(4)

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS – 2000
SECOND SEMESTER EXAMINATIONS
SCHOOL OF MINES

1.	GG	321	Stratigraphy and remote sensing Theory paper I
2.	GG	321	Stratigraphy and remote sensing practical paper II
3.	GG	331	Structural geology I paper I : theory
4.	GG	421	Sedimentology paper I : Theory
5.	GG	421	Sedimentology paper II: practiceal
6.	GG	442	Economic geology of metalliferous ores
7.	GG	442	Economic geology of metalliferous ores paper II: practical
8.	M	325	Groups ring and theory
9.	MG	319	Computer techniques paper I theory
10.	MI	322	Statistics and computer applications
11.	MI	435	Surface mine design
12.	MI	465/MM571	mineral economics/management and economics
13.	MI	475	Mine environment
14	MI	SIS	Rock mechanics II
15	MM	205	Introduction to metallurgy and mineral processing
16.	MM	205	Introduction to metallurgy and mineral processing paper II practical
17.	MM	411	Mineral processing I
18	MM	415	Mineral processing for mining engineers
19	MM	422	Physical metallurgy II
20	MM	442	Hydrometallurgy
21 ✓	MM	552	process design
22	MM	562	Foundry

(4)

THE UNIVERSITY OF ZAMBIA
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THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – MAY 2000

GG321

STRATIGRAPHY AND REMOTE SENSING

PRACTICAL

PAPER II

TIME: THREE HOURS
ANSWER: ALL QUESTIONS. NEATLY DRAWN SKETCHES/ DIAGRAMS RECOMMENDED FOR A FULL MARK.

---

1 (a) Define the term Remote Sensing (2 marks)
(b) Differentiate between Passive and Active remote sensing systems. (4 marks)
(c) State four factors on which interpretation potential of an image is depended on. (8 marks)

2 (a) Fill in the 14 missing blanks indicated by the dotted lines i.e. numbered (a) to (o) in the Table II. (14 marks)

(b) Differentiate between the following terms:
i) Geometric resolution and radiometric resolution. (4 marks)
ii) Spectral resolution and temporal resolution (4 marks)

(c) List five parameters that influence the intensity values in an image giving examples in your answer. (10 marks)

3. Before going for your student mapping class, you were required to undertake a photogeological interpretation of your area. You are therefore required to:

(i) Provide a fully annotated photogeological interpretation on the central air photograph. (40 marks)

(ii) Provide a description of the photogeology of the annotated area. (14 marks)

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – MAY 2000

GG321

STRATIGRAPHY AND REMOTE SENSING

PRACTICAL

PAPER II

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(i) Provide a fully annotated photogeological interpretation on the central air photograph. (40 marks)

(ii) Provide a description of the photogeology of the annotated area. (14 marks)

Table II. Showing Use of the spectral range and the spatial resolution of Landsat TM in image interpretation.

Band	Wavelength	Colour	Characteristics
1	(a).....	Blue-green	(b).....
(c).....	0.52 – 0.60	(d).....	Equal to MSS band 4. Green reflectance peak of vegetation, measure of plant growth
3	(e).....	Red	(f).....
(g).....	0.76-0.90	(h).....	Equal to portions of MSS band 6 & 7. Good for determination of biomass content and mapping shorelines
5	(i).....	Reflected infra-red	(k).....
(l).....	10.4 – 12.5	(m).....	Night-time images useful for thermal mapping and estimates of soil moisture
7	(n).....	Reflected infra-red	(o).....

UNIVERSITY OF ZAMBIA

SECOND SEMISTER EXAMINATIONS - MAY 2000

GG331

STRUCTURAL GEOLOGY I

PAPER II: PRACTICAL

ANSWER: ALL QUESTIONS
TIME: 3 HOURS

Q1. Figure 1 shows geological maps of uniformly dipping beds, which have been faulted. Indicate on the map:

i) Dip direction of the beds by means of the strike and dip symbols
ii) The up-thrown side and down-thrown side of each fault with U and D, respectively.

Q2. Figure 2 is a geological map of an area.

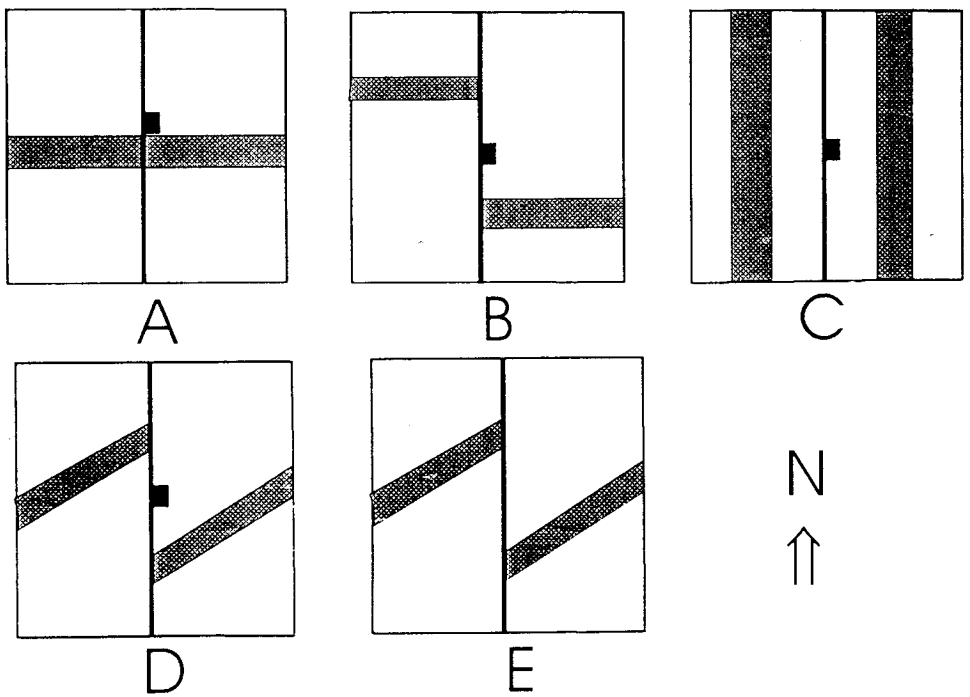
i) Indicate the axial trace with the appropriate symbol
ii) Determine the attitude of the fold axis of the fold and indicate on the map.
iii) Name the type of fold.
iv) Name the fold type if the core of the fold structure consists of older rocks.

Q3. Refer to figure 3

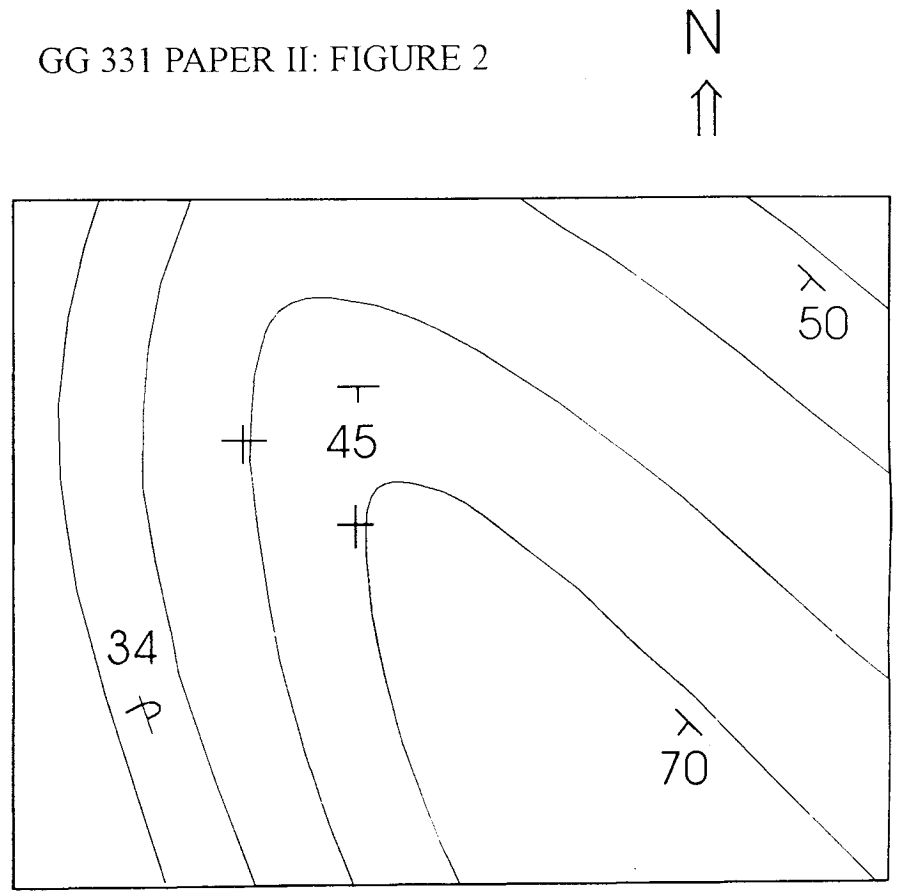
i) Construct strike lines and label them systematically
ii) Draw a geological cross-section along X-Y
iii) List all geological events in chronological order.

END OF EXAMINATION

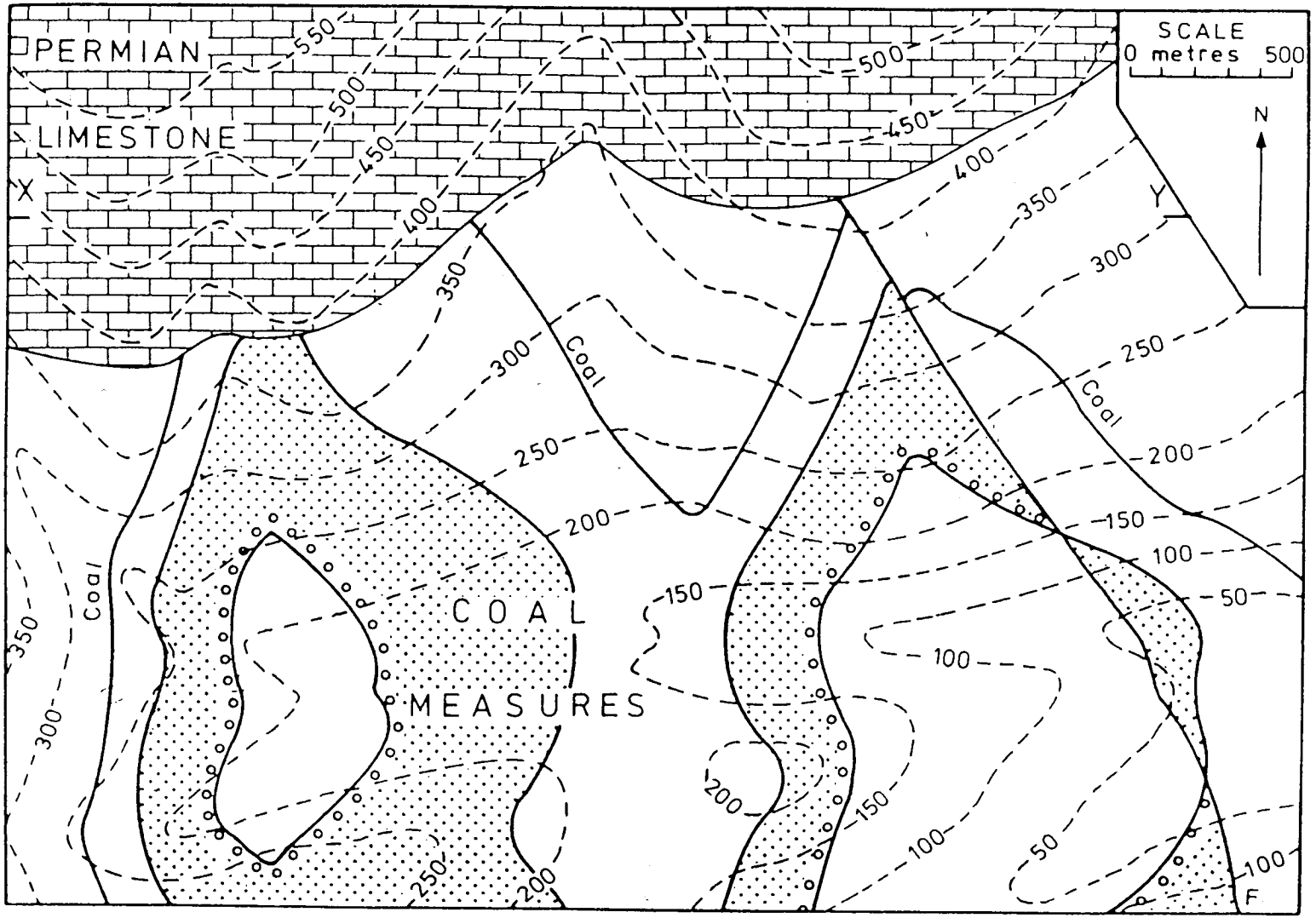
GG 331 PAPER II: FIGURE 1



GG 331 PAPER II: FIGURE 2



GG 331 PAPER II: FIGURE 3.



THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS - MAY 2000

GG 442: ECONOMIC GEOLOGY OF METALLIFEROUS ORES

PAPER II: PRACTICAL

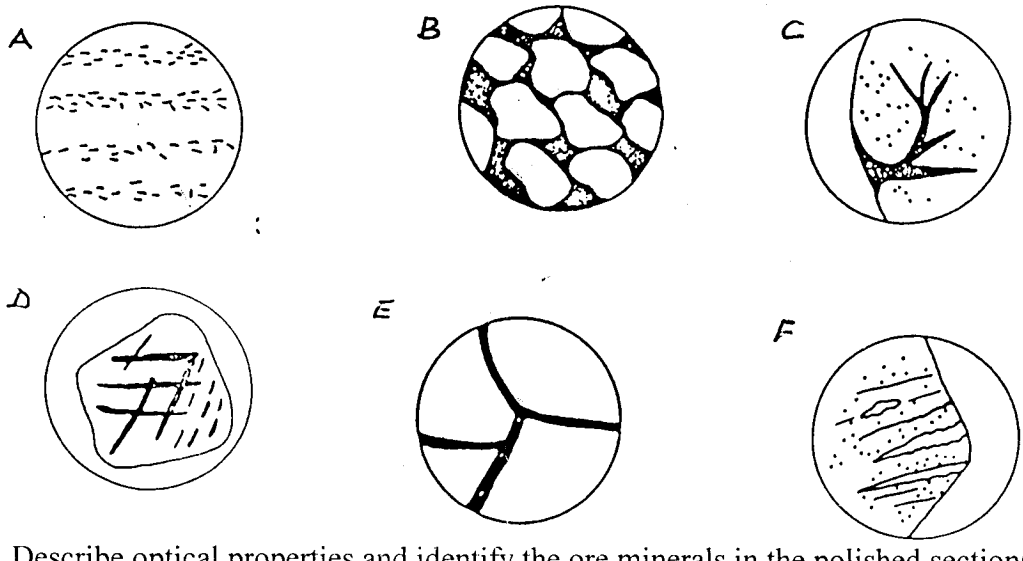
TIME: 3 HOURS
ANSWER: ALL QUESTIONS

Q1. Describe physical properties and identify handspecimens of ore minerals provided.

Q2. Describe how you would adjust a reflected light microscope for the determination of the following optical properties:

(a) Bi-reflectance
(b) Anisotropism
(c) Pleochroism
(d) Internal reflections

Q3. Name the textures in the sketches below.



Q4. Describe optical properties and identify the ore minerals in the polished section(s) provided.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
GEOLOGY DEPARTMENT
SECOND SEMESTER DEFERRED/SUPPLEMENTARY EXAMS
GG 442
ECONOMIC GEOLOGY OF METALLIFEROUS ORES

TIME: THREE HOURS

INSTRUCTION: ANSWER ANY FOUR QUESTION. ALL QUESTIONS CARRY EQUAL MARKS

---

1. Describe the mode of occurrence of sedimentary copper deposits in the geological environment, paying particular attention to deposits in Africa.

2. The Bushveld complex of South Africa is one of the most highly-mineralised regions of the world. Review the economic geology of the complex.

3. Discuss the role of fluid inclusion geothermometry in interpreting the conditions of ore-forming processes. Your answer should include both the positive and negative aspects of this technique.

4. Review the mode of occurrence of carbonate-hosted lead-zinc deposits.

5. Define the term 'ore' and give a concise account on the chemical classification of the ore minerals.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS
MAY 2000

M325 - Groups Ring and Theory

INSTRUCTIONS: This examination paper consists of six(6) questions selected from different topics. Candidates are advised to answer any five (5) questions of their choice. All questions carry equal marks.

TIME ALLOWED: Three (3) Hours.

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1. What is meant by the following terms:

   i) A sylow p-subgroup of the group G?
   ii) A non empty subset H is a subgroup of the group G?

   a) State and prove sylow's second theorem
   b) Show that a finite group G posses a unique sylow subgroup P corresponding to a given prime p if and only if P is normal in G.

   c) Prove that a non empty subset H is a subgroup of G if and only if

   i) $a,b \in H \Rightarrow ab \in H$
   ii) $a \in H \Rightarrow a^{-1} \in H$.

2. Define the following:
   i) The dihedral group G of order n
   ii) A maximal ideal M of a ring R.

   a) Enumerate all the elements of the dihedral group D_4 and form its multiplication table. From your answer or table, find the centre $Z(D_4)$ and determine the structure of $D_4/Z(D_4)$

   b) Prove that if R is a commutative ring with a unit element and M is an ideal of R such that R/M is a field, then M is maximal.

3. What do you understand by the following terms as applied to groups?

   i) ϕ is a homomorphism from a group G onto G′.

   ii) H is a normal subgroup of the group G.

   a) i) Let $G = S_3 = \{e, \phi, \psi, \psi^2, \phi\psi, \phi\psi^2\}$ and $G' = \{e, \phi\}$

   Define the map $f: G \to G'$ by $f(\phi^i, \psi^j) = \phi^i$. Show that f so defined is a homomorphism.

   ii) Let G be a group of integers under addition and let $G = G'$. For the integer $x \in G$ define φ by $\varphi(x) = 2x$. Prove that φ is a homomorphism

   b) Prove that if φ is a homomorphism of G into G′ with Kernel K, then K is a normal subgroup of G.

   c) Show that N is a normal subgroup of G if and only if $gNg^{-1} = N$ for every $g \in G$.

4. Define the following:

   i) a center of a group G.
   ii) a right or left coset of a subgroup H of a group G.

   Prove that

   a) If G is a finite group such that $|G| = p^m$, where p if a prime and $m > 0$; then the centre of G has order p^μ where $O < \mu \leq m$.

   b) the subgroup N of G is a normal subgroup of G if and only if every left coset of N in G is a right coset of N in G.

   c) If H and K are the subgroups of G, HK will be a subgroup of G if and only if HK = KH.

5. What do you understand by the following terms as applied to the group G?

i) G is the internal direct product of $N_1, N_2,...,N_n$.

a) Prove that if G is the internal direct product of $N_1, N_2, ...,N_n$; then for $i \neq j$; $N_i \cap N_j = (e)$ and if $a \in N_i$, $b \in N_j$ then

$$ab = ba.$$

b) State and verify the first isomorphism theorem.

6. Define the following;

i) A field **F**
ii) An integral domain D.

Prove that

a) a finite integral domain is a field.
b) If p is a prime number then Jp, the ring of integers mod p, is a field.

END OF EXAMINATION

University of Zambia
School of Mines
Geology Department

SECOND SEMESTER DEFERRED/SUPPLEMENTARY EXAMS
MG 319 Paper I : Theory
COMPUTER TECHNIQUES

TIME : Two hours

INSTRUCTION : ANSWER ALL QUESTIONS

1/ A computer shop advertises for two different computers, explain for each of the given components in the advert a brief explanation/definition, compare each component between the two units and explain which computer of the two in the final analysis is the most powerful:

COMPUTER 1	*COMPUTER 2*
Intel 200MHz Pentium Processor with MMX technology	Cyrix 233MHz pentium processor
32 Mb SDRAM, 512 Kb pipeline burst cache	64Mb EDO RAM, 256 Kb internal cache
2.1Gb Harddrive	6.3Gb Harddrive
S3 Virge 3D Graphics card 4Mb VRAM	Diamond Stealth 2000V+ 4Mb SVGA Card
24 speed CD-ROM	16 speed CD-ROM
32 bit Soundboard	Soundblaster 16 soundcard
Nokia 15" monitor	Philips Brilliance 17" monitor
US 102 keyboard	UK 102 keyboard
Microsoft Mouse	Logitech Mouse
3Com 16bit network card	28800bps internal modem

2/ Why did one develop a hexadecimal system for use in computers. What is the relationship between hexadecimal system and the binary coded decimal system?

3/ Which three basic logical operators does a computer use? On what principle is the use of the boolean logic in a computer based

4/ What do the following messages on a computer screen signify, and what action do you take?:

- "Exebug virus detected"
- "Error reading drive A; (Abort, Retry, Fail)."
- "The file *mineplant.doc"* allready exists. Overwrite (Y/N)?"
- "Formatting will erase all data. Continue (y/n)."
- "Lost Clusters found. Do you want to repair (y/n)?"

5/ Describe ***all*** steps necessary to avoid virus infection of your diskettes and computer system, and all steps necessary to clean an infected system, including infected diskettes.

THE UNIVERSITY OF ZAMBIA
School of Mines
Mining Engineering Department

MI322 - STATISTICS AND COMPUTER APPLICATIONS

Semester Two Final Examination

May, 2000

ANSWER ALL QUESTIONS
(THREE Hours)

1(A). State and explain the three sources of difficulty typically confronting an investigator:

[6 points]

1(B). Fill-in the Table below

	Population	**Sample**
Definition	a hypothetical set of N observations from which the sample of observations actually obtained can be imagined to come (typically N is very large)	a set of n observations actually obtained (typically n is relatively small)
Measure of location		
Measure of spread		

[9 points]

1C. Write down the formulae for (i) Standard Normal Distribution and (ii) Student's t-Distribution and state the circumstances/conditions for their use.

[5 points]

2. Consider the loader performance data (in tons) in the following table:

LOADER A	LOADER B	LOADER C
66	65	68
66	66	67
68	120	66
65	65	67
67	68	66
66	67	65

2(A). Compute the data in the table using analysis of variance ***[15 points].***

2(B). Is there any difference in the performance of the loaders ? ***[5 points].***

3(A). Define class frequency ***[3 points].***

3(B). Using the data in Table 3(a), fill-in Table 3(b). ***[8 points].***

Table 3(a) Penetration rates for rotary drilling in hard rock

138	164	150	132	144	125	149	157
146	158	140	147	136	148	152	144
168	126	138	176	163	119	154	165
146	173	142	147	135	153	140	135
161	145	135	142	150	156	145	128

Table 3(b) *(NB: Fill-in this table using the data in Table 3(a).*

Length (mm)	**Class mark**	**Tally**	**Frequency**
118 – 126			
127 – 135			
136 – 144			
145 – 153			
154 – 162			
163 – 171			
172 – 180			
		Total =	

3(C). Plot the frequency diagram using the data in Table 3(b) ***[6 points].***

3(D). If

N = total number of observations
i = interval number
n_i = the number of observations in that interval,

what is the frequency in interval number i = 5 ? ***[3 points].***

4. At a mine, on the Copperbelt, management decided to investigate the performance of a supposedly advanced top-hammer drilling equipment from MI322 Hightech Company Ltd. The following data represent the measured performance y (in drilled meters/shift) of this equipment:

27.8, 24.3, 22.8, 26.0, 24.2

For these y data, calculate the variance assuming

(i) that the mean performance of this type of drilling machine is known to be $\eta = 25.0$ meters per shift.

[10 points]

(ii) that the mean performance is unknown ***[10 points]***

5. Monk Mining Company Limited intended to test the cross bit (X) and button bit (B) as one of the measures to improve their drilling productivity. The Company contracted MI322 Consulting firm to carryout the tests. Using randomized experiment, penetration rate of the two bits placed on a two-boom machine was obtained as shown in Table 4, below.

Table 4

Position in the fan	1	2	3	4	5	6	7	8	9	10	11
Bit type	X	X	B	B	X	B	B	B	X	X	B
Penetration rate	29.9	11.4	26.6	23.7	25.3	28.5	14.2	17.9	16.5	21.1	24.3

Using t-distribution as an approximation to the randomization distribution, discuss whether there is a significant difference in performance between the two bits.

