DOCUMENT RESUME

ED 102 125 SE 029 758

AUTHOR Bader, Morris
TITLE Solutions, Unit 2: Molarity, Molality, Concentration Conversions. A Computer-Enriched Module for Introductory Chemistry. Student's Guide and Teacher's Guide.
INSTITUTION Illinois Inst. of Tech., Chicago.
SPONS AGENCY EXXON Education Foundation, New York, N.Y.; National Science Foundation, Washington, D.C.
PUB DATE 76
NOTE 55p.; For related documents, see SE 029 752-763; Not available in hard copy due to marginal legibility of original document

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS *Chemistry; College Science; *Computer Assisted Instruction; Computer Programs; *Higher Education; *Independent Study; Instructional Materials; *Learning Modules; Problem Solving; *Science Education; Science Instruction; Simulation; Undergraduate Study
IDENTIFIERS *Computer Enriched Module Project

ABSTRACT

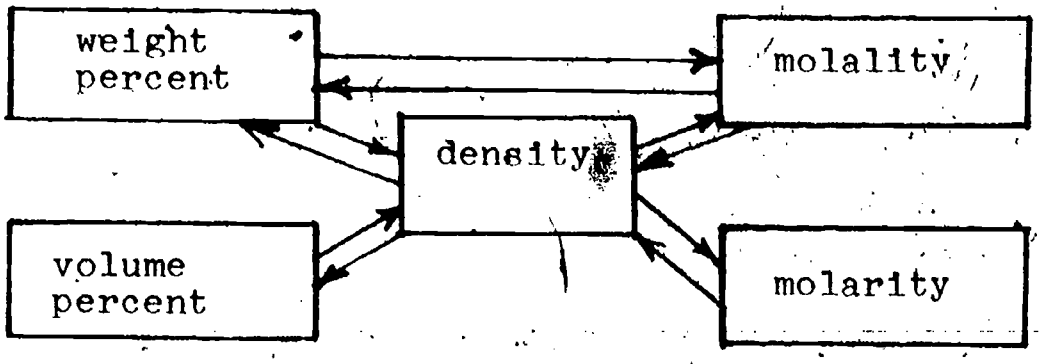
Presented are the teacher's guide and student manual for one of a series of self-instructional, computer-based learning modules for an introductory, undergraduate chemistry course. The student module for this solution concentration unit includes objectives, prerequisites, pretest, discussion, and 20 problem sets. Included in the teacher's guide are implementation instructions, answers to problems, software, a listing in BASIC of the computer program, and 20 unit tests. (BT)

SOLUTIONS

UNIT 2. MOLARITY; MOLALITY, CONCENTRATION CONVERSIONS

MORRIS BADER
MORAVIAN COLLEGE

A COMPUTER-ENRICHED MODULE
FOR INTRODUCTORY CHEMISTRY



Supported by grants from the
National Science Foundation
Exxon Foundation

OBJECTIVES

When you finish this unit you will be able to

1. define molarity and molality.
2. prepare any volume of any particular molar or molal solution.
3. use molarity and molality in chemical problems.
4. convert from one concentration unit to another.

PREREQUISITES

Before you begin this unit you should know

1. the concepts in the unit on introduction to solutions.
2. how to utilize the mole in chemical calculations.
3. how to use metric units of volume and mass.

PRE-TEST

1. Calculate the % by weight of a solution prepared by dissolving 10 mmols of NaCl (MW = 58.5 g/mole) in 5 g of water.
2. How many mls of acetone (CH_3COCH_3), (MW = 58 g/mole) are required to prepare 200 ml of a 15% v/v of acetone in water?
3. Calculate the concentration of Fe^{+2} in PPM of a solution in which 50 mg of $FeSO_4$ was dissolved in one liter of H_2O. (At. wts.: Fe = 55.85, S = 32, O = 16 g/mole)

Answers to pre-test:

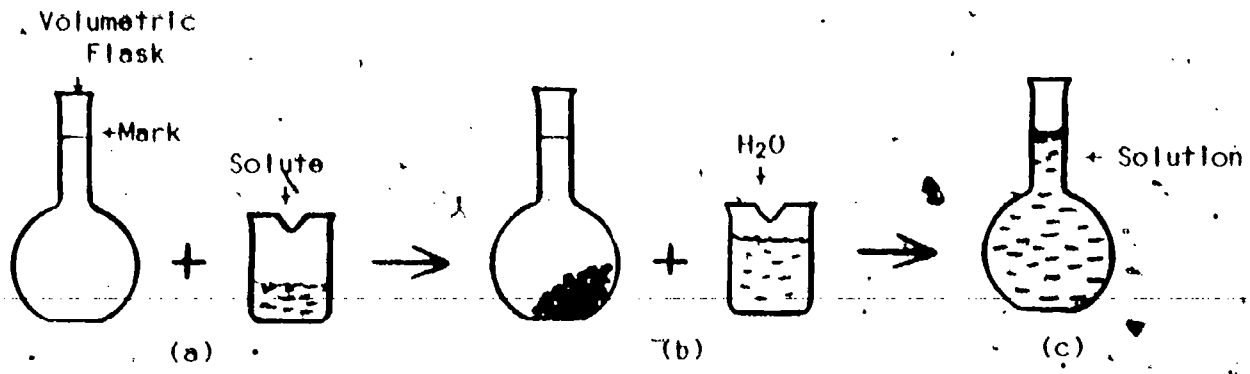
1. 11.7% w/w
2. 30 ml
3. 18.4 PPM

INTRODUCTION

In chemistry there is always a need of measuring out specific amounts of reagents in running chemical reactions. Anyone who has handled a modern analytic balance will agree that this is an extremely accurate device. Yet when one compares the time and effort to weigh a number of samples as opposed to measuring out quantities by volume, as say, teaspoons, cups, or milliliters, everyone will agree that volume measure is many times faster and easier than weight measure. Coupling this with the fact that all chemical reactions occur on a mole ratio basis, it is easy to see how the molar solution was invented. The molar solution dispenses moles of solute on a volume basis. Later we will see that the molal solution is just a rearrangement of the weight percent solution we learned before.

THE MOLAR SOLUTION

The following diagram will describe the preparation of a molar solution.



In (a) a volumetric flask of the size required is obtained. These come in various standard sizes from 5 ml to 2 liters. Next, a given weight of a solute is obtained. This weight represents a definite number of moles. Now water is added (b) and the mixture shaken constantly until the solution "meniscus" is exactly at the mark of the volumetric flask (c). Note that the amount of water added is not measured so long as the total solution reaches the mark on the flask.

Example 1. Suppose now we weighed out 15.96 g of $CuSO_4$ and diluted to 500 ml in a volumetric flask. What would the molarity of the solution be?

1. Molarity = $\frac{\text{no. of moles solute}}{\text{total volume of solution in liters}}$

   In molarity problems we calculate the numerator and denominator separately, and then divide.

2. Moles of solute = $\frac{\text{g of solute}}{\text{MW solute}} = \frac{15.96}{159.6 \text{ g } CuSO_4/\text{mol}}$

3. No. of moles $CuSO_4$ = 0.10 moles

4. Vol. of solution = 500 ml = 0.5 l

5. Molarity = $\frac{0.10 \text{ moles } CuSO_4}{0.50 \text{ liters solution}} = 0.20 \text{ M}$

We see that molarity has the units of $\frac{\text{moles}}{\text{liter}}$.

Let's write down all the formulas we used so far ...

6. No. of moles = $\frac{\text{g solute}}{\text{MW solute (g/mol)}}$

7. 1 liter = 1000 ml

8. Molarity = moles/liter

Since 1 mole = 1000 millimoles (mmol) and 1 liter = 1000 ml, the molarity can also be represented as:

$$M = \frac{\text{no. of mmol}}{\text{no. of ml}}, \text{ or, units of } \frac{\text{mmol}}{\text{ml}}$$

Our 0.20 M solution of $CuSO_4$ would then contain 0.20 moles $CuSO_4$/liter of solution or 0.20 mmols/ml. Note that the molarity value does not change.

Example 2. Suppose you dissolve 30 mmol of NaOH in 0.4 liters. Calculate the molarity. First we notice that the units are not consistent; we need either mmols/ml or moles/liter so we can do it in one of two ways.

Method 1:

$$30 \text{ mmols} = 0.03 \text{ moles}$$

Then

$$M = \frac{0.03 \text{ moles NaOH}}{0.40 \text{ liters}} = \frac{3 \times 10^{-2} \text{ moles}}{4 \times 10^{-1} \text{ liters}}$$

$$= 0.75 \times 10^{-1} \text{ molar}$$

$$M = 7.5 \times 10^{-2} \text{ molar}$$

$$M = 0.075 \text{ molar}$$

Method 2:

$$0.40 \text{ l} = 400 \text{ ml}$$

Then

$$\text{Molarity} = \frac{30 \text{ mmol}}{400 \text{ ml}} = 0.075 \text{ molar}$$

Notice that the same number is obtained in both cases. Try the following problems to see if you have the idea.

Problem 1. Calculate the molarities of the following solutions:

a. contains 50 mmol of solute in 1.5 liters of solution.

b. contains 165.6 g of lead nitrate (MW = 331.2 g/mol) in 250 ml of solution.

c. contains 25.2 milligrams of manganous chloride (MW = 126 g/mol) in 0.1 liter of solution.

Example 3. Let's examine the problrm wherein we delivered a given volume of solution, say 20 ml of a 0.50 M ferrous sulfate ($FeSO_4$), and wish to calculate the number of grams of $FeSO_4$ delivered. (MW $FeSO_4$ = 152. g/mol)

Since

$$\text{Molarity} = \frac{\text{moles solute}}{\text{liters of solution}}$$

then

$$20 \text{ ml solution} \times \frac{0.50 \text{ mmol } FeSO_4}{\text{ml solution}} \times \frac{1 \text{ mol}}{1000 \text{ mmol}} \times \frac{152. \text{ g } FeSO_4}{\text{mol } FeSO_4} =$$

$$= \frac{20 \times 0.50 \times 152.}{1000} \text{ g } FeSO_4 = 1.52 \text{ g}$$

Problem 2. Calculate the number of grams of solute in 100 ml of a 5×10^{-3} M solution of silver nitrate ($AgNO_3$), (MW = 170 g/mol).

Problem 3. How many mls of a 3 M solution can be prepared from 60 grams of sulfuric acid (H_2SO_4), (MW = 98 g/mol)?

Weight percent concentrations can be converted to molarity provided the density of the solution is available.

Example 4. Calculate the molarity of a solution of nitric acid (HNO_3) (MW = 63 g/mol), which is 29.26% w/w HNO_3 and has a specific gravity of 1.18.

The specific gravity is the ratio of the density of an object to the density of water. In the metric system d H_2O = 1 g/ml so the density of the HNO_3 solution is 1.18 g/ml.

One way of solving this problem is to suppose that we had 1000 ml (1 liter) of this solution. Then if we can calculate the number of moles of solute that would be present in the volume of 1 liter, that number of moles would equal the molarity.

