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AGA 222	:	[illegible] FARM ANIMALS
AGA 322	:	[illegible]
AGA 332	:	[illegible]
AGA 342	:	[illegible] AND GENETICS
AGA 412	:	[illegible]
AGA 422	:	[illegible]
AGA 432	:	[illegible] MANAGEMENT FOR ANIMAL [illegible]
AGA 552	:	[illegible] AND BY-PRODUCTS
AGA 562	:	[illegible]
AGC 222	:	[illegible]
AGC 312	:	[illegible]
AGC 342	:	[illegible]
AGC 442	:	[illegible]
AGC 542	:	[illegible]
AGC 552	:	[illegible]
AGC 562	:	[illegible]
AGE 442	:	[illegible] STATISTICS & DATA ANALYSIS
AGE 452	:	[illegible] BUSSINESS MANAGEMENT
AGE 462	:	[illegible] AND PRICING
AGE 562	:	[illegible]
AGE 572	:	[illegible]
AGE 582	:	[illegible] AND EVALUATION
AGF 221	:	[illegible]
AGF 332	:	[illegible]
AGF 332	:	[illegible]
AGF352/BS 482	:	[illegible]
AGF 362	:	[illegible]
AGF 412	:	[illegible]
AGF 422	:	[illegible]
AGF 432	:	[illegible]
AGF 442	:	[illegible]
AGG 322	:	[illegible]
AGS 222	:	[illegible]
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AGS 322	:	[illegible]
AGS 331	:	[illegible]
AGS 342	:	[illegible] FOR ENGINEERS
AGS 422	:	[illegible]
AGS 462	:	[illegible]
AGS 522	:	[illegible]
AGS 542	:	[illegible]

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SEMESTER II EXAMINATIONS
JULY 2001
METHODS IN FOOD ANALYSIS - AGF 332

Instructions: Answer any 4 questions and show your working clearly
Duration: 3 hours

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1. (a) A chromatogram with ideal Gaussian bands has t_r = 9.0 min and $w_{1/2}$ = 2.0 min. How many theoretical plates are present?

   (b) Find the plate height in (a) above if the column is 10 cm long.

   (c) Write the relation between α, k'_1, and k'_2 for two chromatographic peaks. Calculate the number of theoretical plates needed to achieve a resolution of 1.0 if α = 1.05 and k'_2 = 5.00

   (d) Write a rate theory equation that is used to describe band broadening in a packed chromatographic column and discuss all the terms in it.

   (e) Write at least three characteristics of an ideal detector in High Performance Liquid Chromatography (HPLC).

   (f) Detectors are fitted to the Gas Chromatography (GC) and HPLC systems in the department of food science and technology. What are the names of the detectors and briefly discuss their operation under two different subheadings.

2. (a) What is the difference between a single-beam and a double beam spectrophotometer? What are the advantages of a double-beam instrument?

   (b) An unknown element X was mixed with aliquots of a standard solution of element X for UV/Vis analysis. The standard solution contained 1000.0 μg of X per mL.

Volume of unknown (mL)	Volume of standard (mL)	Total volume (mL)	Absorbance
10.0	0	100.0	0.163
10.0	1.00	100.0	0.240
10.0	2.00	100.0	0.319
10.0	3.00	100.0	0.402
10.0	4.00	100.0	0.478

Calculate the concentration of X in the unknown in μg/mL.

(c) Sketch the components of an Atomic Absorption Spectrometer and discuss the operation of one burner-nebulizer system In your discussion use the following subheadings:

(i) Sketch
(ii) Reason for its use
(iii) How it works in relation to atomisation
(iv) What other alternative (only 1) can be used in its place

3. (a) What is electron impact ionisation (EI) in mass spectrometry? How is this used in conjunction with the ion trap mass spectrometer?

(b) For a drift length of 100 cm in a TOF spectrometer, what is the difference in arrival time between ions of m/z = 44 and m/z = 43 when the accelerating voltage is 2800 V?

(c) An NMR signal is observed at 7.3 ppm downfield from TMS in a spectrometer operating at 200 MHz. Calculate the position in Hz of that same signal in a spectrometer operating at 400 MHz.

(d) Predict the relative shape of the NMR spectrum for ethylbromide (CH_3CH_2Br)

(e) Explain the mechanism of nuclear absorption in NMR. Some keywords to include in your explanation could be external magnetic field, precessional motion, energy levels etc. Remember the keywords are just a suggestion.

4. (a) A capillary electrophoresis experiment was conducted at pH 9.0 using an appropriate buffer. Draw a picture of the capillary, showing the placement of the anode, cathode, injector, and detector. Show the direction of net flow.

(b) What is the meaning of the term Electroosmotic Flow (EOF) in capillary electrophoresis (CE)?

(c) Use the van Deemter equation to explain why peaks are generally sharper in CE than in liquid chromatography? (Hint: Look at the terms that are eliminated in CE in the equation and explain on the basis of the term that is retained)

(d) In a capillary electrophoresis system, serum albumin (MW 65 000) has electrophoretic mobility μ_{ep} of 2×10^{-8} m^2/Vs (derived for 10 min migration time in a 55-cm long capillary) in a pH 8.5 buffer and its diffusion coefficient $D_m = 0.059 \times 10^{-9}$ m^2/s at 25 kV. Calculate the number of theoretical plates for the protein on this system.

(d) Do the above calculation for K^+ whose electrophoretic mobility is the same as that in (d) only difference being the diffusion coefficient is 2 x 10^{-9} m^2/s.

(e) What does the differences in plate count tell you?

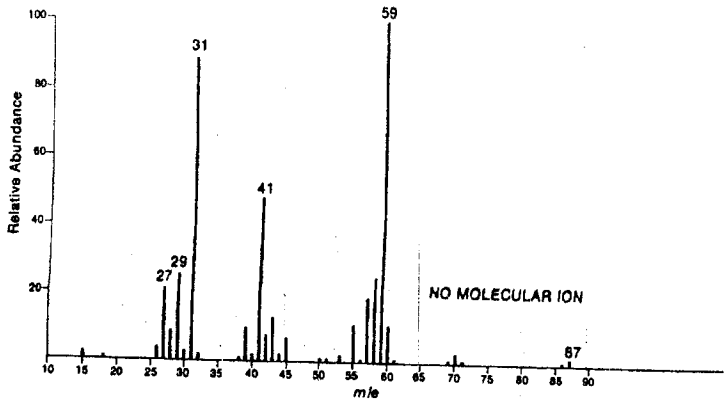
5. (a) Attached to the examination question script are two combined structure problems. The condensed formula for (1) is $C_5H_{12}O$ and (2) is $C_5H_{12}O_2$. Determine the structural formulas for the two compounds.

(b) Discuss two IR sources and two IR detectors.

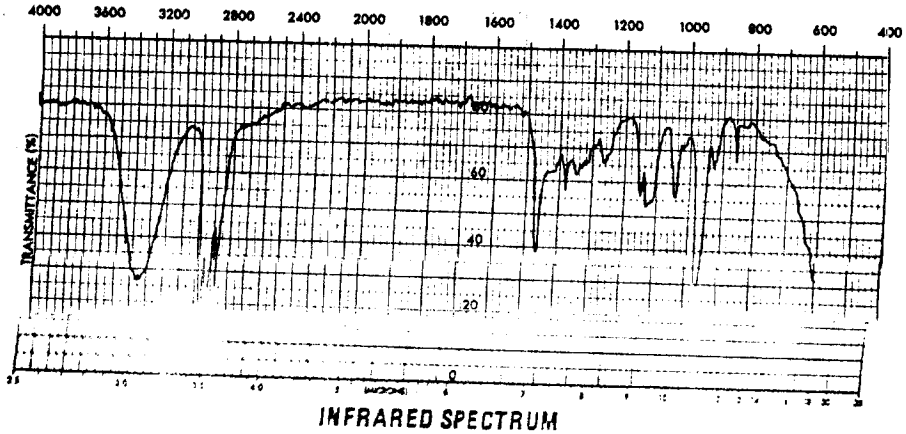
(c) (i) What is the principle behind the operation of a time of flight (TOF) mass spectrometer?

(ii) How would you improve the resolution of two closely spaced peaks in a TOF mass spectrometer? Use an appropriate sketch to illustrate your answer to (ii) above.

