

THE UNIVERSITY OF ZAMBIA LIBRARY
FIRST SEMESTER EXAM PAPER 200~~0~~2
SCHOOL OF MINES

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MM 441

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES**

UNIVERSITY FIRST SEMESTER EXAMINATIONS – 2001/2002

GG 201 – INTRODUCTION TO GEOLOGY

PAPER I: THEORY

INSTRUCTIONS: ANSWER ANY FIVE QUESTIONS USING ILLUSTRATIONS WHEREVER POSSIBLE; ALL QUESTIONS CARRY EQUAL MARKS

TIME: 3 HOURS

- Q1. (a) What is the solar system and when was it born? (5 marks).
- (b) Using the nebular theory describe how the solar system formed. (4 marks)
- (c) Briefly describe how our planet evolved into a ³4 layered body and name these layers. (6 marks)
- (d) In 2001, a widely publicised natural phenomenon occurred in Zambia: What is this phenomenon? How does it come about? What is its major threat on human health? (5 marks)
- Q2. (a) Would you consider water and coal as minerals and why? (3 marks)
- (b) What do the following sets of minerals represent? Diamond and graphite and calcite and aragonite. (1 mark)
- (c) Distinguish between ionic and covalent chemical bonds, giving one example of each bond. (5 marks)
- (d) What is a rock? (1 mark)
- (e) What sort of rock do you think developed after the recent eruption of the Nyirogongo Mountain in eastern Congo DR? (1 mark)
- (f) Describe the following: dyke, sill, pegmatite and batholith. (4 marks)
- (g) Discuss the transport and sedimentation conditions that the following sedimentary rocks would represent? Arkose and quartz sandstones. (5 marks).

- Q3. (a) Describe briefly the following sedimentary structures, stating their Importance in geological aspects:
- (i) Cross-bedding (2 marks)
 - (ii) Graded bedding (2 marks)
 - (iii) Ripples (2 marks)
 - (iv) Unconformity (2 marks)
- (b) How does foliation in metamorphic rocks develop? (2 marks)
- (c) Discuss conditions that influence the formation of folds and faults. (4 marks)
- (d) The Rockies and Andes Mountain Ranges on the western sides of North and South America, respectively, and the Mid-Atlantic Oceanic Ridge are global structural features. Describe and discuss how these global structural features *formed*. (6 marks)
- Q4. (a) What is the principle of superposition? (3 marks)
- (b) What is the principle of original horizontality? (3 marks)
- (c) What are fossils and in which 2 important geological aspects are fossils employed? (3 marks)
- (d) Construct a diagram to show the following sequence of geological events:
- (i) sedimentation of a limestone formation;
 - (ii) folding and uplift of the limestone;
 - (iii) erosion of the folded terrain;
 - (iv) subsidence of the terrain and sedimentation of a sandstone formation.
- (5 marks)
- (e) Name 4 main methods employed in dating geological events absolutely. (2 marks).
- (f) What is the basis of the above methods? (2 marks)
- (g) What is half-life? (2 marks)

- Q5. (a) What is a mineral deposit? (2 marks)
- (b) Determine the concentration factors of the following elements: Au, Zn, Sn, Cu. (refer to Table 1) (2 marks)
- (c) Determine the concentration of Cu in the following minerals: chalcopyrite (CuFeS_2) and chalcocite (Cu_2S). Why are the concentrations different? An ore deposit of chalcopyrite, chalcocite and quartz has a grade of 4% Cu. What is the main cause of this difference between grade and the concentration determined above? (refer to Table 1). (6 marks)
- (d) How is coal formed? (5 marks)
- (e) The copper/cobalt mined in Zambia is both a wasting asset and the main stay of the economy. Explain. (5 marks)
- Q6. (a) Mining, particularly open pit as practiced at Maamba Coal Mine, has the following environmental problems associated with it: land degradation, water pollution, air pollution and noise. Briefly describe and discuss each one of these problems in a general manner and how they may be mitigated. (12 marks)
- (b) Lusaka is mostly underlain by marble, which is highly crystalline and yet it holds significant amounts of water and therefore qualifies as an aquifer. Explain. (5 marks)
- (c) There are several industrial uses that marble is mined for. Name 5 such uses and give one reason for each use. (5 marks)

Table 1

Element	Crustal Abundance (ppm)	Average minimum exploitable grade (%)	Atomic weight (atomic mass unit)
Cu	50	0.4	63.546
Fe	50000	30	55.847
S	260	-	32.06
Au	0.004	0.0001	196.967
Zn	70	4	65.38
Sn	2	0.5	118.69

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

UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

SECOND SEMESTER EXAMINATION – 2001/2002

GG 202 – PHYSICAL GEOLOGY

INSTRUCTIONS: ANSWER QUESTION ONE AND ANY OTHER THREE

TIME: 3 HOURS

- Q1. (a) What is porosity and permeability? (4 marks)
(b) If the porosity of a material is 50% and the volume of open spaces is 70 cm^3 . Determine the volume occupied by grains. Show how the determination is done. (5 marks)
(c) What is Darcy's Law? (2 marks)
(d) Two boreholes, A & B, drilled into an unconfined aquifer in the Lusaka dolostone are separated by a horizontal distance of 60 m. The level of water in borehole A lies at an elevation of 1300 m while in borehole B it is at 1230 m. If the conductivity of the water is measured and found to be 21 m/second while the cross-sectional area through which the water is flowing is 60 m^2 . Determine the volume of water flowing and its flow velocity. Remember to show how you arrive at the values. (15 marks)
(e) Suggest how would you determine the time it takes water to flow from borehole A to borehole B. (2 marks)
- Q2. (a) What is mass movement? (2 marks)
(b) What is an angle of repose and how does it vary with water content? (4 marks)
(c) Distinguish creep from slump (4 marks)
(d) How does absorption of water weaken unconsolidated material? (4 marks)
(e) What is talus and how does it form? (4 marks)
(f) Why would you expect that regions near a continental rift valley might have frequent mass movements? (6 marks)
- Q3. (a) What is a stream? (2 marks)
(b) Name and describe 3 ways in which streams carry sediment. (6 marks)
(c) What is stream discharge? (2 marks)
(d) Suppose a stream is 21 m wide and 5.5 m deep. Water in this stream flows at a rate of 6 m/second. Determine the discharge for this stream. (5 marks)
(e) Make brief notes on the following:
(i) Alluvial fan (2 marks)
(ii) Trellis drainage pattern (2 marks)
(iii) Delta (2 marks)
(g) Distinguish between an influent stream and an effluent stream (3 marks)
- Q4. (a) How are valley glaciers different from continental glaciers? (3 marks)
(b) Describe the main mechanisms of glacier flow. (5 marks)

- (c) How do glaciers erode bedrock? (4 marks)
 - (d) Name & describe 3 kinds of glacial sediment (6 marks)
 - (e) The depletion of the ozone layer has caused raised temperatures. If this continues, discuss environmental problems that are likely to result. (6 marks)
- Q5.
- (a) What is the difference between the way wind transports dust & the way it transports sand? (3 marks)
 - (b) What are the main features of wind erosion? (4 marks)
 - (c) Name and describe 3 types of sand dunes showing their relationship to wind direction & availability of sand (6 marks)
 - (d) What is desertification? (1 mark)
 - (e) What is loess and how is formed? (2 marks)
 - (f) Trucks continually have to haul away sand covering a coastal highway. What do you think might be the source of the sand? Could its encroachment be stopped? (6 marks)
 - (g) What evidence might you find in ancient sandstone that would point to its eolian origin? (5 marks)

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

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES**

**UNIVERSITY FIRST SEMESTER
SUPPLEMENTARY/DEFERRED EXAMINATIONS – 2001/2002**

GG 311: CRYSTALLOGRAPHY AND MINERALOGY

THEORY – PAPER I

TIME: THREE HOURS

ANSWER: ANY FIVE QUESTIONS

- Q1. Describe the following terms:
- (i) Unit cell
 - (ii) Space lattice
 - (iii) Bravais lattices
- Q2. (i) What do you understand by the term 'form' in crystallography.
- (ii) Describe the terms used in the definition of forms.
- Q3. (i) What are allochromatic and idiochromatic minerals. Give examples.
- (ii) What are chromophores.
- Q4. In nature, most minerals do not show perfect crystal form and tend to occur in aggregates of many forms. Describe the main types of aggregation.
- Q5. What is pseudomorphism and in what ways does it happen.
- Q6. (i) What is an optical indicatrix.
- (ii) What is birefringence and what type of minerals exhibit it.
-

END OF EXAMINATION – GOO LUCK!

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS – OCTOBER 2002

GG322

STRATIGRAPHY AND REMOTE SENSING

THEORY

PAPER I

TIME: THREE HOURS

**ANSWER: ANY FIVE QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.
USE SKETCHES WHERE POSSIBLE FOR A FULL MARK**

1. Define the following terms:
 - (a) Stratification
 - (b) Geologic Cycle
 - (c) Principle of original horizontality
 - (d) Lithology
 - (e) Biofacies

2.
 - (a) Explain, with aid of diagrams, Walter's Law .
 - (b) Outline the five main categories of fossil remains or evidence of life in the Precambrian.

3.
 - (a) Describe the Characteristics Features of Lithostratigraphic Units.
 - (b) In sequence stratigraphy, list and define the stratal units in descending order.

4.
 - (a) Outline the 5 main activities recognized in early trace fossil studies as responsible for forming most trace fossils
 - (b)
 - (i) What are the differences between Relative and Absolute Ages.
 - (ii) Describe two methods used in Radiometric Dating indicating their limitations

5.
 - (a) The fossils contained in sedimentary rocks are used as tools in Biostratigraphy. Outline five (5) uses of fossils in Biostratigraphy.
 - (b) Differentiate between the following:
 - (i) Transgression and Regression
 - (ii) Bed and Lamina
 - (iii) Map and Fence Diagram

- (iv) Diastem and Hiatus
- (v) Seismic Stratigraphy and Magneto Stratigraphy

6. (a) As a Stratigrapher at the Geological Survey of Zambia, outline your major concerns when carrying out your duties.
- (b) Fill in the missing words (.....) in the Geological Time Scale below.

EON	.....	PERIOD	.....	AGE
.....	CENOZOIC	Quaternary	Recent	
		.....	Pliocene Oligocene Paleocene	
				65 MY
	.....	Cretaceous Triassic		
	PALEOZOIC	..... Pennsylvanian Devonian Ordovician.....		.....
				590 MY

PRECAMBRIAN (....., Archean)

END --- GOOD LUCK

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES**

**UNIVERSITY FIRST SEMESTER SUPPLEMENTARY/DEFERRED
EXAMINATIONS – 2001/2002**

**GG 411: IGNEOUS PETROLOGY
PAPER I – THEORY**

TIME: THREE HOURS

**ANSWER: ILLUSTRATE YOUR ANSWERS WITH FIGURES,
DIAGRAMS ETC. WHEREVER POSSIBLE**

ANSWER QUESTION ONE AND ANY OTHER FOUR QUESTIONS

- Q1. Fig. 1, illustrates the system MgO-SiO₂ at P = 1 atm.
- (a) What is the mineralogy of the rock formed by equilibrium crystallization of liquid 'A'?
 - (b) and in case of fractional crystallization.
- Q2. Define the following terms:
- (a) Congruent melting
 - (b) Eutectic crystallization
 - (c) Incompatible minerals
- Q3. Give a brief account of the followings:-
- (a) Laccolith
 - (b) Ophiolitic complex
 - (c) Asthenosphere
- Q4. What is magmatic differentiation and what are the main differentiation processes?
- Q5. Give three possible explanations for the formation of symplectitic intergrowth and give examples.
- Q6. Explain the difference between hypersolvus and subsolvus granites
- Q7. Summarise the main characteristics of kimberlites and indicate their usual plate tectonic setting.
-

END OF EXAMINATION – GOOD LUCK!