Step 1. Using the density, find the total weight of 1000 ml of solution.

$$1000 \text{ ml solution} \times \frac{1.18 \text{ g solution}}{\text{ml solution}} = \text{g solution}$$

Step 2. Using the % w/w composition calculate the fraction of the total weight of solution which is solute.

$$\text{g solution} \times \frac{0.2926 \text{ g } HNO_3}{\text{g solution}} = \qquad \text{g } HNO_3$$

Step 3. Using the molecular weight of the solute, convert grams of solute to moles of solute.

$$\text{g } HNO_3 \times \frac{1 \text{ mol } HNO_3}{63 \text{ g } HNO_3} = \qquad \text{moles } HNO_3$$

Step 4. Putting Steps 1 through 3 together:

$$\frac{1000 \times 1.18 \times 0.2926}{63.} = 5.48 \text{ mol } HNO_3$$

Step 5. Molarity $= \frac{5.48 \text{ mol } HNO_3}{1 \text{ liter}} = 5.48 \text{ M}$.

Problem 4. Calculate the molarity of an ammonium hydroxide solution (NH_4OH) which has a specific gravity of 0.96 and contains 9.38% by weight of NH_3.

MOLALITY

The molality concentration arises as a useful concentration unit when dealing with physical interactions between solute and solvent (see Colligative Properties). Be careful to distinguish the difference between molarity and molality.

Molality is defined as moles of solute per kilogram of solvent, or in equation form:

$$\text{molality} = \frac{\text{moles solute}}{\text{kilogram solvent}}$$

An important consideration of molality is that the denominator contains the weight of solvent only, not solution.

Since most experiments in which molality is required involve weighing out both solute and solvent, the following formula is much more operational (useful) and it might be advisable for a student to keep it in mind:

$$\text{molality} = \frac{\text{g of solute}}{\text{g of solvent}} \times \frac{1000 \text{ g/kg}}{(\text{MW solute}) \text{ g/mol}}$$

Example 5. Calculate the molality of a solution prepared by weighing 10 g of chromic sulfate, $Cr_2(SO_4)_3$, in 150 g of water. (MW $Cr_2(SO_4)_3$ = 392)

Then:

$$\text{molality} = \frac{\text{g solute}}{\text{g solvent}} \times \frac{1000}{(\text{MW solute})}$$

$$= \frac{10 \times 1000}{150 \times 392}$$

$$= 0.17 \text{ molal}$$

Example 6. Calculate the molality of a solution prepared by dissolving 0.5 moles KCl in 75 g of water. In this case, since the moles are given directly,

$$\text{molality} = \frac{\text{moles solute}}{\text{g solvent}} \times \frac{1000 \text{ g}}{1 \text{ kg}}$$

$$= \frac{0.5 \times 1000}{75}$$

$$= 6.67 \text{ molal}$$

Here are two problems to try:

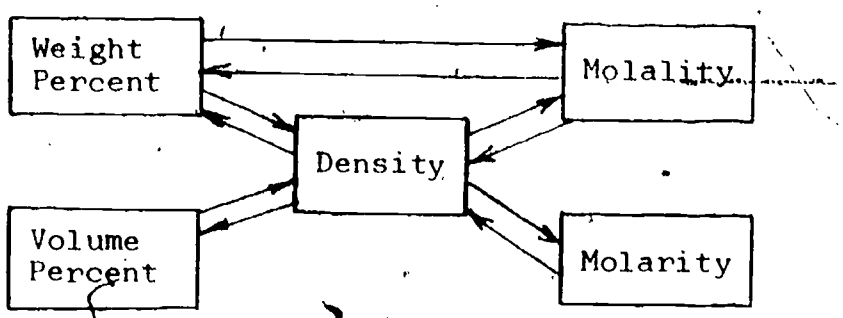
Problem 5. Calculate the molality of a solution prepared by dissolving 2 g of NaOH (MW = 40 g/mol) in 120 ml of water, (density of H_2O = 1 g/ml).

Problem 6. a. Calculate the number of grams of $BaCl_2$ (MW = 208 g/mol) required to prepare a 0.4 molal solution containing 2 kg of water.

b. What would the total solution weigh?

SUMMARY

So far, we have discussed four concentration units -- weight percent, volume percent, molarity and molality. These are all connected and any concentration can be converted to any other providing the density is known.



The diagram shows that density is involved in all conversions except the one between weight percent and molality.

Problem 7. Calculate the molality of a solution which is 10% by weight $CaBr_2$ (MW = 200 g/mol).

Problem 8. How do you think an increase in temperature will affect the concentration of a molar or a molal solution?

You are now ready to take a small quiz on this unit. Log in according to the instructions of your teacher. The computer will then give you a five-problem quiz. Take the quiz home and answer the questions. Then come back and have the computer check your answers. If you need more help, go back over this module and then try the computer quiz again. The computer questions will all be different; no two questions are the same.

Problem Set 1

1. CALCULATE THE WEIGHT PERCENT OF $CrCl_3$ IN A SOLUTION CONTAINING 49.45 G OF $CrCl_3$ IN 396 G OF WATER.

2. HOW MANY ML OF 2.180 M $Ni(NO_3)_2$ IS REQUIRED IN THE PREPARATION OF 49.8 ML OF 0.990 M $Ni(NO_3)_2$?

3. WHAT IS THE MOLARITY OF A 5.13 PERCENT SOLUTION OF $CaBr_2$? THE DENSITY OF THE SOLUTION IS 1.050 G/ML .

4. IF A SOLUTION OF DENSITY 1.169 G/ML IS PREPARED BY DISSOLVING 52.5 G OF $KMnO_4$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE MOLALITY OF $KMnO_4$ IN THE SOLUTION?

Problem Set 2

1. HOW MANY ML OF 2.140 M $CuSO_4 \cdot 5H_2O$ IS REQUIRED IN THE PREPARATION OF 49.0 ML OF 0.402 M $CuSO_4 \cdot 5H_2O$?

2. IF A SOLUTION OF DENSITY 1.418 G/ML IS PREPARED BY DISSOLVING 88.5 G OF $Cd(NO_3)_2$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE MOLARITY OF $Cd(NO_3)_2$ IN THE SOLUTION?

3. CALCULATE THE WEIGHT PERCENT OF $CaBr_2$ IN A SOLUTION CONTAINING 67 G OF WATER IN 1.04 MOLES OF $CaBr_2$.

4. WHAT IS THE MOLARITY OF A 7.83 PERCENT SOLUTION OF $Al_2(SO_4)_3$? THE DENSITY OF THE SOLUTION IS 1.077 G/ML .

Problem Set 3

1. THE DENSITY OF A 1.27 M SOLUTION OF $FeCl_3$ IN WATER IS 1.108 G/ML AT 20 DEG C. CALCULATE THE WEIGHT-PERCENT OF THE SOLUTION.

2. A SOLUTION IS PREPARED BY DISSOLVING 29.85 G OF $KMnO_4$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. THE DENSITY OF THE SOLUTION IS 1.329 G/ML. CALCULATE THE WEIGHT PERCENT OF WATER IN THIS SOLUTION.

3. THE DENSITY OF A 0.77 M SOLUTION OF $MgSO_4$ IN WATER IS 1.060 G/ML AT 20 DEG C. CALCULATE THE MOLALITY OF THE SOLUTION.

4. CALCULATE THE NUMBER OF MOLES OF $MnCl_2$ IN 100.2 ML OF 0.584 M $MnCl_2$.

Problem Set 4

1. CALCULATE THE NUMBER OF MOLES OF $KMnO_4$ IN 97.1 ML OF 0.219 M $KMnO_4$.

2. THE DENSITY OF A 0.85 M SOLUTION OF $CaBr_2$ IN WATER IS 1.038 G/ML AT 20 DEG C. CALCULATE THE WEIGHT PERCENT OF THE SOLUTION.

3. IF A SOLUTION OF DENSITY 1.133 G/ML IS PREPARED BY DISSOLVING 4.5 G OF $MgSO_4$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE MOLALITY OF $MgSO_4$ IN THE SOLUTION?

4. A SOLUTION IS PREPARED BY DISSOLVING 70.50 G OF $Ni(NO_3)_2$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. THE DENSITY OF THE SOLUTION IS 1.113 G/ML. CALCULATE THE WEIGHT PERCENT OF WATER IN THIS SOLUTION.

Problem Set 5

1. CALCULATE THE NUMBER OF MOLES OF $K_2Cr_2O_7$ IN 29.7 ML OF 0.318 M $K_2Cr_2O_7$.

2. 0.855 MOLES OF Na_2CO_3 IS DISSOLVED IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. WHAT IS THE WEIGHT PERCENT OF WATER IN THIS SOLUTION WHOSE DENSITY IS 1.287 G/ML ?

3. THE DENSITY OF A 0.54 M SOLUTION OF KIO_3 IN WATER IS 1.182 G/ML AT 20 DEG C. CALCULATE THE MOLALITY OF THE SOLUTION.

4. WHAT IS THE MOLARITY OF A 5.10 PERCENT SOLUTION OF $(NH_4)_3PO_4$? THE DENSITY OF THE SOLUTION IS 1.050 G/ML .

Problem Set 6

1. THE DENSITY OF 11.0 PERCENT $Ni(NO_3)_2$ SOLUTION IS 1.111 G/ML. WHAT WEIGHT AND WHAT VOLUME OF THIS SOLUTION WILL CONTAIN 51 GRAMS OF $Ni(NO_3)_2$?

2. IF A SOLUTION OF DENSITY 1.030 G/ML IS PREPARED BY DISSOLVING 42.5 G OF KNO_3 IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE MOLALITY OF KNO_3 IN THE SOLUTION?

3. THE DENSITY OF A 0.51 M SOLUTION OF $FeCl_3$ IN WATER IS 1.116 G/ML AT 20 DEG C. CALCULATE THE WEIGHT PERCENT OF THE SOLUTION.

4. CALCULATE THE NUMBER OF MOLES OF Na_2CO_3 IN 50.2 ML OF 0.455 M Na_2CO_3.

Problem Set 7

1. THE DENSITY OF A 1.27 M SOLUTION OF $FeCl_3$ IN WATER IS 1.134 G/ML AT 20 DEG C. CALCULATE THE WEIGHT PERCENT OF THE SOLUTION.

2. FIND THE MOLARITY OF A SOLUTION PREPARED BY DISSOLVING 3.23 G OF KBr IN A TOTAL OF 258 ML OF SOLUTION.

3. CALCULATE THE WEIGHT PERCENT OF $MnCl_2$ IN A SOLUTION CONTAINING 48.198 G OF $MnCl_2$ IN 1013 G OF WATER.

4. IF A SOLUTION OF DENSITY 1.189 G/ML IS PREPARED BY DISSOLVING 64.5 G OF $K_2Cr_2O_7$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE MOLALITY OF $K_2Cr_2O_7$ IN THE SOLUTION?

Problem Set 8

1. CALCULATE THE NUMBER OF MOLES OF $CrCl_3$ IN 69.5 ML OF 0.289 M $CrCl_3$.

2. CALCULATE THE WEIGHT PERCENT OF $K_2Cr_2O_7$ IN A SOLUTION CONTAINING 38.900 G OF $K_2Cr_2O_7$ IN 1004 G OF WATER.

3. IF A SOLUTION OF DENSITY 1.038 G/ML IS PREPARED BY DISSOLVING 90.5 G OF $Cd(NO_3)_2$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE MOLALITY OF $Cd(NO_3)_2$ IN THE SOLUTION?

