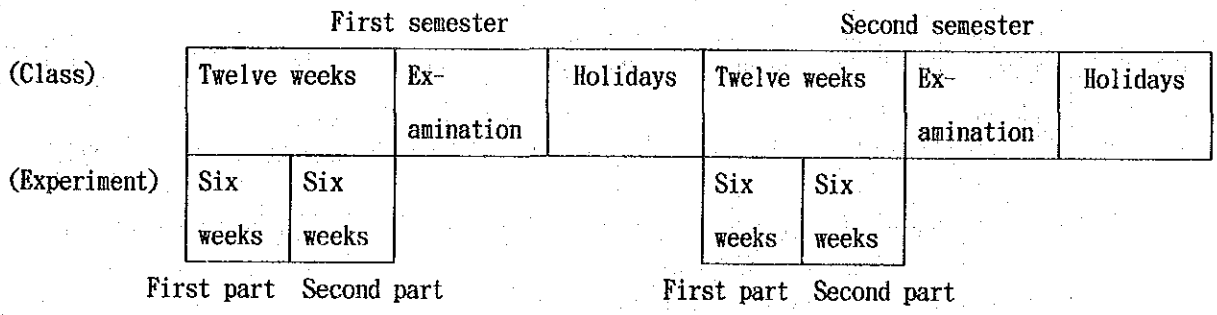
(2) Curriculum Schedule of the Chemistry Department

Curriculum is provided for three grades, and classes and experiments are given according to curriculum and time table of each grade. One year is divided into two semesters which contain twelve weeks respectively. Each semester is further divided into the first and second parts to conduct experiments in all the four sectors in each grade. Examinations are given at the end of each semester. This curriculum schedule is illustrated in the following figure (See Figure-1).

Figure - 1 Curriculum Schedule of the Chemistry Department



All the students in each year take a class at the same time. As the students in the first year take a class with students in other departments, they use a large classroom which is commonly used in the Faculty of Science. The students in the second and third years take a class in classrooms of the Chemistry Department.

Experiment is given in four classes at a common large laboratory for students in the first year. Class hours per student in the first year are four hours once a week, six weeks for one sector; namely, twenty-four hours in total. They perform experiment in four sectors for six weeks respectively in the first and second semesters. Students in the second year are divided into three classes, and students in the third year are two classes, and they conduct experiments in their own laboratory in each sector. Class hours per student in the second and third years are six hours a week and six weeks for one sector; namely thirty-six hours in total. As students in the first year, they conduct experiments in four sectors for six weeks in the first and second semesters. Courses, number of students, and class/experiment schedule are shown below.

Table - 14 Courses and Number of Students in the Chemistry Department

Year	Code	T i t l e	No. of Students
1	CH 101	Physical Chemistry	160
	CH 102	Inorganic and Analytical Chemistry	160
	CH 103	Organic Chemistry	144
	CH 105	General Chemistry	160
2	CH 201	Physical Chemistry	61
	CH 202	Inorganic Chemistry II	61
	CH 203	Organic Chemistry II	65
	CH 204	Analytical Chemistry II	68
	CH 211	Advanced Physical Chemistry	60
	CH 212	Advanced Inorganic Chemistry	59
	CH 213	Advanced Organic Chemistry	65
	CH 214	Advanced Analytical Chemistry	67
3	CH 301	Physical Chemistry	37
	CH 302	Inorganic Chemistry	37
	CH 303	Organic Chemistry	37
	CH 304	Analytical Chemistry	37
	CH 321	Atmospheric Chemistry	10
	CH 351	Industrial Chemistry	26
	CH 361	Polymer Chemistry	26
	CH 322	Bioinorganic Chemistry	26
	CH 332	Inorganic Photochemistry	5
	CH 342	Advanced Solid State Chemistry	8
	CH 323	Medical Chemistry	22
	CH 333	Synthetic Methods and Advanced Org. Spectroscopy	15
	CH 353	Free-Radical and Pericyclic Reactions	5
	CH 324	Environmental Analysis	24
	CH 334	Trace Analysis and Kinetic Methods of Analysis	17
	CH 344	Introduction to Analog Circuits and Devices	3
	HCH 311	Advanced Physical Chemistry	11
	HCH 312	Advanced Inorganic Chemistry	11
	HCH 313	Advanced Organic Chemistry	11
	HCH 314	Advanced Analytical Chemistry	11
	HCH 315	Research Project	11
4	MSC 1	Analytical Chemistry	10
	MSC 2	Analytical Chemistry	13

Figure - 7 Chemistry Department of the University of Zimbabwe
Class and Experiment Schedule

1st Year

1st Semester

	Monday	Tuesday		Wednesday		Thursday		Friday		Saturday
9:00	CH 102			CH 105		CH 102		CH 105		
10:00										
14:00		I.C.	A.C.	I.C.	A.C.	I.C.	A.C.	I.C.	A.C.	
18:00										

2nd Semester

	Monday	Tuesday		Wednesday		Thursday		Friday		Saturday
9:00	CH 108			CH 101		CH 108		CH 101		
10:00										
14:00		P.C.	O.C.	P.C.	O.C.	P.C.	O.C.	P.C.	O.C.	
18:00										

Note : 1. Alphabets and numbers in the table indicate course code.
The underlined indicate experiments.
2. Vertical lines in time column indicate lectures and experiments conducted dividedly in 1st and 2nd sections in a semester.
3. When the same lecture is provided on more than one day, all of them are serial lectures.
4. All the students attend lectures at the same time.
For freshmen, the large auditorium of the Faculty of Science is used.
5. Experiments are given for divided classes, and each student conducts experiment once a week.
6. Abbreviations:
I.C. : Inorganic Chemistry
A.C. : Analytical Chemistry
P.C. : Physical Chemistry
O.C. : Organic Chemistry
OPT : Optional Lecture

Figure - 7 Chemistry Department of the University of Zimbabwe
Class and Experiment Schedule (Continued)

2nd Year

1st Semester

	Monday	Tuesday		Wednesday		Thursday		Friday	Saturday
8:00	CH 202			CH 203		CH 203			
9:00				CH 202		CH 213	CH 212		CH 218 / CH 212
10:00									
12:00	CH 213 / CH 212	I.C.	O.C.	I.C.	O.C.	(I.C.)	(O.C.)		
13:00									
18:00									

2nd Semester

	Monday	Tuesday		Wednesday		Thursday		Friday	Saturday
8:00	CH 201			CH 204		CH 204			
9:00				CH 201		CH 214	CH 211		CH 214 / CH 211
10:00									
12:00	CH 214 / CH 211	A.C.	P.C.	A.C.	P.C.	(A.C.)	(P.C.)		
13:00									
18:00									

Figure - 7 The Chemistry Department of the University of Zimbabwe
Class and Experiment Schedule (Continued)

3rd Year

1st Semester

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
8:00	HCH 311	HCH 314	HCH 311	OPT-B O.C. / OPT-B I.C.	HCH 314	
9:00	HCH 314	OPT-B O.C. / OPT-B I.C.			OPT-C O.C. / OPT-C I.C.	OPT-A I.C. / OPT-A O.C.
10:00	CH 301	CH 304	CH 301		OPT-A I.C. / OPT-A O.C.	
11:00			OPT-C O.C. / OPT-C I.C.	CH 304	OPT-B O.C. / OPT-B I.C.	
12:00			OPT-A I.C. / OPT-A O.C.	OPT-C O.C. / OPT-C I.C.		
13:00	P.C. / A.C.				P.C. / A.C.	
18:00						

2nd Semester

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
8:00	HCH 313	HCH 314	HCH 813	OPT-B A.C. / OPT-B P.C.	HCH 312	
9:00	HCH 312	OPT-B A.C. / OPT-B P.C.			OPT-C A.C. / OPT-C P.C.	OPT-A P.C. / OPT-A P.C.
10:00	CH 303	CH 302	CH 803		OPT-A P.C. / OPT-A P.C.	
11:00			OPT-C A.C. / OPT-C P.C.	CH 802	OPT-B A.C. / OPT-B P.C.	
12:00			OPT-A P.C. / OPT-A P.C.	OPT-C A.C. / OPT-C P.C.		
13:00	O.C. / I.C.				O.C. / I.C.	
18:00						

(3) Study on Alternative Plan

The Project equipment will be installed in laboratories in each field and related equipment rooms. Advanced equipment will be installed in a common equipment room for which a part of the existing building was renovated so that they can be shared by all the fields. Relatively advanced equipment will be installed in equipment rooms next to laboratories in each field to be basically used exclusively by the field.

In studying equipment scale, the alternative plan A which emphasizes convenience in use by installing several units in each room, and the alternative plan B in which the minimum number of one unit is installed in each room will be studied. The comparison of the two plans is shown below.

Table - 15 Comparison of Alternative Plans

Code No.	Name of Equipment	Quantity		Equipment
		Plan A	Plan B	Room
06-2	High Performance Liquid Chromatograph	2	1	1
08-2	Atomic Absorption Spectrophotometer	2	1	1
10-1	Polarograph	2	1	1
10-2	Polarograph	2	0	0
14	Fourier Transform Infrared Sepctrophotometer	6	1	1
15	Ion Chromatograph	2	1	1
17	Coulometer	2	1	1
45	Melting Point Apparatus	6	3	3

In the alternative plan B, the number of equipment per equipment room is one. In this case, one group can perform experiment using the equipment in the laboratory, but the other groups wait for their turn or change their schedule. Such adjustment will limit the planning of experiments. The alternative plan A has little limitation so that experiment schedule can be easily made and offer more opportunities for general and graduate research.

However, experiments using these relatively advanced equipment are included in curriculum for grades 2 & 3. The number of students in 1993 is, 68 in the 2nd year and 37 in the 3rd year. Students in the 2nd year are divided into three classes and those in the 3rd year are divided into two classes to conduct experiments. The number of students in one group for an experiment is from 19 to 23. In an experiment each class is further divided into two or three groups, and each group conducts an experiment according to its own plan. Therefore, there is little inconvenience in experiment planning.

For the Project, the alternative plan B will be selected based on the result of above study to secure efficient use of the equipment.

(4) Conditions of Equipment Selection

After the replacement plans were studied as stated above (3), the quantity of the equipment was determined based on the following policies.

① Expensive and advanced equipment to be shared by all the fields should be installed in the equipment room with the minimum number (one unit).

② Relatively advanced general-purpose equipment should be installed in the equipment next to laboratory of each field with the minimum number per room (one unit).

③ General-purpose equipment which are shared in a laboratory of each field should be installed with the minimum number (one or two units).

④ General-purpose equipment should be provided with quantity required for each laboratory.

4.3 Basic Plan

4.3.1 Necessity of Equipment

Upgrading of facilities and equipment in the Chemistry Department of the University of Zimbabwe is considered to be a part of the Second Five-Year National Development Plan, and it is expected that the students and graduates of the department will take leadership in contributing to raising the level of chemical industry sector. To achieve the goal, some advanced analytical equipment are required to be used for research and education.

As is indicated by the data in the Appendix such as Content of Activities in Each Field and Required Major Equipment (Appendix 7), Educational Curriculum (Appendix 8), and Extracts from Major research Papers (Appendix 12), all of the fifty-five items of equipment selected through discussion with the University are essential. This is distinctively shown in the list of Lectures Unavailable Now Due to Shortage of Equipment (Appendix 9).

4.3.2 Equipment List and Basic Specification of the Major Equipment

(1) Equipment List

The equipment list is shown in the table in the following pages.

Table - 16 Equipment List

Code No.	Name of Equipment	Quantity	Use
01	Fourier Transform Nuclear Magnetic Resonance Spectrometer	1	Analysis of structure of substance (especially natural products)
02	Gas Chromatograph Mass Spectrophotometer	1	Analysis of separation and structure of substance
03	Fourier Transform Infrared Spectrophotometer	1	Analysis of bonding condition and structure of substance
04-1	Ultraviolet/Visible Spectrophotometer	1	Qualitative & quantitative analysis
04-2	Ultraviolet/Visible Spectrophotometer	1	Qualitative & quantitative analysis
05-1	Gas Chromatograph	2	Separation & analysis of gas and liquid
05-2	Gas Chromatograph	3	Separation & analysis of gas and liquid
06-1	High Performance Liquid Chromatograph	1	Composition analysis of liquid
06-2	High Performance Liquid Chromatograph	1	Composition analysis of liquid
07	Fluorophotometric Analyzer	1	Analysis of medical chemicals, and additives in vitamins and foods
08-1	Atomic Absorption Spectrophotometer	1	Qualitative & quantitative of metals
08-2	Atomic Absorption Spectrophotometer	1	Qualitative & quantitative of metals
09	Personal Computer	12	Processing and storage of measurement data
10	Polarograph	1	Qualitative & quantitative metal ion and anion
11	Thermal Analyzer	1	Composition analysis of substance
12	Liquid Nitrogen Plant	1	Pretreatment and analysis apparatus
13	Droplet Counter Courrent Chromatograph & Fraction Collector	1	Purification of amino acid
14	Fourier transform Infrared Spectrophotometer	1	Analysis of bonding condition and structure of substance

Table - 16 Equipment List (Continued)

Code No.	Name of Equipment	Quantity	Use
15	Ion Chromatograph	1	Qualitative & quantitative analysis of anion in liquids
16	Polarimeter	1	Characteristic analysis of hydrocarbon compound
17	Coulometer	1	Measurement of biodegradation by microorganism in chemicals
18	pH Meter/Ion Meter	12	Measurement of hydrogen ion concentration of liquids (acid or alkali)
19	X-Y Recorder	1	For student experiments
20	Recorder	1	For student experiments
21	Photo Copy	1	Formation of materials
22-1	Muffle Furnace	1	weight analysis & measurement of ash content
22-2	Muffle Furnace	3	weight analysis & measurement of ash content
22-3	Muffle Furnace	1	weight analysis & measurement of ash content
22-4	Muffle Furnace	1	weight analysis & measurement of ash content
23	Freeze Dryer	1	Preparation of samples
24	Heavy Duty Juice Extractor	1	Production of samples by extracting plant roots
25	Surface Area Apparatus	1	Measurement of surface area of substance like active carbon and ceramic
26	Peristaltic Pump	4	Measurement of liquid samples
27	Rotation Locurar Counter Current Chromatograph	1	Separation & purification of physiological active substance
28	Table Top Centrifuge	1	Concentration & separation of substance in liquids
29-1	Analytical Balance	6	Measurement of mass
29-2	Analytical Balance	18	Measurement of mass
30-1	Rotary Evaporator	6	Concentration of samples
30-2	Rotary Evaporator	1	Concentration of samples
30-3	Rotary Evaporator	1	Concentration of samples

Table - 16 Equipment List (Continued)