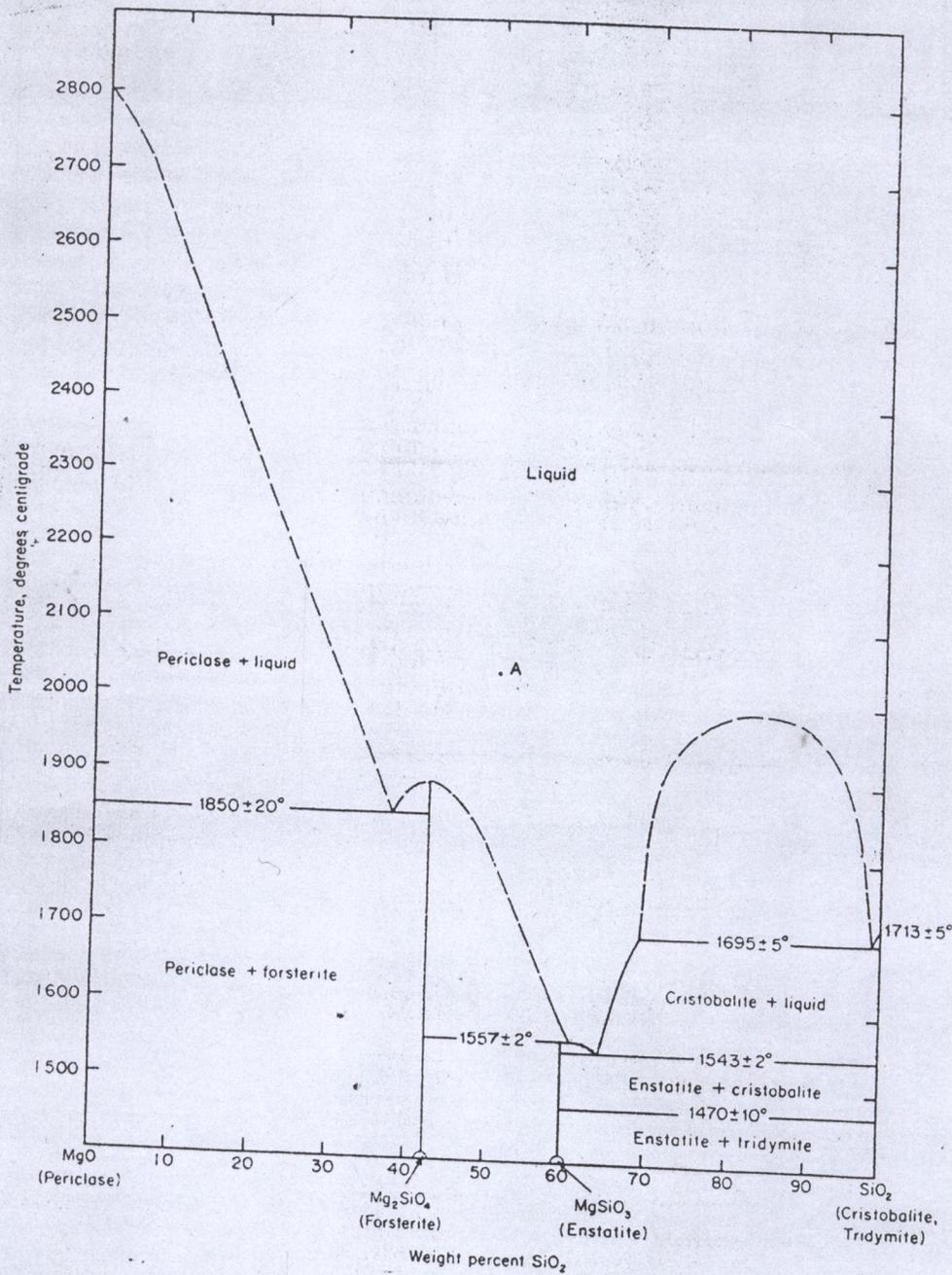


FIGURE 1

UNIVERSITY OF ZAMBIA
UNIVERSITY FIRST SEMESTER EXAMINATION – APRIL 2002
GG421: SEDIMENTOLOGY
(PAPER II – PRACTICAL)

TIME: TWO AND HALF (2 1/2) HOURS
INSTRUCTIONS: ANSWER ALL QUESTIONS. SKETCHES AND DIAGRAMS ARE IMPORTANT FOR A FULL MARK

1. (a) Briefly define the following terms:

- (i) Texture (indicate the 5 grain properties)..... 6 marks
- (ii) Pelagic..... 1 mark
- (iii) Wacke..... 1 mark
- (iv) Peloid..... 1 mark
- (v) Intraclast..... 1 mark

(b) Classify carbonate rocks (limestones and dolomites) using grain size and the Wentworth scale..... 15 marks

(c) What name will you give to a sedimentary rock with the modal grain size of 0.50mm and a composition of framework grains as follows:

Orthoclase	- 10%
Biotite	- 3%
Plagioclase	- 2%
Muscovite	- 4%
Granite fragments	- 15%
Schist fragments	- 5%
Quartz	-61%

(25 marks)

2. A regressive model of a Tidal Flat, Barrier Island / Beach is shown in Fig. 1. Draw a neatly labeled stratigraphic section and explain how such a model (Fig. 1) would have come about. (10 marks)

3. You have been mapping a sedimentary sequence in the Chileleka area and came up with the graphic log below.

You are required to do the following:

- i) Draw a Stratigraphic Section from the completed log (in proper form). (25 marks)
- ii) Interpret the depositional environment of the section in (i). Discuss energy changes, proximity and other environmental factors. (15 marks)

GRAPHIC LOG

Unit No.	Thickness	Upper Contact	Lithology	Primary Sedimentary Structures
1	2m	Erosional Contact between Basement & Unit 1	mudstone, in places with shaly partings	Thinly laminated overlain by massive beds; bioturbated with root traces
2	5m	Gradational	Very fine-to medium-grained sandstone	Horizontal bedding and locally massive
3	7m	Sharp depositional	Coarse-grained to pebbly sandstone	Trough cross-bedding alternating with planar x-beds.
4	8m	Sharp erosional	Matrix supported conglomerates – mainly pebbles	Massive with crude bedding locally horizontal bedding
5	5m	Sharp depositional	Clast-supported conglomerates – mainly cobbles	Complex bed forms with tabular sheets
6	2m	Sharp erosional	mudstone, in places with intraclasts	Massive beds, dessication cracks

END OF EXAM

GOOD LUCK

**UNIVERSITY OF ZAMBIA
GEOLOGY DEPARTMENT**

**GG421 SUPPLEMENTARY EXAMINATION
SEDIMENTOLOGY
JUNE 2002**

PAPER I: THEORY

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER ANY FIVE (5) QUESTIONS. Each question carry equal marks. Well labeled sketches are required for a FULL mark

1. (a) Outline the three general categories of internal sedimentary structures.
(b) List the succession of bed forms that develop during unidirectional flow of sedimentary (0.25 – 0.7mm) in shallow water as flow velocity increases.
(c) What is texture? List the five-grain properties included in texture and define them.

2. (a) Distinguish between the following terms using labeled sketches.
 - i) Glaciolacustrine and glaciomarine
 - ii) Regression and Transgression
 - iii) Oolothconglomerate and paraconglomerate
 - iv) Ooliths (oolids) and peloids
 - v) Matrix and cement in carbonates(c) Draw fully labeled diagrams with explanatory text to explain the following:
 - i) The two major cross-stratification
 - ii) Desiccation cracks and syneresis cracks

3. (a) With an aid of a sketch, classify the sedimentary environments
(b) Outline the processes and deposits associated with Alluvial Fans.
(c) Distinguish between proximal and distal trends on an alluvial fan setting

4. (a) Discuss the braided river system in term of:
 - i) Processes
 - ii) Common elements of the braided model(b) Meandering river system shows in-channel deposits of the "Point Bar" types.
 - i) What is the characteristic feature of an "ideal" point bar sequence?
 - ii) Outline a vertical sequence of an "ideal" point bar.

5. (a) Outline how are lakes created.
(b) Outline the diagnostic features of glacial deposits
(c) Outline the principal beach environments.

- 6 (a) Outline the 4 functions which Facies Models should fulfill.
- (a) List the general features, conditions and processes in ocean basins.
- (b) Reef mounds are common in carbonate platforms. Outline the vertical as well as the lateral zonation of reefs.

END OF EXAMINATION

GOOD LUCK

UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS – 2001/2002

GG 442 – ECONOMIC GEOLOGY OF METALLIFEROUS ORE DEPOSITS

PAPER I: THEORY

INSTRUCTIONS: ANSWER ANY FIVE QUESTIONS USING ILLUSTRATIONS WHEREVER POSSIBLE; ALL QUESTIONS CARRY EQUAL MARKS

TIME: 3 HOURS

- Q1. (a) Name and describe the process that leads to the formation of the chromite deposits.(3 marks)
- (b) Name and distinguish the two forms of chromite deposits giving an example deposit of each type. (12 marks)
- (c) Are these deposits syngenetic or epigenetic and why? (2 marks)
- (d) Name and describe the process that produced the Ni-Cu sulphide deposits.(3 marks)
- Q2. Discuss volcanogenic massive sulphide (VMS) deposits in terms of: tectonic setting, (ii) major host and country rocks, (iii) mode of occurrence, (v) structural control, (iv) main ore and gangue minerals, (v) alteration types, and (vi) possible genesis (20 marks)
- Q3. (a) Describe briefly how the following placer deposits form:
- (i) Residual (2 marks)
- (ii) Eluvial (2 marks)
- (iii) Stream (2 marks)
- (iv) Aeolian (2 marks)
- (b) List six kind of minerals you would expect to be concentrated in the above deposits and why? (3 marks)
- (c) Write brief notes on the following:
- (i) Iron-rich laterites (4.5 marks)
- (ii) Al-laterites (4.5 marks)
- Q4. (a) There are 3 classes of vein deposits. Name and define these 3 classes. (4.5 marks)
- (b) Veins are formed from hydrothermal fluids, which can be derived in three ways. Name and describe these three ways. (4.5 marks)
- (c) In a given area occurs a nearly vertical tabular vein deposit containing mainly pyrite and bornite covered by a 2 m thick humus-bearing soil. This deposit is affected by rain water infiltrating the soil. Name the three

vertical zones and how these zones develop. Discuss how enrichment & what ore minerals would develop from supergene processes, giving typical chemical reactions. (11 marks)

- Q5. (a) What is a skarn and how does it form? (3 marks)
(b) How does an endoskarn differ from an exoskarn? (4 marks)
(c) In what ways does a metamorphic hornfels differ from a skarn? (3 marks)
(d) A skarn associated with the same intrusion and country rocks would be narrow at great depth and wide at shallow depth and it is also evident that shallow-depth skarns form the best grade deposits. Discuss. (8 marks)
(e) Name four of the seven categories of skarn deposits. (2 marks)
- Q6. (a) What are fluid inclusions and what conditions of ore formation can be estimated from fluid inclusions? (4 marks)
(b) Although minerals such as quartz, calcite and fluorite are generally suitable for fluid inclusion studies, they are not useful in estimating formation conditions of skarn deposits, why? (5 marks)
(c) By the way, why are the minerals in (b) generally suitable for fluid inclusion studies? (2 marks)
(d) Define what stable isotopes are and give examples of the three common stable isotopes. (5 marks)
(e) What information in general regarding ore deposits can be derived from stable isotopes? (4 marks)

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

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS – OCTOBER 2002
GG 472
APPLIED GEOCHEMISTRY
PAPER I THEORY

TIME: THREE HOURS

INSTRUCTIONS: Answer one question from each section. All the questions carry equal marks. Use diagrams and equations wherever it is necessary.

SECTION A

1. The chemical composition of water of a river is given in Table 1.

Table 1

Ion	Concentration (moles/kg)
HCO ₃ ⁻	1.90x10 ⁻³
SO ₄ ²⁻	2.65x10 ⁻⁴
Cl ⁻	2.90x10 ⁻⁴
NO ₃ ⁻	4.30x10 ⁻⁵
Ca ²⁺	8.50x10 ⁻⁴
Mg ²⁺	3.70x10 ⁻⁴
Na ⁺	5.17x10 ⁻⁴
K ⁺	4.90x10 ⁻⁵
Fe ²⁺	2.50x10 ⁻⁶
SiO ₂	1.95x10 ⁻⁵
H ⁺	4.60x10 ⁻⁷

Use this data and the thermodynamic data given below to determine the state of saturation of this water with respect to calcite, quartz and microcline.

- $\text{Log} \gamma = A z^2 I^{1/2}$
 $A = 0.5085$
 $K_{\text{sp calcite}} = 10^{-8.35}$

Species	ΔG_f° (Kcal/mole)
Microcline	-892.8
Quartz	-204.75
Calcite	-269.80
Kaolinite	-906.84
K ⁺	-67.7
H ₄ SiO ₄	-312.66
H ₂ O	-56.69
HCO ₃ ⁻	-140.26
CO ₃ ²⁻	-126.17

2. The composition of a basalt and the residual soil derived from it are given below:

	<u>Basalt</u>	<u>Saprolite</u>	<u>gfw</u>
SiO ₂	50.7	35.1	60
Al ₂ O ₃	12.3	26.3	102
CaO	7.83	0.06	56
MgO	4.18	0.26	40
Na ₂ O	2.53	0.02	62
K ₂ O	1.71	0.13	94
Fe ₂ O ₃	15.1	21.5	160
MnO	0.20	0.10	71
TiO ₂	3.19	3.96	80
P ₂ O ₅	0.46	0.11	142
H ₂ O	1.70	12.4	18
Total	100	100	

- a) Calculate the fraction of each component that has been lost from the site of chemical weathering assuming that Al has not been mobilised from the site of chemical weathering.
- b) Arrange the chemical elements given above in increasing order of mobility in this environment.
- c) Discuss briefly the processes that have led to the transformation of the basalt into saprolite.

