THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS –MAY 2011

1. GG322 Stratigraphy and paleaontology (Practical)
2. GG412 Metamorphic petrology II (Practical)
3. GG412 Metamorphic petrology II (theory)
4. GG442 Economic Geology of Metalliferous Mineral Deposits and Petroleum
5. GG442 Economic Geology of Metalliferous Mineral Deposit and Petroleum
6. GG442 Possible Ore Minerals (practical)
7. GG472 Geochemistry
8. GG512 Germmology
9. GG542 Economic Geology of non-metallic mineral deposits
10. GG572 Hydrogeology
11. MI 312 Blasting
12. MI 331 Underground Mining
13. MI 335 Surface Mining
14. MI 535 Coal Mining
15. MI 545 Mine Management
16. MI 565 Mineral Economics II
17. MM 205 Introduction to Minerals Sciences
18. MM 332 Chemical Thermodynamics II
19. MM 352 Heat and Mass Transfer
20. MM 412 Mineral Processing II
21. MM 422 Materials Performance
22. MM 442 Pyrometallurgy
23. MM 452 Process Instrumentation and Control
24. MM 542 Fuels, Furnaces and Refractories
25. MM 552 Process Design
26. MM 562 Foundry

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

SECOND SEMESTER EXAMINATIONS – MAY 2011

GG322 – STRATIGRAPHY AND PALEAONTOLOGY

PAPER II – PRACTICAL

INSTRUCTIONS: Answer all questions.

TIME: Three (3) Hours

Avalanche Ventures Limited (AVL) intends to commence exploring for alluvial gold over its tenement that is underlain by a sequence of sedimentary rocks. There is hardly any detailed geological work that has so far been done on the tenement and the Company could only find logs of two drill holes which were drilled in the area many, many years ago. Collar information of the boreholes indicates that they were drilled 550 metres apart.

Whilst there are no known tectonic activities that would have disturbed the sedimentary rocks since they deposited and possibly have an effect on the mineralisation of gold, it is believed that the mineralisation is lithologically controlled. It is believed that the gold mineralisation is associated with coarse to very coarse grained sandstones.

You are the geologist who has been hired to lead the exploration programme of the tenement and therefore expected to generate as much information from the drill logs of the two bore holes as possible. This is critical because it will form a geological foundation on which the subsequent exploration direction will be based. An understanding of the different facies and depositional environment as well as the interplay of both chemical and physical variables help in the interpretation of the reducing and oxidising conditions, two aspects which are critical in mineralisation.

As a starting point, you are required to do the following:

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

(ii) Draw a stratigraphic section between the two bore holes showing clearly the most likely mineralised horizons (30 marks);

(iii) If GS/2 is located to the east of GS/5, recommend with reasons in which directions the next two bore holes should be drilled (20 marks); and

(iv) Comment with good reasons on whether the rocks of the two localities where the bore holes were drilled, were deposited in the same sub-basin or channel (20 marks).

Log: GS/2 (Bore hole collar = 965m above sea level)

0-2m	Very fine-grained mudstone, in places with shaly partings, desication cracks and root traces;
2-5m	Very fine- to medium-grained sandstone, horizontal bedding and locally massive;

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

Log: GS/5 (Bore hole collar = 973m above sea level)

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

REFERENCE:

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

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
SECOND SEMESTER UNIVERSITY EXAMINATIONS – MAY 2010
GG 412 – METAMORPHIC PETROLOGY
PAPER I – THEORY

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER AT LEAST ONE QUESTION FROM EACH SECTION AND ANY OTHER THREE QUESTIONS USING SKETCHESWHEREVER POSSIBLE. ALL QUESTIONS CARRY EQUAL MARKS.

SECTION A

Q1. Explain the following terms

(a) Geothermal gradient
(b) Polygonal-granoblastic texture
(c) Metamorphic zone
(d) Burial metamorphism.
(e) Mylonite

Q2. (I)

A schistose rock composed of mainly quartz and Biotite contains 5% porphyroblastic garnet and 3% staurolite porphyroblasts.

(a) What name would you give to this rock?
(b) To what chemical type does it belong?
(c) In which of the so-called Barrovian Zones can it be found?

Another gneissose metamorphic rock contains 65% hornblende, 25% plagioclase of andesine composition, 10% quartz and accessorial opaque minerals.

(d) What is its name?
(e) What is the chemical type?
(f) To which metamorphic facies would you attribute this rock?

(II) Two rocks from different localities have been recrystallized under the same T and P conditions during metamorphism. Will they:

(a) Belong to the same metamorphic facies? And explain why
(b) Have identical mineral assemblages? And explain why

Q3. Discuss the role of surface free energy of crystals in the development of metamorphic textures.

Q4. Discuss in detail the main characteristics of cataclastics metamorphism Paying more attention to the following:
a) Metamorphic agent
b) Mineralogy
c) Texture
d) Rock types

Q5. (a) Write a discussion on the metamorphic grade obtained in a metamorphic terrain, where rocks are exposed that show the following mineral parageneses:

rock type 1: quartz-muscovite-biotite-almandine
rock type 2: quartz-albite-microline-muscovite-biotite
rock type 3: calcite-quartz-tremolite-diopside
rock type 4: plagioclase-hornblende-quartz-epidote
rock type 5: quartz (Biotite accessorial)

(b) Discuss for each rock type the probable protolith.

SECTION B

Q1. (a) Write brief notes on the types of chemical reactions that occur during metamorphism.
(b) Use an appropriate P-T phase diagram to discuss the geothermal gradients that are associated with the three classes of facies series of regional metamorphism.
(c) Write notes on the three- fold classification of facies of regional metamorphism with reference to the following aspects:

(i) Characteristic and common minerals
(ii) Common metamorphic facies series
(iii) Associated magmatism.

(a) Belong to the same metamorphic facies? And explain why
(b) Have identical mineral assemblages? And explain why

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(i) Characteristic and common minerals
(ii) Common metamorphic facies series
(iii) Associated magmatism.

Q2. (a) Identify the metamorphic rocks and the major minerals that are likely to be found in rocks whose analyses are given below.

	R1	**R2**	**R3**
SiO_2	64.3	70.7	50.3
TiO_2	1.0	0.5	1.6
Al_2O_3	17.5	14.5	15.7
Fe_2O_3	2.1	1.6	3.6
FeO	4.6	2.0	7.8
MnO	0.1	0.1	0.2
MgO	2.7	1.2	7.0
CaO	1.9	2.2	9.5
Na_2O	1.9	3.2	2.9
K_2O	3.7	3.8	1.1
P_2O_5	0.2	0.2	0.3

Discuss briefly how changes during medium pressure

UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – MAY 2010

GG 412 - METAMORPHIC PETROLOGY
PAPER II PRACTICAL

INSTRUCTIONS: ANSWER ALL QUESTIONS
TIME : THREE (3)HOURS

Q1.
Give a full petrographic description of thin sections A , emphasize on the following
a)Mineralogy
b) Texture
c) Chemical type
d)Metamorphic grade
e) Name the rock

Q2
Figure 1 shows a map of a regional metamorphic terrain, characterised by a succession of isoclinals folded schist's and gneisses. The various rock types of the area contain the following mineral assemblages:

Rock type 1: quartz- calcite-tremolite-albite

Rock type 2: calcite-quartz

Rock type 3: quartz-biotite-muscovite-almandine ;chlorite partially replaces biotite and almandine.

Rock type 4a: quartz –plagioclase-hornblende
4b: quartz-plagioclase-hornblende-diopside

Rock type 5: quartz-almandine-cordierite-sillimanite-biotite – alkali feldspar; chlorite partially replaces almandine.
Rock type 6 : mixed rock consisting of melanocratic, biotite-rich parts and leucratic veins of granitc composition.

Rock type 7: granite

a) write a discussion on the metamorphic grade obtained in this terrain, taking into account that various chemical rock types present. Is there evidence for polymetamorphism?

UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
GEOLOGY DEPARTMENT
UNIVERSITY EXAMINATIONS – MAY 2011

GG 412 - METAMORPHIC PETROLOGY
PAPER II PRACTICAL

QUESTION 2

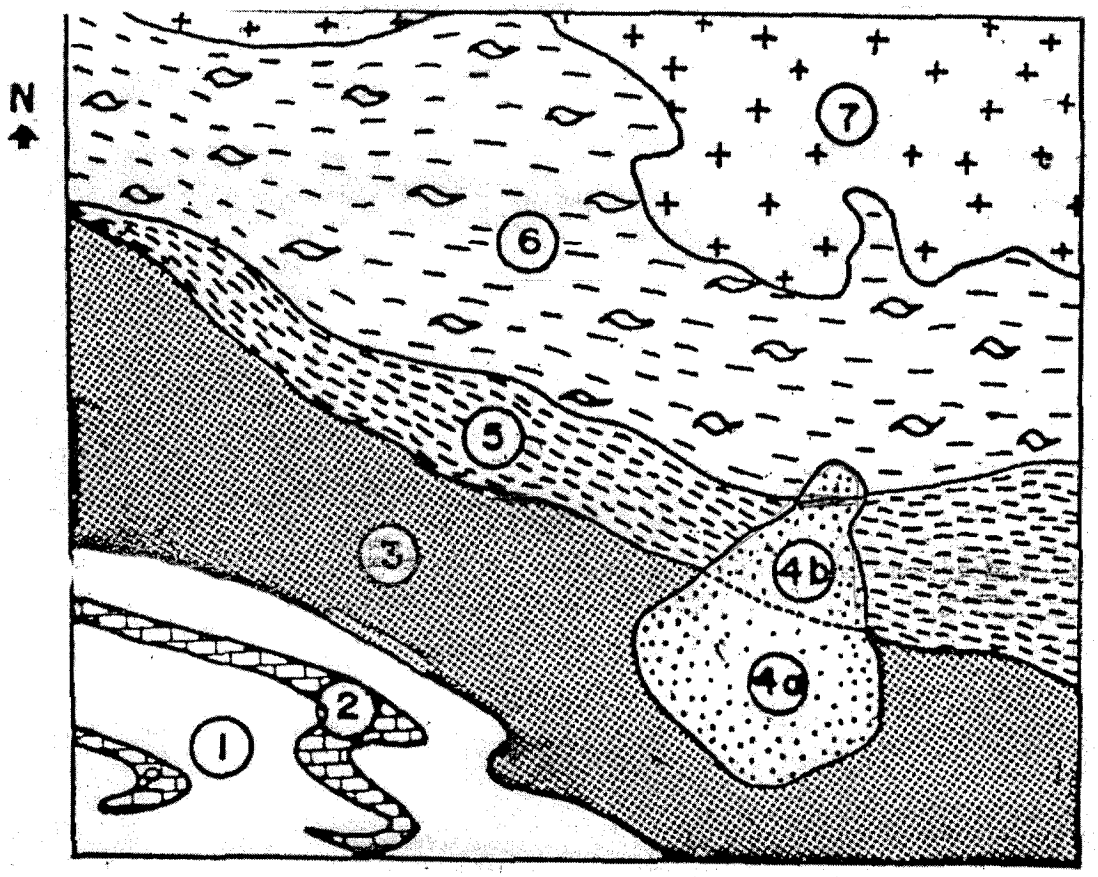

FIGURE 1

b) What name would you give to the boundary between rock type 4a and rock type 4b?
c) Discuss the origin of rock type 6. Would the boundary between rock types 5 and 6 be gradational or sharp?

THE UNIVERSITY OF ZAMBIA

SECOND SEMESTER UNIVERSITY EXAMINATIONS – MAY 2011

GG 442 – GEOLOGY OF METALIFEROUS MINERAL DEPOSITS & PETROLEUM

PAPER II - PRACTICAL

INSTRUCTIONS:	ANSWER ALL QUESTIONS
TIME:	ONE HOUR 30 MINUTES

You are provided with two polished sections. Using the reflected light microscope note down the optical properties and use these properties to identify the ore minerals present and describe the observed textures. (30 marks)

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

2010/2011 ACADEMIC YEAR SEMESTER II EXAMINATIONS

GG442 PRACTICAL EXAMINATION

WEDNESDAY 11TH MAY 2011

POSSIBLE ORE MINERALS

Carrollite: Creamy white with a slight pinkish tint

Arsenopyrite: White with a very strong blue to green anisotropism

Marcasite: Yellowish white with a strong blue, green, yellow, purple gray anisotropism

Hematite: Gray white with bluish tint with a distinct gray blue to gray yellow anisotropism

Cassiterite: Brownish gray

Pyrrhotite: Creamy pinkish brown with a very strong yellow gray to grayish blue anisotropism

Magnetite: Gray with brownish tint & isotropic

Chalcocite: Bluish white

Covellite: Indigo blue with a violet tint & an extreme red-orange to brownish anisotropism

Bornite: Pinkish brown & may tarnish to purple or violet or iridescent

Pyrite: Yellowish white & isotropic

Sphalerite: Gray & anisotropic

Chalcopyrite: Yellow to brass yellow

Pentlandite: light creamy to yellowish & isotropic

Digenite: Grayish blue & isotropic

Cubanite: Creamy gray to yellowish brown with a very strong brownish to blue anisotropism

Galena: White & isotropic

Ilmenite: Brownish with a pink or violet tint & a very strong greenish gray to brownish gray anisotropism

Goethite: Gray with a bluish tint & a distinct gray-brown, gray-yellow, brownish anisotropism

NOTE: WHEN YOU ARE THROUGH WITH THE EXAM PLEASE LEAVE THIS DOCUMENT ON THE BENCH NEXT TO THE MICROSCOPE FOR USE BY THE NEXT STUDENT

THE UNIVERSITY OF ZAMBIA

UNIVERSITY EXAMINATIONS – MAY 2011

GG 472 – GEOCHEMISTRY

PAPER I – THEORY

INSTRUCTIONS: Answer five questions only. All the questions carry equal marks. Use diagrams and equations where ever it is necessary.

TIME: Three Hours

Q1. (a) State the rules of ionic substitution in igneous and metamorphic minerals.
(b) Discuss the role which ionic substitution plays in the distribution of Ni, Cr, Co, Fe, Hf, Zr, U, Ba, Rb, Sr, K and Be during fractional crystallisation of a basaltic magma.

Q2. (a) Write brief notes on the geochemical properties of the REE and their behavior during magmatic differentiation.
(b) Discuss how the distribution patterns of REE can help us to understand the petrogenetic processes that have occurred during the formation of comagmatic rocks.

Q3. The abundances of the major components of a basaltic magma are given in the table below. Discuss briefly how fractional crystallisation of this magma may result in the formation of a series of comagmatic rocks with SiO_2 content ranging from 40 to over 70%.

Oxide	Content (%)
SiO_2	50.06
TiO_2	0.85
Al_2O_3	15.94
Fe_2O_3	3.90
FeO	7.50
MnO	0.20
MgO	6.98
CaO	9.70
Na_2O	2.94
K_2O	1.08
P_2O_5	0.34

Q4. Use appropriate diagrams and some chemical equations to discuss the major factors that control chemical reactions during progressive regional metamorphism of siliceous dolomitic limestones.

