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ABSTRACT

Computer programs which teach concepts and processes related to biology, earth science, and chemistry are presented. The seven biology problems deal with aspects of genetics, evolution and natural selection, gametogenesis, enzymes, photosynthesis, and the transport of material across a membrane. Four earth science problems concern climates, the formation of cumulus clouds, and water budgets. The 12 chemistry problems take up atomic weight, Avogadro's number, radioactive decay, half-life, equilibrium, mass defect, molarity, pH, percent composition, and mass and volume problems. For each lesson the objectives, necessary preliminary preparation, knowledge prerequisites, ways to use the problem, the computer program, and sample printouts are provided. All programs are written in the language BASIC, and the topics are suitable for the high school level. (JK)

DIGITAL EQUIPMENT CORPORATION

education

Basic Simulation Programs

Volumes I & II

Biology
Earth Science
Chemistry

HUNTINGTON COMPUTER PROJECT

A TEACHER'S MANUAL

(COMPUTER - RELATED MATERIALS)

Second Edition

January 31, 1971

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Developed by the Huntington Computer Project during the period May, 1968 and September, 1970. This effort was supported by the National Science Foundation under Grant No. J000079.

The enclosed material is a compilation of computer programs developed during the period May, 1968 to September, 1970. These programs were developed by teachers and students in the high schools which participated with us, and by the Project staff.

All of the enclosed programs have been tested on a Digital Equipment Corporation TSS-8 time-shared computer during the summer of 1970. To the best of our ability, we have assured ourselves that the programs actually run. It should be pointed out, however, that we were not able to make an exhaustive exploration of the programs. There may be undiscovered bugs (if there aren't, it may be the first time in the history of computing). We would appreciate hearing of any which emerge in the future.

These programs run in the version of BASIC which existed on the TSS-8 in August, 1970, and should run on most other versions of BASIC. The major potential problem on other machines is the output format (DEC uses 14 columns per print zone, while some other manufacturers use 15; we used the TAB function, which doesn't exist in all BASIC compiles). It may be necessary to make some minor changes in programs to adjust this format. Another possible problem is in the use of the RANDOMIZE command in some programs to start the random-number generator at a random point. If this command is not available, some other means should be devised for randomizing the start.

It is our sincere hope that these programs and their supporting documentation will be helpful to educators who are exploring the uses of computers in education.

We are anxious to hear of any bugs, errors, or improvements in these programs, and are especially anxious to hear of any novel ways of using them.

Ludwig Braun
Marian Visich, Jr.

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TEACHER ASSISTANCE

DISCIPLINE BIOLOGY

SUBJECT GENETICS

PROGRAM NAME DROS

DESCRIPTION:

This program determines the genetic characteristics of the offspring of a pair of Drosophila flies with specified traits. A game approach is used involving the entire class, in which the students can select different genotypes.

OBJECTIVES:

To show the student:

A. The result of MEIOSIS and the effect of random assortment.

B. That various genetic recombinations occur in sex cells and in genotypes of offspring.

C. That if enough trials are run, Mendelian ratios are verified.

D. That he can simulate different genotypic conditions and determine the probability of the phenotypic outcome.

PRELIMINARY PREPARATION:

A. Student - An understanding of the concepts in the computer program GAMGN . It is best to use DROS as soon as possible after GAMGN .

B. Materials - Eight containers grouped in two sets of four and labeled A, B, C, D. Designate one of the group of four as male chromosomes, and the other as female. Into each container, place two slips of paper, one marked 1 and the other, 2.

Before beginning the program have a student:

1. Take out one slip of paper from each of the containers of the male group and mark the designation on the chalk board. For instance: A1, B2, C2, D1;
2. Take out one slip from each container of the female group and do the same as with the male group.

Decide what the phenotype would be by discussing it in class.

You will run the program using the information you have on the chalk board. It will give you the correct phenotype. See how the class' answer compares with the computer' s.

DISCUSSION:

A. Operational Suggestions

1. Student level - average
2. This program can be used on a classroom basis.
3. Pitfalls to avoid - See that the students run the program several times and keep a record of each run. This is necessary to show the various possible combinations that can occur, and their frequencies.

B. Follow-up

After the program has been run:

1. Get as many runs as possible so that percentages can be determined for each phenotype of the offspring.
2. a) Determine the total number of offspring. Each run represents 1 offspring. Count them.
   b) Determine the total number of offspring which lived.
   c) Determine each phenotype and show that a ratio exists between dominant and recessive traits. (This should follow typical Mendelian ratios)
3. Elicit from the students:
   a) What was their role in the game? (The students conduct meiosis by randomly selecting the genotype of each gamete.)
   b) (When using a small number of runs) Why did the Mendelian ratios not hold true?

```
THIS PROGRAM IS DESIGNED TO GIVE THE GENETIC RESULTANT TRAITS
OF OFFSPRING WHOSE PARENTAGE WAS DISCUSSED IN PROGRAM 'GAMGN'

ARE YOU READY? HERE WE GO.

FOR THE SPERM CELL, WHAT IS 'A'? (TYPE 1 OR 2)? 2
                   WHAT IS 'B'? 1
                   WHAT IS 'C'? 2
                   WHAT IS 'D'? 2
FOR THE EGG CELL, WHAT IS 'A'? (TYPE 1 OR 2)? 2
                  WHAT IS 'B'? 1
                  WHAT IS 'C'? 1
                  WHAT IS 'D'? 1
OFFSPRING HAS NORMAL WINGS
AND IS RED EYED.

     LET'S TRY THIS SEVERAL TIMES AND SEE THE RESULTS WE GET
OVER SEVERAL TRIALS. KEEP A RECORD.
SHALL WE TRY AGAIN? IF YES TYPE 1, IF NO TYPE 0.
? 1
FOR THE SPERM CELL, WHAT IS 'A'? (TYPE 1 OR 2)? 1
                   WHAT IS 'B'? 2
                   WHAT IS 'C'? 2
                   WHAT IS 'D'? 2
FOR THE EGG CELL, WHAT IS 'A'? (TYPE 1 OR 2)? 1
                  WHAT IS 'B'? 2
                  WHAT IS 'C'? 1
                  WHAT IS 'D'? 1
OFFSPRING HAS VESTIGIAL WINGS
AND IS WHITE EYED

SHALL WE TRY AGAIN? IF YES TYPE 1, IF NO TYPE 0.
? 1
FOR THE SPERM CELL, WHAT IS 'A'? (TYPE 1 OR 2)? 1
                   WHAT IS 'B'? 1
                   WHAT IS 'C'? 2
                   WHAT IS 'D'? 2
FOR THE EGG CELL, WHAT IS 'A'? (TYPE 1 OR 2)? 1
                  WHAT IS 'B'? 2
                  WHAT IS 'C'? 1
                  WHAT IS 'D'? 2
OFFSPRING HAS VESTIGIAL WINGS
AND IS RED EYED.

SHALL WE TRY AGAIN? IF YES TYPE 1, IF NO TYPE 0.
? 1
FOR THE SPERM CELL, WHAT IS 'A'? (TYPE 1 OR 2)? 1
                   WHAT IS 'B'? 2
                   WHAT IS 'C'? 2
                   WHAT IS 'D'? 2
FOR THE EGG CELL, WHAT IS 'A'? (TYPE 1 OR 2)? 1
                  WHAT IS 'B'? 2
                  WHAT IS 'C'? 2
                  WHAT IS 'D'? 2
OFFSPRING HAS VESTIGIAL WINGS
AND IS WHITE EYED
```

```
SHALL WE TRY AGAIN? IF YES TYPE 1, IF NO TYPE 0.
? 1
FOR THE SPERM CELL, WHAT IS 'A'? (TYPE 1 OR 2)? 2
                   WHAT IS 'B'? 1
                   WHAT IS 'C'? 1
                   WHAT IS 'D'? 1
FOR THE EGG CELL, WHAT IS 'A'? (TYPE 1 OR 2)? 1
                  WHAT IS 'B'? 1
                  WHAT IS 'C'? 1
                  WHAT IS 'D'? 1
DEVELOPING EMBRYO HAS DIED DUE TO LETHAL GENE ACTION.

SHALL WE TRY AGAIN? IF YES TYPE 1, IF NO TYPE 0.
? 0
     I HOPE THAT I HAVE BEEN OF SOME HELP TO YOU,
AND THAT 5 RUNS PROVIDE ENOUGH INFORMATION.


READY
```

```
100REM THIS PROGRAM DEVELOPED BY R. COOPERMAN--JOHN GLENN HIGH SCHOOL
110 REM  REVISED BY C.LOSIK  7-9-70
119 REM  C IS THE RUN COUNTER, ALL INPUTS ARE TEMPORARY
120 LET C=0
125 REM WE ASSIGN EACH GENE A "WEIGHT",
126 REM AND COMBINE THE WEIGHTS TO GIVE RESULTS !
130PRINT"THIS PROGRAM IS DESIGNED TO GIVE THE GENETIC RESULTANT TRAITS"
140PRINT"OF OFFSPRING WHOSE PARENTAGE WAS DISCUSSED IN PROGRAM 'GAMGN'"
150PRINT
440PRINT"ARE YOU READY? HERE WE GO."
450PRINT
540PRINT"FOR THE SPERM CELL, WHAT IS 'A'? (TYPE 1 OR 2)";
550 INPUT X
551 IF X=1 THEN 559
552 LET X=5
553 GO TO 560
559 LET X=10
560PRINT"                    WHAT IS 'B'";
570 INPUT Y
571 IF Y=1 THEN 579
572 LET Y=100
573 GO TO 580
579 LET Y=50
580PRINT"                    WHAT IS 'C'";
590 INPUT W
591 IF W=1 THEN 599
592 LET W=0
593 GO TO 600
599 LET W=500
600PRINT"                    WHAT IS 'D'";
610 INPUT Z
620PRINT"FOR THE EGG CELL, WHAT IS 'A'? (TYPE 1 OR 2)";
630 INPUT L
631 IF L=1 THEN 639
632 LET L=5
633 GO TO 640
639 LET L=10
640PRINT"                  WHAT IS 'B'";
650 INPUT M
651 IF M=1 THEN 659
652 LET M=100
653 GO TO 660
659 LET M=50
660PRINT"                  WHAT IS 'C'";
670 INPUT N
671 IF N=1 THEN 679
672 LET N=0
673 GO TO 680
679 LET N=500
680PRINT"                  WHAT IS 'D'";
690 INPUT O
```

```
700 LET T=W+N
710 LET S=Y+M
720 LET R=X+L
725 LET C=C+1
730 IF T<999 THEN 750
740PRINT"DEVELOPING EMBRYO HAS DIED DUE TO LETHAL GENE ACTION."
745 GO TO 910
750 IF R<19 THEN 770
760PRINT"OFFSPRING HAS VESTIGIAL WINGS"
765 GO TO 780
770PRINT"OFFSPRING HAS NORMAL WINGS"
780 IF S<199 THEN 800
790PRINT "AND IS WHITE EYED"
795 GO TO 910
800PRINT"AND IS RED EYED."
910 PRINT
915 IF C>1 THEN 940
920PRINT"     LET'S TRY THIS SEVERAL TIMES AND SEE THE RESULTS WE GET"
930PRINT"OVER SEVERAL TRIALS. KEEP A RECORD."
940 PRINT "SHALL WE TRY AGAIN? IF YES TYPE 1, IF NO TYPE 0."
950 INPUT I
960 IF I=1 THEN 540
963 IF I=0 THEN 970
966 GO TO 940
970PRINT"     I HOPE THAT I HAVE BEEN OF SOME HELP TO YOU."
980 PRINT "AND THAT"C"RUNS PROVIDE ENOUGH INFORMATION."
990 END
```

DISCIPLINE BIOLOGY

SUBJECT EVOLUTION

PROGRAM NAME EVOLU

DESCRIPTION:

A population of dark and light pepper moths are studied over a period of 30 years. The student selects the year and direction of environmental changes which favors one or the other. The concept of natural selection in evolution is developed.

OBJECTIVES:

To show the student that:

A. The mutation rate within a population for a specific trait can be stable for a period of time, or can change. The success of the progeny exhibiting this variation is dependent upon environmental conditions.

B. Progeny exhibiting an hereditary trait do not necessarily reach maturity, because of the influence of environment.

C. Evolution depends upon mutation, heredity, and environmental pressures.

PRELIMINARY PREPARATION:

A. Student - An understanding of the following terms: 1) mutation rate, 2) species, 3) environmental change, 4) population.

B. Materials - 1) Specimens showing color variations within any species (optional); and 2) Ditto of the list of assumptions presented in this program (optional). Assumptions are listed below.

DISCUSSION:

A. Operational Suggestions

1. Student level - average
2. Group size - Work in small groups of five or less. Remaining students may be engaged in a related activity.
3. Assumptions - Prior to running the program, the students should be told to assume the following:
   a) The environment initially favors the light moths.
   b) At first, brown moths are produced, but because of environmental pressures they do not reach maturity.
   c) The total population in the area cannot exceed the initial number of moths, because this is the maximum number of moths the environment can support.

DISCUSSION: (con' t)

4. Each group of students should run the program at least two times, varying the environmental pressure; once favoring the dark moths and once favoring the light.
5. You might have the runs of different groups of students reflect different mutation rates.
6. Supervision of the number of program runs per group is necessary since they are not automatically cut off.

B. Suggested Follow-up

These questions may be used to initiate discussion:

1. Why does the mutation rate remain constant? Does it always remain constant under natural conditions? Explain your reasons.
2. Assuming constant environmental conditions, how does changing the mutation rate affect the population? Why?
3. How does changing the mutation rate affect the dark moth population when environmental pressures favor these moths? Why?
4. What environmental pressures could favor the dark moths? (industrial expansion, predators which favor the light or dark moths) (The classic case of the pepper moths and the industrial revolution in England could be discussed at this point.)
5. What possible role might pollutants play in altering a mutation rate? What other factors could affect a mutation rate?
6. Is evolution a slow or fast process? Explain your answer.
7. Why do a few white moths always remain in the population, even though the environment favors the dark moths?
8. What is natural selection? What is its role in evolution?
9. Make a list of all factors important to evolution.

EVOLUTION STUDY

WITHIN A LARGE POPULATION OF PEPPER MOTHS, THERE ARE A FEW INDIVIDUALS WHICH SHOW UP DARKER IN COLOR THAN THE NORMAL LIGHT COLORED MOTHS BECAUSE OF MUTATIONS.

YOU ARE GOING TO STUDY THIS POPULATION OF PEPPER MOTHS FOR 30 YEARS AND SEE WHAT HAPPENS TO THE NUMBER OF DARK MOTHS WHEN YOU ALTER ENVIRONMENTAL CONDITIONS.

SELECT A MUTATION RATE VALUE BETWEEN 1 AND 10. THE HIGHER THE NUMBER, THE HIGHER THE MUTATION RATE IS, AND THUS THERE ARE MORE DARK MOTHS IN OUR POPULATION.
? 9

HOW MANY LIGHT COLORED MOTHS ARE THERE IN THE AREA?
SELECT A NUMBER BETWEEN 1000 AND 1000000 ? 65789

YOU HAVE THE POWER TO CHANGE THE ENVIRONMENT.
AT WHAT POINT IN OUR THIRTY YEAR PERIOD DO YOU WANT
TO IMPLEMENT YOUR POWER? SELECT A YEAR FROM 3 THROUGH 10.
? 5

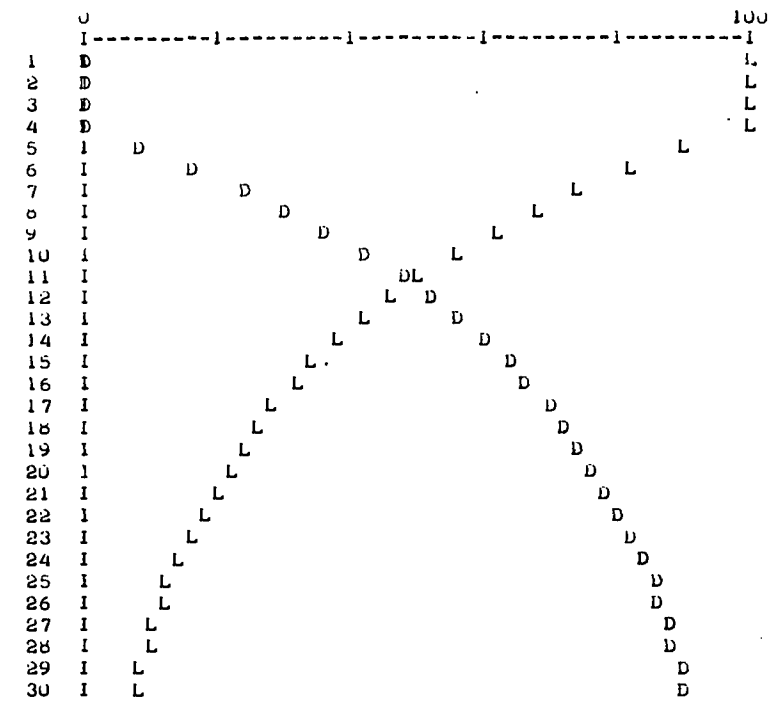
IS THE ENVIRONMENTAL CHANGE GOING TO FAVOR
LIGHT MOTHS (TYPE 1) OR DARK MOTHS (TYPE 2)? 2

HOW DO YOU WISH TO SEE THE RESULTS?
1=TABLE ONLY, 2=GRAPH ONLY, 0=BOTH? 0

FOR A MUTATION RATE OF 9

YEAR	DARK MOTHS	LIGHT MOTHS
1	0	65789
2	0	65789
3	0	65789
4	0	65789
5	5921	59868
6	11309	54480
7	16212	49577
8	20674	45115
9	24734	41055
10	28429	37360
11	31791	33998
12	34851	30938
13	37635	28154
14	40169	25620
15	42475	23314
16	44573	21216
17	46482	19307
18	48220	17569
19	49801	15988
20	51240	14549
21	52549	13240
22	53741	12048
23	54825	10964
24	55812	9977
25	56710	9079
26	57527	8262
27	58271	7518
28	58948	6841
29	59564	6225
30	60124	5665

L=LIGHT MOTHS, D=DARK MOTHS
VALUES GRAPHED AS PERCENTAGE OF POPULATION.



DO YOU WANT TO RUN THIS PROGRAM AGAIN (1=YES,0=NO)? 1

SELECT A MUTATION RATE VALUE BETWEEN 1 AND 10. THE
HIGHER THE NUMBER, THE HIGHER THE MUTATION RATE IS, AND THUS
THERE ARE MORE DARK MOTHS IN OUR POPULATION.
? 9

HOW MANY LIGHT COLORED MOTHS ARE THERE IN THE AREA?
SELECT A NUMBER BETWEEN 1000 AND 1000000 ? 65789

YOU HAVE THE POWER TO CHANGE THE ENVIRONMENT.
AT WHAT POINT IN OUR THIRTY YEAR PERIOD DO YOU WANT
TO IMPLEMENT YOUR POWER? SELECT A YEAR FROM 3 THROUGH 10.
? 5

IS THE ENVIRONMENTAL CHANGE GOING TO FAVOR
LIGHT MOTHS (TYPE 1) OR DARK MOTHS (TYPE 2)? 1

HOW DO YOU WISH TO SEE THE RESULTS?
1=TABLE ONLY, 2=GRAPH ONLY, 0=BOTH? 1

FOR A MUTATION RATE OF 9

YEAR	DARK MOTHS	LIGHT MOTHS
1	0	65789
2	0	65789
3	0	65789
4	0	65789
5	0	65789
6	0	65789
7	0	65789
8	0	65789
9	0	65789
10	0	65789
11	0	65789
12	0	65789
13	0	65789
14	0	65789
15	0	65789
16	0	65789
17	0	65789
18	0	65789
19	0	65789
20	0	65789
21	0	65789
22	0	65789
23	0	65789
24	0	65789
25	0	65789
26	0	65789
27	0	65789
28	0	65789
29	0	65789
30	0	65789

DO YOU WANT TO RUN THIS PROGRAM AGAIN (1=YES,0=NO)? 0

READY

```
100REM PROGRAM DEVELOPED BY DR. A. FRISHMAN, S.U.N.Y. FARMINGDALE
110REM AND R. COOPERMAN, JOHN GLENN HIGH SCHOOL.
112 REM  REVISED BY C.LOSIK  7-6-70
115 REM D=DARK MOTH ARRAY, L=LIGHT MOTH ARRAY, Z=MAX. POPUL.
116 DIM D(31), L(31)
117 PRINT " ","EVOLUTION STUDY"
118 PRINT
120PRINT"WITHIN A LARGE POPULATION OF PEPPER MOTHS, THERE ARE A FEW"
130PRINT"INDIVIDUALS WHICH SHOW UP DARKER IN COLOR THAN THE NORMAL"
140 PRINT "LIGHT COLORED MOTHS BECAUSE OF MUTATIONS."
150PRINT
160PRINT"YOU ARE GOING TO STUDY THIS POPULATION OF PEPPER MOTHS FOR 30"
170PRINT"YEARS AND SEE WHAT HAPPENS TO THE NUMBER OF DARK MOTHS WHEN"
180PRINT"YOU ALTER ENVIRONMENTAL CONDITIONS."
200 PRINT
210 PRINT "SELECT A MUTATION RATE VALUE BETWEEN 1 AND 10.  THE"
220PRINT"HIGHER THE NUMBER, THE HIGHER THE MUTATION RATE IS, AND THUS"
230 PRINT "THERE ARE MORE DARK MOTHS IN OUR POPULATION."
240INPUTM
250IFM<1THEN280
260 IF M<=10 THEN 310
280PRINT"THE MUTATION RATE YOU HAVE CHOSEN DOES NOT FALL WITHIN THE"
290PRINT"PRESCRIBED RANGE 1-10. TRY AGAIN."
300GOTO240
310 PRINT
330 PRINT "HOW MANY LIGHT COLORED MOTHS ARE THERE IN THE AREA?"
340 PRINT "SELECT A NUMBER BETWEEN 1000 AND 1000000 ";
350INPUTP0
360 IF P0<1E3 THEN 390
370 IF P0<=1E6 THEN 420
390PRINT"THE NUMBER OF MOTHS YOU HAVE CHOSEN DOES NOT FALL WITHIN THE"
400PRINT"PRESCRIBED RANGE 1000-1000000. TRY AGAIN."
410GOTO350
420LET Z=P0
430PRINT
440PRINT"YOU HAVE THE POWER TO CHANGE THE ENVIRONMENT."
450PRINT"AT WHAT POINT IN OUR THIRTY YEAR PERIOD DO YOU WANT"
460PRINT"TO IMPLEMENT YOUR POWER? SELECT A YEAR FROM 3 THROUGH 10."
470  INPUT X
480  IF X<3 THEN 492
490  IF X<=10 THEN 500
492  PRINT "THE YEAR CHOSEN DOES NOT FALL WITHIN THE RANGE 3-10."
494  PRINT "TRY AGAIN."
496  GO TO 470
500PRINT
510PRINT"IS THE ENVIRONMENTAL CHANGE GOING TO FAVOR"
520PRINT"LIGHT MOTHS (TYPE 1) OR DARK MOTHS (TYPE 2)";
530INPUT E
532  IF E=1 THEN 540
534  IF E=2 THEN 540
536  PRINT "PLEASE TYPE 1 OR 2 NOT";E
538  GO TO 530
540PRINT
600  REM ONE LOOP FOR CALCULATION
610  FOR T=1 TO 30
615  REM  CHECK IF ENVIRONMENT HAS CHANGED
620  IF T>=X THEN 650
625  REM  NOT YET (FAVORS LIGHT MOTHS)
630  LET P1=0
640  GO TO 710
649  REM  ENVIRONMENT HAS CHANGED
650  IF E<>2 THEN 630
660  LET P1=INT(P1+.01*M*P0+.5)
670  LET P0=INT(Z-P1+.5)
```

```
680 IF P1<2 THEN 710
689 REM  COMPLETE REVERSAL OF POPULATION HAS OCCURED
690 LET P1=2
700 LET P0=0
710 LET L(T)=P0
720 LET D(T)=P1
730 NEXT T
740 REM OUTPUT OF RESULTS
750 PRINT "HOW DO YOU WISH TO SEE THE RESULTS?"
760 PRINT "1=TABLE ONLY, 2=GRAPH ONLY, 3=BOTH";
770 INPUT E
780 FOR T=0TO2
790 IF E=T THEN 825
800 NEXT T
810 PRINT "AW C'MON. I'M NOT DUMB. TRY AGAIN."
820 GO TO 760
823 PRINT
825 PRINT
826 PRINT "FOR A MUTATION RATE OF";M
830 IF E>1 THEN 910
840 PRINT
850 PRINT
860 PRINT "YEAR", "DARK MOTHS", "LIGHT MOTHS"
870 PRINT "----", "---- -----", "----- -----"
875 REM  OUTPUT TABLE
880 FOR T=1 TO 30
890 PRINT T, D(T), L(T)
900 NEXT T
910 IF E=1 THEN 1080
915 PRINT
920 PRINT
925 PRINT " ","L=LIGHT MOTHS,    D=DARK MOTHS"
930 PRINT " ","VALUES GRAPHED AS PERCENTAGE OF POPULATION."
935 PRINT
940 REM SCALE OF GRAPH IS ZERO TO ONE
990 PRINT TAB(5);"0";TAB(54);"100"
1000 PRINT TAB(5);"I---------I---------I---------I---------I---------I"
1010 FOR T=1 TO 30
1020 PRINT T;TAB(5);"I";
1023 LET L(T)=50*L(T)/2
1026 LET D(T)=50*D(T)/2
1030 IF L(T)>D(T) THEN 1060
1040 IF D(T)> L(T) THEN 1070
1050 PRINT TAB(5+L(T));"*"
1055 GO TO 1075
1060 PRINT TAB (5+D(T));"D"; TAB(5+L(T));"L"
1065 GO TO 1075
1070 PRINT TAB(5+L(T));"L";TAB(5+D(T));"D"
1075 NEXT T
1080 PRINT
1090 PRINT
1100 PRINT "DO YOU WANT TO RUN THIS PROGRAM AGAIN (1=YES,0=NO)";
1110 INPUT E
1120 IF E=1 THEN 200
1130 IF E<>0 THEN 1100
1140 END
```

DISCIPLINE BIOLOGY

SUBJECT GAMETOGENESIS + INHERITANCE

PROGRAM NAME GAMGN

DESCRIPTION:

A review of the process of gametogenesis, applying it to the concept of dominant-recessive traits.

OBJECTIVES:

A. To reinforce the meaning of the terms random assortment, meiotic divisions, monoploid, and diploid.

B. To allow the student to make decisions based upon knowledge gained in the program, thus causing the students to think.

C. To review and reinforce both spermatogenesis and oogenesis.

PRELIMINARY PREPARATION:

A. Student

1. Students should be familiar with all phases of meiosis.
2. Genetics should have been introduced so that the student understands the implications of gene action, dominance and recessiveness, homologous and non-homologous chromosomes.
3. Programming and machine knowledge. Keep in mind that for this program the students should be given time to try to determine what genetic traits are represented by the chromosome designation shown in the program.

normal wing - red eye	= A1A2, B1B2, C1C2, D1D2
normal wing - white eye	= A1A2, B2B2, C1C2, D1D2
vestigial wing	= A1A1, B1B2, C1C2, D1D2
lethal gene	= A1A2, B1B2, C1C1, D1D2

red eye	= B1B2 or B1B1
white eye	= B2B2 (recessive)
normal wing	= A1A2 or A2A2
vestigial wing	= A1A1 (recessive)
non lethal gene	= C2C2
lethal gene carrier	= C1C2
lethal (dies)	= C1C1 (recessive)

B. Materials - none necessary

DISCUSSION:

A. Operational Suggestions

1. Student level - Average to above average ability
2. If the student is confused alert him to the fact that chromosomes are letters and the number following the letter represent genes. Similar letters indicate homologous chromosomes. (see program)
3. Read the program ahead of time to make sure your students are familiar with the terms used in the program.
4. If the students are thrown off the machine see that they review with the teacher the concept of gametogenesis before continuing with the program.
5. Ideally, students should work individually. If this is not possible, then work in groups of 5 or less. Allow one group at a time at the computer while the remaining groups are engaged in a related activity.

B. Suggested Follow-up

To maximize the value of this program, it is strongly suggested that the teacher:

1. Elicit from the students:

   What are the gene locations for the various genetic traits (eye color, wing normalcy, lethality)? Which is recessive? Which is dominant? Why is there no chance that the offspring will have the exact chromosomal composition of the father?

2. Ask the following questions, based on the information given, as lead-ins to discussion or as a homework assignment.

   (a) What is a polar body? How does the formation of polar bodies increase the survival chance of the egg cell?
   (b) How is random assortment responsible for genetic trait variations?
   (c) Why is it possible for all offspring to have the same traits without variations?

ARTICULATION INTO NEXT AREA TO BE COVERED:

This program can lead directly into the topic of genetics. A second program, DROS , appearing in the manual, should follow. It demonstrates, with a game, the random recombinations of the chromosomes in offspring, showing all possible combinations and, if repeated often enough, Mendelian ratios.

RUN

THE FOLLOWING DIAGRAMS ARE REPRESENTATIONS OF PRIMARY SEX CELLS. CHROMOSOMES ARE REPRESENTED BY LETTERS.

PRIMARY SPERMATOCYTE

```
----------
( A1 A2  )
(        )
( B1 B2  )
----------
```

PRIMARY OOCYTE

```
----------
( A3 A4  )
(        )
( B3 B4  )
----------
```

BY TYPING IN A NUMBER, WHAT IS THE DIPLOID NUMBER OF CHROMOSOMES FOR THIS ORGANISM? 4

SO YOU SEE THAT A1 + A2, FOR EXAMPLE, ARE PAIRS OF HOMOLOGOUS CHROMOSOMES. IT IS ESSENTIAL THAT AFTER FERTILIZATION, IF THE DIPLOID CONDITION IS TO BE RETAINED THAT WE HAVE SOME MEANS OF PLACING ONLY ONE A AND ONE B CHROMOSOME IN THE SPERM AND ONLY ONE A AND ONE B CHROMOSOME IN THE EGG. THIS INVOLVES MEIOSIS.

LOOK AT THE PRIMARY SPERMATOCYTE ABOVE.
DURING THE FIRST STAGE OF MEIOSIS, THE MALE SEX CELL SHOULD APPEAR AS IT IS IN ONE OF THE FOLLOWING DIAGRAMS.

```
     1          2          3          4          5
----------  ----------  ----------  ----------  ----------
( A1A1   )  ( A1  A2 )  (    A   )  ( A1 A2 )  (         )
(   A2A2 )  (        )  (        )  (        )  (         )
( B1B1   )  (        )  (        )  (        )  (         )
(   B2B2 )  ( B1  B2 )  (    B   )  (        )  ( B1 B2 )
----------  ----------  ----------  ----------  ----------
```

WHICH DIAGRAM MOST CLOSELY REPRESENTS THIS MEIOTIC STAGE ? 1

O.K., NOW WE CAN MOVE ALONG. MEIOTIC DIVISION OCCURS AND WE GET TWO SECONDARY SPERMATOCYTES FROM EACH PRIMARY SPERMATOCYTE AND ONE SECONDARY OOCYTE FROM EACH PRIMARY OOCYTE. EACH SPERMATOCYTE CONTAINS THE FOLLOWING CHROMOSOMES: A1 A2, B1 B2. EACH OOCYTE HAS A3 A4, B3 B4.

THE REASON WHY ONLY ONE OOCYTE IS PRODUCED IS:

1)THE OOCYTE DOES NOT UNDERGO DIVISION.
2)THE OOCYTE DIVIDES AFTER FERTILIZATION.
3)A POLAR BODY IS FORMED.
4)THERE IS AN ERROR IN THE COMPUTER.

