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ABSTRACT

Learning Activity Packages (LAP) relating to the earth and space are presented for use in sampling a new type of learning for a whole year. Eighteen topics are incorporated into five units: (1) introduction to individualized learning, (2) observation versus interpretation, (3) chemistry in the space age, (4) the space age interdisciplines, and (5) humanities and space. A set of self-directed activities is given in each topic, leading students to learn on their own and enter into group discussions. Most activities are especially designed for the purpose and given in separated sheets, while others are in connection with textbooks such as "Investigating the Earth"; "Time, Space, Matter"; "Modern Chemistry" by Metcalfe and others; "Science and Serendipity" by Halacy, Jr.; Apollo missions' slides, etc. Pretests, self-evaluation tests, and posttests are used in evaluation. Also included in the appendices are two remedial units dealing with calculation with decimals and scientific notation of numbers. (CC)

INDIVIDUALIZED INSTRUCTION IN SCIENCE

Learning Activities Package

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E.S.P.

Earth- Space Project

Eastchester Public Schools
Eastchester, New York

RM KUCZMA

PROPERTY OF
EASTCHESTER JUNIOR HIGH SCHOOL
Eastchester, N. Y.
SCIENCE DEPT.

Purchase Date..... No.....

Name of Student..... Yr.....

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LEARNING ACTIVITY PACKAGES

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A MESSAGE TO OUR CITIZENS OF TOMORROW

As astronauts Armstrong, Collins, and Aldrin swept across the country following their historic mission to the Moon, the appeal was to the young people, to the New Age, the Age of Mankind, when man would look upon man as his brother. From outer space you could not see if the Earthlings were yellow, brown, red, black, or white and the continents themselves, on which the nations of the earth lived, seemed very close together. Could awakening Mankind, as one entity, develop a universal consciousness and then, a universal conscience?

The call has been answered by some who are willing and eager to throw away their old prejudices but their efforts have been met with resistance and attack. When the Earth is crying for help in so many directions, how can one think of Space? Yet, for one breathless moment, the first time in recorded history, man became Mankind as one footstep descended on the Moon. There must have been something very special in this simple act to unite the hearts and spirits of humanity.

However, in spite of opposition, some of the effects of Apollo are already beginning to be felt and to stir the imagination. Of what do they give promise? - undreamed of opportunities, of course, but, more immediately, an Earth renewed in body and spirit; a pattern for solving Earth's problems, provided that the will of humanity be strong enough; a catalyst for education, replacing fear and ignorance with knowledge and awareness of the probability of the of the "impossible"; and, most important, the evolution of the idea of the importance and dignity of each and every individual. One human being can make a difference!

In the course you are to study, E.S.P. (Earth-Space Project) the implication in the initials are intentional but not in the conventional sense of supernatural powers but as an undeveloped sense (dormant in all of us) of suddenly seeing the point because of a prepared mind - prepared by knowledge and careful observations to see relationships not apparent on the surface. A long time ago, a scientist by the name of Louis Pasteur said that "Chance favors the prepared mind."

It is hoped that perhaps your mind, too, will be prepared with skills, knowledge, and attitudes that will help you to cope with changes yet undreamed of.

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INDIVIDUALIZED INSTRUCTION
Introductory Remarks

Five, four, three, two, one - - - - - LIFT OFF!
You have probably heard this before. However, let us suppose that you have to decide which of these two people, responsible for this event, are more important - the astronaut who flies the mission or the electrician who wires the space ship? How will you decide?

Would you say that the astronaut is more important because he has to do the actual flying? Perhaps you would be right. On the other hand, would you say that the electrician was more important because it was his responsibility to see that the electrical equipment was in perfect order? If it were not, then the space ship and the astronaut might not be able to complete the mission. In that case, those deciding for the electrician would also be right.

Well, how could two people disagree and still both be right? Very easily, especially if the disagreement concerns people and what they do. Of course, the astronaut is important because he flies the mission but the success of his efforts depends on a space-worthy ship. On the other hand, the electrician could put in the most perfect system known to man but, with no one to fly the ship, the perfection would never be known.

The astronaut, the electrician, and hundreds of thousands of other individuals are needed as a team to reach the goal for which they are working. Each and every individual becomes very important when a job for mankind has to be done. Each individual is important because each has a very special talent to contribute according to his ability and training.

INDIVIDUALIZED INSTRUCTION
Introductory Remarks
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How does the astronaut become what he is and how does the electrician come to do his job so well? They each have to learn what they need to know. Do they both learn in the same way? Probably not. Since they are two different individuals they not only have their own particular talents and abilities but also their particular ways of learning. Perhaps even in school, when they were very young, they each learned how to read and write in ways that were different from each other. As they grew into maturity, their differences still remained, leading one to go into flying and the other into electronics.

Now, what has all this to do with you? Well, you are a very important person because you are an individual having talents and abilities different from any other individual in the world. However, because we are human beings, we all have common steps through which we must go although how we go through these differs. For example, when you first learned how to walk, the way you did it was probably different from any of your brothers or sisters, - in fact, probably different from any other baby in the world. In the same way, when and how you learned to talk,,to read, to write, and to play games with each other was different from any one else.

Even though the "when" and "how" may have been different, you, as an individual, did eventually mature enough to become to be recognized as a fine, young human being. In all of this, the accent was on the word "learn." The opportunity to learn is a gift which all mankind has. Learning goes on all your life. If learning goes on for the rest of your life, then isn't it important to find out how best you, as a very special person, learns? Did you ever stop to think how you learn anything? Perhaps this year, you may have a

chance to find this out for yourself. You will not only be learning about science and how it works but also, more important, you may be able to learn more about yourself and how you work. You are going to sample a type of learning called "Individualized Instruction." What this is and how it will help you will be investigated this year. I hope you find this way of learning helpful. I look forward to knowing you and to helping you discover that special person called YOU.

Now that you have come this far, you are ready to take PRE-TEST I-1. This is not a test of the kind you may have experienced before- it is only a means of getting some information about what you know or think on a particular topic so that we may know where to start our working together. After all, I have no idea about how much you may already know. There is no "mark" with a pre-test. It has nothing to do with your grade so feel free to express yourself honestly.

When you have completed the pre-test, please hand it in and continue with UNIT I, Topic1: INTRODUCTION TO INDIVIDUALIZED LEARNING. This will give you some idea of how we will work together this year.

If there is something you don't understand, please feel free to ask me.

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INDIVIDUALIZED LEARNING

UNIT I: Introduction to Individualized Learning

TOPIC 1: Learning Activity Package (LAP)

OBJECTIVES:

1. To demonstrate your ability to read and understand written material by following instructions given in ACTIVITIES below.

2. To self-test your ability to depend on yourself by handing in, FIVE MINUTES BEFORE THE END OF THE PERIOD, any work you have done. You will not be reminded to do so.

3. To show that you can discuss the relationship between LAP and Individualized Learning by taking a self-evaluation test and entering into a group discussion on the matter.

ACTIVITIES:

1. Read A STUDENT GUIDE AS TO WHAT IS CONTAINED IN A LEARNING ACTIVITY PACKAGE.

2. Take out your pen or pencil, which you should have every day. If you forgot to bring one today, you may use the pencil provided. BE SURE TO RETURN IT FOR SOME ONE ELSE MAY NEED IT.

3. On WORKSHEET I-1-3, provided for you, list the contents of a LAP and briefly note what each one is supposed to do. This will serve as one example of what you will keep in your notebook.

4. Obtain a VOCABULARY SHEET and list any words which are new to you. Check to see if you have spelled them correctly. Add the meaning next to the word.

5. Obtain an ANSWER SHEET and take the SELF-EVALUATION TEST. This is an example of how you can test yourself on material covered.

6. Mark your own test by listening to the answers on the cassette or by using an answer guide which you may obtain. How to mark the test is given in the answer guide.

7. When you feel that you have done all the activities above to the best of your ability, ask for the Post-Test on this Unit. This will serve as an example of whether or not you are ready to go on to the next Unit.

8. Discuss the meaning of Individualized Instruction in a class discussion. This class discussion will serve to show how talking it over in a group helps to exchange opinions and clear up matters not understood. Of equal importance will be the realization that discussions are more interesting and worthwhile if you have some knowledge and experience to back up your opinions.