[20 points]

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
MINING ENGINEERING DEPARTMENT

UNIVERSITY EXAMINATION - MAY 2000

MI-435 SURFACE MINE DESIGN

ANSWER QUESTIONS 6 and 7 and any other THREE QUESTIONS.
All Questions carry equal marks.
TIME: THREE (03) HOURS

Question 1 Write notes on development drilling under the following sub-headings:

- Definition of development drilling (5)
- Objectives of development drilling (5)
- Types of development drilling (5)
- Drill patterns employed in development drilling (5)

Question 2

a) With the aid of corresponding sketches, write notes on the Interpolation Techniques employed in the determination of mineral inventories. (5)

b) Following copper grades were determined from assays of cores obtained from a development drilling campaign:

Drill-Hole Number	Coordinates		Grade (%-Copper)
	Eastings	Northings	
DDH-1	3000	4400	1.75
DDH-2	3300	4900	0.90
DDH-3	2700	4200	1.30
DDH-4	2400	4500	0.65
DDH-5	2700	4900	1.85
DDH-6	3000	5300	1.92
DDH-7	3200	4900	0.85
DDH-8	2800	5800	1.65
DDH-9	2200	4900	0.85
DDH-10	2100	5400	1.05

Estimate the copper grades at points X (3000,4800) and Y (2600,5300), using:

i) Linear Interpolation techniques. (5)
ii) The inverse of the Distance Squared method of interpolation. (10)

Question 3

a) Using the notion of Circular Analysis, state and describe the major elements in Surface Mine planning and design pointing out reciprocal dependencies of various decisions made at each node. (10)

b) Write brief notes on the determination of a Mineral Inventory under following sub-headings:

- Definition of Mineral Inventory (5)
- Objectives of establishing a Mineral Inventory (5)

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
MINING ENGINEERING DEPARTMENT

UNIVERSITY EXAMINATION - MAY 2000

MI-435 SURFACE MINE DESIGN

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Question 4 a) Discuss the main factors that govern the choice of the method of opening-up a mineral deposit for surface mining. (10

b) List and comment on the main elements of capital trenches and give the recommended gradients for various haulage methods employed in surface mining. (10)

Question 5 Define the various levels and types of Mine Planning and with the aid of a suitable example, describe the main typical input data types /variables and outputs from the model. (20)

Question 6 a) With the aid of corresponding sketches, define and write notes on the use and significance of the following in Surface Mining:

- Types of Stripping Ratios (5)
- Break Even Stripping Ratio under Minimum Profit consideration (2)
- Cut-off grade (2)
- Ultimate Pit Design (UPD) or Ultimate Pit Limits (UPL) (2)

b) On the graph paper provided, plot the Stripping Curves for the case given hereunder:

- Maximum selling price	P = 6.5 mU/kg
- Total recovery along production line	a = 0.85
- Ore cost	K = 1.50 mU/tonne
- Waste cost	W = 1.95 mU/tonne
- Ore grade variation	d = 0.25...1.75% (5)

Comment on the Stripping Curves obtained. (4)

Question 7 a) Write notes on the application, merits and demerits of the Positive Moving Cone method in block model evaluation of ore bodies. (2)

b) Shown below is a tabulation of BEV's of corresponding blocks b (i, j) in a 2-D vertical cross-section of an ore body block model.

Given that the pit can be mined to a maximum slope angle of 1 block: 1 block on either side, you are required to draw the 2-D cross-section and determine the pit-outline with the maximum value on the section using:

i) The Positive Moving Cone method (3)
ii) The Dynamic Programming Algorithm (12)
iii) Comment on the results obtained in I) and II) above (3)

Show ALL THE STEPS employed in arriving at the answers.

GOOD LUCK!

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GOOD LUCK!

0	0	0	0	0	0	0	0	0	0	0	0
-1	-1	-1	-1	-1	+4	-1	-1	+4	+4	-1	-1
-1	-1	-1	-1	+3	+3	+3	+3	+3	-1	-1	-1
-1	-1	-1	+2	+2	-2	-2	+2	+2	-1	-1	-1
-2	-2	-1	-1	-1	-1	+3	+3	-1	-1	-2	-2
-2	-2	-2	-1	-1	+6	+3	-2	-1	-2	-2	-2

0	0	0	0	0	0	0	0	0	0	0	0
-1	-1	-1	-1	-1	+4	-1	-1	+4	+4	-1	-1
-1	-1	-1	-1	+3	+3	+3	+3	+3	-1	-1	-1
-1	-1	-1	+2	+2	-2	-2	+2	+2	-1	-1	-1
-2	-2	-1	-1	-1	-1	+3	+3	-1	-1	-2	-2
-2	-2	-2	-1	-1	+6	+3	-2	-1	-2	-2	-2

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS

MI 465/MM 571

MINERAL ECONOMICS/MANAGEMENT AND ECONOMICS

TIME: 3 HOURS
ANSWER: 5 QUESTIONS

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1. Outline some of the main sources of finance for a typical new mining project. Describe how the Stock Exchange can be used in raising the required capital? Why does the small-scale mining sector experience difficulties in raising capital especially from traditional financial institutions? (20 points)

2. Market conditions are characterised by the supply and demand conditions.

   (i) What factors influence the demand function of a product? (5 points)

   (ii) What do you understand by the term "market equilibrium price"? (5 points)

   (iii) What conditions arise if the price is lower than the equilibrium price? (5 points)

   (iv) Consider the following demand function:

   $$P = 940 - 48Q + Q^2$$

   P = Price of the commodity
   Q = Quantity of the commodity demanded at a given price.

   What is the price elasticity of demand at Q = 10 units? (5 points)

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS

MI 465/MM 571

MINERAL ECONOMICS/MANAGEMENT AND ECONOMICS

TIME: 3 HOURS
ANSWER: 5 QUESTIONS

---

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   What is the price elasticity of demand at Q = 10 units? (5 points)

3. What is a mineral policy? What key essential elements must a national mineral policy address? (20 points)

4. A piece of equipment for pollution control cost $840,000 to procure and has an estimated six year depreciable life. The salvage value is $120,000 at the end of six years.

   (i) What is depreciation? What factors affect depreciation? (5 points).

   (ii) Taking into account the salvage value, find the depreciation rate(s) for:

      (a) Straight-line method. (5 points)
      (b) Sum-of-digits method. (5 points)
      (c) In (a) and (b) above, determine the book values at the end of 3 years? (5 points)

5. For the following entries of Stenick Mining Corporation as at 31st March 2000, prepare the following:

   (i) A balance sheet showing current assets, fixed assets, current liabilities, fixed liabilities, other assets, capital stock and retained earnings. (10 points)

   (ii) What is Stenick's working capital and what does the value indicate? (10 points)

6. The management of a mine is considering a proposal from a consulting firm to introduce a new mining technology. The consults claim that their program will result in savings of $7 million per year over a planned 5-year life of the project. Immediate costs to implement the project are $12,000. Projected annual operating costs will be $4,000. The company's minimum acceptable rate-of-return is 6%. Is it justifiable for the mine to introduce new mining technology? (20 points)

Entry	Amount
Cash	816,800
Notes payable	200,00
Marketable securities	2,535,145
Accounts receivable	2,605,701
Accounts payable	1,144,942
Salaries and wages accrued	163,045
Notes receivable	662,761
Loans to officers and employees	10,900
Inventories	6,849,403
Prepaid expenses	155,035
Corporate taxes payable	87,525
Dividends payable	246,240
Investments in affiliated companies	286,081
Bonds payable, 5%, due in ~~1999~~ 2005	497,000
Land, cost	1,000,000
Buildings, cost	3,075,725
Accumulated depreciation on buildings	1,520,751
Machinery, cost	7,874,177
Accumulated depreciation on furniture and fixtures	277,243
Retained earnings	5,772,782
Accumulated depreciation on machinery	3,954,200
Capital stock common (125,000 shares)	12,500,000
Furniture and fixtures, cost	492,000

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
MI475 – Mine Environment
SECOND SEMESTER EXAMINATIONS
MAY 2000

INSTRUCTIONS : Answer all questions

TIME: THREE HOURS

1. (a) Fill in the blank spaces in the table for the composition of atmospheric air

Components	% by Volume	% by Mass
Oxygen(O_2)		
Carbon Dioxide(CO_2)		
Nitrogen(N_2)		
Argon (Ar) and other inert gases like krypton, neon, xenon, etc.		
Total =		

(2.5 marks)

(b) Fill-in the blank spaces in the table for impurities in mine air

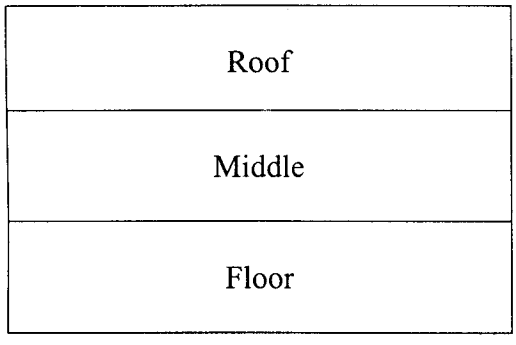
GAS	MOLECULAR MASS	COLOUR	SMELL	TASTE	SPECIFIC GRAVITY	MAXIMUM ALLOWABLE CONCENTRATION
Oxygen					1.105	-
Nitrogen					0.967	-
Carbon dioxide				-	1.529	
Carbon Monoxide				-	0.972	
Hydrogen sulphide					1.175	
Sulphur dioxide				-	2.264	

(5 marks)

(c) If you are a supervisor over coal miners in underground workings,

(i) Indicate (by painting) a cross-section of a drift where you would test for carbon monoxide, and

(ii) State reasons for your selection.



A drift in a coal mine
(Paint the selected section)

(2.5 Marks)

(d) The following are observed pressures and volume flow rates for a fan running at 750 rpm at an air density of 1.23 kg/m^3.

P (pa)	Q (m^3/s)
250	1450
290	2300
3 ~~225~~	~~4800~~ 2850
300	4300
225	5700
100	6700

What would be the operating point if the fan is used to ventilate a mine with a resistance of ~~0.234~~ Ns^2/m^8

(10 marks)

$5.556 * 10^6$

2. (a) Air blast is the term used to describe the air vibrations generated by blasting operations. State the :

(i) THREE factors WITHIN THE CONTROL of the mine operator
(ii) THREE factors OUT OF CONTROL of the mine operator.

(3 marks)

(b) Acid Mine/Rock Drainage involves chemical and biological phenomena. With the help of a diagram, describe the THREE STAGES in the process of its formation.

(12 marks)

(c) With the help of a sketch, indicate factors which would determine whether discharge to the environment would take place.

(5 marks)

3. (a) Fill-in the blank spaces in the table for impurities in mine air

TYPE OF MINE GAS	EXAMPLES
Non-toxic but explosive gases	
	Carbon dioxide, radon and its daughter products
Acutely poisonous gases	
Vapours of water	
	Fog due to condensed water-vapour or mist for fine oil droplets from drills, etc.
Solid impurities	

(6 Marks)

(b) (i) State the THREE properties of dust affecting the development and severity of lung diseases. (3 marks)

(ii) What is the most dangerous particle size range? (1 mark)

(iii) Define terminal settling velocity (2 marks)

(iv) Derive an equation for streamline motion (8 marks)

4. There are three splits A, B and C in parallel. Their resistances are 0.24, 7.48 and 0.61 Ns^2/m^8 respectively. The desired volume flow rates in the splits are:

AIRWAY	VOLUME FLOW RATES (m^3/s)
A	40
B	10
C	25

(a) In order to evaluate the relative merits of three methods of establishing the desired flow rates i.e by regulation, by booster fan(s) or by reducing the resistance. Calculate:

(i) The position and size of regulator(s) required (2 marks)
(ii) The position, volume flow rate and pressure of the booster fan (6 marks)
(iii) The split in which the resistance is to be reduced (2 marks)
(iv) The total air power involved in each case (3 marks)

(b) Discuss the radial flow fans indicating the principle of inducing airflow and blade configurations and their respective characteristic curves. (7 marks)

5. The following parameters are known about five parallel airways:

AIRWAY	WIDTH(m)	HEIGHT(m)	LENGTH(m)	FRICTION FACTOR (NS^2/m^4)
1	2.4	3	560	0.009
2	3	3	1210	0.009
3	2.4	3	700	0.015
4	3.7	3	1570	0.007
5	3	3	1400	0.006

Calculate the air volume flow rate in each airway if the total airflow is 100 m^3/s. Draw the mine characteristic curve and determine the pressure required to send a total of 85 m^3/s through the mine. Neglect shock losses.

(20 marks)

GOOD LUCK!
END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SECOND SEMESTER EXAMINATION - MAY 2000

MI515 ROCK MECHANICS II

TIME: 3 HOURS FULL MARKS : 100

INSTRUCTIONS: ANSWER QUESTIONS 1 AND ANY OTHER FIVE
TOTAL QUESTIONS TO BE ANSWERED, SIX

NOTE: Graph Paper, Tracing Paper and Lambart Equal Area Projection Chart are supplied.

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1. (a) Explain, using a simple diagram, the Mohr-Coulomb criterion of rock failure. Name, and give equations for the properties that can be determined using this failure criteria. (10 Marks)

(b) It is desired to construct a water reservoir in a rock which yielded following results in a trixial compression tests.

