Regional Workshop
on
Training of Teachers in Setting up Microscale Chemistry Laboratory in Secondary Schools

6 - 8 January 2010

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January 2010

Preface

Experimentation is fundamental in learning Science. The crucial role of practical work in School Science Curriculum is universally accepted. A good science curriculum must not only give balanced emphasis on both theory and experiments, but also integrate these two essential and complementary aspects of science in the teaching-learning process.

The National Curriculum Framework 2005 (NCF – 2005) aspires that "at the secondary stage, students should be engaged in learning science as a composite discipline, in working with hands and tools to design more advanced technological modules than in the upper primary stage. Systematic experimentation as a tool to discovery / verify theoretical principles and working on locally significant projects involving science and technology are to be important parts of the curriculum at this stage".

The National Focus Group on teaching of science presents the real situation at the secondary schools. "A major concern is decline of practical work and experimentation at secondary level. The oft-repeated recommendation of integrating experimental work and theory teaching has not been realized because of perceived lack of facilities and trained teachers in most of the schools".

A multifold approach has been suggested to deal with the problem.

i) Encourage practical / creative components of the curriculum through non-formal channels.

ii) introduce some carefully designed experiment in the theoretical paper,

iii) promote experimental culture in schools by improving school laboratories,

iv) with the emphasis on environmentally safe materials, introduce microchemistry as a means of experimentation for the chemistry laboratory. Use of micro-chemical techniques has also the advantage of lower cost and greater safety.

In order to inculcate experimental culture in schools and to provide hands-on experience to both students and teachers even in schools without defined laboratory facilities, NCERT has developed a Microscale Chemistry Laboratory at Headquarters, New Delhi. In addition, Regional Microscale Laboratory is set up both in southern and northern regions (Mysore and Ajmer) to enable the schools to establish Microscale Chemistry Laboratories.

As a part of the Southern Zone activity for the academic year 2009-2010, a Regional Workshop was organized with the following specific objectives :

i) To familiarize teachers to microscale chemistry technique

ii) To initiate teachers to set up microscale chemistry laboratory,

iii) To integrate laboratory experiences with the content and classroom teaching.

The methodology consisted of

i) Identification of Laboratory Exercises from secondary science textbooks.

ii) Experimentation using Microscale Chemistry Kit.

iii) Orientation through demonstration, hands-on experience, group work and discussion.

The participants were drawn from the four Southern States viz. Andhra Pradesh, Karnataka, Kerala and Tamil Nadu.

It is a pleasure to acknowledge the support and guidance received from Prof.G.T.Bhandage, Principal, RIE (NCERT), Mysore in planning and conduct of this workshop. I thank Mrs.B.P.Veenakshi, TGT, DMS, Mysore and Dr.B.S.Lavali Devi, SSL, Maharani's Science College, Mysore for their help during the programme.

M.S.Srimathi

Mysore
January 2010

Dr M S Srimathi
Programme Coordinator

REPORT

On 6th to 8th January 2010, a three-day Regional Workshop on "Training of Teachers in Setting up of Microscale Chemistry Laboratory in Secondary Schools" was organized for Key Resource Persons / Secondary school Teachers of Southern States viz. Andhra Pradesh, Karnataka, Kerala and Tamil Nadu. The inauguration was done by Prof.G.T.Bhandage, Principal, RIE, Mysore on 6th January 2010. Other dignitaries present included Prof.B.S.P.Raju, Head, Department of Education in Science and Mathematics, Prof.C.G.Venkatesha Murthy, Incharge, Department of Extension Education, Dr.N.N.Prahallada, Reader in Education and Editor, RIEM Newsletter, Dr.G.R.Prakash, Incharge Chemistry Section and Dr.M.S.Srimathi, Programme Coordinator. The workshop is held as given in Annexure A.

Dr.G.R.Prakash, welcoming the gathering said that in future Microscale Chemistry Laboratory has a lot of promise due to the following reasons. The microscale technique enables a school to significantly reduce the cost of chemicals, the cost of waste disposal and dangers associated with the manipulation of chemicals. The cost reduction is achieved while still providing the students with the hands-on laboratory experience that is vital to students who might choose to pursue career in science. The introduction of this technique at the secondary level will lead to freshman being better prepared for the type of experimentation that they will encounter in college.

Academic Coordinator of the workshop Dr.M.S.Srimathi explained the advantages of Microscale Chemistry Laboratory developed by NCERT. Using the microscale technique, the experiments in classes six to twelve can be demonstrated with ease and effectively. The miniature laboratory experiment has a specially designed revolving box containing all necessary chemicals and apparatus. Students even need not move from their place to perform the experiments. The learning cycle consists of three phases – exploration, experimentation and transformation. The objective is to motivate student towards doing the experiments in unfamiliar situation (Annexure B).

"Microscale Chemistry amounts to a total quality management approach to the use of chemicals" said Prof.G.T.Bhandage, Principal, RIE, Mysore while inaugurating the workshop. He expressed that issues like how to maintain a pollution-free environment and how to handle chemical wastes are subjects of increasing concern to all scientists, educators and general public. The best way to succeed in this effort is by eliminating chemical wastes at the source. Microscale Chemistry technique as recommended by NCF 2005 can be an alternative to the conventional chemistry laboratory at secondary schools.

Microscale Chemistry is performed by using drastically reduced amounts of chemicals, safe and easy manipulative techniques, miniature laboratory ware and high quality skills. The kit developed by NCERT is quite suitable to achieve the objectives of the science laboratory at schools. Teachers only have to optimize the experimental conditions while shifting from macro to microscale. He remarked that the workshop mode can be effective in achieving a paradigm shift from traditional laboratory to microscale laboratory. In the workshop, teachers can try out the experiments, interact with other teachers and can get orientation to set up the microscale laboratory in their respective schools.

Prof.Bhandage listed the advantages of the microscale techniques like decrease in waste production, reduction of health risks to both students and teachers, cost reduction in chemicals and apparatus, providing hands-on experience to all the students. He called upon the participants, to imbibe the new technique and to adapt in their respective States and schools.

