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ABSTRACT

This guide provides the assessment procedures for use with the seven science units of the grade 6 Conceptually Oriented Program in Elementary Science (COPES) science curriculum program. Included are individual screening assessments for each of the seven grade 6 science units, instructions for using the guide, instructions for scoring the assessment, a scoring guide, and comments on using the results. (SL)

COPES

Conceptually Oriented Program in Elementary Science

Assessment Booklet for Grade Six

Preliminary Edition

NEW YORK UNIVERSITY
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This Booklet contains the assessments to be used in conjunction with the COPES Teacher's Guide for Grade 6 which is one of the products of the COPES project at New York University. The project was supported by funds from the U.S. Office of Education, and the National Science Foundation.

THE COPES STAFF

Morris H. Shamos
Director

J. Darrell Barnard
Associate Director

Janice A. Cutler
Assistant Director

Philip R. Merrifield
Head, Evaluation

Lois Arnold
Editor

Elizabeth Lagerman
Secretary

PREVIOUS MEMBERS OF THE STAFF ASSOCIATED WITH THE DEVELOPMENT OF GRADE 6 TEACHING MATERIALS AND ASSESSMENTS

Joan Alexander
Teaching Assistant

Ronald Caruso
Elementary School Teacher

Dean R. Casperson
Science Educator

Vincent S. Darnowski
Science Educator

Carol J. Dempster
Chemist

Arnold H. Diamond
Evaluation Specialist

Muriel Green
Elementary Science Consultant

Alvin Hertzberg
Elementary Science Consultant

Katherine E. Hill
Evaluation and Elementary Science Specialist

Kit Irvine
Elementary Science Specialist

Dorothy M. Lynch
Administrative Assistant

Joseph H. Rubinstein
Biologist

Anne Saenger
Elementary Science Consultant

Rashid Shah
Evaluation Specialist

Stanley Simmons
Science Teacher

Denver Ulery
Science Teacher

Bobby J. Woodruff
Science Educator

Many teachers and staff members have been actively involved in testing and teaching the COPES materials. A laboratory school at the University, as well as regular classrooms of cooperating teachers, tested the initial Grade 6 Activities and Assessments. Acknowledgement must be extended to those many children who have worked with COPES materials and who have provided us with immediate and invaluable critiques.

Several research studies have been conducted with the COPES materials. Elhannan Keller conducted a study using Minisequence II of Grade 6 in several New York City Public Schools. He devised assessments for that sequence to use for the study, part of his doctoral program at New York University. Adaptations of some of his assessments are included in this Booklet.

Finally, we wish to acknowledge the assistance of the Publications Bureau of N.Y.U. and of David Prestone, Lawrence Trupiano, and James Ceribello of the Fat Cat Studio, who did the illustrations.

Contents

The Grade 6 Assessments

The primary theme of the COPES curriculum is that experience with the ideas underlying common phenomena can lead the child to conceptualize the fundamental and pervasive schemes of modern science. Accordingly, the primary objective of the Grade 6 Assessment materials is to ascertain whether the child has mastered the concepts underlying his experiences with the COPES Activities. It is important that this goal of the Assessments be kept in mind, in contrast to such alternatives as finding out how well the child remembers specific details of what was done, or the degree to which he has acquired a useful skill. The emphasis on mastery of concepts is intentional: it is not that the alternatives are unimportant, but rather that the concept goals are more germane to COPES. However, to a greater extent than in the Assessments for the earlier grades, the specific techniques and context of Activities developed at this level are reflected in the Assessments for Grade 6. Written questions and multiple-choice answers are used as in Grades 4 and 5. Teachers are asked to read all written material aloud while children read it silently.

We have not made an issue of the distinction between concepts and skills; rather, we have tried to apply skills in the enhancement of concept learning, and to introduce concepts as the foci of skills. For example, the child learns the skill of grouping, or classification, concomitantly with the concept of a group as a set of objects having a common property. Also, the concept of a property can be abstracted from observations of objects in groups, while at the same time the skill of making abstractions begins to be learned. Thus an attempt to make a clear distinction between "grouping" as a skill, and "a group" as a concept--or between "property" as a concept and "seeing properties" as a simple kind of abstracting skill--seems more likely to confuse the child than to help him at this stage of his cognitive development. The trained scientist abstracts as he recognizes properties in complex phenomena, and classifies those phenomena into larger groups in terms of perceived properties, without introspecting about whether, at any particular moment, he or she is practicing a skill or applying a concept.

Throughout the Activities, emphasis is placed on concepts and relations rather than on the specific phenomena, or "facts," and so it is in the Assessments. However, what seems a simple relational idea for an older child or an adult may be a quite difficult integrative task for the younger child. To assimilate a new explanatory idea into the body of previous ideas, the child may need a great deal of help in what the psychologist, Jean Piaget, calls *accomodation*--the transformation of previous experience to facilitate the assimilation of new experience. There will also be individual differences in the ease with which children assimilate new ideas, and these differences may appear in different contexts--the same child may readily reach mastery of one concept, but have to struggle with another. For these reasons, the Assessments have been prepared at two levels: *Screening Assessments*, designed for group administration to ascertain which children have attained mastery of the concepts; and *Individual Assessments*, designed for administration to a single child or small group. The Screening Assessments are in the same order as the respective Minisequences in the Grade 6 Teacher's Guide. Extra copies of the assessment pages to be used as masters for the children's copies are located in the last section of this volume. The Individual Assessments constructed to help the teacher focus instruction on those areas in which children need additional help, are included in the Scoring Guide section.

One form of the Individual Assessment is a series of leading questions which take a specific problem from the Screening Assessments and break the problem down into a series of simple questions. There is an intentional similarity in the small-step approach to concept evaluation and the more successful aspects of programmed instruction. Some children need greater help in building up their confidence in their knowledge of the concepts and the small-step, guided inquiry strategy is intended for their benefit. (It is not inappropriate for any beginner, but some might find it tedious.) Using this method, the teacher should improvise and ask the same type of questions as in the example. The example questions are meant as a guide. The teacher should feel free to add, subtract, or adapt the questions in any way he or she feels will help the child. Another form of Individual Assessment is what could be considered a mini-activity: a critical component of an activity is re-done, with greater explication, to assure the child is able to traverse the lines of inference leading to the concept goal.

Because there are so many possible sources of misunderstanding at this grade level, due to both the increasing complexity of the material and the cumulation of learning deficits in some children, we have not provided individual assessment intended to meet all the needs of all children with learning difficulties. Rather, we have indicated procedure, in some instances, in the context of the screening assessments, which should be helpful in providing some structure for the teacher; obviously, the emphasis will have to be upon the learning problem presented by each individual child, and the teacher will need to be most attentive to the representation of the teaching materials provided in the activities, in ways that the individual learner can assimilate.

In these Assessments, it might appear that the usual distinctions between achievement and aptitude are blurred. In a sense this is true, because at this stage of development the child's ability to learn new things is based to a significant degree on what he or she has previously learned. A few children may be able to perform well on these Assessments because their previous experience, interacting with their genetic endowment, permits them to "figure it out". However, for the majority, the experience of the COPES Activities should increase the likelihood that they will do well on the Assessments provided for each Minisequence.

ADMINISTERING AND SCORING THE ASSESSMENTS

Instructions for administering the Assessments are included with the asessment pages. Of course, you will need to make copies of the pages beforehand to distribute to the children. The copies can be made by tearing out the appropriate duplicate assessment page(s) from the section at the back of this booklet. The Assessment pages appear twice--once in context for your reference and once at the back for use in duplication.

The assessment pages are in alphabetical order for an entire Minisequence. The letters, which appear in the upper right hand corner of each page, allow the children to identify the page they are to work on at any given time. The letters also permit you to maintain the correct order in collating the pages. The pages may be collated in groups, Part 1, Part 2, etc.--sometimes the children appreciate the change of pace afforded by collecting one set of papers and passing out the next. The pages may also be distributed as a complete set for the Minisequence.

In the assessments, suggested instructions to be read to the children appear in capital letters, as do the problems themselves. After distributing the assessment pages, read the instructions and then the problems, one by one, together with the possible responses. The children should read the problems along with you, silently, and then circle the letter of the best response. They should be encouraged to think out their responses and not to guess.

We have tried to use language at the level suggested in the Activities themselves. In some problems, however, a child may ask for the meaning of a particular word. If, in your judgment, your answer would provide the answer to the problem, you should decline, considering that he or she does not know the concept being assessed. If you can answer the child simply, without disclosing the answer to the problem itself, you may do so. As a general rule, you should ask the child to respond stating what he or she thinks the word means.

The Scoring Guide for the Assessments is also included. The preferred response for each task is given, together with a commentary. Incorrect alternatives on the multiple-choice questions are discussed when the reasons for their being incorrect are closely related to necessary limits on the concepts, e.g., when the incorrect choice reflects common misconceptions.

QUANTIFYING THE RESPONSES

Discussions of mastery in learning seem inevitably to lead to the question of "percent passing," as a quantification of what mastery is presumed to be. The teacher is the major judge for mastery of school content; the assessment materials help him or her to make that judgement. Using these materials, the group average on the Screening Assessments should be 70% of the tasks successfully completed, as a minimum. For example, if there are ten tasks, a group of 20 children should have at least a total of 140 correctly done. We have no information as yet on the relative difficulty of the tasks, but they have been devised and arranged in a sequence that makes 70% passing reasonable as a group measure, given appropriate instructional use of the Activity material.

For an individual pupil, the level of mastery should be higher, say 80% of the tasks reasonably completed, considering that in some of the tasks the child may have guessed the preferred response. A child doing less well should have the benefit of a discussion of his or her responses with the teacher, and probably the Individual Assessment for the Minisequence. (He or she should be provided with an Individual Assessment and a guide--the teacher, or perhaps a paraprofessional, a parent or an older child.) Remember that the purpose of the Assessment is to assure both teacher and child that mastery of a concept has been achieved.

USING THE RESULTS

It is our intent that the Assessments not be used to differentiate one child from another, e.g., as a basis for "grading". Two major uses of the Assessment responses are intended: First, the teacher may use quantification of the responses as evidence for a decision regarding the mastery of concepts by the group as a whole. The teacher, not the numbers we suggest above, must be the major decision-maker in this context. Should you decide that the group has not mastered the concepts presented in a Mini-sequence, re-examine your use of the teaching materials and the readiness of the group to undertake the experiences. Second, the Assessments should be used as components in the essential feedback you provide the child as he or she strives for mastery of the concepts. Review of the child's performance on the Screening Assessments, and on the Individual Assessment if used, are very important in the child's development of his concept of himself as a learner.

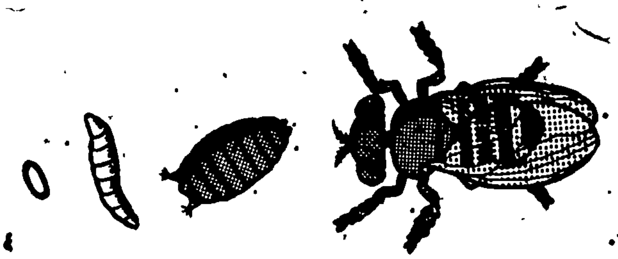
It is the responsibility of the teacher to assess the children's progress, and to distinguish between his or her evaluation of a child's readiness for new learning and any evaluation of that child as an individual person. Comparisons of one child with another in terms of personal worth may well be traumatic, and frequently inhibit the child's participation in future learning situations. However, a realistic appraisal of the child's mastery of significant cognitive aspects of his or her environment should facilitate and motivate continuing intellectual development.

For some years it has been advocated that teachers emphasize their support of children in their attempts to learn. Typically, support has been most evidenced by verbalizations of positive tone--"fine", "good", "OK"--although occasional nonverbal positive reinforcement has been encouraged. The findings from some current research, looking at the distinction between the emotional and cognitive domains of behavior, imply that children who are trying, with mixed success, to acquire a desired cognitive behavior find a consistently positive tone from the teacher very confusing. The confusion arises because the teacher's behavior is inconsistent with the changes (or lack of them) which the child can observe in his own cognitive behavior. For example, if he or she continues to read an inconsistent response (wrong answer) on several tries, but the teacher's only response is one of positive acceptance, the child is likely to wonder whether the teacher is attending to the difficulty. While most instances of the well-known "turn-off" arise from a combination of lack of success and negative attitude from the teacher, many children will turn away from a cognitive task--and even from the teacher--when, having failed by their own evaluation, they decide that the teacher's response is irrelevant because it doesn't relate consistently to their cognitive problem.

The teacher's evaluation of a child's response should be consistent with the situation, as the child perceives it, on two levels: (1) motivating, by rewarding for effort, as that encourages another try; (2) realistic, by rewarding for success at the task, but non-rewarding for lack of it. That kind of guidance provides much more relevent information, and thus engenders a greater effort on the part of the child to focus on the cognitive aspects of the task.

PROVIDING FEEDBACK

We hope you will find the Assessments useful in helping the child to mobilize and focus his or her thinking skills on the COPES experiences. In order to determine their usefulness, we ask your assistance in providing feedback to us regarding the Assessments. Information on confusing instructions and the like are received with some regret, of course, but they are nevertheless welcome. Information on relative difficulty of tasks will be extremely valuable. Don't hesitate to request additional Assessment materials from us, and to suggest new formats that such Assessments might take. We shall be most interested in communicating with you.



Minisequence I

Interactions of Living Things with the Environment

Screening Assessments

The concepts being tested in this Minisequence are:

a. Soil is formed by the interaction of rocks with both living and nonliving components of the environment.

b. As a consequence of their composition, topsoil and subsoil exhibit different interaction properties with water and growing plants.

c. One way in which organisms may interact with their environment is to release carbon dioxide.

d. There are a number of factors that affect the rate at which plants release water vapor to their environment.

e. Living things react to changes in their environment.

There are five parts to this assessment. Each part includes items dealing with one of the above concepts. Parts 1 and 2 may be administered after Activities 2 and 3. Part 4 may be administered after Activity 4 and Part 5 after Activity 5. Each part takes about 10 minutes. After you distribute the pages to the children, have them put their names in the appropriate places.

PART 1

Page A

Have the children turn to page A.

HERE ARE SOME QUESTIONS WITH THREE POSSIBLE ANSWERS EACH. READ EACH QUESTION AND ITS ANSWER SILENTLY WHILE I READ THEM ALOUD TO YOU. AFTER I HAVE FINISHED YOU WILL HAVE A SHORT TIME TO SELECT YOUR CHOICE AND CIRCLE THE LETTER IN FRONT OF IT. (If you think it helpful to the children, read each question again as they select their choice.)

1. WHEN JANICE EXAMINED A PINCH OF SOIL WITH A MAGNIFYING GLASS SHE FOUND SMALL PARTICLES OF MATERIAL THAT LOOKED LIKE FINE SAND. WHICH OF THE FOLLOWING BEST EXPLAINS HOW THE PARTICLES MAY HAVE BECOME A PART OF THE SOIL?

   A. THEY WERE PRODUCED WHEN ROCKS WERE BROKEN UP.

   B. THEY CAME FROM LIVING THINGS IN THE SOIL.

   C. THEY WERE ALWAYS A PART OF THE SOIL.

2. IN CERTAIN PLACES ROCKS ARE COVERED WITH GREEN CRUST-LIKE PLANTS CALLED LICHENS. IF YOU REMOVED A PIECE OF THE CRUSTY LICHENS FROM A ROCK, WHAT WOULD YOU BE MOST SURE TO FIND UNDERNEATH IT?

   A. OTHER SMALL PLANTS.

   B. SMALL PIECES OF ROCKS.

   C. SOLID ROCK.

3. ROCKS ARE FOUND ALL OVER THE EARTH. THEY ARE FOUND IN PLACES WHERE THE RAINFALL IS HEAVY. THEY ARE FOUND IN PLACES WHERE THERE IS VERY LITTLE RAINFALL. WHICH OF THE FOLLOWING BEST DESCRIBES HOW ROCKS IN PLACES WHERE THERE IS HEAVY RAINFALL MAY BE DIFFERENT FROM ROCKS IN PLACES WHERE THE RAINFALL IS MUCH LESS?

A. SINCE ROCKS ARE VERY HARD THERE WOULD BE LITTLE DIFFERENCE.

B. WHERE RAINFALL IS LESS, ROCKS WOULD BE DARKER.

C. WHERE RAINFALL IS HEAVY ROCKS WOULD HAVE WORN AWAY MORE.

4. IN SOME PLACES THERE ARE MANY LARGE ROCKS IN THE SOIL. WHICH OF THE FOLLOWING BEST DESCRIBES WHAT IS HAPPENING TO SUCH ROCKS?

A. THEY ARE SLOWLY BECOMING SMALLER.

B. THEY ARE SLOWLY BECOMING HARDER.

C. THEY ARE SLOWLY BECOMING LARGER.

Have the children turn to page B.

5. TWO SAMPLES OF SOIL ARE EXAMINED BY SOME CHILDREN. ONE IS A LIGHT-COLORED SOIL THAT FEELS ROUGH. THE OTHER IS A DARK-COLORED SOIL THAT FEELS LESS ROUGH. WHICH OF THE FOLLOWING BEST EXPLAINS THE DIFFERENCE IN THE SOILS?

A. SOILS ARE MIXTURES OF LIVING AND NONLIVING MATERIALS.

B. SOME SOILS MAY HAVE MORE MATERIAL FROM LIVING THINGS IN THEM THAN OTHER SOILS.

C. SOILS ARE FORMED BY THE INTERACTION OF ROCKS WITH THEIR ENVIRONMENT.

PART 2

Page C

Distribute pages C and D and have the children turn to page C.

1. MORRIS AND LOIS EXAMINED TWO SAMPLES OF SOIL. ONE WAS LABELED SAMPLE *A* AND THE OTHER SAMPLE *B*. SAMPLE *A* WAS A DARKER COLOR THAN SAMPLE *B* AND HAD MORE PIECES OF DEAD LEAVES, STEMS AND ROOTS IN IT. WHEN WATER WAS POURED THROUGH EQUAL AMOUNTS OF EACH SOIL SAMPLE, SAMPLE *A* ABSORBED MORE WATER THAN SAMPLE *B*. BASED UPON THE ABOVE OBSERVATIONS WHICH OF THE FOLLOWING WOULD YOU SELECT AS BEING THE BEST STATEMENT REGARDING THE DIFFERENCES IN THE TWO SOIL SAMPLES?

A. BOTH SAMPLE *A* AND SAMPLE *B* WERE FORMED BY THE INTERACTION OF ROCKS WITH THEIR ENVIRONMENT.

B. SAMPLE *A* CONTAINS ONLY LIVING THINGS AND SAMPLE *B* CONTAINS ONLY PARTICLES OF ROCK.

C. SAMPLE *B* IS PROBABLY A SAMPLE OF SUBSOIL AND SAMPLE *A* IS PROBABLY A SAMPLE OF TOPSOIL.

2. JANET AND ELIZABETH WERE GIVEN TWO SAMPLES OF SOIL THAT HAD BEEN REMOVED FROM THE SAME FIELD. AFTER THEY HAD CAREFULLY EXAMINED THE TWO SAMPLES, THEY HYPOTHESIZED THAT ONE SAMPLE WAS SUBSOIL AND THE OTHER WAS TOPSOIL. IF THEIR HYPOTHESIS WAS CORRECT, WHAT COULD THEY EXPECT TO HAPPEN IF THE SAME NUMBER OF BEAN SEEDS WERE PLANTED IN EACH SAMPLE AND BOTH SAMPLES WERE GIVEN THE SAME AMOUNT OF WATER?

A. THE BEAN SEEDS WOULD NOT GROW IN SUBSOIL.

B. THE BEANS IN SUBSOIL WOULD GROW BETTER THAN THE BEANS IN TOPSOIL.

C. THE BEANS IN TOPSOIL WOULD GROW BETTER THAN THE BEANS IN SUBSOIL.

3. REREAD THE FIRST PART OF ITEM 2, ABOVE. JANET AND ELIZABETH DECIDED TO TEST THEIR HYPOTHESIS BY ANOTHER METHOD. THIS WAS TO BE DONE BY PUTTING THE SAME AMOUNT OF EACH SAMPLE OF SOIL IN EACH OF TWO PAPER CUPS WHICH HAD SMALL HOLES IN THEIR BOTTOMS. INTO EACH PAPER CUP THE SAME AMOUNT OF WATER WAS POURED. THE WATER THAT PASSED THROUGH EACH SAMPLE WAS COLLECTED AND COMPARED. WHAT WOULD YOU EXPECT TO BE THE RESULTS?

A. THE WATER PASSING THROUGH THE SUBSOIL WAS COLDER THAN THE WATER PASSING THROUGH THE TOPSOIL.

B. MORE OF THE WATER PASSED THROUGH SUBSOIL THAN TOPSOIL.

C. THE SAME AMOUNT OF WATER PASSED THROUGH EACH SAMPLE.

TURN TO PAGE D.

4. JOE AND FRED HAD THREE SAMPLES OF SOIL. SAMPLE *A* WAS TOPSOIL. SAMPLE *B* WAS SUBSOIL. SAMPLE *C* WAS SAND. THEY GOT INTO A DISCUSSION REGARDING WHICH OF THEIR SAMPLES, *A* OR *B*, WOULD REACT WITH WATER MOST LIKE SAMPLE *C*, THE SAND, WHEN THE WATER HOLDING PROPERTIES OF THE SAMPLES WERE COMPARED. THEY PERFORMED AN EXPERIMENT AND FOUND THAT TOPSOIL HELD MORE WATER THAN EITHER SUBSOIL OR SAND. FROM THESE RESULTS THEY CONCLUDED THAT SUBSOIL WAS MORE LIKE SAND. WHICH OF THE FOLLOWING BEST EXPLAINS THEIR RESULTS?

A. TOPSOIL HAS MORE MATERIAL IN IT, THAT IS NOW LIVING OR WAS ONCE ALIVE, THAN EITHER OF THE OTHER SOIL SAMPLES.

B. THE SAND WAS FORMED BY THE ACTION OF WIND, RAIN AND HEAT UPON ROCKS.

C. SUBSOIL HAS PARTICLES OF ROCK IN IT WHICH WERE FORMED BY THE INTERACTION OF ROCKS WITH BOTH LIVING AND NONLIVING THINGS IN THEIR ENVIRONMENT.

5. TWO SAMPLES OF THE SAME AMOUNT OF DIFFERENT KINDS OF SOIL WERE THOROUGHLY SOAKED WITH WATER. THE TWO SOAKED SAMPLES WERE WEIGHED. THEY WERE THEN PUT INTO A WARM OVEN UNTIL BOTH APPEARED TO BE DRY. THE DRY SOIL SAMPLES WERE WEIGHED. THEIR DRY WEIGHTS WERE COMPARED WITH THEIR WET WEIGHTS TO FIND OUT HOW MUCH THEIR WEIGHTS HAD CHANGED. IT WAS FOUND THAT ONE SAMPLE LOST MUCH MORE WEIGHT THAN THE OTHER. WHICH STATEMENT BEST EXPLAINS WHY THE SOIL SAMPLES LOST WEIGHT?

A. HEAT ENERGY CAUSED THE PARTICLES OF SOIL IN THE SAMPLES TO GET LARGER.

B. HEAT ENERGY BROKE UP THE PARTICLES OF SOIL AND MADE THEM SMALLER.

C. HEAT ENERGY CAUSED THE WATER IN THE SOIL TO EVAPORATE.

6. WHICH OF THE SOILS IN QUESTION 5 WAS MORE LIKE A SUBSOIL?

A. THE ONE THAT LOST THE GREATER WEIGHT.

B. THE ONE THAT LOST THE LESSER WEIGHT.

C. CAN'T TELL UNTIL YOU KNOW HOW MUCH THE WEIGHT LOSS WAS.

PART 3

Pages E and F.

Have the children turn to page E.

1. FRESH FRUIT JUICE HAD BEEN SERVED AT A CLASS PARTY ON THE LAST DAY OF SCHOOL BEFORE A ONE-WEEK VACATION. THE CLEAN-UP COMMITTEE OVER-LOOKED A SMALL PITCHER CONTAINING SOME OF THE JUICE. WHEN THE CLASS RETURNED TO THEIR ROOM AFTER THE VACATION, SOMEONE DISCOVERED THE LEFT-OVER JUICE. IT WAS QUITE DIFFERENT FROM THE FRESH JUICE THEY HAD HAD AT THE PARTY. THERE WAS FROTH ON TOP OF THE JUICE. IT SMELLED DIFFERENT. THE CHILDREN SUGGESTED SEVERAL HYPOTHESES TO EXPLAIN WHAT HAD CAUSED THE FROTH ON THE JUICE AND ITS CHANGE IN ODOR. WHICH ONE OF THE FOLLOWING HYPOTHESES DO YOU CONSIDER BEST?

A. SMALL PLANTS, SUCH AS YEAST, MAY HAVE GOTTEN INTO THE JUICE.

B. SOMEONE HAD SHAKEN THE JUICE TO MAKE IT FROTH.

C. HEAT HAD CAUSED SOME OF THE WATER FROM THE JUICE TO EVAPORATE THUS PRODUCING THE FROTH.

WHICH OF THE FOLLOWING IS THE BEST EXPLANATION OF FROTH?

A. FROTH IS FORMED BY SMALL PARTICLES OF DUST FROM THE AIR.

B. FROTH IS FORMED BY BUBBLES OF GAS.

C. FROTH IS MADE UP OF COBWEBS.

2. WHICH ONE OF THE FOLLOWING WOULD BE MOST CONVINCING IN DEMONSTRATING THAT SODA WATER CONTAINS CARBON DIOXIDE?

A. DRINK A BOTTLE OF SODA TO SHOW THAT IT WILL MAKE YOU BELCH. WHEN YOU SWALLOW CARBON DIOXIDE IT MAKES YOU BELCH.

B. PASS SOME OF THE GAS FROM A BOTTLE OF SODA THROUGH A BLUE-GREEN SOLUTION OF AN EXTRACT FROM RED CABBAGE TO SEE IF IT TURNS PURPLE.

C. SHAKE THE BOTTLE OF SODA TO SHOW THAT THE GAS WILL CAUSE THE SODA WATER TO SQUIRT.

3. THE AVERAGE CONCENTRATION OF CARBON DIOXIDE IN THE AIR ABOVE THE GROUND IS GENERALLY VERY SMALL. HOWEVER, IT HAS BEEN FOUND THAT THE CONCENTRATION OF CARBON DIOXIDE IN THE AIR IN SOILS IS MUCH HIGHER. IN OTHER WORDS, THE AIR IN SOILS HAS MANY TIMES MORE CARBON DIOXIDE IN IT PER UNIT VOLUME THAN THE AIR ABOVE THE GROUND. WHICH OF THE FOLLOWING MATERIALS IN SOIL IS MOST LIKELY TO CAUSE THIS CONDITION?

A. LIVING THINGS WHICH GIVE OFF CARBON DIOXIDE.

B. PARTICLES OF ROCK WHICH ARE SHARP.

C. WATER WHICH MAKES THINGS WET.

NOW TURN TO PAGE F.

4. WHILE DIGGING IN THE SOIL, JIM AND ART FOUND SOME OBJECTS THAT LOOKED LIKE WORMS. HOWEVER, THEY DID NOT APPEAR TO BE ALIVE. HERE ARE SOME QUESTIONS THAT THE BOYS AGREED THEY WOULD HAVE TO ANSWER BEFORE THEY COULD BE MORE CERTAIN WHETHER THE OBJECTS WERE ALIVE. WHICH ONE IS THE BEST QUESTION TO ASK?

A. WILL THEY FLOAT IN WATER?

B. WILL THEY EAT LEAVES?

C. DO THEY GIVE OFF CARBON DIOXIDE?

PART 4

Page G

For this part distribute pages G and H and have the children turn to page G.

1. DURING PERIODS WHEN THERE WAS LITTLE OR NO RAIN, ALVIN HAD TO WATER THE PLANTS AROUND HIS HOUSE TO KEEP THEM ALIVE. HE NOTICED THAT PLANTS ON THE WEST SIDE OF HIS HOUSE NEEDED MORE WATER TO KEEP THEM FROM WILTING THAN DID THE SAME KIND OF PLANTS ON THE EAST SIDE OF HIS HOUSE. BOTH SIDES OF THE HOUSE RECEIVED THE SAME AMOUNT OF SUNLIGHT DURING THE DAY. AT REGULAR TIMES DURING THE DAY HE HAD CHECKED THE AIR TEMPERATURE (IN THE SHADE) IN BOTH LOCATIONS AND FOUND THAT THE RANGE IN THE AIR TEMPERATURE THROUGHOUT THE DAY WAS ABOUT THE SAME. SINCE DIFFERENCES IN AIR TEMPERATURE DID NOT APPEAR TO BE THE CAUSE, WHICH OF THE FOLLOWING WOULD BE THE NEXT MOST LIKELY CAUSE?

A. DIFFERENCES IN THE KINDS OF SMALL ANIMALS THAT LIVE ON THE PLANTS.

B. DIFFERENCES IN THE MOVEMENT OF AIR AROUND THE PLANTS.

C. DIFFERENCES IN THE AMOUNT OF CARBON DIOXIDE IN THE AIR AROUND THE PLANTS.

2. WHEN YOUNG CABBAGE PLANTS ARE TRANSPLANTED FROM SMALL POTS TO THE GARDEN, PAPER CAPS OR HOODS ARE GENERALLY PLACED OVER THE SMALL PLANTS. THEY ARE LEFT IN PLACE OVER THE PLANTS FOR SEVERAL DAYS. THIS IS DONE TO KEEP THE YOUNG PLANTS FROM LOSING TOO MUCH WATER VAPOR TO THE AIR SURROUNDING THEM. WHICH OF THE FOLLOWING BEST EXPLAINS HOW THE PAPER HOODS REDUCE WATER LOSS FROM YOUNG PLANTS?

A. REDUCES THE MOVEMENT OF AIR AROUND THE PLANT.

B. KEEPS THE RELATIVE HUMIDITY OF THE AIR AROUND THE PLANTS HIGH.

C. BOTH OF THESE COULD EXPLAIN HOW THE PAPER HOODS WORK.

3. JANICE AND MURIEL DID AN EXPERIMENT TO FIND OUT WHICH PLANT, A SMALL PINETREE OR A GERANIUM PLANT ABOUT THE SAME HEIGHT, LOST MORE WATER TO THE AIR SURROUNDING IT. THEY OBTAINED POTTED PLANTS OF ABOUT THE SAME SIZE. THEY WATERED EACH PLANT WELL. NEXT, THEY COVERED THE POTS AND THE SOIL WITH PLASTIC. THEN, THEY SECURELY TIED A PLASTIC BAG OVER THE STEMS AND LEAVES OF EACH PLANT AND PLACED THE TWO PLANTS NEAR A WINDOW. AFTER 12 HOURS THEY EXAMINED THEIR PLANTS AND FOUND THAT A GREAT DEAL OF WATER HAD CONDENSED ON THE INSIDE OF THE PLASTIC BAG COVERING THE GERANIUM PLANT. HOWEVER, HARDLY ANY WATER HAD CONDENSED INSIDE THE BAG COVERING THE LITTLE PINETREE. JANICE WAS CURIOUS AS TO WHY THE GERANIUM PLANT LOST MORE WATER THAN THE PINETREE. THE FOLLOWING ARE SOME IDEAS THAT SHE THOUGHT ABOUT. WHICH ONE IS THE BEST EXPLANATION OF WHY THE GERANIUM LOST MORE WATER?

A. THERE WAS MORE WIND AROUND THE GERANIUM PLANT.

B. GERANIUM LEAVES ARE LARGER AND BROADER THAN PINE NEEDLES.

C. PINE NEEDLES ARE SHARPER THAN GERANIUM LEAVES.

NOW TURN TO PAGE H.

4. DARRELL HAS OBSERVED THAT THE POTTED PLANTS IN HIS ROOM REQUIRE MORE WATER IN THE SUMMER, ON THE DAYS WHEN THE AIR CONDITIONING EQUIPMENT IS OPERATING THAN WHEN IT IS NOT. HE HAS ALSO OBSERVED THAT HIS PLANTS REQUIRE MORE WATER IN COLD WEATHER WHEN THE HOT-AIR FURNACE IS OPERATING. WHICH OF THE FOLLOWING BEST EXPLAINS WHY DARRELL'S PLANTS REQUIRE MORE WATER UNDER THESE CONDITIONS?

A. PLANTS LOSE MORE WATER WHEN THE RELATIVE HUMIDITY IS LOW THAN WHEN IT IS HIGH.

B. PLANTS LOSE MORE WATER WHEN THE TEMPERATURE IS LOW THAN WHEN IT IS HIGH.

C. PLANTS LOSE MORE WATER WHEN THE AIR IS MOVING THAN WHEN IT IS STILL.

5. IN A GREENHOUSE, PLANTS DO NOT GENERALLY REQUIRE AS MUCH WATER AS THEY WOULD OUT OF DOORS. WHICH OF THE FOLLOWING BEST EXPLAINS WHY THIS MAY BE SO?

A. THERE IS LESS MOVEMENT OF AIR INSIDE THE GREENHOUSE THAN OUT OF DOORS.

B. THE RELATIVE HUMIDITY INSIDE THE GREENHOUSE IS USUALLY HIGHER THAN OUT OF DOORS.

C. BOTH OF THESE ARE GOOD EXPLANATIONS.

PART 5

Page I

Distribute pages I and J and have the children turn to page I.

1. PHIL HAD NOTICED THAT AFTER A HEAVY RAIN THERE WOULD BE MANY EARTHWORMS ON THE SIDEWALK IN FRONT OF HIS HOUSE. ONE DAY IN HIS SCIENCE CLASS HE ASKED THE TEACHER WHY THIS HAPPENED. THE TEACHER DID NOT ANSWER HIM DIRECTLY BUT ASKED THE CHILDREN IN THE CLASS TO SUGGEST POSSIBLE EXPLANATIONS OR HYPOTHESES. MANY HYPOTHESES WERE SUGGESTED. THREE ARE LISTED BELOW. WHICH ONE SEEMS MOST REASONABLE?

A. EARTHWORMS MOVE OUT OF THE SOIL WHEN IT BECOMES SOAKED WITH WATER.

B. SOMETIMES WHEN IT RAINS, IT RAINS EARTHWORMS.

C. WHEN THE SOIL IS WET BIRDS CAN MORE EASILY REMOVE THE EARTHWORMS.

2. WHEN BUDDING TWIGS ARE CUT FROM LEAFLESS BUSHES IN THE WINTER TIME, PLACED IN WATER, AND KEPT INDOORS, THE BUDS SOON DEVELOP INTO LEAVES OR FLOWERS. WHICH OF THE FOLLOWING BEST EXPLAINS WHY THE BUDS DEVELOP FASTER INDOORS?

A. THE TEMPERATURE IS HIGHER INDOORS THAN OUTDOORS.

B. THERE IS MORE WATER INDOORS THAN OUTDOORS.

C. THERE IS MORE LIGHT INDOORS THAN OUTDOORS.

3. WHAT DO YOU EXPECT WOULD HAPPEN TO THE VERY SMALL ANIMALS IN SOIL NEAR THE SURFACE WHEN IT DRIES OUT AND BECOMES HEATED BY THE SUN?

A. THE HEAT AND LACK OF MOISTURE WOULD KILL ALL OF THEM.

B. MANY WOULD MOVE DEEPER INTO THE SOIL WHERE IT IS COOLER AND MORE MOIST.

C. THEY WOULD MOVE TO THE SURFACE WHERE THEY COULD FIND SHADE AND MOISTURE.

4. IF ALL AIR WERE REMOVED FROM A LARGE SAMPLE OF SOIL, WHAT WOULD HAPPEN TO THE THOUSANDS OF SMALL ANIMALS IN IT?

A. THEY WOULD PRODUCE THEIR OWN AIR FROM THE CARBON DIOXIDE THEY GIVE OFF.

B. NOTHING WOULD HAPPEN TO THEM SINCE THEY ARE SO SMALL.

C. THEY WOULD DIE BECAUSE THEY NEED OXYGEN IN ORDER TO LIVE.

NOW TURN TO PAGE J.

5. WHICH OF THE FOLLOWING COMBINATIONS OF FACTORS BEST DESCRIBES A SUITABLE SOIL ENVIRONMENT FOR SMALL ANIMALS?

A. LIGHT, WARM, DRY.

B. DARK, MOIST, HOT.

C. MOIST, DARK, WARM.

1. WHEN JANICE EXAMINED A PINCH OF SOIL WITH A MAGNIFYING GLASS SHE FOUND SMALL PARTICLES OF MATERIAL THAT LOOKED LIKE FINE SAND. WHICH OF THE FOLLOWING BEST EXPLAINS HOW THE PARTICLES MAY HAVE BECOME A PART OF THE SOIL?

A. THEY WERE PRODUCED WHEN ROCKS WERE BROKEN UP.

B. THEY CAME FROM LIVING THINGS IN THE SOIL.

C. THEY WERE ALWAYS A PART OF THE SOIL.

2. IN CERTAIN PLACES ROCKS ARE COVERED WITH GREEN CRUST-LIKE PLANTS CALLED LICHENS. IF YOU REMOVED A PIECE OF THE CRUSTY LICHENS FROM A ROCK, WHAT WOULD YOU BE MOST SURE TO FIND UNDERNEATH IT?

A. OTHER SMALL PLANTS.

B. SMALL PIECES OF ROCKS.

C. SOLID ROCK.

3. ROCKS ARE FOUND ALL OVER THE EARTH. THEY ARE FOUND IN PLACES WHERE THE RAINFALL IS HEAVY. THEY ARE FOUND IN PLACES WHERE THERE IS VERY LITTLE RAINFALL. WHICH OF THE FOLLOWING BEST DESCRIBES HOW ROCKS IN PLACES WHERE THERE IS HEAVY RAINFALL MAY BE DIFFERENT FROM ROCKS IN PLACES WHERE THE RAINFALL IS MUCH LESS?

A. SINCE ROCKS ARE VERY HARD THERE WOULD BE LITTLE DIFFERENCE.

B. WHERE RAINFALL IS LESS, ROCKS WOULD BE DARKER.

C. WHERE RAINFALL IS HEAVY ROCKS WOULD HAVE WORN AWAY MORE.

4. IN SOME PLACES THERE ARE MANY LARGE ROCKS IN THE SOIL. WHICH OF THE FOLLOWING BEST DESCRIBES WHAT IS HAPPENING TO SUCH ROCKS?

A. THEY ARE SLOWLY BECOMING SMALLER.

B. THEY ARE SLOWLY BECOMING HARDER.

C. THEY ARE SLOWLY BECOMING LARGER.

5. TWO SAMPLES OF SOIL ARE EXAMINED BY SOME CHILDREN. ONE IS A LIGHT-COLORED SOIL THAT FEELS ROUGH. THE OTHER IS A DARK-COLORED SOIL THAT FEELS LESS ROUGH. WHICH OF THE FOLLOWING BEST EXPLAINS THE DIFFERENCE IN THE SOILS?

A. SOILS ARE MIXTURES OF LIVING AND NONLIVING MATERIALS.

B. SOME SOILS MAY HAVE MORE MATERIAL FROM LIVING THINGS IN THEM THAN OTHER SOILS.

C. SOILS ARE FORMED BY THE INTERACTION OF ROCKS WITH THEIR ENVIRONMENT.

1. MORRIS AND LOIS EXAMINED TWO SAMPLES OF SOIL. ONE WAS LABELED SAMPLE *A* AND THE OTHER SAMPLE *B*. SAMPLE *A* WAS A DARKER COLOR THAN SAMPLE *B* AND HAD MORE PIECES OF DEAD LEAVES, STEMS AND ROOTS IN IT. WHEN WATER WAS POURED THROUGH EQUAL AMOUNTS OF EACH SOIL SAMPLE, SAMPLE *A* ABSORBED MORE WATER THAN SAMPLE *B*. BASED UPON THE ABOVE OBSERVATIONS WHICH OF THE FOLLOWING WOULD YOU SELECT AS BEING THE BEST STATEMENT REGARDING THE DIFFERENCES IN THE TWO SOIL SAMPLES?

A. BOTH SAMPLE *A* AND SAMPLE *B* WERE FORMED BY THE INTERACTION OF ROCKS WITH THEIR ENVIRONMENT.

B. SAMPLE *A* CONTAINS ONLY LIVING THINGS AND SAMPLE *B* CONTAINS ONLY PARTICLES OF ROCK.

C. SAMPLE *B* IS PROBABLY A SAMPLE OF SUBSOIL AND SAMPLE *A* IS PROBABLY A SAMPLE OF TOPSOIL.

2. JANET AND ELIZABETH WERE GIVEN TWO SAMPLES OF SOIL THAT HAD BEEN REMOVED FROM THE SAME FIELD. AFTER THEY HAD CAREFULLY EXAMINED THE TWO SAMPLES, THEY HYPOTHESIZED THAT ONE SAMPLE WAS SUBSOIL AND THE OTHER WAS TOPSOIL. IF THEIR HYPOTHESIS WAS CORRECT, WHAT COULD THEY EXPECT TO HAPPEN IF THE SAME NUMBER OF BEAN SEEDS WERE PLANTED IN EACH SAMPLE AND BOTH SAMPLES WERE GIVEN THE SAME AMOUNT OF WATER?

A. THE BEAN SEEDS WOULD NOT GROW IN SUBSOIL.

B. THE BEANS IN SUBSOIL WOULD GROW BETTER THAN THE BEANS IN TOPSOIL.

C. THE BEANS IN TOPSOIL WOULD GROW BETTER THAN THE BEANS IN SUBSOIL.

3. REREAD THE FIRST PART OF ITEM 2, ABOVE. JANET AND ELIZABETH DECIDED TO TEST THEIR HYPOTHESIS BY ANOTHER METHOD. THIS WAS TO BE DONE BY PUTTING THE SAME AMOUNT OF EACH SAMPLE OF SOIL IN EACH OF TWO PAPER CUPS WHICH HAD SMALL HOLES IN THEIR BOTTOMS. INTO EACH PAPER CUP THE SAME AMOUNT OF WATER WAS POURED. THE WATER THAT PASSED THROUGH EACH SAMPLE WAS COLLECTED AND COMPARED. WHAT WOULD YOU EXPECT TO BE THE RESULTS?

A. THE WATER PASSING THROUGH THE SUBSOIL WAS COLDER THAN THE WATER PASSING THROUGH THE TOPSOIL.

B. MORE OF THE WATER PASSED THROUGH SUBSOIL THAN TOPSOIL.

C. THE SAME AMOUNT OF WATER PASSED THROUGH EACH SAMPLE.

4. JOE AND FRED HAD THREE SAMPLES OF SOIL. SAMPLE *A* WAS TOPSOIL. SAMPLE *B* WAS SUBSOIL. SAMPLE *C* WAS SAND. THEY GOT INTO A DISCUSSION REGARDING WHICH OF THEIR SAMPLES, *A* OR *B*, WOULD REACT WITH WATER MOST LIKE SAMPLE *C*, THE SAND, WHEN THE WATER HOLDING PROPERTIES OF THE SAMPLES WERE COMPARED. THEY PERFORMED AN EXPERIMENT AND FOUND THAT TOPSOIL HELD MORE WATER THAN EITHER SUBSOIL OR SAND. FROM THESE RESULTS THEY CONCLUDED THAT SUBSOIL WAS MORE LIKE SAND. WHICH OF THE FOLLOWING BEST EXPLAINS THEIR RESULTS?

A. TOPSOIL HAS MORE MATERIAL IN IT, THAT IS NOW LIVING OR WAS ONCE ALIVE, THAN EITHER OF THE OTHER SOIL SAMPLES.

B. THE SAND WAS FORMED BY THE ACTION OF WIND, RAIN, AND HEAT UPON ROCKS.

C. SUBSOIL HAS PARTICLES OF ROCK IN IT WHICH WERE FORMED BY THE INTERACTION OF ROCKS WITH BOTH LIVING AND NONLIVING THINGS IN THEIR ENVIRONMENT.

5. TWO SAMPLES OF THE SAME AMOUNT OF DIFFERENT KINDS OF SOIL WERE THOROUGHLY SOAKED WITH WATER. THE TWO SOAKED SAMPLES WERE WEIGHED. THEY WERE THEN PUT INTO A WARM OVEN UNTIL BOTH APPEARED TO BE DRY. THE DRY SOIL SAMPLES WERE WEIGHED. THEIR DRY WEIGHTS WERE COMPARED WITH THEIR WET WEIGHTS TO FIND OUT HOW MUCH THEIR WEIGHTS HAD CHANGED. IT WAS FOUND THAT ONE SAMPLE LOST MUCH MORE WEIGHT THAN THE OTHER. WHICH STATEMENT BEST EXPLAINS WHY THE SOIL SAMPLES LOST WEIGHT?

A. HEAT ENERGY CAUSED THE PARTICLES OF SOIL IN THE SAMPLES TO GET LARGER.

B. HEAT ENERGY BROKE UP THE PARTICLES OF SOIL AND MADE THEM SMALLER.

C. HEAT ENERGY CAUSED THE WATER IN THE SOIL TO EVAPORATE.

6. WHICH OF THE SOILS IN QUESTION 5 WAS MORE LIKE A SUBSOIL?

A. THE ONE THAT LOST THE GREATER WEIGHT.

B. THE ONE THAT LOST THE LESSER WEIGHT.

C. CAN'T TELL UNTIL YOU KNOW HOW MUCH THE WEIGHT LOSS WAS.

1. FRESH FRUIT JUICE HAD BEEN SERVED AT A CLASS PARTY ON THE LAST DAY OF SCHOOL BEFORE A ONE-WEEK VACATION. THE CLEAN-UP COMMITTEE OVERLOOKED A SMALL PITCHER CONTAINING SOME OF THE JUICE. WHEN THE CLASS RETURNED TO THEIR ROOM AFTER THE VACATION, SOMEONE DISCOVERED THE LEFTOVER JUICE. IT WAS QUITE DIFFERENT FROM THE FRESH JUICE THEY HAD HAD AT THE PARTY. THERE WAS FROTH ON TOP OF THE JUICE. IT SMELLED DIFERENT. THE CHILDREN SUGGESTED SEVERAL HYPOTHESES TO EXPLAIN WHAT HAD CAUSED THE FROTH ON THE JUICE AND ITS CHANGE IN ODOR. WHICH ONE OF THE FOLLOWING HYPOTHESES DO YOU CONSIDER BEST?

A. SMALL PLANTS, SUCH AS YEAST, MAY HAVE GOTTEN INTO THE JUICE.

B. SOMEONE HAD SHAKEN THE JUICE TO MAKE IT FROTH.

C. HEAT HAD CAUSED SOME OF THE WATER FROM THE JUICE TO EVAPORATE, THUS PRODUCING THE FROTH.

WHICH OF THE FOLLOWING IS THE BEST EXPLANATION OF FROTH?

A. FROTH IS FORMED BY SMALL PARTICLES OF DUST FROM THE AIR.

B. FROTH IS FORMED BY BUBBLES OF GAS.

C. FROTH IS MADE UP OF COBWEBS.

2. WHICH ONE OF THE FOLLOWING WOULD BE MOST CONVINCING IN DEMONSTRATING THAT SODA WATER CONTAINS CARBON DIOXIDE?

A. DRINK A BOTTLE OF SODA TO SHOW THAT IT WILL MAKE YOU BELCH. WHEN YOU SWALLOW CARBON DIOXIDE IT MAKES YOU BELCH.

B. PASS SOME OF THE GAS FROM A BOTTLE OF SODA, THROUGH A BLUE-GREEN SOLUTION OF AN EXTRACT FROM RED CABBAGE TO SEE IF IT TURNS PURPLE.

C. SHAKE THE BOTTLE OF SODA TO SHOW THAT THE GAS WILL CAUSE THE SODA WATER TO SQUIRT.

3. THE AVERAGE CONCENTRATION OF CARBON DIOXIDE IN THE AIR ABOVE THE GROUND IS GENERALLY VERY SMALL. HOWEVER, IT HAS BEEN FOUND THAT THE CONCENTRATION OF CARBON DIOXIDE IN THE AIR IN SOILS IS MUCH HIGHER. IN OTHER WORDS THE AIR IN SOILS HAS MANY TIMES MORE CARBON DIOXIDE IN IT PER UNIT VOLUME THAN THE AIR ABOVE THE GROUND. WHICH OF THE FOLLOWING MATERIALS IN SOIL IS MOST LIKELY TO CAUSE THIS CONDITION?

A. LIVING THINGS WHICH GIVE OFF CARBON DIOXIDE.

B. PARTICLES OF ROCK WHICH ARE SHARP.

C. WATER WHICH MAKES THINGS WET.

4. WHILE DIGGING IN THE SOIL JIM AND ART FOUND SOME OBJECTS THAT LOOKED LIKE WORMS. HOWEVER, THEY DID NOT APPEAR TO BE ALIVE. HERE ARE SOME QUESTIONS THAT THE BOYS AGREED THEY WOULD HAVE TO ANSWER BEFORE THEY COULD BE MORE CERTAIN WHETHER THE OBJECTS WERE ALIVE. WHICH ONE IS THE BEST QUESTION TO ASK?

A. WILL THEY FLOAT IN WATER?

B. WILL THEY EAT LEAVES?

C. DO THEY GIVE OFF CARBON DIOXIDE?

1. DURING PERIODS WHEN THERE WAS LITTLE OR NO RAIN, ALVIN HAD TO WATER THE PLANTS AROUND HIS HOUSE TO KEEP THEM ALIVE. HE NOTICED THAT PLANTS ON THE WEST SIDE OF HIS HOUSE NEEDED MORE WATER TO KEEP THEM FROM WILTING THAN DID THE SAME KIND OF PLANTS ON THE EAST SIDE OF HIS HOUSE. BOTH SIDES OF THE HOUSE RECEIVED THE SAME AMOUNT OF SUNLIGHT DURING THE DAY. AT REGULAR TIMES DURING THE DAY HE HAD CHECKED THE AIR TEMPERATURE (IN THE SHADE) IN BOTH LOCATIONS AND FOUND THAT THE RANGE IN THE AIR TEMPERATURE THROUGHOUT THE DAY WAS ABOUT THE SAME. SINCE DIFFERENCES IN AIR TEMPERATURE DID NOT APPEAR TO BE THE CAUSE. WHICH OF THE FOLLOWING WOULD BE THE NEXT MOST LIKELY CAUSE?

A. DIFFERENCES IN THE KINDS OF SMALL ANIMALS THAT LIVE ON THE PLANTS.

B. DIFFERENCES IN THE MOVEMENT OF AIR AROUND THE PLANTS.

C. DIFFERENCES IN THE AMOUNT OF CARBON DIOXIDE IN THE AIR AROUND THE PLANTS.

2. WHEN YOUNG CABBAGE PLANTS ARE TRANSPLANTED FROM SMALL POTS TO THE GARDEN, PAPER CAPS OR HOODS ARE GENERALLY PLACED OVER THE SMALL PLANTS. THEY ARE LEFT IN PLACE OVER THE PLANTS FOR SEVERAL DAYS. THIS IS DONE TO KEEP THE YOUNG PLANTS FROM LOSING TOO MUCH WATER VAPOR TO THE AIR SURROUNDING THEM. WHICH OF THE FOLLOWING BEST EXPLAINS HOW THE PAPER HOODS REDUCE WATER LOSS FROM YOUNG PLANTS?

A. REDUCES THE MOVEMENT OF AIR AROUND THE PLANT.

B. KEEPS THE RELATIVE HUMIDITY OF THE AIR AROUND THE PLANTS HIGH.

C. BOTH OF THESE COULD EXPLAIN HOW THE PAPER HOODS WORK.

3. JANICE AND MURIEL DID AN EXPERIMENT TO FIND OUT WHICH PLANT, A SMALL PINETREE OR A GERANIUM PLANT ABOUT THE SAME HEIGHT, LOST MORE WATER TO THE AIR SURROUNDING IT. THEY OBTAINED POTTED PLANTS OF ABOUT THE SAME SIZE. THEY WATERED EACH PLANT WELL. NEXT THEY COVERED THE POTS AND THE SOIL WITH PLASTIC. THEN, THEY SECURELY TIED A PLASTIC BAG OVER THE STEMS AND LEAVES OF EACH PLANT AND PLACED THE TWO PLANTS NEAR A WINDOW. AFTER 12 HOURS THEY EXAMINED THEIR PLANTS AND FOUND THAT A GREAT DEAL OF WATER HAD CONDENSED ON THE INSIDE OF THE PLASTIC BAG COVERING THE GERANIUM PLANT. HOWEVER, HARDLY ANY WATER HAD CONDENSED INSIDE THE BAG COVERING THE LITTLE PINETREE. JANICE WAS CURIOUS AS TO WHY THE GERANIUM PLANT LOST MORE WATER THAN THE PINETREE. THE FOLLOWING ARE SOME IDEAS THAT SHE THOUGHT ABOUT. WHICH ONE IS THE BEST EXPLANATION OF WHY THE GERANIUM LOST MORE WATER?

A. THERE WAS MORE WIND AROUND THE GERANIUM PLANT.

B. GERANIUM LEAVES ARE LARGER AND BROADER THAN PINE NEEDLES.

C. PINE NEEDLES ARE SHARPER THAN GERANIUM LEAVES.

4. DARRELL HAS OBSERVED THAT THE POTTED PLANTS IN HIS ROOM REQUIRE MORE WATER IN THE SUMMER, ON THE DAYS WHEN THE AIR-CONDITIONING EQUIPMENT IS OPERATING THAN WHEN IT IS NOT. HE HAS ALSO OBSERVED THAT HIS PLANTS REQUIRE MORE WATER IN COLD WEATHER WHEN THE HOT-AIR FURNACE IS OPERATING. WHICH OF THE FOLLOWING BEST EXPLAINS WHY DARRELL'S PLANTS REQUIRE MORE WATER UNDER THESE CONDITIONS?

A. PLANTS LOSE MORE WATER WHEN THE RELATIVE HUMIDITY IS LOW THAN WHEN IT IS HIGH.

B. PLANTS LOSE MORE WATER WHEN THE TEMPERATURE IS LOW THAN WHEN IT IS HIGH.

C. PLANTS LOSE MORE WATER WHEN THE AIR IS MOVING THAN WHEN IT IS STILL.

5. IN A GREENHOUSE, PLANTS DO NOT GENERALLY REQUIRE AS MUCH WATER AS THEY WOULD OUT OF DOORS. WHICH OF THE FOLLOWING BEST EXPLAINS WHY THIS MAY BE SO?

A. THERE IS LESS MOVEMENT OF AIR INSIDE THE GREENHOUSE THAN OUT OF DOORS.

B. THE RELATIVE HUMIDITY INSIDE THE GREENHOUSE IS USUALLY HIGHER THAN OUT OF DOORS.

C. BOTH OF THESE ARE GOOD EXPLANATIONS.

1. PHIL HAD NOTICED THAT AFTER A HEAVY RAIN THERE WOULD BE MANY EARTHWORMS ON THE SIDEWALK IN FRONT OF HIS HOUSE. ONE DAY IN HIS SCIENCE CLASS HE ASKED THE TEACHER WHY THIS HAPPENED. THE TEACHER DID NOT ANSWER HIM DIRECTLY BUT ASKED THE CHILDREN IN THE CLASS TO SUGGEST POSSIBLE EXPLANATIONS OR HYPOTHESES. MANY HYPOTHESES WERE SUGGESTED. THREE ARE LISTED BELOW. WHICH ONE SEEMS MOST REASONABLE?

A. EARTHWORMS MOVE OUT OF THE SOIL WHEN IT BECOMES SOAKED WITH WATER.

B. SOMETIMES WHEN IT RAINS, IT RAINS EARTHWORMS.

C. WHEN THE SOIL IS WET BIRDS CAN MORE EASILY REMOVE THE EARTHWORMS.

2. WHEN BUDDING TWIGS ARE CUT FROM LEAFLESS BUSHES IN THE WINTER TIME, PLACED IN WATER, AND KEPT INDOORS, THE BUDS SOON DEVELOP INTO LEAVES OR FLOWERS. WHICH OF THE FOLLOWING BEST EXPLAINS WHY THE BUDS DEVELOP FASTER INDOORS?

A. THE TEMPERATURE IS HIGHER INDOORS THAN OUTDOORS.

B. THERE IS MORE WATER INDOORS THAN OUTDOORS.

C. THERE IS MORE LIGHT INDOORS THAN OUTDOORS.

3. WHAT DO YOU EXPECT WOULD HAPPEN TO THE VERY SMALL ANIMALS IN SOIL NEAR THE SURFACE WHEN IT DRIES OUT AND BECOMES HEATED BY THE SUN?

A. THE HEAT AND LACK OF MOISTURE WOULD KILL ALL OF THEM.

B. MANY WOULD MOVE DEEPER INTO THE SOIL WHERE IT IS COOLER AND MORE MOIST.

C. THEY WOULD MOVE TO THE SURFACE WHERE THEY COULD FIND SHADE AND MOISTURE.

4. IF ALL AIR WERE REMOVED FROM A LARGE SAMPLE OF SOIL, WHAT WOULD HAPPEN TO THE THOUSANDS OF SMALL ANIMALS IN IT?

A. THEY WOULD PRODUCE THEIR OWN AIR FROM THE CARBON DIOXIDE THEY GIVE OFF.

B. NOTHING WOULD HAPPEN TO THEM SINCE THEY ARE SO SMALL.

C. THEY WOULD DIE BECAUSE THEY NEED OXYGEN IN ORDER TO LIVE.

5. WHICH OF THE FOLLOWING COMBINATIONS OF FACTORS BEST DESCRIBE A SUITABLE SOIL ENVIRONMENT FOR SMALL ANIMALS?

A. LIGHT, WARM, DRY.

B. DARK, MOIST, HOT.

C. MOIST, DARK, WARM.

Minisequence II
Heat Energy and Hydrate Bonds

Screening Assessments

The following concepts were developed in this Minisequence and tested in these assessments:

a. Heat energy that is absorbed by an apparently dry solid salt may drive off water molecules that were bonded to the salt molecules.

b. The bonds between water molecules and the salt molecules in a crystalline structure may be broken when heat energy is absorbed.

c. The heat energy that is absorbed (used) to break bonds holding water molecules in a hydrated salt are released when the bonds re-form.

d. The anhydrous form of a solid salt (the salt minus its bonded water molecules) possesses more energy than the hydrated form (the salt with the bonded water). This extra energy is given off in the form of heat energy when the hydrate bonds are formed.

e. The heat energy that is absorbed to break bonds between molecules will be released when the bonds re-form.

f. When solid salts interact with water to form a solution, the temperature may increase if hydrate bonds form during the interaction.

g. When solid salts interact with water to form a solution, the temperature will decrease if hydrate bonds do not form (or are already formed), and heat energy is absorbed in breaking the bonds holding the molecules within the solid structure.

There are four parts to this assessment. Distribute all assessment pages to the children or you may wish to distribute each part separately. Have the children put their names in the appropriate places. The assessments should take about 30 minutes to administer.

PART 1

Page A

Ask the children to turn to page A.

HERE ARE SOME QUESTIONS WITH THREE POSSIBLE ANSWERS EACH. READ EACH QUESTION AND ITS ANSWER SILENTLY WHILE I READ THEM ALOUD. AFTER I HAVE FINISHED, YOU WILL HAVE A SHORT TIME TO SELECT YOUR CHOICE AND CIRCLE THE LETTER IN FRONT OF IT. (Allow about 30 seconds for each choice. If you think it helpful to the children, read each question again as they select their choice.)

1. A DRY GREEN SALT IS HEATED IN A TEST TUBE. DROPS OF WATER APPEAR IN THE UPPER PART OF THE TUBE. THE SOLID IN THE BOTTOM OF THE TUBE CHANGES COLOR. WATER PROBABLY CAN COME FROM THE DRY SALT BECAUSE THE HEAT ENERGY ABSORBED BY THE GREEN SALT HAS:

   A. DRIVEN OFF WATER THAT IS BONDED TO THE SALT.

   B. CAUSED WATER TO BE ABSORBED FROM THE AIR.

   C. CAUSED THE TOP OF THE TUBE TO GET HOT.

2. WHEN WATER IS ADDED TO A SALT IN WHICH ITS BONDED WATER HAD BEEN REMOVED:

   A. HEAT ENERGY IS GIVEN OFF.

   B. HEAT ENERGY IS ABSORBED.

   C. NOTHING HAPPENS.

3. WHEN HEAT ENERGY IS ADDED TO HYDRATED SALTS (WITH BONDED WATER MOLECULES) IT IS MOST PROBABLE THAT:

A. THE HYDRATE BONDS HOLDING THE WATER TO THE SALT ARE STRONGER THAN THE SALT-TO-SALT BONDS.

B. THE SALT WILL MELT BEFORE THE HYDRATE BONDS HOLDING THE WATER TO THE SALT BREAK.

C. THE HYDRATE BONDS HOLDING THE WATER TO THE SALT WILL GENERALLY BREAK BEFORE THE SALT MELTS.

Have the children turn to page B.

QUESTIONS 4-6 HAVE TO DO WITH THE FOLLOWING SITUATION. AGAIN, DRAW A CIRCLE AROUND YOUR PREFERRED RESPONSE. TWO TEST TUBES CONTAINING EQUAL SIZED SAMPLES OF THE SAME BLUE SALT ARE HEATED. ONE OF THE TEST TUBES IS HEATED LONGER THAN THE OTHER AND THE SOLID TURNS YELLOW. NO CHANGE IS OBSERVED IN THE SALT THAT IS HEATED FOR A SHORT TIME.

4. WHICH SAMPLE OF SALT PROBABLY ABSORBED MORE HEAT ENERGY?

A. THE SALT WHICH REMAINED BLUE.

B. THE SALT WHICH TURNED YELLOW.

C. THEY BOTH ABSORBED THE SAME AMOUNT OF ENERGY.

5. THE SAMPLE OF SALT WHICH REMAINED BLUE IS NOW HEATED FOR A LONGER TIME AND IT ALSO TURNS YELLOW. AFTER BOTH SAMPLES COOL, SOME WATER IS ADDED TO ONLY ONE OF THEM. AFTER THE WATER IS ADDED TO THE ONE SAMPLE OF YELLOW SALT IT BECAME BLUE AND THE TEST TUBE BECAME VERY HOT. WATER IS NOT ADDED TO THE OTHER SAMPLE OF YELLOW SALT AND ITS COLOR DOES NOT CHANGE. WHICH SAMPLE OF SOLID SALT NOW HAS MORE HEAT ENERGY?

A. THE SAMPLE OF SALT WHICH REMAINED YELLOW.

B. THE SAMPLE OF SALT WHICH BECAME BLUE AGAIN.

C. BOTH SAMPLES CONTAIN THE SAME HEAT ENERGY.

6. WHICH OF THESE STATEMENTS IS TRUE REGARDING WHAT HAPPENED IN 5 ABOVE?

A. SOME HYDRATE BONDS WERE BROKEN WHEN THE SAMPLE OF YELLOW SALT BECAME BLUE AGAIN.

B. SOME HYDRATE BONDS WERE RE-FORMED WHEN THE SAMPLE OF YELLOW SALT BECAME BLUE AGAIN.

C. HYDRATE BONDS WERE FORMED IN BOTH THE YELLOW AND BLUE SAMPLES OF SALTS.

PART 2

Have the children turn to page C. Read the following tasks and each item aloud to the children. Allow about three minutes for each task.

TASK I. IN THE FOLLOWING PROCESSES PLACE A + IN THE SQUARE IF YOU THINK HEAT ENERGY IS ABSORBED; PLACE A − IF YOU THINK HEAT ENERGY WILL BE GIVEN OFF.

A. TO BREAK WATER-TO-SALT BONDS. ☐

B. MELTING. ☐

C. TO BREAK MOLECULE-TO-MOLECULE BONDS. ☐

D. ADDING WATER TO A SALT FROM WHICH BONDED WATER MOLECULES HAVE BEEN REMOVED. ☐

E. DISSOLVING. ☐

F. FORMING HYDRATE BONDS. ☐

TASK II. EACH ITEM (A-F) BELOW CONSISTS OF A PAIR OF SUBSTANCES. PLACE A CIRCLE AROUND THE SUBSTANCE IN EACH PAIR WHICH POSSESSES MORE ENERGY. BOTH SAMPLES ARE THE SAME SIZE AND ARE AT THE SAME TEMPERATURE.

A. BLUE VITRIOL	WHITE VITRIOL
B. A GAS	ITS LIQUID
C. A SOLID	ITS LIQUID
D. ANHYDROUS SALT	THE HYDRATED SALT
E. DISSOLVED SALT	THE SOLID SALT
F. STARCH-IODINE COMPLEX	STARCH PLUS IODINE

PART 3

Have the children turn to page D.

THE NEXT 3 QUESTIONS HAVE TO DO WITH A SITUATION WHICH I WILL DESCRIBE TO YOU. EACH QUESTION HAS THREE POSSIBLE ANSWERS. AS I READ THEM ALOUD TO YOU DRAW A CIRCLE AROUND THE LETTER IN FRONT OF THE BEST ANSWER. READ THE QUESTIONS SILENTLY WITH ME.