Test	6_3(Mpa)	6_1(Mpa)
1	1.0	10
2	5.0	30
3	10.0	50

What value of pore water pressure (Pw) will cause fracture of the reservoir rock for the stress condition: $6_3 = 9$ Mpa and $6_1 = 34$ Mpa (10 Marks)

2. (a) Discuss the "tributary area method" of estimating average state of axial stress used in the design of mine pillars. Explain its validity over any other method of pillar design known to you. (8marks)

(b) A flat lying coal seam 4m thick and 100m below ground surface has been planned to mine with 6.0m rooms and 8.0 square pillars, over the lower 3.5m of the seam. Determine the factor of safety (FS) of the pillar and comment on the stability of the pillar for the above layout. The unit weight of the overburden rock is 25KNm-3. The strength of the square pillars of width Wp and height h, is given by

$$S = 7.5 \times h^{-0.66} \times Wp^{0.46}$$ (8 marks)

Where S is in MPa and h and Wp in m.

3. (a) What are the possible modes of failure for rock slopes? Describe with the help of diagrams how these slopes may be prevented against failure? (8 marks)

(b) A Small Scale Mining Company wishes to mine marble from an open-pit and has approached you for the following advise:

(i) Factors on which the stability of the individual bench (in open-pit mining) depend and (4 Marks)

(ii) Angle at which a block of marble, 1m3 having a mass of 2.25 tonnes will begin to slide over the other marble block (which is fixed) if he coefficent of fiction between two surfaces is 0.85 (take value of g = $10N/S^2$ (2 Marks)

(iii) How much would you charge from your client to provide the above consultancy? Give the amount that you will charge (in US dollars) separately for each service for the above service (2 Marks)

4. (a) What is meant by 'Equal Angle projection' and what are its advantages? (8 marks)

(b) Plot on the stereographic projection the 'great circles' and the 'poles' to the planes 156/32 and 304/82. What is the 'acute angle' between these planes? (8 marks)

5. (a) With reference to Geomechanics classification of rock mass. what is meant by RMR and Q? Describe briefly the procedure to determine these values. (8 marks)

(b) For a tunneling site, the rock mass characteristics were found as follows:

R Q D = 90%; Jn = 4.5; Jr = 4; Ja = 4; Jw = 1; SRF = 1

From the above, estimate the value for RMR and comment on the rock type. (8 marks)

6. (a) Discuss the various possible sources of ground stress and describe a method to measure such in situ stress in rock. (8 marks)

(b) From Question number 3b (ii), how high will these marble blocks be stacked over one another until the bottom most block gets crushed? The uniaxial compressive strength of marble is 50 Mpa.

7. (a) What are the different types of mining induced subsidence that may occur? What type of subsidence generally takes place in Zambian Copperbelt? Describe in detail the caving mechanism of such subsidence (8 Marks)

(b) A 4m thick seam is being mined at a depth of 400m. There is a milling factory above that mine workings in which a 8m long lathe machine is installed. Determine the possible 'drop' (interms of gradient) in the lathe machine if 90% subsidence is expected due to mining (8 Marks)

The End

THE UNIVERSITY OF ZAMBIA
UNIVERSITY EXAMINATIONS

MI 562: INVESTMENT ANALYSIS

TIME: 3 HOURS
ANSWER: ALL QUESTIONS

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1. Outline concisely the main sources of finance for a typical new mining project. Describe how the Stock Exchange can be used in raising the required risk capital? (20 points)

2. Discuss in detail the major risks in mineral investment projects. (20 points)

3. Investment decisions are influenced by the country's business environment. Discuss what these main factors are and how they affect the investment climate. (20 points)

4. A mining company has made the following cash flow estimates for its existing mining plan (in constant time 0 dollars).

	Year 1	Year 2	Year 3	Year 4-10
Revenue	100,000,000	150,000,000	200,000,000	300,000,000
Operating cost	50,000,000	70,000,000	90,000,000	130,000,000
Capital expenditure	60,000,000	30,000,000	20,000,000	10,000,000
Taxes	-	10,000,000	40,000,000	80,000,000

There is also an alternative plan which requires an additional capital expenditure of $50 million in year 1. This will be spent on extra equipment which will last up to and including year 10 and then be scrapped. With this equipment, from year 2 onwards, the revenue will improve by 10 percent and operating costs will increase by 5 percent. Taxes will be zero for years 1 and 2 and thereafter increase to $5 million in year 3 and $92 million per year for years 4-10.

Determine the after-tax cash flow distribution associated with:

(i) The existing plan (5 points)
(ii) The alternative plan (5 points)
(iii) If the cost of capital is 10%, which alternative is more favourable? (10 points)

5. An investment project has a capital expenditure of $100 million. Management has decided that capital structure will be:

- 50% debt
- 20% preferred stock
- 30% common stock

Sources of funds are as follows:

- Bonds, face value $1,000, interest at maturity in 18 years. The company will net $900/bond (issuing expenses plus discounts = $100).
- Preferred stock: face value $100, issuing expenses $5, dividend at 10%.
- Common stock: market price $45, net proceeds to the company $40, dividend announced $3.70, expected rate of growth 4%.

It the tax rate is 55%, calculate:

(i) The cost of debt (5 points)
(ii) The cost of preferred stock (5 points)
(iii) The cost of common stock (5 points)
(iv) The weighted average cost of capital for the project (5 points).

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

FINAL EXAMINATION - MAY 2000

MM 205 - INTRODUCTION TO METALLURGY AND MINERAL PROCESSING

TIME: THREE HOURS

READ THE INSTRUCTIONS:

ANSWER: PART A - NUMBER ONE
PART B - THREE QUESTIONS
PART C - TWO QUESTION

PART A

1. State briefly and clearly the following terms:

Ferrous and Non-ferrous metals
Reactive metals
Ore
Run of Mine ore (ROM)
Liberation
Flowsheet
Cementation
Poling
Dead roasting
Hydrophilic

PART B. ANSWER ONLY THREE QUESTIONS

2. (a) What do you understand by countercurrent and co-current operation in a metallurgical process unit. Give a simple example from metallurgical operation.

(b) What do you understand by heterogeneous reaction in a metallurgical process.

(c) What do you understand by short-circuiting of material in a metallurgical process unit in a continuous operation.

(d) Give reasons why many metallurgical operation are carried out in stages. Explain your answer briefly.

(e) Metallurgical operations involve chemical reactions. What is meant by rate-determining step in these metallurgical operation.

3. (a) Explain the importance of grade and recovery relationship in metallurgical processes.

(b) Give a very brief description of the common extraction processes for the production of copper metal.

(c) What is meant by, bulk density and effective density in metallurgical process. How is bulk density and specific gravity calculated.

(d) Discuss briefly the following:
equivalent diameter, spherical diameters, projected area diameter, equivalent sieve aperture diameter, fall diameter.

(e) Describe the various stages of mineral processing by using the block diagram. Explain briefly in simple terms equipment or method used to achieve desired results in each stage.

4. (a) Discuss in simple terms the different types of the breakage mechanism by which the mineral ore may be liberated in the comminution process. Illustrate with a sketch.

(b) Write short but clear notes on the principal used in classification, mention key terms like, terminal velocity, elutriation, free settling, hindered settling and settling rate.

(c) Describe in simple terms froth flotation.

(d) Name three primary fuels, three secondary fuels and three alternative fuels.

(e) Pyro-metallurgical process are usually carried out in three stages briefly state and explain these stages.

5.(a) What fuels can fulfill both these two functions.

(b) The rank of coal shows its degree of coalification. What can you say about the carbon content, the volatile content, ash content and the moisture content with progressive coalification.

(c) Describe briefly how purification and concentration of a leach solution can be done by solvent extraction.

(d) Draw a rough flowsheet for the hydrometallurgical extraction of copper using the sequence: leaching – solvent extraction – electrowinning. Indicate the main process streams with arrows and give the name of the feed or product that form each of these streams.

(e) Why are processes such as leaching and solvent extraction carried out in stages.

PART C. ANSWER ANY TWO QUESTIONS

1. (a) Define the following terms:
(i) Crystal (ii) unit cell (iii) mineral (iv) rock.

(b) With the help of sketches and geometrical relations describe the features of each of the seven crystal systems.

2. (a) Name the eight mineral classes and give one example in each case.
(b) Describe how the silicate minerals are classified on the basis of the arrangement of the silica tetrahedra.

3. (a) Name three ways in which rocks are formed.

(b) Describe the processes that lead to the formation of igneous rocks or sedimentary rocks.

(c) Describe how igneous or sedimentary rocks are classified.

END OF THE EXAMINATION MM 205

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

FINAL EXAMINATION - MAY 2000

MM 205 - INTRODUCTION TO METALLURGY AND MINERAL PROCESSING

PAPER II PRACTICAL

Time: 3 Hours

INSTRUCTIONS: ANSWER ALL THE QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.

~~Section A~~

(1) Identify the basic elements of symmetry present in crystal models a,b,c and d. Classify the models on the basis of these elements of symmetry.

(2) Describe the properties of the seven mineral specimens (e,f,g,h,i,j.k) and identify the minerals. Write the formula of each mineral and identify the group to which it belongs.

(3) Use the given rock specimens (L,M,N,O) to answer the following questions.

(a) Describe the texture and mineralogical composition.

(b) Identify the rock units which the specimens represent.

(c) Discuss the economic value of the rock units represented by the specimens.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SHOOL OF MINES
ETALLURGY AND MINERAL PROCESSING DEPARTMENT
FINAL EXAMINATION - MAY/JUNE 2000

MM332 CHEMICAL THERMODYNAMICS II

IME: 3 HOURS
NSWER: FIVE QUESTIONS

(a) The concentration of sulphur in pig iron after desulphurisation with a basic slag at 1743 K at rious intervals of time is as follows:

Time in seconds	: 0	540	1200	2400	3840
Conc. of sulphur, Kg/m^2 of interface	: 87.1	57.4	30.2	10.0	2.75

Show that the desulphurisation is a first order reaction.

) Show that the time required for the reaction of any given fraction of the material initially esent is independent of the initial concentration for a first - order reaction, but varies with the tial concentration for a second - order reaction.

During carbon dioxide arc welding, carbon and oxygen from the CO_2 enter into solution in iron at 1600°C (1873K) according to

$(CO_2) = [C]_{Fe,wt\%} + 2\,[O]_{Fe,wt\%}$;

$G^\circ = 183,489 - 47.70\,T$ Joules

The final oxygen content of the weld is represented by

$$\log [\%O] = -\frac{6320}{T} + 2.734.$$

Calculate the equilibrium carbon content of the weld if the partial pressure of CO_2 is 1 atm ($101325 N/m^2$) assume the following interaction parameter values :

$e_c^c = -0.13$, $e_o^c = -0.1$, $e_o^o = -0.2$

and $e_c^o = 0.22$.

For the change of standard state $V_{(s)} = V_{(1wt\% \text{ in } Fe)}$

$G^\circ = -15,480 - 45.61\,T$ Joules

Calculate the value of$\tilde{a}^{\circ}_{v}$ at 1600°C. If a liquid Fe-V solution is equilibrated with pure solid VO and a gas containing Po_2 =4.72 x 10^{-10} atm, calculate the activity of V in the liquid solution (a) with respect to solid V as the standard state, (b) with respect to liquid V as the standard state, (c) with respect to the Hernrian standard state, and (d) with respect to the 1 wt% in iron standard state.

se the following additional information

$V_{(s)} + O_2 = 2VO_{(s)}$ $\ddot{A}G^{\circ} = -861{,}485 + 150\ T$

$_{(s)} + V_{(l)} = \ddot{A}H_{(f)}$ 17,573J at 2188K

$_{(s)} = V$ $\ddot{A}G^{\circ} = -15{,}481 - 45.6\ T$

omic masses : V = 50.95 ; Fe = 55.85

(a) The EMF of the cell

$Ag_{2)}|AgCl_{(s)}|Cl_2$(1 atm),Pt

is found to be
$\mathring{a}$(volts) = $0.977 + 5.7 \times 10^{-4}(350-t) - 4.8 \times 10^{-7}(350-t)^2$

in the temperature range t = 100° C to t = 450°C. Calculate the value of $\ddot{A}c_p$ for the cell reaction.

) At 25°C, the EMF of the cell

$Pb|PbCl_2|Hg_2Cl_2|Hg$

is + 0.5357 volt and the temperature coefficient is 1.45 x 10^{-4} volt/degree. Calculate:

(i) The maximum work available from the cell at 25°C per mole of Pb reacted

(ii) The entropy change of the cell reaction

(iii) The heat absorbed by the cell at 25°C per mole of Pb reacted when the cell is operating reversibly.