SECTION B

3. a) Construct an Eh-pH diagram for the system Pu-O-H at STP. Assume that the activities for dissolved species of Pu = 10^{-8} moles/kg.

<u>Species</u>	<u>ΔG_f° (kcal/mole)</u>
Pu ³⁺ (aq)	-138.15
PuO ₂ (c)	-238.53
PuO ₂ ⁺ (aq)	-203.10
H ₂ O (liq)	-56.69
H ⁻ (aq)	0
H ⁺ (aq)	0
H ₂ (g)	0
O ₂ (g)	0
OH ⁻ (aq)	-37.59

- b) Compare your diagram with figure 1 below and discuss how moisture and Eh-pH conditions in the geochemical environment may affect its ability to mobilize or immobilize Plutonium.
 - c) Use the Eh-pH diagrams to Assess the suitability of the sites in the following environments for the disposal of Pu-rich nuclear waste material.
 - i) Sandstone aquifer in the hot-dry desert.
 - ii) Dolomite aquifer in the tropical region.
 - iii) Granitic rock unit of very low porosity and permeability.
4. Discuss briefly the role of surficial processes in the formation of the following types of mineral deposits:
 - a) Supergene enrichment deposits of Cu.
 - b) Evaporite deposits
 - c) Bauxite deposits

SECTION C

- 5 a) Discuss the principle behind using vegetation in geochemical exploration.
 - b) Discuss the limitations of using these methods in exploration for minerals.
 - c) Give some examples of successes where vegetation surveys have been used.
- 6 a) Discuss briefly the three major environmental problems that are associated with copper mining in the Zambian Copperbelt.
 - b) What is Acid Mine Drainage?
 - c) Describe the major reactions that are involved in the development of Acid Mine Drainage.
 - d) Discuss briefly the potential for development of acid mine drainage and its neutralization at the following mines: 1) Nampundwe Mine in Lusaka, 2) Kabwe Pb-Zn Mine, 3) Maamba Coal Mine and 4) Mufulira Copper Mine.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS – OCTOBER 2002
GG 472
APPLIED GEOCHEMISTRY

PAPER II PRACTICAL

TIME: THREE HOURS

INSTRUCTIONS: Answer all the questions.

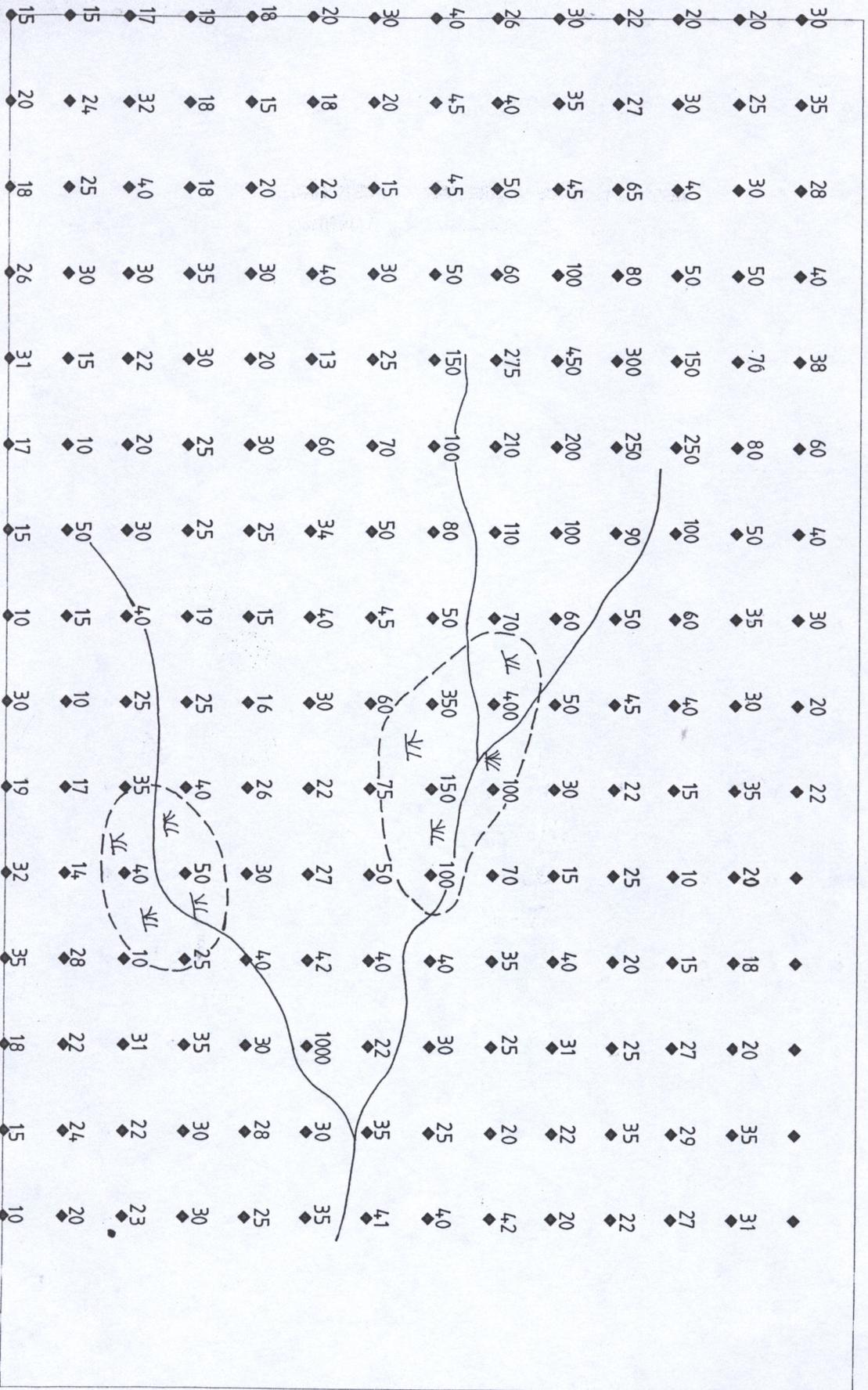
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1. In a detailed survey for Pb deposits that are associated with Zn mineralisation the data given in figure 1 was acquired.
- Use an appropriate statistical technique to split the data set into the appropriate number of sub-populations.
 - Contour the data and delineate anomalous areas.
 - Propose and mark the most appropriate sites for further investigations.
 - Discuss briefly how the major types of dispersion patterns in figure 1 have been formed.
 - Explain how the distribution pattern of Pb would differ from that of Zn.
(70%)
2. The chemical composition of the three mine waters are given in the table below. Use this data to Assess the suitability of these waters for human consumption.

Parameter	Mine water A	Mine Water B	Mine Water C
PH	4.0	7.8	2.2
Zn	10	0.3	10000
Cu	0.04	.001	13
Cd	0.04	.01	22.5
Fe	1.5	0.6	15000
Pb	0.005	0.001	0.8
Sulphate	100	50	60000
Nitrate	13	7	78
TDS	3000	600	1200000

NOTE: The units for the concentration of all the parameters are mg/l except for pH.
(30 %)

END OF EXAMINATION

Figure 1. The Distribution of Zinc (ppm) in A Soil Block



100m
Scale

 Dambo

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
SECOND SEMESTER EXAMINATIONS 2001/2002**

GG 542 ECONOMIC GEOLOGY OF NON-METALLIC MINERAL DEPOSITS

PAPER 1 - THEORY

TIME: Three hours
INSTRUCTIONS: Answer any five questions

1. Describe the main stages in the development of an industrial minerals operation outlining the expected result of each stage
2. Describe the dry process of cement manufacture
3. Many grinding and polishing operations in industry consume a considerable amount of abrasives.
 - (i) Outline the properties of such abrasives
 - (ii) Describe the geological occurrence of two of the most commonly used industrial abrasives
4.
 - (i) What are constructional materials and what have all these materials in common
 - (ii) Outline the main economic constraints and social aspects related to working these materials
5. Outline the properties of road aggregate that Shmizu Construction Company should be using in constructing the Great East Road in Lusaka for
 - (a) Sub-base
 - (b) Road base
 - (c) Wearing course
6. Discuss technological characteristics, which define the quality of non-metallic minerals.

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES**

UNIVERSITY FIRST SEMESTER EXAMINATIONS – 2001-2002

GG 551: EXPLORATION, MINING GEOLOGY AND MANAGEMENT

PRACTICAL – PAPER II

TIME: TWO HOURS

ANSWER: ALL QUESTIONS

1. Describe the characteristics of the igneous and metamorphic ore habitat models in exploration.
2. Discuss factors on which successful mineral exploration depends.
3. (a) Outline three types of ore reserves
(b) You are Shaft II Geologist at Konkola Mine and involved in the re-calculations of ore reserves. Grades for copper (Cu) and cobalt (Co) for one of your boreholes at cut-off grades of 0.80% for Cu and 0.10% for Co are given in the table below. Calculate the average Total Cu and Co for this Borehole.

BH – 1: Cross-cut 3, Level 800m, Shaft II, Konkola Mine																				
Total Cu	0.5 /	0.9 /	2.0 /	2.3 /	1.5 /	6.0 /	4.6 /	5.3 /	4.5 /	3.3 /	4.3 /	1.2 /	4.7 /	6.2 /	3.2 /	2.3	0.67 /	1.0 /	2.1 /	0.7 /
/Co	0.08	0.09	0.3	0.4	0.6	1.0	2.4	0.9	2.0	1.2	1.3	0.5	0.8	2.3	0.9	/0.3	0.08	0.1	0.09	0.09
Depth (m)	0.20	0.30	0.25	0.35	0.20	0.15	0.30	0.25	0.35	0.15	0.25	0.30	0.25	0.10	0.30	0.25	0.15	0.30	0.15	0.20

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

**2001/2002 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS**

**MM 205: INTRODUCTION TO METALLURGY II
(PRACTICAL)**

TIME: THREE HOURS
ANSWER ALL QUESTIONS

- 1 Describe the rock specimens A, B, C, D and E in terms of:
 - (i) Colour
 - (ii) Mineralogical composition
 - (iii) Texture
 - (iv) Structure
 - (v) Type
 - (vi) Name

- 2 Describe the major properties of mineral specimens F, G, H, I and J.
Name the specimens and indicate their mineral class.

- 3 Draw a sketch of every crystal model given K, L, M and N. Indicate how many axes of symmetry they have and to what crystal class they belong.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

2001/2002 ACADEMIC YEAR SECOND SEMESTER

FINAL EXAMINATIONS

MM 332: CHEMICAL THERMODYNAMICS II.

TIME : THREE HOURS

INSTRUCTIONS: QUESTION ONE AND ANY OTHER FOUR. ALL QUESTIONS CARRY EQUAL MARKS

1. 1. The Henrian activity coefficient γ_{Al}^0 for Aluminium in liquid iron-Aluminium alloys is reported to be 0.063 at 1600°C. Calculate the standard free energy of formation of Al_2O_3 at 1600° C for each of the following four standard states for A:

- a) $2Al(l, \text{pure}) + 3/2O_2(g) = Al_2O_3(s)$
- b) $2Al(l, h) + 3/2O_2(g) = Al_2O_3(s)$
- c) $2Al(l, wt) + 3/2O_2(g) = Al_2O_3(s)$
- d) $2Al(l, at) + 3/2O_2(g) = Al_2O_3(s)$

$$\Delta G^0 = -1,682,927 + 323.239T \text{ J/mol.}$$

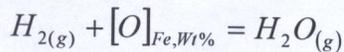
Molecular weights of Aluminium and Iron are 26.98 and 55.85 respectively.