Code No.	Name of Equipment	Quantity	Use
31	Glass Blowing Equipment & Annealing Oven	1	Production & repair of glass tools
32	Bomb Calorimeter	1	Measurement of calories
33	Micro Stopped Flow Spectrophotometer & fluorimeter	1	Quantitative analysis of inorganic substance in liquids
34	NOx Analyzer	1	Measurement of NOx in air for environment protection
35	Circular Dichroism/Optical Rotary Dispersion Meter	1	Identification and analysis of optical active Qualitative & quantitative substance
36	Conductivity Meter	5	Measurement of conductivity of liquids
37-1	Heating Mantle	4	Heating of receiver for concentration of samples
37-2	Heating Mantle	4	Heating of receiver for concentration of samples
37-3	Heating Mantle	4	Heating of receiver for concentration of samples
37-4	Heating Mantle	4	Heating of receiver for concentration of samples
38-1	Vacuum Pump	3	Maintaining vacuum condition, drying samples under normal temperature
38-2	Vacuum Pump	3	Maintaining vacuum condition, drying samples under normal temperature
38-3	Vacuum Pump	4	Maintaining vacuum condition, drying samples under normal temperature
39	High Pressure Autoclave	1	Heating & pasteurization of samples & tools
40-1	Electric Top Loading Balance	7	Measurement of mass
40-2	Electric Top Loading Balance	6	Measurement of mass
40-3	Electric Top Loading Balance	6	Measurement of mass
41	Educational video Material	1	Audio-visual training for analytical methods

Table - 16 Equipment List (Continued)

Code No.	Name of Equipment	Quantity	Use
42	Digital Volt Meter	12	Experiments for physical chemistry
43-1	Viscometer (Brookfield Type)	1	Measurement of viscosity
43-2	Viscometer (Saybolt Type)	1	Measurement of viscosity
44	Abbe Refractometer	1	Measurement of refraction
45	Melting Point Apparatus	3	Measurement of melting point
46	Polarising Microscope	1	Observation of minerals & rocks
47	Ice Maker	1	Experiments of organic Synthesis
48	Over Head Projector	4	Lectures
49	Slide Projector	2	Lectures
50	Wayne Lerr Bridge	1	Physical chemistry experiments
51	Multimeter	2	Physical chemistry experiments
52-1	Soxhlet Extractor	3	Separation of additives in samples
52-2	Soxhlet Extractor	3	Separation of additives in samples
53	Hot Plate & Magnetic Stirrer	10	Heating in chemical analysis
54	Wheaton Micro Sublimation Apparatus	1	Purification of sublimated substance
55	Magnetic Balance (Gouy Type)	1	Measurement of magnetic substance like iron

(2) Basic Specification of the Major Equipment

Basic Specification of the Major Equipment is shown in the table 17.

Table - 17 Basic Specification of Major Equipment

Name of Equipment	Specification
Fourier Transform Nuclear Magnetic Resonance Spectromenter	400MHz, 5mm- $^{1}H/^{19}F/^{13}C/^{31}P$ 4 Nuclear Detector, 5mm-Indirect Detector
Gas Chromatograph Mass Spectrophotometer	GC-MS(Interface Unit, Ion source), Gas chromatograph, Data system, Cooling apparatus
Fourier TransformInfrared Spectrophotometer	Resolution : 0.0026cm $^{-1}$, Raman scattering apparatus, Microspectrophotometer, Detector
Ultraviolet/Visible Spectrophotometer	Wave length : 190-3200nm, Resolntion : 0.1nm, 150mm integrationg sphere
Ultraviolet/Visible Spectrophotometer	Wave length : 190-900nm, Resolution : 0.1nm
Gas Chromatograph	GC mainbody(Coloumn, Sample vaporizer, FPD, ECD Detector), GC work station
Gas Chromatograph	GC mainbody(Coloumn, Sample vaporizer), GC work station, Integrator
High Performance Liquid Chromatograph	HPLC mainbody(UV/Vis spec ·Fluoresence detector, Coloumn oven), Data system
High Performance Liquid Chromatograph	HPLC mainbody(UV/Vis spec, Coloumn oven), Data system
Fluorophotometric Analyzer	Wave length : 200-1200nm ±2nm, color CTR, 150W Xenon lamp
Atomic Absorption Spectrophotometer	AA mainbody(lightsource, operation control), Atomizer, Cooling water equipment
Atomic Absorption Spectrophotometer	AA mainbody, regulator : C_2H_2, H_2O, Cooling water equipment

Table - 17 Basic Specification of Major Equipment (Continued)

Name of Equipment	Specification
Polarograph	Voltage 0-±3900mV, Speed 0.5-2000mV/sec, Pals interval 0.1-9.9sec
Thermal Analyzer	DSC(-140-550℃, Sensitivity of detector 15μW), TGA(R.T -1,750℃), DTA
Liquid Nitrogen Plant	Absorption bed 2 sets, Buffer tank 100l, Cooling apparatus, Tunk
Droplet Counter Courrent Chromatograph	Flow 0.05-3.4 ml/min, Pressure 3MPa, Tem.control : R.T. -50℃
Fourier Transform Infrared Spectrophotometer	Range of wave number 4600-400 cm^{-1}, mirror scanning speed 2-9mm/sec
Ion Chromatograph	Thermal stabilizer, Auto off set, Detector
Muffle Furnace	Max. temp: 1450 ℃, Cavity : 361cm^3
Rotation Locurar Counter Current Chromatogroph	Flow : 0.25-2.5l/sec, Pressure : 5Kg/cm^2, Coloumn : 0-100rpm
Glass Blowing Equipment & Annealing Oven	Glass lathe Distortion taster, Electric furnace,
Micro Stopped Flow Spectrophotometer & fluorimeter	Silica micro cell : 22.5μl, Tem.Range : 0-60℃, Lamp: W, Xe
NOx Analyzer	Measurement range : 0-1000ppm, Sample flow : 1l/min, Repeatability : ±1%
Circular Dichroism/Optical Rotary Dispersion Meter	Wave length : 170-800nm , Band width : 0.2-2nm Scanning width : 1-5000nm/min
High Pressure Autoclave	Pressnre : 2kg/cm^2, Volume : 5l, Temp : 300 ℃
Magnetic Balance (Gouy type)	measurement range : 50 g, sensitivity : 0.1mg

4.3.3 Equipment Location Plan

Location table and map of the equipment to be installed in the new building and existing buildings are attached at the end of this report (See Appendix 14).

4.4 Implementation Plan

4.4.1 Implementing Organization

The Chemistry Department of the University of Zimbabwe is responsible for the implementation of the Project.

After the Exchange of Notes is concluded between the government of Japan and the government of Zimbabwe, the consultant in Japan will enter into contract of detailed design and supervision with the government of Zimbabwe. Then, a Japanese company will enter into contract with them to procure and install the equipment.

4.4.2 Scope of Work

This Project is to upgrade the equipment for education and research in line with renovation of existing school buildings and construction of a new building in the Chemistry Department of the University of Zimbabwe. The cope of work assigned to Japan and Zimbabwe is described in the following table.

Table - 18 Scope of Work of the Project

Scope of Work	Japan	Zimbabwe
1. Equipment		
(1) To procure equipment	○	
(2) To install equipment	○	
(3) To perform trial operation	○	
(4) To instruct how to use equipment	○	
2. Facility work		
(1) Electric wiring		○
(2) Power supply to equipment	○	
(3) Water supply and drainage		○
(4) Air-conditioning and ventilation		○
3. To secure storage place		○
4. To ensure transportation and customs clearance		
(1) Transportation to Zimbabwe	○	
(2) Customs clearance	○	
(3) Tax exemption		○
5. To bear commissions to the Japanese foreign exchange bank for the banking services based upon the B/A		○
6. To accord Japanese nationals in connection with the Project such facilities as may be necessary for their entry into Zimbabwe and stay therin for the performance of their work		○
7. To maintain and use properly and effectively the facilities constructed and equipment provided under the Grant		○
8. To bear all the expenses, other than those to be borne by the Grant, necessary for construction of the facilities as well as for the transportation and installation of the equipment		○
9. To perform all the approval application procedures required for the work.		○

4.4.3 Implementation Plan

(1) Policies of Execution

Considering that the Project is implemented by Japanese Grant Aid, it is to be implemented based on the following policies.

① The equipment should be installed in conformity with the construction and facilities at the site.

② A range of work assigned to Japan and Zimbabwe concerning the content of utilities and the construction work should be clarified to facilitate execution efficiently and smoothly.

③ Preventive actions should be taken to avoid accidents to persons and equipment in transportation, delivery and installation.

④ Efficient communications should be promoted in every stage of the execution between the field, the consultant and equipment delivery vendors to maintain good relationship.

(2) Policies of Supervision

In supervising the execution of the Project, detailed supervisory plan of design should be formulated based on sufficient discussion with parties concerned of the Chemistry Department of the University and the government of Zimbabwe.

① The consultant should coordinate closely with the Chemistry Department of the University regarding specific contents of execution in order to conduct the installation work smoothly. Especially, information should be exchanged to secure conformity of the construction and facilities at the site with installation conditions of the equipment, and a field survey should be sufficiently conducted with respect to facilities, execution content, execution schedule, etc.

② The execution plan should be carefully reviewed regarding delivery and installation work, and the appropriateness of the procurement plan, equipment use and work schedule should be examined.

③ Before transportation of the equipment, inspection of the equipment should be conducted carefully.

④ In the delivery of the equipment, the equipment should be examined to see that they meet design specifications, installation is properly done, trial operation shows a good result, and appropriate instructions have been provided to the Zimbabwe side.

4.4.4 Implementation Schedule

The implementation schedule of the Project is shown below.

Table - 19 Implementation Schedule

No. of Months	1	2	3	4	5	6	7	8	9	10	11	12
Implementation Design	—	(Field Survey)										
	·····	·····	(Domestic Work/Detailed Design/Tender Documentation)									
			—	(Field Confirmation)								
											(Total 3.0 Months)	

No. of Months	1	2	3	4	5	6	7	8	9	10	11	12
Equipment Procurement	·····	·····	·····	·····	·····	·····	(Procurement/Production /Packing/Inspection)					
Delivery							—	—				
Installation	(Installation/Trial Operation/ Operation training/Inspection/Delivery)							—	—			
											(Total 9.5 Months)	

CHAPTER 5

PROJECT EVALUATION AND CONCLUSION

Chapter 5 Project Evaluation and Conclusion

5.1 Project Evaluation

It is no exaggeration to say that the University of Zimbabwe is the only university in Zimbabwe which plays a fundamental role of education and research as a main system of higher education in each sector in Zimbabwe holding a key to improvement and development in industry and economy. This Project is to provide the Chemistry Department of the University of Zimbabwe with educational and research equipment.

The faculty staff system in the Chemistry Department is efficiently working and the student laboratory equipment and medicine storages are also well maintained. This shows a high level of administration of the University of Zimbabwe. Furthermore, all of the educational staff who have obtained doctorates in foreign universities are actively engaged in a fairly high level educational and research work. However, both departments and graduate schools have faced an obstacle in providing effective education except for basic experiments due to deterioration and shortage of facilities and equipment.

Consequently, educational courses for obtaining a doctorate have not been established, and the limit in rearing educational support staff who graduated its department has produced a big gap with the faculty in ability.

In the University of Zimbabwe, building of a new school building and renovation of existing buildings have been already under way as a part of the improvement plan of the Chemistry Department, but most of equipment must be imported from foreign countries. Moreover, they are suffering from a lack of foreign currencies due to the aggravation of economy in Zimbabwe and having a difficulty in procuring equipment by themselves. This Project was formulated to solve such problems.

At present, the University of Zimbabwe or other educational facilities and industrial sectors face a lack of capable educators, researchers and engineers. This is a main factor which hinders independent growth of the nation. If the necessary educational and research equipment are provided to the Chemistry Department by implementing the Project, the efficiency of classes and experiments will be improved to provide a better quality of educational activities. It will also enhance the level of education not only for undergraduates but also graduates. As a result, more talented persons with higher level of educational background will be provided in all of the

educational fields and industrial sectors in Zimbabwe as well as the University.

Improving the Chemistry Department of the University of Zimbabwe to produce many high level of engineers and researchers will meet the demand in each sector of Zimbabwe to develop and stabilize economy, and thereby contribute greatly to the improvement of the standard of living in the nation.

5.2 Conclusion and Recommendations

(1) Conclusion

The Ministry of Higher Education of the Government of Zimbabwe put a top priority on the implementation of this Project. . To improve the educational level of the University of Zimbabwe and to upgrade the facilities and equipment will lead to an elevation of all the educational fields of Zimbabwe and contribute to the development of the nation directly and indirectly. The Chemistry Department of the University of Zimbabwe which is the object of the Project has been contributing to the development of industrial sectors in collaboration with other departments in the Faculty of Science, and Faculties of Engineering and Medicine, etc. as a department which is forming a basic field in chemistry, medicine, food industry, mining industry, agriculture, etc. which form basic sectors in Zimbabwe.

Furthermore, the equipment under the Project include those which were not found in other research institutes and private enterprises. These institutes and enterprises expect that research fields and contents will expand and develop in the futures. As the University of Zimbabwe has a close relationship with outside organizations through a joint research project and entrusted programs, the implementation of the Project will not only improve the facilities in the Chemistry Department but enhance the progress of all related sectors in Zimbabwe.

Therefore, it is considered to be significant to implement the Project under the grant aid from the government of Japan.

(2) Recommendations

It is recommend that the Government of Zimbabwe will take the following measures to conduct the implementation of the Project and operation more effectively and smoothly.

(a) The Chemistry Department of the University of Zimbabwe should be responsible for renovation work required for installation and operation of education and research equipment to be provided under the Project.

(b) Zimbabwe side should conduct various procedures without delay to facilitate the work allotted to Japan side.

(c) Zimbabwe side should clarify the responsibility of administration of equipment to keep them in better conditions.

(d) Zimbabwe side should take budgetary measures to secure procurement of expendable supplies, materials, samples and spare parts required for operation of equipment.

(e) Zimbabwe side should select and employ necessary staff of the Chemistry Department, such as researchers, engineers and operators, required for effective use of supplied equipment.

