions. Draw figures wherever necessary.

TIME: 3 hours
FULL MARKS: 40

		FM
Q.No.1	A bedding plane of a sandstone bed has an orientation of **N30°W, 50°SW**. The bed is cut by a very prominent joint plane whose orientation is **N80°E, 44°SE**. Find out the trend and plunge of the line of intersection made by the two planes. Label all the planes and lines.	**5**
Q.No.2	The two limbs of a fold (limb A and limb B) are oriented **060,40SE and 280,50NE**, respectively. Determine the interlimb angle and the dip and strike of the axial plane of this fold. Label all the planes and lines.	**5**
Q.No.3	A foliation plane has the orientating of **N30W, 40SW**. Using a stereonet rotate this plane on a vertical axis by **80** degrees anticlockwise looking down the axis. Give the new attitude of the plane. Label all the planes and lines.	**5**
Q.No.4	Establish the stratigraphy and thickness of beds and Interpret the given geological map. Construct a neat geological cross section along the given P-Q profile line.	**25**

Note: Some marks are allocated for neat drawings.

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



Map. No. 30: Describe the geology of the area with a suitable cross section

UNIVERSITY OF ZAMBIA

UNIVERSITY OF ZAMBIA EXAMINATIONS: NOVEMBER – DECEMBER, 2018

GGY 4090- GEOCHEMISTRY

PAPER I

INSTRUCTIONS: Answer Any four questions. Use diagrams and equations wherever it is necessary.

TIME: Three (3) Hours
Full Marks: 100

Q.1. Discuss the role of chemical weathering processes would play in the dispersion of ore components from the exposures of the mineralized gabbro and a quartz vein whose composition is given in Table 1. The major minerals in the gabbro are olivine, pyroxene, plagioclase, magnetite and sulphides of Cu, Ni and Fe. The major minerals in the gold-bearing quartz vein include quartz, As-rich pyrite. **(25 marks)**

Table 1 Composition of Gabbro and Quartz vein

Oxide	Gabbro	Quartz vein
SiO_2 %	49.84	97.1
TiO_2 %	0.86	0.13
Al_2O_3 %	15.29	0.1
Fe_2O_3 %	2.11	0.2
FeO %	9.14	1.1
MnO %	0.18	0.01
MgO %	7.62	0.002
CaO %	11.34	0
Na_2O %	2.64	0
K_2O %	0.24	0
Ni %	1.2	0
S %	1.5	0.7
Cu %	0.4	0.002
Au %	0	0.004
As %	0	0.35

Q.2. Write short notes on the following aspects:

(a) Essential and toxic elements. (5 marks)
(b) Acid Mine Drainage. (10 marks)
(c) Pathways for exposure of humans to arsenic and lead in the environment. (5 marks)
(d) Sources of arsenic and lead pollution in the environment. (5 marks)

(25 marks)

Q.3. Use the data given below to construct an Eh-pH diagram for the system Al-O-H at 1 bar pressure and 25 ^{0}C.

Species	**ΔG°_f (Kcal/gfw)**
Al^{3+}(aq)	-115.92
AlO_2^- (aq)	-198.59
$Al(OH)_3$ (gibbsite)	-276.08
H_2O	-56.69
H^+	0
OH^-	0
O_2 (g)	0
H_2 (g)	0

25 marks)

Q.4. (a) Use the equation $-\frac{dN}{dt} \propto N$ to derive the basic equation used in isotopic dating. (7 marks)

(b) Use appropriate equations to derive an equation that shows how the isotope fractionation factor for a mineral pair is related to the δ value. (5 marks)

(c) Use the following data to calculate U-Pb dates for a sample of a U-rich mineral from a gneiss in Greenland. $^{206}Pb/^{204}Pb$ = 53.90, $^{207}Pb/^{204}Pb$ = 20.76, $^{208}Pb/^{204}Pb$=36.94, $^{238}U/^{204}Pb$= 88.746, $^{238}U/^{235}U$=137.88, $^{232}Th/^{204}Pb$=55.38, $(^{208}Pb/^{204}Pb)_o$=33.90, $(^{206}Pb/^{204}Pb)_O$=12.97, $(^{207}Pb/^{204}Pb)_O$= 14.17, λ_1= 1.55125X10^{-10} a^{-1} , λ_2= 9.8485 X10^{-10} a^{-1} , λ_3= 4.9475 X10^{-11} a^{-1}. (13 marks)

(25 marks)

Q.5. Discuss how ionic radius and charge may control the distribution of the following trace elements in the ultramafic, mafic, intermediate, granitic and pegmatitic differentiates during fractional crystallisation of basaltic magmas: Ni, Cr, Co, Zr, Sr, Ba, Rb, B, Be, U, Ta, REE and Sn. **(25 marks)**

Q.6. Discuss the chemical reactions that would take place during low grade regional metamorphism of a sedimentary sequence that comprises mature sandstone, shale, limestone and a siliceous-dolomitic limestone. **(25 marks)**

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

UNIVERSITY OF ZAMBIA

UNIVERSITY OF ZAMBIA EXAMINATIONS: NOVEMBER – DECEMBER, 2018

GGY 4090- GEOCHEMISTRY

PAPER II

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

TIME: Three (3) Hours
Full Marks: 100

Q.1. Use the data given in Table 1 to answer the following questions:

(a) Discuss the mineralogical composition of the samples and use these to identify the rock units or geological materials which the samples represent. (7 marks)
(b) Discuss the degree of geochemical evolution of the specimens that represent igneous rock units. (6 marks)
(c) Discuss the rare element and Ni-Cu-Au mineralisation potential of the rocks. (12 marks)
(d) Discuss the nature of the clastic dispersion patterns that are likely to be associated with the mineralised zones. (10 marks)

(35 Marks)

Q.2. Use the data on the distribution of chemical elements in stream sediments (Table 2) to answer the following questions:

(a) Use appropriate statistical charts to identify sampling sites that have high potential for zinc and copper mineralisation. (45 marks)
(b) Discuss the potential of this area for lead mineralisation. (10 Marks)

(55 Marks)

Q.3. Discuss the geochemical associations of chemical elements that are likely to be found in the given specimens (R1, R2, and R3). **(10 marks)**

Table 1: Composition of samples collected from some geological materials

Oxide (%)	Sample 1	Sample 2	Sample 3	Sample 4
SiO_2	49.84	73.84	97.1	73.75
TiO_2	0.86	0.04	0.13	0.0
Al_2O_3	15.29	14.1	0.1	15.47
Fe_2O_3	2.11	0.41	0.2	0.14
FeO	9.14	-	1.1	0.06
MnO	0.18	0.02	0.01	0.0
MgO	7.62	0.03	0.002	0.0
CaO	11.34	0.75	0	0.01
Na_2O	2.64	5.32	0.02	0.34
K_2O	0.24	4.96	0.005	4.48
P_2O_5	0.01	0.06	0	0.02
Rb (ppm)	38	260	10	2810
Ba "	315	500	2	60
Sr "	452	90	0	1
Ni "	12000	2	0	0.0
S "	15000	2	7000	1
Cu "	4000	30	20	0.0
Au "	0.0	0.0	40	0.0
As "	0.0	0.0	3500	0.0
Sn "	0.0	5	0.1	2000
Ta "	0.0	1	0.0	350
H_2O "	7800	6500	2000	27200

Table 2: Distribution of some elements (in ppm) in the stream sediments of a survey area

S_NO	xcoord	Ycoord	CU	CO	NI	MN	FE	PB	ZN
1	448800	8634900	100	40	40	140	1850	10	30
16	447000	8630000	60	15	45	260	5830	10	10
43	447500	8627400	35	15	60	40	720	10	30
44	447300	8626700	35	20	50	170	3070	10	25
45	446600	8626000	40	15	65	120	2080	10	30
46	446700	8625700	40	20	65	220	4200	10	30
47	446700	8624800	60	20	85	110	6100	10	15
48	446200	8623900	15	10	40	90	1110	0	20
49	446900	8623300	35	15	65	210	3360	10	30
50	447800	8622800	25	15	50	130	1970	10	25
51	447000	8622200	30	15	45	160	2990	10	30
52	446200	8621800	40	20	110	105	4220	10	10
53	446900	8619400	30	20	50	240	3240	0	45
54	449900	8623600	65	30	90	560	7550	20	20
55	450800	8623200	40	20	60	240	5900	20	30
56	451100	8622400	65	30	85	270	6180	20	30
61	453200	8620800	20	20	30	70	1380	10	20
67	449800	8635000	60	20	65	150	3000	20	10
68	450500	8635000	65	15	55	120	2840	10	10
69	450500	8635500	50	15	50	95	2810	10	10
70	449800	8636400	45	15	55	80	3290	10	20
71	450400	8636900	60	55	146	370	10800	10	35
72	450700	8637800	40	25	100	160	7200	10	30
73	451300	8638400	40	20	75	145	6730	20	40
74	451000	8639000	50	25	90	350	8610	20	55
75	449900	8639100	35	20	55	330	4750	20	75
76	448400	8644800	25	10	40	130	3500	10	20
77	449300	8644600	35	15	60	150	4800	10	20
78	450300	8644400	25	40	125	180	9500	10	20
79	451000	8644000	30	20	50	150	5700	10	20
80	451900	8643800	30	20	70	190	5400	10	25
81	451900	8644800	45	30	70	200	9010	20	30
82	452900	8645100	60	30	70	305	8540	20	60
83	454200	8643500	30	40	70	55	2830	20	35
84	453600	8643400	10	10	20	110	2200	0	25
90	451800	8638600	30	25	60	160	4250	10	35
96	454900	8643800	50	20	50	65	2330	10	35
97	456000	8644200	50	10	30	130	5170	10	30
98	457100	8644200	60	20	60	165	5790	20	40
108	453000	8629200	30	20	50	55	3340	10	30
109	452900	8628000	20	20	30	155	2230	10	55
115	453400	8622700	50	20	50	210	1990	10	20
116	452600	8621800	60	25	50	165	1400	20	20

S_NO	xcoord	Ycoord	CU	CO	NI	MN	FE	PB	ZN
120	456000	8628900	30	10	50	60	1230	15	25
122	456900	8637600	70	20	50	170	3370	20	40
123	457400	8636700	120	20	110	220	5000	30	45
124	457700	8635700	100	20	60	220	4960	35	35
125	457900	8634900	65	20	40	490	2180	20	15
126	457000	8634600	340	140	80	130	11250	25	25
127	456000	8634100	240	100	90	605	29760	30	40
128	455000	8633700	270	40	40	1440	9990	30	20
129	454000	8633200	80	30	60	395	3840	20	15
130	452900	8632800	100	40	85	380	4410	30	30
131	452400	8632400	120	50	50	530	6680	10	25
132	454400	8632200	90	20	30	265	2930	10	15
133	455500	8633900	80	20	40	110	1980	5	15
135	457300	8628300	50	30	60	125	7760	20	15
137	458500	8629500	60	20	80	150	4060	10	15
138	459200	8629800	30	10	50	55	3230	20	25
145	463300	8632300	50	10	70	90	8300	30	30
147	464800	8634000	20	5	40	240	2560	20	50
155	457400	8620400	35	20	30	600	4750	10	120
157	458000	8619100	40	10	70	95	1500	30	30
164	460200	8622400	40	20	40	295	3830	5	35
165	457600	8626900	50	25	60	310	4660	10	30
166	458600	8626900	30	15	40	240	3200	0	35
167	459400	8626700	30	20	30	290	4000	10	25
168	460100	8626500	25	10	30	90	2920	10	35
169	459900	8625900	40	5	30	55	2810	10	15
170	459600	8625100	25	10	30	160	1690	10	25
171	459100	8624200	20	10	20	75	4520	10	25
172	459200	8623400	50	20	50	130	7200	15	30
173	460800	8622800	90	20	90	190	8330	20	35
174	461200	8623600	80	35	90	170	10830	20	35
175	461600	8624600	30	40	90	240	3370	20	25
176	461800	8625500	20	20	30	275	9140	10	20
177	461300	8626200	50	50	110	395	8750	15	35
178	465200	8635400	100	30	60	290	5910	20	30
199	462800	8625200	120	10	50	440	6700	5	10
200	463700	8624900	25	10	50	170	1650	0	30
206	467300	8627100	35	30	100	40	2280	10	55
207	467900	8628000	75	35	100	580	8250	40	35
208	468300	8629000	70	20	80	340	8270	20	35
209	468300	8630000	10	5	20	110	2060	0	10
210	468300	8631000	90	10	40	125	5480	10	20
211	468400	8632000	60	25	65	270	8330	20	30

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

UNIVERSITY OF ZAMBIA

UNIVERSITY OF ZAMBIA EXAMINATIONS: NOVEMBER – DECEMBER, 2018

GGY 4101 – GEOLOGY OF ZAMBIA

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

TIME: Three (3) hours
Full Marks: 100

Q.1. Write an account of the geological evolution of Africa from Archean to Neo-Proterozoic with special reference to southern Africa. **(25 marks)**

Q.2. Compare and contrast the Mozambique and Zambezi mobile belts in terms of spatial distribution, geological and tectonic setting, age, as well as the orogenic activities that led to their formation. **(25 marks)**

Q.3. Write a short essay on the Irumide Fold Belt with special emphasis on the tectono-thermal evolution, spatial distribution, geology and economic potential. **(25 marks)**

Q.4. Discuss the geology and tectonic setting of the Lufilian Arc and its significance on the economies of the countries in which it is found. **(25 marks)**

Q.5. Zambia is considered to be a country that has a complex geological setting. Discuss, in chronological order, the geological events that led to this complex geology and the economic potential it has on the country. **(25 marks)**