2. (a) Derive the expression for the depression of the freezing point of a Solvent A due to the addition of a small amount of non-volatile solute B.
- (b) A 1-litre flask contains hydrogen at 27°C and 1 atmosphere. The flask is connected to another flask having a volume of 2 litres and containing oxygen at 27°C and 0.6 atmosphere. The gases diffuse into each under isothermal conditions. Calculate the partial pressure of both hydrogen and oxygen at this temperature.
3. (a) Liquids A and B form ideal solutions. They are isomeric. A solution of composition N_A is found to have a vapour pressure of 650mm Hg at 50°C. It is then distilled until half has been collected as condensate. The condensate has a composition $N_A^C = 0.60$ and the residual liquid a composition of $N_A^L = 0.40$ and vapour pressure of 600 mm Hg at 50°C. Calculate N_B , P_A^0 and P_B^0 .
- (b) A solute, B obeys the following relation in a dilute binary solution of a solvent A and solute B :

$$f_B = kN_B^{\frac{3}{2}}$$

Where N_B is the mole fraction of the solute. Derive the expression for the fugacity of the solvent f_A .

4. An iron-chromium alloy is brought to equilibrium with a $H_2 - H_2O$ mixture in which $\frac{P_{H_2O}}{P_{H_2}} = 0.00353$, in a pure Alumina crucible at $1700^\circ C$. The equilibrium is represented by:



The alloy at equilibrium contains Cr: 1.90%, Al: 0.031% and O: 0.0032% by weight. The values of the various interaction parameters are:

$$\varepsilon_o^o = 0 \quad \varepsilon_o^{Cr} = -0.058 \quad \varepsilon_o^{Al} = -3.15$$

Calculate the free energy change of the above reaction at $1700^\circ C$.

5. Myles investigated the vapour pressure of solid silver and solid silver-palladium alloys in the temperature range $1092 - 1221^\circ K$. The vapour pressure in (mm Hg) were expressed as function of temperature as follows for pure solid silver

$$\log P = \frac{-13,696}{T} + 8.727$$

For solid Ag - Pd alloy $N_{Ag} = 0.802$

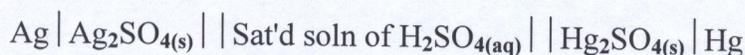
$$\log P = \frac{-13,795}{T} + 8.649$$

- Calculate the fugacity of silver in pure state and in the alloy at temperature $1200^\circ K$.
 - Calculate the activity and activity coefficient of silver in the Ag - Pd solid solution at $1200^\circ K$.
6. 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.

7. The voltage of the cell is given as follows:



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

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

Does the cell absorb or emit heat as cell reaction proceeds?

Gas constant $R = 8.314 \text{ J/K/mol}$, Faraday's constant $96487 \text{ C/g- equivalent}$
 $= 0.08206 \text{ liter.atm/g.moles. K}$

1 Atmosphere = 760 mm Hg
 $= 101325 \text{ N/m}^2, \text{ Pa}$

END OF MM 332 EXAMINATION, GOOD LUCK.

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

**2001/2002 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS**

MM 412: MINERAL PROCESSING II

TIME: THREE HOURS

ANSWER QUESTION 1 AND ANY OTHER FOUR, BUT KEEP YOUR ANSWERS BRIEF AND TO THE POINT. RELATIVE WEIGHT OF EACH QUESTION INDICATED IN BRACKETS

Question 1

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

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

[20 %]

Question 2

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

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

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

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

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

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

Explain your flowsheet in a few words.

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

[20 %]

Question 3

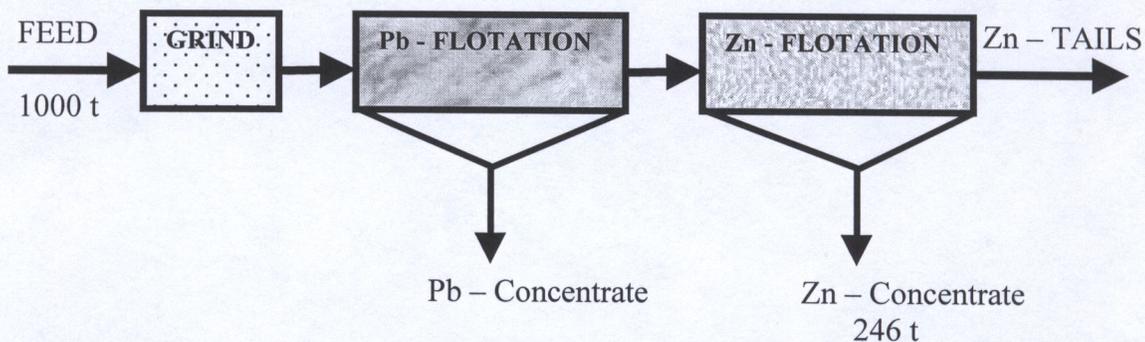
- (a) Describe the operation of a column flotation cell with the aid of a clearly labelled diagram indicating the various zones that can be distinguished.

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

- collectors
- frothers
- modifiers

- (c) Make a working diagram of a Denver DR flotation cell. Indicate the direction of the pulp flow and the froth zone in your diagram.

- (d) 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.

[20 %]

Question 4

- (a) Briefly state the differences between diamagnetic, paramagnetic and ferromagnetic substances.
- (b) What factors limit in practice the intensity of the applied magnetic field?
- (c) Because of these limitations, what else is done in industrial practice to obtain a high magnetic force on the particles to be separated?
- (d) Make a working diagram of a three-stage induced-roll magnetic separator in operation and briefly explain how such equipment functions.
- (e) In industrial concentration of minerals by magnetic separation, flocculation, or agglomeration of particles occur, which entrain gangue and bridge the gaps between the poles. How can this flocculation and entrainment of gangue be minimised and if possible prevented?
- (f) Explain briefly what you understand by high-tension separation with the help of a sketch. What sorts of particles are found in the non-conducting and conducting products?

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

[20 %]

Question 5

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

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

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

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

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

Outline the advantages and disadvantages of this method.

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

[20 %]

Question 6

- (a) Briefly describe the steps, necessary for the attachment and adhesion of solid particles to air bubbles in a mineral pulp.
- (b) Describe the concepts of a 'disjoining pressure', of a 'critical film thickness' and of an 'induction time' in flotation.
- (c) What is the effect of the adsorption of a suitable collector upon the critical film thickness and the induction time?
- (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:

- the theoretically possible recoveries of gn and of sl after two minutes flotation and after six minutes flotation;
- the theoretical concentrate grade (% PbS and % ZnS) after two minutes flotation and after six minutes flotation.

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 gn and sl to be floatable under the conditions chosen.

[20 %]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

2001/2002 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS

MM422: PHYSICAL METALLURGY II

TIME: THREE HOURS

INSTRUCTIONS: ANSWER ALL THE QUESTIONS

- (a) Explain the following terms:
- Bragg's law
 - Structure factor
 - Reciprocal lattice
 - Weiss Zone Law
- (b) In the powder photograph of copper (f.c.c.), a {420} reflection was found but a {210} reflection was not. These observations are due to what are known as "systematic absences." For f.c.c. materials, the only reflections allowed are for h, k, and l all even or all odd. With the aid of a <001> projection of the f.c.c. unit cell, show why the {420} reflection would be present and the {210} reflection absent.
- (a) What is the Pilling-Bedworth rule?
- (b) Describe the anodic protection of materials against corrosion.
- (c) With the aid of appropriate sketches, describe how you would use polarization diagrams to determine the effectiveness of corrosion inhibitors.
- (d) At 25°C, $E_{\text{Fe}/\text{Fe}^{2+}} = -0.44\text{V}$ and $E_{\text{Al}/\text{Al}^{3+}} = -1.67\text{V}$. If you were trying to make a choice between steel and aluminium based on the best corrosion resistance, which would you intuitively choose? Is the choice consistent with the E values above? If not, explain the discrepancy.
- (a) What is the phenomenon on which almost all strengthening mechanisms of materials are based?
- (b) Single crystals are very much weaker than they theoretically should be, because dislocations can operate to produce slip at low values of resolved shear stress. In what way can the presence of grain boundaries in polycrystals lead to higher yield strengths than those of single crystals?
- (c) For each of the materials given below, list those strengthening mechanisms that measurably contribute to the strength of the material in its stated form.
- Pure aluminium sheet, rolled from 0.6 cm to 0.3 cm in thickness.
 - 70%Cu-30%Zn polycrystal.
 - 4.5%Cu-95.5%Al, water-quenched from single phase region and held for 1 hour at 204°C.
 - A very large steel component requiring a hard wear-resistant surface.

Question 6

- (a) Briefly describe the steps, necessary for the attachment and adhesion of solid particles to air bubbles in a mineral pulp.
- (b) Describe the concepts of a 'disjoining pressure', of a 'critical film thickness' and of an 'induction time' in flotation.
- (c) What is the effect of the adsorption of a suitable collector upon the critical film thickness and the induction time?
- (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:

- the theoretically possible recoveries of gn and of sl after two minutes flotation and after six minutes flotation;
- the theoretical concentrate grade (% PbS and % ZnS) after two minutes flotation and after six minutes flotation.

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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 gn and sl to be floatable under the conditions chosen.

[20 %]

END OF EXAMINATION

4. (a) Distinguish between hardness and hardenability.
- (b) Is it possible for two steels to have the same hardenability but different hardnesses? Explain ver-
briefly.
- (c) Figure 1a is the Fe-rich end of the Fe-Fe₃C phase diagram. Figure 1b is a time-temperature transformation (TTT) curve for an Fe-1wt.%Mn - 0.8 wt.% Cr - 1.8 wt.%Ni - 0.6 wt.%C steel. Consider the "C curves" in Figure 1b in the range of about 745 to 535°C. The three curves (going from left to right) indicate:
- 1% transformation to proeutectoid ferrite
 - 1% transformation to pearlite
 - 100% transformation
- Consider an alloy which is isothermally transformed at just above 540°C. At this temperature, the curves (i) and (ii) are coincident i.e. the austenite transforms to 100% pearlite. Conversely, at a temperature of say 660°C the austenite transforms to proeutectoid ferrite and pearlite. Explain detail the above observations.

5. (a) What is the ductile-brittle transition?
- (b) Justify why steels with low ductile-brittle transition temperatures should be the most expensive.
- (c) Write a short account of the need to consider fatigue in engineering design.
- (d) In a steel plate 30 cm wide and 0.64 cm thick, there is a 2.5 cm long crack along the edge (E = 2 x 10¹¹ Pa and G_c = 35000 N/m).
- Calculate the force required to propagate the crack the remaining 27.5 cm across the width of the plate.

$$\sigma_f = \sqrt{\frac{2E\gamma}{\pi c}}$$

- Calculate the force required to break the plate in simple tension if there were no crack. Assume that the fracture strength is 689 MPa.