On the occasion, Prof.B.S.P.Raju, Incharge, Department of Education in Science and Mathematics, called upon the participants to set up the Microscale Chemistry Laboratory in their respective schools and to popularize the technique in the respective regions by working as Key Resource Persons.

Prof.C.G.Venkatesha Murthy, Incharge, Department of Extension Education proposed vote of thanks. He expressed his gratitude to the Southern State Education authorities for deputing the Key Resource Persons/ teachers to the workshop.

In the second session held in the forenoon, Dr.Srimathi explained the various components / glasswares / apparatus of microscale laboratory equipment (Annexure C). She said that microscale laboratory can be taken to any classroom with ease and confidence and it is safe to handle for all. Traditional laboratories are costly with lots of disadvantages. The effectiveness of both traditional and microscale laboratory is just one and the same. Therefore, the time has come to popularize microscale technique in all schools especially in rural areas, she added. She also felt that this is the time to move to "Green Chemistry" techniques, the only way to protect mankind and environment.

In the same session, demonstration of the apparatus was also done. About forty items including micro filtration unit, chromatography chamber, well plate, W-tube, heating block, multimeter, miniature laboratory wares (test tubes, beakers, conical flask, standard flasks, funnel, etc) were displayed to the participants (Annexure D). She explained how each item can be used to perform the experiments.

A few experiments relevant to concept development at the secondary school stage were demonstrated. Study of preparation and properties of gases using W-tube, use of well plate to observe 96 chemical responses simultaneously impressed the teachers very much. Precautions in handling and cleaning procedure for all items were also explained. Arrangement of as many as 40 items in a compact way in the kit was appreciated by the participants.

In the afternoon session, teachers performed experiments from the practical syllabus of class IX and X (Annexure E). Some guidelines and experimental procedures in scaling down from macro to micro amounts were discussed. The draft experiment procedure to perform 30 experiments at the secondary stage was provided to all the teachers (Annexure F) seeking their suggestions and comments for improvisation. During this process, they checked the reproducibility of observation and result compared to the conventional macroscale work. Doubts raised by the teachers were discussed on the spot.

The exercise of providing hands-on experience continued on the next day i.e. 7th January 2010 also. Most of the experiments were conducted by the teachers in groups of two each. At the end of the session, the experimental data collected by them was consolidated (Annexure G). Each group tabulated relevant observations. Individual feedback from all the participants was also obtained. Participants interacted among themselves and with the resource persons to get the know how of the microscale technique and consequent setting up of Microscale Chemistry Laboratory at their respective Block Centes / Resource Centres/ Cluster schools / secondary schools.

On the third day i.e. 8th January 2010, responding to the needs of participants, a demonstration session was held. Preparation of ammonia gas and study of its properties – comparison between macro and microscale technique, selection of suitable acid-base indicators to identify acids and bases and paper chromatographic technique for the separation of constituents of a mixture. This enabled the teachers to have hands-on experience with both traditional ways of experimentation and scaling down the same to adopt microscale techniques.

In the afternoon, participants were given feedback forms seeking their experience with the microscale technique (Annexure H). The feedback consisted of questions like how many experiments were performed, relevance and practicability of microscale technique in real school environment, how they will utilize their training in future, etc. They were also asked to "rate" the programme in terms of claim vs. actual, conduction, learning, adequacy for secondary level science laboratory, etc. (Annexure I).

Mrs Dilys Marina, Asst. Teacher, Govt. P.U.College, Dudda, Mandya district, Karnataka opined that (i) the items present in the kit were adequate and effective in conducting experiments, (ii) microscale kit is effective, mobile, less expensive, easily reachable to remote schools, students can easily acquire the skills of handling the miniature apparatus.

Mr.N.Chakradhar, ZPSS, Kurchapally, Warangal, Andhra Pradesh expressed that the microscale kit is very useful to class seven to class ten students to learn

chemistry concepts effectively. He felt that the technique should be introduced to all the teachers teaching science both at urban and rural areas. He hoped that NCERT will take many training programmes for the teachers in this regard.

Mr.Shamjith, M, HSA, GHSS, Iringalloor, Kozhikode, Kerala opined that microscale chemistry experiments are less expensive, eco-friendly and easy to perform. However, in the beginning of the academic year, students should be trained in handling the apparatus. He also felt that the experiments conducted in the present workshop were relevant to secondary school science teaching.

The participants gave a list of experiments to be included in the future training programmes.

i) To study the volumetric composition of water
ii) To obtain pure water by distillation
iii) To study the allotropic forms of sulphur
iv) To study the chemical properties of phosphorus
v) To distinguish between carbonate and bicarbonates

The concluding session was held in the afternoon of 8th January 2010. In his valedictory address, Prof.G.T.Bhandage, Principal, RIE, Mysore called upon the teachers to take initiative in setting up of Microscale Chemistry Laboratory in their respective States. In the present educational set up, students are stuffed with lot of information and theories both in textbooks and reference books. Without experimentation, they cannot experience the fragrance of chemistry as an experimental science, he opined. Progress in the development of low cost equipments is the need of the hour and NCERT has taken a lead in this direction. He emphasized the teachers to share their experiences of the workshop with their authorities and other teachers and to popularize the microscale chemistry technique.

On this occasion, participation certificates were given to all the teachers. Fifteen teachers from the Southern Region attended the workshop(Annexure J).

The workshop concluded with the vote of thanks proposed by Dr.M.S.Srimathi, Programme Coordinator.