WHICH NUMBER WOULD REPRESENT THE CORRECT ANSWER? 3

CORRECT. NOW LET'S MOVE TO THE FINAL STAGE IN WHICH WE WILL END UP WITH 4 MONOPLOID(HAPLOID) SPERM--1)A1B1 2)A2B2 3)A1B2 4)A2B1 AND ONE OVUM--1)A3B3 OR 2)A4B4 OR 3)A3B4 OR 4)A4B3

WHAT IS THE POSSIBILITY THAT THE OFFSPRING WILL HAVE THE SAME CHROMOSOMAL COMPOSITION AS THE FATHER?
PRINT ONE OF THE FOLLOWING NUMBERS.
1)50 CHANCE 2)NO CHANCE 3)100 CHANCE
4)YOU CAN'T TELL FROM THE INFORMATION GIVEN
? 2
GOOD THINKING.
I HOPE YOU HAVE A FAIRLY GOOD IDEA OF SEVERAL PRINCIPLES INVOLVED, PARTICULARLY RANDOM ASSORTMENT.

NOW LET'S SEE IF WE CAN USE THESE IDEAS TO DETERMINE WHAT OCCURS IN A POPULATION. WE WILL USE AS OUR ORGANISM THE FRUIT FLY, DROSOPHILA, WHICH HAS 8 AS THE DIPLOID NUMBER OF CHROMOSOMES. THE FOLLOWING WILL REPRESENT CERTAIN CONDITIONS IN FRUIT FLIES :

NORMAL WING-RED EYE=A1A2, B1B2, C1C2, D1D2
NORMAL WING-WHITE EYE=A1A2, B2B2, C1C2, D1D2
VESTIGIAL WING=A1A1, B1B2, C1C2, D1D2
LETHAL GENE=A1A2, B1B2, C1C1, D1D2

SUPPOSE WE CROSS THE NORMAL RED EYED WITH THE NORMAL WHITE EYED FRUIT FLY. WHAT COULD THE OFFSPRING LOOK LIKE? LOOK AT THE GENOTYPES CAREFULLY AND SEE IF YOU CAN PICK OUT THE DIFFERENT GENE COMBINATIONS. THEN MAKE ALL POSSIBLE CROSSES. AT A LATER DATE, WE WILL SEE HOW I, THE COMPUTER, CAN SOLVE THIS PROBLEM FOR YOU.
BUT FIRST, TAKE THIS SHEET BACK TO YOUR SEATS AND WORK ON IT.

READY

```
100REM THIS PROGRAM DEVELOPED BY R. COOPERMAN--JOHN GLENN HIGH SCHOOL
105 REM  REVISED BY C.LOSIK  7-9-70
107 REM  ALL INPUTS ARE TEMPORARY
110PRINT"THE FOLLOWING DIAGRAMS ARE REPRESENTATIONS OF PRIMARY SEX"
120PRINT"CELLS. CHROMOSOMES ARE REPRESENTED BY LETTERS."
130PRINT
140PRINT"PRIMARY SPERMATOCYTE          PRIMARY OOCYTE"
150PRINT"      ----------                ----------"
160PRINT"     ( A1 A2  )                ( A3 A4  )"
170PRINT"     (        )                (        )"
180PRINT"     ( B1 B2  )                ( B3 B4  )"
190PRINT"      ----------                ----------"
200PRINT
210LET Y=0
220PRINT"BY TYPING IN A NUMBER,WHAT IS THE DIPLOID NUMBER OF"
230PRINT"CHROMOSOMES FOR THIS ORGANISM";
240INPUT C
250IF C=4 THEN 320
260PRINT
270PRINT" ARE YOU SURE THAT YOU UNDERSTAND WHAT IS MEANT BY DIPLOID"
280PRINT"AND HAPLOID?"
290IF Y=1 THEN 1180
300LET Y=Y+1
310GO TO 220
320PRINT
330PRINT"SO YOU SEE THAT A1 + A2, FOR EXAMPLE, ARE PAIRS OF HOMOLOGOUS"
340PRINT"CHROMOSOMES. IT IS ESSENTIAL THAT AFTER FERTILIZATION, IF THE"
350PRINT"DIPLOID CONDITION IS TO BE RETAINED THAT WE HAVE SOME MEANS OF"
360PRINT"PLACING ONLY ONE A AND ONE B CHROMOSOME IN THE SPERM AND ONLY"
370PRINT"ONE A AND ONE B CHROMOSOME IN THE EGG. THIS INVOLVES MEIOSIS."
380PRINT
390PRINT"LOOK AT THE PRIMARY SPERMATOCYTE ABOVE."
400PRINT"DURING THE FIRST STAGE OF MEIOSIS, THE MALE SEX CELL"
410PRINT"SHOULD APPEAR AS IT IS IN ONE OF THE FOLLOWING DIAGRAMS."
420PRINT
430PRINT"     1           2           3           4           5"
440PRINT"----------  ----------  ----------  ----------  ----------"
450PRINT"( A1A1   )  ( A1  A2 )  (    A    )  (  A1 A2 )  (         )"
460PRINT"(   A2A2 )  (         )  (         )  (         )  (         )"
470PRINT"( B1B1   )  (         )  (         )  (         )  (         )"
480PRINT"(   B2B2 )  ( B1  B2 )  (    B    )  (         )  (  B1 B2 )"
490PRINT"----------  ----------  ----------  ----------  ----------"
500LET X=0
510PRINT
520PRINT"WHICH DIAGRAM MOST CLOSELY REPRESENTS THIS MEIOTIC STAGE ";
530INPUT D
540IF D=1 THEN 600
550PRINT
560PRINT"YOUR REASONING IS FAULTY."
565 PRINT "DO YOU RECALL THAT A TETRAD IS FORMED?"
570IFX=2THEN 1180
580LET X=X+1
590GO TO 520
600PRINT
610PRINT"O.K., NOW WE CAN MOVE ALONG. MEIOTIC DIVISION OCCURS AND"
620PRINT"WE GET TWO SECONDARY SPERMATOCYTES FROM EACH PRIMARY"
630PRINT"SPERMATOCYTE AND ONE SECONDARY OOCYTE FROM EACH PRIMARY "
640PRINT"OOCYTE. EACH SPERMATOCYTE CONTAINS THE FOLLOWING CHROMOSOMES:"
650PRINT"A1 A2, B1 B2.     EACH OOCYTE HAS  A3 A4, B3 B4."
660PRINT
670PRINT"THE REASON WHY ONLY ONE OOCYTE IS PRODUCED IS:"
680PRINT
690PRINT"      1)THE OOCYTE DOES NOT UNDERGO DIVISION."
700PRINT"      2)THE OOCYTE DIVIDES AFTER FERTILIZATION."
```

```
710PRINT"      3)A POLAR BODY IS FORMED."
720PRINT"      4)THERE IS AN ERROR IN THE COMPUTER."
730PRINT
740PRINT"WHICH NUMBER WOULD REPRESENT THE CORRECT ANSWER";
750INPUT E
760PRINT
770IF E=3 THEN 810
780PRINT"STOP GUESSING. THERE IS A PERFECTLY GOOD EXPLANATION WHICH"
790PRINT"HAS A VITAL FUNCTION."
800GO TO 730
810PRINT"CORRECT.      NOW LET'S MOVE TO THE FINAL STAGE IN WHICH"
820PRINT"WE WILL END UP WITH 4 MONOPLOID(HAPLOID) SPERM--1)A1B1"
830PRINT"2)A2B2  3)A1B2  4)A2B1  AND ONE OVUM--1)A3B3 OR  2)A4B4"
840PRINT"OR  3)A3B4  OR  4)A4B3"
850PRINT
860PRINT"WHAT IS THE POSSIBILITY THAT THE OFFSPRING WILL HAVE"
870PRINT"THE SAME CHROMOSOMAL COMPOSITION AS THE FATHER?"
880PRINT"PRINT ONE OF THE FOLLOWING NUMBERS."
890PRINT"      1)50 CHANCE   2)NO CHANCE   3)100 CHANCE"
900PRINT"      4)YOU CAN'T TELL FROM THE INFORMATION GIVEN"
910INPUT F
920IF F=2 THEN 960
930PRINT"YOU COULDN'T BE MORE WRONG. LOOK AT ALL THE CELLS AGAIN AND"
940PRINT"COMPARE ALL POSSIBILITIES."
950GO TO 910
960PRINT"GOOD THINKING."
970PRINT"I HOPE YOU HAVE A FAIRLY GOOD IDEA OF SEVERAL PRINCIPLES"
980PRINT"INVOLVED, PARTICULARLY RANDOM ASSORTMENT."
990PRINT
1000PRINT"NOW LET'S SEE IF WE CAN USE THESE IDEAS TO DETERMINE WHAT"
1010PRINT"OCCURS IN A POPULATION. WE WILL USE AS OUR ORGANISM THE FRUIT"
1020PRINT"FLY, DROSOPHILA, WHICH HAS 8 AS THE DIPLOID NUMBER OF"
1030PRINT"CHROMOSOMES.  THE FOLLOWING WILL REPRESENT CERTAIN CONDITIONS"
1035 PRINT "IN FRUIT FLIES :"
1040PRINT
1050PRINT"NORMAL WING-RED EYE=A1A2, B1B2, C1C2, D1D2"
1060PRINT"NORMAL WING-WHITE EYE=A1A2, B2B2, C1C2, D1D2"
1070PRINT"VESTIGIAL WING=A1A1, B1B2, C1C2, D1D2"
1080PRINT"LETHAL GENE=A1A2, B1B2, C1C1, D1D2"
1090PRINT
1100PRINT"SUPPOSE WE CROSS THE NORMAL RED EYED WITH THE NORMAL WHITE"
1110PRINT"EYED FRUIT FLY. WHAT COULD THE OFFSPRING LOOK LIKE? LOOK AT"
1120PRINT"THE GENOTYPES CAREFULLY AND SEE IF YOU CAN PICK OUT THE"
1130PRINT"DIFFERENT GENE COMBINATIONS. THEN MAKE ALL POSSIBLE CROSSES."
1140PRINT"AT A LATER DATE, WE WILL SEE HOW I, THE COMPUTER, CAN"
1150PRINT"SOLVE THIS PROBLEM FOR YOU."
1160PRINT"BUT FIRST, TAKE THIS SHEET BACK TO YOUR SEATS AND WORK ON IT."
1170 STOP
1180PRINT"      YOU'RE JUST GUESSING. I DON'T HAVE TIME TO FOOL"
1190PRINT"AROUND. TAKE THIS SHEET OUT AND STUDY IT; THEN SEE YOUR"
1200PRINT"TEACHER BEFORE YOU COME BACK TO ME."
1210REM NEXT PROGRAM NAME IS DROS**
1220END

READY
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DISCIPLINE BIOLOGY

SUBJECT CELL MEMBRANES

PROGRAM NAME MEMBR

DESCRIPTION:

This program simulates an experiment on diffusion. Membrane characteristics are "observed" by the student, and means of transport across membranes identified.

OBJECTIVES:

A. To provide background for understanding of transport of materials across living membranes;

B. To evaluate and reinforce an understanding of conditions under which diffusion, osmosis, and active transport take place;

C. To help in the understanding of solution concentrations.

PRELIMINARY PREPARATION:

A. Student - exposed to the meaning of diffusion, osmosis, active transport, and semipermeable; should understand the need for energy expenditure in active transport; and have observed or performed the iodine test for starch.

B. Materials - a prepared ditto of questions to be answered by students as a homework assignment or for classroom discussion.

DISCUSSION:

A. Operational Suggestions

1. Student level - this program has been effective with average and above average students.
2. An incorrect answer results in the students being instructed to return to their seats, correct their answer, and give a reason for its correctness. A correct answer is immediately reinforced.
3. The class is grouped. A maximum of 5 per group is recommended. The groups sequentially run the program until completion, or they are sent away from the machine by an incorrect answer. The other groups may be engaged in performance of the same experiment being "done" by the computer, or in a related activity. Interruption of an actual experiment, as a group goes to the computer, should not affect the results.
4. When the program is to be used with more than one class, it is suggested that the data line in the program (see list) be changed. Since this is a

simple change to make, it can be made between groups within a class. This prevents their memorization and/or transmission to other groups and classes. Examples follow:

140 DATA10, 11, 12, 13, 14 may be changed to:

140 DATA1,2, 3, 4, 5
or 140 DATA4, 2, 6, 9, 1
or 140 DATA2Ø, 3Ø, 4Ø, 5Ø, 6Ø

Any combination of numbers may be inserted. There must be a total of of five, however. since the student is asked to respond to five questions.

It has been found that extensive discussion preceeds the answering of each question on the computer, and in the writing of the rationalizations. This is certainly desirable.

B. Suggested Follow-up

Questions which may be used for discussion, or given as a homework assignment:

1. What happens to the concentration of water within the membrane as the glucose diffuses out? Why?
2. What observations indicated that the iodine had moved into the "cell"?
3. Why couldn't the same observations be made outside of the membrane?
4. What changes in observations would you expect if the cellophane had not been permeable?
5. Can materials diffuse through a semipermeable membrane in both directions at the same time?
6. What is meant by equilibrium?
7. Under what conditions is a cell in complete equilibrium with its environment? (When it is dead.)

CELL MEMBRANES

AN IMPORTANT FUNCTION OF CELL MEMBRANES IS TO CONTROL THE PASSAGE OF MATERIAL INTO AND OUT OF CELLS. THIS PROGRAM GOES INTO THE MEANS BY WHICH THIS PROCESS TAKES PLACE.

IN THIS EXPERIMENT A STARCH AND GLUCOSE SOLUTION WAS PLACED WITHIN A PIECE OF CELLOPHANE TUBING. CELLOPHANE IS POROUS ENOUGH TO PERMIT THE PASSAGE OF SOME SMALLER MOLECULES THROUGH IT. THEREFORE, A CLOSED OFF PIECE OF TUBING CAN REPRESENT A CELL.

AFTER THE STARCH AND GLUCOSE SOLUTION WAS PLACED INTO THE TUBING, THE END WAS TIED OFF AND THE 'CELL' PLACED IN A BEAKER OF WATER TO WHICH A FEW DROPS OF IODINE HAD BEEN ADDED.

LET 10 REPHESENT THE OUTSIDE OF THE MEMBRANE
LET 11 REPRESENT THE INSIDE OF THE MEMBRANE

WHERE IS THE CONCENTRATION OF GLUCOSE THE GREATEST? 11

THAT IS CORRECT. WHERE IS THE CONCENTRATION OF STARCH THE GREATEST? 11

RIGHT. WHERE IS THE CONCENTRATION OF IODINE THE GREATEST? 10

WOW! WHAT A SUPERIOR MIND YOU HAVE, OR IS IT JUST LUCKY GUESSING? WHERE IS THE CONCENTRATION OF WATER THE GREATEST? 10

YES. IF THE MEMBRANE WERE THE OUTER LIMITS OF A LIVING CELL, WHICH OF THE PROCESSES BELOW WOULD ACCOUNT FOR THE MOVEMENT OF GLUCOSE OUT OF THE CELL?

LET OSMOSIS = 12
LET ACTIVE TRANSPORT = 13
LET DIFFUSION = 14
? 14

CORRECT. THE GLUCOSE DIFFUSED FHOM AN AREA OF HIGHER CONCENTRATION TO ONE OF LOWER CONCENTRATION. WHICH PROCESS WOULD ACCOUNT FOR THE MOVEMENT OF THE WATER OUT OF THE CELL? 13

RIGHT. THE CONCENTRATION OF WATER IS GREATER OUTSIDE OF THE CELL THAN INSIDE. ACTIVE TRANSPORT WOULD ACCOUNT FOR MOVEMENT AGAINST DIFFUSION. WHICH PROCESS WOULD EXPLAIN THE TRANSPORT OF WATER INTO THE CELL? 12

YES, OSMOSIS IS DIFFUSION OF WATER THROUGH A SEMIPERMEABLE MEMBRANE. IF THE IODINE OUTSIDE OF THE CELL HAD TURNED BLACK, WHAT PROCESS WOULD HAVE CAUSED IT? 13

YES. SINCE STARCH MOLECULES ARE RELATIVELY LARGE, THE CELL WOULD HAVE TO EXPEND ENERGY TO MOVE THEM ACROSS THE MEMBRANE, EVEN WHEN THE STARCH CONCENTRATION IS GREATER INSIDE THE CELL.

CONGRATULATIONS. YOU HAVE SCORED 100. KEEP UP THE GOOD WORK.

*** END OF PROGRAM ***

READY

```
100REM COURT, G., BIOLOGY, 7/9/69
105 REM  REVISED BY C.LOSIK  7-9-70
107 REM  ALL INPUTS ARE TEMPORARY
110PRINT"                          CELL MEMBRANES"
120PRINT
130READL,M,N,O,P
140DATA10,11,12,13,14
150PRINT
160PRINT"      AN IMPORTANT FUNCTION OF CELL MEMBRANES IS TO CONTROL"
170PRINT"THE PASSAGE OF MATERIAL INTO AND OUT OF CELLS. THIS PROGRAM"
180PRINT"GOES INTO THE MEANS BY WHICH THIS PROCESS TAKES PLACE."
190PRINT
200PRINT"      IN THIS EXPERIMENT A STARCH AND GLUCOSE SOLUTION WAS"
210PRINT"PLACED WITHIN A PIECE OF CELLOPHANE TUBING. CELLOPHANE IS"
220PRINT"POROUS ENOUGH TO PERMIT THE PASSAGE OF SOME SMALLER MOLECULES"
230PRINT"THROUGH IT. THEREFORE, A CLOSED OFF PIECE OF TUBING CAN"
240PRINT"REPRESENT A CELL."
250PRINT
260PRINT"      AFTER THE STARCH AND GLUCOSE SOLUTION WAS PLACED INTO THE"
270PRINT"TUBING, THE END WAS TIED OFF AND THE 'CELL' PLACED IN A BEAKER"
280PRINT"OF WATER TO WHICH A FEW DROPS OF IODINE HAD BEEN ADDED."
290PRINT
300PRINT"      LET "L" REPRESENT THE OUTSIDE OF THE MEMBRANE"
310PRINT"      LET "M" REPRESENT THE INSIDE OF THE MEMBRANE"
320PRINT
330PRINT"WHERE IS THE CONCENTRATION OF GLUCOSE THE GREATEST";
340INPUTA
350PRINT
360IFA=MTHEN410
370PRINT"SORRY. THAT IS NOT THE CORRECT ANSWER. WHY NOT? WRITE YOUR"
380PRINT"REASONS ON A PIECE OF PAPER AND HAVE THEM VERIFIED BY YOUR"
390PRINT"TEACHER BEFORE CALLING THIS PROGRAM AGAIN."
400 STOP
410PRINT"THAT IS CORRECT. WHERE IS THE CONCENTRATION OF STARCH THE"
420PRINT"GREATEST";
430INPUTB
440PRINT
450IFB<>MTHEN370
460PRINT"RIGHT.  WHERE IS THE CONCENTRATION OF IODINE THE GREATEST";
470INPUTC
480PRINT
490IFC<>LTHEN370
500PRINT"WOW!  WHAT A SUPERIOR MIND YOU HAVE, OR IS IT JUST LUCKY"
510PRINT"GUESSING? WHERE IS THE CONCENTRATION OF WATER THE GREATEST";
520INPUTD
530PRINT
540IFD<>LTHEN370
550PRINT"YES.  IF THE MEMBRANE WERE THE OUTER LIMITS OF A LIVING"
560PRINT"CELL, WHICH OF THE PROCESSES BELOW WOULD ACCOUNT FOR THE MOVE-"
570PRINT"MENT OF GLUCOSE OUT OF THE CELL?"
580PRINT
590PRINT"      LET OSMOSIS = "N
600PRINT"      LET ACTIVE TRANSPORT = "O
610PRINT"      LET DIFFUSION = "P
620INPUT E
630PRINT
640IFE<>PTHEN370
650PRINT"CORRECT.  THE GLUCOSE DIFFUSED FROM AN AREA OF HIGHER"
660PRINT"CONCENTRATION TO ONE OF LOWER CONCENTRATION. WHICH PROCESS"
670PRINT"WOULD ACCOUNT FOR THE MOVEMENT OF THE WATER OUT OF THE CELL";
680INPUTF
690PRINT
700IFF<>OTHEN370
```

```
710PRINT"RIGHT.  THE CONCENTRATION OF WATER IS GREATER OUTSIDE OF THE"
720PRINT"CELL THAN INSIDE. ACTIVE TRANSPORT WOULD ACCOUNT FOR MOVE-"
730PRINT"MENT AGAINST DIFFUSION. WHICH PROCESS WOULD EXPLAIN THE"
740PRINT"TRANSPORT OF WATER INTO THE CELL";
750INPUTG
760PRINT
770IFG<>NTHEN370
780PRINT"YES, OSMOSIS IS DIFFUSION OF WATER THROUGH A SEMIPERMEABLE"
790PRINT"MEMBRANE. IF THE IODINE OUTSIDE OF THE CELL HAD TURNED BLACK,"
800PRINT"WHAT PROCESS WOULD HAVE CAUSED IT";
810INPUTH
820PRINT
830IFH=0THEN860
840PRINT"NO.  ";
850GOTO870
860PRINT"YES.  ";
870PRINT"SINCE STARCH MOLECULES ARE RELATIVELY LARGE, THE CELL"
880PRINT"WOULD HAVE TO EXPEND ENERGY TO MOVE THEM ACROSS THE "
890PRINT"MEMBRANE, EVEN WHEN THE STARCH CONCENTRATION IS GREATER"
900PRINT"INSIDE THE CELL."
910PRINT
920IFH<>0THEN960
930PRINT"CONGRATULATIONS.  YOU HAVE SCORED 100. KEEP UP THE GOOD WORK."
950GOTO970
960PRINT"WELL, YOU HAVE DONE WELL IN SPITE OF SOME ERROR."
970PRINT
980PRINT"          ***          END OF PROGRAM          ***"
990END
```

DISCIPLINE BIOLOGY

SUBJECT ENZYMES

PROGRAM NAME NZYMC

DESCRIPTION:

This program covers enzymatic reaction rates, and conveys the idea that enzyme reactions are dependent upon environmental factors such as pH, temperature, and the concentration of the enzymes. A simulated experimental situation is created, whereby the student works with one parameter at a time and can vary the degree of the enzyme reactivity.

OBJECTIVES:

The program presents the students with the following concepts:

A. Enzymatic reaction rates are dependent upon environmental factors: (these include pH, temperature, concentration of enzymes, and substrate)

B. The value of graphing to help in the interpretation of data:

C. The meaning of the term "limiting factor":

D. Different enzymes may vary in degree of reactivity and thereby affect reaction rates:

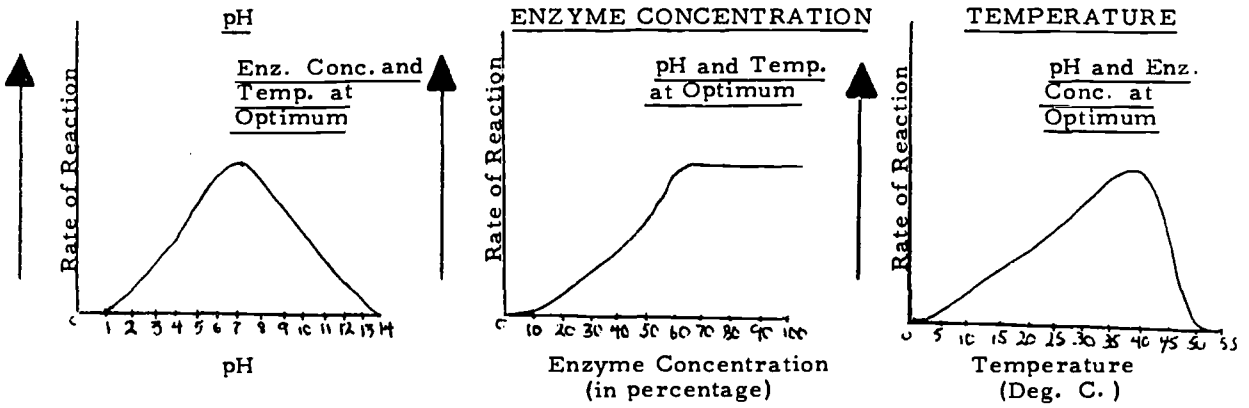
E. Enzymes are not used up, but can take part in additional reactions.

PRELIMINARY PREPARATION:

A. Student - The student should have some understanding of these terms: pH, substrate, enzyme, and chemical reaction. He should know that there is a substrate-enzyme interaction, and that enzymes act as catalytic agents, therefore, more than one reaction can take place with one molecule of the enzyme over a period of time.

B. Materials - graph paper, transparencies of the following plots, and one of the three together for simultaneous viewing. (optional)

[illegible] OF ACTIVITY WHEN VARYING



DISCUSSION:

A. Operational Suggestions

1. Student level - Average to above average ability
2. The student should use all three limiting factors presented in the computer program.
3. Students' graphs should be checked before proceeding with the follow-up question.
4. Students work in groups of 5 or less. Allow one group at a time at the computer while the remaining groups are engaged in a related activity. For Example: Food testing with hydrogen peroxide for catalase activity.

B. Suggested Follow-up

To maximize the value of this program, it is strongly suggested that the teacher:

1. Elicit from the students:

   What represents maximum and minimum reaction rate for pH, temperature, and enzyme concentration? (Use appropriate transparencies or chalkboard)
2. Ask the following questions, based on the plotted graphs, as lead-ins to discussion or as a homework assignment.

   (a) At what point do most reactions take place with regard to pH, enzyme concentration, and temperature? (This and subsequent questions are intended to bring up the ideas of optimal pH, temperature, and enzyme concentration.)
   (b) Why is death caused when pH rises or falls beyond a certain point in a system?

(c) Why does the concentration of enzymes reach a point and then no increase in reactions take place?
(d) What is normal body temperature? What relationship is there between reaction rate and body temperature? High fever? Freezing temperature? (Note: 40 deg. C. is 104 deg. F., which is higher than normal.)
(e) Suppose the pH of a system is 7, enzyme concentration is 90, and temperature is 0 degrees. What is the reaction rate? Why? *
(f) Supppose the temperature is 37 deg. C., enzyme concentration is 30, and pH is 14. What is the reaction rate? Why? *
(g) What is meant by limiting factors?

* Student must examine all three graphs before reaching a conclusion.

```
     THIS PROGRAM IS DESIGNED TO SHOW THAT ENZYME ACTION IS
RELATED TO CERTAIN LIMITING FACTORS. THESE FACTORS INCLUDE PH,
THE CONCENTRATION OF ENZYMES, AND TEMPERATURE. IN THIS PROGRAM
WE ASSUME THAT TWO OF THE THREE FACTORS ARE CONSTANTS AND
WILL CHANGE ONLY ONE AT A TIME. WE ALSO ASSUME THAT EACH
FACTOR WORKS INDEPENDENTLY, ALTHOUGH THIS IS NOT TRUE IN
NATURE.

     YOU HAVE A CHOICE OF THE FOLLOWING LIMITING FACTORS:

1)PH          2)CONCENTRATION OF ENZYMES          3)TEMPERATURE

WHICH NUMBER DO YOU WISH ? 1

*** PH ***

HOW REACTIVE AN ENZYME ARE YOU WORKING WITH? USE A VALUE OF
FROM 1 (NOT VERY REACTIVE) TO 10 (VERY REACTIVE). ? 7.5

PH VALUE      REACTION RATE 0         50         100        150        200
--------      -------------- I---------I---------I---------I---------I
 1             0             *
 2             11.25         I *
 3             30            I     *
 4             56.25         I          *
 5             90            I               *
 6             138.75        I                    *
 7             157.5         I                         *
 8             138.75        I                    *
 9             90            I               *
 10            56.25         I          *
 11            30            I     *
 12            11.25         I *
 13            3.75          *
 14            0             *

DO YOU WISH ANOTHER RUN? IF YES, PRINT 1; IF NO, PRINT 0. ? 1

     YOU HAVE A CHOICE OF THE FOLLOWING LIMITING FACTORS:

1)PH          2)CONCENTRATION OF ENZYMES          3)TEMPERATURE

WHICH NUMBER DO YOU WISH ? 2

*** CONCENTRATION OF ENZYMES ***
HERE WE MUST ASSUME THAT THE SUBSTRATE IS ALWAYS SUFFICIENT.

HOW REACTIVE AN ENZYME ARE YOU WORKING WITH? USE A VALUE OF
FROM 1 (NOT VERY REACTIVE) TO 10 (VERY REACTIVE). 7 7.5

ENZYME CONC.  REACTION RATE 0         50         100        150        200
------------  -------------- I---------I---------I---------I---------I
 10            0             *
 20            33.75         I     *
 30            67.5          I          *
 40            101.25        I               *
 50            135           I                    *
 60            157.5         I                         *
 70            157.5         I                         *
 80            157.5         I                         *
 90            157.5         I                         *
 100           157.5         I                         *
```

```
      YOU HAVE A CHOICE OF THE FOLLOWING LIMITING FACTORS:

1)PH          2)CONCENTRATION OF ENZYMES          3)TEMPERATURE

WHICH NUMBER DO YOU WISH ? 3

*** TEMPERATURE ***

HOW REACTIVE AN ENZYME ARE YOU WORKING WITH? USE A VALUE OF
FROM 1 (NOT VERY REACTIVE) TO 10 (VERY REACTIVE). ? 7.5

DEGREES C.     REACTION RATE 0         50         100        150        200
----------     -------------  I---------I---------I---------I---------I
 0              0              *
 5              11.25          I *
 10             22.5           I   *
 15             41.25          I     *
 20             63.75          I       *
 25             86.25          I         *
 30             112.5          I           *
 35             146.25         I             *
 40             127.5          I           *
 45             37.5           I     *
 50             0              *

DO YOU WISH ANOTHER RUN? IF YES, PRINT 1; IF NO, PRINT 0. ? 0

STUDY THE GRAPHS AND TABLES, AND TRY TO FIGURE
OUT WHAT'S HAPPENING HERE.