4. THE DENSITY OF A 0.35 M SOLUTION OF $Cd(NO_3)_2$ IN WATER IS 1.146 G/ML AT 20 DEG C. CALCULATE THE WEIGHT PERCENT OF THE SOLUTION.

Problem Set 9

1. CALCULATE THE NUMBER OF MOLES OF $Al_2(SO_4)_3$ IN 59.5 ML OF 0.453 M $Al_2(SO_4)_3$.

2. THE DENSITY OF A 1.27 M SOLUTION OF $Cd(NO_3)_2$ IN WATER IS 1.094 G/ML AT 20 DEG C. CALCULATE THE MOLALITY OF THE SOLUTION.

3. IF A SOLUTION OF DENSITY 1.102 G/ML IS PREPARED BY DISSOLVING 2.9 MOLES OF $AgNO_3$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE WEIGHT PERCENT OF $AgNO_3$ IN THE SOLUTION?

4. THE DENSITY OF A 1.39 M SOLUTION OF $Al_2(SO_4)_3$ IN WATER IS 1.172 G/ML AT 20 DEG C. CALCULATE THE WEIGHT PERCENT OF THE SOLUTION.

Problem Set 10

1. THE DENSITY OF 83.7 PERCENT $FeCl_3$ SOLUTION IS 1.184 G/ML. WHAT WEIGHT AND WHAT VOLUME OF THIS SOLUTION WILL CONTAIN 39 GRAMS OF $FeCl_3$?

2. THE DENSITY OF A 1.70 M SOLUTION OF $CrCl_3$ IN WATER IS 1.038 G/ML AT 20 DEG C. CALCULATE THE MOLALITY OF THE SOLUTION.

3. THE DENSITY OF A 1.03 M SOLUTION OF $KMnO_4$ IN WATER IS 1.120 G/ML AT 20 DEG C. CALCULATE THE WEIGHT PERCENT OF THE SOLUTION.

4. CALCULATE THE NUMBER OF MOLES OF $AgNO_3$ IN 20.6 ML OF 0.505 M $AgNO_3$.

Problem Set 11

1. THE DENSITY OF A .82 M SOLUTION OF $Ni(NO_3)_2$ IN WATER IS 1.166 G/ML AT 20 DEG C. CALCULATE THE WEIGHT PERCENT OF THE SOLUTION.

2. IF A SOLUTION OF DENSITY 1.290 G/ML IS PREPARED BY DISSOLVING 4.5 MOLES OF KNO, IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE WEIGHT PERCENT OF KNO, IN THE SOLUTION?

3. THE DENSITY OF A 1.22 M SOLUTION OF BaCl, IN WATER IS 1.098 G/ML AT 20 DEG C. CALCULATE THE MOLALITY OF THE SOLUTION.

4. FIND THE NUMBER OF GRAMS OF CrCl, REQUIRED TO PREPARE 1.60 LITERS OF 3.955 M SOLUTION.

Problem Set 12

1. THE DENSITY OF A 1.15 M SOLUTION OF FeCl, IN WATER IS 1.010 G/ML AT 20 DEG C. CALCULATE THE WEIGHT PERCENT OF THE SOLUTION.

2. CALCULATE THE WEIGHT PERCENT OF CaBr, IN A SOLUTION CONTAINING 4.149 G OF CaBr, IN 773 G OF WATER.

3. TO WHAT VOLUME (ML) MUST 2.17 G OF KIO, BE DILUTED TO MAKE A .591 M SOLUTION ?

4. IF A SOLUTION OF DENSITY 1.292 G/ML IS PREPARED BY DISSOLVING 25.5 G OF AgNO, IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE MOLALITY OF AgNO, IN THE SOLUTION?

Problem Set 13

1. THE DENSITY OF A 1.50 M SOLUTION OF KIO_3 IN WATER IS 1.098 G/ML AT 20 DEG C. CALCULATE THE WEIGHT PERCENT OF THE SOLUTION.

2. 0.109 MOLES OF $CrCl_3$ IS DISSOLVED IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. WHAT IS THE WEIGHT PERCENT OF WATER IN THIS SOLUTION WHOSE DENSITY IS 1.084 G/ML ?

3. CALCULATE THE MOLALITY OF $FeCl_3$ IN A SOLUTION CONTAINING 35.00 GRAMS OF WATER IN 7.47 GRAMS OF $FeCl_3$.

4. TO WHAT VOLUME (ML) MUST 7.17 G OF $FeCl_3$ BE DILUTED TO MAKE A 0.237 M SOLUTION ?

Problem Set 14

1. THE DENSITY OF A 1.14 M SOLUTION OF $Ni(NO_3)_2$ IN WATER IS 1.114 G/ML AT 20 DEG C. CALCULATE THE WEIGHT PERCENT OF THE SOLUTION.

2. THE SOLUBILITY OF $AgNO_3$ IS 86.5 G $AgNO_3$ PER 100 G WATER AT SOME TEMPERATURE. WHAT IS THE WEIGHT PERCENT OF A SATURATED SOLUTION OF $AgNO_3$ AT THIS TEMPERATURE ?

3. THE DENSITY OF A 0.77 M SOLUTION OF $MnCl_2$ IN WATER IS 1.196 G/ML AT 25 DEG C. CALCULATE THE MOLALITY OF THE SOLUTION.

4. CALCULATE THE NUMBER OF MOLES OF Na_3PO_4 IN 32.0 ML OF 0.689 M Na_3PO_4.

Problem Set 15

1. IF A SOLUTION OF DENSITY 1.375 G/ML IS PREPARED BY DISSOLVING 44.5 G OF $Ni(NO_3)_2$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE MOLALITY OF $Ni(NO_3)_2$ IN THE SOLUTION?

2. WHAT IS THE MOLARITY OF A 2.15 PERCENT SOLUTION OF $AgNO_3$? THE DENSITY OF THE SOLUTION IS 1.020 G/ML .

3. FIND THE VOLUME IN LITERS OF 0.376 M $Cd(NO_3)_2$ SOLUTION THAT CAN BE PREPARED FROM 23.50 G OF $Cd(NO_3)_2$.

4. CALCULATE THE WEIGHT PERCENT OF $Al_2(SO_4)_3$ IN A SOLUTION CONTAINING 47 G OF WATER IN 0.81 MOLES OF $Al_2(SO_4)_3$.

Problem Set 16

1. FIND THE NUMBER OF GRAMS OF $CaBr_2$ REQUIRED TO PREPARE 1.00 LITERS OF 4.225 M SOLUTION.

2. THE DENSITY OF 28.7 PERCENT $MgSO_4$ SOLUTION IS 1.129 G/ML. WHAT WEIGHT AND WHAT VOLUME OF THIS SOLUTION WILL CONTAIN 76 GRAMS OF $MgSO_4$?

3. IF A SOLUTION OF DENSITY 1.048 G/ML IS PREPARED BY DISSOLVING 15.5 G OF $Cd(NO_3)_2$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE MOLALITY OF $Cd(NO_3)_2$ IN THE SOLUTION?

4. WHAT IS THE MOLARITY OF A 4.10 PERCENT SOLUTION OF $(NH_4)_3PO_4$? THE DENSITY OF THE SOLUTION IS 1.040 G/ML

Problem Set 17

1. THE DENSITY OF A 1.98 M SOLUTION OF $(NH_4)_3PO_4$ IN WATER IS 1.160 G/ML AT 20 DEG C. CALCULATE THE WEIGHT PERCENT OF THE SOLUTION.

2. IT IS DESIRED TO PREPARE A SOLUTION OF $CaBr_2$ IN 241 ML OF WATER SUCH THAT THE WEIGHT PERCENT OF $CaBr_2$ IS EQUAL TO 8.26. HOW MANY GRAMS OF $CaBr_2$ ARE REQUIRED ?

3. FIND THE VOLUME IN LITERS OF 0.379 M $KMnO_4$ SOLUTION THAT CAN BE PREPARED FROM 22.50 G OF $KMnO_4$.

4. IF A SOLUTION OF DENSITY 1.050 G/ML IS PREPARED BY DISSOLVING 9.5 G OF $(NH_4)_2SO_4$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE MOLALITY OF $(NH_4)_2SO_4$ IN THE SOLUTION?

Problem Set 18

1. CALCULATE THE NUMBER OF MOLES OF Na_3PO_4 IN 39.2 ML OF 0.168 M Na_3PO_4.

2. THE DENSITY OF A 1.64 M SOLUTION OF $CuSO_4 \cdot 5H_2O$ IN WATER IS 1.198 G/ML AT 20 DEG C. CALCULATE THE MOLALITY OF THE SOLUTION.

3. WHAT IS THE MOLARITY OF A 7.80 PERCENT SOLUTION OF $Ni(NO_3)_2$? THE DENSITY OF THE SOLUTION IS 1.077 G/ML .

4. A SOLUTION IS PREPARED BY DISSOLVING 32.10 G OF $NaClO_3$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. THE DENSITY OF THE SOLUTION IS 1.150 G/ML. CALCULATE THE WEIGHT PERCENT OF WATER IN THIS SOLUTION.

Problem Set 19

1. THE DENSITY OF A 1.43 M SOLUTION OF $Cd(NO_3)_2$ IN WATER IS 1.166 G/ML AT 20 DEG C. CALCULATE THE WEIGHT PERCENT OF THE SOLUTION.

2. IF A SOLUTION OF DENSITY 1.328 G/ML IS PREPARED BY DISSOLVING 3.4 MOLES OF $FeCl_3$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE WEIGHT PERCENT OF $FeCl_3$ IN THE SOLUTION?

3. THE DENSITY OF A 0.52 M SOLUTION OF $K_2Cr_2O_7$ IN WATER IS 1.068 G/ML AT 20 DEG C. CALCULATE THE MOLALITY OF THE SOLUTION.

4. FIND THE NUMBER OF GRAMS OF KNO_3 REQUIRED TO PREPARE 1.36 LITERS OF 3.515 M SOLUTION.

Problem Set 20

1. WHAT IS THE MOLARITY OF A 1.29 PERCENT SOLUTION OF $KMnO_4$? THE DENSITY OF THE SOLUTION IS 1.012 G/ML .

2. THE DENSITY OF A 1.70 M SOLUTION OF $CrCl_3$ IN WATER IS 1.156 G/ML AT 20 DEG C. CALCULATE THE MOLALITY OF THE SOLUTION.

3. IT IS DESIRED TO PREPARE A SOLUTION OF KIO_3 IN 121 ML OF WATER SUCH THAT THE WEIGHT PERCENT OF KIO_3 IS EQUAL TO 4.42. HOW MANY GRAMS OF KIO_3 ARE REQUIRED ?

4. FIND THE NUMBER OF GRAMS OF Na_2CO_3 REQUIRED TO PREPARE 1.24 LITERS OF 3.085 M SOLUTION.

The CM Project

The Computer-enriched Module (CM) project is a collaborative effort by 19 faculty members in the disciplines of chemistry, mathematics and physics, to produce self-instructional computer-based materials at the introductory college level in those disciplines. Each module is designed to be usable in an academic environment with minimal computational facilities, and by students and faculty who are not programming experts. It may be used as an adjunct to standard textual materials, or in many cases, as a replacement for them. The primary aim of each module is to use the computer in such a way that students may take a more active role in the development and discovery of concepts and phenomena.