PHIL PERFORMED A CAREFUL EXPERIMENT WITH SOME CRYSTALS HE THOUGHT MIGHT BE HYPO (A HYDRATED SALT CALLED SODIUM THIOSULFATE). HE WANTED TO FIND OUT IF CRYSTALS OF THE SALT WERE REALLY HYDRATED, THAT IS CONTAINED BONDED WATER MOLECULES. HE ADDED 50 UNITS OF HEAT ENERGY TO A WEIGHED SAMPLE OF THE WHITE CRYSTALS OF HYPO.

1. AFTER ADDING THE HEAT ENERGY HE OBSERVED THAT THE CRYSTALS REMAINED WHITE. HIS CONCLUSION SHOULD BE THAT THE ORIGINAL SALT:

A. WAS NOT A HYDRATED SALT SINCE A HYDRATED SALT MUST CHANGE COLOR ON HEATING.

B. MIGHT BE HYDRATED SINCE COLOR DOES NOT HAVE TO CHANGE WHEN THE ANHYDROUS SALT IS FORMED ON HEATING.

C. WAS EASILY MELTED.

2. PHIL AGAIN WEIGHED THE WHITE SALT REMAINING IN THE TEST TUBE AFTER HEATING. IT WEIGHED LESS THAN BEFORE IT WAS HEATED. THIS WAS PROBABLY BECAUSE:

A. ON BEING HEATED, THE WHITE CRYSTALS LOST SOME WATER OF HYDRATION AND THEREFORE WEIGHED LESS.

B. SOME SALT MELTED AND THEREFORE THE SAMPLE WEIGHED LESS.

C. SOME SALT EVAPORATED AND LEFT THE SAMPLE OF SALT.

3. PHIL SUSPECTED THAT THE SALT CRYSTALS WITH WHICH HE STARTED HAD BEEN REALLY HYDRATED SALT CRYSTALS. HE DECIDED TO ADD A FEW DROPS OF WATER TO THE WHITE CRYSTALS AFTER THE 50 UNITS OF HEAT ENERGY HAD BEEN ADDED TO THEM. HE WANTED TO FIND OUT IF ANY HEAT ENERGY WOULD BE TAKEN IN OR GIVEN OFF WHEN HE ADDED WATER. IF SO, HE WANTED TO MEASURE IT. AS HE ADDS THE WATER, THE CRYSTALS STILL APPEAR TO BE DRY. IF WHAT HE SUSPECTED ABOUT THE ORIGINAL CRYSTALS WERE TRUE WHAT ELSE SHOULD HE OBSERVE WHEN HE ADDS A FEW DROPS OF WATER TO THE SAMPLE OF SALT TO WHICH HEAT ENERGY HAD BEEN ADDED?

A. THE SAMPLE SHOULD USE UP 50 UNITS OF HEAT ENERGY AND BECOME COOLER.

B. THE SAMPLE SHOULD GIVE OFF 100 UNITS OF HEAT ENERGY AS WATER MOLECULES AGAIN BOND TO THE SALT.

C. THE SAMPLE SHOULD GIVE OFF 50 UNITS OF HEAT ENERGY AS THE HYDRATE BONDS TO SALT RE-FORM.

PART 4

Ask the children to turn to page E.

THE NEXT 4 QUESTIONS HAVE TO DO WITH STILL ANOTHER SITUATION IN WHICH A SERIES OF ACTIVITIES WERE CONDUCTED AND OBSERVATIONS MADE. BILL TOOK SOME CRYSTALS OF WHITE SALT FROM A CONTAINER WHICH WAS LABELED *A*, AND PUT THEM IN A TEST TUBE. JAN ALSO TOOK SOME CRYSTALS OF A WHITE SALT BUT FROM A CONTAINER LABELED *B* AND PUT THEM INTO A TEST TUBE. BILL AND JAN THEN ADDED A FEW DROPS OF WATER TO THE WHITE CRYSTALS IN EACH OF THEIR TEST TUBES.

HERE ARE SOME OBSERVATIONS AND QUESTIONS. EACH QUESTION IS FOLLOWED BY SEVERAL POSSIBLE ANSWERS TO IT. DRAW A CIRCLE AROUND THE LETTER OF THE ANSWER YOU PREFER.

1. THE TEMPERATURE OF BILL'S TEST TUBE INCREASED. IT BECAME VERY HOT. WHAT IS POSSIBLY HAPPENING IN THE CRYSTALS OF HIS SAMPLE OF SALT?

A. SOLID-TO-SOLID BONDS ARE BEING BROKEN.

B. HYDRATE BONDS ARE BEING FORMED.

C. WATER IS BEING DRIVEN OFF.

2. JAN'S TEST TUBE BECAME COOLER WHEN SHE ADDED THE WATER. SHE ALSO OBSERVED LESS SOLID THAN WHEN SHE STARTED. WHAT DO YOU THINK WAS HAPPENING IN THE CRYSTALS OF HER SAMPLE OF SALT?

A. SOME OF THE WHITE SOLID DISSOLVED IN THE WATER.

B. SOME OF THE WHITE SOLID EVAPORATED.

C. SOME OF THE WATER EVAPORATED.

3. WHY DID JAN'S SAMPLE OF SALT BECOME COOLER?

A. BONDS WITHIN THE CRYSTALS WERE BEING BROKEN.

B. BONDS WERE BEING FORMED WITHIN THE CRYSTALS.

C. BOTH OF THE ABOVE WERE HAPPENING.

4. WERE THE TWO SUBSTANCES INVESTIGATED BY JAN AND BILL THE SAME?

A. YES.

B. NO.

C. THERE IS NO WAY TO TELL.

1. A DRY GREEN SALT IS HEATED IN A TEST TUBE. DROPS OF WATER APPEAR IN THE UPPER PART OF THE TUBE. THE SOLID IN THE BOTTOM OF THE TUBE CHANGES COLOR. WATER PROBABLY CAN COME FROM THE DRY SALT BECAUSE THE HEAT ENERGY ABSORBED BY THE GREEN SALT HAS:

A. DRIVEN OFF WATER THAT IS BONDED TO THE SALT.

B. CAUSED WATER TO BE ABSORBED FROM THE AIR.

C. CAUSED THE TOP OF THE TUBE TO GET HOT.

2. WHEN WATER IS ADDED TO A SALT IN WHICH ITS BONDED WATER HAD BEEN REMOVED:

A. HEAT ENERGY IS GIVEN OFF.

B. HEAT ENERGY IS ABSORBED.

C. NOTHING HAPPENS.

3. WHEN HEAT ENERGY IS ADDED TO HYDRATED SALTS (WITH BONDED WATER MOLECULES) IT IS MOST PROBABLE THAT:

A. THE HYDRATE BONDS HOLDING THE WATER TO THE SALT ARE STRONGER THAN THE SALT-TO-SALT BONDS.

B. THE SALT WILL MELT BEFORE THE HYDRATE BONDS HOLDING THE WATER TO THE SALT BREAK.

C. THE HYDRATE BONDS HOLDING THE WATER TO THE SALT WILL GENERALLY BREAK BEFORE THE SALT MELTS.

TWO TEST TUBES CONTAINING EQUAL SIZED SAMPLES OF THE SAME BLUE SALT ARE HEATED. ONE OF THE TEST TUBES IS HEATED LONGER THAN THE OTHER AND THE SOLID TURNS YELLOW. NO CHANGE IS OBSERVED IN THE SALT THAT IS HEATED FOR A SHORTER TIME.

4. WHICH SAMPLE OF SALT PROBABLY ABSORBED MORE HEAT ENERGY?

   A. THE SALT WHICH REMAINED BLUE.

   B. THE SALT WHICH TURNED YELLOW.

   C. THEY BOTH ABSORBED THE SAME AMOUNT OF ENERGY.

5. THE SAMPLE OF SALT WHICH REMAINED BLUE IS NOW HEATED FOR A LONGER TIME AND IT ALSO TURNS YELLOW. AFTER BOTH SAMPLES COOL, SOME WATER IS ADDED TO ONLY ONE OF THEM. AFTER THE WATER IS ADDED TO THE ONE SAMPLE OF YELLOW SALT IT BECAME BLUE AND THE TEST TUBE BECAME VERY HOT. WATER IS NOT ADDED TO THE OTHER SAMPLE OF YELLOW SALT AND ITS COLOR DOES NOT CHANGE. WHICH SAMPLE OF SOLID SALT NOW HAS MORE HEAT ENERGY?

   A. THE SAMPLE OF SALT WHICH REMAINED YELLOW.

   B. THE SAMPLE OF SALT WHICH BECAME BLUE AGAIN.

   C. BOTH SAMPLES CONTAIN THE SAME HEAT ENERGY.

6. WHICH OF THESE STATEMENTS IS TRUE REGARDING WHAT HAPPENED IN 5 ABOVE?

   A. SOME HYDRATE BONDS WERE BROKEN WHEN THE SAMPLE OF YELLOW SALT BECAME BLUE AGAIN.

   B. SOME HYDRATE BONDS WERE RE-FORMED WHEN THE SAMPLE OF YELLOW SALT BECAME BLUE AGAIN.

   C. HYDRATE BONDS WERE FORMED IN BOTH THE YELLOW AND BLUE SAMPLES OF SALTS.

TASK I: IN THE FOLLOWING PROCESSES PLACE A + IN THE SQUARE IF YOU THINK HEAT ENERGY IS ABSORBED; PLACE A — IF YOU THINK HEAT ENERGY WILL BE GIVEN OFF.

A. TO BREAK WATER-TO-SALT BONDS ☐

B. MELTING ☐

C. TO BREAK MOLECULE-TO-MOLECULE BONDS ☐

D. ADDING WATER TO A SALT FROM WHICH BONDED WATER MOLECULES HAVE BEEN REMOVED. ☐

E. DISSOLVING ☐

F. FORMING HYDRATE BONDS ☐

TASK II. EACH ITEM (A-F) BELOW CONSISTS OF A PAIR OF SUBSTANCES. PLACE A CIRCLE AROUND THE SUBSTANCE IN EACH PAIR WHICH POSSESSES MORE ENERGY. BOTH SAMPLES ARE THE SAME SIZE AND ARE AT THE SAME TEMPERATURE.

A.	BLUE VITRIOL	WHITE VITRIOL
B.	A GAS	ITS LIQUID
C.	A SOLID	ITS LIQUID
D.	ANHYDROUS SALT	THE HYDRATED SALT
E.	DISSOLVED SALT	THE SOLID SALT
F.	STARCH-IODINE COMPLEX	STARCH PLUS IODINE

PHIL PERFORMED A CAREFUL EXPERIMENT WITH SOME CRYSTALS HE THOUGHT MIGHT BE HYPO (A HYDRATED SALT CALLED SODIUM THIOSULFATE). HE WANTED TO FIND OUT IF CRYSTALS OF THE SALT WERE REALLY HYDRATED, THAT IS CONTAINED BONDED WATER MOLECULES. HE ADDED 50 UNITS OF HEAT ENERGY TO A WEIGHED SAMPLE OF THE WHITE CRYSTALS OF HYPO.

1. AFTER ADDING THE HEAT ENERGY HE OBSERVED THAT THE CRYSTALS REMAINED WHITE. HIS CONCLUSION SHOULD BE THAT THE ORIGINAL SALT:

A. WAS NOT A HYDRATED SALT SINCE A HYDRATED SALT MUST CHANGE COLOR ON HEATING.

B. MIGHT BE HYDRATED SINCE COLOR DOES NOT HAVE TO CHANGE WHEN THE ANHYDROUS SALT IS FORMED ON HEATING.

C. WAS EASILY MELTED.

2. PHIL AGAIN WEIGHED THE WHITE SALT REMAINING IN THE TEST TUBE AFTER HEATING. IT WEIGHED LESS THAN BEFORE IT WAS HEATED. THIS WAS PROBABLY BECAUSE:

A. ON BEING HEATED, THE WHITE CRYSTALS LOST SOME WATER OF HYDRATION AND THEREFORE WEIGHED LESS.

B. SOME SALT MELTED AND THEREFORE THE SAMPLE WEIGHED LESS.

C. SOME SALT EVAPORATED AND LEFT THE SAMPLE OF SALT.

3. PHIL SUSPECTED THAT THE SALT CRYSTALS WITH WHICH HE STARTED HAD BEEN REALLY HYDRATED SALT CRYSTALS. HE DECIDED TO ADD A FEW DROPS OF WATER TO THE WHITE CRYSTALS AFTER THE 50 UNITS OF HEAT ENERGY HAD BEEN ADDED TO THEM. HE WANTED TO FIND OUT IF ANY HEAT ENERGY WOULD BE TAKEN IN OR GIVEN OFF WHEN HE ADDED WATER. IF SO, HE WANTED TO MEASURE IT. AS HE ADDS THE WATER, THE CRYSTALS STILL APPEAR TO BE DRY. IF WHAT HE SUSPECTED ABOUT THE ORIGINAL CRYSTALS WERE TRUE WHAT ELSE SHOULD HE OBSERVE WHEN HE ADDS A FEW DROPS OF WATER TO THE SAMPLE OF SALT TO WHICH HEAT ENERGY HAD BEEN ADDED?

A. THE SAMPLE SHOULD USE UP 50 UNITS OF HEAT ENERGY AND BECOME COOLER.

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C. THE SAMPLE SHOULD GIVE OFF 50 UNITS OF HEAT ENERGY AS THE HYDRATE BONDS TO SALT RE-FORM.

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   A. SOME OF THE WHITE SOLID DISSOLVED IN THE WATER.

   B. SOME OF THE WHITE SOLID EVAPORATED.

   C. SOME OF THE WATER EVAPORATED.

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   A. BONDS WITHIN THE CRYSTALS WERE BEING BROKEN.

   B. BONDS WERE BEING FORMED WITHIN THE CRYSTALS.

   C. BOTH OF THE ABOVE WERE HAPPENING.

4. WERE THE TWO SUBSTANCES INVESTIGATED BY JAN AND BILL THE SAME?

   A. YES.

   B. NO.

   C. THERE IS NO WAY TO TELL.

Minisequence III

Copper: A Structural Unit

Screening Assessments

The concepts developed in Minisequence III are:

a. Some molecules are component structural units of larger molecules.

b. A molecule is composed of smaller structural units of matter called atoms.

c. Certain physical properties of crystals are characteristic and unique to a specific molecule, e.g.,color and crystal shape.

d. Certain interaction properties are unique to a specific molecule e.g.,the interaction between starch and iodine.

e. Physical and interaction properties can often be used to confirm the presence of a particular molecule.

f. Atoms can sometimes be displaced from a molecule and then replaced by other atoms.

g. The properties of molecules depend upon the atoms of which they are composed; substitution of a single atom for another atom will change the properties of a molecule.

h. Substances containing the same kind of atoms as a component part may exhibit certain properties in common (e.g., flame color, blue color of hydrated copper salts,) based on the presence of this atom.

The assessment for this Minisequence consists of six parts. Hand out the assessment pages, A through H. Page I will be given out last.

The children should place their names in the appropriate places. This assessment should take about 30-40 minutes to administer.

PART 1

Page A

Have the children turn to page A.

I AM GOING TO ASK SOME QUESTIONS ABOUT PARTS AND WHOLES. YOU SHOULD READ THE QUESTIONS AND CHOICES SILENTLY AS I READ THEM ALOUD TO YOU. WHEN I HAVE READ ALL THE CHOICES, DRAW A CIRCLE AROUND THE LETTER OF THE BEST CHOICE. (Allow about 30 seconds for the children to respond to each item. If you think it helpful, read each question again as they select their choice.)

1. IF YOU WERE TO EXAMINE A TREE, YOU WOULD FIND THE THREE THINGS BELOW. WHICH WOULD BE THE SMALLEST PART?

A. A LEAF

B. A CELL

C. A TWIG

2. A PUDDLE OF WATER IS COMPOSED OF THE THREE THINGS BELOW. WHICH WOULD BE THE SMALLEST PART?

A. A MOLECULE OF WATER

B. A DROP OF WATER

C. A SMALL CUP OF WATER

3. THE DEEP BLUE SOLUTION FORMED WHEN STARCH AND IODINE INTERACT IS COMPOSED OF SEVERAL PARTS, INCLUDING THE FOLLOWING. WHICH OF THE PARTS NOTED BELOW WOULD BE THE SMALLEST?

A. THE STARCH-IODINE COMPLEX

B. THE STARCH MOLECULE

C. A 1/4 TEASPOONFUL OF SOLUTION

PART 2

Page B

Have the children turn to page B.

HERE YOU WILL FIND PAIRS OF STATEMENTS. ONE OF THE STATEMENTS IS TRUE AND ONE IS FALSE. READ BOTH STATEMENTS SILENTLY TO YOURSELF WHILE I READ THEM ALOUD TO YOU. AFTER I HAVE READ BOTH STATEMENTS, DRAW A CIRCLE AROUND THE LETTER OF THE STATEMENT WHICH IS TRUE. (Allow about 30 seconds for the children to respond to each item.)

1. A. THE SMALLEST PARTS THAT ALL LIVING THINGS HAVE IN COMMON ARE LEAVES.

   B. THE SMALLEST PARTS THAT ALL LIVING THINGS HAVE IN COMMON ARE CELLS.

2. A. ALL IRON SULFATE CRYSTALS HAVE THE SAME SHAPE.

   B. IRON SULFATE MAY CRYSTALLIZE IN SEVERAL DIFFERENT SHAPES.

3. A. WATER MOLECULES ARE A PART OF ALL HYDRATE SALTS.

   B. WATER MOLECULES ARE A PART OF ALL KINDS OF SALTS.

4. A. A PART OF THE BLUE VITRIOL MOLECULE IS COPPER.

   B. A PART OF COPPER IS THE BLUE VITRIOL MOLECULE.

5. A. EVERY SALT CONTAINS SOME COPPER.

   B. SOME SALTS DO NOT CONTAIN COPPER.

PART 3

Page C

Have the children turn to page C.

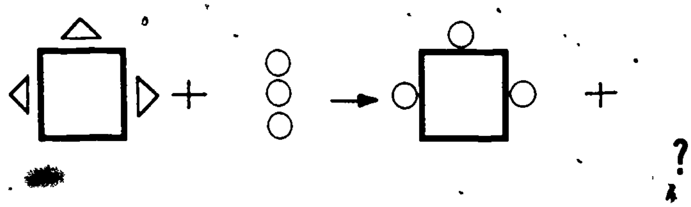
HERE ARE SOME MORE PROBLEMS ABOUT PARTS OF WHOLES. IN EACH ITEM BELOW YOU WILL FIND A PICTURE OF A STRUCTURE MADE UP OF CERTAIN UNIT PARTS.

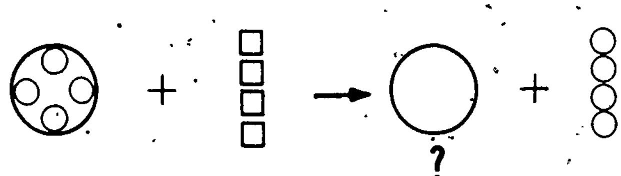
AN INTERACTION IS SHOWN WHICH RESULTS IN CHANGES IN THE ARRANGEMENT OF THE UNIT PARTS. COMPLETE THE STATEMENT OF THE INTERACTION BY DRAWING THE CORRECT FIGURE OVER THE QUESTION MARK OR BY COMPLETING THE PICTURE OVER THE QUESTION MARK.
HERE IS AN EXAMPLE:

XO + Y → YO + ?

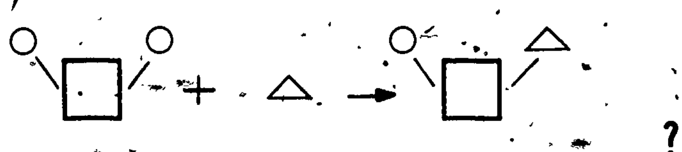
TO COMPLETE THIS "INTERACTION" AN X SHOULD BE PLACED OVER ? .
THE COMPLETED STATEMENT WOULD READ AS:

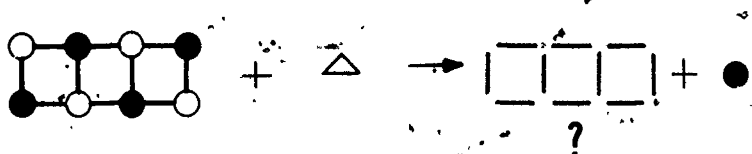
XO + Y → YO + X
?

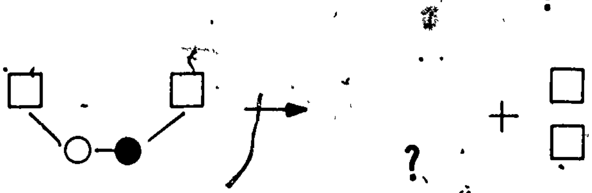
1. 

2. 

TURN TO PAGE D.

3. 

4. 

5. 

PART 4

Page E

Have the children turn to page E.

HERE ARE SOME QUESTIONS WITH THREE POSSIBLE ANSWERS EACH. READ EACH QUESTION AND ITS ANSWER SILENTLY WHILE I READ THEM ALOUD. AFTER I HAVE FINISHED YOU WILL HAVE A SHORT TIME TO SELECT YOUR CHOICE AND CIRCLE THE LETTER IN FRONT OF IT. (Allow about 1 minute for each response.)

1. A MODEL OF THE TWO PARTS OF A SALT MOLECULE IN A BLUE COLORED SOLUTION CAN BE PICTURED AS △—○ WHILE A MODEL OF THE MOLECULES IN A COLORLESS OR POSSIBLY SLIGHTLY YELLOW SOLUTION CAN BE PICTURED AS □—○ . WHICH COULD BE THE APPROPRIATE PAIR OF SYMBOLS FOR THE UNIT PARTICLES MAKING UP THE DISSOLVED SALT MOLECULES?

A. △ STANDS FOR COPPER AND ○ STANDS FOR SULFATE

B. △ STANDS FOR IRON, AND ○ STANDS FOR SULFATE

C. ○ STANDS FOR COPPER, AND △ STANDS FOR IRON.

2. DOTTY PICKED UP TWO JARS EACH CONTAINING BLUE SOLUTION. SHE KNEW THAT ONE SOLUTION CONTAINED COPPER SULFATE. IN ORDER TO IDENTIFY THE SOLUTION CONTAINING COPPER SULFATE, SHE SHOULD:

A. FILTER PART OF THE SOLUTION AND LOOK FOR THE APPEARANCE OF COPPER ON THE FILTER PAPER.

B. PUT A PIECE OF IRON IN PART OF THE SOLUTION AND LOOK FOR THE APPEARANCE OF COPPER ON THE IRON.

C. OBSERVE THE SOLUTION VERY CAREFULLY WITH A MAGNIFIER.

3. MORRIS DISSOLVED SOME BLUE COPPER CHLORIDE SALT IN WATER. HE DECIDED TO REFORM SOME CRYSTALS AND SO HE PLACED SOME OF THE SOLUTION IN AN ALUMINUM PIE PAN. WHAT MIGHT HAPPEN?

A. A BIG HOLE WOULD APPEAR IN THE PAN AND SOME METALLIC COPPER WOULD FORM.

B. NOTHING WOULD CHANGE IN THE APPEARANCE OF THE BLUE COPPER CHLORIDE SOLUTION IN THE PAN.

C. THE WATER WOULD EVAPORATE VERY QUICKLY FROM THE BLUE SOLUTION IN THE PAN.

PART 5

Page F

Have the children turn to pages F and G.

THIS PART OF THE ASSESSMENT HAS SOME QUESTIONS ABOUT A PARTICULAR SITUATION. AFTER I READ ALOUD EACH QUESTION AND ITS POSSIBLE ANSWERS CIRCLE THE LETTER IN FRONT OF YOUR PREFERRED ANSWER. HERE IS THE SITUATION: LIZ IS DOING AN EXPERIMENT WITH A WHITE CRYSTALLINE SALT. SHE OBSERVED THE CRYSTALS WITH A MAGNIFIER AND SAW THAT THEY WERE IN THE SHAPE OF DIAMONDS, ◊. WHEN SHE HEATED SOME OF THE CRYSTALS IN A FLAME, THE FLAME BECAME RED.

1. LIZ DISSOLVED SOME OF THE CRYSTALS IN WATER. WHEN THE SALT RECRYSTALLIZED LIZ OBSERVED THAT THE CRYSTALS WERE ALSO DIAMOND SHAPED. SHE CONSIDERED THIS WAS TO BE EXPECTED SINCE:

A. DIAMOND SHAPED CRYSTALS ARE ALWAYS FORMED BY WHITE SALTS.

B. SHE ALLOWED THE SOLUTION TO STAND OVERNIGHT.

C. WHEN THE SUBSTANCE DISSOLVED IN THE WATER, ITS COMPOSITION HAD NOT CHANGED.

2. LIZ MADE UP SOME MORE SOLUTION. BY ACCIDENT SOME OTHER POWDER FELL IN. THE SOLUTION BECAME CLOUDY. SHE FILTERED IT AND SET ASIDE THE CLEAR LIQUID WHICH CAME THROUGH. SHE OBSERVED THE LIQUID THE NEXT DAY. LONG NEEDLE SHAPED CRYSTALS HAD FORMED. WHICH OF THE FOLLOWING MOST LIKELY EXPLAINS WHAT HAPPENED?

A. THE SOLID SALT WAS THE SAME AS THE ONE SHE STARTED WITH BUT THE CRYSTALS WERE LONGER.

B. DRYING OUT ALWAYS CHANGES CRYSTAL SHAPES.

C. THERE WAS AN INTERACTION WITH THE POWDER AND A DIFFERENT KIND OF MOLECULE WAS FORMED.

3. LIZ THEN HELD THE NEW NEEDLE SHAPED CRYSTALS IN A FLAME. THE FLAME WAS THE SAME COLOR RED AS SHE OBSERVED WITH THE DIAMOND CRYSTALS. WHICH OF THE FOLLOWING BEST EXPLAINS WHY?

A. WHITE CRYSTALS ALWAYS PRODUCE RED FLAMES.

B. THE SAME UNIT PARTICLE WAS PRESENT IN BOTH THE DIAMOND AND NEEDLE SHAPED CRYSTALS.

C. THE WATER AND THE POWDER INTERFERRED WITH THE TESTING IN THE FLAME.

Page G.

NOW TURN TO PAGE G.

4. LIZ DISSOLVED THE NEEDLE SHAPED CRYSTALS. SHE INSERTED A PIECE OF METAL WIRE INTO THE SOLUTION. THE SOLUTION TURNED GREEN. SHE MIGHT EXPECT THAT:

A. OVER A PERIOD OF TIME, THE SOLUTION WOULD BECOME A DARKER GREEN.

B. A NEW KIND OF MOLECULE HAS BEEN FORMED FROM PART OF THE METAL.

C. BOTH *A* AND *B* ABOVE.

5. THE MOST LIKELY REASON FOR THE ABOVE OBSERVATION IS THAT:

A. PARTICLES MAKING UP THE METAL WIRE EXCHANGED PLACES WITH PARTICLES MAKING UP THE SALT MOLECULES IN SOLUTION.

B. METALS GENERALLY FORM GREEN SOLUTIONS.

C. PARTICLES ARE COMING OFF THE WIRE AND MIXING WITH THE DISSOLVED SALT TO MAKE IT GREEN.

6. LIZ TESTED THE GREEN SOLUTION IN A FLAME. IT DID NOT MAKE THE FLAME RED, BUT MADE THE FLAME PURPLE. WHAT IS THE MOST LIKELY REASON?

A. THE GREEN MOLECULES IN THE SOLUTION AND THE ORIGINAL RED FLAME WOULD MAKE THE FLAME PURPLE.

B. THE UNIT PARTICLE RESPONSIBLE FOR THE RED FLAME IS NO LONGER A PART OF THE MOLECULES IN THE SOLUTION.

C. BOTH OF THE ABOVE ARE TRUE.

7. LIZ TESTED ANOTHER PIECE OF THE SAME METAL WIRE. IT IS MOST PROBABLE THAT THE WIRE WOULD PRODUCE A FLAME THAT WAS:

A. RED

B. PURPLE

C. COLORLESS

8. LIZ DECIDED TO GROW CRYSTALS FROM THE GREEN SOLUTION SHE HAD MADE. WHICH OF THE FOLLOWING WOULD SHE MOST LIKELY OBSERVE FOR THE CRYSTALS WHICH FORM?

A. THEY MIGHT BE COLORED GREEN.

B. THEY WOULD CERTAINLY BE NEEDLE SHAPED.

C. THEY MIGHT BE COLORED PURPLE AS WAS THE FLAME.

PART 6

Page H

Hand out page H to the children. You will distribute page I after you collect their responses to page H.

THERE WILL BE THREE TASKS FOR YOU TO DO ABOUT THE FOLLOWING SITUATIONS. THE SITUATIONS HAVE TO DO WITH EXPERIMENTS DONE IN A CLASSROOM IN ANOTHER COUNTRY. THE CHILDREN OBSERVED AND THEN EXPLAINED WHAT THEY THOUGHT WAS HAPPENING TO THE MOLECULES. THEY USED WORD "EQUATIONS". SOME OF THE NAMES THEY USED FOR PARTICLES WERE DIFFERENT FROM THE ONES WE USE. IN GENERAL, THEY FOUND THE FOLLOWING TO OCCUR IN THEIR OBSERVATIONS:

CHLORIDE CRYSTALS WERE CUBE-SHAPED.

SULFATE CRYSTALS WERE NEEDLE-SHAPED.

NITRATE CRYSTALS WERE ANGLE-SHAPED.

AND IN A FLAME "COPIUM" MADE IT RED.

"SCHOOLIUM" MADE IT GREEN.

"TEACHIUM" MADE IT YELLOW.

TASK I: COMPLETE THE FOLLOWING WORD EQUATIONS BY FILLING IN THE BLANK LINES.

A. SCHOOLIUM + TEACHIUM SULFATE → TEACHIUM + __________ SULFATE

B. COPIUM + SCHOOLIUM CHLORIDE → SCHOOLIUM + COPIUM __________

C. COPIUM + TEACHIUM SULFATE → __________ + COPIUM SULFATE

D. POTASSIUM + COPIUM CHLORIDE → __________ + POTASSIUM CHLORIDE

TASK II: KEEP IN MIND THAT THE FOLLOWING COLORS ARE PRODUCED IN FLAMES BY THE INDIVIDUAL UNIT PARTICLES: COPIUM PRODUCES RED; SCHOOLIUM PRODUCES GREEN; TEACHIUM PRODUCES YELLOW.

NOW, IN THE ABOVE WORD EQUATIONS, PLACE A *Y* ON ALL THE SUBSTANCES WHICH COULD MAKE A FLAME YELLOW, AND AN *R* ON ALL THE SUBSTANCES WHICH WOULD MAKE A FLAME RED.

Collect the assessment pages completed by the children and then distribute page I, the final item in this assessment.

Page I

NOW LOOK AT PAGE I.

TASK III: KEEP IN MIND THE OBSERVATIONS THAT CHLORIDES FORM CUBES, SULFATES FORM NEEDLES, AND NITRATES FORM ANGLED CRYSTALS. NOW IN THE FOLLOWING LIST OF SALT MOLECULES PLACE A SQUARE, □, NEXT TO THE MOLECULES YOU EXPECT TO FORM CUBES WHEN THEY CRYSTALLIZE, AND A LINE, —, NEXT TO THOSE WHICH YOU EXPECT TO FORM NEEDLES. HERE IS THE LIST.

A. POTASSIUM CHLORIDE

B. COPIUM SULFATE

C. TEACHIUM CHLORIDE

D. TEACHIUM SULFATE

E. COPIUM NITRATE

F. SODIUM CHLORIDE

G. SCHOOLIUM NITRATE

H. COPPER NITRATE

1. IF YOU WERE TO EXAMINE A TREE, YOU WOULD FIND THE THREE THINGS BELOW. WHICH WOULD BE THE SMALLEST PART?

A. A LEAF

B. A CELL

C. A TWIG

2. A PUDDLE OF WATER IS COMPOSED OF THE THREE THINGS BELOW. WHICH WOULD BE THE SMALLEST PART?

A. A MOLECULE OF WATER

B. A DROP OF WATER

C. A SMALL CUP OF WATER

3. THE DEEP BLUE SOLUTION FORMED WHEN STARCH AND IODINE INTERACT IS COMPOSED OF SEVERAL PARTS, INCLUDING THE FOLLOWING. WHICH OF THE PARTS NOTED BELOW WOULD BE THE SMALLEST?

A. THE STARCH-IODINE COMPLEX

B. THE STARCH MOLECULE

C. A 1/4 TEASPOONFUL OF SOLUTION

1. A. THE SMALLEST PARTS THAT ALL LIVING THINGS HAVE IN COMMON ARE LEAVES.

   B. THE SMALLEST PARTS THAT ALL LIVING THINGS HAVE IN COMMON ARE CELLS.

2. A. ALL IRON SULFATE CRYSTALS HAVE THE SAME SHAPE.

   B. IRON SULFATE MAY CRYSTALLIZE IN SEVERAL DIFFERENT SHAPES.

3. A. WATER MOLECULES ARE A PART OF ALL HYDRATE SALTS.

   B. WATER MOLECULES ARE A PART OF ALL KINDS OF SALTS.

4. A. A PART OF THE BLUE VITRIOL MOLECULE IS COPPER.

   B. A PART OF COPPER IS THE BLUE VITRIOL MOLECULE.

5. A. EVERY SALT CONTAINS SOME COPPER.

   B. SOME SALTS DO NOT CONTAIN COPPER.

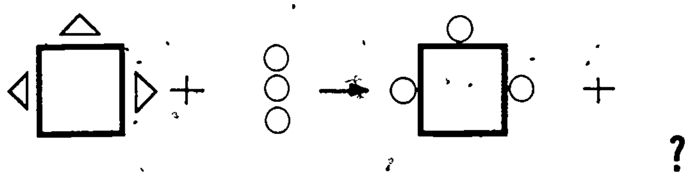
HERE ARE SOME MORE PROBLEMS ABOUT PARTS OF WHOLES. IN EACH ITEM BELOW YOU WILL FIND A PICTURE OF A STRUCTURE MADE UP OF CERTAIN UNIT PARTS. AN INTERACTION IS SHOWN WHICH RESULTS IN CHANGES IN THE ARRANGEMENT OF THE UNIT PARTS. COMPLETE THE STATEMENT OF THE INTERACTION BY DRAWING THE CORRECT FIGURE OVER THE QUESTION MARK OR BY COMPLETING THE PICTURE OVER THE QUESTION MARK.

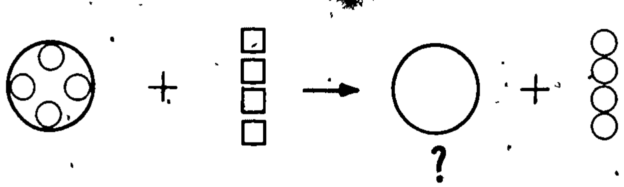
HERE IS AN EXAMPLE:

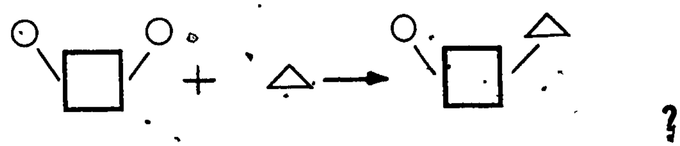
XO + Y ⟶ YO + ?

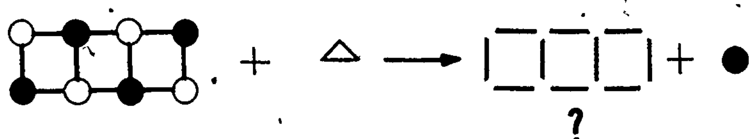
TO COMPLETE THIS "INTERACTION AN X SHOULD BE PLACED OVER ? . THE COMPLETED STATEMENT WOULD READ AS:

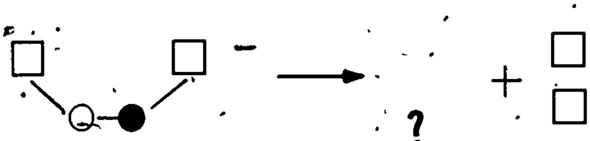
XO + Y ⟶ YO + X
?

1. 

2. 

3. 



5. 

1. A MODEL OF THE TWO PARTS OF A SALT MOLECULE IN A BLUE COLORED SOLUTION CAN BE PICTURED AS △ — ○ WHILE A MODEL OF THE MOLECULES IN A COLORLESS OR POSSIBLEY SLIGHT YELLOW SOLUTION CAN BE PICTURED AS □ - ○. WHICH COULD BE THE APPROPRIATE PAIR OF SYMBOLS FOR THE UNIT PARTICLES MAKING UP THE DISSOLVED SALT MOLECULES?

A. △ STANDS FOR COPPER, AND ○ STANDS FOR SULFATE

B. △ STANDS FOR IRON, AND ○ STANDS FOR SULFATE

C. ○ STANDS FOR COPPER, AND △ STANDS FOR IRON.

2. DOTTY PICKED UP TWO JARS EACH CONTAINING BLUE SOLUTION. SHE KNEW THAT ONE SOLUTION CONTAINED COPPER SULFATE. IN ORDER TO IDENTIFY THE SOLUTION CONTAINING COPPER SULFATE, SHE SHOULD:

A. FILTER PART OF THE SOLUTION AND LOOK FOR THE APPEARANCE OF COPPER IN THE FILTER PAPER.

B. PUT A PIECE OF IRON IN PART OF THE SOLUTION AND LOOK FOR THE APPEARANCE OF COPPER IN THE IRON.

C. OBSERVE THE SOLUTION VERY CAREFULLY WITH A MAGNIFIER.

3. MORRIS DISSOLVED SOME BLUE COPPER CHLORIDE SALT IN WATER. HE DECIDED TO REFORM SOME CRYSTALS AND SO HE PLACED SOME OF THE SOLUTION IN AN ALUMINUM PIE PAN. WHAT MIGHT HAPPEN?

A. A BIG HOLE WOULD APPEAR IN THE PAN AND SOME METALLIC COPPER WOULD FORM.

B. NOTHING WOULD CHANGE IN THE APPEARANCE OF THE BLUE COPPER CHLORIDE SOLUTION IN THE PAN.

C. THE WATER WOULD EVAPORATE VERY QUICKLY FROM THE BLUE SOLUTION IN THE PAN.

LIZ IS DOING AN EXPERIMENT WITH A WHITE CRYSTALLINE SALT. SHE OBSERVED THE CRYSTALS WITH A MAGNIFIER AND SAW THAT THEY WERE IN THE SHAPE OF DIAMONDS, ◊ . WHEN SHE HEATED SOME OF THE CRYSTALS IN A FLAME, THE FLAME BECAME RED.

1. LIZ DISSOLVED SOME OF THE CRYSTALS IN WATER. WHEN THE SALT RECRYSTALLIZED, LIZ OBSERVED THAT THE CRYSTALS WERE ALSO DIAMOND SHAPED. SHE CONSIDERED THIS WAS TO BE EXPECTED SINCE:

   A. DIAMOND SHAPED CRYSTALS ARE ALWAYS FORMED BY WHITE SALTS.

   B. SHE ALLOWED THE SOLUTION TO STAND OVERNIGHT.

   C. WHEN THE SUBSTANCE DISSOLVED IN THE WATER, ITS COMPOSITION HAD NOT CHANGED.

2. LIZ MADE UP SOME MORE SOLUTION. BY ACCIDENT SOME OTHER POWDER FELL IN. THE SOLUTION BECAME CLOUDY. SHE FILTERED IT AND SET ASIDE THE CLEAR LIQUID WHICH CAME THROUGH. SHE OBSERVED THE LIQUID THE NEXT DAY. LONG NEEDLE SHAPED CRYSTALS HAD FORMED. WHICH OF THE FOLLOWING MOST LIKELY EXPLAINS WHAT HAPPENED?

   A. THE SOLID SALT WAS THE SAME AS THE ONE SHE STARTED WITH BUT THE CRYSTALS WERE LONGER.

   B. DRYING OUT ALWAYS CHANGES CRYSTAL SHAPES.

   C. THERE WAS AN INTERACTION WITH THE POWDER AND A DIFFERENT KIND OF MOLECULE WAS FORMED.

3. LIZ THEN HELD THE NEW NEEDLE SHAPED CRYSTALS IN A FLAME, THE FLAME WAS THE SAME COLOR RED AS SHE OBSERVED WITH THE DIAMOND CRYSTALS. WHICH OF THE FOLLOWING BEST EXPLAINS WHY?

   A. WHITE CRYSTALS ALWAYS PRODUCE RED FLAMES.

   B. THE SAME UNIT PARTICLE WAS PRESENT IN BOTH THE DIAMOND AND NEEDLE SHAPED CRYSTALS.

   C. THE WATER AND THE POWDER INTERFERRED WITH THE TESTING IN THE FLAME.

4. LIZ DISSOLVED THE NEEDLE SHAPED CRYSTALS. SHE INSERTED A PIECE OF METAL WIRE INTO THE SOLUTION. THE SOLUTION TURNED GREEN. SHE MIGHT EXPECT THAT:

A. OVER A PERIOD OF TIME, THE SOLUTION WOULD BECOME A DARKER GREEN.

B. A NEW KIND OF MOLECULE HAS BEEN FORMED FROM PART OF THE METAL.

C. BOTH A AND B ABOVE.

5. THE MOST LIKELY REASON FOR THE ABOVE OBSERVATION IS THAT:

A. PARTICLES MAKING UP THE METAL WIRE EXCHANGED PLACES WITH PARTICLES MAKING UP THE SALT MOLECULES IN SOLUTION.

B. METALS GENERALLY FORM GREEN SOLUTIONS.

C. PARTICLES ARE COMING OFF THE WIRE AND MIXING WITH THE DISSOLVED SALT TO MAKE IT GREEN.

6. LIZ TESTED THE GREEN SOLUTION IN A FLAME. IT DID NOT MAKE THE FLAME RED, BUT MADE THE FLAME PURPLE. WHAT IS THE MOST LIKELY REASON?

A. THE GREEN MOLECULES IN THE SOLUTION AND THE ORIGINAL RED FLAME WOULD MAKE THE FLAME PURPLE.

B. THE UNIT PARTICLE RESPONSIBLE FOR THE RED FLAME IS NO LONGER A PART OF THE MOLECULES IN THE SOLUTION.

C. BOTH OF THE ABOVE ARE TRUE.

7. LIZ TESTED ANOTHER PIECE OF THE SAME METAL WIRE, IT IS MOST PROBABLE THAT THE WIRE WOULD PRODUCE A FLAME THAT WAS:

A. RED

B. PURPLE

C. COLORLESS

8. LIZ DECIDED TO GROW CRYSTALS FROM THE GREEN SOLUTION SHE HAD MADE. WHICH OF THE FOLLOWING WOULD SHE MOST LIKELY OBSERVE FOR THE CRYSTALS WHICH FORM?

A. THEY MIGHT BE COLORED GREEN.

B. THEY WOULD CERTAINLY BE NEEDLE SHAPED.

C. THEY MIGHT BE COLORED PURPLE AS WAS THE FLAME.

THE SITUATIONS HAVE TO DO WITH EXPERIMENTS DONE IN A CLASSROOM IN ANOTHER COUNTRY. THE CHILDREN OBSERVED AND THEN EXPLAINED WHAT THEY THOUGHT WAS HAPPENING TO THE MOLECULES. THEY USED WORD "EQUATIONS". SOME OF THE NAMES THEY USED FOR PARTICLES WERE DIFFERENT FROM THE ONES WE USE. IN GENERAL, THEY FOUND THE FOLLOWING TO OCCUR IN THEIR OBSERVATIONS:

CHLORIDE CRYSTALS WERE CUBE-SHAPED.

SULFATE CRYSTALS WERE NEEDLE-SHAPED.

NITRATE CRYSTALS WERE ANGLE-SHAPED.

AND IN A FLAME "COPIUM" MADE IT RED.

"SCHOOLIUM" MADE IT GREEN.

"TEACHIUM" MADE IT YELLOW.

TASK I: COMPLETE THE FOLLOWING WORD EQUATIONS BY FILLING IN THE BLANK LINES.

A. SCHOOLIUM + TEACHIUM SULFATE → TEACHIUM + ____________ SULFATE

B. COPIUM + SCHOOLIUM CHLORIDE → SCHOOLIUM + COPIUM ____________

C. COPIUM + TEACHIUM SULFATE → ____________ + COPIUM SULFATE

D. POTASSIUM + COPIUM CHLORIDE → ____________ + POTASSIUM CHLORIDE

TASK II: KEEP IN MIND THAT THE FOLLOWING COLORS ARE PRODUCED IN FLAMES BY THE INDIVIDUAL UNIT PARTICLES: COPIUM PRODUCES RED; SCHOOLIUM PRODUCES GREEN; TEACHIUM PRODUCES YELLOW.

NOW, IN THE ABOVE WORD EQUATIONS, PLACE A *Y* ON ALL THE SUBSTANCES WHICH COULD MAKE A FLAME YELLOW, AND AN *R* ON ALL THE SUBSTANCES WHICH WOULD MAKE A FLAME RED.

TASK III: KEEP IN MIND THE OBSERVATIONS THAT CHLORIDES FORM CUBES, SULFATES FORM NEEDLES, AND NITRATES FORM ANGLED CRYSTALS. NOW IN THE FOLLOWING LIST OF SALT MOLECULES PLACE A SQUARE, □, NEXT TO THE MOLECULES YOU EXPECT TO FORM CUBES WHEN THEY CRYSTALLIZE, AND A LINE, —, NEXT TO THOSE WHICH YOU EXPECT TO FORM NEEDLES. HERE IS THE LIST.

A. POTASSIUM CHLORIDE

B. COPIUM SULFATE

C. TEACHIUM CHLORIDE

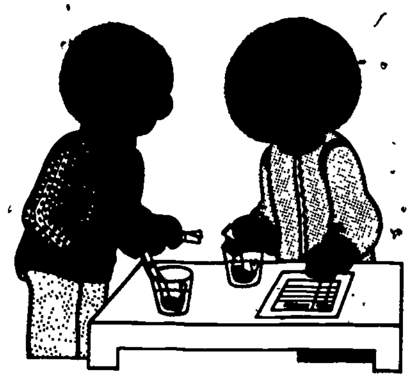
D. TEACHIUM SULFATE

E. COPIUM NITRATE

F. SODIUM CHLORIDE

G. SCHOOLIUM NITRATE

H. COPPER NITRATE



Minisequence IV
A Tendency To Spread Out

Screening Assessments

The concepts developed in Minisequence IV and tested in this set of Assessments are:

a. When two samples of a liquid at different temperatures are placed in thermal contact, such that heat energy transfer can take place,

   1. the heat energy transfer will be from the sample at the higher temperature to that at the lower temperature;

   2. the total heat energy in all parts of the system remains constant. Heat energy is conserved.

b. Although heat energy is conserved on mixing samples of water having different temperatures, the available heat energy, being at a lower temperature, may no longer be able to perform certain work--such as breaking bonds within certain solid substances. That is, the heat energy has been degraded.

c. There is a natural tendency for molecules to spread out into whatever space is available to them.

d. Molecules tend to move from regions of higher concentration to regions of lower concentration, just as in the transfer of heat energy.

e. As the molecules disperse (spread out) over a period of time, there develops a smooth gradation (gradient) in concentration from the higher to the lower concentration regions.

f. Systems, if undisturbed, tend naturally towards equal concentrations of molecules and equal temperatures, a state of equilibrium.

g. The spreading out into regions of lower concentration and the attainment of a state of equilibrium can be thought of as a "net" or average result. At the molecular level, some molecules may be moving in the reverse direction--i.e., into regions of higher concentration.

The Assessment is in four parts; if desired, Part 1, which deals with concepts a and b, may be administered after Activity 3. The remaining parts deal with concepts c through f. Concept g, which is further developed in Minisequence V, will be tested in the next group of Assessments.

Distribute the pages of the assessment and have the children write their names in the appropriate places. Part 1 should take about 15 minutes and Parts 2, 3, and 4 should take another 15 minutes to administer.

PART 1

Page A

Be sure the children have pages A, B, C, D, and E.

IN THIS ASSESSMENT I HAVE SOME QUESTIONS ABOUT THREE SITUATIONS. EACH SITUATION HAS A NUMBER OF DIFFERENT QUESTIONS TO BE ANSWERED. EACH QUESTION IS FOLLOWED BY POSSIBLE ANSWERS OR BLANK SPACES IN WHICH ANSWERS ARE TO BE WRITTEN. I SHALL READ ALOUD EACH QUESTION AND ITS POSSIBLE ANSWERS, WHEREVER THEY ARE GIVEN. YOU MAY READ SILENTLY ALONG WITH ME. CIRCLE THE LETTER IN FRONT OF YOUR PREFERRED RESPONSE TO THE QUESTION OR FILL IN THE BLANK SPACES AFTER I FINISH READING. HERE IS THE FIRST SITUATION.

(If you think it helpful to the children, repeat each question as they select their choices.)

SITUATION I: BETTY WAS INVESTIGATING A CERTAIN WHITE CRYSTALLINE SOLID. SHE FOUND THAT IT WOULD MELT WHENEVER IT WAS PLACED NEXT TO A SURFACE WITH A TEMPERATURE OF 45°C. THE FOLLOWING GRAPHS REPRESENT THE VOLUME-TEMPERATURE PROPERTIES OF FOUR DIFFERENT PAIRS OF WATER SAMPLES.

Page B

KEEP PAGE A IN FRONT OF YOU, BUT TURN TO PAGE B FOR THE FIRST QUESTION.

1. IN THE BLANK SPACES BELOW ENTER THE NUMBER OF h.e.u.'s IN EACH SAMPLE:

PAIR #1	SAMPLE A. ______	SAMPLE B. ______
PAIR #2	SAMPLE C. ______	SAMPLE D. ______
PAIR #3	SAMPLE E. ______	SAMPLE F. ______
PAIR #4	SAMPLE G. ______	SAMPLE H. ______

2. TO THE RIGHT OF EACH PAIR OF GRAPHS CONSTRUCT A GRAPH WHICH SHOWS THE VOLUME-TEMPERATURE PROPERTIES OF THE MIX OBTAINED WHEN THE TWO SAMPLES OF THE PAIR ARE POURED TOGETHER. NOTICE THAT THE FIRST ONE IS ALREADY DONE FOR YOU, BELOW.

3. NOW LOOK AT THE GRAPHS OF THE PAIRS OF WATER SAMPLES *(BEFORE THEY WERE MIXED)*. WITH YOUR PENCIL MARK THE h.e.u.'s ON THE GRAPH WHICH ARE TRANSFERRED OUT FROM ONE OF THE SAMPLES IN EACH PAIR. NOTICE THAT THE FIRST ONE IS ALREADY DONE FOR YOU BELOW.

Page C.

TURN TO PAGE C, BUT STILL KEEP PAGE A IN FRONT OF YOU.

4. BETTY FOUND THAT THE WHITE CRYSTALS MENTIONED EARLIER WOULD MELT WHEN PLACED NEXT TO SAMPLE *F*. WHICH OF THE OTHER SAMPLES CAN ALSO MELT THE CRYSTALS? *A, B, C, D, E OR G?* CIRCLE THE LETTERS OF THE SAMPLES.

5. THE MIX MADE FROM SAMPLES *E AND F* COULD ALSO MELT THE CRYSTALS. THIS WOULD HAPPEN BECAUSE:

A. THE MIX CONTAINS ALL THE h.e.u.'s OF EACH SAMPLE.

B. THE TEMPERATURE OF THE MIX WAS HIGH ENOUGH TO MELT THE SOLID.

C. THE MIX CONTAINS SO MUCH MORE WATER THAN THE SEPARATE SAMPLES.

6. IT WOULD BE EXPECTED THAT THE WHITE SOLID WOULD BE MELTED BY ALL THE MIXES BECAUSE:

A. EACH SAMPLE MAKING UP THE MIX COULD MELT THE SOLID.

B. THE MIX CONTAINS MANY MORE h.e.u.'s THAN THE SEPARATE SAMPLES.

C. THE STATEMENT IS REALLY NOT TRUE.

Page D

Now ask the children to turn to page D. They will not need page A for reference anymore.

HERE IS *SITUATION II:* MURIEL HAD A LARGE CONTAINER WITH 10 MEASURES OF WATER IN IT. THE TEMPERATURE OF THIS SAMPLE WAS 10°C. SHE PLACED INTO THIS LARGE SAMPLE OF WATER A SMALL STOPPERED TUBE CONTAINING ONLY 1 MEASURE OF HOT TEA. THE TEMPERATURE OF THE TEA WAS 80°C. HERE ARE SEVERAL STATEMENTS ABOUT THIS SITUATION. CIRCLE THE LETTER OF THE RESPONSE WHICH BEST COMPLETES EACH STATEMENT.

1. IF MURIEL CALCULATED THE HEAT ENERGY IN EACH SAMPLE BEFORE SHE PLACED THE TUBE OF TEA IN THE LARGE SAMPLE OF WATER, SHE WOULD FIND THAT:

A. BOTH SAMPLES CONTAIN THE SAME AMOUNT OF HEAT ENERGY.

B. THE SMALLER SAMPLE OF TEA CONTAINS MORE HEAT ENERGY THAN THE LARGER SAMPLE OF WATER.

C. THE LARGER SAMPLE OF WATER CONTAINS MORE HEAT ENERGY THAN THE SMALLER SAMPLE OF TEA.

2. AFTER THE TUBE WITH THE TEA WAS SITTING IN THE WATER SAMPLE FOR A FEW MINUTES MURIEL SHOULD EXPECT THAT:

A. HEAT ENERGY WOULD BE TRANSFERRED OUT OF THE SMALLER SAMPLE.

B. HEAT ENERGY WOULD BE TRANSFERRED OUT OF THE LARGER SAMPLE.

C. THERE WOULD BE NO TRANSFER OF HEAT ENERGY FROM EITHER SAMPLE.

3. AFTER THE TUBE WITH THE TEA WAS LEFT IN THE CONTAINER OF WATER FOR ABOUT 10 MINUTES, MURIEL DECIDED TO MEASURE THE TEMPERATURE OF EACH SAMPLE. SHE SHOULD EXPECT TO FIND THAT:

A. THE TEMPERATURE OF BOTH SAMPLES WOULD BE THE SAME.

B. THE TEMPERATURE OF THE SAMPLE OF TEA WOULD BE HIGHER THAN THE LARGER SAMPLE OF WATER.

C. THE TEMPERATURE OF THE LARGER SAMPLE OF WATER WOULD BE HIGHER THAN THE SMALLER SAMPLE OF TEA.

4. AFTER 10 MINUTES MURIEL WOULD NOTICE THAT:

A. THE ORANGE TEA COLOR HAD SPREAD THROUGHOUT THE LARGER CONTAINER OF WATER.

B. THE ORANGE COLOR OF THE TEA HAD BECOME DARKER.

C. THERE WAS NO CHANGE IN THE COLOR OF THE LIQUID IN EITHER CONTAINER.

Page E

NOW TURN TO PAGE E.

SITUATION III: DARRELL PUT A METAL BICYCLE IN HIS ROOM. THE TEMPERATURE OF THE ROOM WAS 25°C. LATER WHEN HE TOUCHED THE METAL PARTS OF THE BICYCLE IT MADE HIS HAND FEEL COOL. HE KNEW THE TEMPERATURE OF HIS BODY WAS GENERALLY ABOUT 37°C.

1. IN EXPLAINING WHY HIS HAND FELT COOL WHEN HE TOUCHED THE BIKE DARRELL REASONED THAT THIS WAS BECAUSE:

A. METALS ALWAYS FEEL COOL TO THE TOUCH.

B. THERE WAS A TRANSFER OF HEAT ENERGY FROM HIS HAND TO THE BIKE.

C. HEAT ENERGY ALWAYS TRANSFERS OUT OF A PERSON'S BODY.

2. IN THE SUMMERTIME HE STORED THE BIKE IN A CLOSED ROOM IN WHICH THE TEMPERATURE WENT UP TO 40°C (THAT IS, 104° ON THE FAHRENHEIT SCALE!). WHAT MIGHT DARRELL NOW EXPECT TO FEEL AS HE PICKED UP HIS METAL BIKE?

A. IT WILL FEEL HOT SINCE ITS TEMPERATURE IS HIGHER THAN DARRELL'S BODY TEMPERATURE.

B. IT WILL STILL FEEL COOL TO THE TOUCH SINCE THE BIKE IS MADE OF METAL.

C. IT WILL FEEL NEITHER COOL NOR HOT SINCE THE TEMPERATURE IS NORMALLY HIGH IN THE SUMMERTIME.

SITUATION IV: SUPPOSE THAT YOU HAVE 5 MEASURES OF WATER AT 15°C IN A METAL CUP SUSPENDED IN A LARGE CONTAINER HOLDING 10 MEASURES OF WATER AT 10°C. SOON HEAT ENERGY WILL BE TRANSFERRED FROM:

A. THE WATER OUTSIDE TO THE WATER INSIDE THE CUP BECAUSE THERE ARE FEWER h.e.u.'s IN THE WATER IN THE CUP.

B. INSIDE THE CUP TO THE OUTSIDE, BECAUSE HEAT ENERGY TRANSFERS FROM HIGH TEMPERATURE TO LOW TEMPERATURE.

C. IN NEITHER DIRECTION BECAUSE THERE IS NO DIRECT CONTACT BETWEEN THE TWO SAMPLES OF WATER.

PART 2

Page F

Have the children turn to page F.

HERE YOU WILL FIND PAIRS OF STATEMENTS. ONE OF THE STATEMENTS IN EACH PAIR IS TRUE AND THE OTHER IS NOT TRUE. READ BOTH STATEMENTS SILENTLY TO YOURSELF WHILE I READ THEM ALOUD TO YOU. AFTER I HAVE READ BOTH STATEMENTS DRAW A CIRCLE AROUND THE LETTER OF THE STATEMENT WHICH IS TRUE.

1. A. HEAT ENERGY IS TRANSFERRED ONLY FROM A REGION OF LOW TEMPERATURE TO A REGION OF HIGH TEMPERATURE.

   B. HEAT ENERGY IS TRANSFERRED ONLY FROM A REGION OF HIGH TEMPERATURE TO A REGION OF LOW TEMPERATURE

2. WHEN TWO SAMPLES OF WATER ARE MIXED:

   A. THE HEAT ENERGY OF THE MIX IS THE SUM OF THE HEAT ENERGIES OF THE TWO SAMPLES.

   B. THE TEMPERATURE OF THE MIX IS THE SUM OF THE TEMPERATURE OF THE TWO SAMPLES.

3. WHEN A SAMPLE OF A SOLUBLE SUBSTANCE IS PLACED IN CONTACT WITH WATER, ITS MOLECULES:

   A. SPREAD OUT UNTIL THEIR CONCENTRATION IS THE SAME THROUGHOUT ALL THE WATER, INCLUDING WHERE THEY WERE ORIGINALLY PLACED.

   B. SPREAD OUT INTO THE WATER AND CONCENTRATE IN REGIONS AWAY FROM WHERE THE SAMPLE WAS FIRST PLACED.

4. A. A SAMPLE OF PURPLE COLORED GAS WILL DIFFUSE THROUGH THE AIR AND BECOME LIGHTER IN COLOR AS IT DOES.

   B. A SAMPLE OF PURPLE COLORED GAS WILL DIFFUSE THROUGH THE AIR AND DARKEN AS IT DOES SO.

PART 3

Page G

Have the children now turn to page G.

HERE ARE THREE STATEMENTS TO BE COMPLETED OR QUESTIONS TO BE ANSWERED. AGAIN, CIRCLE YOUR PREFERRED ANSWER.

1. A TEA BAG IS PLACED IN A LARGE POT FILLED WITH WARM WATER. WHAT WILL BE OBSERVED *IMMEDIATELY?*

   A. ALL THE WATER IN THE POT WILL BECOME AN ORANGE COLOR, THE COLOR OF THE TEA.

   B. ONLY THE WATER AROUND THE TEA BAG WILL BECOME AN ORANGE COLOR.

   C. WATER IN DIFFERENT PARTS OF THE POT WILL BECOME AN ORANGE COLOR.

2. AFTER A FEW MINUTES, WE WOULD EXPECT THAT:

   A. ALL THE WATER IN THE POT WILL BECOME THE SAME ORANGE COLOR.

   B. ALL THE WATER WILL BE ORANGE BUT THE COLOR OF THE WATER NEAR THE SIDES OF THE POT WILL BE LESS.

   C. THE ORANGE COLOR WILL BE OBSERVED ONLY NEXT TO THE SIDES OF THE TEA POT

3. BOB BROUGHT SOME VERY SWEET SMELLING ROSES TO JAN. SHE PUT THEM IN A ROOM AND THEN TOOK A NAP. WHEN SHE AWAKENED, SHE SHOULD EXPECT THAT:

A. THE ODOR OF THE ROSES WOULD BE OBSERVED JUST AROUND THE FLOWERS.

B. THE ODOR OF THE ROSES WOULD PROBABLY BE OBSERVED THROUGHOUT THE ROOM.

C. THE ODOR OF THE ROSES WOULD BE OBSERVED ONLY NEAR THE WINDOWS AND DOOR.

PART 4

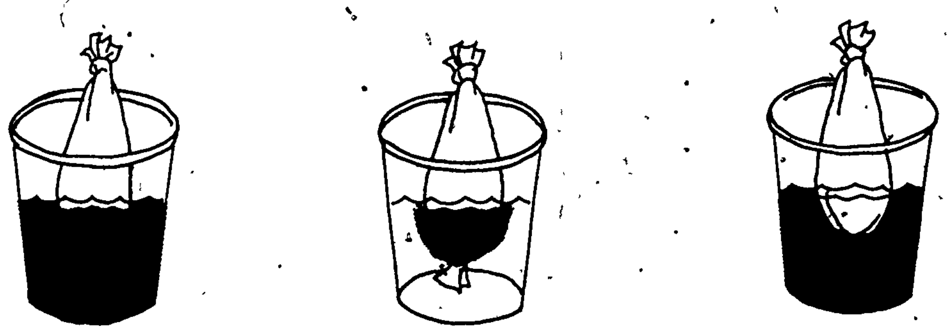
Page H

This last part appears on pages H, I and J.

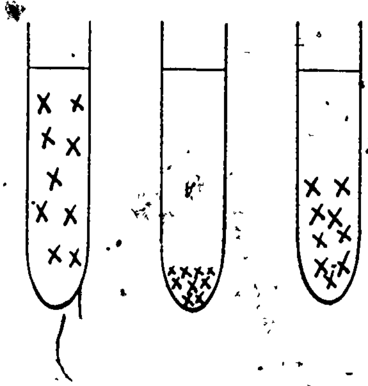
THE FOLLOWING SETS OF PICTURES HAVE TO DO WITH SEQUENCES OF CERTAIN EVENTS WHICH I SHALL DESCRIBE TO YOU. IN THE FIRST THREE SITUATIONS THE PICTURES REPRESENT PARTS OF A SEQUENCE SHOWING WHAT WAS HAPPENING AT DIFFERENT TIMES. LOOK AT EACH SITUATION AND MARK THEM ACCORDING TO THE INSTRUCTIONS I SHALL GIVE YOU. TURN TO PAGE H.

SEQUENCE I: THESE PICTURES REPRESENT A BAG OF COLORED SOLUTION AND SOME CLEAR WATER. PLACE AN *A* ON THE PICTURE WHICH SHOWS WHAT MIGHT BE FIRST IN THE SEQUENCE AND A *Z* ON THE PICTURE WHICH SHOWS WHAT WOULD BE HAPPENING LAST IN THE SEQUENCE.

SEQUENCE II: THESE PICTURES ALSO REPRESENT A SEQUENCE OF EVENTS WHEN A COLORED SOLUTION IS PLACED NEXT TO WATER BUT SEPARATED BY WALLS OF A CELLOPHANE BAG THROUGH WHICH ALL THE MOLECULES CAN MOVE. AGAIN PLACE AN *A* ON THE PICTURE WHICH SHOWS WHAT MIGHT BE FIRST IN THE SEQUENCE AND A *Z* ON THE PICTURE WHICH SHOWS WHAT WOULD BE HAPPENING LAST IN THE SEQUENCE.



SEQUENCE III: CLEAR WATER AND A THICK SYRUP CONTAINING SUGAR MOLECULES WERE POURED INTO THE SAME TEST TUBE THE X's IN THE PICTURE REPRESENT THE SUGAR MOLECULES. PLACE AN *A* ON THE PICTURE WHICH REPRESENTS THE BEGINNING OF THE SEQUENCE AND A *Z* ON THAT PICTURE OF THE SEQUENCE AFTER THE MIXTURE HAD BEEN STANDING FOR A TIME.