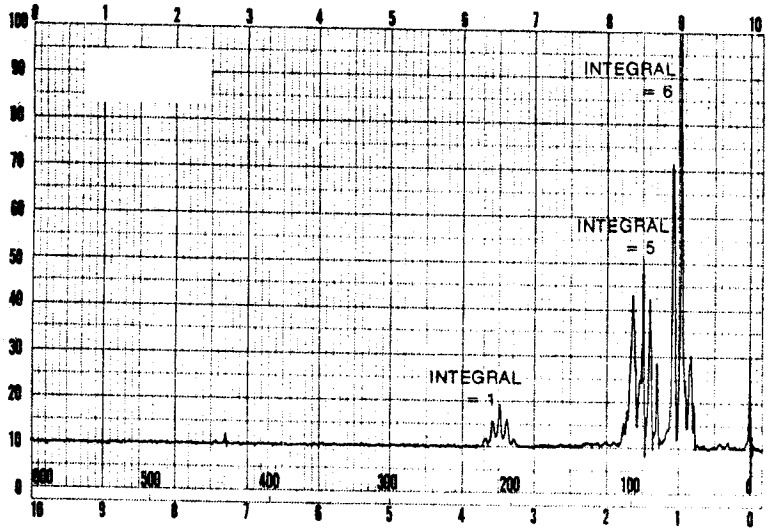
1



MASS SPECTRUM

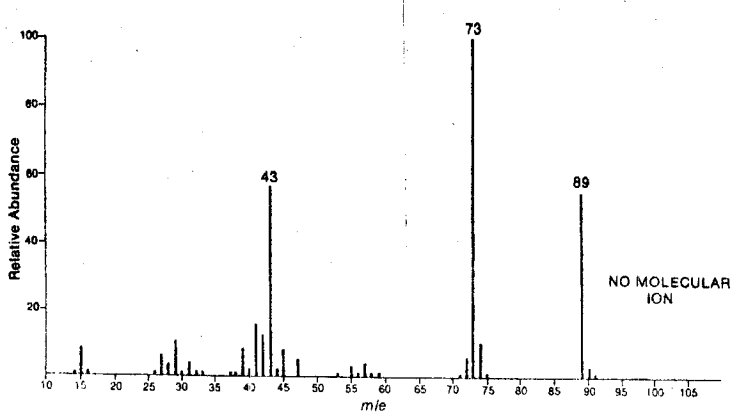


INFRARED SPECTRUM



NMR SPECTRUM

(2)



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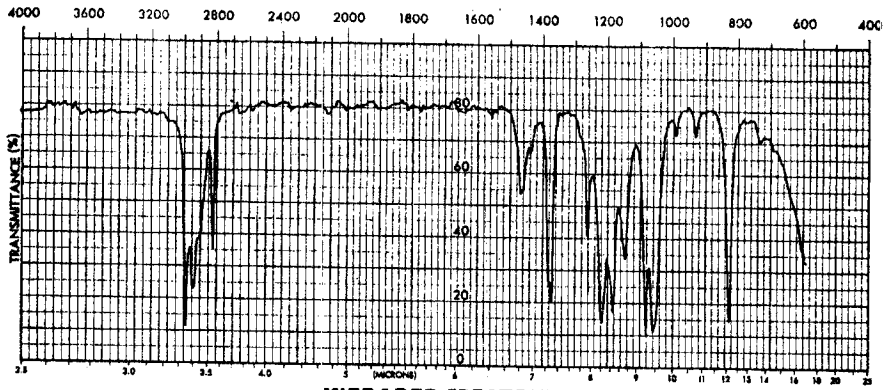

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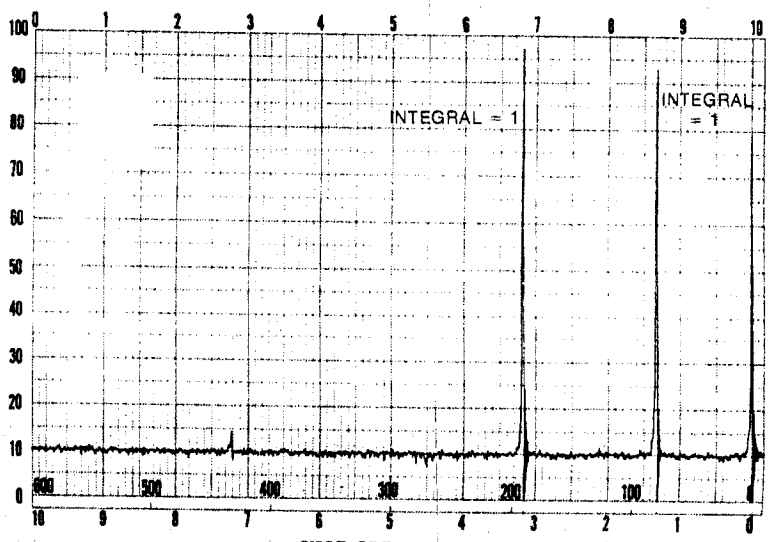

NMR SPECTRUM

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SEMESTER II EXAMINATIONS – OCTOBER 2002

Methods in Food Analysis I AGF 332

ANSWER ALL QUESTIONS
DURATION: 3:00 HOURS

1. (a) Why is high pressure needed in HPLC?

   (b) What are the necessary requisites for an ideal detector in HPLC?

   (c) Discuss the UV/Visible detector in HPLC and the type of analytes this detector can detect?

   (d) A thermally labile compound produced split peaks when it was injected on a Gas Chromatograph (GC) using the splitless technique. Suggest an alternative that would produce better signals and describe the mechanism behind the correction that would occur.

   (e) You are provided with a sample and are required to analyze for a halogenated herbicide (Atrazine) by GC. Among some chemicals provided is Terbuthylazine, another halogenated herbicide but whose retention time significantly differs from that of Atrazine. You also have a choice of detectors i.e. Flame Ionization, Thermal Conductivity and Electron Capture Detectors. Briefly describe a simple procedure with a choice of detector that would anable you to determine atrazine in your sample. Describe separately the operation of the detector you chose for this purpose.

   (f) The table below shows hydrocarbons that were separated on a 30 m long capillary column, coated with *n*-C_8 alkane bonded to porous silica. Column temperature: 25 °C. Detector: flame ionisation. Carrier gas: nitrogen at 25 mL min^{-1}. Retention characteristics are shown in the table.. Calculate the retention index (I) for the unknown. (assume that the retention times given are adjusted for unretained solute)

Compound	**Peak**	**T_r (min)**
Methane	1	0.39
unknown	4	0.86
n-Butane	7	1.75

2. (a) What property of electromagnetic radiation makes it interact with matter?

(b) Sketch and label clearly components of a spectrophotometer.

(c) What is the role of a filter in a grating monochromator?

(d) Discuss the operation of a photomultiplier tube (PMT)

(e) List the types of sources used in the UV/Visible and Infra Red (IR) regions. State what wavelength/wavenumber region is covered by each source.

(f) The force constant for C=C bond is 10.6×10^5 dynes/cm. Calculate the vibration frequency of the bond and convert this value to wavenumbers cm^{-1}. ($m_H = 1.67 \times 10^{-24}$g).

(g) Describe two advantages of fourier transform infra-red (FT-IR)spectroscopy compared to dispersive instruments.

(h) A 1.0000 g sample of steel is dissolved in acid and the solution diluted to 500.0 mL (solution B). A 50.00 mL aliquot of solution B is treated with potassium persulfate in the presence of Ag^+ ions acting as a catalyst, and potassium periodate, whereupon Mn and Cr are oxidized to MnO_4^- and $Cr_2O_7^{2-}$ and diluted to 100.0 mL(solution D). The absorbance of soluti0on D at 440 nm and 545 nm was 0.204 and 0.170 respectively in a 1 cm cell. Calculate the percent Mn and Cr in steel also taking into account the following data from literature:

λ, nm	$\varepsilon(MnO_4^-)$	$\varepsilon(Cr_2O_7^{2-})$
440	95	369
545	2350	11

3. (a) Sketch the quadrupole ion trap showing the electron source, electron gate, the three electrodes and then with reference to the Matheiu equation and the stability diagram, describe its operation.

(b) Write very brief notes on the following:
- (i) Electron Impact Ionization (EI)
- (ii)Chemical Ionization (CI)
- (iii)Matrix Assisted Laser Desorption Ionization (MALDI)

(c) Why do you get extensive fragmentation using EI than CI?

(d) Describe the Time of Flight (TOF) mass spectrometer with the aid of a sketch and under the following sub-headings:
- (i) Ionization
- (ii) Mass Analysis

(iii)Detection
(iv)Detection When Resolution is Poor

4. (a) Sketch the instrumentation for a Capillary Electrophoresis (CE) system.

   (b) What is Electroosmotic Flow in CE?

   (c) What is the order of elution of neutrals, cations and anions on a CE system?

   (d) With reference to flow dynamics, demonstrate by means of sketches what causes peaks in CE to be sharper than those in HPLC then use the van Deemter equation to demonstrate the same effect.

   (e) What is isoelectric focussing (IEF) in capillary electrophoresis? Be very brief.

   (f) In a capillary electrophoresis system, the protein horse heart myoglobin (MW 13,900) has electrophoretic mobility μ_{ep} of 0.65×10^{-4} cm^2/Vs in a pH 8.5 buffer and its diffusion coefficient $D_m = 1 \times 10^{-6}$ cm^2/s at 30, 000 V. Calculate the number of theoretical plates for the protein on this system.

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SEMESTER II EXAMINATIONS – OCTOBER 2002

Methods in Food Analysis I AGF 332 PRACTICAL EXAMINATION

DURATION: 3:00 HOURS

You will be required to determine the zinc (Zn) content of a feed sample using Atomic Absorption Spectrometry (AAS) in this examination. You are supplied with the necessary requisites like standards, apparatus and other materials. All you need to do is to prepare your sample and walk into the AAS room where you will be assisted to read them.

MATERIALS:

1. Zn standard solutions provided and concentrations are as labeled.
2. 2.0 M HCl

PROCEDURE:

As long as you record your activities during the course of the examination, the data you will collect will enable you to calculate the % Zn (wt/wt) in your sample. You need to weigh an appropriate amount of sample into an appropriate vessel and then transfer contents into a muffle furnace. Leave in the furnace for 1 hour and then cool to room temperature. Take up ash with an appropriate volume of acid provided and filter into an appropriate flask. You are now ready to read your sample. If sample overshoots on the AAS, dilute appropriately. Read the standards in a similar manner.

DATA ANALYSIS

Obtain a graph paper and prepare a calibration graph. Interpolate the reading for the sample and calculate the Zn content in your sample.