The Hg electrode in the cell is replaced by an Hg-X alloy in which X_{Hg}=0.3 and where X is inert. The cell EMF at 25°C is found to increase by 0.0089 volt. Calculate the activity of Hg in the alloy at 25°C.

A galvanic cell is set up with electrodes of solid aluminum and solid aluminum-zinc alloy and an electrolyte of a fused $AlCl_3$-NaCl mixture. When the mole fraction of Al in the alloy electrode is 0.38, the EMF of the cell is 7.43 millivolts at 380°C, and the temperature coefficient of the EMF is 2.9×10^{-5} volt/degree. Calculate:

a) The activity of Al in the alloy
b) The partial molar free energy of mixing of Al in the alloy
c) The partial molar enthalpy of mixing of Al in the alloy

Two hypothetical metals, A and B, whose melting-points are 700°C and 500°C respectively, are miscible in all proportions in the liquid state and are partially soluble in one another in the solid state, the maximum solubilities being 5%B and 25%A by weight. The solubilities are 2% and 5% respectively at O°C.

The two metals form a compound A_2B which melts at 750°C and in which neither metal is soluble. The atomic weights of A and B are 30 and 50 respectively. Eutectic are formed at 22% and 60% by weight of B and at temperatures of 450° and 300°C respectively.

(a) Construct and label the equilibrium diagram, assuming that all the lines on it are straight.
(b) Find, in an alloy containing 45% by wt. of A:

(i) Temperatures at which melting begins on heating and at which melting is complete and
(ii) the composition and distribution of the phases at 100°C.

The following conjugate mixtures are found in the Pb-Ag-Al system at 750°C:

Top phase			Pb phase		
Pb	Al	Ag	Pb	Al	Ag
0.1	83.5	16.4	99.5	0.3	0.2
0.2	71.7	28.1	99.4	0.3	0.3
0.4	56.3	43.3	99.0	0.1	0.9
0.8	33.8	65.4	98.0	0.1	1.9
1.8	20.2	78.0	96.0	0.1	3.9

(a) Construct the miscibility gap of the ternary system Ph-Al-Ag at 750°C. Draw in the tie lines.
(b) A Pb bullion contains 25% Ag. Determine the content of the desilverised bullion after a first addition of 10 wt % Al and a second addition to the first stage desilverised Pb of 7 wt % Al.

END OF EXAMINATION 332 PAPER II

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS

SCHOOL OF MINES

DEPARTMENT OF METALLURGY AND MINERAL PROCESSING

First Semester

MM 411 Mineral Processing I

Answer questions 1 and any other four, but keep your answers brief and to the point.

Relative weight of each question indicated in brackets.

Time: 3 hours

Question 1

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

- Work index
- Grindability
- Mesh-of-grind
- Set and gape of a crusher
- Non-Newtonian fluid
- Classification
- Terminal velocity
- Free settling
- Hindered settling

[20%]

Question 2

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

(ii) Why do modern jaw crushers use curved swing-jaw plates?

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

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

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

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

[20%]

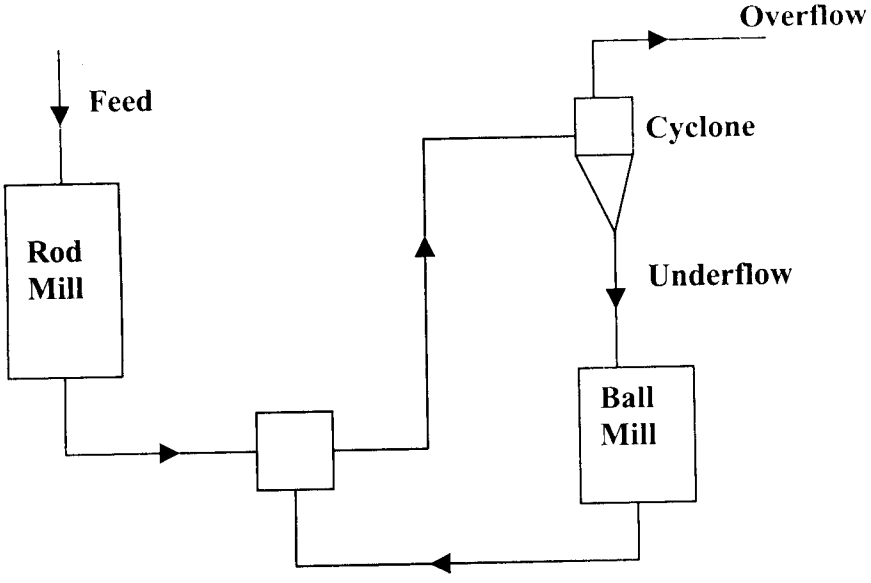
Question 3

(a) Why are rod mills usually run in open circuit and ball mills in closed circuit with a cyclone?

(b) Describe the grinding action of a ball mill indicating the various zones that can be distinguished.

(c) What are the advantages of autogenous mills on suitable ores over conventional circuits?

(d) In a rod mill - ball mill - cyclone circuit shown in the figure below, the feed rate is F t/h, circulating load is B t/h, cyclone feed is C t/h and the cyclone product is O t/h. Samples of the rod mill feed, rod mill discharge, cyclone feed, cyclone underflow, cyclone overflow and ball mill discharge were taken and screen analysed, and the percentage passing 75 μm were f, r, c, u, o and b respectively.



Rod mill – Ball mill – Cyclone circuit

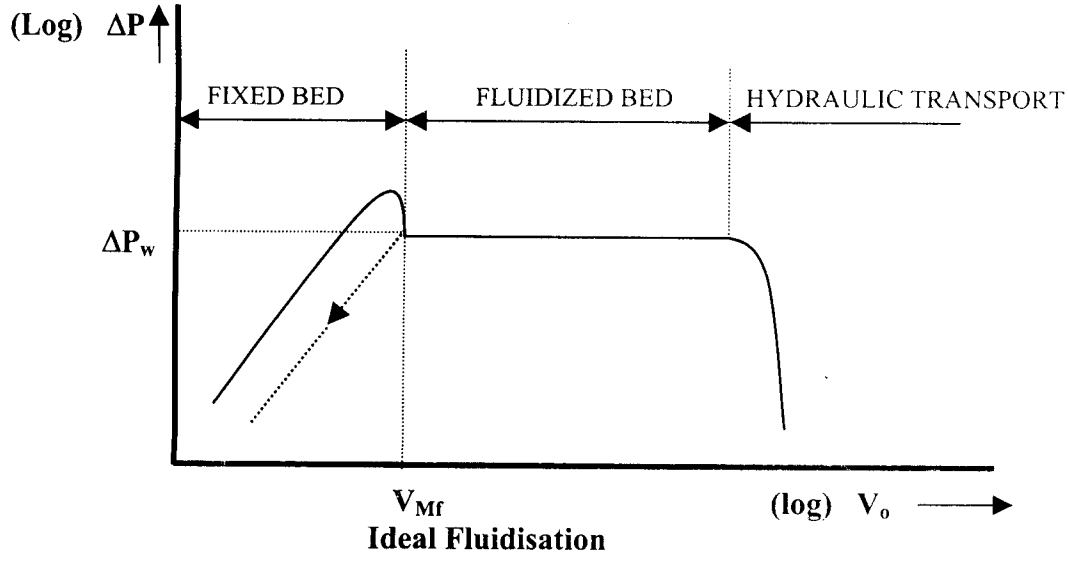
Determine the expression of the circulating load as a percentage of new feed.

If F = 1000 t/h, f = 10%, r = 32%, c = 25%, u = 30%, o = 55% and b = 40% calculate the circulating load as a percentage of new feed.

[20%]

stion 4

al fluidisation can be represented graphically on a double-logarithmic plot as follows:



Ideal Fluidisation

tate what the following parameters stand for: ΔP, ΔP_w, V_o, and V_{mF}.

When is the bed said to be in a state of incipient fluidisation and in a fluidised state?

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y which dimensionless groups can the type of fluidisation be characterised and what iterion is used in this?

Rod mill – Ball mill – Cyclone circuit

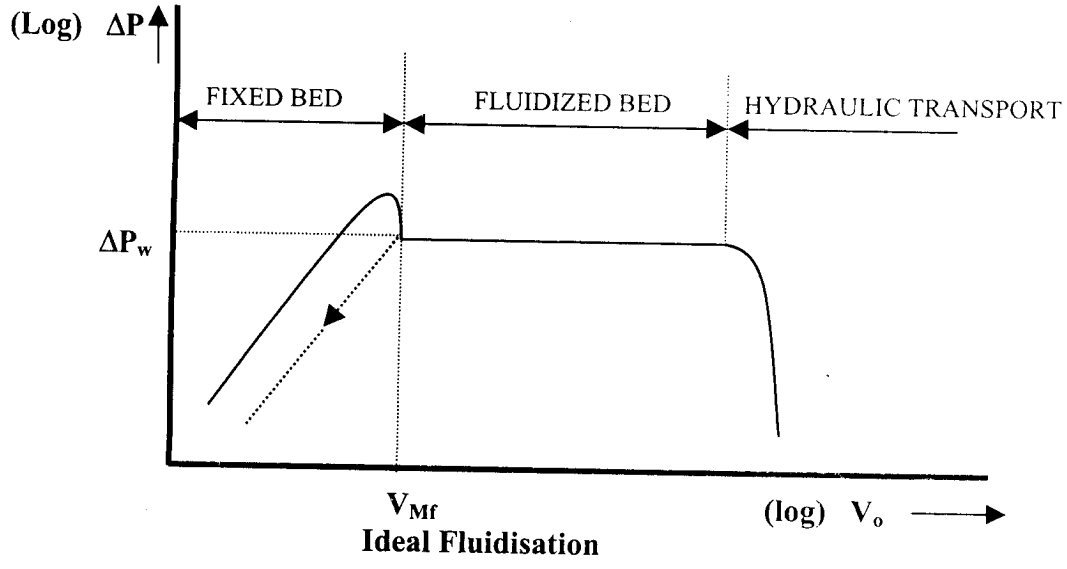
Determine the expression of the circulating load as a percentage of new feed.

If F = 1000 t/h, f = 10%, r = 32%, c = 25%, u = 30%, o = 55% and b = 40% calculate the circulating load as a percentage of new feed.

[20%]

stion 4

l fluidisation can be represented graphically on a double-logarithmic plot as follows:



Ideal Fluidisation

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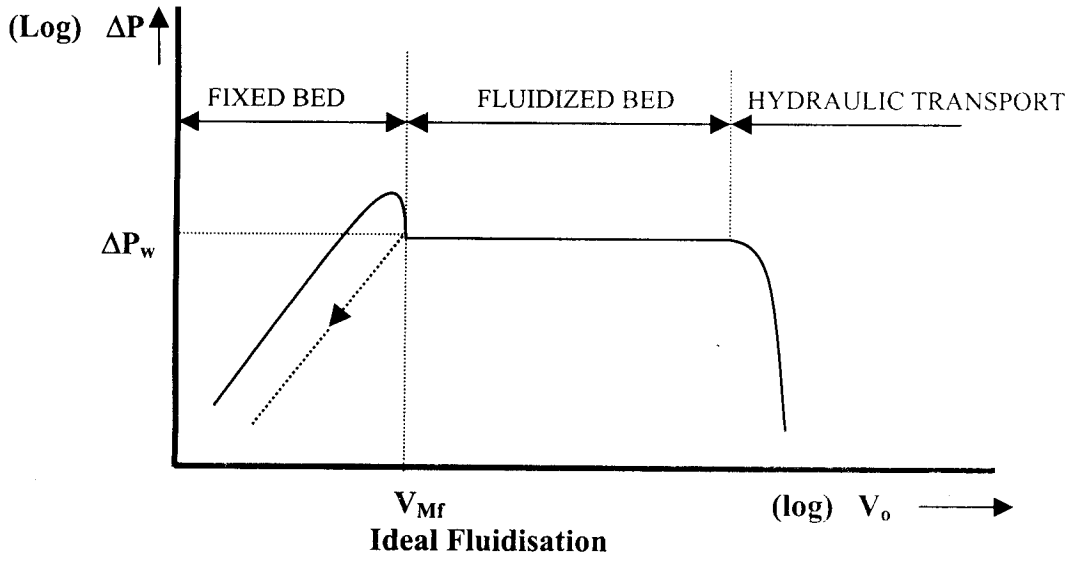
Question 4

Ideal fluidisation can be represented graphically on a double-logarithmic plot as follows:



Ideal Fluidisation

(a) State what the following parameters stand for: ΔP, ΔP_w, V_o, and V_{mF}.

(b) When is the bed said to be in a state of incipient fluidisation and in a fluidised state?