Annexure A

Training of Teachers in Setting up Microscale Chemistry Laboratory in Secondary Schools

SCHEDULE

Venue : RIE, Mysore

January 6, 2010

Registration	:	9.30 am
Inaugural Session	:	10.00 am
Welcome	:	Head, DEE
Introduction of the Programme	:	Dr.G.R.Prakash
Address	:	Prof.G.T.Bhandage
Microscale Technique Presentation (11.30 am)	:	Dr.M.S.Srimathi

Conduct of Experiments in five groups of four teachers/ KRPs

January 7, 2010

Conduct of Experiments	:	9.00 am to 1.00 pm
Group Discussion on Experiments And Experimental Procedure	:	2.00 pm to 5.00 pm

January 8, 2010

Conduct of Experiments	:	9.00 am to 1.00 pm
Groupwise Presentation	:	2.00 pm to 3.30 pm
Feedback and Discussion	:	3.30 pm to 4.00 pm
Valedictory	:	4.00 pm to 5.00 pm

Annexure B

Approach Paper

PAC 18.08 Training of Teachers in Setting up Microscale Chemistry Laboratory in Secondary Schools

Dr.M.S.Srimathi

To learn Science is to do Science. There is no other way of learning science – Dr.D.S.Kothari.

If the Almighty were in one hand to offer me truth and in the other, search for truth, I would humbly but firmly search for truth – Huxley

Those Sciences are vain and full of errors which are not born from experiment, the mother of all certainty – Leonardo Da Vinci

Experimentation occupies a central place in science curriculum. An experimentation is a test or trial or a tentative procedure for the purpose of discovering something. Laboratory work is considered essential in promoting student's learning of science and scientific inquiry. Curriculum changes worldwide are putting increased emphasis on the laboratory instruction for the following reasons.

1. Experiments help students develop the right perspective of science that science is not a theoretical abstraction, rather in an attempt to describe the working of the real world around us.
2. Experiments are among the most effective ways to generate interest in science.
3. Experiments promote basic skills and competencies of doing Science – procedural and manipulative skills, observation skills, skills of representing and interpreting data and the accompanying conceptual and critical abilities.

For these various reasons promoting activity and experiment based learning has been at the heart of many efforts at improving science.

Despite several laudable efforts in the past, experiments, by and large, have continued to be marginalized in our schools.

The importance of experimentation has been recognized in the National Policy of Education for the past several decades. National Curriculum Framework – 2005 vision as secondary school curriculum focuses on the following issues.

a) Science curriculum should enable the students to

i) connect knowledge to life outside the school,

ii) enable students to move beyond the textbooks,

iii) shift learning away from rote methods,

b) At secondary stage, students should be engaged in learning science as a composite discipline, in working with hands and tools to design more advanced technological modules concerning the environment.

c) Systematic experimentation as a tool to discover / verify theoretical principles and working on locally significant projects in science should be the focus of secondary curriculum.

d) Experiments should be part of the content in textbooks in teaching theoretical open-ended experiments and investigative projects should not be marginalised.

e) Questions based on laboratory exercise should be included in the examination paper.

NCF 2005 also expresses deep concern about the present scenario in the school environment…

"A major area of concern is the gradual decline of practical work at secondary and senior secondary levels. The oft repeated recommendation of integrating experimental work and theory teaching has not been realized because of perceived lack of facilities and

trained teachers in most of the schools. Even well endowed schools tend to give only cosmetic importance to laboratory work in the prevailing scheme of things".

A two-fold approach has been suggested.

i) Encourage practical components of the curriculum through non-form channels.

ii) Introduce some carefully designed experiments in the theoretical paper itself.

In addition, the document emphasizes that at secondary stage, microscale chemistry technique as a means of experimentation can be introduced to strengthen the teaching-learning process.

What is Microscale Chemistry?

.....chemistry carried out on a reduced scale using small quantities of chemicals and often simple equipment.

....a branch of analytical chemistry that involves procedures requiring handling of bantam amounts of materials (0.1 to 10 mg).

....is an art and science of performing experiments using (i) drastically reduced amounts of chemicals, (ii) safe and easy manipulative techniques, (iii) miniature laboratory ware, (iv) high quality skills.

Microscale chemistry amounts to a total quality management approach to the use of chemicals. This technique is recognized as small scale chemistry by the International Union of Pure and Applied Chemistry (IUPAC).

Historical Development and Important Milestones of Microscale Chemistry Technique

The feasibility of carrying out chemistry experiments at microscale levels is established in 1800's in central Europe with work of Emish and Pregl. Pregl received Nobel Prize in 1923 for his microscale work.

After World War II, microscale work gained significance in United States. Stephen Thomson of Colorado University developed small scale experiments and published in Chemtrek.

Several groups formed in the north-eastern US to further develop microscale techniques. Professors Mayo, Pike, Butcher and Trumper were the significant contributors.

National Microscale Chemistry Centre (NMC) was established at Merrimack College in Massachusetts under Director Dr.Monosingh in 1993. Initially, objectives of the centre was to promote the use of microscale chemistry technique worldwide and to hold courses, workshops for science teachers.

Journal of Chemical Education, a journal of American Chemical Society began publishing a section entitled "The Microscale Laboratory" in 1989 to report microscale chemistry experiments.

In Canada, Prof.Geoffrey, Rayner Canham and Dr.Alan Slater reported secondary school chemistry experiments in Chem13 News.

First teaching tests occurred at Bowdoin and Merrimack colleges in 1983.

Dr.Stephen Breuer of University of Lanchester produced a manual on microscale chemistry.

A Book on Microscale Chemistry was published in 1997 by John Skinner.

In a joint effort, University of Amsterdam and The Chemistry Communication Centre Foundation are promoting microscale technique at secondary education.

First microscale chemistry textbook was published in 1986.

At present, more than 1000 microscale courses are being offered in US training more than one lakh students every year.

Microscale chemistry centres were established in several countries like South Africa, Mexico, France, China.

In India, NCERT has established a microscale chemistry laboratory at its Headquarters, New Delhi.

Why Microscale Chemistry Laboratory?

Chemistry laboratory is more important than ever. In the so called second phase of secondary education, an increased importance is placed on practical skills and independence of students. Establishing well equipped student laboratories seems to be a feasible suggestion.