Questions:

1. List the most important readings that enabled you to determine the Zn content of your sample.
2. Suggest an alternative method that would be more accurate than the one you just did.

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VLIR-UNZA IUC PROGRAMME

Programme for Institutional University Co-operation between the Flemish Inter-University Council VL.I.R. and the University of Zambia UNZA

VL.I.R.
DEPARTMENT OF FOOD SCIENCE AND TECHNOLOGY

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SECOND SEMETER EXAM

FOOD MICROBIOLOGY AGF 352/BS 482

NB. 1. STRICTLY FOLLOW THE ORDER OF THE QUESTIONS WHEN ANSWERING.

2. READ CAREFULLY QUESTIONS BEFORE ANSWERING.

3. ANSWER ALL QUESTIONS.

QUESTIONS

1. It is often when an outbreak of foodborne infection occurs, in which a number of individuals have consumed the same contaminated foodstuff, the result and symptoms can vary in severity from possible fatality to mild or no illness. Give a detailed explanation of the various factors which can be responsible for such variability (20 pts).
2. Discuss the importance of poultry as source of foodborne infection and how control of disease from this source could be improved by implementation of a HACCP approach, starting at farm level and extending to the consumer's home (15pts).
3. Write an assay of the importance of 'education' in the prevention of foodborne illness. Your answer should make reference to education at school, in the home, and in the workplace (15pts).
4. Discuss the limitations of 'end product testing' for ensuring the microbiological safety of food and how the HACCP approach can overcome these limitations (20 pts).
5. Fermented products and especially milk products are highly recommended in the diet. Discuss how these category of products contribute to the improvement of consumers' health (10 pts).

6. You are given a 10^3 dilution of a suspension of *E.coli*.You then make two successive 1/100 dilutions of this dilution. From the last dilution you make, 0.1 ml is added to a petri dish containing 10 ml of solidified bottom agar and spread over the surface by using a glass rod. After spreading the 0.1 ml aliquot, a top layer of 3ml molten agar (overlay) is poured onto the surface of the bottom agar. After incubation, 44 colonies are counted.

   a. To help you organize your data, the following can be find out
      i. Initial dilution of *E.coli*
      ii. Subsequent dilution of phage:
      iii. Amount inoculated from last dilution.
   b. Does the amount of bottom agar matter in the calculations?
   c. Does the amount of overlay matter in the calculations?
   d. Determine the number of colony forming units (CFUs) per ml of the original *E.coli* suspension (20pts).

0.1-g, 0.01-g, and 0.001-g Volumes Are Used[a]

No. of positive tubes/3 tubes			95% confidence limits	
0.01 g	0.001 g	MPN/g[b]	Lower	Upper
0	0	<3	–	–
1	0	3+	<1	17
0	0	4	<1	21
0	1	7+	2	27
1	0	7	2	28
2	0	11+	4	35
0	0	9	2	38
0	1	14+	5	48
1	0	15	5	50
1	1	20+	7	60
2	0	21	8	62
0	0	23	9	130
0	1	39	10	180
1	0	43	10	210
1	1	75	20	280
2	0	93	30	380
2	1	150	50	500
2	2	210+	80	640
3	0	240	90	1400
3	1	460	100	2400
3	2	1100	300	4800
3	3	>1100	–	–

[a] results, obtained in 95% of tests, are *not* followed by a plus. Less likely results, obtained in only 4% of tests, are followed by a plus. ons of positive tubes not shown occur in less than 1% of tests, and their frequent occurrence indicates that technique is faulty or that is underlying the MPN estimate are not being fulfilled. MPN estimates for combinations that are not shown may be obtained by extrapolation mas's formulae, Section 6.6) to the next highest combination that is shown in the table. For example, a result of 2, 0, 2 would have an pproximately 20, which is the MPN for a more likely result of 2, 1, 1.

[b] res under "MPN/g" in this table may be multiplied by 100 for reporting "MPN/100 g."

THE UNIVERSITY OF ZAMBIA
SCHOOL OF AGRICULTURAL SCIENCES
FOOD SCIENCE AND TECHNOLOGY DEPARTMENT
2001/2002 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATION

TIME: **3 HOURS**
AGF 362: **SENSORY EVALUATION – (THEORY)**
INSTRUCTIONS: **ANSWER ALL QUESTIONS**

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1. (a) The sensory evaluation methods that have been developed serve economic interests what are these **(5 Points)**
   (b) What is the ultimate goal of any sensory evaluation program **(3 Points)?**
2. Chemical irritants stimulate what type of nerve ends? When do these assume practical significance? **(5 Points)**
3. (a) Why is threshold not a constant for a given substance **(3 Points)**

   (b) How would you describe the difference between flavour and texture? **(3 Points)**

4. Describe the ideal location for sensory evaluation. Mention undesirable situations to be avoided when choosing the area for conducting a sensory test **(5 Points)**

5. Name 3 things the storage area should take care of in sensory in sensory evaluation **(3 points)**

6. (a) In product sampling along book is kept in the sensory laboratory to record pertinent data. Name the 3 types of data that you would find in this log book **(5 Points)**

   (b) When using a panel, which is not highly trained, how should the evaluation be scheduled to ensure maximum benefit**? (3 Points)**

7. Name 3 areas that require careful training in, with respect to handling of samples as a minimum requirement in order to participate in a laboratory sensory test with no instruction from the sensory analyst once the test has started. **(3 Points)**

8. Define the following **(3 Points each)**

   (i) Gustation

   (ii) Mutual suggestion

9. What is involved in classification tests? Name one aspect the test does not attempt to standardise and why? **(5 Points)**

10. When is the Two-Out-Of-Five Test used? What is the ideal number for this test? When is the exception made and with how many people? **(6 Points)**

11. When is the Pair- wise Ranking test used? What is the principles of the test **(5 Points)**

12. Name 5 areas where sensory analysis is applied in Industry **(5 Points)**

(b) What are the typical questions in product (matching? Screening versus target/benchmark) **(5 Points)**

END OF EXAM

4. From a series of batch runs with a constant enzyme concentration, the following initial rate data were obtained as a function of initial substrate concentration

Substrate concentration mmol/l	Initial reaction rate mmol/l min
1	0.20
2	0.22
3	0.30
5	0.45
7	0.41
10	0.50
15	0.40
20	0.33

a. Evaluate the Michaelis-Menten kinetic parameters by employing the Langmuir plot, the Linewaever-Burk plot and the Eadie-Hofstee plot. In evaluating the kinetic parameters, do not include data points, which deviate systematically from Michaelis-Menten model and explain the reason for the deviation.

b. Discuss the strength and the weaknesses of each method.**(20 pts)**

5. Derive the mass balance equations (feed, substrate, biomass) in the case of 3 CSTF in series. Give also the yield at each stage.
Why is it interesting to use fermenters in series? **(20 pts)**

6. A continuous fermenter is operated at a series of dilution rates but at constant (sterile) feed concentration, pH, aeration rate and temperature. The data given in the table below were obtained when the limiting substrate concentration was 1200mg/litre and the working volume of the fermenter was 9.8 litres. Estimate the kinetic constants K_m, μ_{max} and k_d as used in the modified Monod equation:

$$\mu = \frac{\mu_{\max} S}{K_s + S} - k_d$$

(k_d is the cell maintenance term).

and also the growth yield coefficient Y.**(25pts)**

Feed flow rate (l/h)	Exit substrate concentration (mg/l)	Dry weight cell density (mg/l)
0.79	36.9	487
1.03	49.1	490
1.31	64.4	489
1.78	93.4	482
2.39	138.8	466
2.68	164.2	465

THE UNIVERSITY OF ZAMBIA
UNIVERSITY SEMESTER II EXAMINATIONS – OCTOBER 2002

Methods in Food Analysis II AGF 422

ANSWER QUESTION 1 AND ANY OTHER THREE QUESTIONS
DURATION: 3:00 HOURS

1. (a) Discuss the operation of a saturated calomel reference electrode (SCE). Give relevant equations and also the desirable factors of such an electrode.

   (b) A cell was prepared by dipping a Cu wire and a saturated calomel electrode (SCE) into 0.10 M $CuSO_4$ solution. The Cu wire was attached to the positive terminal of a potentiometer and the calomel electrode was attached to the negative terminal.

   (i) Write the half reaction for the Cu electrode.
   (ii) Write the Nernst equation for the Cu electrode.
   (iii) Calculate the cell voltage.

   (the potential of the SCE = +0.241 V and $E^{\circ}\ Cu^{2+}/Cu$ = +0.339 V)

   (c) In potentiometry, what is a liquid junction potential (LJP) and how does it arise?

   (d) Describe a liquid based ion selective electrode for the determination of calcium.

   (e) An ammonia gas sensing electrode gave the following calibration points when all solutions contained 1 M NaOH.

NH_3 (M)	E (mV)
1.00×10^{-5}	268.0
5.00×10^{-5}	310.0
1.00×10^{-4}	326.8
5.00×10^{-4}	368.0
1.00×10^{-3}	386.4
5.00×10^{-3}	427.6

A dry food sample weighing 300.4 mg was digested by the Kjeldah procedure to convert all the nitrogen to NH_4^+. The digestion solution was diluted to 1.00 L, and 50.0 mL was transferred to a 100-mL volumetric flask. The 50.0 mL aliquot was treated with 10.0 mL of 10.0 M NaOH plus enough NaI to complex the Hg catalyst from digestion, and diluted to 100.0 mL. When measured with the ammonia electrode, this solution gave a reading of 339.3 mV. Calculate the percentage of nitrogen in the food sample.