END OF EXAMINATION

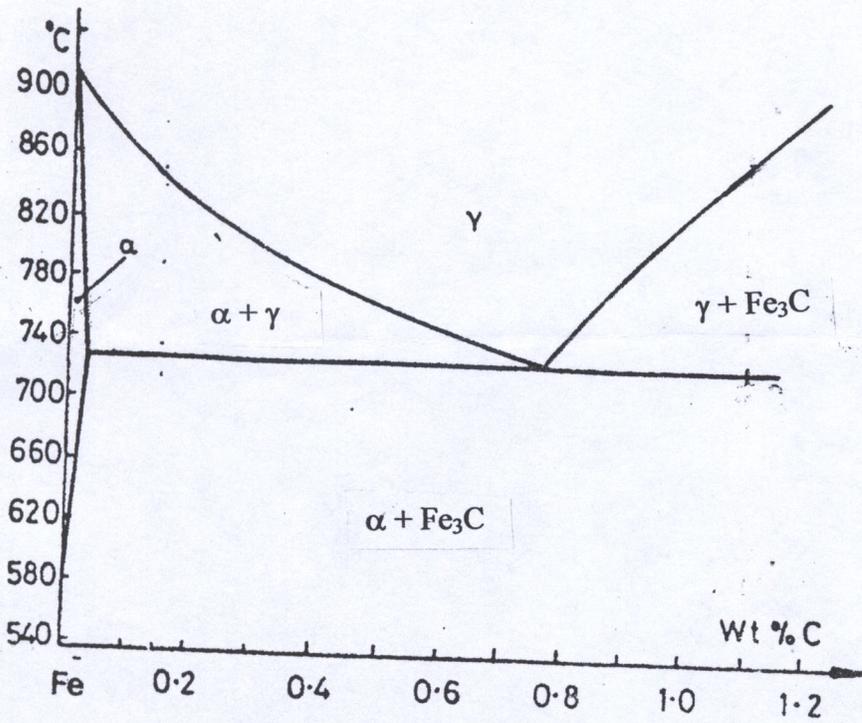


Figure 1a

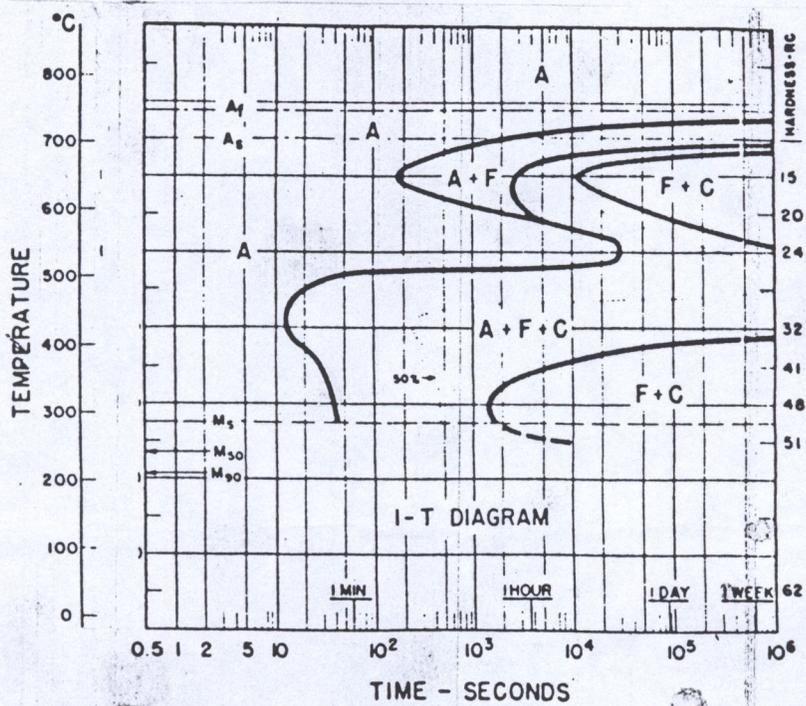


Figure 1b

UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

2001/2002 ACADEMIC YEAR SECOND SEMESTER

FINAL EXAMINATIONS

MM 552: PROCESS DESIGN

TIME : THREE HOURS

INSTRUCTIONS: ANSWER ANY FIVE QUESTIONS

All additional data that the student will require are attached.

1. (a) Show how the following set of equations may be partitioned and indicate the order of solution:

$$\begin{aligned}f_1(x_1, x_2, x_3) &= 0 \\f_2(x_1) &= 0 \\f_3(x_3) &= 0 \\f_4(x_3, x_4) &= 0\end{aligned}$$

(b) You are working in a laboratory and are requested to melt 200 kg of stainless steel, AISI Type 304, with an analysis of 17.5% Cr, 8.5% Ni and 0.5% Mn. Assuming no losses during the melting, compute the charge that you would use for the following available materials:

% :	Cr	Ni	Fe	Mn
alloy scrap	68	20	10	2
ferrochromium	75		25	
electro Ni		100		
electro Fe			100	

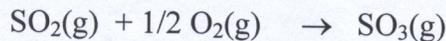
2. (a) The phase rule for ordinary systems is given as $f = C - P + 2$. Suppose that the equilibrium between phases of a single-component metallic system is affected by the applied magnetic field in addition to the temperature and pressure. Determine the maximum number of phases that can co-exist.

(b) A reduction process requires a feed of C, O₂ and MO. This feed produces liquid M and a gas phase containing CO and CO₂. For thermodynamic reasons, the ratio of CO and CO₂ in the product is desired to be K. The mass of MO fed (F kg) to the system and the mass of CO (β kg) in the output gas are given. Set up the equations that must be solved to find the mass of C (W_C), the mass of O₂

(W_{O_2}) and the mass of CO_2 (W_{CO_2}) in the input and output streams. Precedence-order the set of equations to find a sequence that will result in the solution of the set.

Atomic masses: C,12; O,16; M,65.

3. (a) A gas mixture containing 25% H_2 and 75% CH_4 is being heated from 473 K to 673 K at 101.3 kPa pressure. Calculate the total amount of heat needed per kmol of the mixture.
- (b) The gas SO_2 is oxidised at 101.32 kPa in a catalytic converter to SO_3 using 150% excess air. The reaction is



Only 75% conversion to SO_3 is obtained. The SO_2 and the air enter at 573 K and the exit gas mixture leaves at 673 K. There is a heat exchanger in the converter which removes heat. How many kJ are absorbed by the exchanger for 1 kmol SO_2 added? The ΔH_c^0 for the reaction as written is -98.11×10^3 kJ/kmol at 298 K and the mean heat capacity of SO_3 is 63.68 kJ/(kmol)(K).

4. (a) Briefly describe two different contexts in which depreciation may be considered.
- (b) Derive the formula for the present worth of an ordinary annuity, P, where R is the amount due for every period and i is the interest rate for a period of n years.
- (c) You are given the following data for two investments:

Investment number	Total initial fixed capital investment in K1,000,000	Working capital investment in K1,000,000	Annual cash flow to project after taxes in K1,000,000	Life of project in years
1	170	10	52	7
2	210	15	59	8

- (i) In each case, calculate the net present worth at an interest rate of 15%.
- (ii) Verify that the discounted-cash-flow rate of return for investment no 1 is 22%.
5. Hot water is to be heated with hot exhaust gas. The exhaust gas enters the exchanger at 523 K and leaves at 383 K. The cold water enters at 298 K and leaves at 373 K with a flow rate of 2 kg/s. The heat capacity of the water is 4180 J/(kg)(K). The overall heat transfer coefficient is estimated to be 150 W/(m²)(K). Calculate the heat transfer surface area for the following heat exchanger arrangements:

- (i) double-pipe counterflow,
- (ii) one-shell pass, two-tube passes,
- (iii) two-shell passes, four-tube passes,
- (iv) cross-flow with both fluids unmixed.

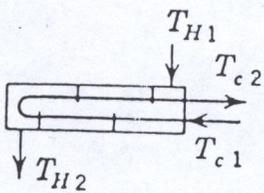
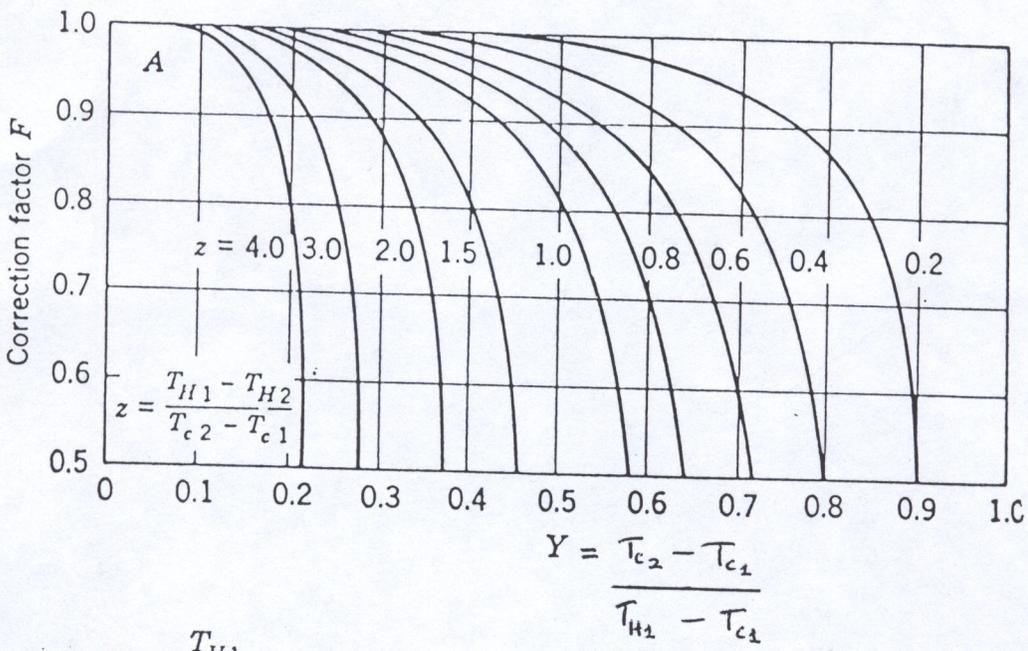
6. (a) Define the term specific speed of a centrifugal pump and deduce an expression for it in terms of the head H , the discharge Q and the speed N . What are the dimensions of the specific speed and how is it related to the type number?

(b) A multi-stage centrifugal pump is required to lift $1.8 \text{ m}^3/\text{min}$ of water from a mine. The total head including friction is 750 m . If the speed of the pump is 2900 rev/min , find the least number of stages if the specific speed per stage is not to be less than 150 in the given units. What would the minimum number of stages be if the pump speed were reduced to 2000 rev/min , everything else remaining the same?

END OF EXAMINATION IN MM 552

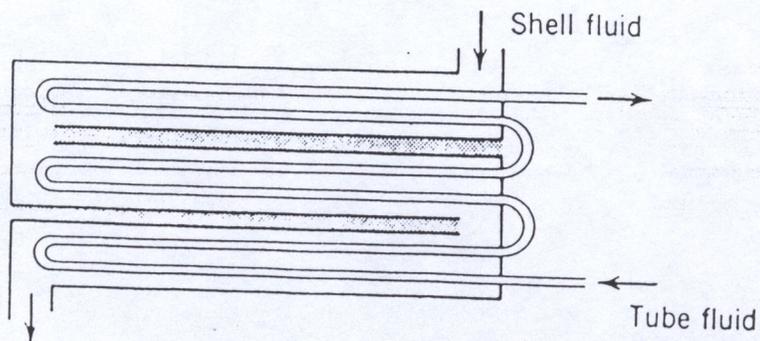
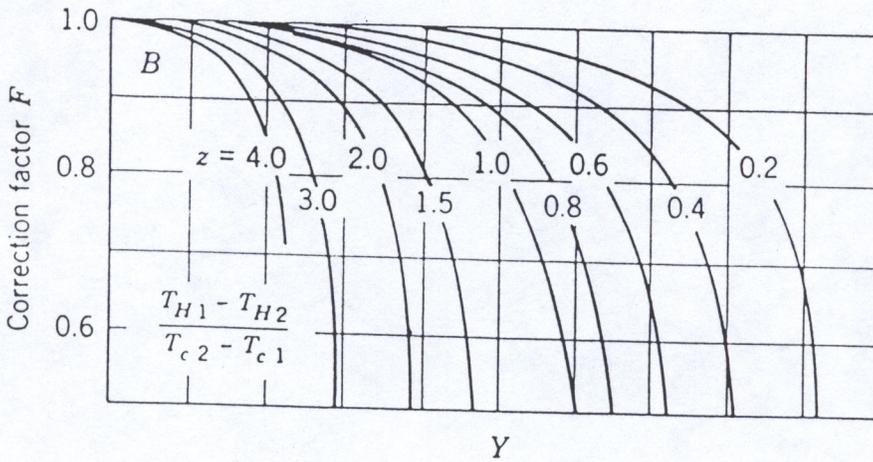
TABLE 1.6-1. Mean Molar Heat Capacities of Gases Between 298 and TK (25 and T°C)
at 101.325 kPa or Less (SI Units: $c_p = \text{kJ/kg mol} \cdot \text{K}$)

T(K)	T(°C)	H ₂	N ₂	CO	Air	O ₂	H ₂ O	CO ₂	CH ₄	SO ₂
298	25	28.86	29.14	29.16	29.19	29.38	33.59	37.20	35.8	39.9
373	100	28.99	29.19	29.24	29.29	29.66	33.85	38.73	37.6	41.2
473	200	29.13	29.29	29.38	29.40	30.07	34.24	40.62	40.3	42.9
573	300	29.18	29.46	29.60	29.61	30.53	34.39	42.32	43.1	44.5
673	400	29.23	29.68	29.88	29.94	31.01	35.21	43.80	45.9	45.8
773	500	29.29	29.97	30.19	30.25	31.46	35.75	45.12	48.8	47.0
873	600	29.35	30.27	30.52	30.56	31.89	36.33	46.28	51.4	47.9
973	700	29.44	30.56	30.84	30.87	32.26	36.91	47.32	54.0	48.8
1073	800	29.56	30.85	31.16	31.18	32.62	37.53	48.27	56.4	49.6
1173	900	29.63	31.16	31.49	31.48	32.97	38.14	49.15	58.8	50.3
1273	1000	29.84	31.43	31.77	31.79	33.25	38.71	49.91	61.0	50.9
1473	1200	30.18	31.97	32.30	32.32	33.78	39.88	51.29	64.9	51.9
1673	1400	30.51	32.40	32.73	32.76	34.19	40.90	52.34		