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UNIT II: OBSERVATION vs INTERPRETATION

TOPIC 1: Observations in Science

OBJECTIVES:

1. To enable the student to describe what he observes.

2. To obtain first hand experience of objects or events.

3. To report observations in the form of charts, tables, graphs or other similar tangible evidence.

ACTIVITIES:

1. Obtain a candle, candle dish, and match. Light the candle. List as many observations as you can)at least 20) about the burning candle.

2. Obtain an alcohol burner and match. Light the burner. List as many observations as you can (at least 20) about the burning alcohol burner.

3. Obtain a film loop on the Bunsen burner. List as many observations as you can about the Bunsen burner as you view it on the film loop.

4. Obtain a Bunsen burner and a match. Consult your teacher as to proper precautions and safety rules in the lighting and use of the burner. List as many observations as you can about the lighted Bunsen burner.

5. Obtain a copy of Experiment II-1-5 and perform the experiment. Write out the data in the form of a Table as shown in the write-up of the experiment. The Table should be put into your notebook.

6. Read from MODERN CHEMISTRY by Metcalfe, Williams, and Castka pages 14 and 15 on the differences between heat and temperature. Keep the information in your notebook.

7. Obtain a copy of MODERN PHYSICAL SCIENCE. Read pages 248-252. Perform the experiment on page 252 and note your observations in your notebook.

8. Obtain a copy of MODERN PHYSICAL SCIENCE. Read pages 31-33. Perform the experiment suggested in pages 31-32 and note your observations in your notebook.

UNIT II

TOPIC 1

ACTIVITIES: (continued)

9. Take Post-Test II-2-11 on all observations.

10. Sceince wears many masks and guises but it can always be recognized when it poses the questions "WHY?" or "WHY NOT?" It makes one request - that its followers have f acts before jumping to conclusions. It always hopes that something new and untried will be given a chance.

    Read about and report on new and startling observations made by past or present scientists that were declared impossible or ridiculed as a big farce. Some suggestions, as a start, might be:

    THE SUN IS THE CENTER OF THE SOLAR SYSTEM
    Nicolas Copernicus

    THE MOON HAS MOUNTAINS AND VOLCANIC CRATERS
    Galileo Galilei

    MAN WILL SOME DAY TRAVEL IN SPACE
    Tsiolkovsky
    Goddard
    Oberth

    THERE IS INTELLIGENT LIFE IN THE UNIVERSE
    I.S. Shklovskii and Carl Sagan

    WE CAME IN PEACE FOR ALL MANKIND
    Armstrong, Collins, Aldrin

11. Obtain from your teacher or library copy of SCIENCE AND SERENDIPITY by D.S. Halacy, Jr., and/or a copy of CHANCE FAVORS THE PREPARED MIND by Bernard E. Schaar.

    Note your observations from these readings in a written report.

12. Discuss SUGGESTED TOPICS FOR TERM INVESTIGATION. Read various points of view in Activity II-1-1-2 for background material.

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UNIT II: OBSERVATION vs INTERPRETATION

TOPIC 2: Mathematics, the Language of Science

OBJECTIVES:

1. To enable the student to make meaningful observations in science through the use of mathematics.

2. To refresh and reinforce the student's use of decimals in problems involving addition, subtraction, multiplication, and division.

3. To enable the student to write numbers in standard scientific notation as an aid to handling very large and very small numbers in science.

4. To refresh and reinforce the student's skill in adding, subtracting, multiplying, and dividing astronomical and atomic figures using scientific notation.

ACTIVITIES:

1. The use of decimals
   a. Remedial Unit: CALCULATION WITH DECIMALS (Activities 1,2,3)
   b. Post Test
   c. Post Retest, if required

2. Practice in Scientific Notation
   a. Remedial Unit: SCIENTIFIC NOTATION (Activities 1-10)
   b. Post Test: Decimals and Scientific Notation
   c. Post Retest, if required
   d. Read pp.13-16 of TERMS, TABLES, AND SKILLS
   e. Study Table 3.1 on p.18 of TERMS, TABLES, AND SKILLS
   f. Read A PROGRAMMED SEQUENCE ON EXPONENTIAL NOTATION by Eugene Roberts.
   g. Obtain filmstrip: SIGNIFICANT FIGURES IN SCIENCE. Answer self-evaluation questions on the strip.

3. Practice in use of the Slide Rule (Optional)
   If you are using a Slide Rule in math, take the opportunity to practice in science the skills learned in mathematics.
   a. Read Chapter 6 of TERMS, TABLES, AND SKILLS as far as pertinent.
   b. Read A PROGRAMMED SEQUENCE ON THE SLIDE RULE by Eugene Roberts
   c. Read VERSALOG by Post
   d. Read EXPONENTS AND THE SLIDE RULE in PHYSICAL SCIENCE: A MODERN APPROACH (Bickel, Eigenfeld, Hogg) pp.480-486
   e. Obtain a simple hand computer from the laboratory
   f. Obtain a copy of CARDIAC (A CARDboard Illustrative Aid to Computation) a Bell Laboratories educational aid.
   g. Books on history of mathematics: LIFE SCIENCE LIBRARY: Mathematics, etc.

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UNIT II: OBSERVATION vs INTERPRETATION

TOPIC 3: The Metric System- linear measurements

OBJECTIVES:

1. To enable a student to measure with a metric ruler.

2. To have the student observe and use the fundamental unit of length.

3. To determine by experimental method the differences between the Metric and the English system of measurement of length.

ACTIVITIES:

1. Read INTRODUCTION TO METRIC SYSTEM: LINEAR MEASUREMENTS to be found in this LAP.

2. Using the two rectangles provided (marked "A" and "B"), clock the time it takes to measure the area of each rectangle in both the English and the Metric systems. Tabulate your observations in chart form. Check your answers at the back of the Unit.

3. Obtain a copy of MODERN CHEMISTRY. Measure the area of this book in both systems. Time the difference. Make a table of your observations. Check your answers with the Answer Sheet provided in back of the Unit.

4. Obtain a penny. Find its area in both systems, timing the difference in both systems. If you do not remember how to find the area of a cylinder, check your math book. How close did you come to the answer given in the back of the Unit?

5. Make two tables, as follows, in your notebook and fill in the appropriate data. Time yourself, as above. Check your answers.

In.	= Ft.	Yd.
1	1/12	1/36
3		
26		
8		
10		
4,280		

mm	= cm	m
1	.1	.001
3		
26		
8		
10		
4,280		

6. When you feel ready to do so, take Post Test II-3-6 on linear measurements in the Metric System.

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UNIT II: OBSERVATION vs INTERPRETATION

TOPIC 4: The Metric System: Measurements in Science - Volume

OBJECTIVES:

1. To enable a student to measure volume with a graduated cylinder as well as a metric ruler.

2. To help student observe and use the fundamental unit of space occupied by matter whether regular or irregular in dimension.

ACTIVITIES:

1. Read INTRODUCTION TO METRIC SYSTEM: VOLUME given in this LAP.

2. Prepare two tables as follows, then fill in the rest of the information required:

Fluid Oz.	Qt.	ml	l (liter)
32	1	32	.032
16		16	
8		8	
4		4	
2		2	
1		1	
½		.5	

Record the time for each method. Check your answer in the back of the UNIT.

3. How many fluid ounces are there in 1 3/4 quarts? How many ml in 1.75 liters? Time yourself again. Record the difference in time. Check your answer.

4. Using MODERN CHEMISTRY, measure the volume of this book in both systems. Time the difference. Make a table of your observations. Check your answer.

5. Obtain a rock sample and find the volume of it in both systems. Record the time difference.

Did you remember to use the graduated cylinder to obtain the volume in the Metric system?

6. How would you find the volume of a penny? Try both systems and time each. If you have forgotten, a penny is really a cylindrical object and you will have to use the formula for the volume of a cylinder. (Use your math book.)

Remember that in the English system you probably use 22/7 as the value for π while in the Metric system you use 3.14.

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THE METRIC SYSTEM: MEASUREMENTS IN SCIENCE
VOLUME
- 2 -

7. Find the volume of a round object (sphere) such as a marble or styrofoam ball. Use your math book to remind yourself of the volume of a sphere. Time yourself, using both systems.

