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ABSTRACT

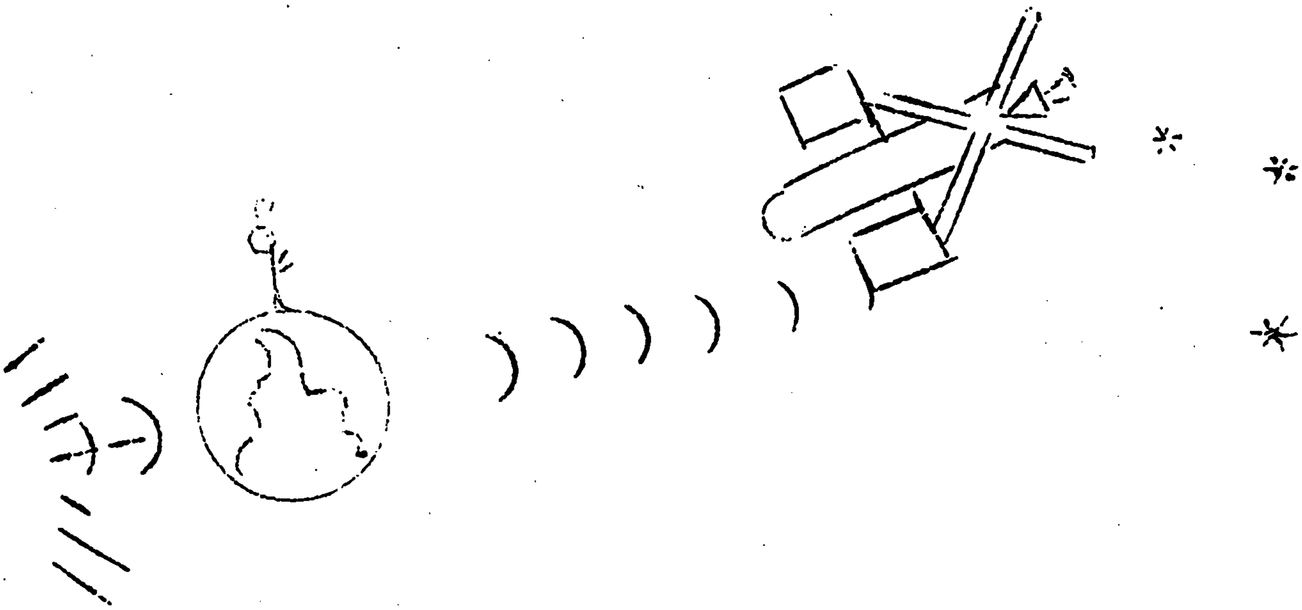
As a supplement to Learning Activity Packages (LAP) of the earth-space project, this manual presents self-directed activities especially designed for individualized instruction. Besides an introduction to LAP characteristics, sets of instructions are given in connection with the metric system, the earth's dimensions, indirect evidence for atomic theory, atomic radius, spectral analyses of energy levels, ionization potential, esters, relationship between a candle and a star, heat content of a candle, mass number, periodic table, photosynthesis, format for term investigation, and precautions in chemistry laboratory. Also included are the following excerpts: Why Support Science?; Living Dangerously in the Age of Science; Point of View (on science development); Will the World Come to a Horrible End?; A Fish Story; and One Small Step--One Giant Leap. Student evaluations are made by using pre-tests, self-evaluation tests, and post-tests. (CC)

INDIVIDUALIZED INSTRUCTION IN SCIENCE

Self-Directed Activities

E.S.P.

Earth-Space Project



Eastchester Public Schools
Eastchester, New York

RM Kuczma

ESP

ACTIVITY I-1-1

A STUDENT GUIDE

AS TO WHAT IS CONTAINED IN A LEARNING ACTIVITY PACKAGE

First, let us answer the question, "What is a LAP?" A LAP or Learning Activity Package, is a set of directions for obtaining specified objectives. It doesn't teach you but rather guides you in obtaining the information you need. Different methods are suggested for your learning. How much you learn depends on you even though your teacher will always be on hand to help.

Just how the directions are carried out and the objectives achieved depend on you as an individual. This means that, instead of always working with the rest of the class as agroup, some of the time you will be working on your own as an individual. You will cover the same material that you would have covered as a group but there are greater benefits to you as an individual, such as:

1. YOU WILL BE WORKING AT YOUR OWN SPEED.

   If you feel, however, that you need extra time, you may finish at home the work not completed at class. This will be your "homework".

2. YOU WILL HAVE THE OPPORTUNITY TO TAILOR THE PROGRAM TO YOUR OWN REQUIREMENTS.

   Because of previous knowledge or experience, you will be free to concentrate more thoroughly on that material with which you are not familiar.

3. YOU WILL HAVE THE OPPORTUNITY TO SELECT THE METHOD YOU WISH TO FOLLOW IN LEARNING.
   Visual aids, such as, film loops or slides, may help you to understand the material in addition to choice of reading references and experiments.

4. YOU MAY WISH TO WORK BY YOURSELF.
   Even if equipment is limited, you will still be able to have your turn. Sometimes, however, after having completed your individual work, you might find it helpful to compare and discuss your results with others.

ACTIVITY I-1-1

Some real advantages have been presented. They should be of benefit and make your work more enjoyable, but, as the saying goes, "You never get anything for nothing." Your contribution is to accept responsibility. No one will be checking constantly to make sure you are working. However, in one way or another, after you have completed the assignment, your knowledge must be tested so, to assure success, you will find it necessary to depend on yourself. However, your teacher will be there to help and guide you.

Let us now take a look at some of the things that make up a LAP:

1. A written guide including:

   a. Unit - the major idea proposed to be learned
   b. Topic - the specific area to be explored
   c. Objectives - goals or guidelines, the achievement of which will help to show your mastry of the learning
   d. Activities - designed to enable you to fulfill the objectives.

      Each Activity has its own set of instructions.

      For purposes of identification, the activities are numbered with the Unit number followed by the Topic number and the particular activity number. For example, I-2-6 stands for Unit I, Topic 2, Activity 6.

2. Vocabulary sheet - to help you to remember new words learned and their correct spelling.

3. Self-Evaluation Test - to test yourself when you think you have mastered the Topic.

4. Answer Sheet for the Self-Evaluation Test. You will mark your own test and use it to recheck your learning.

5. Pre-Test - You will be given a pre-test for a Unit on a Topic to determine your weak and strong points.

6. Post-Test - This is a test designed to see if you have successfully completed sufficient activities and understand the work.

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ACTIVITY I-1-1

You will be expected to keep a notebook which will become your "textbook" and will be needed for review and testing. In addition to the Vocabulary Sheet and the notes you will take as you go through activities and readings, you will keep in this notebook ORIGINAL copies of your activities, the CARBON copies of which will be handed in and then returned with suggestions for rechecking where necessary. In this way, you will be responsible for correcting your own originals and inquiring about points you do not understand.

In order to check on your progress, you will need to obtain a STUDENT PROFILE sheet which you will keep in the front of your notebook. This STUDENT PROFILE will give you a quick summary of the activities you have completed, how well you are doing, and how long it is taking you to do them. You may want to improve your achievement, if they are not what you want them to be, or you may wish to think over better use of your time.

Your grade will consist of the following:

1. Amount of work done (a MINIMUM as well as MAXIMUM number of activities will be posted.)

2. Post-Tests taken

3. Work habits, including:
   a. Use of class time
   b. Care of equipment
   c. Neatness in writing reports
   d. Following directions

4. Attitude or Citizenship
   a. Dependability and honesty
   b. Self-discipline (talking quietly and only when necessary, for example)
   c. Cooperation in clean-up and keeping immediate environment orderly

ESP

PL...SE NOTE: ORIGINAL IS TO BE KEPT IN YOUR NOTEBOOK. CARBON COPY IS TO BE HANDED IN.

NAME ______________________ H.R. __________ PER. __________

EXPERIMENT II-1-5

I. INVESTIGATION: How many calories of heat are produced by one gram of candle?

II. EQUIPMENT: Candle
Test tube (large)
C thermometer
Balance
Pegboard assembly

III. PROCEDURE:

A. Arrange equipment so that candle will heat 100 ml of water in the test tube.
B. Insert thermometer into the test tube.
C. Light the candle and let it burn for five-minute intervals.

IV: OBSERVATIONS:

No. of Trials	Mass of candle at start	Mass of candle at end	Loss of: Mass	T of water: at start	T of water: at end	Inc: in T

A. The average increase in the temperature of the water:

B. The calories of heat produced in each trial:

C. The average number of calories of heat resulting:

D. The average number of grams of candle burned at the end of the investigation.

E. The average number of calories of heat produced by one gram of candle.

V. RESULTS: (Answer the question posed in the Investigation statement)

Discussion Questions: What is heat?
How can heat be measured?

FORMAT FOR TERM INVESTIGATION

PLEASE NOTE: THIS WILL BE A YEAR-LONG INVESTIGATION FINAL PROJECT TO BE HANDED IN AT THE END OF THE YEAR.

THE FIVE PARTS, GIVEN BELOW, WILL BE DUE FOR INSPECTION SEPARATELY ON SPECIFIED DUE DATES.

* * * *

I. STATEMENT OF TOPIC OF CHOICE

II. RESEARCH FOR MATERIAL

To include historical background as well as modern up-to-date concepts

III. SUMMARY OF INVESTIGATION

IV. APPENDIX

To include footnotes (if any), bibliography, and supplementary materials (charts, graphs, pictures, etc.)

V. COMPLETED INVESTIGATION, including

Table of Contents, with numbered pages

Typed or printed materials

BIBLIOGRAPHY & FOOTNOTE FORM

Although you may find that these forms may change from time to time and from publication to publication, the following is one form that is generally accepted. It is important, however, that you note that the BIBLIOGRAPHY and the FOOTNOTE form are not identical.