Q.6. Write concise notes on the characteristics of Greenstone Belts with particular reference to their distribution, both in space and time, in southern Africa; geology; and economic potential. **(25 marks)**

END OF EXAM AND GOOD LUCK

UNIVERSITY OF ZAMBIA

UNIVERSITY OF ZAMBIA EXAMINATIONS: NOVEMBER – DECEMBER, 2018

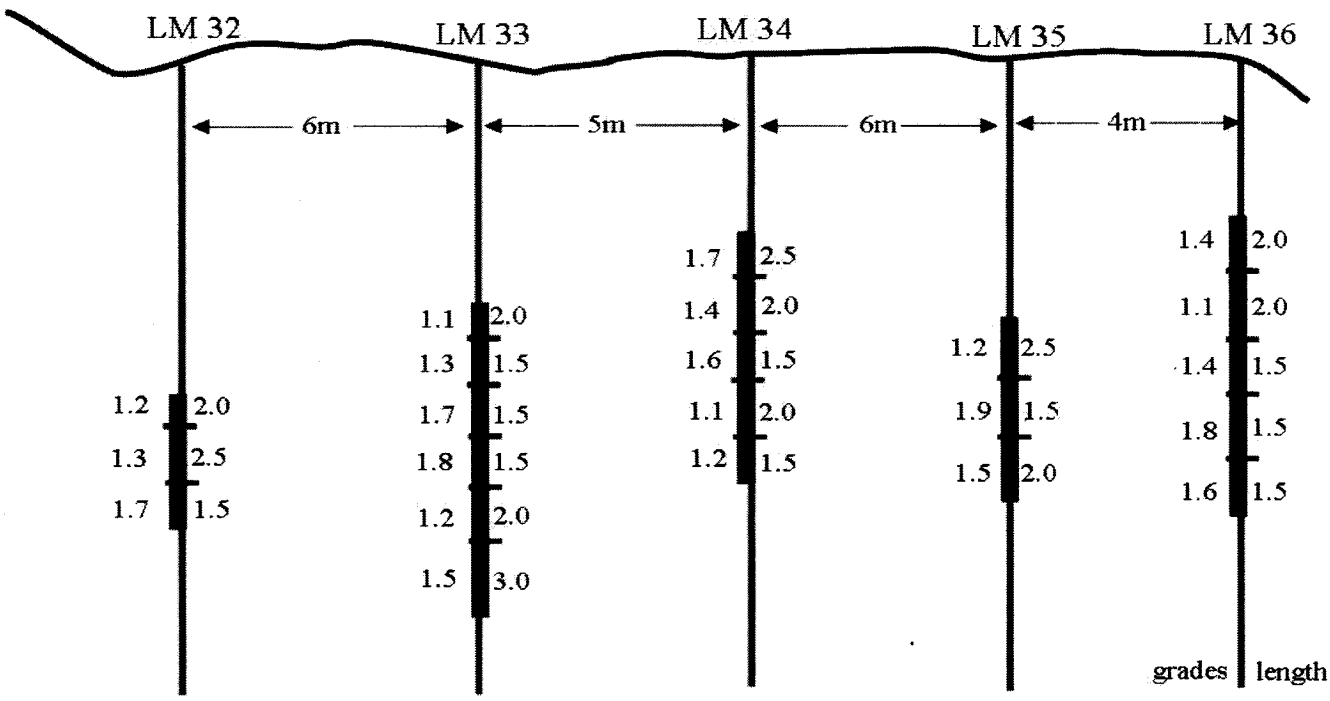
GGY 4119 – MINING GEOLOGY

INSTRUCTIONS: Answer any four questions including question No. 1 which is compulsory. Draw figures wherever necessary.
All questions carry equal marks.

Time 3 hours
Full Marks: 100

Q.1. (COMPULSORY)

a) As a Production Geologist, you have been provided with the section below for a cut back at an open pit mine. The bulk density of copper is 3.2t/m^3 and the thickness of the Ore is 45m. Showing all the necessary calculations, report the estimated mineral resource for the cut back. **(15 marks)**



b) The process of estimating a Mineral Resource can only take place after the estimator is convinced of the soundness of the fundamentals underlying the estimation process. Describe the three assumptions the estimator makes during this process. **(6 marks)**

c) An underground face in the orebody has the following tonnages; quartz vein 95t, hangingwall quartzite 45t and footwall sandstone 55t. If mineralisation is confined to the quartz vein, estimate dilution for this face. **(4 marks)**

Q. 2.

a) Geophysics is a subject of natural science concerned with the physical properties of the Earth. Describe a Passive geophysical method of your choice. **(10 marks)**

b) During geochemical exploration you observed surficial expressions of ore. In order to further test your theory and suspicion, you recommend for Reverse Circulation (RC) to drill through the regolith. Describe comprehensively your choice of drilling including logging, sampling, errors, pros and cons. **(15 marks)**

Q. 3.

a) A pre-feasibility report for a gold mine has the following parameters; (cost of mining and transport per tonne of ore= $2/t), (total waste mining cost to expose tonne of ore = $1.8/t), (cost of treating each tonne of ore = $12.3/t), (overhead and administration costs per tonne= $6.1/t), (metallurgical recovery factor = 90%), Strip ratio = 5:1

   i. Define Breakeven Cut-off grade. **(3 marks)**
   ii. Calculate the breakeven cut-off grade for this gold mine if the selling price for gold is $37.9/g. **(4 marks)**
   iii. Explain with reasons what would happen to the cut-off grade of this gold mine if the selling price was increased leaving all the other operational costs constant **(3 marks)**

b) The Geotech department at an open pit mine has requested for a brief write-up on how the following characteristics of geological structures would affect slope stability **(5 marks)**

   i. Spacing
   ii. Persistence

c) Konkola Copper Mines (chililabombwe) is one of the wettest underground mines in the world pumping nearly 450 million litres of water daily. As a consulting hydrogeologist, describe in brief the strategies/action plan you would put in place to avoid underground flooding. **(10 marks)**

Q. 4.

a) An investor plans to put up a cement manufacturing company and consults your expertise. From the GSD archives, you find a geological map that shows an area underlain by limestone, and tabulated seismic survey data (**Table 1. below**) for the same area. Using your knowledge on Seismic methods of geophysics, advice

the investor on how much overburden they will move before exposing the limestone. ***(Use a graph paper).*** **13 marks**

Table 1. Seismic survey data

Segment 1		Segment 2	
Distance (m)	Time (s)	Distance (m)	Time (s)
0	0	0	0.2
25	0.1	50	0.3
50	0.2	100	0.4
75	0.3	150	0.5
100	0.4	200	0.6
125	0.5	250	0.7

b) As a production geologist at an underground mine, part of the grade control procedure you employ includes assaying of drill samples at your mine's laboratory. Describe how you would perform a QAQC to ascertain the labs *precision, accuracy* and *contamination.* **(12 marks)**

Q. 5.

a) A sampling protocol for a gold mine in Eastern province needs to be established. The main sample reduction path is described below.

Reverse circulation drilling using a 150 mm diameter holes was sampled in 1 meter lengths. The maximum particle size measured by sieving to 95% passed through 15 mm. The drill cuttings were rifle split three times at the rig site before being sent to the lab. In the laboratory, the samples were sub-sampled by splitting to a mass of 1 kg. The split was reduced to 1 mm via a grinder and the sample was sub-sampled using a scoop to remove 300g. The sub-sample was pulverized to a pulp of maximum grain size of 180 µm. The pulp was split to produce 50 g subsample that was sent for fire assay.

i. Prepare a flow chart for this sampling program/protocol. **(4 marks)**

ii. Assess the sampling protocol by plotting the data on a Nomograph (nomograph is attached with a safety line marked). The nomograph has a minimum 1g/t line marked on it to indicate recommended minimum grade for the samples **(6 marks)**

iii. To make the sampling protocol simpler, your senior has suggested the material sent from the site to the lab be reduced to 75µm via a bowl pulverizer. On the same Nomograph, show how this suggested method would affect

sampling and state whether it would be a better option in terms of minimizing error **(5 marks)**

b) What factors do you consider when selecting drilling type and spacing during grade control in surface mining **(4 marks)**

c) As a Grade Control Geologist at an underground mine, advise your samplers on the three types of sample they could collect, and emphasise on the errors associated with each sample type **(6 marks)**

Q. 6.

a) Production figures for an underground mine are shown in table 2 below;

Table 2. Unreconciled production figures

	Stope Reserve			Layout Reserve			Drawn		
Stope ID	Tonnes	Grade (%TCu)	Cu Metal	Tonnes	Grade (%TCu)	Cu Metal	Tonnes	Grade (%TCu)	Cu Metal
SE/1020mL	42,000	1.68	704	43,500	2.01	875	45,000	1.92	865
SE/850mL	54,000	1.39	750	61,000	1.43	870	62,000	1.35	840
NE/1020mL	67,000	1.43	956	65,500	1.56	1,020	68,000	1.40	950
NW/1020mL	72,000	1.46	1,052	76,000	1.62	1,230	74,000	1.50	1,110
NW/975mL	40,000	1.65	659	41,500	1.72	712	43,500	1.70	740
Total	275,000	1.50	4,121	287,500	1.64	4,707	292,500	1.54	4,505

The receipt at the mill was declared as 325,000t @1.94%TCu and 6,320t contained Copper metal. Assuming all the hoisted tonnage came from stope operations, you are asked to:

i. Compute the Metal Reconciliation Factor (MRF) for the mine **(1 mark)**

ii. Compute the Tonnage Reconciliation Factor (TRF) for the mine **(1 mark)**

iii. Reconcile the production figures in table 2 by completing table 3 **(15 marks)**

iv. Using the extraction factor for the mine, suggest reasons why there is a drop in the grade as declared by the mill **(5 marks)**

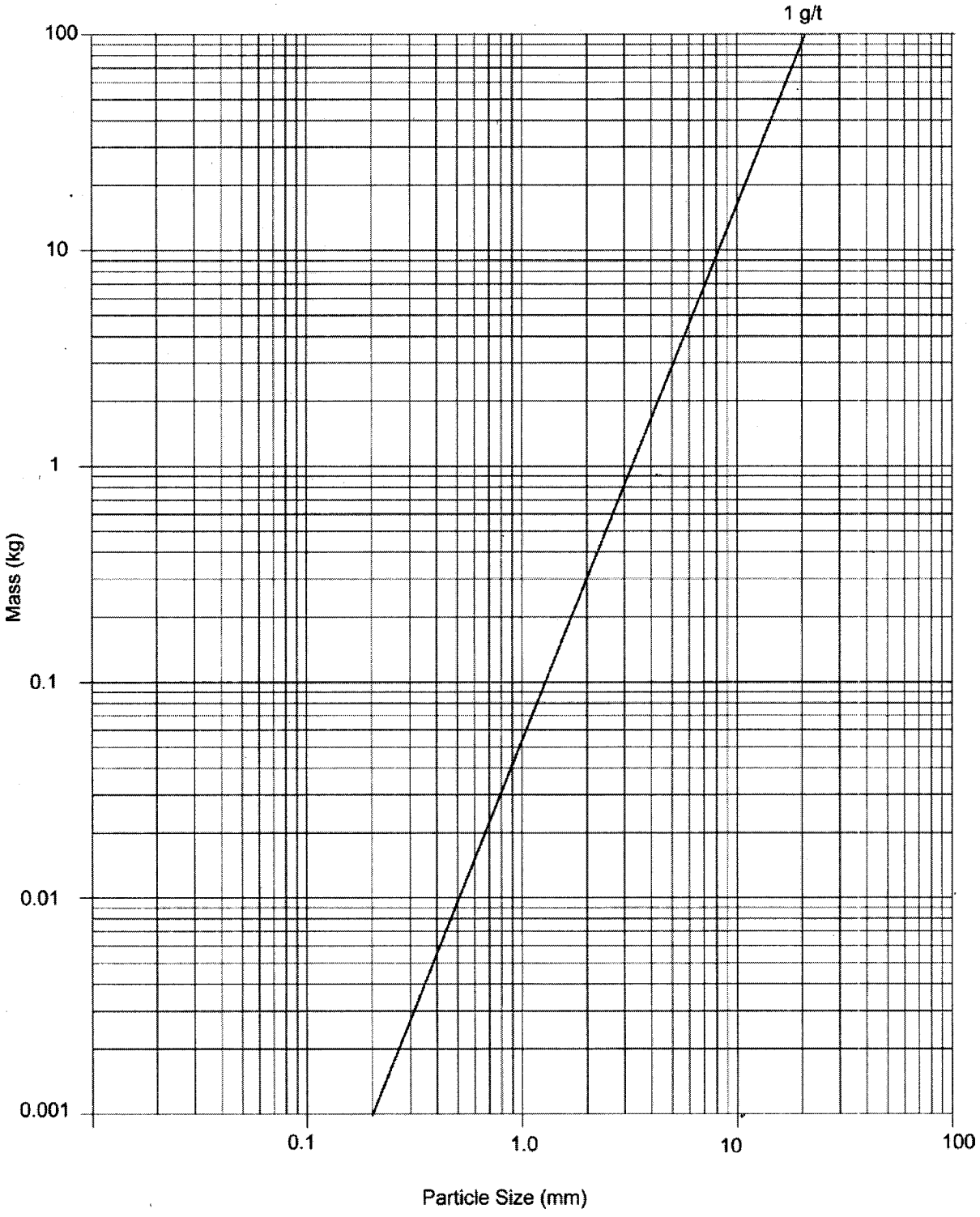
Table 3. Reconciled production figures

	Stope Reserve			Layout Reserve			Reconciled Drawn		
Stope ID	Tonnes	Grade (%TCu)	Cu Metal	Tonnes	Grade (%TCu)	Cu Metal	Tonnes	Grade (%TCu)	Cu Metal
SE/1020mL	42,000	1.68	704	43,500	2.01	875			
SE/850mL	54,000	1.39	750	61,000	1.43	870			
NE/1020mL	67,000	1.43	956	65,500	1.56	1,020			
NW/1020mL	72,000	1.46	1,052	76,000	1.62	1,230			
NW/975mL	40,000	1.65	659	41,500	1.72	712			
Total	275,000	1.50	4,121	287,500	1.64	4,707			

b) Give three (3) reasons why reconciliation is important to any mining operation **(3 marks)**

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

Computer Number:.....Course:.....