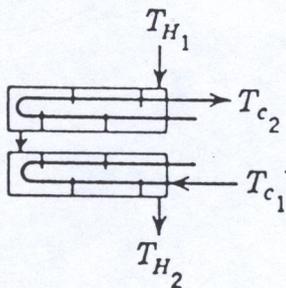
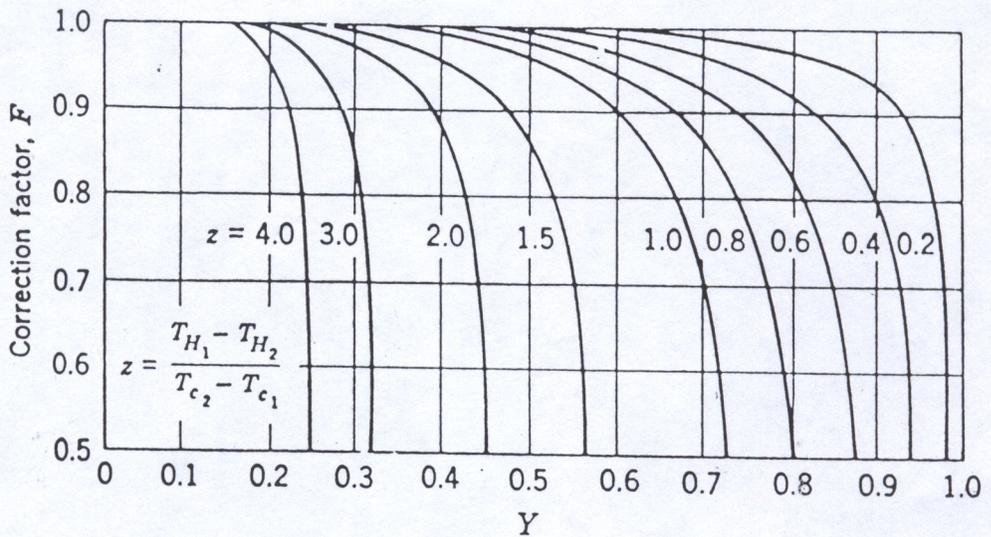
Correction Factor Plot for Exchanger with One Shell Pass and Two, Four, or any Multiple of Tube Passes

(a)



(b)

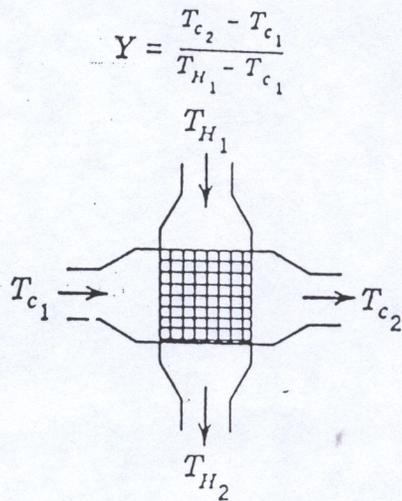
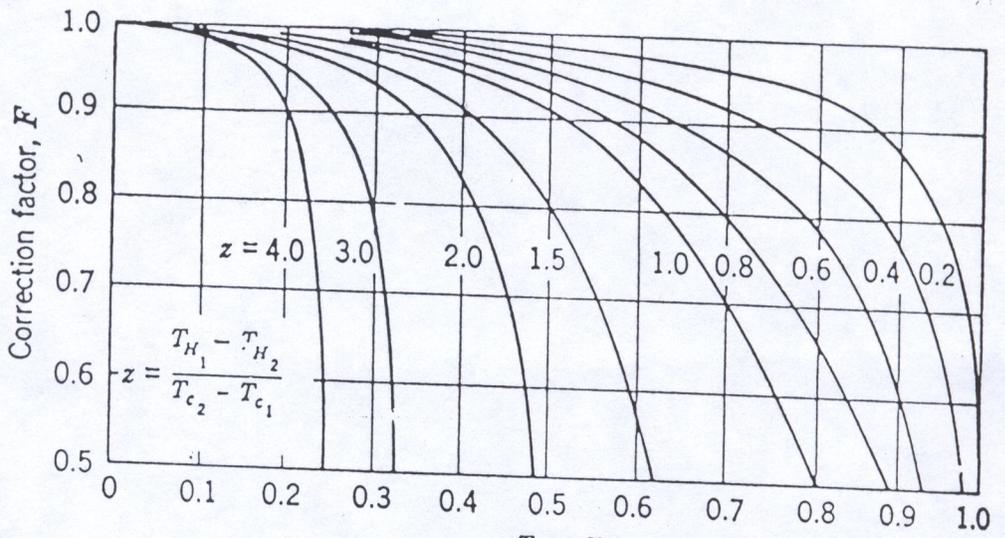
and Shell-and-Tube Heat-Exchanger Analysis



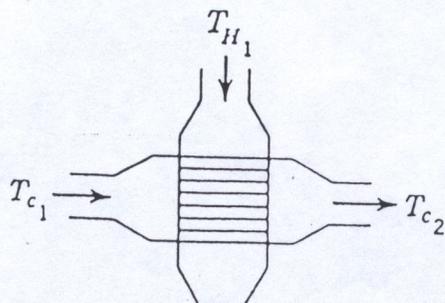
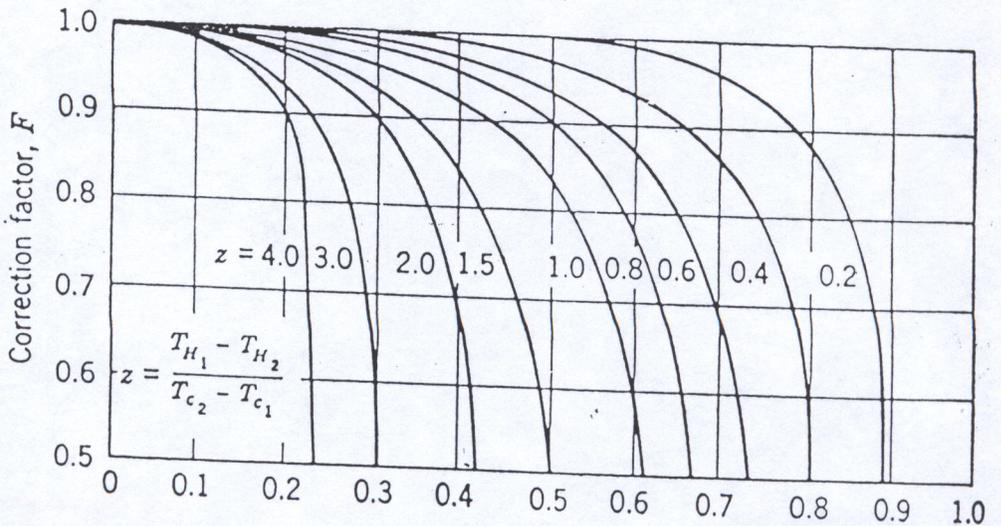
Correction Factor Plot for Exchanger with Two Shell Passes and Four, Eight, or any Multiple of Four Tube Passes.

(c)

Figure 22.9 Correction factors for three shell-and-tube heat exchanger configurations. (a) One shell pass and two or a multiple of two tube passes. (b) One shell pass and three or a multiple of three tube passes. (c) Two shell pass and two or a multiple of two tube passes. (From R. A. Bowman, A. C. Mueller, and W. M. Nagle, *Trans. A.S.M.E.*, **62**, 284, 285 (1940). By permission of the publishers.) Correction factors, F , based on counterflow LMTD.



(a)



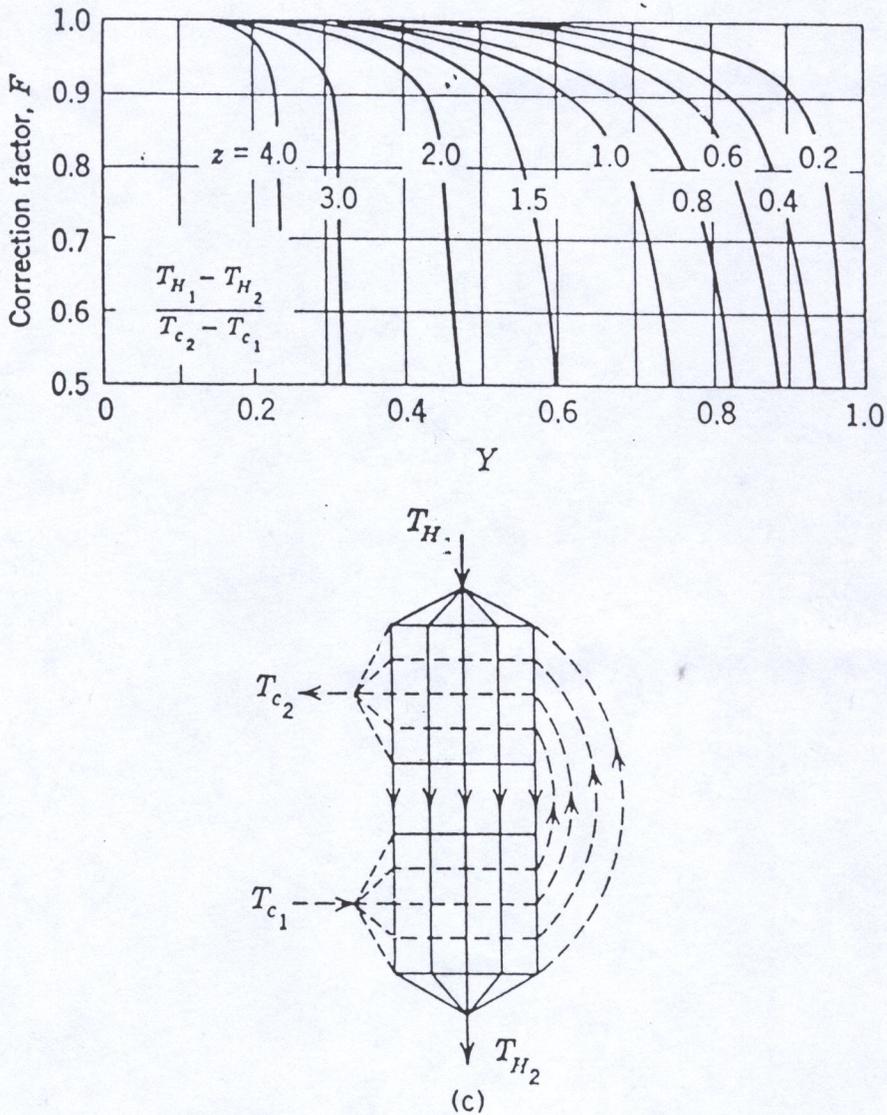


Figure 22.10 Correction factors for three crossflow heat-exchanger configurations. (a) Crossflow, single-pass, both fluids unmixed. (b) Crossflow, single-pass, one fluid unmixed. (c) Crossflow, tube passes mixed; fluid flows over first and second passes in series. (From R. A. Bowman, A. C. Mueller, and W. M. Nagle, *Trans. A.S.M.E.*, 62, 288, 289 (1940). By permission of the publishers.)

THE UNIVERSITY OF ZAMBIA
School of Mines
Mining Engineering Department

MI322 - STATISTICS AND COMPUTER APPLICATIONS

Semester Two Final Examination

November 2002

ANSWER ALL QUESTIONS
(THREE Hours)

- 1(i) With clear definition of the variables involved, what formulae are used in the following circumstances?
- (a) To estimate the sample variance when the population mean η is known.
 - (b) To estimate the statistic in a normal distribution if the standard deviation σ is not known.
 - (c) To estimate the statistic for which we believe, say, that two sets of 10 yields obtained with methods A and B could be treated as *random samples from appropriate populations* of yields with approximately the same form; in particular, that they have the same variance σ^2
 - (d) To estimate the statistic if the only evidence about σ is from the $n_A = x$ runs made with method A and $n_B = x$ runs made with method B.

[12 points]

- 1(ii). What are the FOUR BASIC WAYS with which one can get the FIRST STATISTICAL IMPRESSION of data? **[8 points]**

- 2 MI322 Monk Company contemplated introducing a new drilling machine. To do so, a trial was undertaken to compare the performance of drilling machines A to a trial machine B. Suppose that four trials done on successive days in the order A, A, B, B gave the results 23, 28, 37, 33 (m/hr) and also that, immediately before this trial, a series of drilling data on successive days with machine A gave the results 25, 23, 27, 31, 32, 35, 40, 38, 38, 33, 27, 21, 19, 24, 17, 15, 14, 19, 23, 22 (m/hr). Using the external reference distribution, compute the significance level for the null hypothesis $\eta_B = \eta_A$, when the alternative is $\eta_B > \eta_A$. Is there evidence that B gives higher output than A?