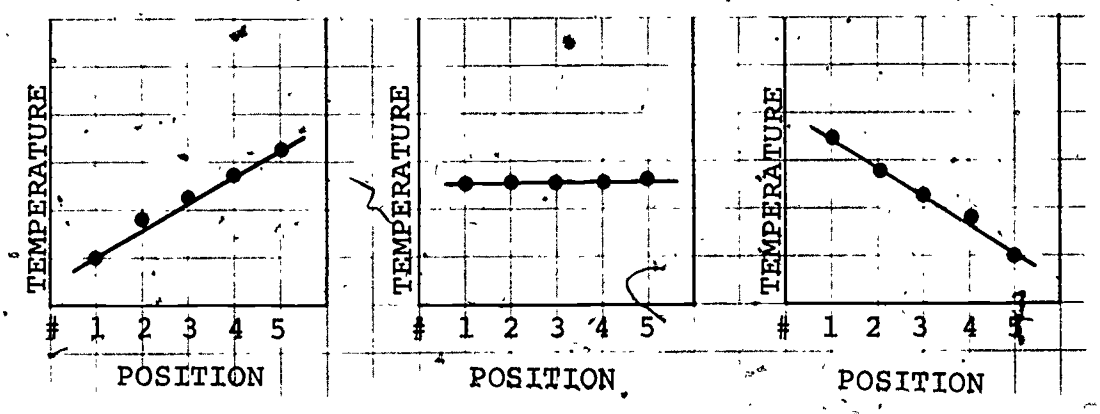
Page I

NOW TURN TO PAGE I.

SEQUENCE IV: THE FOLLOWING GRAPHS REPRESENT A SERIES OF TEMPERATURE MEASUREMENTS TAKEN AT DIFFERENT POSITIONS ALONG A METAL SPOON THAT IS SITTING IN A CUP FILLED WITH VERY HOT CHOCOLATE. FIVE TEMPERATURE MEASUREMENTS ARE MADE: #1 WAS MADE AT A POSITION ON THE SPOON CLOSEST TO THE HOT LIQUID. #5 WAS MADE ON THAT PART OF THE SPOON FARTHEST AWAY. A

RECORD OF THE TEMPERATURES WAS MADE AND A GRAPH WAS CONSTRUCTED TO SHOW HOW THE TEMPERATURES AT THE DIFFERENT POSITIONS ALONG THE SPOON COMPARED WITH EACH OTHER.

a) PLACE AN *X* UNDER THE GRAPH WHICH BEST REPRESENTS THE TEMPERATURES YOU WOULD EXPECT AT DIFFERENT POSITIONS ALONG THE SPOON.



TURN TO PAGE J.

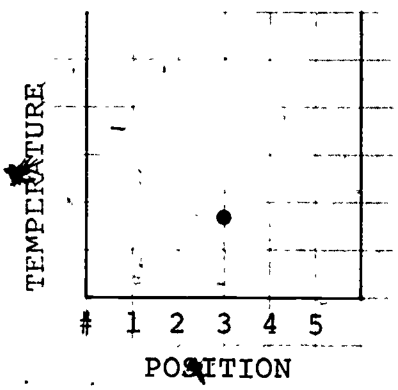
b) IF ALICE SHOULD DECIDE TO PICK UP THE SPOON, AT WHAT POSITION SHOULD SHE PLACE HER FINGERS?

A. AT POSITION #1

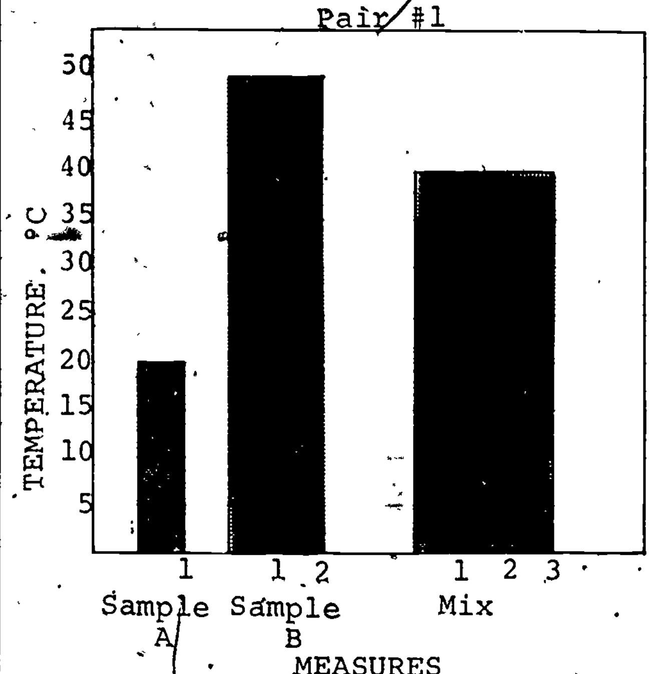
B. AT POSITION #5

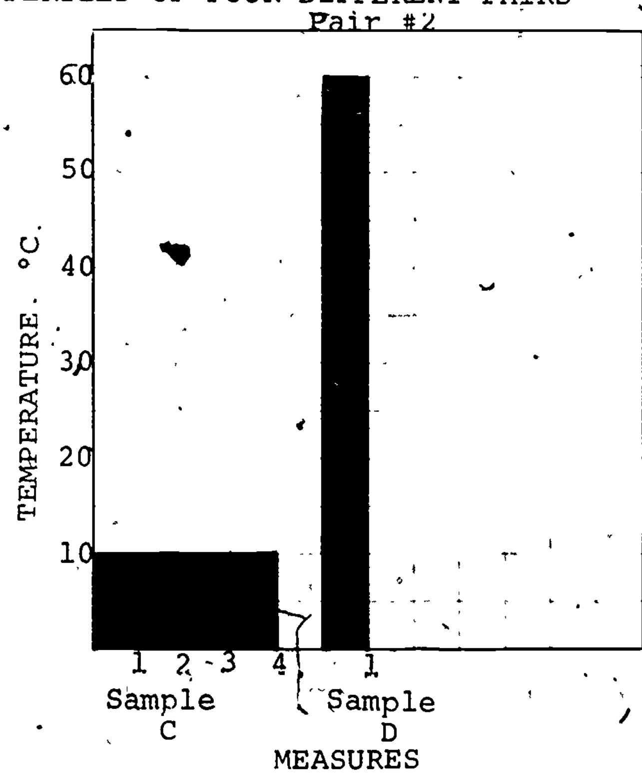
C. AT POSITION #3

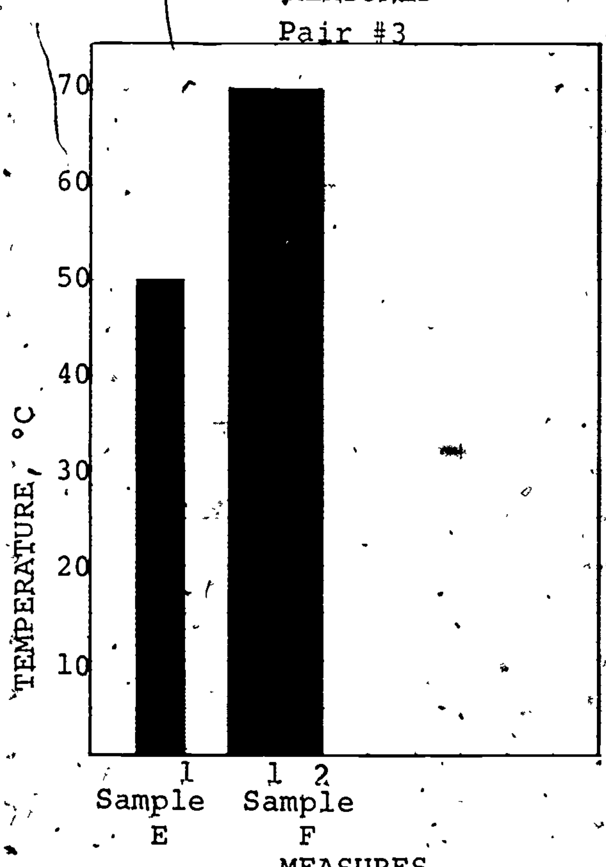
c. THE SPOON IS TAKEN OUT OF THE HOT CHOCOLATE AND PLACED ON THE TABLE. AFTER ABOUT 20 MINUTES ALICE MEASURES THE TEMPERATURE AT THE SAME FIVE POSITIONS ALONG THE METAL SPOON. ON THE CHART BELOW PLACE DOTS TO SHOW WHAT A RECORD OF THE FIVE DIFFERENT TEMPERATURES ALONG THE SPOON WOULD LOOK LIKE. THE TEMPERATURE AT POSITION #3 IS ALREADY ENTERED.

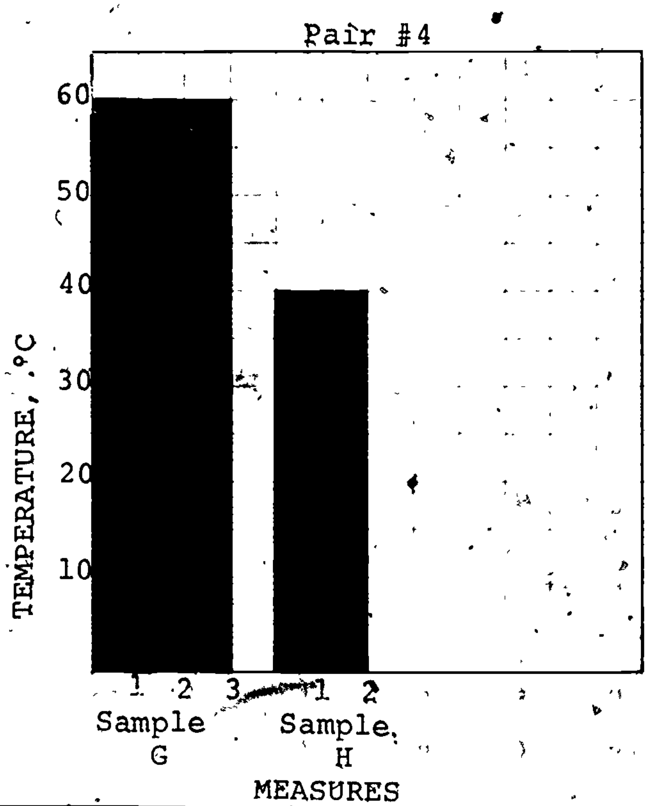


SITUATION I: BETTY WAS INVESTIGATING A CERTAIN WHITE CRYSTALLINE SOLID. SHE FOUND THAT IT WOULD MELT WHENEVER IT WAS PLACED NEXT TO A SURFACE WITH A TEMPERATURE OF 45°C. THE FOLLOWING GRAPHS REPRESENT THE VOLUME-TEMPERATURE PROPERTIES OF FOUR DIFFERENT PAIRS OF WATER SAMPLES.









1. IN THE BLANK SPACES BELOW ENTER THE NUMBER OF h.e.u.'s IN EACH SAMPLE:

PAIR #1 SAMPLE A.__________ SAMPLE B.__________

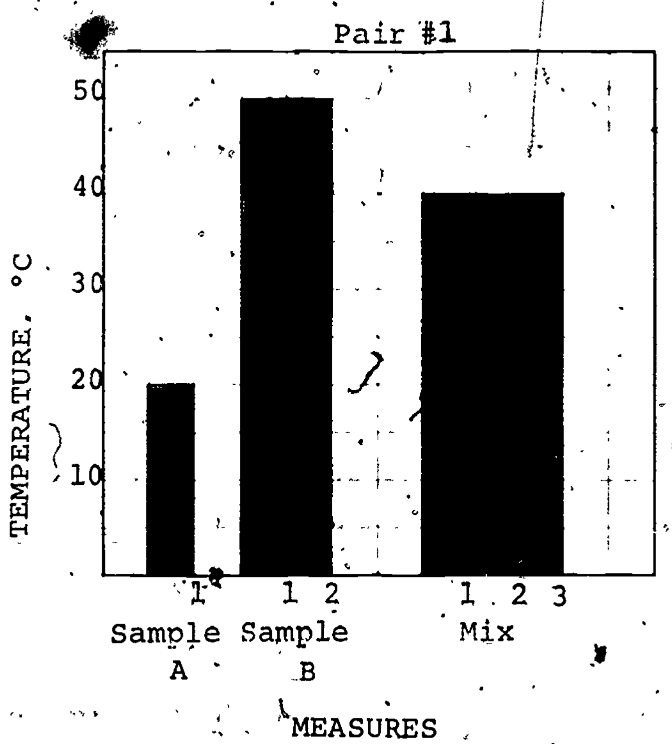
PAIR #2 SAMPLE C.__________ SAMPLE D.__________

PAIR #3 SAMPLE E.__________ SAMPLE F.__________

PAIR #4 SAMPLE G.__________ SAMPLE H.__________

2. TO THE RIGHT OF EACH PAIR OF GRAPHS CONSTRUCT A GRAPH WHICH SHOWS THE VOLUME-TEMPERATURE PROPERTIES OF THE MIX OBTAINED WHEN THE TWO SAMPLES OF THE PAIR ARE POURED TOGETHER. NOTICE THAT THE FIRST ONE IS ALREADY DONE FOR YOU.

3. NOW LOOK AT THE GRAPHS OF THE PAIRS OF WATER SAMPLES *(BEFORE THEY WERE MIXED)*. WITH YOUR PENCIL MARK THE h.e.u.'s ON THE GRAPH WHICH ARE TRANSFERRED OUT FROM ONE OF THE SAMPLES IN EACH PAIR. NOTICE THAT THE FIRST ONE IS ALREADY DONE FOR YOU. BELOW.



4. BETTY FOUND THAT THE WHITE CRYSTALS MENTIONED EARLIER WOULD MELT WHEN PLACED NEXT TO SAMPLE *F*. WHICH OF THE OTHER SAMPLES CAN ALSO MELT THE CRYSTALS? *A, B, C, D, E OR G?* CIRCLE THE LETTERS OF THE SAMPLES.

5. THE MIX MADE FROM SAMPLES *E AND F* COULD ALSO MELT THE CRYSTALS. THIS WOULD HAPPEN BECAUSE:

A. THE MIX CONTAINS ALL THE h.e.u.'s OF EACH SAMPLE.

B. THE TEMPERATURE OF THE MIX WAS HIGH ENOUGH TO MELT THE SOLID.

C. THE MIX CONTAINS SO MUCH MORE WATER THAN THE SEPARATE SAMPLES.

6. IT WOULD BE EXPECTED THAT THE WHITE SOLID WOULD BE MELTED BY ALL THE MIXES BECAUSE:

A. EACH SAMPLE MAKING UP THE MIX COULD MELT THE SOLID.

B. THE MIX CONTAINS MANY MORE h.e.u.'s THAN THE SEPARATE SAMPLES.

C. THE STATEMENT IS REALLY NOT TRUE.

SITUATION II: MURIEL HAD A LARGE CONTAINER WITH 10 MEASURES OF WATER IN IT. THE TEMPERATURE OF THIS SAMPLE WAS 10°C. SHE PLACED INTO THIS LARGE SAMPLE OF WATER A SMALL STOPPERED TUBE CONTAINING ONLY 1 MEASURE OF HOT TEA. THE TEMPERATURE OF THE TEA WAS 80°C. HERE ARE SEVERAL STATEMENTS ABOUT THIS SITUATION. CIRCLE THE LETTER OF THE RESPONSE WHICH BEST COMPLETES EACH STATEMENT.

1. IF MURIEL CALCULATED THE HEAT ENERGY IN EACH SAMPLE BEFORE SHE PLACED THE TUBE OF TEA IN THE LARGE SAMPLE OF WATER, SHE WOULD FIND THAT:

   A. BOTH SAMPLES CONTAIN THE SAME AMOUNT OF HEAT ENERGY.

   B. THE SMALLER SAMPLE OF TEA CONTAINS MORE HEAT ENERGY THAN THE LARGER SAMPLE OF WATER.

   C. THE LARGER SAMPLE OF WATER CONTAINS MORE HEAT ENERGY THAN THE SMALLER SAMPLE OF TEA.

2. AFTER THE TUBE WITH THE TEA WAS SITTING IN THE WATER SAMPLE FOR A FEW MINUTES MURIEL SHOULD EXPECT THAT:

   A. HEAT ENERGY WOULD BE TRANSFERRED OUT OF THE SMALLER SAMPLE.

   B. HEAT ENERGY WOULD BE TRANSFERRED OUT OF THE LARGER SAMPLE.

   C. THERE WOULD BE NO TRANSFER OF HEAT ENERGY FROM EITHER SAMPLE.

3. AFTER THE TUBE WITH THE TEA WAS LEFT IN THE CONTAINER OF WATER FOR ABOUT 10 MINUTES, MURIEL DECIDED TO MEASURE THE TEMPERATURE OF EACH SAMPLE. SHE SHOULD EXPECT TO FIND THAT:

   A. THE TEMPERATURE OF BOTH SAMPLES WOULD BE THE SAME.

   B. THE TEMPERATURE OF THE SAMPLE OF TEA WOULD BE HIGHER THAN THE LARGER SAMPLE OF WATER.

   C. THE TEMPERATURE OF THE LARGER SAMPLE OF WATER WOULD BE HIGHER THAN THE SMALLER SAMPLE OF TEA.

4. AFTER 10 MINUTES MURIEL WOULD NOTICE THAT:

   A. THE ORANGE TEA COLOR HAD SPREAD THROUGHOUT THE LARGER CONTAINER OF WATER.

   B. THE ORANGE COLOR OF THE TEA HAD BECOME DARKER.

   C. THERE WAS NO CHANGE IN THE COLOR OF THE LIQUID IN EITHER CONTAINER.

SITUATION III: DARRELL PUT A METAL BICYCLE IN HIS ROOM. THE TEMPERATURE OF THE ROOM WAS 25°C. LATER WHEN HE TOUCHED THE METAL PARTS OF THE BICYCLE IT MADE HIS HAND FEEL COOL. HE KNEW THE TEMPERATURE OF HIS BODY WAS GENERALLY ABOUT 37°C.

1. IN EXPLAINING WHY HIS HAND FELT COOL WHEN HE TOUCHED THE BIKE DARRELL REASONED THAT THIS WAS BECAUSE :

   A. METALS ALWAYS FEEL COOL TO THE TOUCH.

   B. THERE WAS A TRANSFER OF HEAT ENERGY FROM HIS HAND TO THE BIKE.

   C. HEAT ENERGY ALWAYS TRANSFERS OUT OF A PERSON'S BODY.

2. IN THE SUMMERTIME HE STORED THE BIKE IN A CLOSED ROOM IN WHICH THE TEMPERATURE WENT UP TO 40°C (THAT IS, 104° ON THE FAHRENHEIT SCALE!). WHAT MIGHT DARRELL NOW EXPECT TO FEEL AS HE PICKED UP HIS METAL BIKE?

   A. IT WILL FEEL HOT SINCE ITS TEMPERATURE IS HIGHER THAN DARRELL'S BODY TEMPERATURE.

   B. IT WILL STILL FEEL COOL TO THE TOUCH SINCE THE BIKE IS MADE OF METAL.

   C. IT WILL FEEL NEITHER COOL NOR HOT SINCE THE TEMPERATURE IS NORMALLY HIGH IN THE SUMMERTIME.

SITUATION IV: SUPPOSE THAT YOU HAVE 5 MEASURES OF WATER AT 15°C IN A METAL CUP SUSPENDED IN A LARGE CONTAINER HOLDING 10 MEASURES OF WATER AT 10°C. SOON HEAT ENERGY WILL BE TRANSFERRED FROM:

   A. THE WATER OUTSIDE TO THE WATER INSIDE THE CUP BECAUSE THERE ARE FEWER h.e.u.'s IN THE WATER IN THE CUP.

   B. INSIDE THE CUP TO THE OUTSIDE, BECAUSE HEAT ENERGY TRANSFERS FROM HIGH TEMPRATURE TO LOW TEMPERATURE.

   C. IN NEITHER DIRECTION BECAUSE THERE IS NO DIRECT CONTACT BETWEEN THE TWO SAMPLES OF WATER.

HERE YOU WILL FIND PAIRS OF STATEMENTS. ONE OF THE STATEMENTS IN EACH PAIR IS TRUE AND THE OTHER IS NOT TRUE. READ BOTH STATEMENTS SILENTLY TO YOURSELF WHILE I READ THEM ALOUD TO YOU. AFTER I HAVE READ BOTH STATEMENTS DRAW A CIRCLE AROUND THE LETTER OF THE STATEMENT WHICH IS TRUE.

1. A. HEAT ENERGY IS TRANSFERRED ONLY FROM A REGION OF LOW TEMPERATURE TO A REGION OF HIGH TEMPERATURE.

   B. HEAT ENERGY IS TRANSFERRED ONLY FROM A REGION OF HIGH TEMPERATURE TO A REGION OF LOW TEMPERATURE.

2. WHEN TWO SAMPLES OF WATER ARE MIXED:

   A. THE HEAT ENERGY OF THE MIX IS THE SUM OF THE HEAT ENERGIES OF THE TWO SAMPLES.

   B. THE TEMPERATURE OF THE MIX IS THE SUM OF THE TEMPERATURE OF THE TWO SAMPLES.

3. WHEN A SAMPLE OF A SOLUBLE SUBSTANCE IS PLACED IN CONTACT WITH WATER, ITS MOLECULES:

   A. SPREAD OUT UNTIL THEIR CONCENTRATION IS THE SAME THROUGHOUT ALL THE WATER, INCLUDING WHERE THEY WERE ORIGINALLY PLACED.

   B. SPREAD OUT INTO THE WATER AND CONCENTRATE IN REGIONS AWAY FROM WHERE THE SAMPLE WAS FIRST PLACED.

4. A. A SAMPLE OF PURPLE COLORED GAS WILL DIFFUSE THROUGH THE AIR AND BECOME LIGHTER IN COLOR AS IT DOES.

   B. A SAMPLE OF PURPLE COLORED GAS WILL DIFFUSE THROUGH THE AIR AND DARKEN AS IT DOES SO.

1. A TEA BAG IS PLACED IN A LARGE POT FILLED WITH WARM WATER. WHAT WILL BE OBSERVED *IMMEDIATELY?*

A. ALL THE WATER IN THE POT WILL BECOME AN ORANGE COLOR, THE COLOR OF THE TEA.

B. ONLY THE WATER AROUND THE TEA BAG WILL BECOME AN ORANGE COLOR.

C. WATER IN DIFFERENT PARTS OF THE POT WILL BECOME AN ORANGE COLOR.

2. AFTER A FEW MINUTES, WE WOULD EXPECT THAT:

A. ALL THE WATER IN THE POT WILL BECOME THE SAME ORANGE COLOR.

B. ALL THE WATER WILL BE ORANGE BUT THE COLOR OF THE WATER NEAR THE SIDES OF THE POT WILL BE LESS.

C. THE ORANGE COLOR WILL BE OBSERVED ONLY NEXT TO THE SIDES OF THE TEA POT.

3. BOB BROUGHT SOME VERY SWEET SMELLING ROSES TO JAN. SHE PUT THEM IN A ROOM AND THEN TOOK A NAP. WHEN SHE AWAKENED, SHE SHOULD EXPECT THAT:

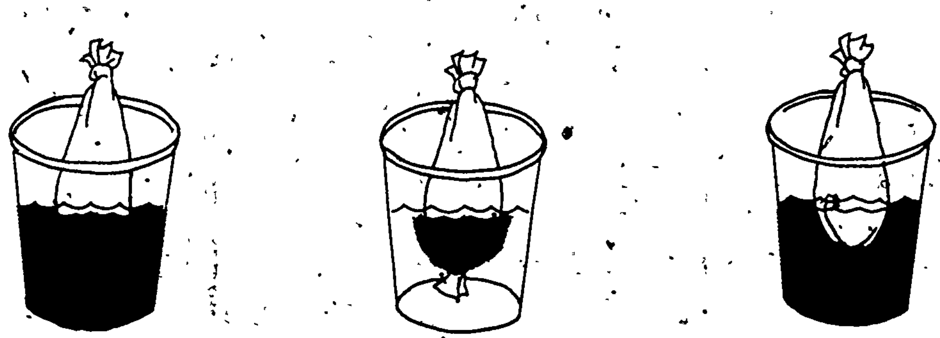
A. THE ODOR OF THE ROSES WOULD BE OBSERVED JUST AROUND THE FLOWERS.

B. THE ODOR OF THE ROSES WOULD PROBABLY BE OBSERVED THROUGHOUT THE ROOM.

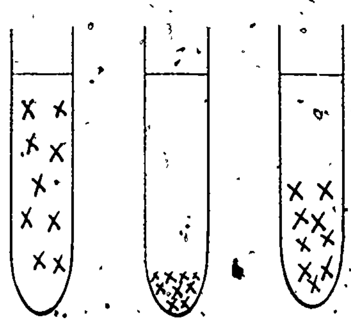
C. THE ODOR OF THE ROSES WOULD BE OBSERVED ONLY NEAR THE WINDOWS AND DOOR.

SEQUENCE I: THESE PICTURES REPRESENT A BAG OF COLORED SOLUTION AND SOME CLEAR WATER. THE MOLECULES OF WATER AND OF DISSOLVED COLORED SUBSTANCE CAN MOVE THROUGH ITS WALLS. PLACE AN *A* ON THE PICTURE WHICH SHOWS WHAT MIGHT BE FIRST IN THE SEQUENCE AND A *Z* ON THE PICTURE WHICH SHOWS WHAT WOULD BE HAPPENING LAST IN THE SEQUENCE.

SEQUENCE II : THESE PICTURES ALSO REPRESENT A SEQUENCE OF EVENTS WHEN A COLORED SOLUTION IS PLACED NEXT TO WATER BUT SEPARATED BY WALLS OF A CELLOPHANE BAG THROUGH WHICH ALL THE MOLECULES CAN MOVE. AGAIN PLACE AN *A* ON THE PICTURE WHICH SHOWS WHAT MIGHT BE FIRST IN THE SEQUENCE AND A *Z* ON THE PICTURE WHICH SHOWS WHAT WOULD BE HAPPENING LAST IN THE SEQUENCE."

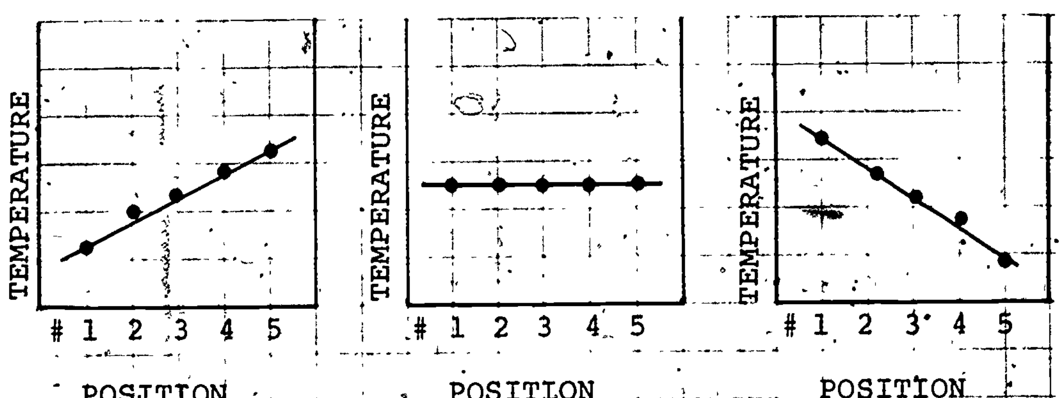


SEQUENCE III: CLEAR WATER AND A THICK SYRUP CONTAINING SUGAR MOLECULES WERE POURED INTO THE SAME TEST TUBE. THE X's IN THE PICTURE REPRESENT THE SUGAR MOLECULES. PLACE AN *A* ON THE PICTURE WHICH REPRESENTS THE BEGINNING OF THE SEQUENCE AND A *Z* ON THAT PICTURE OF THE SEQUENCE AFTER THE MIXTURE HAD BEEN STANDING FOR A TIME.



SEQUENCE IV: THE FOLLOWING GRAPHS REPRESENT A SERIES OF TEMPERATURE MEASUREMENTS TAKEN AT DIFFERENT POSITIONS ALONG A METAL SPOON THAT IS SITTING IN A CUP FILLED WITH VERY HOT CHOCOLATE. FIVE TEMPERATURE MEASUREMENTS ARE MADE: #1 WAS MADE AT A POSITION ON THE SPOON CLOSEST TO THE HOT LIQUID. #5 WAS MADE ON THAT PART OF THE SPOON FARTHEST AWAY. A RECORD OF THE TEMPERATURES WAS MADE AND A GRAPH WAS CONSTRUCTED TO SHOW HOW THE TEMPERATURES AT THE DIFFERENT POSITIONS ALONG THE SPOON COMPARED WITH EACH OTHER.

a. PLACE AN *X* UNDER THE GRAPH WHICH BEST REPRESENTS THE TEMPERATURES YOU WOULD EXPECT AT DIFFERENT POSITIONS ALONG THE SPOON.



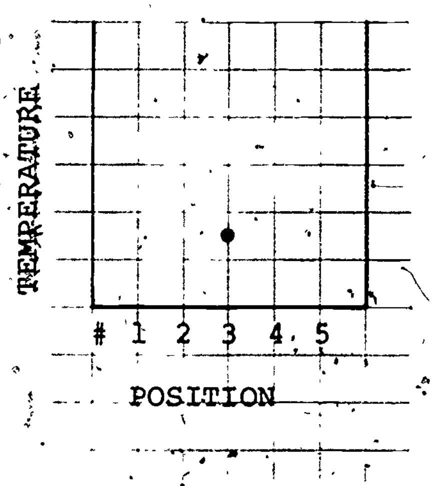
b. IF ALICE SHOULD DECIDE TO PICK UP THE SPOON, AT WHAT POSITION SHOULD SHE PLACE HER FINGERS?

A. AT POSITION #1

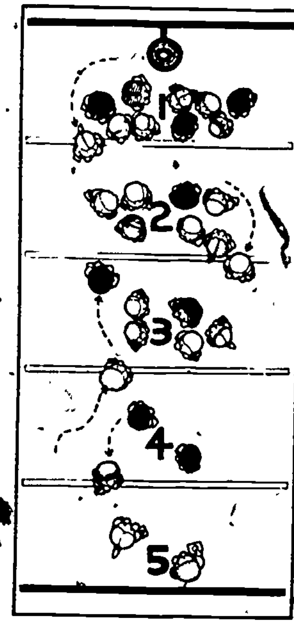
B. AT POSITION #5

C. AT POSITION #3

c. THE SPOON IS TAKEN OUT OF THE HOT CHOCOLATE AND PLACED ON THE TABLE. AFTER ABOUT 20 MINUTES ALICE MEASURES THE TEMPERATURE AT THE SAME FIVE POSITIONS ALONG THE METAL SPOON. ON THE CHART BELOW PLACE DOTS TO SHOW WHAT A RECORD OF THE FIVE DIFFERENT TEMPERATURES ALONG THE SPOON WOULD LOOK LIKE. THE TEMPERATURE AT POSITION #3 IS ALREADY ENTERED.



Miniseqquence V
Random Events: Order Out of Disorder



Screening Assessments

The concepts developed in this sequence of Activities are as follows:

a. The outcome of a random event cannot be predicted with certainty. Examples of random events include movements of individual molecules, radioactive disintegrations, tosses of a coin, etc.

b. The outcome of ~~a random~~ event is completely independent of any prior history.

c. The outcome of a series of random events may exhibit a sense of order and predictability. The larger the number of random events in the collection, the higher the degree of order and predictability.

d. Games of chance which are based on random events can be used to simulate the orderliness of collections of random events.

e. A small sample of random events will exhibit great variability as compared with a larger sized sample; order will emerge as the sample size increases.

f. The movement of individual molecules within a liquid (or gas) is viewed as random. The orderliness of a diffusing column can be thought of as the net result of the random motion of an extremely large number of individual molecules.

g. The transmission of genetic characteristics can also be viewed as a result of random or chance events.

h. As in all series of random events, the inherited characteristics of one individual cannot be predicted with any certainty; however, the distribution of such characteristics in a large collection can be predicted.

Concepts a through f are being tested in the four parts of this assessment. Concept g of Minisequence IV, which serves as a bridge between these two Minisequences, is also tested here in Part 1. If desired, Part 1 can be administered after Activity 3, or all parts can be given when the Activities of Minisequence V have been completed. Parts 1 and 2 may take 15 minutes each to administer; Part 3, 10 minutes and Part 4, 2 minutes.

When you distribute the pages to the children have them place their names in the appropriate places. As usual, suggested instructions to be read to the class appear in upper case.

PART 1

Pages A, B, C and D

Page A

Distribute the assessment pages and direct the children as follows:

THE MATERIAL IN THIS ASSESSMENT DEALS WITH THE ACTIVITIES WE HAVE JUST COMPLETED. I AM GOING TO DESCRIBE THREE SITUATIONS TO YOU. EACH SITUATION WILL BE FOLLOWED EITHER BY SOME QUESTIONS, OR STATEMENTS. THE QUESTIONS ARE TO BE ANSWERED BY FILLING IN THE BLANK SPACES OR BY INDICATING WHETHER YOU AGREE OR DISAGREE WITH A STATEMENT ABOUT THE SITUATION. AS I READ ALOUD TO YOU THE DESCRIPTION OF EACH SITUATION AND THE ITEMS YOU ARE TO COMPLETE, READ SILENTLY WITH ME. YOU WILL BE GIVEN TIME TO COMPLETE THE ITEMS ABOUT EACH SITUATION BEFORE I READ THE NEXT ONE TO YOU. (You may wish to repeat descriptions of situations and the related items if you feel it helpful to the children. Allow about 30 seconds for each item to be completed.)

HERE IS THE FIRST SITUATION ON PAGE A.

SITUATION I: DARRELL VISITED A SCIENCE CLASS AND OBSERVED THREE TEST TUBES TO WHICH BLUE FOOD COLORING HAD BEEN ADDED. THEY LOOKED LIKE THE DIAGRAMS BELOW. THE DOTS SHOW WHERE THE BLUE FOOD COLORING WAS SEEN.

1. WHICH TUBE PROBABLY HAD BEEN STANDING THE LONGEST TIME?

____

2. WHICH TUBE WAS THE LIGHTEST BLUE COLOR? ________________

HERE IS THE SECOND SITUATION.

SITUATION II: JAN HAD A SMALL FISH BOWL SHAPED LIKE A BALL. SHE FILLED IT ALMOST TO THE TOP WITH LIQUID GELATIN. BEFORE THE GELATIN IN THE BOWL SET, JAN PLACED SOME RED FOOD COLORING AT THE BOTTOM OF THE BOWL. AFTER THE GELATIN HAD SET SHE PLACED SOME BLUE COLORING ON TOP OF THE GELATIN. THE BOWL LOOKED LIKE THAT SHOWN BELOW IN FIGURE D.

NOW TURN TO PAGE *B* BUT KEEP PAGE *A* IN FRONT OF YOU. YOU WILL NEED FIGURES *D* AND *E* FOR SOME QUESTIONS ABOUT *SITUATION II*.

Page B

IN FIGURE *D*:
○ REPRESENTS WHERE RED IS SEEN.
● REPRESENTS WHERE BLUE IS SEEN.

1. IN FIGURE E, SKETCH WHAT THE BOWL WOULD LOOK LIKE AFTER SEVERAL WEEKS. REMEMBER THAT ● STANDS FOR BLUE AND ○ STANDS FOR RED.

2. WHAT WOULD BE THE COLOR NEAR THE TOP? ________________

3. WHAT WOULD BE THE COLOR NEAR THE MIDDLE? ________________

IN FRONT OF EACH OF THE FOLLOWING STATEMENTS ABOUT THE MOLECULES OF FOOD COLORING IN THE FISH BOWL, CIRCLE THE *Y* FOR YES IF YOU AGREE; CIRCLE THE *N*, FOR NO, IF YOU DO NOT AGREE.

Y N 4. ALL THE MOLECULES OF THE RED COLORING MOVED TO THE TOP, AND THEN SOME SANK DOWN DUE TO GRAVITY.

Y N 5. ONLY THE MOLECULES OF THE RED FOOD COLORING IN THE TOP LAYER MOVED UP; THE OTHERS DIDN'T MOVE.

Y N 6. ALL MOLECULES OF BOTH FOOD COLORS MOVED IN ALL DIRECTIONS.

Y N 7. THOSE WHICH HIT THE BOWL EITHER STOPPED OR MOVED BACK INTO THE GELATIN AGAIN.

Y N 8. THE DIFFERENCE IN SHADES OF COLOR SHOW MOLECULES MOVED FROM LOW CONCENTRATION TO HIGH CONCENTRATION REGIONS.

Y N 9. ALTHOUGH MOLECULES MOVED RANDOMLY IN ALL DIRECTIONS, THE OVERALL RESULT IS PREDICTABLE.

Page C

Have the children turn to page C.

SITUATION III: SIX CHILDREN (DAVID, GENE, PETER, JANE, PAULINE AND HENRY) DECIDED TO HAVE A CONTEST TO SEE WHICH ONE COULD GET TO A SPACE, MARKED *GOAL*, FIRST, AS SHOWN IN FIGURE F. THE RULE OF THE GAME IS THAT THE RESULT OF SPINNING THE POINTER OF A SPINNER, AS SHOWN IN FIGURE *G*, DECIDES EACH MOVE. ANOTHER RULE OF THE GAME IS THAT MOVES CAN ONLY BE MADE FROM ONE SMALL CIRCLE TO ANOTHER ON THE GRID. IF A PLAYER CANNOT MAKE THE MOVE SHOWN, (BECAUSE THE MOVE WOULD TAKE HIM OFF THE GRID) HE LOSES HIS TURN, AND STAYS WHERE HE IS UNTIL HIS NEXT TURN.

FIGURE F

THE GAME GRID

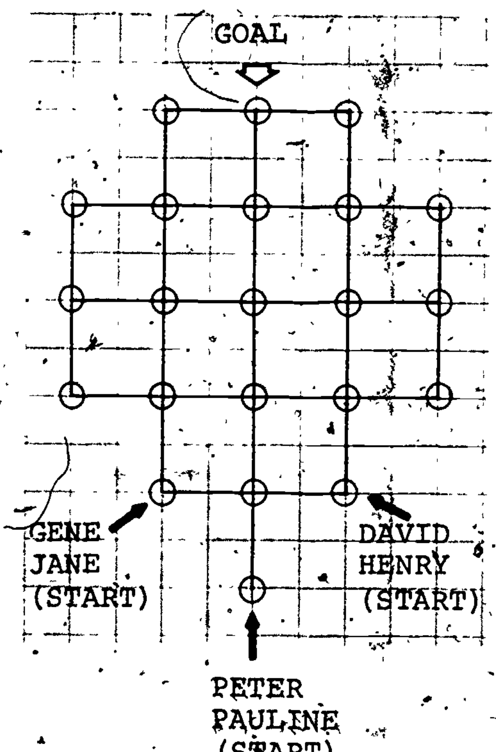
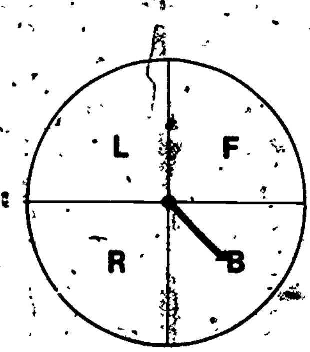


FIGURE G

THE SPINNER



DAVID'S FIRST TWO MOVES WERE *L* AND *F*, (*L*EFT AND *F*ORWARD). GENE'S FIRST TWO MOVES WERE BOTH *F'S*. PETER MOVED *F* AND *R* (*R*IGHT). JANE, PAULINE AND HENRY ALSO TOOK THEIR TURNS. A *B* ON THE SPINNER WOULD MOVE SOMEONE *B*ACKWARDS.

1. PLACE A *D*, *G*, AND *P* ON THE GAME GRID TO SHOW WHERE *DAVID*, *GENE*, AND *PETER* ARE AFTER THEIR SECOND TURNS.

FOR EACH OF THE FOLLOWING STATEMENTS: CIRCLE THE *Y* IF YOU AGREE WITH THE STATEMENT, CIRCLE THE *N* IF YOU DO NOT AGREE; CIRCLE THE *C* IF YOU CAN'T TELL.

Y, N, C 2. AT THE BEGINNING, PETER AND PAULINE HAVE A BETTER CHANCE BECAUSE THEIR PATH IS STRAIGHT TO THE *GOAL*.

Y, N, C 3. ALTHOUGH HE'S HAD 2 *F'S* IN A ROW, GENE HAS THE SAME CHANCE OF GETTING AN *F* AS PETER DOES ON THE THIRD SPIN.

TURN TO PAGE D.

Y, N, C 4. THE CHANCE (PROBABILITY) OF LOSING A TURN AT THE BEGINNING IS GREATER FOR DAVID THAN IT IS FOR GENE.

Y, N, C 5. THE CHANCE (PROBABILITY) OF LOSING A TURN AT THE BEGINNING IS GREATER FOR PETER THAN FOR GENE.

Y, N, C 6. THE CHANCE (PROBABILITY) OF LOSING A TURN ON THE THIRD TURN IS GREATER FOR PETER THAN FOR DAVID.

Y, N, C 7. AFTER THE SIX CHILDREN HAD EACH TAKEN FIVE TURNS, GENE WAS CLOSEST TO THE GOAL.

Y, N, C 8. THE MORE TURNS THE CHILDREN TAKE, THE MORE LIKELY IT IS THAT THEY WILL BE EVENLY SPACED OUT ON THE GRID.

Y, N, C 9. THIS GAME IS AN EXAMPLE OF THE SAME KIND OF MOVEMENT WE BELIEVE MOLECULES MAKE.

PART 2

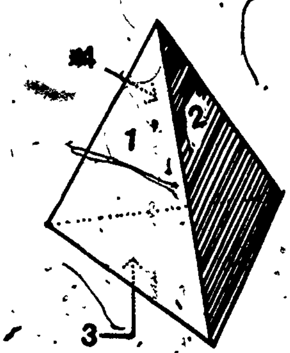
Pages E, F and G.

Hand out pages E, F and G to the children.

Page E

NOW I AM GOING TO DESCRIBE ANOTHER SITUATION TO YOU. AS USUAL THINK ABOUT IT CAREFULLY. AFTER I DESCRIBE IT TO YOU, AND YOU READ ABOUT IT SILENTLY WITH ME, YOU WILL HAVE TIME TO DECIDE WHETHER YOU AGREE OR NOT WITH STATEMENTS ABOUT THIS SITUATION WHICH I SHALL READ TO YOU. (Allow about 30 seconds for the children to decide about each statement.)

IN A MATHEMATICS CLASS MORRIS AND RITA WERE PLAYING A NUMBER-SUMS GAME. THEY USED A 4-SIDED BLOCK FOR THE GAME AS SHOWN TO THE RIGHT. EACH FACE IS IN THE SHAPE OF A TRIANGLE. THE SIDES OF EACH TRIANGLE ARE ALL EQUAL AND ALL FOUR TRIANGLES ARE THE SAME SIZE. EACH FACE OF THE BLOCK IS LABELLED WITH A DIFFERENT NUMBER. THE SIDES WITH THE 3 AND 4 ARE HIDDEN FROM VIEW. THE ARROWS POINT TO THEM. (HAVE YOU ANY QUESTIONS ABOUT THIS OBJECT?) MORRIS AND RITA TOOK TURNS THROWING THE BLOCK. EACH PLAYER MADE TWO THROWS OF THE BLOCK AND KEPT A RECORD OF THE NUMBER ON THE FACE ON WHICH THE BLOCK LANDED. AFTER THE TWO THROWS EACH PLAYER ADDED UP HIS SCORE--THAT IS, ADDED UP THE NUMBERS ON THE FACES ON WHICH THE BLOCK LANDED. ALL POSSIBLE SUMS FOR TWO THROWS ARE LISTED IN THE GRID.



THROW #1

THROW #2	1	2	3	4
1	2	3	4	5
2	3	4	5	6
3	4	5	6	7
4	5	6	7	8

SUMS

ON HIS FIRST TURN, MORRIS GETS THE PAIR (3,1) FOR WHICH THE SUM, AS YOU CAN SEE FROM THE GRID, IS 4.

NOW, READ EACH OF THE FOLLOWING STATEMENTS. IF YOU AGREE WITH THE STATEMENT, CIRCLE THE *Y* FOR YES; IF YOU DO NOT AGREE, CIRCLE THE *N* FOR NO; IF YOU CAN'T TELL, CIRCLE THE *C*. REMEMBER THAT THERE ARE TWO THROWS FOR EACH TURN.

Y, N, C 1. RITA HAS A BETTER THAN EVEN CHANCE OF WINNING ON HER TURN.

Y, N, C 2. THE CHANCE OF RITA GETTING A 4 IS LESS BECAUSE MORRIS ALREADY GOT A 4.

Y, N, C 3. RITA SHOULD EXPECT A 5 MORE THAN ANY OTHER SUM.

Y, N, C 4. IF RITA WINS THIS TURN, MORRIS SHOULD WIN THE NEXT ONE.

Y, N, C 5. THE SUMS OF TWO THROWS RANGE FROM 2 THROUGH 8, A TOTAL OF SIX SEPARATE VALUES. ~~IN A SERIES~~ OF SIX TURNS, EACH VALUE WOULD HAVE TO OCCUR AT LEAST ONCE.

TURN TO PAGE F.

Y, N, C 6. MORRIS SHOULD EXPECT TO GET A SUM GREATER THAN 4 ON HIS NEXT TURN.

Y, N, C 7. MORRIS SHOULD EXPECT TO GET A SUM LESS THAN 6 ON HIS NEXT TURN.

MORRIS AND RITA PLAYED FOR A LONG TIME AND KEPT TALLIES OF THE SUMS THEY GOT AND WHO WON ON EACH TURN.

Y, N, C 8. IN A LONG SERIES OF TURNS, MORRIS AND RITA SHOULD EACH WIN ABOUT AN EQUAL NUMBER OF TURNS.

Y, N, C 9. IN A LONG SERIES OF TURNS, THERE SHOULD BE ABOUT TWICE AS MANY 5's AS THERE ARE 7's.

Y, N, C 10. AS A GENERAL RULE, THE MORE TURNS THERE ARE, THE GREATER IS THE CHANCE OF GETTING AN EXTREME VALUE, SUCH AS A 2 OR AN 8.

The children will now have to look at the tallies and histograms on page G as they mark their choices for statements 11, 12 and 13. TURN TO PAGE G BUT KEEP PAGE F IN FRONT OF YOU ALSO.

Y, N, C 11. AFTER 10 TURNS, THE TALLY OF SUMS FOR MORRIS' DATA, AND THE HISTOGRAM OF THE SUMS, LOOKED LIKE THE FIGURE MARKED *M*. RITA'S TALLY OF HER DATA AND ITS HISTOGRAM IS MORE LIKELY TO LOOK LIKE THAT MARKED *A* THAN THE ONE MARKED *B*.

Y, N, C 12. AFTER 100 TURNS, BOTH TALLIES, AND HISTOGRAMS OF THE DATA, OBTAINED BY MORRIS AND RITA SHOULD BE ALMOST IDENTICAL.

Y, N, C 13. IF MORRIS AND RITA STARTED NEW TALLIES AFTER COMPLETING THEIR 100th TURN, AND MORRIS' DATA FOR HIS NEXT TEN TURNS PRODUCED A TALLY LIKE THAT IN FIGURE *M*. RITA'S TALLY FOR HER 101st TO 110th TURNS WOULD LOOK MORE LIKE *A* THAN *B*.

SUMS	TALLY
2	1
3	2
4	4
5	2
6	1
7	0
8	0

HISTOGRAM

```
FREQUENCY
        X
        X
     X  X  X
  X  X  X  X  X
  2  3  4  5  6  7  8
```

FIGURE M

SUMS	TALLY
2	0
3	3
4	4
5	3
6	0
7	0
8	0

HISTOGRAM

```
FREQUENCY
        X
     X  X  X
     X  X  X
     X  X  X
  2  3  4  5  6  7  8
```

FIGURE A

SUMS	TALLY
2	0
3	1
4	3
5	3
6	1
7	1
8	1

HISTOGRAM

```
FREQUENCY
        X  X
        X  X
     X  X  X  X  X  X
  2  3  4  5  6  7  8
```

FIGURE B

PART 3

Pages H, I and J.

Be sure the children have pages H, I and J for this part of the assessment.

I AM GOING TO DESCRIBE ANOTHER SITUATION NOW. AFTER I DESCRIBE IT THERE WILL BE SOME STATEMENTS TO BE COMPLETED OR QUESTIONS TO BE ANSWERED. THIS TIME EACH STATEMENT OR QUESTION IS FOLLOWED BY THREE POSSIBLE ANSWERS OR COMPLETIONS. AS I READ THEM TO YOU, SELECT THE ONE WHICH ANSWERS OR COMPLETES THE STATEMENT BEST AND DRAW A CIRCLE AROUND ITS LETTER. (Allow the children about 40 seconds to complete each item)

ONE CLOUDY SUMMER DAY, JAN, LOIS AND PHIL WERE PLAYING IN AN OPEN FIELD IN THE PARK. IT STARTED TO RAIN. AT FIRST PHIL FELT A FEW SPRINKLES. THEN LOIS SAW A RAINDROP LAND ON A LEAF. LATER, AFTER THE CHILDREN HAD FOUND SAFE SHELTER, THE RAIN SHOWER TURNED INTO A VIOLENT THUNDERSTORM. LASTING ABOUT ONE HOUR.

THE FOLLOWING ARE STATEMENTS ABOUT HOW THE RAINDROPS FELL. YOU WILL FIND IT HELPFUL TO RECALL WHAT YOU LEARNED ABOUT THE GEIGER COUNTER'S RECORD OF EVENTS. COMPLETE EACH STATEMENT BY CIRCLING THE LETTER OF YOUR CHOICE.

1. THE FIRST DROPS FELL ON PHIL:

   A. BECAUSE HE WAS LARGER THAN THE GIRLS.

   B. BY CHANCE.

   C. FOR SOME OTHER REASON.

2. JAN THOUGHT OF THE FIELD AS DIVIDED INTO SQUARES, ONE-METER ON EACH SIDE. THE *RATE* AT WHICH THE RAINDROPS FELL INTO A CERTAIN SQUARE WOULD BE:

   A. THE SAME AS FOR ALL THE OTHER SQUARES.

   B. GREATER FOR THOSE SQUARES IN THE WESTERN PART OF THE PARK THAN FOR THOSE IN THE EASTERN.

   C. DIFFERENT THAN MOST OF THE OTHER SQUARES.

3. TO GET A GOOD MEASURE OF THE AVERAGE OF HOW MUCH RAIN WOULD FALL IN THE FIELD, A DEVICE CALLED A RAIN GAUGE SHOULD BE PLACED:

A. UNDER A DRAIN FROM THE ROOF OF THE SHELTER HOUSE.

B. IN THE CENTER OF THE OPEN FIELD.

C. IN THAT SQUARE WHICH HAD THE AVERAGE AMOUNT OF RAINFALL IN THE LAST STORM.

4. LOIS WANTED TO KNOW HOW MUCH RAIN FELL IN EACH SQUARE FOR EACH MINUTE. SHE HAD FOUND OUT HOW TO DO THIS FROM THE NATIONAL WEATHER SERVICE, AND SO SHE MADE THE MEASUREMENTS DURING THIS STORM. WHEN SHE ANALYZED THE RESULTS OF THE MEASUREMENTS SHE FOUND THAT IN THE FIRST 15 MINUTES OF THE STORM, WHICH WAS VERY BLUSTERY AND VIOLENT BEFORE IT MOVED TO ANOTHER AREA, THE AMOUNT OF RAIN FALLING PER MINUTE WAS:

A. ALL VERY SMALL IN EVERY SQUARE.

B. BOTH SMALL AND LARGE IN MOST OF THE SQUARES.

C. VERY LARGE IN ALL THE SQUARES.

TURN TO PAGE I.

Page I . .

5. THE AMOUNT OF RAIN FALLING PER MINUTE MEASURED ON ONE RAIN GAUGE IN THE OPEN FIELD FOR THE ENTIRE DURATION OF THE STORM (ONE HOUR) WAS:

A. INCREASING REGULARLY AND THEN DECREASING REGULARLY.

B. GENERALLY LARGER DURING THE MIDDLE OF THE STORM BUT, EVEN THEN, IN SOME MINUTES VERY SMALL AMOUNTS WERE RECORDED.

C. IN EXACTLY THE SAME PATTERN AS WOULD HAVE BEEN MEASURED AND RECORDED IN ANY OTHER PART OF THE FIELD.

6. IF TEN RAIN GAUGES WERE PUT IN WIDELY SEPARATED OPEN AREAS IN THE FIELD DURING THE RAIN STORM, WHICH OF THE FOLLOWING STATEMENTS WOULD BE TRUE ABOUT THE AMOUNTS OF RAINFALL RECORDED?

CIRCLE THE *Y* FOR *YES*; CIRCLE THE *N* FOR *NO*.

Y N A. EACH AREA WILL RECORD THE SAME TOTAL AMOUNT FOR THE 60 MINUTE (ONE-HOUR) PERIOD OF THE STORM.

Y N B. THE PATTERNS OF HEAVY AND LIGHT RAINFALL WOULD BE IDENTICAL AT EACH GAUGE.

Y N C. THE DIFFERENCES, OR VARIATIONS (VARIABILITY), IN AMOUNTS OF RAINFALL PER MINUTE AT A PARTICULAR GAUGE WOULD BE GREATER THAN THE DIFFERENCES BETWEEN THE AVERABE AMOUNTS RECORDED FOR EACH MINUTE BY ALL THE GAUGES.

TURN TO PAGE J BUT KEEP IN MIND QUESTION 6 WHICH YOU HAVE JUST ANSWERED.

Page J

7. BAR GRAPHS WERE MADE TO SHOW THE AMOUNTS OF RAINFALL MEASURED BY EACH OF THE TEN RAIN GAUGES REFERRED TO IN QUESTION 6 ABOVE. DATA WERE TAKEN EVERY 5 MINUTES. A BAR GRAPH WAS ALSO MADE OF THE *AVERAGE* AMOUNT OF RAINFALL REGISTERED BY THE TEN RAIN GAUGES DURING THE 60-MINUTE PERIOD OF THE STORM. THE SOLID-LINE GRAPHS IN BOTH FIGURES *H AND I* BELOW SHOW THE AMOUNT OF RAINFALL AVERAGED FROM ALL TEN GAUGES. EACH HAS A DOTTED LINE GRAPH DRAWN UPON IT TO SHOW AMOUNTS OF RAINFALL THAT MAY HAVE BEEN MEASURED BY ONLY A SINGLE GAUGE. WHICH ONE OF THE SETS OF GRAPHS (FIGURE *H OR I*?) MOST LIKELY REPRESENTS WHAT WAS ACTUALLY MEASURED BY A GAUGE IN THE FIELD? WRITE YOUR ANSWER ON THIS LINE. ______________________

WHY DID YOU SELECT THAT FIGURE? ______________________

____

PART 4

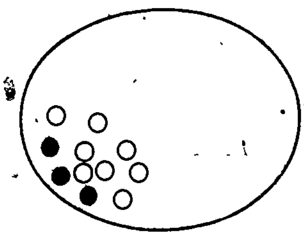
Pages K and L.

Distribute pages K and L to the children.

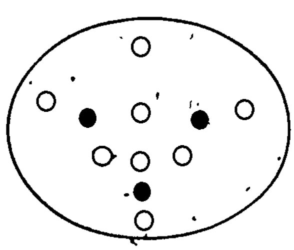
THE FOLLOWING SETS OF PICTURES HAVE TO DO WITH SEQUENCES OF CERTAIN EVENTS WHICH I SHALL DESCRIBE TO YOU. THE PICTURES REPRESENT PARTS OF A SEQUENCE SHOWING WHAT WAS HAPPENING AT DIFFERENT TIMES. LOOK AT EACH SITUATION AND MARK THEM ACCORDING TO THE INSTRUCTIONS I SHALL GIVE YOU.

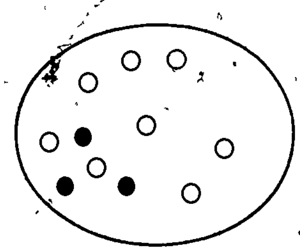
LOOK AT PAGE K.

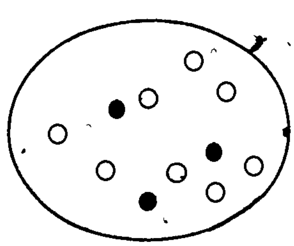
SEQUENCE I: HERE IS A PICTURE OF HOW SOME BLACK AND WHITE MARBLES WERE ARRANGED IN A DISH.

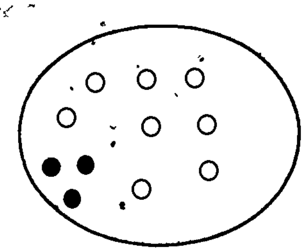


THE DISH WAS THEN PLACED ON A TABLE WHICH WAS SHAKING. AS A RESULT OF THE SHAKING OF THE TABLE THE MARBLES MOVED AROUND IN THE DISH. PLACE A *Z* ON THAT PICTURE WHICH SHOWS THE ARRANGEMENT OF THE MARBLES AFTER THEY HAD BEEN SHAKING FOR A CONSIDERABLE LENGTH OF TIME; PLACE AN *M* ON THAT PICTURE WHICH SHOWS THE MOST LIKELY ARRANGEMENT AFTER ABOUT HALF THE LENGTH OF TIME OF SHAKING. KEEP IN MIND THE INITIAL ARRANGEMENT OF MARBLES BEFORE SHAKING.







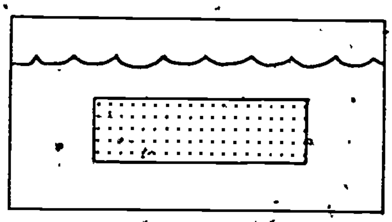


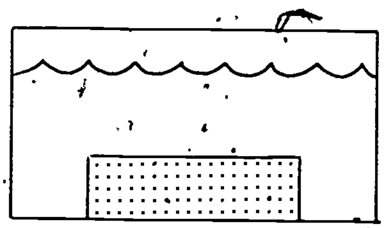
NOW TURN TO PAGE L.

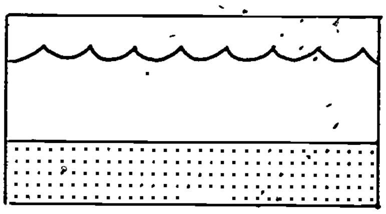
Page L

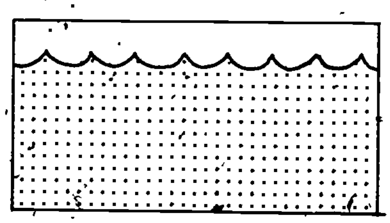
HERE IS THE SECOND SEQUENCE.

SEQUENCE II: THE DOTS IN THESE PICTURES REPRESENT SOME BLUE VITRIOL MOLECULES. THE CLEAR PORTION REPRESENTS WATER. THIS SYSTEM IS ALLOWED TO STAND FOR SEVERAL DAYS. MARK THAT PICTURE WHICH SHOWS THE SITUATION EARLY IN THE SEQUENCE WITH AN *A* AND MARK A *Z* ON THE PICTURE WHICH SHOWS THE SITUATION AFTER A LONG PERIOD OF TIME.

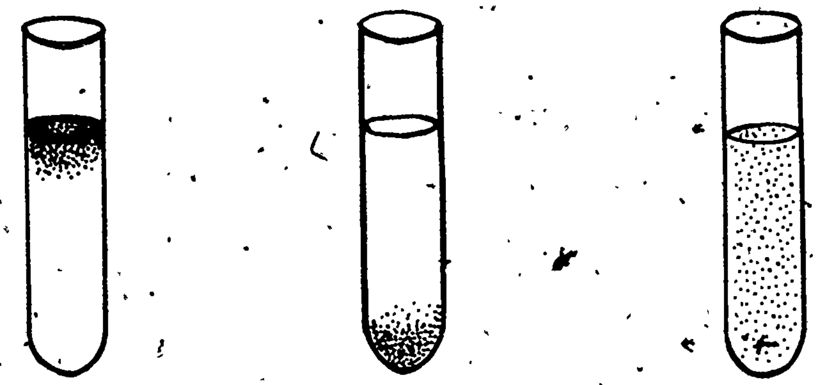








SITUATION I: DARRELL VISITED A SCIENCE CLASS AND OBSERVED THREE TEST TUBES TO WHICH BLUE FOOD COLORING HAD BEEN ADDED. THEY LOOKED LIKE THE DIAGRAMS BELOW. THE DOTS SHOW WHERE THE BLUE FOOD COLORING WAS SEEN.



TUBE A TUBE B TUBE C

1. WHICH TUBE PROBABLY HAD BEEN STANDING THE LONGEST TIME? ____________

2. WHICH TUBE WAS THE LIGHTEST BLUE COLOR? ____________

SITUATION II: JAN HAD A SMALL FISH BOWL SHAPED LIKE A BALL. SHE FILLED IT ALMOST TO THE TOP WITH LIQUID GELATIN. BEFORE THE GELATIN IN THE BOWL SET, JAN PLACED SOME RED FOOD COLORING AT THE BOTTOM OF THE BOWL. AFTER THE GELATIN HAD SET SHE PLACED SOME BLUE COLORING ON TOP OF THE GELATIN. THE BOWL LOOKED LIKE THAT SHOWN BELOW IN FIGURE D.

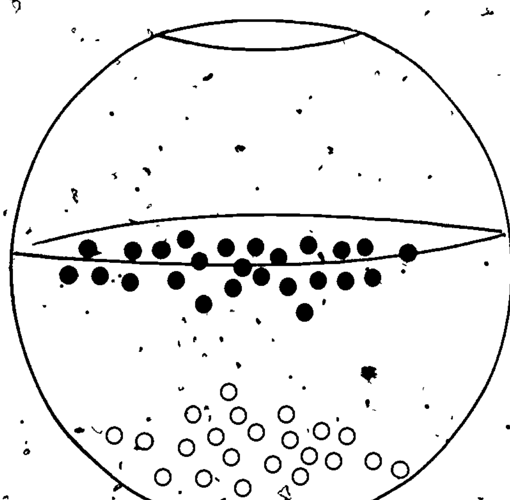


FIGURE D

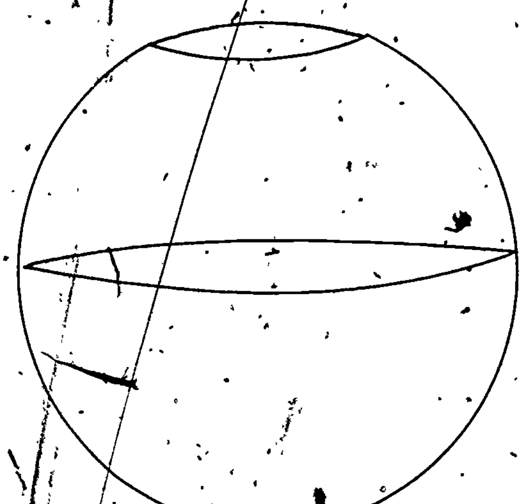


FIGURE E

IN FIGURE *D*:
○ REPRESENTS WHERE RED IS SEEN.
● REPRESENTS WHERE BLUE IS SEEN.

1. IN FIGURE E, SKETCH WHAT THE BOWL WOULD LOOK LIKE AFTER SEVERAL WEEKS. REMEMBER THAT ● STANDS FOR BLUE AND ○ STANDS FOR RED.

2. WHAT WOULD BE THE COLOR NEAR THE TOP? ____________

3. WHAT WOULD BE THE COLOR NEAR THE MIDDLE? ____________

IN FRONT OF EACH OF THE FOLLOWING STATEMENTS ABOUT THE MOLECULES OF FOOD COLORING IN THE FISH BOWL, CIRCLE THE *Y* FOR YES IF YOU AGREE; CIRCLE THE *N*, FOR NO, IF YOU DO NOT AGREE.

Y N 4. ALL THE MOLECULES OF THE RED FOOD COLORING MOVED TO THE TOP, AND THEN SOME SANK DOWN DUE TO GRAVITY.

Y N 5. ONLY THE MOLECULES OF THE RED FOOD COLORING IN THE TOP LAYER MOVED UP; THE OTHERS DIDN'T MOVE.

Y N 6. ALL MOLECULES OF BOTH FOOD COLORS MOVED IN ALL DIRECTIONS.

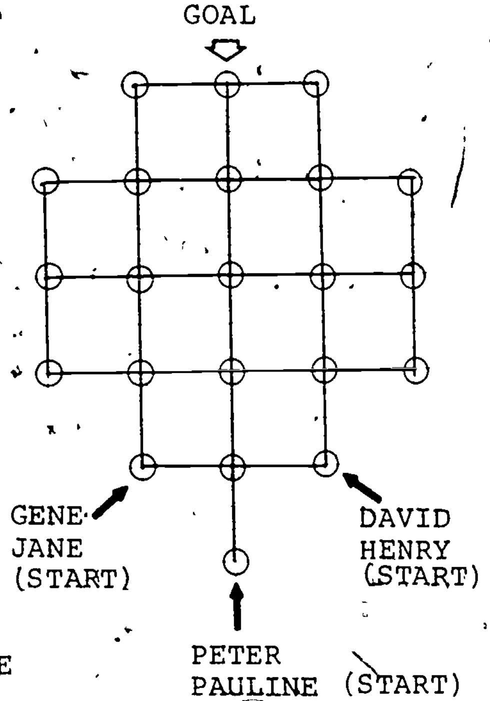
Y N 7. THOSE WHICH HIT THE BOWL EITHER STOPPED OR MOVED BACK INTO THE GELATIN AGAIN.