READY
```

```
100DIMA(15),J(11),H(12)
110REM PROGRAM DEVELOPED BY R. COOPERMAN - JOHN GLENN HIGH SCHOOL
120REM ELWOOD, NEW YORK
121 REM  REVISED BY C.LOSIK  7-6-70
122 REM ALSO SEE NZYM2
123 REM A(I)=PH VALUES, J(I)=CONC. OF ENZYME VALUES, H(I)=TEMP VALUES
124 REM Y=REACTIVITY
125 REM  ALL RESULTS ARE TABULATED AND GRAPHED (NO OPTIONS)
130PRINT"      THIS PROGRAM IS DESIGNED TO SHOW THAT ENZYME ACTION IS"
140FORN=1TO14
150READA(N)
160NEXTN
170PRINT"RELATED TO CERTAIN LIMITING FACTORS. THESE FACTORS INCLUDE PH,"
180FORN=1TO10
190READJ(N)
200NEXTN
210PRINT"THE CONCENTRATION OF ENZYMES, AND TEMPERATURE. IN THIS PROGRAM"
220FORN=1TO11
230READH(N)
240NEXTN
250PRINT"WE ASSUME THAT TWO OF THE THREE FACTORS ARE CONSTANTS AND"
260PRINT"WILL CHANGE ONLY ONE AT A TIME. WE ALSO ASSUME THAT EACH"
270PRINT"FACTOR WORKS INDEPENDENTLY, ALTHOUGH THIS IS NOT TRUE IN"
280PRINT"NATURE."
290PRINT
300PRINT"      YOU HAVE A CHOICE OF THE FOLLOWING LIMITING FACTORS:"
310PRINT
320PRINT"1)PH          2)CONCENTRATION OF ENZYMES          3)TEMPERATURE"
330PRINT
340PRINT"WHICH NUMBER DO YOU WISH ";
350INPUTA
360PRINT
370IFA=1THEN420
380IFA=2THEN680
390IFA=3THEN810
400PRINT"THAT IS NOT A PERMISSIBLE ANSWER."
410GOTO340
420 PRINT "*** PH ***"
430GOSUB520
440PRINT
450 PRINT "PH VALUE","REACTION RATE","0         50         100";
451PRINT "        150        200 "
460 PRINT "--------","------------","I---------I---------I";
461 PRINT "---------I---------I"
470 DATA 0,1.5,4.0,7.5,12.0,18.5,21.0,18.5,12.0,7.5,4.0,1.5,0.5,0
480FORN=1TO14
490 PRINT N,A(N)*Y, "I"; TAB(INT((A(N)*Y+.5)/5)+28);"*"
500NEXTN
510GOTO920
520PRINT
530 LET A=0
540PRINT"HOW REACTIVE AN ENZYME ARE YOU WORKING WITH? USE A VALUE OF"
550PRINT"FROM 1 (NOT VERY REACTIVE) TO 10 (VERY REACTIVE). ";
560INPUTY
570IFY<1THEN600
580 IF Y<=10 THEN 670
600 IF A>=2 THEN 650
610PRINT"TH  NUMBER YOU HAVE CHOSEN DOES NOT FALL WITHIN THE RANGE "
620PRINT"GIVEN.  TRY AGAIN."
630 LET A=A+1
640GOTO560
650 PRINT "NEXT TIME, PLEASE FOLLOW INSTRUCTIONS."
660STOP
670RETURN
680 PRINT "*** CONCENTRATION OF ENZYMES ***"
```

```
690PRINT"HERE WE MUST ASSUME THAT THE SUBSTRATE IS ALWAYS SUFFICIENT."
700GOSUB520
710PRINT
730 PRINT "ENZYME CONC.","REACTION RATE","0          50          100";
731 PRINT "         150         200"
740 PRINT"------------","--------------","I---------I---------I";
741 PRINT "---------I---------I"
750DATA0
760DATA 4.5,9.0,13.5,18.0,21.0,21.0,21.0,21.0,21.0
770 FOR N=1 TO 10
780 PRINT 10*N, U(N)*Y, "I"; TAB(INT((U(N)*Y+.5)/5)+26);"*"
790 NEXT N
800GOTO920
810 PRINT "*** TEMPERATURE ***"
820GOSUB520
830PRINT
840 PRINT "DEGREES C.","REACTION RATE","0          50          100";
841 PRINT "         150         200"
850 PRINT "----------","--------------","I---------I---------I";
851 PRINT "---------I---------I"
860 DATA 0,1.5,3.0,5.5,8.5,11.5,15.0,19.5,17.0,5.0,0
870LEFT=0
880FORM=1TO11
890 PRINT T,R(N)*Y,"I"; TAB(INT((R(N)*Y+.5)/5)+26); "*"
900LEFT=T+5
910NEXT N
920PRINT
930PRINT"DO YOU WISH ANOTHER RUN? IF YES, PRINT 1; IF NO, PRINT 0. ";
940 INPUT A
950PRINT
960 IF A=1 THEN 300
970 IF A<>0 THEN 930
980 PRINT "STUDY THE GRAPHS AND TABLES, AND TRY TO FIGURE"
981 PRINT "OUT WHAT'S HAPPENING HERE."
990END
```

DISCIPLINE BIOLOGY

SUBJECT ENZYME REACTION RATE

PROGRAM NAME NZYM2

DESCRIPTION:

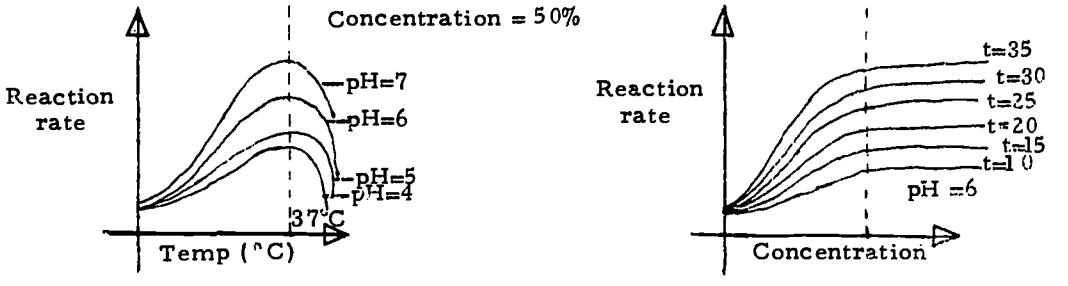
An extension of NZYMC which permits the student to examine the effect on reaction rate with continuous changes in environmental factors.

OBJECTIVES:

In addition to reinforcing the concept that reaction rate is governed by pH, temperature, and enzyme concentration; the program can be used to:

A. Introduce the idea of controlled experimentation where two factors are kept constant and a third is permitted to vary.

B. Develop the idea of plotting experimental data to generate a family of curves as illustrated below.



PRELIMINARY PREPARATION:

A. Student - Same as NZYMC . It might also be helpful if the student has been exposed previously to an actual experimental demonstration in which the change of reaction rate with one or more factors is visually displayed. The rate of bubble formation when one of the reactant products is a gas for example, might serve as one practical illustration of variation of reaction rate with temperature.

B. Materials - none

DISCUSSION:

A. Operational Suggestions

1. This program has not yet been tested in the classroom.
2. Average students should work as part of a group; above-average students could be permitted to work alone.
3. For group effort activity, it would be instructive to use three different groups, each of which holds a different factor constant while the other two factors are allowed to vary.

B. Suggested Follow-up

1. Each group should be required to plot their data, on a board, if possible, so the whole class can see the results. Families of curves should be discussed.
2. Equivalent points on each data set should be compared; e.g. is reaction rate the same when pH is 4, temperature is 25°C and concentration is 50%, regardless of which factor is held constant and the others allowed to vary?
3. Introduce the concepts of interpolation between curves and again check comparable points on each set.
4. Indicate that the maximum reaction rate obtained is the same regardless of the technique used to reach maximum.

```
THIS PROGRAM WILL ENABLE YOU TO SEE THE EFFECTS ON THE RATE OF
REACTION WITHIN A SYSTEM CONTROLLED BY ENZYMES.  THE
REACTION RATE WILL VARY AS THE ENVIRONMENTAL CONDITIONS
VARY.  THESE CONDITIONS, PH, CONCENTRATION OF ENZYMES,
AND TEMPERATURE, IN A NATURAL SITUATION ARE NEVER CONSTANT.
LET'S SEE WHAT CONTROLS THIS RATE IN THESE SYSTEMS.

THE FOLLOWING ARE THE LIMITS WITHIN WHICH EACH OF OUR
ENVIRONMENTAL CONDITIONS CAN VARY.
          1)PH----------BETWEEN 4 AND 10
          2)ENZ. CONC.--BETWEEN 10 AND 100 PERCENT
          3)TEMP.-------BETWEEN 5 AND 47 DEGREES C.

I AM GOING TO PRINT A '?'. YOU MUST THEN TYPE A NUMBER FOR PH,
CONC., AND TEMP. (IN THAT ORDER), WHICH FALLS WITHIN EACH
LIMIT STATED (SEE ABOVE.)
? 4,10,5
PH            CONC.         TEMP.         REACTION RATE
--            -----         -----         -------- ----
 4             10            5             .05

NOTE THE REACTION RATE WITH THE THREE VALUES WHICH YOU
SELECTED TO PROVIDE A BASIS FOR JUDGEMENT OF REACTION
RATE, CHOOSE ANOTHER SET OF VALUES FOR PH, CONC., AND
TEMP.  (SEE LIMITS ABOVE).

? 7,10,5
PH            CONC.         TEMP.         REACTION RATE
--            -----         -----         -------- ----
 7             10            5             4.5
IS THE RESULT A HIGHER OR LOWER REACTION RATE?  IS THE HIGHEST
VALUE OBTAINED A MAXIMUM VALUE?  DO YOU WANT TO TRY ANOTHER
SET OF VALUES (TYPE '1') OR WOULD YOU PREFER A MORE ORGANIZED
APPROACH TO DETERMINE MAXIMUM REACTION RATE (TYPE '2')
? 2

WE ARE NOW GOING TO PERFORM AN EXPERIMENT IN WHICH YOU ARE
TO TYPE IN THE VALUES FOR PH, CONC. AND TEMP. AS YOU DID
BEFORE. HOWEVER,NOW YOU ARE GOING TO BE ABLE TO CHOOSE THE
FACTOR WHICH WILL VARY. THE OTHER TWO FACTORS WILL REMAIN
CONSTANT. (USE DIFFERENT NUMERICAL VALUES FOR EACH FACTOR.)
TO OBTAIN THE MOST SIGNIFICANT DATA, START THE EXPERIMENT
USING LOW NUMERICAL VALUES FOR EACH FACTOR.

I AM GOING TO PRINT A '?'. YOU MUST THEN TYPE A NUMBER FOR PH,
CONC., AND TEMP. (IN THAT ORDER), WHICH FALLS WITHIN EACH
LIMIT STATED (SEE ABOVE.)
? 4,20,5
TYPE THE NUMBER WHICH IS TO BE VARIED.
? 20
PH            CONC.         TEMP.         REACTION RATE
--            -----         -----         -------- ----
 4             20            5             .1
 4             30            5             .13
 4             40            5             .16
 4             50            5             .17
 4             60            5             .19
 4             70            5             .19
 4             80            5             .2
 4             90            5             .2
 4             100           5             .2
```

```
YOU NOW HAVE A SET OF VALUES FOR REACTION RATE AS ONE OF
THE GOVERNING FACTORS IS VARIED AND THE OTHER TWO ARE HELD
CONSTANT. DOES THE REACTION RATE HAVE A MAXIMUM VALUE?
IS THIS THE MAXIMUM POSSIBLE REACTION RATE? TO DETERMINE THIS,
USE THE SAME INITIAL VALUE FOR THE VARYING FACTOR, BUT THIS
TIME TYPE IN DIFFERENT VALUES FOR THE CONSTANT FACTORS.

IF YOU WANT ANOTHER SET OF VALUES FOR REACTION RATE,TYPE '1'
IF YOU ARE SATISFIED THAT YOU KNOW THE VALUES FOR EACH FACTOR'S
MAXIMUM REACTION RATE THEN TYPE '2'.
? 1

I AM GOING TO PRINT A '?'. YOU MUST THEN TYPE A NUMBER FOR PH,
CONC., AND TEMP. (IN THAT ORDER), WHICH FALLS WITHIN EACH
LIMIT STATED (SEE ABOVE.)
? 7,20,5
TYPE THE NUMBER WHICH IS TO BE VARIED.
? 20
PH             CONC.          TEMP.          REACTION RATE
--             -----          -----          -------- ----
 7              20             5              6.86
 7              30             5              12.28
 7              40             5              14.67
 7              50             5              16.28
 7              60             5              17.31
 7              70             5              17.97
 7              80             5              18.39
 7              90             5              18.65
 7              100            5              18.8
IF YOU WANT ANOTHER SET OF VALUES FOR REACTION RATE,TYPE '1'
IF YOU ARE SATISFIED THAT YOU KNOW THE VALUES FOR EACH FACTOR'S
MAXIMUM REACTION RATE THEN TYPE '2'.
? 2

READY
```

```
100REM -- BLESSER, POLYTECH. INST. OF BKLYN.
103 REM  REVISED BY C.LOSIK  7-16-70
105 REM  X=PH, A=ENZ. CONC., T=TEMP
107 REM  FOR EFFICIENCY, ALL CALCULATIONS DONE VIA GOSUB CALLS
110PRINT"THIS PROGRAM WILL ENABLE YOU TO SEE THE EFFECTS ON THE RATE OF"
120PRINT"REACTION WITHIN A SYSTEM CONTROLLED BY ENZYMES.  THE"
130PRINT"REACTION RATE WILL VARY AS THE ENVIRONMENTAL CONDITIONS"
140PRINT"VARY.  THESE CONDITIONS, PH, CONCENTRATION OF ENZYMES,"
150PRINT"AND TEMPERATURE, IN A NATURAL SITUATION ARE NEVER CONSTANT."
160PRINT"LET'S SEE WHAT CONTROLS THIS RATE IN THESE SYSTEMS."
170PRINT
180PRINT"THE FOLLOWING ARE THE LIMITS WITHIN WHICH EACH OF OUR"
190PRINT"ENVIRONMENTAL CONDITIONS CAN VARY."
200PRINT " ";"1)PH----------BETWEEN 4 AND 10"
210PRINT " ";"2)ENZ. CONC.--BETWEEN 10 AND 100 PERCENT"
220PRINT " ";"3)TEMP.-------BETWEEN 5 AND 47 DEGREES C."
240GOSUB1320
310GOSUB1020
320PRINT
330PRINT"NOTE THE REACTION RATE WITH THE THREE VALUES WHICH YOU"
340PRINT"SELECTED TO PROVIDE A BASIS FOR JUDGEMENT OF REACTION"
350PRINT"RATE, CHOOSE ANOTHER SET OF VALUES FOR PH, CONC., AND"
360PRINT"TEMP.  (SEE LIMITS ABOVE)."
370PRINT
380GOSUB1020
390PRINT"IS THE RESULT A HIGHER OR LOWER REACTION RATE?  IS THE HIGHEST"
400PRINT"VALUE OBTAINED A MAXIMUM VALUE?  DO YOU WANT TO TRY ANOTHER"
410PRINT"SET OF VALUES (TYPE '1') OR WOULD YOU PREFER A MORE ORGANIZED"
420PRINT"APPROACH TO DETERMINE MAXIMUM REACTION RATE (TYPE '2')"
430INPUTA
440IFA=2THEN 480
442IF A=1 THEN 450
444 PRINT "PLEASE TYPE 1 OR 2"
446 GO TO 430
450 PRINT "WHAT ARE YOUR NEW VALUES FOR PH, CONC., AND TEMP.";
460GOSUB1020
470GOTO390
480PRINT
490PRINT"WE ARE NOW GOING TO PERFORM AN EXPERIMENT IN WHICH YOU ARE"
500PRINT"TO TYPE IN THE VALUES FOR PH, CONC. AND TEMP. AS YOU DID"
510PRINT"BEFORE. HOWEVER,NOW YOU ARE GOING TO BE ABLE TO CHOOSE THE"
520PRINT"FACTOR WHICH WILL VARY. THE OTHER TWO FACTORS WILL REMAIN"
530PRINT"CONSTANT. (USE DIFFERENT NUMERICAL VALUES FOR EACH FACTOR.)"
540PRINT"TO OBTAIN THE MOST SIGNIFICANT DATA, START THE EXPERIMENT"
550PRINT"USING LOW NUMERICAL VALUES FOR EACH FACTOR."
560LETM=0
570GO SUB 1320
580GOSUB1100
590PRINT"TYPE THE NUMBER WHICH IS TO BE VARIED."
600INPUTX
630IF X=A THEN 725
640IF X=K THEN 795
650 IF X=T THEN 655
652PRINT "PLEASE TYPE THE VALUE FOR PH, CONC., OR TEMP.";
653GO TO 600
655GOSUB 1370
660GOSUB1230
670GOSUB1240
680GOSUB1260
690GOSUB1280
700LETT=T+5
710IFT>=47THEN870
```

```
720 GOTO660
725 GOSUB 1370
730 GOSUB1240
740 GOSUB1260
750 GOSUB1220
760 GOSUB1280
770 IFA>10THEN870
780 LETA=A+.5
790 GOTO750
795 GOSUB 1370
800 GOSUB1220
810 GOSUB1260
820 GOSUB1240
830 GOSUB1280
840 LETK=K+10
850 IFK>100THEN870
860 GOTO820
870 LET M=M+1
880 IFM>=2THEN960
890 PRINT"YOU NOW HAVE A SET OF VALUES FOR REACTION RATE AS ONE OF"
900 PRINT"THE GOVERNING FACTORS IS VARIED AND THE OTHER TWO ARE HELD"
910 PRINT"CONSTANT. DOES THE REACTION RATE HAVE A MAXIMUM VALUE?"
920 PRINT"IS THIS THE MAXIMUM POSSIBLE REACTION RATE? TO DETERMINE THIS,"
930 PRINT"USE THE SAME INITIAL VALUE FOR THE VARYING FACTOR, BUT THIS"
940 PRINT"TIME TYPE IN DIFFERENT VALUES FOR THE CONSTANT FACTORS."
950 PRINT
960 PRINT"IF YOU WANT ANOTHER SET OF VALUES FOR REACTION RATE,TYPE '1'"
970 PRINT"IF YOU ARE SATISFIED THAT YOU KNOW THE VALUES FOR EACH FACTOR'S
980 PRINT"MAXIMUM REACTION RATE THEN TYPE '2'."
990 INPUTB
1000 IFB=1THEN 570
10051F B=2 THEN 1010
1007PRINT "PLEASE TYPE 1 OR 2"
1008GO TO 990
1010STOP
1020 GOSUB1100
1030 GOSUB1220
1040 GOSUB1240
1050 GOSUB1260
1060 GOSUB 1370
1080 GOSUB1280
1090 RETURN
1100 INPUTA,K,T
1105 REM  INPUT AND CHECK BOUNDS
11101FA<4THEN1180
1120 IFA>10THEN1180
1130 IFK<10THEN1180
1140 IFK>100THEN1180
1150 IFT<5THEN1180
1160 IFT>47THEN1180
1170 GOTO1210
1180 PRINT"AT LEAST ONE OF THE VARIABLES DOES NOT LIE WITHIN THE"
1190 PRINT"PRESCRIBED LIMITS. SEE LIMITS ABOVE AND TRY AGAIN."
1200 GOTO1100
1210 RETURN
1220 LETV1=EXP(-((.71*A-4.97)↑2))
1230 RETURN
1240 LETV2=EXP(-.08*K)-2*EXP(-.05*K)+1
1250 RETURN
1260 LETV3=16.3*EXP(.074*T)-EXP(.133*T)
1270 RETURN
1280 LETV=.88*V1*V2*V3
1290 LETV=INT(V*100+0.5)/100
1300 PRINTA,K,T,V
1305 REM  PRINT REACTION RATE
1310 RETURN
1320 PRINT
1330 PRINT"I AM GOING TO PRINT A '?'. YOU MUST THEN TYPE A NUMBER FOR PH9
1340 PRINT "CONC., AND TEMP. (IN THAT ORDER), WHICH FALLS WITHIN EACH"
1350 PRINT "LIMIT STATED (SEE ABOVE.)"
1360 RETURN
1370 PRINT "PH","CONC.","TEMP.","REACTION RATE"
1380 PRINT "--","------","------","--------- ----"
1390 RETURN
1400 END
```

DISCIPLINE BIOLOGY

SUBJECT PHOTOSYNTHESIS

PROGRAM NAME PHOSYN

DESCRIPTION:

This program investigates changes in the rate of photosynthesis when carbon dioxide concentration and light intensity are varied.

OBJECTIVES:

A. To permit the student to see the effects of varying two of the factors of the photosynthetic reaction.

B. To reinforce the concept of the fundamental importance of the process of photosynthesis.

C. To lead the student to develop ideas for increasing a plant' s food output by manipulating factors involved in photosynthesis.

D. To learn or practice graphing.

E. To learn the concept of controlled experimentation.

F. Analysis and interpretation of data.

PRELIMINARY PREPARATION:

A. Student - An understanding of the photosynthetic process.

B. Materials - graph paper

DISCUSSION:

A. Operational Suggestions

1. Student level - average
2. Pitfalls to avoid -
   a. If the student is not familiar with decimals, allow him to use integers for graphing
   b. The computer levels off at a light intensity of 12. If a student selects all of his light intensity values above 11, a straight line of asterisks will appear on the graph.
   c. Remind students that the computer plotted graph is to be viewed sideways. (see run)
3. Students work in groups of 5 or less. Allow one group at a time at the computer while the remaining groups are engaged in a related activity.

B. Suggested Follow-up

The students, after running the program, are expected to graph the results obtained from varying the carbon dioxide concentration.

Elicit from the student:

1. What happens to the rate of photosynthesis as:
   a. The carbon dioxide concentration increases?
   b. The intensity of the light increases?
2. How might you increase the size of tomatoes grown in a greenhouse? What, if any, limitations are there to this type of increase?
3. What is apt to happen to the world's food supply if the amount of carbon dioxide or the light intensity was reduced by one-half?
4. Compare your graph with the graph made on the computer. Point out similarities and differences. Explain them.

```
HELLO. BY NOW YOU SHOULD KNOW FROM YOUR LECTURES WHAT
PHOTOSYNTHESIS IS. THIS LABORATORY WILL ENABLE YOU TO
CONDUCT EXPERIMENTS ON THE COMPUTER WHICH WOULD NOT BE
PRACTICAL DURING CLASS TIME.

SINCE ALL OF OUR FOOD COMES FROM PLANTS, LET'S FIND OUT
HOW CHANGING THE AMOUNT OF CARBON DIOXIDE OR THE INTENSITY
OF LIGHT WILL AFFECT THE PLANT'S RATE OF PHOTOSYNTHESIS,
MEASURED IN MICROGRAMS OF GLUCOSE PRODUCED PER DAY.

LET'S BEGIN WITH CHANGING THE LIGHT INTENSITY. YOU WILL
VARY THIS BY SELECTING INTEGER VALUES IN THE RANGE OF
0 TO 30 (THE UNITS FOR LIGHT INTENSITY ARE IN ERGS/SEC/SQ.CM)
BY VARYING ONLY ONE FACTOR AT A TIME, WE ARE CONDUCTING
A CONTROLLED EXPERIMENT. WE WILL ASSUME THAT OUR PLANT
HAS ALL OF THE CARBON DIOXIDE, WATER AND CHLOROPHYLL
THAT IT NEEDS.

YOU SHOULD CHOOSE BETWEEN FIVE AND TEN LIGHT INTENSITY
VALUES. TYPE IN ONLY ONE VALUE AFTER EACH QUESTION MARK.
BY TYPING IN 100, NO MORE QUESTION MARKS WILL APPEAR AND
THE PROGRAM WILL CONTINUE.
(NOTE: 'RP' MEANS RATE OF PHOTHSYNTHESIS)

LIGHT INTENSITY(LI)? 2
RP= 45
(LI)? 15
RP= 121
(LI)? 7
RP= 99
(LI)? 29
RP= 125
(LI)? 20
RP= 124
(LI)? 5
RP= 84
(LI)? 6
RP= 92
(LI)? 11
RP= 114
(LI)? 12
RP= 116
(LI)? 10
RP= 111

1 = TABLE ONLY, 2 = PLOT ONLY, 3 = BOTH? 3

  LIGHT          RATE OF
INTENSITY     PHOTOSYNTHESIS
---------     --------------
 2              44.81
 5              83.8
 6              92
 7              98.57
 10             111.42
 11             114.12
 12             116.29
 15             120.52
 20             123.52
 29             124.8
```

```
 LIGHT
INTENSITY
                RATE OF PHOTOSYNTHESIS
                0   25   50   75   100  125
                I----I----I----I----I----I
                I
                I
 2              I        *
                I
                I        .
 5              I             *
 6              I              *
 7              I               *
                I
                I
 10             I                 *
 11             I                  *
 12             I                  *
                I
                I
 15             I                   *
                I
                I
                I
                I
 20             I                    *
                I
                I
                I
                I
                I
                I
                I
                I
 29             I                    *
                I
```

O.K. LET'S NOW VARY THE AMOUNT OF CARBON DIOXIDE IN THE
ATMOSPHERE SURROUNDING OUR PLANT.

THIS TIME ASSUME OUR PLANT HAS ALL THE LIGHT, WATER AND
CHLOROPHYLL THAT IT NEEDS.

LET THE VALUES YOU SELECT FOR THE CARBON DIOXIDE CONCENTRATION
BE FOR TWO DECIMAL PLACES ONLY, AND IN THE RANGE OF 0 TO .30
UNITS FOR CO2 CONC. ARE CUBIC CENTIMETERS PER LITER OF AIR.

AS BEFORE, I WILL TYPE IN A '?' AND THEN YOU TYPE IN THE
CARBON DIOXIDE CONC. AVAILABLE TO THE PLANT.
THIS TIME YOU MUST CHOOSE TEN DIFFERENT VALUES.
REMEMBER RP = RATE OF PHOTOSYNTHESIS.

```
CARBON DIOXIDE CONC.(CO2)? .10
RP= 118
(CO2)? .20
RP= 125
(CO2)? .30
RP= 125
(CO2)? .15
RP= 124
(CO2)? .05
RP= 94
(CO2)? .25
RP= 125
(CO2)? .02
RP= 54
(CO2)? 0
RP= 0
(CO2)? .11
RP= 119
(CO2)? .09
RP= 115
```

```
1 = TABLE ONLY, 2 = PLOT ONLY, 3 = BOTH? 3

CO2 CONC.      RATE OF PHOTOSYNTHESIS
--- -----      ---- -- --------------
 0              0
 .02            53.87931
 .05            94.1092
 .09            114.9425
 .1             117.8161
 .11            119.2529
 .15            123.5632
 .2             125
 .25            125
 .3             125

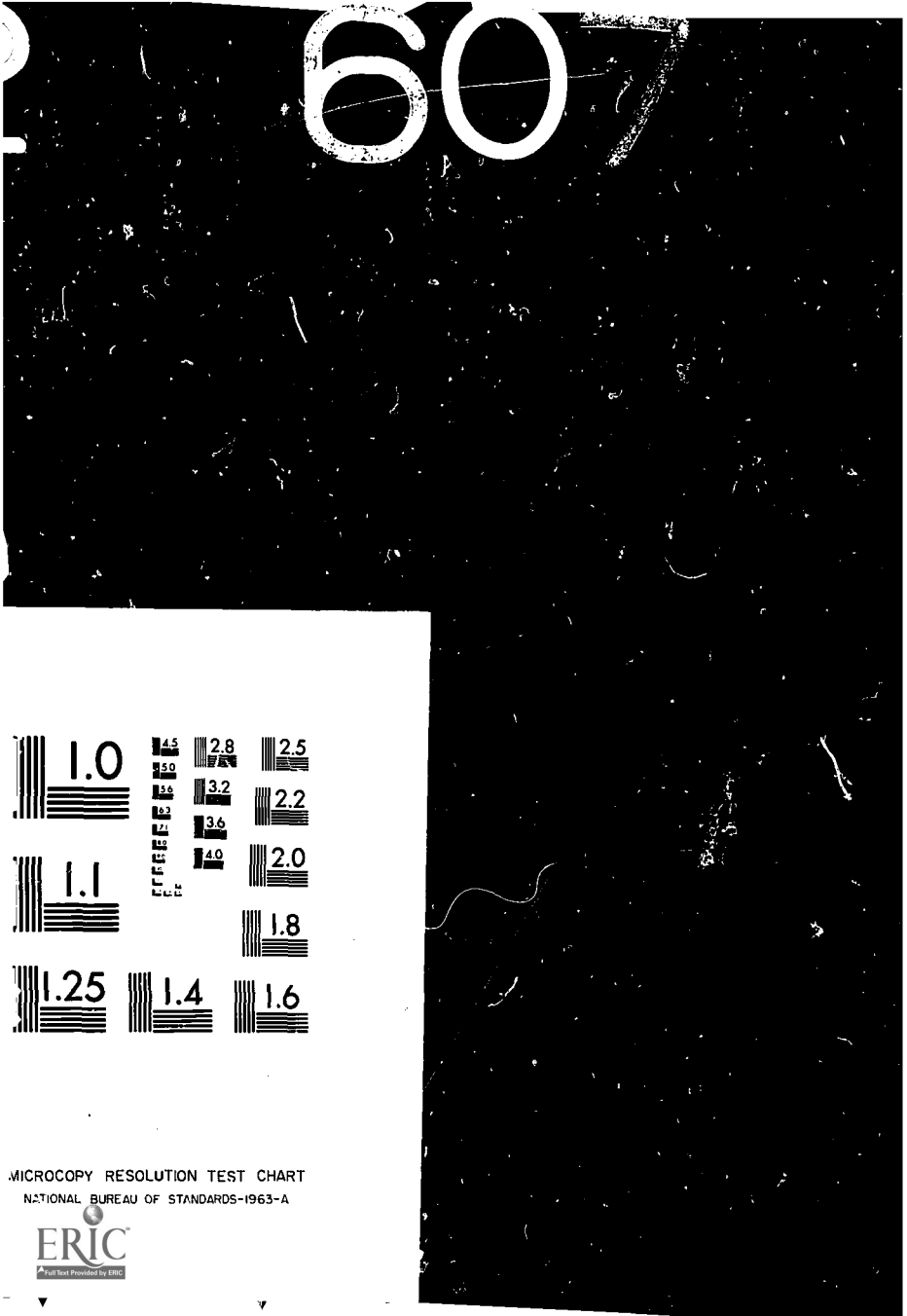
CO2 CONC.
                RATE OF PHOTOSYNTHESIS
                0   25   50   75   100  125
                I----I----I----I----I----I
 0              *
                I
 .02            I         *
                I
                I
 .05            I              *
                I
                I
                I
 .09            I                   *
 .1             I                    *
 .11            I                    *
                I
                I
                I
 .15            I                     *
                I
                I
                I
                I
 .2             I                     *
                I
                I
                I
                I
 .25            I                     *
                I
                I
                I
                I
 .3             I                     *

DO YOU KNOW WHAT IS HAPPENING IN BOTH THESE INSTANCES?