Worldwide, a so called microscale movement is taking place. The idea is simple : convert existing experiments to microscale and save on chemicals. This will save costs, it will be safer for students and also cause much less waste. Moreover, processes will take place much faster, the so called demonstration experiments can become student laboratory experiments enabling "hands on" experience to every pupil. In addition, students will imbibe the idea of "Green Chemistry".

Summary of Advantages :

	Features of Microscale Chemistry Technique	**Advantages**
a)	Use of small amounts of chemicals.	Cost saving.
b)	Less waste generation.	Ecologically sound.
c)	No waterhoses or cooling, less fumes	No need of fuming cupboard
d)	Replacement of many glasswares with plastic wares	Minimization of breakage
e)	Less time consuming.	Performance of more experiments, better teacher-student interaction.

Microscale Chemistry Laboratory developed by NCERT offers the following attributes:

1. This concept is in consensus with the constructivist approach of teaching as recommended by NCF-2005.
2. It is 'SEAT' friendly (Student, Environment, Administrator, Teacher).
3. Any clean table can be a laboratory.
4. Fast, easy to set up, work and clean up.
5. A boon for home school parents and instructors teaching out-of-field.
6. Cost effective way for any school to offer a best laboratory course.
7. Designed to be more affordable time saving and less hazardous than traditional laboratory.
8. Makes chemistry teaching accessible and achievable by almost any one.
9. Immense scope for continuous addition of teaching material or improvisation of the existing apparatus in the kit.
10. Laboratory exercises suggested in the curriculum can be effectively performed.

Setting up of Microscale Chemistry Laboratory in Schools

Microscale Chemistry Laboratory can be easily set up in any school even where there is no provision for a laboratory. The recurring cost of chemicals and apparatus are almost negligible. For a batch of 20 students, 5 kits will be sufficient. The kit can be placed on a table separately or can be taken to the classroom itself to teach chemistry concepts. This laboratory can also replace the existing conventional laboratory.

This laboratory is set up in selected schools in Delhi and encouraging feedback is obtained.

How can one get the apparatus?

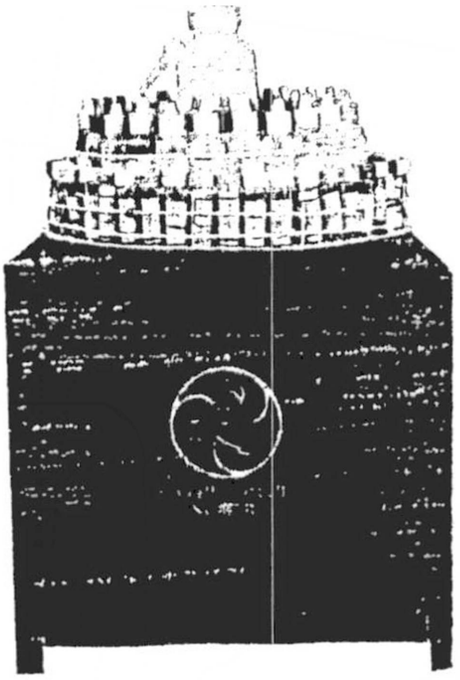
Write to : Head, NIE Workshop
National Institute of Education
National Council of Educational Research and Training
Sri Aurobindo Marg
New Delhi 110 016

Annexure C

SEAT

(Student, Environment, Administrator, Teacher)

Friendly Microscale Chemistry Laboratory



राष्ट्रीय शैक्षिक अनुसंधान और प्रशिक्षण परिषद्
NATIONAL COUNCIL OF EDUCATIONAL RESEARCH AND TRAINING

What is Microscale Chemistry Laboratory Technique ?

Microscale chemistry technique is an environmentally safe pollution prevention method of performing chemistry experiments using small quantities of chemicals without compromising the quality and standard of experiments. We have designed and developed a concept of microscale laboratory where the students need not wander around in search of reagents. The experiments can be performed quickly. These are pollution and hazard free. Conventional laboratory racks and bottles are replaced by a small box containing all the small lab ware and apparatus and on the top of the box are revolving circular racks to hold plastic dispenser bottles which dispense one drop of liquid at a time. In short this method can be called Student, Environment, Administrator and Teacher (SEAT) friendly.

How is it SEAT Friendly ?

Students can perform the experiments while sitting.

Student Friendly

- Our laboratory uses solid chemicals in few milligrams quantities and liquid chemicals in few drops using special low-cost apparatus instead of grams and full test tube chemicals as in traditional laboratories.
- The chemicals used are in very small quantity, thereby reducing the risks of accidents and burns, fumes, etc.
- The experiments are quick to perform saving time for performing more experiments.
- It develops excellent laboratory manipulative skills.
- It develops habit of conservation.

This procedure

- reduces use of chemicals promoting waste reduction at the source.
- offers vastly improved laboratory safety by better laboratory air quality through reduction in :
  - exposure to toxic chemicals
  - fire and explosion hazards

- spills and accidents

- provides clean and congenial environment

Administrator Friendly

- It sharply reduces laboratory cost.
- It lowers glass breakage cost.
- It saves storage space.

Teacher Friendly

- It promotes better student-discipline in the laboratory.
- It is pedagogically superior. Teachers can ask the students to do more experiments in the saved time to help in better conceptual understanding.

What new apparatus are required ?

Below is the list of some of the required apparatus.

1. Small portable box with revolving top for easy access of chemicals and apparatus replacing big racks.
2. Polyethylene dispensing bottles (squeeze type) to dispense liquid chemicals dropwise avoiding contamination of chemicals.
3. Well plates for fast and easy.
4. W-tube for fast gas absorption.
5. Aluminium block for safe determination of melting point and boiling point.
6. Micro burner
7. Micro burettes
8. Plastic droppers for easy transfer of liquids.
9. Miniature glasswares for least consumption of chemicals.
10. Miniature distillation unit
11. Micro filtration unit
12. Micro spatulas.

How many Chemistry experiments can be done with this ?

All the chemistry experiments at school level from class VI and XII can be performed using this lab. We mention a few examples below.