Y N 8. THE DIFFERENCE IN SHADES OF COLOR SHOW MOLECULES MOVED FROM LOW CONCENTRATION TO HIGH CONCENTRATION REGIONS.

Y N 9. ALTHOUGH MOLECULES MOVED RANDOMLY IN ALL DIRECTIONS, THE OVERALL RESULT IS PREDICTABLE.

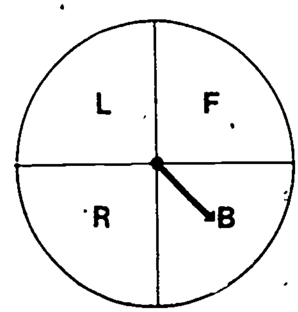
SITUATION III: SIX CHILDREN (DAVID, GENE, PETER, JANE, PAULINE AND HENRY) DECIDED TO HAVE A CONTEST TO SEE WHICH ONE COULD GET TO A SPACE, MARKED *GOAL*, FIRST, AS SHOWN IN FIGURE *F*. THE RULE OF THE GAME IS THAT THE RESULT OF SPINNING THE POINTER OF A SPINNER, AS SHOWN IN FIGURE *G*, DECIDES EACH MOVE. ANOTHER RULE OF THE GAME IS THAT MOVES CAN ONLY BE MADE FROM ONE SMALL CIRCLE TO ANOTHER ON THE GRID. IF A PLAYER CAN NOT MAKE THE MOVE SHOWN, (BECAUSE THE MOVE WOULD TAKE HIM OFF THE GRID) HE LOSES HIS TURN, AND STAYS WHERE HE IS UNTIL HIS NEXT TURN.

FIGURE F



THE GAME GRID

FIGURE G



THE SPINNER

DAVID'S FIRST TWO MOVES WERE *L AND F*, (LEFT AND FORWARD). GENE'S FIRST TWO MOVES WERE BOTH *F'S*. PETER MOVED *F AND R* (RIGHT). JANE, PAULINE AND HENRY ALSO TOOK THEIR TURNS. A *B* ON THE SPINNER WOULD MOVE SOMEONE BACKWARDS.

1. PLACE A *D*, *G*, *AND P* ON THE GAME GRID TO SHOW WHERE *DAVID*, *GENE* AND *PETER* ARE AFTER THEIR SECOND TURNS.

FOR EACH OF THE FOLLOWING STATEMENTS: CIRCLE THE *Y* IF YOU AGREE WITH THE STATEMENT; CIRCLE THE *N* IF YOU DO NOT AGREE; CIRCLE THE *C* IF YOU CAN'T TELL.

Y, N, C 2. AT THE BEGINNING, PETER AND PAULINE HAVE A BETTER CHANCE BECAUSE THEIR PATH IS STRAIGHT TO THE *GOAL*.

Y, N, C. 3. ALTHOUGH HE'S HAD 2 *F'S* IN A ROW, GENE HAS THE SAME CHANCE OF GETTING AN *F* AS PETER DOES ON THE THIRD SPIN.

Y, N, C 4. THE CHANCE (PROBABILITY) OF LOSING A TURN, AT THE BEGINNING IS GREATER FOR DAVID THAN IT IS FOR GENE.

Y, N, C 5. THE CHANCE (PROBABILITY) OF LOSING A TURN, AT THE BEGINNING IS GREATER FOR PETER THAN FOR GENE.

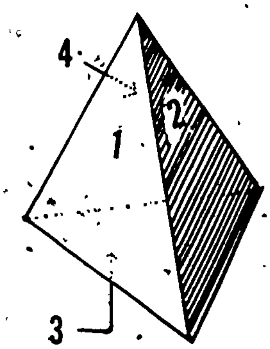
Y, N, C 6. THE CHANCE (PROBABILITY) OF LOSING A TURN ON THE THIRD TURN IS GREATER FOR PETER THAN FOR DAVID.

Y, N, C 7. AFTER THE SIX CHILDREN HAD EACH TAKEN FIVE TURNS, GENE WAS CLOSEST TO THE GOAL.

Y, N, C 8. THE MORE TURNS THE CHILDREN TAKE, THE MORE LIKELY IT IS THAT THEY WILL BE EVENLY SPACED OUT ON THE GRID.

Y, N, C 9. THIS GAME IS AN EXAMPLE OF THE SAME KIND OF MOVEMENT WE BELIEVE MOLECULES MAKE.

IN A MATHEMATICS CLASS MORRIS AND RITA WERE PLAYING A NUMBER-SUMS GAME. THEY USED A 4-SIDED BLOCK FOR THE GAME AS SHOWN TO THE RIGHT. EACH FACE IS IN THE SHAPE OF A TRIANGLE. THE SIDES OF EACH TRIANGLE ARE ALL EQUAL AND ALL FOUR TRIANGLES ARE THE SAME SIZE. EACH FACE OF THE BLOCK IS LABELLED WITH A DIFFERENT NUMBER. THE SIDES WITH THE 3 AND 4 ARE HIDDEN FROM VIEW. THE ARROWS POINT TO THEM. (HAVE YOU ANY QUESTIONS ABOUT THIS OBJECT?) MORRIS AND RITA TOOK TURNS THROWING THE BLOCK. EACH PLAYER MADE TWO THROWS OF THE BLOCK, AND KEPT A RECORD OF THE NUMBER ON THE FACE ON WHICH THE BLOCK LANDED. AFTER THE TWO THROWS EACH PLAYER ADDED UP HIS SCORE--THAT IS, ADDED UP THE NUMBERS ON THE FACES ON WHICH THE BLOCK LANDED. ALL POSSIBLE SUMS FOR TWO THROWS ARE LISTED IN THE GRID.



THROW #1

THROW #2	1	2	3	4
1	2	3	4	5
2	3	4	5	6
3	4	5	6	7
4	5	6	7	8

SUMS

ON HIS FIRST TURN, MORRIS GETS THE PAIR (3,1) FOR WHICH THE SUM, AS YOU CAN SEE FROM THE GRID, IS 4.

NOW, READ EACH OF THE FOLLOWING STATEMENTS. IF YOU AGREE WITH THE STATEMENT, CIRCLE THE *Y* FOR YES; IF YOU DO NOT AGREE, CIRCLE THE *N* FOR NO; IF YOU CAN'T TELL CIRCLE THE *C*. REMEMBER THAT THERE ARE TWO THROWS FOR EACH TURN.

Y, N, C 1. RITA HAS A BETTER THAN EVEN CHANCE OF WINNING ON HER TURN.

Y, N, C 2. THE CHANCE OF RITA GETTING A 4 IS LESS BECAUSE MORRIS ALREADY GO A 4.

Y, N, C 3. RITA SHOULD EXPECT A 5 MORE THAN ANY OTHER SUM.

Y, N, C 4. IF RITA WINS THIS TURN, MORRIS SHOULD WIN THE NEXT ONE.

Y, N, C 5. THE SUMS OF TWO THROWS RANGE FROM 2 THROUGH 8, A TOTAL OF SIX SEPARATE VALUES. IN A SERIES OF SIX TURNS, EACH VALUE WOULD HAVE TO OCCUR AT LEAST ONCE.

Y, N, C 6. MORRIS SHOULD EXPECT TO GET A SUM GREATER THAN 4 ON HIS NEXT TURN.

Y, N, C 7. MORRIS SHOULD EXPECT TO GET A SUM LESS THAN 6 ON HIS NEXT TURN.

MORRIS AND RITA PLAYED FOR A LONG TIME AND KEPT TALLIES OF THE SUMS THEY GOT AND WHO WON ON EACH TURN.

Y, N, C 8. IN A LONG SERIES OF TURNS, MORRIS AND RITA SHOULD EACH WIN ABOUT AN EQUAL NUMBER OF TURNS.

Y, N, C 9. IN A LONG SERIES OF TURNS, THERE SHOULD BE ABOUT TWICE AS MANY 5's AS THERE ARE 7's.

Y, N, C 10. AS A GENERAL RULE, THE MORE TURNS THERE ARE, THE GREATER IS THE CHANCE OF GETTING AN EXTREME VALUE, SUCH AS A 2 OR AN 8.

Y, N, C 11. AFTER 10 TURNS, THE TALLY OF SUMS FOR MORRIS' DATA AND THE HISTOGRAM OF THE SUMS, LOOKED LIKE THE FIGURE MARKED *M*. RITA'S TALLY OF HER DATA AND ITS HISTOGRAM IS MORE LIKELY TO LOOK LIKE THAT MARKED *A* THAN THE ONE MARKED *B*.

Y, N, C 12. AFTER 100 TURNS, BOTH TALLIES, AND HISTOGRAMS OF THE DATA, OBTAINED BY MORRIS AND RITA SHOULD BE ALMOST IDENTICAL.

Y, N, C 13. IF MORRIS AND RITA STARTED NEW TALLIES AFTER COMPLETING THEIR 100th TURN, AND MORRIS' DATA FOR HIS NEXT TEN TURNS PRODUCED A TALLY LIKE THAT IN FIGURE *M*. RITA'S TALLY FOR HER 101st TO 110th TURNS WOULD LOOK MORE LIKE *A* THAN *B*.

SUMS	TALLY
2	1
3	2
4	4
5	2
6	1
7	0
8	0

HISTOGRAM

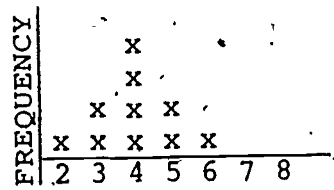


FIGURE M

SUMS	TALLY
2	0
3	3
4	4
5	3
6	0
7	0
8	0

HISTOGRAM

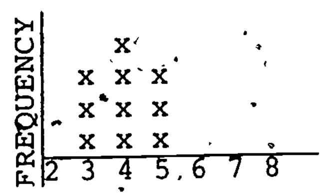


FIGURE A

SUMS	TALLY
2	0
3	1
4	3
5	3
6	1
7	1
8	1

HISTOGRAM

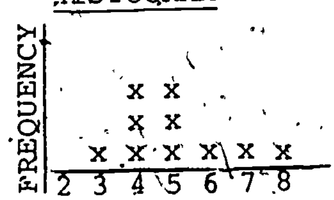


FIGURE B

ONE CLOUDY SUMMER DAY, JAN, LOIS AND PHIL WERE PLAYING IN AN OPEN FIELD IN THE PARK. IT STARTED TO RAIN. AT FIRST PHIL FELT A FEW SPRINKLES. THEN LOIS SAW A RAINDROP LAND ON A LEAF. LATER, AFTER THE CHILDREN HAD FOUND SAFE SHELTER, THE RAIN SHOWER TURNED INTO A VIOLENT THUNDERSTORM, LASTING ABOUT ONE HOUR.

THE FOLLOWING ARE STATEMENTS ABOUT HOW THE RAINDROPS FELL. YOU WILL FIND IT HELPFUL TO RECALL WHAT YOU LEARNED ABOUT THE GEIGER COUNTER'S RECORD OF EVENTS.

1. THE FIRST DROPS FELL ON PHIL:

   A. BECAUSE HE WAS LARGER THAN THE GIRLS.

   B. BY CHANCE.

   C. FOR SOME OTHER REASON.

2. JAN THOUGHT OF THE FIELD AS DIVIDED INTO SQUARES, ONE-METER ON EACH SIDE. THE *RATE* AT WHICH THE RAINDROPS FELL INTO A CERTAIN SQUARE WOULD BE:

   A. THE SAME AS FOR ALL THE OTHER SQUARES.

   B. GREATER FOR THOSE SQUARES IN THE WESTERN PART OF THE PARK THAN FOR THOSE IN THE EASTERN.

   C. DIFFERENT THAN MOST OF THE OTHER SQUARES.

3. TO GET A GOOD MEASURE OF THE AVERAGE OF HOW MUCH RAIN WOULD FALL IN THE FIELD, A DEVICE CALLED A RAIN GAUGE SHOULD BE PLACED:

   A. UNDER A DRAIN FROM THE ROOF OF THE SHELTER HOUSE.

   B. IN THE CENTER OF THE OPEN FIELD.

   C. IN THAT SQUARE WHICH HAD THE AVERAGE AMOUNT OF RAINFALL IN THE LAST STORM.

4. LOIS WANTED TO KNOW HOW MUCH RAIN FELL IN EACH SQUARE FOR EACH MINUTE. SHE HAD FOUND OUT HOW TO DO THIS FROM THE NATIONAL WEATHER SERVICE, AND SO SHE MADE THE MEASUREMENTS DURING THIS STORM. WHEN SHE ANALYZED THE RESULTS OF THE MEASUREMENTS SHE FOUND THAT IN THE FIRST 15 MINUTES OF THE STORM, WHICH WAS VERY BLUSTERY AND VIOLENT BEFORE IT MOVED TO ANOTHER AREA, THE AMOUNT OF RAIN FALLING PER MINUTE WAS:

   A. ALL VERY SMALL IN EVERY SQUARE.

   B. BOTH SMALL AND LARGE IN MOST OF THE SQUARES.

   C. VERY LARGE IN ALL THE SQUARES.

5. THE AMOUNT OF RAIN FALLING PER MINUTE MEASURED ON ONE RAIN GAUGE IN THE OPEN FIELD FOR THE ENTIRE DURATION OF THE STORM (ONE HOUR) WAS:

A. INCREASING REGULARLY AND THEN DECREASING REGULARLY.

B. GENERALLY LARGER DURING THE MIDDLE OF THE STORM BUT, EVEN THEN, IN SOME MINUTES VERY SMALL AMOUNTS WERE RECORDED.

C. IN EXACTLY THE SAME PATTERN AS WOULD HAVE BEEN MEASURED AND RECORDED IN ANY OTHER PART OF THE FIELD.

6. IF TEN RAIN GAUGES WERE PUT IN WIDELY SEPARATED OPEN AREAS IN THE FIELD DURING THE RAIN STORM, WHICH OF THE FOLLOWING STATEMENTS WOULD BE TRUE ABOUT THE AMOUNTS OF RAINFALL RECORDED?

CIRCLE THE *Y* FOR *YES*; CIRCLE THE *N* FOR *NO*.

Y N A. EACH AREA WILL RECORD THE SAME TOTAL AMOUNT FOR THE 60 MINUTE (ONE-HOUR) PERIOD OF THE STORM.

Y N B. THE PATTERNS OF HEAVY AND LIGHT RAINFALL WOULD BE IDENTICAL AT EACH GAUGE.

Y N C. THE DIFFERENCES, OR VARIATIONS (VARIABILITY), IN AMOUNTS OF RAINFALL PER MINUTE AT A PARTICULAR GAUGE WOULD BE GREATER THAN THE DIFFERENCES BETWEEN THE AVERAGE AMOUNTS RECORDED FOR EACH MINUTE BY ALL THE GAUGES.

7. BAR GRAPHS WERE MADE TO SHOW THE AMOUNTS OF RAINFALL MEASURED BY EACH OF THE TEN RAIN GAUGES REFERRED TO IN QUESTION 6 ABOVE. DATA WERE TAKEN EVERY 5 MINUTES. A BAR GRAPH WAS ALSO MADE OF THE *AVERAGE* AMOUNT OF RAINFALL REGISTERED BY THE TEN RAIN GAUGES DURING THE 60-MINUTE PERIOD OF THE STORM. THE SOLID-LINE GRAPHS IN BOTH FIGURES *H AND I* BELOW SHOW THE AMOUNT OF RAINFALL AVERAGED FROM ALL TEN GAUGES. EACH HAS A DOTTED LINE GRAPH DRAWN UPON IT TO SHOW AMOUNTS OF RAINFALL THAT MAY HAVE BEEN MEASURED BY ONLY A SINGLE GAUGE. WHICH ONE OF THE SETS OF GRAPHS (FIGURE *H OR I*?) MOST LIKELY REPRESENTS WHAT WAS ACTUALLY MEASURED BY A GAUGE IN THE FIELD?
WRITE YOUR ANSWER ON THIS LINE. ______________________

WHY DID YOU SELECT THAT FIGURE? ______________________

____

FIGURE H

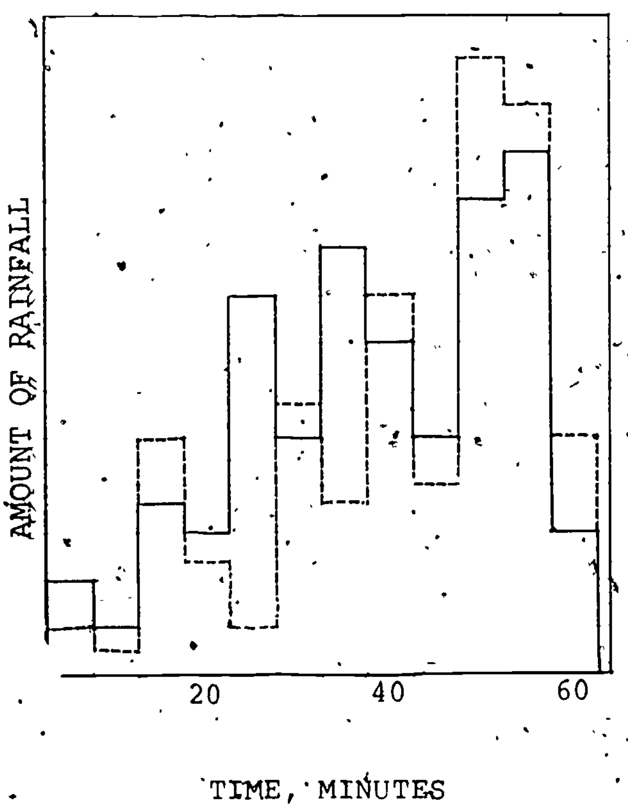
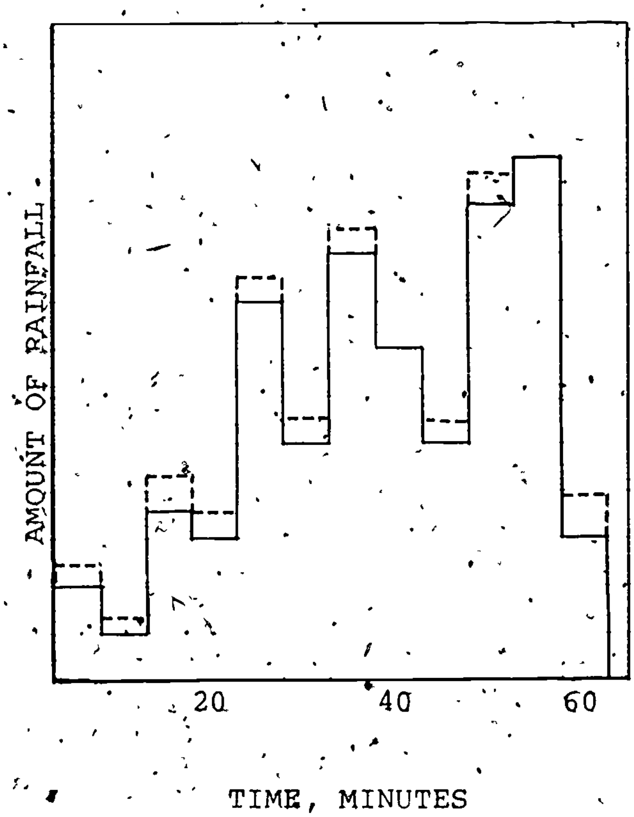


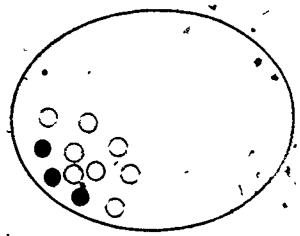
FIGURE I



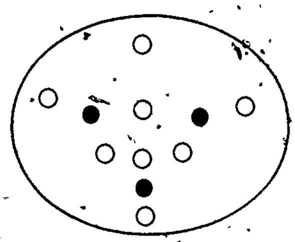
———— AVERAGE

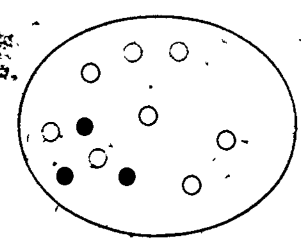
- - - - - ONE RAIN GAUGE

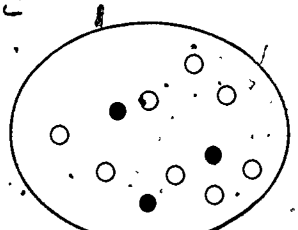
SEQUENCE I: HERE IS A PICTURE OF HOW SOME BLACK AND WHITE MARBLES WERE ARRANGED IN A DISH.

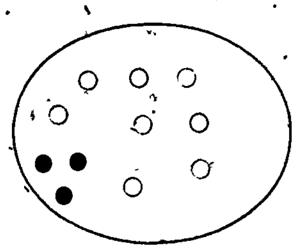


THE DISH WAS THEN PLACED ON A TABLE WHICH WAS SHAKING. AS A RESULT OF THE SHAKING OF THE TABLE THE MARBLES MOVED AROUND IN THE DISH. PLACE A *Z* ON THAT PICTURE WHICH SHOWS THE ARRANGEMENT OF THE MARBLES AFTER THEY HAD BEEN SHAKING FOR A CONSIDERABLE LENGTH OF TIME; PLACE AN *M* ON THAT PICTURE WHICH SHOWS THE MOST LIKELY ARRANGEMENT AFTER ABOUT HALF THE LENGTH OF TIME OF SHAKING. KEEP IN MIND THE INITIAL ARRANGEMENT OF MARBLES BEFORE SHAKING.

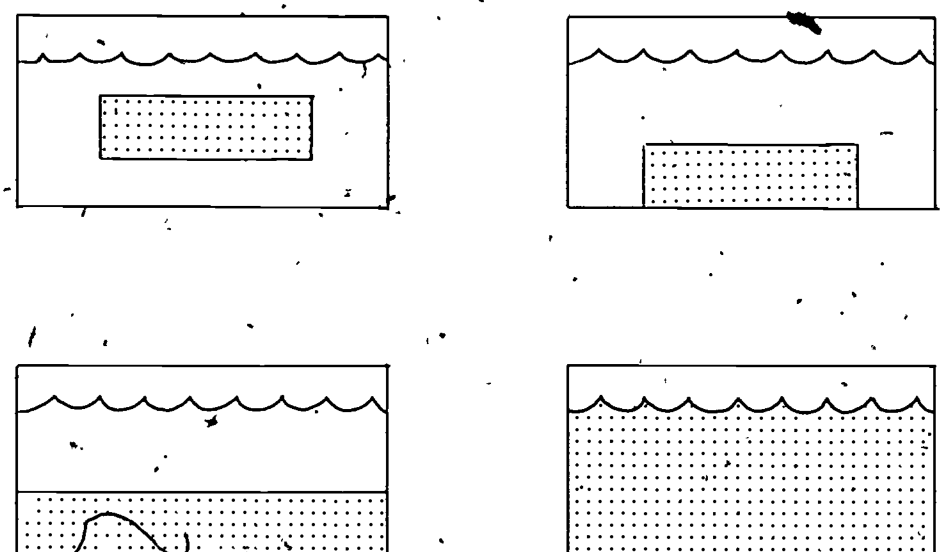


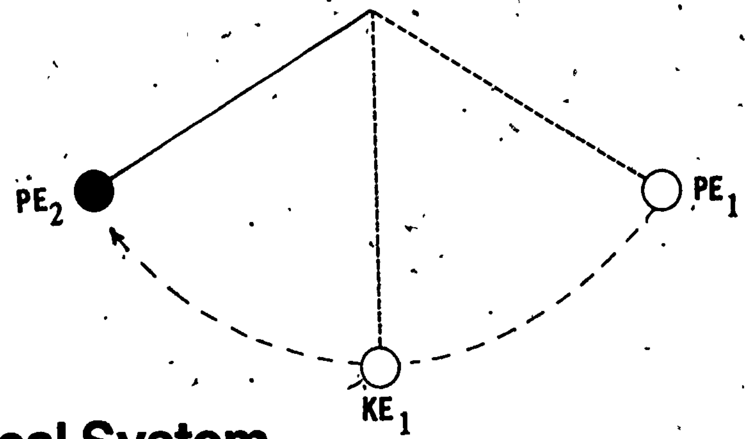






SEQUENCE II: THE DOTS IN THESE PICTURES REPRESENT SOME BLUE VITRIOL MOLECULES. THE CLEAR PORTION REPRESENTS WATER. THIS SYSTEM IS ALLOWED TO STAND FOR SEVERAL DAYS. MARK THAT PICTURE WHICH SHOWS THE SITUATION EARLY IN THE SEQUENCE WITH AN *A* AND MARK A *Z* ON THE PICTURE WHICH SHOWS THE SITUATION AFTER A LONG PERIOD OF TIME.





Minisequence VI

Towards an Ideal Mechanical System

Screening Assessments

The concepts developed in Minisequence VI and tested in this Assessment are:

a. The total amount of energy (mechanical plus thermal) in a system remains constant.

b. In an ideal system, the different forms of mechanical energy (potential and kinetic) can be converted from one to the other without any loss of mechanical energy.

c. The kinetic energy of an object can be transformed into thermal energy.

d. The amount of work done to increase the gravitational potential energy of an object (lifting it against gravity) does not depend on the path through which the object is raised.

e. A loss in the mechanical energy of a system may be accounted for by the production of thermal energy due to frictional effects.

There are three parts to this group of assessments. Part 1 is concerned mainly with concept (d); Part 2 with concepts (b) and (e); and Part 3 with concepts (a), (c), and (e).

Distribute the assessment pages to the children and have them write their names in the appropriate places. You may wish to distribute each part separately. This assessment should take about 30 to 40 minutes to administer.

PART 1

Page A

Have the children turn to page A.

I AM GOING TO ASK YOU SOME QUESTIONS. EACH HAS THREE POSSIBLE ANSWERS. YOU SHOULD READ SILENTLY ALONG WITH ME. DRAW A CIRCLE AROUND THE LETTER OF THE BEST ANSWER AFTER I FINISH READING EACH QUESTION ALOUD. (Allow about 30 seconds for each choice. If you feel it helpful for the children, read the questions aloud again as they make their choices.)

1. JANICE WALKED TO THE TOP OF A HILL. SHE CARRIED A BALL WITH HER. WHEN SHE REACHED THE TOP OF THE HILL, DARRELL, WHO WAS AT THE BOTTOM OF THE HILL, THREW A SECOND BALL TO HER. COMPARE THE POTENTIAL ENERGIES OF THE FIRST AND SECOND BALLS WHEN THEY ARE AT THE TOP OF THE HILL.

   A. THE SECOND BALL HAS MORE POTENTIAL ENERGY.

   B. JANICE'S FIRST BALL HAS MORE POTENTIAL ENERGY.

   C. BOTH BALLS HAVE THE SAME POTENTIAL ENERGY.

2. DEAN CARRIED A BASKETBALL FROM THE BASEMENT OF HIS HOUSE TO THE ROOF. HE FOUND ANOTHER BASKETBALL ON THE ROOF. COMPARE THE POTENTIAL ENERGIES OF THE TWO BASKETBALLS.

   A. THE ONE HE CARRIED UP HAS MORE POTENTIAL ENERGY.

   B. THE ONE THAT WAS ALREADY UP THERE HAS MORE POTENTIAL ENERGY.

   C. THEY BOTH HAVE THE SAME AMOUNT OF POTENTIAL ENERGY.

3. DIANE EXERTED 10 FORCE-UNITS TO LIFT A BRICK 5 FEET. THEO STOOD ON THE ROOF OF HER HOUSE AND PULLED UP A BALL 20 FEET TO THE TOP. THEO EXERTED 5 FORCE-UNITS TO RAISE THE BALL. COMPARE THE POTENTIAL ENERGIES OF THE BALL AND THE BRICK AFTER THEY WERE LIFTED.

   A. THE BALL HAS MORE POTENTIAL ENERGY.

   B. THE BRICK HAS MORE POTENTIAL ENERGY.

   C. THEY BOTH HAVE THE SAME AMOUNT OF POTENTIAL ENERGY.

PART 2

Page B

Have the children look at page B.

AGAIN I AM GOING TO ASK SOME QUESTIONS. EACH QUESTION HAS THREE POSSIBLE ANSWERS. AFTER I READ ALOUD EACH QUESTION AND ITS POSSIBLE ANSWERS, DRAW A CIRCLE AROUND THE LETTER IN FRONT OF THE ANSWER YOU PREFER. YOU MAY READ SILENTLY WHILE I READ ALOUD. (Allow about 30 seconds for the children to make their choices for each question.) HERE IS THE FIRST QUESTION.

1. ARNOLD HAS A LAWN MOWER AND HE CALCULATED VERY CAREFULLY HOW MUCH WORK IT TOOK TO PUSH IT. HE FOUND THAT THE AMOUNT OF WORK HE PUT INTO THE MOWER DID NOT EQUAL THE AMOUNT OF WORK THE MOWER DID. WHICH STATEMENT IS TRUE?

   A. THE MOWER WILL ALWAYS DO MORE WORK THAN IS PUT INTO IT.

   B. THE MOWER WILL ALWAYS DO LESS WORK THAN IS PUT INTO IT.

   C. SOMETIMES THE MOWER WILL DO MORE WORK AND SOMETIMES LESS WORK.

2. ARNOLD WANTS TO SHOW THAT THE TOTAL AMOUNT OF WORK HE PUT INTO THE LAWN MOWER CAN BE ACCOUNTED FOR. IN ADDITION TO THE AMOUNT OF WORK THE MOWER DOES WHAT ELSE SHOULD HE CALCULATE?

   A. THE AMOUNT OF POTENTIAL ENERGY PRODUCED AS THE MOWER CUT.

   B. THE AMOUNT OF HEAT ENERGY PRODUCED AS THE MOWER CUT THE GRASS.

   C. THE AMOUNT OF HEAT ENERGY PRODUCED BY THE SUN.

3. ARNOLD DOES NOT LIKE THE IDEA OF PUTTING SO MUCH MORE WORK INTO THE MOWER THAN HE GETS OUT. WHAT SHOULD HE DO?

   A. GET A LARGER MOWER.

   B. OIL THE MOWER TO REDUCE FRICTION.

   C. OIL THE MOWER TO INCREASE FRICTION.

4. PRETEND YOU ARE ON ANOTHER PLANET IN SPACE WHERE THERE IS NO FRICTION. A PENDULUM BOB IS PULLED BACK AND RELEASED. WHAT WILL EVENTUALLY HAPPEN TO THE PENDULUM?

A. IT WILL EVENTUALLY STOP MOVING.

B. IT WILL TEND TO SPEED UP.

C. IT WILL NEVER STOP.

5. WHAT POSITION WILL THE PENDULUM REACH AT EACH SWING?

A. THE SAME HEIGHT.

B. A LOWER HEIGHT.

C. A HIGHER HEIGHT.

Page C

TURN TO PAGE C.

6. WHY WOULD IT BE DIFFICULT TO PLAY GOLF ON THIS FRICTIONLESS PLANET?

A. THE PLAYER COULD GET A PERFECT SWING EACH TIME.

B. THE BALL WOULD STOP ROLLING TOO SOON.

C. THE BALL WOULD NEVER STOP ROLLING.

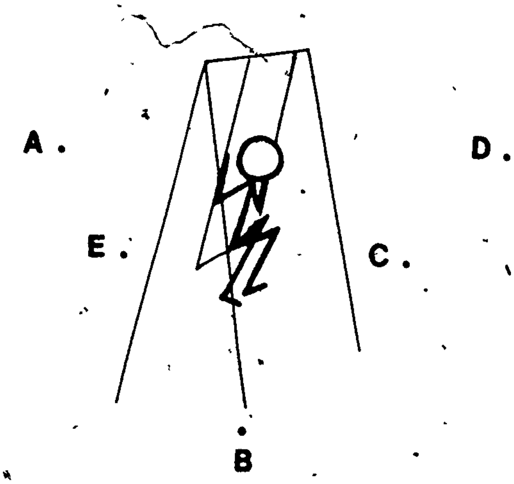
PART 3

Page D

IN THE REMAINDER OF THIS ASSESSMENT I SHALL READ ALOUD A DESCRIPTION OF SEVERAL SITUATIONS INVOLVING THE IDEAS WE HAVE BEEN WORKING WITH. AFTER EACH SITUATION I SHALL READ SOME QUESTIONS ABOUT THE SITUATION. EACH OF THESE QUESTIONS WILL ALSO HAVE THREE POSSIBLE ANSWERS. I SHALL PAUSE BETWEEN EACH QUESTION SO YOU CAN CIRCLE THE LETTER IN FRONT OF THE ANSWER YOU PREFER. LOOK AT PAGE D. HERE IS THE FIRST SITUATION. READ SILENTLY

WHILE I READ ALOUD. (Allow about 30 seconds for the children to respond to each question.)

SITUATION I: MORRIS IS ON A SWING WHICH LOOKS LIKE THE ONE IN THE PICTURE. THE LETTERS *A, B, C, D AND E* REPRESENT DIFFERENT POSITIONS THAT THE SWING WILL REACH WHEN IT IS SWINGING. MORRIS AND THE SWING ARE PULLED BACK TO POSITION *A* AND THEN RELEASED.



1. AT WHICH POSITION IS MORRIS' POTENTIAL ENERGY THE GREATEST?

   A. AT POSITION *A*.

   B. AT POSITION *B*.

   C. AT POSITION *C*.

2. AT WHICH POSITION IS HIS KINETIC ENERGY THE GREATEST?

   A. AT POSITION *A*.

   B. AT POSITION *B*.

   C. AT POSITION *C*.

3. AT WHICH TWO POSITIONS IS HIS POTENTIAL ENERGY ABOUT THE SAME?

A. AT POSITIONS *A AND B*.

B. AT POSITIONS *B AND C*.

C. AT POSITIONS *A AND D*.

Page E

NOW TURN TO PAGE E, BUT YOU MAY STILL WANT TO LOOK AT THE PICTURN ON PAGE D.

4. AT WHICH POSITION IS MORRIS MOVING THE FASTEST?

A. POSITION *A*.

B. POSITION *B*.

C. POSITION *C*.

5. AT WHICH POSITION IS MORRIS MOVING THE SLOWEST?

A. AT POSITION *A*.

B. AT POSITION *B*.

C. AT POSITION *C*.

6. MORRIS SWINGS FROM POSITION *A* TO *E* TO *B* TO *C* TO *D*. AT POSITION *C* WHAT CAN BE SAID ABOUT MORRIS' SWINGING?

A. HE IS SPEEDING UP.

B. HE IS SLOWING DOWN.

C. THERE IS NO WAY TO TELL.

7. WHAT WILL PROBABLY CAUSE THE SWING TO STOP?

A. MORRIS' WEIGHT.

B. THE LENGTH OF THE ROPES HOLDING THE SWING.

C. THE RUBBING OF PARTS OF THE SWING AS IT MOVES.

8. WHAT WILL HAPPEN TO THE TEMPERATURE AT THE POINT WHERE THE ROPES HOLDING THE SWING ARE ATTACHED AT THE TOP?

A. NO CHANGE WILL OCCUR.

B. THE TEMPERATURE WILL RISE.

C. THE TEMPERATURE WILL DECREASE.

Page F

Have the children turn to page F but remind them they can look at the picture on page D to help them make their choice.

9. SOMEBODY PLACES A BOX IN FRONT OF THE SWING NOW SO THAT MORRIS' LEGS HIT IT WHEN HE SWINGS DOWN. IT GETS MOVED WHEN MORRIS BUMPS INTO IT. HE DECIDES TO SEE FROM WHICH POSITION HE SHOULD START SO THAT THE BOX WILL MOVE THE FARTHEST. HE SHOULD START TO SWING FROM:

A. POSITION *E*.

B. POSITION *A*.

C. IT MAKES NO DIFFERENCE.

Page G

NOW TURN TO PAGE G.

SITUATION II: JOE AND ARNIE WERE BATTING BALLS. LOIS WAS THE PITCHER AND SHE ALSO CAUGHT THE BALLS THE BOYS BATTED. JOE COULD SWING HIS BAT FASTER THAN ARNIE. HERE ARE THE QUESTIONS. CIRCLE THE LETTER FOR THE ANSWER YOU PREFER. (Allow about 30 seconds for each choice.)

1. WHAT WOULD SHE HAVE OBSERVED ABOUT THE SPEED OF THE BALLS SHE CAUGHT FROM JOE COMPARED WITH THE ONES FROM ARNIE?

A. THE SPEEDS WERE THE SAME BECAUSE BALLS CAN GO ONLY SO FAST.

B. JOE'S BALL WAS FASTER BECAUSE HIS FASTER SWING GAVE IT MORE KINETIC ENERGY.

C. ARNIE'S BALL WAS FASTER BECAUSE HE DIDN'T HAVE TO WORK SO HARD.

2. LOIS' GLOVE BECAME VERY WARM AFTER SHE CAUGHT EACH BALL. THE MOST LIKELY REASON FOR THIS IS THAT:

A. A BALL GETS VERY WARM AS IT MOVES THROUGH THE AIR.

B. THE KINETIC ENERGY OF THE MOVING BALL IS CONVERTED TO HEAT ENERGY WHEN IT IS CAUGHT.

C. BASEBALL IS USUALLY PLAYED IN THE SUMMERTIME WHEN IT IS MUCH WARMER THAN IN THE WINTERTIME.

3. IF LOIS WANTED HER GLOVE NOT TO GET SO WARM, SHE SHOULD PICK THE BALL UP AFTER IT HAD BOUNCED ON THE GROUND BECAUSE:

A. IT WOULD THEN HAVE LESS KINETIC ENERGY.

B. BOUNCING COOLS IT OFF.

C. IT WOULD BE MOVING FASTER AFTER IT BOUNCED.

Page H

Have the children turn to page H.

SITUATION III: BOBBY GOES DOWN A SLIDE AT A PLAYGROUND. AT THE TOP OF THE SLIDE HE HAS 100 UNITS OF POTENTIAL ENERGY. AS HE SLIDES HE NOTICES THAT THE SLIDE AND HIS JEANS BECOME WARM.

1. WHAT WOULD YOU PREDICT ABOUT BOBBY'S KINETIC ENERGY AS HE LEAVES THE SLIDE BEFORE HE LANDS?

A. HE WILL LEAVE THE SLIDE WITH 100 UNITS OF KINETIC ENERGY.

B. HIS KINETIC ENERGY WILL BE LESS THAN 100 UNITS WHEN HE LEAVES THE SLIDE.

C. HE WILL GAIN ENERGY AND LEAVE THE SLIDE WITH MORE THAN 100 UNITS OF KINETIC ENERGY.

2. IF BOBBY WANTS TO GO OFF THE SLIDE WITH ALMOST TWICE AS MUCH KINETIC ENERGY AS HE DID BEFORE, HE SHOULD:

A. RUB WAX ON THE SLIDE SO HE CAN GO DOWN FASTER.

B. CHOOSE A SLIDE THAT IS TWICE AS LONG BUT NOT AS HIGH.

C. CHOOSE A SLIDE THAT IS TWICE AS HIGH BUT NOT AS LONG.

3. IF BOBBY WANTS TO MAKE SURE HIS JEANS DON'T GET SO WARM, HE SHOULD:

A. RUB SOME WAX ON THE SLIDE.

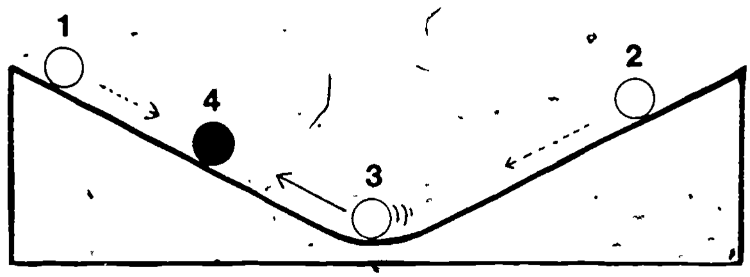
B. GO DOWN AS QUICKLY AS POSSIBLE.

C. EITHER OF THE ABOVE.

Page I

Have the children turn to page I.

HERE IS AN ILLUSTRATION FOR *SITUATION IV:*



SITUATION IV: A BALL ROLLS BACK AND FORTH ON THE COASTER AS SHOWN. IT IS RELEASED FROM POSITION 1, ROLLS TO POSITION 2, AND THEN ROLLS BACK AGAIN. AT POSITION 1, WHERE IT STARTS, IT HAS 50 UNITS OF POTENTIAL ENERGY WITH RESPECT TO THE GROUND. CIRCLE THE LETTER IN FRONT OF THE CHOICE YOU PREFER AS AN ANSWER TO EACH ITEM.

1. WHEN IT ARRIVES AT POSITION 2, THE BALL HAS 40 UNITS OF POTENTIAL ENERGY. THE AMOUNT OF HEAT ENERGY PRODUCED IN THE SURFACES WOULD BE EQUIVALENT TO:

A. 10 UNITS OF ENERGY -- THE DIFFERENCE BETWEEN 50 AND 40.

B. 5 UNITS -- HALF THE DIFFERENCE SINCE IT HAS TO GO BACK AGAIN.

C. 20 UNITS -- SINCE IT CAN STILL MOVE DOWNWARDS.

2. WHEN THE BALL ARRIVES AT POSITION 3, IT HAS:

A. MINIMUM POTENTIAL ENERGY.

B. MAXIMUM KINETIC ENERGY.

C. BOTH STATEMENTS ARE TRUE.

3. WHEN IT ARRIVES AT POSITION 3, ROLLING FROM POSITION 2, THE BALL IS FOUND TO BE MOVING WITH KINETIC ENERGY EQUIVALENT TO 30 UNITS. THUS IT CAN BE INFERRED THAT AFTER IT LEFT POSITION 1 and FINALLY CAME TO POSITION 3:

A. ITS KINETIC ENERGY WAS PRODUCED AT THE EXPENSE OF HEAT ENERGY.

B. A TOTAL OF 20 UNITS OF HEAT ENERGY WAS PRODUCED.

C. NO MORE HEAT ENERGY WAS PRODUCED GOING FROM 2 to 3. THE ENERGY WENT INTO MORE KINETIC ENERGY.

Page J

TURN NOW TO PAGE J.

4. THE BALL THEN ROLLS UP TO POSITION 4 AND STOPS BEFORE ROLLING DOWN AGAIN. WITH THE BALL AT THIS POSITION, 4, THE ENERGIES OF THE BALL AND SURFACES COULD BEST BE DESCRIBED AS:

A. A BALL WITH ABOUT 20 UNITS OF POTENTIAL ENERGY AND SURFACES WITH ABOUT 30 UNITS OF HEAT ENERGY.

B. A BALL WITH 20 UNITS OF POTENTIAL ENERGY, 20 UNITS OF KINETIC ENERGY AND 10 UNITS OF HEAT ENERGY DISTRIBUTED OVER THE SURFACES.

C. A BALL WITH A TOTAL OF 50 UNITS OF HEAT ENERGY.

1. JANICE WALKED TO THE TOP OF A HILL. SHE CARRIED A BALL WITH HER. WHEN SHE REACHED THE TOP OF THE HILL, DARRELL, WHO WAS AT THE BOTTOM OF THE HILL, THREW A SECOND BALL TO HER. COMPARE THE POTENTIAL ENERGIES OF THE FIRST AND SECOND BALLS WHEN THEY ARE AT THE TOP OF THE HILL.

A. THE SECOND BALL HAS MORE POTENTIAL ENERGY.

B. JANICE'S FIRST BALL HAS MORE POTENTIAL ENERGY.

C. BOTH BALLS HAVE THE SAME POTENTIAL ENERGY.

2. DEAN CARRIED A BASKETBALL FROM THE BASEMENT OF HIS HOUSE TO THE ROOF. HE FOUND ANOTHER BASKETBALL ON THE ROOF. COMPARE THE POTENTIAL ENERGIES OF THE TWO BASKETBALLS.

A. THE ONE HE CARRIED UP HAS MORE POTENTIAL ENERGY.

B. THE ONE THAT WAS ALREADY UP THERE HAS MORE POTENTIAL ENERGY.

C. THEY BOTH HAVE THE SAME AMOUNT OF POTENTIAL ENERGY.

3. DIANE EXERTED 10 FORCE-UNITS TO LIFT A BRICK 5 FEET. THEO STOOD ON THE ROOF OF HER HOUSE AND PULLED UP A BALL 20 FEET TO THE TOP. THEO EXERTED 5 FORCE-UNITS TO RAISE THE BALL. COMPARE THE POTENTIAL ENERGIES OF THE BALL AND THE BRICK AFTER THEY WERE LIFTED.

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C. THEY BOTH HAVE THE SAME AMOUNT OF POTENTIAL ENERGY.

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A. THE MOWER WILL ALWAYS DO MORE WORK THAN IS PUT INTO IT.

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C. SOMETIMES THE MOWER WILL DO MORE WORK AND SOMETIMES LESS WORK.

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B. THE AMOUNT OF HEAT ENERGY PRODUCED AS THE MOWER CUT THE GRASS.

C. THE AMOUNT OF HEAT ENERGY PRODUCED BY THE SUN.

3. ARNOLD DOES NOT LIKE THE IDEA OF PUTTING SO MUCH MORE WORK INTO THE MOWER THAN HE GETS OUT. WHAT SHOULD HE DO?

A. GET A LARGER MOWER.

B. OIL THE MOWER TO REDUCE FRICTION.

C. OIL THE MOWER TO INCREASE FRICTION.

4. PRETEND YOU ARE ON ANOTHER PLANET IN SPACE WHERE THERE IS NO FRICTION. A PENDULUM BOB IS PULLED BACK AND RELEASED. WHAT WILL EVENTUALLY HAPPEN TO THE PENDULUM?

A. IT WILL EVENTUALLY STOP MOVING.

B. IT WILL TEND TO SPEED UP.

C. IT WILL NEVER STOP.

5. WHAT POSITION WILL THE PENDULUM REACH AT EACH SWING?

A. THE SAME HEIGHT.

B. A LOWER HEIGHT.

C. A HIGHER HEIGHT.

6. WHY WOULD IT BE DIFFICULT TO PLAY GOLF ON THIS FRICTIONLESS PLANET?

A. THE PLAYER COULD GET A PERFECT SWING EACH TIME.

B. THE BALL WOULD STOP ROLLING TOO SOON.

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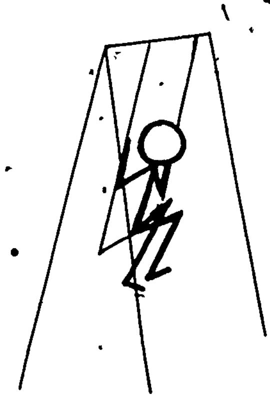
SITUATION I: MORRIS IS ON A SWING WHICH LOOKS LIKE THE ONE IN THE PICTURE. THE LETTERS *A, B, C, D AND E* REPRESENT DIFFERENT POSITIONS THAT THE SWING WILL REACH WHEN IT IS SWINGING. MORRIS AND THE SWING ARE PULLED BACK TO POSITION *A* AND THEN RELEASED.



1. AT WHICH POSITION IS MORRIS' POTENTIAL ENERGY THE GREATEST?

   A. AT POSITION *A*.

   B. AT POSITION *B*.

   C. AT POSITION *C*.

2. AT WHICH POSITION IS HIS KINETIC ENERGY THE GREATEST?

   A. AT POSITION *A*.

   B. AT POSITION *B*.

   C. AT POSITION *C*.

3. AT WHICH TWO POSITIONS IS HIS POTENTIAL ENERGY ABOUT THE SAME?

   A. AT POSITIONS *A and B*.

   B. AT POSITIONS *B and C*.

   C. AT POSITIONS *A and D*.

4. AT WHICH POSITION IS MORRIS MOVING THE FASTEST?

A. POSITION *A*.

B. POSITION *B*.

C. POSITION *C*.

5. AT WHICH POSITION IS MORRIS MOVING THE SLOWEST?

A. AT POSITION *A*.

B. AT POSITION *B*.

C. AT POSITION *C*.

6. MORRIS SWINGS FROM POSITION *A* TO *E* TO *B* TO *C* TO *D*. AT POSITION *C* WHAT CAN BE SAID ABOUT MORRIS' SWINGING?

A. HE IS SPEEDING UP.

B. HE IS SLOWING DOWN.

C. THERE IS NO WAY TO TELL.

7. WHAT WILL PROBABLY CAUSE THE SWING TO STOP?

A. MORRIS' WEIGHT.

B. THE LENGTH OF THE ROPES HOLDING THE SWING.

C. THE RUBBING OF PARTS OF THE SWING AS IT MOVES.

8. WHAT WILL HAPPEN TO THE TEMPERATURE AT THE POINT WHERE THE ROPES HOLDING THE SWING ARE ATTACHED AT THE TOP?

A. NO CHANGE WILL OCCUR.

B. THE TEMPERATURE WILL RISE.

C. THE TEMPERATURE WILL DECREASE.

9. SOMEBODY PLACES A BOX IN FRONT OF THE SWING NOW SO THAT MORRIS' LEGS HIT IT WHEN HE SWINGS DOWN. IT GETS MOVED WHEN MORRIS BUMPS INTO IT. HE DECIDES TO SEE FROM WHICH POSITION HE SHOULD START SO THAT THE BOX WILL MOVE THE FARTHEST. HE SHOULD START TO SWING FROM:

A. POSITION *E*.

B. POSITION *A*.

C. IT MAKES NO DIFFERENCE.

SITUATION II: JOE AND ARNIE WERE BATTING BALLS. LOIS WAS THE PITCHER AND SHE ALSO CAUGHT THE BALLS THE BOYS BATTED. JOE COULD SWING HIS BAT FASTER THAN ARNIE. HERE ARE THE QUESTIONS. CIRCLE THE LETTER FOR THE ANSWER YOU PREFER.

1. WHAT WOULD SHE HAVE OBSERVED ABOUT THE SPEED OF THE BALLS SHE CAUGHT FROM JOE COMPARED WITH THE ONES FROM ARNIE?

   A. THE SPEEDS WERE THE SAME BECAUSE BALLS CAN GO ONLY SO FAST.

   B. JOE'S BALL WAS FASTER BECAUSE HIS FASTER SWING GAVE IT MORE KINETIC ENERGY.

   C. ARNIE'S BALL WAS FASTER BECAUSE HE DIDN'T HAVE TO WORK SO HARD.

2. LOIS' GLOVE BECAME VERY WARM AFTER SHE CAUGHT EACH BALL. THE MOST LIKELY REASON FOR THIS IS THAT:

   A. A BALL GETS VERY WARM AS IT MOVES THROUGH THE AIR.

   B. THE KINETIC ENERGY OF THE MOVING BALL IS CONVERTED TO HEAT ENERGY WHEN IT IS CAUGHT.

   C. BASEBALL IS USUALLY PLAYED IN THE SUMMERTIME WHEN IT IS MUCH WARMER THAN IN THE WINTERTIME.

3. IF LOIS WANTED HER GLOVE NOT TO GET SO WARM, SHE SHOULD PICK THE BALL UP AFTER IT HAD BOUNCED ON THE GROUND BECAUSE:

   A. IT WOULD THEN HAVE LESS KINETIC ENERGY.

   B. BOUNCING COOLS IT OFF.

   C. IT WOULD BE MOVING FASTER AFTER IT BOUNCED.

SITUATION III: BOBBY GOES DOWN A SLIDE AT A PLAYGROUND. AT THE TOP OF THE SLIDE HE HAS 100 UNITS OF POTENTIAL ENERGY. AS HE SLIDES HE NOTICES THAT THE SLIDE AND HIS JEANS BECOME WARM.

1. WHAT WOULD YOU PREDICT ABOUT BOBBY'S KINETIC ENERGY AS HE LEAVES THE SLIDE BEFORE HE LANDS?

   A. HE WILL LEAVE THE SLIDE WITH 100 UNITS OF KINETIC ENERGY.

   B. HIS KINETIC ENERGY WILL BE LESS THAN 100 UNITS WHEN HE LEAVES THE SLIDE.

   C. HE WILL GAIN ENERGY AND LEAVE THE SLIDE WITH MORE THAN 100 UNITS OF KINETIC ENERGY.

2. IF BOBBY WANTS TO GO OFF THE SLIDE WITH ALMOST TWICE AS MUCH KINETIC ENERGY AS HE DID BEFORE, HE SHOULD:

   A. RUB WAX ON THE SLIDE SO HE CAN GO DOWN FASTER.

   B. CHOOSE A SLIDE THAT IS TWICE AS LONG BUT NOT AS HIGH.

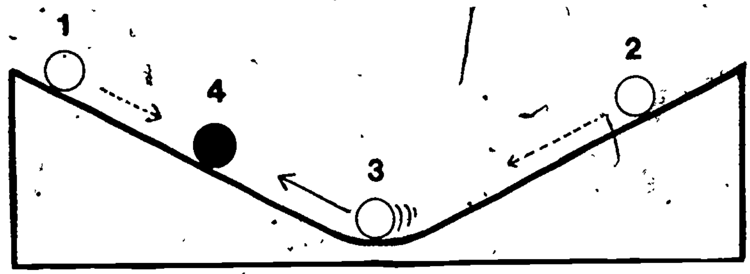
   C. CHOOSE A SLIDE THAT IS TWICE AS HIGH BUT NOT AS LONG.

3. IF BOBBY WANTS TO MAKE SURE HIS JEANS DON'T GET SO WARM, HE SHOULD:

   A. RUB SOME WAX ON THE SLIDE.

   B. GO DOWN AS QUICKLY AS POSSIBLE.

   C. EITHER OF THE ABOVE.



SITUATION IV: A BALL ROLLS BACK AND FORTH ON THE COASTER AS SHOWN. IT IS RELEASED FROM POSTION 1, ROLLS TO POSITION 2, THEN ROLLS BACK AGAIN. AT POSITION 1, WHERE IT STARTS, IT HAS 50 UNITS OF POTENTIAL ENERGY WITH RESPECT TO THE GROUND. CIRCLE THE LETTER IN FRONT OF THE CHOICE YOU PREFER AS AN ANSWER TO EACH ITEM.

1. WHEN IT ARRIVES AT POSITION 2, THE BALL HAS 40 UNITS OF POTENTIAL ENERGY. THE AMOUNT OF HEAT ENERGY PRODUCED IN THE SURFACES WOULD BE EQUIVALENT TO:

   A. 10 UNITS OF ENERGY -- THE DIFFERENCE BETWEEN 50 AND 40.

   B. 5 UNITS -- HALF THE DIFFERENCE SINCE IT HAS TO GO BACK AGAIN.

   C. 20 UNITS -- SINCE IT CAN STILL MOVE DOWNWARDS.

2. WHEN THE BALL ARRIVES AT POSITION 3, IT HAS:

   A. MINIMUM POTENTIAL ENERGY.

   B. MAXIMUM KINETIC ENERGY.

   C. BOTH STATEMENTS ARE TRUE.

3. WHEN IT ARRIVES AT POSITION 3, ROLLING FROM POSITION 2, THE BALL IS FOUND TO BE MOVING WITH KINETIC ENERGY EQUIVALENT TO 30 UNITS. THUS IT CAN BE INFERRED THAT AFTER IT LEFT POSITION 1 AND FINALLY CAME TO POSITION 3:

   A. ITS KINETIC ENERGY WAS PRODUCED AT THE EXPENSE OF HEAT ENERGY.

   B. A TOTAL OF 20 UNITS OF HEAT ENERGY WAS PRODUCED.

   C. NO MORE HEAT ENERGY WAS PRODUCED GOING FROM 2 TO 3. THE ENERGY WENT INTO MORE KINETIC ENERGY.

4. THE BALL THEN ROLLS UP TO POSITION 4 AND STOPS BEFORE ROLLING DOWN AGAIN. WITH THE BALL AT THIS POSITION, 4, THE ENERGIES OF THE BALL AND SURFACES COULD BEST BE DESCRIBED AS:

A. A BALL WITH ABOUT 20 UNITS OF POTENTIAL ENERGY AND SURFACES WITH ABOUT 30 UNITS OF HEAT ENERGY.

B. A BALL WITH 20 UNITS OF POTENTIAL ENERGY, 20 UNITS OF KINETIC ENERGY AND 10 UNITS OF HEAT ENERGY DISTRIBUTED OVER THE SURFACES.

C. A BALL WITH A TOTAL OF 50 UNITS OF HEAT ENERGY.

Scoring Guide for the Assessments

This Scoring Guide is provided for easy reference in evaluating children's performances on the Screening Assessments. As noted elsewhere, these assessments are oriented to the mastery of concepts by each child, not to the possible objective of differentiating, or "grading", the children. Each teacher should decide on a quantity index for mastery, based on the time spent on the Activities; the items have been prepared so that 70% agreement with the Scoring Guide would be considered adequate for a mastery criterion. Should the children's overall performance fall below the criteria set by the teacher, the time spent on COPES, the teacher's preparation, the children's involvement in science should be reviewed.

For each Minisequence, selected comments on the preferred and alternative responses are offered as an aid to class discussion of the Screening Assessments as a feedback for learning, if desired. In addition, an example of a small-step dialogue or discussion may be provided for a problem in each Minisequence, for use as an individual assessment-instruction for those children who do not show mastery on the Screening Assessments. The teacher may develop similar dialogues for other problems as needed.

MINISEQUENCE I Screening Assessments

PREFERRED RESPONSE	COMMENTARY
PART 1	
1. A	(C) Particles of rock have always been a part of the soil. However, they were formed from rock as it was broken up.
2. B	Under certain conditions you might find all of these (A, B and C), however the one you would be most sure to find is B.

PREFERRED RESPONSE	COMMENTARY
3. C	(A) Even though rocks are hard, moving water eventually wears them away.
4. A	No comment necessary
5. B	The organic material formed by living things makes soils feel less rough.
PART 2	
1. C	No comment necessary
2. C	No comment necessary
3. B	Generally, topsoil will hold more water than subsoil because it contains more organic material.
4. A	The organic material in topsoil increases its water-holding capacity.
5. C	No comment necessary
B	The subsoil would hold less water, therefore it would lose less weight when heated.
PART 3	
1. A	(B) Bubbles can be formed by shaking a liquid since air becomes trapped in the liquid. However such bubbles last for only a short time. Yeast cells give off a gas called carbon dioxide. Bubbles of it form the froth.
B	
2. B	(A) This is true, however, any gas will also make you belch (B) This was the test for carbon dioxide that was established in these activities.

PREFERRED RESPONSE	COMMENTARY
3. A	No comment necessary
4. C	As emphasized in these activities all living things give off carbon dioxide.
PART 4	
1. B	No comment necessary
2. C	Both air movement and relative humidity affect water loss from plants.
3. B	No comment necessary
4. A	(C) It is assumed that air movement is about the same under both conditions. The relative humidity is lower when hot air is circulated through the house.
5. C	No comment necessary
PART 5	
1. A	No comment necessary
2. A	(B) It is true that twigs will use more water indoors, however this is brought on by the higher temperature indoors.
3. B	This is essentially what happened in the insect trap in Activity 5.
4. C	(A) There is carbon dioxide in the air but living things must obtain oxygen from the air.
5. C	No comment necessary

Individual Assessment

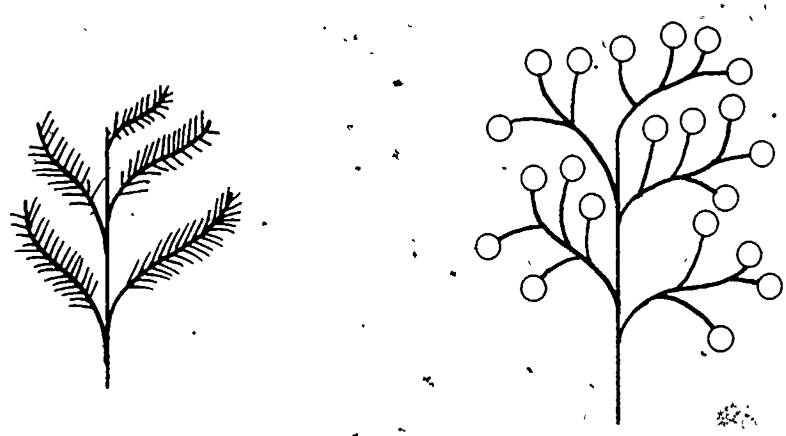
An example of a Small-Step Dialogue based on Part 4 Problem 3

Key

T: TEACHER STATEMENT OR QUESTION READ ALOUD TO THE CHILD OR SMALL GROUP OF CHILDREN.

C: *Child's possible response.*

T: HERE ARE DRAWING OF TWO KINDS OF PLANTS. (Sketch the following on the chalkboard.)



T: WHICH ONE IS MORE LIKE A PINE TREE? WHICH IS MORE LIKE A GERANIUM PLANT?

C: *The first is more like a pine tree. The second is more like a geranium plant.* (If the child cannot tell the difference, tell him which is which.)

T: HOW ARE THE LEAVES OF THE PINE TREE DIFFERENT FROM THE LEAVES OF THE GERANIUM PLANT.

C: *They are much smaller. They are long, narrow, and sharp.*

T: BECAUSE OF THEIR SIZE AND SHAPE WHAT ARE PINE LEAVES USUALLY CALLED?

C: *Pine needles.*

T: IF YOU WERE TO SPREAD OUT ALL OF THE LEAVES FROM JANICE AND MURIEL'S GERANIUM PLANT ON ONE SHEET OF PAPER AND ALL OF THE LEAVES OF THEIR LITTLE PINE TREE ON ANOTHER, WHICH WOULD COVER MORE OF THE SHEET.

C: *The geranium leaves would cover more.*

T: SINCE THE GERANIUM PLANT HAS MORE LEAF SURFACE EXPOSED TO THE AIR THAN THE LITTLE PINE TREE, WHICH WOULD LOSE MORE WATER TO THE AIR?

C: *The geranium plant.*

T: IN JANICE AND MURIEL'S EXPERIMENT WHY WERE TWO PLANTS OF ABOUT THE SAME HEIGHT SELECTED?

C: *To try to control the experiment better. If one plant were larger than the other it would not be a fair comparison.*

T: WHY WERE THE POTS AND TOP OF THE SOIL COVERED WITH A PLASTIC WRAP?

C: *To keep light, temperature, and air conditions the same for both plants.*

T: IF WATER CONDENSED INSIDE THE BAGS THAT WERE TIED OVER THE PLANTS, WHERE MUST IT HAVE COME FROM?

C: *The stems and leaves of the plants.*

T: SINCE THE MAIN DIFFERENCE IN THE TWO PLANTS WERE THEIR LEAVES, WHICH EXPLANATION (A, B, OR C) APPEARS TO BE BEST?

C: *B*

MINISEQUENCE II Screening Assessments

PREFERRED RESPONSE	COMMENTARY
PART 1	
1. A	1. The appearance of drops of water as heat energy is added is evidence that water is being driven off. The water was probably bonded to the salt, since the salt was dry to start with.
2. A	2. When the hydrate bonds re-form, heat energy is given off. This same release of energy occurs when any bond is formed.
3. C	3. In general, as the children have experienced in the Activities, the bonds holding water molecules to a salt (the hydrate bonds) break before the solid-solid bonds. When solid-solid bonds break the salt melts.
4. B	4. This sample was heated longer; thus more heat energy was added to it. Also, the color changed, whereas the other sample showed no such change.
5. A	5. The yellow salt s[illegible] has the added heat energy which had produced the yellow color from the blue salt. When water was added to one of the yellow samples it became blue again. Apparently the blue form is the hydrated form and the yellow the anhydrous (water-free) form of the salt. Thus when water was added, the yellow salt re-formed hydrate bonds, became blue and released its

PREFERRED RESPONSE	COMMENTARY
	extra energy as heat energy to the surroundings.
6. B	6. See response above.
PART 2	
Task I. A. +	A. Heat energy is absorbed in the breaking of any bond.
B. +	B. See A above.
C. +	C. See A above.
D. -	D. Hydrate bonds will be formed Thus heat energy will be given off.
E. +	E. This process involves the breaking of solid-solid bonds--thus heat energy is absorbed. Some dissolving, however, is accompanied by hydrate bond formation. If so, the combination of the two processes will result in heat energy being absorbed or liberated depending on which process predominates. This can lead to interesting side excursions for some children.
F. -	F. See D above.
Task II	
A circle should be around:	
A. white vitriol	A. Heat energy is absorbed by blue vitriol to form white vitriol--an observation made many times by the chil-

PREFERRED RESPONSE	COMMENTARY
	dren. Thus the white form has more energy. Also, whenever bonds are broken, the resulting substance (without the bonds) possesses more energy.
B. Gas	B. A liquid absorbs energy to become a gas. As the schematics have shown in discussing changes of state, a gas possesses more energy than either a liquid or solid. Gas molecules can move more freely than the liquid. If both the gas and liquid are at the same temperature the gas molecules possess more potential energy since they have been pulled away from their neighboring molecules in the liquid.
C. Liquid	C. Same argument as for B above.
D. Anhydrous salt	D. See A above.
E. Dissolved salt	E. See response to E in Task I.
F. Starch *plus* iodine	F. The complex represents a bond between starch and iodine. the breaking of a bond requires energy. Thus the same reasoning applies that when bonds break the resulting substance(s) has additional energy. In Activity 5 of this Minisequence, the children found that the deep blue color of the complex disappeared as heat energy was added. Sta Starch *plus* iodine resulted.