(c) Ideal fluidisation, as represented by the fluidisation curve above, is not always realised. Two phenomena that often occur in practice are channelling and slugging. Explain the underlined terms.

(d) Liquid-solid systems generally exhibit particulate fluidisation where as gas-solid systems, on the other hand, usually shows aggregative fluidisation. What is particulate fluidisation and aggregative fluidisation? Explain why the two types of fluidisation are different.

(e) By which dimensionless groups can the type of fluidisation be characterised and what criterion is used in this?

[20%]

Question 5

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

(b) What do you understand by the separating size of a hydrocyclone?

(c) Hydrocyclones have replaced mechanical classifiers in most modern grinding plants. What are the advantages of hydrocyclones over mechanical classifiers?

(d) 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.

(ii) The separating size can be adjusted with overflow weir bars. Describe what happens to the separating size by either lowering or raising the overflow weir bars.

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

[20%]

Question 6

(a) What is understood by the 'fall diameter' of a particle and what is understood by its 'quartz diameter'?

(b) What do you understand by the 'free settling ratio' of two minerals and what do you understand by their 'hindered settling ratio'?

(c) Explain briefly, but clearly, why hindered settling ratios are larger than the corresponding free settling ratios.

(d) The relationship of Richardson and Zaki is written as follows:

$$\frac{v_h}{v_t} = \varepsilon^n$$

(i) What do the various symbols, used in this equation, represent?

(ii) For what type of particles is this relationship valid?

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

DEPARTMENT OF METALLURGY/MINERAL PROCESSING

FINAL EXAMINATIONS MAY 2000.

MM412 MINERAL PROCESSING II

ANSWER QUESTION 1 AND ANY OTHER FOUR.
TIME 3 HOURS

1. Briefly explain the following terms in Mineral Processing. Each question carry 2 marks, total 20.

- Reverse flotation
- Hydrophobicity
- Solid handling capacity of a thickener
- floatability
- Suspensions in Heavy medium separation
- Collectors
- Modifiers/Regulators
- Dewatering
- Optimum mesh of grind
- "pinning effect" in high-tension separation.

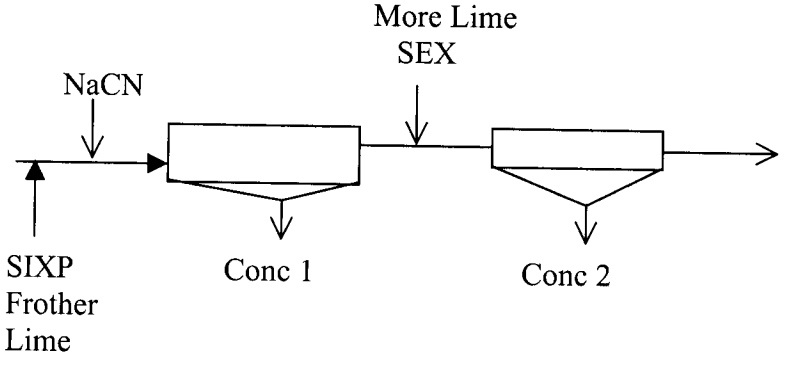
2. (a) What is the role of collectors and name the various collectors you know to be used in both oxide and sulphide minerals? How does chain length of the collector affect the hydrophobicity, selectivity and solubility if the collector?(5)

(b) What is the importance of laboratory flotation tests and how is it carried out on a new deposit. What are most important steps in this procedure?What are the main reasons of carrying out Pilot Plant testwork (4)

(c) Distinguish a simple flotation circuit from a Rougher-Scavanger-Cleaner circuit. (2)

(d) What are the major consideration in flowsheet design and relate these to the recovery and the grade of the minerals of interest. (2)

(e) How would you carry out a flotation of the ore shown below, by explaining the role of each reagent: (6)



Ore contains the following minerals:
Chalcopyrite, Bornite, Chalcocite, Oxidic Cobalt minerals
Cobaltiferrous Pyrite, Carrollite, Mica, Azurite.

(b) What kind of flotation is referred to above? What would be the other alternative approach, which will give, concentrates 1 and 2. (1)

3. (a) Briefly explain the differences between diamagnetism, paramagnetism and ferromagnetism. Using a rough diagram, show how the intensity of magnetism varies in relation to the applied magnetic field for each of these three groups of behaviour. (4)

(b) Draw a working diagram of an induced roll magnetic separator in operation and briefly give an example how it works. For what purposes is this widely used? (6)

(c) What is the main advantage of wet high-intensity magnetic separators over dry-high intensity magnetic separators? (3)

(d) What factors limit in practice the intensity of the applied field in magnetic separation equipment? (3)

(e) Apart from increasing the intensity of the applied field, what else can be done to achieve a large magnetic force upon the particles to be separated. How is this done in most modern magnetic separation? equipment. (4)

4. (a) Draw a vertical cross-section of a thickener in operation, showing and naming its important parts and the various zones that can be distinguished.(6)

(b) What are the functions of the rakes in a thickener? Briefly explain the circumstances that would necessitate raising the rakes and Subsequently lowering of the rakes. (4)

(c) What circumstances would necessitate recirculation of the thickener underflow and how does this affect the operation of the thickener? (4)

(d) The main design parameters of a thickener are its surface area and its depth. What quality does the surface area and the depth control? (2)

(e) Describe briefly the differences between 'coagulation' and flocculation. (4)

5. (a) Why is the disposal of tailing very important in any given mineral? processing operation? What factors play a role in determining the nature of the disposal of tailing. (8)

(b) Draw cross sectional view of the upstream tailings dam and describe how it is constructed using a central line and subsequently cycloning? (6)

(c) What are the main advantages of water reclamation.

With a diagram, show how the downstream method of tailing dam differs from upstream. What is the main drawback in this method?(6)

6. (a) Modelling of flotation processes requires the knowledge of hydrodynamic and surface forces in bubble-particle interaction. Define flotation in terms of the probability (P) of a particle being collected by a bubble in the pulp phase and give its simplified form for fine particles. (6)

(b) Draw a detailed diagram of a standard flotation column labelling all important parts. Briefly explain how the columns differ in their operations from the ordinary cell. (6)

Compare the operation of a Davcra cell to that of Flotation column And point out their similarities.(3)

(c) Show a detailed diagram of an Hallimond tube and explain how it functions and how Data obtained could be used to determine the recovery of the mineral floated. (5)

7. (a) What is the principle of heavy medium separation and what are the main advantages of these methods as compared with other gravity separation processes?(4)

(b) Name the various heavy liquids used in the laboratory and discuss their main drawbacks in industrial applications. Give examples of suspensions used in industry, mentioning the most important properties, which are required to be met. How are these recovered for re-use?(6)

(c) Draw a functional diagram of a Wemco separator and explain it effects the separation of the floats from the sinks.(6)

(d) How are laboratory testing done to determine the suitability of heavy medium separation and how are results interpreted? (6)

END OF MM 412 EXAMINATION

UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

FINAL EXAMINATION – MAY 2000

MM415 – MINERAL PROCESSING FOR MINING ENGINEERS

TIME: THREE HOURS

ANSWER NUMBER ONE AND ANY OTHER 4 QUESTIONS

1. Explain briefly and clearly the following terms as used in mineral processing:

Optimum mesh of grind
Middling fraction
Free - settling of two minerals
d_{50}
Scavenger circuit
Reduction ratio
Reverse flotation
Jigging
Enrichment ratio
Stockpile live capacity and angle of repose

2.

(a) Calculate the power required for a typical copper ore milling facility that has a design capacity of 1500 t/hr with the work index of 25 kW-hr ton. The primary crusher is a 3500mm gyratory designed to operate at 30mm open side setting. Feed to be direct from the conveyor belt. The desired product size is such that p is 25mm. The feed is 80% passing size three-quarter that of gyratory crusher feed opening.

(b) Give a simplified statement of the three hypotheses on energy consumption in comminution as proposed respectively by Kirk, Von Rittinger and Bond. Indicate the usual ranges of particle sizes in which these hypotheses are valid.

(c) Give a concise explanation on the effect on the product size of the following key parameters:

(i) grinding media
(ii) liners
(iii) speed of the grinding mill

(d) Explain and illustrate graphically the relations between:

(i) grinding mill capacity
(ii) cost of grinding
(iii) power
(iv) the degree of fineness

3(a) Discuss briefly screen performance and major factors that influence the choice of industrial screen to be used.

(b) Explain with illustration the function of hydro cyclone and its classification mechanism.

(c) On the basis the data given below for a rod milling operation calculate the circulating load in the grinding circuit. Draw this flowsheet.

feed to rod mill = 80t/hr (dry weight basis)
rod mill discharge = 70% solids
cyclone feed = 50% solids
cyclone overflow = 35% solids
cyclone underflow = 85% solids

(d) What are the advantages of the hydro cyclones over mechanical classifiers.

4. (a) Briefly describe in clear terms the process of flotation and explain the role of the different chemical reagents used.

(b) What is the importance of pulp potential and pH in froth flotation.

(c) Explain the role of rougher, scavenger, cleaner and re-cleaner cells in the flotation circuit.

(d) Briefly describe the different types of the flotation machines (cells).

5. (a) Write short and precise notes on ore handling and storage strategies in mineral processing.

(b) What is dewatering, describe, in fair details the major industrial methods used for dewatering.

(c) What are the factors involved in tailings dam construction. Illustrate with sketches.

(d) Indicate with the aid of a flowsheet dewatering stages and the points at which water is recycled in mineral processing. What factors determine water recirculation

6.(a) What do you understand by gravity separation and name two methods used to accomplish gravity separation.

(b) Explain briefly the requirement of the solid particles to be used as a medium in heavy media cyclones.

(c) Write short clear notes on heavy medium separation as used in the coal industry.

(d) How do you define recovery efficiency during coal washing.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – MAY 2000

MM422

PHYSICAL METALLURGY II

E: THREE HOURS

WER: ALL THE QUESTIONS

Single crystals are very much weaker than they should theoretically 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 polycystals lead to higher yield strengths than those of single crystals?

) What feature of a binary phase diagram is essential in determining if any of the alloys in the system are capable of precipitation hardening?

) Why is it preferable to precipitation-harden alloys such as Al-4.5%Cu first by quenching to a low temperature and then reheating to the ageing temperature rather than by quenching directly to the ageing temperature?

ne Fe-rich end of the Fe-Fe_3C phase diagram is attached.

) For an Fe-1.1w/oC alloy, determine the microconstituents present and their relative amounts at a temperature just below the eutectoid temperature.

) Compare the microstructures that would be obtained if the alloy in part (a) were
(i) Austenitised and slowly cooled to temperature 1.
(ii) Austenitised and slowly cooled to temperature 2.
(iii) Isothermally transformed at temperature 3.
(iv) Austenitised and quenched in ice-cold water.

) For the decomposition of austenite to pearlite, it can be shown that the fraction of austenite transformed (f(t)) is related to the nucleation rate (N) and the growth rate (G) by the following expression:

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

If N=1000 $cm^{-3}s^{-1}$ and G=$3x10^{-5}$ cm s^{-1}, what is the time required to obtain 50% transformation?

) What is the Pilling-Bedworth rule?

) A scratch through chromium-plated steel rusts quickly but a scratch through the surface layer of galvanised steel does not. Why the difference?

In the prevention of corrosion, organic coatings such as paints and varnishes are commonly used. State four major advantages of paints as compared to other coatings.

In class it was stated that materials with the active-passive transition can be prevented from undergoing corrosion even in very aggressive environments. What is the active-passive transition and give an example of a material which exhibits this transition?

Describe, with the aid of appropriate sketches, how you would use x-ray diffraction (XRD) to determine the following:
(i) phase changes in an alloy system
(ii) residual stress
(iii) order-disorder phenomena

The following angles were calculated from each line on the powder x-ray photograph of a cubic element:

$\theta = 16.5,\quad 18.2,\quad 19.6,\quad 27.3,\quad 28.4,\quad 31.6,\quad 33.5 \quad \text{and} \quad 34.5$

(i) index the lines
(ii) determine the crystal system of the element
(iii) calculate the lattice parameter

Note: $\lambda = 1.5418$ A

With the aid of an appropriate sketch, show how you would use a Goodman diagram to determine the allowable stress during cyclic loading.

A Non-Destructive Testing (NDT) evaluation of a component shows that there are cracks present of 3 mm which grew by fatigue to a final crack length under service conditions of 8 mm, determined by fast fracture.

Calculate the percentage increase in fatigue life for the component if
(i) the final crack length is extended (by 2 mm) to 10mm through the use of a material of higher fracture toughness.
(ii) the initial crack size is reduced (by 2 mm) to 1 mm.