   Check your answers in #6 and #7 by comparison. After converting the English to the Metric or vice-versa, both answers should be the same.

8. Perform the following experiment. Hand in a carbon copy of the completed experiment. Be sure to use all five steps.

   PROBLEM: Measuring the volume of irregular objects by displacement of water.

   Pour sand into a graduated cylinder, about one-half to three-quarters full. Record the volume. Pour the sand into a small dry beaker while you do the next step.

   Pour some water into the graduated cylinder filling it about one-fourth to one-third full. Record the volume.

   Add the sand to the water in the graduated cylinder.

   Make a chart of your observations, including the following data:
   - Volume of sand . . . . . .
   - Volume of water . . . . . .
   - Volume of sand + water expected . . . . . .
   - Volume of sand + water actually obtained . . . . . .
   - Difference, if any, between expected and actual results.

   In your results, explain the observations made.

9. Take the Post Test for volume measurements.

10. Read about the first man to discover the principle of water displacement in MODERN PHYSICAL SCIENCE pp.217-219. Using a rock sample, try the experiment suggested on p.218 (overflow can). Check the mass of the water displaced with the results you obtained in volume reading of the sample. Is there any relationship between the mass and the volume of water displaced?

    Write down your reaction to this find. It will be used in future activities.

    Write out the experiment in the suggested format and hand in the carbon copy.

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UNIT II: OBSERVATION vs INTERPRETATION

TOPIC 5: The Metric System: Measurements in Science - Mass

OBJECTIVES:

1. To enable a student to measure with a balance using bead equivalents of grams.

2. To observe and use the fundamental unit of amount of matter or mass.

ACTIVITIES:

1. Read INTRODUCTION TO METRIC SYSTEM: MASS given in this LAP.

2. Prepare two tables as follows and complete the information missing:

Oz.	Lb.	gm	kgm
16	1	16	.016
8		8	
4		4	
1		1	
½		.5	
1/5		.2	

Record the difference in time in performing the task.

3. Obtain Experiment II-5-3, an Equal Arm Balance, and a box of beads.

Read instructions on pages 11-14 (paragraphs 2,4-2.6)

Prepare the balance.

Answer all questions in your notebook.

4. When you feel ready, take the Post Test for Mass measurements.

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UNIT II: OBSERVATION vs INTERPRETATION

TOPIC 6: Universal Units of Measurement

OBJECTIVES:

1. Using selected readings and visual aids, to help make the student aware of the development of the Metric System.

2. To focus attention on the relationship among the fundamental units of measurement by readings and self-tests from various sources.

ACTIVITIES:

1. Read INTRODUCTION TO METRIC SYSTEM: HISTORY AND MODERN DEVELOPMENT in Activity II-6-1.

2. Read pages 4-9 in MODERN PHYSICAL SCIENCE. Answer the questions given on page 9 in QUICK QUIZ.

3. Read Units 12 and 13 (pages 11-14) in MODERN CHEMISTRY. In your notebook record data given.

4. Read Chapter 1 of TERMS, TABLES, AND SKILLS. Answer questions 5-18 in "excercises" on page 11 and hand in.

5. Obtain the folder on COMPARISON BETWEEN ENGLISH AND METRIC SYSTEMS (Activity II-6-5). Use the overhead projector to view the data given. Note your observations in your notebook.

6. Read NBS URGES 10-YEAR METRIC CONVERSION PLAN, given in Activity II-6-7. Write down, in your notebook, your reaction to conversion.

7. Take Post-Test II-6-7 on Universal Units of Measurement.

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UNIT II: OBSERVATION vs INTERPRETATION

TOPIC 7: Interpretation of Data

OBJECTIVES:

1. To prepare students for use of the graph as a tool in putting order into unorganized collected data.

2. To have students experience the predictive value of graphing.

ACTIVITIES:

1. Read Chpater 8: Recording Data in TERMS, TABLES, SKILLS and note in your notebooks the criteria for recording experimental data.

2. Read Chapter 10: Techniques of Graphing in TERMS, TABLES, SKILLS and record in your notebook information on coordinates, scale, labeling axes, location of points, and connection of plotted points.

3. Look through the various types of graphs given in Chapter 12 of TERMS, TABLES, SKILLS. Relate the data given to the resulting graph.

4. Using the data you collected in the conversion table (beads to grams) graph the information obtained using "grams" for the X axis and "beads" for the Y axis. Join the plotted points. If it were possible to have absolutely accurate measurements, what kind of line would have resulted? What did you find in your graph?

5. Read Chapter 9, pages 52-55: Error Analysis in TERMS, TABLES, SKILLS. Record in your notebook the kinds of errors possible and the probable causes. Did any of these apply to your graph?

6. Hand in your completed graph, noting your comments on the probability of errors.

7. Obtain filmstrip: ANALYZING SCIENTIFIC DATA.

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UNIT III: CHEMISTRY IN THE SPACE AGE

TOPIC 1: Laboratory Techniques

OBJECTIVES:

1. To have the students prepare simple laboratory apparatus for use in further experiments.

2. To alert the students to safety in the laboratory.

ACTIVITIES:

1. Glass tubing: cutting, fire polishing, bending

2. Transfer of liquids

3. Transfer of solids

4. Heating of liquids

5. Filtration

6. Evaporation

7. Collection of gas: test tube generator

   flask generator

8. Review your notes on the proper use of the Bunsen burner.

9. Obtain and view film loops on SAFETY IN THE LABORATORY and read Activity III-1-9: WARNING TO ALL STUDENTS IN CHEMISTRY LABORATORY.

10. Take Post-Test on Laboratory Techniques.

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UNIT III: CHEMISTRY IN THE SPACE AGE

TOPIC 2: Investigating the Nature of Matter

OBJECTIVES:

1. To develop laboratory techniques in observing and recording some characteristic properties of matter.

2. To relate laboratory experiences and findings to earth-space.

ACTIVITIES:

1. Obtain Experiment III-2-1: DENSITY OF SOLIDS. Hand in a written report of findings.

2. Obtain Activity III-2-3: DENSITY OF LIQUIDS. Perform the activity and hand in written report.

3. Prepare laboratory equipment for DENSITY OF GASES. Perform the activity and hand in written report.

4. Obtain Activity III-2-4: DETERMINATION OF MASS, VOLUME, AND DENSITY OF THE EARTH. Hand in written report.

5. Obtain Activity III-2-5: FREEZING MELTING POINT. Perform the experiment and hand in written report together with graph of data.

6. Perform Activity III-2-6: THERMAL EXPANSION OF SOLIDS. Hand in written report of results.

7. Perform Activity III-2-7: ELASTICITY OF GASES. Hand in written report of results.

8. Activity III-2-8: SOLUBILITY - EFFECT OF TEMPERATURE ON SOLUBILITY

9. Activity III-2-9: FRACTIONAL DISTILLATION

10. Activity III-2-10: FRACTIONAL CRYSTALLIZATION

11. Activity III-2-11: LAW OF DEFINITE PROPORTIONS

12. Activity III-2-12: CRYSTALS

13. Obtain Activity III-2-13: EVOLUTION OF THE MOON: THERMAL HISTORY using knowledge of activities above.

14. Take Post-Test III-2-14.

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UNIT III: CHEMISTRY IN THE SPACE AGE

TOPIC 3: Indirect Evidence for Atomic Theory

OBJECTIVES:

1. To explore by experiment the indirect evidence for the structure of the atom.

2. To enable the student to read and use the PERIODIC CHART as a table of interpretation and prediction.

ACTIVITIES:

1. Read Activity III-3-1: INTRODUCTION TO THE ATOM, taking notes for future use. Perform one or more of the following as examples of seeking indirect evidence for the structure of the atom:

   Activity III-3-1A: CONDUCTIVITY OF SOLUTIONS
   Activity III-3-1B: IS WATER H_2O or HO?
   Activity III-3-1C: MYSTERY BOX

2. Read Activity III-3-?: INTRODUCTION TO ENERGY LEVELS. Perform the Activity on Spectral Analysis. Hand in report of your results.