The purpose of the BIBLIOGRAPHY is quite different from that of the FOOTNOTE. The bibliography, IN ALPHABETICAL ORDER, lists the references used in preparing your report. The footnotes, NUMBERED CHRONOLOGICALLY, cite the exact place where quoted or paraphrased materials were found. IT IS NOT ALPHABETICAL.

The following examples are offered to show the differences between the two forms:

BIBLIOGRAPHY:

Bondi, Hermann. THE UNIVERSE AT LARGE. Doubleday & Company, Inc., Garden City, New York, 1960.

Bonner, William, THE MYSTERY OF THE EXPANDING UNIVERSE. The Macmillan Company, New York, 1964.

Hynek, J. Allen and Norman D. Anderson. CHALLENGE OF THE UNIVERSE. McGraw-Hill Book Company, New York, 1962

Seaborg, Glenn T. and Justin L. Bloom. "The Synthetic Elements: IV" SCIENTIFIC AMERICAN, Volume 220, Number 4, Scientific American, Inc., New York, April, 1969.

"Thermography in Medicine," ENCYCLOPEDIA: SCIENCE SUPPLEMENT, Grolier, Inc., Canada, 1968.

FOOTNOTE:

1William Bonner, THE MYSTERY OF THE EXPANDING UNIVERSE, The Macmillan Company, New York, 1964, p.59.

2Glenn T. Seaborg and Justin L. Bloom, "The Synthetic Elements: IV," SCIENTIFIC AMERICAN, Volume 220, Number 4, Scientific American, Inc., New York, April, 1969, p.56.

3Ibid., p.63.

4Hermann Bondi, THE UNIVERSE AT LARGE, Doubleday & Company, Inc., Garden City, New York, 1960, pp.100-105.

5Bonner, op. cit., pp.69-73

6"Thermography in Medicine," ENCYCLOPEDIA: SCIENCE SUPPLEMENT, Grolier, Inc., Canada, 1968, p.108.

DIG TECHNOLOGY

Editorial

WHY SUPPORT SCIENCE?

Dr. Ernst Stuhlinger of NASA was questioned by Missionary Sister Mary Jucunda of Zambia, Africa, about the effort and wealth spent on space exploration in view of so much suffering on earth. A part of his reply follows:

"Your letter was one of many which are reaching me every day, but it has touched me more deeply than all the others because it came so much from the depth of a searching mind and a compassionate heart. I will try to answer your question as best as I possibly can.

I believe, like many of my friends, that travelling to the Moon and eventually to Mars and to other planets is a venture which we should undertake now. I even believe that this project, in the long run, will contribute more to the solution of these grave problems we are facing here on earth than many other potential projects of help which are debated and discussed year after year, and which are so extremely slow in yielding tangible results.

Before trying to describe in more detail how our space program is contributing to the solution of our earthly problems, I would like to relate briefly a true story which may help support the argument. About four hundred years ago, there lived a Count in a small town in Germany. He was of the benign counts, and he gave a large part of his income to the poor in his town. This was much appreciated because poverty was abundant during medieval times and there were epidemics of the plague which ravaged the country frequently.

One day, the Count met a strange man. He had a workbench and little laboratory in his house, and he labored hard during the daytime so that he could afford a few hours every evening to work in his laboratory. He ground small lenses from pieces of glass: he mounted the lenses in tubes and he used these gadgets to look at very small objects. The Count was particularly fascinated by the tiny creatures which could be observed with the strong magnification, and which nobody had ever seen before. He invited the man to move with his laboratory to the castle, to become a member of the count's household and to devote henceforth all his time to the development and perfection of his optical gadgets as a special employee of the Count.

The townspeople, however, became angry when they realized that the Count was wasting his money, as they thought, on a stunt without purpose. "We are suffering from the plague," they said, "while he is paying that man for a useless hobby!" but, the Count remained firm. "I give you as much as I can afford," he said, "but I will

DIG TECHNOLOGY

also support this man and his work because I know that someday something good will come out of it!" Indeed, something very good came out of this work, and also out of similar work done by others at other places: the microscope.

It is well known that the microscope has contributed more than any other invention to the progress of medicine, and that the elimination of the plague and many other contagious diseases from most parts of the world is largely a result of studies which the microscope made possible. The Count, by retaining some of his spending money for research and discovery, contributed by giving all he could possibly spare to his plague-ridden community.

Every year, about a thousand technical innovations generated in the space program find their ways into our earthly technology where they lead to better kitchen appliances and farm equipment, better sewing machines and radios, better ships and airplanes, better weather forecasting and storm warning, better communications, better medical instruments, better utensils and tools for everyday life. Presumably, you will ask now why we must develop first a life support system for our moon-travelling astronauts, before we can build a remote-reading sensor system for heart patients. The answer is simple: significant progress in the solution of technical problems is frequently made not by a direct approach, but by first setting a goal of high challenge which offers a strong motivation for innovative work, which fires the imagination and spurs men to expend their best efforts, and which acts as a catalyst by inducing chains of other reactions.

Space flight, without any doubt, is playing exactly this role. The voyage to Mars will certainly not be a direct source of food for the hungry. However, it will lead to so many new technologies and capabilities that the spinoffs from this project alone will be worth may times the cost of its implementation."

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The history of mankind's progress has been punctuated by many important events which, at the time of their inception, were looked upon as useless, such as, electricity, the "wireless," and the telephone. In another concept, Alaska was once considered useless and the money spent for it wasteful when so much could be done with the sum to alleviate the problems at home!

Can you think of other examples of short-sighted pre-judgments?

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EARTH, I CARE, Volume 1, Number 6, Earth Care, Inc., Somerville, New Jersey, December, 1971

LIVING DANGEROUSLY IN THE AGE OF SCIENCE

"Mankind has always lived dangerously. The four horsemen of the Apocalypse - war, famine, pestilence, and death - came galloping out of nowhere to destroy unsuspecting, defenseless populations.

Science has made human existence infinitely more secure . . but, . . Whatever mankind has gained in security in the scientific age, it has lost in innocence. It has acquired knowledge of dangers but not the wisdom to deal with them .... His reactions are still predominantly emotional - that means, qualitative ... Americans are continuously exposed to speculations about troubles which could befall them, of dangers lurking ... but they have not learned to evaluate such information critically - that means, quantitatively - and to react accordingly... Communist countries are trying to protect themselves from this tide of worry... How long this unconcern ...will last ... we cannot tell. In the long run, even the Great Wall of China may provide no adequate defense against the infection of knowledge!

The only effective defense against knowledge is more knowledge. It is popular today to emphasize the need of counteracting the fear and despair created by exploding technology by restoring the emphasis on the humanities, on ethical value systems. They alone, it is said, could give people stability and strengthen their will to assert themselves against soulless technology. But man cannot return from the maturity of knowledge to the innocence of ignorance. Mankind needs a new sense of values, a new philosophy, perhaps even a new religion, but these must incorporate and not exclude scientific knowledge. We must make full use of and not throw away our technological capabilities. Humanism must learn to use mathematics, and not submerge it once again in a flood of qualitative, emotional responses.

Malaria means evil air. It was believed that this disease - the greatest single killer of men on Earth - was caused by something noxious in the air of the marshy flatlands near Rome. Science discovered that the danger lurked not in the air, but in the mosquitoes breeding in the swamps and carrying infection to humans through their bites. Chemicals were found - especially DDT - which, sprayed on the swamps, eliminated the disease-spreading mosquitoes within a few years ...Then ... a popular movement arose against chemical insecticides in general and DDT in particular. This movement spread, first in America, and then all over the world. Under its pressure, the Ceylonese government abandoned the DDT-spraying program. The next year, the number of deaths from malaria rose from practically zero to one million ...

LIVING DANGEROUSLY IN THE AGE OF SCIENCE
- 2 -

The answer to dangers raised by the unthinking, massive use of chemical insecticides lies not in prohibiting their use ... It does not lie in depending on mysterious "natural" forces... It can be found only in rational limitation of the use of presently known insecticides and their gradual replacement by less dangerous ones, and in the development of biological control methods ...

We need not a flight back into ignorance but a more rational use of our knowledge ...

Future generations of mankind must grow up, not in sullen alienation or in violent rebellion against the realities of human existence in the age of science, but in clear understanding of the situation created by the scientific revolution with informed will and intellectual capacity to resolve the deadlock, into which evolution of the human animal and his socity, and the growth of his mastery over the forces of nature has brought him. Whether mankind will be successful in taming the three apocalyptic horses of the technological age - nuclear war, population explosion and destruction of the human habitat - depends on sufficiently rapid transportation of the body of knowledge and pattern of attitudes which we transmit to coming generations. A fundamental aspect of the needed intellectual growth is widespread transition fromqualitative to quantitative thinking, and consequent channeling of man's most constructive emotions into constructive action."

Rabinowitch, Eugene. THOUGHTS FOR 1972 - SCIENCE AND PUBLIC AFFAIRS, Bulletin of the Atomic Scientists, Volume XXVIII, Number 1, Educational Foundation for Nuclear Science, Chicago, Illinois, January, 1972.

POINT OF VIEW

One of the most visible and disturbing attitudes held by some students is a strong disillusionment with science and technology.

Some students say science is irrelevant to the important problems of society, while others consider it entirely too relevant - in fact responsible for many of our problems.

A few young people have rejected the entire rational approach to problem solving altogether. Some ex amples of this are the view of a small minority that violence is an acceptable means of political expression: the use of drugs which impair the ability toreason, and the curious and rapidly growing interest in the occult.