UNIVERSITY OF ZAMBIA

UNIVERSITY OF ZAMBIA EXAMINATIONS: NOVEMBER – DECEMBER, 2018

GGY4125 AND MET 3429 - COMPUTER TECHNIQUES

Paper I

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1. **INSTRUCTIONS: This exam has TWO sections**
2. **Section A carries 40 marks and Section B carries 60 marks**
3. **Two answer booklets will be issued. Section A in one booklet and Section B in another booklet.**

Time: Three (3) hours

Full Marks: 100

SECTION A

Instruction:

Answer Question 1. Question 1 carries 20 marks
Answer any one from Questions 2 and 3. Each question carries 20 marks

Q. 1. (Compulsory)

a) Define the following; [4 marks]

i. Program

ii. Algorithm

iii. Syntax Error

iv. Runtime Error

b) Assuming num = 20, determine the value of each of the following Python expressions: [8 marks]

i. num / 12
ii. 123 % 100
iii. 8 + 3 * 7
iv. (0 == 1) and (2 < 3)
v. not ((4.5 < 12.9) and (6 * 2 <= 13))
vi. (0 == 1) or (2 < 3)
vii. (0 == 1) or (2 < 3) and (7 < 6)
viii. (2 < 3) or (0 == 1) and (7 < 6)

c) What will the following Python program print out? [3 marks]

```
x = 3
if 2 > x :
   print ('First')
else :
   print ('Second')
   if 2 > x :
      print ('Third')
   print ('Fourth')
print ('Fifth')
```

d) Compare and contrast *lists*, *tuples* and *dictionaries* in Python [5 marks]

(20 marks)

Q. 2.

a) Give *three (3)* reasons why a Geologist/Metallurgist would need programming knowledge [6 marks]

b) Which of the following are valid Python identifiers? [4 marks]

i.	N1	vii.	Good_Show
ii.	N_1	viii.	Number
iii.	N.1	ix.	NUMBER
iv.	N-1	x.	RateOfIncrease
v.	Zzzzzzz	xi.	2Good2BeTrue
vi.	SumUp	xii.	XYZ

c) Write the output produced by this program below. [8 marks]

```
words = 'this IS NoT EvEN'
print (words.title())
print (words.replace("IS", 'was'))
print (words.upper())
print (words * 2)
```

d) Find the error in the following program. [2 marks]

```
line = input("Type a word")
print ("You typed", line)
line = (line + "h")
num = int(line)
print ("You typed the number ", num)
```

(20 marks)

Q. 3.

a) What is an IDE? Give ***four (4)*** examples of IDE's used with Python [4 marks]

b) Convert each of the following (non-Python) expressions into Python expressions: [7 marks]

a. $3x$
b. $3x + y$
c. $(x + y)/7$
d. $(3x + y)/(z + 2)$
e. x is evenly divisible by 12
f. x plus 7 is more than 100 or else x is less than fifty
g. $x \leq y$ *and* $2 \leq z$

c) Write a Python program that will prompt a user to enter a temperature as an integer. Your program will print "it is hot" is the temperature is over 100, "it is cold" if the temperature is under 60, and "it is just right" if the temperature is between 61 and 99 inclusive. The program continues to ask for temperatures, and evaluates them as above, until the user enters a temperature of 0. [5 marks]

d) What is printed by the Python code? [2 marks]

i. **def** func(x)**:**
ii. **print**(2*x)
iii. func(5)
iv. func(4)

e) Complete the function definition so it returns the square of the product of the parameters, so **sqrProd(2, 5) returns (2*5)*(2*5) = 100** [2 marks]

i. def sqrProd(x, y)**:**

(20 marks)

SECTION B

Answer any 3 from the following questions. Each carries 20 marks..

Q. 1.

1. Every day, people around the world rely on different types of computers. List and explain any five (5) different types of computers? [10 marks]

2. List and describe any five input devices? [5 marks]

3. What is a Computer System? [2 marks] What is the difference between Software and Hardware with examples? [3 marks]

(20 marks)

Q. 2.

1. List the three different categories of storage media? [3] Explain any one storage media with examples? [3 marks]
2. What is the difference between CD-R/DVD-R and CD-RW/DVD-RW [4 marks]
3. Explain the five generations of a computer? [10 marks]

(20 marks)

Q. 3.

1. Explain how ICT is used in the following sector
   i. Education [2 marks]
   ii. E-Commerce [2 marks]
   iii. Healthcare [2 marks]
   iv. Industry [2 marks]
   v. Banking [2 marks]
2. Give some guidelines on using E-mail and Internet Usage? [5 marks]
3. In the advancement of ICT, it is easy for anyone to retrieve your information from the Internet. Your information may be exposed and stolen. List some unethical computer code of conducts? [5 marks]

(20 marks)

Q. 4

1. Define computer security? What are the different types of computer security? [6 marks]
2. In order to make sure your computer is secured, what are the computer security list you need to follow? [4 marks]
3. List and explain any five malicious code that affects the computers? [10 marks]

(20 marks)

End of Exam

UNIVERSITY OF ZAMBIA

UNIVERSITY OF ZAMBIA EXAMINATIONS: NOVEMBER – DECEMBER, 2018

GGY4125 AND MET 3429 - COMPUTER TECHNIQUES

Paper II

---

1. **INSTRUCTIONS: This exam has TWO sections**
2. **Section A carries 25 marks and Section B carries 25 marks**
3. **Two answer booklets will be issued. Section A in one booklet and Section B in another booklet.**

Time: Three (3) hours

Full Marks: 50

Section – A

Duration: 1 hours **Marks: 25**

A. Execute Python expressions

Execute each of the following expressions.

- If it executes without an error, then:
  - **Value** - state the value that it evaluates to
- If it suffers an error during evaluation:
  - **Error** - describe the error (in one phrase—a brief explanation in your own words)
  - **Frame** - state the name of the current environment frame: "global" or a function name
  - **Operator** - state the operator that caused the error
  - **Arguments** - state the values to which the operator was being applied

Your answer will contain either part "**value**", or parts "**error**", "**frame**", "**operator**", and "**arguments**".

1. (4.0 + 5) * 6
2. len(str(5 * 2)) + "10"

B. Execute Python statements

Execute each of the following code snippets, just as if they were written in a program. (Each one is a sequence of statements.) Your answer to each question contains up to 5 parts.

- **Output** - write any output that it prints (before any error). This part might be blank. If it does not print any output.

If there is an error during execution:

- **Error** - describe the error (in one phrase—a brief explanation in your own words)
- **Frame** - state the name of the current environment frame: "global" or a function name
- **Operator** - state the operator that caused the error
- **Arguments** - state the values to which the operator was being applied

Your answer will contain either only part "**output**", or parts "**output**", "**error**", "**frame**", "**operator**", and "**arguments**".

3.
```
a = [1, 2]
b = [ ]
b = b + a
b = b + a
a.append(3)
print (b)
```

4.
```
a = [1, 2]
b = [ ]
b.append(a)
b.append(a)
a.append(3)
print (b)
```

5.
```
lst = [1, 2, 3]
myvar = lst[0]
lst[0] = 18
print (lst)
print (myvar)
```

6.
```
myvar = 18
lst = [myvar, 2, 3]
myvar = 22
print (lst)
print (myvar)
```

7.
```
plane = ("Passengers", "Luggage")
plane[1] = "Snakes"
print (plane)
```

8. numb3rs = ([1, 2, 3], [4, 5, 6])
   numb3rs[0][2] = 0
   print (numb3rs)

Section B

Duration: 2 hours **Marks: 25**

1. Create a Mail merge to send letter to your 5 employee that they have been selected to spend their Christmas and New Year holidays for 3 days and 2 nights in David Livingstone Safari Lodge and Spa[5]

2. Create a clustered column chart from a below table(Months will be in X axis and Sales in y axis) [5]

	Jan	Feb	Mar	Apr	May	June
Cookies	100	100	120	160	150	140
Cupcakes	185	165	145	155	105	125
Pies	110	150	170	150	115	180

3. Type a one page document (any topic) and insert the following items[5]
   - Hyperlink
   - Image
   - Comment
   - Footnote for any 2 words
   - Text Box

4. Create a PowerPoint presentation, select any one from the following topic [10]
   a) Child Labor
   b) Gender Based Violence

End of Exam

THE UNIVERSITY OF ZAMBIA

UNIVERSITY FINAL EXAMINATIONS – NOVEMBER 2018

MET 2419
INTRODUCTION TO MINERAL SCIENCES

TIME : THREE (3) HOURS

INSTRUCTIONS :
1. ANSWER A TOTAL OF FOUR (4) QUESTIONS;
2. ANY ONE QUESTION FROM EACH OF SECTIONS (A) & (B),
3. ANY TWO QUESTIONS FROM SECTION C
4. USE SEPARATE ANSWER BOOKLETS FOR EACH SECTION

SECTION A: INTRODUCTION TO GEOLOGY

Q 1

(a) Define the following terms:

(i) Crystal
(ii) Unit cell
(iii) Primitive (P) lattice
(iv) Axes of symmetry
(v) Mirror plane

(b) Classify the 4 crystals in the Table below into crystal systems using the characteristic elements of symmetry to be drawn from the data provided:

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

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

Q 2

(a) Define what physical properties are.

(b) Distinguish between colour and streak.

(c) Why is colour not a diagnostic physical property of minerals?

(d) Distinguish between transparency and opacity.

(e) Define the following terms:

(i) Lustre
(ii) Hardness
(iii) Cleavage
(iv) Fracture

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

Q 3

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

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

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

(c) Define the following terms

(i) Mineral
(ii) Atom
(iii) Isotope
(iv) Proton
(v) Electron

(d) How do cations and anions form?

(e) Distinguish between covalent and ionic chemical bonds.

SECTION B: INTRODUCTION TO MINING ENGINEERING

Q 1

a) There are sequences of activities involved in modern mine layout planning. Explain briefly the factors considered for each activity. (7 %)

b) Explain why accurate drilling of blast holes is important for optimizing rock fragmentation. (5 %)

c) Explain how poor rock fragmentation and high dilution affect metallurgical processes. (8 %)

Q 2

a) Describe factors considered in determining underground mining method. (8 %)

b) Describe the four functional components of drilling system (6 %)

c) With the help of diagrams, differentiate between:

(i) Drive and crosscut (3 %)
(ii) Raise and winze (3 %)

SECTION C: INTRODUCTION TO METALLURGY & MINERAL PROCESSING

Q 1

(a) Give reasons why recycling of metals is very prominent now and important.(7 %)

(b) Explain the principle of froth flotation. What are rougher, scavenger and cleaner cells in froth flotation circuits? Explain the role and objectives in each case. (7 %)

(c) It is given that a complex sulphide ore contains galena, sphalerite, bornite, chalcopyrite and pyrite and that its treatment by froth flotation yields three different concentrates: a lead concentrate, a zinc concentrate and a copper concentrate. The main reagents used in this flotation process are

- Copper sulphate
- Lime
- Sodium dichromate
- Sodium iso-propyl xanthate
- Methyl iso-butyl carbinol
- Sodium cyanide

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

(d) What distinguishes between unit operations and unit processes? Give examples of two of each type in metallurgical treatment and explain why many times it is necessary to carry out unit operations or processes in several stages or steps (5%)

Q 2

(a) Why is agglomeration carried out for most pyrometallurgical metal extraction processes such as smelting? Mention some of agglomeration processes. (9 %)

(b) What is roasting? Explain why concentrates are roasted prior to both leaching and smelting. (6 %)

(c) What is Cementation? Mention any two leaching method and explain in detail how it is carried out in terms of extractions times, yield or recovery, particle sizes, controls and costs involved. (10 %)

Q 3

(a) Compare between copper electro-winning and electro-refining and give the anode and cathode reactions that occur during the electrowinning of copper. What are starting sheets and what are they made of? (10 %)

(b) As applied to the hydrometallurgical route of copper extraction, briefly explain the principle of solvent extraction in relation to the role of an extractant and the equilibrium reaction given below. Identify which reaction is the extraction or stripping one and state which species are organic or aqueous. What is advance electrolyte and spent electrolyte? (10 %)

$RH_n + Me^{n+} = RMe + nH^+$

(c) Define the terms "recovery" and "grade" as applied to mineral processing.

How are the two related? Briefly discuss and illustrate the relationship graphically.

(5%)

END OF EXAMINATION IN MET 2419

UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
UNIVERSITY EXAMINATIONS – NOVEMBER 2018

MET 3430- CHEMICAL THERMODYNAMICS.