3. Referring to page 566 in MODERN CHEMISTRY, prepare a chart for electronic arrangement of the elements. Obtain the latest information from data in class discussion.

4. Obtain the expanded PERIODIC CHART and fill in name, symbol, and atomic number according to instructions given. (Use Periodic Chart in TIME, TABLES, TERMS on page 124, for reference.)

5. Fill in where indicated on CHART the valence electrons. Note the "family" groupings.

6. Obtain Activity III-3-6: USING THE CONCEPT OF VALENCE

7. Obtain Activity on IONIZATION POTENTIAL. Prepare graph and enter information into the Periodic Chart.

8. Obtain Activity on ATOMIC RADIUS. Prepare graph and enter information to Periodic Chart.
9. Obtain Activity on MASS NUMBER: Enter information in Periodic Chart. Check on difference between atomic weight and mass number.
10. Read DEVELOPMENT OF PERIODIC CHART. Check your Periodic Chart as directed and hand it in with report requested. Read Chapter 5 in MODERN CHEMISTRY. Answer and hand in Group A questions on p.76.
11. Obtain Activity on CONSTRUCTION OF ATOMIC MODELS. Display your results.
12. Take Post-Test III-3-12.

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UNIT IV: THE SPACE AGE

TOPIC 1: Space Astronomy

OBJECTIVES:

1. To relate experience in chemistry laboratory to the earth-space continuum.

2. Through experimental data to accumulate evidence for the environmental importance of the sun to earth.

3. To explore through experiment the nature and relationship of the chemistry of the stars-nuclear chemistry-for the benefit of mankind.

4. To quantitatively measure some properties of magnetism and relate to importance of this force to the earth.

ACTIVITIES:

1. Obtain Activity IV-1-1: BECQUEREL AND RADIOACTIVITY. After performing the experiment, hand in your results.

2. Read Chapter 10 to page 430: NUCLEONICS in MODERN PHYSICAL SCIENCE. Answer and hand in the questions on page 430.

3. Obtain Activity IV-1-3: RADIOACTIVE DATING of sample X. Hand in the results of your experiment.

4. Read pages 430-444 in MODERN PHYSICAL SCIENCE. Hand in the answers to questions on page 444.

5. Obtain and read Activity IV-1-5: NUCLEAR POWER. Put into your notebook points of interest. Indicate your reaction to the questions expressed and hold for class discussion.

6. Read pages 20-21 in INVESTIGATING THE EARTH. Obtain graph paper and plot the information given on page 21. Let the "year" be the X axis and the "sunspot number" be the Y axis. Answer the questions on page 21. Hand in your investigation as a report.

7. Obtain Activity IV-17: DO SUNSPOTS AFFECT THE WEATHER?

8. Read Chapter 24 in INVESTIGATING THE EARTH: STARS AS OTHER SUNS. Hand in the answers to questions on pages 521,525, and 529 as well as "Questions and Problems - A" on page 532.

9. Perform the activities suggested in Chapter 24 above as given on page 525,527,528,530. Hand in reports of those you completed. (Light intensity curve, Spectral analysis, Luminesity vs temperature, Diameter of the sun.)

10. Read pages 120-125 in INVESTIGATING THE EARTH. Perform the Experiment IV-1-10: MAGNETIC SPHERES and hand in your results.

11. Answer the questions in THOUGHT AND DISCUSSION on page 125 in the above and hand in.

12. Obtain Activity IV-1-12: INVESTIGATING A MAGNETIC FIELD. After performing the activity, answer the questions and hand in the entire report.

13. Obtain Activity IV-1-13: THE COMPASS. Write up the activity and hand in the results.

14. Obtain Activity IV-1-14: HOW THE HEAVENS INFLUENCE OUR LIVES and read the opinion expressed. Write a brief report on your acceptance or rejection of this opinion.

15. Read Chapter 25 in INVESTIGATING THE EARTH: STELLAR EVOLUTION AND GALAXIES. Perform activity on page 543 and 548. Hand in written report of activities completed.

16. Read Chapter 25 above and answer questions on page 544, 547, and 549. Hand in the results.

17. Read Chapter 26 in INVESTIGATING THE EARTH: THE UNIVERSE AND ITS ORIGIN. Answer and hand in "Thought and Discussion" results on pages 558,564 and 567.

18. Obtain Activity IV-1-18: DETERMINING THE DENSITY OF THE SUN. Hand in the results of your findings.

19. Read pages 114-123 in MODERN EARTH SCIENCE, putting into your notebook any diagrams as given. Obtain Activity IV-1-19 on the PERPETUAL CALENDAR and follow the instructions in making such a calendar.

20. Listen to term investigation report on SPACE ASTRONOMY brought in by other students.

21. Take Post-Test IV-1-21.

ESP

UNIT IV: THE SPACE AGE

TOPIC 2: Selenology

OBJECTIVES:

1. To familiarize the student with the surface of the moon and its probable development through observation of photographs and map construction of the near and far sides of the moon.

2. To investigate the importance of moon exploration to the earth by analyzing the Apollo experiments left on the moon.

3. To compare the composition of earth and moon rocks with samples of earth specimens and descriptive data of moon specimens.

4. Through research and reading to determine and list the historic steps taken by mankind in the changing view of Earth and its place in the universe.

ACTIVITIES:

1. Obtain Activity IV-2-1 (Investigation Book #8 TSM). Compare the earth and moon as shown in the photographs. List the similarities and differences in your notebook.

2. Review the notes you took on the film, THE EARTH IN CHANGE. List any forces changing the earth's surface that might explain changes on the moon's surface.

3. Obtain Experiment IV-2-3: FORMATION OF CRATERS. Hand in the results of your experience.

4. Obtain Experiment IV-2-4: FORMATION OF VOLCANOES. Hand in the results of your experiment.

5. Select activities from DISCOVERING THE MOON. Perform the activities and hand in a report of your experience.

6. Observe the photograph on page 23 of Investigation Book #8 and determine a sequence of events based on the following:

   a. platform
   b. people on platform
   c. gulleys on crater walls
   d. meteorite impact
   e. crater
   f. broken rocks in foreground
   g. vegetation

   In your notebook, number the correct sequence to be used for class discussion.

7. Examine the photograph on pages 34 and 35 of Investigation Book #8 (TSM). List the sequence of events which you think took place to produce this result. Back up your opinion.

8. Obtain a copy of the outline map of the Mare Imbrium area. Identify and mark the various features. Following this, complete the activity as follows:

   a. Determine what feature is the youngest, the oldest, and those in between. Support your opinion.

   b. Using colored pencils, color the map according to your determination above. Show the various stages from youngest to oldest by a map legend. You should have no less than five stages.

   c. List a brief history of the formation of the Mare Imbrium area.

   d. Check your opinion with the idea of "superposition", an important concept in geology. Read pages 50-51 of EARTH SCIENCE (Silver Burdett) on the Principle of Superposition. Look up this principle in other science books, such as, pp.391-3 in MODERN EARTH SCIENCE AND p.383 in INVESTIGATING THE EARTH.

9. Read Activity IV-2-9: INFORMATION GAINED FROM THE MOON. Write your reaction to the opinions expressed, especially that of Dr. H.H.Schmitt, geologist-astronaut, on IMPORTANCE OF INFORMATION GAINED FROM THE MOON. Hand in your results.

10. Obtain copy of Activity IV-2-10: APOLLO LUNAR SURFACE EXPERIMENTS PACKAGE (ALSEP). Make a list of the experiments, stating their purpose. Keep this information in your notebook for class discussion.

11. Obtain Activity IV-2-11: MOON ROCKS. Compare the moon rocks described with earth samples. Use the ROCK AND MINERAL INDENTIFICATION CHART provided in the activity to list the various factors.

12. View the APOLLO MISSIONS slides. Write down in your notebook the slide viewed and your observations.

13. Listen to term investigation report on SELENOLOGY brought in by other students.

14. Take Post-Test IV-2-14.

ESP

UNIT IV: SPACE AGE

TOPIC 3: The Laws of Physics

OBJECTIVES:

1. To enable the student, through experimentation, to observe and apply the Bernoulli principle to conventional aircraft, supersonic models, space shuttle, and future aircraft.