Of direct concern to the future of science is the fact that fewer of the most talented students are selecting scientific careers. I view these attitudes as one expression of a declining national interest in basic science. Given the human inclination to over-reaction (the pendulum effect), this trend could easily lead to a future dearth of first-rate scientific leadership.

My recent month-long stint as a substitute high-school physics teacher helped me see more clearly how scientists at the "grass roots" level can make useful contributions toward a partial solution. Specifically, scientists should make clear the difference between science as KNOWLEDGE, having no inherent ethical characteristics, and science-related ACTIVITIES, which affect society more or less directly and involve moral responsibility for their consequences. Students see misapplications of scientific knowledge in war and pollution and conclude that the acquisition of that knowledge (research) is a harmful activity.

This opinion is shared by a few scientists who feel that research in certain areas should be curtailed because such knowledge contains the POTENTIAL for immoral or socially harmful application outside the laboratory. Such reasoning, if carried to its logical conclusion would lead us to become a species of intellectual ostrich which has stopped inquiring about the world it inhabits. Pure science should be viewed as the independent intellectual experience it is.

POINT OF VIEW
- 2 -

What's more, in my view the scientist is obligated to participate in political decisions regarding the use of science, even though the research activity itself is ethically and socilogically neutral. The research applications, as well as the SCIENTIST himself, have an important impact on society. Our social structure is irrevocably linked to technology: its future will be greatly influenced by new technologies to be drawn from the available body of scientific knowledge .....

We should also accelerate the trend for scientists to involve themselves in the political process and thus demonstrate by example the public and socially useful role of the scientist. And we ought to establish a climate of opinion that will ensure that science continues to attract its fair share of the brilliant and highly motivated people who will provide scientific leadership 10 or 20 years from now.

W. W. WARREN, JR., BTL, PHYSICS

WILL THE WORLD COME TO A HORRIBLE END?

"Doomsday predictions have been popular since biblical times, but the sources of doom are changing. Famine, war, and pestilence have always been the old-time favorites - so much so that people have almost learned to live with them. The possibility of destruction of life on Earth by the impact of a large asteroid, or by the radiation effects of a close-by supernova or a solar superflare, has not evoked much public concern - which is perhaps surprising because the probability of such natural catastrophe, though small, is finite.

Instead, the current fashion seems to be to predict ecological disasters. For a while there was great concern that we would run out of oxygen because of the burning of fossile fuels. This particular concern was laid to rest recently and condlusively. Another concern for global oxygen came from the possible effect of DDT on marine phytoplankton. This particular problem was first raised by L. V. Berkner and L. C. Marshall, but is judged to be a problem no more. After many years of speculation and discussion, the effects of fossil fuel burning on climate seem to be reasonably clear. While there has been an actual increase in the CO_2 content, the "greenhouse effect" of climate warming has been small, and even negative, because of the overwhelming effects of atmospheric dust which tends to cool the atmosphere. Even the long-range effects of CO_2 are likely to be reduced, partly because of the buffering action of the ocean, partly because of the increased photosynthetic absorption and storage by prospective exhaustion of fossil fuels.

New technologies do not always produce major clear-cut global effects. For example, operation of a fleet of SST's might decrease stratospheric temperature somewhat because of the emission of water vapor; on the other hand, it might also increase stratospheric temperature because of the production of particles. But there is no evidence for sea-level changes or for adverse effects on life due to increased ultraviolet transmission.

Does this mean that we can now forget about ecological disasters? On the contrary; it is absolutely necessary to investigate each and every one of the side effects of our modern technology to its final conclusion and examine their possible influence on the global climate and on the ocean. There is probably nothing more important to man's future on this planet than anunderstanding of the long-range effects of his activities. The history of Earth gives abundant evidence of cataclysmic happenings. The stability of climate, for example, is not known, nor is it known how close we are to the limit where another ice age could be triggered. The possibility that we might inadvertently set off an irreversible reaction must constantly be kept in mind.

WILL THE WORLD COME TO A HORRIBLE END?

At the same time, we should be careful not to cry "wolf" needlessly or too often. The public and the media give special weight to statements from anyone who is a scientist, provided they make news. Scientific credibility can easily be lost by exaggerated claims and extravagant statements. We need to provide a voice of reason, not just of alarm. As scientists, we have the responsibility to speak up, but we also must know when to stop talking."

S. FRED SINGER, Chairman, Committee on Environmental Quality, American Geophysical Union, Washington, D. C.

ACTIVITY II-1-12 G

A FISH STORY

It was a very large egg. The egg was so large, it was embarrassing for the mother to look at it. The egg rested in a shallow depression filled with water. Now and then it rolled violently in the water and bobbed up and down. The little animal on the inside struggled to free itself from its prison. Finally the protective envelope split, and the little animal flipped himself into the pond and stared into the eyes of his mother..

The offspring definitely had a face that only a mother could love, but the most curious thing about him was not his face at all. His front appendages were NOT fins! Where he should have jad two respectable fins, he had two ugly, muscular, bony projections with five useless digits on the end of each.

The father looked at his son with concern. Then he looked at his wife. "This must be your fault. This has never happened on my side of the family. All my ancestors were perfectly normal."

In order to hide her guilt, the mother shyly cleaned her pectoral fin on a piece of projecting rock. In the meantime, Junior climbed up the muddy bank and scooted headfirst into the water. His parents watched him. Junior pulled himself onto the muddy bank; and then by digging his digits into the soft ooze, he squirmed and twisted until he was free of the water. He stared back at his father.

Father look at mother. "I can't condone this kind of behavior.. Do something."

Mother was helpless. She could shout, but Junior could see only the silent bubbles rising to the surface of the water. Presently he slid into the water again.

All of this was making father angry. "I forbid him to do that again. I suggest you spend more time teaching this child how to seim." He flipped his caudal fin and swam off, leaving a vapor trail of displaced algae.

Mother looked at her son. How do you teach someone how to swim who is not equipped for it? But she did her best. Day after day she showed him how to position himself in the water, how to use his tail fin, and how to surface and dive. Junior failed completely. He propelled himself to the surface of the water and then sank like a rock. To move from one place to another, he had to crawl along the muddy bottom. It was a real effort for him to breathe, since it was such a struggle to reach the pond surace and gulp the air, so he spent most of his time playing in the shallow water where gulping air was easier..

Because of this, he became an outcast. Even members of his own family avoided him, and his father looked upon Junior as an unhappy accident.

"All the fish in this pond have lobed fins. I have lobed fins, your mother has lobed fins, your sisters and brothers have lobed fins." He looked as though he might cry. He glared at Junior.

Junior's trips up the pond bank became more frequent and, each time, the return trip took longer. He had strange tales to tell his mother when he returned. He talked about how bright the sun was, and how it dried his skin and made him thirsty. He talked about how heavy he felt on land, but most of all he talked about the other ponds he had not yet reached.

As time passed, Junior matured. His arms became stronger. He could stay for long periods out of water. He felt that he was making progress but the meaning of the word was not clear to him.. Does progress mean that you become more like those around you? Or does progress mean that you move towards a goal? If you are different, can you make progress? Junior felt guilty so he spent most of his time on the muddy pond bank which had become his second home.

One day he noticed that his spot was farther from the waterline than it had been the day before. The day after that the distance was still farther. It suddenly dawned on him that the pond was drying up. He told the rest of the community. They laughed at him..

The next day Junior left the pond. His strong legs pulled him across the mud flats, and he soon found himself some distance from his home pond. From the shelter of a rotten log, he watched the pond become another mud flat. As he watched, a thought flashed across his mind: "Progress means the opportunity to survive!" He dove into another pond.

He felt right at home. The pond was muddy and cool and full of friendly fish. Junior told them about his experience. He showed them his forelimbs that gave him the opportunity to survive. He told them that forelimbs were more progressive than fins because they allowed him to search for water. He went so far as to state that some day his descendants would be romping around on land and using pools only to play in.

"Very interesting," said one fish, "I wonder if your few remaining friends back in your pond agree with you."

He looked at Junior's forelegs. "What if you found yourself a mile from shore at a depth of 50 feet?"

Another question was thrown at him from the rear of the audience.

"We don't understand what you mean by OPPORTUNITY. In this pond we like to think we have EQUAL opportunities." The audience nodded their collective heads in agreement.

Junior stood his ground. "Why do you think I left my home pond? They say the early bird gets the worm, but which fish gets it? You and I both know it's the fish with the biggest, fastest' fins. I should know. I've been eating leftovers all my life."

The noise became deafening. Crayfish scrambled for cover. The pond became thick with churning bodies. Screams of protest were heard; and somewhere in the deep, a voice shouted, "He's not even a fish!"

Junior escaped by pulling himself up on the bank. He knew he could never go back in.

He set out for another pond. That pond was millions of years away. It stretched across timeless dawns and melted into the twilight of modern time.

Did he mak it? Of course he did, or we wouldn't be here, would we? But it does make you wonder how many ponds are left and how to know the right one when you find it and, when you do find it,will you be allowed to go in.

Erwin A ..Steinkamp

SCIENCE AND MATH WEEKLY, Volume 7, Issue 13, January 4, 1967, T.E.
American Education Publications, Inc., Middletown, Connecticut

ACTIVITY II-3-1
INTRODUCTION TO METRIC SYSTEM
Linear Measurements

Our system of measurement in the United States (the English system seems fairly easy to us. We know that, for example, 1 foot is equal to 12 inches or that 1 yard equals 3 feet because we have used these figures all our lives. However, what about considering how many inches there are in 6,721 yards? In order to get the answer, we have to multiply:

```
   6721
X ____3  (1 yard = 3 feet)
  20163
X ___12  (12 inches = 1 foot)
 241956  in.
```

Suppose, instead of doing all that multiplying, you could just move a decimal point? How many millimeters in 6721 meters? Since the Metric system is based on tens, and there are 1000 mm (millimeters) in one m (meter), to find out how many mm in 6721 m, all you need to do is move the decimal point three places (thousands):

6721 m = 6721 000 mm
/
understood decimal

Most of the world feels that moving decimal points is much easier and more accurate than multiplying various units as in the English system. Therefore, most of the world today uses a system of measurement called the Metric system. Instead of having to worry over fractions, inches, feet, yards, rods, furlongs, ounces, pounds, quarts, pecks, etc., etc., all you would have to remember are milli, centi, and kilo:

milli	stands for	1/1000	of a certain quantity
centi	"	1/100	"
kilo	"	1000 times	

You probably recall the prefixes for larger and smaller units used in the Metric system in the information on Scientific Notation. Can you remember what MEGA (as in megacycle) represented?