PREFERRED RESPONSE	COMMENTARY
PART 3	
1. B	1. Color need not change when hydrated salts are heated. The children had such experiences with salts such as epsom salt, hypo, etc. As for (C), nothing was mentioned about melting.
2. A	2. If, as suspected, the salt was hydrated, then the loss of the bonded water on heating would result in the loss of substance from the system. The sample would therefore weigh proportionately less. Melting does not change the weight of substance (see Grade 4, Minisequence I.).
3. C	3. The de-hydration process is a reversible one. If the children realize this, they should reason that as the system returns to its original hydrated condition, it will give off as much heat energy (50) units as were originally put in.
PART 4	
1. B	1. Giving off heat energy means that bonds are forming. Since water is being added, then it is most likely that hydrate bonds (water to salt bonds) are the bonds being formed. The other two responses represent the breaking of bonds--requiring the absorption of heat

PREFERRED RESPONSE	COMMENTARY
	energy--which would have cooled the sample.
2. A	2. Less solid means some dissolved in the added water. Also, if no hydrate bonds form, the dissolving process requires the absorption of heat energy. See response to PART 2, Task I, item F.
3. A	3. Lowering of temperature (cooling) means heat energy is absorbed. Thus, bonds are being broken. This can occur only in option (A).
4. B	4. Self-evident from the markedly different interactions with water.

Individual Assessment

Two small-step dialogues are provided for Minisequence II. This individual assessment assumes that item 2 of Part 1 was answered incorrectly. Similar stepwise dialogues can be used for other items. What is presented here should merely be *illustrative* of the approach to be taken. Individual children and teaching styles may call for other individual approaches.

Dialogue A:

The problem states that a salt once had some water bonded to it, but that the water had been removed. (See Key on page 128)

T: WHENEVER A BOND BETWEEN PARTICLES IS BROKEN, DOES IT TAKE IN HEAT ENERGY TO DO THIS, OR DOES IT GIVE OFF HEAT ENERGY?

C: *I'm not sure.*

T: LET US LOOK AT THE SITUATION IN A PIECE OF ICE. HOW DOES ICE COMPARE WITH LIQUID WATER?

C: *Ice is a solid and water is liquid.*

T: WHAT KIND OF PARTICLES OR MOLECULES ARE IN EACH?

C: *Water molecules.*

T: WHY IS THERE SUCH A DIFFERENCE BETWEEN ICE AND WATER?

C: *In one the particles are held in place; in the other water particles are free to move about.*

T: WELL, WE CALL THE FORCES THAT HOLD THE WATER PARTICLES IN PLACE "BONDS". WHAT WOULD HAPPEN IF YOU PUT A PIECE OF ICE ON A HOT PLATE?

C: *It would melt.*

T: WHAT DOES THAT MEAN IS HAPPENING TO THE BONDS WHICH HELD THE WATER MOLECULES IN PLACE?

C: *The bonds are being broken.*

T: WHAT WAS THE ICE GETTING FROM THE HOT PLATE?

C: *Heat energy.*

T: SO, DOES IT TAKE IN HEAT ENERGY TO BREAK THE BONDS?

C: *Apparently.*

T: AND WHERE DID IT GET IT?

C: *From the hot plate.*

T: WHAT HAPPENS IF YOU PUT ICE IN A SAMPLE OF WATER?

C: *It melts.*

T: WHAT HAPPENS TO THE TEMPERATURE OF THE WATER?

C: *It goes down.*

T: WHERE DID THE ICE GET ITS HEAT ENERGY TO MELT?

C: *From the water -- its temperature went down.*

T: NOW LET US REVIEW -- WHAT DOES IT TAKE TO BREAK A BOND? DOES IT ABSORB HEAT ENERGY? OR DOES IT GIVE IT UP?

C: *Heat energy is absorbed -- it is used to break the bond.*

T: LET US NOW LOOK AT A DIFFERENT KIND OF SOLID. HERE WATER MOLECULES ARE STUCK ON, OR BONDED, NOT TO EACH OTHER BUT

TO MOLECULES OF A SALT. (A schematic of the model on page 143 of the Guide can be shown the child). DO YOU REMEMBER WHAT THE BLUE VITRIOL LOOKED LIKE?

C: *It was blue.*

T: DID IT LOOK AS IF IT HAD LIQUID WATER IN IT?

C: *No, it looked dry.*

T: SO THE WATER MOLECULES WERE NOT FREE TO MOVE ABOUT. WHY DO YOU THINK THIS IS SO?

C: *I guess they were held in place by bonds, as the ice was.*

T: IF I ADDED HEAT ENERGY TO THESE BONDS WHAT DO YOU THINK MIGHT HAPPEN?

C: *These bonds would also break.*

T: IS HEAT ENERGY ABSORBED OR GIVEN OFF TO BREAK THIS BOND?

C: *Absorbed -- that is, taken in.*

T: THERE ARE SOME NAMES USED TO DESCRIBE SALTS WHICH HAVE BONDED WATER. (If the child does not remember the names, tell him that salts with bonded water are called *hydrated* salts, and if the water is removed we call them *dehydrated* or an *anhydrous* salt. It is not essential he remember the names but he should be aware of the properties of a "de-watered" salt versus one with bonded water). LET US LOOK AT THE RETURN "TRIP". IF HEAT ENERGY IS ABSORBED TO BREAK A BOND, WHAT DO YOU THINK IS INVOLVED IF WE PUT SOME WATER MOLECULES BACK ON THE DEHYDRATED SALT?

C: *We have to form bonds between the salt and water molecules.*

T: IF HEAT ENERGY MUST BE ABSORBED TO BREAK A BOND, WHAT DO YOU THINK WILL BE OBSERVED WHEN A BOND FORMS? WILL HEAT ENERGY BE ABSORBED AGAIN OR BE GIVEN OFF? REMEMBER WE ARE MERELY REVERSING THE PROCEDURE.

C: *Heat energy should be given out.*

T: AND WHAT DO YOU EXPECT TO HAPPEN IF SOME MOLECULES OF WATER COME INTO CONTACT WITH A SALT WHICH HAD ITS ATTACHED WATER MOLECULES REMOVED? (Use the schematic to illustrate this)

C: *The water molecules will stick to or bond to the places where they were before.*

T: THEN WHAT IS THE CORRECT RESPONSE TO THE QUESTION? (You may wish to repeat it with its options.

C: *(A)-heat energy is given off.*

T: AND HOW WOULD YOU KNOW IF HEAT ENERGY WERE GIVEN OFF?

C: *The surroundings would get hot.*

At this point you might wish to remind them of their experience with the blue vitriol. When water was removed, it became white. When water was re-bonded, the blue color returned -- evidence of the re-bonding -- and the tube became very hot.

Dialogue B:

If the child answered the item above incorrectly, he may very likely also answer an item such as (C) in Task II of Part 2 incorrectly. Based on the same reasoning pattern developed above and using ice as an example of a solid, here is a suggested form of questioning:

T: IN WHICH DO THE PARTICLES MOVE ABOUT MORE FREELY, SOLID WATER OR LIQUID WATER?

C: *Liquid.*

T: WHAT DID IT TAKE TO MELT ICE?

C: *Heat energy had to be absorbed.*

T: WHERE IS THIS HEAT ENERGY AFTER THE ICE IS MELTED?

C: *In the particles of freely moving liquid water.*

T: NOW, WHICH HAS MORE ENERGY, THE SOLID ICE OR LIQUID WATER?

C: *Water.*

T: WHICH DO WE CIRCLE IN ITEM C?

C: *Its liquid.*

A similar discussion with individual children can be directed to the other items in Part 2. Each item deals with the absorption of heat energy or its liberation as bonds are either broken or formed, and the corollary that the substances formed when heat energy is absorbed will then possess this added heat energy.

MINISEQUENCE III Screening Assessments

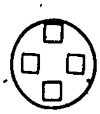
PREFERRED RESPONSE	COMMENTARY
PART 1	
1. B.	1. No comment (definition).
2. A.	2. No comment (definition).
3. B.	3. Since it is but part of the starch-iodine complex, the starch molecule must be smaller than the complex.
PART 2	
1. B.	1. Cells are part of leaves. In addition, not all living things possess leaves.
2. A.	2. Crystal shape is characteristic of a particular crystallizable substance, although the size may vary.
3. A.	3. By definition, a hydrated salt is one which contains bound water molecules, but not all salts are hydrated.
4. A.	4. Copper is one component of the salt called blue vitriol (also called copper sulfate). It is but one of the atoms making up the blue vitriol molecule.
5. B.	5. No comment.

PART 3

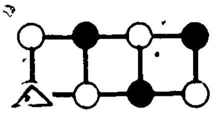
The intent of this group of questions is to assess the children's awareness of 1) conservation of units--to account for all units even during an interaction interchange and 2) the mechanism of the interchange, where units merely replace each other or where units would be either gained or given up. In one sense these items can be considered as models of molecules, where the symbols within the structure represent either an atom or a smaller molecule within a larger one.

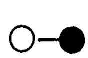
PREFERRED RESPONSE

1. 

2. 

3. 

4. 

5. 

COMMENTARY

1. Three triangles should be drawn since three circles were added for the exchange. If only one triangle is inserted over the question mark, the child has exchanged the proper shaped unit but is not conserving numbers of units.

2. Since all 4 circles are shown removed then there should be 4 squares within the large circle.

3. Only 1 △ is illustrated as exchanging with one ○, therefore one circle should be shown as "freed".

4. The △ should be inserted in a place for <u>any one</u> of the 4 black circles. The rest of the structure remains the same. The operation represents a single exchange of a △ "atom" for a ● "atom".

5. Since 2 squares are shown as the "product", then all that is required for the response is to indicate

PREFFERED RESPONSE

COMMENTARY

removal of the square "atoms" from the original "molecule". The preferred response also shows that lines to the squares are removed. In the models developed by the children these lines represented the "bonds" between unit particles. If the particle is gone (as the removal of the squares in this example) then the bond line should also be removed. However, not all children may indicate this. The major import is the removal of the squares from the model.

PART 4

1. A

1. The information has been given that a model of the molecules in the blue solution can be represented by △—○ whereas the model of the yellow molecules is represented by □—○. Molecules of salts containing copper are blue. Since also appears in the yellow solution, it must stand for the sulfate and the triangle stand for the copper. In (B) the triangle cannot stand for the iron since it represents part of some blue molecules. The children have found that when iron took the place of copper, the blue color disappeared. (C) cannot be correct since both the circle and the triangle are symbols for the molecules in the blue solution, and from their experience the copper does not pair up with the iron to form

PREFERRED RESPONSE	COMMENTARY
	a soluble salt.
2. B.	2. One of the interactions they have been investigating, which identifies a copper salt, is the displacement of copper out of solution by iron. Copper will not come out of combination merely by filtering. The blue solutions of copper salts will go right through the filter. Nor can any copper be observed visually in a blue solution of a copper salt.
3. A.	3. As in (2) above, copper salts are identified by their interaction properties with metals. Although the experience noted in this item may not be part of the sequence (but was proposed as an extending experience) the children should be able to infer that the replacement interaction will proceed in the same manner as the iron with the copper sulfate. Since the metal will get used up, (as the iron in the nail did) a hole will appear in the pan. Actually the aluminum interacting with copper chloride is very rapid and takes place with great evolution of heat energy.
PART 5	
1. C.	1. Dissolving does not change composition. The same crystal shape should be obtained when the water evaporates.
2. C.	2. The change in crystal shape

PREFERRED RESPONSE	COMMENTARY
	would indicate that a substance of different composition (a different salt) was formed by the interaction with the white powder. (A) is incorrect since the crystal shape has changed--from diamond to needle-shaped.
3. B.	3. The color produced in a flame is characteristic of a particular unit particle--whether in the free form, as a metal, or combined with other units, or atoms, in a molecule. Since the flame is still red, then whatever change occurred in the molecule, as indicated by question 2, the unit responsible for the red flame was still present in the new molecule. Also, the unit particle obtained in exchange from the white powder either does not produce a characteristic flame color or the temperature of the sterno flame is not high enough.
4. C.	4. (A) is expected as long as some of the metal wire is present. The interaction will take place producing more of the green colored molecules. (B) is also true since a substance different in properties (the green color) appears. Thus the preferred inclusive response is (C).
5. A.	5. This process is similar to the exchange interaction they have been investigating between the iron nail and the copper sulfate solution. In that instance a model of the interaction was developed as an exchange of iron

PREFERRED RESPONSE	COMMENTARY
	units from the nail (atoms of iron) for copper units in the blue vitriol molecule.
6. B.	6. The colors produced in a flame are characteristic of a particular unit or atom, whether "free" (as in a metal) or combined, as in a salt. The yellow flame color of sodium would be obtained if metallic sodium were heated or if common table salt (sodium chloride) were tested in the flame. Thus, in this test item, if the flame is no longer red, the atom (or particle in some children's language) responsible for that red flame is no longer a part of the green molecule. It was probably replaced by the metal atoms in the interaction with the wire. (A) is a complete distractor. The combination of green and red colors would not result in purple.
7. B.	7. Since it is suspected that the newly formed green molecules have just acquired atoms from the metal wire, it could be inferred that the new flame color (purple) is a property of the metal wire atoms. (A) should not be expected since the original salt (before interaction with the metal wire) made the flame red.
8. A.	8. It would be suspected that the newly formed green molecules as discussed above would also produce green crystals. The children have observed similar results within the Activities when they obtained blue crystals

PREFERRED RESPONSE | COMMENTARY

from the blue solutions of copper sulfate. (B) There is no reason to expect needle-shaped crystals. (C) The color produced in the flame is not necessarily associated with the color of the solutions. Thus the sodium salts forming colorless solutions produce very intense yellow flames. In the flame, however, these green crystals would make the flame purple.

PART 6

This part of the assessments tests for concepts c, d, f and g. Task I tests for concept d; Task II, concept g; and Task III concept c.

TASK I

a. schoolium

b. chloride

c. teachium

d. copium

I.

No comments. These are simple exchanges.

TASK II

"Y" should be placed over teachium sulfate and teachium in (a).
"Y" should be placed over teachium sulfate and teachium in (c).

II.

If children place a "Y" *only* over the teachium then they have missed the point that the color of the flame is characteristic of the unit particle (atom) whether bound up with other units or not.

PREFERRED RESPONSE	COMMENTARY
"R" should be placed over copium and copium chloride in (b); "R" should also be placed over copium and copium sulfate in (c) and copium chloride and copium in (d).	The same comment applies to the placement of the "R".
TASK III	III.
There should be a square placed next to: (a), (c) and (f). There should be a line placed next to: (b) and (d).	No comments.

Individual Assessment

The activities within the Minisequence itself are rich with experiences for the children. A review, or a repeat, of the interaction properties investigated between copper sulfate and iron is suggested if the child has answered incorrectly items such as 2 and 3 in Part 4, and Parts 5 and 6. Although concepts other than those dealing with the interaction are tested in these parts, it is this interaction concept which is paramount. Thus the present discussion centers around this concept. In addition, *model building* has been emphasized in the Minisequence. The interaction mentioned above has been used to develop the *model* of the molecule as being composed of smaller parts (atoms), which parts can be exchanged one for the other. This idea may have to be re-presented and reviewed with those children who have answered Parts 3 and 6 incorrectly.

The items in Part 3, in particular, are an extension of the concept of representing "parts of wholes" and the interchange of the "parts". The items are set up so that the child not only must keep track of the specific particle being exchanged (identified by a specific symbol) but also must keep track of *how many* particles -- as a one-to-one exchange is made. If the child has answered the question incorrectly, go over each item with him or her, emphasizing both number and shape of the symbol. In item 4 be sure there is only one exchange made -- i.e., only one triangle is shown as a "reactant" and only one black circle as a "product". The triangle is to be inserted in any one of the four places occupied by a black circle.

The rest of the model should be repeated as presented.

For another review, consider Part 5 with its 8 questions. Several concepts which were developed in a number of the Activities are tested in this part of the assessment. Question 1 deals with concept (c) and its corollary, concept (e). The crystal shape obtained from a particular substance was used throughout these Activities to identify the presence of that substance. If a child answers this question incorrectly, re-introduce the experiences of Activity 1 and let him dissolve and recrystallize several times some specific salts such as sodium chloride, potassium chloride, epsom salt and copper sulfate. The child should find that particular shapes will always be formed from particular substances.

If question 2 is incorrectly answered, you can refer to the "sameness" of the crystal shapes from a specific substance and re-present the experiences with the interaction between the iron nail and the copper sulfate. A typical line of question can then be pursued, as follows:

WHAT WAS THE SHAPE OF CRYSTAL OBTAINED FROM COPPER SULFATE?

WHAT SHAPED CRYSTAL WAS OBTAINED AFTER THE IRON INTERACTED WITH THE BLUE COPPER SULFATE?

WAS IT STILL BLUE?

WHAT ABOUT THE SHAPE?

WAS IT THE SAME SUBSTANCE OR A DIFFERENT SUBSTANCE?

WHAT IS THE EVIDENCE? (Color had changed; crystal shape was different).

If you feel it desireable, have the children repeat the experiment as found in the second part of Activity 3.

Question 4, Part 5 is illustrative but not identical with the interactions they have been investigating. Again, emphasis is on the fact that if the properties have changed, it is a signal that a different substance has been formed by the interaction.

IF THE SOLUTION IS GREEN, WHAT WOULD THEY THINK IS THE COLOR OF THE DISSOLVED MOLECULES? (Green)

WERE THE "GREEN" MOLECULES PRESENT BEFORE THE METAL WIRE WAS PUT IN? (No).

SO, IT MAY BE A NEW MOLECULE. WHAT WAS DIFFERENT IN THIS SOLUTION THAT MIGHT HAVE MADE IT BECOME GREEN? (The metal wire).

THE GREEN SOLUTION RESULTED FROM THE METAL. IF MORE "GREEN" MOLECULES ARE PUT INTO THE SOLUTION, WHAT WOULD THEY PREDICT ABOUT THE COLOR? (It would get darker green).

WHAT ABOUT THE RESPONSE TO OPTION A?

IS IT CORRECT OR NOT? (Correct).

WHAT ABOUT B? IS THE "GREEN" MOLECULE DIFFERENT FROM THOSE IN THE COLORLESS SOLUTION? (Yes, definitely -- it is a different color).

THEN IS B CORRECT ALSO? (Yes)

SO WHAT IS THE PREFERRED RESPONSE TO THIS QUESTION? (It must be C, since both A and B are correct).

MINISEQUENCE IV Screening Assessments

PREFERRED RESPONSE	COMMENTARY
PART 1	
SITUATION I:	
1. The h.e.u. in each sample are: sample A: 30 (1 x 30) sample B: 100 (2 x 50) sample C: 40 (4 x 10) sample D: 60 (1 x 60) sample E: 50 (1 x 50) sample F: 140 (2 x 70) sample G: 180 (3 x 60) sample H: 80 (2 x 40)	
2. The graphs for the mixes for each pair of samples should be:	
pair #2: 5 spaces across and up to the 20°C line	The mix for #2 contains a total of 100 h.e.u.; 5 measures of water and therefore a T of 20°C.
pair #3: 3 spaces across and up to between 60° and 65°C	This mix contains a total of 190 h.e.u.; 3 measures of water and therefore a T of 190/3 = 63+°C.
pair #4: 5 spaces across and up to between 50 and 55°C (52°C)	This mix contains a total of 260 h.e.u.; 5 measures of water and a T, this, of 52°C (260/5).

PREFERRED RESPONSE	COMMENTARY
3. pair #2: shade in squares on the graph for sample D from 20 to 60°C. pair #3: shade in squares on the graph for sample F from 63 to 70°C pair #4: shade in squares on the graph for sample G from 52 to 60°C	3. The final mix is at a temperature lower than one of the samples. The effect of physically mixing the two is similar to that of transferring heat energy through a wall, as in Activity 3. As in the activity mentioned, the higher temperature sample has, in effect, transferred the shaded heat energy units to be distributed throughout the molecules of the lower temperature sample. The "evening-out" process on the graph is in effect an averaging of the h.e.u. amongst all the measures of water (see e.g. Mini III of Grade 3 and the Mini II Water-Mix of Grade 4).
4. circle the samples B, D, E and G.	4. These samples are above 45°C, the melting temperature of the solid.
5. B	5. It is only temperature which determines if a solid will melt. Some children may incorrectly select (A) since they are aware that heat energy is absorbed during the melting process. However, the temperature of the system must be above the melting temperature of the solid. This is an example of conservation of energy (all the h.e.u. are present in the mix) but also of degradation of energy--it can no longer melt the solid. The energy is available, but at a lower temperature.
6. C	6. Some mixes are at temperatures lower than 45°C.

PREFERRED RESPONSE	COMMENTARY
SITUATION II:	
1. C	1. Heat energy depends on the product of V and T. The large sample of cool water has 10 x 10 = 100 h.e.u. The small sample of hot tea has 1 x 80 = 80 h.e.u.
2. A	2. Transfer of heat energy occurs from the higher temperature sample to the lower (no matter what the heat energy content is).
3. A	3. Whenever two parts of a system in thermal contact are at different temperatures heat energy transfer will take place until all parts are at the same temperature, unless heat energy is continually supplied. Some may incorrectly select (C) since the smaller sample transferred some of its heat energy to the cooler water. Also, if they had incorrectly selected B in (2) above then they might select B here also, if they have not understood the concept that while standing in contact temperatures will become equal throughout all parts of a system.
4. C	4. There is a physical barrier, although not to thermal energy exchange. The separating wall is not the same as the semi-permeable membrane they used with the food colors. Thus, the orange-colored molecules of tea cannot pass through the glass.

PREFERRED RESPONSE	COMMENTARY
SITUATION III:	
1. B	1. As stated above, heat energy transfers when 2 objects are in thermal contact and a temperature difference exists between them. In this situation Darrell's hand is warmer than the bike. There will therefore be a transfer of heat energy *out* of his hand, which results in the sensation of his hand feeling cool. (A) is a common misconception.
2. A	2. Since the metal is now at a higher temperature than Darrell's hand, the transfer will be from the bike *to* the hand. These transfers (as in 1 above) take place readily with metals since they are such good conductors of heat energy. In this second question, Darrell's hand will feel very warm when he touches the bike. As stated above, B is a common misconception.
	Both these situations are classic examples used frequently to illustrate the direction of heat transfer.
SITUATION IV:	
1. B	1. See all the prior comments on the direction of heat energy transfer.

PREFERRED RESPONSE	COMMENTARY
PART 2	
1. B	1. No further comment--this is a major concept developed in this Minisequence.
2. A	2. Heat energy is conserved in mixing. This is the basis for predicting the temperature of mixes of water samples, as done in Activities 1 and 2.
3. A	3. Based on their observations in Activity 4.
4. A	4. As colored molecules move (diffuse) away from their source, the color appears to be evenly distributed throughout the region. The overall effect of such a diffusion will be a lighter color throughout the larger region--it will be at a lower concentration. Similarly, in mixing hot and cold water, the mix will be at a lower temperature than the hot sample.
PART 3	
1. B	1. Diffusion of the orange colored molecules from the region of the tea bag takes time.
2. A	2. It is expected that complete mixing or diffusion would have occurred in this time.

PREFERRED RESPONSE	COMMENTARY
3. B	3. Although the odor will still be strongest next to the flowers (the source), molecules possessing the sweet flower odor would have diffused throughout the room. C is not correct. The flowers are still in the room, therefore the odor would be present throughout the room.
PART 4	
SEQUENCE I:	
A on the picture to the left Z on the picture in the middle.	Molecules diffuse from regions of high concentration to low; they also tend to distribute evenly throughout available space--unless an outside agent removes or adds some.
SEQUENCE II:	
A on the picture to the right Z on the picture to the left OR A on the picture in the middle Z on the picture to the left	In the first preferred response for this sequence the higher concentration of "colored" molecules starts off *outside* the bag. The middle would be impossible since all the molecules could not move into the bag. In the second acceptable response, the right picture is impossible in such a sequence since the molecules would be most unlikely to go out of the bag completely.
SEQUENCE III:	
A on the middle tube Z on the left tube	Again the pair is chosen which represents the net movement of molecules from

PREFERRED RESPONSE	COMMENTARY
	from higher to lower concentration regions until the concentration becomes equal throughout the region. This occurs even if it appears to go "against gravity".
SEQUENCE IV:	
a) X on the graph to the right	a) The highest temperature would be at position #1--nearest the source of heat energy. This situation is similar to the measurements of temperature along the nail which was heated at one end with a candle (Activity 7).
b) B	b) the coolest position.
c) Dots should be placed at the same height as position 3 at the lines designated for positions 1, 2, 4 and 5	c) Once the source of heat energy is removed, the temperature becomes equal throughout the spoon.

Individual Assessment

For those children who do not meet the teacher's standards of performance on the Screening Assessments, we suggest individual discussions of the items with elaboration of the commentary on the preferred, and when offered, the alternative responses. In particular, we suggest step-wise review of the items in Part 1 and the time-sequences in Part 4 with the individual child. No small-step dialogue example is offered for this Minisequence.

PREFERRED RESPONSE	COMMENTARY
PART 1	
SITUATION I:	
1. Figure C	1. Diffusion is greatest in this tube. It could not be Figure B since the blue food coloring molecules would not all sink down to the bottom but would spread throughout the tube. Even if they had been placed in the bottom of the tube, and gelatin or water carefully added above them, with time all the molecules would have diffused throughout as pictured in Figure C, the preferred response.
2. Figure C	2. It could not be Figures A or B since in these tubes all the blue food coloring molecules are concentrated in a small volume, either at the top or the bottom of the tube. In C the colored molecules are spread out over the total volume. Their concentration is less, although their numbers may be the same. Since the concentration is less, this tube will appear to be less blue.
SITUATION II:	
1. ● and ○ should be intermixed, evenly in the middle with a greater con-	1. After several weeks both red and blue molecules would have diffused throughout the

PREFERRED RESPONSE	COMMENTARY
centration of ● at the top and ○ near the bottom.	bowl, but there would still remain higher concentration of red near the bottom and blue near the top.
2. bluish violet	2. see #1 above (blue plus a little red)
3. purple or violet	3. see #1 above (Roughly equal amounts of blue and red).
4. N	4. Diffusion is a "spreading out" process; hence it always takes place in the direction of lower concentration, whether or not this is in the downward direction.
5. N	5. Our concept of molecular movement is that all molecules move randomly in all directions. The net effect of the movement results in the observation of diffusion from a boundary layer. See concept (f).
6. Y	6. See response to 5 above.
7. Y	7. Concept (f) again.
8. N	8. It is just the reverse. This is an extension of the concepts developed in the previous Minisequence IV, where both molecules and heat energy were observed to transfer from high concentration or high temperature regions to lower concentration or lower temperature regions.

PREFERRED RESPONSE

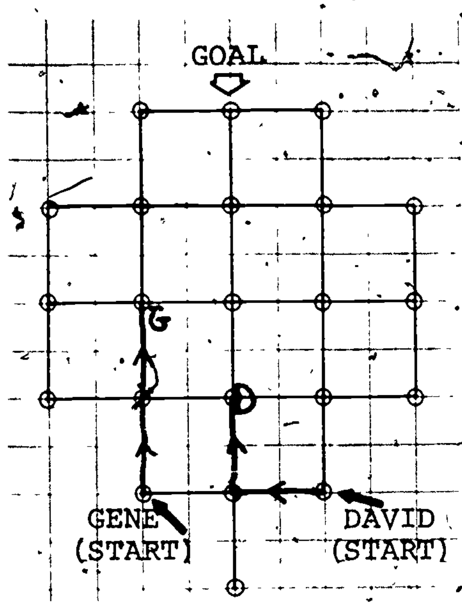
COMMENTARY

9. Y

9. See concept (f) and discussion on 5 above.

SITUATION III:

1.



1. Follow instructions. The arrows indicate the path.

2. N or C

2. The number of steps to the goal is the same. The *a priori* probability of any of the four directions (Forward, (F), Backward (B), Left (L) or Right (R) is the same. Therefore the probability for each of the players taking the shortest route is the same. A complete analysis of this game is quite complex, involving such things as probabilities of being on the edges where a player may lose his turn. For instance, the fact that David is closer to the right-hand edge might result in his losing a turn. But this may be offset by the higher chance that Peter may lose a turn, even though his path is straight, since initially, he can move only forward (F).

PREFERRED RESPONSE	COMMENTARY
	If the child perceives all the possible complexities of the game, he or she may quite properly mark C.
3. Y	3. The result of any one spin is independent of the previous spins. This is a basic concept in games of chance, such as spinners, introduced to children as early as the Grade 4 teaching materials.
4. N	4. It would be lhe same for each player--two chances out of four, or one out of two would result in loss of a turn, since these directed moves cannot be made. Hence the probability of each losing a turn can be expressed as 1 out of 2, or p (probability) = ½.
5. Y	5. Peter can move in only one direction; therefore he has 3 chances out of 4 of losing a turn. Becasue of his starting position he can only move forward (F).
6. Y	6. As the players make their third move, they are in positions marked for the response to question #1 above. In those positions, David will not lose a turn, since he can move in any one of the four directions. Thus we can say his probability of *losing* a turn is zero. (p = 0). But Peter is at an edge and thus he has two chances (out of four) of losing a turn--if

PREFERRED RESPONSE	COMMENTARY
	his spin directs him to move back or to the right. Peter's probability of losing a turn is thus 2 out of 4 ($p = \frac{1}{2}$).
7. C	7. It is impossible to tell which child would be closer. As an *estimate*, David has a better chance of being closer than Gene does, because Gene has the greater risk of losing a turn.
8. Y	8. This is the general principle that a large sampling, or many random moves, would result in an overall predictable pattern. They have observed this, starting in Grade 3, with respect to sampling size. It was also reinforced in Activity 2, where they observed uniform spreading of the children throughout the room, although each child's individual moves were random (dictated by chance stopping of the spinner) and could not be predicted. This sampling idea also emerged from the data on averaging counts from the Geiger counter.
9. Y	9. The analog is not exact since molecules would not lose a turn but rebound into an available space after hitting a wall, etc. but it is close.

PREFERRED RESPONSE	COMMENTARY
PART 2	
1. Y	1. Looking at the grid, there are 10 sums greater than 4 out of a total of 16. Thus the probability of getting a sum *greater* than 4 on Rita's next turn would be 10 out of 16 (10/16 = 5/8), which is greater than ½.
2. N	2. Each player's throws are independent of the other's. This is the same case as the spinner in *SITUATION III* of Part 1.
3. Y	3. Looking at the grid, the sum of 5 occurs more times than any other sum. (p = 4/16 or ¼).
4. N	4. Same as response to #2 above.
5. N	5. Each throw is independent, as discussed in #2, no matter what the previous throw was.
6. Y	6. Looking at the grid, a sum greater than 4 has the highest expectancy. See response to item #1 above.
7. Y	7. As in getting a sum greater than 4, getting a sum *less* than six also has a high expectancy. Looking at the grid, there are 10 possible sums less than six. Thus, its probability would be 10 out of 16 (p = 10/16 = 5/8).

PREFERRED RESPONSE	COMMENTARY
8. Y	8. Since each player's throws are independent of the other's and of previous throws, there is an equal chance that either one will win the same number of plays. Winning, of course, cannot be predicted for any given individual throw--but the overall average effect will be than each one should have the same number of wins.
9. Y	9. See the grid. There are four possible sums yielding 5 and only two possible sums yielding 7. Thus, over a long series of throws, the results should reflect the theoretical probability. In grade 5 children confirmed the theoretical predictions on probable throws of a pair of dice and found that the data did eventually reflect what was predicted from the grid.
10. Y	10. The greater the number of turns, the greater is the chance that any possible value, even though it can result from only one combination, will occur. Of course, as stated in the commentary for #5, one cannot predict a specific value for a particular throw or pair of throws in advance. One can only predict the probability for that sum.
11. C	11. Although the most frequent value (the mode) in A is the same as in M, the spread is a bit small. The range depicted in B seems more

PREFERRED RESPONSE	COMMENTARY
	reasonable. Also, the most frequent value is close to 5, a value one should expect. But this sample size is rather small, and the data depicted in *either* A or B could easily occur in these few chance events.
12. Y	12. The larger the number of chance or random events the more order will appear in the total collection, as seen in a histogram of the data. These ideas were expanded upon in Grade 5, Minisequence V; see concept (c).
13. C	13. The 101 to 110th set of throws is independent of the first 100 sets. Contrast the situation here with a sample of only 10 pairs of throws with the response to #12 above with its 100 pairs of throws. See comment #11 regarding sample size.
PART 3.	
1. B	1. Chance is the most reasonable explanation.
2. C	2. This is but one example of expected variation in measured data (variability). (A) cannot be so, either from sampling theory or from actual observations on rainfall. (B) is ambiguous.
3. B	3. Of course, (A) cannot be considered. And (C) is

PREFERRED RESPONSE	COMMENTARY
	inadequate since, based on expected variability, the average may not be *reproduced* in a particular square. (B) is the best response according to experimental standards and also corresponds to the U.S. Weather Bureau's recommendation.
4 B	4. A and C contradict both the description of the storm and the concept of expected inherent variability, or variations, in data.
5. B	5. (C) cannot be true since, again, because of inherent variability, the pattern of rainfall will not be expected to be identical in all sectors. The correct response, B, takes into account the description of what happened in the storm as it progressed and of expected variations in the collected data. A is an unlikely situation, since such regularity is not to be expected.
6. A False	6. A. See above discussion on expected variability in the rainfall.
B False	B. Again, expected variability in the results would preclude the truthfulness of this statement.
C True	C. Since the highs and lows are evened-out when an average is calculated, comparisons of averages will show less variations.

PREFERRED RESPONSE	COMMENTARY
7. Figure #1	7. A single set of measurements, as portrayed by the dotted, lines on the histogram, would exhibit more deviations from the average than depicted in figure #2. The data in #2 shows too much agreement between the one set of measurements and the averages of *all* the ten gauges positioned at different locations in the field.

PART 4

SEQUENCE I:

A *Z* should be placed on the picture in the lower left; an *M* on the picture in the upper right.	The lower left picture of the black and white marbles shows the greatest degree of "mixing" of the two types of marbles. This least amount of *order* is most likely (probable) after long-term shaking. The upper right exhibits a moderate amount of distribution of the black marbles with the whites. Thus it is selected for that desription of the situation after half the length of time. The upper left picture exhibits a very high degree of order in the distribution of the black marbles. Thus, it would be least likely to be expected by random movements of the marbles on the shaking table. The initial picture shows a high degree of order in that all the black marbles are bunched together. The lower right picture is only slightly different. Therefore it should not be se-

PREFERRED RESPONSE

COMMENTARY

lected for a most likely arrangement after shaking for a long time or even "half-time" unless the table were tilted in that direction. Chance movement, of course, would not preclude the possibility that uniform arrangement or clumping of marbles might show up at the end of the sequence...but this is considered unlikely; that is, of low probability, but not impossible.

SEQUENCE II:

An *A* should be placed on the upper right; a *Z* on the lower right.

The upper left is impossible. A solution of blue vitriol would not layer in the middle of water. It is most likely that the sequence starts with a pool of blue solution as shown in the upper right. The completely diffused state as shown in lower right is most likely last in the sequence. If a layer forms from the pool, depicted in the upper right, then the lower left is a possible middle picture for the sequence. However, this question was not asked; and diffusion out from the pool of that marked *A* would probably not result in such a uniformly distributed layer but would start to diffuse up as well as sideways from the pool.

Individual Assessment

No small-step dialogue example is offered for this Minisequence, because of the examples for previous Minisequences (I, II & III) and the very detailed discussions in the commentary for the Screening Assessments in the above Scoring Guide. Depending on the particular items an individual child may have not met your performance expectancy, you may wish to re-present the items as you discuss his or her responses in detail with the child.

PREFERRED RESPONSE	COMMENTARY
PART 1	
1. C	1. The potential energy (P.E.) of an object depends only on the work required to get it to a particular position. Work to lift an object is operationally defined as the product of the weight of the object (the force required to lift it) and the distance lifted. It does not depend on <u>how</u> the object arrived at a particular position.
2. C	2. See comment for (1) above.
3. A	3. The work performed by Theo on the ball (5 x 20) is more than Diane performed on the brick (10 x 5). Therefore, the ball has more P.E. since it was lifted higher, even though it weighs less than the brick. (B) is incorrect since the P.E. of the brick is only 10 x 5 = 50 units. If, however, Diane had lifted <u>three</u> bricks, using 30 (3 x 10) force units to lift, then Diane's group of bricks would now have a P.E. of 150 (30 x 5) even though Theo's ball was lifted higher. The work to lift, and thus the P.E. of an object, depends on the <u>product</u> of total weight and height lifted.

PREFERRED RESPONSE	COMMENTARY
PART 2	
1. B	1. In mechanical systems, particularly where parts rub against, or move over each other, there will be friction resulting in the production of some heat energy at the expense of some mechanical energy. This inefficiency of the mower will result in less work output.
2. B	2. See comment above.
3. B	3. Lubricating by oiling metal parts will reduce friction and thus reduce the amount of mechanical energy converted to heat energy. (A) is not an acceptable response since changing the size of the machine will not necessarily reduce friction.
4. C	4. Once the bob is raised (given some P.E.) and then released it will start to swing. If there is no loss in mechanical energy due to friction then the bob will continue to swing--never stopping. Of course, our real world is not a frictionless one and so a bob would eventually stop swinging. (A) describes what would occur in our real world.
5. A	5. Since there is no "loss" of mechanical energy due to friction, (A) is true. (C) cannot be true because that implies that the bob is getting <u>more</u> energy. This is impossible unless an outside agent supplied it.

PREFERRED RESPONSE	COMMENTARY
6. C	6. See response to (4) above.
PART 3	
Situation I:	
1. A	1. This position is at the greatest height.
2. B	2. At the lowest position (B) all the potential energy with respect to this position has been converted to kinetic energy (K.E.). Thus maximum K.E. is at B.
3. C	3. (A) and (D) are at about the same heights above the ground.
4. B	4. He will be moving the fastest at that position where he has maximum K.E. (See response to (2) above.) Some children may reason that at position (C) the swing is moving up to (D). In order to get there the swing has to be moving somewhat rapidly. But at position (C), which is higher than (B), part of the K.E. the swing had at (B) would have been converted to P.E. (C) is thus an incorrect response
5. A	5. At (B) he is moving most rapidly (see above). At (C) he is either moving up to (D) or is coming back from (D). He is moving less rapidly than at (B). However, at (A), one of the highest positions of the swing, he is either moving most slowly preparing to reverse his direction or has stopped completely before he descends down to (B) again.

PREFERRED RESPONSE	COMMENTARY
6. B	6. As discussed above, in moving from (B) to (C) Morris and the swing are gaining P.E. at the expense of K.E. Thus they will be slowing down.
7. C	7. See commentary for response to Part 2, question 1.
8. B	8. Since friction will be mainly at those points, and since heat energy is produced during the rubbing, the temperature will rise.
9. B	9. Position (A) being higher off the ground than (E), means that Morris would be starting off with more P.E. and thus colliding with more K.E. when he arrives at the box at (B), than if he had started from (E). The greater the K.E. on collision, the farther the box can be moved.
Situation II:	
1. B	1. Since Joe swings his bat faster, it imparts more K.E. to the ball -- resulting in Joe's ball moving more rapidly. (C) cannot be true since the moving ball acquires its K.E. from the impact with the moving bat.
2. B	2. The ball is completely stopped in the glove. All its energy (kinetic) is transferred into heat energy...as the children discussed in Activity 1.

PREFERRED RESPONSE	COMMENTARY
	In (A) the frictional effects as the ball moves through the air are minimal compared with the complete conversion of the K.E. as noted above.
3. A	3. As was observed with the bouncing balls in Activity 1, the ball rebounds with less energy after colliding with the floor. Thus the bounce would result in the ball coming to the catcher with less K.E. -- to be converted to heat energy when caught. (B) is incorrect. Actually bouncing would warm up the ball -- very slightly -- as well as the surface on which it bounced.
Situation III:	
1. B	1. If there were no friction, then all of the P.E. at the top of the slide (100 units) would be converted to Bobby's K.E. as he left the slide. However, since it was stated that he noticed his jeans became warm, it indicates that some mechanical energy has been converted to heat energy due to the rubbing action between Bobby and the slide. The remaining energy with which he leaves the slide must therefore be less than the 100 units.
2. C	2. Using a slide which is twice as high means starting off at the top with twice as much P.E. There would still be some losses due to friction when he leaves at the bottom.

PREFERRED RESPONSE	COMMENTARY
	But it can be predicted that he would go off with about twice the K.E. as before, especially since the slide is not as long. (A) cannot be correct since the K.E. comes only from the initial P.E. Reducing friction by applying wax cannot double the K.E. but would certainly increase it.
3. A	3. Here, of course, rubbing on wax will reduce friction and thus reduce the amount of heat energy produced.
Situation IV:	
1. A	1. Conservation, or accounting for all the energy, would indicate that, starting with 50 units and ending with 40 units means that 10 units have been converted (by frictional effects) to heat energy.
2. C	2. As in the analysis of pendulum swings, at the bottom of the swing there is minimum P.E. but maximum K.E. It will be moving most rapidly.
3. B	3. As stated in the description of the situation the ball starts off at (1) with 50 units of energy. Since it is moving at (3) with 30 units of energy, and since at (3) it has all its mechanical energy in the form of kinetic, then it can be deduced that the difference, 20 units, is in the form of heat energy

PREFERRED RESPONSE	COMMENTARY
	produced by friction between the ball and coaster surfaces.
4. A	4. Since position 4 is at about half the height as position 2, it is logical to conclude that the ball has about half the potential energy at position 4 (40 units/2 = 20 units). The ball is not moving, thus all its energy is potential. The difference from the starting mechanical energy (50 units) would appear as heat energy produced by friction. A is the correct response. (C) cannot be correct. There must be some potential energy since the ball at #4 is still on the slope. Some may incorrectly reason that all the energy (the 50 units) is in the form of heat energy since the ball has stopped rolling for the moment. But at position #4 it can still roll down. It is only when the ball comes to a complete rest (at the base of the coaster) that all its initial mechanical energy has been converted to 50 units of heat energy.

Individual Assessment

The concepts developed in this Grade 6 Minisequence are an extension of those in Minisequence II of Grade 5. Potential energy and kinetic energy, along with their interconverstions and interrelationships, were introduced in the earlier grade. For those children who have scored poorly on items directed to the concept of these forms of mechanical energy, as presented, e.g., in Part 1 and Part 3 (items 1 through 6) a review of the assessments in Grade 5 would be helpful.

As the Grade 6 activities develop, emphasis is also directed to the conservation of mechanical energy in these interconversions -- that is, the children should be developing some sense of accountability of the energies.

The example of a review discussion directed to these ideas of accountability is based upon the child answering incorrectly question 5 of Part 2 and *Situation III* of Part 3. There are two small-step dialogues provided. Again, be reminded that these dialogues are merely illustrative of what you may pursue with a child who has not shown mastery. Individual differences amongst children may require different approaches. The first small-step dialogue is concerned with question 5 of Part 2.

Dialogue A:

T: WHAT DOES IT TAKE TO RAISE THE BOB OF A PENDULUM?

C: *Work.*

T: HOW WOULD THE AMOUNT OF WORK BE MEASURED?

C: *By the distance it is raised.*

T: ANYTHING ELSE?

C: *How heavy it is.*

T: DOES THE BOB HAVE ANY ENERGY IN THIS POSITION?

C: *Yes.*

T: HOW DO YOU KNOW?

C: *Well, if I let it go it can swing down.*

T: BUT IS SWINGING DOWN AN EXAMPLE OF ENERGY?

C: *Well, if something moves, we say it has energy of motion.*

T: BUT WHY DO WE CALL IT ENERGY?

C: *Because if something were put in its way it could make it move -- it could do work on it.*

T: THEREFORE, WHEN THE BOB IS UP AND NOT MOVING, WHAT KIND OF ENERGY DOES IT HAVE?

C: *It has the possibility of getting kinetic energy.*

T: WE CALL IT *POTENTIAL ENERGY* WHEN SOMETHING IS LIFTED UP AND HAS THE POSSIBILITY OF GETTING INTO MOTION.

T: WHAT HAPPENS TO A BOB AFTER IT SWINGS DOWN?

C: *It swings up to the other side.*

T: WHY DO YOU THINK IT SWINGS UP?

C: *It was moving and was held on the string, so it swings up.*

T: WHERE WAS IT MOVING THE FASTEST?

C: *At the bottom of the swing.*

T: WHAT HAPPFNS TO THE KINETIC ENERGY AS IT MOVES UP ON THE OTHER PART OF THE SWING?

C: *I'm not sure.*

T: DOES IT MOVE AS FAST?

C: *No.*

T: HOW DO YOU KNOW?

C: *It stops eventually on the other side -- so I guess it slows down.*

T: WHEN DOES IT STOP COMPLETELY ON THE OTHER SIDE?

C: *When it comes to the top of the swing.*

T: DOES IT HAVE KINETIC ENERGY THERE?

C: *Not if it's not moving.*

T: BUT AT THIS SPOT ON THE TOP OF THE SWING WHAT KIND OF ENERGY DOES IT HAVE? OR HAS IT NONE?

C: *I'm not too sure.*

T: LET US LOOK AT THE SITUATION. THE BOB WAS MOVING -- IT MOVED UP TO A CERTAIN HEIGHT. IF I LET IT ALONE IT WILL SWING DOWN AGAIN -- SO WHAT KIND OF ENERGY DOES IT HAVE AT THE TOP? (You might use the schematic of swings as introduced in the Guide on page 438.)

C: *It will be potential energy.. it's been raised (lifted) up.*

T: IF ALL THE KINETIC ENERGY IT HAD AT THE BOTTOM WENT BACK TO POTENTIAL, HOW HIGH WOULD THE BOB GO?

C: *As high as it was released -- if all the original potential energy went into energy of motion.*

T: NOW IN THE QUESTION ASKED, WHAT WOULD BE THE RESPONSE? REMEMBER THAT IT SAID THERE WAS NO FRICTION.

C: *(A) would be the answer.*

T: WHAT MIGHT HAVE BEEN THE ANSWER IF THERE WERE FRICTION?

C: *Friction where?*

T: WHERE DOES FRICTION USUALLY OCCUR?

C: *When a ball bounces?*

T: WHERE ELSE?

C: *When I rub something?*

T: YES. WHENEVER TWO THINGS RUB AGAINST EACH OTHER, WE SAY FRICTION IS INVOLVED. WHAT DO YOU OBSERVE WHEN YOU RUB THINGS TOGETHER? LIKE YOUR HANDS?

C: *They get warm..*

T: AND WHAT IS THIS AN EVIDENCE OF?

C: *Heat energy.*

T: SO IF SOME MACHINE HAS RUBBING PARTS, WILL ANY MECHANICAL ENERGY BE CONVERTED TO HEAT ENERGY?

C: *Yes, if there is friction.*

T: THEN IN THE PENDULUM WHAT WOULD BE RUBBING?

C: *The only things would be the string at the top.*

T: CORRECT. AND IF THERE IS FRICTION HERE, WHAT MIGHT HAPPEN TO THE POTENTIAL ENERGY WE GAVE THE BOB WHEN WE RAISED IT AT THE START?

C: *Some would get used up in the friction.*

T: UNDER THOSE CONDITIONS (WHERE FRICTION OCCURS) WHAT WOULD BE THE RESPONSE -- THE SAME HEIGHT OR A LOWER HEIGHT?

C: *Lower height -- it would have less potential energy.*

Dialogue B:

T: NOW LET US LOOK AT SITUATION III, OF PART 3. IT IS VERY SIMILAR. WHAT KIND OF ENERGY DID BOBBY HAVE AT THE TOP OF THE SLIDE? (You may wish to read the situation again to the child.)

C: *Potential.*

T: WHAT KIND OF ENERGY DID HE HAVE AS HE SLID OFF AT THE BOTTOM?

C: *Kinetic energy -- energy of motion.*

T: IF THERE WERE NO FRICTION, HOW MUCH KINETIC ENERGY WOULD HE HAVE AS HE LEFT THE SLIDE?

C: *100 units -- as much as the potential.*

T: COULD THERE BE ANY "LOSSESS"? WAS THERE ANY RUBBING OR FRICTION?

C: *Yes, it said that Bobby's pants felt warm.*

T: WHERE WAS THE RUBBING?

C: *Between the seat of his pants and the surface of the slide.*

T: SO COULD HE LEAVE WITH 100 UNITS OF KINETIC ENERGY?

C: *No.*

T: WHAT WOULD BE THE CORRECT RESPONSE TO THIS QUESTION, THEN?

C: *It must be (B).*

T: WHAT HAPPENED TO THE ENERGY DIFFERENCE? DID IT JUST DISAPPEAR?

C: *No, it was in the form of heat energy formed from the rubbing.*

T: IF WE GAVE BOBBY MORE POTENTIAL ENERGY TO START WITH, HOW WOULD THIS AFFECT HOW MUCH KINETIC ENERGY HE WOULD HAVE WHEN HE LEFT THE SLIDE?

C: *He would have more kinetic energy.*

T: HOW CAN WE INCREASE HIS P.E.?

C: *Give him a push?*

T: WHAT DETERMINES POTENTIAL ENERGY? (A PUSH OR THE HEIGHT WE LIFT SOMETHING?

C: *A push gets it moving so I guess the push gives it kinetic-- potential energy depends on how high it is lifted so Bobby would have to go higher to have more potential energy.*

T: SO COULD (B) BE THE CORRECT RESPONSE?

C: *No..because there we say the slide is not as high.*

T: WHAT IS THE CORRECT RESPONSE?

C: *It must be (C)... it's only there that the slide will be much higher.*

T: NOW, THE LAST QUESTION. WHAT MAKES HIS JEANS WARM?

C: *Friction.*

T: HOW DO WE REDUCE FRICTION?

C: *By reducing the rubbing action.*

T: WILL LUBRICATION DO THIS?

C: *Yes.*

T: WHAT SUBSTANCES MIGHT LUBRICATE OR SMOOTH THE RUBBING SURFACES?

C: *I assume the wax that's mentioned in (A).*

T: COULD (B) BE A POSSIBLE ANSWER?

C: *Going down rapidly doesn't lessen the rubbing.*

T: SO WHICH IS THE CORRECT RESPONSE?

C: *It must be (A).*

Assessment Pages for Duplication

1. WHEN JANICE EXAMINED A PINCH OF SOIL WITH A MAGNIFYING GLASS SHE FOUND SMALL PARTICLES OF MATERIAL THAT LOOKED LIKE FINE SAND. WHICH OF THE FOLLOWING BEST EXPLAINS HOW THE PARTICLES MAY HAVE BECOME A PART OF THE SOIL?

A. THEY WERE PRODUCED WHEN ROCKS WERE BROKEN UP.

B. THEY CAME FROM LIVING THINGS IN THE SOIL.

C. THEY WERE ALWAYS A PART OF THE SOIL.

2. IN CERTAIN PLACES ROCKS ARE COVERED WITH GREEN CRUST-LIKE PLANTS CALLED LICHENS. IF YOU REMOVED A PIECE OF THE CRUSTY LICHENS FROM A ROCK, WHAT WOULD YOU BE MOST SURE TO FIND UNDERNEATH IT?

A. OTHER SMALL PLANTS.

B. SMALL PIECES OF ROCKS.

C. SOLID ROCK.

3. ROCKS ARE FOUND ALL OVER THE EARTH. THEY ARE FOUND IN PLACES WHERE THE RAINFALL IS HEAVY. THEY ARE FOUND IN PLACES WHERE THERE IS VERY LITTLE RAINFALL. WHICH OF THE FOLLOWING BEST DESCRIBES HOW ROCKS IN PLACES WHERE THERE IS HEAVY RAINFALL MAY BE DIFFERENT FROM ROCKS IN PLACES WHERE THE RAINFALL IS MUCH LESS?

A. SINCE ROCKS ARE VERY HARD THERE WOULD BE LITTLE DIFFERENCE.

B. WHERE RAINFALL IS LESS, ROCKS WOULD BE DARKER.

C. WHERE RAINFALL IS HEAVY ROCKS WOULD HAVE WORN AWAY MORE.

4. IN SOME PLACES THERE ARE MANY LARGE ROCKS IN THE SOIL. WHICH OF THE FOLLOWING BEST DESCRIBES WHAT IS HAPPENING TO SUCH ROCKS?

A. THEY ARE SLOWLY BECOMING SMALLER.

B. THEY ARE SLOWLY BECOMING HARDER.

C. THEY ARE SLOWLY BECOMING LARGER.

5. TWO SAMPLES OF SOIL ARE EXAMINED BY SOME CHILDREN. ONE IS A LIGHT-COLORED SOIL THAT FEELS ROUGH. THE OTHER IS A DARK-COLORED SOIL THAT FEELS LESS ROUGH. WHICH OF THE FOLLOWING BEST EXPLAINS THE DIFFERENCE IN THE SOILS?

A. SOILS ARE MIXTURES OF LIVING AND NONLIVING MATERIALS.

B. SOME SOILS MAY HAVE MORE MATERIAL FROM LIVING THINGS IN THEM THAN OTHER SOILS.

C. SOILS ARE FORMED BY THE INTERACTION OF ROCKS WITH THEIR ENVIRONMENT.

1. MORRIS AND LOIS EXAMINED TWO SAMPLES OF SOIL. ONE WAS LABELED SAMPLE *A* AND THE OTHER SAMPLE *B*. SAMPLE *A* WAS A DARKER COLOR THAN SAMPLE *B* AND HAD MORE PIECES OF DEAD LEAVES, STEMS AND ROOTS IN IT. WHEN WATER WAS POURED THROUGH EQUAL AMOUNTS OF EACH SOIL SAMPLE, SAMPLE *A* ABSORBED MORE WATER THAN SAMPLE *B*. BASED UPON THE ABOVE OBSERVATIONS WHICH OF THE FOLLOWING WOULD YOU SELECT AS BEING THE BEST STATEMENT REGARDING THE DIFFERENCES IN THE TWO SOIL SAMPLES?

A. BOTH SAMPLE *A* AND SAMPLE *B* WERE FORMED BY THE INTERACTION OF ROCKS WITH THEIR ENVIRONMENT.

B. SAMPLE *A* CONTAINS ONLY LIVING THINGS AND SAMPLE *B* CONTAINS ONLY PARTICLES OF ROCK.

C. SAMPLE *B* IS PROBABLY A SAMPLE OF SUBSOIL AND SAMPLE *A* IS PROBABLY A SAMPLE OF TOPSOIL.

2. JANET AND ELIZABETH WERE GIVEN TWO SAMPLES OF SOIL THAT HAD BEEN REMOVED FROM THE SAME FIELD. AFTER THEY HAD CAREFULLY EXAMINED THE TWO SAMPLES, THEY HYPOTHESIZED THAT ONE SAMPLE WAS SUBSOIL AND THE OTHER WAS TOPSOIL. IF THEIR HYPOTHESIS WAS CORRECT, WHAT COULD THEY EXPECT TO HAPPEN IF THE SAME NUMBER OF BEAN SEEDS WERE PLANTED IN EACH SAMPLE AND BOTH SAMPLES WERE GIVEN THE SAME AMOUNT OF WATER?

A. THE BEAN SEEDS WOULD NOT GROW IN SUBSOIL.

B. THE BEANS IN SUBSOIL WOULD GROW BETTER THAN THE BEANS IN TOPSOIL.

C. THE BEANS IN TOPSOIL WOULD GROW BETTER THAN THE BEANS IN SUBSOIL.

3. REREAD THE FIRST PART OF ITEM 2, ABOVE. JANET AND ELIZABETH DECIDED TO TEST THEIR HYPOTHESIS BY ANOTHER METHOD. THIS WAS TO BE DONE BY PUTTING THE SAME AMOUNT OF EACH SAMPLE OF SOIL IN EACH OF TWO PAPER CUPS WHICH HAD SMALL HOLES IN THEIR BOTTOMS. INTO EACH PAPER CUP THE SAME AMOUNT OF WATER WAS POURED. THE WATER THAT PASSED THROUGH EACH SAMPLE WAS COLLECTED AND COMPARED. WHAT WOULD YOU EXPECT TO BE THE RESULTS?

A. THE WATER PASSING THROUGH THE SUBSOIL WAS COLDER THAN THE WATER PASSING THROUGH THE TOPSOIL.

B. MORE OF THE WATER PASSED THROUGH SUBSOIL THAN TOPSOIL.

C. THE SAME AMOUNT OF WATER PASSED THROUGH EACH SAMPLE.

4. JOE AND FRED HAD THREE SAMPLES OF SOIL. SAMPLE *A* WAS TOPSOIL. SAMPLE *B* WAS SUBSOIL. SAMPLE *C* WAS SAND. THEY GOT INTO A DISCUSSION REGARDING WHICH OF THEIR SAMPLES, *A* OR *B*, WOULD REACT WITH WATER MOST LIKE SAMPLE *C*, THE SAND, WHEN THE WATER HOLDING PROPERTIES OF THE SAMPLES WERE COMPARED. THEY PERFORMED AN EXPERIMENT AND FOUND THAT TOPSOIL HELD MORE WATER THAN EITHER SUBSOIL OR SAND. FROM THESE RESULTS THEY CONCLUDED THAT SUBSOIL WAS MORE LIKE SAND. WHICH OF THE FOLLOWING BEST EXPLAINS THEIR RESULTS?

A. TOPSOIL HAS MORE MATERIAL IN IT, THAT IS NOW LIVING OR WAS ONCE ALIVE, THAN EITHER OF THE OTHER SOIL SAMPLES.

B. THE SAND WAS FORMED BY THE ACTION OF WIND, RAIN, AND HEAT UPON ROCKS.

C. SUBSOIL HAS PARTICLES OF ROCK IN IT WHICH WERE FORMED BY THE INTERACTION OF ROCKS WITH BOTH LIVING AND NONLIVING THINGS IN THEIR ENVIRONMENT.

5. TWO SAMPLES OF THE SAME AMOUNT OF DIFFERENT KINDS OF SOIL WERE THOROUGHLY SOAKED WITH WATER. THE TWO SOAKED SAMPLES WERE WEIGHED. THEY WERE THEN PUT INTO A WARM OVEN UNTIL BOTH APPEARED TO BE DRY. THE DRY SOIL SAMPLES WERE WEIGHED. THEIR DRY WEIGHTS WERE COMPARED WITH THEIR WET WEIGHTS TO FIND OUT HOW MUCH THEIR WEIGHTS HAD CHANGED. IT WAS FOUND THAT ONE SAMPLE LOST MUCH MORE WEIGHT THAN THE OTHER. WHICH STATEMENT BEST EXPLAINS WHY THE SOIL SAMPLES LOST WEIGHT?

A. HEAT ENERGY CAUSED THE PARTICLES OF SOIL IN THE SAMPLES TO GET LARGER.

B. HEAT ENERGY BROKE UP THE PARTICLES OF SOIL AND MADE THEM SMALLER.

C. HEAT ENERGY CAUSED THE WATER IN THE SOIL TO EVAPORATE.

6. WHICH OF THE SOILS IN QUESTION 5 WAS MORE LIKE A SUBSOIL?

A. THE ONE THAT LOST THE GREATER WEIGHT.

B. THE ONE THAT LOST THE LESSER WEIGHT.

C. CAN'T TELL UNTIL YOU KNOW HOW MUCH THE WEIGHT LOSS WAS.

1. FRESH FRUIT JUICE HAD BEEN SERVED AT A CLASS PARTY ON THE LAST DAY OF SCHOOL BEFORE A ONE-WEEK VACATION. THE CLEAN-UP COMMITTEE OVERLOOKED A SMALL PITCHER CONTAINING SOME OF THE JUICE. WHEN THE CLASS RETURNED TO THEIR ROOM AFTER THE VACATION, SOMEONE DISCOVERED THE LEFTOVER JUICE. IT WAS QUITE DIFFERENT FROM THE FRESH JUICE THEY HAD HAD AT THE PARTY. THERE WAS FROTH ON TOP OF THE JUICE. IT SMELLED DIFERENT. THE CHILDREN SUGGESTED SEVERAL HYPOTHESES TO EXPLAIN WHAT HAD CAUSED THE FROTH ON THE JUICE AND ITS CHANGE IN ODOR. WHICH ONE OF THE FOLLOWING HYPOTHESES DO YOU CONSIDER BEST?

A. SMALL PLANTS, SUCH AS YEAST, MAY HAVE GOTTEN INTO THE JUICE.

B. SOMEONE HAD SHAKEN THE JUICE TO MAKE IT FROTH.

C. HEAT HAD CAUSED SOME OF THE WATER FROM THE JUICE TO EVAPORATE, THUS PRODUCING THE FROTH.

WHICH OF THE FOLLOWING IS THE BEST EXPLANATION OF FROTH?

A. FROTH IS FORMED BY SMALL PARTICLES OF DUST FROM THE AIR.

B. FROTH IS FORMED BY BUBBLES OF GAS.

C. FROTH IS MADE UP OF COBWEBS.

2. WHICH ONE OF THE FOLLOWING WOULD BE MOST CONVINCING IN DEMONSTRATING THAT SODA WATER CONTAINS CARBON DIOXIDE?

A. DRINK A BOTTLE OF SODA TO SHOW THAT IT WILL MAKE YOU BELCH. WHEN YOU SWALLOW CARBON DIOXIDE IT MAKES YOU BELCH.

B. PASS SOME OF THE GAS FROM A BOTTLE OF SODA, THROUGH A BLUE-GREEN SOLUTION OF AN EXTRACT FROM RED CABBAGE TO SEE IF IT TURNS PURPLE.

C. SHAKE THE BOTTLE OF SODA TO SHOW THAT THE GAS WILL CAUSE THE SODA WATER TO SQUIRT.

3. THE AVERAGE CONCENTRATION OF CARBON DIOXIDE IN THE AIR ABOVE THE GROUND IS GENERALLY VERY SMALL. HOWEVER, IT HAS BEEN FOUND THAT THE CONCENTRATION OF CARBON DIOXIDE IN THE AIR IN SOILS IS MUCH HIGHER. IN OTHER WORDS THE AIR IN SOILS HAS MANY TIMES MORE CARBON DIOXIDE IN IT PER UNIT VOLUME THAN THE AIR ABOVE THE GROUND. WHICH OF THE FOLLOWING MATERIALS IN SOIL IS MOST LIKELY TO CAUSE THIS CONDITION?

A. LIVING THINGS WHICH GIVE OFF CARBON DIOXIDE.

B. PARTICLES OF ROCK WHICH ARE SHARP.

C. WATER WHICH MAKES THINGS WET.

4. WHILE DIGGING IN THE SOIL JIM AND ART FOUND SOME OBJECTS THAT LOOKED LIKE WORMS. HOWEVER, THEY DID NOT APPEAR TO BE ALIVE. HERE ARE SOME QUESTIONS THAT THE BOYS AGREED THEY WOULD HAVE TO ANSWER BEFORE THEY COULD BE MORE CERTAIN WHETHER THE OBJECTS WERE ALIVE. WHICH ONE IS THE BEST QUESTION TO ASK?

A. WILL THEY FLOAT IN WATER?

B. WILL THEY EAT LEAVES?

C. DO THEY GIVE OFF CARBON DIOXIDE?

1. DURING PERIODS WHEN THERE WAS LITTLE OR NO RAIN, ALVIN HAD TO WATER THE PLANTS AROUND HIS HOUSE TO KEEP THEM ALIVE. HE NOTICED THAT PLANTS ON THE WEST SIDE OF HIS HOUSE NEEDED MORE WATER TO KEEP THEM FROM WILTING THAN DID THE SAME KIND OF PLANTS ON THE EAST SIDE OF HIS HOUSE. BOTH SIDES OF THE HOUSE RECEIVED THE SAME AMOUNT OF SUNLIGHT DURING THE DAY. AT REGULAR TIMES DURING THE DAY HE HAD CHECKED THE AIR TEMPERATURE (IN THE SHADE) IN BOTH LOCATIONS AND FOUND THAT THE RANGE IN THE AIR TEMPERATURE THROUGHOUT THE DAY WAS ABOUT THE SAME. SINCE DIFFERENCES IN AIR TEMPERATURE DID NOT APPEAR TO BE THE CAUSE, WHICH OF THE FOLLOWING WOULD BE THE NEXT MOST LIKELY CAUSE?

A. DIFFERENCES IN THE KINDS OF SMALL ANIMALS THAT LIVE ON THE PLANTS.

B. DIFFERENCES IN THE MOVEMENT OF AIR AROUND THE PLANTS.

C. DIFFERENCES IN THE AMOUNT OF CARBON DIOXIDE IN THE AIR AROUND THE PLANTS.

2. WHEN YOUNG CABBAGE PLANTS ARE TRANSPLANTED FROM SMALL POTS TO THE GARDEN, PAPER CAPS OR HOODS ARE GENERALLY PLACED OVER THE SMALL PLANTS. THEY ARE LEFT IN PLACE OVER THE PLANTS FOR SEVERAL DAYS. THIS IS DONE TO KEEP THE YOUNG PLANTS FROM LOSING TOO MUCH WATER VAPOR TO THE AIR SURROUNDING THEM. WHICH OF THE FOLLOWING BEST EXPLAINS HOW THE PAPER HOODS REDUCE WATER LOSS FROM YOUNG PLANTS?