READY
```

```
100 REM F. H. COOPER, WYANDANCH H.S., REVISED 7/69
105 REM  REVISED BY C.LOSIK  7-9-70
106 REM V(I)=INPUT VALUES (LIGHT INTENSITY, CO2 CONC.)
107 REM R(I)=RATE OF PHOTOSYNTHESIS
110 DIM V(31),R(31)
120 PRINT "HELLO. BY NOW YOU SHOULD KNOW FROM YOUR LECTURES WHAT"
130 PRINT "PHOTOSYNTHESIS IS. THIS LABORATORY WILL ENABLE YOU TO"
140 PRINT "CONDUCT EXPERIMENTS ON THE COMPUTER WHICH WOULD NOT BE"
150 PRINT "PRACTICAL DURING CLASS TIME."
160 PRINT
200 PRINT "SINCE ALL OF OUR FOOD COMES FROM PLANTS, LET'S FIND OUT"
210 PRINT "HOW CHANGING THE AMOUNT OF CARBON DIOXIDE OR THE INTENSITY"
220 PRINT "OF LIGHT WILL AFFECT THE PLANT'S RATE OF PHOTOSYNTHESIS,"
230 PRINT "MEASURED IN MICROGRAMS OF GLUCOSE PRODUCED PER DAY."
240 PRINT
290 PRINT "LET'S BEGIN WITH CHANGING THE LIGHT INTENSITY. YOU WILL"
300 PRINT "VARY THIS BY SELECTING INTEGER VALUES IN THE RANGE OF"
310PRINT"0 TO 30 (THE UNITS FOR LIGHT INTENSITY ARE IN ERGS/SEC/SQ.CM)"
315 PRINT "BY VARYING ONLY ONE FACTOR AT A TIME, WE ARE CONDUCTING"
320 PRINT "A CONTROLLED EXPERIMENT. WE WILL ASSUME THAT OUR PLANT"
330 PRINT "HAS ALL OF THE CARBON DIOXIDE, WATER AND CHLOROPHYLL"
335 PRINT "THAT IT NEEDS."
340 PRINT
350 PRINT "YOU SHOULD CHOOSE BETWEEN FIVE AND TEN LIGHT INTENSITY"
360 PRINT "VALUES. TYPE IN ONLY ONE VALUE AFTER EACH QUESTION MARK."
380 PRINT "BY TYPING IN 100, NO MORE QUESTION MARKS WILL APPEAR AND"
390PRINT"THE PROGRAM WILL CONTINUE."
395 PRINT "(NOTE: 'RP' MEANS RATE OF PHOTHSYNTHESIS)"
400 PRINT
410 PRINT "LIGHT INTENSITY";
412 REM  INITIALIZE
413 FOR I=0 TO 30
415 LET V(I)=-1
417 NEXT I
419 FOR I=1 TO 10
420 PRINT "(LI)";
430 INPUT W
435 IF W=100 THEN 560
440 IF W>30 THEN 510
450 IF W<0 THEN 510
460 IF W<>INT(W) THEN 510
470 LET V(W)=W
480 LET R(W)=INT(12500*(1-EXP(-.222*V(W)))+.05)/100
490 PRINT "RP=";INT(R(W)+.5)
500 GO TO 550
510 PRINT "WRONG!  USE ONLY INTEGER VALUES BETWEEN 0 AND 30."
520 PRINT "TRY AGAIN."
530 GO TO 430
550 NEXT I
560 PRINT
565 REM  CHOICE OF OUTPUT
570 PRINT "1 = TABLE ONLY, 2 = PLOT ONLY, 3 = BOTH";
580 INPUT W
590 IF W=1 THEN 600
593 IF W=2 THEN 650
595 IF W=3 THEN 600
596 GO TO 570
600 PRINT
605 PRINT "  LIGHT","   RATE OF"
610 PRINT "INTENSITY","PHOTOSYNTHESIS"
615 PRINT "----------","--------------"
620 GOSUB 1500
630 IF W<>3 THEN 760
650 PRINT
660 PRINT "  LIGHT"
670 PRINT "INTENSITY"
680 GOSUB 1600
760 PRINT
770 PRINT
780 PRINT "O.K. LET'S NOW VARY THE AMOUNT OF CARBON DIOXIDE IN THE"
790 PRINT "ATMOSPHERE SURROUNDING OUR PLANT."
```

```
800 PRINT
810 PRINT "THIS TIME ASSUME OUR PLANT HAS ALL THE LIGHT, WATER AND"
820 PRINT "CHLOROPHYLL THAT IT NEEDS."
830 PRINT
840PRINT"LET THE VALUES YOU SELECT FOR THE CARBON DIOXIDE CONCENTRATION"
850 PRINT"BE FOR TWO DECIMAL PLACES ONLY, AND IN THE RANGE OF 0 TO .30"
860 PRINT "UNITS FOR CO2 CONC. ARE CUBIC CENTIMETERS PER LITER OF AIR."
890 PRINT
900 PRINT "AS BEFORE, I WILL TYPE IN A '?' AND THEN YOU TYPE IN THE"
910 PRINT "CARBON DIOXIDE CONC. AVAILABLE TO THE PLANT."
920 PRINT "THIS TIME YOU MUST CHOOSE TEN DIFFERENT VALUES."
925 PRINT "REMEMBER RP = RATE OF PHOTOSYNTHESIS."
930 PRINT
940 PRINT "CARBON DIOXIDE CONC.";
941 REM  INITIALIZE
942 FOR I=0 TO 30
944 LET V(I)=-1
946 NEXT I
948 FOR I=1 TO 10
950 PRINT "(CO2)";
960 INPUT W
970 IF W=100 THEN 1050
980 IF W<0 THEN 1040
990 IF W>.3 THEN 1040
995 LET Q=100*W
1000 IF ABS(Q-INT(Q+.5))>.00001 THEN 1040
1003 REM  FUDGE 1005 CAUSE INTEGER MESSES UP
1005 LET Q=INT(100*W+.5)
1010 LET V(Q)=W
1020 LET R(Q)=INT(175*(1-EXP(-28*V(Q)))+.005)/174*125
1025 PRINT "RP=";INT(R(Q)+.5)
1030 GO TO 1050
1040 PRINT "INPUT VALUES BETWEEN 0 AND .3 TO TWO PLACES ONLY"
1041 PRINT "TRY AGAIN"
1045 GO TO 960
1050 NEXT I
1060 PRINT
1070 PRINT "1 = TABLE ONLY, 2 = PLOT ONLY, 3 = BOTH";
1080 INPUT W
1090 IF W=1 THEN 1100
1093 IF W=2 THEN 1150
1095 IF W=3 THEN 1100
1096 GO TO 1070
1100 PRINT
1105 PRINT "CO2 CONC.","RATE OF PHOTOSYNTHESIS"
1110 PRINT "--- -----","---- -- --------------"
1120 GOSUB 1500
1130 IF W<>3 THEN 1200
1150 PRINT
1160 PRINT "CO2 CONC."
1180 GOSUB 1600
1200 PRINT
1210 PRINT
1220 PRINT "DO YOU KNOW WHAT IS HAPPENING IN BOTH THESE INSTANCES?"
1230 STOP
1499 REM  TABLE PRINTER
1500 FOR I=0 TO 30
1510 IF V(I)<0 THEN 1530
1520 PRINT V(I),R(I)
1530 NEXT I
1540 RETURN
1599 REM  PLOT ROUTINE
1600 PRINT " ","RATE OF PHOTOSYNTHESIS"
1610 PRINT " ","0   25   50   75   100  125"
1620 PRINT " ","I----I----I----I----I----I"
1630 FOR I=0 TO 30
1633 IF V(I)>=0 THEN 1645
1636 PRINT " ","I"
1640 GO TO 1670
1645 PRINT V(I),"I";TAB(14+INT(R(I)/5+.5));"*"
1670 NEXT I
1680 RETURN
1700 END
```


60
1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
6.3
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A
ERIC
Full Text Provided by ERIC

DISCIPLINE EARTH SCIENCE

SUBJECT CLIMATES

PROGRAM NAME CLIMAT

DESCRIPTION:

This program is designed to give students practice in identifying climates and climatic patterns. As the program runs, students are asked questions regarding precipitation and potential evapotranspiration on the basis of P and P. E. curves randomly selected and matched by the computer. At the conclusion of the program they are asked to specifically identify the climate of the region, (i. e. Tropical rain forest, Humid continental) on the basis of these curves, his answers, and the computer' s corrections.

OBJECTIVES:

The program presents the student with the following concepts:

A. The value of graphing to help in the interpretation of data;

B. There are a limited number of characteristic annual precipitation patterns which affect the earth;

C. The P. E. characteristics of a region are primarily related to 1) latitude and 2) proximity to large bodies of water;

D. Combinations of P and P. E. patterns yield a relatively small, distinct number of climates;

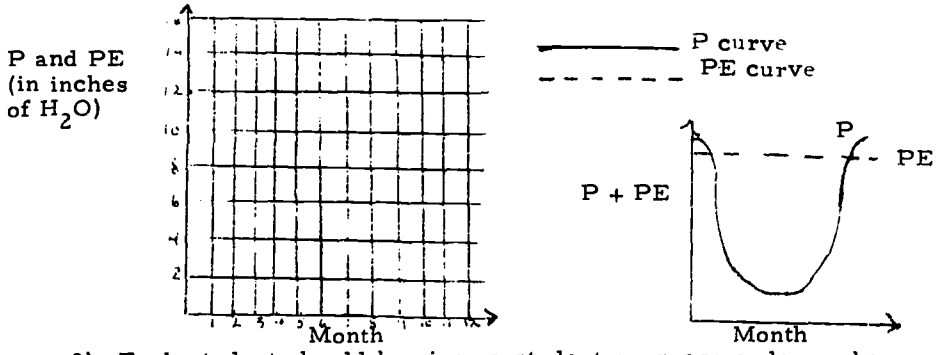
E. The precipitation patterns are modified by the prevailing wind pattern, regional geography and altitude.

PRELIMINARY PREPARATION:

A. Student - The student should have been introduced to the general climatic regions and their characteristics. He should also have some understanding of the earth' s wind belts and how they affect precipitation on the windward and lee side of mountains and continents.

PRELIMINARY PREPARATION: (con' t)

B. Materials - 1) Dittos of graphs set up to permit students to rapidly graph the P and P. E. Curves:



2) Each student should be given a student progress code number. This activates the selection of P and P. E. curves for that student when typed into the computer. Each time a student uses the program he should be given a NEW progress code number.

DISCUSSION:

This program is for students of average ability. It should be used individually or in groups of 5 or less.

Student graphs are employed only to help the student rapidly assimilate the numberical data presented by the computer. They need not be checked beforehand by the teacher, but should be used during the follow-up discussion of the students' run.

The follow-up discussion on a class, group, or individual basis will greatly enhance the value of the lesson and the student comprehension of the entire topic of climates.

As proficiency increases (or with superior students), the student might be asked to complete the program by inspection of the data without actually plotting the P and P. E. curves.

In the program, the criteria used in evaluating P patterns are:

80" - wet climate
13-80" - moderate precipitation
<13" - arid or dry climate

Although these values may not agree exactly with values taught by individual teachers, they are close enough to accepted standards to make the use of the program extremely worthwhile.

DISCUSSION: (con' t)

As with many of the other programs presented here, this program may be used in a demonstration lesson -- using the computer to provide data and questions; and the class to suggest and evaluate responses to be fed into the machine. Later, individuals or groups might be permitted to use the program as previously discussed. (If the program is used in this manner, the teacher might wish to prepare transparencies of the data and curves in advance for use during the computer run.)

O.K., HERE ARE SOME VALUES FOR THE PRECIPITATION (P) AND FOR THE POTENTIAL EVAPOTRANSPIRATION (PE) OF AN AREA:

MONTH	P	PE
1	14	0
2	10	3
3	9	7
4	16	10
5	9	13
6	14	14
7	13	13
8	8	10
9	12	7
10	8	3
11	13	1
12	11	0

TOTAL PRECIPITATION = 137 INCHES

O.K., PLOT YOUR GRAPH ON THE PAPER PROVIDED YOU AND WHEN YOU ARE READY TO CONTINUE.... MERELY TYPE ANY NUMBER AND THE RETURN KEY. ? 0

READY? GOOD, NOW TELL ME . . . DOES YOUR GRAPH SHOW THAT THE CLIMATE HAS DEFINITE WET AND DRY SEASONS (1=YES, 0=NO) ? 0

TELL ME, IS THE CLIMATE [1] WET, [2] DRY, OR [3] MODERATE ALL YEAR? 1

NICE GOING, SMARTY PANTS. KEEP UP THE GOOD WORK.
BY CHECKING THE PE CURVE ON YOUR GRAPH, WOULD YOU SAY THAT THE SUMMERS ARE [1] HOT, [2] WARM, OR [3] COOL? 2

AW C'MON, YOU COULDN'T POSSIBLY MEAN THAT....
YOU SHOULD HAVE SAID 1

FROM THE SAME INFORMATION (PE GRAPH), WOULD YOU SAY THAT THE WINTERS ARE [1] COLD, [2] MILD, OR [3] WARM? 1

IT WARMS MY HEART TO HEAR YOU SAY THAT. GOOD GOING.

WELL, BY NOW YOU MUST HAVE AN INKLING AS TO THE TYPE OF CLIMATE WE HAVE HERE. BELOW IS A COMPLETE LISTING OF ALL THE CLIMATES IN THE WORLD. REFER TO THEM BY THEIR NUMBER ONLY.

NUMBER	NAME OF CLIMATE
1	TROPICAL RAINFOREST
2	TROPICAL EAST COAST
3	TROPICAL MONSOON
4	TROPICAL SAVANNA
5	TROPICAL DESERT
6	MEDITERRANEAN
7	MARINE WEST COAST
8	HUMID CONTINENTAL
9	HUMID SUBTROPICAL
10	MIDDLE LATITUDE GRASSLANDS
11	MIDDLE LATITUDE DESERT
12	SUBARTIC CLIMATES
13 OR 14	HIGHLAND CLIMATES (TROPICAL OR MIDDLE LATITUDES)
15	POLAR TUNDRA
16	POLAR ICECAP

WHAT IS THE NUMBER OF THE CLIMATE WE HAVE (WE'LL ACCEPT THE FACT THAT THEY MAY OVERLAP)? 1

MY SUGGESTION - STICK TO LANGUAGES OR SOCIAL STUDIES.
YOU SHOULD HAVE SAID 8 . GOOD DAY TO YOU.

READY

```
100REM--E.A.GALLETTA,PATCHOGUE-M.S.,4/22/69 EARTH SCIENCE (BTICAC)
105REM--PROGRAM ON CLIMATES
110REM--REWRITTEN--7/26/69--BASIC--<ROD>
112 REM  REVISED BY TONY PEREZ, WALT WHITMAN HS, 8-69
113 REM  RE-REVISED BY C.LOSIK  8-26-70
115DIM L(56)
118 RANDOMIZE
120READ N,L(N)
125IFN<>56THEN120
130LET T=0
155PRINT"O.K., HERE ARE SOME VALUES FOR THE PRECIPITATION (P) AND FOR"
160PRINT"THE POTENTIAL EVAPOTRANSPIRATION (PE) OF AN AREA:"
165PRINT
170PRINT" ","MONTH","  P","  PE"
175PRINT" ","=====","=====","======"
195LETP=INT(10*RND(1))
200IFP>6THEN195
205IFP<1THEN195
210LETE=INT(10*RND(1))
215IFE>4THEN210
220 IFE<1THEN210
225LETZ=5*E+6*P
230 IF (Z-21)*(Z-22)*(Z-17)*(Z-38)=0 THEN 195
235FORI=1TO12
240PRINT" ",I,
245IFP>1THEN255
250LETP1=12*COS(.261*I)↑2+2*RND(-1)
255IFP<>2THEN265
260LETP1=12*SIN(.261*I)+2*RND(-1)
265IFP<>3THEN275
270LETP1=2+3*RND(-1)
275IFP<>4THEN285
280LETP1=2*RND(-1)
285IFP<>5THEN295
290LETP1=7+10*RND(-1)
295IFP<>6THEN305
300LETP1=3*COS(.5+.15*I)↑2
305PRINTINT(P1),
310IFE>1THEN320
315LETE1=10*SIN(.261*I)↑2
320IFE<>2THEN330
325LETE1=12*SIN(.261*I)↑2
330IFE<>3THEN340
335LETE1=2*SIN(.5+.15*I)↑2
340IFE<>4THEN350
345LETE1=8+4*RND(-1)
350LETT=T+INT(P1)
```

```
355PRINTINT(E1+(E1/10)*2)
360NEXTI
365PRINT
370PRINT"TOTAL PRECIPITATION =";T;"INCHES"
375PRINT
380PRINT"O.K., PLOT YOUR GRAPH ON THE PAPER PROVIDED YOU"
385PRINT"AND WHEN YOU ARE READY TO CONTINUE.... MERELY TYPE"
390PRINT"ANY NUMBER AND THE RETURN KEY.          ";
395INPUTQ
400PRINT
405PRINT"READY?  GOOD, NOW TELL ME . . . DOES YOUR GRAPH SHOW THAT"
410PRINT"THE CLIMATE HAS DEFINITE WET AND DRY SEASONS (1=YES, 0=NO) ";
420 INPUT S
425PRINT
430IFS=0THEN505
433 IF S<>1 THEN 405
435IFP<3THEN560
437 LET B=0
440 GO SUB 1045
445PRINT"TELL ME, IS THE CLIMATE [1] WET, [2] DRY, OR [3] MODERATE ALL"
450PRINT"YEAR";
455 INPUT S
460PRINT
465IFS=1THEN525
470IFS=3THEN545
473 IF S<>2 THEN 445
475IFT<13THEN625
480IFT>80THEN495
485GOSUB1040
490GOTO630
495GOSUB1020
500GOTO630
505IFP>2THEN445
510IFP=2THEN475
515GOSUB1020
520GOTO560
525IFT>80THEN625
530IFT>=13THEN485
535GOSUB1030
540GOTO630
545IF(T-13)*(80-T)>=0THEN625
550IFT<13THEN535
555IFT>80THEN495
560PRINT"TELL ME, WHICH IS THE WET SEASON, [1] THE WINTER OR [2] THE"
565PRINT"SUMMER";
570PRINT
575 INPUT S
580PRINT
585IFS=1THEN605
587 IF S<>2 THEN 560
```

```
590IFP=2THEN625
595GOSUB1020
600GOTO630
605IFP=1THEN625
610GOSUB1020
615GOTO630
620PRINT
625PRINT"NICE GOING, SMARTY PANTS.  KEEP UP THE GOOD WORK."
630PRINT"BY CHECKING THE PE CURVE ON YOUR GRAPH, WOULD YOU SAY THAT THE"
635PRINT"SUMMERS ARE [1] HOT, [2] WARM, OR [3] COOL";
640 INPUT S
645PRINT
650IFS=2THEN695
655IFS=3THEN715
657 IF S<>1 THEN 625
660IFE=3THEN725
665IFE=4THEN725
667 IF E=1 THEN 725
670GOSUB1020
675GOTO730
695IFE=1THEN725
700IFE<>3THEN670
705GOSUB1040
710GOTO730
715IFE=3THEN725
720IFE<>3THEN670
725PRINT"YOU HAVE RESTORED MY FAITH IN TEENAGERS."
730PRINT"FROM THE SAME INFORMATION (PE GRAPH), WOULD YOU SAY THAT THE"
735PRINT"WINTERS ARE [1] COLD, [2] MILD, OR [3] WARM";
740 INPUT S
745PRINT
750IFS=2THEN790
755IFS=3THEN810
760 IF S<>1 THEN 730
765IFE<3THEN825
770GOSUB1030
775GOTO830
780GOSUB1040
785GOTO830
790IFE=3THEN825
795IFE=4THEN760
800GOSUB1020
805GOTO830
810IFE=3THEN770
815IFE=4THEN830
820GOTO800
825PRINT"IT WARMS MY HEART TO HEAR YOU SAY THAT.  GOOD GOING."
830PRINT
835PRINT"WELL, BY NOW YOU MUST HAVE AN INKLING AS TO THE TYPE OF"
840PRINT"CLIMATE WE HAVE HERE.  BELOW IS A COMPLETE LISTING OF ALL THE"
```

```
845PRINT"CLIMATES IN THE WORLD.  REFER TO THEM BY THEIR NUMBER ONLY."
850PRINT
855PRINT
860PRINT"NUMBER","NAME OF CLIMATE"
865PRINT"======","================"
870PRINT"1","TROPICAL RAINFOREST"
875PRINT"2","TROPICAL EAST COAST"
880PRINT"3","TROPICAL MONSOON"
885PRINT"4","TROPICAL SAVANNA"
890PRINT"5","TROPICAL DESERT"
895PRINT"6","MEDITERRANEAN"
900PRINT"7","MARINE WEST COAST"
905PRINT"8","HUMID CONTINENTAL"
910PRINT"9","HUMID SUBTROPICAL"
915PRINT"10","MIDDLE LATITUDE GRASSLANDS"
920PRINT"11","MIDDLE LATITUDE DESERT"
925PRINT"12","SUBARTIC CLIMATES"
930PRINT"13 OR 14","HIGHLAND CLIMATES"
935PRINT" ","(TROPICAL OR MIDDLE LATITUDES)"
940PRINT"15","POLAR TUNDRA"
945PRINT"16","POLAR ICECAP"
950PRINT
955PRINT"WHAT IS THE NUMBER OF THE CLIMATE WE HAVE (WE'LL ACCEPT THE"
960 PRINT "FACT THAT THEY MAY OVERLAP)";
965INPUTS
970PRINT
975PRINT
980PRINT
985IFS=L(Z)THEN1005
990PRINT"MY SUGGESTION - STICK TO LANGUAGES OR SOCIAL STUDIES."
995PRINT"YOU SHOULD HAVE SAID";L(Z);".  GOOD DAY TO YOU."
1000STOP
1005PRINT"YOUR FORTUNE AS A METEOROLOGIST IS BUDDING.  IT WAS"
1010PRINT"VERY NICE TO WORK WITH YOU.  SO LONG."
1015STOP
1020LETB=1
1025GOTO1045
1030LETB=2
1035GOTO1045
1040LETB=3
1045PRINT"AW C'MON, YOU COULDN'T POSSIBLY MEAN THAT...."
1050PRINT"YOU SHOULD HAVE SAID";B
1055PRINT
1060RETURN
1085DATA11,6,16,7,23,10,26,3,27,15
1090DATA28,8,29,11,32,3,33,13,34,11
1095DA
TA35,9,39,16,40,6,41,13,44,5
1100DATA46,10,45,16,50,1,51,12,56,4
1105DATA39,4,44,5,35,9,40,8,45,1,41,15,46,12,51,5,56,16
1110DATA0,0
1115END
```

DISCIPLINE EARTH SCIENCE

SUBJECT CLOUD FORMATION

PROGRAM NAME CLOUDS

DESCRIPTION:

This program tests student ability to solve problems related to the formation of cumuliform clouds (i. e. L. C. L., temperature at various altitudes). In Phase I of the program students enter the variables and unknowns of previously assigned problems. The computer checks the students' answers and supplies the correct answers if an error is detected.

When Phase I is completed the computer automatically presents a group of new problems for the student to solve and check at the machine.

OBJECTIVES:

The program attempts to reinforce and apply the following concepts:

A. There is a specific rate at which temperature drops in a rising parcel of unsaturated air.

B. Once air becomes saturated and condensation begins, the lapse rate decreases due to the release of latent heat of vaporization.

C. The base level of a cloud (LCL), and temperatures within it can be calculated from ground level data.

PRELIMINARY PREPARATION:

A. Student - Students should be familiar with the terms and values of the dry and wet adiabatic lapse rates, normal lapse rate, and the formula for calculating the Lifting-Condensation Level.

B. Materials - Printed sets of problems with the following variables and unknowns:
   1. Air temperature on the ground.
   2. Dew point on the ground
   3. Temperature at the base of the cloud.
   4. The elevation, in feet, of the base of the cloud (LCL).

DISCUSSION:

This program is designed for average students. Individuals should be permitted to go to the computer to check any problem or groups of problems whenever the machine is free. The teacher in the lesson acts solely as a resource person to help those students unable to arrive at correct responses because of conceptual errors - not mechanical errors.

To speed the lesson, Phase II of the program may be omitted entirely, by procedure 1, or from early runs by procedure 2.

Procedure 1

Erase Lines 561 - 699, 770 - 790 and change line 557 to read: If P > 1 then 2000.

Procedure 2

Change line 557 to read: If P > 1 then 2000

When you are ready to use Phase II merely retype line 557 as originally listed.

CLOUD MINE

STRONG CONVECTION CURRENTS ARE CAUSING ADIABATIC COOLING OF AIR WHERE YOU ARE AND ARE RESPONSIBLE FOR THE FORMATION OF A CLOUD. BOTH THE DRY AND THE MOIST ADIABATIC (AS WELL AS THE NORMAL LAPSE RATES) ARE CONSIDERED IN THIS PROGRAM.

LEGEND

1=THE TEMPERATURE ON THE GROUND
2=THE DEW POINT TEMPERATURE ON THE GROUND
3=THE TEMPERATURE AT THE BASE OF THE CLOUD
4=THE ELEVATION, IN FEET, OF THE CLOUD BASE

CHOOSE ANY TWO OF THE ABOVE VARIABLES AND SELECT VALUES FOR THEM. TYPE THEM IN AS:
VARIABLE CODE ,VALUE, VARIABLE CODE ,VALUE...(E.G. 1,50,2,30)

? 1,50,2,41

OKAY, TYPE IN YOUR CALCULATED VALUE FOR
THE TEMPERATURE AT THE BASE OF THE CLOUD
FOLLOWED BY A COMMA, AND THEN TYPE IN YOUR VALUE FOR
THE ELEVATION, IN FEET, OF THE CLOUD BASE
? 39,8000

VERY GOOD. VERY, VERY GOOD.

DO YOU HAVE ANY OTHER PROBLEMS YOU WOULD LIKE TO TRY?
(1=YES, 0=NO) : ? 1

USING THE SAME LEGEND AS BEFORE...
CHOOSE ANY TWO OF THE ABOVE VARIABLES AND SELECT VALUES FOR THEM. TYPE THEM IN AS:
VARIABLE CODE ,VALUE, VARIABLE CODE ,VALUE...(E.G. 1,50,2,30)

? 1,50,3,85

OKAY, TYPE IN YOUR CALCULATED VALUE FOR
THE DEW POINT TEMPERATURE ON THE GROUND
FOLLOWED BY A COMMA, AND THEN TYPE IN YOUR VALUE FOR
THE ELEVATION, IN FEET, OF THE CLOUD BASE
? 30,4000

IT LOOKS LIKE WE GOOFED SOME PLACE.
LET'S SEE WHAT THE CORRECT VALUES ARE.

50 DEGREES - THE TEMPERATURE ON THE GROUND
29.54545 DEGREES - THE DEW POINT TEMPERATURE ON THE GROUND
85 DEGREES - THE TEMPERATURE AT THE BASE OF THE CLOUD
4545.455 FEET - THE ELEVATION, IN FEET, OF THE CLOUD BASE

DO YOU HAVE ANY OTHER PROBLEMS YOU WOULD LIKE TO TRY?
(1=YES, 0=NO) : ? 0

WELL, BEFORE YOU LEAVE, I HAVE A FEW I'D LIKE YOU TO TRY...
BASED ON YOUR VALUES, THE HEIGHT OF THE CLOUD
(MEASURED FROM THE CLOUD BASE) IS 18181.82 FT. CAN YOU TELL ME:

WHAT IS THE TEMPERATURE AT EACH OF THESE ALTITUDES:
1 3182 FT
2 31818 FT
3 13636 FT

THE TEMPERATURE AT 3182 FT. IS ? 30

SORRY. YOU WERE DOING GREAT THERE FOR A WHILE.
WELL, BACK TO THE BOOKS. THE VALUES YOU SHOULD HAVE ARE:

1 THE TEMPERATURE AT 3182 FEET IS 32.5 DEGREES
2 THE TEMPERATURE AT 31818 FEET IS -61.36364 DEGREES
3 THE TEMPERATURE AT 13636 FEET IS -2.272727 DEGREES

READY

```
10REM--A.C.CAGGIANO+E.A.GALLETTA, PATCHOGUE H.S., 11-20-68
11REM--REVISED BY CHARLES LOSIK AND TONY PEREZ  7/18/69
12 REM  RE-REVISED BY C.LOSIK  8-26-70
20REM--THIS PROGRAM IS ASSOCIATED WITH CLOUD FORMATION
25REM PHASE I OF PROGRAM BEGINS HERE.  STUDENTS WILL BE GIVEN
26REM INTRODUCTORY INFORMATION AND BE ALLOWED TO ASK AND ANSWER
27REM ANY NUMBER OF PROBLEMS. WHEN THEY INPUT NO. 2 (LINES 554-556)
28REM PROGRAM SENDS THEM TO PHASE II (LINE 561 AND FOLLOWING).
30PRINT" ","CLOUD NINE"
40PRINT" ","========="
45 DIM B(2), T(4), Q(3), A(3), C(3)
50PRINT
60PRINT"   STRONG CONVECTION CURRENTS ARE CAUSING ADIABATIC"
70PRINT"COOLING OF AIR WHERE YOU ARE AND ARE RESPONSIBLE FOR THE"
80PRINT"FORMATION OF A CLOUD.  BOTH THE DRY AND THE MOIST ADIABATIC"
90PRINT"(AS WELL AS THE NORMAL LAPSE RATES) ARE CONSIDERED IN THIS"
91PRINT"PROGRAM."
100PRINT
105 PRINT
110PRINT" ","LEGEND"
120PRINT" ","======"
140PRINT"1=";
150GOSUB1000
160PRINT"2=";
170GOSUB1010
180PRINT"3=";
190GOSUB1020
200PRINT"4=";
210GOSUB1030
220PRINT
225 PRINT
230 PRINT"CHOOSE ANY TWO OF THE ABOVE VARIABLES AND SELECT VALUES FOR"
231 PRINT"THEM.  TYPE THEM IN AS:"
232PRINT"VARIABLE CODE ,VALUE, VARIABLE CODE ,VALUE...(E.G. 1,50,2,30)"
233 PRINT
240 LET X=0
242 LET Y=0
245 LET A=0
246 LET B=0
247 LET B(1)=0
248 LET B(2)=0
250INPUTB(1),A,B(2),B
290PRINT
300FORI=1TO4
310IFB(1)=ITHEN330
320NEXTI
330LETT(1)=A
340FORJ=1TO4
350IFB(2)=JTHEN370
360NEXTJ
370LETT(J)=B
380IFI<>JTHEN405
390PRINT"YOU CAN'T USE THE SAME VALUES TWICE."
395GOTO250
405PRINT"OKAY, TYPE IN YOUR CALCULATED VALUE FOR";
406PRINT
410IFJ=I<>2THEN425
411LETT=(T(1)-T(2))/4.5
412LETT(4)=1000*T
413LETT(3)=T(2)-T
414GOSUB1020
415GOSUB1050
416GOSUB1030
417INPUTX,Y
418IFABS(X-T(3))>=.6THEN500
```

```
419IFABS(Y-T(4))>=.6THEN500
420GOTO550
425IFJ*I<>3THEN440
426LETT=(T(1)-T(3))/5.5
427LETT(4)=1000*T
428LETT(2)=T+T(3)
429GOSUB1010
430GOSUB1050
431GOSUB1030
432INPUTX,Y
433IFABS(X-T(2))>=.6THEN500
434IFABS(Y-T(4))>=.6THEN500
435GOTO550
440IFJ*I<>4THEN455
441LETT=T(4)/1000
442LETT(2)=T(1)-4.5*T
443LETT(3)=T(2)-T
444GOSUB1010
445GOSUB1050
446GOSUB1080
447INPUTX,Y
448IFABS(X-T(2))>=.6THEN500
449IFABS(Y-T(3))>=.6THEN500
450PRINT"OKAY, TYPE IN YOUR CALCULATED VALUE FOR"
455IFJ*I<>6THEN470
456LETT=T(2)-T(3)
457LETT(4)=1000*T
458LETT(1)=T(3)+5.5*T
459GOSUB1000
460GOSUB1050
461GOSUB1030
462INPUTX,Y
463IFABS(X-T(1))>=.6THEN500
464IFABS(Y-T(4))>=.6THEN500
465GOTO550
470IFJ*I<>8THEN485
471LETT=T(4)/1000
472LETT(3)=T(2)+T
473LETT(1)=T(2)+6.5*T
474GOSUB1010
475GOSUB1050
476GOSUB1080
477INPUTX,Y
478IFABS(X-T(1))>=.6THEN500
479IFABS(Y-T(3))>=.6THEN500
480GOTO550
481IFABS(X-T(3))>=.6THEN500
485IFJ*I<>12THEN390
486LETT=T(4)/1000
487LETT(1)=T(3)+5.5*T
488LETT(2)=T(3)+T
489GOSUB1000
490GOSUB1050
491GOSUB1010
492INPUTX,Y
493IFABS(X-T(1))>=.6THEN500
494IFABS(Y-T(2))>=.6THEN500
495GOTO550
500PRINT
502PRINT"IT LOOKS LIKE WE GOOFED SOME PLACE."
505PRINT"LET'S SEE WHAT THE CORRECT VALUES ARE."
507PRINT
510 PRINT T(1)"DEGREES - ";
512 GO SUB 1000
515 PRINT T(2)"DEGREES - ";
517 GO SUB 1010
520 PRINT T(3)"DEGREES - ";
522 GO SUB 1080
525 PRINT T(4)"FEET - ";
527 GO SUB 1030
```

```
530 PRINT
535GOTO554
550PRINT
552PRINT"VERY GOOD.  VERY, VERY GOOD."
553PRINT
554PRINT"DO YOU HAVE ANY OTHER PROBLEMS YOU WOULD LIKE TO TRY?"
555 PRINT "(1=YES, 0=NO) : ";
556 INPUT P
557IFP<1THEN561
558PRINT
559PRINT"USING THE SAME LEGEND AS BEFORE..."
560GOTO230
561LETH=(T(1)-T(3))*2000-7*T(4)
562REM LINE 561 CALCULATES ALTITUDE FOR TOP OF CLOUD AND BEGINS
563REM  PHASE II OF PROGRAM.  PROBLEM NO.2 IN THIS PART (CALCULATION
564REM  OF TEMP. ABOVE CLOUD TOP) INVOLVES USE OF THE NORMAL LAPSE RATE.
565PRINT
567PRINT"WELL, BEFORE YOU LEAVE, I HAVE A FEW I'D LIKE YOU TO TRY..."
570PRINT"BASED ON YOUR VALUES, THE HEIGHT OF THE CLOUD"
580PRINT"(MEASURED FROM THE CLOUD BASE) IS ";H;" FT.  CAN YOU TELL ME:"
600LETQ(1)=.7*T(4)
601LETQ(2)=T(4)+1.5*H
602LETQ(3)=T(4)+.5*H
610LETA(1)=T(1)-T(4)*3.85E-3
611LETA(2)=T(1)-(T(4)+1.5*H)*3.5E-3
612LETA(3)=T(3)-1.5E-3*H
614PRINT
615PRINT"WHAT IS THE TEMPERATURE AT EACH OF THESE ALTITUDES:"
640FORN=1TO3
685PRINT" ";N;INT(Q(N)+.5);"FT"
687NEXT N
688PRINT
689FORN=1TO3
630PRINT"THE TEMPERATURE AT ";INT(Q(N)+.5);" FT. IS ";
631INPUTC(N)
635IFABS(C(N)-A(N))>1.1THEN750
640NEXTN
699PRINT
700PRINT"WOW, YOU MUST BE A BRAIN.  AND YOU PROBALLY KNOW"
710PRINT"A LOT ABOUT CLOUDS AND THINGS LIKE THAT.  IT WAS VERY"
720PRINT"NICE TO WORK WITH SOMEONE WHO UNDERSTANDS ME."
730PRINT" ","THANK YOU AND . . . . PEACE AND LONG LIFE"
740STOP
750PRINT
755PRINT"SORRY.  YOU WERE DOING GREAT THERE FOR A WHILE."
760PRINT"WELL, BACK TO THE BOOKS.  THE VALUES YOU SHOULD HAVE ARE:"
765PRINT
770FORN=1TO3
774PRINTN;
780PRINT"THE TEMPERATURE AT";INT(Q(N)+.5);"FEET IS ";A(N);"DEGREES"
790NEXTN
830STOP
1000PRIN
T"THE TEMPERATURE ON THE GROUND"
1005RETURN
1010PRINT"THE DEW POINT TEMPERATURE ON THE GROUND"
1015RETURN
1020PRINT"THE TEMPERATURE AT THE BASE OF THE CLOUD"
1025RETURN
1030PRINT"THE ELEVATION, IN FEET, OF THE CLOUD BASE"
1035RETURN
1040PRINT"FOLLOWED BY A COMMA, AND THEN TYPE IN YOUR VALUE FOR "
1055RETURN
9000END
```

DISCIPLINE EARTH SCIENCE

SUBJECT WATER BUDGET

PROGRAM NAME WATER1

DESCRIPTION:

This is a tutorial program which takes a student through the step-by-step calculations of a water budget, checks the correctness of his responses, and indicates the location of his errors. In difficult parts of the budget instructions, clues are given before the student is asked to re-calculate his work.

OBJECTIVES:

This program is designed to:

A. Enable students to "visualize" an areas' climate in terms of its moisture patterns of usage, storage, recharge, and deficit.

B. Illustrate the relationship of deficit and surplus in light of growing seasons for crops, watering of lawns, the need for irrigation, and the occurrence of floods.

C. Develop the skills necessary for the successful completion of a water budget.

PRELIMINARY PREPARATION:

A. Student - Students should understand the following terms: potential evapotranspiration, actual evapotranspiration, deficit, and surplus. The concept of a change in value of a number (Δ-ST or 'delta' -ST) should also have been covered.

B. Materials - Ditto sheets containing water budget tables should be available for each class member. A sample table follows:

WATER BUDGET

FOR:_____

Progress code no.		J	F	M	A	M	J	J	A	S	O	N	D
	P												
	PE												
	P-PE												
	ST												
	ΔST												
	AE												
	D												
	S												

A set of water budget graphs should also be available if the teacher wishes to have his classes complete the graph in addition to the water budget. See: Investigating the Earth, Teacher's Guide, Part I. P. 402 of the Earth Science Curriculum Project.

DISCUSSION:

This program is applicable to individual or small group (5 or less) instruction, and is designed for average students.

The progress code number assigned to the student indicates to the program the extent to which the student has progressed through the program. These numbers should be chosen according to the following table:

Progress Code #	Stage of Calculation of Water Budget
0-10	Introductory information
11-20	Student is ready for "P-PE" section of program
21-30	ready for "ST" section of program
31-40	ready for " -ST" section of program
41-50	ready for "A.E." section of program
51-60	ready for "D" section of program
61-70	ready for "S" section of program

Each student may work on a different water budget by entering a unique set of data in lines 43 and 44. Line 42 also may be changed to indicate the region whose water budget is under study.

This program should be used in conjunction with program WATER2.