In order to make it even easier for you to remember the prefixes, it may help to think of the meter as one dollar:

If 1 dollar represents 1 meter
then, just as

<u>100 cents</u> = 1 dollar	<u>100 centi</u>meters = 1 meter
<u>1 cent</u> = 1/100 of a dollar	<u>1 centi</u>meter = 1/100 of a meter
<u>10 mills</u> = 1 cent	<u>10 milli</u>meters = 1 centimeter

As you can see, our currency is easy to use because it is based on tens, just like the Metric system.

Obtain a ruler that has both systems on it. Note on the Metric side that each centimeter is divided into ten millimeters. Two centimeters + 5 millimeters would be written as 2.5 cm since the 5 millimeters (mm) are tenths of a centimeter (cm). Into how many parts is the inch divided? How many inches does 2.5 cm represent?

You will need the ruler for the rest of the activities so keep it as you go on to Activity 2.

ACTIVITY II-3-2

A

B

ACTIVITY II-4-1
INTRODUCTION TO METRIC SYSTEM
Volume

Lines are not the only things we measure. We also need to know how much space objects may occupy. This taking up of space is called "volume" and, in the English system, you are probably familiar with the word "cubic" such as, cubic feet or cubic yards. In the Metric system, the unit of volume is the cubic centimeter. The same ease of working with numbers applies to volume as it did to linear measurements. In the Metric volume, you work with decimals. You do not have to worry about fractions or conversion from unit to unit.

If you are measuring a regular object, such as, a book, you can use a ruler to get the three measurements needed: length, width, and height. What happens, however, if you have to measure the volume of an irregular object, such as, a rock or a nail? It would take too long a time and probably would not be accurate anyway if you had to use a ruler. The Metric system gives us an easy, practical method to do this difficult job. It is called "water displacement." You probably have experienced water displacement - when you have stepped into the bathtub! The water you had run into the tub reached a certain height when you shut off the water coming from the faucet. When you stepped into the tub, did you ever notice how the water rose? What caused it to rise? Of course, <u>you</u> did. Since two bodies of matter cannot occupy the same space at the same time, either the water molecules or you had to give way. Since you are a solid compared to the water which is a liquid, the water molecules had to give way for you and the molecules displaced by you had to go some where so you saw the water level rise. By how much did the water level rise? By the amount of space you occupied. You displaced the water molecules by the amount of space that you took up. Could you measure how much space you took up? You have probably guessed that the amount was equal to the amount of rise in the water level. In other words, the difference in the water levels was equal to your volume.

Instead of using a bathtub to measure irregular objects, scientists use a very handy tool called the "graduated cylinder." The "graduated" refers to the markings on the cylinder. If you look at a graduated cylinder you may notice that it is marked in units of ten, just like the Metric ruler. However, since these units deal with a liquid and, therefore, volume - the unit of measure is the milli<u>li</u>ter instead of milli<u>me</u>ter as you noticed in using the ruler. Abbreviated it would be ml instead of mm. However, since ml and cm^3 both are units of volume, these may be used interchangeably. Why this is so will be explained later.

PLEASE NOTE: In using a graduated cylinder, you may observe that the liquid contained therein is not flat but curved. (The proper way to read the liquid is to hold the area at eye level.) This curve is called the "meniscus." The lowest part of the meniscus is the correct reading, provided the liquid wets the cylinder. In the case of mercury, however, which is a metal but in liquid form at room temperature, the cylinder remains dry and the correct reading is taken at the top of the meniscus.

ACTIVITY II-5-1
INTRODUCTION TO METRIC SYSTEM
Mass

One of the most important concepts of matter in the modern age is that of mass. It is especially important since we have started space exploration.

Mass in science refers to the quantity of matter - how much there is of a substance. This is quite different from how much it weighs. A given quantity of matter will remain the same if nothing is done to remove any part of it but its weight will change depending on how the force of gravity acts upon it. The greater the pull of gravity, the greater the weight; the weaker the pull of gravity, the smaller the weight. Mass, then, is the amount of matter in a substance while weight is the degree to which gravity is pulling on the given amount. An astronaut, weighing on Earth about 160 pounds, will in deep outer space weigh zero while on the moon, about one-sixth his Earth weight. However, whether in space or on the moon, the amount of matter of which he is made remains the same although his weight varies with the gravitational environment. Mass is constant, while weight changes.

Working with a factor that would constantly change would be complicated and inaccurate to say the least. For that reason, science used the concept of mass. How can we overcome the force of gravity on Earth (or anywhere) in making mass measurements? Isn't gravity constantly pulling on the amount of matter we are measuring?

ACTIVITY II-5-1
INTRODUCTION TO METRIC SYSTEM
MASS
- 2 -

To overcome this problem, science makes use of the equal arm balance which measures the unknown quantity of matter against a known quantity set up as a standard. Balancing one against the other cancels the effect of gravity.

The standard used is the gram. Undoubtedly some other intelligence on some other planet has its own standard but, should we ever meet, comparisons could be made and a conversion system made. It, therefore, really makes no difference what standard is used - stones, beads,grain or whatever, AS LONG AS EVERYONE ELSE USES THE SAME UNIT.

How this standard came to be universally adopted on the planet Earth will be discussed in the next Topic.

ACTIVITY II-6-1

INTRODUCTION TO METRIC SYSTEM: HISTORY AND MODERN DEVELOPMENT OF MEASUREMENT

Mankind has always had a need to make measurements. How did we, in the United States, come to use the British or English system rather than the Metric? As the name itself implies, it was imposed on us when we were colonies of England. Because we have become accustomed to this system, it seems easy to us but a look into its beginnings and accuracy have made us aware, in this modern age, that it might be to our advantage to make a change to a system now being used universally. Even England itself has now gone on the Metric system.

Britain was (and still is) a form of monarchy. Tradition gave royalty undue powers and obedience. When man began to need to make more accurate measurements, the monarchy decided that 3 barley corns should equal an inch; that its royal foot should equal "one foot"; that that the standard yard would be the length from its royal nose to its outstretched arm; that a rod would equal the length required to hold the royal attendants; etc. Of course, since royalty's measurements were not all the same, the measurements from court to court would vary with the shoe size or arm length! This, then, was the precise mode of measurement which we inherited.

There was one saving grace, however. When we declared our Independence, our forefathers had the good sense to make our monetary system based on tens, like the Metric system.

ACTIVITY II-6-1
INTRODUCTION TO METRIC SYSTEM:
HISTORY AND MODERN DEVELOPMENT OF MEASUREMENT
- 2 -

In the meantime, other nations around the world realized the need for an international standard and, in 1792, soon after the French Revolution, French scientists met and determined a standard measurement for the meter, based on measuring one ten-millionth of the distance from the equator to the North Pole on the meridian that passes through Paris. A platinum bar measuring this distance was then used as the standard meter. In 1875, a meter stick, based on the bar adopted as the standard meter, was placed at the International Bureau of Weights and Measures at Sevres, France. This was still not a very precise instrument of measurement since expansion and contraction of metals did make changes in the length and no one could be absolutely sure about the accuracy of one ten-millionths of the distance from the equator to the North Pole on the meridian that passed through Paris but it was certainly more accurate than barley corns or a king's foot.

In 1960, a standard was used that could be duplicated in every laboratory around the world - the wavelength of the orange light from a Krypton isotope (an element of Krypton having same atomic number but different atomic mass). The wavelength is given as 1,650,763.73 Å or 1.65×10^6 Å. The Å stands for "angstroms" and is a unit of measuring wavelengths and other dimensions too small for our normal purposes. One angstrom is equal to 1×10^{-8} cm. Since wave lengths are a characteristic property of what is called the "Electromagnetic Spectrum" (see the chart on page 143 in TERMS,

ACTIVITY II-6-1
INTRODUCTION TO METRIC SYSTEM:
HISTORY AND MODERN DEVELOPMENT OF MEASUREMENT

TABLES, AND SKILLS), this would not be affected by heat or cold or other physical factors which could alter measurements of metals.

In 1964, the 12th General Conference on Weights and Measures defined the liter as a volume exactly equal to the cubic decimeter or 1000 cm^3. In order to save time and space, instead of using cm^3 this was shortened to cc (cubic centimeter). Since milliliter is the unit for volume for liquids (but still volume) today cc and ml are used interchangeably inasmuch as cc also stands for volume. Laboratory apparatus is usually marked "ml" although one may see "cc" on some.

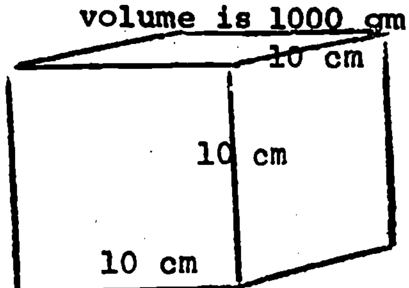
It was further decided that the mass of water at its greatest density filling the volume would equal 1000grams or gm. Please note that gram is abbreviated to "gm" in the modern use since "g" - the older use - may now be confused with our space use of gravity as small "g".