A. REDUCES THE MOVEMENT OF AIR AROUND THE PLANT.

B. KEEPS THE RELATIVE HUMIDITY OF THE AIR AROUND THE PLANTS HIGH.

C. BOTH OF THESE COULD EXPLAIN HOW THE PAPER HOODS WORK.

3. JANICE AND MURIEL DID AN EXPERIMENT TO FIND OUT WHICH PLANT, A SMALL PINETREE OR A GERANIUM PLANT ABOUT THE SAME HEIGHT, LOST MORE WATER TO THE AIR SURROUNDING IT. THEY OBTAINED POTTED PLANTS OF ABOUT THE SAME SIZE. THEY WATERED EACH PLANT WELL. NEXT THEY COVERED THE POTS AND THE SOIL WITH PLASTIC. THEN, THEY SECURELY TIED A PLASTIC BAG OVER THE STEMS AND LEAVES OF EACH PLANT AND PLACED THE TWO PLANTS NEAR A WINDOW. AFTER 12 HOURS THEY EXAMINED THEIR PLANTS AND FOUND THAT A GREAT DEAL OF WATER HAD CONDENSED ON THE INSIDE OF THE PLASTIC BAG COVERING THE GERANIUM PLANT. HOWEVER, HARDLY ANY WATER HAD CONDENSED INSIDE THE BAG COVERING THE LITTLE PINETREE. JANICE WAS CURIOUS AS TO WHY THE GERANIUM PLANT LOST MORE WATER THAN THE PINETREE. THE FOLLOWING ARE SOME IDEAS THAT SHE THOUGHT ABOUT. WHICH ONE IS THE BEST EXPLANATION OF WHY THE GERANIUM LOST MORE WATER?

A. THERE WAS MORE WIND AROUND THE GERANIUM PLANT.

B. GERANIUM LEAVES ARE LARGER AND BROADER THAN PINE NEEDLES.

C. PINE NEEDLES ARE SHARPER THAN GERANIUM LEAVES.

4. DARRELL HAS OBSERVED THAT THE POTTED PLANTS IN HIS ROOM REQUIRE MORE WATER IN THE SUMMER, ON THE DAYS WHEN THE AIR-CONDITIONING EQUIPMENT IS OPERATING THAN WHEN IT IS NOT. HE HAS ALSO OBSERVED THAT HIS PLANTS REQUIRE MORE WATER IN COLD WEATHER WHEN THE HOT-AIR FURNACE IS OPERATING. WHICH OF THE FOLLOWING BEST EXPLAINS WHY DARRELL'S PLANTS REQUIRE MORE WATER UNDER THESE CONDITIONS?

A. PLANTS LOSE MORE WATER WHEN THE RELATIVE HUMIDITY IS LOW THAN WHEN IT IS HIGH.

B. PLANTS LOSE MORE WATER WHEN THE TEMPERATURE IS LOW THAN WHEN IT IS HIGH.

C. PLANTS LOSE MORE WATER WHEN THE AIR IS MOVING THAN WHEN IT IS STILL.

5. IN A GREENHOUSE, PLANTS DO NOT GENERALLY REQUIRE AS MUCH WATER AS THEY WOULD OUT OF DOORS. WHICH OF THE FOLLOWING BEST EXPLAINS WHY THIS MAY BE SO?

A. THERE IS LESS MOVEMENT OF AIR INSIDE THE GREENHOUSE THAN OUT OF DOORS.

B. THE RELATIVE HUMIDITY INSIDE THE GREENHOUSE IS USUALLY HIGHER THAN OUT OF DOORS.

C. BOTH OF THESE ARE GOOD EXPLANATIONS.

1. PHIL HAD NOTICED THAT AFTER A HEAVY RAIN THERE WOULD BE MANY EARTHWORMS ON THE SIDEWALK IN FRONT OF HIS HOUSE. ONE DAY IN HIS SCIENCE CLASS HE ASKED THE TEACHER WHY THIS HAPPENED. THE TEACHER DID NOT ANSWER HIM DIRECTLY BUT ASKED THE CHILDREN IN THE CLASS TO SUGGEST POSSIBLE EXPLANATIONS OR HYPOTHESES. MANY HYPOTHESES WERE SUGGESTED. THREE ARE LISTED BELOW. WHICH ONE SEEMS MOST REASONABLE?

A. EARTHWORMS MOVE OUT OF THE SOIL WHEN IT BECOMES SOAKED WITH WATER.

B. SOMETIMES WHEN IT RAINS, IT RAINS EARTHWORMS.

C. WHEN THE SOIL IS WET BIRDS CAN MORE EASILY REMOVE THE EARTHWORMS.

2. WHEN BUDDING TWIGS ARE CUT FROM LEAFLESS BUSHES IN THE WINTER TIME, PLACED IN WATER, AND KEPT INDOORS, THE BUDS SOON DEVELOP INTO LEAVES OR FLOWERS. WHICH OF THE FOLLOWING BEST EXPLAINS WHY THE BUDS DEVELOP FASTER INDOORS?

A. THE TEMPERATURE IS HIGHER INDOORS THAN OUTDOORS.

B. THERE IS MORE WATER INDOORS THAN OUTDOORS.

C. THERE IS MORE LIGHT INDOORS THAN OUTDOORS.

3. WHAT DO YOU EXPECT WOULD HAPPEN TO THE VERY SMALL ANIMALS IN SOIL NEAR THE SURFACE WHEN IT DRIES OUT AND BECOMES HEATED BY THE SUN?

A. THE HEAT AND LACK OF MOISTURE WOULD KILL ALL OF THEM.

B. MANY WOULD MOVE DEEPER INTO THE SOIL WHERE IT IS COOLER AND MORE MOIST.

C. THEY WOULD MOVE TO THE SURFACE WHERE THEY COULD FIND SHADE AND MOISTURE.

4. IF ALL AIR WERE REMOVED FROM A LARGE SAMPLE OF SOIL, WHAT WOULD HAPPEN TO THE THOUSANDS OF SMALL ANIMALS IN IT?

A. THEY WOULD PRODUCE THEIR OWN AIR FROM THE CARBON DIOXIDE THEY GIVE OFF.

B. NOTHING WOULD HAPPEN TO THEM SINCE THEY ARE SO SMALL.

C. THEY WOULD DIE BECAUSE THEY NEED OXYGEN IN ORDER TO LIVE.

5. WHICH OF THE FOLLOWING COMBINATIONS OF FACTORS BEST DESCRIBE A SUITABLE SOIL ENVIRONMENT FOR SMALL ANIMALS?

A. LIGHT, WARM, DRY.

B. DARK, MOIST, HOT.

C. MOIST, DARK, WARM.

1. A DRY GREEN SALT IS HEATED IN A TEST TUBE. DROPS OF WATER APPEAR IN THE UPPER PART OF THE TUBE. THE SOLID IN THE BOTTOM OF THE TUBE CHANGES COLOR. WATER PROBABLY CAN COME FROM THE DRY SALT BECAUSE THE HEAT ENERGY ABSORBED BY THE GREEN SALT HAS:

A. DRIVEN OFF WATER THAT IS BONDED TO THE SALT.

B. CAUSED WATER TO BE ABSORBED FROM THE AIR.

C. CAUSED THE TOP OF THE TUBE TO GET HOT.

2. WHEN WATER IS ADDED TO A SALT IN WHICH ITS BONDED WATER HAD BEEN REMOVED:

A. HEAT ENERGY IS GIVEN OFF.

B. HEAT ENERGY IS ABSORBED.

C. NOTHING HAPPENS.

3. WHEN HEAT ENERGY IS ADDED TO HYDRATED SALTS (WITH BONDED WATER MOLECULES) IT IS MOST PROBABLE THAT:

A. THE HYDRATE BONDS HOLDING THE WATER TO THE SALT ARE STRONGER THAN THE SALT-TO-SALT BONDS.

B. THE SALT WILL MELT BEFORE THE HYDRATE BONDS HOLDING THE WATER TO THE SALT BREAK.

C. THE HYDRATE BONDS HOLDING THE WATER TO THE SALT WILL GENERALLY BREAK BEFORE THE SALT MELTS.

TWO TEST TUBES CONTAINING EQUAL SIZED SAMPLES OF THE SAME BLUE SALT ARE HEATED. ONE OF THE TEST TUBES IS HEATED LONGER THAN THE OTHER AND THE SOLID TURNS YELLOW. NO CHANGE IS OBSERVED IN THE SALT THAT IS HEATED FOR A SHORTER TIME.

4. WHICH SAMPLE OF SALT PROBABLY ABSORBED MORE HEAT ENERGY?

A. THE SALT WHICH REMAINED BLUE.

B. THE SALT WHICH TURNED YELLOW.

C. THEY BOTH ABSORBED THE SAME AMOUNT OF ENERGY.

5. THE SAMPLE OF SALT WHICH REMAINED BLUE IS NOW HEATED FOR A LONGER TIME AND IT ALSO TURNS YELLOW. AFTER BOTH SAMPLES COOL, SOME WATER IS ADDED TO ONLY ONE OF THEM. AFTER THE WATER IS ADDED TO THE ONE SAMPLE OF YELLOW SALT IT BECAME BLUE AND THE TEST TUBE BECAME VERY HOT. WATER IS NOT ADDED TO THE OTHER SAMPLE OF YELLOW SALT AND ITS COLOR DOES NOT CHANGE. WHICH SAMPLE OF SOLID SALT NOW HAS MORE HEAT ENERGY?

A. THE SAMPLE OF SALT WHICH REMAINED YELLOW.

B. THE SAMPLE OF SALT WHICH BECAME BLUE AGAIN.

C. BOTH SAMPLES CONTAIN THE SAME HEAT ENERGY.

6. WHICH OF THESE STATEMENTS IS TRUE REGARDING WHAT HAPPENED IN 5 ABOVE?

A. SOME HYDRATE BONDS WERE BROKEN WHEN THE SAMPLE OF YELLOW SALT BECAME BLUE AGAIN.

B. SOME HYDRATE BONDS WERE RE-FORMED WHEN THE SAMPLE OF YELLOW SALT BECAME BLUE AGAIN.

C. HYDRATE BONDS WERE FORMED IN BOTH THE YELLOW AND BLUE SAMPLES OF SALTS.

TASK I. IN THE FOLLOWING PROCESSES PLACE A + IN THE SQUARE IF YOU THINK HEAT ENERGY IS ABSORBED; PLACE A — IF YOU THINK HEAT ENERGY WILL BE GIVEN OFF.

A. TO BREAK WATER-TO-SALT BONDS ☐

B. MELTING ☐

C. TO BREAK MOLECULE-TO-MOLECULE BONDS ☐

D. ADDING WATER TO A SALT FROM WHICH BONDED WATER MOLECULES HAVE BEEN REMOVED. ☐

E. DISSOLVING ☐

F. FORMING HYDRATE BONDS ☐

TASK II. EACH ITEM (A-F) BELOW CONSISTS OF A PAIR OF SUBSTANCES. PLACE A CIRCLE AROUND THE SUBSTANCE IN EACH PAIR WHICH POSSESSES MORE ENERGY. BOTH SAMPLES ARE THE SAME SIZE AND ARE AT THE SAME TEMPERATURE.

A.	BLUE VITRIOL	WHITE VITRIOL
B.	A GAS	ITS LIQUID
C.	A SOLID	ITS LIQUID
D.	ANHYDROUS SALT	THE HYDRATED SALT
E.	DISSOLVED SALT	THE SOLID SALT
F.	STARCH-IODINE COMPLEX	STARCH PLUS IODINE

PHIL PERFORMED A CAREFUL EXPERIMENT WITH SOME CRYSTALS HE THOUGHT MIGHT BE HYPO (A HYDRATED SALT CALLED SODIUM THIOSULFATE). HE WANTED TO FIND OUT IF CRYSTALS OF THE SALT WERE REALLY HYDRATED, THAT IS CONTAINED BONDED WATER MOLECULES. HE ADDED 50 UNITS OF HEAT ENERGY TO A WEIGHED SAMPLE OF THE WHITE CRYSTALS OF HYPO.

1. AFTER ADDING THE HEAT ENERGY HE OBSERVED THAT THE CRYSTALS REMAINED WHITE. HIS CONCLUSION SHOULD BE THAT THE ORIGINAL SALT:

A. WAS NOT A HYDRATED SALT SINCE A HYDRATED SALT MUST CHANGE COLOR ON HEATING.

B. MIGHT BE HYDRATED SINCE COLOR DOES NOT HAVE TO CHANGE WHEN THE ANHYDROUS SALT IS FORMED ON HEATING.

C. WAS EASILY MELTED.

2. PHIL AGAIN WEIGHED THE WHITE SALT REMAINING IN THE TEST TUBE AFTER HEATING. IT WEIGHED LESS THAN BEFORE IT WAS HEATED. THIS WAS PROBABLY BECAUSE:

A. ON BEING HEATED, THE WHITE CRYSTALS LOST SOME WATER OF HYDRATION AND THEREFORE WEIGHED LESS.

B. SOME SALT MELTED AND THEREFORE THE SAMPLE WEIGHED LESS.

C. SOME SALT EVAPORATED AND LEFT THE SAMPLE OF SALT.

3. PHIL SUSPECTED THAT THE SALT CRYSTALS WITH WHICH HE STARTED HAD BEEN REALLY HYDRATED SALT CRYSTALS. HE DECIDED TO ADD A FEW DROPS OF WATER TO THE WHITE CRYSTALS AFTER THE 50 UNITS OF HEAT ENERGY HAD BEEN ADDED TO THEM. HE WANTED TO FIND OUT IF ANY HEAT ENERGY WOULD BE TAKEN IN OR GIVEN OFF WHEN HE ADDED WATER. IF SO, HE WANTED TO MEASURE IT. AS HE ADDS THE WATER, THE CRYSTALS STILL APPEAR TO BE DRY. IF WHAT HE SUSPECTED ABOUT THE ORIGINAL CRYSTALS WERE TRUE WHAT ELSE SHOULD HE OBSERVE WHEN HE ADDS A FEW DROPS OF WATER TO THE SAMPLE OF SALT TO WHICH HEAT ENERGY HAD BEEN ADDED?

A. THE SAMPLE SHOULD USE UP 50 UNITS OF HEAT ENERGY AND BECOME COOLER.

B. THE SAMPLE SHOULD GIVE OFF 100 UNITS OF HEAT ENERGY AS WATER MOLECULES AGAIN BOND TO THE SALT.

C. THE SAMPLE SHOULD GIVE OFF 50 UNITS OF HEAT ENERGY AS THE HYDRATE BONDS TO SALT RE-FORM.

BILL TOOK SOME CRYSTALS OF WHITE SALT FROM A CONTAINER WHICH WAS LABELED *A*, AND PUT THEM IN A TEST TUBE. JAN ALSO TOOK SOME CRYSTALS OF A WHITE SALT BUT FROM A CONTAINER LABELED *B* AND PUT THEM INTO A TEST TUBE. BILL AND JAN THEN ADDED A FEW DROPS OF WATER TO THE WHITE CRYSTALS IN EACH OF THEIR TEST TUBES.

1. THE TEMPERATURE OF BILL'S TEST TUBE INCREASED. IT BECAME VERY HOT. WHAT IS POSSIBLY HAPPENING IN THE CRYSTALS OF HIS SAMPLE OF SALT?

   A. SOLID-TO-SOLID BONDS ARE BEING BROKEN.

   B. HYDRATE BONDS ARE BEING FORMED.

   C. WATER IS BEING DRIVEN OFF.

2. JAN'S TEST TUBE BECAME COOLER WHEN SHE ADDED THE WATER. SHE ALSO OBSERVED LESS SOLID THAN WHEN SHE STARTED. WHAT DO YOU THINK WAS HAPPENING IN THE CRYSTALS OF HER SAMPLE OF SALT?

   A. SOME OF THE WHITE SOLID DISSOLVED IN THE WATER.

   B. SOME OF THE WHITE SOLID EVAPORATED.

   C. SOME OF THE WATER EVAPORATED.

3. WHY DID JAN'S SAMPLE OF SALT BECOME COOLER?

   A. BONDS WITHIN THE CRYSTALS WERE BEING BROKEN.

   B. BONDS WERE BEING FORMED WITHIN THE CRYSTALS.

   C. BOTH OF THE ABOVE WERE HAPPENING.

4. WERE THE TWO SUBSTANCES INVESTIGATED BY JAN AND BILL THE SAME?

   A. YES.

   B. NO.

   C. THERE IS NO WAY TO TELL.

1. IF YOU WERE TO EXAMINE A TREE, YOU WOULD FIND THE THREE THINGS BELOW. WHICH WOULD BE THE SMALLEST PART?

A. A LEAF

B. A CELL

C. A TWIG

2. A PUDDLE OF WATER IS COMPOSED OF THE THREE THINGS BELOW. WHICH WOULD BE THE SMALLEST PART?

A. A MOLECULE OF WATER

B. A DROP OF WATER

C. A SMALL CUP OF WATER

3. THE DEEP BLUE SOLUTION FORMED WHEN STARCH AND IODINE INTERACT IS COMPOSED OF SEVERAL PARTS, INCLUDING THE FOLLOWING. WHICH OF THE PARTS NOTED BELOW WOULD BE THE SMALLEST?

A. THE STARCH-IODINE COMPLEX

B. THE STARCH MOLECULE

C. A 1/4 TEASPOONFUL OF SOLUTION

1. A. THE SMALLEST PARTS THAT ALL LIVING THINGS HAVE IN COMMON ARE LEAVES.

   B. THE SMALLEST PARTS THAT ALL LIVING THINGS HAVE IN COMMON ARE CELLS.

2. A. ALL IRON SULFATE CRYSTALS HAVE THE SAME SHAPE.

   B. IRON SULFATE MAY CRYSTALLIZE IN SEVERAL DIFFERENT SHAPES.

3. A. WATER MOLECULES ARE A PART OF ALL HYDRATE SALTS.

   B. WATER MOLECULES ARE A PART OF ALL KINDS OF SALTS.

4. A. A PART OF THE BLUE VITRIOL MOLECULE IS COPPER.

   B. A PART OF COPPER IS THE BLUE VITRIOL MOLECULE.

5. A. EVERY SALT CONTAINS SOME COPPER.

   B. SOME SALTS DO NOT CONTAIN COPPER.

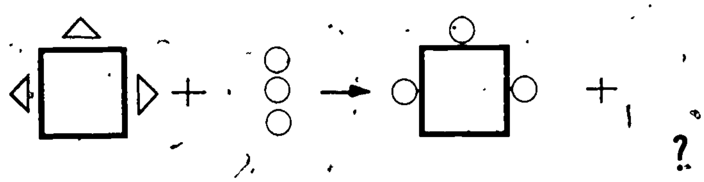
HERE ARE SOME MORE PROBLEMS ABOUT PARTS OF WHOLES. IN EACH ITEM BELOW YOU WILL FIND A PICTURE OF A STRUCTURE MADE UP OF CERTAIN UNIT PARTS. AN INTERACTION IS SHOWN WHICH RESULTS IN CHANGES IN THE ARRANGEMENT OF THE UNIT PARTS. COMPLETE THE STATEMENT OF THE INTERACTION BY DRAWING THE CORRECT FIGURE OVER THE QUESTION MARK OR BY COMPLETING THE PICTURE OVER THE QUESTION MARK.

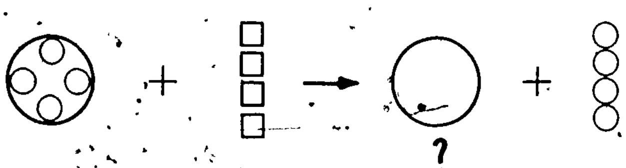
HERE IS AN EXAMPLE:

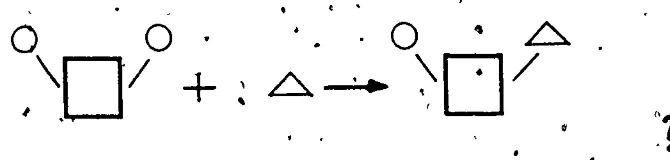
XO + Y ⟶ YO + ?

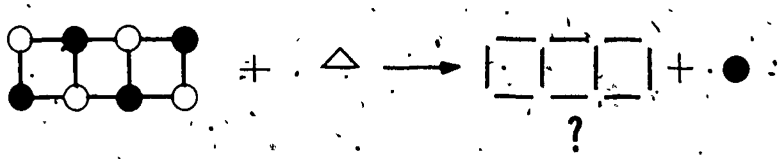
TO COMPLETE THIS "INTERACTION AN X SHOULD BE PLACED OVER ? . THE COMPLETED STATEMENT WOULD READ AS:

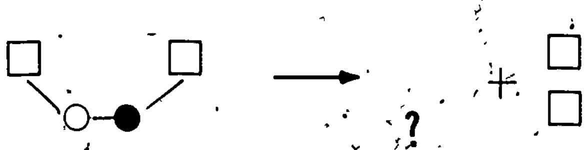
XO + Y ⟶ YO + X
?

1. 

2. 

3. 

4. 

5. 

1. A MODEL OF THE TWO PARTS OF A SALT MOLECULE IN A BLUE COLORED SOLUTION CAN BE PICTURED AS: △ — ○ WHILE A MODEL OF THE MOLECULES IN A COLORLESS OR POSSIBLEY SLIGHT YELLOW SOLUTION CAN BE PICTURED AS □ - ○. WHICH COULD BE THE APPROPRIATE PAIR OF SYMBOLS FOR THE UNIT PARTICLES MAKING UP THE DISSOLVED SALT MOLECULES?

A. △ STANDS FOR COPPER, AND ○ STANDS FOR SULFATE

B. △ STANDS FOR IRON, AND ⊙ STANDS FOR SULFATE

C. ○ STANDS FOR COPPER, AND △ STANDS FOR IRON.

2. DOTTY PICKED UP TWO JARS EACH CONTAINING BLUE SOLUTION. SHE KNEW THAT ONE SOLUTION CONTAINED COPPER SULFATE. IN ORDER TO IDENTIFY THE SOLUTION CONTAINING COPPER SULFATE, SHE SHOULD:

A. FILTER PART OF THE SOLUTION AND LOOK FOR THE APPEARANCE OF COPPER IN THE FILTER PAPER.

B. PUT A PIECE OF IRON IN PART OF THE SOLUTION AND LOOK FOR THE APPEARANCE OF COPPER IN THE IRON.

C. OBSERVE THE SOLUTION VERY CAREFULLY WITH A MAGNIFIER.

3. MORRIS DISSOLVED SOME BLUE COPPER CHLORIDE SALT IN WATER. HE DECIDED TO REFORM SOME CRYSTALS AND SO HE PLACED SOME OF THE SOLUTION IN AN ALUMINUM PIE PAN. WHAT MIGHT HAPPEN?

A. A BIG HOLE WOULD APPEAR IN THE PAN AND SOME METALLIC COPPER WOULD FORM.

B. NOTHING WOULD CHANGE IN THE APPEARANCE OF THE BLUE COPPER CHLORIDE SOLUTION IN THE PAN.

C. THE WATER WOULD EVAPORATE VERY QUICKLY FROM THE BLUE SOLUTION IN THE PAN.

LIZ IS DOING AN EXPERIMENT WITH A WHITE CRYSTALLINE SALT. SHE OBSERVED THE CRYSTALS WITH A MAGNIFIER AND SAW THAT THEY WERE IN THE SHAPE OF DIAMONDS, ◊ . WHEN SHE HEATED SOME OF THE CRYSTALS IN A FLAME, THE FLAME BECAME RED.

1. LIZ DISSOLVED SOME OF THE CRYSTALS IN WATER. WHEN THE SALT RECRYSTALLIZED, LIZ OBSERVED THAT THE CRYSTALS WERE ALSO DIAMOND SHAPED. SHE CONSIDERED THIS WAS TO BE EXPECTED SINCE:

A. DIAMOND SHAPED CRYSTALS ARE ALWAYS FORMED BY WHITE SALTS.

B. SHE ALLOWED THE SOLUTION TO STAND OVERNIGHT.

C. WHEN THE SUBSTANCE DISSOLVED IN THE WATER, ITS COMPOSITION HAD NOT CHANGED.

2. LIZ MADE UP SOME MORE SOLUTION. BY ACCIDENT SOME OTHER POWDER FELL IN. THE SOLUTION BECAME CLOUDY. SHE FILTERED IT AND SET ASIDE THE CLEAR LIQUID WHICH CAME THROUGH. SHE OBSERVED THE LIQUID THE NEXT DAY. LONG NEEDLE SHAPED CRYSTALS HAD FORMED. WHICH OF THE FOLLOWING MOST LIKELY EXPLAINS WHAT HAPPENED?

A. THE SOLID SALT WAS THE SAME AS THE ONE SHE STARTED WITH BUT THE CRYSTALS WERE LONGER.

B. DRYING OUT ALWAYS CHANGES CRYSTAL SHAPES.

C. THERE WAS AN INTERACTION WITH THE POWDER AND A DIFFERENT KIND OF MOLECULE WAS FORMED.

3. LIZ THEN HELD THE NEW NEEDLE SHAPED CRYSTALS IN A FLAME, THE FLAME WAS THE SAME COLOR RED AS SHE OBSERVED WITH THE DIAMOND CRYSTALS. WHICH OF THE FOLLOWING BEST EXPLAINS WHY?

A. WHITE CRYSTALS ALWAYS PRODUCE RED FLAMES.

B. THE SAME UNIT PARTICLE WAS PRESENT IN BOTH THE DIAMOND AND NEEDLE SHAPED CRYSTALS.

C. THE WATER AND THE POWDER INTERFERRED WITH THE TESTING IN THE FLAME.

4. LIZ DISSOLVED THE NEEDLE SHAPED CRYSTALS. SHE INSERTED A PIECE OF METAL WIRE INTO THE SOLUTION. THE SOLUTION TURNED GREEN. SHE MIGHT EXPECT THAT:

A. OVER A PERIOD OF TIME, THE SOLUTION WOULD BECOME A DARKER GREEN.

B. A NEW KIND OF MOLECULE HAS BEEN FORMED FROM PART OF THE METAL.

C. BOTH A AND B ABOVE.

5. THE MOST LIKELY REASON FOR THE ABOVE OBSERVATION IS THAT:

A. PARTICLES MAKING UP THE METAL WIRE EXCHANGED PLACES WITH PARTICLES MAKING UP THE SALT MOLECULES IN SOLUTION.

B. METALS GENERALLY FORM GREEN SOLUTIONS.

C. PARTICLES ARE COMING OFF THE WIRE AND MIXING WITH THE DISSOLVED SALT TO MAKE IT GREEN.

6. LIZ TESTED THE GREEN SOLUTION IN A FLAME. IT DID NOT MAKE THE FLAME RED, BUT MADE THE FLAME PURPLE. WHAT IS THE MOST LIKELY REASON?

A. THE GREEN MOLECULES IN THE SOLUTION AND THE ORIGINAL RED FLAME WOULD MAKE THE FLAME PURPLE.

B. THE UNIT PARTICLE RESPONSIBLE FOR THE RED FLAME IS NO LONGER A PART OF THE MOLECULES IN THE SOLUTION.

C. BOTH OF THE ABOVE ARE TRUE.

7. LIZ TESTED ANOTHER PIECE OF THE SAME METAL WIRE, IT IS MOST PROBABLE THAT THE WIRE WOULD PRODUCE A FLAME THAT WAS:

A. RED

B. PURPLE

C. COLORLESS

8. LIZ DECIDED TO GROW CRYSTALS FROM THE GREEN SOLUTION SHE HAD MADE. WHICH OF THE FOLLOWING WOULD SHE MOST LIKELY OBSERVE FOR THE CRYSTALS WHICH FORM?

A. THEY MIGHT BE COLORED GREEN.

B. THEY WOULD CERTAINLY BE NEEDLE SHAPED.

C. THEY MIGHT BE COLORED PURPLE AS WAS THE FLAME.

THE SITUATIONS HAVE TO DO WITH EXPERIMENTS DONE IN A CLASSROOM IN ANOTHER COUNTRY. THE CHILDREN OBSERVED AND THEN EXPLAINED WHAT THEY THOUGHT WAS HAPPENING TO THE MOLECULES. THEY USED WOR "EQUATIONS". SOME OF THE NAMES THEY USED FOR PARTICLES WERE DIFFERENT FROM THE ONES WE USE. IN GENERAL, THEY FOUND THE FOLLOWING TO OCCUR IN THEIR OBSERVATIONS:

CHLORIDE CRYSTALS WERE CUBE-SHAPED.

SULFATE CRYSTALS WERE NEEDLE-SHAPED.

NITRATE CRYSTALS WERE ANGLE-SHAPED.

AND IN A FLAME "COPIUM" MADE IT RED.

"SCHOOLIUM" MADE IT GREEN.

"TEACHIUM" MADE IT YELLOW.

TASK I: COMPLETE THE FOLLOWING WORD EQUATIONS BY FILLING IN THE BLANK LINES.

A. SCHOOLIUM + TEACHIUM SULFATE → TEACHIUM + ____________ SULFATE

B. COPIUM + SCHOOLIUM CHLORIDE → SCHOOLIUM + COPIUM ____________

C. COPIUM + TEACHIUM SULFATE → ____________ + COPIUM SULFATE

D. POTASSIUM + COPIUM CHLORIDE → ____________ + POTASSIUM CHLORIDE

TASK II: KEEP IN MIND THAT THE FOLLOWING COLORS ARE PRODUCED IN FLAMES BY THE INDIVIDUAL UNIT PARTICLES: COPIUM PRODUCES RED; SCHOOLIUM PRODUCES GREEN; TEACHIUM PRODUCES YELLOW.

NOW, IN THE ABOVE WORD EQUATIONS, PLACE A *Y* ON ALL THE SUBSTANCES WHICH COULD MAKE A FLAME YELLOW, AND AN *R* ON ALL THE SUBSTANCES WHICH WOULD MAKE A FLAME RED.

TASK III: KEEP IN MIND THE OBSERVATIONS THAT CHLORIDES FORM CUBES, SULFATES FORM NEEDLES, AND NITRATES FORM ANGLED CRYSTALS. NOW IN THE FOLLOWING LIST OF SALT MOLECULES PLACE A SQUARE ☐ NEXT TO THE MOLECULES YOU EXPECT TO FORM CUBES WHEN THEY CRYSTALLIZE AND A LINE, —, NEXT TO THOSE WHICH YOU EXPECT TO FORM NEEDLES. HERE IS THE LIST.

A. POTASSIUM CHLORIDE

B. COPIUM SULFATE

C. TEACHIUM CHLORIDE

D. TEACHIUM SULFATE

E. COPIUM NITRATE

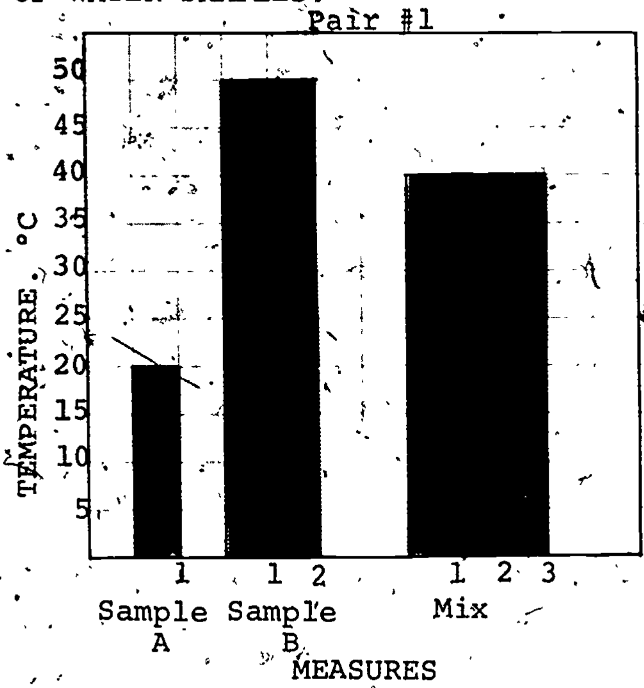
F. SODIUM CHLORIDE

G. SCHOOLIUM NITRATE

H. COPPER NITRATE

SITUATION I: BETTY WAS INVESTIGATING A CERTAIN WHITE CRYSTALLINE SOLID. SHE FOUND THAT IT WOULD MELT WHENEVER IT WAS PLACED NEXT TO A SURFACE WITH A TEMPERATURE OF 45°C. THE FOLLOWING GRAPHS REPRESENT THE VOLUME-TEMPERATURE PROPERTIES OF FOUR DIFFERENT PAIRS OF WATER SAMPLES.

Pair #1



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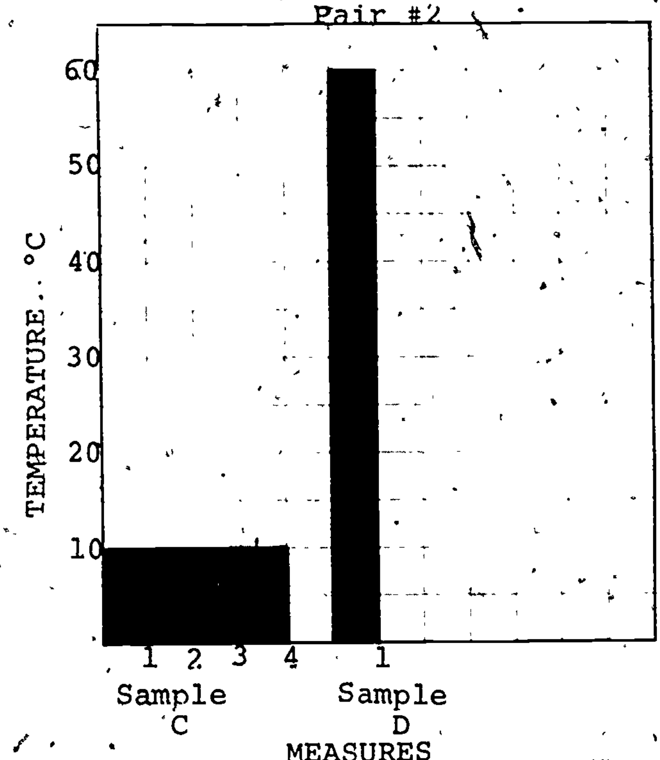

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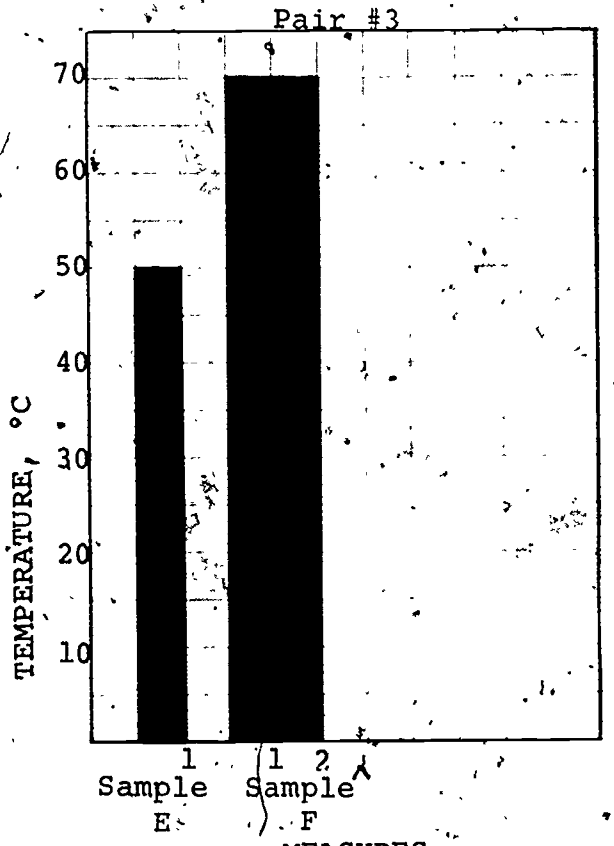

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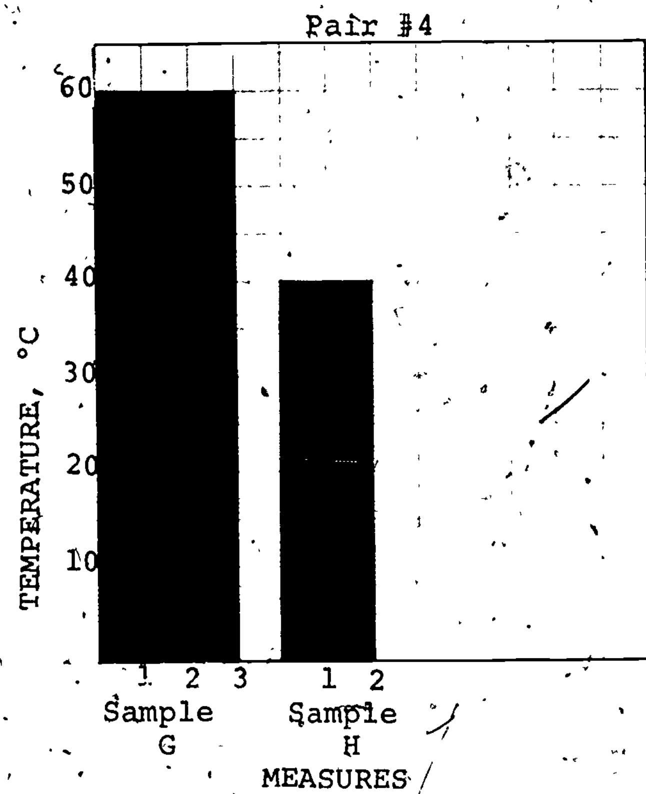
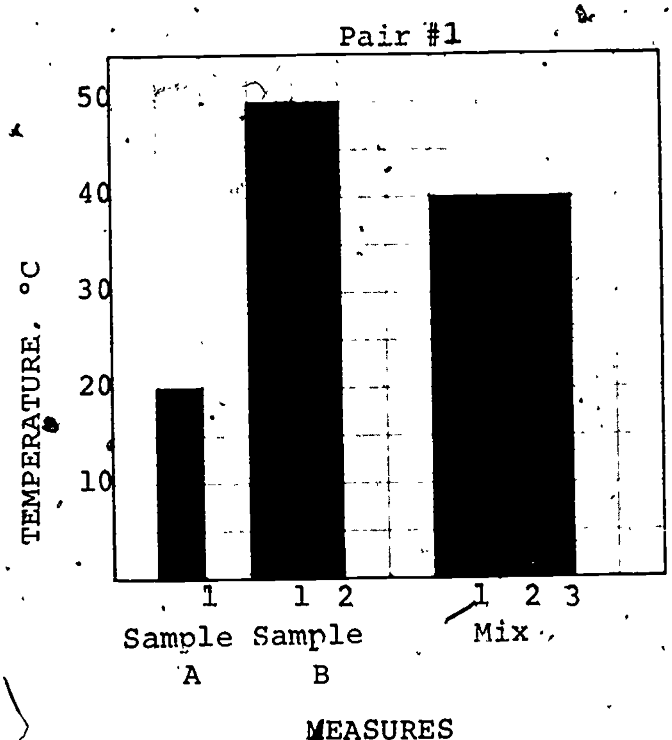


1. IN THE BLANK SPACES BELOW ENTER THE NUMBER OF h.e.u.'s IN EACH SAMPLE:

PAIR #1	SAMPLE A. ____________	SAMPLE B. ____________
PAIR #2	SAMPLE C. ____________	SAMPLE D. ____________
PAIR #3	SAMPLE E. ____________	SAMPLE F. ____________
PAIR #4	SAMPLE G. ____________	SAMPLE H. ____________

2. TO THE RIGHT OF EACH PAIR OF GRAPHS CONSTRUCT A GRAPH WHICH SHOWS THE VOLUME-TEMPERATURE PROPERTIES OF THE MIX OBTAINED WHEN THE TWO SAMPLES OF THE PAIR ARE POURED TOGETHER. NOTICE THAT THE FIRST ONE IS ALREADY DONE FOR YOU.

3. NOW LOOK AT THE GRAPHS OF THE PAIRS OF WATER SAMPLES *(BEFORE THEY WERE MIXED)*. WITH YOUR PENCIL MARK THE h.e.u.'s ON THE GRAPH WHICH ARE TRANSFERRED OUT FROM ONE OF THE SAMPLES IN EACH PAIR. NOTICE THAT THE FIRST ONE IS ALREADY DONE FOR YOU, BELOW.



4. BETTY FOUND THAT THE WHITE CRYSTALS MENTIONED EARLIER WOULD MELT WHEN PLACED NEXT TO SAMPLE *F*. WHICH OF THE OTHER SAMPLES CAN ALSO MELT THE CRYSTALS? *A, B, C, D, E OR G?* CIRCLE THE LETTERS OF THE SAMPLES.

5. THE MIX MADE FROM SAMPLES *E AND F* COULD ALSO MELT THE CRYSTALS. THIS WOULD HAPPEN BECAUSE:

   A. THE MIX CONTAINS ALL THE h.e.u.'s OF EACH SAMPLE.

   B. THE TEMPERATURE OF THE MIX WAS HIGH ENOUGH TO MELT THE SOLID.

   C. THE MIX CONTAINS SO MUCH MORE WATER THAN THE SEPARATE SAMPLES.

6. IT WOULD BE EXPECTED THAT THE WHITE SOLID WOULD BE MELTED BY ALL THE MIXES BECAUSE:

   A. EACH SAMPLE MAKING UP THE MIX COULD MELT THE SOLID.

   B. THE MIX CONTAINS MANY MORE h.e.u.'s THAN THE SEPARATE SAMPLES.

   C. THE STATEMENT IS REALLY NOT TRUE.

SITUATION II: MURIEL HAD A LARGE CONTAINER WITH 10 MEASURES OF WATER IN IT. THE TEMPERATURE OF THIS SAMPLE WAS 10°C. SHE PLACED INTO THIS LARGE SAMPLE OF WATER A SMALL STOPPERED TUBE CONTAINING ONLY 1 MEASURE OF HOT TEA. THE TEMPERATURE OF THE TEA WAS 80°C. HERE ARE SEVERAL STATEMENTS ABOUT THIS SITUATION. CIRCLE THE LETTER OF THE RESPONSE WHICH BEST COMPLETES EACH STATEMENT.

1. IF MURIEL CALCULATED THE HEAT ENERGY IN EACH SAMPLE BEFORE SHE PLACED THE TUBE OF TEA IN THE LARGE SAMPLE OF WATER, SHE WOULD FIND THAT:

   A. BOTH SAMPLES CONTAIN THE SAME AMOUNT OF HEAT ENERGY.

   B. THE SMALLER SAMPLE OF TEA CONTAINS MORE HEAT ENERGY THAN THE LARGER SAMPLE OF WATER.

   C. THE LARGER SAMPLE OF WATER CONTAINS MORE HEAT ENERGY THAN THE SMALLER SAMPLE OF TEA.

2. AFTER THE TUBE WITH THE TEA WAS SITTING IN THE WATER SAMPLE FOR A FEW MINUTES MURIEL SHOULD EXPECT THAT:

   A. HEAT ENERGY WOULD BE TRANSFERRED OUT OF THE SMALLER SAMPLE.

   B. HEAT ENERGY WOULD BE TRANSFERRED OUT OF THE LARGER SAMPLE.

   C. THERE WOULD BE NO TRANSFER OF HEAT ENERGY FROM EITHER SAMPLE.

3. AFTER THE TUBE WITH THE TEA WAS LEFT IN THE CONTAINER OF WATER FOR ABOUT 10 MINUTES, MURIEL DECIDED TO MEASURE THE TEMPERATURE OF EACH SAMPLE. SHE SHOULD EXPECT TO FIND THAT:

   A. THE TEMPERATURE OF BOTH SAMPLES WOULD BE THE SAME.

   B. THE TEMPERATURE OF THE SAMPLE OF TEA WOULD BE HIGHER THAN THE LARGER SAMPLE OF WATER.

   C. THE TEMPERATURE OF THE LARGER SAMPLE OF WATER WOULD BE HIGHER THAN THE SMALLER SAMPLE OF TEA.

4. AFTER 10 MINUTES MURIEL WOULD NOTICE THAT:

   A. THE ORANGE TEA COLOR HAD SPREAD THROUGHOUT THE LARGER CONTAINER OF WATER.

   B. THE ORANGE COLOR OF THE TEA HAD BECOME DARKER.

   C. THERE WAS NO CHANGE IN THE COLOR OF THE LIQUID IN EITHER CONTAINER.

SITUATION III: DARRELL PUT A METAL BICYCLE IN HIS ROOM. THE TEMPERATURE OF THE ROOM WAS 25°C. LATER WHEN HE TOUCHED THE METAL PARTS OF THE BICYCLE IT MADE HIS HAND FEEL COOL. HE KNEW THE TEMPERATURE OF HIS BODY WAS GENERALLY ABOUT 37°C.

1. IN EXPLAINING WHY HIS HAND FELT COOL WHEN HE TOUCHED THE BIKE DARRELL REASONED THAT THIS WAS BECAUSE :

A. METALS ALWAYS FEEL COOL TO THE TOUCH.

B. THERE WAS A TRANSFER OF HEAT ENERGY FROM HIS HAND TO THE BIKE.

C. HEAT ENERGY ALWAYS TRANSFERS OUT OF A PERSON'S BODY.

2. IN THE SUMMERTIME HE STORED THE BIKE IN A CLOSED ROOM IN WHICH THE TEMPERATURE WENT UP TO 40°C (THAT IS, 104° ON THE FAHRENHEIT SCALE!). WHAT MIGHT DARRELL NOW EXPECT TO FEEL AS HE PICKED UP HIS METAL BIKE?

A. IT WILL FEEL HOT SINCE ITS TEMPERATURE IS HIGHER THAN DARRELL'S BODY TEMPERATURE.

B. IT WILL STILL FEEL COOL TO THE TOUCH SINCE THE BIKE IS MADE OF METAL.

C. IT WILL FEEL NEITHER COOL NOR HOT SINCE THE TEMPERATURE IS NORMALLY HIGH IN THE SUMMERTIME.

SITUATION IV: SUPPOSE THAT YOU HAVE 5 MEASURES OF WATER AT 15°C IN A METAL CUP SUSPENDED IN A LARGE CONTAINER HOLDING 10 MEASURES OF WATER AT 10°C. SOON HEAT ENERGY WILL BE TRANSFERRED FROM:

A. THE WATER OUTSIDE TO THE WATER INSIDE THE CUP BECAUSE THERE ARE FEWER h.e.u.'s IN THE WATER IN THE CUP.

B. INSIDE THE CUP TO THE OUTSIDE, BECAUSE HEAT ENERGY TRANSFERS FROM HIGH TEMPRATURE TO LOW TEMPERATURE.

C. IN NEITHER DIRECTION BECAUSE THERE IS NO DIRECT CONTACT BETWEEN THE TWO SAMPLES OF WATER.

HERE YOU WILL FIND PAIRS OF STATEMENTS. ONE OF THE STATEMENTS IN EACH PAIR IS TRUE AND THE OTHER IS NOT TRUE. READ BOTH STATEMENTS SILENTLY TO YOURSELF WHILE I READ THEM ALOUD TO YOU. AFTER I HAVE READ BOTH STATEMENTS DRAW A CIRCLE AROUND THE LETTER OF THE STATEMENT WHICH IS TRUE.

1. A. HEAT ENERGY IS TRANSFERRED ONLY FROM A REGION OF LOW TEMPERATURE TO A REGION OF HIGH TEMPERATURE.

   B. HEAT ENERGY IS TRANSFERRED ONLY FROM A REGION OF HIGH TEMPERATURE TO A REGION OF LOW TEMPERATURE.

2. WHEN TWO SAMPLES OF WATER ARE MIXED:

   A. THE HEAT ENERGY OF THE MIX IS THE SUM OF THE HEAT ENERGIES OF THE TWO SAMPLES.

   B. THE TEMPERATURE OF THE MIX IS THE SUM OF THE TEMPERATURE OF THE TWO SAMPLES.

3. WHEN A SAMPLE OF A SOLUBLE SUBSTANCE IS PLACED IN CONTACT WITH WATER, ITS MOLECULES:

   A. SPREAD OUT UNTIL THEIR CONCENTRATION IS THE SAME THROUGHOUT ALL THE WATER, INCLUDING WHERE THEY WERE ORIGINALLY PLACED.

   B. SPREAD OUT INTO THE WATER AND CONCENTRATE IN REGIONS AWAY FROM WHERE THE SAMPLE WAS FIRST PLACED.

4. A. A SAMPLE OF PURPLE COLORED GAS WILL DIFFUSE THROUGH THE AIR AND BECOME LIGHTER IN COLOR AS IT DOES.

   B. A SAMPLE OF PURPLE COLORED GAS WILL DIFFUSE THROUGH THE AIR AND DARKEN AS IT DOES SO.

1. A TEA BAG IS PLACED IN A LARGE POT FILLED WITH WARM WATER. WHAT WILL BE OBSERVED *IMMEDIATELY?*

   A. ALL THE WATER IN THE POT WILL BECOME AN ORANGE COLOR, THE COLOR OF THE TEA.

   B. ONLY THE WATER AROUND THE TEA BAG WILL BECOME AN ORANGE COLOR.

   C. WATER IN DIFFERENT PARTS OF THE POT WILL BECOME AN ORANGE COLOR.

2. AFTER A FEW MINUTES, WE WOULD EXPECT THAT:

   A. ALL THE WATER IN THE POT WILL BECOME THE SAME ORANGE COLOR.

   B. ALL THE WATER WILL BE ORANGE BUT THE COLOR OF THE WATER NEAR THE SIDES OF THE POT WILL BE LESS.

   C. THE ORANGE COLOR WILL BE OBSERVED ONLY NEXT TO THE SIDES OF THE TEA POT.

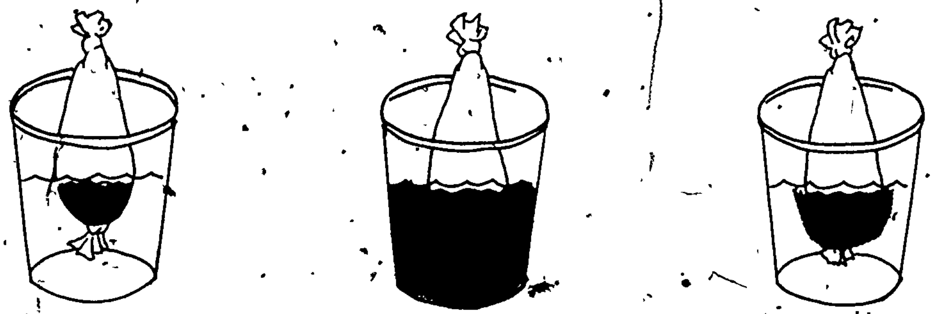
3. BOB BROUGHT SOME VERY SWEET SMELLING ROSES TO JAN. SHE PUT THEM IN A ROOM AND THEN TOOK A NAP. WHEN SHE AWAKENED, SHE SHOULD EXPECT THAT:

   A. THE ODOR OF THE ROSES WOULD BE OBSERVED JUST AROUND THE FLOWERS.

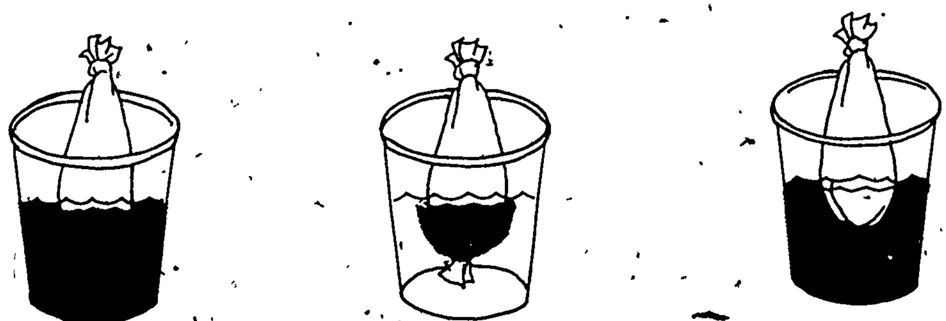
   B. THE ODOR OF THE ROSES WOULD PROBABLY BE OBSERVED THROUGHOUT THE ROOM.

   C. THE ODOR OF THE ROSES WOULD BE OBSERVED ONLY NEAR THE WINDOWS AND DOOR.

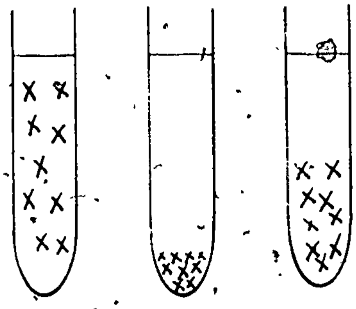
SEQUENCE I: THESE PICTURES REPRESENT A BAG OF COLORED SOLUTION AND SOME CLEAR WATER. THE MOLECULES OF WATER AND OF DISSOLVED COLORED SUBSTANCE CAN MOVE THROUGH ITS WALLS. PLACE AN *A* ON THE PICTURE WHICH SHOWS WHAT MIGHT BE FIRST IN THE SEQUENCE AND A *Z* ON THE PICTURE WHICH SHOWS WHAT WOULD BE HAPPENING LAST IN THE SEQUENCE.



SEQUENCE II: THESE PICTURES ALSO REPRESENT A SEQUENCE OF EVENTS WHEN A COLORED SOLUTION IS PLACED NEXT TO WATER BUT SEPARATED BY WALLS OF A CELLOPHANE BAG THROUGH WHICH ALL THE MOLECULES CAN MOVE. AGAIN PLACE AN *A* ON THE PICTURE WHICH SHOWS WHAT MIGHT BE FIRST IN THE SEQUENCE AND A *Z* ON THE PICTURE WHICH SHOWS WHAT WOULD BE HAPPENING LAST IN THE SEQUENCE."

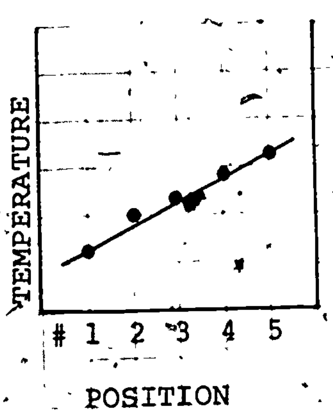


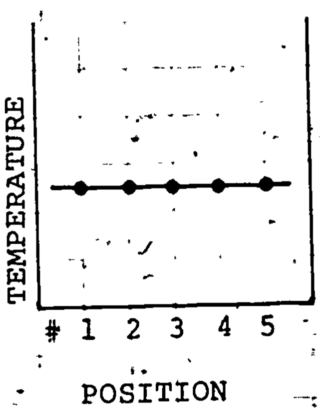
SEQUENCE III: CLEAR WATER AND A THICK SYRUP CONTAINING SUGAR MOLECULES WERE POURED INTO THE SAME TEST TUBE. THE X's IN THE PICTURE REPRESENT THE SUGAR MOLECULES. PLACE AN *A* ON THE PICTURE WHICH REPRESENTS THE BEGINNING OF THE SEQUENCE AND A *Z* ON THAT PICTURE OF THE SEQUENCE AFTER THE MIXTURE HAD BEEN STANDING FOR A TIME.

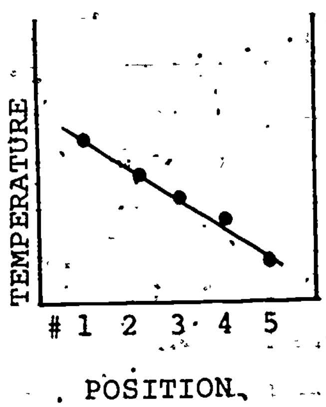


SEQUENCE IV: THE FOLLOWING GRAPHS REPRESENT A SERIES OF TEMPERATURE MEASUREMENTS TAKEN AT DIFFERENT POSITIONS ALONG A METAL SPOON THAT IS SITTING IN A CUP FILLED WITH VERY HOT CHOCOLATE. FIVE TEMPERATURE MEASUREMENTS ARE MADE: #1 WAS MADE AT A POSITION ON THE SPOON CLOSEST TO THE HOT LIQUID. #5 WAS MADE ON THAT PART OF THE SPOON FARTHEST AWAY. A RECORD OF THE TEMPERATURES WAS MADE AND A GRAPH WAS CONSTRUCTED TO SHOW HOW THE TEMPERATURES AT THE DIFFERENT POSITIONS ALONG THE SPOON COMPARED WITH EACH OTHER.

a) PLACE AN X UNDER THE GRAPH WHICH BEST REPRESENTS THE TEMPERATURES YOU WOULD EXPECT AT DIFFERENT POSITIONS ALONG THE SPOON.







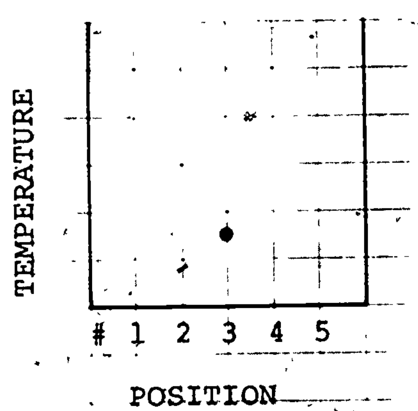
b. IF ALICE SHOULD DECIDE TO PICK UP THE SPOON, AT WHAT POSITION SHOULD SHE PLACE HER FINGERS?

A. AT POSITION #1

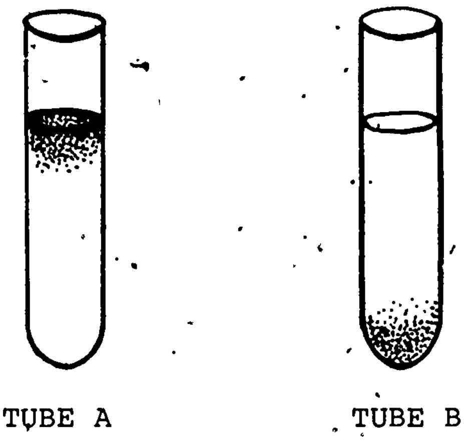
B. AT POSITION #5

C. AT POSITION #3

c. THE SPOON IS TAKEN OUT OF THE HOT CHOCOLATE AND PLACED ON THE TABLE. AFTER ABOUT 20 MINUTES ALICE MEASURES THE TEMPERATURE AT THE SAME FIVE POSITIONS ALONG THE METAL SPOON. ON THE CHART BELOW PLACE DOTS TO SHOW WHAT A RECORD OF THE FIVE DIFFERENT TEMPERATURES ALONG THE SPOON WOULD LOOK LIKE. THE TEMPERATURE AT POSITION #3 IS ALREADY ENTERED.



SITUATION I: DARRELL VISITED A SCIENCE CLASS AND OBSERVED THREE TEST TUBES TO WHICH BLUE FOOD COLORING HAD BEEN ADDED. THEY LOOKED LIKE THE DIAGRAMS BELOW. THE DOTS SHOW WHERE THE BLUE FOOD COLORING WAS SEEN.



1. WHICH TUBE PROBABLY HAD BEEN STANDING THE LONGEST TIME? ____________

2. WHICH TUBE WAS THE LIGHTEST BLUE COLOR? ____________

SITUATION II: JAN HAD A SMALL FISH BOWL SHAPED LIKE A BALL. SHE FILLED IT ALMOST TO THE TOP WITH LIQUID GELATIN. BEFORE THE GELATIN IN THE BOWL SET, JAN PLACED SOME RED FOOD COLORING AT THE BOTTOM OF THE BOWL. AFTER THE GELATIN HAD SET SHE PLACED SOME BLUE COLORING ON TOP OF THE GELATIN. THE BOWL LOOKED LIKE THAT SHOWN BELOW IN FIGURE D.

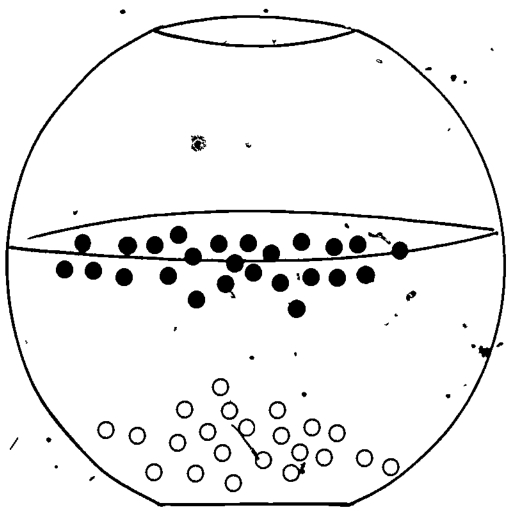


FIGURE D

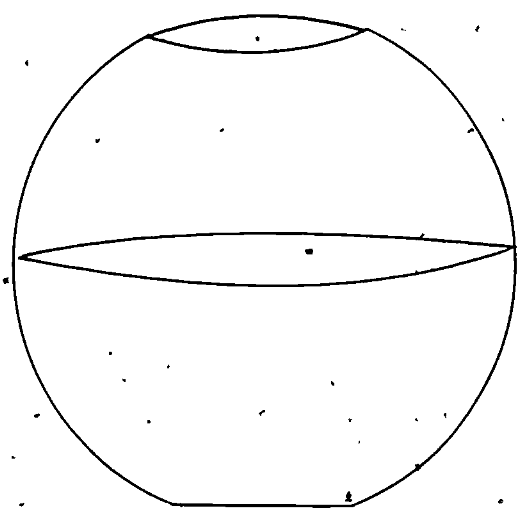


FIGURE E

249

IN FIGURE *D*:
○ REPRESENTS WHERE RED IS SEEN.
● REPRESENTS WHERE BLUE IS SEEN.

1. IN FIGURE E, SKETCH WHAT THE BOWL WOULD LOOK LIKE AFTER SEVERAL WEEKS. REMEMBER THAT ● STANDS FOR BLUE AND ○ STANDS FOR RED.

2. WHAT WOULD BE THE COLOR NEAR THE TOP? ____________________

3. WHAT WOULD BE THE COLOR NEAR THE MIDDLE? ____________________

IN FRONT OF EACH OF THE FOLLOWING STATEMENTS ABOUT THE MOLECULES OF FOOD COLORING IN THE FISH BOWL, CIRCLE THE *Y* FOR YES IF YOU AGREE; CIRCLE THE *N*, FOR NO, IF YOU DO NOT AGREE.

Y N 4. ALL THE MOLECULES OF THE RED FOOD COLORING MOVED TO THE TOP, AND THEN SOME SANK DOWN DUE TO GRAVITY.

Y N 5. ONLY THE MOLECULES OF THE RED FOOD COLORING IN THE TOP LAYER MOVED UP; THE OTHERS DIDN'T MOVE.

Y N 6. ALL MOLECULES OF BOTH FOOD COLORS MOVED IN ALL DIRECTIONS.

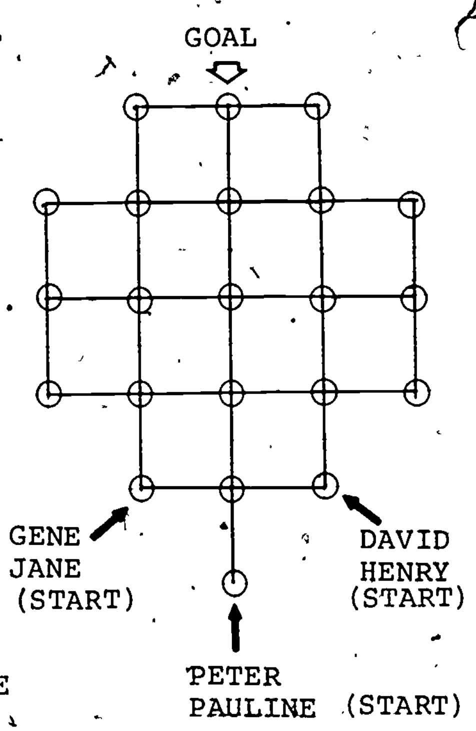
Y N 7. THOSE WHICH HIT THE BOWL EITHER STOPPED OR MOVED BACK INTO THE GELATIN AGAIN.

Y N 8. THE DIFFERENCE IN SHADES OF COLOR SHOW MOLECULES MOVED FROM LOW CONCENTRATION TO HIGH CONCENTRATION REGIONS.

Y N 9. ALTHOUGH MOLECULES MOVED RANDOMLY IN ALL DIRECTIONS, THE OVERALL RESULT IS PREDICTABLE.

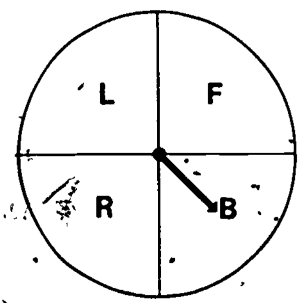
SITUATION III: SIX CHILDREN (DAVID, GENE, PETER, JANE, PAULINE AND HENRY) DECIDED TO HAVE A CONTEST TO SEE WHICH ONE COULD GET TO A SPACE, MARKED *GOAL*, FIRST, AS SHOWN IN FIGURE *F*. THE RULE OF THE GAME IS THAT THE RESULT OF SPINNING THE POINTER OF A SPINNER, AS SHOWN IN FIGURE *G*, DECIDES EACH MOVE. ANOTHER RULE OF THE GAME IS THAT MOVES CAN ONLY BE MADE FROM ONE SMALL CIRCLE TO ANOTHER ON THE GRID. IF A PLAYER CAN NOT MAKE THE MOVE SHOWN, (BECAUSE THE MOVE WOULD TAKE HIM OFF THE GRID) HE LOSES HIS TURN, AND STAYS WHERE HE IS UNTIL HIS NEXT TURN.