Q5. Describe the major reactions that are likely to take place during progressive regional metamorphism of a rock unit whose chemical composition is given below.

Oxide	Content (%)
SiO_2	59.93
TiO_2	0.85
Al_2O_3	16.62
Fe_2O_3	3.03
FeO	3.18
MgO	2.63
CaO	2.18
Na_2O	1.73
K_2O	3.54
H_2O	4.34

Q6. Describe the major radioactive systems that are employed in dating of igneous and metamorphic rocks with reference to the following aspects.

Parent/daughter nuclides
Type of decay
Effective age range
Mathematical equation used
Typical materials that are dated

Q7. Discuss briefly the application of stable isotopes of H, O and S with respect to determination of the temperature of formation of assemblages of rock forming and sulfide minerals as well as the sources of hydrothermal solutions.

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

THE UNIVERSITY OF ZAMBIA

SECOND SEMESTER UNIVERSITY EXAMINATIONS

APRIL 2011 SEMESTER EXAMINATION

GG 512: GEMMOLOGY

TIME : THREE [3] HOURS FULL MARKS : 100

INSTRUCTIONS: ANSWER ONLY FIVE QUESTIONS

QUESTION 1

Emerald and garnet form by very different geologic processes and are consequently found in different geologic settings. **Describe** the processes responsible for the formation of each and state the geological setting in which they are found. **[20 marks]**

QUESTION 2

Discuss the **factors** that account for the rarity and durability of most gem materials. **[20 marks]**

QUESTION 3

List the **technique(s)** used to distinguish the following:

a) Synthetic amethyst from natural amethyst. **[3 marks]**
b) Emerald from green glass **[2 marks]**
c) Natural emerald from synthetic emerald **[3 marks]**
d) Synthetic ruby from natural ruby **[3 marks]**
e) Ruby from garnet **[3 marks]**
f) Diamond from cubic zirconia **[3 marks]**
g) Topaz from citrine **[3 marks]**

QUESTION 4

Write brief notes on the following:

a) Refractive index **[5 marks]**
b) Pleochroism **[5 marks]**
c) Absorption **[5 marks]**
d) Specific gravity **[5 marks]**

THE UNIVERSITY OF ZAMBIA
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SECOND SEMESTER UNIVERSITY EXAMINATIONS – MAY 2011

GG 542 – ECONOMIC GEOLOGY OF NON-METALLIC MINERAL DEPOSITS

INSTRUCTIONS: There are five (5) questions in this examination. You are required to answer any four (4) questions. All questions carry equal marks.

TIME: Three (3) hours

Q1. A. You have been retained to appraise a limestone and dolomite claim by an industrial minerals dealer for possible supply to the agricultural, sugar processing, cement manufacturing, water treatment and pig iron & non-ferrous metals industries. In each case; discuss how lime, limestone and/or dolomite might find their application, commenting on product chemical composition specifications where applicable. **(15 marks)**

B. Construct a flow chart adopted in the dry process of cement manufacturing, with brief notes about each stage. **(10 marks)**

Q2. A. Kaolin and kaolinitic clays find their application in different industries including Ceramics, Agricultural, Refractory, among others. In each case, give examples of specific applications, commenting on relevant properties of the clays for respective examples. **(10 marks)**

B. In tabular format, list ten (10) applications of gypsum, with relevant comments on each application. **(10 marks)**

C. Briefly describe what constitutes high-quality gypsum and list five (5) most common impurities in the commodity, commenting on the allowable limit for those impurities regarded as detrimental. **(5 marks)**

Q3. A. Mention the main types of deposit from which phosphate rock may be extracted, with notes on the advantages of one source over the other. **(5 marks)**

B. Briefly describe the desirable characteristics of phosphate rock or concentrate for it to be suitable for the manufacture of phosphatic fertilizers. **(5 marks)**

C. Fluorspar may be marketed as metallurgical, acid, ceramic or optical grade, briefly describe each of them including their respective chemical specifications. **(15 marks)**

Q4. A. A road contractor wants to set a quarry for road aggregate at a particular site and has retained you for professional advice on how suitable the underlying geology is for the purpose. The site geology may be described as part of a dome, comprising a layered igneous core of dunites, pyroxenites and diorites and an outward-dipping metasedimentary shell of feldspathic quartzites and marbles. Other lithologies include karoo age ferruginous sandstones and siltstones and pyritic Jurassic granite. Evidently, kaolinite and bentonite are the prevalent alteration products, most probably resulting from the meta-igneous and sedimentary packages respectively. Making use of the provided information, appraise this site and rank the aggregate sources based on the preferred properties for road aggregate. **(15 marks)**

B. Describe the major properties and corresponding uses of zeolites. **(10 marks)**

Q5. A. List the desirable physical and chemical properties which make corundum suitable for use as an abrasive. **(5 marks)**

B. What natural and synthetic materials can replace corundum as an abrasive? **(2 marks)**

C. State the major sources of rare-earth elements. **(3 marks)**

D. List five (5) major applications of Rare-Earth elements. **(5 marks)**

E. Where are the known potentially exploitable rare-earth element occurrences in Zambia and in what host rock do they occur? **(5 marks)**

F. State the physical properties and uses of asbestos and name the most important commercial varieties of the commodity. **(5 marks)**

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

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES
GEOLOGY DEPARTMENT

GG 572 – HYDROGEOLOGY **FINAL EXAMINATION MAY 2011**

TIME: THREE (3) HOURS

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

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1. Explain, briefly, the following:

   a) Zone of Aeration 2 marks
   b) Intrinsic Permeability 2 marks
   c) Leaky Aquifer 2 marks
   d) Darcy Velocity, V, compared to the average interstitial Velocity, Va 2 marks
   e) The general Partial Differential Equation for unsteady flow of groundwater, given in Radial coordinates. The terms in the Equation should be defined. 2 marks
   f) Hyetograph 2 marks
   g) Cone of Depression 2 marks
   h) Assumptions made in the use of the NONEQUILIBRIUM or THEIS, EQUATION 6 marks

Total 20 marks

2. a) Describe the Cooper – Jacob Method of pumping test to determine aquifer parameters State under what conditions the Method can be used

10 marks

b) A well is being pumped at a constant rate of 0.0038 cubic metre per second. Given are the following: T = 0.0028 square metre per second, r = 90 meters, S = 0.00098 and that W(u) = 0.36 for u = 0.71. Find the drawdown in the observation well for a time period of one thousand (1000) seconds.

10 marks

3. Assume that the University of Zambia Management has commissioned you to site a borehole to have a yield of more than ten (10) liters per second, on the Great East Road Campus, UNZA.

a) Briefly describe the hydrogeology of the Campus, indicating which parts of UNZA you would target to get this yield, giving reasons for your choices(s).

b) Describe any appropriate geophysical method you would employ for the selection of a site, for test drilling.

20 marks

4. a) Describe how to conduct a STEP – DRAWDOWN pumping test analysis to determine Formation Loss, B, and Well Loss C, Coefficients, for n = 2.

b) State a ROUGH RULE OF THUMB for recognizing an inefficient well.

20 marks

5. a) Given a free flowing (artesian) well, sketch the steady, unidirectional flow with respect to x, for this confined aquifer of uniform thickness. Indicate for this borehole;

(i) impermeable layer (s)
(ii) ground surface
(iii) confined aquifer
(iv) piezometric surface (line)
(v) the borehole
(vi) direction of groundwater flow
(vii) direction of increasing x

b) Describe with aid of diagram steady flow in an unconfined aquifer between two water bodies with vertical boundaries.

The flow is unidirectional, and is with respect to x. At x = 0, the first water body has head of h_o which is greater than the head h_l at the other boundary at x greater than zero.

20 marks

6. a) Suppose it is required to prepare a digital simulation of the UNZA Great East Road Campus groundwater aquifer:

(i) Write down the Partial Differential Equation (P.D.E) you would employ to describe the flow through an areally extensive aquifer. Define all the terms in the P.D.E.

(ii) Application of Finite Difference techniques to the groundwater flow can be derived by an appropriate Taylor's series expansion.

Write down a Taylor's Series for a function $f(x+h)$, where x is the independent variable and h is a constant.

(iii) What type of BOUNDARY CONDITION(S) would be applicable for the numerical modeling of UNZA Campus.?

(iv) Which time period or year would ideally be suited for setting INITIAL CONDITIONS for this model.?

(v) Write down the condition that must be satisfied by the model parameters in order to achieve stability in the one-dimensional, homogeneous and isotropic case.

10 marks

b) Assume that a confined aquifer of total length of 12 meters has a head on the left and right sides of the region of 8 meters at t = 0. Also assume that the head on the right side takes on the value of 2 meters for all t greater than zero.

The region (aquifer) is divided into three elements of delta y of 4 meters and that the thickness of the confined aquifer is 2 meters. The hydraulic conductivity k = 0.5m/day and storage coefficient S = 0.02.

Given the initial condition that $h^0_4 = 8.0$m.

(i) Sketch the one-dimensional flow problem
(ii) Use the EXPLICIT METHOD to determine future head for the first time step.

10 marks

7. Describe (a) brief geology and (b) expected water quality in terms of physical, chemical, biological parameters, and indicating potential source of pollution, if any, for the following public institution boreholes:

(i) The Borehole which is located about 50 metres west of Odys Fuel Service Station, at Arcades, along the Great East Road.
(ii) UNZA Borehole situated some 40 metres south of the School of Mines
(iii) UNZA Borehole located about 100 metres west of the Main Campus Security check point.
(iv) The Boreholes belonging to the Lusaka Water and Sewerage Company located in the Mass Media Area.

20 marks

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SECOND SEMESTER UNIVERSITY EXAMINATIONS
APRIL, 2011
MI 312 – BLASTING

TIME : THREE (03) HOURS **FULL MARKS: 100**
INSTRUCTIONS: ANSWER QUESTION ONE (01) ANY FOUR (04)

Question 1

Given

Bench height:	K=20 m
Width of the round:	w=40m
Blasthole diameter:	d=102mm
Charge concentration	l_b =8.5 kg/m
Correction for vertical drilling	R_1 = 0.95
No correction for rock constant	
Hole inclination:	Vertical
Explosive:	ANFO, poured into the blasthole
Charging condition:	Dry holes

Calculate the drilling pattern:

a) Maximum burden **(2 Marks)**
b) Subdrilling **(2 Marks)**
c) Depth of blasthole **(2 Marks)**
d) Error in drilling **(4 Marks)**
e) Practical Burden **(2 Marks)**
f) Practical Spacing **(2 Marks)**
g) Adjustment for width of round **(2 Marks)**
h) Specific drilling **(4 Marks)**

Question 2

A drift measuring 4 x 3.5 meters is to be driven in waste the hanging wall. The diameter of the blast holes is 57mm and the designed length is 2.5 meters. It is proposed to initiate a second face by using a burn cut. The diameter of large hole is 120 mm. The face advance per round is 85 %.

a) Design four squares of the cut and put appropriate burdens and widths **(10 Marks)**
b) Calculate volume of ore per face advance when entire face is blasted **(5 Marks)**
c) Calculate specific drilling of the designed cut? **(5 Marks)**

Question 3

a) Find oxygen balance of an explosive mixture consisting of **45 %** Tetryl and 55 % Ammonium nitrate. **(5 Marks)**

b) Using ANFO density 1gm/cm^3 and 88 mm. blasthole diameter and average length of the hole 15 m, what is the drilling pattern for copper ore with powder Q= 0.350 g/m^3? **(5 Marks)**

c) Determine the diameter of the blast hole and spacing to be used in main stoping given te following information:

- Uniaxial compressive strength of ore, 100 Mpa
- Ring Burden = 2.5 m
- Coefficient of hole closure m= 1.2

(10 Marks)

Question 4

a) Complete the following table 4.1:

Table 4.1 Explosives and characteristics

Explosive	Chemical Makeup	Advantages	Disadvantages
ANFO			
Dynamite			
Slurries			
Emulsions			

(10 Marks)

a) Calculate the loading density in kg/m of an emulsion with a density of 1.08 g/cc and a diameter of 40 mm. **(5 Marks)**

b) Calculate the detonation pressure in MPa of gelatin dynamite which has a density of 1.54 g/cc and detonation velocity of 5,300 *m/s*.

(5 Marks)

Question 5

Briefly explain:

a) Different firing devices and intiating methods for blasting the charge **(10 Marks)**

b) With the help of clear diagrams describe any two methods used for determing explosive strength.

(10 Marks)

Question 6

a) Assume a blast of 250 VA detonators with resistance of 3.6 Ohms each. The firing cable has a resistance of 5 Ohms and A CID 330 VA blasting machine is used. In accordance with the instruction on the machine, the round should contain 50 detonators in the series. The total number of series in the circuit is five and are connected in parallel. Find the resistance at the firing point.

(15 Marks)

b) What are some of the possible errors that may be encountered in mesuring the resistance of the circuit in 6. a)

(5 Marks)

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

THE UNIVERSITY OF ZAMBIA

SECOND SEMESTER UNIVERSITY EXAMINATIONS

APRIL 2011

MI 331 – UNDERGROUND MINING

TIME : THREE (03) HOURS **FULL MARKS: 100**

INSTRUCTIONS: ANSWER QUESTION 1 ANY FOUR (04) QUESTIONS

Question 1

Establish production plan and schedule for formation of slot measuring 20m x 10m x 60 m in sublevel open stoping as shown in figure 1.1 given the follwing conditions:

- Blasthole diameter d=102 mm
- Coeffient of rock hardness f=6
- Widith of slot W= 10 m
- Specific gravity of ore γ= 2.5
- Cross section area of dritfs/cross cuts A= 6.25 m^2
- Cross section area of slot raise 2.1 m^2
- Loading density, U= 8kg/m
- Charging coefficients 0.75.....0.89
- Mineral conent in extracted ore mass c= 2.4 %
- Average mineral content in Block reserves 2.6
- Recovery 85 %
- Productivity of drilling machine 120 m/shift
- Productivity of Pneumatic charging machine 1100 kg/shift