In summary then:

1. The meter is based on a wavelength of Krypton

2. The volume is based on one cubic decimeter (which, in turn, is based on the meter) One decimeter = 10 centimeters.

3. The mass of water at its greatest density filling the volume is 1000 gm (1 kgm)



= 1000 cubic centimeters
1000 cc (cm^3) (linear)

1000 cc holds 1000 ml (volume)

1000 ml has mass of 1000 gm (mass)

THEREFORE: if 1000 cc is equivalent to 1000 ml which is 1000 gm
then 1 cc " 1 ml " 1 gm

ACTIVITY II-6-1

INTRODUCTION TO METRIC SYSTEM:
HISTORY AND MODERN DEVELOPMENT OF MEASUREMENT

If we add one other fundamental unit to the centimeter-gram, that is, TIME, we have the fundamental units of the CGS Metric system: centimeter-gram-second. These three - standing for length, mass, and time - are considered the fundamental units of measurement. All other units are combinations of these three. It is interesting to note that time is also standardized on the vibrations of the Cesium atom and work is now in progress to firther the accuracy of time by use of the vibrations of the Hydrogen atom.

For some scientific work it may be more convenient to use 1000 cm and 1000 gm instead of 1 cm and 1 gm. This becomes known as the MKS Metric system: meter-kilogram-second. (The English system, as you probably have guessed by now, is called the "Foot-Pound-Second" system of FPS.)

A year after the Civil War, Congress had before it a bill to change our English system to the Metric. More than a hundred years have gone by with nothing done. This past summer, the bill was once more brought before Congress for consideration. If you were a member of Congress, how would you vote?

The Metric system is now being used in the design of rockets, for example, the "Maverick" is the first U.S. missile to be completely designed on the Metric system. Model rocketry has now converted to the Metric. Of course, science classes use the Metric system because of the need for greater accuracy and desire to eliminate time wasted ih doing mathematical problems in the English. It has been estimated from the experience of other countries that it takes approximately two generations to make a complete conversion to the Metric. How long do you think it will take us?

REMEMBER AT ALL TIMES: You are participating in a LABORatory and not labORATORY

WARNING TO ALL STUDENTS IN CHEMISTRY LABORATORY

1. Do not smell, touch, or in any way handle any chemicals except under teacher supervision.

2. Do not plug in any electrical equipment except under teacher supervision.

3. Report any defects in gas fixtures, electrical outlets, and connections immediately.

4. In case of fire, NEVER USE WATER ON: sodium, potassium, calcium, calcium carbide, sulfuric.

5. Do not discard broken glassware, chemical residues, etc., into the wastepaper basket unless directed to do so. Place in specified area only.

6. Do not experiment with rocket fuels.

7. Never add water to concentrated sulphuric acid. ADD ACID TO WATER in small quantities, stirring all the time.

8. Do not handle white phosphorous. This must be kept under water.

9. Never look into the mouth of a test tube while heating it. Point it away from yourself or any other person watching.

10. When heating liquids in test tubes, heat from upper portion then downward.

11. If bunsen burner burns atspud, shut off gas supply immediately. Do not touch the barrel.

12. In experiments of gas collection by water displacement, delivery tube must be removed from generating flask at end of experiment. If thistle tube is used for addition of acid, make sure that delivery tube is not clogged.

13. Do not handle glass tubing immediately after firing.

14. Use rubber gloves when handling appreciable quantities of acids or alkalies.

WARNING TO ALL STUDENTS IN CHEMISTRY LABORATORY

15. Never force glass tubing into stoppers.

16. In case of mercury spill, do not handle with your hands or let it get on gold belongings, such as, rings.

17. In preparing oxygen, do not contaminate oxidizing agents
    do not drop wood splints into hot mixtures

18. In preparing hydrogen, never ignite gas coming from generator until you are sure there is no air residue.

19. In dehydration of sucrose by concentrated sulphuric acid, never touch the lump of carbon remaining.

20. In preparation of halogens (bromide, chlorine, iodine) do not inhale vapors.

* * * * * * * * * * *

ESP

ACTIVITY III-2-4

UNIVERSAL UNITS OF MEASUREMENT: EARTH

I. PROBLEM: To determine the mass, volume, and density of the earth. (METRIC SYSTEM only)

II. EQUIPMENT:

Styrofoam ball	Galena
Pins	Calcite
Protractor	Balance
	Graduated cylinder

III: PROCEDURE:

A. Determining the mass of the earth
1. Using the formula for density, rewrite the formula so that mass equals the other factors.
2. What information will be needed before proceeding?

B. Determining the volume of the earth
1. Determine the geometric figure that represents earth.
2. Find the formula for the volume of such a figure.
3. What further information will be needed before you can proceed with the volume?
4. Find the formula that could be used for finding radius.
5. What further information will be needed?
6. Determining the circumference of the earth:
   a. The method of Erotosthenes
      Read pages 32-33 in EARTH SCIENCE (Silver Burdett)
   b. Recheck with styrofoam ball as the earth

C. Having the circumference, find the radius -
   " " radius " " volume

D. With the volume calculated, determine the density of earth:

Since the density of the earth is an average of the density of its interior and of its surface, use the two mineral samples to obtain the average density. Galena will represent the earth's interior while the calcite will represent the earth's surface.

E. Determine the mass of the earth

IV. OBSERVATION: Answer all the questions

V. RESULTS:

A. The mass of the earth is: ______________gm
B. The volume of the earth is: ________________cm^3
C. The density of the earth is:____________________gm/cm^3

ACTIVITY III-3-1A
INDIRECT EVIDENCE FOR ATOMIC THEORY

I. PROBLEM: To explain conductivity of solutions

II. EQUIPMENT: Conductivity Apparatus
Dilute solutions of sodium chloride
sodium hydroxide
hydrochloric acid
sugar
alcohol

III: PROCEDURE:

1. Support the electrodes in the solution by clamping to a stand.

2. Insert plug into a 110 volt AC outlet. DO NOT TOUCH THE ELECTRODES. (They should be immersed in the liquid.)

3. Note the brightness of the 25 watt lamp (or other wattage).

4. Remove the plug from the outlet. Loosen clamp and move electrodes upward permitting beaker with solution to be removed. Rinse the electrodes with water before repeating activity with other solutions to minimize contamination.

IV: OBSERVATION:

1. Prepare a comparative chart of solutions used and brightness of lamp.

2. List any other observations you may have made.

V. RESULTS:

1. List those solutions which conduct a current (electrolytes).

2. List those solutions which do not conduct a current (nonelectrolytes).

3. Explain what you think constitutes the difference between electrolytes and nonelectrolytes.

4. From observation alone, it would appear that there may be a break in the circuit inasmuch as the electrodes are not connected by any wire through which electrons might flow. How, then, does the lamp light when it does?

5. Summarize an explanation of the conductivity of solutions.

ESP

ACTIVITY III-3-1B
INDIRECT EVIDENCE FOR ATOMIC THEORY

I. PROBLEM: To demonstrate that water is H_20 and not HO

II. EQUIPMENT: Electrolysis Apparatus
Dilute HCl or N_aOH, depending on apparatus used

III. PROCEDURE:

1. Fill the beaker of apparatus about half full with water.
2. Prepare the two test tubes for gas collection.
3. Connect 6V battery to terminals of apparatus.
4. Add the acid or base.

IV: OBSERVATION:

1. Note in which test tube collection of gas is faster. To which battery terminal is this test tube connected?
2. Note to which battery terminal the slower collecting test tube is attached?
3. Of what significance are the above two observations?
4. When one test tube is full, disconnect the battery clips and note where the level of water is in the second tube.
5. Determine the volume of gas collected in each tube after having tested with flaming or glowing splint to prove your guess as to which gas is which. (Since water is made of hydrogen and oxygen, which tube held which?)
6. What is the ratio of hydrogen to oxygen according to your data?

V. RESULTS:
1. Answer the questions in Observation.
2. What is the theory behind the concept of water as H_20 rather than HO?
3. How did your experience prove or disprove the theory?
4. Noting that electrolysis is the process of decomposition of a liquid (in this case, water) by means of an electric current, how would you explain the collection of gases at the electrodes?

ACTIVITY III-3-2
INTRODUCTION TO ENERGY LEVELS
Spectral Analysis

HISTORICAL BACKGROUND:

In 1887, Jacob Balmer studied the spectrograph of hydrogen and found characteristic lines.

This observation remained merely a scientific curiosity until Niels Bohr, a young reserach student at Rutherford's laboratory, suggested that the lines in the Balmer spectra were the results of specific frequencies. He further suggested that the electrons do not radiate energy while in orbit but only when changing from outer to inner orbit. When an electron absorbs energy, it jumps to an outer orbit. When it falls back, it emits the energy which, if within the visible spectrum, we then see as a color.

EMISSION SPECTRA: may be

1. Continuous: incandescent solids or liquids and incandescent gases under high pressure

2. Bright line: incadescent or electrically excited gases under low pressure

(SEE COLOR PLATES II AND III between pages 230 and 231 in MODERN CHEMISTRY)

- - - - - - - - - - - - -

INSTRUCTIONS:

1. Observe various salts available by color of flame and spectroscope. Note the Angstrom scale.

2. Observe fluorescent light and white light with spectroscope.

3. Observe elements (hydrogen, helium, etc.) under high voltage.

4. In each case, draw the spectrum according to scale.

5. Write up your experience as an experiment for possible use by other students:

    I. PROBLEM
    II. EQUIPMENT
    III. PROCEDURE
    IV. OBSERVATION
    V. RESULTS

ACTIVITY III-3-7
IMPORTANCE AND USE OF IONIZATION POTENTIAL

In your observation of various spectra, it was pointed out that the different lines were considered evidence for different levels of energy within the atom. When heat or electrical energy were applied to an atom, the electrons were activated to "jump" from inner to outer shells. The atom in this condition is called as one in an "excited state." As the electrons dropped back to lower energy levels nearer the nucleus, they gave off energy in the form of light. Each different colored line represented a different wavelength of energy. Electrons in their normal shells, with energy at minimum, are said to be in "ground or rest" state.