FIGURE F



THE GAME GRID

FIGURE. G



THE SPINNER

DAVID'S FIRST TWO MOVES WERE *L AND F*, (LEFT AND FORWARD). GENE'S FIRST TWO MOVES WERE BOTH *F'S*. PETER MOVED *F AND R* (RIGHT). JANE, PAULINE AND HENRY ALSO TOOK THEIR TURNS. A *B* ON THE SPINNER WOULD MOVE SOMEONE *B*ACKWARDS.

1. PLACE A *D, G, AND P* ON THE GAME GRID TO SHOW WHERE *D*AVID, *G*ENE AND *P*ETER ARE AFTER THEIR SECOND TURNS.

FOR EACH OF THE FOLLOWING STATEMENTS: CIRCLE THE *Y* IF YOU AGREE WITH THE STATEMENT; CIRCLE THE *N* IF YOU DO NOT AGREE; CIRCLE THE *C* IF YOU CAN'T TELL.

Y, N, C 2. AT THE BEGINNING, PETER AND PAULINE HAVE A BETTER CHANCE BECAUSE THEIR PATH IS STRAIGHT TO THE *GOAL*.

Y, N, C. 3. ALTHOUGH HE'S HAD 2 *F'S* IN A ROW, GENE HAS THE SAME CHANCE OF GETTING AN *F* AS PETER DOES ON THE THIRD SPIN.

Y, N, C 4. THE CHANCE (PROBABILITY) OF LOSING A TURN, AT THE BEGINNING IS GREATER FOR DAVID THAN IT IS FOR GENE.

Y, N, C 5. THE CHANCE (PROBABILITY) OF LOSING A TURN, AT THE BEGINNING IS GREATER FOR PETER THAN FOR GENE.

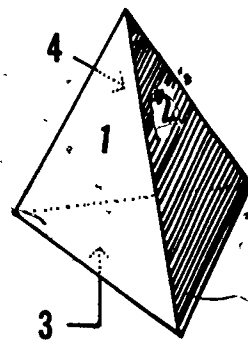
Y, N, C 6. THE CHANCE (PROBABILITY) OF LOSING A TURN ON THE THIRD TURN IS GREATER FOR PETER THAN FOR DAVID.

Y, N, C 7. AFTER THE SIX CHILDREN HAD EACH TAKEN FIVE TURNS, GENE WAS CLOSEST TO THE GOAL.

Y, N, C 8. THE MORE TURNS THE CHILDREN TAKE, THE MORE LIKELY IT IS THAT THEY WILL BE EVENLY SPACED OUT ON THE GRID.

Y, N, C 9. THIS GAME IS AN EXAMPLE OF THE SAME KIND OF MOVEMENT WE BELIEVE MOLECULES MAKE.

IN A MATHEMATICS CLASS MORRIS AND RITA WERE PLAYING A NUMBER-SUMS GAME. THEY USED A 4-SIDED BLOCK FOR THE GAME AS SHOWN TO THE RIGHT. EACH FACE IS IN THE SHAPE OF A TRIANGLE. THE SIDES OF EACH TRIANGLE ARE ALL EQUAL AND ALL FOUR TRIANGLES ARE THE SAME SIZE. EACH FACE OF THE BLOCK IS LABELLED WITH A DIFFERENT NUMBER. THE SIDES WITH THE 3 AND 4 ARE HIDDEN FROM VIEW. THE ARROWS POINT TO THEM. (HAVE YOU ANY QUESTIONS ABOUT THIS OBJECT?) MORRIS AND RITA TOOK TURNS THROWING THE BLOCK. EACH PLAYER MADE TWO THROWS OF THE BLOCK, AND KEPT A RECORD OF THE NUMBER ON THE FACE ON WHICH THE BLOCK LANDED. AFTER THE TWO THROWS EACH PLAYER ADDED UP HIS SCORE--THAT IS, ADDED UP THE NUMBERS ON THE FACES ON WHICH THE BLOCK LANDED. ALL POSSIBLE SUMS FOR TWO THROWS ARE LISTED IN THE GRID.



THROW #1

THROW #2	1	2	3	4
1	2	3	4	5
2	3	4	5	6
3	4	5	6	7
4	5	6	7	8

SUMS

ON HIS FIRST TURN, MORRIS GETS THE PAIR (3,1) FOR WHICH THE SUM, AS YOU CAN SEE FROM THE GRID, IS 4.

NOW, READ EACH OF THE FOLLOWING STATEMENTS. IF YOU AGREE WITH THE STATEMENT, CIRCLE THE *Y* FOR YES; IF YOU DO NOT AGREE, CIRCLE THE *N* FOR NO; IF YOU CAN'T TELL CIRCLE THE *C*. REMEMBER THAT THERE ARE TWO THROWS FOR EACH TURN.

Y, N, C 1. RITA HAS A BETTER THAN EVEN CHANCE OF WINNING ON HER TURN.

Y, N, C 2. THE CHANCE OF RITA GETTING A 4 IS LESS BECAUSE MORRIS ALREADY GO A 4.

Y, N, C 3. RITA SHOULD EXPECT A 5 MORE THAN ANY OTHER SUM.

Y, N, C 4. IF RITA WINS THIS TURN, MORRIS SHOULD WIN THE NEXT ONE.

Y, N, C 5. THE SUMS OF TWO THROWS RANGE FROM 2 THROUGH 8, A TOTAL OF SIX SEPARATE VALUES. IN A SERIES OF SIX TURNS, EACH VALUE WOULD HAVE TO OCCUR AT LEAST ONCE.

Y, N, C 6. MORRIS SHOULD EXPECT TO GET A SUM GREATER THAN 4 ON HIS NEXT TURN.

Y, N, C 7. MORRIS SHOULD EXPECT TO GET A SUM LESS THAN 6 ON HIS NEXT TURN.

MORRIS AND RITA PLAYED FOR A LONG TIME AND KEPT TALLIES OF THE SUMS THEY GOT AND WHO WON ON EACH TURN.

Y, N, C 8. IN A LONG SERIES OF TURNS, MORRIS AND RITA SHOULD EACH WIN ABOUT AN EQUAL NUMBER OF TURNS.

Y, N, C 9. IN A LONG SERIES OF TURNS, THERE SHOULD BE ABOUT TWICE AS MANY 5's AS THERE ARE 7's.

Y, N, C 10. AS A GENERAL RULE, THE MORE TURNS THERE ARE, THE GREATER IS THE CHANCE OF GETTING AN EXTREME VALUE, SUCH AS A 2 OR AN 8.

Y, N, C 11. AFTER 10 TURNS, THE TALLY OF SUMS FOR MORRIS' DATA, AND THE HISTOGRAM OF THE SUMS, LOOKED LIKE THE FIGURE MARKED *M*. RITA'S TALLY OF HER DATA AND ITS HISTOGRAM IS MORE LIKELY TO LOOK LIKE THAT MARKED *A* THAN THE ONE MARKED *B*.

Y, N, C 12. AFTER 100 TURNS, BOTH TALLIES, AND HISTOGRAMS OF THE DATA, OBTAINED BY MORRIS AND RITA SHOULD BE ALMOST IDENTICAL.

Y, N, C 13. IF MORRIS AND RITA STARTED NEW TALLIES AFTER COMPLETING THEIR 100th TURN, AND MORRIS' DATA FOR HIS NEXT TEN TURNS PRODUCED A TALLY LIKE THAT IN FIGURE *M*. RITA'S TALLY FOR HER 101st TO 110th TURNS WOULD LOOK MORE LIKE *A* THAN *B*.

SUMS	TALLY
2	1
3	2
4	4
5	2
6	1
7	0
8	0

HISTOGRAM

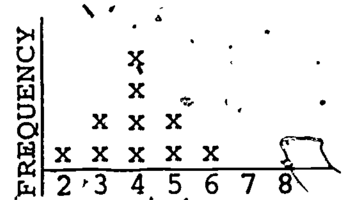


FIGURE M

SUMS	TALLY
2	0
3	3
4	4
5	3
6	0
7	0
8	0

HISTOGRAM

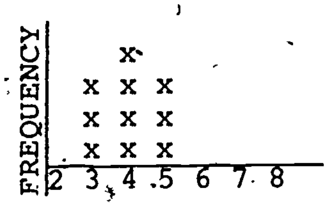


FIGURE A

SUMS	TALLY
2	0
3	1
4	3
5	3
6	1
7	1
8	1

HISTOGRAM

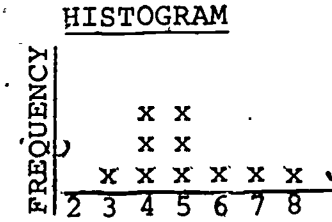


FIGURE B

ONE CLOUDY SUMMER DAY, JAN, LOIS AND PHIL WERE PLAYING IN AN OPEN FIELD IN THE PARK. IT STARTED TO RAIN. AT FIRST PHIL FELT A FEW SPRINKLES. THEN LOIS SAW A RAINDROP LAND ON A LEAF. LATER, AFTER THE CHILDREN HAD FOUND SAFE SHELTER, THE RAIN SHOWER TURNED INTO A VIOLENT THUNDERSTORM, LASTING ABOUT ONE HOUR.

THE FOLLOWING ARE STATEMENTS ABOUT HOW THE RAINDROPS FELL. YOU WILL FIND IT HELPFUL TO RECALL WHAT YOU LEARNED ABOUT THE GEIGER COUNTER'S RECORD OF EVENTS.

1. THE FIRST DROPS FELL ON PHIL:

   A. BECAUSE HE WAS LARGER THAN THE GIRLS.

   B. BY CHANCE.

   C. FOR SOME OTHER REASON.

2. JAN THOUGHT OF THE FIELD AS DIVIDED INTO SQUARES, ONE-METER ON EACH SIDE. THE *RATE* AT WHICH THE RAINDROPS FELL INTO A CERTAIN SQUARE WOULD BE:

   A. THE SAME AS FOR ALL THE OTHER SQUARES.

   B. GREATER FOR THOSE SQUARES IN THE WESTERN PART OF THE PARK THAN FOR THOSE IN THE EASTERN.

   C. DIFFERENT THAN MOST OF THE OTHER SQUARES.

3. TO GET A GOOD MEASURE OF THE AVERAGE OF HOW MUCH RAIN WOULD FALL IN THE FIELD, A DEVICE CALLED A RAIN GAUGE SHOULD BE PLACED:

   A. UNDER A DRAIN FROM THE ROOF OF THE SHELTER HOUSE.

   B. IN THE CENTER OF THE OPEN FIELD.

   C. IN THAT SQUARE WHICH HAD THE AVERAGE AMOUNT OF RAINFALL IN THE LAST STORM.

4. LOIS WANTED TO KNOW HOW MUCH RAIN FELL IN EACH SQUARE FOR EACH MINUTE. SHE HAD FOUND OUT HOW TO DO THIS FROM THE NATIONAL WEATHER SERVICE, AND SO SHE MADE THE MEASUREMENTS DURING THIS STORM. WHEN SHE ANALYZED THE RESULTS OF THE MEASUREMENTS SHE FOUND THAT IN THE FIRST 15 MINUTES OF THE STORM, WHICH WAS VERY BLUSTERY AND VIOLENT BEFORE IT MOVED TO ANOTHER AREA, THE AMOUNT OF RAIN FALLING PER MINUTE WAS:

   A. ALL VERY SMALL IN EVERY SQUARE.

   B. BOTH SMALL AND LARGE IN MOST OF THE SQUARES.

   C. VERY LARGE IN ALL THE SQUARES.

5. THE AMOUNT OF RAIN FALLING PER MINUTE MEASURED ON ONE RAIN GAUGE IN THE OPEN FIELD FOR THE ENTIRE DURATION OF THE STORM (ONE HOUR) WAS:

A. INCREASING REGULARLY AND THEN DECREASING REGULARLY.

B. GENERALLY LARGER DURING THE MIDDLE OF THE STORM BUT, EVEN THEN, IN SOME MINUTES VERY SMALL AMOUNTS WERE RECORDED.

C. IN EXACTLY THE SAME PATTERN AS WOULD HAVE BEEN MEASURED AND RECORDED IN ANY OTHER PART OF THE FIELD.

6. IF TEN RAIN GAUGES WERE PUT IN WIDELY SEPARATED OPEN AREAS IN THE FIELD DURING THE RAIN STORM, WHICH OF THE FOLLOWING STATEMENTS WOULD BE TRUE ABOUT THE AMOUNTS OF RAINFALL RECORDED?

CIRCLE THE *Y* FOR *YES*; CIRCLE THE *N* FOR *NO*.

Y N A. EACH AREA WILL RECORD THE SAME TOTAL AMOUNT FOR THE 60 MINUTE (ONE-HOUR) PERIOD OF THE STORM.

Y N B. THE PATTERNS OF HEAVY AND LIGHT RAINFALL WOULD BE IDENTICAL AT EACH GAUGE.

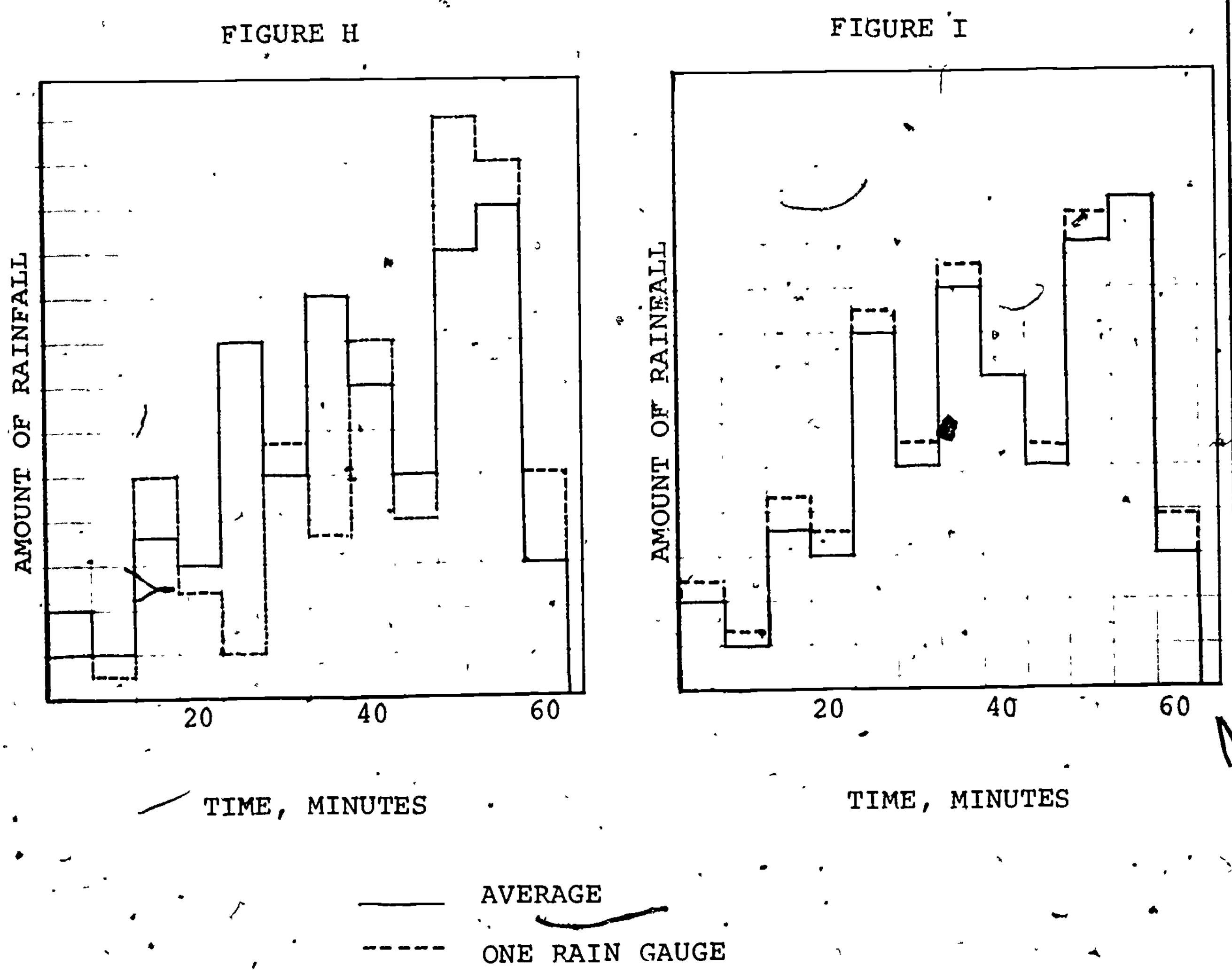
Y N C. THE DIFFERENCES, OR VARIATIONS (VARIABILITY), IN AMOUNTS OF RAINFALL PER MINUTE AT A PARTICULAR GAUGE WOULD BE GREATER THAN THE DIFFERENCES BETWEEN THE AVERAGE AMOUNTS RECORDED FOR EACH MINUTE BY ALL THE GAUGES.

7. BAR GRAPHS WERE MADE TO SHOW THE AMOUNTS OF RAINFALL MEASURED BY EACH OF THE TEN RAIN GAUGES REFERRED TO IN QUESTION 6 ABOVE. DATA WERE TAKEN EVERY 5 MINUTES. A BAR GRAPH WAS ALSO MADE OF THE *AVERAGE* AMOUNT OF RAINFALL REGISTERED BY THE TEN RAIN GAUGES DURING THE 60-MINUTE PERIOD OF THE STORM. THE SOLID-LINE GRAPHS IN BOTH FIGURES *H AND I* BELOW SHOW THE AMOUNT OF RAINFALL AVERAGED FROM ALL TEN GAUGES. EACH HAS A DOTTED LINE GRAPH DRAWN UPON IT TO SHOW AMOUNTS OF RAINFALL THAT MAY HAVE BEEN MEASURED BY ONLY A SINGLE GAUGE. WHICH ONE OF THE SETS OF GRAPHS (FIGURE *H OR I*?) MOST LIKELY REPRESENTS WHAT WAS ACTUALLY MEASURED BY A GAUGE IN THE FIELD?

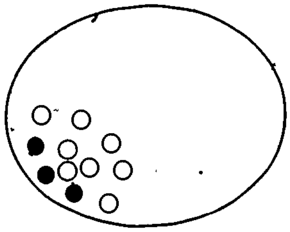
WRITE YOUR ANSWER ON THIS LINE. ______________________

WHY DID YOU SELECT THAT FIGURE? ______________________

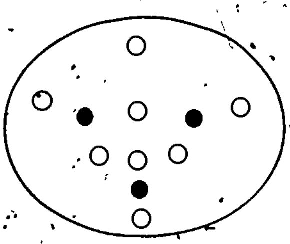
____

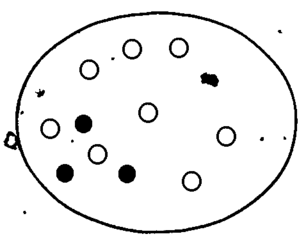


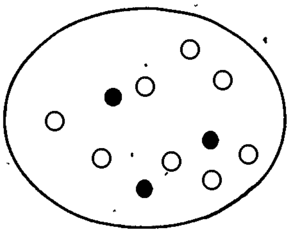
SEQUENCE I: HERE IS A PICTURE OF HOW SOME BLACK AND WHITE MARBLES WERE ARRANGED IN A DISH.

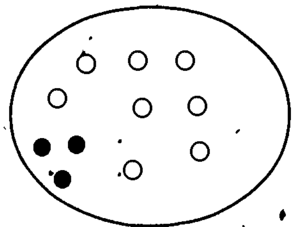


THE DISH WAS THEN PLACED ON A TABLE WHICH WAS SHAKING. AS A RESULT OF THE SHAKING OF THE TABLE THE MARBLES MOVED AROUND IN THE DISH. PLACE A *Z* ON THAT PICTURE WHICH SHOWS THE ARRANGEMENT OF THE MARBLES AFTER THEY HAD BEEN SHAKING FOR A CONSIDERABLE LENGTH OF TIME; PLACE AN *M* ON THAT PICTURE WHICH SHOWS THE MOST LIKELY ARRANGEMENT AFTER ABOUT HALF THE LENGTH OF TIME OF SHAKING. KEEP IN MIND THE INITIAL ARRANGEMENT OF MARBLES BEFORE SHAKING.



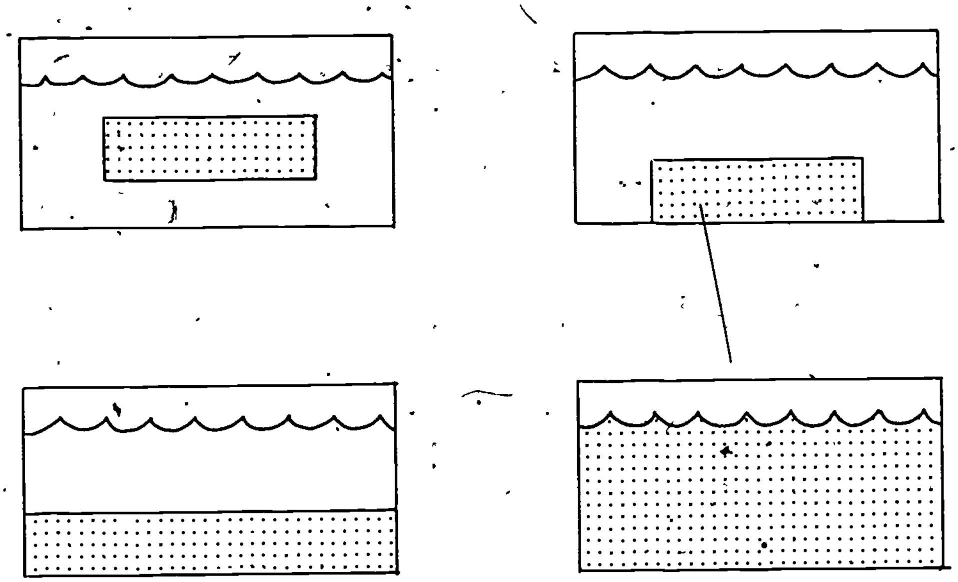






269

SEQUENCE II: THE DOTS IN THESE PICTURES REPRESENT SOME BLUE VITRIOL MOLECULES. THE CLEAR PORTION REPRESENTS WATER. THIS SYSTEM IS ALLOWED TO STAND FOR SEVERAL DAYS. MARK THAT PICTURE WHICH SHOWS THE SITUATION EARLY IN THE SEQUENCE WITH AN *A* AND MARK A *Z* ON THE PICTURE WHICH SHOWS THE SITUATION AFTER A LONG PERIOD OF TIME.



1. JANICE WALKED TO THE TOP OF A HILL. SHE CARRIED A BALL WITH HER. WHEN SHE REACHED THE TOP OF THE HILL, DARRELL, WHO WAS AT THE BOTTOM OF THE HILL, THREW A SECOND BALL TO HER. COMPARE THE POTENTIAL ENERGIES OF THE FIRST AND SECOND BALLS WHEN THEY ARE AT THE TOP OF THE HILL.

A. THE SECOND BALL HAS MORE POTENTIAL ENERGY.

B. JANICE'S FIRST BALL HAS MORE POTENTIAL ENERGY.

C. BOTH BALLS HAVE THE SAME POTENTIAL ENERGY.

2. DEAN CARRIED A BASKETBALL FROM THE BASEMENT OF HIS HOUSE TO THE ROOF. HE FOUND ANOTHER BASKETBALL ON THE ROOF. COMPARE THE POTENTIAL ENERGIES OF THE TWO BASKETBALLS.

A. THE ONE HE CARRIED UP HAS MORE POTENTIAL ENERGY.

B. THE ONE THAT WAS ALREADY UP THERE HAS MORE POTENTIAL ENERGY.

C. THEY BOTH HAVE THE SAME AMOUNT OF POTENTIAL ENERGY.

3. DIANE EXERTED 10 FORCE-UNITS TO LIFT A BRICK 5 FEET. THEO STOOD ON THE ROOF OF HER HOUSE AND PULLED UP A BALL 20 FEET TO THE TOP. THEO EXERTED 5 FORCE-UNITS TO RAISE THE BALL. COMPARE THE POTENTIAL ENERGIES OF THE BALL AND THE BRICK AFTER THEY WERE LIFTED.

A. THE BALL HAS MORE POTENTIAL ENERGY.

B. THE BRICK HAS MORE POTENTIAL ENERGY.

C. THEY BOTH HAVE THE SAME AMOUNT OF POTENTIAL ENERGY.

1. ARNOLD HAS A LAWN MOWER AND HE CALCULATED VERY CAREFULLY HOW MUCH WORK IT TOOK TO PUSH IT. HE FOUND THAT THE AMOUNT OF WORK HE PUT INTO THE MOWER DID NOT EQUAL THE AMOUNT OF WORK THE MOWER DID. WHICH STATEMENT IS TRUE?

A. THE MOWER WILL ALWAYS DO MORE WORK THAN IS PUT INTO IT.

B. THE MOWER WILL ALWAYS DO LESS WORK THAN IS PUT INTO IT.

C. SOMETIMES THE MOWER WILL DO MORE WORK AND SOMETIMES LESS WORK.

2. ARNOLD WANTS TO SHOW THAT THE TOTAL AMOUNT OF WORK HE PUT INTO THE LAWN MOWER CAN BE ACCOUNTED FOR. IN ADDITION TO THE AMOUNT OF WORK THE MOWER DOES WHAT ELSE SHOULD HE CALCULATE?

A. THE AMOUNT OF POTENTIAL ENERGY PRODUCED AS THE MOWER CUT.

B. THE AMOUNT OF HEAT ENERGY PRODUCED AS THE MOWER CUT THE GRASS.

C. THE AMOUNT OF HEAT ENERGY PRODUCED BY THE SUN.

3. ARNOLD DOES NOT LIKE THE IDEA OF PUTTING SO MUCH MORE WORK INTO THE MOWER THAN HE GETS OUT. WHAT SHOULD HE DO?

A. GET A LARGER MOWER.

B. OIL THE MOWER TO REDUCE FRICTION.

C. OIL THE MOWER TO INCREASE FRICTION.

4. PRETEND YOU ARE ON ANOTHER PLANET IN SPACE WHERE THERE IS NO FRICTION. A PENDULUM BOB IS PULLED BACK AND RELEASED. WHAT WILL EVENTUALLY HAPPEN TO THE PENDULUM?

A. IT WILL EVENTUALLY STOP MOVING.

B. IT WILL TEND TO SPEED UP.

C. IT WILL NEVER STOP.

5. WHAT POSITION WILL THE PENDULUM REACH AT EACH SWING?

A. THE SAME HEIGHT.

B. A LOWER HEIGHT.

C. A HIGHER HEIGHT.

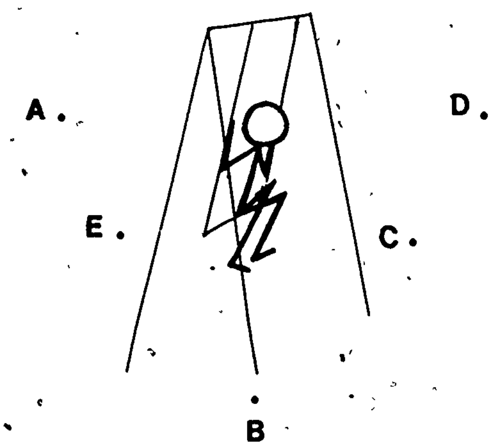
6. WHY WOULD IT BE DIFFICULT TO PLAY GOLF ON THIS FRICTIONLESS PLANET?

A. THE PLAYER COULD GET A PERFECT SWING EACH TIME.

B. THE BALL WOULD STOP ROLLING TOO SOON.

C. THE BALL WOULD NEVER STOP ROLLING.

SITUATION I: MORRIS IS ON A SWING WHICH LOOKS LIKE THE ONE IN THE PICTURE. THE LETTERS *A, B, C, D AND E* REPRESENT DIFFERENT POSITIONS THAT THE SWING WILL REACH WHEN IT IS SWINGING. MORRIS AND THE SWING ARE PULLED BACK TO POSITION *A* AND THEN RELEASED.



1. AT WHICH POSITION IS MORRIS' POTENTIAL ENERGY THE GREATEST?

   A. AT POSITION *A*.

   B. AT POSITION *B*.

   C. AT POSITION *C*.

2. AT WHICH POSITION IS HIS KINETIC ENERGY THE GREATEST?

   A. AT POSITION *A*.

   B. AT POSITION *B*.

   C. AT POSITION *C*.

3. AT WHICH TWO POSITIONS IS HIS POTENTIAL ENERGY ABOUT THE SAME?

   A. AT POSITIONS *A and B*.

   B. AT POSITIONS *B and C*.

   C. AT POSITIONS *A and D*.

4. AT WHICH POSITION IS MORRIS MOVING THE FASTEST?

   A. POSITION *A*.

   B. POSITION *B*.

   C. POSITION *C*.

5. AT WHICH POSITION IS MORRIS MOVING THE SLOWEST?

   A. AT POSITION *A*.

   B. AT POSITION *B*.

   C. AT POSITION *C*.

6. MORRIS SWINGS FROM POSITION *A* TO *E* TO *B* TO *C* TO *D*. AT POSITION *C* WHAT CAN BE SAID ABOUT MORRIS' SWINGING?

   A. HE IS SPEEDING UP.

   B. HE IS SLOWING DOWN.

   C. THERE IS NO WAY TO TELL.

7. WHAT WILL PROBABLY CAUSE THE SWING TO STOP?

   A. MORRIS' WEIGHT.

   B. THE LENGTH OF THE ROPES HOLDING THE SWING.

   C. THE RUBBING OF PARTS OF THE SWING AS IT MOVES.

8. WHAT WILL HAPPEN TO THE TEMPERATURE AT THE POINT WHERE THE ROPES HOLDING THE SWING ARE ATTACHED AT THE TOP?

   A. NO CHANGE WILL OCCUR.

   B. THE TEMPERATURE WILL RISE.

   C. THE TEMPERATURE WILL DECREASE.

9. SOMEBODY PLACES A BOX IN FRONT OF THE SWING NOW SO THAT MORRIS' LEGS HIT IT WHEN HE SWINGS DOWN. IT GETS MOVED WHEN MORRIS BUMPS INTO IT. HE DECIDES TO SEE FROM WHICH POSITION HE SHOULD START SO THAT THE BOX WILL MOVE THE FARTHEST. HE SHOULD START TO SWING FROM:

A. POSITION *E*.

B. POSITION *A*.

C. IT MAKES NO DIFFERENCE.

SITUATION II: JOE AND ARNIE WERE BATTING BALLS. LOIS WAS THE PITCHER AND SHE ALSO CAUGHT THE BALLS THE BOYS BATTED. JOE COULD SWING HIS BAT FASTER THAN ARNIE. HERE ARE THE QUESTIONS. CIRCLE THE LETTER FOR THE ANSWER YOU PREFER.

1. WHAT WOULD SHE HAVE OBSERVED ABOUT THE SPEED OF THE BALLS SHE CAUGHT FROM JOE COMPARED WITH THE ONES FROM ARNIE?

   A. THE SPEEDS WERE THE SAME BECAUSE BALLS CAN GO ONLY SO FAST.

   B. JOE'S BALL WAS FASTER BECAUSE HIS FASTER SWING GAVE IT MORE KINETIC ENERGY.

   C. ARNIE'S BALL WAS FASTER BECAUSE HE DIDN'T HAVE TO WORK SO HARD.

2. LOIS' GLOVE BECAME VERY WARM AFTER SHE CAUGHT EACH BALL. THE MOST LIKELY REASON FOR THIS IS THAT:

   A. A BALL GETS VERY WARM AS IT MOVES THROUGH THE AIR.

   B. THE KINETIC ENERGY OF THE MOVING BALL IS CONVERTED TO HEAT ENERGY WHEN IT IS CAUGHT.

   C. BASEBALL IS USUALLY PLAYED IN THE SUMMERTIME WHEN IT IS MUCH WARMER THAN IN THE WINTERTIME.

3. IF LOIS WANTED HER GLOVE NOT TO GET SO WARM, SHE SHOULD PICK THE BALL UP AFTER IT HAD BOUNCED ON THE GROUND BECAUSE:

   A. IT WOULD THEN HAVE LESS KINETIC ENERGY.

   B. BOUNCING COOLS IT OFF.

   C. IT WOULD BE MOVING FASTER AFTER IT BOUNCED.

SITUATION III: BOBBY GOES DOWN A SLIDE AT A PLAYGROUND. AT THE TOP OF THE SLIDE HE HAS 100 UNITS OF POTENTIAL ENERGY. AS HE SLIDES HE NOTICES THAT THE SLIDE AND HIS JEANS BECOME WARM.

1. WHAT WOULD YOU PREDICT ABOUT BOBBY'S KINETIC ENERGY AS HE LEAVES THE SLIDE BEFORE HE LANDS?

   A. HE WILL LEAVE THE SLIDE WITH 100 UNITS OF KINETIC ENERGY.

   B. HIS KINETIC ENERGY WILL BE LESS THAN 100 UNITS WHEN HE LEAVES THE SLIDE.

   C. HE WILL GAIN ENERGY AND LEAVE THE SLIDE WITH MORE THAN 100 UNITS OF KINETIC ENERGY.

2. IF BOBBY WANTS TO GO OFF THE SLIDE WITH ALMOST TWICE AS MUCH KINETIC ENERGY AS HE DID BEFORE, HE SHOULD:

   A. RUB WAX ON THE SLIDE SO HE CAN GO DOWN FASTER.

   B. CHOOSE A SLIDE THAT IS TWICE AS LONG BUT NOT AS HIGH.

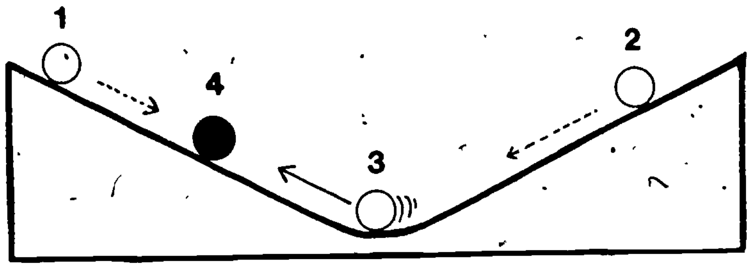
   C. CHOOSE A SLIDE THAT IS TWICE AS HIGH BUT NOT AS LONG.

3. IF BOBBY WANTS TO MAKE SURE HIS JEANS DON'T GET SO WARM, HE SHOULD:

   A. RUB SOME WAX ON THE SLIDE.

   B. GO DOWN AS QUICKLY AS POSSIBLE.

   C. EITHER OF THE ABOVE.



SITUATION IV: A BALL ROLLS BACK AND FORTH ON THE COASTER AS SHOWN. IT IS RELEASED FROM POSTION 1, ROLLS TO POSITION 2, THEN ROLLS BACK AGAIN. AT POSITION 1, WHERE IT STARTS, IT HAS 50 UNITS OF POTENTIAL ENERGY WITH RESPECT TO THE GROUND. CIRCLE THE LETTER IN FRONT OF THE CHOICE YOU PREFER AS AN ANSWER TO EACH ITEM.

1. WHEN IT ARRIVES AT POSITION 2, THE BALL HAS 40 UNITS OF POTENTIAL ENERGY. THE AMOUNT OF HEAT ENERGY PRODUCED IN THE SURFACES WOULD BE EQUIVALENT TO:

   A. 10 UNITS OF ENERGY -- THE DIFFERENCE BETWEEN 50 AND 40.

   B. 5 UNITS -- HALF THE DIFFERENCE SINCE IT HAS TO GO BACK AGAIN.

   C. 20 UNITS -- SINCE IT CAN STILL MOVE DOWNWARDS.

2. WHEN THE BALL ARRIVES AT POSITION 3, IT HAS:

   A. MINIMUM POTENTIAL ENERGY.

   B. MAXIMUM KINETIC ENERGY.

   C. BOTH STATEMENTS ARE TRUE.

3. WHEN IT ARRIVES AT POSITION 3, ROLLING FROM POSITION 2, THE BALL IS FOUND TO BE MOVING WITH KINETIC ENERGY EQUIVALENT TO 30 UNITS. THUS IT CAN BE INFERRED THAT AFTER IT LEFT POSITION 1 AND FINALLY CAME TO POSITION 3:

   A. ITS KINETIC ENERGY WAS PRODUCED AT THE EXPENSE OF HEAT ENERGY.

   B. A TOTAL OF 20 UNITS OF HEAT ENERGY WAS PRODUCED.

   C. NO MORE HEAT ENERGY WAS PRODUCED GOING FROM 2 TO 3. THE ENERGY WENT INTO MORE KINETIC ENERGY.

4. THE BALL THEN ROLLS UP TO POSITION 4 AND STOPS BEFORE ROLLING DOWN AGAIN. WITH THE BALL AT THIS POSITION, 4, THE ENERGIES OF THE BALL AND SURFACES COULD BEST BE DESCRIBED AS:

A. A BALL WITH ABOUT 20 UNITS OF POTENTIAL ENERGY AND SURFACES WITH ABOUT 30 UNITS OF HEAT ENERGY.

B. A BALL WITH 20 UNITS OF POTENTIAL ENERGY, 20 UNITS OF KINETIC ENERGY AND 10 UNITS OF HEAT ENERGY DISTRIBUTED OVER THE SURFACES.

C. A BALL WITH A TOTAL OF 50 UNITS OF HEAT ENERGY.

APPENDIX A

State and Jurisdictional Summaries

Appendix A provides a listing of summary information submitted by the States and other Jurisdictions for the National Water Quality Inventory Report for 1976.

These summaries have been excerpted directly from reports received from each State and Jurisdiction. The reader can obtain more complete information by writing to the applicable agency included on the title page which precedes each of the following summaries.

APPENDIX A
Summary - State of Alabama

Complete copies of the State of Alabama 305(b) Report can be obtained from the Agency listed below:

Alabama Water Improvement Commission
State Office Building
Montgomery, AL 36104

Introduction

In 1974, the first water quality report to Congress in accordance with Section 305(b) of Public Law 92-500 for the State of Alabama was. prepared. The result was a voluminous report which not only included a statewide review of water quality for 1974 but also contained detailed information concerning the fourteen river basins of Alabama. This information included a description of each basin, water uses in the basin, water quality of the basin, and non-point source pollution in the basin. For 1975, the water quality report to Congress will follow a format similar to that used for the 1974 report; however, in the interest of brevity, the report will only concern itself with water quality.

New information in the form of relative condition factors for selected Alabama fish is included in the 1975 report, and it is expected that such additions will be included in subsequent reports as data are made available. The relative condition factors were computed by using the formula $Kn = \frac{W}{\hat{W}}$, where W equals the weight of a fish of a specific length and $\hat{W}$ is the computed weight for the same length, derived from the equation $\hat{W} = aL^b$ for particular species in Alabama river systems. The $\hat{W}$ values were taken from *Tables for Computing Relative Conditions of Some Common Freshwater Fishes* by W.E. Swingle and E.W. Shell. After individual values were computed, an overall average for all fish at the station was reported.

Water Quality

Completion of 1975 statewide trend station monitoring produced data comparable to that obtained during 1974. There was, however, an 8.3 percent increase in stations which met current water quality objectives during 1975 as compared to 1974. A total of 43.6 percent of the trend stations met water quality objectives during 1975, while 35.3 percent of the trend stations achieved current water quality objectives during 1974. Various reasons for this improvement in water quality will be discussed in later portions of this report.

It must be kept in mind that the majority of the trend stations were chosen in order to monitor problem areas in the State and, therefore, the data presented cannot be used to draw precise analogies with the status of quality in other areas of the State. It should also be recognized that the gradual implementation of industrial and/or municipal treatment facilities will manifest itself in an upgrading of water quality in trend station data over time.

Although some improvement in water quality was observed during 1975, two years of monitoring data is still insufficient for observation of long-term trends. Hopefully, a period of five to ten years will produce monitoring data of statistical significance with respect to changes in water quality. This period should also coincide with the completion of the majority of treatment facilities now in various stages of progress, and the expected enhancement of water quality should be evident.

There are, however, situations where the ultimate achievement of water quality objectives is most doubtful. Although improvement in quality may be observed, it is anticipated that such areas will experience a level of quality less than that desired for some time into the future. Such situations are encountered when natural flows of receiving streams are considerably less than the amount of effluent, treated, or inadequately treated waste presently entering the stream.

Total number of trend monitoring stations and stations meeting water quality objectives are indicated in Figure 1. Parameter measured at those stations are listed in Table 1.

TABLE 1

WATER QUALITY DATE AVAILABLE FROM THE ALABAMA WATER IMPROVEMENT COMMISSION TREND STATION NETWORK

*Air temperature	*Total dissolved solids
*Water temperature	*Total suspended solids
*Dissolved oxygen	*Volatile suspended solids
*DO percent of saturation	*Fecal coliform
*Biochemical oxygen demand	*Flow
*pH	*Weather
*Alkalinity	*Date collected
*Hardness	*Time collected
*Color	**Iron
*Turbidity	**Copper
*Nitrates	**Zinc
*Chlorides	**Chromium
*Phosphates	***Cyanide

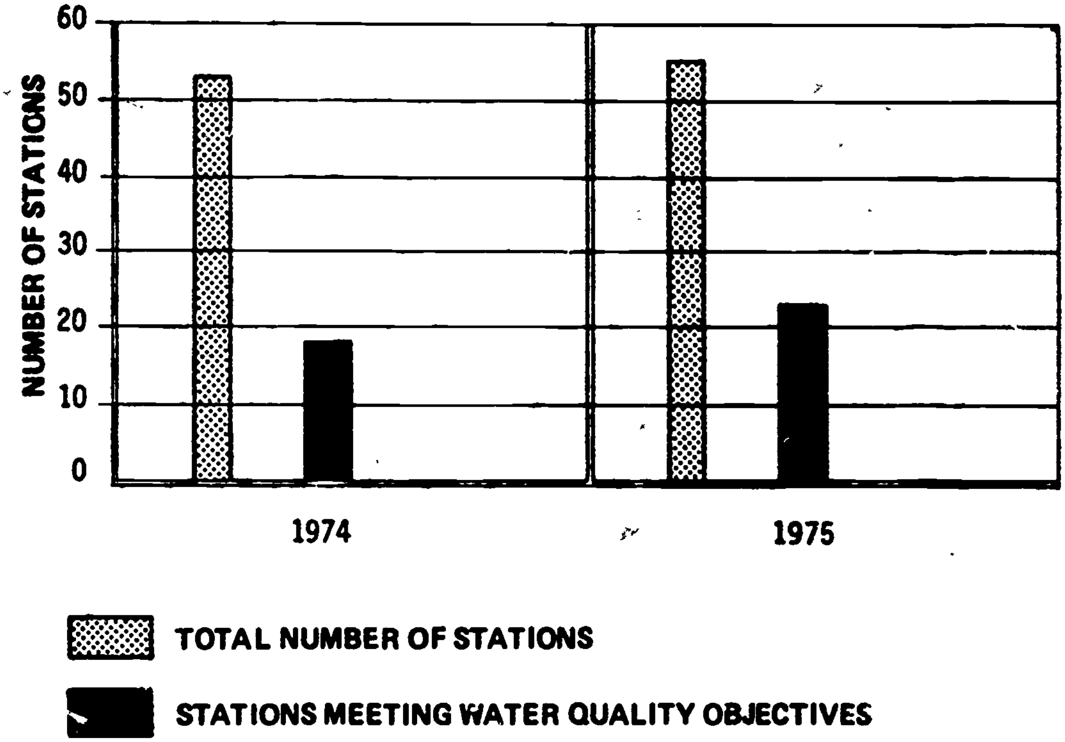
*Monthly.
**Quarterly.
***Annually.

Non-point Source Pollution

With the majority of the Commission's available resources primarily concerned with point source pollution, degradation of water quality resulting from non-point source pollution has not been the focus of extensive evaluation throughout the State. However, with improvements in the point source area, identification and implementation of non-point source pollution abatement will ensue as resources permit. The Commission has taken some initial steps in the area of non-point source pollution, and it is expected that information obtained from the completion of the 208 planning processes will help to identify non-point source pollution and costs associated with attainment of water quality goals where control of non-point source pollution is involved.

FIGURE 1

WATER IMPROVEMENT COMMISSION TREND MONITORING STATIONS AND WATER QUALITY STATUS



NOTE: TREND STATIONS WERE CHOOSEN TO MONITOR PROBLEM AREAS IN THE STATE AND DATA OBTAINED AT THESE STATIONS ARE NOT INDICATIVE OF THE OVERALL STATUS OF THE WATER QUALITY IN THE STATE.

Silviculture

The Commission has adopted certain forest practices guidelines intended to address water quality problems which may be associated with silvicultural practices. These guidelines suggest the use and maintenance of buffer zones and incorporate other recommendations concerning silvicultural activities near watercourses. In addition, a three-year study to evaluate water quality problems and the effectiveness of these guidelines was initiated during the summer of 1975 with the hope that data generated from this study would give some insight into water quality problems associated with operations in Alabama. In conjunction with the adoption of guidelines, a cooperative statewide educational program between the Commission and the State Forestry Association aimed toward the forest industry was initiated. The use of radio, television, and newspapers, along with training sessions, comprise the bulk of this educational approach.

Construction

Cooperation between the State Highway Department and the Commission in the form of Commission staff review of highway project proposals and subsequent recommendations by the staff to ensure water quality is another step to reduce non-point source pollution.

Non-point source pollution arising from dredge and fill projects is being kept to a minimum as a result of the state certification program under the provisions of Section 401(a)(1) of the Federal Water Pollution Control Act Amendments of 1972. All proposed projects are reviewed by the staff to ensure that water quality will be maintained before projects can proceed.

Mining

In 1974, the Commission adopted certain surface mining regulations in an effort to address non-point source pollution from the mining of minerals in the State. These regulations require the submittal of pollution abatement plans prior to the initiation of mining. This prior planning for protection of water quality, when coupled with Staff inspection activity, has been most successful in addressing the water pollution problems associated with mining.

Agriculture

Non-point source pollution problems which result from agricultural activities are handled on a compliant basis. The majority of these compliants are concerned with feed lot operations and aerial application of pesticides. In the former instance, relatively simple and inexpensive treatment and management practices are available, and the Commission's staff works in close cooperation with the Soil Conservation Service and other agriculturally oriented agencies to correct these deficiencies when encountered. In addition, informational materials relating to proper disposal of animal waste are made available and distributed throughout the State.

The Commission's staff worked closely with the Department of Agriculture in the development of regulations concerning the aerial application of pesticides, and participates with the Department to correct problems associated with pesticides where appropriate.

Fish Mortality Associated with Non-point Source Pollution

During 1975, twenty-nine (29) fish kills were investigated by the Commission's staff of which seven (7) were attributable to non-point source pollution (Table 2), while during 1974, eleven (11) fish kills were attributable to this same cause. The reduction for 1975 is manifested in the reduced number of pesticide related fish kills, and it is felt to be indicative of an increased awareness of the problems which can result when the careless use of economic poisons prevails. It is hoped that in the future, the number of pesticide related fish kills will decrease as the users of these economic poisons become increasingly aware of the hazards involved.

TABLE 2

SUMMARY OF 1975 FISH KILLS BY
RIVER BASIN AND CAUSE

	Number	Pesticides	Suspected pesticides	Industrial wastes	Municipal wastes	Natural	Construction	Illegal poisoning	Unknown	Transportation	Other
River Basin											
Alabama	3	-	-	1	1	-	-	1	1	-	-
Coosa	3	-	-	-	-	2	1	-	-	-	-
Chattahoochee	1	-	-	-	-	-	-	-	-	-	1
Escambia	1	-	-	1	-	-	-	-	-	-	-
Mobile	5	1	-	-	-	1	-	-	1	-	2
Perdido	1	-	-	-	-	-	-	-	-	-	1
Tennessee	11	1	4	-	-	1	-	-	4	-	1
Warrior	4	-	-	1	1	-	-	-	-	2	-
Total	29	2	4	2	2	4	1	1	6	2	5

58

APPENDIX A
Summary - State of Alaska

Complete copies of the State of Alaska 305(b) Report can be obtained from the State agency listed below:

State of Alaska Department of Environmental Conservation
Pouch O
Juneau, AL 99811

Since the State of Alaska did not provide a short summary in its 305(b) Report, this summary consists of excerpts from that report. The following summary was provided by EPA Region X.

Current Water Quality and Recent Trends

Alaska reports that its waters are generally in compliance with water quality standards except in a few areas that are discussed withthin the document. Some percentage of waters within Alaska do not meet standards due to natural conditions. The extent of these conditions was not, and presently cannot, be quantified. Parameters associated with man-induced pollution problems in the State include bacteria, dissolved oxygen, pH, toxic sulfite waste liquor, oil, and suspended solids.

There is an apparent need for an improved water quality surveillance program in Alaska (including trend stations and intensive surveys). Present assessments are based on marginal-to-inadequate data; interpretations and extrapolations of the data are unreliable. Obtaining a minimum data base in Alaska would be costly. Transportation difficulties and extreme weather conditions make sample collection costs almost prohibitive. Region X does not include Alaska stations in the National Water Quality Surveillance System (NWQSS) because the cost to maintain even a few stations would exceed its monitoring budget allotment for the entire four-state region. Additional surveillance funds earmarked specifically for Alaska would be necessary for the Region to initiate NWQSS stations in the State.

Water Quality Goals and Control Programs

Alaska's water quality standards are its water quality goals, and control programs are designed to maintain those standards. In its 305(b) Report for 1976, the State makes the judgement that most waters presently meet Federal 1983 goals. Point source pollution control programs and associated improvements are discussed for several areas, even though most improvements can only be discussed from a qualitative standpoint. Non-point source programs are at an infant stage.

Costs and Benefits

Alaska has made an effort toward defining costs involved in meeting 1983 goals, where there are data available. The State expresses concern over existing and proposed effluent guidelines, which may curtail the pulp and paper and placer industries. Alaska has identified benefits that will be derived by maintaining good water quality, but could not quantify them.

Non-point Sources

Alaska has identified six major non-point source categories of concern. They are siliviculture in southeast Alaska, where a great amount of logging takes place; urban runoff in major cities like Anchorage (Alaska's largest city); village sanitation; road and pipeline construction; waste oil disposal; and placer mining. Natural high sediment levels occur in many of the streams in the State; with little water quality data available, it is virtually impossible to differentiate between natural and man-caused pollution from non-point sources. This point is repeatedly addressed in Alaska's report.

APPENDIX A
Summary - State of Arizona

Complete copies of the State of Arizona 305(b) Report can be obtained from the State agency listed below:

Bureau of Water Quality Control
Division of Environmental Health Services
Arizona Department of Health Services
1740 West Adams St.
Phoenix, AZ 85007

Background Information

Arizona has a wide variety of climatic zones, but most of the State receives less than 20 inches of precipitation a year. Over half the State receives less than 10 inches per year. Evaporation rates are high.

The quality of surface water in Arizona, in general, is near levels associated with natural conditions. The State is fortunate not to have reached the critical point of environmental deterioration that has occured elsewhere in this country. Thus, Arizona's water quality program is concerned more with maintenance than with restoration. However, it is essential that problems be recognized and comprehensive plans developed in time to combat future demands on water resources, provide control of water quality, and provide control of water pollution. Much of the water quality information and studies needed to define problems and provide solutions to water quality problems in the State is inadequate. Data used to prepare this report was limited to that which was readily available. Consequently, this report is not as specific as might be desirable. It is difficult to cite specific violations in water quality because quantity and quality of data are not adequate for this purpose at many locations.

Water Quality and Violations

A total of 336 violations of surface water standards were observed in 1975; 80 in the Fixed Station Network, 48 in the two intensive surveys, and 208 in the Lake Eutrophication Survey. Other violations were observed on miscellaneous samples from time to time, but they have not been tabulated herein

Water quality is highly dependent upn the geology and morphology of the receiving watershed. In this arid region, surface water comes mainly from surface runoff and shallow precipitation. Base flow is small and can be highly mineralized. Runoff from rainfall and snow melt can be of good mineral quality but high in suspended sediments. In addition, irrigation of soils can contribute significant amounts of unleached salts. During the intensive surveys of the past three years, potential violations in bacteriological, turbidity, pH, toxic metals, and proposed nutrient standards were observed. High turbidity levels following runoff events are common throughout the State. Sources of this turbidity remain to be identified.

Bacteriological problems are associated with agricultural and recreational waters. The two uses are often concurrent, making it difficult to judge the sanitary significance of violations in indicator organisms. Potential problems have been observed in the Verde River, Oak Creek, the Colorado River, and the Salt River Lakes (Roosevelt, Apache, Canyon, and Saguro).

Problems with toxic metals can occur downstream from mining activities in mineralized areas. Areas of concern are the lower reaches of the San Francisco River and San Pedro River, and the reach of the Gila River from Coolidge Dam to the Ashurst-Hayden Diversion Dam.

Violations of nutrient standards, specifically total phosphates, are presumed to be related to municipal and agricultural discharges. However, some contribution may be attributed to leaching of natural phosphates from soils. This relative proportion that is contributed by each source remains to be determined.

Trends

The bulk of data is still too scarce to adequately delineate major trends in water quality, but, with continued operation of the Fixed Station Network, this deficiency will eventually be alleviated.

Some improvements in water quality have occurred in water bodies that serve as receiving streams for treatment plant effluents. The improvements are traceable either to an improvement in the quality of the effluent due to new plant construction and/or better operating techniques or to a discontinuance of the discharge altogether.

Water quality in some areas has shown a decline because development was so rapid that adequate waste treatment facilities could not keep up. Small existing plants became overloaded and had to discharge inadequately treated water. The Pinetop-Lakeside area has been plagued with failing septic tank systems for years. This problem will hopefully be remedied soon with the construction of a new centralized collection and treatment system. Other areas with similar problems include Greer, Bullhead City, the Parker Strip and areas near Prescott.

Some degradation of groundwater supplies may have already taken place. There is concern about the Globe-Miami area, the area south of Tucson and a new proposed operation in the Tombstone area. Implementation of a groundwater monitoring network should determine the extent of the problem and will undoubtedly uncover some more problem areas.

Program Impacts

In the past, water quality has been inadequate to assess, not only current water quality conditions, but also long-range trends and changes that had resulted from programs of the Bureau, other agencies, and private industry. Recent program activities, resulting from Public Law 92-500, have been significant steps taken to alleviate this deficiency. Intensive surveys were conducted in an effort to begin establishing background levels of water quality. A fixed station network has been implemented to monitor long-term water quality trends and, hopefully, to flag serious degradations in surface water quality at the earliest possible stages. The compliance monitoring program, an integral part of the National Pollutant Discharge System (NPDES), has helped to improve general maintenance and operation of treatment plants across the State, resulting in a better quality effluent.

The greatest positive impact has been on the construction of waste treatment facilities. Such construction has allowed Arizona to maintain the quality of its receiving waters at near natural levels. Twenty-three treatment facilities have been built in the five years preceding FY 76. Twelve facilities were upgraded and eleven were new systems. Five of the new systems reused the effluent in some manner, while six facilities created new discharges which may constitute a degradation rather than an upgrading of water quality.

The permit program, while controversial, has had the benefit of forcing facilities to be concerned about the quality of their effluent. But the program will cause an unnecessary economic loss by upgrading facilities (such as lagoons) that are not causing any problems with receiving waters. Problems will also occur when facilities are unable to meet monitoring requirements. It is difficult to go from no self-monitoring to levels required by 1977. This is particularly true where private laboratories and municipal laboratories are either nonexistent or at minimal levels. The changes in test methodology that are occuring will keep test procedures in turmoil for some time. Some facilities will be reluctant to purchase expensive test equipment for a particular test (coliform—MPN vs. MF) when test procedures are uncertain.

The impacts of basin planning activities and Section 208 planning activities will take some time to materialize because they are, by design, long-range planning programs. However, increased State and Federal presence may have some immediate beneficial impact on programs dealing with water pollution. Several of the basin plans, prepared under contract by outside consultants, are either completed or in the final draft stages. The rest will soon be completed. The 208 planning process is still in its early stages. The Governor of Arizona has designated the six regional Councils of Government (COGs) as the official Section 208 planning agencies. The Bureau's input and role in coordinating these activities has not yet been determined.

Much of the early program grant documents submitted in response to deadlines imposed by PL 92-500 and subsequent EPA regulations were of necessity hastily prepared and are of questionable value. The time spent preparing such documents has delayed working aspects of various State programs. In a State like ours where staffing is meager, the time lost to ongoing projects has been significant. Lost working time can be justified by planning activities that result in future time savings. It remains to be seen whether or not such savings will be realized.

The facilities inspection program and the operator training and certification program probably have the most visible impact on water quality, at least on the quality of wastewater treatment plant discharges. Deficiencies in plant operation and maintenance that are discovered during routine inspections are often corrected either on the spot or shortly thereafter. As a result of the operator training program, the general knowledge of Arizona's plant operators is slowly but steadily improving, the end result being more competently operated treatment plants.

Water Use

The principal water use in Arizona is irrigation agriculture. Two-thirds of the water used is pumped from groundwater reservoirs. Total yearly water use is estimated at 7.7 million acre-feet, 5 million acre-feet of which was pumped from groundwater storage.

Future uses will remain similar, but there will be changes in the use pattern. Municipal and industrial usage will increase. Agricultural usage may decrease as groundwater supplies are depleted.

Segments where Water Quality Standards Will Not be Met

Full implementation of Public Law 92-500 should help maintain the existing water quality levels of Arizona waters. Some problem areas will be corrected through construction and permit activities. However, some problems may remain. There will be problems with streams that discharge only following rainfall events. Such streams are subject to flash flooding and tubidity levels in excess of State standards. Normally dry streams that receive a well-treated wastewater discharge may also present problems. Stream reaches below mineralized areas may have problems with metals accumulation.

Costs to Achieve Water Quality Goals

Costs to support the construction grant program and State water pollution control program, as administered by the Arizona Department of Health Services through September of 1981, are estimated at $617,949,000. Total construction needs are $612,249,000 of the total amount Program support should require a minimum of $5,7000,000, but this level of funding is unlikely. State and Federal budgets appear to be committed to near current funding levels for program activities; thus $2,450,000 is apt to be available rather then $5,700,000. This will mean that some programs may not be implemented prior to September 1981 while other programs will receive a lower priority.

Control of Non-Point Sources

Non-point sources may contribute bacteria, turbidity, toxic metals and nutrients to Arizona waters in amounts sufficient to cause violations in water quality standards. The nature of the problem has yet to be delineated. It will likely take several seasons to identify and quantify such problems. Sampling sites for such problem identification need to be established. Some locations for non-point source identification were included in the primary monitoring network as required under Section 106 appendix regulations as published on August 28, 1974. However, other stations needed for non-point source evaluation could not be justified because the Section 106 regulations allowed for only intensive surveys and primary stations. Since the parametric coverage required at primary stations was both extensive and inflexible, adequate resources were simply unavailable. The current proposed regulations allow for more flexibility at "Fixed" stations. The new regulations should allow for study of problem areas that require more time than that needed for intensive studies but do not warrant the expense of long-term stations with comprehensive parametric coverage. When data are available to identify sources and pollutant levels, control measures will be studied. Implementation of such control measures cannot be delineated until specific problems have been identified.

APPENDIX A
Summary - State of Arkansas

Complete copies of the State of Arkansas 305(b) Report can be obtained from the State agency listed below:

Arkansas Department of Pollution Control and Ecology
8001 National Drive
Little Rock, AR 72209

Summary

The most significant conclusion from the analysis of current water water quality is that substantially all of the waters located in the highly agriculturalized Mississippi delta region of Arkansas do not now meet the 1983 aquatic life and recreational water quality goals of the Federal Water Pollution Act Amendments of 1972. Further, due to the nature of the problems, it is considered unlikely that the goals will be met in these waters by 1983 or any time in the forseeable future (see Figures 1 and 2).

With the exception of the main stem of the White River and the upper St. Francis River, none of the major Arkansas delta streams meet all of the water quality requirements for swimming and the propagation of desirable species of fish and aquatic life. In most cases, several of the appropriate parameters are substantially in violation of the minimum requirements. In particular, widespread violations of fecal coliform, dissolved oxygen and turbidity standards occur, and significant contributions of a variety of pesticides are found, including endrin, dieldrin, DDT and its metabolites, and toxaphene.

FIGURE 1

STREAMS OR SEGMENTS NOT PRESENTLY MEETING FISHING AND SWIMMING 1983 GOALS

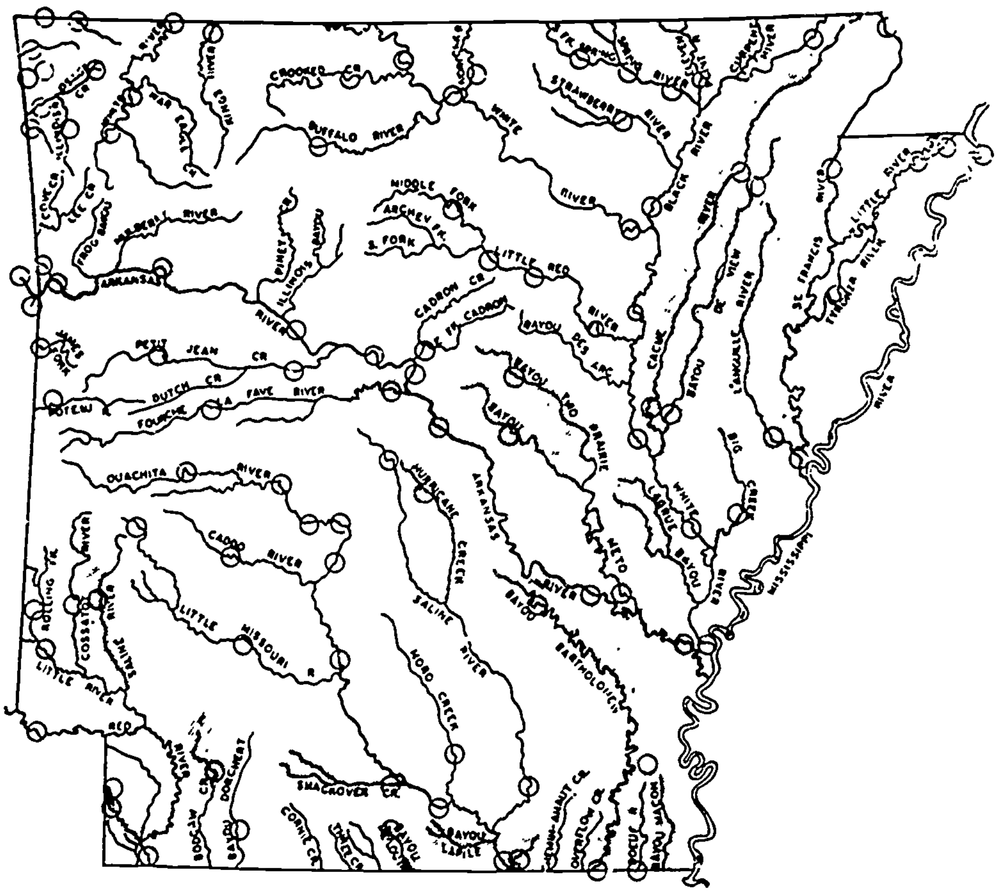
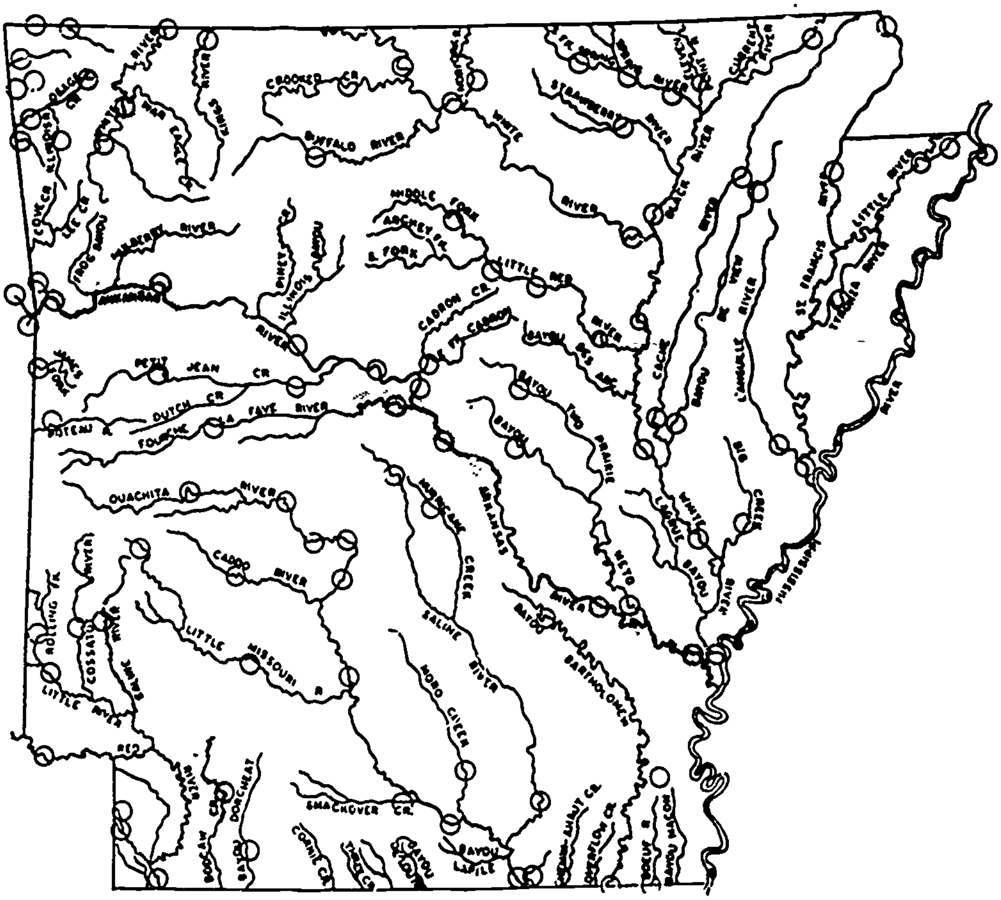


FIGURE 2

WATERS NOT CURRENTLY SUPPORTING FISHING AND SWIMMING BUT EXPECTED TO BY 1983



In the remainder of the State's waters, 1983 water quality goals are now being met or, with a few notable exceptions, are expected to be met by 1983. A number of streams or segments outside the delta are not now meeting the goals due to fecal coliform or dissolved oxygen problems related to point source discharges of inadequately treated municipal sewage. These problems are expected to be cleared up by 1983. Greatest improvements are expected in the main stem of the Arkansas River, which has already shown substantial water quality gains in recent years. Other streams are affected by acid mine drainage or oil field brine problems that will probably improve significantly by 1983 under current programs but will still not meet the stated goals due to the nature of the pollutant input.