- Microscale Titration
- Microscale Gravimetric Determination
- Microscale Qualitative Analysis
- Potentiometric titrations
- Estimation of solubility product
- Verification of pK of an acid
- Equilibrium, pH and all other physical chemistry experiments.

3. Microscale in Organic Chemistry Experiments

- Organic qualitative analysis and small scale distillation and preparation
- Tests for functional groups

How can the Laboratory be set up ?

This laboratory can easily be set up with minimum cost by placing revolving boxes on the table in schools where there is no chemistry laboratory. The recurring costs of chemicals and glasswares are almost negligible. This laboratory can also easily replace the existing traditional laboratory. This can also be used as a mobile laboratory. NCERT has recommended the use of microscale chemistry laboratory in schools under NCF 2005.

How can one get the apparatus ?

Head, NIE Workshop
National Institute of Education
National Council of Educational Research and Training
Sri Aurobindo Marg
New Delhi 110 016

Email : hari_gupta200@yahoo.com
Phone : EPABX 91-11-26560620
91-11-26864811
Extension : 572 or 564
Fax : 91-11-26868419

Annexure D

List of Items of Microscale Chemistry Kit for Senior Secondary Stage suitable for four students

	Name of the Item	Quantity
1.	Wooden Box with revolving top	1
2.	Micro Beaker (10 ml)	12
3.	Beaker (50 ml)	6
4.	Micro filtration unit	2
5.	Watch glass (small)	2
6.	Well plate (96 wells)	4
7.	Measuring cylinder (10 ml)	2
8.	Microburette (5 ml)	4
9.	Petridish	2
10.	Micro Test Tube	24
11.	Proppettes (Droppers	20
12.	Glass Rod	2
13.	Micro titration flask (25 ml)	4
14.	Capillary tube	1 box
15.	Thermometer (0.1° C and 1° C)	2
16.	Stirrer	2
17.	Calorimeter	1
18.	Circular Whatman Paper	20 piece
19.	Micro burner	2
20.	Tripod	2
21.	W-tube	10
22.	Multimeter	1
23.	Micro Volumetric Flasks 25ml	2
24.	Dropper with 2 ml syringe	6
25.	Salt bridge (U-tube) with wick	1
26.	Dispensing bottles (15 ml)	30
27.	Small containers (vial)	20
28.	Round bottom flask (35 ml)	2

29.	China dish	2
30.	Fusion tube	1 box
31.	Chromatography jar (7" × 1")	1
32.	Wash bottles (100 ml)	2
33.	Microspatula	2
34.	pH paper	1 pack
35.	Al block	1
36.	Microfunnels	2
37.	Tweezers	2
38.	Two way burette clamp with stand	2
39.	Test tube holder	2

Annexure I

4. SCIENCE

(Code No. 086 / 090)

The subject of Science plays an important role in developing in children well-defined abilities in cognitive, affective and psychomotor domains. It augments the spirit of enquiry, creativity, objectivity and asthetic sensibility.

Whereas the upper primary stage demands that plentiful opportunities should be provided to the students to engage them with the processes of science like observing, recording observations, drawing, tabulation, plotting graphs etc., the secondary stage expects abstraction and quantitative reasoning to occupy a more central place in the teaching and learning of Science. Thus, the idea of atoms and molecules being the building blocks of matter makes its appearance, as does Newton's law of Gravitation.

The present syllabus has been designed around six broad themes viz. Food, Materials, the world of the living, how things work, moving things, people and ideas, natural phenomenon and natural reasources. Special care has been taken to avoid temptation of adding too many concepts than can be comfortably learnt in the given time frame. No attempt has been made to be comprehensive.

At this stage, while science is still a common subject, the disciplines of Physics, Chemistry and Biology begin to emerge. The students should be exposed to experiences as well as modes of reasoning that are typical of the subject.

COURSE STRUCTURE

CLASS IX (THEORY)

One Paper **Time : 2½ hours.** **Marks : 60**

Unit		Marks
I.	Food	05
II.	Matter - ITS nature and behaviour	15
III.	Organisation in living world	13
IV.	Motion, Force and Work	20
V.	Our Environment	07
	Total	60

Theme : Food

(10 Periods)

Unit 1 : Food

Plant and animal breeding and selection for quality improvement and management ; use of fertilizers, manure protection from pests and diseases; organic farming.

Theme : Materials (50 Periods)

Unit 2 : Matter - Nature and behaviour

Definition of matter; solid, liquid and gas; characteristics - shape, volume, density; change of state-melting (absorption of heat), freezing, evaporation (Cooling by evaporation), condensation, sublimation.

Nature of matter : Elements, compounds and mixtures. Heterogenous and homogenous mixtures, colloids and suspensions.

Particle nature, basic units : atoms and molecules. Law of constant proportions. Atomic and molecular masses.

Mole Concept : Relationship of mole to mass of the particles and numbers. Valency. Chemical formula of common compounds.

Structure of atom : Electrons, protons and neutrons; Isotopes and isobars.

Theme : The World of the living (45 Periods)

Unit 3 : Organization in the living world.

Biological Diversity : Diversity of plants and animals - basic issues in scientific naming, basis of classification. Hierarchy of categories / groups, Major groups of plants (salient features) (Bacteria, Thalophyta, Bryo phyta, Pteridophyta, gymnosperms and Angiosperms). Major groups of animals (salient features) (Non-chordates upto phyla and chordates upto classes).

Cell - Basic Unit of life : Cell as a basic unit of life; prokaryotic and eukaryotic cells, multicellular organisms; cell membrane and cell wall, cell organelles; chloroplast, mitochondria, vacuoles, ER, golgi apparatus; nucleus, chromosomes - basic structure, number.

Tissues, organs, organ systems, organism.

Structure and functions of animal and plant tissues (four types in animals; merismatic and permanent tissues in plants).

Health and diseases : Health and its failure. Disease and its causes. Diseases caused by microbes and their prevention - Typhoid, diarrhoea, malaria, hepatitis, rabies, AIDS, TB, polio; pulse polio programme.