In establishing the production follow the following sequence:

a) Calculate blasting parameters and plot holes on the graph paper **(3 Marks)**
b) Generate table and determine total length of holes and explosives **(3 Marks)**
c) Determine volume of ore broken per slice **(2 Marks)**
d) Calculate powder factor **(1Mark)**
e) Determine specific drilling **(2 Marks)**
f) Determine amount of ore broken per meter of blasthole **(1 Marks)**
g) Shift spent of charging entire slot **(2 Marks)**
h) Shift spent of drilling entire slot **(2 Marks)**
i) Total number of rounds for entire slot **(2 Marks)**

j) Total extracted ore mass from the slot **(2 Marks)**

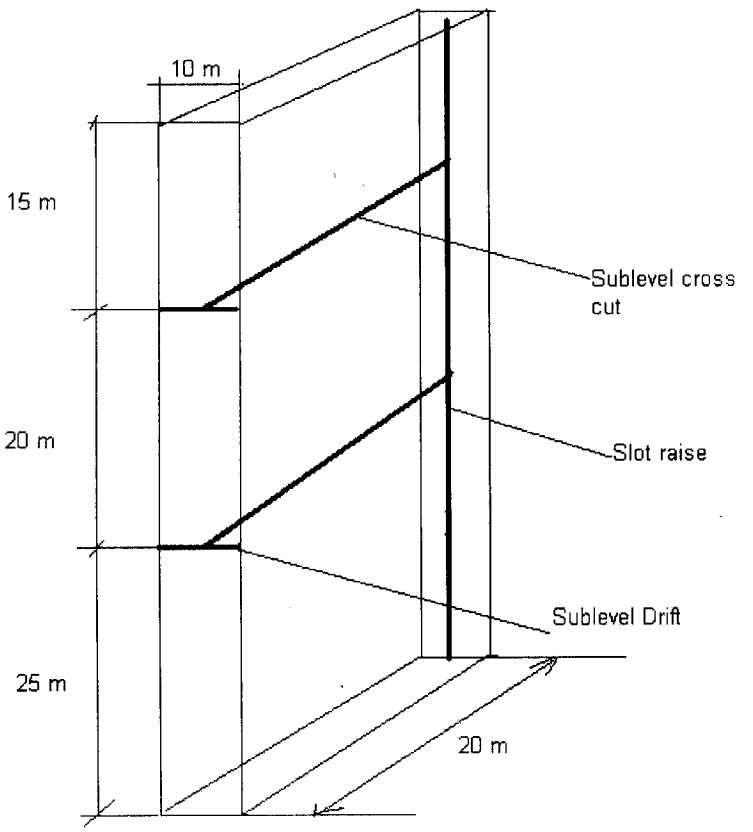


Figure 1.1 Formation of slot in sublevel stoping

Question 2

With the help of clear diagram explain shrinkage mining method under the following headings:

a) Main features of the mining method **(5 Marks)**
b) Sphere of application **(5Marks)**
c) Development sequence and **(5Marks)**
d) Extraction sequence **(5 Marks)**

Question 3

a) A mining filed with a span of 2000 m^2 is to be mined using sublevel caving method. From mining experience, it is established that average vertical depression within the level is 20 m/year. If recovery is 85 % and dilution is 10 %, calculate the theoretical annual productivity of the mine. **(10 Marks)**

b) Briefly describe factors affecting the choice of the level interval. **(10 Marks)**

Question 4

With the help of clear diagrams explain:

a) Kvapil & Janelid *ellipsoid concept* of gravity ore flow in caving methods **(10 Marks)**

b) Factors affecting ore draw in caving methods **(10 Marks)**

Question 5

A deposit has a width of 50 m, a length of 2000 m and a depth of 1000m. The average ore density is 3.5 t/m^3 . The mining company has to build a new haulage level asks if the interval shall be 100 m, 150 m or 200 m. The production is estimated at 4 million t/a of ore. The required fixed investment estimated at \$50 million, and the valuable at \$25 million per 100 m. The interest rate is 15 %. The problem is to find the best depth for the new level.

(20 Marks)

Question 6

Using clear diagrams,

a) derive parameters (Burden, spacing, powder factor etc) using K. C. Livingstone's theory for spherical charges in VCR **(10 Marks)**

b) Construct spherical charge **(5 Marks)**

c) Why is powder factor usually very low in VCR? **(5 Marks)**

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

THE UNIVERSITY OF ZAMBIA
SECOND SEMESTER UNIVERSITY EXAMINATIONS

APRIL 2011 SEMESTER EXAMINATION

MI 335: SURFACE MINING

TIME : THREE [3] HOURS FULL MARKS : 100

INSTRUCTIONS: (i) ANSWER QUESTION 1 AND ANY OTHER 3

(ii) USE TABLES 2 AND 3 PROVIDED TO ANSWER QUESTION 1

QUESTION 1

a) **Determine and show,** from the orebody net revenue per block data in **Table 1,** the **ultimate pit limit** for the most profitable pit (**Cut 1**) using **2D Lerchs Grossman algorithm**. Assume the slope is 1:1 and that positive values coincide with ore. Show all intermediate tables in your computations **[15 Marks]**

b) Define **three** stripping ratio driven mining strategy using diagrams and two physical and economical parameters that must be coupled with stripping ratio for determining capital, operating finance and equipment requirement **[8 Marks]**

c) Define the following terms as used in open pit mining

i. Open pit optimisation **[1 Marks]**

ii. Net Revenue per block ($) **[1 Marks]**

QUESTION 2

a) **Hydraulic shovels** are the commonly used surface mining equipments. Clearly explain the application of this equipment **[4 Marks]**

b) **Clearly** describe the function of **four (4) equipment** that is used for road making and maintenance in open pit mining **[8 Marks]**

c) Open pit mining requires dumps trucks must work like clock time. Briefly **explain** the **functional differences** between **dump trucks, scrapers** and **graders** **[6 Marks]**

d) Explain with the help of suitable diagrams, crucial parameters that are greatly influenced by ramp gradient and quality for open pit rubber tyred rolling equipment **[3 Marks]**

e) Using a suitable formula, define the terms **discounted cashflows** and **internal rate of return** as used in evaluation of surface mining project investment **[4 Marks]**

QUESTION 3

a) **Define** the term '**geotechnical template**' and give **three examples** of geotechnical templates commonly used in surface mining **[5 Marks]**

b) **Differentiate** between **in-pit** drainage and **ex-pit** or **perimeter** drainage **[4 Marks]**

c) **Describe** two types of **pit entry systems** with the aid of sketches **[8 Marks]**

d) **Define** the **two (2)** main systems of waste dumping with the aid of suitable diagrams and state two advantages for each system **[8 Marks]**

QUESTION 4

a) **Identify** the **major surface mining methods** and tabulate the orebody characteristics favourable for their selection and clearly outlining advantages and disadvantages for each method **[15 Marks]**

b) **Briefly** explain **five main drilling patterns** that you would employ for exploration of a potential deposit commonly used in mineral exploration around the world**[5 Marks]**

c) **Briefly** describe **five (5) factors** that critically influence the method of drilling, pattern and size of drill holes in geological modelling **[5 Marks]**

QUESTION 5

a) **Show diagrammatically**, the linkage of **information models** used in a mine planning project information system which is essential for due diligence studies **[7 Marks]**

b) **Briefly** define **seven (7) key drivers** of mineral and metal prices on the '**Arbiter To Die, To Limp and To Live**' **[7 Marks]**

c) What is an **Environmental Management Plan [EMP]** and state the significance for a surface mining project **[6 Marks]**

d) Define the **critical parameters** abstracted from metallurgical flow sheets for the purposes of open pit business planning and metallurgical modelling **[5 Marks]**

GOOD LUCK!!!

Table 1: Net Revenue Values [NRV] per block

-14	-14	2	3	11	38	121	88	141	88	56	-14	-14	-14	-14	-14
-14	-14	-14	8	39	149	82	105	203	101	75	-14	-14	-14	-14	-14
-14	-14	-14	-14	49	89	192	559	301	121	69	-14	-14	-14	-14	-14
-14	7	7	17	54	63	105	407	603	158	10	-14	-14	-14	-14	-14
-14	9	6	-14	2	-14	70	44	171	59	-14	-14	-14	-14	-14	-14
-14	2	55	4	-14	1	22	28	18	-14	-14	-14	-14	-14	-14	-14
-14	14	-14	-14	-14	-14	-14	-14	-14	-14	-14	-14	-14	-14	-14	-14

Table 2:

Table 3:

THE UNIVERSITY OF ZAMBIA

SECOND SEMESTER UNIVERSITY EXAMINATIONS

MAY 2011 SEMESTER EXAMINATION

MI 535: COAL MINING

TIME : THREE [3] HOURS FULL MARKS : 100

INSTRUCTIONS: ANSWER QUESTION 1 AND ANY OTHER FIVE

QUESTION 1

According to the Zambian Mining Regulations (1973), there are certain requirements to be abided in connection with standard of ventilation, precautions against mine dust and water inundation. Write these requirements and suggest what you would do if the values are not par with the regulations. **[20 Marks]**

QUESTION 2

a) In the run-of mine (ROM) of coal impurities such as rock pebbles, phosphorus and sulfur are generally present. Write clearly, the principle to separate them from the coal. **[10 Marks]**

b) What would happen if the impurities stated above are not removed and sold for various purposes? **[6 Marks]**

QUESTION 3

a) What is meant by rank of coal and what are the parameters on which it depends? Whether the rank of coal can be improved? **[10 Marks]**

b) Discuss, the impacts of coal miming on the environment, if any. How this can be controlled? In this context, how do you see the future of coal mining in two to three decades or so? **[6 Marks]**

QUESTION 4

a) A coal seam, 3.0m thick, lying at a depth of 380m, known to be highly prone to spontaneous combustion, to be mined. Above the surface of the coal deposit there are some important buildings which must be protected. Immediate return of capital for the management is not a priority.

Describe a suitable method for the extraction of this deposit and suggest the size of the pillars if the gallery width is to be kept = to 4.8m. **[10 Marks]**

b) Name four geological intrusions and their effects, on coal mining **[6 Marks]**

QUESTION 5

a) A coal seam, 12 m thick to be mined at a depth of 700 m. Describe the principle of mining this thickness of coal. Explain the difficulties and dangers one can experience in mining such a thick deposit. **[10 Marks]**

b) What are the general considerations for the adoption of a longwall advance mining? Name the equipment which is used for cutting and transportation of coal from the face to the trunk road. **[6 Marks]**

QUESTION 6

a) **DESIGN** a longwall face to give an approximate yearly output of 260,000 tonnes from the data given below:

- thickness of coal seam=2.0 m
- length of the coal face = 200 m
- web (depth of cut) of shearer =1.0 m
- Average sharer speed = 2.0 m
- Number of coal cutting shift / day =2
- only 60 % of 8- hour shift is utilized by shearer for cutting coal
- average specific gravity of coal=1.30

Express the answer in million tonnes nearest to a whole number (not in decimal). **[10 Marks]**

b) Draw a layout of the face you designed and show the location of different equipment you will be using for this purpose. **[6 Marks]**

QUESTION 7

a) What is HORIZON mining? Where is it best suited? Describe in brief the principle of extraction used in this method. **[10 Marks]**

b) If the depth of a shaft is 300m, thickness of coal seam to be extracted is 3.0 m, calculate the diameter of the shaft in meters using mining engineers method. **[6 Marks]**

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SECOND SEMESTER UNIVERSITY EXAMINATIONS

APRIL 2011 SEMESTER EXAMINATION

MI 545: MINE MANAGEMENT

TIME : THREE [3] HOURS FULL MARKS : 100

INSTRUCTIONS: ANSWER ALL QUESTIONS

QUESTION 1

a) Discuss the wider meaning(s) of Managements as a study **[5 Marks]**

b) What are the major functions of Leadership? **[5 Marks]**

c) List Fayol's principles of Management **[5 Marks]**

d) What qualities should a good Business Manager possess? **[5 Marks]**

QUESTION 2

a) Discuss the major ideas of Taylor and his "Machine Model Theory" of Management **[5 Marks]**

b) Weber's work on Bureaucracy has been praised and criticized, discuss why? **[5 Marks]**

c) The Human Relations approach was put to test by the "Hawthorne Experiments". Discuss the experiments and their major conclusions **[5 Marks]**

d) Discuss four distortions of perception as a process and their consequences on Managerial Style of leadership **[5 Marks]**

QUESTION 3

a) Discuss the similarities of all Organizations **[5 Marks]**

b) Write about the functions of key components of Organizations **[5 Marks]**

c) From a value and culture of Management, discuss the major types of Organizations **[5 Marks]**

d) From a Structural Mechanistic Management view, discuss the strengths and weaknesses of:

i)	Hierarchical Organizations	**[2 Marks]**
ii)	Multilayer Organizations	**[1 Mark]**
iii)	Centralized Organizations	**[1 Mark]**
iv)	Decentralized Organizations	**[1 Mark]**

QUESTION 4

a) Discuss the origin of money, and the reasons why people still need and keep money **[5 Marks]**

b) When you are to borrow money, how should you prepare your proposal and what is the Bank looking for? **[5 Marks]**

c) Discuss the functions of key Financial Institutions **[5 Marks]**

d) How do you raise money on a Stock Exchange? **[5 Marks]**

QUESTION 5

You are given a Balance Sheet as attached

a) List the major financial ratios and their use **[5 Marks]**

b) Calculate the ratios that would indicate risk exposure **[5 Marks]**

c) Calculate the ratios that would show use of assets **[5 Marks]**

d) Calculate the ratios that would indicate Management Efficiency **[5 Marks]**

END OF EXAM

You are given a Balance Sheet and Profit and Loss Statement for a Company as follows:

TABLE 8 - 1 BALANCE SHEET OF GENERAL BUSINESS CORPORATION ON DECEMBER, 31 1986 AND 1987

			1986	1987
Assets (uses of funds)	$	$	$	$
(1) Cash			11,009.00	12,571.00
(2) Maketable securities			5,977.00	7,519.00
(3) Accounts receiveable			33,581.00	31,053.00
(4) Inventories			59,443.00	56,521.00
(5) Other current assets			7,210.00	9,470.00
Total current assets			**117,220.00**	**117,134.00**
(6) Investments			28,122.00	29,818.00
(7) Property, plant and equipment			511,486.00	523,283.00
(8) Total asset (TA)			**656,828.00**	**670,235.00**
Liabilities (sources of funds)				
(9) Accounts payable			40,600.00	44,343.00
(10) Other current liabilities			38,991.00	39,816.00
Accrued expenses	17,800.00	19,006.00		
Notes payable	20,090.00	19,610.00		
Income taxes payable	1,101.00	1,200.00		
Total current liabilities			**79,591.00**	**84,159.00**
(11) Long-term debt			234,090.00	212,717.00
(12) Deferred tax			39,119.00	46,840.00
Total long-term liabilities			**273,209.00**	**259,557.00**
(13) Shareholder equity (EQ)			304,028.00	326,519.00
Total liabilities and equity			**656,828.00**	**670,235.00**

TABLE 8 - 2 INCOME AND EXPENSE STATEMENTS FOR GENERAL BUSINESS CORPORATION FOR THE YEARS ENDING DECEMBER, 31, 1986 AND 1987

	1986		1987	
	$	$	$	$
(14) Sales (S)		1,056,922.00		1,130,439.00
(15) Plus: Other income		433.00		1,484.00
Equals: Total revenue		**1,057,355.00**		**1,131,923.00**
Expenses				
(16) Cost of goods sold	694,329.00		728,861.00	
(17) Exercise taxes	196,335.00		207,452.00	
(18) Marketing and admininstrative expenses	100,385.00		110,641.00	
Less: Total operating expenses	**991,049.00**		**1,046,954.00**	
Earnings before interest and taxes (EBIT)	66,306.00		84,969.00	
(19) Interest expense	17,443.00		14,526.00	
(20) Other expenses	334.00		9,528.00	
Less: Total expenses		**1,008,826.00**		**1,071,008.00**
(21) Equals: Earnings before taxes		48,529.00		60,915.00
(22) Less: Coroporate income taxes		21,980.00		30,019.00
(23) Equals: Net income after taxes (IN)		26,549.00		30,896.00
(24) Less: Cash divided payment (CD)		13,270.00		15,448.00
(25) Equals: Addition to retained earnings (RE)		13,279.00		15,448.00
Per share data for common stock:				
(26) Number of shares outstanding		19,310.00		19,310.00
(27) Market price per share of stock		15.50		19.00
(28) Earnnings per share after tax (EPS)		1.37		1.60
(29) Cash dividents per share (CDPS)		0.68		0.80
(30) Price-earnings ratio (P/E)		11.27 times		11.875 times