APPENDIX

Appendix-1 Members of the Basic Design Study Team

- Basic Design Study

Name	Assignment	Affiliation
Takumi HIKIDA	Team Leader Chemical Education	Professor, Department of Chemistry Tokyo Institute of Technology
Yasuo MUKAI	Industrial Development Planner	Development Specialist,JICA
Chikara KURIHARA	Project Manager	Chemicals Inspection & Testing Institute, Japan
Soichi TAKAI	Equipment Planner	Chemicals Inspection & Testing Institute, Japan
*Mizuhiko Fukagawa	Installation Planner	Chemicals Inspection & Testing Institute, Japan

Mark(*)shows Cooperator

Appendix-2 Itineraries of the Basic Design Study Team

- Basic Design Study

No.	Date	Activities
1	Aug./14(Sat.)	Leaving Tokyo
2	15(Sun.)	Arrive in London
3	16(Mon.)	Arrive in Harare,Visit Japan Embassy(Mr.OKAMOTO), Discuss.of Itineraries,Visit the Chemistry Depart. of University of Zimbabwe
4	17(Tues.)	Visit Mr.CHIVANDA(Deputy Director of the Ministry of Higher Education) Discuss.with Chem.Dep.of U.Z.,Explain Inception Report. Quetions & Answers
5	18(Wed.)	Visit The Ministry of Finance,Explain Inception Report Visit J.O.C.D
6	19(Thur.)	Visit INCHEM,KUTSAGA Research Station,Depart.of Technology of the Office of the President & Cabine and LEVER BROTHERS(PVT)Ltd.
7	20(Fri.)	Visit Bindura Nickel Cooperation Ltd.
8	21(Sat.)	Discuss. with each Member of Mission
9	22(Sun.)	Preparation of Draft Minuts of Discuss.

No.	Date	Activities
10	23(Mon.)	Discuss.with the Chemistry Dept.for Requested Equipment Report Draft Minuts of Discuss. to Japan Embassy
11	24(Tues.)	Discuss.with the Chemistry Dept.for Requested Equipment Report of the Minuts of Discuss. Survey other Departments Signature of the Minuts of Discuss.at the Ministry of Higher Education
12	25(Wed.)	Selection for Requested Equipment, Installation of Equipment
13	26(Thur.)	- do -
14	27(Fri.)	Visit CAPS(PVT)Ltd., Selection for Requested Equipment, Installation of Equipment
15	28(Sat.)	Discuss. with each Member of Mission Preparation of Data
16	29(Sun.)	- do -
17	30(Mon.)	Selection for Requested Equipment, Installation of Equipment Visit Dr.MUDENGE(A Minister of Higher Education) Preparation of Final Installation of Equipment

No.	Date	Activities
18	31(Tues.)	Preparation of Final Installation of Equipment Visit Japan Embassy
19	Sep./1(Wed.)	Visit Philips Electrical(pvt)Ltd., S.D.L Instruments(Pvt)Ltd.,and Protea Medical Services(Pvt)Ltd.
20	2(Thur.)	Visit Business Equipment Corporation, SA Scientific Products(Pvt)Ltd.,and KUTSAGA Research Station
21	3(Fri.)	Pelmer Equipment Ltd. Glassblowing Industries(Pvt)Ltd.
22	4(Sat.)	Collection of Data, Leaving Harare
23	5(Sun.)	Arrive in London
24	6(Mon.)	Leaving London
25	7(Teus.)	Arrive in Tokyo

Appendix-3 List of the Pertinent Officials in Zimbabwe

1. Ministry of Higher Education

Dr. I.S.G.MUDENGE Minister

Bureau of Man Power Planning

Dr. L.E.MUJANGAJA	Director
Mr. C.G.CHIVANDA	Deputy Director
Mr..F.CHAGA	A/A Director
Mrs. C.CHIGWAMBA,	E.O.Project & Aid
Mr. A.MUJAA	S.Administration Officer

University of Zimbabwe

Prof.F.W.G.Hill	Pro-Vice Chancellor
Mr.T.TSODZO	Assistant to the Vice Chancellor

Chemistry Department

Dr. J.M.MAKHUBALO	Chairman
Ph.Dr. Sreekanth B.JONNALAGADDA	Professor

Organic Chemistry

Dr. Zvitendo James DURI	Lecturer

Inorganic Chemistry

Dr. Robert Morlet TINDWA	Lecturer
Dr. E.G.HOVE	Lecturer

Physical Chemistry

Dr. John MARKS	Lecturer

Analytical Chemistry

Dr. Rogers Charles Chikara GURIRA	Senior Lecturer
Mr.Israel S. NJAGU	Senior, Chief Technician
Mrs.M.MURANDU	Senior Assistant Registror of Information

2. *Office of The President and Cabinet*

Department of Technology

Mr. I.C.CHIRI	Deputy Secretary

3. Ministry of Finance

Mr. Obert MATSHAJAGA	Under Secretary
Ms. Albina SUNDUZA	Assistant Secretary

4. Indutrial Chemical Association of Zimbabwe (INCHEM)

Mr. Chales ROBERT	Managing Director of Chemical Enterprises
Mr. Ashton NDLOVU	Marketing Manager of Chemplex Corporation Ltd.

5. Tobaco Research Station

Mr. L.TOET	Director of Tobaco Research Board
Mrs. Lilian GORA	Chief of Chemist

6. Private Company

1) Bindura Nickel Corporation Ltd.

Mrs. Annie NHLENA	Chief Chemist
Mr.Canissius NYAKONDA	Senior Chemist

2) Glassblowing Industries (Pvt)Ltd.

Mr. Roger WARING	Managing Director

3) Lever Brothers (PVT)Ltd.

Dr. T.MAHACHI	General Development Manager & Head of P.P.Business Group
Mr. Ishmael SAMOYA	Development Manager(Foods)
Mr. Arthur MAMVURA	Development Manager(Detergents)

4) CAPS (PVT) Ltd.

Mr. Gordon M.PANGETI	Quality Control Manager
Mr. Ernest KUNENE	Divisional Head, Research & Development Division
Mr.Ptros N. NDANGA	Quality Assurance, Microbiology Department Manager

6) Philips Electrical (Pvt) Ltd.

Mr. Loe RAMOS	National Service Manager
Mr. Langton MUKOYI	Application Sailes Engineer

6) S.D.L INSTRUMENTS (Pvt) Ltd.

Mr. Trevor THOMSEN	Director
Mr. Roscoe DICKINSON	Managing Director

7) Protea Medical Services (Pvt) Ltd.

Mr. Bryan HILL	Managing Director

8) SMM Instruments (Pvt) Ltd.

Mr. Nick BAYES	General Manager Zimbabwe

9) SA Scientific Products (Ptv) Ltd.
ILSA(Ptv)Ltd.

Mr. Ken RUDDOCK	Group Divisional Manager, Africa

10) Business Equipment Corporation

Mr. Bothwell DHLIWAYO	Branch Manager
Mr. Ian ROBERTSON	Manager-Scientific Instruments Division
Mr. David LLOYD	Sales Co-ordinator Scientific Instruments Division

11) Pelmer Equipment Ltd.

Mr. Neil TAYLOR	Regional Director

7. Embassy of Japan

Mr. Haruo OKAMOTO	Minister
Toshiaki SAITO	First Secretary

Appendix-4 Minutes of the Discussion

MINUTES OF DISCUSSIONS
ON
THE BASIC DESIGN STUDY
ON
THE PROJECT FOR DEVELOPMENT OF CHEMICAL SCIENCE
AT THE UNIVERSITY OF ZIMBABWE
IN THE REPUBLIC OF ZIMBABWE

In response to a request from the Government of the Republic of Zimbabwe, the Government of Japan decided to conduct a basic design study on the Project for Development of Chemical Science at the University of Zimbabwe (hereinafter referred to as "the Project"), and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Zimbabwe a study team headed by Professor Takumi HIKIDA, Department of Chemistry, Faculty of Science, Tokyo Institute of Technology and scheduled to stay in the country from the 16th of August to the 4th of September, 1993.

The team held a series of discussions on the Project with the officials concerned of the Government of Zimbabwe and conducted a site survey at the study area.

In the course of discussions and survey, both parties have confirmed the main items described on the attached sheets. The team will proceed to further works and prepare Basic Design Study Report.

Harare, the 24th August, 1993.

Prof. Takumi HIKIDA
Team Leader
Basic Design Study Team
Japan International Cooperation
Agency (JICA)

Mr. C. G. CHIVANDA
Deputy Director,
Man Power Planning,
Ministry of Higher Education
The Government of Zimbabwe

ATTACHMENT

1.OBJECTIVE OF THE PROJECT

The objective of the Project is to provide necessary educational equipment for the Chemistry Department, the University of Zimbabwe, in order to enhance such activities as developing human resources to contribute to the development of chemical education and chemical industries in Zimbabwe.

2.RESPONSIBLE MINISTRY AND IMPLEMENTING AGENCY

The Responsible Agency of the Project is the Ministry of Higher Education and the Implementing Agency is the Chemistry Department of the University of Zimbabwe.

3.PROJECT SITE

The site of the Project is located at the Chemistry Department of the University of Zimbabwe. (Annex-3)

4.CONTENTS OF THE PROJECT

(1) After the series of discussions, the items listed in Annex-1 are finally requested from Zimbabwe side. However, the final contents of the Project will be decided after further studies.

(2) Both parties have agreed to select the final contents of the Project with considering following criteria of items ;

1) priority for appropriate educational usage
2) no overlapping with existing equipment
3) availability of installation works
4) availability of necessary utility supplies
5) availability of operation and maintenance including the technical support of after sales service from the manufacturers
6) no overlapping items among the laboratories
7) budgetary support for operation and maintenance
8) to meet the present education and research status

5.JAPANESE GRANT AID PROGRAM

Zimbabwe side has understood the system of the Japan's Grant Aid Program explained by the Team.

6. NECESSARY MEASURES TO BE TAKEN BY ZIMBABWE SIDE

Zimbabwe side will take necessary measures listed in Annex-2 on condition that the Grant Aid by the Government of Japan is extended to the Project.

7. COUNTERMEASURES FOR ENVIRONMENTAL PROTECTION

The University of Zimbabwe will take necessary measures to control toxic substances for environmental protection on operation of the Project, according to the recommendation from Japan side.

8. FURTHER SCHEDULE OF THE STUDY

(1) The consultant will proceed the further studies in Zimbabwe until the 4th of September, 1993.

(2) JICA will complete the Study Report in English and send it to Zimbabwe in December, 1993, after technical examination on the result of discussions and site survey in Zimbabwe.

Annex-1

SUMMARY OF THE REQUEST OF ZIMBABWE SIDE

The request of Zimbabwe side are as follows ;

(1)Chemistry Department priority items

FTNMR

GC-MS

FTIR

(2)Teaching and research equipment for the sections below,

a. Analytical Chemistry Section

b. Inorganic Chemistry Section

c. Organic Chemistry Section

d. Physical Chemistry Section

f. Common Items

Items in the sections

UV/VIS spectrophotometer

GC

HPLC

AA

TGA/DTA

Ion chromatograph

others

Annex-2

NECESSARY MEASURES TO BE TAKEN BY ZIMBABWE SIDE

(1) To secure proper space to install the equipment procured under the Project.

(2) To provide necessary facilities to operate the equipment procured under the Project properly such as ; electricity, water of good quality, drainage, fume exhaust and other incidental facilities.

(3) To ensure prompt unloading, tax exemption, customs clearance at port of disembarkation in Zimbabwe and prompt internal transportation therein of the products procured under the Grant Aid.

(4) To exempt Japanese physical or judicial persons (hereinafter referred to as "Japanese nationals") engaged in the Project from customs duties, internal taxes and other fiscal levies which may be imposed in Zimbabwe with respect to the supply of the products and services under the verified contracts.

(5) To accord Japanese nationals whose services may be required in condition with the supply of the products and the services under the verified contracts such facilities as may be necessary for their entry into Zimbabwe and stay therein for the performance of their works.

(6) To ensure the necessary budget and personnel for the proper and effective operation and maintenance of the equipment procured under the Grant Aid.

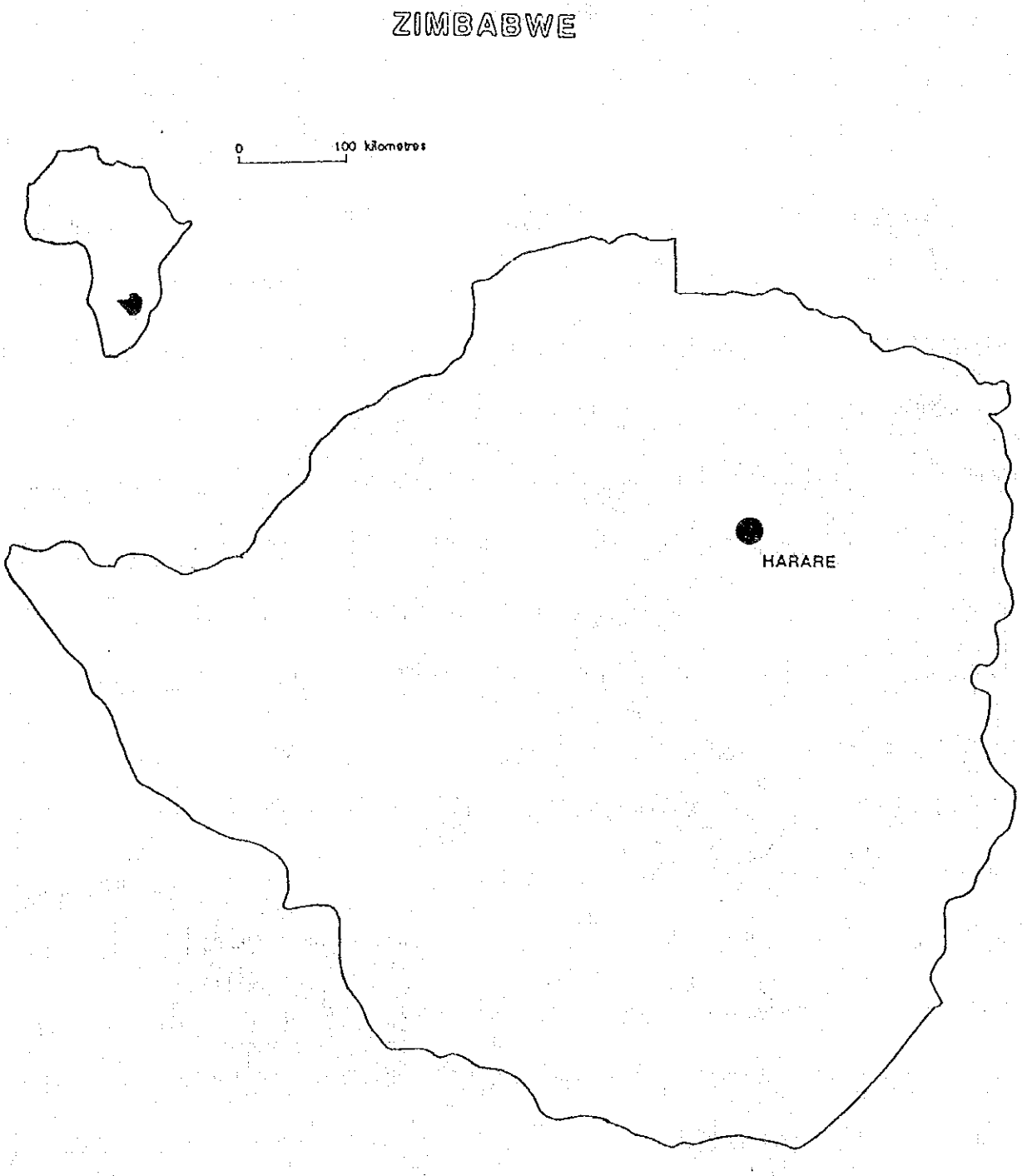
(7) To provide necessary permission, licence and other authorization for carrying out the Project.