So far, you were aware that energy could be used to rearrange electrons within an atom. Suppose, however, that a large amount of energy were provided sufficient for the valence electrons not only to be rearranged but also to be ejected from the atom - to break away from the atom. Before electrons can be separated from an atom, the attractive force between the negative electron and the positive nucleus must be broken. The amount of energy required to cause this breaking away in any given atom is called the ionization potential of that element. The unit for this energy is "electron volt" written usually as ev.

The ionization potential, as given, accounts for the amount of energy needed to remove a single electron. To remove more than one takes increasing amounts of energy. When elements combine to form compounds, their respective IP (ionization potential) determine the

ACTIVITY III-3-7
IMPORTANCE AND USE OF IONIZATION POTENTIAL

kinds of bonds that will be formed to hold the structure together. Although there are several combinations, the three main kinds of bonding are IONIC, COVALENT, and METALLIC.

In ionic bonding, valence electrons are lost or gained with resulting ions formed which then join together. In this case, the IP will show unequal energies. Ionic compounds are sometimes called electrovalent. NaCl is an example - a compound made up of ions, not molecules.

In covalent bonding, valence electrons are neither lost nor gained but shared equally between the two atoms concerned - cooperating in their sharing of one electron from each atom. In such cases, the IP of each is usually equal or almost equal. When only one pair of electrons holds two atoms together, we speak of a single covalent bond or single bond. Two covalent bonds are referred to as double bonding. Three shared pairs are called triple bonding.

Sometimes the center of negative charge does not exactly coincide with the center of positive charge, causing one end of the molecule or compound to be more negative while the other end becomes more positive. Water is a good example of what is called a "dipolar" covalent molecule. HOLD A CHARGED RUBBER ROD TO A STREAM OF RUNNING WATER. How could you explain what you observe?

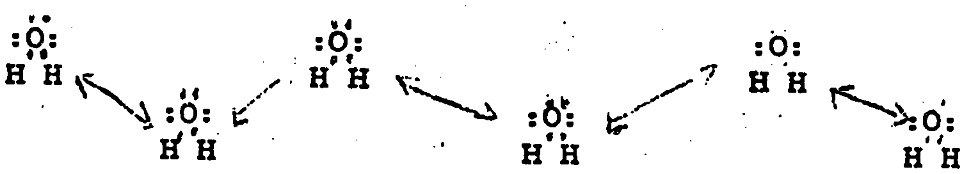
If it happens that one atom supplies both electrons, then we have what is referred to as a coordinate covalent bond or coordinate bond. the ammonium ion is an example: NH_4^+

```
  H
H:N:H
  H
```

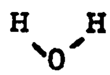
The third main type of bond, the metallic, is different from the ionic or covalent because the valence electrons, swimming in a cloud of electrons since the atoms are usually large, are not tightly held to the nucleus and are free to move around, making them good conductors of electricity since moving electrons constitute electricity. If these electrons were moving in a wire, we would then have current electricity.

A special kind of bonding that is of interest not only to the chemist but also to the biologist is the "radical". In this case, a group of atoms of unlike elements are joined together to form an ion and acts in a chemical reaction as it it were one entity. Its valence number is usually the sum of the total valences. The hydroxide ion is OH since oxygen, with a valence of -2, and hydrogen, with a valence of -1, produce a radical with a valence of -1 since -2 and +1 equal -1.

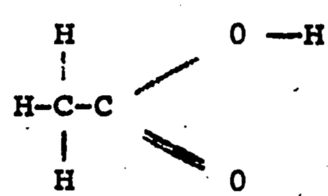
Another bonding of considerable interest to both chemist and biologist is "hydrogen bonding." This is an electrostatic attractive bond between molecules with hydrogen atoms bonded to such atoms as oxygen or nitrogen. The hydrogen bonding in water helps to explain many of the properties of water such as boiling, freezing, and density of ice. The hydrogen bonding in water may be represented as:



How can bonding be represented? The electron-dot method, above, is one of the ways used. Another symbol used to show bonding is the bond line:



A compound with bond lines is referred to as a "structural" formula giving a two-dimensional picture of a three-dimensional structure. This type of bonding representation is very useful in showing organic compounds where structure is of prime importance. In organic chemistry the bond line usually represents a shared pair of electrons. One line shows single bonding while two lines show double bonding:



STRUCTURAL FORMULA OF ACETIC ACID, CH_3COOH
Organic Compound

Prediction of what kind of bonding will take place is possible through an understanding of the ionization potential and its counterpart, the ELECTRONEGATIVITY of an atom, or the ability of the atom to attract electrons.

Bonding leads to the concept of the formation of compounds and the writing of these compounds into chemical equations for ease in reading and visualizing reactions. Achemical equation consists of three main parts:

$$\text{Reactants} \xrightarrow{\text{(Yield)}} \text{Products}$$

WORD EQUATION: Hydrogen + Oxygen react to yield Water

CHEMICAL " : $H_2 + O_2 \longrightarrow H_2O$

Since, according to the Law of Conservation of Mass, atoms cannot be gained or lose in a chemical reaction, the chemical equation must be balanced so that the number of atoms in the Reactant side equals the number of atoms in the Product side. Looking at the equation: $H_2 + O_2 \longrightarrow H_2O$ and adding up the atoms, we find:

	H	O
Reactant	2	2
Product	2	1

The equation is not balanced and some correction must be made. Where should we begin to do this? The obvious discrepancy lies with the number of oxygen atoms - another oxygen atom is needed in the Product side of the equation:

$$H_2 + O_2 \longrightarrow 2\ H_2O$$

(This "2" is called a "coefficient"

Why do we put the "2" before the water molecule and not in front of the oxygen atom or as a subscript (number following the atom and immediately below the symbol)? You probably will recall from your previous experiments with water that the formula for the water molecule has to be H_2O. Putting the subscript 2 a fter the oxygen atom would produce H_2O_2 which is not the formula for water but of peroxide! Putting the coefficient of 2 between the hydrogen and the oxygen would distort the formula. This cannot be done since the formula cannot be changed without changing the substance.

Now looking at the equation $H_2 + O_2 \longrightarrow 2\ H_2O$ would you say that the Reactants equal the Product?

	H	O
R	2	2
P	4	2

The equation is still not balanced although the original imbalance of oxygen seems to have been corrected. What can we do now? Just add 2 more hydrogen atoms to the Reactant:

$$\underline{2}\ H_2 + O_2 \longrightarrow 2\ H_2O$$

	H	O
R	4	2
P	4	2

The equation is now balanced.

Eventually you will be able to do this balancing by "eyeball" computation but, should you need visual aid with more complecated equations, you will know how to do this simply with the chart..

As a review, try this: $Al + S \longrightarrow Al_2S_3$

	Al	S
R	~~1~~ 2	~~1~~ 3
P	2	3

The balanced equation is: $2\ Al + 3S \longrightarrow Al_2S_3$

If you are wondering why Al and S were written without subscripts, as was the case of H_2 and O_2, you will find the answer in an activity associated with this unit explaining that certain gases, called DIATOMIC (two atoms), ca n exist only as molecules and not in atomic form. The formula for oxygen gas is O_2 and for hydrogen H_2, therefore. Al and S are not gases and so each element can stand alone. Two molecules of the diatomic gases would be represented as: $\underline{2}\ O_2$ and $\underline{2}\ H_2$ while the two elements, Al and S, would appear as: $\underline{2}$ Al and $\underline{2}$ S, if more than one atom were indicated..

In reading the coefficient properly, please note that while H_2O is made up of two hydrogen atoms and one oxygen atom, 2 (H_2O) is made up of four hydrogen atoms and two oxygen.

How many atoms would be involved in 3 (H_2O)? How many in 3 Al?

ACTIVITY III-3-7
IMPORTANCE AND USE OF IONIZATION POTENTIAL

There are four basic types of equations: Synthesis (composition)
Analysis (decomposition)
Single Replacement
Double Replacement

In addition to the four basic types of equations, there is one that is important in both electrochemistry and in life processes. This is the REDOX reaction or equation which is a contraction of oxidation-reduction. In oxidation, electrons are lost while in reduction electrons are gained. Redox, then, deals with transfer of electrons. A substance that loses electrons is "oxidized" while one that gains electrons is "reduced." Oxidation does not have to involve oxygen. In addition, oxidation in life involves not only removal of electrons but also of H ions. Our commercial batteries operate on the principle of redox as well as our life batteries, the "ATP."

If we take the following equation, for example:

$$Fe + Cl_2 \longrightarrow Fe\,Cl_3$$

and balance it:

$$2\,Fe + 3\,Cl_2 \longrightarrow 2\,Fe\,Cl_3$$

we are then ready to rewrite it as a redox reaction:

$$2\,Fe^{o} - 3\,e \longrightarrow 2\,Fe^{+3} \quad \text{(oxidation)}$$

$$3\,Cl^{o} + 3\,e \longrightarrow 3\,Cl^{-} \quad \text{(reduction)}$$

In the redox equation, the element that loses electrons is oxidized while the element that gains electrons is reduced, so in the above example we would say that iron was oxidized while chlorine was reduced.

ACTIVITY III-3-7

IMPORTANCE AND USE OF IONIZATION POTENTIAL

In our commercial batteries, the element at the anode is the receiver of electrons given off by the element at the cathode which is the source of electrons. Since the anode gains electrons, it is reduced and since the cathode loses electrons, it is oxidized. Another way of saying this is that the anode is the oxidizer while the cathode is the reducer.