The equation for fatigue

$$\frac{da}{dN} = C\Delta K^m$$

can be integrated to a useful form

$$\frac{2}{2-m}\left| a_f^{1-m/2} - a_o^{1-m/2} \right| = C\Delta\sigma^m \pi^{m/2} N_f$$

for all values of $m \neq 2$, where N_f = number of cycles to failure. Take the Paris exponent (m) to be 3 for the material in question.

END OF EXAMINATION IN MM422

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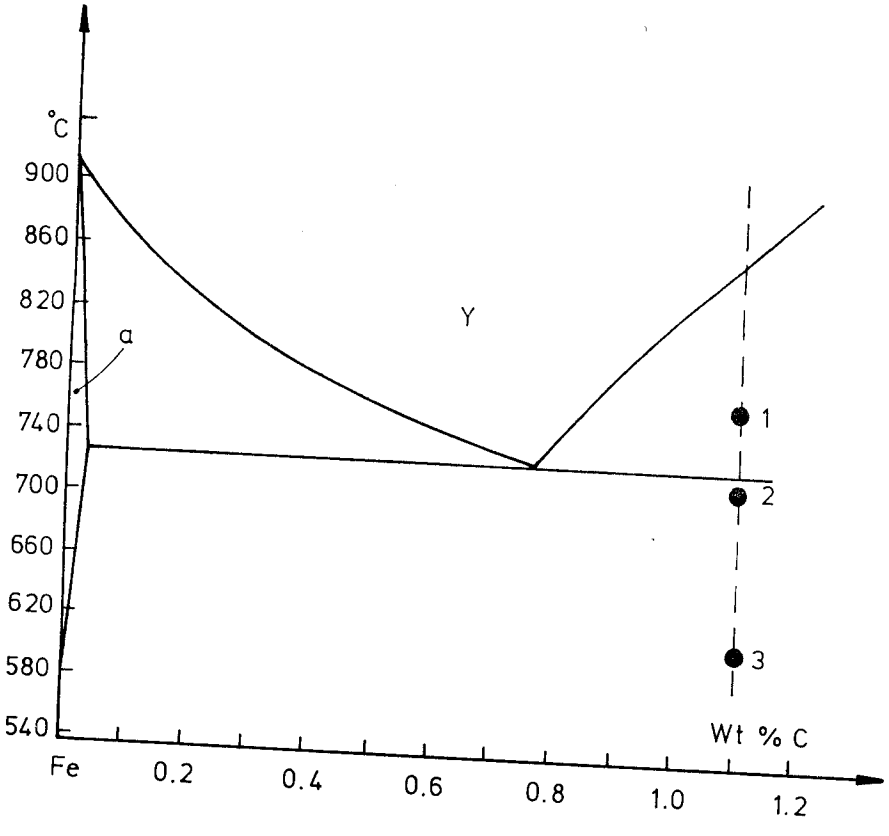
END OF EXAMINATION IN MM422


°C
900
860
820
780
740
700
660
620
580
540
Fe
0.2
0.4
0.6
0.8
1.0
1.2
Wt % C
α
Y
1
2
3

QUADRATIC FORMS OF MILLER INDICES

Cubic					Hexagonal	
	hkl					
$h^2+k^2+l^2$	Simple	Face-centered	Body-centered	Diamond	h^2+hk+k^2	hk
1	100				1	10
2	110	. . .	110		2	
3	111	111	. . .	111	3	11
4	200	200	200		4	20
5	210				5	
6	211	. . .	211		6	
7					7	21
8	220	220	220	220	8	
9	300, 221				9	30
10	310	. . .	310		10	
11	311	311	. . .	311	11	
12	222	222	222		12	22
13	320				13	31
14	321	. . .	321		14	
15					15	
16	400	400	400	400	16	40
17	410, 322				17	
18	411, 330	. . .	411, 330		18	
19	331	331	. . .	331	19	32
20	420	420	420		20	
21	421				21	41
22	332	. . .	332		22	
23					23	
24	422	422	422	422	24	
25	500, 430				25	50
26	510, 431	. . .	510, 431		26	
27	511, 333	511, 333	. . .	511, 333	27	33
28					28	42
29	520, 432				29	
30	521	. . .	521		30	
31					31	51
32	440	440	440	440	32	
33	522, 441				33	
34	530, 433	. . .	530, 433		34	
35	531	531	. . .	531	35	
36	600, 442	600, 442	600, 442		36	60
37	610				37	43
38	611, 532	. . .	611, 532		38	
39					39	52
40	620	620	620	620	40	
41	621, 540, 443				41	
42	541	. . .	541		42	
43	533	533	. . .	533	43	61
44	622	622	622		44	
45	630, 542				45	
46	631	. . .	631		46	
47					47	
48	444	444	444	444	48	44
49	700, 632				49	70, 53
50	710, 550, 543	. . .	710, 550, 543		50	
51	711, 551	711, 551	. . .	711, 551	51	
52	640	640	640		52	62
53	720, 641				53	
54	721, 633, 552	. . .	721, 633, 552		54	
55					55	
56	642	642	642	642	56	
57	722, 544				57	71
58	730	. . .	730		58	
59	731, 553	731, 553	. . .	731, 553	59	

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - SECOND SEMESTER, 1999/2000

MM 442

HYDROMETALLURGY

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

TIME: THREE HOURS

1(a) As applied to the leaching of concentrate particles, answer the following questions:

(i) Write down the formula of Fick's first law of diffusion and explain the symbols that appear in it. (2%)

(ii) Assuming that Nernst's model is valid for lixiviant diffusion through the boundary layer around concentrate particles, use Fick's first law to identify the factors that would have an influence on the rate of boundary layer diffusion. (9%)

(b) In a laboratory experiment 250 grams of a calcine with 8% zinc is leached with 500 cm^3 of leachant. The pregnant solution has a zinc concentration which is too high to be measured directly by Atomic Absorption Spectrophotometry (AAS). One cm^3 of the pregnant solution is pipetted and diluted with distilled water to yield 250 ml of a solution "P". 10 cm^3 of solution "P" is in turn pipetted and diluted with distilled water to yield 100 ml of a solution "Q". By AAS, solution "Q" is found to have 15 ppm zinc. What percentage of the zinc in the feed is leached in the experiment? (9%)

2. In a continuous agitation leaching operation 4 tonnes of a solute-free lixiviant is used for every 2 tonnes of a concentrate. The concentrate contains 40% desired values which are all leachable, 10% moisture, and the remainder is insoluble material. All leachable values dissolve in the leach tank, fed with concentrate and leachant only, before the pulp is introduced into the first thickener of a 3 stage

counter current decantation washing unit. For every 2 tonnes concentrate leached, 5 tonnes of pure wash water is added in the last thickener (thickener number 3) which yields a disposable sludge.

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

(b) What is the amount of pregnant solution produced for every 2 tonnes of concentrate leached, assuming the sludge of thickeners 1, 2, and 3 contain 50%, 40%, and 25% by weight solids, respectively. (4%)

(c) With a further assumption of a repulping efficiency of 90% for the first thickener and 100% for each of the other two thickeners, calculate the percentage of dissolved values recovered into the pregnant solution in this plant. (10%)

(d) Suggest possible ways of increasing the dissolved value recovery, pointing out any demerits of the proposals you make. (4%)

3. 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 984 dissolved in a suitable diluent. Data obtained pertaining to these equilibrium experiments is shown below.

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

(a) Construct an equilibrium extraction isotherm for LIX 984 using the data given.(5%)

(b) 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 984 entering extraction will be completely barren. Answer the following, assuming an organic to aqueous volumetric flowrate ratio of 0.7:

3.b(i) What will be the Cu content of the loaded organic? (2%)

(ii) Predict the number of useful stages which will be required for such an operation assuming 100% stage efficiency. (8%)

(c) Explain the difference in the way chelating and acid extractants work. (5%)

4.a. With reference to the metallurgy of copper distinguish between electrowinning and electrorefining. (4%)

b(i) Calculate the total cathode area required to electrowin 50% of manganese (Mn^{2+}) as manganese metal from a feed stream with a flow rate of 1 l/s and a manganese concentration of 30 g/l if the applied current density is 6 A/dm^2 at a current efficiency of 65%. (F = 96500 C/mol; Mn relative atomic weight = 54.94)(11%)

(ii) For the conditions specified above, compute the energy required in kWhr to deposit 1 kg of manganese. (5%)

5. Study Fig. 1 which is attached and then answer the following questions:

(a) Give the names and chemical formulae of the common ore minerals of uranium.(2%)

(b) Explain why uranium ores are leached by oxidative dissolution and for one of the minerals write down the dissolution reaction. (5%)

c(i) Outline the purification of uranium leach solutions by ion exchange. (5%)

(ii) What is meant by the break-through capacity during ion exchange and how is it determined? (4%)

(d) What is the relevance of line "A-A" of Fig. 1 in uranium extraction? (4%)

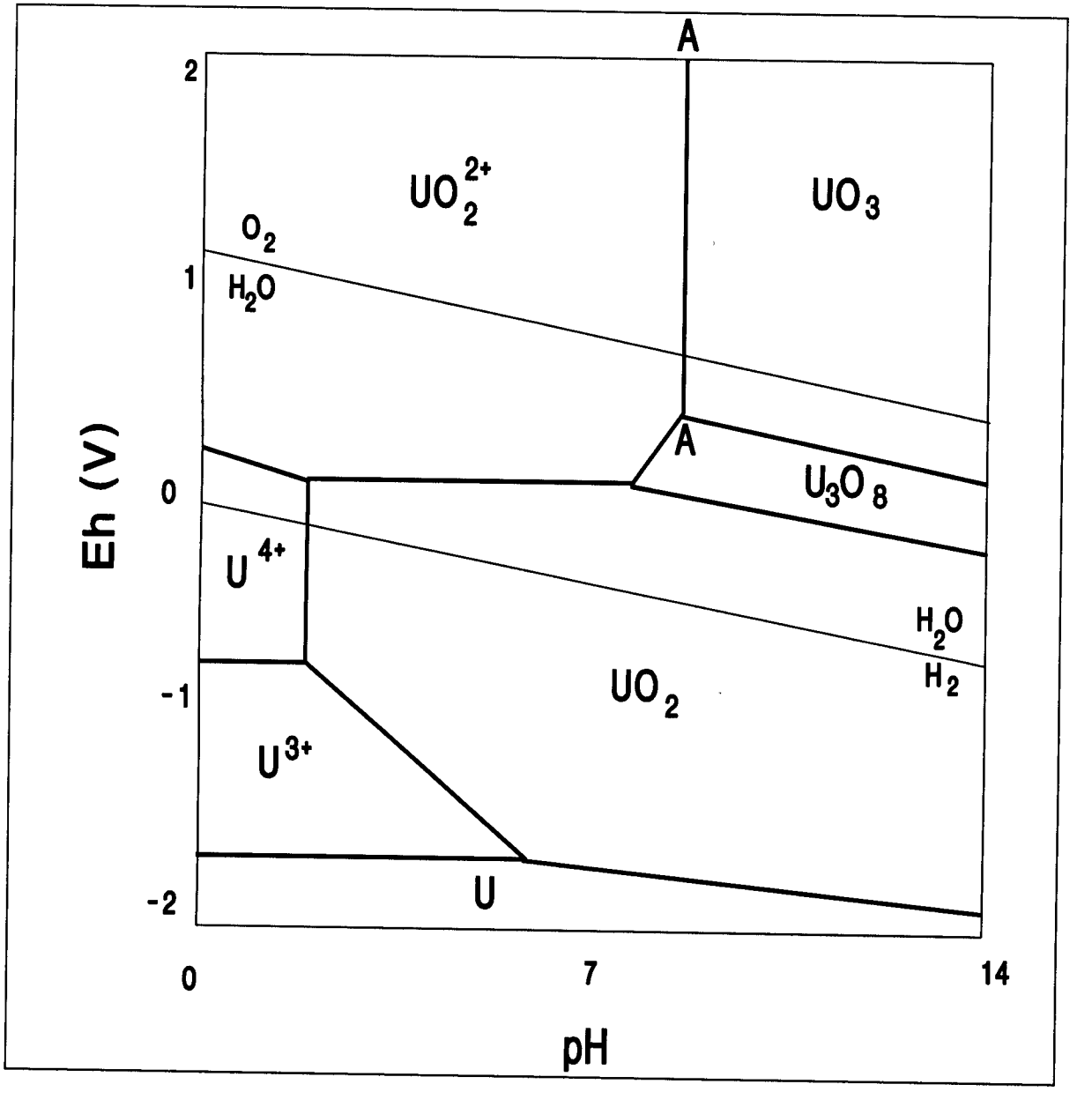


Fig. 1: The U-H_2O system at 25 °C and a soluble uranium concentration of 10^{-2} M