(f) Distinguish between Thermogravimetric (TG), Differential Thermal Analysis (DTA) and Differential Scanning Calorimetry (DSC).

(g) Distinguish between Circular Dichroism (CD) and Optical Rotatory Dispersion (ORD).

2. (a) In polarography, how do you distinguish waves due to reduction of oxygen from analyte waves? Is it desirable to have oxygen in solution when measurements are made and if not how do you remove it from solution?

(b) Distinguish between DC and Pulse polarography. In your discussion focus on the critical points only such as voltage ramps, types of signals e.t.c.

(c) Discuss the Karl Fischer titration of water in foods.

(d) What are amperometric titrations in voltammetry?

(e) Cd^{2+} was used as an internal standard in the analysis of Pb^{2+} by differential pulse polarography. Cd^{2+} gives a reduction wave at -0.60 V and Pb^{2+} gives a reduction wave at -0.40 V. It was first verified that the ratio of peak heights is proportional to the ratio of concentration over the whole range employed in the experiment. Results for known and unknown mixtures are given below.

Analyte	**Concentration (M)**	**Current (μA)**
Known		
Cd^{2+}	3.23×10^{-5}	2.00
Pb^{2+}	4.18×10^{-5}	3.00
Unknown + Internal Standard		
Cd^{2+}	?	1.64
Pb^{2+}	?	1.56

The unknown mixture was prepared by mixing 25.00 mL of unknown (containing only Pb^{2+}) plus 10.00 mL of 3.23×10^{-4} M Cd^{2+} and diluting to 50.00 mL. Calculate the concentration of Pb^{2+} in the undiluted solution.

3. (a) Sketch appropriate instrumental components for X ray analysis and discuss them briefly.

(b) Distinguish between X-Ray Fluorescence and X-Ray absorption measurements.

(c) Write very short notes on
   (i) wavelength dispersion
   (ii) and energy dispersion in X-ray methods of analysis.

(d) Calculate the short wavelength limit for an X-ray operated at 30 kV.

(e) Derive the Bragg equation for the relationship of the X-ray wavelength and the distance between crystal planes in a crystal.

4. (a) Briefly describe the principle behind Electron Spectroscopy for Chemical Analysis (ESCA).

(b) What do you understand by the term "chemical shift" in ESCA?

(c) What type of sources are used in ESCA?

(d) Briefly describe the principle behind Auger Emission Spectroscopy (AES).

(e) A transition could be labeled *KLL* in AES, what does this imply?

(d) Spectra in AES is almost indistinguishable in AES. What characteristic is used to identify elements. Briefly explain.

5. (a) Distinguish between Quality Assurance and Quality Control.

(b) Discuss the meanings of the following giving relevant equations where appropriate:
   (i) Limit of Detection (LOD)
   (ii) Method Detection Limit (MDL)
   (iii)Instrument Detection Limit (IDL)
   (iv)Limit of Quantitation (LOQ)
   (v) Method Sensitivity

(c) One gram of an organic compound was dissolved in 50.00 mL of water. This solution in a 20 cm tube read +2.676° in a polarimeter, while distilled water in the same tube read +0.016°. Calculate the specific rotation of the substance

(d) Descuss how you should report an analyte as detected or not detected.

THE UNIVERSITY OF ZAMBIA

SCHOOL OF AGRICULTURAL SCIENCES

SECOND SEMESTER FINAL EXAMINATIONS
OCTOBER/NOVEMBER 2002

AGF 432 APPLIED STATISTICS

INSTRUCTIONS: 1. Attempt **Question 1 and any Two (2) Questions** from Questions 2, 3, 4 and 5.

2. Statistical Tables and Useful Formulae are provided.

3. You are allowed to use standard Scientific Calculators.

TIME ALLOWED: Three (3) Hours

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1. The managers of a Food Processing Company with ten operating plants of similar size producing small components have observed the following pattern of expenditure on inspection and contaminated parts delivered to the customer.

Observation Number	Inspection expenditure per 1000 units (Kwacha)	Contaminated parts per 1000 units delivered
1	25	50
2	30	35
3	15	60
4	75	15
5	40	46
6	65	20
7	45	28
8	24	45
9	35	42
10	70	22

(a) Find the product moment coefficient, **r,** between inspection expenditure and the number of faulty items delivered.
Briefly explain what this number implies.

(b) Determine the regression line for the given data.

(c) The managers wish to know the likely number of defects of 50 parts per 1,000 spent on inspection. Using the regression line in (b), find the number of defects.

(d) Calculate the standard error of regression.

Attempt Any Two (2) Questions from Questions 2, 3, 4 and 5.

2. A group of 8 Food Science and Technology students are tested in Applied Statistics (A.S.) and Biochemistry (B.C.). Their rankings in the two tests were:

Student	A.S. Ranking	B.C. Ranking
A	2	3
B	7	6
C	6	4
D	1	2
E	4	5
F	3	1
G	5	8
H	8	7

(a) Find the Spearman Rank Correlation Coefficient for the above data.

(b) Briefly explain the meaning of this number in relation to the students' performances in the two types of tests.

(c) Assume that students E and F achieved equal marks in Applied Statistics (A.S.) and were given third place. Construct a new ranking table for the revised data.

(d) Using the slight adjustment to the formula by $(t^3 - t)/ 12$, where **t** is the number of tied rankings, find the new Spearman Rank Correlation Coefficient.

(e) How do the numbers in (a) and (d) compare?

---

3. A Production Planning Department is considering the production schedules for period 9. In particular, they wish to calculate the time to be allocated for the manufacture of a batch of 100 of a computer controlled machine tool called ROBO XI. The first ROBO XI took 80 hours to make and it is known from past experience that there is a learning effect. From past records the following information is available:

Cumulative Production (units)	ROBO XI Cumulative time taken (hours)	Time per units (hours)
600	18,153.6	30.256
1200	32,676	27.23

They calculate that the cumulative production at the beginning of period 9 will be 3000 units.

(a) What type of learning curve model do the records suggest?

(b) What type of learning curve do the records show?

(c) Calculate the learning coefficient for a 90% learning curve.

(d) Calculate the time allowance necessary for the batch of 100 in period 9.

---

4. (a) Analysis of Food Science Laboratory expenses shows that the expenses are dependent on the kilometres travelled (x_1) by the Departmental Driver looking for chemicals and the type of journey (x_2).

The general form is:

$$y = a + b_1x_1 + b_2x_2.$$

Calculations have produced the following values (where **y** is expenses per month)

$$y = \$86 + 0.37\ x_1 + 0.08\ x_2,$$

$$r^2_{x_1} = 0.78$$

$$r^2_{x_2} = 0.16$$

$$R^2 = 0.88$$

Briefly explain these values.

(b) For a given operation a 10% marginal learning curve operates. Assuming that the first unit takes 30 minutes, how long does the 20^{th} unit take?

(c) Assume the same problem as for (b) above, but with a 30% cumulative average learning curve.

---

5. In an experiment conducted by 20 Food Science and Technology students, the observations made were with:

$\overline{X_1} = 4.0$	$\sum x_1^2 = 76.0$	$\sum x_1 y = 212.8$
$\overline{X_2} = 8.0$	$\sum x_2^2 = 304.0$	$\sum x_2 y = 364.8$
$\overline{Y} = 20.0$	$\sum y^2 = 1216.0$	$\sum x_1 x_2 = 0.$

(a) Find the values of $\mathbf{b_1}$ and $\mathbf{b_2}$ in the multiple regression equation

$$\mathbf{Y' = a + b_1X_1 + b_2X_2}$$

(b) Find the value of $\mathbf{b_1}$ in the regression equation $\mathbf{Y' = a + b_1X_1}$.

Is this value of $\mathbf{b_1}$ equal to the value of $\mathbf{b_1}$ in the multiple regression equation?

(c) Is the value of $\mathbf{b_2}$ in the regression equation $\mathbf{Y' = a + b_2X_2}$ equal to the value of $\mathbf{b_2}$ obtained in the multiple regression equation?

(e) Is $\mathbf{MS_{reg}}$ significant with $\alpha = \mathbf{0.05}$?