[20 points]

- 3(i) Prove that the SLOPE of the least-squares regression line of y and x can be written as

$$b = \frac{\sum (x - \bar{x})(y - \bar{y})}{\sum (x - \bar{x})^2}$$

[8 points]

- 3(ii) Northern Frontier Gold Mining Company wanted to predict the hole alignment deviation for their open pit drilling. This, the Company thought, would help them design optimal benches and blasting patterns. Tests were conducted and results obtained are shown in Table 3.1. With the help of regression analysis, derive an equation for alignment deviation for drill holes at the open-pit.

Table 3.1

Hole depth (m)	8	22	35	40	57	73	78	87	98
Number of measurements	6	9	2	8	4	5	7	1	3
Alignment deviation (cm)	6.16	9.88	14.35	24.06	30.34	32.17	42.18	43.23	48.76

[12 points]

4. Four different loaders were tested for their performance. The allocation of drivers and loading times were random. The average tonnage pulled per hour was then recorded, as shown in Table 4.1. In clear steps, determine if there is a difference in the performance of the loaders.

Table 4.1

A	B	C	D
62	63	68	56
60	67	66	62
63	71	71	60
59	64	67	61
	65	68	63
	66	68	64
			63
			59

[20 points]

5. The results shown in Table 5.1 were obtained from a test on the wear of two different materials used on soles of mine safety boots. The hypothesis H_0 of interest is not always the null hypothesis of "no difference". Suppose that increased wear of the cheaper material could be tolerated so long as it was not greater than 0.10, do the data contradict the hypothesis H_0 that $\delta = \delta_0 = 0.10$ (the alternative H_1 being that $\delta > 0.10$)?

Table 5.1 Data on the amount of wear of soles of mine safety shoes measured with two different materials A and B.

Boy	Material A	Material B	B - A difference <i>d</i>
1	13.2(L)	14.0(R)	0.8
2	8.2(L)	8.8(R)	0.6
3	10.9(R)	11.2(L)	0.3
4	14.3(L)	14.2(R)	-0.1
5	10.7(R)	11.8(L)	1.1
6	6.6(L)	6.4(R)	-0.2
7	9.5(L)	9.8(R)	0.3
8	10.8(L)	11.3(R)	0.5
9	8.8(R)	9.3(L)	0.5
10	13.3(L)	13.6(R)	0.3
		average difference =	0.42

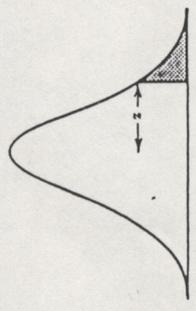


TABLE A. Tail area of unit normal distribution

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.4960	0.4920	0.4880	0.4840	0.4801	0.4761	0.4721	0.4681	0.4641
0.1	0.4602	0.4562	0.4522	0.4483	0.4443	0.4404	0.4364	0.4325	0.4286	0.4247
0.2	0.4207	0.4168	0.4129	0.4090	0.4052	0.4013	0.3974	0.3936	0.3897	0.3859
0.3	0.3821	0.3783	0.3745	0.3707	0.3669	0.3632	0.3594	0.3557	0.3520	0.3483
0.4	0.3446	0.3409	0.3372	0.3336	0.3300	0.3264	0.3228	0.3192	0.3156	0.3121
0.5	0.3085	0.3050	0.3015	0.2981	0.2946	0.2912	0.2877	0.2843	0.2810	0.2776
0.6	0.2743	0.2709	0.2676	0.2643	0.2611	0.2578	0.2546	0.2514	0.2483	0.2451
0.7	0.2420	0.2389	0.2358	0.2327	0.2296	0.2266	0.2235	0.2206	0.2177	0.2148
0.8	0.2119	0.2090	0.2061	0.2033	0.2005	0.1977	0.1949	0.1922	0.1894	0.1867
0.9	0.1841	0.1814	0.1788	0.1762	0.1736	0.1711	0.1685	0.1660	0.1635	0.1611
1.0	0.1587	0.1562	0.1539	0.1515	0.1492	0.1469	0.1446	0.1423	0.1401	0.1379
1.1	0.1357	0.1335	0.1314	0.1292	0.1271	0.1251	0.1230	0.1210	0.1190	0.1170
1.2	0.1151	0.1131	0.1112	0.1093	0.1075	0.1056	0.1038	0.1020	0.1003	0.0985
1.3	0.0968	0.0951	0.0934	0.0918	0.0901	0.0885	0.0869	0.0853	0.0838	0.0823
1.4	0.0808	0.0793	0.0778	0.0764	0.0749	0.0735	0.0721	0.0708	0.0694	0.0681
1.5	0.0668	0.0655	0.0643	0.0630	0.0618	0.0606	0.0594	0.0582	0.0571	0.0559
1.6	0.0548	0.0537	0.0526	0.0516	0.0505	0.0495	0.0485	0.0475	0.0465	0.0455
1.7	0.0446	0.0436	0.0427	0.0418	0.0409	0.0401	0.0392	0.0384	0.0375	0.0367
1.8	0.0359	0.0351	0.0344	0.0336	0.0329	0.0322	0.0314	0.0307	0.0301	0.0294
1.9	0.0287	0.0281	0.0274	0.0268	0.0262	0.0256	0.0250	0.0244	0.0239	0.0233
2.0	0.0228	0.0222	0.0217	0.0212	0.0207	0.0202	0.0197	0.0192	0.0188	0.0183
2.1	0.0179	0.0174	0.0170	0.0166	0.0162	0.0158	0.0154	0.0150	0.0146	0.0143
2.2	0.0139	0.0136	0.0132	0.0129	0.0125	0.0122	0.0119	0.0116	0.0113	0.0110
2.3	0.0107	0.0104	0.0102	0.0099	0.0096	0.0094	0.0091	0.0089	0.0087	0.0084
2.4	0.0082	0.0080	0.0078	0.0075	0.0073	0.0071	0.0069	0.0068	0.0066	0.0064
2.5	0.0062	0.0060	0.0059	0.0057	0.0055	0.0054	0.0052	0.0051	0.0049	0.0048
2.6	0.0047	0.0045	0.0044	0.0043	0.0041	0.0040	0.0039	0.0038	0.0037	0.0036
2.7	0.0035	0.0034	0.0033	0.0032	0.0031	0.0030	0.0029	0.0028	0.0027	0.0026
2.8	0.0026	0.0025	0.0024	0.0023	0.0022	0.0022	0.0021	0.0021	0.0020	0.0019
2.9	0.0019	0.0018	0.0018	0.0017	0.0016	0.0016	0.0015	0.0015	0.0014	0.0014
3.0	0.0013	0.0013	0.0013	0.0012	0.0012	0.0011	0.0011	0.0011	0.0010	0.0010
3.1	0.0010	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008	0.0007	0.0007
3.2	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005
3.3	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003
3.4	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002
3.5	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
3.6	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
3.7	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
3.8	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
3.9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

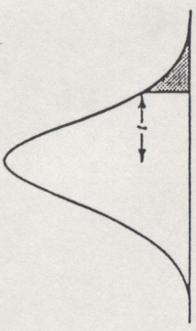


TABLE B1. Probability points of the *t* distribution with *v* degrees of freedom

v	tail area probability									
	0.4	0.25	0.1	0.05	0.025	0.01	0.005	0.0025	0.001	0.0005
1	0.325	1.000	3.078	6.314	12.706	31.821	63.657	127.32	318.31	636.62
2	0.289	0.816	1.886	2.920	4.303	6.965	9.925	14.089	22.326	31.598
3	0.277	0.765	1.638	2.353	3.182	4.541	5.841	7.453	10.213	12.924
4	0.271	0.741	1.533	2.132	2.776	3.747	4.604	5.598	7.173	8.610
5	0.267	0.727	1.476	2.015	2.571	3.365	4.032	4.773	5.893	6.869
6	0.265	0.718	1.440	1.943	2.447	3.143	3.707	4.317	5.208	5.959
7	0.263	0.711	1.415	1.895	2.365	2.998	3.499	4.029	4.785	5.408
8	0.262	0.706	1.397	1.860	2.306	2.896	3.355	3.833	4.501	5.041
9	0.261	0.703	1.383	1.833	2.262	2.821	3.250	3.690	4.297	4.781
10	0.260	0.700	1.372	1.812	2.228	2.764	3.169	3.581	4.144	4.587
11	0.260	0.697	1.363	1.796	2.201	2.718	3.106	3.497	4.025	4.437
12	0.259	0.695	1.356	1.782	2.179	2.681	3.055	3.428	3.930	4.318
13	0.259	0.694	1.350	1.771	2.160	2.650	3.012	3.372	3.852	4.221
14	0.258	0.692	1.345	1.761	2.145	2.624	2.977	3.326	3.787	4.140
15	0.258	0.691	1.341	1.753	2.131	2.602	2.947	3.286	3.733	4.073
16	0.258	0.690	1.337	1.746	2.120	2.583	2.921	3.252	3.686	4.015
17	0.257	0.689	1.333	1.740	2.110	2.567	2.898	3.222	3.646	3.965
18	0.257	0.688	1.330	1.734	2.101	2.552	2.878	3.197	3.610	3.922
19	0.257	0.688	1.328	1.729	2.093	2.539	2.861	3.174	3.579	3.883
20	0.257	0.687	1.325	1.725	2.086	2.528	2.845	3.153	3.552	3.850
21	0.257	0.686	1.323	1.721	2.080	2.518	2.831	3.135	3.527	3.819
22	0.256	0.686	1.321	1.717	2.074	2.508	2.819	3.119	3.505	3.792
23	0.256	0.685	1.319	1.714	2.069	2.500	2.807	3.104	3.485	3.767
24	0.256	0.685	1.318	1.711	2.064	2.492	2.797	3.091	3.467	3.745
25	0.256	0.684	1.316	1.708	2.060	2.485	2.787	3.078	3.450	3.725
26	0.256	0.684	1.315	1.706	2.056	2.479	2.779	3.067	3.435	3.707
27	0.256	0.684	1.314	1.703	2.052	2.473	2.771	3.057	3.421	3.690
28	0.256	0.683	1.313	1.701	2.048	2.467	2.763	3.047	3.408	3.674
29	0.256	0.683	1.311	1.699	2.045	2.462	2.756	3.038	3.396	3.659
30	0.256	0.683	1.310	1.697	2.042	2.457	2.750	3.030	3.385	3.646
40	0.255	0.681	1.303	1.684	2.021	2.423	2.704	2.971	3.307	3.551
60	0.254	0.679	1.296	1.671	2.000	2.390	2.660	2.915	3.232	3.460
120	0.254	0.677	1.289	1.658	1.980	2.358	2.617	2.860	3.160	3.373
∞	0.253	0.674	1.282	1.645	1.960	2.326	2.576	2.807	3.090	3.291

Source taken with permission from E. S. Pearson and H. O. Hartley (Eds.) (1958), *Biometrika Tables for Statisticians*, Vol. 1, Cambridge University Press.
 Parts of the table are also taken from Table III of Fisher and Yates: *Statistical Tables for Biological, Agricultural and Medical Research*, published by Longman Group Ltd., London (previously published by Oliver and Boyd, Edinburgh), by permission of the authors and publishers.

UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
Department of Mine Engineering

End of Semester II, Final Examination, 2001/2002
MI475: Mine Environment

TIME ALLOWED: 3 hours

INSTRUCTIONS: This examination paper consists of six questions. You are only allowed to answer five (5) questions. Questions one (1), two (2) and three (3) are compulsory.

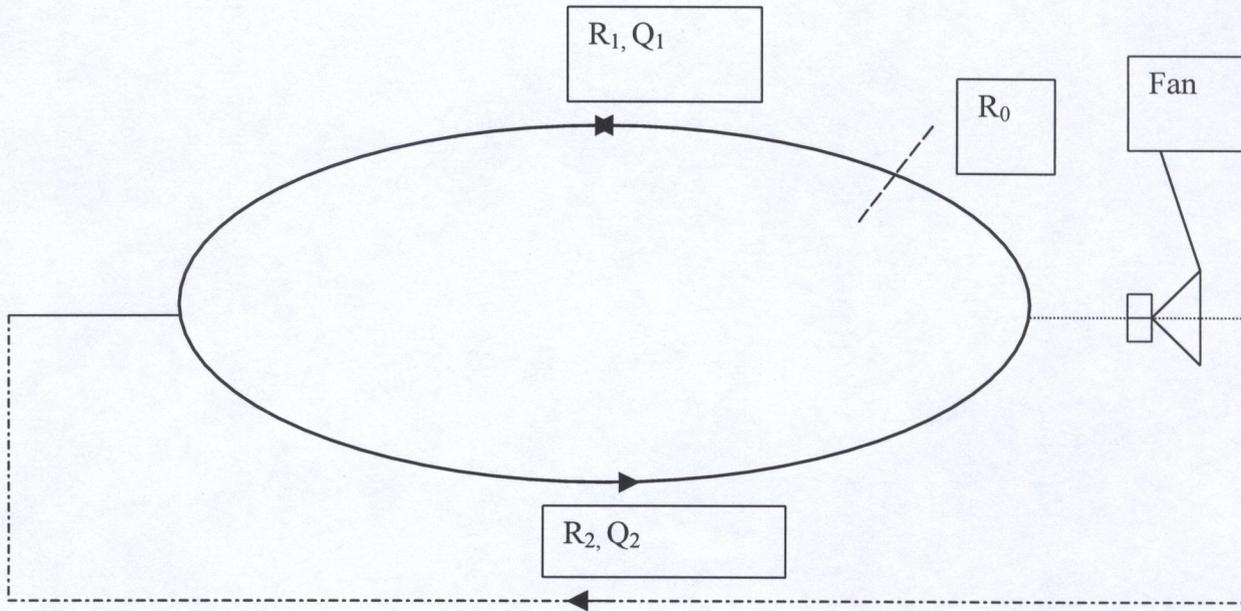
Note: Marks will be given for neatly drawn illustrations/diagrams. Wrongly presented illustrations will also attract negative marks.