Time : THREE hours

Answer : Five Question and note that <u>All questions carry equal marks.</u>

1. (a) Derive the expression for the elevation of the boiling point of a Solvent A due to the addition of a small amount of non-volatile solute B. [15]

   (b) A 2 mass % solution of a substance of unknown molecular weight in toluene as solvent has a boiling point of 110.25°C. The normal boiling point of toluene is 110°C and its latent heat of vaporisation is 533 J/gm; the solute is non-volatile. Calculate the molecular weight of the solute given that the molecular weight of toluene is 92gm/gm mole.[5]

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

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

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

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

3. What you understand by Kinetics in Thermodynamics. Give in general the zero, first and second order equation and their half life of the reaction. [5]

   State the relationship between the rate of reaction and the concentration of the reactants and the temperature of the reaction. [3]

   What are the do you understand by the following this thermodynamics:

   i) Collision theory [3]

   ii) The rate of absolute theory [3]

The inversion of sucrose proceeded as follows in a certain experiment

Time (Min.)	0	30	60	90	130	180
Sucrose inverted (Moles/dm^3)	0	0.1001	0.1946	0.2770	0.3726	0.4676

The initial concentration of sucrose was 1.0023 moles per dm^3. Calculate the first order rate constant and the half life of the reaction. [6]

4. In electrochemistry, what are the main electrochemical cells and gives example of how they work. [4]

The voltage of the cell is given as follows:

$Ag \mid Ag_2SO_{4(s)} \mid \mid$ Sat'd soln of $Hg_2SO_{4(s)} \mid \mid Hg_2SO_{4(s)} \mid Hg$

Is found to be 0.140 V at 25° C and it's temperature coefficient is 0.00015 volts/°C.

(a) give the half electrode reactions and the overall reaction. [2]
(b) Calculate ΔG, ΔH and ΔS for the cell reaction. [12]

Does the cell absorb or emit heat as cell reaction proceeds? [2]

Gas constant R = 8.314 J/K/mol, Faraday's constant 96487 C/g- equivalent
1 Atmosphere = 760 mm Hg
= 101325 N/m^2, Pa.

5. In the production of Zinc by the reduction of zinc oxide with carbon the initial reactants ZnO and C are at a temperature of 298°K. The final products, Zn vapour and CO gas are at a temperature of 1273°K . Calculate the heat required, in calories per kilogram of zinc produced.

The following data has being determined experimentally.

Compound	ΔH^o_f at 298°K (Cal/g.mole)	C_p(Cal/g.mole.°K)
ZnO(s)	- 83,800	$11.71 + (1.22 \times 10^{-3}T) - 2.18 \times 10^{5}T^{-2}$
C(s)	0	$0.026 + (9.31 \times 10^{-3}T) - 0.354 \times 10^{5}T^{-2}$
Zn(s)	0	$5.35 + (2.40 \times 10^{-3}T)$
CO(g)	- 26,420	$6.79 + (0.98 \times 10^{-3}T) - 0.11 \times 10^{5}T^{-2}$
Zn(l)	-	7.50
Zn(g)	-	5.00

Additionally,

Zn(s) = Zn(l) T_m = 692.5 °K; ΔH^o_m = 1740 Cal/g.mol
Zn(l) = Zn(g) T_b = 1180 °K ; ΔH^o_{vap} = 27,565 Cal/g.mol [20]

6. (a) For an ideal solution, derive ΔV_{mix}, ΔG_{mix}, ΔS_{mix} and ΔH_{mix}.[4]

(b) 1-liter flask contains hydrogen at 27°C and 1 atm pressure. The flask is connected to another flask having volume of 2 liters and containing oxygen at 27°C and 0.6 atm pressure. The gases are allowed to diffuse into each other under isothermal conditions. Calculate G^m [8] and S^m [4] for the mixing process assuming that the gases behave ideally. From these values find the H^m[4]

7. (i) State the first law of thermodynamics. [2]

(ii) Give a short statement of the Hess's law of heat of reaction.[2]

(iii) State the second law of thermodynamics as given by Clausius statement and compare this statement to that of Kelvin-Planck statement.[2]

(iv) State the statement of the third law of thermodynamics. [2]

A Carnot heat engine operates in a cycle involving a series of sub processes. These cyclic processes may involve the use of an ideal gas, real gas, liquid or solid. The total cycle is composed of two adiabatic steps and two reversible isothermal steps. Draw the P-V diagram of this cycle and show how the Carnot cycle is carried out consisting of the various steps A, B, C and D. Derive the expression for the overall net work done in the system and hence the efficiency of the engine. [8]

A Carnot heat engine operates between reservoirs at 1200°C and 200°C. The isothermal process at the hotter reservoir consists of an expansion (reversible) from an initial pressure of 5×10^5 N/m^2 to 4×10^4 N/m^2. Assuming that the working substance is a kilo mole of ideal gas, calculate

(a) The efficiency of the heat engine.[2]

(b) The heat absorbed from a hotter reservoir and the heat rejected to the colder reservoir. [2]

END OF MET 3430 EXAMINATION

UNIVERSITY OF ZAMBIA.

SCHOOL OF MINES.

UNIVERSITY EXAMINATIONS – NOVEMBER 2018.

MET 3449 - HEAT AND MASS TRANSFER.

Time : THREE HOURS.

Answer : Five Questions and note that All questions carry equal marks.

---

1. (a) Using the **M, L** and **T** system of basic dimensions, derive the dimensional representation of each of the following physical variables: [10]

(i) Specific weight (weight per unit volume)
(ii) Angular velocity
(iii) Moment of a force
(iv) Energy
(v) Viscosity

(b) Using the **F, L** and **T** system of basic dimensions, derive the dimensional representation of each of the variables in part (a). [2]

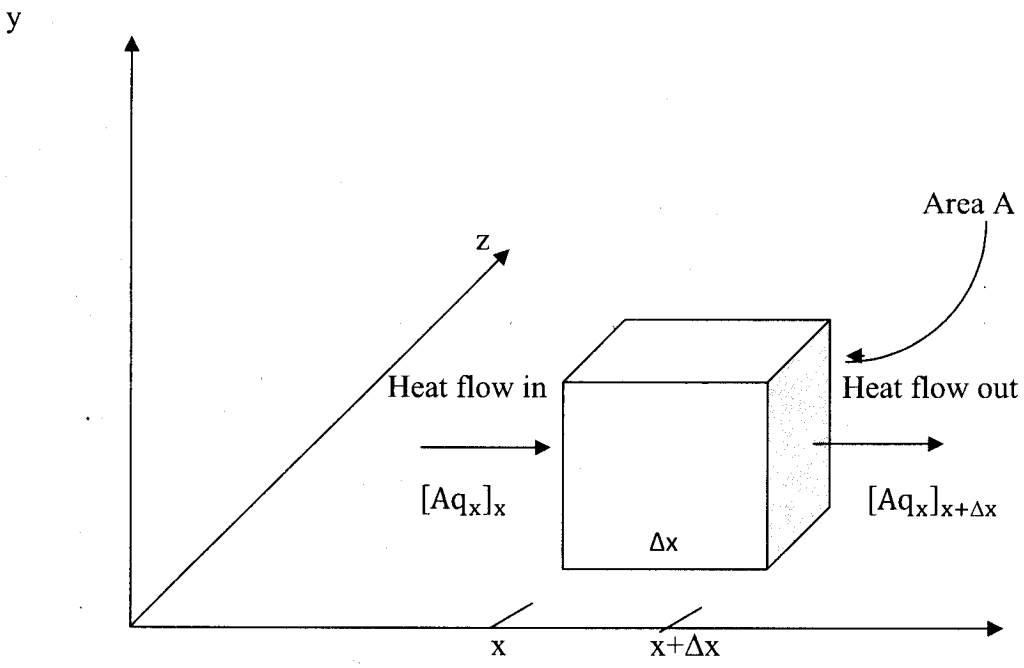
(c) It is found experimentally that the terminal settling velocity v_0 of a spherical particle in a fluid is a function of the following quantities:

particle diameter d,
buoyant weight of particle (weight of particle – weight of displaced fluid) W,
fluid density ρ,
fluid viscosity μ.

Obtain a relationship for v_0 using dimensional analysis. Use both the Rayleigh and Buckingham methods in the **MLT** system of basic dimensions. [5]

Stokes established, from theoretical considerations, that for small particles which settle at very low velocities, the settling velocity is independent of the density of the fluid except in so far as this affects the buoyancy. Show that the settling velocity must then be inversely proportional to the viscosity of the fluid. [3]

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



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

$$\underset{\text{I}}{\begin{pmatrix}\text{Net rate of}\\ \text{heat gain by}\\ \text{conduction}\end{pmatrix}} + \underset{\text{II}}{\begin{pmatrix}\text{rate of}\\ \text{energy}\\ \text{generation}\end{pmatrix}} = \underset{\text{III}}{\begin{pmatrix}\text{rate of}\\ \text{increase of}\\ \text{internal energy}\end{pmatrix}} \qquad [10]$$

Various quantities are important to take in account ie:

c_p = specific capacity of the material, J/(kg. °C)
g = energy generation rate per unit volume, W/m^3
q = conduction heat flux in the x direction, W/m^2
t = time, s
ρ = density of material, kg/m^3
k = Thermal conductivity of material, W/(m. °C)

Give a compact equation and a special case when the thermal conductivity *k* of the material is constant and this equation in rectangular, cylindrical and spherical coordinate systems. [6]

3. (a) What do you understand by the following terms

(i) Mass Transfer and Mass transfer coefficient [2]
(ii) Equimolecular counter diffusion? Give a typical example. [2]
(iii) Fick's first law and equation [2]
(iv) Define the term diffusion coefficient and name three properties on which it is dependant. [2]
(v) Explain why diffusion coefficients of gases are higher than that of liquid and solids. [2]

(b) Derive an expresssion for the mass trafer of a Compent A into Component B involving equal molecular counter diffusion for two points 1 and 2 each have an area S normal to the direction of mass diffusion. Let us assume that we have a steady mass flow.

A component **A** mass balance is gives

$$S N_{Az}|_z - S N_{Az}|_{z+\Delta z} = 0$$

Through a distant Δz applying the Fick's law of diffusion, and with boundary conditions

B. C. 1 : At $z = z_1$, $c_A = c_{A1}$

B. C. 2 : At $z = z_2$, $c_A = c_{A2}$ [5]

Consider two large vessels, each containing uniform mixtures of Nitrogen (A) and carbon dioxide (B) at 1 atm, T = 288.9 K but at different concentrations. Vessel 1 contains 90 mole percent N_2 and 10 mole percent CO_2 whereas Vessel 2 contains 20 mole percent N_2 and 80 percent mole percent CO_2. The two vessels are connected by a duct of d = 0.1524 m inside diameter and L= 1.22 m long. If the mass diffusivity for N_2-CO_2 mixture at 1 atm and 288.9 K can be taken as $D = 0.16 \times 10^{-4}$ m^2/s.

Determine the rate of transfer of Nitrogen and Carbon dioxide between the two vessels by assuming that steady-state transfer takes place in view of the large capacity of the two reservoirs. [5]

4.a) Consider a slab of thickness L, with the boundary surfaces maintained at constant temperatures T_1 and T_2 respectively. There is no energy generation in the solid and the thermal conductivity k is constant.

Develop 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. [5]

(i) Calculate the heat transfer rate through A = 10 m^2 of the slab for $T_{\infty 1} = 160^0C$, $T_{\infty 2} = 50^0C$, $h_1 = 500$ W/(m^2. ^{0}C), $h_2 = 500$ W/(m^2. ^{0}C), L = 8 cm and k = 70 W/(m. ^{0}C).[2]

(ii) 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) [3]

(iii) 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. [3]

5. The inner surface of a hollow sphere are maintained at uniform temperatures T_1 and T_2 respectively at r = a and the outer surface at r = b . The thermal conductivity k of the solid is constant.

a) Derive an expression for the one-dimensional, steady-state temperature distribution T(r) in the sphere. [4]

b) Derive an expression for the radial heat flow rate Q through the hollow sphere. [4]

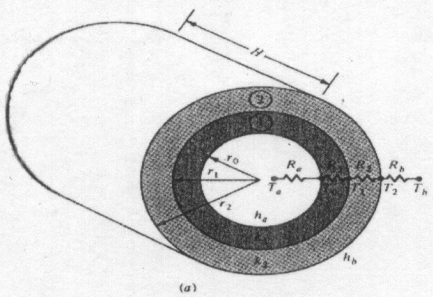
c) Derive an expression for the thermal resistance of the hollow sphere. [4]

d) A hollow sphere of inside radius r = a and outside radius r = b is electrically heated at a constant rate of q_0 W/m^2. At the outer surface, it dissipates heat by convection into a fluid at temperature T_∞ with a heat transfer coefficient h. The thermal conductivity k of the solid is taken to be constant. [4]

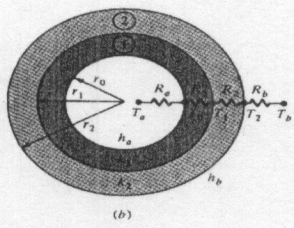
Derive expressions for the determination of the inner and outer surface temperatures T_1 and T_2 of the sphere.

Calculate the inner and outer surface temperatures for a = 3 cm, b = 5 cm, h = 400 W/(m^2· ^{0}C), $T_\infty = 100^0$C, k = 15 W/(m · ^{0}C) and $q_0 = 10^5$ W/m^2. [4]

6. Consider a composite cylinder structure comprising two coaxial layers in perfect thermal contact as shown in Figure (a) below ignore (b)



(a)



(b)

A hot fluid at a temperature T_a flows inside the tube, and heat is transferred to the tube wall with a heat transfer coefficient h_a. Heat transfer takes place on the outside of the tube from its exterior surface to a cold fluid at temperature T_b with a heat transfer coefficient h_b. The total rate of heat

flow Q from the hot fluid to the cold fluid over the length H of the cylindrical structure is the same through each layer.

(i) Derive an expression for the heat Flux on the surface of the cylinder.

(ii) A steel tube with 5-cm ID, 7.6-cm OD and $k_1 = 15$ W/(m·^{0}C) is covered with insulation of thickness t = 2 cm and $k_2 = 0.2$ W/(m·^{0}C). A hot gas at $T_a = 330^0$C, $h_a = 400$ W/(m^2 ·^{0}C) flows inside the tube. The outer surface of the insulation is exposed to cooler air at $T_b = 30^0$C with $h_b = 60$ W/(m^2 ·^{0}C).