CM Project Staff

Chemistry	Mathematics	Physics
C. J. Jameson Chem. Group Leader U. of Ill. - CC Chicago, IL	J. H. Mayne Math. Group Leader Loyola University Chicago, IL	H. Weinstock Phys. Group Leader IIT Chicago, IL
M. Bader Moravian College Bethlehem, PA	R. A. Alo Carnegie-Mellon U. Pittsburgh, PA	D. Davidson Pima Comm. Coll. Tucson, AR
A. K. Jameson Loyola University Chicago, IL	N. C. Harbertson Cal. St. Univ. Fresno, CA	P. Goldstein Jersey City St. C. Jersey City, NJ
J. Manock Western Carolina U. Cullowhee, NC	L. C. Leinbach Gettysburg College Gettysburg, PA	W. Lang MacMurray College Jacksonville, IL
R. T. O'Neill Xavier University Cincinnati, OH	J. C. Mathews Iowa State Univ. Ames, IA	L. E. Turner, Jr. Pacific Union Coll. Angwin, CA
F. A. Settle, Jr. Va. Military Inst. Lexington, VA	L. E. Mauland U. of North Dakota Grand Forks, ND	S. L. Wiley Cal. State Univ. Dominguez Hills, CA
R. Williams (formerly) U. of Neb. Lincoln, NB		

Address all correspondence to

Professor H. Weinstock
Director, CM Project
Physics Department
Illinois Institute of Technology
Chicago, Illinois 60616

TEACHER'S GUIDE TO
A MODULE ON SOLUTIONS
UNIT 2. MOLARITY, MOLALITY, AND CONCENTRATION CONVERSIONS

MORRIS BADER

MORAVIAN COLLEGE

a computer-enriched module

for introductory chemistry

featuring the program

CTEST

Supported by grants from the
National Science Foundation
Exxon Foundation

TEACHER'S GUIDE TO UNIT ON A MODULE ON SOLUTIONS; MOLARITY, MOLALITY AND CONCENTRATION CONVERSIONS

EDUCATIONAL OBJECTIVES

This module is a continuation of Unit 1, a module on weight percent, volume percent and PPM. Even so, both modules may be used independently of one another although the concepts of Unit 1 naturally precede these included here. In this unit emphasis is placed on fundamental definitions and the ability to convert from one concentration unit to another.

The factor method has been used throughout with careful attention to number unit labels.

IMPLEMENTATION

This module is meant to be used at the student's own pace. The design has been to keep the readings brief and to maintain a constant level of difficulty. In using this module the student is not pressured into jumping across the pages in the random frenzy of a scavenger hunt. The examples are many and simple exercises follow the student as he progresses through the material.

At any time the student can go to the computer and ask for a written quiz. The quiz consists of a series of five questions picked at random from a set of 25 questions and will guarantee that he will receive at least one question in each of the five concentration areas discussed in the module. This means that there is the possibility of 5^5 or 3125 different exams. Moreover, the numbers chosen in each question will be picked at random by the computer when the quiz is generated. The important aspect of this quiz is that the student can take the quiz home and return at any later time to check his results. With this approach, the student does not waste expensive computer time working out the problems at the site. In addition, the programming is kept to a minimum, so that the instructor need not be concerned with keeping files or records of any sort. There are no answers stored in the computer, only the algorithm for the solution of the problem. When the student re-enters his quiz number, he is in actuality re-initializing a random number generator

which reprograms internally the same quiz as was printed out. The computer quiz is meant to encourage self-testing as a quantitative means of determining mastery of the subject matter.

ANSWERS TO PROBLEMS

1. a. 50 mmol = 0.05 mol

$$\text{molarity} = \frac{0.05 \text{ mol}}{1.5 \text{ l}} = 0.033 \text{ M}$$

b. $$\text{mols } Pb(NO_3)_2 = \frac{165.6 \text{ g}}{331.2 \text{ g/mol}} = 0.5 \text{ mol}$$

$$\text{molarity} = \frac{0.5 \text{ mol}}{0.25 \text{ l}} = 2 \text{ M}$$

c. $$\text{mmol of } MnCl_2 = \frac{25.2 \text{ mg}}{126. \text{ mg/mmol}} = 0.2 \text{ mmol}$$

$$\text{molarity} = \frac{0.2 \text{ mmol}}{100 \text{ ml}} = 2 \times 10^{-3} \text{ M}$$

2. moles of $AgNO_3$ = 0.1 ℓ × 5×10^{-3} mol/ℓ

= 5×10^{-4} moles.

g $AgNO_3$ = 5×10^{-4} moles × 170 g/mol

= 0.085 g

3. moles H_2SO_4 = $\frac{60 \text{ g}}{98 \text{ g/mol}}$ = 0.612 moles

mmoles H_2SO_4 = 612

Then 3 M = $\frac{612 \text{ mmoles}}{x \text{ ml soln}}$

x = 204 ml of solution

4. Assume 1 ℓ of solution

Wt of solution = 1000 ml × 0.96 g/ml = 960 g

960 g × 0.0938 = 90.05 g NH_3

$$\text{moles } (NH_3) = \frac{90.05 \text{ g}}{17 \text{ g/mol}} = 5.30 \text{ M}$$

5. $\text{molality} = \frac{\text{g solute} \times 1000}{\text{g solvent} \times \text{MW solute}}$

$$= \frac{2 \text{ g NaOH} \times 1000}{120 \text{ g } H_2O \times 40 \text{ g/mol}}$$

molality NaOH = 0.42 m

6. $\text{Molality} = \frac{\text{g } BaCl_2 \times 1000}{\text{g } H_2O \times \text{MW } BaCl_2}$

$$0.4 \text{ m} = \frac{x \text{ g } BaCl_2 \times 1000}{2000 \text{ g } H_2O \times 208}$$

$x = \text{g } BaCl_2 = 166 \text{ g } BaCl_2$

Total weight = 166 + 2000 = 2166 g solution

7. 10% w/w = 10 g $CaBr_2$ per 90 g H_2O

$$\text{Molality} = \frac{10 \text{ g } CaBr_2}{90 \text{ g } H_2O} \times \frac{1000}{200}$$

$$= 0.56 \text{ m}$$

8. Since the units of molarity are moles/liter, and volume is a temperature-dependent quantity, a solution will usually tend to increase its volume with temperature, hence its molarity will then decrease. Molality, being based totally on weight measurements, will not change its concentration with a change in temperature.

ANSWERS TO PROBLEM SETS

TEST 1

1. 1.11E+01
2. 2.26E+01
3. 2.70E-01
4. 2.97E-01

TEST 2

1. 9.20E+00
2. 2.82E-01
3. 7.57E+01
4. 2.47E-01

TEST 3

1. 1.86E+01
2. 9.78E+01
3. 8.01E-01
4. 5.85E-02

TEST 4

1. 2.13E-02
2. 1.63E+01
3. 3.31E-02
4. 9.37E+01

TEST 5

1. 9.44E-03
2. 9.30E+01
3. 5.08E-01
4. 3.39E-01

TEST 6

1. 463.70 G, 417.37 ML
2. 4.25E-01
3. 7.47E+00
4. 2.28E-02

TEST 7

1. 1.82E+01
2. 1.05E-01
3. 4.54E+00
4. 1.95E-01

TEST 8

1. 2.01E-02
2. 3.73E+00
3. 4.04E-01
4. 7.26E+00

TEST 9

1. 2.70E-02
2. 1.60E+00
3. 4.42E+01
4. 4.05E+01

TEST 10

1. 46.60 G, 39.37 ML
2. 2.21E+00
3. 1.52E+01
4. 1.04E-02

TEST 11

1. 1.28E+01
2. 3.49E+
3. 1.16E+00
4. 1.00E+03

TEST 12

1. 1.85E+01
2. 5.34E-01
3. 1.72E+01
4. 1.18E-01

TEST 13

1. 2.95E+01
2. 9.84E+01
3. 1.32E+00
4. 1.87E+02

TEST 14

1. 1.87E+01
2. 4.64E+01
3. 6.99E-01
4. 2.20E-02

TEST 15

1. 1.83E-01
2. 1.29E-01
3. 2.64E-01
4. 8.55E+01

TEST 16

1. 8.45E+02
2. 264.82 G, 234.62 ML
3. 6.35E-02
4. 2.70E-01

TEST 17

1. 2.56E+01
2. 2.17E+01
3. 3.76E-01
4. 5.78E-02

TEST 18

1. 6.59E-03
2. 2.09E+00
3. 4.60E-0
4. 9.72E+01

TEST 19

1. 2.90E+01

2. 4.15E+01

3. 5.63E-01

4. 4.83E+02

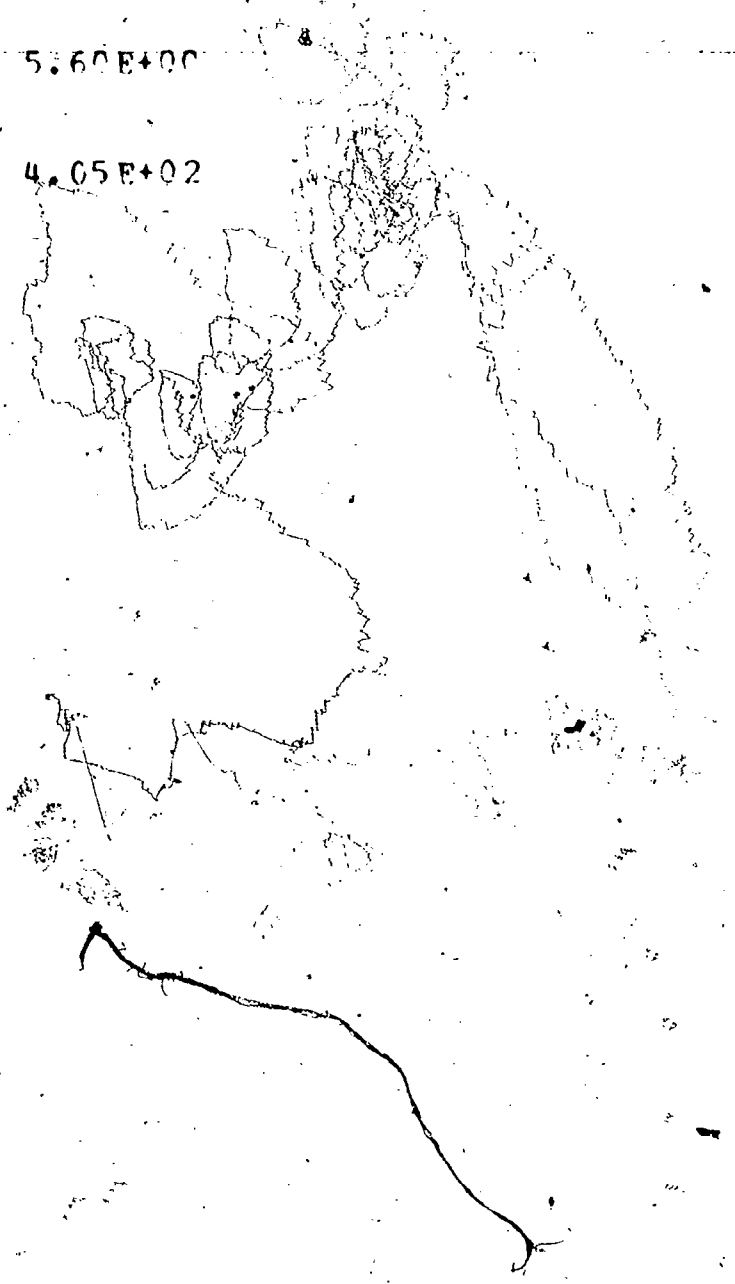
TEST 20

1. 8.26E-02

2. 1.91E+00

3. 5.60E+00

4. 4.05E+02



SOFTWARE

The computer program is written in standard BASIC common to nearly all computers with interactive capability. Random number generation may, however, vary from one machine to another. In this version RND(0) will generate a completely random number where a negative argument of RND will duplicate a prior sequence. The string arrays are simple and available in all versions of BASIC. Since files and file manipulations do vary considerably from one machine to another, this quiz program has avoided all use of files. Thus, the program has been designed to be as machine independent as possible. The programming technique is such that an instructor can easily substitute for any individual question in the set, or create an entirely new quiz using the structure of the method given here. The total time for a student on the computer should not exceed 15 minutes. On the second pass; the student returns with the answers to have them graded. The program as written will accept student responses correct to ±5%. This spread may be increased by minor changes in statements 1330 and 1335.