One more equation or reaction is to be considered since it involves the H^+ ion mentioned previously. The reaction is called "neutralization" usually referred to in connection with acids and bases. It was usually accepted that if you took a base and an acid in dilute form and put them together in proper proportion, evaporation of the resulting union would produce a salt. It would be said that an acid and base would "neutralize" each other.

According to a modern theory of acids and bases (Bronsted Theory) the reaction takes place as follows:

APPARENT REACTION: $NaOH + NCl \longrightarrow NaCl + H_2O$

Balanced: ?
(check by student)

IONIC EQUATION: $Na^+ + OH^- + H^+ + Cl^- \longrightarrow Na^+Cl^- + H_2^+ O^{-2}$

ACTUAL NEUTRALIZATION: $H^+ \cdot H_2O + OH^- \longrightarrow H_2O$

THE ACID WAS: Hydronium ion (H_3O) because it donated H^+

THE BASE WAS: Hydroxyl (OH) ion because it accepted H^+

"SPECTATOR" IONS: Na^+ and Cl^-

According to this theory, the modern definition of an acid is a substance that donates PROTONS (H^+) while a base accepts PROTONS.

ESP

ACTIVITY III-3-7

IMPORTANCE AND USE OF IONIZATION POTENTIAL

DIRECTIONS

A. From a chart of Ionization Potential (pg. 73 in MODERN CHEMISTRY) fill in the proper square in each element in your Periodic Chart. Note the current readings:

ATOMIC NUMBER	CURRENT IP (ev)
14	8.5
15	10.5
19	4.3
21	6.5
32	8.0
33	10.0
34	9.8
39	6.4
41	6.9
42	7.1
43	7.3
44	7.4
45	7.5
58	5.6
59	5.5
60	5.5
65	6.0
71	6.2
72	6.8
73	7.9
76	8.5
77	9.1
83	7.3
92	6.1

Please note that the ev data is a good example of the constant need for alertness as science progresses. Data and theories may change with improved techniques and expanding knowledge. You may wish to check the data with the latest information given. If you find any changes, please bring these to class for presentation.

B. Using the data available, graph the information with Atomic Number as the X axis and IP as the Y axis.

C. Write a report of your experience and interpretation of the graph. Your problem will be prediction of IP values for those atoms not yet showing IP.

D. Read Chapter 8: CHEMICAL EQUATIONS in MODERN CHEMISTRY. Hand in answers to completed equations #1-20 on pages 121-2. In each case, state whether the reaction is an example of:

S (synthesis)
A (analysis)
SR (single replacement)
DR (double replacement)

Recall that some elements exist in the DIATOMIC form as molecules:

O_2 F_2 Cl_2 Br_2 I_2 H_2 N_2

E. Look through Chapter 22 in MODERN CHEMISTRY and make note of the redox reactions. Hand in answers to questions 1-5 on page 396, Group A.

F. Read Chapter 6 in MODERN CHEMISTRY. Hand in answers to questions 1-11, pages 94-5, Group A.

G. Read Chapter 13: IONIZATION in MODERN CHEMISTRY. Hand in answers to questions 1-14 in Group A on page 215.

H. Obtain Experiment III-3-7-H: NEUTRALIZATION. Hand in written report of your experience.

ESP

ACTIVITY III-3-8
ATOMIC RADIUS

The diameter of atoms is measured by an indirect method (X-ray diffraction patterns) since atoms are too small to measure directly. For example, about 100,000,000 H atoms would occupy a space equal to 1 cm, if they were lined up next to each other.

The unit used to designate such small lengths is ANGSTROM (Å) which is 0.00000001 cm or:

$$Å = 10^{-8} \text{ cm}$$

The diameter of H is given as 10^{-8} Å. Therefore, its radius = 0.5 Å. Obtain the radii of the rest of the atoms in the Periodic Chart from a class source of textbook such as pages 578-9 in MODERN CHEMISTRY.

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I. PROBLEM: Prediction of atomic radius of elements not yet measured.

II. MATERIALS: Source of atomic radii
Graph Paper
Periodic Chart

III. PROCEDURE:

A. Enter the atomic radius of the elements in designated area in the Periodic Chart.

B. Prepare a graph, using atomic number as the X axis and atomic radius as the Y axis.

IV: OBSERVATION:

A. Is any pattern observed in the graph?

B. Note the change in size of atoms proceeding:
1. across the Chart
2. top to bottom of Chart

V. RESULTS:

Prediction of atomic radius of:

#61............	96............
83............	97............
84............	98............
85............	99............
88............	100............
89............	101............
91............	102............
92............	103............
93............	104............
94............	105............
95............	112............

ACTIVITY III-3-9
MASS NUMBER

I. PROBLEM: Prediction of mass number of elements not yet determined.

II. MATERIALS: Mass Number Chart
Graph paper
Periodic Chart

III. PROCEDURE:

A. Enter the mass number of the elements in designated areas in the Periodic Chart.

B. Prepare a graph, using atomic number as the X axis and mass number as the Y axis.

IV: OBSERVATION:

A. Is any pattern observed in the graph?

B. What discrepancy do you observe concerning the following elements:

#19 and #20
27 and 28
34 and 35
52 and 53
84 and 85
90 and 91
93 through 100
101 and 102

V. RESULTS:

A. Pattern observed:

B. Explanation of discrepancy in mass numbers:

C. Prediction of mass number of atoms #: 104
105
112

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The mass number represents the number of protons and neutrons in the longest lived isotope known to date. It is an integer closest to atomic mass. Atomic mass, on the other hand, is the "weight" arrived at by averaging all known isotopes of an element. It is designated "amu" - atomic mass unit - and is not a whole number.

ESP

ACTIVITY III-3-9

MASS NUMBER

AT. NO.	SYMBOL	A*
1	H	1
2	He	4
3	Li	7
4	Be	9
5	B	11
6	C	12
7	N	14
8	O	16
9	F	19
10	Ne	20
11	Na	23
12	Mg	24
13	Al	27
14	Si	28
15	P	31
16	S	32
17	Cl	35
18	Ar	40
19	K	39
20	Ca	40
21	Sc	45
22	Ti	48
23	V	51
24	Cr	52
25	Mn	55
26	Fe	56
27	Co	59
28	Ni	58
29	Cu	63
30	Zn	64
31	Ga	69
32	Ge	74
33	As	75
34	Se	80
35	Br	79
36	Kr	84
37	Rb	85
38	Sr	88
39	Y	89
40	Zr	90

AT. NO.	SYMBOL	A*
41	Nb	93
42	Mo	98
43	Tc	99
44	Ru	102
45	Rh	103
46	Pd	106
47	Ag	107
48	Cd	114
49	In	115
50	Sn	120
51	Sb	121
52	Te	130
53	I	127
54	Xe	132
55	Cs	133
56	Ba	135
57	La	139
58	Ce	140
59	Pr	141
60	Nd	142
61	Pm	145
		147
62	Sm	152
63	Eu	153
64	Gd	158
65	Tb	159
66	Dy	164
67	Ho	165
68	Er	166
69	Tm	169
70	Yb	174
71	Lu	175
72	Hf	180
73	Ta	181
74	W	184
75	Re	187
76	Os	192
77	Ir	193
78	Pt	195
79	Au	197
80	Hg	202

AT. NO.	SYMBOL	A*
81	Tl	205
82	Pb	208
83	Bi	209
84	Po	210
85	At	210
86	Rn	222
87	Pr	223
88	Ra	226
89	Ac	227
90	Th	232
91	Pa	231
92	U	238
93	Np	239
		237
94	Pu	238
		239
		242
95	Am	241
		243
96	Cm	242
		247
97	Bk	243
		249
98	Cf	244
		251
99	Es	253
		254
100	Fm	255
		253
101	Md	256
102	No	254
103	Lw	257
104	(Ku)	...
105	(Du)	...
106		
107		
108		
109		
110		
111		
112	(EKA-Hg)	...

*In the language of modern atomic structure: "A" = mass number

$A = Z + N$

"Z" = number of protons

"N" = number of neutrons

ISOTOPE: Atoms of a single element whose nuclei contain the same number of protons (same atomic number) but which contain different numbers of neutrons are called "Isotopes." Isotopes of hydrogen would be: H-1: H-2: H-3. What are the names of these three isotopes?

ESP

ACTIVITY III-3-10
SUMMARY OF PERIODIC TABLE

I. PRESENT DATA:

A. PERIODIC TABLE is a table of predictable events in the chemical behavior of atoms.

It is a systematic arrangement of elements based on atomic number (number of protons).

*It was developed by Henry Moseley in 1913 after observing X-ray studies of the elements.

B. PERIODIC LAW: The chemical properties of elements recur after certain intervals, provided the elements are arranged in a table in the order of their atomic numbers.

1. ATOMIC NUMBER: proceeds consecutively
2. VALENCE NUMBERS: proceed from +1 +2 +3 ±4 to -3 -2 -1 0
   metals — e lenders; nonmetals — e borrowers

3. IONIZATION POTENTIAL: relationship to activity
   a. Most active metal: Fr #87 (3.9 ev)
   b. Most active nonmetal: F #9 (17.4 ev)

4. MASS NUMBER (p + n) vs ATOMIC MASS (a.m.u.)
   a. Discrepancy in prediction due to ISOTOPES - various forms of the same element differing only in weight.
   b. Since 1961, atomic weight based on CARBON-12, the most abundant isotope of C with a.m.u. of exactly 12. Carbon itself has an a.m.u. of 12.0111. Formerly weight was based on oxygen-approximate weight of 16.