2. To construct and launch a rocket, experiencing through observation and experiment, the steps from the pendulum to Saturn V.

3. To develop the Laws of Motion through experiment and observation, relating them to celestial mechanics.

4. Through experiment to develop fundamental principles of electrical power and to relate them to space exploration.

ACTIVITIES:

1. Obtain Activity IV-31-: FIFTY YEARS OF AERONAUTICAL RESEARCH. Begin a "Progress Chart" in your notebook to which you will add current information.

2. Obtain Activity IV-3-2: AERONAUTICS - THE FIRST STEP TO SPACE. Perform the activities and hand in the results of your investigations.

3. Obtain copies of prize-winning paper planes and explain their flight.

4. Read Activity IV-3-4: SUPERSONIC TRANSPORT. Prepare material for class discussion giving opinions for and against this type of aircraft.

5. Obtain Activity IV-3-5: FUTURE AIRCRAFT. Relate information to current progress in this field.

6. Obtain and draw the cockpit of conventional aircraft. Compare this to the instrument panel of spacecraft.

7. Obtain Activity IV-3-7: GALILEO'S PULSILOGIA AND THE DEVELOPMENT OF THE PENDULUM. Perform the experiments suggested and hand in your results.

8. Obtain Activity IV-3-8: ROCKETRY AND SPACE EXPLORATION. Perform the activities and hand in your observations.

9. Build a rocket as a class project. Plan for a class launch. Bring into class suggestions to improvement in performance.

UNIT IV: SPACE AGE

TOPIC 3: The Laws of Physics

10. Obtain Activity IV-3-10: SPACE MOTION. Relate Newton's Laws to each activity performed and hand in your results.

11. Obtain Activity IV-3-11: FROM A VOLTAIC CELL TO SPACE FUEL CELLS. Demonstrate your results in a class presentation.

12. Build a model rocket launch system. Relate your activity to Ohm's Law.

13. Read Activity IV-3-13: PROPULSION SYSTEMS OF THE FUTURE. Suggest topics for class discussion.

ESP

UNIT IV: THE SPACE AGE

TOPIC 4: Space Biology

OBJECTIVES:

1. To lay a foundation for elementary organic chemistry, biochemistry, and the possibility of extraterrestrial biology through simple construction of models and experiments.

2. To introduce the student to the problems of life in outer space through experimentation and observations.

ACTIVITIES:

1. Read Activity IV-4-1: FROM A CANDLE TO A STAR. Answer the questions asked and hand in to be used as a basis for class discussion.

2. Perform Experiment IV-4-2: ESTERS. Write up the results and hand them in.

3. Obtain Activity IV-4-3: BUILDING ORGANIC COMPOUNDS. Hand in the results of your activity.

4. Read Activity IV-4-4: PHOTOSYNTHESIS. Take notes in preparation for class discussion. Look for examples of protons or electrons picked up from a donor and passed on by carriers. If available, obtain a copy of BIOLOGICAL SCIENCE: MOLECULES TO MAN (BSCS) and read about electron transport.

5. Obtain Activity IV-4-5: BUILDING BIOCHEMICAL COMPOUNDS: DNA. Hand in your results.

6. Read Activity IV-4-6: CHEMICAL EVOLUTION. Prepare notes for a class discussion.

7. Obtain Activity IV-4-7: EXPERIENCING WEIGHTLESSNESS. If possible, arrange for class participation in actual flight in a small plane.

8. Obtain Activity IV-4-8: ACTIVITIES IN SPACE BIOLOGY. Hand in the results of your activities.

ACTIVITIES: (Continued)

9. Keep a record of your daily moods, using a scale such as 1 to 6 to stand for feelings from depression (1) to optimism (6). Graph your results, using time as the X axis and mood values as the Y axis. Astronauts do this in an effort for better self-control. Can you make an predictions about yourself?

10. Projecting into the future, it is conceivable that "moon children" will someday be born to moon colonists. What biological problems might these children (or when grown into adults) encounter on visiting the Earth? Prepare your ideas for a class discussion.

11. Obtain Activity IV-4-11: BUILDING LIFE-FORMING COMPOUNDS FOUND IN SPACE. Read also Chapter 8 in CHEMISTRY IN THE SPACE AGE (Gardner). Hand in your report, including current information you have found.

ESP

UNIT V: HUMANITIES AND SPACE

TOPIC 1: Role of the Satellites

OBJECTIVES:

1. To help the students identify the various types of satellites.

2. To review the scientific principles involved in the systems used in the satellites.

3. To emphasize the importance of satellites as sentries of our near and far environments.

ACTIVITIES:

1. Obtain Activity V-1-1: THE STORY OF SATELLITES. Use the information to start a "Satellite Watch" in your notebook. The data might be classified as follows:

   UNMANNED: Communications
   - ATS (Application Technology Satellites)
   - CAS (Cooperative Application Satellites)
   - INTELSAT (covering the Atlantic, Pacific, Indian Oceans)
   - GEOS (Geophysical Orbiting Satellite)
   - DEEP SPACE (Mariner, Pioneer, Viking)
   - NOAA (National Oceanographic and Atmospheric Administration)
   - COMSAT (Communications Satellite Corp.)
   - ESRO (Earth Space Research Organization)

   Observations
   - ITOS (Improved Tiros)
   - NIMBUS (Weather Communications Satellite)
   - SMS (Synchronous Meteorological Satellite)
   - ERTS (Earth Resources Technological Satellite)
   - OGO (Orbiting Geophysical Observatory)
   - OSO (Orbiting Solar Observatory)

   MANNED: SKYLAB
   SPACE STATIONS

2. Obtain Activity V-1-2: WEATHER. Perform the suggested activities and hand in your results.

3. Investigate source of electrical power in spacecraft including alkaline batteries, solar cells, fuel cells, and nuclear energy. Present information for class discussion.

ACTIVITIES: (Continued)

4. Investigate attitude control of spacecraft through use of solar pressure, gravity, magnetic fields, miniature rockets, gyro and inertia wheels. Explain how forces that cause disorientation are overcome. (tridyne)

5. Using commonplace objects (such as cans and bottle tops, etc.) construct models of satellites.

6. Summarize the functions of satellites and keep in your notebook for class discussion.

ESP

UNIT V: HUMANITIES AND SPACE

TOPIC 2: Mankind and Space

OBJECTIVES:

1. To have the students specify the benefits to mankind derived from space exploration.

2. To identify through research and observation problems that have developed on the Spaceship Earth.

3. To have the students project into the future, through the role playing of science fiction writing, alternate solutions to the problems of "saving the earth from man."

ACTIVITIES:

1. Obtain Activity V-2-1: BENEFITS FROM SPACE. Make a list for class discussion.

2. Obtain and read Congressional Hearings on SPACE PROGRAM BENEFITS, FOR THE BENEFIT OF ALL MANKIND.

3. READ: PRIORITIES FOR SPACE RESEARCH (1971-1980) by the National Academy of Sciences.

4. Obtain Activity V-2-4: PROBLEMS ON THE SPACESHIP EARTH. Hand in the results of your activities.

5. Modern science fiction, based on science facts and/or theories, helps to present alternate solutions to present and future problems. Select some scientific fact or theory discussed this year that might apply to one of the problems on Earth and project it into the future. The problem may not be solved satisfactorily but it may suggest other alternates. Present your idea for class discussion.

6. Collect science fiction ideas (from books you have read) which prove the contention that yesterday's science fiction is today's reality.

7. Obtain Activity V-2-7: FUTURE PREDICTIONS? Write your opinion on any of the ideas of interest to you.

UNIT V: HUMANITIES AND SPACE

TOPIC 3: Planetary Probes of the Future

OBJECTIVES:

1. Through reading and discussion to up-date the students' information on events that may play a part in his future.

2. To have the student apply his present knowledge of life as we know it to the possibility of life on other planets now being explored through discussion of optimum environmental conditions and life detection instruments.