THE UNIVERSITY OF ZAMBIA
SECOND SEMESTER UNIVERSITY EXAMINATIONS

APRIL 2011 SEMESTER EXAMINATION

MI 565: MINERAL ECONOMICS II

TIME : THREE [3] HOURS **FULL MARKS : 100**

INSTRUCTIONS: ANSWER FIVE QUESTIONS

QUESTION 1

a) Discuss the major concerns in the Management of an Economy **[5 Marks]**

b) In a globalizing world, some countries are loosing others are gaining wealth, why? **[5 Marks]**

c) Discuss the reasons why statistical measurements of National Income are sometimes misleading statements of national wealth? **[5 Marks]**

d) Discuss the Saving and Consumption functions **[5 Marks]**

QUESTION 2

a) Suppose the model of an economy is given as follows:

- $C = 50 + 0.75Y$
- $I = \bar{I} = 100$ $I = \bar{I} = 100$
- $G = \bar{G} = 50$
- $X = \bar{X} = 20$
- $M = 10 + 0.2Y$
- $T = \bar{G} = 25$

Find:

i) Equilibrium level of national income **[1 Mark]**

ii) Consumption level at equilibrium level of income, and **[2 Marks]**

iii) Total imports at equilibrium level of income **[2 Marks]**

QUESTION 3

a) Summarize the major proposals of the Harod-Domer growth model and its major shortcomings **[5 Marks]**

b) Summarize the major proposals of the Neo-Classical growth model and its major shortcomings. **[5 Marks]**

c) Economies go through booms and bursts. What does the monetary over investment theory say is the case. **[5 Marks]**

d) What are the key objectives of stabilization and how do governments achieve stabilization? **[5 Marks]**

QUESTION 4

(a) How does tax affect business operations, personal effort to work and why is government increasingly using taxes to manage the economy? **[5 Marks]**

(b) Illustrate the major causes of "enclave economics" and the best way to reform them. **[5 Marks]**

(c) Write about the major components of monetary policy and why it fails to work in developing countries. **[5 Marks]**

(d) A Counter Cyclical Fiscal Policy has limitations in its operations in developing countries, **discuss**. **[5 Marks]**

QUESTION 5

a) What should be the components of a good mineral policy? **[5 Marks]**

b) Discuss why it is difficult to reconcile interests in claimants of benefits from "Mineral Rents". **[5 Marks]**

c) What is the one variable that differentiates successful and prospering societies? **[5 Marks]**

d) Why is development determined by political and sociological and leadership factors process **[5 Marks]**

QUESTION 6

(a) Differentiate forward contracts from future contracts. **[10 Marks]**

(b) What are the major functions of commodity exchanges? **[10 Marks]**

END OF EXAM

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – MAY 2011

MM 205 – INTRODUCTION TO MINERAL SCIENCES

TIME: THREE HOURS

ANSWER **ANY** FIVE QUESTIONS AND ALL CARRY EQUAL MARKS

SECTION I: INTRODUCTION TO GEOLOGY AND MINING

1. (a) What is metamorphism? [2]

(b) Why is metamorphism referred to as an iso-chemical process? [2]

(c) Sketch a rock cycle and indicate on it the processes that the various rocks. [4]

(d) What is ore and why is it regarded as a special rock? [3]

(e) Distinguish chemical weathering from physical weathering. [3]

(f) Give one example of each of the 3 broad categories of rocks. [3]

(g) Describe briefly how nearly hexagonally-shaped mudcracks develop. [3]

2. (a) What is a mineral? [2]

(b) Give any three mineral examples [3]

(c) State and describe any two of the three main values of minerals. [3]

(d) Define the following terms: (i) anion, (ii) ionic bond, (iii) ring silicates [4]

(e) Determine Miller Indices of crystal faces that have the following crystallographic intercepts: (i) 1/2, infinity, 3/5; (ii) 2, 2/3, infinity; (iii) 1, 5/7, 1/3 [4]

(f) With reference to crystallographic axes sketch a crystal face with the following Miller Indices: (111) & (101). [4]

3. (a) Before an actual mining begins there are some essential works must be carried out. Describe, briefly, these works stating approximate TIME and the COST involved in each operation. [10]

(b) What are the advantages and disadvantages of surface mining compared to underground mining? [6]

There are certain methods classed as NOVEL method of mining. List at least FOUR of them. What minerals are also found in the bed of the sea? [4]

4. (a) In underground mining provision of artificial SUPPORTS and VENTILATION are essential components of mining. Why is it so? Write their purposes in detail. [10]

(b) How will you ensure that all sections of underground places are getting adequate amount of fresh and cool air? [5]

If the cross-section area of an air passage is doubled and the velocity of air is reduced by half, what would be the effect on total quantity of air flowing through That passage? [5]

SECTION II: INTRODUCTION TO METALLURGY AND MINERAL PROCESSING

5. (a) Illustrate using a diagram a differential flotation circuit for a 10,000 tonnes per day lead-zinc ore (12% Pb and 10% Zn) that yields lead and zinc concentrates at 40% and 24% respectively. Explain what is contained in the final tailings? [12]

(b) Suggest some changes you would make to the above type of flow sheet in order to recover three types of concentrates from a complex sulphide ore which is said to have copper, cobalt and nickel. [8]

6. (a) If given in flotation that F, C and T are weights of the feed, concentrate and tailings respectively in a given time with corresponding copper content in the three assaying *f*, *c* and *t*. The material balance for copper (metal contained in the three streams) will then be;

$Ff = Cc + Tt$ .....(1) given that initially $F = C + T$

or $Ft = Cc + (F - C)t$ .....(2)

Determine the ratio of concentration (F/C) in terms of *f*, *c* and *t* by using equation (1) in combination with the following; [6]

$Ft = Ct + Tt$ .....(3)

(b) If recovery of metal in the plant is (Cc/Ff), use result in (a) to determine recovery in percent given that the feed to a flotation plant assays 1.2% copper and the concentrate produced assays 30% Cu while the tailings are 0.12% Cu. [6]

(c) Illustrate the major differences between electro-winning and electro-refining processes at a tank house. [8]

END OF EXAMINATION IN MM 205

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – MAY 2011

MM 332

CHEMICAL THERMODYNAMICS II

TIME: Three Hours

ANSWER: Question one (compulsory) and any other four (4) questions. The relative weight of each question is indicated in brackets.

1.

(a) State and explain Raoult's law of ideal solution. What are the basic requirements for a liquid solution to be ideal? **[4]**

(b) A container measuring V litres in volume is divided by partitions into three unequal compartments that contain 1 g.mole of helium gas, 2 g.moles of neon gas, and 3 g.moles of argon gas. The initial temperature and pressure for each gas are 25°C and 1.2 atm. The gases are allowed to mix. Calculate the **[8]**

(i) Volume of the container
(ii) Mole fraction of each gas in the mixture, and
(iii) Partial pressure of each gas in the mixture
(iv) Change in Gibbs free energy, ΔG^M, and
(v) Change in entropy, ΔS^M

sustained by the system during the mixing process. Assume that the gases behave ideally.

(c) The partial pressures of A exerted by A-B alloys at 1000 K are

X_A	1	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2
$P_A \times 10^6$	5	4.4	3.75	2.9	1.8	1.1	0.8	0.6	0.4

(i) Determine the composition range over which Henry's law is obeyed by the solute A, and
(ii) Determine the value of the Henry's law constant at 1000 K, if the temperature variation of the Henry's law constant is given as

$$\log k_A = -\frac{109.3}{T} - 0.2886$$

(iii) Calculate $\Delta\overline{H}_A^M$ in composition range over which A obeys Henry's law, and
(iv) Write an equation for the variation of ΔH^M with composition over the same composition range. **[8]**

2.

(a) Kubaschewski and Alcock (1967) reported the data given in Table 2 below for relative integral molar enthalpy and entropy for bismuth-thalium liquid solutions at 623 K. **[13]**

(i) Derive from these data the values of the relative integral molar free energies for the liquid solutions at 623 K.

(ii) Obtain the relative partial molar free energies for bismuth and thalium at X_{Tl} = 0.2 and 0.6.

(iii) Calculate the activities of bismuth and thalium at these two compositions.

Table 2: Relative integral molar enthalpy and entropy for bismuth-thalium liquid solutions at 623 K

X_{Tl}	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
H^M (J/mole)	0.0	-1113	-2063	-2887	-3703	-4268	-4561	-4289	-3452	-2008	0.0
S^M (J/mole K)	0.0	2.70	4.14	5.06	5.40	5.48	5.31	4.85	3.98	2.59	0.0

(b) The Henrian activity coefficient γ_{Al}^{O} 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 (s) at 1600 °C for each of the following three standard states for Al:

(i) 2Al (l, pure) + 3/2 O_2 (g) = Al_2O_3 (s)

(ii) 2Al (l, h) + 3/2 O_2 (g) = Al_2O_3 (s)

(iii) 2Al (l, wt) + 3/2 O_2 (g) = Al_2O_3 (s) **[7]**

For the reaction 2{Al}+ 3/2 (O_2) = <Al_2O_3> the general equation $\Delta G_f^o = \Delta\overline{H}^o - T\Delta\overline{S}^o$ applies where; $-\Delta\overline{H}^o[J/g.mole]$ = 1,682,927 & $-\Delta\overline{S}^o[J/g.mole\,K]$ = 323.239 for the temperature range 933-2315 K.

3.

A liquid Fe-Al alloy is in equilibrium with solid Al_2O_3 and a gas phase containing oxygen.

(i) Derive a relationship linking the equilibrium activity of Al in the Fe-Al alloy with the partial pressure of oxygen in the gas phase when the 1-wt% standard state is used for the aluminium dissolved in iron. **[4]**

(ii) State under what conditions this relationship can be used to determine the equilibrium wt% of Al in the solution. **[3]**

(iii) If the 1-wt% standard state is a real thermodynamic state, what is the oxygen pressure of gas in equilibrium with an Al_2O_3-saturated Fe-Al solution containing 0.06 wt% Al at 1600 °C? **[4]**

(iv) Calculate the wt% Al and wt% O in liquid iron saturated with Al_2O_3(s) and in equilibrium with oxygen gas at 2.77 x 10^{-15} atm. The following data are provided:

For the reaction: 2Al(l, wt) + 3/2 O_2(g) = Al_2O_3(s); $\Delta G_{f(wt)}^o$ is -870 626 J at 1873 K;

For the dissolution of oxygen in pure liquid iron,

$$\tfrac{1}{2}\,O_2\,(g,\,1\ atm) = O\,(l,\,wt);\ \Delta G^{o}_{r\rightarrow wt} = -122{,}559\,J \quad at \quad 1873\,K$$

$$e^{O}_{O} = -0.20;\quad e^{Al}_{O} = -3.9;\quad e^{Al}_{Al} = 0.048;\quad e^{O}_{Al} = -6.6$$

[9]

4.

(a) If the rate of reaction

A + B = Products

depends upon the concentration of both A and B such that the reaction is second-order, derive the rate equation for a second-order process. Assume the concentrations of A and B to be C_A and C_B respectively at time t. **[5]**

(b) A second-order reaction has an initial concentration of the reactants of 0.4 moles/litre each. The reaction is 30 % percent complete in 80 minutes. Calculate the rate constant and the time it would take for the reaction to be 80 % complete. **[4]**

(c) The following data were obtained for the kinetics of reduction of FeO in slag by carbon in molten pig iron at a certain temperature: **[11]**

Concentration of FeO in slag, wt %	20.00	11.50	9.35	7.10	4.40
Time, min	0	1.0	1.5	2.0	3.0

(i) Using the Van't Hoff's differential method, calculate the order of the reaction with respect to FeO

(ii) Taking the order of reaction calculated in (i) above, calculate the rate constant and half-life for this process.

5.

(a) The standard free energy of formation of MnO in the temperature range 298 to 1500 K is given as ΔG^{o} = -384 700 + 72.8T joules, and the standard free energy of formation of H_2O in the temperature range 298 to 2500 K is given as ΔG^{o} = -246 000 + 54.8T joules. That is, for the reaction; **[10]**

$$Mn_{(s)} + H_2O_{(g)} = MnO_{(s)} + H_{2(g)};\ \Delta G^{o} = -\ 138\ 700 + 18.0\ T\ joules$$

(i) Calculate the H_2/H_2O ratio in equilibrium with pure Mn and MnO at 1400 K

(ii) The reaction $Mn + H_2O = MnO + H_2$ is set up in a Galvanic cell. Calculate

(1) the standard e.m.f. of the cell,

(2) the maximum work obtainable from this cell, and the

(3) heat transfer between the cell and its constant-temperature heat reservoir when it is operated reversibly.

(iii) Calculate the e.m.f. of the cell when the ratio of the pressures of H_2 and H_2O is 1000/1

(b) The emf of the cell: Cd(l) | Cd^{2+} (in melt) | Cd-Pb (l, $X_{Cd} = 0.128$) is found to be 37.4 mV at 500°C. The temperature coefficient of the cell emf is 99.1 μV/°K.

(i) Find $\Delta G^M_{Cd}\left(=\overline{G}_{Cd} - G^o_{Cd}\right)$ and $\Delta S^M_{Cd}\left(=\overline{S}_{Cd} - S^o_{Cd}\right)$ at 500°C.

(ii) Determine the value of a_{Cd} in the alloy, relative to pure liquid Cd as the standard state

(iii) Calculate the vapour pressure of Cd over the Cd-Pb alloy, given that the vapour pressure of pure liquid Cd is 13.5 Torr at 500°C.

(v) Ascertain whether the Cd-Pb system at XCd = 0.128 exhibits a positive or negative deviation from Raoult's law.

The Faraday's constant, F = 96 487 C/g-equivalent
Universal gas constant, R = 8.314 J/k/mol

[10]

6.

(a) Everett et *al.*, (1957) investigated the activity of zinc in liquid copper-zinc alloys in the temperature range 1069-1303 K. They found that the activity coefficient for zinc can be expressed as follows:

$$RT \ln \gamma_{Zn} = -31{,}630 X^2_{Cu}$$ Where R = 8.3143 J/mole K.

(i) Calculate the partial pressure of zinc, P_{Zn}, over a solution having the composition $X_{Zn} = 0.4$ and $X_{Cu} = 0.6$ at 1300 K. The vapour pressure of pure liquid zinc is given by **[5]**

$$\log P^o_{Zn} = -\frac{6620}{T} - (1.255 \log T) + 12.34 \; mm\,Hg$$

(ii) Derive a relationship for the activity coefficient of copper at 1300 K using an expression for the activity coefficient of zinc given above in liquid copper-zinc alloys. **[5]**

(b) The following data have been obtained for Cr-Ti solutions at 1523 K.