END OF EXAMINATION

USEFUL FORMULAE

1. $y = ax^b$

2. $b = \dfrac{\log(1 - \text{proportinate decrease})}{\log 2}$

3. $r = \dfrac{n\sum xy - \sum x \sum y}{\sqrt{n\sum x^2 - (\sum x)^2} \times \sqrt{n\sum y^2 - (\sum y)^2}}$

4. $a = \dfrac{\sum y - b\sum x}{n}$

5. $b = \dfrac{n\sum xy - \sum x\sum y}{n\sum x^2 - (\sum x)^2}$

6. $R = 1 - \dfrac{6\sum d^2}{n(n^2 - 1)}$

7. $S_e = \sqrt{\dfrac{\sum y^2 - a\sum y - b\sum xy}{n-2}}$

8. $R = 1 - \dfrac{6(\sum d^2 + \frac{t^3 - t}{12})}{n(n^2 - 1)}$

9. $R^2 = \dfrac{a\sum y + b_1\sum x_1 y + b_2\sum x_2 y - \frac{(\sum y)^2}{n}}{\sum y^2 - \frac{(\sum y)^2}{n}}$

10. $r = \dfrac{\sum xy}{\sqrt{(\sum x^2)(\sum y^2)}}$

11. $r_{y1} = \dfrac{\sum x_1 y}{\sqrt{(\sum x_1^2)(\sum y^2)}}$

12. $$r_{12} = \frac{\sum x_1 x_2}{\sqrt{(\sum x_1^2)(\sum x_2^2)}}$$

13. $$MS_{reg} = b_1 \sum x_1 y + b_2 \sum x_2 y$$

14. $$b_1 = \frac{(\sum x_1 y)(\sum x_2^2) - (\sum x_2 y)(\sum x_1 x_2)}{(\sum x_1^2)(\sum x_2^2) - (\sum x_1 x_2)^2}$$

15. $$F = \frac{R_{yy'}^2 / k}{(1 - R_{yy'}^2)/(n-k-1)} = \frac{(r_{y1} - r_{y2} r_{12})^2 / (1 - r_{12}^2)}{(1 - R_{yy'}^2)/(n-k-1)}$$

THE UNIVERSITY OF ZAMBIA
SCHOOL OF AGRICULTURAL SCIENCES
FOOD SCIENCE AND TECHNOLOGY DEPARTMENT
2001/2002 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATION

AGF 442: FOOD PACKAGING (Theory Examination)
TIME: 3 HOURS
INSTRUCTION: ANSWER ALL QUESTIONS

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1. When does packaging become part of domestic refuse? **(2 Points)**

2. What makes sodium carbonate the most expensive component in glass production? Explain your answer in detail **(5 Points)**

3. (a) Why is it not possible for most plastic to undergo biodegradation? **(2 Points)**

   (b) Explain why burying of plastics is not a good idea in as far as cleaning and managing the environment is concerned **(2 Points).**

   (c) Why are plastic packages generally not designed to be recycled? **(2 Points)**

4. What were the reasons for food regulations? Why was the 1958 Food Additives Amendment to the Food Drug and Cosmetic Act of the U.S. Federal Regulations significant to the food packaging business. **(5 Points)**

5. **(a)** What is a Food additive? **(2 Points)**
   (b) What are 5 points that constitutes Federal fair packaging and labelling bill of 1966? **(5 Points)**
   (c) In Zambia which line ministry is in charge of the food Laws? Which statutory body of this ministry ensures that the Laws of Zambia as they affect food are followed? **(3 Points)**

6. In the last decade better results in making plastic more biodegradable have been achieved. Name 2 methods that have been documented and explain how each method works and how it is different from the other. **(5 Points)**

7. What are production aids in packaging? Give examples of 6 of these and explain briefly how each is a production aids **(7 Points)**

8. (a) What is global migration? What are its advantages and disadvantages? **(3 Points)**

   (b) Give two examples of the migration phenomenon which were known long before scientific studies were introduced **(2 Points)**

   (c) When is it necessary to conduct a specific migration test? **(1 Point)**

9. (a) What is sugar bloom? What causes it in chocolate? What storage humidities encourage it in milk chocolate and in plain chocolate. **(5 Points)**

   (b) What is fat bloom? How is it formed in chocolate? Name 3 packaging materials for chocolate and name 4 things, which the packaging protects the chocolate from. **(8 Points).**

10. (a) What causes bread staling? What are the objectives of bread packaging? Name 3 packaging materials used for bread packaging **(5 Points).**

    (b) On the sorption isotherm where will you place all cookies (biscuits)? What will be your major concern in ensuring that their quality is maintained? What type of packaging material will you recommend based on the information from the sorption isotherm? **(5Points).**

11. Packaging requirement of simple, compound and complex confectionary are dependent on a number of factors name five **(5 points).**

12. (a) Packaging requirements for potato chips (crisps) ensures that the product quality is maintained. Name 3 things for which packaging of potato chips are used against in the quest to maintain product quality **(3 Points)**.

    (b) The nutrient content of chips (i) Protein content (ii) Water content and (ii) Carbohydrates content, all in percent **(3 points)**

THE UNIVERSITY OF ZAMBIA

AGG 322 [Forage Crop Production] final exam
October/November 2002

INSTRUCTIONS

1. Answer all questions
2. Maximum time allowed = 3 hours

1.
   a. What are the main factors involved in the condition of bloat? [5 marks]
   b. What are forages? [5 marks]
   c. What are Mallard products? [5 marks]
   d. Why is the use of tabular compositions of mineral contents unreliable [5 marks]

2. What are the important criteria in the estimation of forage quality? [20 marks]

3.
   a. Why do grass species regenerate more easily than legumes after grazing ruminants on a mixed pasture? [5 marks]
   b. Name the biotic components of a grassland ecosystem and briefly mention their roles. [15 marks]

4. Microelement deficiencies and imbalances occur in grazing cattle and sheep in many regions of the world. Which elements are the most frequently involved in tropical regions? [20 marks]

5. How are ruminants able to digest fibrous carbohydrates, such as cellulose, as food? [20 marks]

Damsels and lads, it has been a pleasure introducing you to the science of forage crops. We wish you everything of the best as you apply these concepts in the industry.

THE UNIVERSITY OF ZAMBIA

UNIVERSITY SECOND SEMESTER EXAMINATIONS
JULY 2001

AGS 222 FUNDAMENTALS OF SOIL SCIENCE II

TIME: 3 HOURS **MARKS:** 100

INSTRUCTIONS: ANSWER ALL QUESTIONS

1. a) Why may a soil, developed from basic parent material become acid? [5]

   b) Can Na_2CO_3 and $CaSO_4$ be used as liming material? Clearly justify your answer. [4]

   c) Why do plants tolerate a lower pH on organic than mineral soils? [4]

2. a) Describe the mechanisms of pH-buffering in the pH ranges of 3–4 and 8-9. [10]

   b) Explain the differences in the lime requirement (LR) among the three soils: [5]

Soil	% organic matter	Texture	LR
A	2.0	Sandy Loam	5t ha^{-1}
B	3.9	Sandy Loam	10t ha^{-1}
C	2.1	Clay	10t ha^{-1}

3. Discuss the reasons for the poor correlation often found between soil test values and crop performance in the field. [10]

4. A 5t ha^{-1} crop of maize transpired 3.2 x 10^9g of water per season. If the average P concentration in the soil solution during the growing season is 0.15 mg $dm,^{-3}$ and an adequate P content in plant tissue is 0.2%, would mass flow supply enough P to meet plant requirements? How much is the deficit or excess in terms of kg ha^{-1} of P_2O_5 equivalent ?(P = 30.938g). [10]

5. An extraction of a 10g soil sample gave the following results:

Exchangeable ions (mg)					
Ca^{++}	Mg^{++}	K^+	Na^+	H^+	Al^{3+}
1.547	0.454	0.743	0.250	0.0151	0.0134

   a) Calculate the ECEC. [12]

b) Calculate the BS [4]

c) If the desired acid saturation for maize is 20%, how much (kg ha^{-1}) pure (100%) $CaCO_3$ would be required to correct the problem in the top 20cm of the soil.? [4]

d) If only an agricultural lime with a neutralizing value of 45% is available, how much of this material would need to be applied to the soil? [2]

6. a) Outline the basis for classifying soils, giving an example of a classification system of each. [4]

b) Describe the characteristics of the following diagnostic horizons. Albic, Ochric, Umbric, Argillic, Kandic. [10]

7. Using the following data, a). plot the moisture characteristic curve of the soil. [10]

Soil depth Cm	**Soil water content g/100g soil**				
	Dbgcm^{-3}	**0.1BAR**	**1.0BAR**	**3.0BAR**	**15.0BAR**
0 – 15	1.21	22.36	23.31	7.00	5.24
15 – 30	1.26	25.09	25.12	10.91	8.68
30 – 45	1.33	26.03	28.93	12.00	10.13
45 – 60	1.40	24.90	21.49	12.50	10.35

b) Calculate the plant available water at each depth in (i) gravimetric and (ii) volume basis. [2]

c) What is the total depth (mm) of water storage in this soil profile? [4]

END OF EXAM

THE UNIVERSITY OF ZAMBIA
SCHOOL OF AGRICULTURAL SCIENCES
DEPARTMENT OF SOIL SCIENCE
2001/2002 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATION

AGS 222: **FUNDAMENTALS OF SOIL SCIENCE**
TIME: **3 HOURS**
INSTRUCTIONS: **ANSWER ALL QUESTIONS** **100 MARKS**

1. Describe the conditions under which the following soil structures would normally be formed: granular, crumb, columnar and platty. [8]

2. (a) Given that the diffusion coefficient of K^+ in soil is 2.5×10^{-6} $cm^2 s^{-1}$, what is the minimum distance that fertilizer granules must be placed in order to be within reach of plant roots during the first 10 days of seedling emergence? [4]

   (b) If a soil solution contains about 0.2 mg P dm^{-3}, would mass flow deliver enough P to the roots to meet plant requirements of 20 kg P_2O_5 ha^{-1} given that the crop transpires 3.4×10^6 dm^3 of water per ha per season? Use mwt P = 31. [6]

3. (a) Explain the reactions of P in soil that cause it to be deficient. [6]

   (b) In reclaiming a sodic soil, it is often advisable to also incorporate some organic matter. Why? Explain the processes involved in reclamation. [9]

4. (a) How can a soil developed from basic parent material become acid? [6]

   (b) Give balanced equations for the reaction of any four liming materials in an acid soil. [8]