ACTIVITIES:

1. Obtain and read Activity V-3-1: INTERPLANETARY TRAVEL. Take notes on controversial points for class discussion.

2. Obtain and read Activity V-3-2: THE SEARCH FOR EXTRATERRESTRIAL LIFE. Express your opinion in a written report.

3. Read RED GIANTS AND WHITE DWARFS by Robert Jastrow. Express points of agreement and disagreement.

4. Read INTELLIGENT LIFE IN THE UNIVERSE by Shklovskii and Sagan. Note points for class discussion.

5. Read WE ARE NOT ALONE by Walter Sullivan. Note your opinions for and against those offered in the book.

6. Read EXTRATERRESTRIAL BIOLOGY by Richard Young. Discuss the experiments suggested.

7. Prepare notes for class discussion on THE IMPACT ON MANKIND SHOULD LIFE BE FOUND IN OUTER SPACE.

8. Astronaut Donald K. Slayton was grounded for ten years because of atrial fibrillation. During the ten years, he continued to correct his problem through proper medical aid and a determination to fly again. He was finally given a medical OK and put back on flight status. He also spent his time studying Russian.

   Is there a lesson to be learned from Astronaut Slayton's experience?

APPENDIX A
UNIT: REMEDIAL

TOPIC: Calculation with decimals

OBJECTIVES:

1. To enable the student to make meaningful observations in science through the use of mathematics.

2. To refresh and reinforce the student's use of decimals in problems involving addition, subtraction, multiplication, and division.

ACTIVITIES:

1. Addition and subtraction

When adding with decimal numbers it is important first to make sure the decimal points all line up in a column. Then you simply add as usual. The decimal point in the answer is in the same column as the numbers above. For example, add the following numbers: 5.2, 6.14, 91.368, and 17.4. Be sure to line up the numbers properly. Your column should look like the following:

```
   5 . 2
   6 . 1 4
 9 1 . 3 6 8
 1 7 . 4
-------------
 1 2 0 . 1 0 8
```

When subtracting, you do exactly the same thing - putting numbers and decimals in proper columns - but this time substract rather than add.

If you think you now understand, complete the following problems in your notebook. Check the answers by looking at the Answer Sheet at the end of the Unit.

ADD THE FOLLOWING NUMBERS:

A. 4.3, 6.273, 173.504

B. 0.007, 5.01, 6.049, 2.3

C. 3.9, 5.04943, 2.67

D. 16.42, 897.463, 8.0004

TOPIC: Calculation with decimals

ACTIVITIES:

1. SUBTRACT THE FOLLOWING NUMBERS:

   E. 14.73 - 9.6

   F. 742.04 - 16.73

   G. 7.46932 - 2.24

   H. 3.407 - 2.3

   I. 74.2 - 67.354

2. Multiplication

   Multiply the numbers as usual just as if the decimal points were not there.

   Count the number of places there are to the right of the decimal in each number.

   Add the number of decimal places.

   In the answer, begin at the number on the right and count back to the left the number of decimal places found in #3.

   For example, in multiplying 2.7 X 3.2:

$$\begin{array}{rl} & 2.7 \quad \text{(1 decimal place)} \\ \times & 3.2 \quad \text{(1 decimal place)} \\ & 54 \\ & 81 \\ \hline & 8.64 \quad \text{(2 decimal places needed)} \end{array}$$

$$8\,6\,4 = 8.64$$

$$\leftarrow 2\text{-}1$$

MULTIPLY THE FOLLOWING NUMBERS in your notebook if you think you now understand. Check the answers by looking at the Answer Sheet at the end of the Unit.

TOPIC: Calculation with decimals

A. 5.5 X 2.3

B. 3.82 X 1.3

C. 5.004 X .001

D. 23.42 X .25

E. 7.03 X 6.7

F. 47.1 X 3.22

G. .33 X .44

3. Division

For dividing with decimals, follow the steps below:

Determine which is the divisor and which the dividend --

Quotient
Divisor/ Dividend

Count the number of places there are to the right of the decimal in the divisor

3.24/ 9.73 (2 places)

Move the decimal point in the divisor to the right that (2) number of places

3.24/ 9.72 = 324/ 9.72

Find the decimal point in the dividend and move the decimal to the right the same number of places as you did the divisor

324/ 9.72, = 324/ 972

Move the decimal up into the quotient section directly above the new position in the dividend:

324/ 972.

Now divide, making sure the quotient numbers are placed in their proper places

3.0
324/ 972.0
972
0 0

APPENDIX A

UNIT: REMEDIAL

TOPIC: Calculation with decimals

Work out the following in your notebook. Check answers by looking at the Answer Sheet at the end of the Unit.

DIVIDE THE FOLLOWING. Please note that $\div$ means divided by.

A. $62.7 \div 3.4$

B. $6.248 \div .2$

C. $3.624 \div 3$

D. $396.4 \div 2.4$

E. $.5226 \div .13$

F. $.549 \div .9$

ANSWER SHEET

UNIT: REMEDIAL
TOPIC: Calculation with Decimals

1. A. 184.077
   B
   B. 13.366
   C. 11.61943
   D. 921.8834
   E. 5.13
   F. 725.31
   G. 5.22932
   H. 1.107
   I. 6.846

2. A. 12.65
   B. 4.966
   C. .005004
   D. 5.8550
   E. 47.101
   F. 151.662
   G. .1452

3. A. 18.4
   B. 31.24
   C. 1.208
   D. 165.2
   E. 4.02
   F. .61

APPENDIX B
UNIT: REMEDIAL

TOPIC: Scientific Notation

OBJECTIVES:

1. To enable the student to write numbers in standard scientific notation as an aid to handling very large and very small numbers in science.

2. To refresh and reinforce the student's skill in adding, subtracting, multiplying, and dividing astronomical and atomic figures using scientific notation.

ACTIVITIES:

1. In order to write numbers in scientific notation, it is important to learn how to express powers of ten. Every number may be expressed as the product of two numbers:

   (figures given in the problem) X (power of ten)

   Copy the following set into your notebook. Count the places determining the power of ten:

   1,000,000,000,000 .....1×10^{12}.....TERA

   1,000,000,000 .....1×10^{9} .....GIGA

   1,000,000 .....1×10^{6} .....MEGA

   1,000 .....1×10^{3} .....KILO

   100 .....1×10^{2} .....MECTO

   10 .....1×10^{1} .....DEKA

   1 .....1×10^{0} .....

   0.1 .....1×10^{-1}.....DECI

   0.01 .....1×10^{-2}.....CENTI

   0.001 .....1×10^{-3}.....MILLI

   0.000.001 .....1×10^{-6}.....MICRO

   0.000.000.001 ..... 1×10^{-9}.....NANO

   0.000,000,000,001 ..... 1×10^{-12}.....PICO

TOPIC: Scientific Notation

2. Another way of expressing scientific notation is as follows:

10^{-5}	10^{-4}	10^{-3}	10^{-1}	10^{0}	10^{1}	10^{3}	10^{4}	10^{5}
.00001	.0001	.001	.1	1	10	1000	10000	100000
/ 1		/ 1				/		/
10X10X10X10X10		10X10X10				(10X10X10)		(10X10X10X10X10)

In your notebook, copy the powers of ten heading but including the missing power.

Substituting "5" for the "1" under the power of 10^{0}, enter the proper figures. Check your answer with the Answer Sheet.

3. Scientific notation may be looked at as a "shorthand" or time saver where large numbers are concerned. For example,

7,000,000
may be written: 7×10^{6}

This is a product of two factors - 7 is one factor and the other 10^{0} which is a power of 10. In counting the number of places to determine the power of ten, you probably realized that "7" was the significant number and that the zeros served to place the decimal point, understood after the last zero.

Generally speaking, all digits that make up a number, except zeros that designate ten, hundreds, thousands, etc., are significant figures. For example, in:

375,000

"375" are significant since they identify that particular number. In scientific notation, it would be written as:

3.75×10^{5}

Some other examples are:

$83.000 = 8.3 \times 10^{4}$

$845,000,000,000 = 8.45 \times 10^{11}$

$0.0716 = 7.16 \times 10^{-2}$

$0.000,000,342 = 3.42 \times 10^{-7}$

TOPIC: Scientific Notation

In each case, you put a decimal after the first significant figure and then count the number of places TO THE RIGHT if the number is more than 1 and TO THE LEFT if the number is less than 1.

TURN TO PAGE 16 in TERMS, TABLES AND SKILLS (Bobby J. Woodruff). Work out examples 1-15 in your notebook. Check your answers on page 150. Redo those problems which you found incorrect.