CTEST Program for Self-Test on Solutions

```
>LIST
CTEST
  10 REM THIS PROGRAM WRITTEN BY M.BADER 8/10/73,AT IIT
  15 REM THIS IS A 2 -PASS QUIZ PROGRAM IN WHICH 5 PROBLEMS WILL
  20 REM BE SELECTED AT RANDOM.  AFTER ANSWERING THE QUESTIONS THE
  25 REM STUDENT WILL RETURN AND SUBMIT HIS ANSWERS.  THE COMPUTER
  30 REM WILL THEN GRADE HIS RESULTS
  35 DIM A(5),T(5),N$(40),S$(20),Y$(3),L$(7)
  40 K=0
  45 G=0
  50 PRINT
  55 PRINT "PLEASE TYPE IN YOUR NAME"
  60 INPUT N$
  65 PRINT "PLEASE ENTER YOUR QUIZ SECTION."
  70 INPUT S$
  75 PRINT "O.K. "N$" DO YOU WISH TO TAKE A TEST OR HAVE YOUR "
  80 PRINT "RESULTS GRADED? IF YOU WISH TO TAKE A TEST RESPOND"
  85 PRINT "(YES), IF YOU WISH TO HAVE AN EXAM GRADED RESPOND (NO)."
  90 P=1
  95 INPUT Y$
 100 IF Y$="YES" THEN 185
 105 K=K+1
 110 IF Y$="NO" THEN 130
 115 IF K>3 THEN 1465
 120 PRINT "PLEASE ENTER YES OR NO."
 125 GOTO 75
 130 PRINT "PLEASE ENTER YOUR EXAM NUMBER."
 135 INPUT X
 140 PRINT &
     "PLEASE ENTER YOUR 5 ANSWERS IN THE EXACT ORDER OF THE QUESTIONS."

 145 PRINT "PRESS (RETURN) AFTER EACH INPUT."
 150 FOR U=1 TO 5
 155   INPUT T(U)
 160 NEXT U
 165 R=X
 170 Z=-R
 175 P=2
 180 GOTO 195
 185 R=INT(10000.5+40000*RND(0))
 190 Z=-R
 195 PRINT
 200 PRINT
 205 PRINT &
     "-------------------------------------------------------------&

-"
 210 PRINT
 215 PRINT "EXAM NO.  "R;TAB(35);"NAME  "N$
 220 PRINT DAT$(1,27);TAB(35);"SECTION  "S$
 225 PRINT
 230 IF P<>1 THEN 255
 235 PRINT "THERE ARE 5 QUESTIONS ON THIS EXAM. THESE ARE ALL ON "
 240 PRINT "SOLUTION CONCENTRATIONS. PLEASE ANSWER THESE QUESTIONS"
 245 PRINT "AT HOME, AND COME BACK WHEN YOU ARE READY TO HAVE YOUR"
 250 PRINT "EXAM GRADED."
 255 PRINT
```

```
260 PRINT
265 I=0
270 R=INT(1.5+4*RND(Z))
275 Z=0
280 GOSUB 1440
285 GOTO R OF 290,335,375,425,475
290 R1=INT(10.5+10*RND(Z))
295 R2=INT(12.5+3*RND(Z))/10
300 R3=INT(20.5+3*RND(Z))
305 IF P<>1 THEN 325
310 PRINT "A";R1;"PERCENT BY WEIGHT SOLUTION OF SOLUTE A IN WATER"
315 PRINT "HAS A DENSITY OF ";R2;" G/ML. IF ";R3;" ML OF THIS SOLUTION"

320 PRINT &
    "IS EVAPORATED TO DRYNESS. HOW MANY GRAMS OF SOLID A WILL REMAIN."
325 A(I)=R1*R2*R3/100
330 GOTO 515
335 R1=INT(3.5+2*RND(Z))
340 R2=INT(1.5+4*RND(Z))
345 IF P<>1 THEN 365
350 PRINT R1;" MOLES OF AMMONIA,NH3,(MW=17),WAS DISSOLVED IN ";R2
355 PRINT &
    "LITERS OF WATER(DENS=1.0G/ML).CALCULATE THE PERCENT BY WEIGHT"
360 PRINT "OF NH3 IN THE SOLUTION."
365 A(I)=100*(R1*17)/(1000*R2+R1*17)
370 GOTO 515
375 R1=INT(88.5+10*RND(Z))
380 R2=INT(160.5+25*RND(Z))/100
385 R3=INT(5.5+10*RND(Z))/10
390 IF P<>1 THEN 415
395 PRINT "A SOLUTION OF SULFURIC ACID,H2S04,(MW=98),HAS A CONCEN-"
400 PRINT "TRATION OF ";R1;" %W/W H2S04 AND A DENSITY OF ";R2
405 PRINT "G/ML. CALCULATE THE WEIGHT OF H2S04,IN GRAMS, CONTAINED IN"

410 PRINT R3;" LITERS OF SOLUTION."
415 A(I)=R1*R2*R3*10
420 GOTO 515
425 R1=INT(11.5+4*RND(Z))/10
430 R2=INT(5.5+5*RND(Z))
435 R3=INT(1.5+4*RND(Z))
440 IF P<>1 THEN 465
445 PRINT "A DILUTE SOLUTION OF SODIUM ACETATE,NAC2H302,(MW=82),HAS A"

450 PRINT "SPECIFIC GRAVITY OF ";R1;" AND CONTAINS ";R2;&
    " %W/W OF SOLUTE."
455 PRINT "HOW MANY GRAMS OF SOLUTE ARE PRESENT IN ";R3;" ML OF "
460 PRINT "SOLUTION?"
465 A(I)=R1*R2*R3/100
470 GOTO 515
475 R1=INT(5.5+5*RND(Z))
480 R2=INT(40.5+10*RND(Z))
485 IF P<>1 THEN 510
490 PRINT "ASSUMING NO VOLUME CHANGE ON MIXING,CALCULATE THE %V/V"
495 PRINT "OF A SOLUTION CONTAINING ";R1;" GRAMS OF ALCMHOL,C2H50H,"
500 PRINT "(MW=46),IN ";R2;" ML OF WATER. DENS.ALC.=0.8 G/ML,"
505 PRINT "DENS.H20=1 G/ML."
510 A(I)=100*(R1/.8)/(R2+R1/.8)
```

```
515 R=INT(1.5+4*RND(Z))
520 GOSUB 1440
525 GOTO R OF 530,560,600,635,665
530 R1=INT(6.5+2*RND(Z))
535 IF P<>1 THEN 550
540 PRINT "THE SOLUBILITY OF THE INSECTICIDE LINDANE ,C6H6CL6,(MW=291)"
545 PRINT "IS APPROX. ";R1;&
    " PPM. CALCULATE THE MOLALITY OF THIS SOLUTION."
550 A(I)=R1/(1000*291)
555 GOTO 690
560 R1=INT(6.5+2*RND(Z))
565 R2=INT(1.5+4*RND(Z))
570 IF P<>1 THEN 590
575 PRINT &
    "THE SOLUBILITY OF THE INSECTICIDE LINDANE,C6H6CL6,(MW=291),IS"
580 PRINT "APPROX. ";R1;&
    " PPM. HOW MANY MOLES OF LINDANE ARE PRESENT IN"
585 PRINT R2;"LITERS OF A SATURATED SOLUTION. DENS. =1 G/ML."
590 A(I)=R1*R2/(1000*291)
595 GOTO 690
600 R1=INT(1.5+4*RND(Z))*.000001
605 R2=INT(2.5+7*RND(Z))
610 IF P<>1 THEN 625
615 PRINT "IF SEA WATER CONTAINS ";R1;&
    " PPM OF GOLD,HOW MANY TONS OF SEA"
620 PRINT "WATER MUST BE PROCESSED TO EXTRACT";R2;"GRAMS OF GOLD?"
625 A(I)=500*R2/(454*R1)
630 GOTO 690
635 R1=INT(1.5+3*RND(Z))*.0001
640 IF P<>1 THEN 655
645 PRINT "THE SOLUBILITY OF NITROGEN GAS,N2,IN WATER IS APPROX. ";R1
650 PRINT "MOLAR. CALCULATE THIS SOLUBILITY IN PPM."
655 A(I)=28*1000*R1
660 GOTO 690
665 R1=INT(1.5+4*RND(Z))*.001
670 IF P<>1 THEN 685
675 PRINT "THE SOLUBILITY OF OXYGEN GAS,02,IN WATER IS APPROX. ";R1
680 PRINT "MOLAR. CALCULATE THIS SOLUBILITY IN PPM."
685 A(I)=32*1000*R1
690 R=INT(1.5+4*RND(Z))
695 GOSUB 1440
700 GOTO R OF 705,750,795,830,870
705 R1=INT(1.5+9*RND(Z))
710 R2=INT(150.5+100*RND(Z))
715 R3=INT(12.5+3*RND(Z))/10
720 IF P<>1 THEN 740
725 PRINT "A SUGAR SOLUTION CONTAINS";R1;"GRAMS OF SUCROSE,C12H22011,"
730 PRINT "(MW=342),PER ";R2;" ML OF SOLUTION.THE DENSITY IS ";R3;&
    " G/ML."
735 PRINT "CALCULATE THE MOLARITY OF THIS SOLUTION."
740 A(I)=1000*R1/(342*R2)
745 GOTO 905
750 R1=INT(100.5+100*RND(Z))
755 R2=INT(2+3*RND(Z))
```

```
760 R3=INT(400.5+100*RND(Z))
765 R4=INT(1.5+9*RND(Z))/10
770 IF P<>1 THEN 785
775 PRINT R1;"ML OF "JR2;" MOLAR CUSO4 WAS MIXED WITH "JR3;" ML OF "JR4
780 PRINT "MOLAR CUSO4.  CALCULATE THE FINAL MOLARITY."
785 A(1)=(R1*R2+R3*R4)/(R1+R3)
790 GOTO 905
795 R1=INT(1.5+9*RND(Z))
800 R2=INT(10.5+20*RND(Z))
805 IF P<>1 THEN 820
810 PRINT "HOW MANY LITERS OF "JR1;"
    "MOLAR SOLUTION CAN BE PREPARED FROM"
815 PRINT R2;"GRAMS OF BA(OH)2, (MW=171)?"
820 A(1)=R2/(171*R1)
825 GOTO 905
830 R1=INT(300.5+400*RND(Z))
835 R2=INT(10.5+20*RND(Z))
840 IF P<>1 THEN 860
845 PRINT R1;"ML OF A SOLUTION OF HCL REACTS COMPLETELY WITH "JR2;
850 PRINT "GRAMS OF ZINC, (MW=65.4). CALCULATE THE MOLARITY OF THE "
855 PRINT "HCL SOLUTION."
860 A(1)=(2000*R2)/(R1*65.4)
865 GOTO 905
870 R1=INT(1.5+4*RND(Z))
875 R2=INT(1.5+4*RND(Z))
880 IF P<>1 THEN 900
885 PRINT "HOW MANY GRAMS OF CUSO4.5H2O , (HYDRATED CRYSTAL), MUST BE "
890 PRINT "TAKEN TO PREPARE "JR1;"LITERS OF A "JR2;"MOLAR SOLUTION OF"
895 PRINT "CUSO4."
900 A(1)=R1*R2*249.6
905 R=INT(1.5+4*RND(Z))
910 GOSUB 1440
915 GOTO R OF 920,955,985,1020,1060
920 R1=INT(5.5+10*RND(Z))
925 R2=INT(200.5+300*RND(Z))
930 IF P<>1 THEN 945
935 PRINT R1;"GRAMS OF NA2CO3, (MW=106)WAS DISSOLVED IN"JR2;"GRAMS OF"
940 PRINT "WATER. CALCULATE THE MOLALITY OF THIS SOLUTION."
945 A(1)=(1000*R1)/(106*R2)
950 GOTO 1090
955 R1=INT(10.5+10*RND(Z))
960 IF P<>1 THEN 975
965 PRINT "A SOLUTION IS"JR1;"PERCENT BY WEIGHT KI, (MW=58). CALCULATE"
970 PRINT "THE MOLALITY OF THIS SOLUTION."
975 A(1)=(1000*R1)/((100-R1)*58)
980 GOTO 1090
985 R1=INT(2.5+3*RND(Z))
990 R2=INT(12.5+4*RND(Z))/10
995 IF P<>1 THEN 1010
1000 PRINT "A"JR1;"MOLAR SOLUTION OF KMNO4, (MW=158), HAS A DENSITY OF"
1005 PRINT R2;"G/ML. CALCULATE THE MOLALITY OF THIS SOLUTION."
1010 A(1)=1000*R1/((1000*R2)-158*R1)
1015 GOTO 1090
1020 R1=INT(1.5+4*RND(Z))
1025 R2=INT(6.5+4*RND(Z))
```

```
1030 IF P<>1 THEN 1050
1035 PRINT &
     "GLYCERINE,C3H803,(MW=98),MIXES WITH WATER IN ALL PRØPØRTIØNS."
1040 PRINT "CALCULATE THE MØLALITY ØF A MIXTURE ØF";R1;&
     "MOLES ØF GLYCERINE"
1045 PRINT "WITH";R2;"MØLES ØF WATER. THE WATER IS THE SØLVENT."
1050 A(I)=1000*R1/(18*R2)
1055 GØTØ 1090
1060 R1=INT(10.5+10*RND(Z))
1065 R2=INT(200.5+100*RND(Z))
1070 IF P<>1 THEN 1085
1075 PRINT R1;"GRAMS ØF AGNØ3,(MW=170),DISSØLVED IN";R2;"GRAMS ØF WATER"

1080 PRINT "YIELDS A SØLUTIØN ØF WHAT MØLALITY?"
1085 A(I)=1000*R1/(170*R2)
1090 R=INT(1.5+4*RND(Z))
1095 GØSUB 1440
1100 GØTØ R ØF 1105,1150,1180,1225,1275
1105 R1=INT(20.5+80*RND(Z))
1110 R2=INT(1.5+4*RND(Z))
1115 R3=INT(200.5+100*RND(Z))
1120 R4=INT(5.5+3*RND(Z))/10
1125 IF P<>1 THEN 1140
1130 PRINT &
     "CALCULATE THE TØTAL HYDRØXIDE IØN MØLARITY ØBTAINED BY MIXING"
1135 PRINT R1;"ML ØF";R2;"MØLAR NAØH WITH";R3;"ML ØF";R4;&
     "MOLAR BA(ØH)2."
1140 A(I)=((R1*R2)+(2*R3*R4))/(R1+R3)
1145 GØTØ 1305
1150 R1=INT(7.5+8*RND(Z))
1155 IF P<>1 THEN 1170
1160 PRINT "A SØLUTIØN IS";R1;"%W/W ZN3(P04)2,(MW=386). CALCULATE THE "

1165 PRINT "MØLALITY ØF THIS SOLUTIØN."
1170 A(I)=1000*R1/((100-R1)*386)
1175 GØTØ 1305
1180 R1=INT(1.5+4*RND(Z))
1185 R2=INT(1.5+4*RND(Z))
1190 R3=INT(6.5+4*RND(Z))
1195 IF P<>1 THEN 1215
1200 PRINT &
     "HØW MANY GRAMS ØF PURE ETHYLENE GLYCØL,C2H602,(MW=62),MUST BE"
1205 PRINT "ADDED TØ";R1;"KILØGRAMS ØF A";R2;&
     "%W/W SØLUTIØN TØ RAISE THE"
1210 PRINT "CØNCENTRATIØN TØ";R3;"%W/W ?"
1215 A(I)=1000*R1*(R3-R2)/(100-R3)
1220 GØTØ 1305
1225 R1=INT(1.5+4*RND(Z))
1230 R2=INT(6.5+4*RND(Z))
1235 R3=INT(1.5+4*RND(Z))
1240 IF P<>1 THEN 1265
1245 PRINT "WHAT WEIGHT ØF PURE WATER MUST BE ADDED TØ";R1;&
     "KILØGRAMS ØF"
1250 PRINT "AN AQUEØUS SØLUTIØN ØF ETHYLENE GLYCØL,C2H602,(MW=62),TØ"
1255 PRINT "LØWER THE CØNCENTRATIØN FRØM";R2;"%W/W ETHYLENE GLYCØL TØ"
1260 PRINT R3;"%W/W ."
1265 A(I)=1000*R1*(R2-R3)/R3
```

```
1270 GØTØ 1305
1275 R1=INT(1.5+4*RND(Z))
1280 R2=INT(11.5+4*RND(Z))/10
1285 IF P<>1 THEN 1300
1290 PRINT "A";R1;"MØLAR SØLUTIØN ØF KØH, (MW=56), HAS A DENSITY ØF";R2
1295 PRINT "G/ML. CALCULATE THE MØLALITY ØF THIS SØLUTIØN."
1300 A(I)=1000*R1/(1000*R2-56*R1)
1305 IF P=1 THEN 1380
1310 PRINT "CØRRECT","YØUR"
1315 PRINT "ANSWER","ANSWER","RESULT"
1320 PRINT
1325 FØR I=1 TØ 5
1330   IF A(I)>1.05*T(I) THEN 1355
1335   IF A(I)<.95*T(I) THEN 1355
1340   L$="CØRRECT"
1345   G=G+20
1350   GØTØ 1360
1355   L$="WRØNG  "
1360   PRINT A(I),T(I),L$
1365 NEXT I
1370 PRINT
1375 PRINT "YØUR GRADE ØN THIS QUIZ IS";G;"%."
1380 PRINT
1385 PRINT &
     "----------------------------------------------------------------&

--"
1390 IF G<>100 THEN 1400
1395 PRINT "MARVELØUS FRIEND, YØU HAVE BEATEN THIS BRØKEN MACHINE."
1400 PRINT "GØØD LUCK ";N$;" AND HURRY BACK."
1405 PRINT
1410 IF P=1 THEN 9999
1415 PRINT &
     "WØULD YØU LIKE TØ TAKE ANØTHER QUIZ? PLEASE ANSWER YES ØR NØ."
1420 INPUT Y$
1425 P=1
1430 IF Y$="YES" THEN 185
1435 GØTØ 9999
1440 I=I+1
1445 IF P=2 THEN 1460
1450 PRINT
1455 PRINT "QUESTIØN. ";I
1460 RETURN
1465 PRINT "SØRRY ";N$;" PLEASE GET SØME HELP. SØ LØNG FØR NØW."
9999 END
>
```