```
WHAT IS YOUR PROGRESS CODE NUMBER? 5

WATER BUDGET FOR RUTLAND,VT.:
==========================================
P:
 57   45   63   74   80   90   86   86   92   94   88   56
PE:
 0    0    0    28   75   114  133  114  78   41   8    0
NOW, RETURN TO YOUR SEATS AND SEPARATELY WORK OUT YOUR VALUES
    FOR:  'P-PE'    AND 'STORAGE'.
RETURN ONLY AFTER YOUR TEACHER HAS CHECKED YOUR WORK AND GIVEN
     YOU A NEW PROGRESS CODE NUMBER!


READY

RUN

WHAT IS YOUR PROGRESS CODE NUMBER? 15


PRINT YOUR 12 VALUES FOR P-PE WHEN YOU SEE THE QUESTION
   MARK.  AFTER EACH OF THE VALUES PRINT A COMMA (,)--BUT
   DO NOT PRINT A COMMA AFTER YOUR LAST VALUE; SIMPLY HIT
   'RETURN'.
? 55,45,63,46,5,-24,-47,-28,14,53,80,56,
TOO MUCH INPUT.  EXCESS IGNORED
OUCH!! THERE'S AN ERROR AT MONTH  1 .  RETYPE THIS LINE.
? 57,45,63,46,5,-24,-47,-28,14,53,80,56
GOOD WORK!
NOW LET'S SEE HOW WELL YOUR VALUES FOR 'ST' CAME OUT.  PRINT
   THEM AFTER THE QUESTION MARK.
? 100,100,100,100,100,76,29,1,15,68,100,100
YOUR VALUES FOR 'STORAGE' ARE CORRECT.
  HAVE YOU FINISHED THE REST OF THE WATER BUDGET?
(1=YES, 0=NO) ? ? 0
OK! GO BACK TO YOUR SEATS AND WORK OUT 'DELTA-ST' AND 'A.E.'


READY
```

```
1 REM  CLASS ROOM EDITION OF WB -- PEREZ 5/1/69
2 DIM P(12),Z(12),X(12),T(12),A(12),V(12),S(12),D(12),E(12)
3 DIM Q(12)
4 REM  REVISED BY C.LOSIK  8-26-70
10 PRINT"WHAT IS YOUR PROGRESS CODE NUMBER";
13 INPUT B
14PRINT
30 FOR I = 1 TO 12
32READP(I)
34LETZ(I)=P(I)
36IFB>10THEN48
40IFI>1THEN47
42PRINT"WATER BUDGET FOR RUTLAND,VT.:"
43DATA57,46,63,74,80,90,86,86,92,94,88,56
44DATA0,0,0,28,75,114,133,114,78,41,8,0
45PRINT"================================================="
46 PRINT "P:"
47 GOSUB 500
48 NEXT I
49 PRINT
50 FOR I = 1 TO 12
51 READ T(I)
52  LET Z(I)=T(I)
53 IF B>10 THEN 58
55 IF I>1 THEN 57
56  PRINT "PE:"
57 GOSUB 500
58 NEXT I
70 IF B > 10 THEN 90
80 PRINT"NOW, RETURN TO YOUR SEATS AND SEPARATELY WORK OUT YOUR VALUES"
81 PRINT"     FOR:  'P-PE'     AND 'STORAGE'."
83 PRINT"RETURN ONLY AFTER YOUR TEACHER HAS CHECKED YOUR WORK AND GIVEN"
84 PRINT"      YOU A NEW PROGRESS CODE NUMBER!"
85 GOTO 999
90 IF B > 20 THEN 110
100 PRINT"PRINT YOUR 12 VALUES FOR P-PE WHEN YOU SEE THE QUESTION"
101 PRINT"    MARK.  AFTER EACH OF THE VALUES PRINT A COMMA (,)--BUT"
102 PRINT"    DO NOT PRINT A COMMA AFTER YOUR LAST VALUE; SIMPLY HIT"
103 PRINT"    'RETURN'."
105 GOSUB 530
110FORI=1TO12
115LETX(I)=P(I)-T(I)
117IFB>20THEN130
120 IF X(I)=Q(I) THEN 130
121PRINT"OUCH!!  THERE'S AN ERROR AT MONTH ";I".  RETYPE THIS LINE."
122 GOTO105
130 NEXT I
137 IF B > 30 THEN 200
138 IF B > 20 THEN 142
140 PRINT "GOOD WORK!"
142 PRINT"NOW LET'S SEE HOW WELL YOUR VALUES FOR 'ST' CAME OUT.  PRINT "
143 PRINT"    THEM AFTER THE QUESTION MARK."
150 GOSUB 530
200 FOR I = 1 TO 12
201IFX(I)>=0THEN208
202  LET G = 0
203 LET S(I) = T + X(I)
204  LET T = S(I)
205IFS(I)<=0THEN275
206 LET G = 0
207 NEXT I
208 LET T = 100
209 LET S(I) = X(I)+G
210 LET G = S(I)
```

```
211 LET T = 100
212 LET S(I) = X(I)+G
213IFS(I)>=100THEN280
215 GOTO 207
275 LET S(I) = 0
276 GOTO 281
280LETS(I)=100
281LETN1=I+1
282LETG=I
290FORI=N1TO12
310LETM=I-1
311LETN=I+1
320GOSUB352
321NEXTI
324 FOR I = 1 TO G
325  LET M = I-1
327  IF I>1 THEN 332
328  LET M=12
332 GOSUB 352
333 NEXT I
334 GOTO 400
352 LET S(I)=S(M)+X(I)
355 IF S(I)>=100 THEN 363
357 IF S(I)<1 THEN 380
360 GOTO 368
363 LET E(I)=S(I)-100
364 LET S(I)=100
368 LET V(I)=S(I)-S(M)
369 LET A(I)=T(I)
371 GOTO 389
380 LET S(I)=0
382  LET D(I)=ABS(P(I)+S(M)-T(I))
383  LET A(I)=S(M)+P(I)
384   LET V(I)=S(I)-S(M)
389 RETURN
400 IF B > 30 THEN 440
401  FOR I = 1 TO 12
402 IF Q(I) = S(I) THEN 420
404PRINT"SORRY ABOUT THAT!! MONTH"I;"IS IN ERROR. RECALCULATE PLEASE."
410 GOTO 999
420 NEXT I
425 PRINT"YOUR VALUES FOR 'STORAGE' ARE CORRECT."
426 PRINT"  HAVE YOU FINISHED THE REST OF THE WATER BUDGET?"
427 PRINT "(1=YES, 0=NO) : ";
428 INPUT L
430IFL=1THEN441
433 IF L<>0 THEN 426
435PRINT"OK! GO BACK TO YOUR SEATS AND WORK OUT 'DELTA-ST' AND 'A.E.'"
439 GOTO 999
440 IF B > 40 THEN 455
441 PRINT"LET'S SEE YOUR VALUES FOR 'DELTA-ST'."
443 GOSUB 530
444 FOR I = 1 TO 12
446IFQ(I)=V(I)THEN451
447PRINT"THERE SEEMS TO BE AN ERROR IN MONTH "I".  BETTER TAKE A LOOK"
448 PRINT"  AT YOUR VALUES. REMEMBER DELTA-ST = ST FOR LAST MONTH MINU
449PRINT"  ST FOR THIS MONTH.  PLEASE LEAVE AND RECHECK YOUR WORK."
450GOTO999
451NEXTI
453 PRINT"THESE VALUES ARE FINE."
455 IF B>50 THEN 470
456PRINT"HOW DID YOUR A.E. VALUES COME OUT?  JUST LIST THEM AS BEFORE.
457 GOSUB 530
458FORI=1TO12
459IFQ(I)=A(I)THEN465
460PRINT"OOPS!  YOU DID IT! MONTH"I"IS INCORRECT...RECALCULATE!!!"
```

```
461 GO TO 999
465 NEXT I
466 PRINT"GOOD WORK!  THEY'RE ALL CORRECT."
470 IF B>60 THEN 485
471 PRINT"PLEASE LIST YOUR 'D' VALUES."
473 GOSUB 530
474 FOR I = 1 TO 12
475   IF Q(I)=D(I) THEN 480
476PRINT"YOU HAVE A DEFICIT WHENEVER P.E.>A.E.---AND---ST=0.  THE"
477PRINT"  DEFICIT = THE AMT.OF H2O YOU'R SHORT TO MEET THE P.E. FOR"
478PRINT"  MONTH"I".  THAT IS: D=PE-AE.  HAVE ANOTHER TRY....."
479 GOTO 999
480 NEXT I
485PRINT"NOW FOR THE FINAL ROW.  PLEASE PRINT YOUR 'SURPLUS' FIGURES."
486 GOSUB 530
487  FOR I = 1 TO 12
488    IF Q (I)= E (I) THEN 495
489PRINT"A SURPLUS OCCURS ONLY WHEN 'ST'=>100. DID THIS CONDITION EXIST"
490PRINT"FOR MONTH"I"? IF SO THEN 'S'=EXCESS 'P' NOT NEEDED FOR P.E."
491PRINT"  SEE YOU AFTER YOU HAVE RECALCULATED!!!!"
492GOTO999
495  NEXT I
497 PRINT"WELL, IT LOOKS LIKE YOU DID IT.  FINE!!"
499 GO TO 999
500PRINTZ(I);
502IFZ(I)>99THEN525
503IFZ(I)>9THEN520
504IFZ(I)>-1THEN515
505IFZ(I)>-10THEN520
506IFZ(I)>-1000THEN525
515PRINT" ";
520PRINT" ";
525RETURN
530INPUTQ(1),Q(2),Q(3),Q(4),Q(5),Q(6),Q(7),Q(8),Q(9),Q(10),Q(11),Q(12)
533RETURN
999END
```

DISCIPLINE EARTH SCIENCE

SUBJECT WATER BUDGET

PROGRAM NAME WATER2

DESCRIPTION:

This program prints out a completed water budget. It may be used by a teacher to quickly calculate a series of water budgets he plans to use or it may be employed with more advanced students to check out an entire budget in one run.

OBJECTIVES:

A. To free teachers from the time-consuming task of calculating a number of practice water budgets.

B. To allow students a rapid means of verifying budgets they have been assigned for practice and drill.

PRELIMINARY PREPARATION:

A. Student - Students should be completely familiar with the concepts of evapotranspiration, water surplus, water storage, and water deficit.

B. Materials - A ditto of water budget tables as shown below:

WATER BUDGET
FOR:_____

	J	F	M	A	M	J	J	A	S	O	N	D
P												
PE												
P-PE												
ST												
ΔST												
AE												
D												
S												

DISCUSSION:

To place a particular water budget in the program:

1. Call up the program by name.

2. Type the precipitation data on line 5; the P. E. data on line 6 and the title of the budget on line 4.

   example:

   ```
   4PRINT " Water Budget for N. Y., N. Y.:"
   5DATA 89, 86, 98, 86, 84, 85, 106, 113, 88, 88, 82, 85
   6DATA 0, 0, 12, 40, 86, 125, 149, 132, 94, 55, 22, 2
   ```

3. Type " RUN"

The complete water budget will print out. (Check the value for P and PE to make sure you have typed them in correctly.)

To add other budgets repeat steps 2 and 3 until all budgets have been completed.

Additional P and PE data for other regions can be found in Investigating the Earth, Teacher's Guide, Part I, pages 392-397.

```
WATER BUDGET FOR ANCHORAGE, ALASKA:
============================================================

P:
 22    18    13    10    12    22    48    68    66    47    25    23
PE:
 0     0     0     18    71    104   115   105   65    21    0     0
P-PE:
 22    18    13    -8    -59   -82   -67   -37   1     26    25    23
DELTA-ST:
 22    3     0     -8    -59   -33   0     0     1     26    25    23
STORAGE-(ST):
 97    100   100   92    33    0     0     0     1     27    52    75
AE:
 0     0     0     18    71    55    48    68    65    21    0     0
D:
 0     0     0     0     0     49    67    37    0     0     0     0
SURPLUS:
 0     15    13    0     0     0     0     0     0     0     0     0

TOTAL P =       374
TOTAL PE =      499
P/PE = .749499

READY
```

```
1 REM   CALCULATES WATER BUDGET -- PEREZ 20MAR69
2DIM P(12),Z(12),X(12),I(12)
3 REM   LINES 4,5,6 ARE FOR "TITLE LINE", "P DATA", & "P.E. DATA"
4 PRINT"WATER BUDGET FOR ANCHORAGE, ALASKA:"
5DATA22,18,13,10,12,22,46,68,66,47,25,23
6DATA0,0,0,18,71,104,115,105,65,21,0,0
7PRINT"=============================================================="
8 PRINT
9 PRINT "P:"
10 FOR I = 1 TO 12
11   READ P(I)
12 LET Z(I)=P(I)
13 GOSUB 499
15 NEXT I
16 PRINT
20 DIM T(12)
30 PRINT"PE:"
40 FOR I = 1 TO 12
41    READ T(I)
42 LET Z(I)=T(I)
44 GOSUB 499
45  NEXT I
46 PRINT
50 PRINT "P-PE:"
61 FOR I = 1 TO 12
62 LET X(I)=P(I)-T(I)
65 LET Z(I)=X(I)
66 GOSUB 499
67 NEXT I
68 PRINT
69 GOTO 99
97 LET G = 0
98 DIM A(12),V(12)
99 DIM S(13),D(13),E(12)
100 FOR I = 1 TO 12
101 IF X(I)>=0 THEN 108
102 LET G = 0
103 LET S(I) = T + X(I)
104  LET T = S(I)
105  IF S(I)<=0 THEN 175
106 LET G = 0
107 NEXT I
108  LET T = 100
109  LET S(I) = X(I)+G
110  LET G = S(I)
111 LET T = 100
112 LET S(I) = X(I)+G
113 IF S(I)>=100 THEN 180
115 GOTO 107
175 LET S(I) =0
176 GOTO 181
180 LET S(I)=100
181 LET N1 = I + 1
182 LET G = I
190 FOR I = N1 TO 12
210 LET N=I-1
211 LET N = I+1
220 GOSUB 252
221 NEXT I
224 FOR I=1 TO G
225 LET N=I-1
227IFI>1THEN232
228 LET N=12
```

```
232 GOSUB 258
233 NEXT I
234 GOTO 391
258 LET S(I)=S(M)+X(I)
255 IF S(I)>=100 THEN 263
257 IF S(I)<1 THEN 280
260 GOTO 268
261 GOTO 268
263 LET E(I)=S(I)-100
264 LET S(I)=100
268 LET V(I)=S(I)-S(M)
269 LET A(I)=T(I)
271 GOTO 289
280 LET S(I)=0
282   LET D(I)=ABS(P(I)+S(M)-T(I))
283   LET A(I)=S(M)+P(I)
284   LET V(I)=S(I)-S(M)
289 RETURN
391 PRINT "DELTA-ST:"
392 FOR I = 1 TO 12
393 LET Z(I)=V(I)
394 GOSUB 499
395 NEXT I
396 PRINT
399 PRINT"STORAGE-(ST):"
400 FOR I=1 TO 12
405 LET Z(I)=S(I)
406 GOSUB 499
410 NEXT I
415 PRINT
419 PRINT"AE:"
420 FOR I = 1 TO 12
425 LET Z(I)=A(I)
426 GOSUB 499
427 NEXT I
428 PRINT
439 PRINT "D:"
440 FOR I = 1 TO 12
445 LET Z(I)=D(I)
446 GOSUB 499
450 NEXT I
451 PRINT
459 PRINT "SURPLUS:"
460 FOR I = 1 TO 12
465 LET Z(I)=E(I)
466 GOSUB 499
468 NEXT I
470 PRINT
475 FOR I = 1 TO 12
477  LET O=P(I)+O
479  LET H=T(I)+H
480  NEXT I
481 PRINT
482 PRINT "TOTAL P =";O
483 PRINT "TOTAL PE =";H
484 PRINT "P/PE ="O/H
485 GOTO 999
499 PRINT Z(I);
500 IF Z(I)>99 THEN 525
501 IF Z(I)>9 THEN 520
502 IF Z(I)>-1 THEN 515
503 IF Z(I)>-10 THEN 515
504 IF Z(I)>-1000 THEN 520
505 REM 504 READS >1000 TO PREVENT SPACING AFTER NUMBERS  BETWEEN
506 REM              -100 AND -1000
515 PRINT " ";
520 PRINT " ";
525 RETURN
999END
```

DISCIPLINE CHEMISTRY

SUBJECT ATOMIC WEIGHT (ATOMIC MASS)

PROGRAM NAME ATWT

DESCRIPTION:

This program will calculate the atomic weight (atomic mass) of an element from the % abundance of each isotope of the element. The % abundance may be found in the chemistry handbook.

OBJECTIVES:

To show that the atomic weight is an average weight and not the weight of any particular atom.

PRELIMINARY PREPARATION:

A. Student - The student should have an introductory understanding of atomic weight, mass number, and isotopes.

B. Materials - A chemistry handbook from which mass numbers and % abundances may be obtained is necessary.

DISCUSSION:

It is usually difficult to get the point across that the atomic weight is an average weight and not the weight of any particular atom. This point can be made rather easily if the calculations for atomic weight are examined. This program will enable the teacher, in a few minutes during his discussion, to do a large number of calculations. This is particularly impressive when the teacher uses % data that is significant to 5-6 figures, and thus produces an atomic weight as accurate as those given in most tables.

If the teacher is interested in discussing programming with his students, this program is a good one to use. It has the advantage of being short, but still containing a number of interesting programming techniques.

```
THIS PROGRAM WILL CALCULATE THE ATOMIC WEIGHT (ATOMIC MASS)
FROM THE PERCENT ABUNDANCE OF EACH ISOTOPE.  PERCENT
ABUNDANCES MAY BE FOUND IN THE CHEMISTRY HANDBOOK.

HOW MANY ISOTOPES DOES THE ELEMENT HAVE ? 7

INPUT THE MASS NUMBER AND THE PERCENT ABUNDANCE FOR
EACH OF THE 7 ISOTOPES.

ISOTOPE NO. 1  ? 196,.15
ISOTOPE NO. 2  ? 198,10
ISOTOPE NO. 3  ? 199,16.9
ISOTOPE NO. 4  ? 200,23.1
ISOTOPE NO. 5  ? 201,13.2
ISOTOPE NO. 6  ? 202,29.8
ISOTOPE NO. 7  ? 204,6.8


ATOMIC WEIGHT (ATOMIC MASS) IS 200.525

ANOTHER RUN (1=YES, 0=NO) ? 0


READY
```

```
100 REM  HARRY DORFMAN  7-15-69
105 REM  REVISED BY C.LOSIK  8-12-70
106 REM  B(I) ARE THE MASS NOS., C(I) ARE THE PERCENTS
110 PRINT " THIS PROGRAM WILL CALCULATE THE ATOMIC WEIGHT (ATOMIC MASS)"
120 PRINT " FROM THE PERCENT ABUNDANCE OF EACH ISOTOPE.  PERCENT"
130 PRINT " ABUNDANCES MAY BE FOUND IN THE CHEMISTRY HANDBOOK."
140 PRINT
150 PRINT " HOW MANY ISOTOPES DOES THE ELEMENT HAVE ";
160 INPUT A
163 IF ABS(A-INT(A))>.0001 THEN 150
166 PRINT
170 PRINT " INPUT THE MASS NUMBER AND THE PERCENT ABUNDANCE FOR"
180 PRINT " EACH OF THE"A"ISOTOPES."
185 PRINT
190 DIM B(20),C(20)
193 LET D=0
196 LET E=0
200 FOR I=1 TO A
205 PRINT " ISOTOPE NO."I" ";
210 INPUT B(I),C(I)
213 LET D=D+B(I)*C(I)
216 LET E=E+C(I)
220 NEXT I
235 PRINT
245 PRINT
300 IF ABS(E-100)<.2 THEN 309
302 PRINT
304 PRINT " THE PERCENT ABUNDANCE DOES NOT TOTAL 100."
305 PRINT " CHECK PERCENTAGES AND REENTER DATA."
306 GO TO 185
309 LET D=D/100
310 PRINT " ATOMIC WEIGHT (ATOMIC MASS) IS"D
315 PRINT
320 PRINT " ANOTHER RUN (1=YES, 0=NO) ";
330 INPUT A
335 PRINT
340 IF A=1 THEN 140
350 IF A<>0 THEN 320
360 END
```

DISCIPLINE CHEMISTRY

SUBJECT AVOGADRO' S NUMBER

PROGRAM NAME AVOGA

DESCRIPTION:

A class presentation designed to calculate Avogadro' s number, by using the molecular weight of a compound and dividing by the combined actual weight of the total numbers of neutrons and protons in a single molecule.

OBJECTIVES:

To show by calculation, the value of Avogadro' s Number, and to reinforce the concept of Avogadro' s hypothesis.

PRELIMINARY PREPARATION:

A. Student - The student must be familiar with atomic structure, atomic mass, nuclear particles, and isotopes.

B. Materials - none

DISCUSSION:

A. Operational Suggestions

The presentation of this program can be utilized to occupy one forty-five minute teaching period, even though the actual running time is approximately 10 minutes.

B. Suggested Follow-up

The occurrence of built-in error, due to the use of average atomic weights, generally provokes discussion as to the reasons for the error.

```
IF INSTRUCTIONS DESIRED, TYPE 1,  IF NOT, TYPE 0? 1

THIS PROGRAM WILL CALCULATE AVOGADRO'S NUMBER BY USING
ANY PURE GASEOUS ELEMENT OR BINARY COMPOUND.

THIS VALUE WILL BE CALCULATED BY USING THE MASS IN GRAMS
OF THE NEUTRON, WHICH IS : 1.674363E-24
AND THE MASS OF THE PROTON, WHICH IS : 1.672059E-24

YOU MUST SUPPLY THE ATOMIC NUMBER AND THE ATOMIC WEIGHT OF
EACH ELEMENT USED.  CARRY DIGITS UP TO 6 PLACES IF YOU
WISH.  WHEN THE MACHINE ASKS (?) INPUT THE ATOMIC NUMBER
AND THE ATOMIC WEIGHT OF THE FIRST ELEMENT, THEN THE
ATOMIC NUMBER AND THE ATOMIC WEIGHT OF THE SECOND IN THE
FORM A,B,C,D.  IF USING SINGLE ELEMENTS, BE SURE TO
PUT IN 0 FOR VALUES C AND D.

               **************

NOW INPUT THE VALUES FOR YOUR COMPOUND
? 6,12.0012,8,15.9994
INPUT THE NUMBER OF ATOMS FOR EACH ELEMENT.
(CO2 WOULD BE 1,2)  :? 1,2

*** THE NUMBER OF PARTICLES PER MOLE OF THIS GAS IS 5.976496E+23

WOULD YOU LIKE TO TRY ANOTHER PROBLEM ?
TYPE 1 IF YES, TYPE 0 IF NO  ? 1

               **************

NOW INPUT THE VALUES FOR YOUR COMPOUND
? 8,15.994,0,0
INPUT THE NUMBER OF ATOMS FOR EACH ELEMENT.
(CO2 WOULD BE 1,2)  :? 2,0

*** THE NUMBER OF PARTICLES PER MOLE OF THIS GAS IS 5.976497E+23

WOULD YOU LIKE TO TRY ANOTHER PROBLEM ?
TYPE 1 IF YES, TYPE 0 IF NO  ? 0


READY
```

```
100 REM  JOHN MARCHISOTTO  PIB SUMMER '69  7/2/69
103 REM  REVISED BY C.LOSIK  7-27-70
105 REM  A,B=AT NO, AT WT OF FIRST,  C,D=AT NO, AT WT OF SECOND
106 REM  E,F=# ATOMS FIRST, # ATOMS SECOND
110 PRINT "IF INSTRUCTIONS DESIRED, TYPE 1,  IF NOT, TYPE 0";
112 REM  G=PROTON MASS, H=NEUTRON MASS
113 LET G=1.602E-19/9.561E4
116 LET H=1.0086*G/1.0072
120 INPUT N
130 IF N=0 THEN 220
131 IF N<>1 THEN 110
135 PRINT
140 PRINT "THIS PROGRAM WILL CALCULATE AVOGADRO'S NUMBER BY USING"
150 PRINT "ANY PURE GASEOUS ELEMENT OR BINARY COMPOUND."
151 PRINT
152 PRINT "THIS VALUE WILL BE CALCULATED BY USING THE MASS IN GRAMS"
153 PRINT "OF THE NEUTRON, WHICH IS :";H
154 PRINT "AND THE MASS OF THE PROTON, WHICH IS :";G
155 PRINT
156 PRINT "YOU MUST SUPPLY THE ATOMIC NUMBER AND THE ATOMIC WEIGHT OF"
157 PRINT "EACH ELEMENT USED.  CARRY DIGITS UP TO 6 PLACES IF YOU"
158 PRINT "WISH.  WHEN THE MACHINE ASKS (?) INPUT THE ATOMIC NUMBER"
159 PRINT "AND THE ATOMIC WEIGHT OF THE FIRST ELEMENT, THEN THE"
160 PRINT "ATOMIC NUMBER AND THE ATOMIC WEIGHT OF THE SECOND IN THE"
161 PRINT "FORM A,B,C,D.  IF USING SINGLE ELEMENTS, BE SURE TO"
162 PRINT "PUT IN 0 FOR VALUES C AND D."
220 PRINT
222 PRINT " ","***************"
224 PRINT
230 PRINT "NOW INPUT THE VALUES FOR YOUR COMPOUND"
240 INPUT A,B,C,D
250 PRINT "INPUT THE NUMBER OF ATOMS FOR EACH ELEMENT."
260 PRINT "(CO2 WOULD BE 1,2)  :";
270 INPUT E,F
339 PRINT
340 PRINT "*** THE NUMBER OF PARTICLES PER MOLE OF THIS GAS IS";
350 PRINT ((E*B)+(F*D))/((((E*A)+(F*C))*G)+((E*(B-A))+(F*(D-C)))*H)
355 PRINT
360 PRINT "WOULD YOU LIKE TO TRY ANOTHER PROBLEM ?"
370 PRINT "TYPE 1 IF YES, TYPE 0 IF NO  ";
380 INPUT N
390 IF N=1 THEN 220
395 IF N<>0 THEN 370
400 END
```

DISCIPLINE CHEMISTRY

SUBJECT RADIOACTIVE DECAY

PROGRAM NAME DECAY1

DESCRIPTION:

Radioactive decay is treated pseudo-quantitatively, by permitting the student to determine the approximate number of radioactive particles remaining after various times.

OBJECTIVES:

To induce a "feel" for exponential decay, by repeated exercises.

PRELIMINARY PREPARATION:

A. Student-Awareness of terms: Half-life, exponential, and radioactivity

B. Materials-none

DISCUSSION:

The concept of radioactive decay is presented in a game format, allowing the student to challenge his own ability in determining (with 5, 10, or 20% error), the number of radioactive "chips" remaining after various times. The number of chips successively decreases with each trial, increasing the level of difficulty as the program runs. In each case, the exact number remaining is given, following the students' entered value.

Individuals or small groups find this program exciting. They enjoy the game approach, at least the first time through it, and seem to be motivated by the opportunity to "break the bank."

This program can be used as an integral part of a class lesson to introduce the concept, or to motivate group discussion and participation concerning the phenomenon.

```
                ---THE NEW CLEA CASINO---

     MR. A. TOM MICK, GENERAL MANAGER OF THE NEW CLEA CASINO,
HAS, AT TIME  T=0,  DISCOVERED  100,000 RADIOACTIVE PLAYING
CHIPS AT HIS TABLE. THEIR HALF-LIFE IS 10 MINUTES. EACH CHIP
TRANSMUTES SPONTANEOUSLY AND COMPLETELY IN A RANDOM FASHION.

     AT VARIOUS TIMES T, AFTER T=0, YOU MUST DETERMINE WITHIN
A CERTAIN PERCENTAGE, HOW MANY CHIPS ARE LEFT.

     TO FURTHER THE INTEREST OF THE GAME, YOU WILL START WITH
$1,000 AND THE HOUSE WITH AN UNSPECIFIED AMOUNT.  HALF THE
MONEY YOU HAVE WILL RIDE ON EACH GUESS YOU TAKE.  LET'S SEE
IF YOU CAN BREAK THE HOUSE BEFORE THE CHIPS RUN OUT.

THE HOUSE OFFERS THE FOLLOWING ODDS:
     2) 2 TO 1 ODDS FOR GUESSING WITHIN 20 PERCENT
     4) 4 TO 1 ODDS FOR GUESSING WITHIN 10 PERCENT
     8) 8 TO 1 ODDS FOR GUESSING WITHIN  5 PERCENT.

ENTER THE NUMBER 2, 4, OR 8 FOR THE ODDS YOU WANT AFTER THE
QUESTION MARK IN THE COLUMN LABELLED ODDS.

YOUR $          HOUSE $         TIME (MIN)      ODDS

 1000           1.000000E+6     7.2             ? 8
HOW MANY CHIPS LEFT ? 60700
ACTUAL NUMBER LEFT IS  60716
YOU WON. TRY AGAIN.

 5000           996000          13.9            ? 8
HOW MANY CHIPS LEFT ? 38150
ACTUAL NUMBER LEFT IS  38164
YOU WON. TRY AGAIN.