Transport of materials in the living systems : Diffusion / exchange of substances between cells and their environment and between the cells themselves in the living system; role in nutrition, water and food transport, excretion, gaseous exchange.

Theme : Moving things, people and ideas (60 Periods)

Unit 4 : Motion, Force and Work

Motion : displacement, velocity; uniform and non-uniform motion along a straight line; acceleration, distance - time and velocity-time graphs for uniform and uniformly accelerated motion, equations of motion by graphical method; elementary idea of uniform circular motion.

Force and Newton's laws : Force and motion, Newton's laws of motion, inertia of a body, inertia and mass momentum, force and acceleration. Elementary idea of conservation of momentum, action and reaction forces.

Gravitation : Gravitation; universal law of gravitation. force of gravitation of the earth (gravity), acceleration due gravity; mass and weight; free fall.

Work, Energy and Power : Work done by a force. energy, power; kinetic and potential energy; law of conservatio of energy.

Floatation : Thrust and pressure. Archimedes' principle, buoyancy, elementary idea of relative density.

Sound : Nature of sound and its propagation in various media, speed of sound, range of hearing in humans; ultrasound reflection of sound; echo and SONAR.

Structure of the human ear (auditory aspect only).

Theme : Natural Resources (15 Periods)

Unit 5 : Our Environment

Physical resources : Air, Water, Soil.

Air for respiration. for combustion. for moderating temperatures. movements of air and its role in bringing rai across India.

Air, water and soil pollution (brief introduction). Holes in ozone layer and the probable damages.

Bio-geo chemical cycles in nature : water, oxygen, carbon, nitrogen

PRACTICALS

LIST OF EXPERIMENTS

Marks : 40 (20 + 2

1. **To prepare**

a) a true solution of common salt, sugar and alum

b) a suspension of soil, chalk powder and fine sand in water

c) a colloidal of starch in water and egg albumin in water and distinguish between these on the basis of

i) transparency

ii) filtration criterion

iii) stability

2. To prepare

a) a mixture

b) a compound

using iron filings and sulphur powder and distinguish between these on the basis of :

i) appearance i.e., homogeneity and heterogeneity

ii) behaviour towards a magnet

iii) behaviour towards carbon disulphide a solvant.

iv) effect of heat.

3. To carry out the following chemical reactions and record observations. Also to identify the type of reaction involved in each case.

i) Iron with copper sulphate solution in water.

ii) Burning of Magnesium in air.

iii) Zinc with dilute sulphuric acid

iv) Heating of Lead Nitrate.

v) Sodium sulphate with Barium chloride in the form of their solutions in water.

4. To verify laws of reflection of sound.

5. To determine the density of solid (denser than water) by using a spring balance and a measuring cylinder.

6. To establish the relation between the loss in weight of a solid when fully immersed in

i) tap water

ii) strongly salty water, with the weight of water displaced by it by taking at least two different solids.

7. To measure the temperature of hot water as it cools and plot a temperature-time graph.

8. To determine the velocity of a pulse propagated through a stretched string/slinky.

9. To prepare stained temporary mounts of (a) onion peel and (b) human cheek cells and to record observations and draw their labeled diagrams.

10. To identify parenchyma and sclerenchyma tissues in plants, striped muscle fibers and nerve cells in animals, from prepared slides and to draw their labeled diagrams.

11. To separate the components of a mixture of sand, common salt and ammonium chloride (or camphor) by sublimation.

12. To determine the melting point of ice and the boiling point of water.

13. To test (a) the presence of starch in the given food sample (b) the presence of the adulterant metanil yellow in dal.

14. To study the characteristic of spirogyra/Agaricus, Moss/Fern, Pinus (either with male or female conre) and an Angiospermic plant. Draw and give two identifying features of groups they belong to.

15. To observe and draw the given specimens—earthworm, cockroach, bony fish and bird. For each specimen record

    (a) one specific feature of its phylum

    (b) one adaptive feature with reference to its habitat.

SCHEME OF EVALUATION

Multiple choice type question written test (School based) : 20 Marks

Hands-on practicals examination (school based) : 20 Marks

CLASS X

(Theory)

One Paper **Time : 2½ hours** **Marks : 60**

	Unit	Marks
I.	Chemical Substances	18
II.	World of living	16
III.	Effects of Current	10
IV.	Light	8
V.	Natural Resources	8
	Total	60

Theme : Materials **(55 Periods)**

Unit 1 : Chemical Substances - Nature and Behaviour

Acids, bases and salts : General properties, examples and uses.

Chemical reactions : Types of chemical reactions : combination, decomposition, displacement, double displacement, precipitation, neutralization, oxidation and reduction in terms of gain and loss of oxygen and hydrogen.

Metals and non metals : Brief discussion of basic metallurgical processes. Properties of common metals. Elementary idea about bonding.

Carbon Compounds : Carbon compounds, elementary idea about bonding.

Saturated hydrocarbons, alcohols, carboxylic acids (no preparation, only properties).

Some Important chemical compounds : Soap-cleansing action of soap.

Periodic classification of elements : Gradations in properties : Mendeleev periodic table.

Theme : The world of the living (50 Periods)

Unit 2 : Our environment

Our environment : Environmental problems, their solutions. Biodegradable, non biodegradable, ozone depletion.

Life Processes : "living" things; Basic concept of nutrition, respiration, transport and excretion in plants and animals.

Control and Co-ordination in plants and animals : Tropic movements in plants; Introduction to plant hormones; control and co-ordination in animals : voluntary, involuntary and reflex action, nervous system; chemical co-ordination animal hormones.

Reproduction : Reproduction in plants and animals. Need for and methods of family planning. Safe sex vs HIV/ AIDS. Child bearing and women's health.

Heridity and evolution : Heridity; Origin of life : brief introduction; Basic concepts of evolution.

Theme : How things work. (35 Periods)

Unit 3 : Effects of Current

Potential, Potential difference, Ohm's law; Series combination of resistors, parallel combination of resistors; Power dissipation due to current; Inter relation between P, V, I and R.