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS - MAY 2000

MM 542

FUELS, FURNACES AND REFRACTORIES

TIME: THREE HOURS
ANSWER: ALL QUESTIONS

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

   (b) Name **five** properties of coal that should be specified in the measure of grade of coal. (2%)

   (c) Name **two** purposes for which the storage procedures of coal are designed. (2%)

   (d) Name **two** factors that contribute to spontaneous combustion of stored coal. (2%)
   How can coal be stored safely? (4%)

   (e) Describe the **four** ingredients that are determined in proximate analysis of coal. (8%)

2. (a) The attainment of high temperatures when using pulverised fuel is influenced by certain behaviour of the fuel during burning. Describe how this behaviour helps achieve high temperatures. (5%)

   (b) What are the four principal applications of surplus heat from a primary operation (2%)

   (c) With the help of sketches describe the difference between parallel and counter flow patterns in heat exchangers. (6%)

   (d) Briefly describe (a) Recuperators and (b) Regenerators (6%)

   (e) Describe the manufacture of producer gas (6%)

3. (a) Define calorific value in scientific form. (2%)

   (b) Calculate the ideal flame temperature of Producer gas under the following conditions:

   (i) Gas at room temperature (20°C) (6%)
   (ii) Gas at 800 °C (preheated) (12%)

Assume complete oxidation, perfect mixing and instantaneous combustion of the fuel. The following data is available for the fuel:

COMPONENT	VOL %	Cp, J/g °C
H_2	14	0-600: 14.44 600-1400: 12.76
CO	30	0-1400: 1.21
CH_4	1.6	0-700: 3.35 700-1400: 3.98
C_3H_8	0.4	0-1400: 3.77
CO_2	4	0-400: 1.55 400-1400: 1.28
N_2	50	0-1400: 1.19
H_2O	-	0-1400: 2.18
O_2	-	0-500: 1.21 500-1400: 1.13

For 1 m^3 of gas, the following reactions, all expressed in litres, take place;

(a) $140\ H_2 + 70\ O_2 = 140\ H_2O + q\ 70\ N_2$

(b) $300\ CO + 150\ O_2 = 300\ CO_2 + q\ 150\ N_2$

(c) $16\ CH_4 + 32\ O_2 = 16\ CO_2 + 32\ H_2O + q\ 32\ N_2$

(d) $4\ C_3H_8 + 20\ O_2 = 12\ CO_2 + 16\ H_2O + q\ 20\ N_2$

where $q = 79/21 = 3.76$

The heat of reaction for the overall reaction (producer gas) $\Delta H = 5{,}651\ KJ/m^3$

4. (a) Some of the most important properties of refractory materials which directly determine their ability to withstand destructive factors during service are:

(i) Refractoriness
(ii) Thermal shock or spalling resistance and
(iii) Slag resistance

Describe how these properties may be evaluated. (6%)

(b) Describe the standard route followed in the manufacture of refractories. (4%)

(c) Describe the main factors that are considered in furnace construction. (4%)

(d) Give a description and example of Shaft Furnaces. (6%)

5 (a) With the aid of a diagram describe the important allotropic forms of silica (4%)

(b) Describe the manufacture of silica bricks (6%)

(c) State four properties of silica bricks (4%)

(d) What has been the two principal uses of silica bricks (4%)

(e) It is almost impossible to cool a furnace lined with silica brickwork below 300 °C. Why? (2%)

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
UNIVERSITY EXAMINATION - MAY 2000
MM 452
PROCESS CONTROL AND INSTRUMENTATION

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

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1. (a) A thermometer having a time constant of 1 min is initially at 50^0C. It is immersed in a bath maintained at 100^0C. If at t=1.5 min, the thermometer is removed from the bath and put in a bath at 75^0C, determine the maximum temperature indicated by the thermometer. What will be the indicated temperature at t=20 min?
(b) Given a system with the transfer function

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

Find Y(t) if X(t) is a unit step function. If $T_1/T_2 = 5$, show the numerical values of the initial and ultimate values. Check by using the initial-value and the final-value theorems.

2. (a) Three identical tanks are operating in series in a noninteracting fashion. For each tank, R=1, τ=1. If the deviation in the flow rate to the first tank is an impulse function of magnitude 2, obtain an expression for H (t), the deviation in level in the third tank. Calculate the maximum value of this deviation.
(b) A process system consists of two tanks operating in a noninteracting way. A unit step change is made to the flow rate in tank 1. The transient response is critically damped, with τ=0.6 min. What is the change in level of the second tank after 1 min, expressed as a fraction of the total change?

3. A step change of magnitude 3 is introduced into the transfer function

$$\frac{Y(s)}{X(s)} = \frac{10}{2s^2 + 0.3s + 0.5}$$

Determine
(a) Percent overshoot
(b) Rise time
(c) Period of oscillation

4. Process liquid is continuously fed into a perfectly mixed tank in which it is heated by a steam coil. Feed rate F is 22 000 kg /h of material with a constant density of 850 kg/m^3 and a heat capacity C_p of 2.1 kJ/kg.^{0}C. The holdup in the tank, V, is constant at 1800 kg and the inlet feed temperature ,T_0, is 25 ^{0}C.

(b) Determine the value of K for which two of the roots are on the imaginary axis, and determine the values of these imaginary roots and the remaining two roots.

END OF EXAMINATION IN MM 452

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

UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
UNIVERSITY EXAMINATION - MAY 2000
MM 552
PROCESS DESIGN

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

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1. (a) Suggest how the following sets of equations may be solved:

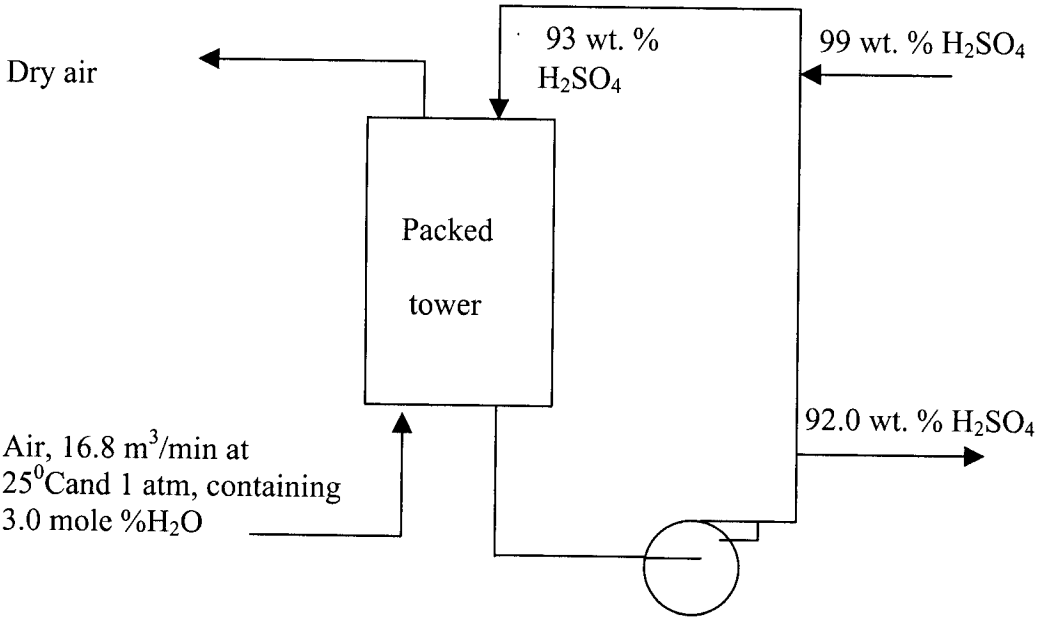
(i)
$$f_1(x_1, x_3) = 0$$
$$f_2(x_2) = 0$$
$$f_3(x_2, x_3) = 0$$

(ii)
$$f_1(x_1, x_3) = 0$$
$$f_2(x_2, x_3) = 0$$
$$f_3(x_1, x_2) = 0$$

(b) You are working in a laboratory and are requested to melt 100 kg of stainless steel, AISI type 304, with an analysis of 17.5 % Cr, 8.0 % Ni and 0.5 % Mn. Calculate the charge you would use for the following available materials:

Material	% Cr	% Ni	%Fe	% Mn
alloyscrap	68	20	10	2
ferrochromium	75		25	
electro Ni		100		
electro Fe			100	

2. The air used to burn S or FeS_2 in making sulphuric acid must first be dried. Passing it counter to a stream of concentrated H_2SO_4 flowing through a packed tower does this. The acid enters the tower at 93 weight percent and is diluted as it absorbs H_2O. Some 92.0 weight percent H_2SO_4 is withdrawn from the system as the acid recycles, and the acid concentration is returned to 93 weight percent by adding 99 weight percent H_2SO_4 as shown in the figure below.



From these data and the flow diagram, calculate
(a) the mass of 99 weight percent H_2SO_4 in kg added per hour,
(b) the rate of flow of 93 weight percent H_2SO_4 entering the top of the column in kg/h.

R=8.314 J/mole.K
1 atm=1.013×10^5 N/m^2

3. A furnace burns a liquid coal tar for fuel derived from coke ovens. Calculate the heat transferred (kJ/kg fuel) in the furnace if the combustion gases leave at 1500 K (2200 ^{0}F). The burners operate with 20 percent excess air with an average heat capacity of 28.9 kJ/kmol.K. Take the fuel supply temperature as 323 K and the air inlet temperature as 288 K. The heat capacity data of the gases is provided in the figure where 1 cal = 4.180 J.

The properties of the fuel are:
Carbon, 87.5 wt % ; Hydrogen, 8 wt % ; Oxygen, 3.5 wt %; Nitrogen, 1 wt %.

Net calorific value	39 540 kJ/kg at 298 K
Latent heat of vaporisation	350 kJ/kg at 298 K (for H_2O)
Heat capacity	1.6 kJ/kg.K

Atomic masses: C, 12; H, 1 ; O, 16 ; N, 14 .

4. (a) Briefly discuss the discounted-cash-flow rate of return and the net present worth measures of profitability. How would you use these measures to compare alternative investments?
(b) For a project, estimated to last 10 years, revenues from the annual sales and total annual expenses over a three-year period are given in the following table in millions of Kwacha (mZMK or mK):

Year	A_S (mZMK)	A_{TE} (mZMK)
0	0	0
1	400	100
2	500	100
3	500	110

The fixed capital investment, C_{FC}, is 1000 million Kwacha. Plant items have a zero a salvage value. Working capital, C_{WC}, is 90 million Kwacha, and the cost of land, C_L, is 10 million Kwacha.There are no allowances other than depreciation. The fractional rate of tax, t, is 0.50. Using straight-line depreciation accounting and a discount factor of 10 %, calculate
(i) the annual discounted cash flow, A_{DCF}, for each year,
(ii) the cumulative net present worth (NPV or NPW) at the end of each year.

5. (a) Briefly describe the two general types of regenerative heat exchangers.
(b) Engine oil is to be cooled from 353 K to 323 K by using a single-pass concentric-tube heat exchanger with cooling water available at 293 K. Water flows inside a tube with an ID of D_i=2.5 cm at a rate of 0.12 kg/s and oil flows through the annulus at a rate of 0.16 kg/s. The heat transfer coefficients for the water side and the oil side are 1000 W/m^2.K and 80 W/m^2.K respectively. The fouling factors are 5500 W/m^2.K on the water side and 5500 W/m^2.K on the oil side. The tube wall resistance is negligible. The specific heats of water and oil can be taken as 4180 J/kg.K and 2090 J/kg.K respectively. External heat losses from the exchanger are to be neglected.

Calculate the tube length for (i) a countercurrent flow arrangement, (ii) a parallel flow arrangement.

6. (a) Describe how a continuous rotary vacuum-drum filter works.
(b) An experimental filter press having an area of 0.0414 m^2 is used to filter aqueous $BaCO_3$ slurry at a constant pressure of 267 kPa. The filtration equation obtained is

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

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

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

7. (a) Explain what is meant by the specific speed of a centrifugal pump and show that its value is

$$N_s = NQ^{1/2} / H^{3/4}$$

where N is the rotational speed of the impeller, Q the discharge and H the operating head.

(b) A centrifugal pump, having four stages in parallel, delivers 11 m^3/min of liquid against a head of 24.7 m, the diameter of the impellers being 225 mm and the speed 1700 rev/min.
A pump is to be made up with a number of identical stages in series. Each stage is to be of similar construction to each of those in the first pump. The pump is to run at 1250 rev/min and to deliver 14.5 m^3/min against a head of 248 m. Find the diameter of impellers and the number of stages required.

END OF EXAMINATION IN MM 552