   (c) Ten grams of finely ground (<2 mm) anthill soil required 15 cm^3 of 0.1 M HCl to completely neutralize it. Calculate the Calcium Carbonate Equivalent or Neutralizing Value of the sample. [8]

5. Assuming a soil bulk density of 1.3 g cm^{-3} in the top 20 cm, calculate the respective cation saturation percentage that would result from addition of:

   (a) 20 kg K ha^{-1} on a Silt Clay Loam with a CEC of 26 cmol (+) kg^{-1} [4]

   (b) 800 kg Ca ha^{-1} on a Clay with CEC of 33 cmol (+) kg^{-1}. [4]

   (c) 100 kg N ha^{-1} (as ammonium) on a Loamy Sand with CEC of 7 cmol (+) kg^{-1}. [6]

6. (a) Given that a soil sample is saturated on a suction table in the laboratory, calculate the limiting radius of pores which remain full of water when the table is subjected to suctions of $1/_{10}$ bar, $1/_3$ bar; 1 bar; 5 bar, 10 bar and 15 bar. [12]

(b) What conclusion can you draw from this calculation. [3]

7. The following data were obtained from three different soils.

Soil	D_b	Gravimetric moisture g/100 g				
	g cm^{-3}	15	10	1.0	0.33	0.1 bar
A.	1.5	17	21	25	27	32
B.	1.7	5	5	7	8	9
C.	1.4	10	14	16	17	20

(a) Plot the pF curves for each of the soils and indicate curves for Sand, Loam and Clay. [6]

(b) If maize is grown in these soils and if the active-root zones are assumed to be 20, 30 and 50 cm in the three soils respectively, calculate the plant available water in:

(i) percent by volume [5]
(ii) depth of water (mm) [5]

END OF EXAM

THE UNIVESITY OF ZAMBIA
SCHOOL OF AGRICULTURAL SCIENCES

2001/2002 ACADEMIC YEAR SECOND SEMESTER
DEFERRED FINAL EXAMINATION

AGS 222 FUNDAMENTALS OF SOIL SCIENCE

DATE : 15TH NOVEMBER,2002

TIME : 3 HOURS **MARKS: 80**

ANSWER ALL QUESTIONS

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1. Soil A was monocropped with maize for three years while soil B was left under grass fallow for the same period. Soil samples from both treatments were dry and wet sieved, giving the following data.

Diameter of Aggregate mm	Average Diameter mm		Aggregate % After dry sieving		Aggregate % After wet sieving	
	Soil A	Soil B	Soil A	Soil B	Soil A	Soil B
8-5	8.0	6.5	18	20	10	15
5-3	6.0	4.0	42	40	23	18
3-2	4.0	2.5	20	15	37	20
2-0	5.0	1.0	20	25	30	47

a) Determine in which soil treatment soil aggregation was enhanced? (10 marks)

b) Describe some relevant soil aggregate bonding mechanisms ((10 marks)

2. (a) Using well balanced equations of specific reactions, show how P is fixed in the soil (8 marks)

(b) What are the possible agronomic solutions to P fixation in acid soil? (3 marks)

3. Describe the mechanisms of nutrient element movement to plant root surfaces, specifying in each case an example of a nutrient element mainly transported by the particular mechanism (10 marks)

4. Given that the basic ions were extracted by neutral lMNH4Aoc and acid ions by 1MKCl from a 50 g soil samples giving the following values:

Ca^{++} = 36 mg	Na^{+} = 11mg
Mg^{++} = 30 mg	Zn^{2+} = 15 mg (mw = 56)
Al^{3+} = 35 mg	Cu^{2+} = 15 mg (mw = 64)
H^{+} = 28 mg	Mn^{2+} = 3mg (mw = 55)
K^{+} = 15 mg	Pb^{2+} = 3 mg (mw 207)

Calculate

(a) The Effective Cation Exchange Capacity (ECEC) (10 marks)
(b) The Base Saturation (BS) in percentage terms (%) (3 marks)
(c) Comment on the suitability of this soil for plant growth (2 marks)

5. (a) A 5 ton ha^{-1} crop of maize transpired 4.8 X 10^{-9} g of water in one season. Given that the average concentration of K in the soil solution was 0.25 mg dm^{-3} and that K adequacy in plant tissue is 1%, would mass flow supply and meet the crop's requirement? (5 marks)

(b) List eight natural processes that cause pH changes in soil. (8 marks)

6. (a) Distinguish between the following terms: (8 marks)

(a) granule and concretion
(b) crumb and granuler structure
(c) clod and ped
(d) nitrogen fixation and K fixation

(b) What is the pH when $[H^{+}]$ = 3.27 X 10^{-4}M, the $[H^{+}]$ when pH 8.87 and the pH of 0.001M NaOH? (3 marks)

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF AGRICULTURAL SCIENCES
DEPARTMENT OF SOIL SCIENCE
2001/2002 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATION

AGS: 322 - SOIL PHYSICS
TIME: 3 HOURS
ANSWER: ALL QUESTIONS

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1) Briefly define the following terms: ***(15 marks)***

a) Void ratio
b) Crop coefficient
c) Laplace equation
d) Soil water capacity
e) Thermal conductivity of soils

2) Draw and define the different zones of the soil water content distribution in a homogenous soil profile that can be distinguished during a vertical downward water entry at the soil surface during infiltration. ***(10 marks)***

3) A thin clay layer with a hydraulic conductivity (*Ks*) of *0.1 cm* day^{-1} is sandwiched somewhere inside a soil column of height *1.0 m* that is otherwise filled with sand (*Ks* = *200 cm* day^{-1}). A height of water (*0.1 m*) is maintained at the soil surface. ***(25 marks)***

a) If the clay layer was not present, what would be the steady state flux rate (*q*) in the soil column? ($m\ d^{-1}$)
b) If the actual steady state flux rate (*q*) is *15 cm* day^{-1}, how thick is the clay layer? (*m*)
c) Calculate the pressure head (*dH*) at the clay-sand interface for two special cases where:
    i) A clay layer is above the sand (*m*)
    ii) A clay layer is below the sand (*m*)

d) Make a schematic drawing of the system and a potential diagram when a clay layer is below the sand layer

4) With the aid of a drawing, derive the two equations that are used to calculate the soil matric head (h) and hydraulic head (H) from a mercury manometer tensiometer.

(*15marks*)

5) The soil water contents at field capacity and wilting point for sandy loam soil profile are *0.300* and *0.050* cm^3cm^{-3} respectively. Find the depth of water penetration (*cm*) of a *58 mm* rainfall if the initial soil water content of the soil profile is measured as given below:

(*10 marks*)

Table 1: Soil profile water content and bulk density

Depth (m)	Soil Water Content (g water/100g soil)	Bulk Density (kg m^{-3})
0.00 – 0.05	5	1200
0.05 - 0.20	10	1300
0.20 – 0.50	15	1400
0.50 – 0.80	15	1400
0.80 – 1.00	17	1500
1.20 – 1.45	19	1600

6) During an experiment to quantify crop water requirements of winter maize on a farm in Gwembe district the following data was collected using neutron probe and tensiometers installed on a representative site in one of the maize fields. The average hydraulic conductivity function for the soil is given by: (*25 marks*)

$$K_{(\bar{\theta})} = 4.4 * 10^{-12} \cdot \exp^{107.6*\theta} \text{ mm/hr}$$

Table 2: Measured field data of matric head and volumetric soil water content during crop water requirement experiment

Depth (cm)	July 1, 2001		July 15, 2001	
	Matric head (h) (cm)	*Volumetric Water content (%)*	*Matric head (h) (cm)*	*Volumetric Water content (%)*
10	-278.2	16.8	-754.4	5.4
20	-225.4	15.3	-556.6	3.2
30	-172.5	18.6	-358.8	11.1
40	-154.3	16.0	-273.9	12.3
50	-136.1	17.3	-189.0	14.7
60	-156.8	17.4	-176.5	13.7
70	-177.4	16.8	-164.0	13.8
80	-139.3	22.5	-145.8	21.2
90	-101.2	24.1	-127.6	23.2
100	-116.4	20.5	-130.8	20.4
110	-131.6	15.2	-134.0	14.4

Given this data set of matric head and volumetric water content data:

a) Determine the average depth of the plane of zero flux during the measured time intervals

b) If the maximum rooting depth of the maize crop was 40 cm determine the crop evapotranspiration rate ($mm\ day^{-1}$)

c) How much water was lost through evapotranspiration in a 10 hectare field of maize (m^3)

d) If the reference crop evapotranspiration during this period was 6.5 mm day^{-1}, determine the crop coefficient of maize

e) Determine the quantity of drainage flux occurring at 50 cm soil depth ($m^3\ ha^{-1}\ day^{-1}$) and what is the direction of water flow?