First Pass on Obtaining a Computer Quiz

```
>RUN
CTEST
PLEASE TYPE IN YOUR NAME.
?MORRIS
PLEASE ENTER YOUR QUIZ SECTION.
?89
O.K. MORRIS DO YOU WISH TO TAKE A TEST OR HAVE YOUR
RESULTS GRADED? IF YOU WISH TO TAKE A TEST RESPOND
(YES OR NO)
?YES

EXAM NO.  21624                    NAME - MORRIS
TUE, AUG 20, 1974, 10:32 PM        SECTION  89

THERE ARE 5 QUESTIONS ON THIS EXAM. THESE ARE ALL ON
SOLUTION CONCENTRATIONS. PLEASE ANSWER THESE QUESTIONS
AT HOME, AND COME BACK WHEN YOU ARE READY TO HAVE YOUR
EXAM GRADED.

QUESTION.  1
 3     MOLES OF AMMONIA, NH3, (MW=17), WAS DISSOLVED IN  4
LITERS OF WATER (DENS=1.G/ML). CALCULATE THE PERCENT BY WEIGHT
OF NH3 IN THE SOLUTION.

QUESTION.  2
THE SOLUBILITY OF THE INSECTICIDE LINDANE, C6H6CL6, (MW=291), IS
APPROX.  7     PPM. HOW MANY MOLES OF LINDANE ARE PRESENT IN
 2    LITERS OF A SATURATED SOLUTION. DENS. =1 G/ML.

QUESTION.  3
HOW MANY LITERS OF  7    MOLAR SOLUTION CAN BE PREPARED FROM
 14   GRAMS OF BA(OH)2, (MW=171)?

QUESTION.  4
A SOLUTION IS 18   PERCENT BY WEIGHT KF, (MW=58), CALCULATE
THE MOLALITY OF THIS SOLUTION.

QUESTION.  5
HOW MANY GRAMS OF PURE ETHYLENE GLYCOL, C2H6O2, (MW=62), MUST BE
ADDED TO 2    KILOGRAMS OF A 2    %W/W SOLUTION TO RAISE THE
CONCENTRATION TO 8    %W/W ?

?GOOD LUCKMORRISAND HURRY BACK.
```