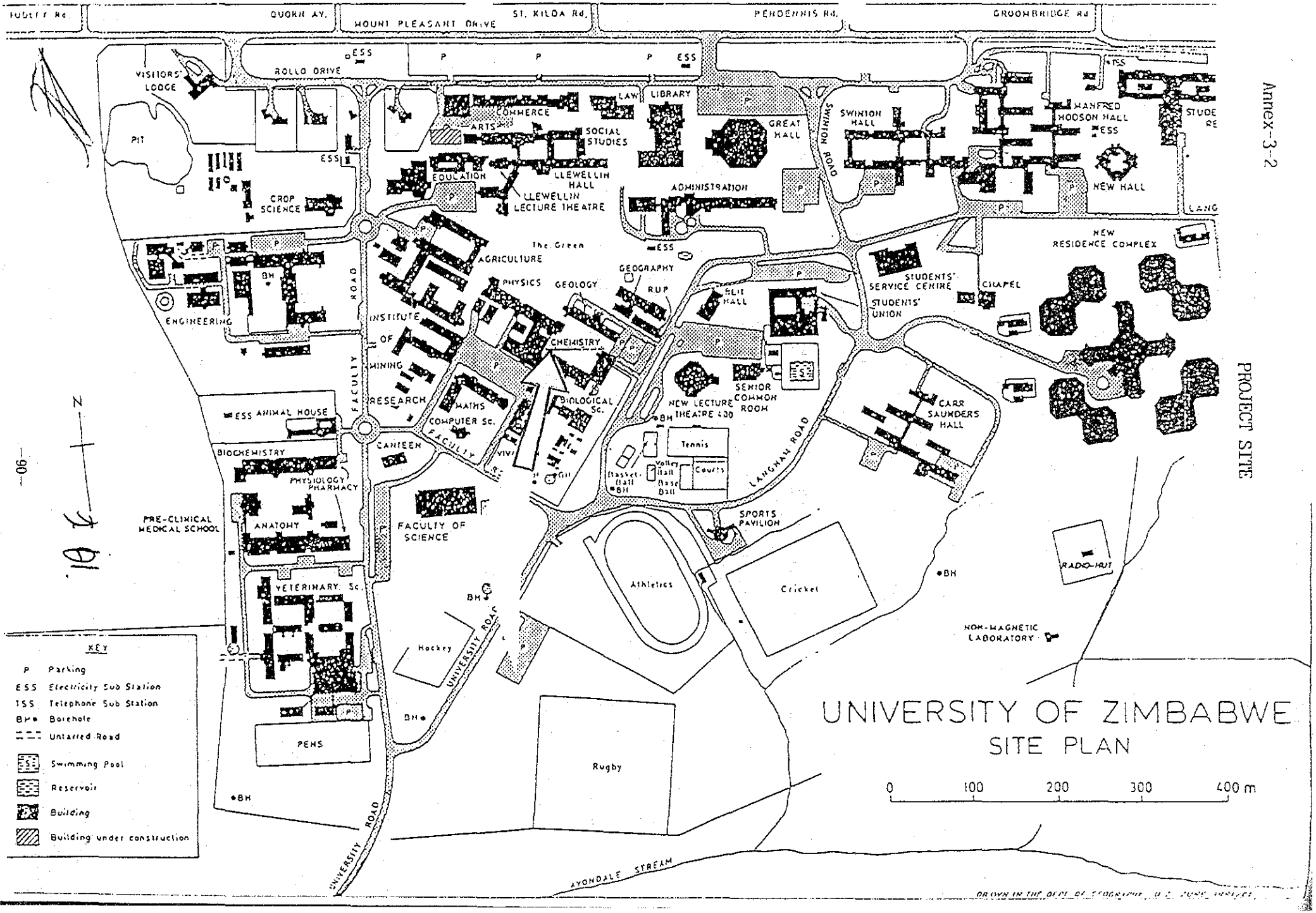
(8) To bear two kinds of commission to the Japanese foreign exchange bank for the banking services, based upon the "Banking Arrangement", namely, the advising commission of the "Authorization to Pay" and payment commission.

(9) To bear all the expenses, other than those to be borne by the Grant Aid.

Annex-3-1

PROJECT SITE





Annex-3-2

PROJECT SITE

—90—

Appendix-5 Graduate Employment Statistics of Chemistry Department

7. Graduate employment statistics.

GRADUATE EMPLOYMENT STATISTICS

B.Sc. Honours/General 1990 Faculty of Science

Source: Department of Students' Affairs, U.Z.

Total Number of Graduates : 232
Known Destination: 98
Unknown Destination: 134

Destination	Not Specified	Male	Female	Total
Not indicated	0	1	1	2
Teaching Govt	1	33	11	45
Employed by U.Z.	0	3	3	6
Postgrad: U.Z.	1	10	0	11
Agric-Govt	0	4	0	4
Agric-Pvt Sector	1	1	0	2
Finance - Pvt Sector	0	2	0	2
Management Pvt Sector	0	1	0	1

2.

Science - Gvt	0	2	1	8
Other : Pvt	0	10	2	12
Church	0	1	0	1
Unemployed	0	4	0	4
Other	0	0	1	1
Totals	3	77	19	98

GRADUATE EMPLOYMENT STATISTICS

B.Sc(Honours), Faculty of Science 1990

Total: 66 Known Destination 59(89,4%) Unknown D 7 (10,6%)

Destination	Male	Female	Total	Percentage
Govt(Non-Teaching)	14	8	22	33,3%
Municipality	0	0	0	0
Parastatal	2	0	2	3,0
Private Sector	10	2	12	18,2
U.Z. employment	4	4	8	12,1
U.Z. Postgraduate	3	1	4	6,1
Postgraduate(Elsewhere)	2	0	2	3,0
Teaching: Schools	2	5	7	10,6
Teaching: College	0	0	0	0

2.

N.G.O.	0	0	0	0
Unemployed	0	1	1	1,5
Unknown	7	0	7	10,6
Other	0	1	1	1,5
Totals	**44**	22	66	100

GRADUATE EMPLOYMENT STATISTICS

B.Sc. General 1989 Faculty of Science

Total: 108 Known Destination 76,9%(83) Unknown D (23,1%) 25

Destination	Male	Female	Total	Percentage
Govt (Non-Teaching)	24	2	26	24,1%
Municipality	0	0	0	0%
Parastatal	9	1	10	9,3
Private Sector	11	7	18	16,7
U.Z. employment	4	3	7	6.5
U.Z. Postgradaute	1	0	1	0,9
Postgraduate(Elsewhere)	1	0	1	0,9
Teaching: Schools	16	2	18	16,7
Teaching: Colleges	0	0	0	0

2.

N.G.O	1	0	1	0,1
Unemployed	0	1	1	0,9
Unknown	22	3	25	23,1
Other	0	0	0	0
Totals	89	19	108	100

GRADUATE EMPLOYMENT STATISTICS

B.Sc. General 1987

Total Number of Graduates: 47
Total Response: 42 (89,4%)
No Response: 5 (10,6%)

Source : Department of Students Affairs University of Zimbabwe

Destinations	Male	Female	Total	Percentage
Govt: Non Teaching	7	1	8	17%
Parastatal	3	0	3	6,4%
Municipality	0	0	0	0
Private Sector	8	0	8	17%
U.Z. Employed	2	1	3	6,4
Postgrad: U.Z.	6	1	7	14,9%
Postgraduate(Elsewhere)	0	0	0	0
Teaching: U.Z.	0	0	0	0

2.

Teaching Schools	9	0	9	19,14%
Teaching: Colleges	0	0	0	0
N.G.O	0	0	0	0
Unemployed	1	0	1	2,12%
Unknown	5	0	5	10,6
Other	2(1 emigrated) (1 Repeat)	1 emigrated	3	6,4%
Totals	43	4	47	100

Appendix-6 Staff of Chemistry Department

Professor and Lecturers

1.	Dr. J. MAKHUBALO	Chairman
2.	Dr. S. B. JONNALAGADDA	Professor
3.	Dr. R. H. SIMOYI	Associate Professor
4.	Dr. Z. J. DURI	Lecturer
5.	Dr. R. C. GURIRA	Lecturer
6.	Dr. E. G. HOVE	Lecturer
7.	Dr. K. M. KERYOU	Lecturer
8.	Dr. I. LOVE	Lecturer
9.	Dr. J. MARKS	Lecturer
10.	Dr. A. S. MATHUTHU	Lecturer
11.	Dr. P. P. MEBE	Lecturer
12.	Dr. S. SIBANDA	Lecturer
13.	Dr. S. D. SITHOLE	Lecturer
14.	Dr. F. M. ZARANYIKA	Lecturer
15.	Dr. R. TINDWA	Lecturer
16.	Dr. O. A. OYETUNJI	Lecturer

Assistants

1. BSc. S. M. CHABUKA
2. BSc. G. NENZOU
3. BSc. T. MAUNGANIDZE
4. BSc. P. MAKUHUNGA
5. BSc. M. NYAGANI
6. BSc. M. MAZVIMBA

Engineers

1.	Mr. I. S. NJAGU	Senior, Chief Technician
2.	Mr. S. F. CHADA	
3.	Mr. M. DUBE	
4.	Mr. P. DOTITO	
5.	Mr. I. STORDART	
6.	Mr. K. TOGARASEYI	
7.	Others 12 persons	

Appendix-7 Staff Abilities, Their Research Focus and Major Equipment

(1)

STAFF ABILITIES

RESEARCH PROGRAMMES AND CONSULTANCY SERVICES

The staff of the Chemistry Department are engaged in several areas of research, both basic and applied. They maintain close ties with the chemical and related industries through the Industrial Chemical Association of Zimbabwe and through the activities related to the industrial training programme associated with their Bachelor of Technology degree. Students at both undergraduate and graduate levels (MSc and PhD) are actively involved in research and in this way receive training on the methodology applied to the solution of problems of the chemical industry. Members of the department also offer consultancy services in their areas of specialisation. Research interests amongst members may be broadly classified under the following headings.

a. Environmental Chemistry

Pollution studies related to pest control, chemical and agricultural fertilisers in the soil and water environment. Heavy metal and organic chemical pollution from the industrial and mining industries. Toxicology of aquatic systems. These involve both fundamental research and environmental impact studies. Air pollution in industrial areas is also being studied. This work involves both research, consultancy and cooperation with government agencies.

Contact: Dr M. Zaranyika, DR A.S Mathuthu, Dr J.M. Makhubalo, Prof S.B. Jonnalagadda, Dr S.D. Sithole.

b. Natural Products Research

Research involves the collection and collation of data on medicinal plants, The collection and biological identification of plant/animal specimens, and extraction of plant and animal products, subsequent isolation and screening characterisation of compounds for the following purposes:- The production of medicinal compounds for diseases control with particular reference to cancer, malaria, urinogental problems, immunostimulants and AIDS; the isolation of useful chemicals for the food and chemical industries with particular reference to agricultural and essential oils.

Contact: Dr Z.J. Duri, Dr P.P. Mebe, Dr S. Sibanda.

c. Agrochemical Research

The development and understanding of the role of fertilisers and other trace elements in soils. The objective being to improve soil fertility. Current research is centred on metal-metal interactions in

biological systems, the effect of light on soils and detoxication of soil and crops.

Contact: Dr J. Marks, Dr M.F. Zaranyika.

d. Atmospheric Research

Studies on levels of gaseous pollutants. Ambient ozone levels as a function of altitude. Rainwater quality in Zimbabwe. Toxic metal pollutants in the atomsphere.

Contact: Prof S.B. Jonnalagadda, Dr S.D. Sithole.

e. Characterisation and Inorganic Materials (minerals)

Studies in this area involve the investigation of thermal properties and the thermal decomposition of inorganic compounds, minerals in particular under controlled thermodynamic conditions using thermoanalytical techniques of TG-DTA.

Contact: Dr S.D. Sithole.

f. Exploitation of New Resources

Celulose and starch are the most abundant natural products of photosynthesis. The potential of these renewable resources as chemical raw material has yet to be fully exploited. Both basic and applied research aimed at understanding the behaviour of these materials as new chemical raw materials is underway in the department. Current research is centered on chemical conversion cellulose to sugars and modification of starches using physical and chemical methods.

Contact: Dr M.F. Zaranyika and Dr S. Sibanda.

g. Chemical Kinetics Research

Fundamental research into the nature of chemical reactions with emphasis on chaotic and oscillating behaviour; these studies have a direct relation to physiological functions such as heart beat.

Contact: Prof R.H. Simoyi.

h. Industrial Processes

The chemical equilibria involved in the metallurgical conversion processes for copper and nickel extraction are being studied. A computer simulation of the processes is being constructed, taking into account the thermodynamics of the possible reactions throughout the duration of the conversion. This allows the possibility of predicting the effects of modification of the process conditions.

Contact: Dr I. Love.

i. Synthesis and Structure of new chemicals

Fundamental research in organic and inorganic chemistry to establish new pathways and new substances of research and industrial importance.

Contact: Dr E.G. Hove.

j. Analytical Research and Consultancy

The development of new and appropiate methods of chemical analysis for industry and research. Instrumentation studies.

Contact: Dr J.M. Makhubalo, Dr R.C. Gurira, Dr M. Zaranyika, Dr A.S Mathuthu, Dr S.D. Sithole.

k. Industrial Products and Import Substitution Studies

Local manufacture of many useful products is being investigated such as inks, gelatine, chemicals for schools, polyurethanes from castor oil, essential oils for cosmetics, waxes for the engineering industry and numerous others.

Contact: Dr Z.J. Duri, Dr I. Love

l. Chemical Education studies

Investigations are being carried out into how students structure new knowledge and link it to their earlier understanding of chemical concepts. Current work has involved ideas and concepts in energetics and thermodynamics.

Contact: Dr I. Love.

Appendix-8 Curriculum of The Chemistry Department

UNIVERSITY OF ZIMBABWE

CHEMISTRY DEPARTMENT

FIRST YEAR COURSES 1992:

Lectures: CH101 AND CH104 WEDNESDAY AND FRIDAY AT 09 HOURS IN SCIENCE LT400

CH102 AND CH103 MONDAY & TUESDAY AT 09 HOURS IN SCIENCE LT400.