Magnets : Magnetic field, field lines, field due to a current carrying wire, field due to current carrying coil or solenoid; Force on current carrying conductor, Fleming's left hand rule. Electro magnetic induction. Induced potential difference, Induced current. Direct current. Alternating current; frequency of AC. Advantage of AC over DC. Domestic electric circuits.

Theme : Natural Phenomena (20 Periods)

Unit 4 : Convergence and divergence of light. Images formed by a concave mirror; related concepts; centre of curvature; principal axis. Optic centre, focus, focal length.

Refraction; laws of refraction.

Image formed by a convex lens; functioning of a lens in human eye; problems of vision and remedies. Application spherical mirrors and lenses.

Appreciations of concept of refraction; velocity of light; refractive index; twinkling of stars; dispersion of li Scattering of light.

Theme : Natural Resources

(20 Periods)

Unit 5 : Conservation of natural resources : Management of natural resources. Conservation and judicio use of natural resources. Forest and wild life, coal and petroleum conservation. People's participation. Chip movement. Legal perspectives in conservation and international scenario.

The Regional environment : Big dams : advantages and limitations; alternatives if any. Water harvesting. Sustainal of natural resources.

Sources of energy : Different forms of energy, leading to different sources for human use : fossil fuels, solar en biogas; wind, water and tidal energy; nuclear energy. Renewable versus non - renewable sources.

PRACTICALS

LIST OF EXPERIMENTS

Marks : 40 (20 +

1. To find the pH of the following samples by using pH paper/universal indicator.
   - i) Dilute Hydrochloric acid
   - ii) Dilute NaOH solution
   - iii) Dilute Ethanoic acid solution
   - iv) Lemon juice
   - v) Water
   - vi) Dilute Sodium Bicarbonate Solution.
2. To study the properties of acids and bases HCl & NaOH by their reaction with
   - i) Litmus solution (Blue/Red)
   - ii) Zinc metal
   - iii) Solid Sodium Carbonate
3. To determine the focal length of
   - a) Concave mirror
   - b) Convex lens

   by obtaining the image of a distant object.

To trace the path of a ray of light passing through a rectangular glass slab for different angles of incidence. Measure the angle of incidence, angle of refraction, angle of emergence and interpret the result.

To study the dependence of current (I) on the potential difference (V) across a resistor and determine its resistance. Also plot a graph between V and I.

To determine the equivalent resistance of two resistors when connected in series.

To determine the equivalent resistance of two resistors when connected in parallel.

To prepare a temporary mount of a leaf peel to show stomata.

To show experimentally that light is necessary for photosynthesis.

To show experimentally that carbon dioxide is given out during respiration.

To study (a) binary fission in Amoeba and (b) budding in yeast with the help of prepared slides.

To determine the percentage of water absorbed by raisins.

To prepare SO_2 gas, observe its following properties and draw inferences in respect of

i) odour

ii) solubility in water

iii) effect on litmus paper

iv) action on acidified potassium dichromate solution.

a) To observe the action of Zn, Fe, Cu and Al metals on the following salt solutions.

i) $ZnSO_4$ (aq.)

ii) $FeSO_4$ (aq.)

iii) $CuSO_4$ (aq.)

iv) $Al_2(SO_4)_3$ (aq.)

b) Arrange Zn, Fe, Cu and Al metals in the decreasing order of reactivity based on the above result.

To study the following properties of acetic acid (ethanoic acid) :

i) odour

ii) solubility in water

iii) effect on litmus

iv) reaction with sodium bicarbonate

SCHEME OF EVALUATION :

External Examination (to be conducted by the Board through multiple choice type written test)	**20 Marks**
School-based hands-on practical examination.	**20 Marks**

Annexure F

List of Experiments

1. Study of chemical reactions.
2. Types of chemical reactions.
3. Oxidation and reduction
4. Acids and bases in the laboratory.
5. Reaction of acids and bases with metals.
6. Reaction of metal carbonates and metal hydrogen carbonates with acids.
7. How do acids and bases react with each other ?
8. Reaction of metallic oxides with acids.
9. What happens to an acid or a base in a water solution?
10. Dissolution of acid or base in water.
11. Strengths of acid and base solutions.
12. pH of soil samples
13. pH of salts
14. Are the crystals of salts really dry ?
15. Oxide formation with metal and non-metal.
16. What happens when metals are burnt in air?
17. Reactions of metals with water
18. Reaction of metals with acids
19. How do metals react with solutions of other metal salts?
20. Properties of ionic compounds
21. Corrosion – investigating the conditions under which iron rusts.
22. Combustion
23. Oxidation
24. Reduction of ethanol with sodium
25. Properties of ethanoic acid (acetic acid)
26. Reaction of ethanoic acid with carbonates and hydrogen carbonates
27. Cleaning action of soap
28. Hardness of water
29. Action of detergents
30. Is the dye in black ink a single colour?

Annexure G

Training of Teachers in Setting up Microscale Chemistry Laboratory in Secondary Schools

Experiment No.	Aim / Title	Kit materials used	Experimental observations/ measurements	Efficacy in comparison with conventional method	Suggestions for improvement/ modification of experiment/ procedure	Suitable for demonstration	Study activity
1.							
2.							
3.							
4.							
5.							

Experi-ment No.	Aim / Title	Kit materials used	Experimental observations/ measurements	Efficacy in comparison with conventional method	Suggestions for improvement/ modification of experiment/ procedure	Suitable for demonstration	Study activity
6.							
7.							
8.							
9.							
10.							

Experi-ment No.	Aim / Title	Kit materials used	Experimental observations/ measurements	Efficacy in comparison with conventional method	Suggestions for improvement/ modification of experiment/ procedure	Suitable for demonstration	Study activity
11.							
12.							
13.							
14.							
15.							

Experi-ment No.	Aim / Title	Kit materials used	Experimental observations/ measurements	Efficacy in comparison with conventional method	Suggestions for improvement/ modification of experiment/ procedure	Suitable for demonstration	Study activity
16.							
17.							
18.							
19.							
20.							