 25000          976000          26.9            ? 8
HOW MANY CHIPS LEFT ? 15500
ACTUAL NUMBER LEFT IS  15502
YOU WON. TRY AGAIN.

 125000         876000          30.7            ? 8
HOW MANY CHIPS LEFT ? 11900
ACTUAL NUMBER LEFT IS  11913
YOU CAN BREAK THE HOUSE IF YOU TRY A LONG SHOT.

 625000         376000          46.4            ? 8
HOW MANY CHIPS LEFT ? 3500
ACTUAL NUMBER LEFT IS  3494
YOU BROKE THE HOUSE. YOU NEEDED ONLY THE MINIMUM NUMBER OF GUESSES.
CONGRATULATIONS.
YOU MUST KNOW A LOT ABOUT RADIOACTIVITY AND THINGS.
THANKS FOR PLAYING..
-------------------------------------------------------------

                                        CHECK NO. 3499

                                    DATE: ------------19--


 PAY TO THE ORDER OF--------CASH------$ 1.001000E+6

 THE NEW CLEA CASINO                    A. TOM MICK
                                        GENERAL MANAGER

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

DONT SPEND IT ALL IN ONE PLACE.

READY
```

```
100 REM  RICHARD F. PAV, PATCHOGUE H.S., (PHYSICS)  REVISED NOV. 86,1968
105 RANDOMIZE
110 REM  THIS IS A GAME BASED ON RADIOACTIVE DECAY.
120 PRINT "                ---THE NEW CLEA CASINO---"
130 PRINT
140 PRINT "     MR. A. TOM MICK, GENERAL MANAGER OF THE NEW CLEA CASINO"
150 PRINT "HAS, AT TIME  T=0,  DISCOVERED  100,000 RADIOACTIVE PLAYING"
160 PRINT "CHIPS AT HIS TABLE. THEIR HALF-LIFE IS 10 MINUTES. EACH CHIP"
170 PRINT "TRANSMUTES SPONTANEOUSLY AND COMPLETELY IN A RANDOM FASHION."
180 PRINT
190 PRINT "     AT VARIOUS TIMES T, AFTER T=0, YOU MUST DETERMINE WITHIN
200 PRINT "A CERTAIN PERCENTAGE, HOW MANY CHIPS ARE LEFT."
210 PRINT
220 PRINT "     TO FURTHER THE INTEREST OF THE GAME, YOU WILL START WITH
230 PRINT "$1,000 AND THE HOUSE WITH AN UNSPECIFIED AMOUNT.  HALF THE"
240 PRINT "MONEY YOU HAVE WILL RIDE ON EACH GUESS YOU TAKE.  LET'S SEE"
250 PRINT "IF YOU CAN BREAK THE HOUSE BEFORE THE CHIPS RUN OUT."
260 PRINT
270 PRINT "THE HOUSE OFFERS THE FOLLOWING ODDS:"
280 PRINT "     8) 2 TO 1 ODDS FOR GUESSING WITHIN 20 PERCENT"
290 PRINT "     4) 4 TO 1 ODDS FOR GUESSING WITHIN 10 PERCENT"
300 PRINT "     8) 8 TO 1 ODDS FOR GUESSING WITHIN  5 PERCENT."
310 PRINT
320 PRINT "ENTER THE NUMBER 8, 4, OR 8 FOR THE ODDS YOU WANT AFTER THE"
330 PRINT "QUESTION MARK IN THE COLUMN LABELLED ODDS."
340 PRINT
350 PRINT "YOUR $",  "HOUSE $",  "TIME (MIN)",  "ODDS"
360 LET A=0
370 LET B=0
380 LET T=0
390 LET Y=1000
400 LET C=0
410 PRINT
420 IF ABS(G-D)<1500 THEN 450
430 LET G=5
440 LET D=2
450 LET B=B+1
460 FOR I=1 TO 3+A+ABS(G-D)
470 LET T3=INT(100*RND(-Y))/10
480 NEXT I
490 LET T=T+T3
500 LET D=INT(1E5*EXP(-.0693*T))
510 IF D=0 THEN 860
520 PRINT Y,1001000-Y,T,
530 INPUT A
540 IF A=2 THEN 610
550 IF A=4 THEN 610
560 IF A=8 THEN 610
570 PRINT "SORRY PAL, WE DONT OFFER THOSE ODDS."
580 IF C=1 THEN 820
590 LET C=1
600 GOTO 580
610 PRINT "HOW MANY CHIPS LEFT ";
620 INPUT G
630 PRINT "ACTUAL NUMBER LEFT IS ";D
640 IF A=2 THEN 700
650 IF A=4 THEN 680
660 LET P=.05
670 GOTO 710
680 LET P=.1
690 GOTO 710
700 LET P=.2
```

```
710 LET T=10*B
720 IF ABS(D-G)<=P*D THEN 770
730 LET Y=INT(Y-Y/8)
740 IF Y<=50 THEN 820
750 PRINT "TOO BAD, YOU LOST. TRY AGAIN."
760 GOTO 400
770 LET Y=INT(Y+A*Y/2)
780 IF 1000000-Y<1 THEN 890
790 IF Y>825 THEN 840
800 PRINT "YOU WON. TRY AGAIN."
810 GOTO 400
820 PRINT "IT SEEMS YOU JUST CANT GET THE HANG OF IT. SAVE YOUR BREAD."
830 GOTO 960
840 PRINT "YOU CAN BREAK THE HOUSE IF YOU TRY A LONG SHOT."
850 GOTO 400
860 PRINT "OOOOPS... SORRY PAL, THE LAST CHIP JUST DISINTEGRATED."
870 PRINT "THE HOUSE IS CLOSED."
880 GOTO 960
890 PRINT "YOU BROKE THE HOUSE. YOU NEEDED ONLY ";
895 LET Y=1001000
900 IF B>5 THEN 930
910 PRINT "THE MINIMUM NUMBER OF GUESSES."
920 GOTO 940
930 PRINT B;"GUESSES."
940 PRINT "CONGRATULATIONS."
950 PRINT "YOU MUST KNOW A LOT ABOUT RADIOACTIVITY AND THINGS."
960 PRINT "THANKS FOR PLAYING.."
970 PRINT
980 PRINT "------------------------------------------------------------"
990 PRINT
1000 PRINT "                                        CHECK NO."B*D
1010 PRINT
1020 PRINT "                                    DATE: ";
1030 PRINT "-------------19--"
1040 PRINT
1050 PRINT
1060 PRINT " PAY TO THE ORDER OF--";
1070 PRINT "-------CASH-------";
1080 PRINT "$";Y
1090 PRINT
1100 PRINT
1110 PRINT " THE NEW CLEA CASINO                    A. TOM MICK"
1120 PRINT "                                        GENERAL MANAGER"
1130 PRINT
1140 PRINT "------------------------------------------------------------"
1150 PRINT
1160 PRINT "DONT SPEND IT ALL IN ONE PLACE."
1170END
```

DISCIPLINE CHEMISTRY-PHYSICS

SUBJECT NUCLEAR DECAY

PROGRAM NAME DECAY2

DESCRIPTION:

This program will do the following:

A. Calculate half-life from 2 readings on a geiger counter, and the time between them.

B. Calculate mass of a radioactive sample remaining after some given amount of time.

C. Prints out a table showing mass or number of particles of a radioactive sample remaining vs. some range of time.

OBJECTIVES:

A. To provide tables and graphs for a better understanding of the exponential decay of a radioactive substance.

B. To provide a calculator for determining the amount of mass of a radioactive sample remaining after some given amount of time.

C. To provide a calculator for half-life experiments.

PRELIMINARY PREPARATION:

A. Student - The student should have a general introduction to half-life before the use of the program.

B. Materials - none

DISCUSSION:

It is difficult to teach about the exponential (logarithmic) manner by which radioactive elements decay without meaningful illustrations and simulations.

DISCUSSION: (con' t)

With this program, a number of interesting possibilities are available. For example, if the initial mass is 100 g and the time is equal to 10 half-lives with an increment equal to the half-life, the student will see the mass decrease to 0.1 g during that time. More important, the example may be generalized to show that for any radioactive sample:

after 1 half-life 50% of the substance remains
after 2 half-life 25% of the substance remains
after 3 half-life 12.5% of the substance remains
after 10 half-life 0.1% of the substance remains

You may also illustrate nuclear decay by using particles instead of mass. Use Avogadro' s number of particles with students who feel comfortable with scientific notation. For the others, you may use a number up to 1,000,000 without having exponential numbers print out in the table.

The fact that the teletype unit takes about 8 seconds to type out a line provides you with cute little gimmicks. Set up a run with 8 seconds (or any multiple of 8) and the print-out of the table will keep time with the decay of the sample substance.

Please note that the half-life calculations are not accurate for a small number of particles, thus it is misleading to make runs go to zero mass or zero particles.

```
DO YOU WANT INSTRUCTIONS (1=YES, 0=NO) : ? 1
  THIS PROGRAM WILL DO THE FOLLOWING:
       CHOICE 1 - CALCULATES HALF-LIFE FROM TWO READINGS
                  ON A GEIGER COUNTER.
       CHOICE 2 - CALCULATES HOW MUCH OF A RADIOACTIVE SAMPLE
                  WILL REMAIN AFTER SOME GIVEN AMOUNT OF TIME
       CHOICE 3 - PRINTS OUT A TABLE SHOWING MASS OF SAMPLE
                  VS. TIME OR NO. OF PARTICLES VS. TIME.
                  (GRAPH OPTIONAL) NOTE: FOR THE TABLE YOU
                  MUST INPUT TOTAL TIME AND TIME INCREMENT.
                   EXAMPLE: IF TOTAL TIME=100 AND TIME
                  INCREMENT=10, THEN TIME IN THE TABLE WILL
                  BE 10,20,30,.....,100.
        CHOICE 4 - END OF PROGRAM

                  NOTE: IN ANY ONE PROBLEM, TIME MUST
                  ALWAYS BE INPUTED IN THE SAME UNITS
                  OF MEASURE (IE: SECS.,MINS.,ETC.)

**********

WHAT IS YOUR CHOICE? 1

 WHAT IS THE INITIAL READING ON THE GEIGER COUNTER,
 THE SECOND READING, AND THE TIME BETWEEN READINGS.
? 1500,3000,36

INITIAL READING= 3000 SECOND READING= 1500 TIME= 36
HALF-LIFE= 35.99755

**********

WHAT IS YOUR CHOICE? 1

 WHAT IS THE INITIAL READING ON THE GEIGER COUNTER,
 THE SECOND READING, AND THE TIME BETWEEN READINGS.
? 775,1256,212
INITIAL READING= 1256 SECOND READING= 775 TIME= 212
HALF-LIFE= 304.3265

**********

WHAT IS YOUR CHOICE? 2

WHAT IS THE HALF-LIFE, INITIAL MASS OF SAMPLE, AND
TOTAL TIME OF DECAY? 16,56,76

HALF-LIFE= 16 INITIAL MASS= 56 TOTAL TIME= 76
MASS OF SAMPLE REMAINING= 3.000952

**********

WHAT IS YOUR CHOICE? 3

DO YOU WANT TO WORK WITH PARTICLES OR MASS? (ANSWER 1 FOR
 PARTICLES OR 2 FOR MASS) ? 1

 WHAT IS THE HALF-LIFE, INITIAL NUMBER OF PARTICLES IN THE
SAMPLE, TOTAL ELAPSED TIME FOR DECAY, AND THE
INCREMENT OF ELAPSED TIME? 10,6.02E23,100,10

HALF-LIFE= 10 INITIAL NO. OF PARTICLES= 6.020000E+23
TOTAL TIME= 100 INCREMENT= 10
```

TIME	PARTICLES	PART. LOSS	TOTAL PART. LOSS
0	6.020000E+23	0	0
10	3.010142E+23	3.009858E+23	3.009858E+23
20	1.505142E+23	1.505000E+23	4.514858E+23
30	7.526065E+22	7.525355E+22	5.267393E+23
40	3.76321UE+22	3.762855E+22	5.643679E+23
50	1.881694E+22	1.881516E+22	5.831831E+23
60	9.406913E+21	9.406826E+21	5.925911E+23
70	4.704677E+21	4.704235E+21	5.972953E+23
80	2.352459E+21	2.352218E+21	5.996475E+23
90	1.176201E+21	1.176170E+21	6.008237E+23
100	5.881681E+20	5.881126E+20	6.014118E+23

DO YOU WANT THE ABOVE DATA GRAPHED? (1=YES, 0=NO)? 1

MASS (OR PARTICLES) REMAINING

```
            0
6.020000E+23
TIME        |---------|---------|---------|---------|---------|
0           I                                                   *
10          I                             *
20          I                   *
30          I         *
40          I     *
50          I   *
60          I *
70          I*
80          I*
90          I*
100         I*
```

****

WHAT IS YOUR CHOICE? 3

DO YOU WANT TO WORK WITH PARTICLES OR MASS? (ANSWER 1 FOR PARTICLES OR 2 FOR MASS) ? 2

WHAT IS THE HALF-LIFE, INITIAL MASS OF SAMPLE, TOTAL ELAPSED TIME FOR DECAY, AND THE INCREMENT OF ELAPSED TIME? 15,100,150,15

HALF-LIFE= 15 INITIAL MASS= 100 TOTAL TIME= 150 INCREMENT= 15

TIME	MASS	MASS LOSS	TOTAL MASS LOSS
0	100	0	0
15	50.00236	49.99764	49.99764
30	25.00236	25	74.99764
45	12.50177	12.50059	87.49823
60	6.25118	6.25059	93.74882
75	3.125737	3.125443	96.87426
90	1.562942	1.562795	98.43706
105	.7815061	.7814344	99.21849
120	.3907725	.3907356	99.60923
135	.1953955	.195377	99.8046
150	.09770234	.09769313	99.90229

```
DO YOU WANT THE ABOVE DATA GRAPHED? (1-YES, 0-NO)? 1

                              MASS (OR PARTICLES) REMAINING

                  0                                                  100
TIME              I---------I---------I---------I---------I---------I
 0                I                                                  *
 15               I                              *
 30               I                   *
 45               I          *
 60               I    *
 75               I  *
 90               I*
 105              *
 120              *
 135              *
 150              *

**********

WHAT IS YOUR CHOICE? 4


READY
```

```
100 REM M. DOWKAN+ J. MARCHISOTTO PIB 7/24/69
105 REM  REVISED BY C.LOSIK  8-12-70
110 REM CALCULATION OF HALF-LIFE AND REMAINING MASS INCLUDING
120 REM TABLES AND GRAPHS.
122 PRINT "DO YOU WANT INSTRUCTIONS (1=YES, 0=NO) ? ";
124 INPUT A
126 IF A=0 THEN 300
128 IF A<>1 THEN 122
130 PRINT "  THIS PROGRAM WILL DO THE FOLLOWING:"
140 PRINT "       CHOICE 1 = CALCULATES HALF-LIFE FROM TWO READINGS"
150 PRINT "                  ON A GEIGER COUNTER."
160PRINT"       CHOICE 2 = CALCULATES HOW MUCH OF A RADIOACTIVE SAMPLE"
170PRINT"                  WILL REMAIN AFTER SOME GIVEN AMOUNT OF TIME"
180 PRINT "       CHOICE 3 = PRINTS OUT A TABLE SHOWING MASS OF SAMPLE"
190 PRINT"                  VS. TIME OR NO. OF PARTICLES VS. TIME."
200 PRINT"                  (GRAPH OPTIONAL) NOTE: FOR THE TABLE YOU"
210 PRINT"                  MUST INPUT TOTAL TIME AND TIME INCREMENT."
220PRINT"                  EXAMPLE: IF TOTAL TIME=100 AND TIME"
230 PRINT"                  INCREMENT=10, THEN TIME IN THE TABLE WILL"
240 PRINT"                  BE 10,20,30,.....,100."
250 PRINT"       CHOICE 4 = END OF PROGRAM"
260 PRINT
270 PRINT"                  NOTE: IN ANY ONE PROBLEM,TIME MUST"
280 PRINT"                  ALWAYS BE INPUTED IN THE SAME UNITS"
290 PRINT"                  OF MEASURE (IE: SECS.,MINS.,ETC.)"
300 PRINT
310 PRINT"**********"
320 PRINT
330 PRINT "WHAT IS YOUR CHOICE";
340 INPUT A
350PRINT
360 IF A=1 THEN 410
370 IF A=2 THEN 450
380 IF A=3 THEN 570
390 IF A<>4 THEN 320
400 STOP
410PRINT" WHAT IS THE INITIAL READING ON THE GEIGER COUNTER,"
420 PRINT" THE SECOND READING, AND THE TIME BETWEEN READINGS."
430 INPUT B,A,C
433 IF A>B THEN 440
435 PRINT "INITIAL READING IS ALWAYS LESS THAN FINAL READING."
437  GO TO 430
440 LET D=(.6931*C)/LOG(A/B)
450 PRINT
460 PRINT "INITIAL READING="A;"SECOND READING="B;"TIME="C
470 PRINT "HALF-LIFE="D
480 GO TO 300
490 PRINT "WHAT IS THE HALF-LIFE, INITIAL MASS OF SAMPLE, AND"
500 PRINT "TOTAL TIME OF DECAY";
510 INPUT E,F,G
520 LET H=F*EXP(-.6931*G/E)
530 PRINT
540PRINT"HALF-LIFE="E;"INITIAL MASS="F;"TOTAL TIME="G
550 PRINT "MASS OF SAMPLE REMAINING="H
560 GO TO 300
570 PRINT "DO YOU WANT TO WORK WITH PARTICLES OR MASS? (ANSWER 1 FOR"
580 PRINT" PARTICLES OR 2 FOR MASS) ";
590 INPUT J
600 PRINT
610 IF J=1 THEN 760
615 IF J<>2 THEN 570
620 PRINT" WHAT IS THE HALF-LIFE, INITIAL MASS OF SAMPLE,TOTAL"
630 PRINT"ELAPSED TIME FOR DECAY, AND THE INCREMENT OF "
640 PRINT"ELAPSED TIME";
650 INPUT E,F,G,M
660 LET V=
670 LET C=0
```

16

```
680 LET Z=F
690 PRINT
700 IF J=1 THEN 800
710 PRINT"HALF-LIFE="E;"INITIAL MASS="F;"TOTAL TIME="K;"INCREMENT="M
720 PRINT
730 PRINT "TIME", "MASS", "MASS LOSS", "TOTAL MASS LOSS"
740 PRINT "-----", "-----", "----- ----", "----- ---- ----"
750 GO TO 850
760 PRINT" WHAT IS THE HALF-LIFE, INITIAL NUMBER OF PARTICLES IN THE"
770 PRINT" SAMPLE, TOTAL ELAPSED TIME FOR DECAY, AND THE "
780 PRINT" INCREMENT OF ELAPSED TIME";
790GO TO 650
795 PRINT
800 PRINT"HALF-LIFE="E;"INITIAL NO. OF PARTICLES="F
810 PRINT"TOTAL TIME="K;"INCREMENT="M
820 PRINT
830 PRINT" TIME", " PARTICLES", "PART. LOSS", "TOTAL PART. LOSS"
840 PRINT" ----", " ----------", "----- ----", "----- ----- ----"
850 PRINT
860 FOR G = 0 TO K STEP M
870 LET H=F*EXP(-.6931*G/E)
880 LET W=ABS(H-Z)
890 LET Q=Q+W
900 IF F >1E6 THEN 920
910 IF J=1 THEN 940
920 PRINT G,H,W,Q
930 GO TO 950
940 PRINT INT(G+.5),INT(H+.5),INT(W+.5),INT(Q+.5)
950 LET Z=H
960 NEXT G
970 PRINT
980 PRINT
990 PRINT
1000 PRINT" DO YOU WANT THE ABOVE DATA GRAPHED? (1=YES, 0=NO)";
1010 INPUT R
1020 IF R=0 THEN 300
1023 IF R<>1 THEN 1000
1030 PRINT
1040 PRINT
1050 PRINT
1060 PRINT TAB(30);"MASS (OR PARTICLES) REMAINING"
1070 PRINT
1080 PRINT " ","0";TAB(62);F
1100PRINT"TIME","I---------I---------I---------I---------I---------I"
1120 FOR G = 0 TO K STEP M
1130 LET H=F*EXP(-.6931*G/E)
1140 LET H1=INT(H/F*50+.5)
1150 IF H1<=50 THEN 1170
1160 LET H1=50
1170 PRINT G,"I";TAB(H1+14.5);"*"
1250 NEXT G
1260 GO TO 300
1280 END
```

DISCIPLINE CHEMISTRY

SUBJECT EMPIRICAL FORMULAE

PROGRAM NAME EMPIR

DESCRIPTION:

A classroom demonstration designed to calculate the empirical formulae from atomic mass (atomic weight) and percent composition.

OBJECTIVES:

A. To distinguish between molecular and empirical formulae

B. To illustrate the law of multiple proportions.

C. To emphasize the unity of the atom when writing chemical formulae

D. To demonstrate the importance of accurate calculation with empirical formulae problems

PRELIMINARY PREPARATION:

A. Student - The student should have some experience in writing chemical formulae and calculating percent composition from chemical formulae. An understanding of significant figures would also add to the value of the lesson.

B. Materials - none

DISCUSSION:

In this program the atomic number is used for identification only and has no part in the actual calculations.

The student generally has difficulty understanding the function of the ratio in calculating empirical formulae. This program is designed to emphasize that function.

The importance of significant figures could also be illustrated. The students' tendency to approximate generally results in numbers of questionable value. In this program, by using a series of calculations for the same compound with figures of progressively greater accuracy, an empirical formula closer to whole numbers will be obtained.

```
 THIS PROGRAM WILL FIND THE EMPIRICAL FORMULA FOR
ANY COMPOUND CONTAINING UP TO FIVE DIFFERENT ELEMENTS

  WHEN INFORMATION IS REQUESTED, TYPE IN THE ATOMIC
 NUMBER, THE ATOMIC WEIGHT, AND THE PCT COMPOSITION BY
 WEIGHT IN THAT ORDER; FOR EXAMPLE, IN THE COMPOUND SO2,
 THE DATA WOULD BE ENTERED AS FOLLOWS:  16,32.50 FOR
 SULFUR AND 8,16,50 FOR OXYGEN.

 HOW MANY ELEMENTS DOES YOUR UNKNOWN COMPOUND CONTAIN? 2
 ENTER THE ATOMIC NUMBER, THE ATOMIC WEIGHT, AND THE
 PCT COMPOSITION FOR EACH OF THE ELEMENTS IN YOUR COMPOUND.
 BE SURE TO ENTER ONE SET OF NUMBERS FOR EACH QUESTION MARK.

      1 .  ? 26,55.9,69.96
      2 .  ? 8,16,30.04

 ATOMIC          PCT.          INITIAL          RATIO*2          RATIO*3
NUMBER          COMP.          RATIO
 26              69.96          1                2                3
 8               30.04          1.5              3                4.5

 TO FIND THE EMPIRICAL FORMULA LOCATE THE FIRST RATIO
 COLUMN IN WHICH ALL OF THE NUMBERS MOST CLOSELY APPROXIMATE
 A WHOLE NUMBER.
IF YOU WOULD LIKE TO TRY AGAIN TYPE 1, IF NOT TYPE 0.? 1

 HOW MANY ELEMENTS DOES YOUR UNKNOWN COMPOUND CONTAIN? 3
 ENTER THE ATOMIC NUMBER, THE ATOMIC WEIGHT, AND THE
 PCT COMPOSITION FOR EACH OF THE ELEMENTS IN YOUR COMPOUND.
 BE SURE TO ENTER ONE SET OF NUMBERS FOR EACH QUESTION MARK.

      1 .  ? 1,1,2
      2 .  ? 16,32,32.7
      3 .  ? 8,16,65.3

 ATOMIC          PCT.          INITIAL          RATIO*2          RATIO*3
NUMBER          COMP.          RATIO
 1               2              2                3.9              5.9
 16              32.7           1                2                3
 8               65.3           4                8                12

IF YOU WOULD LIKE TO TRY AGAIN TYPE 1, IF NOT TYPE 0.? 1

 HOW MANY ELEMENTS DOES YOUR UNKNOWN COMPOUND CONTAIN? 1
 THE EMPIRICAL FORMULA FOR A COMPOUND THAT CONTAINS ONLY
 A SINGLE ELEMENT IS STRAIGHTFORWARD.

IF YOU WOULD LIKE TO TRY AGAIN TYPE 1, IF NOT TYPE 0.? 0


READY
```

```
100  REM  JOHN MARCHISOTTO  BASIC  7/14/69  PB1  EMPIR*
105 REM  REVISED BY C.LOSIK  7-31-70
106 REM A(I)=ATOMIC NOS, B(I)=AT WTS AND THEN C(1)/B(1), C(I)=PCT COMP
130 PRINT " THIS PROGRAM WILL FIND THE EMPIRICAL FORMULA FOR "
140 PRINT "ANY COMPOUND CONTAINING UP TO FIVE DIFFERENT ELEMENTS"
150 PRINT
160 PRINT "  WHEN INFORMATION IS REQUESTED, TYPE IN THE ATOMIC"
170 PRINT " NUMBER, THE ATOMIC WEIGHT, AND THE PCT COMPOSITION BY"
180 PRINT " WEIGHT IN THAT ORDER; FOR EXAMPLE, IN THE COMPOUND SO2,"
190 PRINT " THE DATA WOULD BE ENTERED AS FOLLOWS:  16,32,50 FOR"
200 PRINT " SULFUR AND 8,16,50 FOR OXYGEN."
210 PRINT
220 DIM A(5),B(5),C(5)
230 LET W=0
240 PRINT " HOW MANY ELEMENTS DOES YOUR UNKNOWN COMPOUND CONTAIN";
280 INPUT Z
285 IF Z=1 THEN 930
290 FOR I=2 TO 5
295 IF I=Z THEN 320
300 NEXT I
305 PRINT "ENTER AN INTEGER FROM 1 TO 5."
310 GO TO 240
320 PRINT " ENTER THE ATOMIC NUMBER, THE ATOMIC WEIGHT, AND THE"
330 PRINT " PCT COMPOSITION FOR EACH OF THE ELEMENTS IN YOUR COMPOUND."
340 PRINT " BE SURE TO ENTER ONE SET OF NUMBERS FOR EACH QUESTION MARK."
350 LET S=0
355 LET F=1E25
357 PRINT
360 FOR I=1 TO Z
370 PRINT TAB(5);I;".  ";
380 INPUT A(I), B(I), C(I)
383 LET B(I)=C(I)/B(I)
385 IF B(I)>F THEN 390
387 LET F=B(I)
389 REM  MAKE SURE SUM OF PCT COMPS = 100
390 LET S=S+C(I)
400 NEXT I
410 IF ABS(S-100)<.1 THEN 760
420 PRINT "THE PCT COMPOSITION DOES NOT TOTAL 100 PERCENT."
430 PRINT "ADJUST DATA AND REENTER."
440 GO TO 320
700 REM  PRINT RATIOS
760 PRINT
770 PRINT " ATOMIC"," PCT. ","INITIAL","RATIO*2","RATIO*3"
780 PRINT "NUMBER","COMP.","RATIO"
800 FOR I=1 TO Z
810 PRINT A(I),C(I),INT(10*B(I)/F+.5)/10,
820 PRINT INT(20*B(I)/F+.5)/10,
830 PRINT INT(30*B(I)/F+.5)/10
840 NEXT I
845 PRINT
850 IF W = 1 THEN 950
870 PRINT " TO FIND THE EMPIRICAL FORMULA LOCATE THE FIRST RATIO"
880PRINT" COLUMN IN WHICH ALL OF THE NUMBERS MOST CLOSELY APPROXIMATE"
890 PRINT " A WHOLE NUMBER."
900 GO TO 950
930 PRINT " THE EMPIRICAL FORMULA FOR A COMPOUND THAT CONTAINS ONLY"
940 PRINT " A SINGLE ELEMENT IS STRAIGHTFORWARD."
945 PRINT
950 PRINT "IF YOU WOULD LIKE TO TRY AGAIN TYPE 1, IF NOT TYPE 0.";
980 INPUT W
985 PRINT
990 IF W = 1 THEN 240
1000 IF W<>0 THEN 950
1070 END
```

DISCIPLINE CHEMISTRY

SUBJECT EQUILIBRIUM

PROGRAM NAME EQUIL1 and EQUIL2

DESCRIPTION:

This program calculates the effects of concentration changes in the equilibrium systems $2HI \rightleftharpoons H_2 + I_2$ and $PCl_5 \rightleftharpoons PCl_3 + Cl_2$.

OBJECTIVES:

A. To show that an equilibrium system is a dynamic one.

B. To illustrate and reinforce Le Chateliers principle.

C. An exercise in the interpretation of experimental data.

D. The significance of the Equilibrium constants.

PRELIMINARY PREPARATION:

A. Student - The student should have been made aware of "reversible" reactions, equilibrium systems and Le Chateliers principle.

B. Materials - none

DISCUSSION:

These two programs can be used as classroom demonstrations to illustrate the effect of varying the concentration of one of the products of a system at Equilibrium. The results are given not only as a table, but also graphically, since it was found that students have less trouble recognizing trends when they can be illustrated.

The equilibrium constant can also be changed to show its effect on the equilibrium system.

As always, the teacher should have run the program he wishes to use prior to its classroom presentation since the choice of constants will determine the slope of the curves.

NOTE:

The vertical axis (horizontal on the output) is labeled in percent of maximum y value.