Second Pass for Quiz Grading

```
>RUN
CTEST
PLEASE TYPE IN YOUR NAME
?MORRIS
PLEASE ENTER YOUR QUIZ SECTION.
?09
O.K. MORRIS DO YOU WISH TO TAKE A TEST OR HAVE YOUR
RESULTS GRADED? IF YOU WISH TO TAKE A TEST RESPOND
(YES OR NO)
?NO
PLEASE ENTER YOUR EXAM NUMBER.
?31624
PLEASE ENTER YOUR 5 ANSWERS IN THE EXACT ORDER OF THE QUESTIONS.
PRESS (RETURN) AFTER EACH INPUT.
?1.25895
?45
?12
?3.76
?125

EXAM NO.  31624                    NAME  MORRIS
TUE, AUG 20, 1974, 10:42 PM        SECTION 09

CORRECT ANSWER  YOUR ANSWER    RESULT
 1.25895         1.25895       CORRECT
 4.81100E-05     45            WRONG
 1.16959E-02     12            WRONG
 3.78469         3.76          CORRECT
 130.435         125           CORRECT

YOUR GRADE ON THIS QUIZ IS 60   %.

GOOD LUCKMORRISAND HURRY BACK.
```

Discourse Where Student Attempts to Befuddle Computer

```
)RUN
CTEST
PLEASE TYPE IN YOUR NAME
?MORRIS
PLEASE ENTER YOUR QUIZ SECTION.
?89
O.K. MORRIS DO YOU WISH TO TAKE A TEST OR HAVE YOUR
RESULTS GRADED? IF YOU WISH TO TAKE A TEST RESPOND
(YES OR NO)
?MAY
PLEASE ENTER YES OR NO.
O.K. MORRIS DO YOU WISH TO TAKE A TEST OR HAVE YOUR
RESULTS GRADED? IF YOU WISH TO TAKE A TEST RESPOND
(YES OR NO)
?MAY
PLEASE ENTER YES OR NO.
O.K. MORRIS DO YOU WISH TO TAKE A TEST OR HAVE YOUR
RESULTS GRADED? IF YOU WISH TO TAKE A TEST RESPOND
(YES OR NO)
?K
PLEASE ENTER YES OR NO.
O.K. MORRIS DO YOU WISH TO TAKE A TEST OR HAVE YOUR
RESULTS GRADED? IF YOU WISH TO TAKE A TEST RESPOND
(YES OR NO)
?K
SORRYMORRISPLEASE GET SOME HELP. SO LONG FOR NOW.
```

Unit Test on Concentration Units time=15 min.

TEST 1

1. TO WHAT VOLUME (ML) MUST 9.17 G OF KBr BE DILUTED TO MAKE A 0.196 M SOLUTION ?

2. THE SOLUBILITY OF $MnCl_2$ IS 66.4 G $MnCl_2$ PER 100 G WATER AT SOME TEMPERATURE. WHAT IS THE WEIGHT PERCENT OF A SATURATED SOLUTION OF $MnCl_2$ AT THIS TEMPERATURE ?

3. IF A SOLUTION OF DENSITY 1.116 G/ML IS PREPARED BY DISSOLVING 30.5 G OF $Al_2(SO_4)_3$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE MOLALITY OF $Al_2(SO_4)_3$ IN THE SOLUTION?

4. A SOLUTION IS PREPARED BY DISSOLVING 49.80 GRAMS OF $BaCl_2$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. THE DENSITY OF THE SOLUTION IS 1.19 G/ML. CALCULATE THE MOLE FRACTION OF WATER IN THIS SOLUTION.

TEST 1

1. 4.14E+02

2. 3.99E+01

3. 8.21E-02

4. 9.96E-01

Unit Test on Concentration Units time=15 min.

TEST 2

1. TO WHAT VOLUME (ML) MUST 1.37 G OF KNO_3 BE DILUTED TO MAKE A 0.641 M SOLUTION ?

2. CALCULATE THE MOLALITY OF $MgSO_4$ IN A SOLUTION CONTAINING 41.00 GRAMS OF WATER IN 8.77 GRAMS OF $MgSO_4$.

3. THE DENSITY OF 52.0 PERCENT $(NH_4)_3PO_4$ SOLUTION IS 1.152 G/ML. WHAT WEIGHT AND WHAT VOLUME OF THIS SOLUTION WILL CONTAIN 82 GRAMS OF $(NH_4)_3PO_4$?

4. A SOLUTION IS PREPARED BY DISSOLVING 115.80 GRAMS OF $BaCl_2$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. THE DENSITY OF THE SOLUTION IS 1.15 G/ML. CALCULATE THE MOLE FRACTION OF WATER IN THIS SOLUTION.

TEST 2

1. 2.12E+01

2. 1.78E+00

3. 157.70 G, 136.89 ML

4. 9.90E-01

Unit Test on Concentration Units time=15 min.

TEST 3

1. A SOLUTION IS PREPARED BY DISSOLVING 8.10 G OF $NaClO_3$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. THE DENSITY OF THE SOLUTION IS 1.153 G/ML. CALCULATE THE WEIGHT PERCENT OF WATER IN THIS SOLUTION.

2. A SOLUTION IS PREPARED BY DISSOLVING 60.60 GRAMS OF $MnCl_2$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. THE DENSITY OF THE SOLUTION IS 1.35 G/ML. CALCULATE THE MOLE FRACTION OF WATER IN THIS SOLUTION.

3. IF A SOLUTION OF DENSITY 1.489 G/ML IS PREPARED BY DISSOLVING 80.5 G OF $KMnO_4$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE MOLALITY OF $KMnO_4$ IN THE SOLUTION?

4. TO WHAT VOLUME (ML) MUST 0.42 G OF KIO_3 BE DILUTED TO MAKE A 0.251 M SOLUTION ?

TEST 3

1. 9.93E+01

2. 9.93E-01

3. 3.62E-01

4. 7.87E+00

Unit Test on Concentration Units time=15 min.

TEST 4

1. THE DENSITY OF 42.7 PERCENT $MgSO_4$ SOLUTION IS 1.143 G/ML. WHAT WEIGHT AND WHAT VOLUME OF THIS SOLUTION WILL CONTAIN 28 GRAMS OF $MgSO_4$?

2. CALCULATE THE MOLALITY OF $BaCl_2$ IN A SOLUTION CONTAINING 13.00 GRAMS OF WATER IN 6.42 GRAMS OF $BaCl_2$.

3. IT IS DESIRED TO PREPARE A SOLUTION OF $Al_2(SO_4)_3$ IN 350 ML OF WATER SUCH THAT THE MOLE FRACTION OF $Al_2(SO_4)_3$ IS EQUAL TO 0.0416 . HOW MANY GRAMS OF $Al_2(SO_4)_3$ ARE REQUIRED?

4. TO WHAT VOLUME (ML) MUST 9.22 G OF $MgSO_4$ BE DILUTED TO MAKE A 0.307 M SOLUTION ?

TEST 4

1. 65.58 G, 57.39 ML

2. 2.37E+00

3. 2.89E+02

4. 2.50E+02

Unit Test on Concentration Units time=15 min.

TEST 5

1. FIND THE VOLUME IN LITERS OF 0.220 M Na_3PO_4 SOLUTION THAT CAN BE PREPARED FROM 5.50 G OF Na_3PO_4.

2. CALCULATE THE MOLE FRACTION OF $(NH_4)_3PO_4$ IN A SOLUTION CONTAINING 21.00 G OF $(NH_4)_3PO_4$ IN 602.0 GRAMS OF WATER.

3. IF A SOLUTION OF DENSITY 1.055 G/ML IS PREPARED BY DISSOLVING 44.5 G OF $Ni(NO_3)_2$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE MOLALITY OF $Ni(NO_3)_2$ IN THE SOLUTION?

4. A SOLUTION IS PREPARED BY DISSOLVING 43.95 G OF $Al_2(SO_4)_3$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. THE DENSITY OF THE SOLUTION IS 1.331 G/ML. CALCULATE THE WEIGHT PERCENT OF WATER IN THIS SOLUTION.

TEST 5

1. 1.47E-01

2. 3.96E-03

3. 2.41E-01

4. 9.67E+01

Unit Test on Concentration Units time=15 min.

TEST 6

1. 0.558 MOLES OF $K_2Cr_2O_7$ IS DISSOLVED IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. WHAT IS THE WEIGHT PERCENT OF WATER IN THIS SOLUTION WHOSE DENSITY IS 1.159 G/ML ?

2. IT IS DESIRED TO PREPARE A SOLUTION OF KBr IN 25 ML OF WATER SUCH THAT THE MOLE FRACTION OF KBr IS EQUAL TO 0.0133 . HOW MANY GRAMS OF KBr ARE REQUIRED?

3. IF A SOLUTION OF DENSITY 1.268 G/ML IS PREPARED BY DISSOLVING 49.5 G OF $Cd(NO_3)_2$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE MOLALITY OF $Cd(NO_3)_2$ IN THE SOLUTION?

4. CALCULATE THE NUMBER OF MOLES OF $CaBr_2$ IN 47.1 ML OF 0.383 M $CaBr_2$.

TEST 6

1. 8.58E+01

2. 2.23E+00

3. 1.72E-01

4. 1.80E-02

Unit Test on Concentration Units time=15 min.

TEST 7

1. THE DENSITY OF A 1.78 M SOLUTION OF Na_3PO_4 IN WATER IS 1.10 G/ML AT 20 DEG C. CALCULATE THE WEIGHT PERCENT OF THE SOLUTION.

2. CALCULATE THE MOLE FRACTION OF MgSO4 IN A SOLUTION CONTAINING 36.35 G OF MgSO4 IN 200.0 GRAMS OF WATER.

3. IF A SOLUTION OF DENSITY 1.035 G/ML IS PREPARED BY DISSOLVING 57.5 G OF KIO_3 IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE MOLALITY OF KIO_3 IN THE SOLUTION?

4. WHAT IS THE MOLARITY OF A 2.28 PERCENT SOLUTION OF $K_2Cr_2O_7$? THE DENSITY OF THE SOLUTION IS 1.022 G/ML .

TEST 7

1. 2.45E+01

2. 2.65E-02

3. 1.95E-01

4. 7.92E-02

Unit Test on Concentration Units time=15 min.

TEST 8

1. A SOLUTION IS PREPARED BY DISSOLVING 48.45 G OF $CaBr_2$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. THE DENSITY OF THE SOLUTION IS 1.150 G/ML. CALCULATE THE WEIGHT PERCENT OF WATER IN THIS SOLUTION.

2. CALCULATE THE MOLE FRACTION OF $K_2Cr_2O_7$ IN A SOLUTION CONTAINING 3.90 G OF $K_2Cr_2O_7$ IN 407.0 GRAMS OF WATER.

3. CALCULATE THE MOLALITY OF $MgSO_4$ IN A SOLUTION CONTAINING 15.00 GRAMS OF WATER IN 4.17 GRAMS OF $MgSO_4$.

4. FIND THE NUMBER OF GRAMS OF $KMnO_4$ REQUIRED TO PREPARE 1.20 LITERS OF 4.205 M SOLUTION.

TEST 8

1. 9.58E+01

2. 5.86E-04

3. 2.31E+00

4. 7.97E+02

Unit Test on Concentration Units, time=15 min.