X_{Cr}	0.09	0.19	0.27	0.37	0.47	0.67	0.78	0.89
a_{Cr}	0.302	0.532	0.660	0.778	0.820	0.863	0.863	0.906

Using an appropriate form of the Gibbs-Duhem equation, calculate the activity of titanium in a Cr-Ti solution containing 60 atom % Ti. **[10]**

END OF EXAMINATION IN MM 332

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – MAY 2011

MM 352

HEAT AND MASS TRANSFER

TIME: Three Hours

ANSWER: Question one (compulsory) and any other two (2) questions from section A. Any two (2) questions from section B.

The relative weight of each question in both sections A and B is indicated in brackets.

SECTION A: Answer question one (compulsory) and any other two (2) questions from this section.

1.

(a) For convective heat transfer to water flowing in a tube, the film coefficient is given by

$$h = \frac{150(1+0.011T)u^{0.8}}{d^{0.2}} \quad \frac{Btu}{(h)(ft^2)(^oF)}$$

Where T is the mean water temperature (^oF)
u is the water velocity (ft/s)
d is the inside diameter of the tube (in)

What is the equivalent equation in SI units? **[7]**

(b) (i) What do you understand by the term "dimensional analysis"?
(ii) Explain the term "dimensional homogeneity" **[4]**

(iii) It is found experimentally that the terminal settling velocity u_0 of a spherical particle in a fluid is a function of the following quantities: particle diameter, d; buoyant weight of particle (weight of particle - weight of displaced fluid), W; fluid density, ρ, and fluid viscosity, μ.

Using the Rayleigh method, obtain a relationship for u_0 using dimensional analysis. Stokes established, from theoretical considerations, that for small particles which settle at very low velocities, the settling velocity is independent of the density of the fluid except in so far as this affects the buoyancy. Show that the settling velocity *must* then be inversely proportional to the viscosity of the fluid. **[9]**

2.

(a) Consider a slab in the region $0 \leq x \leq L$ having boundary surfaces at $x = 0$ and $x = L$ kept at uniform temperatures T_o and T_l respectively. The thermal conductivity k(T) of the material varies with temperature linearly in the form: $k(T) = k_o(1 + \beta T)$, where k_o is a constant thermal conductivity and the constant β is the temperature coefficient of thermal conductivity.

(i) Develop an expression for the rate of heat flow Q through an area A of the slab **[5]**

(ii) If the slab is L = 0.18 m thick and the surfaces at x = 0 and x = L are maintained at T_o = 500 K and T_l = 300 K respectively, calculate the heat flow rate per 1 m^2 of the slab for k_o = 0.2 W/(m.°C) and $\beta = 2 \times 10^{-3}$ K^{-1}.**[3]**

(b) The inner surface of a high temperature reactor will operate at 1623 K. The wall of the reactor will have an overall thickness of 350 mm and is to be made up of an inner layer of firebrick material (k_r = 0.86 W/(m.K)), covered with a layer of insulation (k_i = 0.16 W/(m.K)). This insulating material has a maximum operating temperature of 1473 K. The ambient temperature will be 293 K and it is estimated that the heat transfer coefficient at the exposed surface of the insulation will be 10 W/(m^2.K).

(i) Calculate the thickness of refractory and insulation which gives minimum heat loss, and the magnitude of this loss in W/m^2. **[6]**

(ii) Also, calculate the surface temperature of the insulation. **[3]**

(iii) If the calculated heat loss is unacceptable, would the addition of another layer of insulation be a satisfactory solution? Give your reasons. **[3]**

3.

(a) A household electric iron has a steel base [ρ = 7840 kg/m^3, C_p = 450 J/(kg.°C, and k = 70 W/(m.°C)] which weighs M = 1 kg. The base has an ironing surface of A = 0.025 m^2 and is heated from the other surface with a 250-W heating element. Initially the iron is at a uniform temperature of T_i = 20°C. Suddenly the heating starts, and the iron dissipates heat by convection from the ironing surface into an ambient at T_∞ = 25°C with a heat transfer coefficient h = 50 W/(m^2.°C).

(i) Calculate the temperature of the iron t = 5 min after the start of heating

(ii) What would the equilibrium temperature of the iron be if the control did not switch off the current? **[8]**

(b) A steel plate [$\alpha = 1.2 \times 10^{-5}$ m^2/s, k = 43 W/(m.°C), C_p = 465 J/(kg.°C), and ρ = 7833 kg/m^3] of thickness 10 cm, initially at a uniform temperature of 240°C, is suddenly immersed in an oil bath at 40°C. The convection heat transfer coefficient between the fluid and the surface is 600 W/(m^2.°C). Using the transient temperature charts provided in appendix A, answer the following questions;

(i) How long will it take for the center-plane to cool to 100°C? **[4]**

(ii) What is the temperature at a depth 3 cm from the outer surface? **[4]**

(iii) Calculate the energy removed from the plate during this time. **[4]**

4.

(a) A long hollow cylinder has an inner radius of 10cm, an outer radius of 20 cm, and a thermal conductivity k = 50 W/(m.°C). The inner surface is heated uniformly at a constant rate $q_a = 1.16 \times 10^5$ W/m^2, and the outer surface is maintained at zero temperature. Calculate the temperature of the inner surface. **[8]**

(b) Saturated steam at 267°F is flowing inside a ¾ in. steel pipe having an ID of 0.824 in. and an OD of 1.050 in. The pipe is insulated with 1.5 in. of insulation on the outside. The convective coefficient for the inside steam surface of the pipe is estimated as h_i = 1000 btu/(h.ft^2.°F), and the convective coefficient on the outside of the lagging is estimated as h_o = 2 btu/(h.ft^2.°F). The mean thermal conductivity of the metal is 45 W/(m.K) or 26 btu/(h.ft.°F) and 0.064 W/(m.K) or 0.037 btu/(h.ft.°F) for the insulation.

(i) Calculate the heat loss for 1 ft of pipe using resistances if the surrounding air is at 80°F. **[7]**

(ii) Repeat using the overall U_i based on the inside area A_i. **[5]**

SECTION B: Answer any two (2) questions from this section.

5.

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

(b) Give reasons why liquid mass diffusivities depend on concentration **[5]**

(c) Estimate the liquid diffusion coefficient of ethanol, C_2H_5OH, in a dilute solution of water at 10°C. **[10]**

Given that Atomic Volume for

(i) Carbon =14.8 cm^3/g mole

(ii) Oxygen =7.4 cm^3/g mole

(iii) Hydrogen=3.7 cm^3/g mole

Viscosity =1.45 centipoises

Molecular weight of water =18

Association parameter for water = 2.26

6.

(a) Calculate the gas film coefficient K_G for the absorption of sulphur dioxide from a dilute mixture with air in a wetted wall column using the experimental data below

Inside diameter of column, d = 25mm

Gas velocity = 2.2 m/s

Gas temperature = 293K

Gas viscosity = 1.78×10^{-5} Ns/m^2

Gas density = 1.22kg/ m^3

Diffusivity, D = 12.2×10^{-6} m^2/s

Gas constant, R = 8.314 kJ/Kmol.K

Use the Gilliland and sherwood's correlation given below to calculate the effective film thickness x (mm) **[12]**

$$\frac{d}{x} = 0.023 Re^{0.83}.Sc^{0.44}$$

(b) Define the mass transfer coefficient **[4]**

(c) Explain why diffusion coefficients are higher in gases than in liquids and solids **[4]**

7.

(a) Ammonia gas is diffusing through a uniform tube 0.10m long containing N_2 gas (B) at 1.0132×10^5 Pa and 25°C. This is a case of equimolar counter diffusion. At point 1, $P_{A1} = 1.013 \times 10^4$ Pa and at point 2, $P_{A2} = 0.507 \times 10^4$ Pa. The diffusivity $D_{AB} = 0.230 \times 10^{-4} m^2/s$

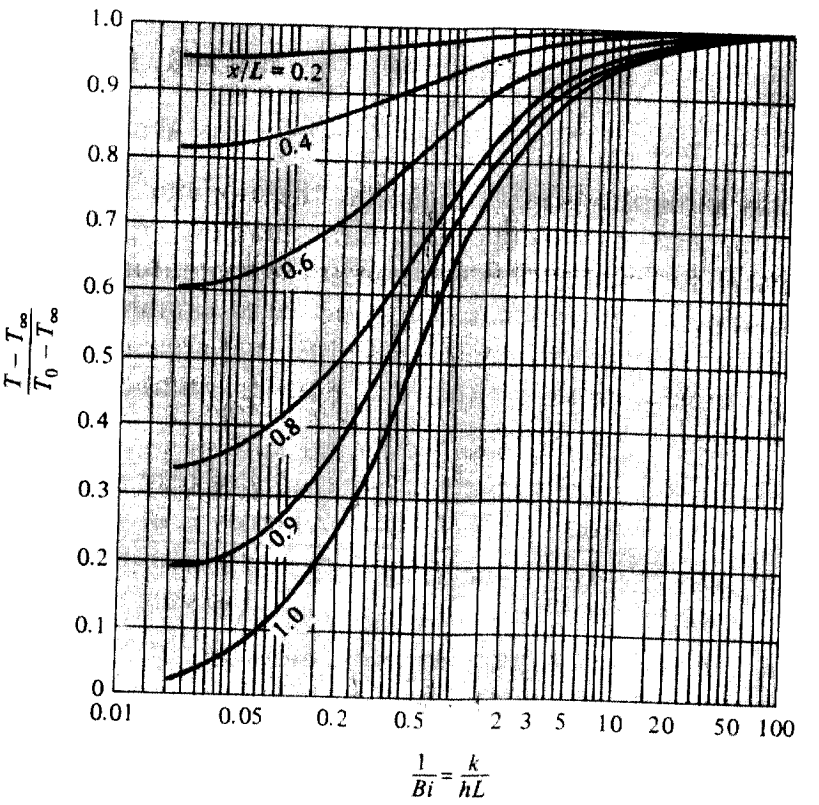
(i) Calculate the flux N_A at steady state **[6]**

(ii) Repeat for N_B (Show your working) **[6]**

(b) Considering a control volume in the fluid, show that $N_{AZ} = h_D (C_{A1} - C_{A2})$, stating all the assumptions made and define h_D. **[8]**

END OF EXAMINATION IN MM 352

APPENDIX A



(c)

Figure 1: (c) Position correction for use with part (b) below.

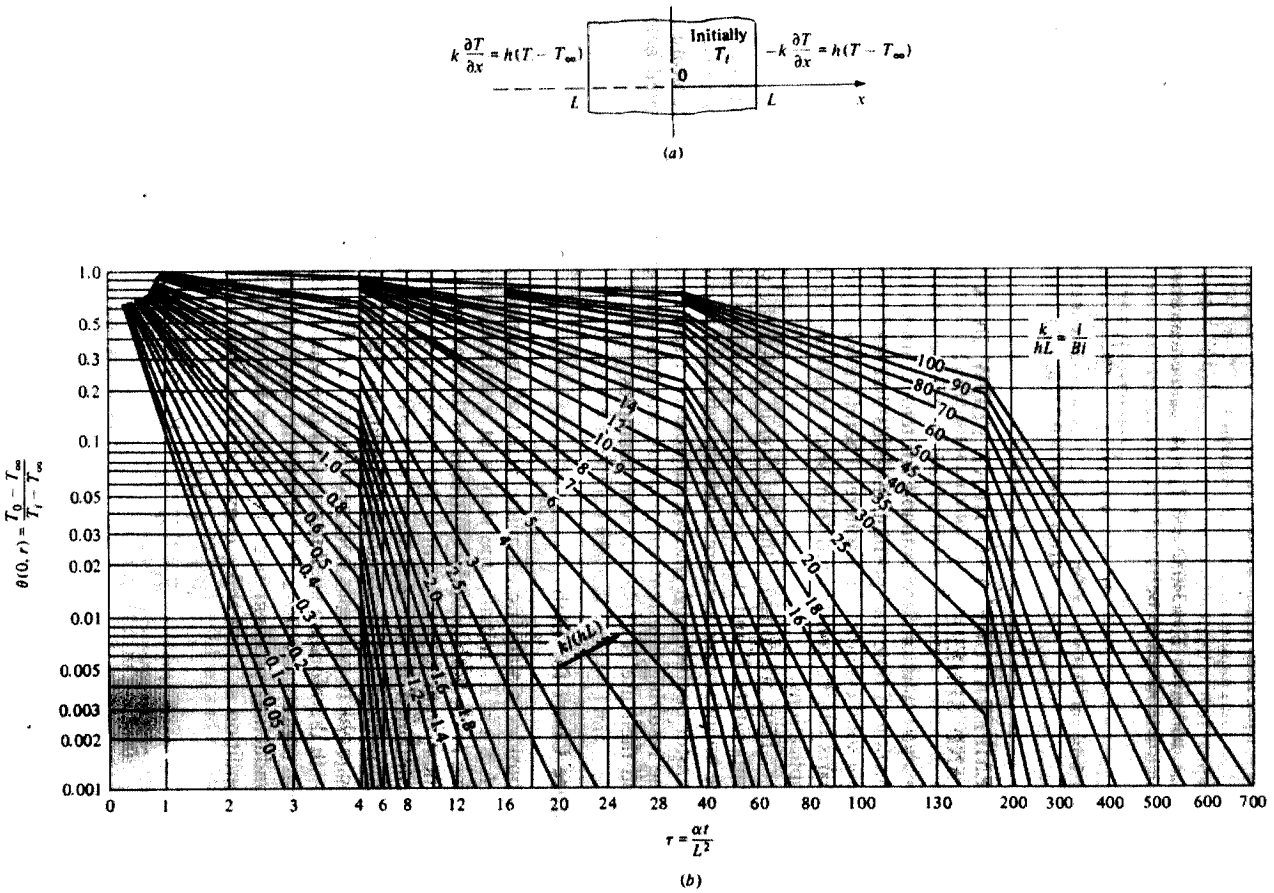


Figure 2: Transient temperature chart for a slab of thickness 2L subjected to convection at both boundary surfaces. (a) Geometry, coordinates and boundary conditions for the physical problem; (b) Dimensionless temperature θ (0, τ) at the center plane, x = 0