5. ATOMIC RADIUS
   a. Decreases across the Periodic Table - increasing nuclear charge
   b. Increases down the Table - increasing number of shells.
   c. Inert gas discrepancy: e shielding cancels increased nuclear charge

6. FAMILIES OR GROUPS (18) - Prediction of typical behavior
   a. Group "A"
   b. Group "B" - Transition: 2 outermost energy levels incomplete
   c. Triads: 26,27,28,44,45,46,76,77,78 - stable because of completed half-filled inner rings

*First Periodic Table, by Mendeleev in 1869, was based on atomic weight.

ACTIVITY III-3-10
SUMMARY OF PERIODIC TABLE

Fe,Co, and Ni show magnetic properties: result of greater number of e spinning in same direction over smaller number spinning in opposite direction

7. Periods (7: indicating number of shells)

   a. LANTHANIDE AND ACTINIDE SERIES: inner transition elements - three outermost energy levels incomplete but having very similar chemical properties because of valence of +2..

   b. LANTHANIDE - not as rare as given name indicates - for example, #57.. 58, and 60 are more abundant than lead.

   c. ACTINIDE - transuranium - ALL MAN-MADE AFTER U.

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USING THE PERIODIC TABLE AS A TABLE OF PREDICTABLE EVENTS IN THE CHEMICAL BEHAVIOR OF ATOMS, try to describe some atoms not yet discovered as to possible:

Valence number
Metallic or nonmetallic
Activity or inertness
Mass number
Size
Family or grouping
Number of shells

- - - - - - - - - - - - - - -

II. PREDICTIONS FOR FUTURE GROWTH OF PERIODIC TABLE

*Russia and the U.S. cooperating in search for element #114 (eka-lead).

KURCHATOVIUM (#104) believed to be the first in a new series of elements, - increasing longer half lives.

Element #110 now being searched for as the beginning of long-lived elements.

*Suggested method: bombardment of U-238 with U=238:

$$^{238}_{92}U + ^{238}_{92}U \longrightarrow ^{476}_{184} \longrightarrow ^{298}_{114} + ^{166}_{70}Yb + 12n$$

ACTIVITY IV-4-1
FROM A CANDLE TO A STAR

At the beginning of the year we used a candle with which to start the important skill of objective observation as contrasted to the subjective interpretation. One of the most persistent observations was that "wax" was being melted down as the candle continued to burn. Was this an observation or an interpretation?

Using identification techniques, it would have been observed that the "waxy" substance of the candle was different from that of other "waxy" substances such as moth balls. It would have also been observed that the graph of the candle "wax" as it melted was not exactly the same as that obtained in other "waxy" substances. Further testing of the "waxy" substance would have led to another field of chemistry - that of organic chemistry. The waxy substance could be a product of natural fats and oils from plants or animals. It might also be a paraffin wax, a hydrocarbon, or a combination of a fat and paraffin. If a natural product, the substance might be an "ester" - colorless and odorless for candles although highly fragrant for other purposes. In either case, however, whether paraffin or ester, these are "organic" compounds.

In ancient times it was recognized that alcohols, fats, and sugars were formed by living processes while clay, gems, and ores were obtained directly from the crust of the earth. The compounds of "life" processes were referred to as ORGANIC while compounds similar to the minerals of the earth were called INORGANIC.

ACTIVITY IV-4-1

FROM A CANDLE TO A STAR

The term ORGANIC CHEMISTRY, then, is inherited from the day when the science of chemistry was comparatively primitive. Urea was classed as organic because it was formed as a waste product in the metabolism of animals. Not until the 19th Century was it discovered in the laboratory by Friedrich Wohler that urea could be produced by inorganic "non-living" substances. This was unheard of and thought as impossible. It was not until 1845 that the idea of a vital "life" force was finally discarded. Since then our knowledge of organic chemistry has grown until today more than a million different organic compounds have been identified. By contrast, the inorganic compounds in the world number about 50,000. Organic chemistry now includes not only "living" substances but also synthetics, such as, detergents, nylon, plastics, vitamins, rubber, etc.

To be classified as organic, a compound should have at least one C-H or C-C bond. Certain compounds, such as, CS_2, $COCl_2$ (phosgene - a poisonous gas), and urea ($[(H_2N_2)\ C=O]$) are studied in organic chemistry although they do not possess a C-H or C-C bond. These compounds lie in a region between organic and inorganic. This in-between area, where a substance may be one thing at one time and another at another time or bear the possibilities of both, has been discussed several times previously. Perhaps you may recall amorphous carbon or the metalloids. Can you think of other examples? In this Unit we shall find still another example of the "in-between" state in a bit of matter called the virus. Today, modern chemistry defines

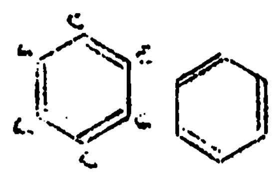
ACTIVITY IV-4-1
FROM A CANDLE TO A STAR

ORGANIC chemistry as the study of compounds of carbon and INORGANIC chemistry as the study of metals and minerals (compounds containing both metals and nonmetals). Living things, as we know life on this planet, are a combination of both organic and inorganic elements and compounds. How does the present fad for "organic farming" and "organic vitamins" fit into the known facts?

Organic compounds may be differentiated into hydrocarbons, fats, carbohydrates, vitamins and porteins. The hydrocarbon series includes:

1. Alkanes (methane series) with single bonds -C-
2. Alkanes (ethylene series) with double bonds C=C

   Alkadienes 2 double bonds -C=C-C=C-
3. Alkynes (acetylene series) with triple bonds -C≡C-
4. Aromatic (benzene series) with single and double bonds alternating in a hexagon



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In order to get a better idea of hydrocarbons, read Chapter 17 in MODERN CHEMISTRY or other book describing hydrocarbons. Answer and hand in the questions on page 303, Group A: 1 through 5.

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ACTIVITY QUESTIONS: (for clarification, use a chemistry text)

1. What is an "ester"?

2. What is a "paraffin"?

3. What is an "organic" compound? What are the differences between organic and inorganic compounds?

4. AlkaSeltzer, with which you worked, is made up of aspirin, sodium bicarbonate, citric acid, and monocalcium phosphate. Would you say that it is organic or inorganic? Why?

   To help you answer the question, you might recall the following:

   Aspirin:  Sodium Bicarbonate: $NaHCO_3$

   Citric Acid: $HOOCCH_2C(OH)(COOH)Ch_2COOH$

   Monocalcium Phosphate: $CaH(PO_4)$

5. What is sugar? Of what elements is it made? Is it organic or inorganic? Why?

6. What are proteins? Of what elements are they made? Are they organic or inorganic? Why?

   (To check your answers to #5 and #6, read Chapter 19 in MODERN CHEMISTRY.)

7. What are vitamins? Of what elements are they made? Are they organic or inorganic? Why?

8. In later discussions we shall try to see if there is any relationship between life as we know it and the stars. For the present, do you think there is any relationship between a candle and a star? Why?

ESP

ACTIVITY IV-4-2
ESTERS

An acid and an alcohol react to form a compound called an "ester." Natural esters give fruits and flowers their characteristic flavors and odors.

The modern organic chemist has learned how to duplicate many of the natural esters so that today many of our fruit flavors and perfumes are made in the laboratory.

I. PROBLEM: Formation of an ester

II. EQUIPMENT: Beaker
- Large test tube
- Amyl alcohol ($C_5H_{11}OH$)
- Acetic acid ($HC_2H_3O_2$)
- Sulfuric acid (H_2SO_4)

III. PROCEDURE:

1. Fill the beaker half full with water and set on ring stand or tripod. Heat the water until it boils.
2. Using the large test tube, put in 10 drops of amyl alcohol.
3. Add 19 drops of water, Ъ drop of acetic acid, and 10 drops of concentrated sulfuric acid. (The H_2SO_4 acts as a catalyst)
4. Gently shake the tube, then place it in the boiling water for 2 minutes.

IV. OBSERVATION:

1. Describe the contents of the test tube.
2. Is there a predominant color?
3. Of what does the odor remind you?

V. RESULTS:

1. Write a word equation for the reaction that took place.
2. Where might this product be used?

ESP

ACTIVITY IV-4-4
INTRODUCTION TO PHOTOSYNTHESIS

Of the many observations which you made concerning organic and inorganic compounds, the following two were probably recognized as being common to both:

1. They were made up of atoms
2. They were formed by joining together of electromagnetic "bonds" symbolically indicated by dots or lines.

It was probably further observed by you as you constructed the various models that the joining or bonding depended on the number of possible joining sites, different for each of the particular atoms involved. You probably also noticed that it took quite a bit of energy on your part to join the atoms into molecules. Conceivably, taking them apart would also require energy. This is an important observation. When atoms are put together in chemical reactions or taken apart, energy is required. The ionization potential gives a clue as to the strength of the bond. Related to this, ionic bonds are easier to put together and to take apart than covalent. Single bonds are easier to make and break than double, and double easier than triple. In other words, it takes energy to make or break bonds. A chemical reaction may be said to be the action of making and breaking bonds. In view of this, how would you explain the energy-producing effect of sugar?

An important natural phenomena which man has not yet been able to imitate is the process by which green plants use the energy from the sun to produce such organic compounds as sugars, fats, proteins, and vitamins. The making and breaking of bonds to change carbon

ACTIVITY IV-4-4

INTRODUCTION TO PHOTOSYNTHESIS

dioxide into sugar is told in the story of photosynthesis. It was once believed that water and carbon dioxide were simply re-combined to result in sugar and oxygen. The present story is much more complicated, involving electron and proton transfer as well as light and dark phases. The electrons and protons travel by way of a chain of electron carriers. These carriers are chemical substances which pick up the H^+ or e from a donor and pass them on. Reduction takes place when the H^+ or e are picked up. What of oxidation?