In streams where industrial waste discharges occur, the improvements that have been or will be noted by implementation of the best practicable control technology (BPT) requirements of PL 92-500 are often quite significant, but incremental improvements expected by going from BPT to BAT (best available control technology) will often be obscured because of non-point source pollutant input to receiving waters. This is particularly true of industries discharging to south Arkansas streams affected by oil field brines.

Little detailed information is available on the eutrophication potential of Arkansas' lakes. When the results of the 1974 National Eutrophication Survey become available, they will be included in future editions of this report. In general, however, the large clearwater impoundments in Arkansas contain good to excellent quality water but are, in some cases, threatened by rapid and uncontrolled shoreline development, particularly when inadequate methods of domestic waste disposal are used.

Regular water quality monitoring is presently performed on approximately 6,150 miles of the State's potentially fishable, swimmable streams. This total includes all of the major streams of the State. From a purely water quality standpoint, all of these streams would be suitable for the above uses in the absence of man's influences. However, considering the present effects of man's influences on the quality of these waters, it is projected that 4,450 miles, or 72 percent, will meet the 1983 goals of PL 92-500. This leaves 1,700 miles, or 28 percent, that will not meet the goals, generally because of non-point source pollution.

In 1974, a sewerage works "needs" survey for Arkansas was completed. The total amount needed for the correction of all categories of sewerage problems was calculated to be $1,336,858,000.

There are 351 Arkansas towns without any type of sewer system, representing a population of 72,248. Approximately 25 of these communities either have plans completed or construction plans under way for new sewage collection and treatment systems.

There have been very few data collected as yet on the type of treatment needed and costs necessary to meet the best practicable treatment technology (BPT) and best available treatment technology (BAT) requirements for industrial dischargers in 1977 and 1983, respectively. Possibly an industrial treatment costs questionnaire would be the best way to produce this information, and this method will be undertaken if necessary for inclusion in future reports.

There are three major groups of industries in Arkansas that are significant both for the number of people employed and for their polluting potential. These include the food products industry, the forestry-related products industry, and the chemical products and petroleum refining industry. Rough treatment cost estimates were made on various segments of these industries; however, these at best provide only vague indications of total costs.

Recent proposals have been made by EPA relative to permit requirements for point source discharges from concentrated feedlots, silvicultural activities and agricultural operations, including irrigation return flows. As yet we have no information on control costs for these point sources. It might be noted, however, that the establishment of permit requirements for agricultural discharges, such as irrigation return flows and fish farming operations, will have considerable impact in terms of administrative costs alone in a highly agriculturalized state such as Arkansas, with concomitant benefits being rather unlikely.

Information on non-point source control costs is totally lacking. The implementation of Section 208 planning should produce such information.

An assessment of social and economic benefits resulting from pollution control programs must first consider the many aspects of recreation found in and on the waters of the State. There are approximately 10,000 miles of fishable streams and 600,000 acres of man-made and natural lakes in Arkansas. During 1973, 437,081 resident fishing licenses were sold in the State. In 1975, 95,757 trout stamps were issued, and the State ranked 7th nationally by selling 201,348 nonresident fishing licenses.

There are 32 state parks in Arkansas, most of which feature water-based recreational facilities. In 1975, 6,943,000 people visited these parks. There are an estimated 300,000 boats on Arkansas' waters, with boating activities including fishing, sailing, waterskiing and canoeing. During 1975, over 34 million people visited the 20 U.S. Corps of Engineers recreational facilities in the State. It is entirely obvious that water-based recreation provides vast economic and social benefits to the people of Arkansas, and that prevention and control of water pollution is a significant factor in preserving and enhancing these benefits.

In 1975, as a result of water pollution control programs, the classification of two streams was upgraded to permit body contact recreation where such had previously been undesirable due to pollution. Also, two tertiary treatment facilities were completed, which discharge to the watershed of the Buffalo National River, providing a considerable measure of protection for this unique and immensely valuable natural treasure.

The evalution of non-point source water pollution in Arkansas and the development of control programs for the various categories of such pollution is just now getting started under the areawide wastewater management planning provisions of Section 208 of PL 92-500.

As mentioned previously, agricultural non-point source pollution is the category of most significance in Arkansas. The erosion control programs the U.S. Soil Conservation Service, if completely implemented, would result in considerable improvement in the quality of runoff from agricultural watersheds, but it is questionable whether this program alone would allow water quality goals to be met. This would, however, be an important step, and we would welcome the solution of the financial problems that have retarded implementation of this program.

The severity of non-point source pollution from the widespread silvicultural activities in Arkansas is an area of considerable question and controversy. Representatives of all aspects of forestry interests as well as the general public have considered the problem and recommended specific steps to define and control the problems that are found to exist. The formation of a research task force for this and other areas of non-point source pollution is being considered as a part of the Section 208 planning program.

Acid mine drainage continues to be a problem in the bauxite mining areas of Arkansas and in other very localized areas. Control efforts are under way in the bauxite areas that should alleviate the problems somewhat, but a thorough evaluation of the effects of these programs is not scheduled until the summer of 1978.

Information on non-point source pollution related to construction activities and urban runoff will be forthcoming following completion of Section 208 studies planned or in progress for the areas designated as having substantial water quality control problems as a result of urban-industrial concentrations or other factors. These designated areas are Texarkana-Miller County, Little Rock-North Little Rock, Fort Smith and Pine Bluff.

Brine pollution from both point and non-point source pollution in the South Arkansas oil fields is a problem of long standing and will continue to be a problem for some time regardless of control efforts. Recent surveys of this area, however, have resulted in specific recommendations designed to minimize the problems as much as possible.

APPENDIX A
Summary - State of California

Complete copies of the State of California 305(b) Report can be obtained from the State agency listed below:

California State Water Resources Control Board
1416 Ninth St.
Sacramento, CA 95814

Summary

The purpose of the Annual Water Quality Inventory report is to present a summary of water quality conditions, problems and control activities. The Inventory fulfills the requirement of Section 305(b) of the Federal Water Pollution Control Act Amendments of 1972 (PL 92-500).

Rather than attempt an exhaustive survey and reproduction of all water quality data gathered in water year 1975 (October 1974-September 1975), a task which would duplicate the efforts of numerous local, State and Federal agencies, conditions on selected water bodies have been highlighted.

Historical data for five major representative rivers are presented in Chapter 3 to portray long-term water quality trends. These rivers, the Klamath, Sacramento, San Joaquin, Truckee and Colorado, are each indicators of water quality conditions in important areas of California. Actual data obtained at stations on each of the Priority I rivers are tabulated in Appendix A to this report. In addition, the history of Regional Board activities to improve water quality in San Francisco Bay, Los Angeles-Long Beach harbors and San Diego Bay is highlighted.

Analysis of water quality data for 1975 indicates that conditions in California are generally outstanding and water quality usually meets standards, as shown in Chapter 4. Water quality problems do exist, however, and summarized descriptions of these problems are presented in Chapter 5. The number and severity of water quality problems caused by point source discharges has markedly decreased in the last several years, due primarily to the enforcement activities under the State's Porter-Cologne Act and the stimulus to facility construction provided by grants from the State's Clean Water Bond Fund and from Federal construction grant funds.

The major water quality problems facing the State of California in the next decade will be the most difficult to resolve. These are nonpoint source problems, which are generally widespread geographically, difficult to define exactly, and usually the result of long-held land use practices. Examples are: Sediment and debris washed into streams as a result of logging practices; groundwater mineralization; increasing salinity in the Colorado River which supplies water to large areas of southern California; increasing salinity of the Salton Sea, endangering fish life and the local recreation industry; and seawater intrusion into formerly usable groundwater aquifers at numerous points along the coastline. These problems are often due to complex causes which have their roots in historically institutionalized practices. Solutions will often be prohibitively expensive, as well as politically difficult to achieve. However, these are the major issues which the State and Regional Boards must confront and resolve in order to make significant progress in solving problems related to the quality of California's waters.

The cost of achieving the national water quality objectives established in PL 92-500 will be staggeringly high. Estimates of the costs of meeting Federal objectives for treatment of municipal sanitary sewage and storm water are contained in Chapter 6. A total of 1.6 billion in grants has been committed from State and federal funding sources for constructing municipal sewerage facilities. The total estimated cost of municipal projects needed to meet Federal 1977 waste treatment standards is 4.2 billion.

A brief summary of the impact on the environment of wastewater treatment facility construction and implementation of the control measures necessary to successfully attach the larger non-point source problems is presented in Chapter 7.

APPENDIX A
Summary - State of Connecticut

Complete Copies of the State of Connecticut 305(b) Report can be obtained from the State agency listed below:

Division of Water Compliance and
Hazardous Substances
Department of Environmental Protection
165 Capitol Avenue
Hartford, CT 06115

Executive Summary

Water Quality Monitoring

The State of Connecticut presently operates two types of monitoring programs. These two programs are dissimilar in nature because they have been established for different purposes.

The first program is the short-term intensive water quality program which generates a large volume of water quality data during a relatively short period of time (several days). The purpose of this data is to provide a "complete description" of water quality in a critical stream segment during critical conditions (low flow and high temperature). The value of this program is that with the data generated by this monitoring program, mathematical representations of water quality reactions can be used to predict treatment levels which will result in the achievement or the maintenance of water quality standards.

The second program is the long-term or trend monitoring program. The purpose of this program is to monitor water quality over a long period so that water quality trends may be discovered. The value of this program is that documentation of water quality changes provides the basis of evaluating the effectiveness of water pollution control programs, and indicates a need for redirection or expansion of current water pollution control efforts.

Long-term Trend Monitoring

In 1967, a long-term trend monitoring network or primary monitoring network was established. This network consisted of 96 stations throughout the State. Sample collection and analysis were accomplished during the spring, summer and fall for a total of three samples per station per year. Parametric coverage consisted of physical, chemical, and bacteriological parameters. This network has been replaced by a new monitoring network which was initiated in July, 1973.

The monitoring network, started in July, 1973, consists of 43 stations in the entire State. Samples are collected monthly and are analyzed for physical, chemical, and bacteriological parameters. Additionally, sediment samples are analyzed once per year. This network is expected to be increased to 90 stations as funding becomes available. Table 1 lists the physical and chemical parameters being monitored. In addition to the physical, chemical and bacteriological parameters, the State is also monitoring biological communities. At present, there are 30 biological stations in Connecticut. The inclusion of biological monitoring is a necessary advancement in the monitoring program since Connecticut's Water Quality Standards state: "The water shall be free from chemical constituents in concentrations or combinations which would be harmful to human, animal, or aquatic life..."

Without biological data to relate the chemical data to the biological communities, compliance or non-compliance with the above requirement could not adequately be determined.

TABLE 1

PHYSICAL/CHEMICAL PARAMETERS MEASURED BY U.S. GEOLOGICAL SURVEY UNDER CONNECTICUT'S PRESENT LONG-TERM MONITORING PROGRAM

Date
Time
Salinity (ppt)
Instantaneous discharge (cfs)
Dissolved manganese
Dissolved iron
Dissolved copper
Dissolved calcium
Dissolved zinc
Dissolved magnesium
Dissolved sulfate
Dissolved chloride
Total phosphorous
Dissolved ammonia nitrogen
Total nitrite plus nitrate
Organic nitrogen
Total Kjeidahl nitrogen
Total nitrogen (N)
Total nitrate (NO_3)
Total organic carbon
Air temperature
Dissolved oxygen
Percent saturation
Weather
Immediate coliform
Fecal coliform
Streptococci (fecal)
MBAS
Color
Turbidity
Oil and grease
Cyanide
Chlorophyll 11-A
Chlorophyll 11-B
Floating algae mats (severity)
pH
Bicarbonate (HCO_3)
Carbonate (CO3)
Alkalinity as $CACO_3$
Hardness (Ca, Mg)
Non-carbonate hardness
Specific conductance
Total residue
Floating debris (severity)

In addition to the biological sampling and analyses, the following are being provided:

1. An extensive literature survey of existing data collected by Federal agencies, universities and private organizations for each body of water samples. The survey will cover physical characteristics and land use characteristics.
2. Sampling reports which will contain a discussion of composition complexity, stability, and productivity of each biological community and detailed interpretation of the significance of these factors with respect to water quality impacts from local land use patterns and direct pollution loadings.
3. An evaluation of the program and program redesign recommendations.
4. A study to determine the most effective manner in which the Department of Environmental Protection can absorb and continue the monitoring program at the end of the contractual period.
5. A field and classroom training program.
6. A reference library.
7. Reference collections.
8. Field and laboratory equipment.

Linear Regression Analysis

The data gathered by the State's long-term trend monitoring network were used to make an analysis which would discern any statistically valid trends over the period of record. The linear regression analysis uses a time-dependent variable (along with other variables such as flow and temperature), to identify trends in the data.

The findings of this study overwhelmingly indicate that water quality in the State of Connecticut is improving. Of the 92 tests performed, 67 or 73 percent show signs of improvement. Of these 35, 40 percent show improvement at the 90 percent level of confidence and 35 tests show that the rate of improvement is significant.

Also, of importance is the finding that of the 92 tests performed only 5 percent show signs of degradation.

As the data base improves and expands in terms of the number of measurements, it is expected that the data will show stronger trends. Most of these trends are already in the direction of improvement. As more measurements are available the trend of improvement should be strengthened.

Most of the improvement which this study reveals is due to the control of point source pollution through the application of best practicable wastewater treatment technology. As the State Water Pollution Control Program progresses to application of advanced waste treatment systems and, as necessary, control of non-point source pollution, improvement in water quality can be expected to continue.

Basin Planning—Section 303(e)

The phase I basin planning process in Connecticut will culminate in June, 1976 with the submittal of the remaining draft basin plans covering the entire State. These plans will include loading allocations for water quality limited segments where feasible. Load allocations for more complex systems or systems with incomplete data bases are still being analyzed. These basin plans will then be incorporated into the annual State strategy for water pollution control.

Area-wide Waste Treatment Management Planning—Section 208

Connecticut submitted an application in May of 1975 for an $8.9 million statewide Section 208 program. This program was not funded by the EPA and the State has initiated a legal action to obtain the funds. (NOTE: In 1976, the state was awarded a $1 million Section 208 grant at 75 percent EPA funding).

Facilities Planning—Section 201

The general cost breakdown for Section 201 construction grants is given in the report. Specific grants by municipality are given in Appendix E of the report, the Construction Grants List. Advanced waste treatment grant allocations reflect load allocation analysis from completed Section 303(e) plans.

NPDES Permit Program—Section 402

In 1975 there were 214 NPDES permits issued. This brings the total permits issued since 1974 to 589. Of the cumulative total, 85 major municipal permits were issued in 1974 and 40 minor municipal permits were issued in 1974-75. The remainder of the permits (464) are non-municipal.

Past Activities

Connecticut began a statewide program of comprehensive water pollution control in 1925 when it established the State Water Commission. This commission established a pollution abatement program in conjunction with the State Department of Health. In 1957 the State Legislature superseded this commission with the Water Resources Commission. Connecticut drafted the Clean Water Act in 1967. This act called for the restoration of water quality consistent wtih the uses and wishes of the State's citizens. The subsequent water quality standards prepared by the State in 1967, were approved in total by the Federal government in 1970. These stream classifications were revised in 1973 by the State to reflect water quality improvements. The Water Resources Commission acted as the State Water Pollution Control Agency until the present Department of Environmental Protection was established by the General Assembly in 1971.

Before 1972, the State's water quality goals did not require a minimum standard of "B" for every stream in

Connecticut. The new goals, in part a result of the 1972 Amendments, will have effects on future growth and development patterns, due to the cost of attaining and maintaining these goals. State programs for clean water have attempted to address water quality problems which result from many sources including septic system failures, the discharge of inadequately treated domestic sewage and industrial wastes, periodic raw sewage discharges resulting from combined storm and sanitary sewer systems, and the effects of groundwater and surface water inflow and infiltration to sewers as well as those of urban runoff and other "non-point" sources. Much of the momentum gained under Connecticut's Clean Water Program initiated in 1967 was reduced when the State could no longer pre-finance water pollution control projects. The momentum was further reduced due to several procedural requirements of PL 92-500.

Progress

A survey was conducted in 1975 by the Water Compliance Unit of DEP to determine the progress made in upgrading water quality. The survey found that since 1967, 165 stream miles or 25 percent of all State streams requiring upgrading have been improved to comply with the 1983 water quality goals. These improvements are mainly attributable to the success of the State's program in expanding and upgrading treatment plants to secondary treatment providing extensions of sewer serve where needed, eliminating or providing appropriate treatment of industrial waste discharges and eliminating a number of raw sewage discharges caused by sewer system infiltration and combined storm and sanitary sewer systems.

A summary of water quality inventory indicates that all basins suffer from non-point source pollution in varying degrees. Large river basins with water quality limited segments like the Connecticut River are hampered in improvement efforts because of combined sewer and non-point source problems. As basin plans are completed, the State will develop its strategy for meeting these future water quality needs. The progress of improving water quality will depend largely on the levels of Federal construction funding realized for this purpose especially with respect to allocations for combined sewerage facility correction which are presently non-existent and where administration requirements limit the ability to realize project goals with available funds.

APPENDIX A
Summary - State of Delaware

Complete copies of the State of Delaware 305(b) Report can be obtained from the State agency listed below:

Division of Environmental Control
Department of Natural Resources and
Environmental Control
Tatnall Building, Capitol Complex
Dover, DE 19901

Summary

Delaware's streams are generally in very good condition. As reported last year, ten stream segments are already meeting the 1983 goals of the Federal Water Pollution Amendments of 1972. Four additional segments are expected to meet these goals by next year. The remaining seven should be able to meet the goals by 1983.

Most of Delaware's streams support the propagation and maintenance of fish and wildlife. The major area where this is not the case is the Delaware River from the State Line to the vicinity of the Chesapeake and Delaware Canal where pollution prevents some, though not all, species from flourishing.

Improvements in this section of the river remain dependent upon the upgrading of major industrial and municipal treatment facilities upstream in the States of Pennsylvania and New Jersey. The elimination and/or control of point sources in the stream basins have highlighted non-point sources which include pollution of manmade origin from urban and industrial areas, and that of natural origin such as wildlife and waterfowl. During the remainder of this decade, Delaware will concentrate on quantifying the effect of the non-point source problems and attempt optimum control strategy. Completion of Section 208 Plans by areawide waste management agencies will assist the State in this effort. An evaluation of the State's water quality is presented in Table 1 at the end of this summary.

The United States Environmental Protection Agency (EPA) has delegated its authority to the Department of Natural Resources and Environmental Control (DNREC) for issuing National Pollution Discharge Elimination System (NPDES) permits. These permits establish a timetable for meeting the State and Federal requirements of best practicable technology by July 1, 1977. Some municipal waste discharges cannot meet the deadline because construction, although underway, will not be completed by that date. The permit requirements have also eliminated a number of discharges which are now connected to wastewater collection and treatment systems or converted to another type of discharge, e. g., spray irrigation.

Delaware's Water Quality Management Program is a continuing one and recognizes that issuance of permits alone does not mean achievement of all standards. It takes years for plans and programs to be put into effect and, once completed, additional time is needed for the various stream segments to recover. In some estuaries it may not be possible to meet shellfish and swimming criteria for total and fecal coliforms because of the substantial migratory bird population.

The State has a continuing concern with ground water quality degradation and is taking forceful action to prevent it. The experience with landfalls that have resulted in aquifer contamination has led to the establishment of strict, new standards for such disposal methods. Both their location and construction are carefully regulated. The expanding population of Delaware has also increased the demand for septic tank use and this, too, is being carefully scrutinized and regulated.

Delaware also faces eutrophication problems in most of its lakes and ponds. The Department has cooperated with the EPA in the National Eutrophication Survey of Selected Ponds in the State of Delaware.

Another problem enumerated last year is the encroachment of urban development along the shores of the inland bays. The growth rate of such development has been slowed because of economic conditions, but the potential exists for accelerated growth with the improvement of the economy.

The cost estimates for wastewater treatment facilities have not changed from last year's report. Many water and related land use activities will, it is hoped, reduce the total costs through non-structure control programs.

In order to provide a uniform basis for various planning activities a special consortium of planners representing all interested parties was created to study population projection procedures. This effort has resulted in a new population forecast for the coming decade which will be used by all agencies.

This summarizes Delaware's problems and its plans to cope with them as we move to make all of our water quality compatible with the goals established by Congress.

TABLE 1

1975 SEGMENT EVALUATION

Segment description	Segment number	Classification WQL/EL	State priority	Evaluation of water quality
Naaman's Creek	1	EL	15	III
Brandywine Creek	2	EL	12	I
White Clay Creek	3	EL	7	II
Upper Christina	4	WQL	1	II-
Lower Christina	4	EL	1	III
Red Lion Creek	5	WQL	10	II
Chesapeake & Delaware Canal	6	WQL	9	I
Blackbird-Appoquinimink	7	EL	4	II
Chesapeake Drainage System	8	EL	19	I
Smyrna River	9	EL	11	II
Leipsic River	10	EL	14	II
St. Jones River	11	EL	6	II
Choptank River	12	EL	20	I
Murderkill River	13	EL	13	II
Mispillion River	14	EL	16	II
Cedar Creek	15	EL	17	II
Broadkill River	16	WQL	8	III
Nanticoke River	17	WQL	3	I
Indian River	18	WQL	2	I
Little Assawoman	19	EL	5	II
Buntings Branch	20	EL	18	III
Delaware River - River Mile 78.8 to river mile 59.5				III
59.5 to river mile 48.2				II
Delaware Bay				I
Atlantic Ocean				I

NOTE: A detailed assessment of each segment is provided in the text of the report.

KEY:

I -- Waters of good to excellent water quality which basically meets all water quality criteria with only minor, infrequent violations of water quality standards.

II -- Waters of fair to good water quality which periodically have some problems in one or more water quality criteria.

III -- Waters in which there is perennial problem in meeting one or more water quality criteria. Most of these are tidal waters impacted by the natural process of the estuarine system.

APPENDIX A
Summary - District of Columbia

Complete copies of the District of Columbia 305(b) Report can be obtained from the State Agency listed below:

Department of Environmental Services
Water Resources Management Administration
415-12th St. NW Room 307
Washington, D. C. 20004

This report represents the first annual update of the 305(b) Report for the District of Columbia. It is an appendix to the 1975 305(b) Report issued in April 1975. As an appendix, this report details only progress and problems the District has had in implementing the provisions of the 1972 Federal Water Pollution Control Act (PL 92-500) in the past year. Information concerning previous water quality trends and historical aspects of the problems the District faces can be found in the 1975 305(b) Report.

Construction Progress at Blue Plains Wastewater Treatment Plant

Much progress has been made toward the implementation of full secondary treatment at Blue Plains. During 1975, contracts for additional secondary treatment facilities achieved 90 percent completion. Contracts on solids processing, primary flow metering, the chemical building, the multi-media filtration facility, and the central operations facility were in progress all year. All of these contracts are approaching completion. Contracts for nitrification sedimentation, instrumentation, and expansion of a raw wastewater pumping station were initiated in 1975. These contracts were 28 percent, 36 percent, 5 percent, and 2 percent complete respectively at the year's end.

Construction during 1975 was slowed by a six-month labor strike. As a result, construction slipped about six months behind schedule. Completion of all construction is now scheduled for late 1978, with facilities coming on line in mid-1979.

NPDES Permit Program

The District has not elected to seek the authority to issue NPDES Permits. The District, however, has retained certification authority. Authority and responsibility for issuing the permits lies with the EPA. The EPA issued no permits to industrial or commercial discharges in the District during 1975.

Monitoring Program

The D.C. Department of Environmental Services' (DES) Bureau of Wastewater Treatment's monitoring program remained unchanged throughout 1975. Results were circulated and monthly summaries released. Some biological sampling was done in cooperation with William T. Mason of the Interstate Commission on the Potomac River Basin. Biological sampling will be upgraded in 1976, with the addition of a biologist to the Bureau of Wastewater Treatment laboratory staff.

In addition to the sampling program of the Bureau of Wastewater Treatment, the DES, Bureau of Air and Water Quality Control sampled 24 stations in free flowing streams, including Rock Creek. The number of stations was reduced to 10 in 1976. Samples are collected monthly and processed at the Bureau of Wastewater Treatment's Blue Plains Laboratory. Due to a lack of staff, Rock Creek samples were not taken during January, February, May, July, August, and November.

During 1975, work started on the formulation of PEP, a comprehensive monitoring plan for the Potomac Estuary. The Interstate Commission on the Potomac Basin was requested to formulate a monitoring program which would address two major issues: First, changes in water quality which occur as the result of improvements in area wide waste treatment in the absence of denitrification at Blue Plains; and second, data required for the calibration and verification of mathematical models capable of predicting the additional improvements which would occur in estuarine water quality if denitrification were to be implemented at Blue Plains. The results of PEP will be integrated with the District's Water Quality Monitoring Program in 1976.

Sludge Disposal

Disposal of Blue Plains sewage sludge, both raw and digested, has been and will continue to be one of the most serious, difficult, and complex problems facing water pollution control efforts in the District. During 1975, a court-ordered agreement specifying the responsibilities of each of the jurisdictions using the Blue Plains facility, with regard to sludge disposal, want into effect. Daily operations of the trenching of sludge have gone relatively smoothly under the provisions of that agreement.

Trenching, however, cannot continue to be the method of choice for sludge disposal much longer. One prime reason for this is the large amount of land which will be required to hold the increasing daily volume of sludge to be produced at Blue Plains. Some 600 acres/year would be required for the 1980 production of 1,800 wet tons/day. Further, since the disposal sites are not to be used for other purposes for a minimum of five years, a minimum of 3,000 acres would be required on a continuing basis. An investment of this size is impractical given the current value of land in the metropolitan area.

Attempts at providing viable alternative methods of sludge disposal have been stymied because of the other environmental problems they may create. A pilot facility designed to produce a commercial soil builder from the sludge has run afoul of stringent air pollution control requirements. Incineration also contributes to the air pollution problem and is quite costly, and also could contribute to violations of Federal Ambient Air Quality Standards. Composting of the raw sludge seems to be technically feasible and financially attractive, if a market for the compost can be found. However, no real marketing to test salability can take place until the necessary approvals are obtained and health permits are issued.

The Blue Plains Technical Committee, in response to the court requirement that agreement be reached on a permanent solution to the sludge problem by July 1, 1976, has been developing a program which would provide such a solution. No final agreement was reached in 1975. When such an agreement is reached it will balance the risks and benefits of the alternatives outlined above.

Non-point Source Programs

Through 1975, the District sought EPA approval for an engineering study of treatment alternatives for combined sewage overflows. As of this writing, approval for the study has been given, but contracts have not been signed.

The District has been participating in the development of non-point source studies by the Metropolitan Washington Resources Planning Board (WRPB) for the Section 208 planning program. As presently conceived, these studies should provide a firm estimate of the amounts of non-point source pollutants contributed to the estuary by land in various kinds of use. Pollutant loadings will also be related to type, frequency, and duration of storms.

Primary data for the study will be gathered in the Occoquon and Four Mile Run watersheds of Northern Virginia, directly across the Potomac from the District. Demonstration of the applicability of the results of the Northern Virginia studies to other jurisdictions in the metropolitan area will be accomplished by using the Northern Virginia data to preduct pollutant loadings for watersheds in Montgomery County, Maryland, and then comparing those predictions to actual data to be taken in the same Montgomery County watersheds.

The WRPB studies, in conjunction with the District's combined sewer engineering study will provide the necessary data base for formulating a rational, efficient, coordinated program for non-point source controls in the metropolitan area.

1975 Water Quality

Water Quality in the District's three major streams, the Potomac, the Anacostia, and Rock Creek will be discussed seperately.

Potomac River

With the exception of coliform bacteria, water quality in the Potomac mainstem of the District was quite good. No nuisance algal blooms of note were recorded, and dissolved oxygen problems, so prominent in the past seem to have diminished. No violations of DO standards for the mainstem were recorded in 1975. Water quality in the Potomac mainstem was probably improved by the high flows recorded in 1975.

Coliform measurements in the Potomac frequently violated the District's standards. Because of this, the Potomac did not meet the FWPCA 1983 goals of 'fishable and swimmable water.

Anacostia River

Water quality in the Anacostia remains very poor. Major problems are low dissolved oxygen and high coliform levels. The extremely poor water quality in the Anacostia is due both to the District's own urban and combined sewer runoff and the high levels of pollutants entering the District from the Anacostia tributaries in Maryland.

Rock Creek

Very scanty data are available from Rock Creek for 1975. No creditable conclusions as to water quality trends can therefore be drawn. Few dissolved oxygen problems seem to exist, coliform counts are quite high, and suspended solids are quite variable, as is to be expected in a small urban stream.

Future Water Quality

As reported in the 1974 305(b) report, modeling studies done for the National Commission on Water Quality indicate that dissolved oxygen standards in the estuary will be met when full secondary treatment facilities are on line at Blue Plains. The 1975 Water Quality data gathered by the District substantiates this conclusion.

Most of the District's remaining water quality problems are due to non-point sources of pollution, both in the District and in the surrounding metropolitan area. The Metropolitan WRPB is undertaking the responsibility for Section 208 Planning in the metropolitan area. One of the major responsibilities of the planning effort is to prepare an areawide scheme for control of non-point source pollutants. Until this plan is complete it is impossible to speculate on the extent of future improvements in water quality problems caused by non-point source pollutants.

Regardless of the plan formulated by the WRPB, the control of non-point source pollutants in the Washington Area is expected to be a difficult and complex task. Therefore it is not anticipated that the 1983 water quality goals of PL 92-500 will be met in the streams of the District by 1983. In particular, bacteriological standards violations will still likely occur, making swimming hazardous. In addition, there will likely remain the potential for noxious blooms of algae in the estuary. Large diurnal variations in dissolved oxygen are likely as a result of such blooms, if and when they occur, causing temporary but perhaps critical violations of dissolved oxygen standards.

Cost of Water Pollution Control

Costs for water pollution control in the District have risen markedly since the early 1950's. In fact, costs per-million-gallons treated will have risen ten-fold when the facilities currently under construction have been completed. This is largely due to the approximately 500 million dollar capital cost of Blue Plains expansion. If denitrification facilities are constructed, capital costs will rise yet another hundred million. O&M costs for the Blue Plains plant are estimated to be about 35 million per year without denitrification, and over 46 million per year with denitrification.

Costs for storm water treatment in the District cannot be firmly estimated at this time, but could conceivably be higher than 1 billion dollars. Since no NPDES permits have been issued to industrial dischargers, industrial waste treatment cost estimates are not available at this time.

Obviously, such large costs will be hard for the District's taxpayers to bear, even with Federal grants. The District believes that the benefits to be derived from such enormous proposed expenditures must be critically examined.

APPENDIX A
Summary - State of Florida

Complete copies of the State of Florida 305(b) Report can be obtained from the State agency listed below:

Department of Pollution Control
2562 Executive Center Circle
Tallahassee, FL 32301

Summary

The water resources of Florida are among the most unique, valuable, and widespread of any State in the Nation. The shoreline of Florida fronts on the Gulf of Mexico and the Atlantic Ocean. Including saltwater rivers, islands, bays, and sounds, the shoreline extends for nearly 11,000 linear miles. Inland waters include 1,711 named streams ranging in length from 0.4 miles to 818 miles. There are 7,712 named and unnamed lakes ranging in size from one acre to almost one-half million acres. The only living coral reef in the continental United States forms the eastern barrier of the Florida Keys.

The wildlife resources of Florida are numerous and diverse. Commercially valuable fisheries harvest shellfish and finfish. Water sports, including sport fishing, in conjunction with the mild climate, act as attractions to the millions of tourists who visit Florida annually.

Freshwater streams are being considered as potential sources of potable water for the rapidly growing metropolitan areas of southern Florida, and these same streams are being proposed for impoundment and industrial development. Maintaining the quality of its waters must be a high priority of the State since the economy of Florida, more than that of most other States, relies on activities which are dependent upon the aesthetics and the natural resources associated with plentiful supplies of clean, high quality water.

Even though clean waters are an economic asset of considerable value to the people of Florida, considerable stresses have been placed on the aquatic systems of Florida by industrial development and by the rapid, recent increase in the population. (Florida's population has increased by the greatest absolute number of any State in the past few years, and it has been projected to double by 1985.) Florida waters are polluted from several different sources. Industrial polluters include agricultural processors, chemical plants, paper mills, and electrical power plants. Domestic wastes from households and wastes from smaller commercial operations are discharged to the waters of the State by sewage treatment plants, ocean outfalls, and septic tank drainage. Pollutants not attributable to specific sources include storm runoff from urban areas; drainage from farms, forests, and mines; intrusion of saltwater into depleted freshwater aquifers; and discharges from ports and marinas. Another major source of pollution in Florida is dredge and fill activities involving the destruction of submerged lands and wetlands, disposal of dredged spoil, and shoreline alteration.

This latter source of pollution is a particular problem in Florida. Large numbers of people from other parts of the country are retiring to Florida or are building vacation houses here. This influx of people has contributed to large demands for water-front property. This has been met by land developments in which canals have been dredged through wetlands and uplands, marshes have been filled, and canal-front lots are constructed. These land use practices have stressed the aquatic ecosystem by eliminating natural drainage and allowing poor water quality conditions to develop, by removing productive wetlands from the ecosystem, by reducing the habitat available for larval fish and shellfish, and by reducing the capacity of the wetlands to filter pollutants from runoff. These problems taken together make uncontrolled proliferation of canal systems and shoreline alteration a serious long-term Florida water quality problem. In the long term, these activities may have the potential to damage or to destroy many of the aesthetics and natural resources which originally attracted retirees and vacationers to Florida.

More immediate water quality problems are related to cultural eutrophication, the human-aided and abetted increase in the rate of aging of a body of water. Data presented in this report show that the levels of nutrients (nitrogen and phosphorous) in almost every basin segment in Florida are higher than the accepted norms. Secondary water quality problems demonstrated by data in this report include low levels of dissolved oxygen and high populations of coliform bacteria. More rarely, high levels of phytoplankton are found.

The State of Florida has responded to the problem of water pollution by adopting and implementing a number of environmental protection statutes (e. g. Chapters 253, 373, and 403, F. S.). In Florida, the Department of Environmental Regulation is the administering agency for programs under the Federal Water Pollution Control Act of 1972 (P. L. 92-500). The goals of the Federal and State programs are to manage discharge of domestic and industrial waste, to control non-point source pollution, and to regulate the alteration of bottoms and shorelines of State waters. The State has also adopted minimum conditions for the quality of its waters and has established a water quality classification based on the uses of water bodies.

Point discharges of domestic and industrial wastes are permitted under State and Federal (NPDES) programs. Non-point source pollution will be managed by the State and by the areawide 208 programs and by management practices to reduce pollutants in runoff. The State has a well-developed permitting system to require permits for construction projects affecting submerged lands and wetlands. Such projects are evaluated for immediate and long-term impacts on the aquatic ecosystem. These programs are discussed in more detail in Chapters II and III of this report.

Ten bodies of water in the State did not meet the Class III water use criteria (safe recreation and fish and wildlife) in 1975. Six of these waters are expected to be consistently within these criteria by 1983. Maintaining and enhanceing water quality in the waters of the State will require more advanced treatment of domestic wastes, control of non-point sources of pollution, and greater protection of wetlands. These programs are necessary to maintain the quality of the Florida environment, and they will become even more urgent if the population increases as rapidly as has been projected.

APPENDIX A
Summary - State of Georgia

Complete copies of the State of Georgia 305(b) Report can be obtained from the State agency listed below:

Environmental Protection Division
Department of Natural Resources
270 Washington St., S.W.
Atlanta, GA 30334

Summary

Current Water Quality and Trends

Most of Georgia's waters are of good quality. Since there are more than 1,500 wastewater discharges from municipalities, industries, and private developments in the State, and since there are many non-point sources of pollution which have significant effects on water quality, the 130 water quality monitoring stations being operated cannot assess adequately the effects of all point and non-point sources of water pollution in the State. However, monitoring stations are located on major streams at sites which do not reflect much of the human impact on the State's waterways. Based on this network of stations, intensive stream surveys, operating reports from wastewater treatments facilities, and other staff knowledge, water quality in Georgia can be characterized as good or excellent for approximately 90 percent of the estimated 20,000 total miles of streams. Unfortunately, many of those streams not meeting water quality standards are major ones where significant water uses are adversely affected.

It is estimated that approximately 90 percent of all the stream miles in Georgia were meeting fishing and swimming water quality criteria in 1975. Less than 90 percent of the mileage of major streams met these criteria, however. It is further estimated that some 5 percent of Georgia's streams cannot meet the water quality criteria for fishing or swimming due to natural conditions. These waters include primarily the swamp-like streams of South Georgia which exhibit naturally low dissolved oxygen, low pH (acid), and high water temperatures during summer and fall months. The fact that these natural waters in South Georgia and other parts of the State do not meet fishing and swimming criteria certainly does not mean that they are not fishable and swimmable. People have recreated in certain of these waters for years, and fish have thrived in these streams for thousands of years.

As in past years, water quality criteria violated most were those for dissolved oxygen and fecal coliform bacteria. Suspended solids, originating from soil erosion caused by man's land-disturbing activities, and the resultant desposition of sediment in streams, continues to be the largest water quality problem caused by non-point sources of pollution. Significant water quality deterioration due to heavy metals, pesticides, toxins, aciditv, and alkalinity were not observed in Georgia in 1975.

Major problem areas in the State during 1975 continue to be the South River downstream from the City of Atlanta and DeKalb County, the Flint River downstream from Atlanta, College Park, and Clayton County; and the Chattahoochee River downstream from Fulton County, Cobb County, and Atlanta. There continue to be periodic water quality standards violations downstream from urban/industrial areas such as Albany, Athens, Augusta, Brunswick, Columbus, Dalton, Macon, Rome, Savannah, and Valdosta.

The trend-monitoring program has shown that the water quality is stable at most of the 130 stations around the State and that definite improvement trends are occuring at a number of stations. No downward trends of water quality have been documented.

Water Quality Goals

The Federal goal of having all waters in the United States meet fishing and swimming criteria by 1983 will not be accomplished in Georgia. Certain streams in the State will not be able to meet thse criteria due to their heavily urbanized watersheds which result in poor quality urban runoff; other streams are so small in relation to the amounts of wastewater discharged into them that it will be economically and perhaps technically impossible for some discharges to provide sufficiently high degrees of treatment to allow water quality standards to be met.

It is not possible to predict the locations where and extend to which human influence will prevent waters in Georgia from meeting the 1983 Federal goal of meeting fishing and swimming standards, but it is believed that those stream segments unable to meet the standards in 1983 will be less than 19 percent of the total stream miles in the State, if sufficient Federal construction grant allocations are provided for municipal wastewater treatment needs between now and then. The estimated 5 percent of all stream miles in Georgia which cannot meet fishing and swimming water quality criteria due to natural conditions will not change. There are at least two dozen industries discharging treated wastewater to streams so small that it is fairly certain that levels of treatment in excess of best available technology economically achievable (BAT) will be required if the streams are to meet fishing criteria. There are some 166 municipally owned wastewater treatment facilities presently discharging to stream segments where levels of treatment higher than secondary are needed in order to meet water quality standards. Facilities Planning under the Federal grants program should be completed for nearly all of these municipal discharges by the end of 1977; this planning will determine what needs to be done and how much it will cost to solve these water quality problems. Until the planning is completed, it will not be known to what extent these municipalities can financially and administratively implement programs to achieve water quality standards.

Effects of Control Programs on Water Quality

Georgia's water quality control programs for point sources of wastewater are currently based on the following strategies:

1. Require municipalities to use PL 92-500 grants for construction of treatment facilities where needed to upgrade the quality of municipal effluents to secondary treatment standards or higher treatment standards where required by water quality in receiving streams; and

2. Require all industrial dischargers to meet Best Practicable Technology (BPT) treatment standards or higher treatment standards where required by water quality in receiving streams.

Municipal grants are awarded in accordance with Georgia'a construction grants priority system with the highest priorities being put on solving the most serious water pollution problems. Only about 1.5 percent of all municipal wastewater generated in the State is receiving primary treatment or no treatment, but in many cases existing treatment facilities do not meet the Federal effluent guidelines and/or do not provide treatment sufficient to meet water quality standards. Eighty-four of Georgia's 106 major industrial dischargers were in various stages of design or construction of BPT facilities. Of 455 minor industrial dischargers in Georgia, it is estimated that about 50 percent were providing BPT for their wastewaters at the end of 1975.

A number of significant water quality improvements were seen in major streams around the State in 1975 as a result of the State's control programs. The Lower Savannah River showed no dissolved oxygen violations at the Fort Jackson monitoring site for the first year of record (i. e., the period of years over which official water quality data have been collected), due to completion of treatment facilities at all major sources of organic wastewater. Water quality in the Ocmulgee River improved substantially as a result of the start-up of Macon's Rocky Creek water pollution control plant. Only two violations of dissolved oxygen criteria were found at the Ocmulgee River automatic monitor downstream of Macon during 1975, as compared with 144 violations in 1974. Water quality in the Conasauga River at Tilton downstream from Dalton continues to show an upward trend due to that City's water pollution control programs. Again, 1975 was the first year of record in which no dissolved oxygen violations were found at the Tilton monitoring site.

Substantial improvements in the quality of the Chattahoochee River are expected in 1976 since construction will finally be completed on the City of Atlanta's R. M. Clayton treatment plant and improved operations are expected at the other major treatment facilities discharging to the River. Current control programs underway in DeKalb and Clayton Counties and the City of Atlanta will significantly improve the quality of the South and Flint Rivers in 1979 with completion of the advanced wastewater systems currently being planned. The quality of the Lower Savannah River will be increased even further with the completion of water pollution facilities for the American Cyanamid Company. Many other improvements less significant than these previously named will occur around the State within the next several years.

Non-point Source Pollution

Control of non-point source pollution was a low priority with the State Water Quality Control Section prior to 1975. During 1975, the Water Quality Control Section initiated a statewide non-point source pollution assessment. The assessment will be completed during the next two years and the State will establish priorities and control strategies for non-point sources as a part of the continuing planning process. The Erosion and Sedimentation Act passed during the 1975 session of the Georgia Legislature provides for the establishment and implementation of a statewide comprehensive soil erosion and sediment control program. The State Environmental Protection Division and local governments are given certain mandates to promulgate and enforce ordinances for the control of erosion and sedimentation. This will be an integral part of the State's control programs for non-point sources of water pollution.

Costs and Benefits

In 1975, $75.7 million were obligated by local, state, and federal governments for municipal wastewater projects in Georgia, thus satisfying about 7 percent of the $1.1 billion of needs projected in the 1974 National Needs Survey for improvements to wastewater treatment plants and construction of new interceptor sewers, force mains, and pumping stations. The 1974 needs estimates were for facilities to meet existing stream standards, but some of the existing standards are lower than those for fishing and swimming. The 1974 Needs Survey covers only capital costs for building municipal wastewater treatment facilities; it does not reflect municipal operating costs which were in the tens of millions of dollars during 1975 and which can only increase in the future. Therefore, the total costs of meeting the Federal goals will far exceed the estimates made in the Needs Survey.

It is estimated that Georgia's industries have expended more that $225 million since 1965 to reach the levels of treatment provided for industrial wastewaters today, and an additional $50 million will be spent by these industries to achieve BPT by 1977. If industries are required to upgrade treatment to BAT, it is estimated that they will have to spend an additional $200 to $250 million.

At this time, it is not possible to quantify the social and economic benefits of water pollution control programs already completed and to be accomplished in the future. It was learned in 1975 that fish were returning to areas of the Lower Savannah River where they had not been in many years. Successful fishing in the Conasauga River downstream from Dalton's wastewater discharge was also reported—a vast improvement over conditions five years ago. It will be difficult to quantify the benefits of improvements in fishing and recreation opportunities that will accrue throughout the State as a result of the present water quality control efforts, but they will continue to accrue. A method for quantifying benefits is needed.

Recommendations

The Congress should delay for at least 5 to 10 years the requirement for industries to reach BAT. The effects of current water pollution control programs should be seen before decisions are made requiring more treatment. The Congress should continue to provide a significant level of funding ($5-$7 billion per year) for the PL 92-500 construction grants program with a fair and equitable allocation formula for at least another five years, or it will be impossible for substantial additional progress to be made in Georgia toward making all waters meet fishable and swimmable criteria. The Federal grant share must continue at the 75 percent level to enable local governments to finance required improvements and establish the necessary operation and maintenance programs with local funds.

The 1977 deadline should be extended on a case-by-case basis for publicly owned systems as construction grants funds are made available. Also, the certification of states to administer the construction grants program should be authorized by the Congress with adequate financial support to enable the states to conduct an efficient and effective program. In addition, the combination of Step 2 and Step 3 grants into one grant would expedite the program.

APPENDIX A
Summary - Guam

Complete copies of the Guam 305(b) Report can be obtained from the State agency listed below:

Guam Environmental Protection Agency
Box 2999
Agana, Guam 96910

Summary

Guam's overall water quality changed little between the time of our first report to the Congress (April 1975) and this year's. Between May 20-22, 1976, Typhoon Pamela struck the Island with winds up to 190 mph. This storm was a mixed blessing vis-a-vis environmental impact. In near-shore reef areas and estuaries, sediments were washed ashore or further out to sea, thus 'cleaning' the waters and making them less turbid. However, expansion of eroded areas in southern Guam occured due to the heavy accompanying rains. In addition, the stripping of most of the Island's vegetation made these areas more fire prone, resulting in several extensive grass fires, particularly in the Umatac Area. The largest impact from a water quality point of view, however, may be the thrust the storm gave to the local construction and development industry due to the infusion of large amounts of Federal aid. Many of these future projects will no doubt carry with them the associated impacts of erosion and siltation and generation of polluted stormwater.

Bacterial pollution and heavy sediment loads continues to characterize Guam's central and southern rivers, particularly the Umatac, Asan, Agana, and Pago. Problems of uncontrolled sewage discharges from cesspools, pit privies, and direct drainage into rivers account for a large number of violations. The continued poor quality of the Pago River is attributable to the sporadic operation and maintenance of the Yona Sewage Treatment Plant and the poor location of its outfall.

Extensive clearing and grading, coupled with areas of natural erosion, have increased turbidity levels in some river basins. Although Islandwide permits for clearing and grading dropped considerably from 1974-5 because of the lull in construction activity, the erosional effects of the typhoon, both immediate and long-range, have offset this reduction.

The percentage of Island homes with improper sewage disposal or septic tank systems has declined somewhat due to the gradual elimination of substandard dwellings through urban renewal and a movement toward construction of permanent concrete dwellings by Island residents. Coordination between the Guam Environmental Protection Agency (GEPA) and the Federal Housing Administration has helped to check the number of new homes with improper sewage disposal systems. In addition, the increased activity in interceptor sewage construction in Mangilao, Chalan Pago/Ordot, Barrigada, and Maite will make sewers available to many more homes.

Although actual changes in water quality were not evident, several events have occured within the past year which may have a substantial beneficial impact on water quality in the future.

After several months of negotiation, on January 9, 1976 Gillham, Koebig and Koebig, consultants for the Government of Guam, were authorized to work on an Islandwide Wastewater Facilities Plan. This effort is the initial step in the provision of sewage collection lines, and treatment to Guam's southern villages, and the expansion and upgrading of existing lines in the north. Public hearings were held in March 1976 in the villages of Umatac and Merizo to present alternative plans for these villages. Additional hearings are scheduled for Inarajan and Talofofo in July and August 1976. The entire effort is due for completion by April 1, 1977.

On November 13, 1975, at the combined request of GEPA, Bureau of Planning, and the U.S. Geological Survey, and after a careful review of the available information, Governor Ricardo J. Bordallo requested that the Administrator, U.S. Environmental Protection Agency (EPA), designate the entire northern portion of Guam, stretching north from the southern boundaries of Chalan Pago and Ordot, under Section 1424(e) of the Safe Drinking Water Act, as our principal water supply source. Such designation by the EPA will result in the protection of our groundwaters from any Federal actions which could significantly impair their quality. Notice of the EPA's intent to designate our northern aquifer was published in the Federal Register on April 26, 1976.

In May 1975, the GEPA submitted an application to EPA for a 100 percent grant, under Section 208 of the Federal Water Pollution Control Act, for funds to perform an Islandwide water quality program to study the impact of, and determine methods to control, erosion, urban runoff, and land discharges of residential sewage. A major portion of the 208 program is developing public awareness of environmental problems and providing input to programs designed to curb them. The application was subsequently approved and, on May 13, 1976, a detailed work program was transmitted to the EPA specifying the objectives, manpower, training, and cost necessary to achieve the goals of the two-year program.

After three public hearings and four public GEPA Board of Directors' meetings, Guam's Revised Water Quality Standards were adopted on September 25, 1975. The Standards establish specific pollutant criteria for surface and potable water, new use classifications for Island waters (including conservation), and general effluent limitations for waste discharge. On March 29, 1976, the Standards were approved by the Federal Government.

In addition to the Water Quality Standards, Regulations for Well Drilling and Erosion Control were also adopted by the Agency's Board of Directors during 1975.

GEPA's Water Basin Planning Program, under Section 303(e) of the Federal Water Pollution Control Act, produced an overall Island water planning profile and a specific plan for most of northern Guam, classed as Segment A. The plan identified major water areas, types, and uses and the location and types of waste discharges affecting these uses. The Basin Planning Program will be incorporated into the 208 Comprehensive Water Quality Planning Program and a plan for controlling both point and non-point pollution will be developed by July 1, 1978.

Because so many long-range water quality programs were initiated in 1975, evaluation of their impact in regard to meeting the 1983 national goals cannot be determined. Guam's third Report to Congress will detail the impact of these new pollution control efforts.

APPENDIX A
Summary - State of Hawaii

Complete copies of the State of Hawaii 305(b) Report can be obtained from the State agency listed below:

Environmental Health Division
Department of Health
P.O. Box 3378
Honolulu, HI 96801

Introduction and Summary of Extent of Water Pollution in Hawaii

Water Quality in the State of Hawaii was reported last year in a document prepared for the EPA and the Congress of the United States in fulfillment of Section 305(b) of PL 92-500. It presented a broad overview and assessment of major water quality problems, critical issues, and needed control actions as viewed by the State's water pollution control programs. The issues that were then addressed remain fundamentally unchanged in this year's analysis, in particular, with respect to non-point source pollution. This is still cited as the major concern of the State.

Considering the same fundamental issues and problems, it is appropriate in this 305(b) report to draw the same conclusions as follows:

1. All municipal point discharges are under the permit system committed to compliance schedules for application of best practicable technology currently available, but adherence to compliance schedules is dependent entirely upon availability of construction funds.
2. Almost all industrial point discharges from raw cane sugar factories have been eliminated by recycling wastewaters to sugarcane fields for irrigation. The exception is the non-irrigated plantations along the Hanakua Coast on the Island of Hawaii. The topography, climate, and cane cultivation and harvesting are unique factors which make the application of conventional technology ineffective and expensive for achieving water quality standards. Strict effluent limits based on water quality standards could incur costs high enough to disrupt economic health of these industries unless innovative waste management schemes are developed.
3. Non-point sources of discharges such as storm runoff, soil erosion, seepage from individual sewage disposal systems, and agricultural operations, are a major class of discharges affecting water quality. Control technology and regulatory programs are considered to be related to land use, for which guidelines are as yet undeveloped.
4. Two major shellfish growing areas are now subject to contamination by sewage effluents and urban runoff. Plans have been developed for diversion of sewage effluents to other disposal sites. Further regulatory controls must be developed to safeguard against contamination from pesticides and heavy metals in urban runoff.
5. Regulations governing the design, construction, installation, operation, and maintenance of *sewage treatment and disposal systems* (public and private) are prescribed in Chapter 38, Public Health Regulations, Department of Health, State of Hawaii. Minimum standards governing treatment and disposal systems have been in the process of revision.
6. Point source discharges are controlled under the federally mandated National Pollutant Discharge Elimination System (NPDES) delegated to the State on November 28, 1974, under which any discharge into State waters requires a permit. Permits have been issued to 95 percent of the major and minor discharges in the State.
7. With progress toward the goal of "zero-discharge," *subsurface emplacement of effluents* and deep ocean outfalls are becoming more prevalent. Subsurface emplacement of effluents must be controlled to protect groundwaters. A permit system for the discharge of effluents into injection wells is being developed.
8. As point sources of pollution are brought under control, the major emphasis in water pollution will shift to control of the pollution that arises from dispersed areas. The major *nonpoint sources of pollution* in Hawaii are runoff: Urban, agricultural, and construction.
9. *Physical controls* should include:
   Use of impoundments or catch basins to reduce the rate and amount of runoff;
   Watershed treatment to reduce the rate and amount of runoff; and
   Retention of open spaces within the urban areas to reduce the total amount of runoff.
10. *Environmental policies* should consist of:
    Procedures to control urban litter and to enforce general sanitary conditions;
    Strict performance standards controlling grading and exposing bare soil during construction; and
    Regulations to control the open storage and drainage in commercial and industrial areas.
11. *Zoning* has has been and will continue to be used as the primary control over the location, density, and direction or urban growth. With little modification, these same ordinances can be used to implement water quality-related land use plans.

APPENDIX A
Summary - State of Idaho

Complete copies of the State of Idaho 305(b) Report can be obtained from the State agency listed below:

Department of Health and Welfare
Statehouse
Boise, ID 83720

Summary

This report updates the Water Year 1974 Water Quality Status Report.

Water quality data presented indicate that significant reductions in municipal and industrial point source pollutant loads over the past few years have had a measurable effect in some streams. It is also apparent that non-point source pollutant loadings have a major impact on stream water quality so that water quality standards and goals may not be achieved for many streams until such sources are considerably reduced.

The NPDES permit program is functioning well in Idaho with good progress being made in attaining compliance with the 1977 treatment requirements.

Considerable progress has been made in developing a non-point source pollution control program. The first non-point source pollution control strategy for Idaho was developed in March 1976. Agriculture (including irrigated and non-irrigated croplands, and range and dry pasture) and silviculture are considered to have the most significant effect on water quality of all land use activities The extent of non-point pollution sources is not expected to decrease without uniform statewide application of sound management practices.

The recommendations for revising Public Law 92-500 by the National Commission on Water Quality are generally supported with some few exceptions noted in the report. There are other recommendations pertaining to Sections 208, 305(b) and 404 of the Act, and financing of agricultural pollution control facilities.

Recommendations on Public Law 92-500

The following discussion is based on the "Report to the Congress by the National Commission on Water Quality" dated March 18, 1976 and specifically the section titled "Recommendations (Summary)" (see Appendix A-1 to this appendix).

The 1977 Requirements

- Recommendation No. I

A. There is a definite need for authority to grant extensions of time to municipal, industrial and agricultrual dischargers to meet the 1977 requirements on a case-by-case basis. Such time extensions should not extend beyond July 1, 1983.

B. Congress should only authorize a deferral of the 1977 requirements on a case-by-case basis and not, as suggested, a waiving or modification of the 1977 requirements. It appears that applications for waivers or modifications on a case-by-case basis could result in an administrative nightmare for the EPA.

C. Congress should provide authority for waiving, deferral, or modification of the 1977 requirements on a category-by-category basis, particularly for existing publicly-owned oxidation ponds and lagoons and deminimus situations. However, the States should be provided the authority to require the application of the 1977 requirements on a case-by-case basis within each category, if needed, to meet water quality standards.

The 1983 Goals and Requirements

- Recommendation No. II

A. The 1983 goal of fishable, swimmable waters must be maintained.

B. Congress should postpone the deadline for implementation of the 1983 requirements until: (1) Non-point source control measures (including irrigation return flows) are implemented; (2) the 1977 requirements are implemented; and (3) the results of these measures are documented by a complete assessment of water quality improvements achieved. Additional Federal funds should be provided to the States so that a complete assessment may be made of water quality improvements. After these three criteria have been completed, a new Commission, similar to the National Commission on Water Quality, should evaluate the progress made and make a determination as to whether uniform applicaton of more stringent effluent limitations than the 1977 requirements is justified and necessary for attainment of national water quality goals.

Decentralization

- Recomendation No. III

Congress should authorize the EPA Administrator to issue certification to any State to exercise full authority and responsibility for planning and for administration of the discharge permit and construction grants programs. However, many State pollution control agencies would probably not be able to apply for such certification unless adequate Federal or State resources were provided to administer the programs. When such certification is made, the EPA staff should be reduced and EPA should assume a more secondary role to the States. The EPA should then concentrate on formulating criteria review, allocating Federal resources, research and development, and technical assistance.

In addition, it is strongly recommended that the current nation-wide organization of the EPA be modified and patterned after the more progressive EPA Region X. The EPA's ten national regions should be decentralized in order to strengthen individual State programs. EPA Region X has an operations office in each State within the region. Since this concept was implemented, the interrelationship of State/EPA has improved tremendously in Idaho.

Federal Financial Assistance

- **Recommendation No. IV**

Congress should provide Federal grants for constructing publicly-owned treatment works by authorizing funding of the program at $5 billion per year for at least ten years.

Elimination of the Discharge of Pollutants and Research and Development Needs

- **Recommendation No. V**

A. Congress should redefine the goal of elimination of discharge of pollutants by 1985 and, instead, stress conservation and reuse of resources. When practical, the State should strive for elimination of pollutant discharges into the nation's waters.

B. Congress should provide adequate financing to accelerate *practical* research directed toward developing and demonstrating promised techniques for recycling, reuse, land application and other resource-conserving options for waste management. Where possible, State water pollution control agency administration of the research programs should be emphasized.

C. Congress should encourage research on toxic pollutants and their effects.

D. No comment.

E. See Paragraph B above.

Irrigated Agriculture

- **Recommendation No. VI**

A. Congress should authorize flexibility in the application of control requirements in this category of discharge and recognize the need for the development of applying resource systems on a site specific basis. Identified problems must be resolved within a reasonable period of time in order to meet water quality goals.

B. No comment.

- **Other Recommendations**

1. Section 305(b) should be revised to require State water quality status reports bi-annually rather than annually.
2. Section 404 should be revised to allow State operation of dredge and fill permit system where a State already has adequate authority to regulate such discharges.
3. Congress should consider the provision of Federal funding to State and local planning agencies where necessary to implement Section 208 water quality management plans.
4. Congress should consider developing a financing program which would provide low interest loans to agriculture interests on a high-priority basis where structural measures are needed to control pollutant discharges.

APPENDIX A-1
RECOMMENDATIONS (SUMMARY)

THE 1977 REQUIREMENTS

I. *The Commission recommends that*

A. Congress authorize granting extensions of time to municipal, industrial and agricultural dischargers to meet the 1977 requirements on a case-by-case basis where:

1. The discharger can demonstrate reasonable progress toward compliance with the July 1, 1977 deadline; or

2. Lack of Federal construction grant funds has caused delay; or

3. The discharger can demonstrate other good and sufficient cause;

Provided that in no case shall such extensions of time extend beyond (a specified date such as September 30, 1980) or until the cause for delay has been removed.

B. Congress authorize waiving, deferral or modification of the 1977 requirements on a case-by-case basis where the discharger demonstrates to the satisfaction of the Administrator (or a state administrator where a state has been certified) that adverse environmental impacts of such action will be minimal or nonexistent, or that the capital or operation and maintenance costs are disproportionate to projected environmental gains.

C. Congress authorize waiving, deferral, or modification of the 1977 requirements on a category-by-category basis for near shore ocean discharges of publicly owned treatment works, pretreatment requirements, existing publicly owned oxidation ponds and lagoons, and de minimus situation where the Administrator determines that the adverse environmental impacts of such action will be minimal or nonexistant, or that the capital or operating and maintenance costs are disproportionate to projected environmental gains.

THE 1983 GOAL AND REQUIREMENTS

II. The Commission recommends that

A. Congress retain the national goal, "... that whenever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water be achieved by July 1, 1983;"

B. Congress postpone the deadline by which municipal, agricultural and industrial discharges shall be required to meet the 1983 requirements from July 1, 1983 to (a date not less than five and no more than ten years after 1983) provided the following interim actions are assured:

1. Effluent limitations for 1977 are reviewed pericdically and revised, if appropriate, to reflect advances in practicable control technology,

2. Periodically review and aggressively enforce higher levels of treatment than required by the 1977 effluent limitations where the 1977 requirements will not achieve Federally approved State water quality standards and where more stringent limitations will significantly help in achieving water quality standards;

3. Review and alter new source performance standards periodically as technology is perfected to ensure a high level of control or treatment of new pollutant sources;

4. a. Where possible, toxic pollutants in toxic concentrations shall be controlled in applicable effluent limitations and permits.

b. Effluent limitations based on technology to eliminate the discharge c oxic pollutants in toxic concentrations into the nat 's waters shall be implemented as soon as possible nt no later than October 1, 1980;

5. a. Apply control or treatment measures to combined storm and sanitary sewer flows and to urban stormwater flows when these measures are cost effective and will significantly help in achieving water quality standards.

b. Control or treatment measures shall be applied to agricultural and non-point discharges when these measures are cost effective and will significantly help in achieving water quality standards.

For these measures, Congress could utilize the capabilities of existing institutions and their resources, and may wish to consider additional Federal resources to carry out the necessary programs;

6. An on-going national assessment of the quality of the nation's waters shall be undertaken to determine progress toward water quality goals and objectives and the progress periodically reported to the Congress; and

7. No later than 1985 a Commission similar to the National Commission on Water Quality shall evaluate progress toward these goals and make appropriate recommendations, at which time Congress may consider whether uniform application of more stringent effluent limitations that the 1977 requirements is justified and desirable.

DECENTRALIZATION

III. The Commission recommends that

Congress authorize certification, upon application, to any state to exercise full authority and responsibility for planning, and for administration of the discharge permit and construction grant program, provided:

A. A statewide water quality plan and program is approved at the time of certification.

B. The state demonstrates

1. It has the appropriate statutory authority and directions, manpower and appropriations, administrative or judicial penalties and remedies; and

2. It meets such other qualifications as the Congress may determine necessary to perform such functions.

C. That certification be for a period of five or more years renewable after that based on progress toward improved water quality, and that the state agrees the certification may be withdrawn, after public hearing, on a showing of unsat. ctory progress, but that certification shall continue in force unless and until it is withdrawn by the Administrator.

As the certification process proceeds, the Federal role in the national water quality program should be that of formulation of criteria review and approval of state programs, allocation of Federal resources, research and development and technical assistance, review of state progress and performance and more detailed supervision of those functions not certified to the states.

FEDERAL FINANCIAL ASSISTANCE

IV. The Commission recommends that

Congress provide stability for the program of Federal grants for the construction of publicl ied control or treatment works by authorizing and indic ng its intent to fund the progran at (not less that $5 billion nor more than $10 billion per year) for a fixed term of years (not less than five nor more than ten) at 75 percent of the cost of construction, provided that:

A. Priorities for the award of grants for eligible publicly owned treatment works within a state shall be established by the state provided that the ordering of priorities shall be based unon cost effectiveness and upon the ability of a project to contribute substantially toward the "goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water."

B. In pursuit of the objective of ultimate