B Sc General Part I, B Sc Agriculture (Soil Science) Part I

B Pharm Part I, B Sc (Engineering - Metallurgy) Part II

CH101 PHYSICAL CHEMISTRY (SECOND SEMESTER)

CH101A:	Introduction to Chemical thermodynamics
12 Lectures 3 Tutorials Dr Love	First Law of Thermodynamics, state functions, work and heat. Reversible and irreversible changes. Enthalpy changes, heat capacities and thermochemistry. Spontaneity, the Second Law and entropy. Gibbs free energy function, chemical potential and activities. The drive to equilibrium and equilibrium expressions, the response of equilibria to changes in conditions. Changes of enthalpy and entropy with temperature.
CH101B:	Reaction Kinetics and Electrochemistry
12 Lectures 3 Tutorials Dr Marks	Differential rate equations and order. Transition states and catalysis. Integrated rate equations: reversible reactions, consecutive reactions, steady state approximation, pre-equilibria and enzyme kinetics. Ionic conductivity and applications. Electrochemical cells and electrode potentials.

Electrochemical work, the Nernst equation and equilibrium constants. Primary and secondary cells, fuel cells and electrolytic cells.

Practical Course:

Experiments in reaction kinetics, pH, conductometric and potentiometric titrations and absorption.

UNIVERSITY OF ZIMBABWE
CHEMISTRY DEPARTMENT

SECOND YEAR COURSES 1992:

PHYSICAL CHEMISTRY B.Sc. Part II

CH 201 PHYSICAL CHEMISTRY II (24 h lectures, 24 h practical)

201 A: Quantum mechanics and spectroscopy:

8 lectures

Dr Marks

Introduction to quantisation and duality, simple applications of the Schrodinger equation (translation, rotation and vibration). Angular momentum and atomic spectroscopy, term symbols. Fundamentals of spectroscopy- populations, transitions, selection rules and intensities, line-widths, Beer-Lambert law, Frank-Condon principle and photochemical processes.

201 B: Chemical thermodynamics:

8 lectures

Professor Jonnalagadda

Review of first and second law of thermodynamics. Maxwell's relations. Joule-Thompson effect. Third law of thermodynamics and determination of absolute entropy. Fundamental equation of Chemical thermodynamics. Clapeyron equation and Clausius-Clapeyron equation. Gibbs-Duhem equation. Determination of partial molar properties. Activity and activity coefficients. Henry,s law constant.

201 C: General & gas phase kinetics:

8 lectures

Dr Keryou

Simple collision theory of bimolecular reactions. Absolute reaction rate theory. Comparison with simple collision theory. Theory of unimolecular reactions. Lindemann mechanism. Rice-Ramsperger-Kassel theory. Chain reactions.

2/...

CH 211: FURTHER PHYSICAL CHEMISTRY (18h lectures and 6h practical)

211 A: 6 lectures Marks	<u>Molecular spectroscopy</u>: Spectroscopic techniques. Electro- magnetic radiation. Microwave (rotational) and infrared (vibrational-rotational) and electronic Dr spectroscopy (including Raman spectroscopy). Spectroscopy of molecules.
211 B: 6 lectures Professor Jonnalagadda	<u>Phase equilibria</u>: Gibbs phase rule. Binary systems. Liquid-liquid systems. Levers rule. Solid-liquid systems, congruent and incongruent compound formation. Cooling curves. Fractional crystallization. Liquid-vapour systems. Fractional and stream distillation. Ternary systems.
211 C: 6 lectures Dr Keryou	<u>Surface Chemistry</u>: Colloids, classification, preparation and properties. Liquid interfaces, adsorption. Solid-gas interface and isotherms. Heterogenous catalysis. Solid-liquid interfaces, adsorption and applications.

INORGANIC CHEMISTRY

COURSE DESCRIPTIONS: B.Sc. Part III (1993)
CORE COURSES: (PHYSICAL CHEMISTRY) (Pre-requisite: CH201)

CH/HCH 301 PHYSICAL CHEMISTRY III (24 h lectures, 24 h practical)

301 A: Ionics and Solution Chemistry (18 lectures)
(Prof. S.B. Jonnalagadda)
Kinetics and mechanisms of thermal and photochemical reactions. Kinetics of reactions in solution. Activation and diffusion controlled reactions. Theories of reactions. Debye-Hückel theory. Ionic activity. Ion transport. Kinetic salt effect. Fast reactions. Homogeneous catalysis.

301 B: Molecular orbital theory (6 lectures)
(Dr. J.A. Marks)
Molecular Orbital theory. Variation method; Perturbation theory. Hückel MO theory. Frontier molecular orbital theory.
Practical : Experiments in spectroscopy, kinetics & ionics.

HCH 311 Advance Physical Chemistry (36 h lecture & 12 h practical
311 A: Quantum Chemsitry and Magnetic & Electrical Properties (12 lectures)
(Dr. J.A. Marks)

Atomic structure. Angular momentum and atomic spectroscopy. Electronic spectroscopy of molecule. Origin o transitions. Resonance spectroscopy: NMR, ESR and NQR. Photochemical processes. Lasers.
Electrical properties. Permanent and transient dipole moments. Polarizability. Refractive index. Clausis-Mossotti equation. Origin of optical activity. Intermolecular forces. Classification of interactions. Lennard Jones (6-12) potential. Gas and liquids. Gas imperfections. The Virial equation. Behaviour of real gases. The critical point. Van der Walls equation. Law of corresponding states. Liquids as modified gases. The structure of liquids. Bernal's experiments. x-ray diffraction studies of liquids and the pair distribution function. Liquid crystals.
Magnetic properties. Magnetic susceptibility. Para-, ferro-antiferro- and ferrimagnetism.

311 B: Applied Group Theory (12 lectures)
(Dr. I. Love)

Symmetry operations and groups, reducible and irreducible representations; symmetry adapted orbitals; molecular vibrations; free atom theory, infinitesimal rotations, vector coupling.

311 C: Surface Chemistry: (12 lectures)
(Dr. J.A. Marks)

The liquid interface: Surface tension; molecular origin; measurement. Spreading, adhesion and cohesion; wettability and contact angle; monolayers, micellisation. Surfactants and the Gibbs sdsorption isotherm. Colloid chemistry - lyophobic colloids; particle size determination; stability; applications. Foams and gels - properties and structure, applications. Biological surfaces - behaviour and structure. Solid-gas interfaces - Langmuir and BET isotherms; thermodynamics of adsorption; heterogeneous catalysis.
Practical course: Experiments on molecular properties, electrochemistry and surface chemistry.

ELECTIVE COURSES (Half courses) (18 lectures and 6 h practical)

Option A (Anybody)

CH/HCH 321 Industrial Chemistry (Dr. Chernova)
Flow diagrams and unit operations. Material and heat balances. Fluid flow, heat transfer, mass transfer (Distillation, extraction and adsorption). Characteristics and choice of reactors. Social, economic and environmental factors.

Option B (Anybody except the students doing Biological Sciences and Physics as major)

CH/HCH 331 Polymer Chemistry: (Dr. M. Savov)
Introduction to Polymers. Polymers and polymer based industries. Classification schemes. Molecular mass and its determination. Polymerization reaction. Functionality and kinetic schemes. Properties of polymers. Applications of plastics.

Option C (Anybody except the students doing mathematics as major)

CH/HCH 341 Atmospheric Chemistry: (Prof. S.B. Jonnalagadda)
Structure, composition and evolution of the atmosphere. Characteristics of aerosols. Chemistry of the troposphere. Chemistry of the stratosphere and ozone reactions. Gaseous pollutants. Monitoring methods and control of atmospheric pollution.

CH102: INORGANIC CHEMISTRY

(24 hours theory & 20 hours practical, 4 tutorials)

CH102A: Atomic structure and chemical bonding

14 Lectures

3 Tutorials

Quantisation of energy and radiation. Quality and wave mechanics. Hydrogen atom orbitals and quantum numbers. Penetration effects, Pauli principle, aufbau and Hund rules and the electronic structure of atoms. Periodicity of atomic properties. Ionic bonding - lattice energies. Polyatomic molecules - VSEPR, hydbridisation, multicentre bonds, VB structures. Intermolecular forces - van der Waal's hydrogen bonding; metallic bonding.

CH102B: Introduction to transition metal and 10 coordination

Lectures

1 Tutorial

Electronic structure and periodicity of transition metal properties. Coordination numbers and structures, types of ligands, nomenclature and isomerism. Introduction to bonding in coordination compounds in terms of valence band and crystal field theories. Introduction to the magnetic properties of transition metal complexes.

Practical Course:

The practicals will cover investigations of the reactions of elements and their compounds and qualitative analysis of cations and anions.

INORGANIC CHEMISTRY B.Sc. PART II

CH 202 INORGANIC CHEMISTRY II

This course will consist of three parts:

i) Coordination chemistry (9 lectures)

ii) Periodic Properties and Introduction to main group chemistry (15 lectures)

iii) Practical inorganic chemistry (24 hours)

202 A: Coordination Chemistry

24 Lectures

Dr. Tindwa

Further examination of the bonding of coordination compounds in terms of the crystal field molecular orbital theories. Crystal field stabilisation energies, octahedral site stabilisation energies. John-Teller effects in

3/...

compounds. Effects of crystal field on ionic sites. Introduction to the electronic spectra of transition metal complex ions and the spectrochemical series. Stbaility of complex ions in solution. Redox properties of ions and complexes in solution.

202B: Periodic properties of the elements and introduction to main group chemistry

General trends in the periodic properties of the elements S-and p-block CHEMISTRY: Alkali metals, alkali earths and hydrogen, general trends in the p-block elements and the chemistry of their compounds.

202C: Practical Inorganic Chemistry

24 hours

Dr. Key

Preparation of transition metal and main group compounds and complexes. Investigation of the chemical and physical properties of those substances prepared.

CH212: FURTHER INORGANIC CHEMISTRY

18 Lectures plus 6 hours Practical

Dr. Kandilarov

This course will consist of three parts:

i) Transition metal chemistry (9 lectures)
ii) Solid state chemistry (9 lectures)
iii) Practical inorganic chemistry (This is another 6 hours session with CH202 (iii) described previously)

212A: Transition Metal Chemistry

Trends in periods and groups are examined for d-block and f-block elements emphasising electronic structure differences. The detailed chemistry of selected elements and compounds will then be examined.

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212B: Solid State Chemistry

Factors influencing type of lattice adopted. General chemistry of solids and glasses including bonding in metals. Conductors, insulators, insulators and semiconductors. Defects in solids and non-stoichiometric compounds.

INORGANIC CHEMISTRY : PART III 1993

CH302: INORGANIC CHEMISTRY III

(24 hours lectures, 24 hours practicals)

This course consists of three parts:

(i) Further properties of transition metal compounds (12 lectures)

(ii) Organometallic chemistry (12 lectures)

(iii) Practical inorganic chemistry (24 hours)

(i) Further properties of transition metal compounds
Lecturer: Dr Oyetunji

Detailed interpretation of the electronic spectra and magnetic properties O.R.D. and M.C.D. spectra of a complexes of d and f block elements. Examination of ligand substitution and electron transfer inorganic reaction mechanisms including an introduction to photochemical reactions.

(ii) Organometallic Chemistry
Lecturer: Dr Hove

Fundamental concepts - including the effective atomic number rule and metal-carbon bonding. Binary and substituted metal carbonyl complexes. Cyclopentadienyl and cyclopentadienyl-like metal complexes. The complexes of other carboxylic ligands and complexes containing alkenes, alkynes and -enyl ligands. Organometallic complexes containing nitric oxide and other small molecules.

(iii) Practical Inorganic Chemistry
Lecturer: Dr Hove

Preparation and investigation of chemical and physical properties of organometallic and transition metal compounds.

Electives:
Special Topics in Inorganic Chemistry

(i) Option A : Further Solid State Chemistry(18 lectures)

(ii) Option B : Bioinorganic Chemistry (18 lectures)

(iii) Option C : Inorganic Photochemistry(18 lectures)

(i) Further solid state chemistry (Option A)
Lecturer: Dr Hove

X-ray diffraction - solid state symmetry, crystallographic systems and point groups, single crystal photography and powder patterns, diffraction data collection and reducing intensity data. Phase determination and structural solution methods, least squares refinement.

(ii) Bioinorganic Chemistry (Option B)
Lecturer: Dr Tindwa

Introduction to methodology. Iron porphyrins and heme proteins; O_2 carriers. Oxygeneses and cytochromes. Non-heme iron proteins and enzymes. Copper proteins and enxymes. Molybdenum enzymes. Copper proteins and enzymes. Molybdenum enzymes and proteins. Vitamin B_{12} Zinc and Cobalt enzymes. Photosynthesis and alkaline metals-transport across membranes, environmental bioinorganic.

(iii) Inorganic Photochemistry (Option C)
Lecturer: Dr Oyetunji

Methodology and equipment. Photolysis of inorganic ions in solution. Excited states of transition metal complexes. change-transfer photochemistry, substitutional photochemistry of the transition elements. Electron transfer reactions, solar energy conversion-photosynthesis. Photoelectrochemical cells.

PART III HONOURS
HCH312 : ADVANCED INORGANIC CHEMISTRY IV
36 hours lectures 12 hours practicals)

This course consists of four parts.

(i) Advanced main group chemistry

(ii) Further organometallic chemistry

(iii) Physical methods in inorganic chemistry

(iv) Inorganic practicals (12 hours)

(i) Advanced main group chemistry (12 lectures)
Dr Tindwa

Rings-Borazines, phosphazenes and ohter homocyclic and heterocyclic systems. Chains-catenation and heterocatanation incalation chemistry and superconductors, isopoly and heteropoly anions. Cages-Boranes-carboranes phosphorous, oxygen/phosphorous and sulphur cages other inorganic cages. Clusters-metal carbonyl clusters, di-Tri-and higher order carbonyls, bonding theories Wades rule. Metal halide and other clusters.

(ii) Further organometallic chemistry (12 lectures)
Dr Hove

Qualitative molecular orbital description of bonding between bis (cyclopentadienyl) moieties and I - and II - type ligands. Dynamic intramolecular rearrangements of organometallic complexes. Insertion, elimination abstraction, oxidative-addition and reductive-elimination reactions. Applications of organometallic complexes to industrial homogenous catalysis and synthesis.

(iii) Physical methods in inorganic chemistry (12 lectures)
Dr Hove

Magnetic-chemistry & methodology. NMR spectroscopy. ESR and NQR spectroscopy. Vibrational spectroscopy-rational spectra. Mossbauer spectroscopy Electronic and photoelectronic spectroscopy. Mass spectrometry, Diffraction methods.

(iv) Inorganic practicals (12 hours)

Further advanced chemical and physical measurements on transition metal, orgnaometallic, bioinorganic and main group compounds, prepared in the laboratory, will be carried out.