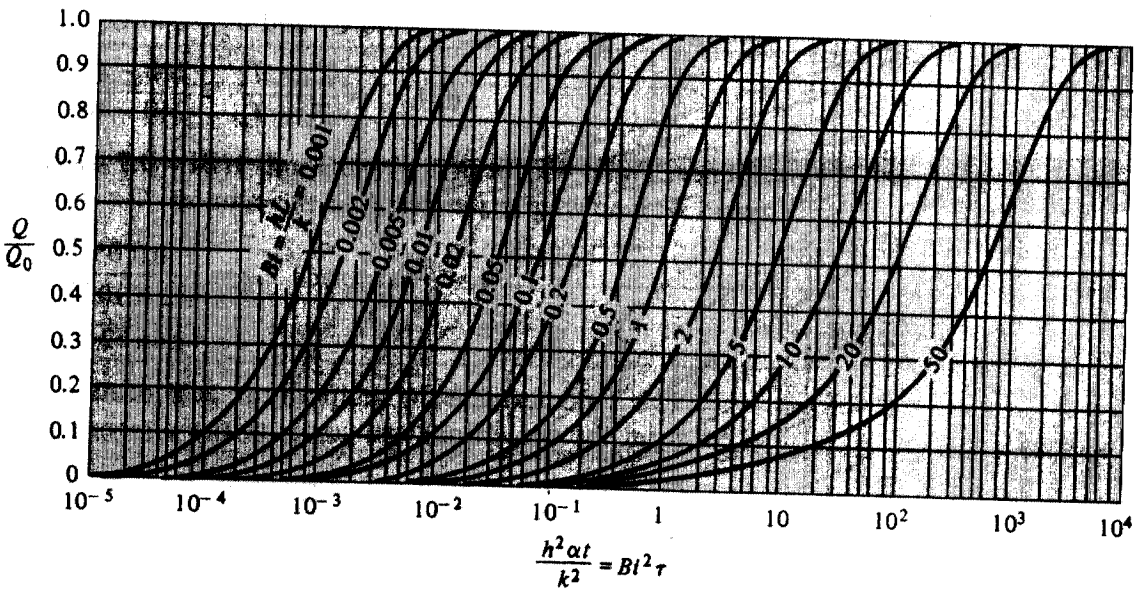


Figure 3: Dimensionless heat transferred Q/Q_o for a slab of thickness 2L

Useful Conversion Factors

Area
$1\ m^2 = 10.764\ ft^2$

Density
$1\ kg/m^3 = 0.06243\ lb/ft^3$

Diffusivity (heat, mass, momentum)
$1\ m^2/s = 10.7639\ ft^2/s$

Energy, heat, power
$1\ J = 1\ W \cdot s = 1\ N \cdot m = 10^7\ erg$
$1\ J = 0.73756\ ft \cdot lbf$
$1\ cal = 4.1868\ J$ (or $W \cdot s$ or $N \cdot m$)
$1\ kcal = 3.968\ Btu$
$1\ Wh = 3.413\ Btu$

Heat capacity, specific heat
$1\ W/°C = 1.8961\ Btu/(h \cdot °F)$
$1\ kJ/(kg \cdot °C) = 0.23885\ Btu/(lb \cdot °F)$
$1\ cal/(g \cdot °C) = 1\ Btu/(lb \cdot °F)$

Heat flux
$1\ W/m^2 = 0.317\ Btu/(h \cdot ft^2)$

Heat generation rate
$1\ W/m^3 = 0.0966\ Btu/(h \cdot ft^3)$

Heat transfer coefficient
$1\ W/(m^2 \cdot °C) = 0.1761\ Btu/(h \cdot ft^2 \cdot °F)$

Length
$1\ m = 3.2808\ ft$

Mass
$1\ kg = 2.2046\ lb$

Pressure, force
$1\ bar = 10^5\ N/m^2 = 10^5\ Pa$
$1\ atm = 14.696\ lbf/in^2$
$1\ atm = 1.0132\ bar$
$1\ Pa = 1\ N/m^2$

Specific heat
$1\ J/(g \cdot °C) = 0.23885\ Btu/(lb \cdot °F)$
$1\ J/(g \cdot °C) = 0.23885\ cal/(g \cdot °C)$

Temperature
$1\ K = 1.8°R$
$T(K) = 1/1.8(°F - 32) + 273.15$

Thermal conductivity
$1\ W/(m \cdot °C) = 0.5779\ Btu/(h \cdot ft \cdot °F)$

Viscosity, dynamic
$1\ P = 1\ g/(cm \cdot s)$
$1\ kg/(m \cdot s) = 0.672\ lb_m/(ft \cdot s)$

Volume
$1\ m^3 = 35.315\ ft^3$
$1\ gal\ (U.S.) = 0.13368\ ft^3$

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – MAY 2011

MM 412 – MINERAL PROCESSING II

TIME: THREE HOURS

ANSWER ANY FIVE QUESTIONS. RELATIVE WEIGHT OF EACH QUESTION IS INDICATED IN BRACKETS.

---

1. Classification of solid particles is very important, more especially in those industries where various products and by- products are a must to be used for various purposes. To achieve very fine classification or separation, the principle of sedimentation and elutriation is normally used in practice. For these purposes:
gravity settling tanks, **[7]**
elutriators **[7]**
and very often **spitzkastens** are used. **[6]**

With the help of clear illustrative diagrams, describe the operation principles of each of them.

2. (a) Describe in details the operation of a **shaking table** and outline the various important operating variables used in the model development for the shaking table and explain how these variables affect the operation of the shaking table. [10]

(b) The **hydro cyclone** is the most widely used centrifugal separator. Describe the **hydro cyclone** and how it operates. How is the efficiency of the cyclone measured or determined? [10]

3. Describe how the following separation methods work:

(a) Gravity separation [4]
(b) Magnetic separation [4]
(c) Electrostatic separation [4]
(d) Froth flotation [4]
(e) Electro flotation [4]

4. The particle Reynold's number is defined as, $Re_p = (d_p \text{ u } \rho)/\mu$, which should not exceed a threshold value of 2 for the Stoke's law to be applicable.

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(a) From first principles, derive an expression for the maximum particle diameter for Stoke's law to apply in the case of a particle settling freely under gravity. State all the assumptions [10]

(b) An effluent containing a mineral in suspension with solid and water densities of 2600 and 1000 kg/m^3 respectively is pumped into a batch vessel 5m high and left for 30 minutes prior to discharge into a river. The viscosity of water is 0.001Pa s. Calculate the maximum particle diameter that will be in the discharge. [5]

(c) What is the difference between Coagulation and flocculation? Mention some examples of both as used in dewatering operations. [5]

5. Explain the role of the following in flotation with some example

(a) Collectors [5]
(b) Frothers [4]
(c) Regulators [4]
(d) Modifiers [5]
(e) Contact angles [2]

6. (a) In the disposal of tailing you can use, upstream dam by cycloning, centre-line dam or the downstream dam. How do the three methods differ and which is the most widely used? [15]

(b) What are the important measures to be taken before the disposal of any tailings? [5]

END OF EXAMINATION IN MM 412

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – MAY 2011

MM 412 – MINERAL PROCESSING II

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END OF EXAMINATION IN MM 412

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – MAY 2011

MM 422 – MATERIALS PERFORMANCE

TIME: THREE HOURS

ANSWER TWO QUESTIONS IN SECTION A AND THREE QUESTIONS IN SECTION B. RELATIVE WEIGHT OF EACH QUESTION IS INDICATED IN BRACKETS.

SECTION A

1. What materials would you select for the following applications and why?
   (a) Automobile radiator core
   (b) Plumbing accessories
   (c) Solder for electronic equipment
   (d) Domestic table knife

[12]

2. Discuss the validity of the following statements, in each case explaining your reasoning:
   (a) There is a very significant difference between the theoretical, and actual fracture strength of materials.
   (b) In the presence of an aggressive environment, a material may actually fail below K_{IC}.
   (c) Plane stress always results in plane strain deformation.
   (d) On an x-ray diffractometer pattern from an fcc material, 211 and 310 peaks will always be absent.

[12]

3. (a) What is creep and in which materials does it commonly occur?
   (b) Other things being equal, which will have the lowest creep rate?
      (i) Steel in service with a high tensile stress and low temperature
      (ii) Steel in service with a low tensile stress and high temperature
      (iii) Steel in service with a high tensile stress and high temperature
      (iv) Steel in service with a low tensile stress and low temperature

   Explain your reasoning in the consideration of each item (i)-(iv).

[12]

SECTION B

4. (a) What is the fatigue limit and in which materials is it most likely to be noticeable?
   (b) Explain the significance of Miner's Law with respect to the prediction of service life of engineering components.

$$\sum_{i=1}^{\infty} \frac{n_i}{N_i} = 1$$

where n_i = number of cycles applied at stress S_i and N_i = number of cycles to cause failure at stress S_i

(c) In class it was stated that for engineering components, the ASME has recommended that a curve which is less than the experimental curve by two orders of magnitude for stress or twenty for number of cycles to failure should be used in design (Figure 1). Justify why this should be so.

(d) A fatigue specimen is cyclic loaded as follows: (1) The specimen is loaded in tension for 1 sec at 1,500 MPa/s, starting from a zero load; (2) it is then held at its maximum load for 1 sec; and (3) it is unloaded for 1 sec at –1,500 MPa/s. This cycle is then repeated over and over.

(i) Draw several cycles showing the cyclic loading pattern.

(ii) Determine the mean stress σ_m, alternating stress σ_a and stress ratio R.

[25]

5. (a) Distinguish between the terms malleability and ductility.

(b) For a material that does not show a pronounced yield point on its stress-strain curve, describe with the aid of an appropriate sketch, how you would determine its yield strength.

(c) A load-elongation curve obtained by tensile testing a specimen of α-Brass is shown in Figure 2. Determine the following

(i) Tensile strength

(ii) Apparent fracture strength

(iii) 0.2% yield strength

(iv) The constants k and m in the expression $\sigma = K\varepsilon^m$

[25]

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

(b) Draw curves indicating the linear, parabolic, logarithmic and inversely logarithmic growth laws for oxidation. State the growth laws that would be obeyed by an oxide that offers excellent protection against further oxidation.

(c) Up to what temperature is iron (steel) resistant to oxidation in air? Explain why this is so.

(d) How can the high-temperature oxidation of steel be controlled?

[25]

7. (a) What are the main differences between reflection (as applied to light) and diffraction?

(b) What is the significance of Bragg's law in diffraction studies?

$$n\lambda = 2dSin\theta$$

(c) Describe how you would use x-ray diffraction to document the existence of residual stress in a material.

(d) The crystal structure of blende (ZnS) is face-centred cubic with one formula unit

per lattice point. For a Zn atom placed at the origin of the unit cell and a S atom at ¼¼¼

(i) Write down and simplify the expression for the structure factor F_{hkl} of blende.

(ii) Evaluate the intensities of the 111, 200 and 220 reflections assuming that atomic scattering factors are proportional to atomic numbers which are 30 and 16 for Zn and S, respectively. Note that the intensity is proportional to $|F|^2$.

$$F_{hkl} = \sum_{n=1}^{N} f_n \exp 2\pi i(hx_n + ky_n + lz_n)$$

[25]

END OF EXAMINATION IN MM422

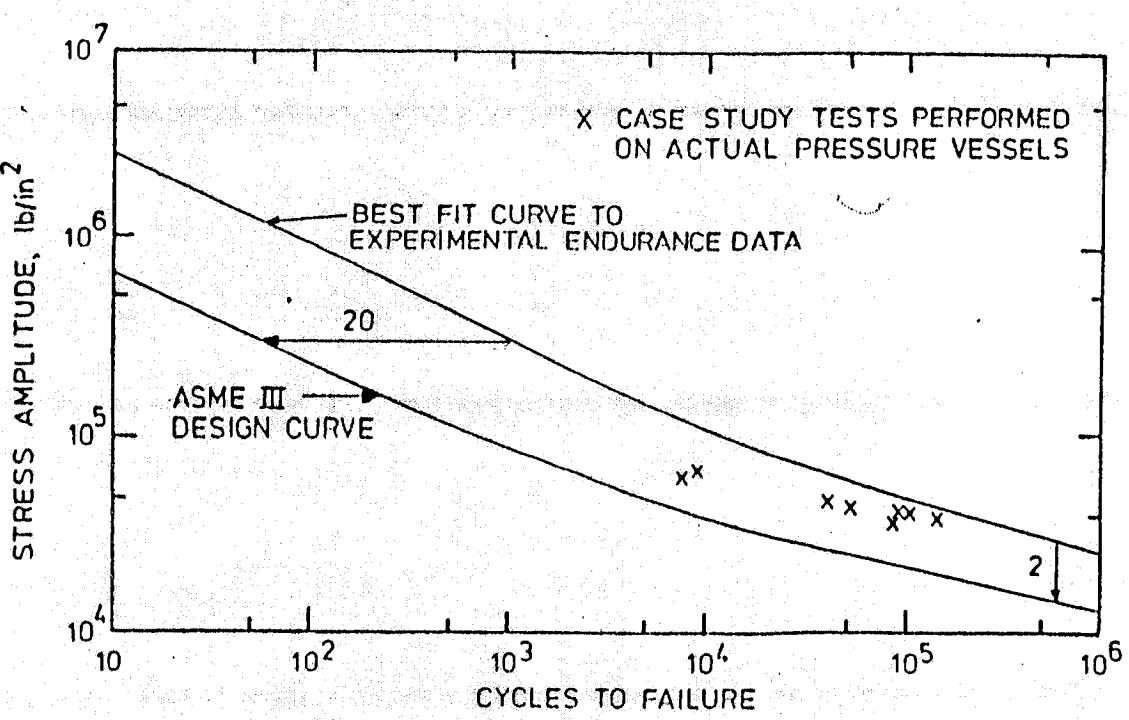

Figure 1. Experimental and ASME Design Curves.