THE UNIVERSITY OF ZAMBIA
SCHOOL OF AGRICULTURAL SCIENCES
DEPARTMENT OF SOIL SCIENCE
2001/2002 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATION

AGS 331: SOIL SURVEY TECHNIQUES
TIME: 3 HOURS
INSTRUCTIONS: ANSWER ALL QUESTIONS (CALCULATOR ALLOWED)

1. An investor would like to buy 1000ha of land in Namwala to develop a mixed irrigated wheat, rainfed maize and beef ranch. Convince this investor that a soil survey is necessary. [[10]

2. Soil Surveys may be general purpose or special purpose. Explain [10}

3. A prospective farmer approaches you and asks for a soil survey. Outline in detail the main steps you would undertake to execute this job. [10]

4. (a) With suitable examples where necessary, explain the concept of the soil map unit. [10]

   (b) In a soil mapping quality control excise a soil surveyor measures the top soil and content in one map unit. Following results are obtained:

Point	% sand content
1	26
2	36
3	72
4	18
5	45
6	56
7	11
8	50
9	46
10	40

   Comment on the dependability of his mapping, given that the maximum permissible variability of this soil property is 15% [4]

5. What are the main soil survey levels as used in Zambia [10]

6. Explain the main shortcomings of the Zambian land capability classification system. [10]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF AGRICULTURAL SCIENCES
2001/2002 ACADEMIC YEAR SECOND SEMESTER

FINAL EXAMINATIONS

AGS 342 : FUNDAMENTALS OF SOIL SCIENCE FOR ENGINEERS

TIME: 3 HOURS
INSTRUCTIONS: ANSWER ALL QUESTIONS

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1. (a) Name one 1:1 (dimorphic) and one 2:1 trimorphic clay mineral. [2]

   (b) Draw a simple well labeled diagram to illustrate the structures of illite and chlorite [5]

   (c) Briefly comment on the degrees of expansion of illite and vermiculite [3]

2. Explain each of the following terms [10]

   (a) metamorphism
   (b) mineral
   (c) crystal lattice
   (d) cleavage
   (e) Silicate clay

3. (a) A soil has bulk density of 1.32g cm^{-3} and particle density of 2.63g cm^{-3}. What is the total porosity of this soil? [3]

   (b) A moist soil with bulk density of 1.5g cm^{-3} weighs 800g. When it is oven dried, it weighs 690g. What is the soil wetness on volumetric basis?[3]

   (c) Given a 250g moist soil, calculate the moisture content on a wet mass and dry mass base if the oven dried weight was 228g. [4]

4. How do convective or diffusive air flow happen and how would each affect the composition of soil air? [10]

5. (a) What are the origins of soil charge and what is the significance of soil charge. [6]

   (b) Why do we normally refer to soils as negatively charged? Compare this state to variable charge soils. [4]

6. Define each of the following : [10]

(a) Soil consistency
(b) Soil plasticity
(c) Capillarity
(d) Contact angle
(e) Osmotic pressure

7. Give the principle and working for each of the following methods for moisture content determination. [10]

(a) Gravimetric
(b) Gypsum block
(c) Calcium Carbide
(d) Tensiometer

8. What is the volume of flow of water through a soil sample which has a hydraulic head of 9cm, cross sectional area of 15cm ^{2}, sample length of 7cm and permeability coefficient of 10^{-4} cm sec $^{-1}$? [10]

9. (a) Define solid density and bulk density. Give examples for mineral soils and organic soils [5]

(b) How is solid density related to total porosity? [5]

10. (a) What might happen to capillary rise of water from ground-water table to the soil surface when a coarse textured soil overlays a fine textured soil? [5]

(b) What are the two steps followed in particle size analysis by the Hydrometer (Mechanical) method? [5]

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF AGRICULTURAL SCIENCES
DEPARTMENT OF SOIL SCIENCE
2001/2002 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATION

AGS 422: SOIL MICROBIOLOLOGY
TIME: 3 HOURS
INSTRUCTIONS: ANSWER ALL QUESTIONS 60 MARKS

1. (a) Why does the number of introduced microrganisms in soil decrease relative to the native microbes? [4]

   (b) What attributes of microrganisms make them good biological filters? [6]

2. (a) Describe the essential characteristics of a culture medium selective for algae and for fungi. [4]

   (b) Describe the medical and agronomic usefulness of actionomycetes. [5]

3. A farmer has three water bodies for possible stocking with fish. Twenty (20 cm^3) water samples were titrated with 0.001M $Na_2Cr_2O_7$ and consumed 8.5, 15.6 and 18.0 cm^3 to reach the titration end point. Which of the water bodies is suitable, assuming fish require a BOD of at least 5 ppm?. [10]

4. Demonstrate whether the following transformations are reduction or oxidation:
   (i) N_2 ---------- NH_3
   (ii) NO^-_3 ---------- NH^-_2
   (iii) CO---------- CH_4
   (iv) C_2H_2 ---------- C_2H_4
   (v) NO^-_3 ---------- N_2O
   (vi) SO_4^{2-} ---------- H_2S [11]

5 (a) How do you reconcile the fact that plants absorb nutrients in forms that are products of aerobic processes and that paddy rice is grown under flooded conditions? [5]

   (b) How can aerobic Rhizobium bacteria survive in an anaerobic environment of the root nodule while aerobic conditions are necessary for N_2 fixation? [5]

6. Discuss the advantages of composting organic materials compared to their direct application onto lands. [10]

END OF EXAM

THE UNIVERSITY OF ZAMBIA

SCHOOL OF AGRICULTURAL SCIENCES

DEPARTMENT OF SOIL SCIENCE

2001/2002 ACADEMIC YEAR SECOND SEMESTER

FINAL EXAMINATION

AGS: 462 - SOIL PHYSICS FOR ENGINEERS

TIME: 3 HOURS

ANSWER: ALL QUESTIONS

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1) Briefly define the following terms: ***(15 marks)***

   a) Void ratio
   b) Crop coefficient
   c) Laplace equation
   d) Soil water capacity
   e) Thermal conductivity of soils

2) Draw and define the different zones of the soil water content distribution in a homogenous soil profile that can be distinguished during a vertical downward water entry at the soil surface during infiltration. ***(10 marks)***

3) A thin clay layer with a hydraulic conductivity (*Ks*) of *0.1 cm* day^{-1} is sandwiched somewhere inside a soil column of height *1.0 m* that is otherwise filled with sand (*Ks* = *200 cm* day^{-1}). A height of water (*0.1 m*) is maintained at the soil surface. ***(25 marks)***

   a) If the clay layer was not present, what would be the steady state flux rate (*q*) in the soil column? ($m\ d^{-1}$)
   b) If the actual steady state flux rate (*q*) is *15 cm* day^{-1}, how thick is the clay layer? (*m*)
   c) Calculate the pressure head (*dH*) at the clay-sand interface for two special cases where:
      i) A clay layer is above the sand (*m*)
      ii) A clay layer is below the sand (*m*)

d) Make a schematic drawing of the system and a potential diagram when a clay layer is below the sand layer

4) With the aid of a drawing, derive the two equations that are used to calculate the soil matric head (h) and hydraulic head (H) from a mercury manometer tensiometer.

(*15marks*)

5) The soil water contents at field capacity and wilting point for sandy loam soil profile are *0.300* and *0.050* cm^3cm^{-3} respectively. Find the depth of water penetration (*cm*) of a *58 mm* rainfall if the initial soil water content of the soil profile is measured as given below:

(*10 marks*)

Table 1: Soil profile water content and bulk density

Depth (m)	Soil Water Content (g water/100g soil)	Bulk Density (kg m^{-3})
0.00 – 0.05	5	1200
0.05 - 0.20	10	1300
0.20 – 0.50	15	1400
0.50 – 0.80	15	1400
0.80 – 1.00	17	1500
1.20 – 1.45	19	1600

6) During an experiment to quantify crop water requirements of winter maize on a farm in Gwembe district the following data was collected using neutron probe and tensiometers installed on a representative site in one of the maize fields. The average hydraulic conductivity function for the soil is given by: (*25 marks*)

$$K_{(\bar{\theta})} = 4.4 * 10^{-12} \cdot \exp^{107.6*\theta} \text{ mm/hr}$$

Table 2: Measured field data of matric head and volumetric soil water content during crop water requirement experiment

Depth (cm)	July 1, 2001		July 15, 2001	
	Matric head (h) (cm)	*Volumetric Water content (%)*	*Matric head (h) (cm)*	*Volumetric Water content (%)*
10	-278.2	16.8	-754.4	5.4
20	-225.4	15.3	-556.6	3.2
30	-172.5	18.6	-358.8	11.1
40	-154.3	16.0	-273.9	12.3
50	-136.1	17.3	-189.0	14.7
60	-156.8	17.4	-176.5	13.7
70	-177.4	16.8	-164.0	13.8
80	-139.3	22.5	-145.8	21.2
90	-101.2	24.1	-127.6	23.2
100	-116.4	20.5	-130.8	20.4
110	-131.6	15.2	-134.0	14.4

Given this data set of matric head and volumetric water content data:

a) Determine the average depth of the plane of zero flux during the measured time intervals

b) If the maximum rooting depth of the maize crop was 40 cm determine the crop evapotranspiration rate ($mm\ day^{-1}$)

c) How much water was lost through evapotranspiration in a 10 hectare field of maize (m^3)

d) If the reference crop evapotranspiration during this period was 6.5 mm day^{-1}, determine the crop coefficient of maize

e) Determine the quantity of drainage flux occurring at 50 cm soil depth ($m^3\ ha^{-1}\ day^{-1}$) and what is the direction of water flow?