Experi-ment No.	Aim / Title	Kit materials used	Experimental observations/ measurements	Efficacy in comparison with conventional method	Suggestions for improvement/ modification of experiment/ procedure	Suitable for demonstration	Study activity
21.							
22.							
23.							
24.							
25.							

Experi-ment No.	Aim / Title	Kit materials used	Experimental observations/ measurements	Efficacy in comparison with conventional method	Suggestions for improvement/ modification of experiment/ procedure	Suitable for demonstration	Study activity
26.							
27.							
28.							
29.							
30.							

Annexure II

Training of Teachers in Setting up of Microscale Chemistry Laboratory in Secondary Schools

6 -8th January 2010

Venue : RIE, Mysore

Feedback Form

Name :

Address:

1. How many experiments could you perform? Name them.

2. Whether experiments are relevant in secondary school science teaching?

3. Give your suggestions:

i) Duration of the Programme (less, more, appropriate)

ii) Handling of the apparatus

iii) Adequacy of items in the kit

iv) Comparison of conventional laboratory work and microscale chemistry experiments.

v) Experimental Procedure given.

4. Rating the Programme :

i) Claim vs Actual : Poor / Average / Good / Very Good / Excellent

ii) Conduction : Poor / Average / Good / Very Good / Excellent

iii) Learning : Poor / Average / Good / Very Good / Excellent

iv) Relevance to secondary practical course

5. Affordability of the kit for a secondary school.

6. How would you utilise this training?

7. Comment on the other aspects, if any.

*****

Annexure I

Feedback from Participants

1. **Experiments done :**

All the fifteen participants showed immense interest to perform the experiments. Thirty experiments were chosen from secondary stage textbook. All the experiments were conducted by all the participants who worked in groups of two. In addition to these, preparation and study of the properties of hydrogen chloride gas was done by them.

2. **Duration of the Programme :**

Majority of the participants (about 70%) opined that the duration of the programme was appropriate. Five of them expressed that a little longer duration (five days) would be desirable. They felt that longer duration programme would enable them to have a comparative account of both macro and micro techniques.

3. **Handling the Apparatus**

Miniature glasswares, plastic reagent bottles, W-tube, heating block, micro-filtration set, etc. received great appreciation from the participants. They felt that both students and teachers require some training in handling the apparatus preferably in the beginning of the academic year. They emphasized that one demonstration session can be arranged exclusively for the students before the actual commencement of practical classes. Later, students can be allowed to handle the kit.

4. **Adequacy of Items**

In general, the teachers felt that the items provided in the kit are adequate to perform experiments of class 8,9 and 10. However they expressed that inclusion of some items like big size test tube (to hold 8 ml liquids), platinum loop microbalance would be of advantage.

5. Rating the Programme

The participants were asked to "rate" the programme. For rating five areas were taken. These areas are (a) claim vs. actual, (b) conduction, (c) learning, (d) adequacy for secondary practical course, (e) affordability. For first three areas, the points were poor, average, good, very good and excellent.

In general, the teachers opined that the microscale chemistry kit developed by NCERT is of immense use in carrying out chemistry experiments at secondary stage.

Items	Rating Scale			
	Average	**Good**	**Very good**	**Excellent**
Claim vs. actual	--	10	3	2
Conduction	2	5	1	7
Learning	1	8	6	--

All the teachers expressed that the microscale kit is adequate and affordable in a secondary school.

6. Utilization of the Training Programme

Handling the microscale apparatus was a first experience to all the participants. With their hands-on-experience, the teachers were willing to take initiative in setting up microscale chemistry laboratory in their respective schools/state. They opined that to make a beginning, they will avail local resources, utilize low cost material, to conduct the science experiments. A similar kit to perform experiments in physics and biology area will be tried out.

7. Comments on Other Aspects

a) The apparatus can be a component of the mobile science laboratory.

b) The workshop to be organized at district level in Southern States.

c) The kit to be supplied to all schools by the authorities.

****

Annexure J

List of Participants

1. Sharada H S
   Assistant Mistress
   Govt. High School
   Yaraganahalli
   Mysore – 11

2. M.Gopichand
   School Assistant (Physical Science)
   Govt. High School (Boys)
   New Town, Anantapur
   Andhra Pradesh

3. Latha K
   Assistant Mistress
   Govt Composite High School
   Nizamia, Ashoka Road
   Mysore

4. Dilys Marina
   Assistant Teacher
   Govt. P U College
   Dudda Mandya Taluk
   Mandya

5. Sundaran K
   H S A (PS)
   P P M H S S
   Kottukkala, Kondotty,
   Malappuram (Dt), Kerala

6. K. Lal
   HSA, SRVNSS VHSS
   Chhirakkadavu
   Thekkathu
   Kavala Post
   Kottayam Post, Kerala 686 519

7. Shamjith M
   HSA, GHSS, Iringallur
   Kozhikode, Kerala

8. Manoj Kumar P P
HSA, GHSS, Kannadharamba
Kannur (Dist) 670 604

9. Rajan
HSA (Physical Science)
GVHSS Vattenad (PO)
Koottanad
Palakkad, Kerala 679 533

10. Raghavendra
Asst. Teacher
Govt. High School, Nagamanal
Mandya Dist.

11. T N Sridhar
Zilla Parshad High School (Mandal)
Addakal, Mahabubnagar (Dist)
Andhra Pradesh

12. V Vijaya Bhaskar Reddy
School Assistant
Govt. High School
Mahatma Gandhi Road
Mahabubnagar – 1, Andhra Pradesh

13. Shankara M
Assistant Master
Govt. Composite P U College
Varuna, Mysore (Tq)

14. A V Sudhakar
School Assistant
Z P H S Inukurti
Podalakur (Md)
Nellore Dist, Andhra Pradesh

15. M.Chakradhar
School Assistant, ZPSS
Kurchapally, Raghunathpally
Warangal, Andhra Pradesh