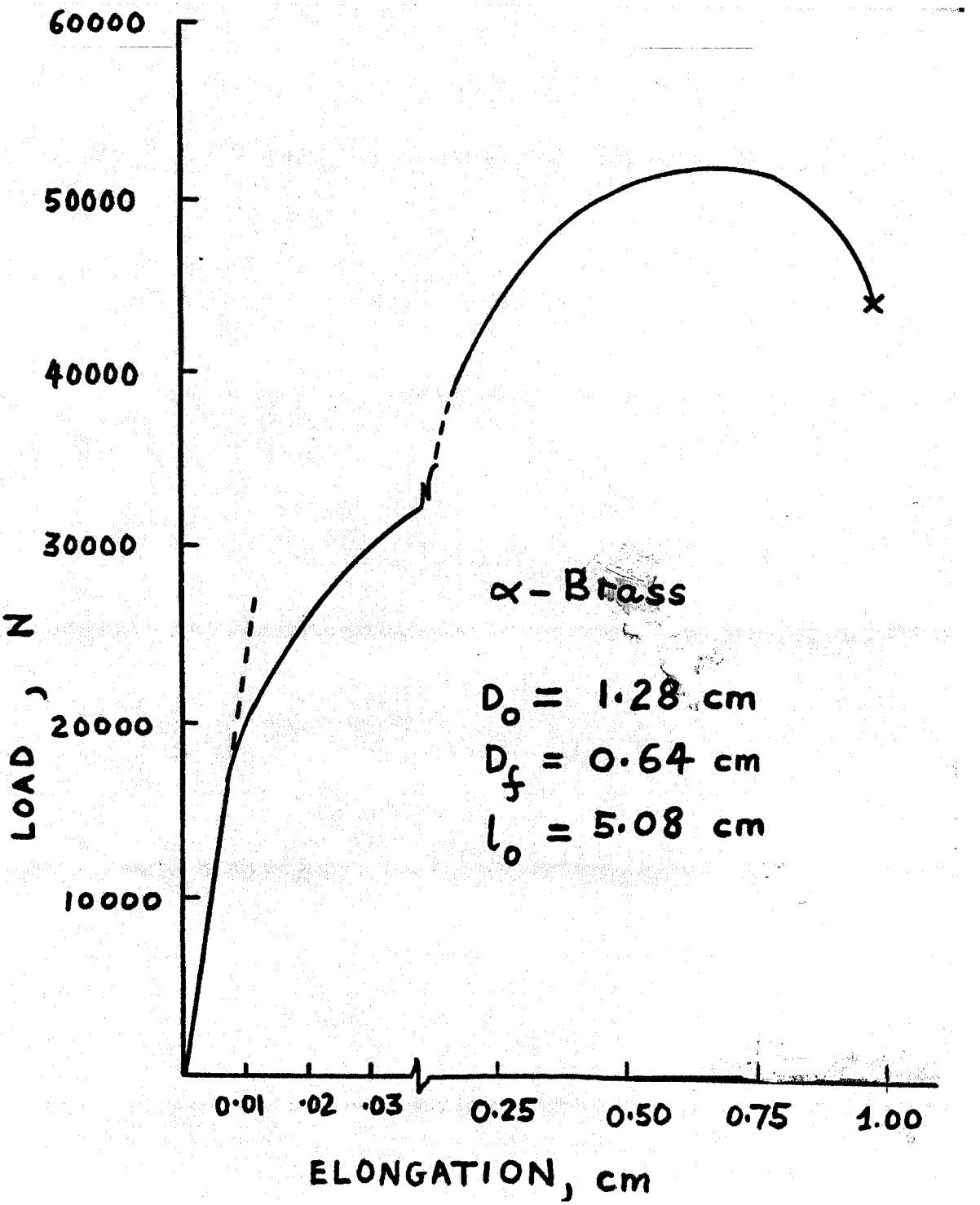

Figure 2. Load-Elongation curve for α-Brass.

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SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – MAY 2011

MM 442 – PYROMETALLURGY

TIME: THREE HOURS

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

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1 (a) State, with reasons the important operating parameters in the roasting of sulphide minerals. [7]

(b) With the aid of a clearly labelled diagram, outline how roasting is carried out in a Multiple Hearth roaster. What are the relative merits and demerits of this roasting unit? [6]

(c) Describe the sintering of sulphide mineral particles under the headings:-

(i) Objectives of the process
(ii) Nature of the feed
(iii) The equipment used
(iv) The sintering mechanism

[7]

2 (a) Starting from Fick's First Law of diffusion, show that for the oxidizing roast of sulphide minerals the last traces of sulphur are not readily removed. State any assumptions made in your answer. [6]

(b) Use the data given below to draw part of the Mo-S-O predominance area diagram at 625°C and clearly label the 3 stability regions of molybdenum compounds. [12]

(c) A molybdenite concentrate is roasted at 625°C and I atm pressure in a furnace with 5% O_2 and 15% SO_2. Use the diagram drawn above to deduce which molybdenum compound or compounds will be stable in the calcine assuming equilibrium is attained. [2]

Thermodynamic data

(i) $MoO_2 + 2SO_2 = MoS_2 + 3O_2$
$\Delta G^\circ_T = 218900 - 38.0T$ cal/mol

(ii) $MoS_2 + 3.5O_2 = MoO_3 + 2SO_2$
$\Delta G^\circ_T = -257600 + 57.5T$ cal/mol

(iii) $MoO_2 + 0.5O_2 = MoO_3$

$\Delta G^{o}_{T} = -38700 + 19.5T$ cal/mol

The value of R = 1.986 cal/deg/mol

3. Pure sphalerite (ZnS) is roasted completely to ZnO with excess air in a continuous process operated at 900°C. If the off-gas has 5.5% SO_2, determine on the basis of 1 kg ZnS roasted:

(a) The off-gas composition. (Atomic weights: Zn = 65.4, S = 32.1. One kilomole of a gas occupies 22.41 Nm^3 while air comprises 79%N_2 and 21%O_2 [6]

(b) The Heat deficit or surplus of the roasting operation if both ZnS and air enter the roaster at 25°C and if heat losses amount to 20% of the exothermic heat of reaction. Relevant data follows. [14]

Thermodynamic data

$H^{o}_{T} - H^{o}_{298} = aT + 0.5bT^2 + c/T + d$ cal/mol

Substance	a	b x 10^3	c x 10^{-5}	D	H^{o}_{298}
ZnS	10.6	2.51	-	-3270	-22600
ZnO	30.09	9.91	-	-9407	-212000
O_2	7.16	1.00	-0.40	-2044	-
N_2	6.66	1.02	-	-2030	-
SO_2	10.38	2.54	-1.42	-2729	-70940

4 (a) Discuss the factors that influence the smelting rate of matte in a reverberatory furnace. [5]

(b) A copper matte contains 60% Cu. Assuming ideal behaviour, what is the full composition and phase analysis?
(Data: Fe = 55.8, Cu = 63.5, S = 32.1) [7]

(c) Describe copper matte converting under the headings:

(i) Feed Materials
(ii) Process Chemistry
(iii) The products
(iv) Why is the converter not bottom blown?

[8]

5 (a) What is the objective of copper fire-refining? [5]
(b) What equipment is used for copper fire-refining? [5]
(c) Discuss the chemistry of copper fire-refining. [10]

END OF EXAMINATION IN MM 442

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MINES

DEPARTMENT OF METALLURGY AND MINERAL PROCESSING

UNIVERSITY EXAMINATIONS – MAY 2011

MM 452: PROCESS INSTRUMENTATION AND CONTROL

TIME : **3 HOURS**
ANSWER : **ANY FIVE QUESTIONS.**
WHERE APPLICABLE, ALL CALCULATIONS ARE TO BE DONE CORRECT TO THREE DECIMAL PLACES.
ADDITIONAL INFORMATION IS PROVIDED WITH THIS EXAM

Question 1

(a) Define functional transforms and operational transforms giving a brief example of each of these terms.

(3 marks)

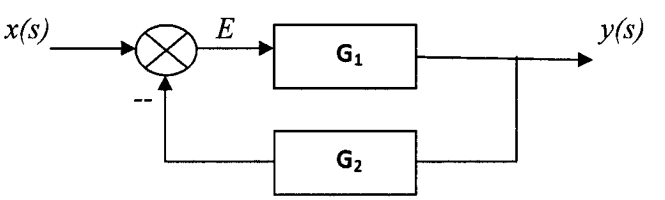
(b) Derive a system model to describe transient behaviour in a tank in series process. By using deviation variables Use the Laplace transform to show this system and finally expressing this model in terms of a transfer function.

(5 marks)

(c) Derive a transfer function for the block diagram below.

(i) Show that

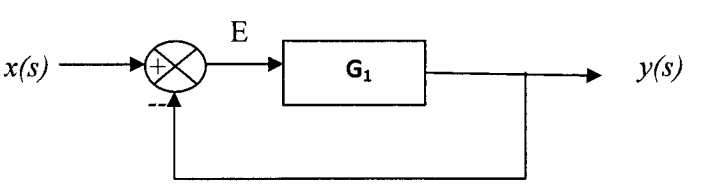
$$\frac{y(s)}{x(s)} = \frac{G1}{1 + G1G2}$$



(4 marks)

(ii) Show that

$$\frac{y(s)}{x(s)} = \frac{G1}{\frac{1}{G1} + 1}$$



(4 marks)

(d) The transfer function of a hydraulic system comprising of a hydraulic valve and actuator is G(s) = 1/ (Ts). Write down the closed loop transfer.

(2 marks)

(e) Find the general solution for the given equation.

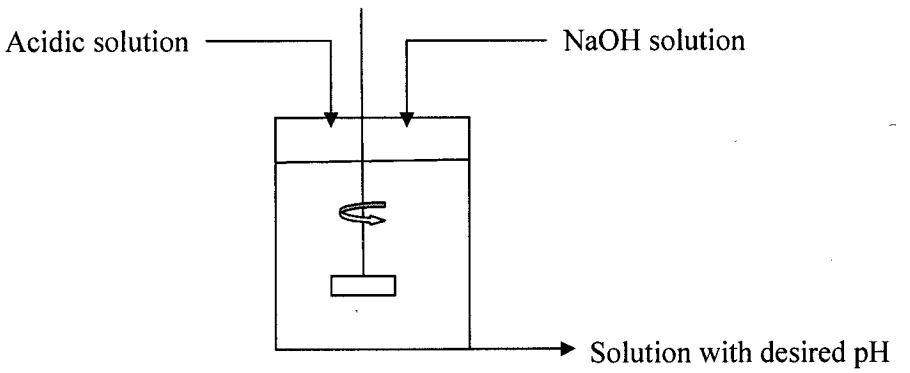
$$y = C_1e^{-t} + C_2e^{2t}$$

(2 marks)

Question 2

(a) What are the four basic components of a control system and how would they help you design a control system for maintaining the pH of the liquid in the stirred tank, where the volume of the fluid in the tank is kept constant. What would be your objective? Develop a block diagram for this system (figure shown below).

(6marks)



(b) Develop a block diagram of a two-input control system in a home shower with separate valves for hot and cold water who's main objective should be to obtain a desired temperature of the shower water and flow rate. What kind of a system is this? Explain its significance.

(4marks)

(c) With the help of a simple sketch, devise a Control System to fill a container with water after it is emptied by a stopcock at the bottom. The system must automatically shut off water when the container is filled. Considering that this system is first order system, develop a material balance expressing the liquid level as a function of time and explain the term t_{fill}.

(5marks)

(d) Solve each of the differential equations

a) $x\frac{dy}{dx} = y + \sqrt{x^2 + y^2}$ b) $y'' + 4y = cos2x$

(5marks)

Question 3

(a) Explain why Dead time is different from lag?

(3marks)

(b) A first order system is

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

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

(5marks)

(c) A first-order system is represented by

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

Develop an expression that shows how the output y(t) changes in response to the inputs . Calculate y at t =2 and at t = 3. What is the ultimate value of y?

(5marks)

(d.) Solve the following initial value problems.

a) $y'' - 5y' + 6y = 2e^x$

b) $y'' - 4y = 16e^{2x}$, $y(0) = 0$, $y'(0) = 4$

(7marks)

Question 4

(a) A control scheme is the plan by which we intend to control a process, name four steps that are involved in developing a control scheme for the blending tank, explaining briefly each of these steps.

(3marks)

(b) Our blending tank under proportional control has the following system model:

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

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

You are given the following values:

$\tau = 300$ s; $C_{Ac} = 400$ kg/m^3; $F = 0.02$ m^3/s ; $K_c = 0.0001$ m^6/kg s.

Using the integrating factor method,

(i) Calculate the value of C'_{Ao} at t = 200 s for C'_{Ai} = U (t – 50), $C'_{Ao,setpt}$ = U (t – 100)

(ii) Calculate the offset and the corresponding value of F'_c.

(10 marks)

(c) Solve each of the given differential equations.

a) $\frac{d^2y}{dx^2} + y = 0$ b) $x^2\frac{d^2y}{dx^2} + x\frac{dy}{dx} = 0$

(7marks)

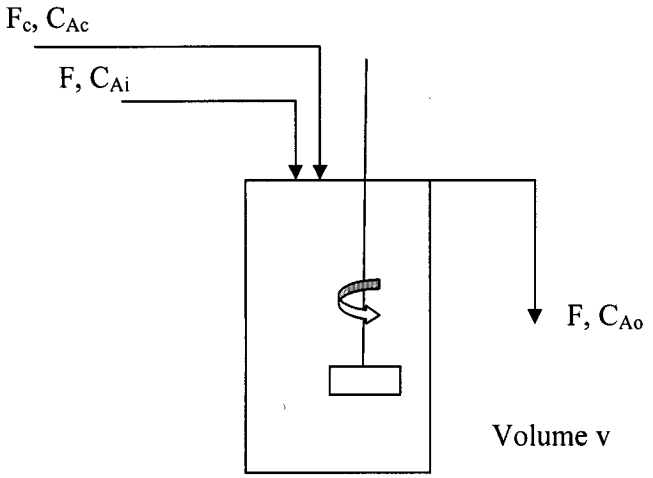
Question 5

(a) Explain briefly the characteristics of the frequency response?

(3marks)

(b) The diagram below shows concentration control in a blending tank. Develop a material balance express this balance in terms of deviation variables.

(7marks)



(c) A laser jet printer uses a laser beam to print copy rapidly for a computer. The laser is positioned by a control input, r(t), so that we have

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

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

(5 marks)

(d) Find the integrating factor and hence solve the differential equations

a) $x\frac{dy}{dx} + 3y = 6x^3$ b) $\frac{dy}{dx} + \frac{y}{x} = sinx$ (5marks)

Question 6

(a) What does the deviations from reference conditions represent and is it possible to recover the physical variables?

(3marks)

(b) With the help of a simple sketch, draw two tanks in series with a single inlet and outlet streams each tank operating in overflow. Develop a material balance for this system expressing the output in Laplace domain formulation or as transfer functions

(4marks)

(c) Solve the following differential equation by Laplace Transform.

$$\frac{d^2x}{dt^2} + \frac{2dx}{dt} + 2x = 2 \quad , \quad x(0) = x'(0) = 0$$

(5marks)

(d) Compare the time response of a system with the transfer function shown below to a unit impulse and unit step input. And sketch a graph showing the step Response.

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

(5marks)

(e) Find a general solution for the given equation.

$t^2dy + (2ty - t + 1)\,dt = 0$ (3marks)

ADDITIONAL INFORMATION PROVIDED

The first-order ODE is as follows:

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

The solution is

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

Table of Laplace Transforms

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

Inversion by partial fractions

METHOD 1

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

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

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

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

where a_1 and b_1 are constants evaluated in the partial fraction expansion and $F_1(s)$ is a series of fractions arising from F(s).

Then the inverse transform arising from the complex root reduces to

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

METHOD 2

Suppose x(s) after partial fraction expansion becomes

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

Then

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

The inverse transform arising from the above becomes

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

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – MAY 2011

MM 542 – FUELS, FURNACES AND REFRACTORIES

TIME: THREE HOURS

ANSWER ANY FIVE QUESTIONS. THE CREDIT FOR A FULL ANSWER IS SHOWN IN BRACKETS BESIDE EACH QUESTION

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

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

   Briefly describe the determination of these properties [9]

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

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

   (b) Outline four properties of silica [4]

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

   (d) Casually made dolomite bricks "perish" and "dust". What is the meaning of these two expressions in this context? And how can

"perishing" and "dusting" be minimised in the manufacture of dolomite bricks? [4]

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

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

(b) Distinguish between zircon and zirconia [4]

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

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

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

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

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

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

(d) Calculate the ideal flame temperature for the combustion of methane by air preheated to 600 degrees C. [8]

The heat of combustion is given by:

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

Specific heats:

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

1 mole of gas occupies 22.4 litres at STP

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

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

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

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

(e) Calculate the volume of air required, and the composition of the flue gases when 1 kg of oil is burnt stoichiometrically, where the oil analysis is 85% C and 15% H. [8]

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

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

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

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

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

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

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

END OF EXAMINATION IN MM 542

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – MAY 2011

MM 552 – PROCESS DESIGN

TIME: THREE HOURS

ANSWER ANY FIVE QUESTIONS. ADDITIONAL DATA IS PROVIDED WITH THE QUESTION PAPER

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1. (a) Briefly discuss the significance of degrees of freedom in process design. [3]

(b) Deduce the number design variables in the case of a pump that is pumping a liquid. How may these be utilised? [3]

(c) Indicate the order of solution of the following sets of equations:

(i) $f_1(x_1, x_3) = 0$

$f_2(x_2) = 0$

$f_3(x_2, x_3) = 0$

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

$f_2(x_1, x_3) = 0$

$f_3(x_4) = 0$

$f_4(x_3, x_4) = 0$

Use the **single node** representation for the order of solution. [6]

(d) A Cu – 5% Sn – 10% Si – 5% Zn alloy is melted. If there is a 10% loss of Zn from the charge during melting, and the following alloys are available, how many kg of each alloy would you charge to make 100 kg of alloy?