Question 1 (20 Marks)

(I) Refer to diagram 1 below. In order to regulate air flow in the two branches with initial aerodynamic resistances of R_1 and two R_2 , It is decided to carry out a “Negative air flow regulation” by introducing a ventilation window with unknown Resistance R_0 . The initial values of R_1 and R_2 are 0.1 and 0.3 $NS^{-2}m^{-8}$ respectively, while $Q_1=39.87 m^3/s$ and $Q_2=28.2 m^3/s$. If the characteristic of the fan installed in the circuit is given by $P=500 - 5Q$, find the resistance R_0 of the ventilation window that when placed in series with R_1 will reduce the airflow by $5 m^3/s$ ($q_1=-5 m^3$). **(10 Marks)**

(II) With the help of a simple diagonal ventilation network, derive equations for determining circuit characteristics (resistance, quantity of air flow and Pressure drops). **(5 Marks)**

(111) Estimate the pressure drop in a 0.50 m diameter pipe of uniform cross section area. The length of the duct is 100 m, while the average velocity of air is 2.5 m /s. Take any appropriate value of coefficient of viscosity μ . **(5 Marks)**



Question 2 (20 Marks)

(I) An installed fan connected to a ducting measuring 75 m by 540 mm provides ventilation for an engine room through this duct. The fan is found to have the following characteristics:

Fan characteristics	Point 1	Point 2	Point 3
Air quantity, m ³ /s	3.0	4.0	5.0
Static pressure, Pa	880	722	450

If the density of air handled by the fan is **1.25 kg/m³** and that the friction coefficient k for the duct determined at an air density of **1.2 kg/m³** is **0.004 NS²m⁻⁴**, **a)** calculate the quantity of air circulated by the fan. Assume the shock pressure loss in the duct at the entrance to the duct to be 18% of the friction pressure loss in the duct. **b)** What will be the increase in the fan quantity if an evase of an outlet diameter of **1120 mm** and an efficiency of **80 %** is fitted at the delivery end of the duct? **(10 Marks)**

(11) Name five major factors that have to be considered when selecting a mine fan. **(5 Marks)**

III) Fans can either be installed in series or in parallel. Explain what necessitates these types of installations and under what conditions they are done?

(5 Marks)

Question 3 (20 Marks)

(I) Describe in detail various methods of ventilation systems used in mines and where possible, draw a simple ventilation diagrams to illustrate your explanation. What are the advantages and disadvantages of each of this ventilation system?

(12 Marks)

(II) With the help of clear diagrams explain the ventilation systems in development ends citing as clearly as possible the location of forcing and exhaust fans.

(8 Marks)

Question 4(20 Marks)

(I) A pipe carrying compressed air runs from the shaft-top up to the shaft bottom. The depth of the shaft is 800 m, while the temperatures at the shaft top and shaft bottom are 300 and 303 k respectively. If the moisture contents of air at the shaft-top and shaft-bottom are $m_1=25$ and $m_2=28$ g/kg of dry compressed air respectively, find the amount of heat added to the mine air by this compressed air. Take mass flow rate $M=1.2$ kg/s; specific heat of compressed air $C_p=1005$ j/kg.K and latent heat of evaporation of water $l=2500$ j/g

(12 Marks)

(II) Describe the process of auto-compression of mine air in the shaft.

(8 Marks)

Question 5 (20 Marks)

(I) Explain how you understand by the following terms:

Static head of airway

(1 Marks)

Velocity head of air way

(1 Marks)

Shock losses in airway

(1 Marks)

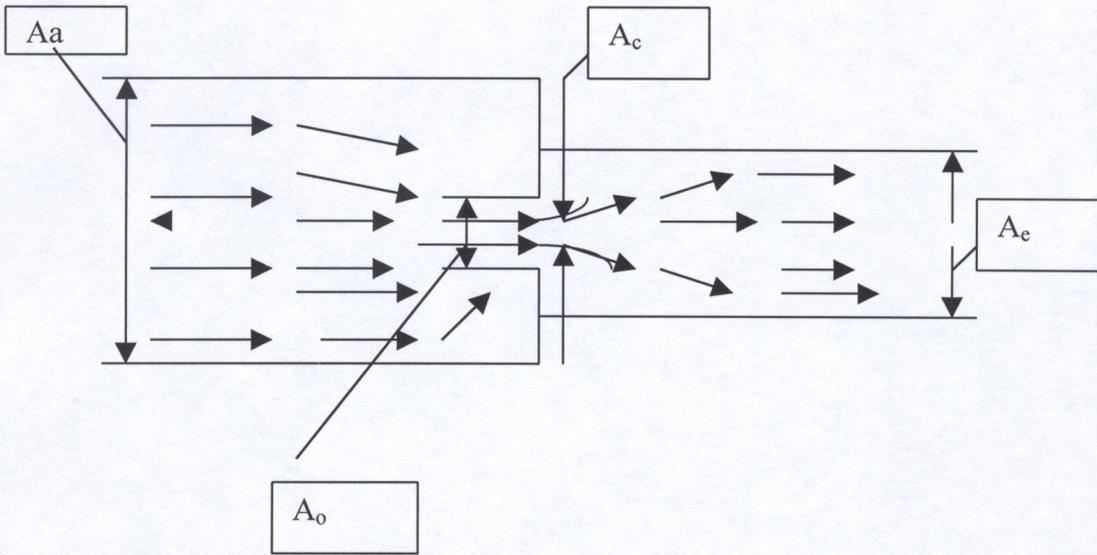
Kinematic viscosity

(1 Marks)

Shock factor

(1 Marks)

(II) Consider the diagram below showing the flow pattern of air at area change. A_a , A_o and A_e are cross section areas at various points of corresponding mine airways. A_c – vena contracta



Given that the coefficient of contraction for the said flow pattern is $C=A_c/A_o$, Derive the values of shock factors X_a , X_o and X_e corresponding to velocity pressures at A_a , A_o and A_e . **(10 Marks)**

(III) How do you understand by the term “Resistance of leakage air ways” and how is pressure drop computed in this case? **(5 Marks)**

Question 6 (20 Marks)

I) Describe five (5) major factors that cause Natural Ventilation in Mines and three (3) artificial aids to this type of ventilation.

(8Marks)

II) Find the natural Ventilation pressure prevailing at one of the mines for following conditions:

Mining depth 500 m

Average temperature in down cast shaft 297.5 K

Average temperature in up cast shaft 300.5 K

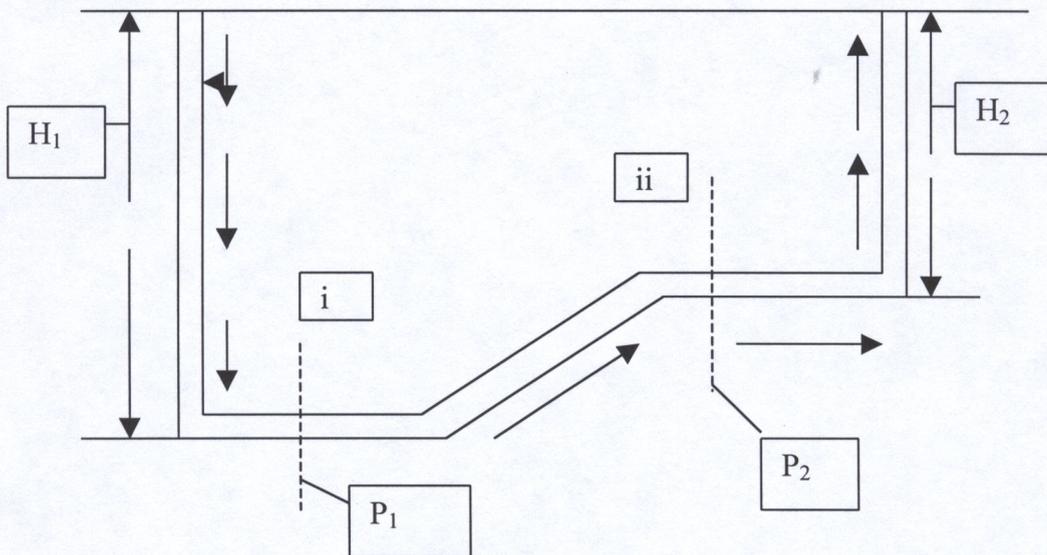
Barometric reading at pit bottom 100.5 KPa

Barometric reading at pit top 95.50 KPa

(6 Marks)

III) Below is a simple diagram expressing the law of air motion in the mine openings. Taking the walls of these openings to be leakage free, and the mass of air passing through these openings to be constant, derive the expression for the equation of continuity. Take P_1 and P_2 as static pressures at cross section areas i and ii respectively; H_1 and H_2 – Corresponding heights at these points.

(6Marks)



*** END OF EXAMINATION ***

THE UNIVERSITY OF ZAMBIA

END OF SEMESER EXAMINATION (APRIL 2002)

MI 535: COAL MINING METHODS

INSTRUCTIONS:

- Answer any six questions
 - All questions carry equal marks
 - Questions should be answered in the order they appear.
 - Up to four(04) MARKS will be awarded for neat diagrams and presentations
-

1. (a) Some geological and geotechnical information are necessary in case of mining a coal deposit. Discuss these information and their relevance to mining clearly.
- (b) What affects the quality of coal? Is it possible to improve the quality of run-of-mine of cal? If so, describe briefly the principle of doing so
2. (a) The Science and art of mining of coal differ to a great extent from that of metal mining. Discuss the reasons behind it.
- (b) An exploration team reported hitting into a coal seam at a depth of 700m dipping at 30 degrees. The measured length of the core that came out from the drill barred was 3.5 m. If the plan area of the coal deposit was 500m X 500m, calculate the reserve of coal in millions of tonnes (rounded to two decimal places). Take the spgra of coal = 1.27.
3. (a) Explain the circumstances that favour longwall retreat mining method.
- (b) List the factors that are necessary in deciding the size of the panel in room and pillar mining. Give the reasons for all those factors that you will list.
4. (a) A number of factor must be taken into account whether or not to use a shortwall mining. Discuss these factors clearly.
- (b) With the help of diagrams describe a shortwall mining method and show and label the necessary equipment in use.

What O.M.S. you expect from such a face? Give the break down of the personal you would engage to get the OMS you suggest.

5. (a) List the factors on which the length of a longwall face depends?
- (b) Estimate the length of a longwall face to produce 400,000 (four hundred thousand) tonnes of coal annually from the data given below:
- Thickness of the coal seam = 3m
 - Web of DERD Shearer = 0.6m
 - Av. Speed of DERD shearer = 3.0m/min
 - Number of production shift = 03 (three) per day
 - Shift duration eight (08) hours to which 40% of it is an idle time
 - Working days available = 300/year
 - Take density of coal = 1.25 (if required in the calculation).

6. (a) A coal seam at a depth of 550m dips at 30 degrees to be mined. Describe with the help of diagrams a suitable method for mining such a deposit.

State the advantages of the method you describe.

- (b) What size of the coal pillar should be left on the rise side, the dip side and along the strike to protect the shaft in the above situation?

7. (a) What are the possible hazards associated with coal mining from
- i. Methane
 - ii. Coal dust and
 - iii. Water inundation

State the requirements of the Coal Mines Regulations to safeguard against above hazards.

- (b) A room and pillar mining is having problem with 'low production' and "low productivity. Suggests the measures, separately, to improve these two problems.

*****END OF EXAMINATION and GOOD LUCK *****