DEPARTMENT OF CHEMISTRY

ORGANIC CHEMISTRY COURSES 1993

Part I B.Sc. General

1.0 CH103 : (24L)

ZJD 1.1 Introduction to stereochemistry: (6L)

Concept of isomerism leading to different types of isomerism i.e. stereoisomerism and structural isomerism, e.g. skeletal, postional and functional group isomerism. Stereoisomerism e.g. configurational and conformational stereisomers. Geometrical and optical isomers, enantiomers. Compounds containing an asymmetric atom other than carbon. Projection formulae i.e. Fischer, sawhorse, Newman, 3 - D. D/L convention and limitations. R/S system of nomenclature. Compounds with more than two chiral centres.

ZJD 1.2 Benzene Chemistry (6L)

Briefly, nomenclature of substituted benzene, sources of and structure of benzene. Aromatic character of benzene i.e sextet theory, valence bond theory, Huckel (4n + 2) rule for aromaticity. Reactions of benzene i.e. electrophilic aromatic substitution halobenzenes and nucleophilic aromatic substitution. Emphasis throughout is on effects of substituents on the benzene ring i.e. inductive and mesomeric effects.

PPM 1.3 Systematic Aliphatic Chemistry (12 L)

Bonding and structure. Nature of organic compounds, Organic reactions, alkenes, (structure and reactivity), reactions and preparation. Alkyl halides and their reactions i.e. electrophilic substitution, preparation of alkyl halides. Alcohols, ethers and epoxides. Carbonyl compounds - nucleophilic addition reactions. Carboxylic acid derivatives and their reactions. Introduction to aldol condensations. Aliphatic amines, and their reactions.

ZJD 1.4 Organic Practicals(6 x 4 hr)

Practicals augment the theory aspects of the courses taught.

PART II B.Sc. General

1.0 CH203 (24 L)

ZJD 1.1 Introduction to Organic Spectroscopy (10 L)

Introduction to the theory and application of IR, UV, NMR and MS spectroscopy. Correlation of positions of peak or bands in the spectra to organic functional groups. Spectral presentation, interpretation and structure determination. Factors affecting the positions, peaks or bands in spectra of some organic compounds. Sample preparation.

SS 1.2 Synthetic Methods I and Reaction Mechanisms (14 L)

Planning a synthesis, cost, safety, availability of chemicals, literature survey etc.

Functional group protection - brief survey. Formation of C-C bonds by base-catalysed condensations e.g. aldol, Claisen, Perkin and Knoevenagel condensations, use of enamines in synthesis.

Formation of C-C bonds by acid-catalysed condensation. Friedel-Crafts, chloromethylations and formylation reactions. The Mannich reaction and Mannich bases as intermediates in synthesis. Multi-centre reactions, e.g. Wittig and Diels-Alder reactions.

Oxidation reactions: Oppennauer, manganese dioxide, oxidation of diols (lead tetraacetate; periodic acid, metaperiodate etc).

Epoxidation of alkenes and ring opening. Reduction reactions-heterogeneous and homogeneous catalytic hydrogenation. Dissolving metal reductions and de-oxygenation reactions.

2.0 CH213

PPM 2.1 Stereochemistry and Alicyclic Chemistry: (9L)

Configuration and conformational isomerism in simple aliphatic compounds; Chirality and elements of symmetry (axis, centre and plane). Stereoisomerism in biphenyls and other aromatic systems (atropisomerism), and in allene and spiro compounds.

Monocyclic ring systems - properties, stability

factors and stereochemistry due to substitution. Axial and equatorial bonding in cyclohexane. Conformational analysis of cyclohexane, mono- and di-substituted cyclohexane, two-fused six-membered rings leading to steroid structure and nomenclature. Influence of conformation and axial an equitorial orientation on reactivity.

SS 2.2 Rearrangement Reactions (9L)

Wagner-Meerwein, Wolff Beckman, Hoffman, Curtius and benzilic acid. Mechanistic approach is emphasized.

3.0 Organic Practicals (6 x 5 hr)

Practicals augment the Theory aspects of the courses taught.

Part III B.Sc. General

CH303 : (24L)

ZJD 1.1 Heterocyclic Chemistry (8L)

Nomenclature. Comparative properties, unified by mechanistic emphasis of pyrrrole, furan, thiophen, indole, pyridine, pyrimidine and intra-molecular processes. Specific examples of synthesis applied to members of the above class. Reactions of individual aromatic systems.

PM 1.2 Further Aromatic Chemistry (8L)

Benzyne mechanism. Simplied M.O. treatment of aromatic character applied to selected polycyclic aroamtic compounds (carbocyclic and heterocyclic systems). Criteria for aromatic character. Systematic chemistry of naphthalene, phenanthrene and anthracene. Syntheses of these compounds will be illustrated.

SS 1.3 Carbohydrate Chemistry (8L)

Nomenclature of sugars, main classifications, projection formulae and configuration of simple sugars. Cyclic hemiacetals, anomerism and mutarotation, reactions of monosaccharides, cyclic acetals and ketals, esterification, reduction and oxidation reactions, hydrazone and osazone formation, chain-extension and chain-shortening reactions.

Relative stereochemistry of monosaccharides. Molecuar weight determination of oligo- and poly-saccharides and the use of enzymes in structural elucidation.

CH313 (36L) Electives

2.0 Elective A (18L)

SS 2.1 Synthetic Methods II (9L)

Organometallics and organonon-metallics in organic synthesis. Organometallics in organic synthesis. Formation of - bonds involving transition metals - their reactivities and liberation of organic compounds. - Allylmetal Derivatives and Reactions. Synthons in the synthesis of carbon-chains and carbocycles. selective Functional group Interconversions (FG1) Retro-Analysis of simple Organic compounds. Methods in construction of complex molecules.

ZJD 2.2 Advanced Organic Spectroscopy (9L)

Further nmr spectroscopy e.g. ^{13}C, methods for the simplification of complex spectra; 2-D and 3-D nmr spectroscopy.

Mass spectroscopy - instrumentation.
Isotope abundances, molecular ion-structure and recognition; metastable ions; fragmentation processes, fragmentations associated with functional groups. MS/MS/MS studies.

3.0 Elective B (18L)

SS 3.1 Free-Radical Reactions (9L)

Basic principles involved in free-radical reactions. Reactions of free-radicals. Formation of carbon-halogen carbon-carbon, carbon-oxygen, carbon-nitrogen and other bonds.

PPM 3.2 Pericyclic Reactions (9L)

Electroctrocyclic, sigmatropic rearrangements, cyclo-addition and cyclo-elimination. Understanding of orbital symmetry will be emphasized.

4.0 Elective C (18L)

ZJD 4.1 Medicinal Chemistry (18L)

Introduction to immunology Chemotherapy of Infection: Bacterial Infection, Fungal infection, Parasitic infection, Viral infection Malaria, Protozoal and Helmipthic -(Selected drugs used in the treatment of) Plant drug Analysis, Crude drug preparation.

Note: Each student to take only one elective(A, B and C)

Part III B.Sc Honours

HCH313 (36 L) Natural Products Chemistry Core

PPM 3.1 Acetate Derived Natural Products (12L)

Terpenoids and steroids: biosynthesis, stereochemistry and structural elucidation.

ZJD 3.2 Shikimic acid derived Natural Products (12L)

Shikimic acid, Tryptophan and related cpds Gallic acid, phenylalamine and related cpds. Derivatives of hydroxycinnamic acid lignin. Establishment of Shikimic acid pathway.

SS 3.3 Botanic Insecticides (12L)

Natural pyrethroids - structural eludication and structure-activity rlationship. Synthetic pyrethroids. Metabolic pathways of detoxification.

CH303 (24L) Core

Taken together with B.Sc. General students

CH313 (36L) Electives (A, B and C)

Up to two electives may be taken (together with B.Sc. General students.

4.0 Organic Practicals (9 x 5 hr)

Practicals augment theory aspects of courses taught.

PPM/pn

CH104: ANALYTICAL CHEMISTRY I (SOLUTION AND THEORY OF QUANTITATIVE CHEMICAL ANALYSIS)

(24 Lectures, 4 Tutorials)

1. Fundamental Concepts:

   - Chemical Composition of Solutions:
     Concentration of solutions, activity and activity coefficients, chemical equations and stoichiometry;

   - Elementary Treatment of Analytical Data:
     Error and deviation, significant figures, the central tendency of a set of results, precision, accuracy of an analysis: confidence limits; handling small sets of results.

   - Chemical Equilibrium:
     Equilibrium and equilibrium constraints, ionization of weak acids, formation of complexes, simultaneous equilibria - use of conditional constants; activity

coefficients and chemical equilibrium solubility of precipitates - the solubility product oxidation-reduction equilibria.

- Acid-base equilibria:
  Acid-base theory; acidity of solutions, pH; ionization of polyprotic acids; buffers; reagents and indicators for neutralization titrations; deviation of titration curves for simple and complex acid-base systems; acid-base titrations in nonaqueous media.

- Gravimetric Methods of Analysis:
  Mechanism of precipitation, conditions for analytical precipitation, precipitation from homogeneous solution; impurities in precipitates; washing, filtering and heating precipitates.

3. - Volumetric (Titrimetric) Methods of Analysis:
  General principles, acid-base titrations; acid-base titrates in non-aqueous solvents; precipitation formation titrations; complex and complex formation titrations, oxidation-reduction titrations.

4. Practical Course: (20 hours)
Gravimetric determination to include examples of simple and systematic gravimetric analysis: Volumetric determination to include examples of alkalimetry, acidimetry, redox, precipitation and complexometric titrations.

CH204: ANALYTICAL CHEMISTRY II

Drs Zaranyika and Mathuthu (INSTRUMENTAL METHODS OF CHEMICAL ANALYSIS I)
(24 Lectures, 24 Hours Practicals)

204A: Introduction to Instrumental Methods

Types of analytical methods; instruments and instrument components; uncertainties in instrumental measurements; precision and accuracy, types of errors, distribution of indeterminate uncertainties, uncertainties in calibration curves; sensitivity and detection limit for instruments.

204B: Electrochemical Methods

Ion selective electrodes. Potentiometric methods, coulometric methods, DC polarography and voltammetry.

204C: Spectroscopic Methods

Classification on basis of type of radiation employed, type of transition involved and whether molecular or atomic; Optical Spectroscopic methods: Instrumentation, radiation sources, wavelength selectors, radiation detectors; Molecular UV-Visible spectrophotometry: Applications to organic and inorganic analysis, Beer's Law, deviations from Beer's Law. Quantitative techniques including precision absorption spectrometry; Flame atomic spectrometry: Atomic absorption, emission and fluorescence spectrometry, theory

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of instrumentation and applications.

204D: Chromatographic Methods

Introduction to chromatographic separations: Types and classification of chromatographic methods. Theories of chromatographic separations; GC chromatography; instrumentation, qualitative and quantitative analysis. Application of GC.

Practicals

24 Hours

Electroanalytical methods, UV/Visible spectrophotometry, flame atomic absorption and emission spectrometry, and gas chromatography.

CH214: FURTHER ANALYTICAL CHEMISTRY

Drs Mathuthu Sithole

(18 Lectures, 6 Hours Practicals)

Molecular fluorescence, phosphorescence and chemilumniscence spectroscopy; theory, instrumentation and applications; Infra-red absorption spectroscopy; theory; instrumentation, sample handling, quantitative applications; electrothermal, plasma, arc and spark atomization atomic spectroscopy; modified voltametric methods; differential pulse, cyclic, anodic stripping and a.c. polarography;

Practicals

Experiments will be selected from the following topics: Fluorescence and IR spectrophotometry, non-flame atomic spectrometry, or modified voltametric methods.

PART III ANALYTICAL COURSES ON OFFER FOR 1993

CH 304 Analytical Chemistry III (Instrumental Methods of Analysis) 24 lectures + 24h practicals

Electrochemical methods

Linear and Cyclic Voltammetry

Spectroscopic Methods:

Mass spectrometry X-ray spectrometry: absorption and diffraction methods and X-ray fluorescence, Radiochemical methods; Neutron Activation Analysis (NAA), isotopic dilution and radiometric methods.

Chromatographic Methods:

Modern liquid chormatography (HPLC) and its various modes; (liquid-liquid, bonded phase, ion-exchange, size exclusion) and ion chromatography.

Practicals

These will involve practicals on cyclic voltammetry atomic absorption, UV/Visible, HPLC, ion-exchange, and literature search.

HCH314 Advanced analytical Chemistry III
36 lectures and 12 h practicals

Topic will include: Flow Injection techniques, Chemometrics, Fourier transform techniques (with emphaiss on IR and NMR), hyphenated techniques (GC-FTIR, GC-MS, MS-MS and LC-MS), further developments in ion chromatography, electron and ion spectroscopy. Lecturers: Drs Makhubalo, Mathuthu, Zaranyika and Gurira.

Practicals

Analysis of real samples using both classical and instrumental techniques.

HCH/CH324 Further Topics in Applied Analytical Chemistry

Option A: Environmental Analysis (18 lectures)

Nature and types of air and water pollutants, sources of pollutants; analysis of environmental pollutants,

sampling, isolation, concentration techniques, analytical methods and environmental monitoring.
Lecturers: Drs Makhubalo and Mathuthu

Option B: HCH/CH334 Introduction to Analog Circuits and Devices (18 lectures)

Data domains, electrical quantities and basic circuits, AC-quantities and measurements, semiconductor devices and power control, operational amplifiers, principles and applications.
Lecturer: Dr Sithole

Option C: Trace Analysis and kinetic methods of Chemical analysis

General problems of handling low concentration materials, factors which cause loss of material, facotrs which, cause contamination, sampling problems, isolation and concentration techniques, separation methods, determination methods and their optimization, kinetic methods of analysis, analysis of environmental samples by GC, atomic Absorption and emission spectrometry and UV-visible spectrophotometry.
Lecturers: Dr Zaranyika and Professor Jonnalagadda

Appendix-9 Experiments Not Currently Possible Because of Lack of Equipment

1-7

EXPERIMENTS NOT CURRENTLY POSSIBLE BECAUSE OF LACK OF EQUIPMENT

PHYSICAL CHEMISTRY

NOTE ON 1ST YEAR

Insufficient apparatus to carryout 2,3,4&5 without sharing equipment & doing experiment as a pair.

SECOND YEAR

1. Viscometry of polymer solution and oils viscometer.
2. Polymerisation kinetics - viscometry
3. Cyclic voltammetry and electrode kinetics polarography.
4. Polarographic titrations - polarography.
5. Electrographic and magnetic properties of the D. polemunents of polar molecular in solution wyane kene bridge.
6. Surface area measurements for studies of physical adsorption of gases surface chem.
7. Kinetics of inversion of sugar - polarimeter.
8. Thermodynamic behaviour - spectroscopy.
9. Photochemical studies - fluorimeter.
10. Liquid - vapour phase equilibria - Abbe refractometer.
11. Selected fast reaction kinetics - stopped flow apparatus.
12. Reaction modelling and computer simulations.