THE UNIVERSITY OF ZAMBIA

SCHOOL OF AGRICULTURAL SCIENCES

2001/2002 ACADEMIC YEAR SECOND SEMESTER

FINAL EXAMINATIONS

AGS 522: **SOIL AND PLANT ANALYSIS**

TIME: **3 HOURS**

INSTRUCTIONS: **ANSWER ALL QUESTIONS**

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1. (a) In the process of reading P concentration on the spectrometer, your sample reading registers a value higher than your standard. Is this acceptable and what if anything would you do to your sample and calculation? [5]

   (b) Upon reading your S sample on the colorimeter, it registers zero. What would you do with your sample, and or your standard? [5]

2. Given the following foliar analysis data, discuss the nutrient concentration levels for crops generally and suggest symptoms that may be observed on a soya plant.[10]

N	-	1.2%	Zn	-	25mg kg^{-1}
P	-	0.5%	Mn	-	200mg kg^{-1}
K	-	3.5%	Fe	-	80mg kg^{-1}
Ca	-	0.1%	B	-	5mg kg^{-1}
Mg	-	0.4%			

3. There are several methods for P analysis. Discuss two of them and outline the basis of their chemistry [5]

4. Given a stock solution that is 2.5N HCl how would you prepare a 0.01N solution. [5]

5. Select the best answer: (10)

(i) The portion of nutrient present in the soil solution is most appropriately referred to as:

(a) capacity factor

(b) active factor

(c) intensity factor

(d) latent factor

(ii) Soil test correlation

(a) seeks to find the amount of fertilizer required at various soil test levels.

(b) must always be done in the field

(c) examines how the amount of nutrient extracted is related to crop uptake

(d) b and c

(iii) The pH meter should be standardized:

(a) daily

(b) weekly

(c) before use

(d) After each sample reading

(iv) A deficiency of which of the following micronutrients is the least likely to occur on alkaline soils?

(a) B
(b) Mo
(c) Zn
(d) Mn

(v) Which of the following is more likely to cause temporary Zn deficiency?

(a) close planting
(b) Fertilizer source
(c) soil pH 7.5
(d) low soil temperature

(vi) Which of the following sampling tools will likely lead to the most contamination of subsoil samples when taking deep samples?

(a) Oakfield probe
(b) Screw anger
(c) bucket anger
(d) b and c

(vii) The lower leaves of a potato crop are turning yellow. The pattern is from the tip down the margins and it is inter-veinal. What deficiency is this?

(a) N
(b) Zn
(c) K
(d) N, K

(viii) Why is nutrient concentration in younger plants usually higher than in older plants?

(ix) SLAN mean

(a) Sufficient Levels of All Nutrients
(b) Special Limits of Acidic Nutrients
(c) Sufficiency level of available nutrients
(d) None of the above

(x) A useful but non-essential element

(a) Causes toxicity always
(b) May sometimes substitute an essential element
(c) Does not affect yield levels
(d) Doubles yield levels

6. Discuss one soil analysis procedure for micronutrients How would you go about it, and how would you interpret the results? [5]

7. How would you go about a soil test calibration exercise and how would you handle the data? [5]

8. In order to determine the calcium content of a lime sample,10g material was weighed, digested and diluted to 250ml. Out of this a 10ml aliquot was diluted to 200ml mark in a volumetric flask. Upon reading than the standards. The technician diluted this solution 5 times. The reading registered thereafter was 5mg Ca L^{-1}. Report Ca content in the sample on a percentage basis[10]

9. Given the following soil test result, indicate your interpretation and where you would make fertilizer recommendation for potatoes [10]

Element	Test Level	Interpretation	Recommend (Y or N)
N	0.2%		
P	30mg kg^{-1}		
K	9 mg kg^{-1}		
Ca	10 mg kg^{-1}		
Mg	35mg kg^{-1}		
S	10mg kg^{-1}		
Mn	50mg kg^{-1}		
Zn	4mg kg^{-1}		
Fe	10mg kg^{-1}		
Cu	0.1mg kg^{-1}		
B	0.2mg kg^{-1}		

(a) What is the role of NaOH in the Kjeldahl distillation process? [5]

10. (b) What are the catalysts used in this procedure and what do they do? [5]

11. Tissue contamination may be a problem.

(a) Discuss the washing procedure for leaf analysis samples.
(b) Why would you wash leaf samples?
(c) Which elements might you be concerned about?
(d) When might you recommend that sample not be washed? [10]

12. Discuss and differentiate between the plant deficiency symptoms of K, Mg and Zn. (10)

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF AGRICULTURAL SCIENCES
DEPARTMENT OF SOIL SCIENCE
2001/2002 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATION

AGS: 542 – SOIL GENESIS AND CLASSFICATION

TIME: 3 HOURS
INSTRUCTIONS: ANSWER ALL QUESTIONS (SOIL TAXONOMY MANUALS ALLOWED)

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1. (a) A soil has developed in situ from calcite in Kawamba. The soil is red, coarse – textured (sandy) and acidic. Explain how this might be possible. [4]

   (b) Explain the main factors and processes that have led to the differentiation of soils among the three agro-ecological zones in Zambia. [6]

2. (a) What are the major shortcomings of Jenny's factorial approach in studying soil formation? [5]

   (b) According to the concept of the soil catena, soils are related and occur in a predictable pattern across a slope. Suggest assumptions that must be true in order for this theory to work. [5]

3. Contrast between the following:

   (a) Enrichment and cumulization

   (b) Illuviation and lessivage [10]

4. Explain the relationship between the following parameters in soil formation.

   (a) Rainfall and base saturation

   (b) Rainfall and Organic matter

   (c) Temperature and clay content

   (d) Temperature and soil colours [10]

5. (a) Most soil classification systems are based on soil properties and not soil genesis. What advantages does this have? [4]

(b) With suitable examples where necessary explain the basic differences between a technical classification and a natural classification system [6]

6. Below is a soil profile description representative of a certain soil map unit. For this soil:

(a) Determine the epidedon and subsurface diagnostic horizon, giving reasons for your answer. [4]

(b) Classify the soil according to soil taxonomy up to the family level [4]

(c) Suggest the main limitations and potentials of this soil for rainfed arable farming. [2]

END OF EXAMINATION

Profile no. 05
Map Unit: dKpt
Agro-Eco zone: 9
Vegetation: Thickets
Geology: Limestone/dolomite
Surface features: Few rock outcrops
Authors: D.Banda/V.Shitumbanuma
Classification:
FAO (1988):
USDA (1987):

Area: Nanga Farm
Site:
Elevation:
Topography: foot-slopes
Drainage: well drained
Erosion: moderate-sheet
Date described: 22/12/91

SERIES: Kapeta clay loam.

Ad	0-20cm	Dark reddish brown (2.5YR 3/4) moist; clay loam: moderate medium and coarse subangular blocky structure; slightly hard when dry, friable when moist, slightly plastic and slightly sticky when wet; many fine tubular pores; many fine, common medium, few coarse roots; clear smooth boundary.
BA	20-50cm	Dark reddish brown (2.5YR 3/6) dry, dark reddish brown (2.5YR 3/4) moist; clay; moderate fine and medium subangular blocky structure; slightly hard when dry, friable when moist, slightly plastic and slightly sticky when wet; many fine tubular pores; common fine, few medium roots; clear smooth boundary.
Bt1	50-90cm	Dark reddish brown (2.5YR 3/6) dry, dark reddish brown (2.5YR 3/4) moist; clay; moderate fine and medium subangular blocky structure; slightly hard when dry, friable when moist, plastic and sticky when wet; common fine tubular pores; few quartz-siltstone gravels; few fine, very few fine roots; clear smooth boundary.
Bt2	90-120cm	Dark reddish brown (2.5YR 3/6) dry, dark reddish brown (2.5YR 3/4) moist; clay loam; moderate fine and medium subangular blocky structure; slightly hard when dry, friable when moist, plastic and sticky when wet; common quartz-siltstone gravels and stones; common fine tubular pores; very few fine roots; clear smooth boundary.
Cr	120cm+	Rock (limestone)

PROFILE No.05: LABORATORY ANALYSIS RESULTS

h	Horizon	Texture	%Clay	%Silt	%Sand
-20	Ad	CL	24.8	30.8	44.4
20-50	BA	L	26.8	30.8	42.4
50-90	Bt1	CL	30.8	26.8	42.4
90-120	Bt2	CL	34.8	30.8	34.4

Depth (cm)	Horizon	Exch. cations (meq/100g soil)					Avail. P (ppm)
		K	Na	Ca	Mg	Al+H	
0-20	Ad	1.89	0.07	7.1	3.5	TR	1.72
20-50	BA	0.89	0.06	4.3	6.2	TR	3.05
50-90	Bt1	1.01	0.09	7.0	5.3	TR	3.29
90-120	Bt2	0.94	0.10	14.3	5.5	TR	2.8

Depth (cm)	Horizon	CEC (meq/100g soil)	CEC (meq/100g clay)	Base sat. (%)
0-20	Ad	12.58	50.73	100
20-50	BA	11.36	42.39	100
50-90	Bt1	13.30	43.18	100
90-120	Bt2	20.79	59.74	100

Depth (cm)	Horizon	pH (CaCl2)	Total N. (%)	Org.C (%)	ESP (%)	ECe (mS/cm)
0-20	Ad	5.2	0.39	1.90	0.56	0.38
20-50	BA	5.6	0.24	0.76	0.53	0.23
50-90	Bt1	5.8	0.32	0.69	0.68	0.20
90-120	Bt2	6.3	0.35	0.69	0.48	0.28

Depth (cm)	Horizon	B	Zn	Cu	Fe	Mn
		(<----------ppm----------)				
0-20	Ad	0.06	0.20	1.36	0.61	0.46
20-50	BA	0.07	0.15	1.56	0.36	0.24
50-90	Bt1	0.24	0.26	1.65	0.31	0.14
90-120	Bt2	0.03	0.36	1.83	0.33	0.31