```
THIS PROGRAM WILL INVESTIGATE THE EQUILIBRIUM SYSTEM

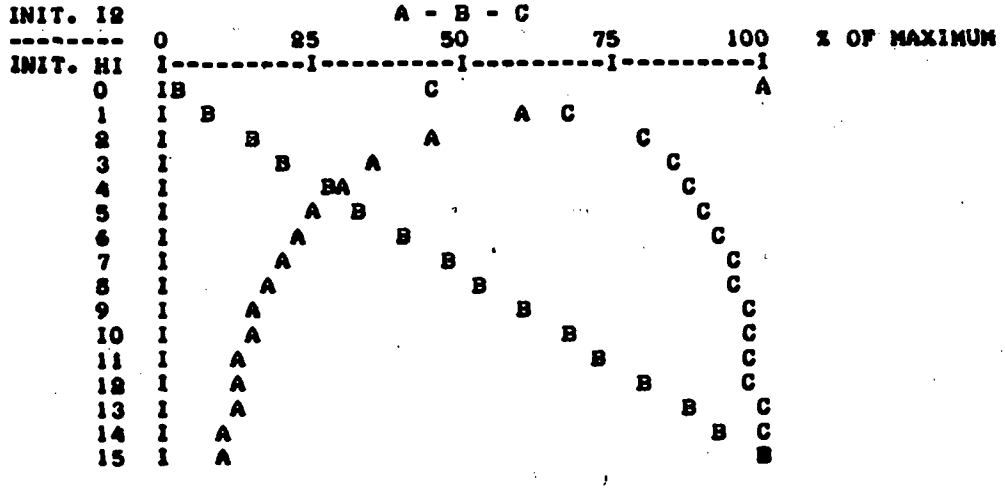
            2HI = H2 + I2

WHAT IS THE EQUILIBRIUM CONSTANT? .5
WHAT IS THE INITIAL CONCENTRATION OF HI? 2

WOULD YOU LIKE THE RESULTS PLOTTED (1), TABULATED (2)
OR BOTH (3) (TYPE THE APPROPRIATE NUMBER)? 3
```

INIT. I2 / INIT. HI	EQUIL. H2 / INIT. HI	EQUIL. I2 / INIT. HI	EQUIL. HI / INIT. HI
0	.2928932	.2928932	.4142136
1	.1771243	1.177124	.6457513
2	.1291713	2.129171	.7416574
3	.1020842	3.102084	.7958316
4	.08452404	4.084524	.8309519
5	.0721727	5.072173	.8556546
6	.06299609	6.062996	.8740078
7	.05590278	7.055903	.8881944
8	.0502585	8.050252	.899495
9	.04564393	9.045644	.9087121
10	.04161236	10.04161	.9163753
11	.03857601	11.03858	.922848
12	.03580582	12.03581	.9283884
13	.03340775	13.03341	.9331845
14	.03131127	14.03131	.9373775
15	.0294627	15.02946	.9410746

```
A: (EQUIL. H2)/(INIT. HI)      MAXIMUM IS  .2928932
B: (EQUIL. I2)/(INIT. HI)      MAXIMUM IS  15.02946
C: (EQUIL. HI)/(INIT. HI)      MAXIMUM IS  .9410746
```




```
*****

WOULD YOU LIKE ANOTHER RUN (1-YES, 0-NO)? 0

READY
```

```
100 REM EQUILIBRIUM SYSTEM, JOHN MARCHISOTTO
101 REM REVISED 8/20/70 (D. PESSEL)
105 DIM D(80),E(20),F(80),W(3)
106 LET D1=0
107 LET E1=0
108 LET F1=0
120 PRINT "THIS PROGRAM WILL INVESTIGATE THE EQUILIBRIUM SYSTEM"
121 PRINT
122 PRINT "              2HI = H2 + I2"
130 PRINT
140 PRINT "WHAT IS THE EQUILIBRIUM CONSTANT";
141 INPUT K
142 IF K>=0 THEN 150
143 PRINT "THE EQUILIBRIUM CONSTANT MUST BE NON-NEGATIVE."
144 GO TO 140
150 PRINT "WHAT IS THE INITIAL CONCENTRATION OF HI";
151 INPUT C
152 IF C>=0 THEN 159
153 PRINT "THE INITIAL CONCENTRATION OF HI MUST BE NON-NEGATIVE."
154 GO TO 150
159 PRINT
160 PRINT "WOULD YOU LIKE THE RESULTS PLOTTED (1), TABULATED (2)"
161 PRINT "OR BOTH (3) (TYPE THE APPROPRIATE NUMBER)";
162 INPUT Q1
180 IF Q1<2 THEN 195
183 PRINT
184 PRINT
185 PRINT "INIT. I2","  EQUIL. H2","  EQUIL. I2","  EQUIL. HI"
186 PRINT "--------","  ---------","  ---------","  ---------"
187 PRINT "INIT. HI","  INIT. HI","  INIT. HI","  INIT. HI"
188 PRINT
195 LET A=4*K
196 LET B=1-A
200 FOR X=1 TO 16
201 LET X1=X-1
210 LET D(X)=(-(A+X1)+SQR((A+X1)↑2+A*B))/(2*B)
220 LET E(X)=X1+D(X)
230 LET F(X)=1-2*D(X)
240 IF Q1<2 THEN 260
250 PRINT X1,D(X),E(X),F(X)
260 IF D(X)<D1 THEN 270
265 LET D1=D(X)
270 IF E(X)<E1 THEN 280
275 LET E1=E(X)
280 IF F(X)<F1 THEN 290
285 LET F1=F(X)
290 NEXT X
295 IF Q1<>2 THEN 395
300 PRINT
330 PRINT "*****"
331 PRINT
340 PRINT "WOULD YOU LIKE ANOTHER RUN (1-YES, 0-NO)";
350 INPUT Q2
360 IF Q2>0 THEN 140
370 STOP
390 REM PLOTTING ROUTINE FOR THREE CURVES
395 PRINT
396 PRINT
400 PRINT "A: (EQUIL. H2)/(INIT. HI)       MAXIMUM IS "D1
401 PRINT "B: (EQUIL. I2)/(INIT. HI)       MAXIMUM IS "E1
402 PRINT "C: (EQUIL. HI)/(INIT. HI)       MAXIMUM IS "F1
403 PRINT
404 PRINT "INIT. I2";TAB(26);"A - B - C"
405 PRINT "--------  0         25         50         75         100";
```

```
406 PRINT "   % OF MAXIMUM"
408 PRINT "INIT. HI  I---------I---------I---------I---------I"
410 FOR X=1 TO 16
420 PRINT TAB(5);X-1;TAB(10);"I";
430 LET W(1)=INT(40*D(X)/D1+.5)
431 LET W(2)=INT(40*E(X)/E1+.5)
432 LET W(3)=INT(40*F(X)/F1+.5)
580 REM  FIND WHICH IS SMALLEST, THEN PRINT IT AND MAXIMIZE IT
600 FOR Q=1 TO 3
605 LET K1=1E20
610 FOR I=1 TO 3
620 IF W(I)>K1 THEN 640
630 LET K1=W(I)
640 NEXT I
650 PRINT TAB(K1+10);
660 FOR I=1 TO 3
670 IF ABS(W(I)-K1)<.0001 THEN 700
680 NEXT I
690 STOP
700 IF I<>1 THEN 730
710 PRINT "A";
720 GO TO 780
730 IF I<>2 THEN 760
740 PRINT "B";
750 GO TO 780
760 IF I<>3 THEN 690
770 PRINT "C";
780 LET W(I)=1E25
790 NEXT Q
795 PRINT " "
800 NEXT X
810 PRINT
815 PRINT
820 GO TO 330
999 END
```

```
THIS PROGRAM WILL INVESTIGATE THE EQUILIBRIUM SYSTEM

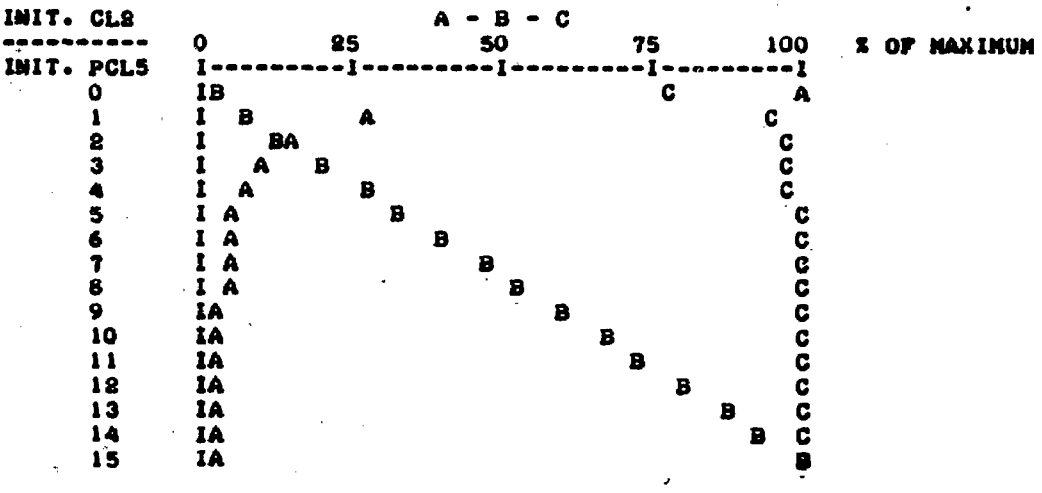
            PCL5 = PCL3 + CL2

WHAT IS THE EQUILIBRIUM CONSTANT? .75
WHAT IS THE INITIAL CONCENTRATION OF PCL5? 10

WOULD YOU LIKE THE RESULTS PLOTTED (1), TABULATED (8)
OR BOTH (3) (TYPE THE APPROPRIATE NUMBER)? 3
```

INIT. CL2 / INIT. PCL5	EQUIL. PCL3 / INIT. PCL5	EQUIL. CL2 / INIT. PCL5	EQUIL. PCL5 / INIT. PCL5
0	.2389168	.2389168	.7610832
1	.06574643	1.065746	.9342536
2	.03553601	2.035536	.964464
3	.0241998	3.0242	.9758002
4	.01832259	4.018323	.9816774
5	.01473555	5.014736	.9852645
6	.0123207	6.012321	.9876793
7	.01058486	7.010585	.9894151
8	9.277403E-3	8.009277	.9907226
9	8.256272E-3	9.008257	.991743
10	7.438660E-3	10.00744	.9925613
11	6.767869E-3	11.00677	.9932321
12	6.206003E-3	12.00621	.993792
13	5.733609E-3	13.00573	.9942664
14	5.326569E-3	14.00533	.9946734
15	4.973471E-3	15.00497	.9950265

```
A: (EQUIL. PCL3)/(INIT. PCL5)       MAXIMUM IS  .2389168
B: (EQUIL. CL2)/(INIT. PCL5)        MAXIMUM IS  15.00497
C: (EQUIL. PCL5)/(INIT. PCL5)       MAXIMUM IS  .9950265
```




```
*****

WOULD YOU LIKE ANOTHER RUN (1-YES, 0-NO)? 0

READY
```

```
100 REM EQUILIBRIUM SYSTEM, JOHN MARCHISOTTO
101 REM REVISED 8/20/70 (D. PESSEL)
105 DIM D(20),E(20),F(20),W(3)
106 LET D1=0
107 LET E1=0
108 LET F1=0
120 PRINT "THIS PROGRAM WILL INVESTIGATE THE EQUILIBRIUM SYSTEM"
121 PRINT
122 PRINT "             PCL5 = PCL3 + CL2"
130 PRINT
140 PRINT "WHAT IS THE EQUILIBRIUM CONSTANT";
141 INPUT K
142 IF K>=0 THEN 150
143 PRINT "THE EQUILIBRIUM CONSTANT MUST BE NON-NEGATIVE."
144 GO TO 140
150 PRINT "WHAT IS THE INITIAL CONCENTRATION OF PCL5";
151 INPUT A
152 IF A>=0 THEN 159
153 PRINT "THE INITIAL CONCENTHATION OF PCL5 MUST BE NON-NEGATIVE."
154 GO TO 150
159 PRINT
160 PRINT "WOULD YOU LIKE THE RESULTS PLOTTED (1), TABULATED (2)"
161 PRINT "OR BOTH (3) (TYPE THE APPROPRIATE NUMBER)";
162 INPUT Q1
180 IF Q1<2 THEN 195
183 PRINT
184 PRINT
185 PRINT "INIT. CL2","  EQUIL. PCL3","  EQUIL. CL2","  EQUIL. PCL5"
186 PRINT "----------","  ----------","  ----------","  ----------"
187 PRINT "INIT. PCL5","  INIT. PCL5","  INIT. PCL5","  INIT. PCL5"
188 PRINT
195 LET B=K/A
200 FOR X=1 TO 16
201 LET X1=X-1
210 LET D(X)=(-(B+X1)+SQR((B+X1)*(B+X1)+4*B))/2
220 LET E(X)=X1+D(X)
230 LET F(X)=1-D(X)
240 IF Q1<2 THEN 260
250 PRINT X1,D(X),E(X),F(X)
260 IF D(X)<D1 THEN 270
265 LET D1=D(X)
270 IF E(X)<E1 THEN 280
275 LET E1=E(X)
280 IF F(X)<F1 THEN 290
285 LET F1=F(X)
290 NEXT X
295 IF Q1<>2 THEN 395
300 PRINT
330 PRINT "******"
331 PRINT
340 PRINT "WOULD YOU LIKE ANOTHER RUN (1-YES, 0-NO)";
350 INPUT Q2
360 IF Q2>0 THEN 140
370 STOP
390 REM PLOTTING ROUTINE FOR THREE CURVES
395 PRINT
396 PRINT
400 PRINT "A: (EQUIL. PCL3)/(INIT. PCL5)       MAXIMUM IS "D1
401 PRINT "B: (EQUIL. CL2)/(INIT. PCL5)        MAXIMUM IS "E1
402 PRINT "C: (EQUIL. PCL5)/(INIT. PCL5)       MAXIMUM IS "F1
403 PRINT
404 PRINT "INIT. CL2";TAB(29);"A - B - C"
405 PRINT "----------   0        25        50        75        100";
406 PRINT "   % OF MAXIMUM"
```

```
406 PRINT "INIT. PCL5   I---------I---------I---------I---------I"
410 FOR X=1 TO 16
420 PRINT TAB(5)}X-1}TAB(13)}"I"}
430 LET W(1)=INT(40*D(X)/D1+.5)
431 LET W(2)=INT(40*E(X)/E1+.5)
432 LET W(3)=INT(40*F(X)/F1+.5)
560 REM  FIND WHICH IS SMALLEST, THEN PRINT IT AND MAXIMIZE IT
600 FOR Q=1 TO 3
605 LET K1=1E80
610 FOR I=1 TO 3
620 IF W(I)>K1 THEN 640
630 LET K1=W(I)
640 NEXT I
650 PRINT TAB(K1+13)}
660 FOR I=1 TO 3
670 IF ABS(W(I)-K1)<.0001 THEN 700
680 NEXT I
690 STOP
700 IF I<>1 THEN 730
710 PRINT "A"}
720 GO TO 780
730 IF I<>2 THEN 760
740 PRINT "B"}
750 GO TO 780
760 IF I<>3 THEN 690
770 PRINT "C"}
780 LET W(I)=1E25
790 NEXT Q
795 PRINT " "
800 NEXT X
810 PRINT
815 PRINT
880 GO TO 330
999 END
```

DISCIPLINE CHEMISTRY

SUBJECT KINETICS

PROGRAM NAME KINET

DESCRIPTION:

A class room presentation designed to calculate equilibrium concentrations and graph the progress (concentration vs. time) from initiation to equilibrium for the general reaction $A \rightleftharpoons P$.

OBJECTIVES:

A) An understanding of Equilibrium

B) The significance of the magnitude of the Equilibrum constant.

C) The relationship of the rate constant to the point of equilibrium.

PRELIMINARY PREPARATION:

A. Student (1) The distinction between initial and equilibrium concentration should be made very clear.

(2) The meaning of the terms " Rate constant" and " Equilibrium constant. "

B. Materials - None

DISCUSSION:

To insure the success of this program in a teaching situation, the teacher should run the program prior to its use in the classroom. This is necessary to insure that the choice of constants illustrates the point to be made and the amount of classroom time be kept to a minimum.

By varying the equilibrium constant it is possible to move the point of equilibrium on the concentration axis, and show the relative concentrations of product and reactant as a function of the value of the equilibrium constant.

The effect of different rate constants on the time it takes to attain equilibrium can also be shown. The point at which the two curves approach a straight line is the point of equilibrium (if the two curves intersect a dot is used as the point).

In this program, time is plotted in ten equal steps from initiation of the reaction to equilibrium. The time to attain equilibrium is different depending on the constant used. It should be pointed out that while the point of equilibrium on the graph may appear to be at the same spot, the units of time are changing, thus the point on the graph is different.

```
 FOR THE EQUILIBRIUM PROBLEMS YOU ARE ABOUT TO DO, THE
 DATA MAY BE PRESENTED IN THE FOLLOWING MANNER:
    (INDICATE YOUR CHOICE BY NUMBER)

          CHOICE 1 = TABLE OF DATA
          CHOICE 2 = GRAPH OF DATA
          CHOICE 3 = TABLE AND GRAPH OF DATA
          CHOICE 4 = END PROGRAM

 WHAT IS YOUR CHOICE? 3

 LET F = THE FORWARD RATE CONSTANT
 LET K = THE EQUILIBRIUM CONSTANT FOR THE REACTION A =P
 TYPE IN THE CONSTANTS F AND K IN THAT ORDER.
? 5,1

                ******************************

 LET A1 = ORIGINAL CONCENTRATION OF A
 LET A = PERCENT CONCENTRATION OF A  (A/A1*100)
 LET P = PERCENT CONCENTRATION OF P  (P/A1*100)

 TIME          A             P
 ----          ---           ---
 0             100           0
 .069          75.0788       24.9212
 .138          62.57893      37.42107
 .207          56.30929      43.69071
 .276          53.16459      46.83541
 .345          51.58728      48.41272
 .414          50.79614      49.20386
 .483          50.39933      49.60067
 .552          50.20029      49.79971
 .621          50.10046      49.89954
 .69           50.05039      49.94961

                PERCENT CONCENTRATION OF A(*) AND P(+)

              0        25        50        75        100
  TIME        I---------I---------I---------I---------I
 0            +                                       *
 .069         I         +                   *
 .138         I              +         *
 .207         I                +    *
 .276         I                  + *
 .345         I                  + *
 .414         I                  •
 .483         I                  •
 .552         I                  •
 .621         I                  •
 .69          I                  •
```

```
 WHAT IS YOUR CHOICE? 2

 LET F = THE FORWARD RATE CONSTANT
 LET K = THE EQUILIBRIUM CONSTANT FOR THE REACTION A =P
 TYPE IN THE CONSTANTS F AND K IN THAT ORDER.
? 5,0.1

                ********************************

                  PERCENT CONCENTRATION OF A(*) AND P(+)

              0         25         50         75         100
  TIME        I---------I---------I---------I---------I
 0            I+                                      *
 .01254545    I +                                   *
 .02509091    I  +                                 *
 .03763636    I  +                                 *
 .05018182    I  +                                 *
 .06272727    I   +                               *
 .07527273    I   +                               *
 .08781818    I   +                               *
 .1003636     I   +                               *
 .1129091     I   +                               *
 .1254545     I   +                               *

 WHAT IS YOUR CHOICE? 2

 LET F = THE FORWARD RATE CONSTANT
 LET K = THE EQUILIBRIUM CONSTANT FOR THE REACTION A =P
 TYPE IN THE CONSTANTS F AND K IN THAT ORDER.
? 10,0.1

                ********************************

                  PERCENT CONCENTRATION OF A(*) AND P(+)

              0         25         50         75         100
  TIME        I---------I---------I---------I---------I
 0            I+                                      *
 6.272727E-3  I +                                   *
 .01254545    I  +                                 *
 .01881818    I  +                                 *
 .02509091    I  +                                 *
 .03136364    I                                   *
 .037636 6          .                             *
 .04390909    I     +                             *
 .05018182    I     +                             *
 .05645455    I     +                             *
 .06272727    I     +                             *
```

```
WHAT IS YOUR CHOICE? 2

LET F = THE FORWARD RATE CONSTANT
LET K = THE EQUILIBRIUM CONSTANT FOR THE REACTION A =P
TYPE IN THE CONSTANTS F AND K IN THAT ORDER.
? 5,.5

                    ******************************

                      PERCENT CONCENTRATION OF A(*) AND P(+)

                    0         25         50         75         100
  TIME              I---------I---------I---------I---------I
 0                  #                                       *
 .046               I       +                           *
 .092               I         +                       *
 .138               I           +                   *
 .184               I           +                   *
 .23                I            +                  *
 .276               I            +                  *
 .322               I            +                  *
 .368               I            +                  *
 .414               I            +                  *
 .46                I            +                  *

WHAT IS YOUR CHOICE? 2

LET F = THE FORWARD RATE CONSTANT
LET K = THE EQUILIBRIUM CONSTANT FOR THE REACTION A =P
TYPE IN THE CONSTANTS F AND K IN THAT ORDER.
? 5,.2

                    ******************************

                      PERCENT CONCENTRATION OF A(*) AND P(+)

                    0         25         50         75         100
  TIME              I---------I---------I---------I---------I
 0                  #                                       *
 .023               I   +                                 *
 .046               I     +                             *
 .069               I       +                         *
 .092               I       +                         *
 .115               I       +                         *
 .138               I         +                       *
 .161               I         +                       *
 .184               I         +                       *
 .207               I         +                       *
 .23                I         +                       *

WHAT IS YOUR CHOICE? 4


READY
```

```
100 REM  KINET  HOWARD SHANNON  HARBORFIELDS HS  8/15/68
110 REM      REVISED 7/28/69  PIB J. MARCHISOTTO
115 REM  REVISED BY C.LOSIK  7-28-70
116 REM  F,K ARE DEFINED BELOW; L IS THE TIME INCREMENT;
117 REM  G IS THE DECAY CONSTANT; D IS THE FRACTION OF 'P'
120 REM     THIS PROGRAM STUDIES THE KINETICS OF A SINGLE SPECIES
130 REM (A) GOING TO A SINGLE SPECIES (P),AND APPROACHES EQUILIBRIUM
140 REM WITH (P).
150 REM          IE. ISOMER EQUILIBRIUM
160 REM      IF THE EQUILIBRIUM CONSTANT IS VERY LARGE (K>10,000),
170 REM IT CAN BE ASSUMED THAT ALL OF THE REACTANT GOES TO PRODUCT.
180 REM THIS PHOGRAM CAN THEN BE USED FOR RADIOACTIVE DECAY.
190 REM      AN INPUT OF THE FORWARD RATE CONSTANT AND THE EQUILIBRIUM
200 REM CONSTANT WILL GIVE A PRINTOUT OF THE CONCENTRATION OF (A)
210 REM AND (P) COMPARED TO THE INITIAL CONCENTRATION OF (A) AT 10
220 REM EQUAL TIME INTERVALS AS IT APPROACHES 99.9PERCENT TO EQUILIBRIUM
230 PRINT "  FOR THE EQUILIBRIUM PROBLEMS YOU ARE ABOUT TO DO, THE "
240 PRINT "  DATA MAY BE PRESENTED IN THE FOLLOWING MANNER:  "
250 PRINT "     (INDICATE YOUR CHOICE BY NUMBER)"
260 PRINT
270 PRINT "            CHOICE 1 = TABLE OF DATA"
280 PRINT "            CHOICE 2 = GRAPH OF DATA"
290 PRINT "            CHOICE 3 = TABLE AND GRAPH OF DATA"
300 PRINT "            CHOICE 4 = END PROGRAM"
310 PRINT
320 PRINT " WHAT IS YOUR CHOICE";
330 INPUT Q
340 IF Q> 4 THEN 1120
350 IF Q<1 THEN 1120
360 IF Q = 4 THEN 1140
370 PRINT
380 PHINT " LET F = THE FORWARD RATE CONSTANT"
390 PRINT " LET K = THE EQUILIBRIUM CONSTANT FOR THE HEACTION A =P"
400 PRINT " TYPE IN THE CONSTANTS F AND K IN THAT ORDER."
410 INPUT F,K
420 PRINT
460 PRINT
470 PRINT "              ******************************"
480 PRINT
500 LET H = K/(K+1)
520 LET G = F/H
530 LET L=.69/G
550 LET T = -L
552 IF Q=2 THEN 690
560 PRINT " LET A1 = ORIGINAL CONCENTRATION OF A"
570 PRINT " LET A = PERCENT CONCENTRATION OF A  (A/A1*100)"
580 PRINT " LET P = PERCENT CONCENTRATION OF P  (P/A1*100)"
590 PRINT
```

```
600 PRINT " TIME "," A "," P "
610 PRINT " ---- "," --- "," --- "
620 FOR I = 0 TO 10
630 LET T = T +L
640 LET D = H* (1-EXP(-G*T))
650 PRINT T,(1-D)*100,D*100
660 NEXT I
670 LET T =-L
680 IF Q = 1 THEN 310
690 PRINT
700 PRINT"                    PERCENT CONCENTRATION OF A(*) AND P(+)"
710 PRINT
720 PRINT " ",     "0         25         50         75         100"
730 PRINT "  TIME","I---------I---------I---------I---------I"
740 FOR I = 0 TO 10
750 LET T = T+L
760 LET D = H*(1-EXP(-G*T))
770 LET X = 1-D
775 PRINT I*L,"I";
780 IF INT(40*D+.5) = INT(40*X+.5) THEN 930
790IF INT(40*D+.5)> INT(40*X+.5) THEN 1000
800 PRINT TAB(40*D+14.5);"+";TAB(40*X+14.5);"*"
850 GO TO 1100
930 PRINT TAB(40*D+14.5);"."
950 GO TO 1100
1000 PRINT TAB(40*X+14.5);"*";TAB(40*D+14.5);"+"
1100 NEXT I
1110 GO TO 310
1120 PRINT " YOUR CHOICE MUST BE A NUMBER BETWEEN 1 AND 4, TRY AGAIN."
1130 GO TO 310
1140 END
```

DISCIPLINE CHEMISTRY

SUBJECT MASS DEFECT

PROGRAM NAME MASSD

DESCRIPTION:

A classroom presentation that could be used to calculate mass defect, and give the answer in terms of usable energy (kw-hr. of electricity).

OBJECTIVES:

A. To calculate and explain mass defect.

B. To introduce the concept of binding energy.

C. Conversion of mass to energy. (atomic power)

PRELIMINARY PREPARATION:

A. Student - The student should have an understanding of nuclear particles, and the law of conservation of mass and energy.

B. Materials - The teacher should make available a table of isotopes that lists the actual mass. (Handbook of Chemistry and Physics, Chemical Rubber Company)

DISCUSSION:

It should be noted that the masses used here include the electrons. The very small difference which would be obtained if the bare nuclear mass were known is negligible for the purpose of this calculation.

Time permitting, it would be beneficial to have the student investigate the conversion of atomic mass units(AMU) to calories and kilowatt-hours in order to recognize the significance of the units and the magnitude of the numbers involved.

```
  THIS PROGRAM IS DESIGNED TO INVESTIGATE MASS DEFECT

  WHICH OF THE ELEMENTS WOULD YOU LIKE TO CONSIDER?
REMEMBER WE ARE DEALING WITH A SINGLE ATOM, THEREFORE
IN ADDITION TO THE ATOMIC NUMBER WE ARE GOING TO NEED THE
ACTUAL MASS (IN AMU) AND THE MASS NUMBER OF THE ISOTOPE
YOU WANT TO WORK WITH.

WHEN THE MACHINE TYPES A QUESTION MARK (?) TYPE IN
YOUR ANSWER THEN HIT RETURN KEY. USE NUMBERS OF UP TO
SIX SIGNIFICANT FIGURES. ROUND IF NECESSARY TO 6 DIGITS.
IN THE VALUES FOR MASS DEFECT.


THE ATOMIC NUMBER IS ? 8
THE ACTUAL MASS IS ? 15.9949
THE MASS NUMBER IS ? 16

THE SUM OF THE MASS OF THE 8 PROTONS AND THE 8 NEUTRONS
PLUS THE WEIGHT OF THE 8 ELECTRONS IS THE CALCULATED
MASS.

 CALCULATED MASS  -  ACTUAL MASS  =  MASS DEFECT
     16.13199     -    15.9949     =     .1371

THE MASS DEFECT IN TERMS OF ENERGY IS THE EQUIVALENT OF
2936 X 10^9 CAL. PER MOLE OF THIS SUBSTANCE,
OR 184 X 10^9 CAL. PER GRAM.

IF WE DIVIDE THIS BINDING ENERGY BY THE NUMBER OF
PARTICLES IN THE NUCLEUS, WE GET A RATIO KNOWN AS THE
BINDING ENERGY PER NUCLEON, WHICH IS A MEASURE OF THE
STABILITY OF THE NUCLEUS.  THE MORE 'BINDING'
PER NUCLEON, THE MORE STABLE IS THE NUCLEUS.
THE BINDING ENERGY PER NUCLEON IS : 1.276744E-5 ERGS. PER NUCLEON, OR
3.047121E-13 CAL. PER NUC.,
WHICH IS MORE COMMONLY EXPRESSED AS 800 MEV.

THE AMOUNT OF ENERGY (BINDING ENERGY) CONTAINED IN ONE
GRAM OF THIS SUBSTANCE WOULD BE SUFFICIENT TO SUPPLY ALL
THE ELECTRICAL NEEDS IN AN AVERAGE ONE FAMILY HOUSE USING
15 KW-HRS. PER DAY FOR A PERIOD OF 14245 DAYS OR
39 YEARS.

IF YOU WOULD LIKE TO RUN ANOTHER PROBLEM TYPE IN 1,
 IF NOT TYPE IN 0.
? 0

              **************

READY
```

```
100 REM JOHN MARCHISOTTO  PIB SUMMER 69   BASIC
105 REM  REVISED BY C.LOSIK  7-22-70
106 REM  AT NO=A, MASS=B, MASS NO=C
107 REM  MASS DEFECT IS F
130 PRINT"    THIS PROGRAM IS DESIGNED TO INVESTIGATE MASS DEFECT"
140 PRINT
150 PRINT"    WHICH OF THE ELEMENTS WOULD YOU LIKE TO CONSIDER? "
160 PRINT" REMEMBER WE ARE DEALING WITH A SINGLE ATOM, THEREFORE"
170 PRINT" IN ADDITION TO THE ATOMIC NUMBER WE ARE GOING TO NEED THE"
180 PRINT" ACTUAL MASS (IN AMU) AND THE MASS NUMBER OF THE ISOTOPE"
190 PRINT" YOU WANT TO WORK WITH."
200 PRINT
210 PRINT " WHEN THE MACHINE TYPES A QUESTION MARK (?) TYPE IN"
220 PRINT " YOUR ANSWER THEN HIT RETURN KEY. USE NUMBERS OF UP TO"
230 PRINT " SIX SIGNIFICANT FIGURES. ROUND IF NECESSARY TO 6 DIGITS."
237 PRINT "IN THE VALUES FOR MASS DEFECT."
238 PRINT
240 PRINT
250 PRINT " THE ATOMIC NUMBER IS ";
260 INPUT A
270 PRINT " THE ACTUAL MASS IS ";
280 INPUT C
290 PRINT " THE MASS NUMBER IS ";
300 INPUT B
310 PRINT
320 REM  G IS AVOGADRO'S NUMBER
330 LET G=6.023E23
340 LET D = B - A
350 LET E=(1.00728*A)+(1.00867*D)+(5.48597E-4*A)
360 LET F=INT(1E4*(E-C)+.5)/1E4
370 PRINT " THE SUM OF THE MASS OF THE"A"PROTONS AND THE"D"NEUTRONS"
380 PRINT " PLUS THE WEIGHT OF THE"A"ELECTRONS IS THE CALCULATED"
390 PRINT " MASS."
400 PRINT
410 PRINT"  CALCULATED MASS  -  ACTUAL MASS  =  MASS DEFECT"
420 PRINT"     "E,"     -  "C;"     =    "F
430 PRINT
440 REM   CONVERSION FACTORS:
450 REM        1.49 X 10-3 ERGS PER AMU
460 REM        4.19 X 10 7 ERGS PER CAL.
470 REM        3.6  X 10 13 ERGS PER KW-H
475 REM         931.0 MEV PER AMU
480 LET H=(1.49E-3*F*G)/4.19E7
490 PRINT " THE MASS DEFECT IN TERMS OF ENERGY IS THE EQUIVALENT OF"
500 PRINT INT(H/1E9+.5)"X 10↑9 CAL. PER MOLE OF THIS SUBSTANCE,"
510 PRINT "OR"INT((H/C)/1E9+.5)"X 10↑9 CAL. PER GRAM."
511 PRINT
512 PRINT " IF WE DIVIDE THIS BINDING ENERGY BY THE NUMBER OF"
```

```
513 PRINT " PARTICLES IN THE NUCLEUS, WE GET A RATIO KNOWN AS THE"
514 PRINT " BINDING ENERGY PER NUCLEON, WHICH IS A MEASURE OF THE"
515 PRINT " STABILITY OF THE NUCLEUS.  THE MORE 'BINDING'"
516 PRINT " PER NUCLEON, THE MORE STABLE IS THE NUCLEUS."
517 PRINT " THE BINDING ENERGY PER NUCLEON IS :";
518 PRINT 1.49E-3*F/B"ERGS. PER NUCLEON, OR";
519 PRINT 1.49E-3*F/(B*4.19E7)"CAL. PER NUC.,"
520PRINT" WHICH IS MORE COMMONLY EXPRESSED AS"100*INT(931*F/B+.5)"MEV."
522 LET J = ((H/C)*4.19E7/3.6E13)/15
525 PRINT
530 PRINT " THE AMOUNT OF ENERGY (BINDING ENERGY) CONTAINED IN ONE"
540 PRINT " GRAM OF THIS SUBSTANCE WOULD BE SUFFICIENT TO SUPPLY ALL"
550 PRINT " THE ELECTRICAL NEEDS IN AN AVERAGE ONE FAMILY HOUSE USING"
560 PRINT " 15 KW-HRS. PER DAY FOR A PERIOD OF"INT(J+.5)"DAYS OR"
565 PRINT INT((J/365)+.5)"YEARS."
570 PRINT
580 PRINT " IF YOU WOULD LIKE TO RUN ANOTHER PROBLEM TYPE IN 1,"
590 PRINT " IF NOT TYPE IN 0."
600 INPUT M
610 PRINT
620 PRINT " ","***************"
630 IF M=1 THEN 240
640 IF M<>0 THEN 580
650 END

READY
```

DISCIPLINE CHEMISTRY

SUBJECT ACID - BASE TITRATION

PROGRAM NAME MOLAR

DESCRIPTION:

This program will calculate molarity by using data obtained from an acid-base titration.

OBJECTIVES:

To provide the teacher and the student with a molarity calculator to be used where either finds it applicable.

PRELIMINARY PREPARATION:

A. Student - This program can be used with students who have had no preliminary preparation or those with extensive preparation.

B. Materials - none

DISCUSSION:

It should be noted that normality is no longer in the New York State syllabus. It thus becomes necessary to teach titration calculations in the molarity systems by way of moles of H^+ reacted vs. moles of OH^- reacted, a much preferred method. This program does just that.

This program may be used in lab, as check on homework problems, and for tutorial work.

The teacher may also wish to show the logic of programs in general by using this very elementary program. The teacher need only take the list and explain it line by line to enhance the students' understanding. The equation used to solve the problems is:

$$\text{Moles } H^+ = \text{Moles } OH^-$$

$$(M_A)(V_A)(n) = (M)(V_B)(n)$$

V = volume in liters
n = subscript of the H^+ or OH^-

```
THIS PROGRAM IS DESIGNED TO CALCULATE THE UNKNOWN MOLARITY
IN AN ACID-BASE TITRATION.