HONOURS EXPERIMENTS

1. Kinetics of rapid reaction (stopped flow techniques
2. Applications rapid kinetics in multi channel detection (stopped flow techniques)
3. Kinetic - Analytical methods - stopped flow and UV - visible spectrophotometer
4. Polymer kinetics by viscosity Brookfield viscometer.

5. High resolution gasphase spectra of SO_2, HCl, I_2 and 4_2 (- FTIR, UV-visible).

6. NMR studies of reaction dynamics.

7. Characterisation of gaseous pollutants in ambient air - NO_x analyser.

EXAMPLES OF NEW EXPTS

1. Heats of combustion Bomb calorimeter

2. Ester hydrolysis kinetics - conductommetry

3. Activity of coefficients flam cell measurements potentiality

4. Introductory experiments on fast electrons - stopped flow apparatus

3

ANALYTICAL CHEMISTRY

YEAR	EXPERIENCE	EQUIPMENT
SECOND	Fundamentals of Polarograhic Analysis	Polarographic analyser (Present equipment is only good for Cyclic Voltammetry)
	Fluorescence analysis	Fluorospectro-photometer
THIRD	Differential pulse, Polarography Anodic	Polarographic Analyser with these stripping voltammetry capabilities
	Ion Chromatographic Analysis	Ion Chromatograph
	Non-flame Atomic Absorption Analysis	non-Flame spectrometer e.g. Graphote Furnace
	Analysis of experimental Data eg. Linear Regression	Computers
MSc	Analysis of Solid mixture by Thermal methods	Thermal Analyzer
	Emission Spectrogra-phic Analysis	ICP or Emission Spectrograph
	FT-IR Analysis	FT-IR spectrometer
	FT-NMR Principles	FT-NMR Spectrometer
	GC/MS Analysis	GC/MS
	Atomic Spectroscopy	Atomic and Flame Spectrophotometer
	Molecular Spectroscopy	UV/visible spectrophotometers
	Analysis of $MgCO_3/CaCO_3$ Solid mixture	TA/DTA Thermal Analysis
	Electronics practicals dc power supplies OP, AMP	Signal generator oscilloscope, multimeters, diodes

		4	resistors, capacitors Transistors, OP-AMP circuit boards, DMM

ORGANIC CHEMISTRY

YEAR	PRACTICAL	EQUIPMENT
SECOND	Prep & Synthesis of organic cpds (Library search) and their analysis using IR, NMR (improvised), UV	NMR, UV, IR isomantles rotavapours
	Hydrogenation of simple molecules & the analysis of pds (cangesthan due to limited Parr atmos hydrogenator	
	Functional gp protection and analysis	NMR UV IR Isomantes
	Isolation of certain Phytochemicals from natural Products & their analysis lack of soxhlets is a limiting factor.	NMR, UV IR large rotavapors soxhlets

INORGANIC CHEMISTRY

EXTRA EXPERIMENTS

2nd and 3rd spectroscopy - high resolution, UV-VIS & TR, gas handling equipment

Surface Chem. - Vacuum lines absorption isortherm studies

Electrochem - Controlled voltage out puts, polarograph, to study electrode kinetics.

1. Synthesis of Ammonium Tetrafluoroberyllate $(NH_4)_2[BeF_4]$

2. Synthesis of Ammonium Tetrafluoroborate $[NH_4BF_4]^3$

3. Preparation of 3-(n^5-Cyclopentachenyl) -1,2-chicamba-3-cobalta-closododecaborane (II)

4. Synthesis of $Co(m/mt)_4(NO_3)_2\ H_2O$

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EQUIPMENT FOR EACH EXPERIMENT

FIRST YEAR LAB	EXPERIMENT	APPARATUS
QUANTITATIVE INORGANIC ANALYSIS	VOLUMETRIC ANALYSIS GRAVIMETRIC ANALYSIS	ANALYTICAL BALANCES TOP LOADING BALANCES VOLUMETRIC GLASSWARE
QUALITATIVE INORGANIC ANALYSIS	CONFIRMATORY TESTS IDENTIFICATION OF ANIONS & CATIONS PREP. OF COMPLEXES	VACUUM PUMP GLASSWARE
ORGANIC CHEMISTRY	ORGANIC SYNTHESIS ORGANIC REACTIONS QUALITATIVE ANALYSIS PURIFICATIONS ESTERIFICATION B.P& M.P DETERMINATION RECRYSTALLISATION	VACUUM PUMP QUICKFIT GLASSWARE M.pt APPARATUS WATER BATHS HOT PLATES OVENS TOP LOADING BALANCES

EQUIPMENT FOR EACH EXPERIMENT IN PHYSICAL CHEMISTRY

YEAR	EXPERIMENT	EQUIPMENT FOR EACH EXPERIMENT
FIRST	KINETICS	STOP WATCH, GLASSWARE
	POTENTIOMETRIC TITRATION	DIGITAL VOLTMETER, GLASSWARE STANDARD ELECTRODES
	pH TITRATIONS	pH METERS, GLASSWARE
	CONDUCTIMETRIC TITRATION	CONDUCTIVITY METERS, GLASSWARE
	SPECTROPHOTOMETIC EXP- BEER-LAMBERT LAW	SPECTROPHOTOMETER (MANUAL WAVELENGTH SETTING), GLASSWARE
SECOND	KINETICS	SPECTROPHOTOMETERS, CONDUCTIVITY METERS, STOP WATCHES,WATER BATHS
	THERMODYNAMICS AND PHASE EQUILIBRA	HIGH PRECISION THERMOMETERS ADIABATIC CONTAINERS THERMOMETERS
	ELECTROCHEMISTRY	VARIOUS CELLS, WATER BATHS HIGH PRECISION DVM, VARIOUS ELECTRODES, CONDUCTIVITY CELLS
	SURFACE CHEMISTRY	SURFACE BALANCE, CAPILARY RISE EQUIPMENT
THIRD	PRESENT RANGE OF EXPERIMENTS SIMMILAR TO PART II	AS FOR SECOND YEAR
HONOURS	AS FOR THIRD YEAR	AS FOR THIRD YEAR

EQUIPMENT FOR EACH EXPERIMENT FOR ORGANIC CHEMISTRY

YEAR	EXPERIMENT	EQUIPMENT
SECOND	PREPARATION AND SYNHESIS OF ORGANIC CPOUNDS (LIBRARY SEARCH) AND THEIR ANALYSIS *USING IR, NMR (IMPROVISED)* UV	BALANCES, WATER BATHS, HEATING MANTLES, M.P. APPARATUS THERMOMETERS, REFRACTOMETERS *INFRARED SPECTROPHOTOMETER*, GC UV SPECTROPHOTOMETER, OVENS HOT PLATES, MAGNETIC STIRRERS ROTAVAPOURS, BURNERS, GLASSWARE MACHANICAL STIRRERS, OIL BATHS
	HYDROGENATION OF SIMPLE MOLECULES & THE ANALYSIS OF PRODUCTS	
	FUNCTIONAL GROUP PROTECTION AND ANALYSIS	
	ISOLATION OF CERTAIN PHYTO-CHEMICALS FROM NATURAL *PRODUCTS & THEIR ANALYSIS*	
THIRD	ORGANIC SYNTHESIS SPECTROCHEMICAL IDENTIFI-CATION OF ORGANIC COMPOUNDS *NATURAL PRODUCTS SEPARATION* PURIFICATION AND IDENTIFICATION	SAME AS ABOVE
HONOURS	SAME AS ABOVE + PROJECTS	SAME AS ABOVE

EQUIPMENT FOR EACH EXPERIMENT IN ANALYTICAL CHEMISTRY

YEAR	EXPERIMENT	EQUIPMENT
SECOND	UV SPECTROPHOTOMETRIC DETERMINATION OF ASPIRIN AND CAFEINE IN CAFENOL TABLETS USING SOLVENT EXTRACTION.	ANALYTICAL BALANCE, UV-VIS SPECTROPHOTOMETER EQUIPED WITH A AN EPSON PRINTER
	COULOMETRY	COULOMETRIC EQUIPMENT COMPRISING PLATINIUM ELECTRODES, POWER SUPPLY AND HIGH PRESICION DVM
	UV-VIS SPECTROPHOMETRY DETERMINATION IRON WITH 1,10 PHENANTHROLINE	UV-VIS SPECTROPHOTOMETER EQUIPPED WITH AN EPSON PRINTER ANALYTICAL BALANCE
	ATOMIC ABSORPTION SPECTROPHOTOMETRY OF Fe BY AA USING THE METHOD OF STANDARD ADDITION	ATOMIC ABSORPTION SPECTROPHOTOMETER, ANALYTICAL BALANCE
	FLAME PHOTOMETRY DETERMINATION OF Na_2O & K_2O IN CEMENT	ATOMIC ABSORPTION SPECTROPHOTOMETER, ANALYTICAL BALANCE
THIRD	GC PRINCIPLES	GC, RECORDER, PRINTER, SYRINGES
	CYCLIC VOLTAMMETRY	POLAROGRAPHIC ANALYSER, X-Y RECORDER, GOLD & PLATINUM ELECTRODES, ANALYTICAL BALANCE
	RPHPLC, A STUDY OF FUNDAMENTALS AND THE DETERMINATION OF ASPIRIN AND CAFIENE IN AC TABLETS	HPLC, RECORDER, ANALYTICAL BALANCE
	ANALYSIS OF FOOD SAMPLE BY AA	ATOMIC ABSORPTION SPECTROPHOTO METER, ANALYTICAL BALANCE
	SPECTROPHOTOMETRIC DETERMINATION OF SYNTHETIC COLOURANTS IN FOOD	UV-VIS SPECTROPHOTOMETER EQUIPED WITH PRINTER, ANALYTICAL BALANCE

YEAR	EXPERIMENT	EQUIPMENT
MSc ONE	LIQUID-LIQUID EXTRACTION AND/OR EXTRACTION METHODS	ANALYTICAL BALANCES
	USE OF CATION-EXCHANGE RESIN IN SEPERATING OF ORGANIC SUBSTANCES, SEPERATION & DETERMINATION IN PHARMACEUTICAL PREPARATIONS	COLUMN OF CATION EXCHANGE RESIN SPECTROPHOTOMETER & EPSON PRINTER, SILICA CELLS FOR UV ABSORPTION, ANALYTICAL BALANCE
	A NEW MODEL OF GLC APPLYING THE KINETICS OF GASEOUS ADSORPTION AT SURFACES.	GC EQUIPPED WITH A PRINTER
	RPHPLC OF BETA-DIKETONE METAL CHELATES	
	ATOMIC SPECTROSCOPY	ATOMIC AND FLAME EMISSION SPECTROSCOPHOTOMETER
	MOLECULAR SPECTROSCOPY	UV/VISIBLE SPECTROPHOTOMETER
MSc TWO	PROJECTS	UV-VIS SPECTROPHOTOMETER, GC, HPLC, ATOMIC ABSORPTION SPECTROPHOTMETER, pH METERS, ION SELECTIVE ELECTRODES, ANALYTICAL BALANCES, CONDUCTIVITY METERS POLAROGRAPHIC EQUIPMENT MECURY STILL

EQUIPMENT FOR EACH EXPERIMENT IN INORGANIC CHEMISTRY

YEAR	EXPERIMENT	EQUIPMENT
SECOND	d-BLOCK ELEMENTS TITANIUM	UV-VIS SPECTROPHOTOMETER HOT PLATE, ANALYTICAL BALANCE
	d-BLOCK ELEMENTS VANADIUM	BUNSEN BURNER, HEATING MANTLE
	d-BLOCK ELEMENTS CHROMIUM	ANALYTICAL BALANCE, BUNSEN BURNER, MAGNETIC STIRRER WATER PUMP
	d-BLOCK ELEMENTS MANGANESE	FREEZER, BUNSEN BURNER, WATER BATH, ANALYTICAL BALANCE
	d-BLOCK ELEMENTS IRON	BALANCE, BUNSEN BURNER, WATER PUMP
	d-BLOCK ELEMENTS COBALT	BUNSEN BURNER, POLARIMETER VISIBLE SPECTROPHOTOMETER FREEZER, HOT PLATE, VACUUM DESSICATOR, VACUUM PUMP
	d-BLOCK ELEMENTS NICKEL	ANALYTICAL BALANCE, GUOY BALANCE, ELECTROMAGNET
	D-BLOCK ELEMENTS COPPER	BALANCE-TOP PAN, FREEZER BUNSEN BURNER, HEATING MANTLE VISIBLE SPECTROMETER
	COBALT(II) AND (III) COORDINATION COMPOUNDS	pH METER, STEAM BATH, OVEN, BALANCE,BUNSEN BURNER, WATER PUMP, INFRARED SPECTROMETER VISIBLE SPECTROMETER
	p-BLOCK ELEMENTS GROUP IV	BALANCE, HEATING MANTLE
	p-BLOCK ELEMENTS	BALNCE, WATER PUMP, BUNSEN BURNER, WATER BATH, FREEZER
THIRD	THE CHARACTERISATION OF A COMPLEX USING INFRARED SPECTROSCOPY	BALANCE, STEAM BATH, CENTRIFUGE WATER PUMP, HEATING MANTLE HOT PLATE, IR SPECTROMETER KBr MINI PRESS
	AN OXYGEN CARRYING COMPLEX	MECHANICAL STIRRER, GOUY BALANCE IR SPECTROMETER, BALANCE VACUUM OVEN
	CARBONYL STRETCHING FREQUENCIES IN METAL	HEATING MANTLE, BALANCE IR SPECTROMETER

YEAR	EXPERIMENT	EQUIPMENT
THIRD	COMPLEX ION COMPOSITION BY JOB'S METHOD	UV-VIS SPECTROMETER BALANCE
	THE CHEMISTRY OF CHROMIUM	BALANCE, BUNSEN BURNER, HOT PLATE, VISIBLE SPECTROMETER IR SPECTROMETER
	PREPARATION OF BIS-(CYCLO PENTADIENYL) IRON	HEATING MANTLE, WATER PUMP MECHANICAL STIRRER, ANALYTICAL BALANCE, IR SPECTROMETER
	SYNTHESIS AND SPECTRAL STUDY OF Cu(II) COMPLEXES	BALANCE, HOT PLATE, WATER PUMP BUNSEN BURNER, UV-VIS SPECTROMETER
	SYNTHESIS & CHARACTERISATION OF FERROCENE DERIVATIVES	BALANCE, M.P APPARATUS STEAM BATH, FREEZER, WATER PUMP IR SPECTROMETER
	THE CHEMISTRY OF NICKEL	BALANCE, ROTAVAPOUR, WATER PUMP UV-VIS SPECTROMETER, INFRARED SPECTROMETER