4. Problems in science using scientific notation

A. Light year

A "light year" is the distance traveled by light in one earth year.

Light travels at a speed of 186,000 mi/sec (English)
30,000,000,000 cm/sec (Metric)

In your notebook, calculate a light year in cm. Use the following pattern to aid you in your calculations:

30,000,000,000 cm/sec
X 60 sec (60 sec = 1 min)

..... cm/min
X 60 min (60 min = 1 hr)

..... cm/hr
X 24 hr (24 hr = 1 day)

.....
X 365 days (365 days = 1 yr)

Answer: ..... cm/year (light year)

Repeat the above problem but this time use scientific notation. Check your answers with Answer Sheet at the back of the Unit.

B. What is the mass of a PROTON? (How much matter exists in a proton?)

0,000 000 000 000 000 000 000 001 67 gm

Write this figure into your notebook and then rewrite it in scientific notation. Check your answer with the Answer Sheet in back of the Unit.

UNIT: REMEDIAL

TOPIC: Scientific Notation

C. What is the mass of an ELECTRON? (How much matter exists in an electron?)

0,000 000 000 000 000 000 000 000 000 91 gm

Write this figure into your notebook, properly labeled, and then rewrite it in scientific notation. Check your answer with the Answer Sheet in back of the Unit.

IF YOU FOUND THAT YOUR ARE STILL HAVING TROUBLE WITH SCIENTIFIC NOTATION, TRY THE FOLLOWING ACTIVITIES. IF YOU WERE ABLE TO DO ALL THE PROBLEMS GIVEN SO FAR WITHOUT DIFFICULTY, YOU MAY SKIP THIS SECTION AND GO ON TO ACTIVITY 8.

* *

5. In scientific notation we want to change the way the number appears and not its value. We must adjust the answer so that it really has the same value as before.

To change the appearance and not the value, we move the decimal point and then adjust the final result by multiplying by 10, 100,1000 or 1/10, 1/100, 1/1000 depending on which way we move the decimal and how many places.

In scientific notation we move the decimal point until it is placed after the greatest place value number. For example:

7984 is the same as 798.4 X 10 (decimal moved 1 place)

or

79.84×10^2 (79.84 X 10 X 10)
decimal moved 2 places

or

7.984×10^3 (7.984 X 10 X 10 X 10)
decimal moved 3 places

Since "7" has the greatest place value, 7.984×10^3 would be the correct form in scientific notation.

DO THE FOLLOWING IN YOUR NOTEBOOK:

Change 768 to scientific form by

a. putting the decimal after the greatest place value number:
7. 6 8 (decimal moved 2 places)

TOPIC: Scientific Notation

b. adjusting this change by multiplying 7.68 X 10 X 10

c. writing the correct form as 7.68×10^2

Change 78,959.5 to scientific form by:

a. putting the decimal after the greatest place value number:
7. 8 9 5 9 5 (decimal moved 4 places)

b. adjusting this change by multiplying 7.89595 X 10 X 10 X 10 X 10 X 10

c. correct form: 7.89595×10^4

6. Complete the following chart in your notebook and check the answers in the Answer Sheet in the back of the Unit:

NUMBER	EXPANDED SCIENTIFIC FORM	SCIENTIFIC FORM
384	3.84 X 10 X 10	3.84×10^2
55.4		
76.37		
237		
486.2		
963.22		
1374		
7542.6		
6384.57		
11,463		
16,824.5		
84,923.76		
246,892		
861,394.2		
1,830.402		
2,560,000		
40,004.000		
98,000,000		
476,000,000		
3,967,000,000		

After having completed this chart, you may be better able to understand why scientists feel that SCIENTIFIC NOTATION is a "shorthand" for writing large numbers.

7. So far the numbers considered have been larger than "one". It is just as easy to work with numbers that are less than one. For example, to change

.69

to the expanded scientific form, move the decimal after the first significant figure:

6.9 (one place)

and multiply by 1/10 this time, instead of by 10, since the number .69 is less than one:

6.9 X 1/10

In the same way, the number:

.00076 becomes 7.6 (four places)

7.6 X 1/10 X 1/10 X 1/10 X 1/10

In scientific notation:

$6.9 \times 1/10 = 6.9 \times 10^{-1}$

$7.6 \times 1/10 \times 1/10 \times 1/10 \times 1/10 = 7.6 \times 10^{-4}$

COMPLETE THE FOLLOWING CHART in your notebook and check the answers in the Answer Sheet in the back of the Unit:

NUMBER	EXPANDED SCIENTIFIC FORM	SCIENTIFIC NOTATION
.65	6.5 X 1/10	6.5×10^{-1}
.7		
.06		
.082		
.080		
.002		
.0006		
.0034		
.01234		
.00005		
.0105		
.0000008		
.67432		
.00574		
.00000001 .073		

TOPIC: Scientific Notation

8. Scientific Notation helps the scientist to handle large numbers more easily. You may have noticed that, in some of the examples used, the number of decimal places was also quite large. In order to further simplify the handling of large numbers, unlimited significant figures may be rounded off.

If the extra digits are less than 5, the preceding figure is not changed:

13.462 13.46

If the digit to be dropped is greater than 5, the last figure kept is increased by 1:

13.468 13.47

If the digit to be dropped is exactly 5, round off so that the retained figure is an even number:

13.465 13.46

13.475 13.48

In our work, we shall use no more than TWO decimal places which may be further rounded off to one place.

TO REFRESH YOUR MEMORY OF SIGNIFICANT FIGURES IN SCIENTIFIC NOTATION AND THE ROUNDING OFF OF THE FIGURES, do the excercises on page 19 of TERMS, TABLES, AND SKILLS. Check your answers at the back of the book. Rewrite in scientific notation.

Round off each of the answers. Check your final answer at the end of the Unit.

9. SCIENTIFIC NOTATION IN ADDITION AND SUBTRACTION

In order to add or subtract numbers using scientific notation, it is important and necessary to have the exponents of 10 the same. (You may recall that when you add or subtract the items have to be similar - when you are adding "apples" you can't put in a few oranges.)

For example, in order to add the following:

$$\begin{array}{rl} & 2.6 \times 10^{3} \\ + & 6.2 \times 10^{4} \\ & \underline{5.2 \times 10^{1}} \end{array}$$

TOPIC: Scientific Notation

the exponents of ten must first be made the same. It does not matter which power you choose but the final answer must be in the correct scientific notation form.

$2.6 \times 10^3 = 2.6 \times 10^3$ or $.26 \times 10^4$

$6.2 \times 10^4 = 62.0 \times 10^3$ 6.2×10^4

$5.2 \times 10^1 = .052 \times 10^3$ $.0052 \times 10^4$

64.652×10^3 6.4652×10^4

6.4652×10^4

Round off, we get 6.5×10^4

PROBLEM: In your notebook, work out the addition of the following:

a. 1.72×10^7

$+ \quad 0.15 \times 10^3$

627.1×10^4

Be sure to write out the answer in final scientific notation form and to round off the figures. Check your answer in the Answer Sheet at the back of the Unit.

Do the same as above for the following:

b. 2.6×10^{-4}

$+ \quad 3.4 \times 10^{-7}$

Check your answer as above.