(a) Calculate the heat loss from the tube to the air for H = 10 m of tube.

(b) Calculate all the interfacial temperatures.

END OF MET 3449 EXAMINATION.

UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
DEFERRED UNIVERSITY EXAMINATON –DECEMBER 2018

MET 4111 – COMMINUTION AND CLASSIFICATION

ANSWER FIVE QUESTIONS TIME: 3 HOURS

==========

Question 1

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

- Work index
- Sphericity of a particle
- Middlings
- Bulk density
- Angle of nip
- Classification
- Terminal velocity of a particle
- Graded crushing
- Fall diameter
- Comminution

[20%]

Question 2

(a) (i) Describe the crushing action of a jaw crusher with the aid of a clearly labelled diagram. **[5]**

(ii) Why do modern jaw crushers use curved swing-jaw plates? **[1]**

(iii) How could the reduction ratio of a jaw crusher be altered for small adjustments, and for large adjustments? **[2]**

(b) (i) Describe the crushing action of a gyratory crusher with the aid of a clearly labelled diagram. **[5]**

(ii) What do you understand by the set of the gyratory crusher and how could this be adjusted? **[3]**

(iii) Describe the protection mechanisms of jaw crushers and gyratory crushers when an uncrushable material (e.g. tramp metal) enters the crushing cavity. **[4]**

[20%]

Question 3

a. In a conventional closed circuit grinding operation (Figure 1), the cyclone overflow line is instrumented with a magnetic flowmeter and nuclear density gauge, and the mass of dry ore fed to flotation is 20 t/h. The feed from the ore bin is sampled, and is found to contain 7 % moisture. The cyclone feed contains 35 % solids, the cyclone underflow 60 % solids, and the overflow 15 % solids.

Calculate:

(i) The circulating load on the circuit as a percentage of new feed. **[4]**
(ii) The amount of water required to dilute the ball mill discharge. **[5]**

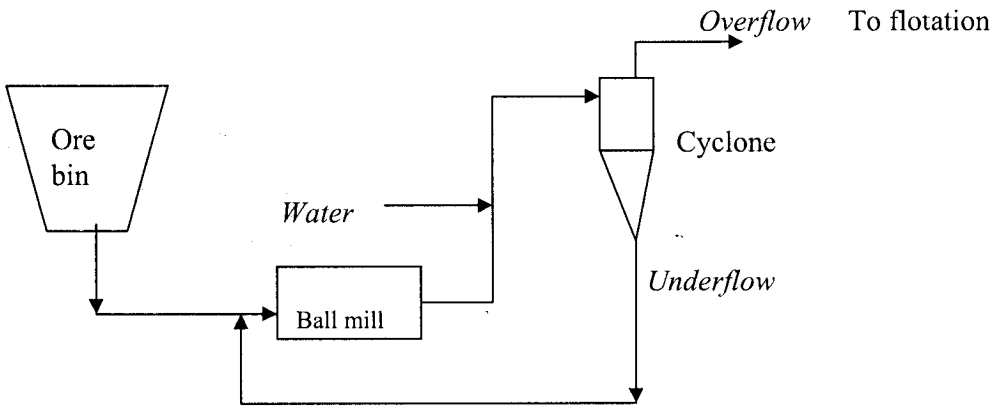


Figure 1: Closed circuit grinding flowsheet

b. Describe with a simple sketch the operation of the Symons standard cone crusher. What is the purpose of the parallel zone and what do you understand by the set of the cone crusher? **[8]**

c. What are the advantages of autogenous mills on suitable ores over conventional circuits? **[3]**

[20%]

Question 4

a. State three factors, which increases the efficiency of screening and three factors, which decreases the efficiency of screening. **[6]**

b. Particles that are nearly the same size as the screen apertures are called "near-mesh" particles. What are the problems caused by such particles and how could this be overcome in a normal plant operation if the plant is sufficiently large? **[3]**

c. Very often the new feed to a crusher is screened to remove the material, which is already sufficiently fine to pass on to the next stage, and only the screen oversize passes through the crusher. State three advantages that this "scalping" of new feed gives. **[3]**

d. Give four reasons why industrial sizing of broken rock may be carried out. **[4]**

e. What do you understand by the 'free settling ratio' of two minerals and what do you understand by their 'hindered settling ratio'? **[4]**

[20 %]

Question 5

a. In a grinding circuit, a SAG mill operates with a 10, 000 hp motor. Typical power draw is 80% of maximum. The 80 percent passing feed size to the mill is 5 inches and the mill discharge has an 80 percent passing size of 2.1 mm. Calculate the Operating Work Index for this mill if the feed tonnage rate is 1200 t/h. **[5]**

b. What are the two major function liners of tumbling mill perform? Give the three main groups into which mill liners can be classified. **[5]**

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

d. 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? **[3]**

e. Describe the grinding action of a ball mill indicating the various zones that can be distinguished. **[4]**

[20 %]

Question 6

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

What are the main design variables and operating parameters of this cyclone? **[8]**

(b) Hydrocyclones have replaced mechanical classifiers in most modern grinding plants. What are the advantages of hydrocyclones over mechanical classifiers? **[2]**

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

(i) Describe the operation of this classifier with the aid of a clearly labelled diagram, showing the various zones that can be distinguished. **[4]**

(ii) What operation controls can be used on this type of classifier and state briefly how these controls influence the separation size in this classifier? **[3]**

(iii) Describe what happens to the separating size when the feed to the classifier is diluted below and beyond the critical dilution. **[3]**

[20%]

[20%]

END OF MET 4111 DEFERRED EXAMINATION
GOOD LUCK!!

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS – NOVEMBER 2018

MET 4122 – CONCENTRATION AND DEWATERING

Answer: Any 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:

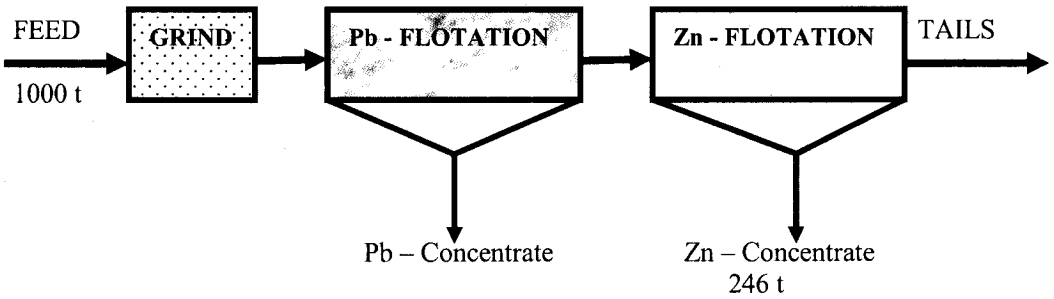
- copper sulphate
- lime
- sodium cyanide
- sodium di-chromate
- sodium iso-propyl xanthate
- tri-ethoxy butane

(i) State briefly what the function would be of each of the above reagents in this flotation process. **[7.5 marks]**

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

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

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



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

Complete the above metallurgical balance for one shift, during which 1000 tonnes of this ore were treated. **[8.5 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 six minutes flotation; **[3 marks]**

(ii) the theoretical concentrate grade of galena and sphalerite (% PbS and % ZnS) after two minutes flotation. [**6 marks]**

(iii) the amount (in grams) of the silicate gangue contained in the concentrate after two minutes of flotation. **[3 marks]**

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

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

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

7.

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

What are the most serious problems associated with the disposal of tailings and how are they minimised? **[5 marks]**

- END OF MET 4122 EXAM –
GOOD LUCK !

THE UNIVERSITY OF ZAMBIA

DEFFERED UNIVERSITY EXAMINATIONS – DECEMBER 2018

MET 4229
HYDROMETALLURGY

TIME : THREE (3) HOURS

INSTRUCTIONS : ANSWER ALL THE QUESTIONS

Question 1

(a) Define Cementation
(b) State five important parameters of cementation.
(c) Explain why the cementation of copper on scrap iron requires a higher than stoichiometric amount of iron.
(d) 160, 000 litres of pregnant solution bound for Zinc electrowinning contains 0.05 g/l cadmium as an impurity.
  (i) Calculate the amount of zinc dust required to cement out the cadmium from solution.
  (ii) If the final zinc concentration after cementation is 130 g/l, calculate how much cadmium is left in solution. The solution temperature is 45°C.

Data:Atomic weights : Zn = 65.4; Cd = 112.4

$Zn^{2+} + 2e^- = Zn$ $E^o = -0.763$ V

$Cd^{2+} + 2e^- = Cd$ $E^o = -0.403$ V (20%)

Question 2

(a) A solution obtained from a typical agitation leaching operation contains 2.51 g/l Cu at a pH of 1.9. Portions of this solution are equilibrated with different volumes of LIX 864 dissolved in a suitable diluent. Data obtained pertaining to these equilibrium experiments is shown in the given table.

Phase ratio V_O/V_A	10/1	5/1	2/1	1/1	1/2	1/5	1/10
g/l Cu in extract	1.42	1.63	2.34	3.15	3.50	3.59	3.69
g/l Cu in raffinate	0.056	0.070	0.18	0.68	1.41	2.08	2.31

(i) Construct an equilibrium extraction isotherm for LIX 864 using the data given. (2%)

(ii) A continuous counter - current operation is to be used for extracting copper from a solution with 2.51 g/l Cu, and it is anticipated that the stripped organic with LIX 864 entering extraction will be completely barren. Answer the following, assuming an organic: aqueous volumetric flowrate ratio of 0.7:

(1) What will be the copper content of the loaded organic? (2%)
(2) Predict the number of stages which will be required for such an operation assuming 100% stage efficiency. (2%)
(3) Explain why the areas of the stages in your McCabe -Thiele diagram are not equal. (6%)

(iii) (b) Discuss four factors that you would consider in order to optimize a leaching plant. (4%)

(iv) Give four most important properties required for each of the following solvent extraction terms: (i) Diluent and (ii) Solvent. (4%)

Question 3

(a) Give reasons why NaCl solution is added to the $CuSO_4$ electrolyte during electro-refining. (4%)

(b) Discuss the effects observed when a high currency density is used during electrowinning and electrorefining processes. (2%)

(c) Discuss three examples of industrial applications of cementation (10%)

(d) Briefly describe two different ways in which the capacity of the resin in ion exchange can be measured. (4%)

Question 4

a) Construct a pourbaix diagram for the nickel-water system at 25°C over the pH range 0 to 11 and indicate the stability regions for the various species. Take the concentration of Ni^{2+} in solution as 10^{-3} mol.dm^{-3}. (5%)

Thermodynamic data

$Ni^{2+} + 2e- = Ni\ (s)$	$E^o = -0.25$ V
$Ni^{2+} + H_2O = NiO\ (s) + 2H^+$	$K = 6.607 * 10^{-13}$
$NiO\ (s) + 2e- + 2H^+ = Ni\ (s) + H_2O$	$E^o = -0.11$ V
$2H^+ + 2e- = H_2$	$E^o = 0$ V
$O_2 + 4H^+ + 4e- = 2H_2O$	$E^o = 1.23$ V

b) Briefly describe five limitations of a pourbaix diagram. (5%)

c) Sketch a simplified block-flow diagram for copper-cobalt production and describe the process in detail. (10%)

Question 5

(a) In a continuous agitation operation 2.25 tonnes of solute-free lixiviant is used for every 1.25 tonnes of slurry. The slurry contains 20% of leachable values, 10% moisture, and the remainder is insoluble material. All leachable values dissolve before the pulp is introduced into the first thickener of a three stage CCD washing unit. For every 1.25 tonnes of slurry leached, three tonnes of fresh wash water is added in the last thickener which yields a disposable residue.

(i) Draw a clearly labelled diagram which would best represent the operation as described above (2%).

(ii) What is the amount of pregnant solution produced for every 1.25 tonnes of slurry leached, assuming an underflow liquid/solid ratio of 2 in each thickener. (3%)

(iii) Assuming an underflow liquid weight ratio of 2 in each thickener and re-pulping efficiency of 100%, compute the percentage of dissolved values recovered into the pregnant solution. (9%)

(iv) Propose possible ways of increasing the dissolved value recovery, stating any drawbacks of your recommendations (6%).

END OF DEFFERED EXAMINATION IN MET 4229

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – NOVEMBER 2018

MET 4249 – FUELS, FURNACES AND REFRACTORIES

TIME: THREE HOURS

ANSWER: ANY FIVE QUESTIONS.