	%Cu	**%Sn**	**%Zn**	**%Si**
Alloy A	**70.0**		**30.0**	
Alloy B	**83.5**	**15.0**		**1.5**
Alloy C	**69.0**	**1.0**		**30.0**
Pure Cu	**100.0**			

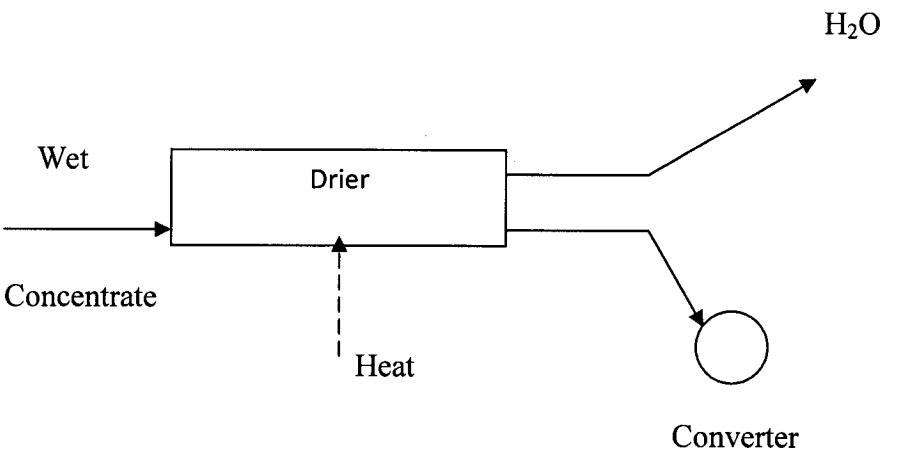
Use W_A, W_B, W_C and W_{Cu} for the masses. [8]

2. (a) If pure H_2 is burned completely with 32% excess air, what is the flue gas analysis? [5]

(b) A coal containing 81% total carbon and 6% unoxidised hydrogen is burned in dry air. The rest of the coal is solid inert. The amount of excess air is 30%. Calculate the number of kg of air per kg of coal and the molar composition of the stack gas, assuming the gas contains no CO. [10]

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

The flow diagram is as below:



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

Molecular weight of **air** is 29. [5]

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

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

Derive the heat balance for a closed system from the above equation. [5]

(b) Producer gas is burned with 10% excess air that is preheated to 1000^0C (1530^0F). The composition of the producer gas is as follows:

Component	%	$\Delta H_c^0 \times 10^{-3}$ kJ/kmol
CO	28	-282.989
CO_2	4	
H_2	4	-241.826
CH_4	2	-890.346
H_2O(g)	1	
N_2	61	

The exit gas mixture leaves at 1500^0C(2730^0F). The heat of combustion of H_2 is based upon producing H_2O(g). Calculate the kmols in the exit gas and the heat, in MJ, transferred for *100 kmols of producer gas*.

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

The average specific heat capacity data are as follows:

Gas	c_P (in kJ/kmol.^{0}C)
CO_2	52.756
H_2O	41.030
O_2	34.330
N_2	32.240
Air	34.10

[15]

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

[4]

(b) A heat exchanger is required to cool 3200 kg/h of benzene (c_p = 1.74 kJ/kg ^{0}C) from 72^{0}C to 42^{0}C using cooling water(c_p = 4.18 kJ/kg ^{0}C) at a flow rate of 2200 kg/h and 15^{0}C inlet temperature. Calculate the area required for a 1-4 shell and tube heat exchanger. The overall heat transfer coefficient may be taken as 0.28 kW/m^2 ^{0}C. [10]

(c) A simple counterflow heat exchanger operates under the following conditions:

Fluid A, inlet and outlet temperatures 80^{0}C and 40^{0}C

Fluid B, inlet and outlet temperatures 20^{0}C and 40^{0}C

Determine the log-mean temperature difference, the effectiveness of the exchanger and the number of transfer units. [6]

5. (a) It is desired to warm an oil of specific heat 2.0 kJ/(kg)(K) from 300 to 325 K by passing it through a tubular heat exchanger with metal tubes of inner diameter 10 mm. Water of specific heat 4.17 kJ/(kg)(K) flows along the outside of the tubes with inlet temperature 372 and outlet temperature 361 K. The overall heat transfer coefficient from the water to oil, based on the inside area of the tubes, may be assumed constant at 230 W/(m^2)(K) and 75 g/s of oil is passed through each tube. The oil is to make two passes through the exchanger. The water makes one pass along the outside of the tubes.

Calculate

(i) the length of the tubes required,
(ii) the water flow rate in **kg/h**.

[12]

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

6. (a) Describe the discounted-cash-flow rate of return measure of profitability.

[4]

(b) Derive the relationship between the uniform periodic payment, R, made during **n** discrete periods and the present worth, P, of the ordinary annuity at an interest rate **i**. [6]

(c) An engineer in charge of the design of a small plant must choose either a batch or a continuous system. The batch system offers a lower initial outlay but, owing to high labour requirements, exhibits a higher operating cost. The cash flows (***in millions of Kwacha***) relevant to this problem have been estimated as follows:

System	Year	Years	Discounted-cash-flow rate of return
	zero	One to ten	
Batch system	-2000	560	25%
Continuous system	-3000	765	22%

Calculate the net present worth at 10%. Check the values of the discounted-cash-flow rate of return by calculating the % error assuming the value of cash outlay in the table is correct. If the company requires a minimum rate of return of 10%, which system should be chosen? [10]

END OF EXAMINATION IN MM 552

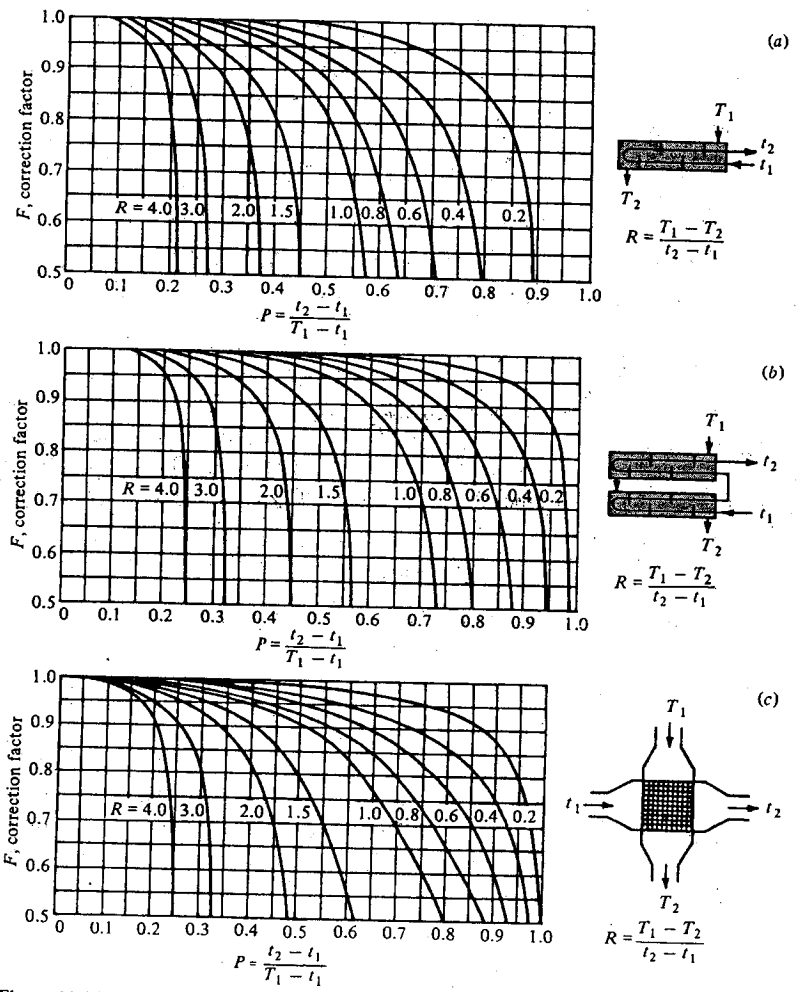


Figure 11-16 Correction factor F for computing $\Delta T_{\text{corrected}}$ for multipass and cross-flow exchangers. (*a*) One shell pass and two tube pass or multiple of two tube pass; (*b*) two shell pass and four tube pass or multiple of four tube pass; (*c*) single-pass, cross-flow, both fluids unmixed. (*From Bowman, Mueller, and Nagle* [45].)

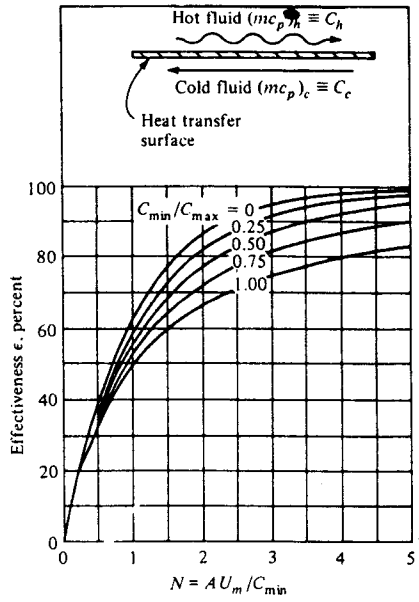


Figure 11-18 Effectiveness for a counterflow heat exchanger. (*From Kays and London [10].*)

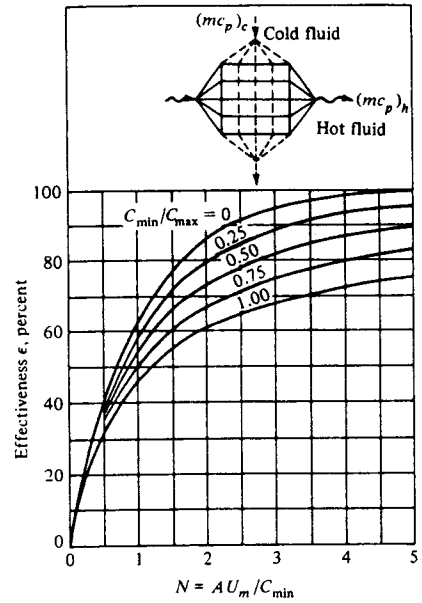


Figure 11-19 Effectiveness for a cross-flow heat exchanger, both fluids unmixed. (*From Kays and London [10].*)

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MINES

UNIVERSITY EXAMINATIONS – MAY 2011

MM 562 – FOUNDRY

TIME: THREE HOURS

ANSWER ALL FIVE QUESTIONS AND ALL CARRY EQUAL MARKS

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1. (a) Use the Bernoulli's relation to determine dimensions of a top poured gating system for the production of a casting that weighs 4 tonnes with a specific gravity of 7.65 if the flow of metal in the system is 4.5×10^{-4} m^3/sec and the total potential energy is equivalent to 0.045 m. [8]

(b) Calculate the pouring time of a 140 mm x 270 mm x 510 mm casting using a 25.4 mm x 25.4 mm ingate and a constant head of 140 mm. Neglect orifice and frictional effects. [6]

Using a binary equilibrium phase diagram, explain how the residual liquid as well as the nucleating solids are enriched and deficient in solute elements during the course of solidification. [6]

2. (a) An induction furnace is charged with metallic materials to give a base iron with the following composition; C: 3.5-4.0%, Si: 2.8-3.0%, Mn: 0.2-1.0%, S:0.01-0.03%. The charge time to tap time was 1-2 hours and the melt rate was 2-5 tonnes/hour. The tapping temperature was in the range 1400 – 1500 °C.

Based on two tonnes of output from the furnace and a silicon balance of 2.8% required at tapping, calculate the actual weight of silicon required for the production of this cast iron. Use the data given in the two tables below. [15]

(b) Explain why the ferrosilicon and not any other component of the charge is used to control the final content of silicon in the output from the furnace? [5]

Table 1: Composition of charges in percentage

Charge	C	Si	Mn	S	P
Cast iron scrap	3.2	2.0	0.50	0.03	0.01
Mild steel scrap	0.20	0.20	0.80	0.08	0.01
Carburiser	99.93	-	-	-	-
Ferrosilicon	-	75.0	-	-	-

Table 2: Charge Calculation for two metric tonnes of metal

Charge	Mass (kg)	Mass (%)	C	Si	Mn	S	P
Cast iron scrap	1200	60	1.92	1.20	0.3	0.02	0.01
Mild steel scrap	740	38.5	0.08	0.08	0.31	0.04	0.04
Carburiser	30	1.50	1.50	-	-	-	-
Total							

3. (a) The material balance in a Scheil equation is derived from the differential relation as shown below. Evaluate the solute composition, C_S, given the conditions as indicated and show initial conditions.

$$(C_L - C_S)\,\partial f_S = (1 - f_S)\,\partial C_L$$

$(1 - f_S)$ = volume fraction of liquid remaining

f_S = volume fraction solidified

From the expression for solute composition, estimate the solute composition for a Cu-Sn alloy 75% solidified with partition coefficient value of 0.15 and containing 5% tin. [15]

(b) Explain what commercial purpose the principle of continuous solute rejection into the bulk liquid is possible during the process of solidification. [5]

4. (a) Evaluate the total iron, Fe, yield in a cupola furnace melt of cast iron given the following data; [10]

(i) Input to furnace

Material	Pig A	Pig B	Scrap	Steel	FeMn	Coke
Weight, kg	298.4	99,5	398.0	199.0	3.58	132.5
% Fe	92.0	93.2	93.8	99.2	50.0	1.0

(ii) Output from furnace

Material	Cast iron	Slag
Weight, kg	1000.0	68.0
% Fe	93.4	2.25

(b) Suggest some reasons why casting soundness is considered important over other factors such as the metallurgical structure and metal yield from the process. [10]

5. (a) Give two examples of advantages of powder metallurgy (PM) products have over conventionally made products. What would you say is the major limitation of PM process? [10]

(b) Briefly highlight properties of three (3) common cast irons with specific examples of commercial products. [10]

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