PROBLEM: In your notebook, work out the subtraction of the following:

c. 3.93×10^7

$- \quad 7.81 \times 10^6$

d. 2.9×10^{-4}

$- \quad 6.4 \times 10^{-5}$

TOPIC: Scientific Notation

10. SCIENTIFIC NOTATION IN MULTIPLICATION AND DIVISION

In order to multiply or divide numbers using scientific notation:

Multiply or divide the significant figures just as you would in any other problem with decimals

BUT

Add the exponents when multiplying

Subtract the exponents when dividing

For example:

$$\begin{array}{r} 3.2 \times 10^{3} \\ \times\ 1.5 \times 10^{2} \\ \hline 160 \\ 32 \\ \hline 4.80 \times 10^{3+2} \end{array} = 4.8 \times 10^{5}$$

Another example would be:

$$\begin{array}{r} 3.2 \times 10^{-3} \\ \times\ 1.5 \times 10^{2} \\ \hline 160 \\ 32 \\ \hline 4.80 \times 10^{-3+2} \end{array} = 4.8 \times 10^{-1}$$

IN YOUR NOTEBOOK, work out the following multiplication problems:

a. $(3.2 \times 10^{-3}) \times (1.5 \times 10^{-2})$

b. $(2.0 \times 10^{8}) \times (8.0 \times 10^{2})$

c. (8,200) X (510) BE SURE TO REWRITE IN SCIENTIFIC NOTATION

d. (910) X (0.00030)

e. $(7.2 \times 10^{4})\ (6.3 \times 10^{7})$

f. $(6.3 \times 10^{5})\ (1.2 \times 10^{4})$

g. $(2.2 \times 10^{4})\ (4.44 \times 10^{1})$

h. $(8.74 \times 10^{2})\ (4.1 \times 10^{2})$

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j. $(2.5 \times 10^{7})\ (1.5 \times 10^{-2})$

k. $(3.4 \times 10^{2})\ (5.2 \times 10^{-3})$

l. $(2.4 \times 10^{-2})\ (2.4 \times 10^{-6})$

m. $(1 \times 10^{5})\ (2 \times 10^{7})$

n. $(3 \times 10^{-11})\ (3 \times 12^{-12})$

Check your answers in the Answer Sheet at the end of the Unit.

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

IN YOUR NOTEBOOK, work out the following division problems:

Remember that although the significant numbers are divided as usual, the EXPONENTS are SUBTRACTED as for example:

$$\frac{6.6 \times 10^{4}}{2.2 \times 10^{2}} = 3 \times 10^{(4)-(2)} = 3 \times 10^{2}$$

$$\frac{8 \times 10^{2}}{4 \times 10^{4}} = 2 \times 10^{(2)-(-4)} = 2 \times 10^{-2}$$

$$\frac{6 \times 10^{-4}}{3 \times 10^{5}} = 2 \times 10\ (-4) - (+5) = 2 \times 10^{-9}$$

$$\frac{6 \times 10^{5}}{3 \times 10^{-2}} = 2 \times 10^{(+5)-(-2)} = 2 \times 10^{7}$$

o. $\frac{8.4 \times 10^{7}}{2.1 \times 10^{-4}}$

p. $\frac{8.4 \times 10^{-7}}{2.1 \times 10^{-4}}$

q. $\frac{2.73 \times 10^{4}}{9.1 \times 10^{-2}}$

r. $2.6 \times 10^{4} \div 1.3 \times 10^{2}$

s. $3.8 \times 10^{5} \div 2 \times 10^{-2}$

t. $1.8 \times 10^{7} \div 9 \times 10^{6}$

u. $8 \times 10^{3} \div 4 \times 10^{1}$

v. $8 \times 10^{-2} \div 8 \times 10^{3}$

w. $6 \times 10^{4} \div 2 \times 10^{-7}$

x. $5 \times 10^{6} \div 1 \times 10^{5}$

y. $6.52 \times 10^{5} \div 4 \times 10^{2}$

z. $1.344 \times 10^{8} \div 6 \times 10^{1}$

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ANSWER SHEET

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2.

10^{-5}	10^{-4}	10^{-3}	10^{-2}	10^{-1}	10^{0}	10^{1}	10^{2}
.00005	.0005	.005	.05	.5	5	50	500

10^{3}	10^{4}	10^{5}
5000	50000	5000000

3. (See pg. 150 in TERMS, TABLES, AND SKILLS)

4. A. 946,080,000,000,000,000 cm/yr

9.4608×10^{17}

B. 1.67×10^{-24} gm

C. 9.1×10^{-28}

6.

EXPANDED	SCIENTIFIC NOTATION
5.54 X 10	5.54×10^{1}
7.637 X 10	7.637×10^{1}
2.37 X 10 X 10	2.37×10^{2}
4.862 X 10 X 10	4.862×10^{2}
9.6322 X 10 X 10	9.6322×10^{2}
1.374 X 10 X 10 X 10	1.374×10^{3}
7.5426 X 10 X 10 X 10	7.5426×10^{3}
6.38457 X 10 X 10 X 10	6.38457×10^{3}
1.1463 X 10 X 10 X 10 X10	1.1463×10^{4}
1.68245 X 10 X 10 X10 X 10	1.68245×10^{4}
8.492376 X 10 X 10 X 10 X 10	8.492376×10^{4}
2.46892 X 10 X 10 X 10 X 10 X 10	2.46892×10^{5}
8.613942 X 10 X 10 X10 X10 X 10	8.613942×10^{5}
1.830402 X 10 X 10 X 10	1.830420×10^{3}

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EXPANDED	SCIENTIFIC NOTATION
2.56 X 10 X 10 X 10 X 10 X 10 X 10	2.56×10^{6}
4.0004 X 10 X 10 X 10 X 10 X 10 X 10 X 10	4.004×10^{7}
9.8 X 10 X 10 X 10 X 10 X 10 X 10 X 10	9.8×10^{7}
4.76 X 10 X 10 X 10 X 10 X 10 X 10 X 10 X 10	4.76×10^{8}
3.967X10 X 10 X 10 X 10 X 10 X 10 X 10 X 10 X 10	3.967×10^{9}

7. EXPANDED	SCIENTIFIC NOTATION
7 X 1/10	7×10^{-1}
6 X 1/10 X 1/10	6×10^{-2}
8.2 X 1/10 X 1/10	8.2×10^{-2}
8.0 X 1/10 X 1/10	8.0×10^{-2}
2 X 1/10 X 1/10 X 1/10	2×10^{-3}
6 X 1/10 X 1/10 X 1/10 X 1/10	6×10^{-4}
3.4 X 1/10 X 1/10 X 1/10	3.4×10^{-3}
1.23 X 1/10 X 1/10	1.23×10^{-2}
5 X 1/10 X 1/10 X 1/10 X 1/10 X 1/10	5×10^{-5}
8 X 1/10 X 1/10 X 1/10 X 1/10 X 1/10 X 1/10X1/10	8×10^{-7}
6.7432 X 1/10	6.7432×10^{-1}
5.74 X 1/10 X 1/10 X 1/10	5.74×10^{-3}
1 X1/10X1/10X1/10X1/10X1/10X1/10X1/10X1/10	1×10^{-8}
7.3 X 1/10 X 1/10	7.3×10^{-2}

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8.	(1) 2.9625×10^{-4}	3×10^{4}
	(2) 2.006×10^{-2}	2.01×10^{-2}
	(3) 3.017×10^{0}	3.02×10^{0}
	(4) 1.0082×10^{1}	1.01×10^{1}
	(5) 1.1×10^{-4}	1.1×10^{-4}
	(6) 9×10^{-6}	9×10^{-6}
	(7) 3.000009×10^{0}	3×10^{0}
	(8) 2.690×10^{3}	2.7×10^{3}
	(9) 6.50×10^{9}	6.5×10^{0}
	(10) 9×10^{2}	9×10^{2}
	(11) 6.0013×10^{4}	6×10^{4}
	(12) 2.1040×10^{1}	2.1×10^{1}
	(13) 7.01×10^{6}	7.01×10^{6}
	(14) 2.00×10^{3}	2×10^{3}
	(15) 9.060×10^{5}	9.1×10^{5}

9. a. 6.3×10^{6}
b. 3.43×10^{-2}
c. 4.7×10^{7}
d. 2.3×10^{-4}

10. a. 4.8×10^{-5}
b. 1.6×10^{11}
c. 4.2×10^{6}
d. 2.7×10^{-1}
e. 4.5×10^{12}
f. 7.6×10^{9}
g. 9.8×10^{5}
h. 3.6×10^{5}
j. 3.8×10^{5}
k. 1.8×10^{0}
l. 5.8×10^{-8}
m. 2×10^{12}
n. 9×10^{-23}
o. 4×10^{11}
p. 4×10^{-3}
q. 3×10^{5}
r. 2×10^{2}
s. 1.9×10^{7}
t. 2×10^{0}
u. 2×10^{2}
v. 1×10^{-5}
w. 3×10^{11}
x. 5×10^{1}
y. 1.63×10^{3}
z. 2.24×10^{7}