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1. (a) Give a brief description of the following furnaces:
   - (i) Hearth Furnaces [2]
   - (ii) Shaft Furnaces [2]
   - (iii) Converters [2]

   (b) The most important properties of refractory materials generally considered are
   - (i) Refractoriness
   - (ii) Spalling resistance; and
   - (iii) Slag resistance

   Briefly describe the determination of these properties [9]

   (c) Outline the standard route followed in the manufacture of refractories, and show sketches of the firing furnaces used. [5]

2. (a) With the aid of a sketch, describe the important allotropic forms of silica [4]

   (b) Outline four properties of silica [4]

   (c) Draw the SiO_2-Al_2O_3 equilibrium diagram [4]

   (d) Casually made dolomite bricks "perish" and "dust". What is the meaning of these two expressions in this context? And how can "perishing" and "dusting" be minimised in the manufacture of dolomite bricks? [4]

   (e) Give the common applications of dolomite bricks [4]

3. (a) What is a special refractory? Give examples of special refractories and their applications [4]

(b) Distinguish between zircon and zirconia [4]

(c) State the three advantages of slip-casting of refractories. [4]

(d) With the aid of a diagram, describe "pressure sintering" [4]

(f) State the four points used to assess whether insulation can be justified in pyrometallurgy [4]

4. (a) Draw two typical oil burners. [6]

(b) State the factors that determine flame temperature in the combustion of a fuel. [3]

(c) What are the assumptions made in calculating an ideal flame temperature? [3]

(d) Calculate the ideal flame temperature for the combustion of methane by air preheated to 500 degrees C. [8]

The heat of combustion is given by:

$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O;$ $\Delta H = -191\ 800$ cal/mol

Specific heats:

Air	= 0.324 cal/l/°C
CO_2	=0.58 cal/l/°C
H_2O	= 0.46 cal/l/°C
N_2	= 0.36 cal/l/°C

1 mole of gas occupies 22.4 litres at STP

5. (a) State the various classifications of fuels [4]

(b) What are the main chemical components of fossil fuels [1]

(c) Define the calorific value of a fuel [1]

(d) Calculate the net calorific value of a gas mixture containing 50% H_2, 40% CO, 5% CH_4, and 5% N_2. The heats of oxidation are -57 800, -67 623 and -191 800 cal/mol respectively. [6]

(e) Calculate the volume of air required, and the composition of the flue gases when 1 kg of oil is burnt stoichiometrically, where the oil analysis is 86% C and 14% H. [8]

6. (a) The storage procedures for coal are designed for two purposes, what are they? [2]

(b) There are several factors that can contribute to the spontaneous combustion of coal, what are they? [3]

(c) What is meant by carbonisation of coal, and what are its main objectives? [3]

(d) What are the conditions under which coal is carbonised to produce coke? [1]

(e) The carbonisation of coal is done at two different temperature ranges, what are they and which of the two resulting coke components is used in pig iron manufacture? [2]

(f) State the commonly used physical tests of coke. [3]

(g) In the combustion of a solid fuel, draw sketches showing gas analysis and temperature distribution in coke beds of a very un-reactive fuel and a very reactive fuel. [6]

END OF EXAMINATION IN MET 4249

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – NOVEMBER 2018

MET 4319 – PHASE TRANSFORMATIONS

TIME: THREE HOURS

ANSWER: ALL QUESTIONS

Q 1.1

(a) State the Hume-Rothery rules that components A and B must satisfy in order to form a substitutional solid solution.
(b) Why are alloying elements added to plain carbon steel?
(c) Given the Fe-C below state the maximum solubility of carbon in alpha- ferrite and Austenite. Explain the solubility's will either be the same or different.
(d) Mention four different phases observed in Iron-Carbon diagrams and state the characteristics of each phase mentioned.
(e) Describe how martensite is formed? What are the two unique characteristics of martensite formed in ferrous materials?

Question 2

(a) Why does diffusion occur in solids and state some of the factors that can influence it.
(b) Describe the mechanism of interstitial diffusion.
(c) An FCC iron-carbon alloy initially containing 0.20 wt-% C is carburized at an elevated temperature and in an atmosphere that gives a surface carbon concentration constant at 1.0 wt-%. If after 49.5 h the concentration of carbon is 0.35 wt-% at a position 4.0 mm below the surface, determine the temperature at which the treatment was carried out given that: $D_o = 2.3 * 10^{-5}$ m^2/s and $Q_d = 148{,}000$ J/mol for diffusion of C in FCC Fe.

Tabulation of Error Function Values

z	$erf(z)$	z	$erf(z)$	z	$erf(z)$
0	0	0.55	0.5633	1.3	0.9340
0.025	0.0282	0.60	0.6039	1.4	0.9523
0.05	0.0564	0.65	0.6420	1.5	0.9661
0.10	0.1125	0.70	0.6778	1.6	0.9763
0.15	0.1680	0.75	0.7112	1.7	0.9838
0.20	0.2227	0.80	0.7421	1.8	0.9891
0.25	0.2763	0.85	0.7707	1.9	0.9928
0.30	0.3286	0.90	0.7970	2.0	0.9953
0.35	0.3794	0.95	0.8209	2.2	0.9981
0.40	0.4284	1.0	0.8427	2.4	0.9993
0.45	0.4755	1.1	0.8802	2.6	0.9998
0.50	0.5205	1.2	0.9103	2.8	0.9999

(d) Distinguish between homogeneous and heterogeneous nucleation.

Question 3

(a) State equipment often used for observing dislocations in a material stating advantages and disadvantages for using the equipment.

(b) Estimate the number of vacancies in cu at 27°C given that the number of regular lattice sites is $8*10^{22}$ atoms /cm^3 and the energy for vacancy formation of 0.9 eV/atom. ($K_B = 8.62*10^{-5}$ eV/atom-K).

(c) Mention two different dislocation types and describe their mechanisms.

(d) What is required for vacancy motion to occur?

(e) Distinguish between burgers vector and a unit vector?

(f) Distinguish between a glide and climb dislocation motion?

(g) Mention two sources of dislocations.

Question 4

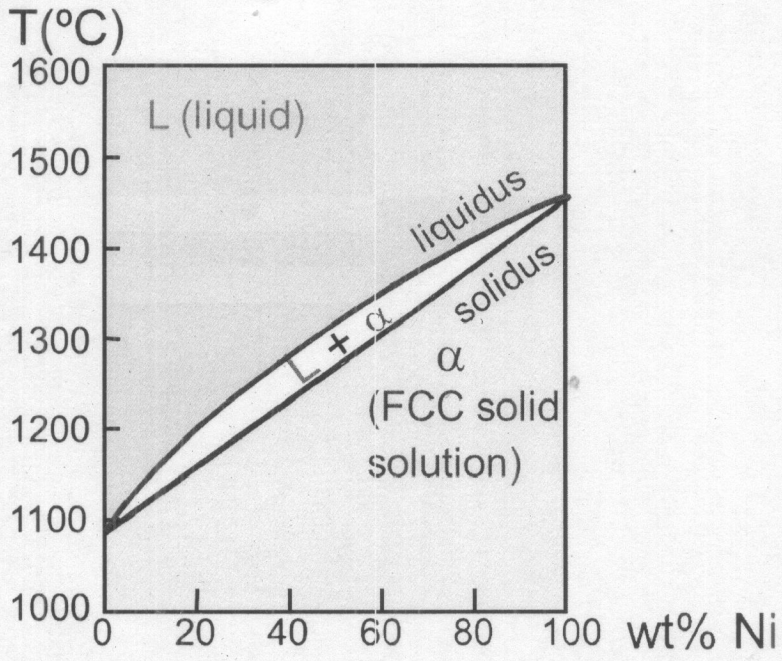
(a) For constant pressure, one form of the phase rule is

P+F = C+1

Where P= number of phases, F= degrees of freedom and C=number of components.

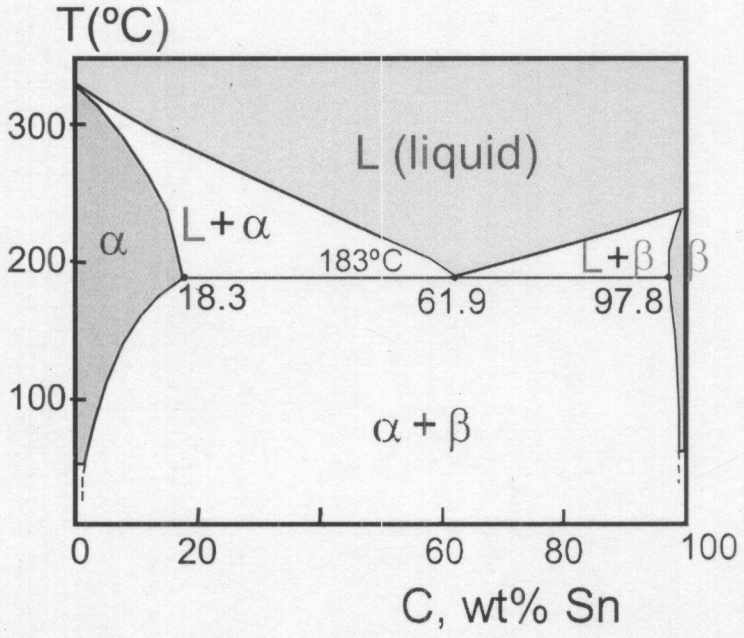
(b) Consider the case of an A-B phase diagram where C=2 and the variables are T. X_A, and X_B. Discuss the significance of the value of F when P is 1, 2 and 3.

(c) Determine the phase present, composition of the phases and phase amounts given an alloy with composition of 35 wt% Ni at 1250°C.



Cu-Ni phase diagram

(c) For a 40wt% Sn-60wt% Pb alloy at 100°C determine (a) the phase present, the phase compositions and relative amount of each phase.



(d) Describe how cooling curves are determined and state what they are used for.

Question 5

The equation for free energy change associated with nucleation is

$$\Delta G = \frac{4}{3}\pi r^3 \Delta G_V + 4\pi r^2 \gamma_{\alpha\beta}$$

(a) For a spherical nucleus, derive the expressions for the critical nucleus size and the energy barrier to nucleation under homogeneous nucleation conditions.

(b) A material has the values ΔG = -10 MJm^{-3} and γ= 0.5 Jm^{-2} for particles of a second phase to form. Calculate the critical particle size for homogenous nucleation and growth of the second phase.

(c) Why is homogenous nucleation such a rare phenomenon?

END OF MET 4319 EXAMINATION

SCHOOL OF MINES
DEPARTMENT OF METALLURGY AND MINERAL PROCESSING
UNIVERSITY EXAMINATION NOVEMBER 2018

MET 4459: PROCESS INSTRUMENTATION AND CONTROL

TIME : THREE HOURS
ANSWER : FIVE questions

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

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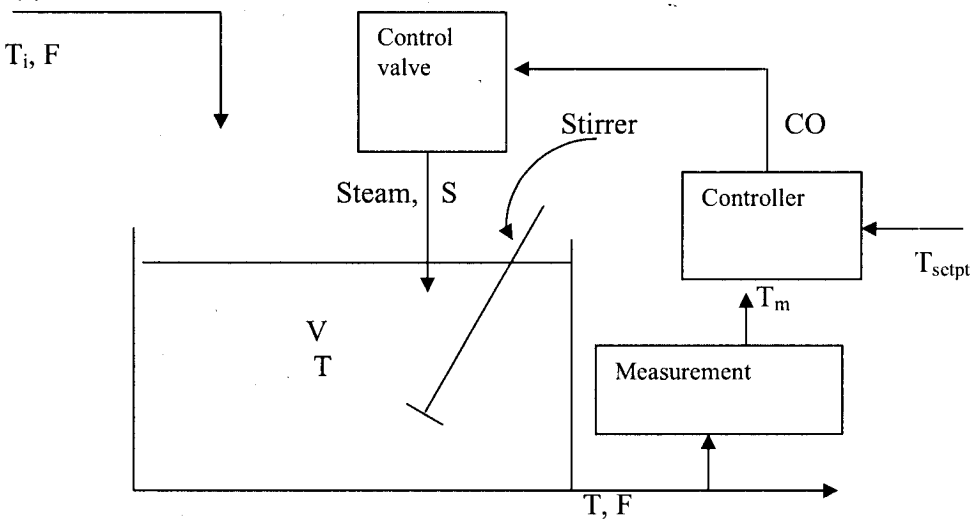
1. (a) What is the job we have to do in process control?

(3 marks)

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

(4 marks)

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



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

(3 marks)

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

(4 marks)

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

(i) $y^2 = C_1(t + C_1)$ **(3 marks)**

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

2. (a) Consider the following dynamic equation:

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

Derive the expression for y(t).

(6 marks)

(b) You are given the following dynamic equation:

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

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

3. (a) What is feedback control? **(4 marks)**

(b) A first-order system is represented by

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

The input changes linearly with time as

$$x(t) = t$$

(i) Determine the time constant τ and the gain K. What is the significance of these variables? **(2 marks)**

(ii) Develop an expression that shows how the output y(t) changes in response to the input above. **(8 marks)**

(iii) Define Z(t) as follows:

$$Z(t) = y(t) - x(t).$$

What is the absolute minimum value and what is the absolute maximum value of Z(t)? At what times do these extremes occur? **(6 marks)**

4. (a) What is a system in process control?

(4 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.

Using the integrating factor method for what follows.

(i) Suppose $C'_{Ao,setpt} = U(t - 100)$ kg/m^3, calculate the value of C'_{Ao} at t = 150 s and t = 200 s.

(10 marks)

(ii) For the parameters given, determine the values of F'_c at t = 150 s and t = 200 s.

(3 marks)

(iii) What is the offset and the corresponding value of $F'_c.(\infty)$.

(3 marks)

5. (a) Describe the major components of a feedback loop.

(5 marks)

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

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

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

6. (a)Briefly describe a Bode plot for a first order system.

(4 marks)

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

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

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

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

(5 marks)

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

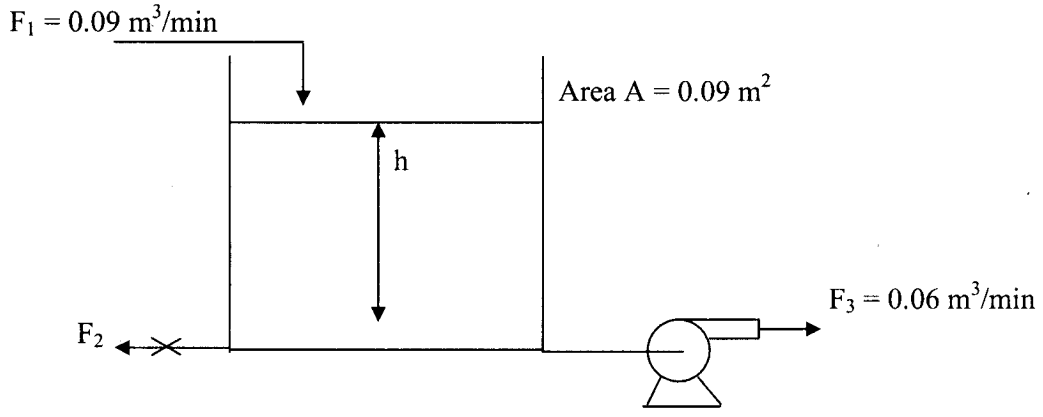
(2 marks)

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

(5 marks)

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

(4 marks)



7. (a) Comment on the stability of a system.