Appendix-10 Chemistry Department Priority List

8/17 '93

CHEMISTRY DEPARTMENT PRIORITY LIST

NAME

1. FTNMR(400 MHz)
2. MS [redacted]) GC-MS
3. FTIR [redacted]
4. ~~X-RAY CRYSTALLOGRAPH~~

R: Research
T: Teaching

PRIORITY		ANALYTICAL	INORGANIC	ORGANIC	PHYSICAL	STORES 1
1	R	Plasma emission spectrometer	Rotary evaporators	Droplet counter current Chromatography	Stopped flow apparatus with accessories	IBM computer and dot matrix printer
	T	Gas Chromatograph	UV/VS spectrometer and accessories	GLC instrument	UV-Vis Spectrometer with Thermostat & recording accessories	AV- source video
2	R	Atomic absorption spectrometer	Heating mantles	Polarimeter $1cm^3$ capacity	IBM Compatible 386 DX or 486 computer (8 Mb memory, 100 Mb Hard Disc), One with Coprocessor	Liquid nitrogen production plant
	T	HPLC and accessories	Balances (2 top pan)	90 MHz NMR spectrometer	Polarograph with accessories (Rotating electrodes & Electronics)	
3	R	UV/VIS Spectrophotometer	Vacuum pump	CD-ORD apparatus	UV-Visible Spectrophotometer, Double beam	Photocopier heavy duty
	T	Fluorescence spectrophotometer and accessories	Balances(2 analytical)	Spectrophotometer UV	IBM Compatible 386 Computer with Dot Matrix Printers	
4	R	Ion Chromatograph	Drying oven with vacuum pump accessory	Craig Post apparatus 200 stage (10:10ml)	UV fluorescent SO_2/H_2S analyser	Pick up truck 1 ton
	T	Polarograph	pH meters - digital	Spectrophotometer IR	Single beam Visible spectrophotometer	
5	R	Polarograph	pH meter - digital	Rotavapor 10L capacity	GC with accessories	Glass annealing oven
	T	Atomic Absorption spectrometer	Hotplate/stirrers	HPLC instrument	Glassware	
6	R	HPLC plus ancillary equipment	Dewar flasks	Rotavapor 5L capacity	$NO-NO_2-NO_x$ analyser	Arc welder heavy duty
	T	UV/VIS spectrophotometer	Ovens	Balances Top loading	Florimeter	

PRIORITY		ANALYTICAL	INORGANIC	ORGANIC	PHYSICAL	STORES 2
7	R	Fluorescence Spectro-photometer and accessories	Balance (analytical)	jet 1-standard vacuum system	Low level UVphotometric O_3 analyser	Strain viewer
	T	Infrared spectrophotometer and accessories	Thermometers	Evaporators (Rotary Hake)	Voltmeters	
8	R	DTA/TG Differential Thermal Analysis/Thermogravimetric Analysis balance	Vacuum desiccators	Rotary Evaporator	CO-CO_2-HC infrared analyser	Carbon reamers/carbon rods set
	T	Ion selective meter, computer compatible	M.P. apparatus	Quick fit kits	pH meters	
9	R	Gas Chromatograph	Desiccators	Mini diazald apparatus	Polarographic analyzer and accessories	Flair land torch
	T	Ion selective electrodes for Ca^{2+}, Cu^{2+}, Cd^{2+}, Pb^{2+}, Cl^{-}, F^{-}, DO, etc	Dewar flasks	Melting point apparatus	Conductivity meters (4 s.f)	
10	R	GC Mass Spectrometer	Steam generators	Soxhlet extractor (11, 21, 31)	Chemicals and glassware	Glass blowing torch & nozzles
	T		Centrifuge	Hot plates (magnetic stirrer) Gallenkamp Magnetic followers	Conductivity meters (3 s.f)	
11	R	Nitrox ultra high purity gas generator	UV/VIS spectrometer	Fraction collector	Peristaltic pumps,1-250ml/hr	Adjustable bulb holder sets
	T		Rotary evaporators	Heating mantles electrothermal Capacity 100/50/250/500ml 1l/5l	Chiller Units	

PRIORITY	ANALYTICAL	INORGANIC	ORGANIC	PHYSICAL	STORES 3
12 R	Air samples and gas samples	De-ioniser for water	Freeze dryer	pH meter and ion selective electrodes, Auto calibration	Bench drill diamond
T		Conductivity apparatus	Extraction apparatus Soxhlet extractors Extraction thimbles	Ice maker	
13 R	Coulometer	QVR.20 Quantum yield reactor	Hot stage melting apparatus	Zetasizer	Forceps
T		Polarimeter	Analytical balances	Recorders (Flat bed)	
14 R	Karl Ficsher Titrator	APQ 40 photoreactor and accessories	Desiccator (vacuum)	Wratten gel filters	Head stock for grinding glass
T		Fluorescence spectrophotometer & accessories	Fractional distillation apparatus	Hot plate/Stirrers	
15 R	Peristaltic pumps	Flash photolysis equipment: KA 020/w Flash photolysis spectrometer	Precision vacuum oven	Optical Integrating sphere	Glass blowing spectacles didymium
T		Ice-maker	Flasks shakers	Bomb Calorimeter	
16 R	TLC Scanner (densitometer)	Annular jackets photolysis spectrometer	Heavy duty juice extractor	10 nm band pass interference filters	Bench swivel
T		Gas Chromatograph	Stirrers Heipolph stirrers Contenco stirrers	Heater Circulators	
17 R	Polarimeter	Opt. 850 Kinetic spectrometer work station	GLC and accessories(frits, guard tubes, probes)	Portable air samplers each with complete kit	Glass working tools
T		HPLC columns	Vacuum desiccators	Abbey Refractometer and Accessories	

PRIORITY	ANALYTICAL	INORGANIC	ORGANIC	PHYSICAL	STORES
18 R	Microwave Oven	Flash photolysis Accessories	Heating mantles (100ml-5l), (5x100ml, 5x250ml, 2x500ml, 2x1L, 2x5L)	Air sample collectors (Impinges and cylinders)	Vernier Sliding calipers
T		Semi-microbalance(top pan)	Power controllers (Electrothermal)	Ozonizer	
19 R	Vacuum dry oven	Gas Chromatography Equipment: Gas chromatograph, Electron capture and flame photometric detector	Disc press for KBr	Particulate (Cascade) monitor	Glass cutter
T		Ion-selective electrodes for Ca^{2+}, Cu^{2+}, Cd^{2+}, Pb^{2+}, Cl^{-}, F^{-}, DO, etc	Gas pressure regulators two stage oxygen, air, nitrogen, CO_2, Helium, Hydrogen	Ice-Flake maker	
20 R	Electronic balances	Computing Integrator PU 4811 Accessories and spares	Top Loading balance	Holographic Monochromator (180-2000 nm at 0.5 nm)	Cock bores set and sharpener
T		Kipps apparatus	Lamps UV portable lamps UV viewing cabinet	Air Compressor	
21 R		Desiccators(vacuum)	Densitometer	Air conditioner	Soda glass burette stopcorks
T			Lubricants Rubber grease general Silicone grease PTFE aerosol Apieson grease and waxes Apieson greases	Triple water distillation Apparatus	
22 R		Water baths	M.S.E. medium size centrifuge	microwave oven	Standard glass tubing borosilicate glass
T			Mixer/blender	Constant Current/Voltage Power supplier	

PRIORITY	INORGANIC	ORGANIC	PHYSICAL	STORES 5
23 R	Furnaces(muffle)	Desiccators		Rotaflow stopcorks straight
T		Ovens - General purpose	Low Voltage (Variable Power supplier	
24 R	Polarographs and accessories	Wheaton micro sublimation apparatus		Cones
T		Aspirators	Vacuum Rotary pumps	
25 R	Multimeters	Varitemp heat gun		Cones with long tips C88 or rolled shoulder double
T		Vacuum pump	pH Meters-Digital	
26 R	Ultrasonic baths	Ito's chromatographic planetary centrifuge(CPC)		Spherical joints, ball and cup
T		Hand R + S refractometers	Balance - Electronic, Analytical	
27 R		Prep. column and teflon tubing for CPC and accessories (syringe)		Flat flange joints
T		Abbe refractometers	Balance- Electronic	
28 R		Pharmacia gradient marker (2x500ml capacity)		High vacuum stopcorks size 2-8
T		Ice maker	Vacuum pump	
29 R		Ovens (drying)		
T		Teflon stop cocks, Quickfit ratoflo stopcorks	Travelling microscope vertical transverse & Hor. transverse	

PRIORITY		ORGANIC	PHYSICAL
30	R	Bioslizer (microtome)	
	T	Centrifuges (Bench type)	Digital Multimeters
31	R	Viscograph(Brabender-rheotest)	
	T	Heavy duty vacuum pump	Polarimeter
32	R	Microwave oven	
	T	Dewar vacuum vessels	Ovens- Fully automatic
33	R	Thermostats	
	T	Chromatography Equipment . Paper chromatography kit Thin layer Kit Atomiser Tanks Glass tanks Columns	Refrigerator/ Freezer
34	R	Scanning microscope with polarised light	
	T	Dispensers (syringe)	Deioniser
35	R	Magnetic stirrer - hot plates	
	T	Heating tapes	Shakers-Universal
36	R	TLC developing tanks with lids (12.1 x 10.8 x 8.3 cm, 27.5 x 27.5 x 7.5 cm)	
	T	Varitemp heat gun	UV and ultrasonic Bath

PRIORITY		ORGANIC	PHYSICAL
37	R	Flash chromatograph, 600ml Z14,738-9 with solvent reservoir, 200ml Z14,736-2 with solvent reservoir	
	T	Centrifuge	Flask shaker
38	R	Flex - column chromatography column, I.D. 2.5 cm x 20 cm	
	T	Baths Student water bath Sand bath Ultrasonic	Fortin Mercury Barometer
39	R	Chromatography sprayer (4 x 50ml)	
	T	Macro diazald kit and replacement parts	He, Ne LASER - Power Supply & Related Apparatus
40	R	Liquid-liquid extractors (reciprocating)	
	T	Wheaton micro sublimation apparatus	Isomantles
41	R	Glassware	
	T	Ovens	Stopwatch timers
42	R	Thermometers digital	
	T		Pirani Gauges + sensors

PRIORITY		ORGANIC	PHYSICAL
43	R	Micro syringes	
	T		Stirrer Motor 1/4hp
44	R	Spray bottle for chromatography	
	T		
45	R	High pressure hydrogenerator	Peristaltic pump
	T		
46	R	Krugelrhor distillation apparatus	Vacuum Desiccator
	T		
47	R	Filtration apparatus Filter holder including membrane Filter papers (Whatman)	Magnetic stirrer
	T		
48	R	Freeze dryer	Syringe Pump
	T		
49	R	Furnace Muffle	Optical bench
	T		
50	R	Water - still	UV lamps
	T		Viscometer Saybolt

PRIORITY	ORGANIC	PHYSICAL
51 R		
T		
52 R		Cryostats + Dewars
T		
53 R		Viscometer Brookfield
T		
54 R		Dunouy Tensiometer
T		
55 R		Slide Projector & Accessories
T		
56 R		Portable Over head Projector
T		
57 R		Thin Film Evaporator
T		
58 R		Variable Transformer
T		
59 R		Data logger
T		Flow meters liquid, gas

Appendix-11 List of Major Equipment and Their Various Uses

No.	Equipment	Uses
1	Fourier Tarnsform Nuclear Magnetic Resonance Spectrometer	1)Structure analysis of medicine and natural organic materials 2)Identification of structure of synthetic products in organic chemistry 3)Analysis of fine structure of synthetic high polymer 4)Diagnosis by identification of metabolism in urine and blood 5)Study on ecology and pathology by measuring of ATP in vivisection 6)Diagnosis by observation of tissue by image scanning 7)Structure analysis of multi dimens-ions(high dimensions)of protein
2	Gas chromatograph mass-spectrometer	1)Separative, quantitative and qualitative analysis of organic compounds (It is possible to detect less than ppm unit) 2)It is possible to analyse pesticids and Dioxine by double focusing mass-spectrometer 3)It is possible to analyse environmental pollutants
3	Fourier Tarnsform Infrared Spectrophotometer	1)Gas analysis 2)Analysis of medicine 3)Surface analysis

No.	Equipment	Uses
3	Fourier Tarnsform Infrared Spectrophotometer	4)Analysis of air and water pollutants 5)Analysis of additives in foods and cosmetics and clearlyfication of their deterioration
4	Gas chromatograph	1)Analysis of gases and liquids 2)It is possible to identify various materials with many detectors
5	High performance liquid chromatograph	1)Analysis of liquid samples (including soluble solid) 2)Analysis of medical science, biochemistry, pharmacy, polymer science, natural products science, food and environmental pollutants
6	Fluorophotometric Analyzer	1)Analysis of vitamine, additives in foods and dyes etc. 2)Analysis of Ca in cells by using special reagents 3)Analysis of conducting cells etc.
7	Atomic Absorption Spectro-photometer	1)Analysis of many kind of metals 2)Analysis of metals in animals and plants, soils, atomospher, water and foods
8	Polarograph	1)Analysis of anions and kations 2)Measuring of reversible reaction on electrode of organic compounds

No.	Equipment	Uses
8	Polarograph	3)Measuring of oxidation-reduction potential
9	Thermal Analyzer (TG/DTA)	1)Analysis of thermal degradation process of polymers (Identification and determination of materials) 2)Estimation of thermal stability of materials & reagents
10	Liquid Nitrogen Plant	1)Supply of liquid nitrogen for maintenance of NMR and other equipment
11	Droplet Counter Current Chromatograph	1)Separation of active materials 2)Separation and refinement of amino antibiotics 3)Determination of chemical equivalent for determinating of molecular weight
12	Ion Chromatograph	1)Determination of anion and kation
13	Polarimeter	1)Identification of saccharide, amino acid and narcotics & determination of optical density on their materials
14	Coulometer	1)Biodegradation test of chemicals & other materials

No.	Equipment	Uses
15	Rotation Locurar Counter Current Chromatograph	1)Separation of active materials 2)Separation and refinement of amino acid, nucleotide, amine and antibiotics 3)Determination of chemical equivalent for determinating of molecular weight
16	NOx Analyser	1)Measuring of NOx in atmosphere
17	Circular Dichroism Optical Rotatory Dispersion	1)Analysis of stereostructure of optical active molecular 2)Identification and determination of optical active materials
18	Polarising Microscope	1)Optical observation of mineral and rock
19	Magnetic Balance (Gouy Type)	1)Balance for measuring magnetic susceptibility of materials