 WHAT IS THE SUBSCRIPT OF THE H+ IN THE ACID FORMULA,
 AND THE SUBSCRIPT OF THE OH- IN THE BASE FORMULA? 2,1

 HOW MANY ML OF ACID, AND HOW MANY ML OF BASE
 WERE USED? 19.7,10.0

 IS THE KNOWN MOLARITY FOR THE ACID OR THE BASE?
 ANSWER 1 FOR ACID OR 2 FOR BASE? 1

 WHAT IS THE MOLARITY OF THE ACID? 5.5


 ANSWER: THE BASE IS  21.67 M.


 DO YOU WANT TO WORK ANOTHER PROBLEM?  ANSWER 1 FOR YES
 OR 0 FOR NO? 1

 **************


 WHAT IS THE SUBSCRIPT OF THE H+ IN THE ACID FORMULA,
 AND THE SUBSCRIPT OF THE OH- IN THE BASE FORMULA? 3,1

 HOW MANY ML OF ACID, AND HOW MANY ML OF BASE
 WERE USED? 0,29.3

 IS THE KNOWN MOLARITY FOR THE ACID OR THE BASE?
 ANSWER 1 FOR ACID OR 2 FOR BASE? 1

 WHAT IS THE MOLARITY OF THE ACID? 2.0


 ANSWER: THE BASE IS  0 M.


 DO YOU WANT TO WORK ANOTHER PROBLEM?  ANSWER 1 FOR YES
 OR 0 FOR NO? 1


 **************


 WHAT IS THE SUBSCRIPT OF THE H+ IN THE ACID FORMULA,
 AND THE SUBSCRIPT OF THE OH- IN THE BASE FORMULA? 2,1

 HOW MANY ML OF ACID, AND HOW MANY ML OF BASE
 WERE USED? 15.0,24.7

 IS THE KNOWN MOLARITY FOR THE ACID OR THE BASE?
 ANSWER 1 FOR ACID OR 2 FOR BASE? 2

 WHAT IS THE MOLARITY OF THE BASE? 1.5


 ANSWER: THE ACID IS  1.23 M.


 DO YOU WANT TO WORK ANOTHER PROBLEM?  ANSWER 1 FOR YES
 OR 0 FOR NO? 0

 **************

READY
```

```
100 REM HARRY DORFMAN 7/16/68 JOHN GLENN H.S. ( REV. 7/10/69 )
105 REM  REVISED BY C.LOSIK  7-23-70
110 PRINT "THIS PROGRAM IS DESIGNED TO CALCULATE THE UNKNOWN MOLARITY"
120 PRINT "IN AN ACID-BASE TITRATION."
130 PRINT
140 PRINT
150 PRINT " WHAT IS THE SUBSCRIPT OF THE H+ IN THE ACID FORMULA,"
160 PRINT " AND THE SUBSCRIPT OF THE OH- IN THE BASE FORMULA";
165 REM  D,C= # OF H+,  # OF OH-
170 INPUT D,C
180 PRINT
190 PRINT " HOW MANY ML OF ACID, AND HOW MANY ML OF BASE"
200 PRINT " WERE USED";
205 REM  E,F= ML ACID, ML BASE
210 INPUT E,F
220 PRINT
230 PRINT " IS THE KNOWN MOLARITY FOR THE ACID OR THE BASE?"
240 PRINT " ANSWER 1 FOR ACID OR 2 FOR BASE";
250 INPUT Z
260 PRINT
270 IF Z = 2 THEN 360
280 IF Z<>1 THEN 240
290 PRINT " WHAT IS THE MOLARITY OF THE ACID";
300 INPUT A
310 LETB= (E*A*D)/(C*F)
320 PRINT
330 PRINT
340 PRINT " ANSWER: THE BASE IS "INT(100*B+.5)/100"M."
350 GO TO 420
360 PRINT " WHAT IS THE MOLARITY OF THE BASE";
370 INPUT B
380 LET A=(C*F*B)/(D*E)
390 PRINT
400 PRINT
410 PRINT " ANSWER: THE ACID IS "INT(100*A+.5)/100"M."
420 PRINT
430 PRINT
440 PRINT " DO YOU WANT TO WORK ANOTHER PROBLEM?  ANSWER 1 FOR YES"
450 PRINT " OR 0 FOR NO";
460 INPUT X
462 PRINT
464 PRINT " ***************"
470 IF X=1 THEN 130
480 IF X<>0 THEN 430
490 END
```

DISCIPLINE CHEMISTRY

SUBJECT pH, pOH, PCT. DISSOCIATION

PROGRAM NAME PHPOH

DESCRIPTION:

A class presentation designed to calculate pH, pOH, and percent dissociation of weak monoprotic acids, using the quadratic equations for rigorous solutions.

OBJECTIVES:

A. To illustrate the relationships between the magnitude of the K_a value, and the strength of the acid.

B. To show the relationship between pOH and pH.

PRELIMINARY PREPARATION:

Student - The distinction between weak and strong acids should have been covered. The student should also be aware of the role hydrogen ion concentration plays in acid-base calculations, and the effect it has on hydroxide ion concentration.

DISCUSSION:

This program can be used in different ways, depending upon the ability level of the group.

1. With groups of average abilities, it is used primarily as a calculator, to solve large numbers of problems in a minimum amount of time.
2. In above average groups, the program listing was used as a device to illustrate theory. The entire lesson consists of an extensive step-wise explanation of the program list. In these classes all students were familiar with the Basic programming language. Some calculations built into the program (lines 41-43) are not part of the normal curriculum, but are necessary to solve the problem as the product of the K_a value and the concentration approaches 1×10^{-14}.

```
THIS PROGRAM WILL FIND THE PH, POH, AND PCT DISSOCIATION
FOR ANY WEAK MONOPROTIC ACID.

KA OF ACID =? 1E-5
 MOLAR CONCENTRATION OF ACID =? 1

PH= 2.5        POH= 11.5      PCT. DISSOCIATION= .3157262

 ANY MORE PROBLEMS (1=YES, 0=NO)? 1

KA OF ACID =? 1E-3
 MOLAR CONCENTRATION OF ACID =? 2

PH= 1.35       POH= 12.65     PCT. DISSOCIATION= 2.211206

 ANY MORE PROBLEMS (1=YES, 0=NO)? 1

KA OF ACID =? 1E-10
 MOLAR CONCENTRATION OF ACID =? 1

PH= 5          POH= 9         PCT. DISSOCIATION= 9.998950E-4

 ANY MORE PROBLEMS (1=YES, 0=NO)? 1

KA OF ACID =? 1E-15
 MOLAR CONCENTRATION OF ACID =? 2

PH= 6.96       POH= 7.04      PCT. DISSOCIATION= 9.128709E-7

 ANY MORE PROBLEMS (1=YES, 0=NO)? 0

READY
```

```
100 REM PHPOH*  JOHN MARCHISOTTO 7/10/69  CHEMISTRY BASIC
101 REM  REVISED BY C.LOSIK  7-22-70
103 REM A IS THE KA, B IS THE MOLAR CONC.
110 REM  PROGRAM DOES ONE CALCULATION AT A TIME !
140 PRINT "THIS PROGRAM WILL FIND THE PH, POH, AND PCT DISSOCIATION"
150 PRINT "FOR ANY WEAK MONOPROTIC ACID."
170 PRINT
180 PRINT "KA OF ACID =";
190 INPUT A
200 IF A<=0.5 THEN 210
202 PRINT "ANSWER INVALID FOR WEAK ACID.  TRY AGAIN."
204 GO TO 190
210 PRINT " MOLAR CONCENTRATION OF ACID =";
220 INPUT B
230 PRINT
240 LET S = A*B
250 IF S>=1E-12 THEN 280
260 LET H = SQR(S+1E-14)
270 GO TO 290
280 LET H =-A/2+(SQR(A↑2+(4*A*B)))/2
290 LET T = 1E-14/H
300 LET R = H-T
310 LET C = -LOG (H)/2.303
320 LET D = 14 - C
330 IF B<1E-5 THEN 360
340 LET E = R/B*100
350 GO TO 370
360 LET E = 100
370 PRINT "PH="INT(100*C+.5)/100,"POH="INT(100*D+.5)/100,
380 PRINT "PCT. DISSOCIATION="E
390 PRINT
410 PRINT " ANY MORE PROBLEMS (1=YES, 0=NO)";
430 INPUT N
440 IF N=1 THEN 170
445 IF N<>0 THEN 410
450 END
```

DISCIPLINE CHEMISTRY

SUBJECT PERCENT COMPOSITION

PROGRAM NAME PRCNT

DESCRIPTION:

This program is designed to calculate the percent composition (by weight) of a compound that may contain up to 5 elements. The program also contains a detailed sample calculation which is optional.

OBJECTIVES:

A. For the students who are familiar with percentage, this program may be used as a self-teaching device to show how this concept applies to a chemical situation.

B. The program may be used as a calculator to:

1) Illustrate the Law of Multiple Proportions
2) Illustrate the Law of Definite Proportions
3) Work out percent water of hydration, percent sulfate, nitrate, etc. (see discussion)
4) Check homework problems, class problems, lab problems, etc.

C. The program may be used as a tutorial device for students having difficulty.

PRELIMINARY PREPARATION:

A. Student - The student should at least have an understanding of the concept of percentage. The teacher may also wish to discuss how this concept applies to chemical compounds.

B. Materials - none

DISCUSSION:

This program makes it possible for the teacher to spend very little time in class on percent composition and still have the student receive ample instruction and drill on the topic. This is possible since the program may be used in a number of situations such as teaching, self-teaching, and tutorial.

It should be brought to the students' attention that % water of hydration, % sulfate, % nitrate, etc., may be calculated by treating the groups of atoms as a single element when entering data.

```
     THIS PROGRAM IS DESIGNED TO CALCULATE THE PERCENT
COMPOSITION BY WEIGHT OF A COMPOUND THAT MAY CONTAIN
FROM 2 TO 5 ELEMENTS.

 DO YOU WANT TO SEE A SAMPLE CALCULATION?
ANSWER 1 FOR YES OR 0 (ZERO) FOR NO? 1

EXAMPLE :   THE PERCENT COMPOSITION OF SULFURIC ACID

LET W1 = ATOMIC WEIGHT OF HYDROGEN
 LET A1 = THE NO. OF HYDROGEN ATOMS IN THE FORMULA
LET W2 = THE ATOMIC WEIGHT OF SULFUR
 LET A2 = THE NO. OF SULFUR ATOMS IN THE FORMULA
LET W3 = THE ATOMIC WEIGHT OF OXYGEN
 LET A3 = THE NO. OF OXYGEN ATOMS IN THE FORMULA

 Y= FORMULA WEIGHT OF SULFURIC ACID
 Y= (W1*A1) + (W2*A2) + (W3*A3)
 Y= (1.008*2) + (32.064*1) + (15.999*4)
 Y= 98.076

PERCENT H = (W1*A1/Y)*100
PERCENT H = (1.008*2/98.076)*100
PERCENT H = 2.005

PERCENT S = (W2*A2/Y)*100
PERCENT S = (32.064*1/98.076)*100
PERCENT S = 32.693

PERCENT O = (W3*A3/Y)*100
PERCENT O = (15.999*4/98.076)*100
PERCENT O = 65.2514

 DO YOU WANT TO DO A PROBLEM ?
ANSWER 1 FOR YES OR 0 (ZERO) FOR NO? 1

 WHAT IS THE NUMBER OF ELEMENTS IN THE FORMULA? 3
 TYPE (THE ATOMIC WEIGHT,NO. OF ATOMS) FOR EACH ELEMENT,
 ONE ELEMENT TO A LINE.
? 12.011,12
? 1.008,22
? 15.999,11
              ******************************

FORMULA WEIGHT = 342.297

ATOMIC WEIGHT  NO. OF ATOMS   PERCENT COMPOSITION
 12.011        12             42.10729
 1.008         22             6.478564
 15.999        11             51.41412

              ******************************

 DO YOU WANT TO DO ANOTHER PROBLEM?
ANSWER 1 FOR YES OR 0 (ZERO) FOR NO? 0


READY
```

```
100 REM R. SHANNON, HARBORFIELDS H.S. 7/23/68  (REV 7/15/69)
105 REM  REVISED BY C.LOSIK  7-23-70
106 REM  THE SAMPLE CALCULATION EAPLAINS HOW THIS PROGRAM WORKS
110 REM CALCULATES PERCENTAGE COMPOSITION BY WEIGHT OF A COMPOUND
120 PRINT "     THIS PROGRAM IS DESIGNED TO CALCULATE THE PERCENT"
130 PRINT "COMPOSITION BY WEIGHT OF A COMPOUND THAT MAY CONTAIN"
140 PRINT "FROM 2 TO 5 ELEMENTS."
150 PRINT
160 PRINT " DO YOU WANT TO SEE A SAMPLE CALCULATION?"
170 PRINT "ANSWER 1 FOR YES OR 0 (ZERO) FOR NO";
180 INPUT  X
190 IF X = 0 THEN 460
193 IF X<>1 THEN 170
199 PRINT
200 PRINT  "EXAMPLE :   THE PERCENT COMPOSITION OF SULFURIC ACID "
210 PRINT
220 PRINT "LET W1 = ATOMIC WEIGHT OF HYDROGEN"
230 PRINT " LET A1 = THE NO. OF HYDROGEN ATOMS IN THE FORMULA"
240 PRINT "LET W2 = THE ATOMIC WEIGHT OF SULFUR"
250 PRINT " LET A2 = THE NO. OF SULFUR ATOMS IN THE FORMULA"
260 PRINT "LET W3 = THE ATOMIC WEIGHT OF OXYGEN"
270 PRINT " LET A3 = THE NO. OF OXYGEN ATOMS IN THE FORMULA "
280 PRINT
290 PRINT " Y= FORMULA WEIGHT OF SULFURIC ACID"
300 PRINT " Y= (W1*A1) + (W2*A2) + (W3*A3)"
310 PRINT " Y= (1.008*2) + (32.064*1) + (15.999*4)"
320 PRINT " Y= 98.076"
330 PRINT
340 PRINT "PERCENT H = (W1*A1/Y)*100"
350 PRINT "PERCENT H = (1.008*2/98.076)*100"
360 PRINT "PERCENT H = 2.005"
370 PRINT
380 PRINT "PERCENT S = (W2*A2/Y)*100"
390 PRINT "PERCENT S = (32.064*1/98.076)*100"
400 PRINT "PERCENT S = 32.693"
410 PRINT
420 PRINT "PERCENT O = (W3*A3/Y)*100"
430 PRINT "PERCENT O = (15.999*4/98.076)*100"
440 PRINT "PERCENT O = 65.2514"
450 PRINT
460 PRINT " DO YOU WANT TO DO A PROBLEM ?"
470 PRINT "ANSWER 1 FOR YES OR 0 (ZERO) FOR NO";
480 INPUT X
490 IF X = 0 THEN 770
493 IF X<>1 THEN 470
500  DIM W(5), A(5)
505 PRINT
510 PRINT " WHAT IS THE NUMBER OF ELEMENTS IN THE FORMULA";
520 REM J = NO. OF ELEMENTS IN THE FORMULA
530 INPUT J
533 REM THIS LOOP CHECKS FOR VALID ANSWER
535 FOR I=2 TO 5
540 IF I=J THEN 560
545 NEXT I
550 PRINT "THIS PROGRAM CONSIDERS COMPOUNDS WITH 2 TO 5 ELEMENTS."
552 GO TO 510
560 LET Y = 0
570 PRINT " TYPE (THE ATOMIC WEIGHT,NO. OF ATOMS) FOR EACH ELEMENT,"
580 PRINT " ONE ELEMENT TO A LINE."
590 FOR I = 0 TO J-1
```

```
600 INPUT W(I),A(I)
610 REM Y = FORMULA WEIGHT
620     LET Y= Y+W(I)*A(I)
630 NEXT I
640 PRINT "                    ******************************"
645 PRINT
650 PRINT "FORMULA WEIGHT =";  Y
660 PRINT
670 PRINT "ATOMIC WEIGHT  NO. OF ATOMS   PERCENT COMPOSITION"
680 REM U = NO. OF ELEMENTS IN THE FORMULA
690 FOR I = 0 TO U-1
700 PRINT W(I),A(I),W(I)*A(I)/Y*100
710 NEXT I
720 PRINT
730 PRINT "                    ******************************"
740 PRINT
750 PRINT" DO YOU WANT TO DO ANOTHER PROBLEM?"
760 GO TO 470
770 END
```

DISCIPLINE CHEMISTRY

SUBJECT STOICHIOMETRY

PROGRAM NAME STOICH

DESCRIPTION:

This program solves mass-mass, mass-volume, and volume-volume problems. The input may be in grams and/or moles and the output will be in grams, moles and/or liters

OBJECTIVES:

To provide the teacher and the student with a stoichiometry calculator to be used where either finds it applicable.

PRELIMINARY PREPARATION:

A. Student - The student must have an introduction to stoichiometry.

B. Materials - none

DISCUSSION:

Some of the situations where this program is useful:

A. In Class
   1. Enables teacher to cover a large number of problems without using time to do calculations.
   2. Can be used in conjunction with a problem exercise in class so teacher can go around and give individual help.

B. Outside of Class
   1. Tutorial Work
   2. Students can check homework problems during study periods or after school.

```
 DO YOU WISH TO SKIP THE INSTRUCTIONS? 1 FOR YES ,0 FOR NO? 0
THIS PROGRAM IS DESIGNED TO SOLVE:
       1. MASS-MASS PROBLEMS
       2. MASS-VOLUME PROBLEMS
       3. VOLUME-VOLUME PROBLEMS

SOME GENERAL INSTRUCTIONS FOR USING THE PROGRAM WILL
BE HELPFUL AT THIS TIME.
     1. IF TWO PIECES OF DATA ARE REQUESTED, BE SURE TO
        GIVE THEM IN THE ORDER REQUESTED AND SEPARATE
        THEM WITH A COMMA.
     2. THE BALANCED EQUATION IS THE FIRST THING
        NEEDED WITH EACH TYPE OF PROBLEM SO HAVE IT PREPARED.
     3. THE FORMULA WEIGHTS ARE NEEDED NEXT SO HAVE THEM
        PREPARED.


PICK THE TYPE OF CALCULATION YOU DESIRE BY ANSWERING THE
FOLLOWING QUESTION WITH A 1,2, OR 3:
             1 FOR MASS-MASS CALCULATIONS
             2 FOR MASS-VOLUME CALCULATIONS
             3 FOR VOLUME-VOLUME CALCULATIONS

WHAT IS THE NUMBER OF YOUR CHOICE? 1
             ***************

 PROVIDE THE FOLLOWING DATA FOR THIS MASS-MASS PROBLEM:

HOW MANY MOLES OF KNOWN COMPOUND AND UNKNOWN COMPOUND
ARE SHOWN IN THE BALANCED CHEMICAL EQUATION? 1,1
WHAT IS THE FORMULA WEIGHT OF THE KNOWN COMPOUND
 AND THE UNKNOWN COMPOUND ? 100,56
 WHAT MASS, IN GRAMS, OF THE KNOWN COMPOUND IS INVOLVED
 IN THE CHEMICAL REACTION?  IF THIS INFORMATION IS AVAILABLE
 IN MOLES ANSWER ZERO (0) AND WAIT FOR THE NEXT QUESTION? 50.0
 ANSWERS: ..................  .5  MOLES OF UNKN. CPD.
          .................. 28  GRAMS OF UNKN. CPD.

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DO YOU WISH TO SOLVE ANOTHER PROBLEM?  ANSWER 1 FOR M-M,
 2 FOR M-V, 3 FOR V-V, AND ZERO (0) TO END THE PROGRAM.? 2

             ***************

 PROVIDE THE FOLLOWING DATA FOR THIS MASS-VOLUME PROBLEM:

 HOW MANY MOLES OF KNOWN COMPOUND AND UNKNOWN COMPOUND
 ARE SHOWN IN THE BALANCED EQUATION? 2,2
WHAT IS THE FORMULA WEIGHT OF THE KNOWN COMPOUND AND THE
 UNKNOWN COMPOUND? 18,2
 WHAT MASS, IN GRAMS, OF THE KNOWN COMPOUND IS INVOLVED
 IN THE CHEMICAL REACTION? IF ONLY VOLUME IS KNOWN
 ANSWER ZERO (0) AND WAIT FOR THE NEXT QUESTION? 20.0
ANSWERS: ............................. 1.111111 MOLES OF UNKN. GAS
         ............................. 24.88889  LITERS OF UNKN. GAS

             ***************

DO YOU WISH TO SOLVE ANOTHER PROBLEM?  ANSWER 1 FOR M-M,
 2 FOR M-V, 3 FOR V-V, AND ZERO (0) TO END THE PROGRAM.? 3

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PROVIDE THE FOLLOWING DATA FOR THIS VOLUME-VOLUME PROBLEM:

HOW MANY MOLES KNOWN GAS AND UNKNOWN GAS ARE SHOWN
 IN THE BALANCED EQUATION? 1,3,3
 WHAT IS THE VOLUME IN LITERS OF THE KNOWN GAS INVOLVED
 IN THE CHEMICAL REACTION? (VOLUME MUST BE AT STP.)? 146
ANSWER: ............................ 336.9231 LITERS OF UNKN. GAS

               ***************

DO YOU WISH TO SOLVE ANOTHER PROBLEM?  ANSWER 1 FOR M-M,
 2 FOR M-V, 3 FOR V-V, AND ZERO (0) TO END THE PROGRAM.? 1

               ***************

 PROVIDE THE FOLLOWING DATA FOR THIS MASS-MASS PROBLEM:

HOW MANY MOLES OF KNOWN COMPOUND AND UNKNOWN COMPOUND
ARE SHOWN IN THE BALANCED CHEMICAL EQUATION? 1,1
WHAT IS THE FORMULA WEIGHT OF THE KNOWN COMPOUND
 AND THE UNKNOWN COMPOUND ? 56,74
 WHAT MASS, IN GRAMS, OF THE KNOWN COMPOUND IS INVOLVED
 IN THE CHEMICAL REACTION?  IF THIS INFORMATION IS AVAILABLE
 IN MOLES ANSWER ZERO (0) AND WAIT FOR THE NEXT QUESTION? 0
 HOW MANY MOLES OF KNOWN COMPOUND WERE INVOLVED IN
 THE CHEMICAL REACTION? 2.9
 ANSWERS: ................... 2.9  MOLES OF UNKN. CPD.
          ................... 214.6  GRAMS OF UNKN. CPD.

               ***************

DO YOU WISH TO SOLVE ANOTHER PROBLEM?  ANSWER 1 FOR M-M,
 2 FOR M-V, 3 FOR V-V, AND ZERO (0) TO END THE PROGRAM.? 8

               ***************

 PROVIDE THE FOLLOWING DATA FOR THIS MASS-VOLUME PROBLEM:

 HOW MANY MOLES OF KNOWN COMPOUND AND UNKNOWN COMPOUND
 ARE SHOWN IN THE BALANCED EQUATION? 1,2
WHAT IS THE FORMULA WEIGHT OF THE KNOWN COMPOUND AND THE
 UNKNOWN COMPOUND? 2,23
 WHAT MASS, IN GRAMS, OF THE KNOWN COMPOUND IS INVOLVED
 IN THE CHEMICAL REACTION? IF ONLY VOLUME IS KNOWN
 ANSWER ZERO (0) AND WAIT FOR THE NEXT QUESTION? 0
 WHAT IS THE VOLUME, IN LITERS, OF THE KNOWN GAS
INVOLVED IN THE CHEMICAL REACTION? (VOLUME MUST BE AT STP)? 212
 ANSWERS:..................... 18.92857  MOLES OF UNKN. CPD.
          ..................... 435.3571  GRAMS OF UNKN. CPD.

               ***************

DO YOU WISH TO SOLVE ANOTHER PROBLEM?  ANSWER 1 FOR M-M,
 2 FOR M-V, 3 FOR V-V, AND ZERO (0) TO END THE PROGRAM.? 0

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READY
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100 REM HARRY DORFMAN, JOHN GLENN H.S.7/23/68  ( REV.7/9/69 )
105 REM  REVISED BY C.LOSIK   7-22-70
106 REM  DIFFERENT VARIABLES ARE USED IN EACH PROBLEM
107 REM  THEIR MEANING MAY BE DETERMINED BY LOOKING AT EACH SECTION
108 REM  OF THE PROGRAM (VARS. CORRESPOND WITH INPUTS AND PRINTS)
110 REM THIS PROGRAM IS DESIGNED TO SOLVE MASS-MASS,MASS-VOLUME,
120 REM AND VOLUME-VOLUME PROBLEMS.
123 REM
125 REM  EACH INPUT HAS A DIFFERENT LETTER CORRESPONDING TO
126 REM  THE INFORMATION IN THE PRINTED QUESTION.
130 REM
140 PRINT " DO YOU WISH TO SKIP THE INSTRUCTIONS? 1 FOR YES ,0 FOR NO";
150 INPUT Z
160 IF Z=1 THEN 320
162 IF Z<>0 THEN 130
170 PRINT "THIS PROGRAM IS DESIGNED TO SOLVE:"
180 PRINT "        1. MASS-MASS PROBLEMS"
190 PRINT "        2. MASS-VOLUME PROBLEMS"
200 PRINT "        3. VOLUME-VOLUME PROBLEMS"
210 PRINT
220 PRINT "SOME GENERAL INSTRUCTIONS FOR USING THE PROGRAM WILL"
230 PRINT "BE HELPFUL AT THIS TIME."
240 PRINT "      1. IF TWO PIECES OF DATA ARE REQUESTED, BE SURE TO"
250 PRINT "         GIVE THEM IN THE ORDER REQUESTED AND SEPARATE"
260 PRINT "         THEM WITH A COMMA."
270 PRINT "      2. THE BALANCED EQUATION IS THE FIRST THING"
280 PRINT"           NEEDED WITH EACH TYPE OF PROBLEM SO HAVE IT PREPARED."
290 PRINT "      3. THE FORMULA WEIGHTS ARE NEEDED NEXT SO HAVE THEM"
300 PRINT "         PREPARED."
310 PRINT
320 PRINT
330 PRINT "PICK THE TYPE OF CALCULATION YOU DESIRE BY ANSWERING THE"
340 PRINT"FOLLOWING QUESTION WITH A 1,2, OR 3:"
350 PRINT"              1 FOR MASS-MASS CALCULATIONS"
360 PRINT"              2 FOR MASS-VOLUME CALCULATIONS"
370 PRINT"              3 FOR VOLUME-VOLUME CALCULATIONS"
380 PRINT
390 PRINT "WHAT IS THE NUMBER OF YOUR CHOICE";
400 INPUT A
410 PRINT " ","***************"
420 PRINT
430 IF A=1 THEN 470
440 IF A=2 THEN 830
450 IF A=3 THEN1150
455 PRINT "USE 1, 2, OR 3.  TRY AGAIN."
460 GO TO 390
470 PRINT" PROVIDE THE FOLLOWING DATA FOR THIS MASS-MASS PROBLEM:"
480 PRINT
490 PRINT"HOW MANY MOLES OF KNOWN COMPOUND AND UNKNOWN COMPOUND"
500 PRINT "ARE SHOWN IN THE BALANCED CHEMICAL EQUATION";
510 INPUT B,C
520 PRINT"WHAT IS THE FORMULA WEIGHT OF THE KNOWN COMPOUND"
530 PRINT " AND THE UNKNOWN COMPOUND ";
540 INPUT D,E
550 PRINT" WHAT MASS, IN GRAMS, OF THE KNOWN COMPOUND IS INVOLVED"
560PRINT" IN THE CHEMICAL REACTION?  IF THIS INFORMATION IS AVAILABLE"
570 PRINT " IN MOLES ANSWER ZERO (0) AND WAIT FOR THE NEXT QUESTION";
580 INPUT F
590 IF F=0 THEN620
600 LET G=F/D
610 GO TO 650
620 PRINT" HOW MANY MOLES OF KNOWN COMPOUND WERE INVOLVED IN"
630 PRINT " THE CHEMICAL REACTION";
640 INPUT G
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650 LET R=(C/B)*G
660 PRINT" ANSWERS: ....................."R" MOLES OF UNKN. CPD."
670 LET U=R*E
680 PRINT "          ....................."U" GRAMS OF UNKN. CPD."
690 PRINT
700 PRINT " ","***************"
710 PRINT
720 PRINT"DO YOU WISH TO SOLVE ANOTHER PROBLEM?  ANSWER 1 FOR M-M,"
730 PRINT " 2 FOR M-V, 3 FOR V-V, AND ZERO (0) TO END THE PROGRAM.";
740 INPUT Y
745 PRINT
750 PRINT " ","***************"
760 PRINT
770 IF Y=1 THEN 470
780 IF Y=2 THEN 830
790 IF Y=3 THEN 1150
800 IF Y<>0 THEN 810
805 STOP
810 PRINT " YOU MUST USE 0,1,2, OR 3.  TRY AGAIN."
820 GO TO 720
830 PRINT " PROVIDE THE FOLLOWING DATA FOR THIS MASS-VOLUME PROBLEM:"
840 PRINT
850 PRINT " HOW MANY MOLES OF KNOWN COMPOUND AND UNKNOWN COMPOUND"
860 PRINT " ARE SHOWN IN THE BALANCED EQUATION";
870 INPUT K,L
880 PRINT "WHAT IS THE FORMULA WEIGHT OF THE KNOWN COMPOUND AND THE"
890 PRINT " UNKNOWN COMPOUND";
900 INPUT M,N
910 PRINT" WHAT MASS, IN GRAMS, OF THE KNOWN COMPOUND IS INVOLVED"
920 PRINT" IN THE CHEMICAL REACTION? IF ONLY VOLUME IS KNOWN"
930 PRINT " ANSWER ZERO (0) AND WAIT FOR THE NEXT QUESTION";
940 INPUT P
950 IF P=0 THEN 1040
960 LET R=(L/K)*(P/M)
970 PRINT"ANSWERS: ..........................."R"MOLES OF UNKN. GAS"
980 LET S=R*22.4
990 PRINT"          ..........................."S" LITERS OF UNKN. GAS"
1030 GO TO 690
1040 PRINT" WHAT IS THE VOLUME, IN LITERS, OF THE KNOWN GAS"
1050 PRINT"INVOLVED IN THE CHEMICAL REACTION? (VOLUME MUST BE AT STP)";
1060 INPUT W
1070 LET T=(W/22.4)*(L/K)
1080 PRINT" ANSWERS:....................."T" MOLES OF UNKN. CPD."
1090 LET U=T*N
1100 PRINT"          ....................."U" GRAMS OF UNKN. CPD."
1140 GO TO 690
1150 PRINT "PROVIDE THE FOLLOWING DATA FOR THIS VOLUME-VOLUME PROBLEM:"
1160 PRINT
1170 PRINT "HOW MANY MOLES KNOWN GAS AND UNKNOWN GAS ARE SHOWN"
1180 PRINT " IN THE BALANCED EQUATION";
1190 INPUT U,V
1200 PRINT" WHAT IS THE VOLUME IN LITERS OF THE KNOWN GAS INVOLVED"
1210 PRINT " IN THE CHEMICAL REACTION? (VOLUME MUST BE AT STP.)";
1220 INPUT W
1230 LET X=(V/U)*W
1240 PRINT"ANSWER: ..........................."X"LITERS OF UNKN. GAS"
1280 GO TO 690
1300 END

READY
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