(3 marks)

(b) Given that

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

Determine y(t) at t = 10 or y(10). **(4 marks)**

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

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

(i) Find $T'(t)$ for a unit step change in $T_i'(t)$. **(10marks)**

(ii) What is the ultimate value $T'(\infty)$. Check with the final value theorem. **(3 marks)**

END OF EXAMINATION IN MET 4459

Here is the additional information.

The first-order ODE is as follows:

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

The solution is

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

Table of Laplace Transforms

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

Inversion by partial fractions

METHOD 1

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

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

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

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

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

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

METHOD 2

Suppose x(s) after partial fraction expansion becomes

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

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

The inverse transform arising from the above becomes

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

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – NOVEMBER 2018

MIN 2019 – INTRODUCTION TO MINING

INSTRUCTIONS: **ANSWER ANY FIVE QUESTIONS**

EACH QUESTION CARRIES 20 MARKS

TIME: **3 HOURS** TOTAL MARKS: **100**

Question 1

a) Describe five stages in the life of a mine **[8marks]**
b) Describe the production cycle involved in mine development and exploitation **[6marks]**
c) Differentiate between:
   i. Winze and Raise **[3marks]**
   ii. Mineral Resources and Mineral Reserves **[3marks]**

Question 2

a) Explain five factors that are considered in the determination of mining cut-off grade **[6marks]**
b) Describe factors considered in classification of mining methods **[8marks]**
c) An open pit project has a cylindrical ore body with 110m length and 20m diameter, calculate the stripping ratio if the overburden is cone shaped with 29m diameter and 160m height **[6marks]**

Question 3

a) In rock bolting support system, explain the relationship between the bolt tension and torque [6**marks]**
b) In shaft sinking, describe five advantages of raise boring as compared to conventional shaft mining **[7marks]**
c) In rock drilling, force of 15kN is applied on two circular bits with diameters 0.1m and 0.2m, calculate:
   i. The stresses produced by each bit on the rock **[4marks]**
   ii. Make comments on stresses and penetration rates **[3marks]**

Question 4

a) Explain the difference between a drum winder and a friction winder **[8marks]**

b) With the help of stress/strain curves, explain how wire rope factor of safety in a hoisting system is determined **[6marks]**

c) In a friction winder, slippage occurs in friction-sheave hoist if the ratio of the rope tensions exceeds a theoretical limit, explain:

   i. How the slippage on the friction winder is a function of angle of wrap **[3marks]**

   ii. How coefficient of friction is estimated when calculating the theoretical limit **[3marks]**

Question 5

a) In blast design, explain how spacing and burden affect rock fragmentation **[6marks]**

b) How is the rate of propagation of explosive chemical reaction affect pressure and shock wave distribution? **[6marks]**

c) Given 70 Kilo-bars detonation pressure of emulsion explosive and 230 m/s velocity of detonation:

   i. Calculate density of the explosive **[4marks]**

   ii. With reference to classification of explosives, describe this type of explosive **[4marks]**

Question 6

a) In underground mining, air is supplied to mine working areas by natural and/or artificial ventilation. Explain the principle of artificial ventilation **[5marks]**

b) In an explosive reaction, explain how oxygen balancing affect properties of explosive **[7marks]**

c) Calculate the required bits, rods, coupling sleeves, shank adapters and production in cubic metres given: **[8marks]**

Tunnel length	=	300m
Tunnel area	=	$40m^3$
Depth of round	=	4.6m (with 95% advance)
Number of holes	=	55 holes per round
Average service life:		
45mm button bit	=	300m
Coupling sleeves	=	1,600m
R38 rods	=	1,600m
Shank adapters	=	2,500m

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY NOVEMBER 2018
MIN 3019 - INTRODUCTION TO GEMOLOGY

INSTRUCTIONS: ANSWER ANY 5 QUESTIONS **TOTAL MARKS 100**
TIME: 3 HOURS

QUESTION 1

(i) What do you understand by the term "gemstone material"? **[4 marks]**

(ii) Comment on the following materials:

a) Simulants **[4 marks]**

b) Synthetic gemstones **[4 marks]**

c) Composite stones **[4 marks]**

(iii) Besides ornamental uses and with a help of examples, discuss other uses of gemstone materials. **[4 marks]**

QUESTION 2

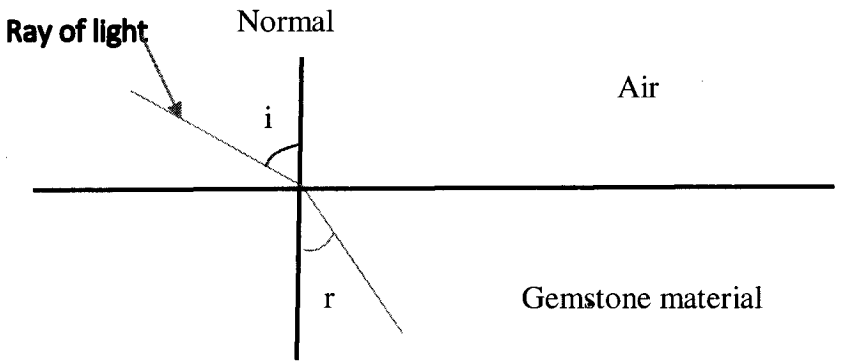
(i) Discuss factors that are considered important in the valuation of both rough and Cut gemstones? **[15 marks]**

(ii) What factors are considered before the rough material undergoes lapidary processing? **[5 marks]**

QUESTION 3

(i) What is refractive index? **[8 marks]**

(ii) Given the diagram below indicating a ray of light entering a gemstone material from air medium at an angle of incidence "i" and refracted at an angle "r". If the angle of incidence is 60^0 and the angle of refraction "r" is 30^0, calculate the refractive index of this gemstone material. **[6 marks]**



(iii) Why is refractive index important? **[6 marks]**

QUESTION 4

Physical properties of gems are important and used in the identification of gemstones. ***Define*** and ***discuss*** the importance of the following properties giving examples.

(i) Cleavage **[5 marks]**
(ii) Hardness **[5 marks]**
(iii) Fracture **[5 marks]**
(iv) Toughness **[5 marks]**

QUESTION 5

Write short notes on the following optical properties of gemstones:

(i) Pleochroism **[4 marks]**
(ii) Birefringence **[4 marks]**
(iii) Isotropic or Anisotropic gemstones **[4 marks]**
(iv) Optical character **[4 marks]**
(v) Dispersion **[4 marks]**

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – NOVEMBER 2018

MIN 3029 – BASIC ROCK MECHANICS

INSTRUCTIONS: **ANSWER QUESTION ONE AND ANY OTHER FIVE. ANSWERS TO BE IN THE ORDER THEY APPEAR IN THE QUESTION PAPER**

TIME: **3 HOURS** TOTAL MARKS: **100**

QUESTION 1

(a) Rock Mechanics is the vehicle of solving mining, civil and geological engineering problems, comment (05 marks)

(b) When attempting to solve mechanical behaviour of rocks it is necessary to assume that the rock possess five properties. Name the properties (05 marks)

(c) Why are not all properties of the rock called "index property"? Name five properties that are known as index property (05 marks)

(d) What is the purpose of measuring sonic velocity? (05 marks)

QUESTION 2

(a) Numerous schemes have been devised to classify rocks; list them. Currently they are three methods which uses six, five and four parameters. Name the methods and write the parameters used (10 marks)

(b) Following the Q system by Barton et al., the Value of a rock mass of Q is equal to 30. What would be the value in terms of RMR? Comment on the rock type. (06 marks)

QUESTION 3

(a) (i) What are known as engineering properties of in-situ rock? (05 marks)

(ii) Describe the method for determining tensile strength of a rock. (05 marks)

(iii) Write the advantages of performing point load test index. How is it calculated, write the formula? (06 marks)

QUESTION 4

(a) Describe with the help of figures the modes of failure of slope in hard rocks. (10 marks)

(b) Why some rocks when they come in contact with water their strength is reduced? How can you verify this property? (06 marks)

QUESTION 5

(a) The Kirsch's solution allows calculations of the influence of joints in a circular opening underground. Using polar coordinates (r and a), write the equations to calculate (i) radial stress, (ii) tangential stress and (iii) sheer stress. (06 marks)

(b)Given the radius (α) of a circular opening of 2.5m at a depth (z) end to 650m, the average density of overburden = 27.7KNm^{-3}. Calculate the value of radial stress (σ_r) and tangential stress (θ) at the crown of the tunnel. Assume Poisson's ratio = 0.25. (10 marks)

QUESTION 6

(a) (i) What is meant by active support and passive support? Explain using neat diagrams (05 marks)

(ii) Write six advantages of using rock bolts over the conventional support system. (05 marks)

(b) If the working load per bolt = 10 tonne, unit weight of the rock to be reinforced = 25KNm^{-3} and height of the rock strata to be reinforced = 4m, calculate the spacing required in both longitudinal and transverse direction. (06 marks)

QUESTION 7

(a) Is it possible to improve the properties of a rock? Describe the ways in which it can be done. (08 marks)

(b) (i) What is meant by continuous and discontinuous subsidence? Write the circumstances in which these are caused (04 marks)

(ii) How can mining induced subsidence be controlled? (04 marks)

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS – NOVEMBER 2018

MIN 3059 – INTRODUCTION TO MINERAL ECONOMICS

INSTRUCTIONS: ANSWER ANY **FIVE (05)** QUESTIONS
TIME : 3 HOURS **TOTAL MARKS:** 100

Question 1

(a) Distinguish between microeconomics and macroeconomics giving examples where possible. **[4 marks]**

(b) What are the effects of macroeconomics on the mineral sector? **[4 marks]**

(c) Explain briefly each of the following terms:

(i) Oligopoly **[3 marks]**
(ii) Marginal cost **[3 marks]**
(iii) Partnership **[3 marks]**
(iv) Co-operatives **[3 marks]**

Question 2

(a) Discuss any Four (04) the objectives of Mineral Taxation in any country. Give examples where possible. **[4 marks]**

(b) Write short notes on each of the following;

(i) Effects of inflation on the economy **[2 marks]**
(ii) Elasticity of Demand **[2 marks]**
(iii) Withholding tax **[2 marks]**
(iv) Causes of the shift in demand curve **[2 marks]**

(c) What are the effects of Ad Valorem and Severances taxes on mineral development? Explain with a help of a diagram. **[8 marks]**

Question 3

(a) Draw a diagram of a perfectly inelastic demand curve. Suggest an example of a good for which demand might be perfectly inelastic. **[3 marks]**

(b) Define the "Law of Supply". **[4 marks]**

(c) Draw the supply and demand curve. **[2 marks]**

From the supply and demand curve drawn in (c), answer the following questions;

(i) Label the equilibrium point as **E1** **[1 mark]**

(ii) Show how the supply curve will change if a mining company achieve a technological breakthrough that allows them to mine ore more cheaply. **[2 marks]**

Question 6

(a) What are the major causes of depreciation of an asset? **[2 marks]**

(b) Discuss briefly the terms "**Book Value**" and "**Salvage value**"? **[4 marks]**

(c) EYB Mining Corporation purchased underground mining equipment at a cost of US$10000 each. From past records, the equipment should have an economic life of 8 years. They can be sold for an average of US$2000 each after 8 years of use. The company currently receives 7% interest on invested funds. Using **Declining-balance method**, determine;

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

END OF EXAMINATION

FORMULA SHEET

Depreciation rate = $1-\left(\frac{S}{P}\right)^{\frac{1}{n}}$

Book value at the end of year N

$$= P\left\{1-\left[1-\left(\frac{S}{P}\right)^{\frac{1}{n}}\right]\right\}^{N}$$

$$= P\left(\frac{S}{P}\right)^{\frac{N}{n}}$$

Annual depreciation Charge =

$$= \text{Book value at } (N-1)x\left(1-\left(\frac{S}{P}\right)^{\frac{1}{n}}\right)$$

Book value at end of year N = $P\left(\frac{S}{P}\right)^{\frac{N}{n}}$

THE UNIVERSITY OF ZAMBIA

UNIVERSITY DEFERRED EXAMINATIONS – DECEMBER 2018

MIN 4015 DRILLING AND BLASTING

INSTRUCTIONS: ANSWER ALL 5 QUESTIONS. TOTAL MARKS: 100

TIME: 3 HOURS

1(a) In rock drilling, there is a perception that if you increase thrust, penetration rate will also increase. Comment on this view. **[2 marks]**

1(b) What are the **three major obstacles** to developing large stopes in mining industry? **[6 marks]**

1(c). In mining industry, accurate drilling is paramount. What are the main
(i) categories of hole deviations **[6 marks]**
(ii) respective sources of hole deviations. **[6 marks]**

2 For the two photos 2.1 and 2.2 shown below, taken from road cuts,

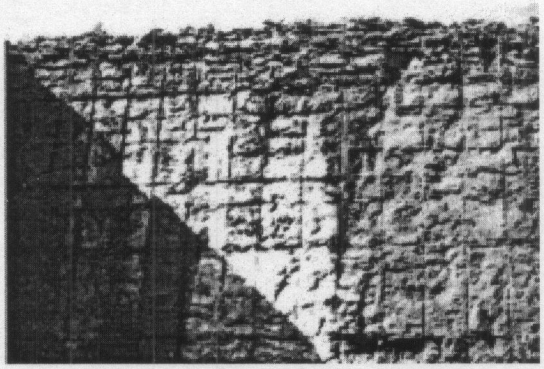


Photo 2.1

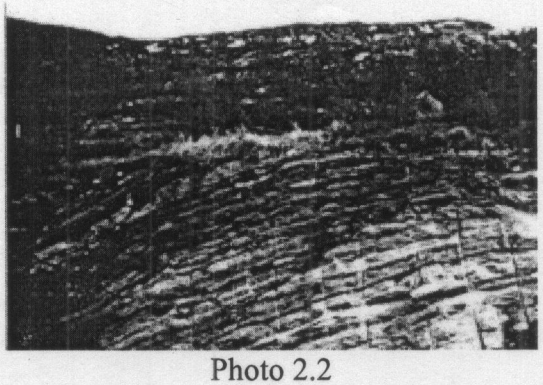


Photo 2.2

2(a) give a short description of the geological structure. **[4 marks]**

2(b) What types of hole deviations do you observe in the photos? **[4 marks]**

2(c) Describe the major economic consequences due to poor drilling in mining stopes for ore production, related to the following:

(i) rock breakage **[2 marks]**
(ii) quality of rock material blasted **[2 marks]**
(iii) transportation **[2 marks]**
(iv) rock stability **[2 marks]**
(v) ventilation **[2 marks]**
(vi) drilling inputs **[2 marks]**

3(a) Explain the effect of increased thrust on

(i) Torque **[2 marks]**
(ii) hole straightness. **[2 marks]**

3(b) Distinguish between particle and sonic velocities. **[6 marks]**

3(c) If we measure the stress in the drill steel for pistons 2 and 3 (Figure 3.1) we get the diagram shown in Figure 3.2.

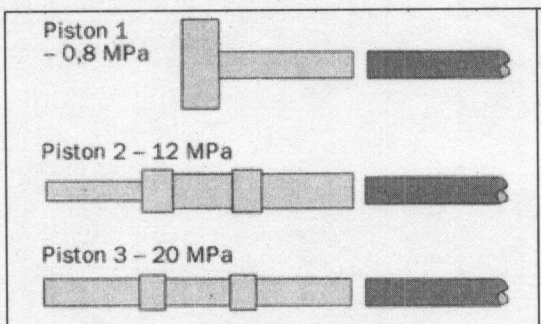


Figure 3.1

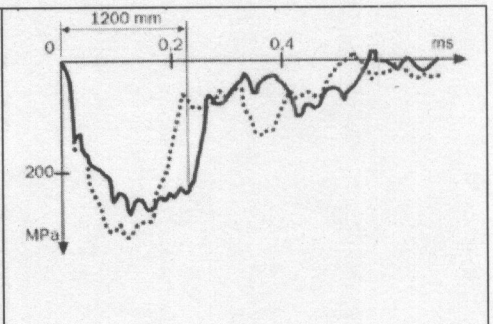


Figure 3.2

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

(i) What energy forms do you expect to be used by Piston 1, and Pistons 2 and 3? **[2 marks]**

(ii) Given that an extension rod with a diameter of 38 mm has a cross-sectional area of about 975 mm^2, ***how much force (in tonnes)*** is produced at 25 kg/mm^2 stress for transmission to the rock via the drill steel and bit? **[8 marks]**

4(a) What is the most commonly used FLUSHING MEDIUM in underground rock drilling for mining? Give reasons why. **[3 Points]**

4(b) Discuss the general influence on percussive and rotary drilling by

(i) Igneous rocks **[4 marks]**

(ii) Sedimentary rocks **[4 marks]**

(iii) Metamorphic rocks **[4 marks]**

4(c) Mention at least five (5) important engineering properties of rock material that have an overall effect on the drilling and the choice of excavation. What can be said about them, in ONE SENTENCE for each of them? **[5 marks]**

5 Mining Eng Company is looking for a specialist to design a bench blast based on the conditions shown in Table 5.1 below.

Table 5.1: Bench blast design conditions

Bench height:	K = 15 m
Width of the round:	w = 26 m
Blasthole diameter:	d = 76 mm
Rock constant	c = 0.4
Hole inclination:	3:1
Explosive:	Emulite 150 in 65 mm plastic hoses dropped into the hole
Charging condition:	Dry holes

Your company, Monks. has just won a bid to design the blast, and has assigned you to perform calculations. With the help of Table 5.2 below and

(a) a CLEARLY LABELED BENCH DIAGRAM, **[3 marks]**

determine the following blast design parameters in the sequence indicated:

(b) **Drilling Pattern**

Maximum burden, Subdrilling, Depth of blasthole, Error in drilling, Practical burden, Practical spacing, Adjustment for the width of the round, and Specific drilling. **[1 mark each, Total 8 marks)]**

(c) **Charges**

Concentration of bottom charge, Height of bottom charge, Weight of bottom charge, Stemming, Concentration of column charge, Length of column charge, Weight of column charge, Total charge, and Specific charge.

[1 mark each, Total 9 marks)]

Table 5.2: Charge concentration for different blasthole diameters and different explosives

Blasthole diameter (mm)	**51**	**64**	**76**	**89**	**102**	**127**	**152**
ANFO, kg/m	1.6	2.6	3.6	5.0	6.5	10.1	14.5
Emulite 150 (cut and dropped into dry Blastholes), kg/m	2.3	3.7	5.0	7.1	9.3	-	-
Bulk emulite, kg/m	2.4	3.9	5.3	7.5	9.9	15.3	21.9
Dynamex M (Charged With pneumatic charging Machine and ROBOT), Kg/m	2.6	4.0	5.6	7.8	10.2	-	-

===== END OF EXAM =====

UNIVERSITY OF ZAMBIA

UNIVERSITY DEFERED EXAMINATION- DECEMBER, 2018

MIN 4045 – UNDERGROUND MINING

INSTRUCTIONS: Answer All Questions. **FULL MARKS:** 100

TIME: 3 hrs

Question 1

Will the help of clear diagrams/table, determine rock blasting parameters based on rock strength in *sublevel open stopping* given the following data: uniaxial compressive strength-100 MPa; Coefficient of hole closure- 1.1; Hole diameter- 105 mm; Charging density β-1.1, Rock uniformity coefficient α-1; Charging coefficient of blast hole δ- 0.85; loading density, U – 6.5 kg/m; Density of ore γ=3.6 t/m^3; thickness of slice being broken B=15 m and is equal to thickness of ore-body; height of sublevel h=25 m. Why is fan layout sometimes associated with poor fragmentation?

[20 Marks]

Question 2

Draw any variant of Vertical Crater Retreat (VCR) and briefly explain the mining method under the following headings:

- Main characteristic features of the method **[5 Marks]**
- KC Livingstone's Method of determining blasting parameters **[5 Marks]**
- Development and Extraction sequence **[10 Marks]**

Question 3

(a) Explain the flow process of ore draw in sublevel caving using ellipsoid of motion and limit ellipsoid concept developed by Kvapil and Janelide. **[10 Marks]**

(b) Briefly describe the effects of the following factors on ore draw control:

- Cave ore mass height **[2 Marks]**
- Granular metric composition of ore **[2 Marks]**
- Angle of repose **[2 Marks]**
- Moisture content and physical properties of rocks **[2 Marks]**
- Width between draw holes **[2 Marks]**

Question 4

a) In what circumstances can sublevel caving method be replaced with cut and fill mining method when mining a given deposit?

[10 Marks]

b) Explain in detail the geo-mechanical basis for classification of mining methods.

[10 Mark]

Question 5

Briefly explain 4 (four) different mining method selection tools and their short comings. What are the short comings of using this method? **[20 Marks]**

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

UNIVERSITY OF ZAMBIA

UNIVERSITY DEFERED EXAMINATIONS - DECEMBER 2018

MIN 4075 – MATERIALS HANDLING

TIME: 3HRS **FULL MARKS: 100**

INSTRUCTIONS: *Answer ALL questions.*

Question 1

With the help of diagrams, explain in detail the components of the shaft plant system under the following headings:

a. Elements of surface plant **[5 Marks]**
b. Mechanical construction and types of hoisting systems **[10 Marks]**
c. Types and Section of hoisting ropes **[10 Marks]**

Question 2

Explain briefly with the help of labelled diagram functions of elements of the shaft station/underground plant associated with materials handling of ore. **[20 Marks]**

Question 3

What factors and job conditions determine the selection and application of the Load Haul Machines (LHDs)?

Question 4

a. The constant failure rates of shovel, dump truck, working face, and dumping place are 0.005 failures per hour, 0.006 failures per hour, 0.007 failures per hour and 0.008 failures per hour, respectively. Calculate the open pit series system mean time to failure (MTTF).

[10 Marks]

b. Assume that a piece of mining equipment is composed of four replaceable subsystems 1, 2, 3, and 4 with constant failure rates $\lambda_1 = 0.0004$ failures/h, $\lambda_2 = 0.0005$ failures/h, $\lambda_3 = 0.0007$ failures/h, and $\lambda_4 = 0.0008$ failures/h, respectively. Corrective maintenance times associated with subsystems 1, 2, 3, and 4 are $T_1 = 2h$, $T_2 = 3h$, $T_3 = 1.5h$, and $T_4 = 0.5h$, respectively. Calculate the mining equipment mean time to repair (MTTR).

[10 Marks]

Question 5

A hoisting consists of the following elements:

Constant time travel	80 sec
Acceleration = retardation time	6 sec
Load = dump time	8 sec
Shift time	7.5 hr
Shift per day	3
Skip capacity	11 tones
Tension of loaded skip	19,000 N
Tension in empty skip	12,500 N

For a balanced hoisting system,

Calculate the expected daily production from the shaft. **[10 Marks]**

Check and comment on rope slippage **[10 Marks]**

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

UNIVERSITY OF ZAMBIA

UNIVERSITY DEFERED EXAMINATION – DECEMBER 2018

MIN 4085 MINE VENTILATION

TIME: 3HRS **FULL MARKS: 100**

INSTRUCTIONS: Answer five (5) questions

Question 1

~~Consider a two mesh network shown in figure 1~~. A differential pressure of 2500 Pa is applied across the circuit and natural ventilating pressure of 500 Pa acts in the direction of air flow within mesh 1. A regulator, $R_{6\ is}$ constructed in the rightmost branch in order to limit the airflow in the branch to $20m^3/s$. Given the resistances of all airways, find the distribution air flow and the resistance of the regulator.

[20 Marks]

Question 2

Explain with the help of simple diagram the following methods used for cleaning contaminated mine air from dust:

a. Thermal Precipitation **[5 Marks]**
b. Electrical precipitation **[5 Marks]**
c. Gravitational method **[5 Marks]**
d. Optical Method **[5 Marks]**

Question 3

a. A 4.88 m diameter service and production shaft is used to down cast 184 m^3/s of fresh air to the underground workings. An altimeter survey indicated that the shaft has a pressure loss of 1.057 kPa from the surface collar to the 1200ml production level. The shaft is equipped with guides and other support structure for skip hosting of the muck. Determine coefficient of friction K and R factors for the shaft.

[10 Marks]

b. A pipe of diameter 2 cm rises through vertical distance of 5 m over the total pipe length of 2000 m. Water of mean temperature 15 ^0C flows up the tube to exit at atmospheric pressure of 100 kPa. If the required flow rate is 1.6 litres per minute, find the resistance of the pipe, the work done against friction and the head of water that must be applied at the pipe entrance. **[10Marks]**

Question 4

Determine the total equivalent resistance, the total (mine) static head and the quantity of

air flowing through each air way, assuming natural splitting in fig 3. Assume the resistance for each airway to be 0.559 Ns^2/m^8 and the total quantity to be 47.19 m^3/s

[20 Marks]

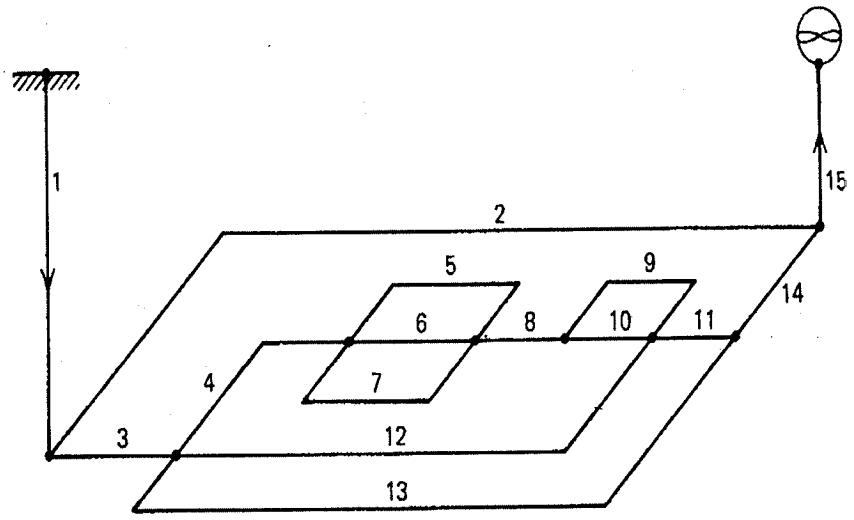


Figure 3. Schematic diagram of Mine ventilation circuits

Question 5

At the top of a mine downcast shaft the barometric pressure is 100 kPa and the air temperature is
18.0 °C. At the shaft bottom, the corresponding measurements are 110 kPa and 27.4 °C Respectively. The airflow measured at the shaft top is 200 m^3/s. If the shaft is dry, determine
(a) The air densities at the shaft top and shaft bottom,
(b) The mass flow of air
(c) The volume flow of air at the shaft bottom

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