TEST 9

1. THE DENSITY OF 82.6 PERCENT KBr SOLUTION IS 1.183 G/ML. WHAT WEIGHT AND WHAT VOLUME OF THIS SOLUTION WILL CONTAIN 99 GRAMS OF KBr ?

2. A SOLUTION IS PREPARED BY DISSOLVING 42.45 GRAMS OF $CaBr_2$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. THE DENSITY OF THE SOLUTION IS 1.40 G/ML. CALCULATE THE MOLE FRACTION OF WATER IN THIS SOLUTION.

3. IF A SOLUTION OF DENSITY 1.314 G/ML IS PREPARED BY DISSOLVING 23.5 G OF $CrCl_3$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE MOLALITY OF $CrCl_3$ IN THE SOLUTION?

4. WHAT IS THE MOLARITY OF A 4.12 PERCENT SOLUTION OF $CuSO_4 \cdot 5H_2O$? THE DENSITY OF THE SOLUTION IS 1.040 G/ML

TEST 9

1. 119.86 G, 101.35 ML

2. 9.97E-01

3. 1.15E-01

4. 1.72E-01

Unit Test on Concentration Units time=15 min.

TEST 10

1. THE DENSITY OF A 1.38 M SOLUTION OF $BaCl_2$ IN WATER IS 1.074 G/ML AT 20 DEG C. CALCULATE THE MOLALITY OF THE SOLUTION.

2. THE DENSITY OF 45.9 PERCENT $KMnO_4$ SOLUTION IS 1.146 G/ML. WHAT WEIGHT AND WHAT VOLUME OF THIS SOLUTION WILL CONTAIN 98 GRAMS OF $KMnO_4$?

3. TO WHAT VOLUME (ML) MUST 1.61 G OF $Cd(NO_3)_2$ BE DILUTED TO MAKE A 0.936 M SOLUTION ?

4. A SOLUTION IS PREPARED BY DISSOLVING 116.85 GRAMS OF $KMnO_4$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. THE DENSITY OF THE SOLUTION IS 1.21 G/ML. CALCULATE THE MOLE FRACTION OF WATER IN THIS SOLUTION.

TEST 10

1. 1.76E+00

2. 213.51 G, 186.33 ML

3. 7.29E+00

4. 9.88E-01

Unit Test on Concentration Units time=15 min.

TEST 11

1. IF A SOLUTION OF DENSITY 1.188 G/ML IS PREPARED BY DISSOLVING 86.5 G OF $Cd(NO_3)_2$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE MOLALITY OF $Cd(NO_3)_2$ IN THE SOLUTION?

2. THE SOLUBILITY OF $AgNO_3$ IS 76.5 G $AgNO_3$ PER 100 G WATER AT SOME TEMPERATURE. WHAT IS THE WEIGHT PERCENT OF A SATURATED SOLUTION OF $AgNO_3$ AT THIS TEMPERATURE ?

3. TO WHAT VOLUME (ML) MUST 5.94 G OF $K_2Cr_2O_7$ BE DILUTED TO MAKE A 0.578 M SOLUTION ?

4. A SOLUTION IS PREPARED BY DISSOLVING 113.85 GRAMS OF $KMnO_4$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. THE DENSITY OF THE SOLUTION IS 1.26 G/ML. CALCULATE THE MOLE FRACTION OF WATER IN THIS SOLUTION.

TEST 11

1. 3.32E-01

2. 4.33E+01

3. 3.49E+01

4. 9.89E-01

Unit Test on Concentration Units time=15 min.

TEST 12

1. TO WHAT VOLUME (ML) MUST 1.33 G OF $(NH_4)_3PO_4$ BE DILUTED TO MAKE A 0.160 M SOLUTION ?

2. CALCULATE THE MOLALITY OF $Cd(NO_3)_2$ IN A SOLUTION CONTAINING 81.00 GRAMS OF WATER IN 1.06 GRAMS OF $Cd(NO_3)_2$.

3. CALCULATE THE MOLE FRACTION OF $(NH_4)_3PO_4$ IN A SOLUTION CONTAINING 45.00 G OF $(NH_4)_3PO_4$ IN 456.0 GRAMS OF WATER.

4. A SOLUTION IS PREPARED BY DISSOLVING 37.95 G OF $Al_2(SO_4)_3$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. THE DENSITY OF THE SOLUTION IS 1.133 G/ML. CALCULATE THE WEIGHT PERCENT OF WATER IN THIS SOLUTION.

TEST 12

1. 5.27E+01

2. 5.53E-02

3. 1.11E-02

4. 9.67E+01

Unit Test on Concentration Units time=15 min.

TEST 13

1. A SOLUTION IS PREPARED BY DISSOLVING 15.00 GRAMS OF $(NH_4)_3PO_4$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. THE DENSITY OF THE SOLUTION IS 1.09 G/ML. CALCULATE THE MOLE FRACTION OF WATER IN THIS SOLUTION.

2. FIND THE MOLARITY OF A SOLUTION PREPARED BY DISSOLVING 0.55 G OF KIO_3 IN A TOTAL OF 384 ML OF SOLUTION.

3. IF A SOLUTION OF DENSITY 1.293 G/ML IS PREPARED BY DISSOLVING 3.6 MOLES OF $MgSO_4$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE WEIGHT PERCENT OF $MgSO_4$ IN THE SOLUTION?

4. CALCULATE THE MOLALITY OF $Al_2(SO_4)_3$ IN A SOLUTION CONTAINING 64.00 GRAMS OF WATER IN 2.03 GRAMS OF $Al_2(SO_4)_3$.

TEST 13

1. 9.98E-01

2. 6.75E-03

3. 3.39E+01

4. 9.27E-02

Unit Test on Concentration Units time=15 min.

TEST 14

1. CALCULATE THE MOLALITY OF $CaBr_2$ IN A SOLUTION CONTAINING 69.00 GRAMS OF WATER IN 7.13 GRAMS OF $CaBr_2$.

2. A SOLUTION IS PREPARED BY DISSOLVING 55.80 GRAMS OF $BaCl_2$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. THE DENSITY OF THE SOLUTION IS 1.22 G/ML. CALCULATE THE MOLE FRACTION OF WATER IN THIS SOLUTION.

3. THE DENSITY OF A 1.98 M SOLUTION OF $CrCl_3$ IN WATER IS 1.196 G/ML AT 20 DEG C. CALCULATE THE WEIGHT PERCENT OF THE SOLUTION.

4. FIND THE VOLUME IN LITERS OF 0.117 M $FeCl_3$ SOLUTION THAT CAN BE PREPARED FROM 39.50 G OF $FeCl_3$.

TEST 14

1. 5.31E-01

2. 9.96E-01

3. 2.62E+01

4. 2.08E+00

Unit Test on Concentration Units time=15 min.

TEST 15

1. FIND THE MOLARITY OF A SOLUTION PREPARED BY DISSOLVING 3.49 G OF $K_2Cr_2O_7$ IN A TOTAL OF 325 ML OF SOLUTION.

2. IT IS DESIRED TO PREPARE A SOLUTION OF $NaClO_3$ IN 214 ML OF WATER SUCH THAT THE MOLE FRACTION OF $NaClO_3$ IS EQUAL TO 0.0437. HOW MANY GRAMS OF $NaClO_3$ ARE REQUIRED?

3. CALCULATE THE MOLALITY OF $CaBr_2$ IN A SOLUTION CONTAINING 100.00 GRAMS OF WATER IN 2.73 GRAMS OF $CaBr_2$.

4. THE DENSITY OF 56.0 PERCENT $(NH_4)_3PO_4$ SOLUTION IS 1.156 G/ML. WHAT WEIGHT AND WHAT VOLUME OF THIS SOLUTION WILL CONTAIN 84 GRAMS OF $(NH_4)_3PO_4$?

TEST 15

1. 3.65E-02

2. 5.78E+01

3. 1.37E-01

4. 150.00 G, 129.76 ML

Unit Test on Concentration Units time=15 min.

TEST 16

1. THE DENSITY OF A 0.45 M SOLUTION OF $MnCl_2$ IN WATER IS 1.030 G/ML AT 20 DEG C. CALCULATE THE MOLALITY OF THE SOLUTION.

2. 0.358 MOLES OF $K_2Cr_2O_7$ IS DISSOLVED IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. WHAT IS THE WEIGHT PERCENT OF WATER IN THIS SOLUTION WHOSE DENSITY IS 1.416 G/ML ?

3. FIND THE VOLUME IN LITERS OF 0.516 M $Cd(NO_3)_2$ SOLUTION THAT CAN BE PREPARED FROM 58.50 G OF $Cd(NO_3)_2$.

4. CALCULATE THE MOLE FRACTION OF $Cd(NO_3)_2$ IN A SOLUTION CONTAINING 37.80 G OF $Cd(NO_3)_2$ IN 698.0 GRAMS OF WATER.

TEST 16

1. 4.60E-01

2. 9.26E+01

3. 4.80E-01

4. 4.11E-03

Unit Test on Concentration Units time=15 min.

TEST 17

1. THE DENSITY OF A 0.42 M SOLUTION OF KIO_3 IN WATER IS 1.034 G/ML AT 20 DEG C. CALCULATE THE WEIGHT PERCENT OF THE SOLUTION.

2. CALCULATE THE MOLE FRACTION OF $K_2Cr_2O_7$ IN A SOLUTION CONTAINING 33.90 G OF $K_2Cr_2O_7$ IN 971.0 GRAMS OF WATER.

3. IF A SOLUTION OF DENSITY 1.047 G/ML IS PREPARED BY DISSOLVING 42.5 G OF Na_2CO_3 IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE MOLALITY OF Na_2CO_3 IN THE SOLUTION?

4. TO WHAT VOLUME (ML) MUST 2.52 G OF $Cd(NO_3)_2$ BE DILUTED TO MAKE A 0.896 M SOLUTION ?

TEST 17

1. 8.73E+00

2. 2.13E-03

3. 3.99E-01

4. 1.19E+01

Unit Test on Concentration Units time=15 min..

TEST 18

1. THE DENSITY OF A 0.65 M SOLUTION OF $AgNO_3$ IN WATER IS 1.070 G/ML AT 20 DEG C. CALCULATE THE WEIGHT PERCENT OF THE SOLUTION.

2. THE DENSITY OF A 0.23 M SOLUTION OF $FeCl_3$ IN WATER IS 1.048 G/ML AT 20 DEG C. CALCULATE THE MOLALITY OF THE SOLUTION.

3. A SOLUTION IS PREPARED BY DISSOLVING 132.90 GRAMS OF KBr IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. THE DENSITY OF THE SOLUTION IS 1.30 G/ML. CALCULATE THE MOLE FRACTION OF WATER IN THIS SOLUTION.

4. WHAT IS THE MOLARITY OF A 3.29 PERCENT SOLUTION OF $KMnO_4$? THE DENSITY OF THE SOLUTION IS 1.032 G/ML.

TEST 18

1. 1.03E+01
2. 2.32E-01
3. 9.83E-01
4. 2.15E-01

Unit Test on Concentration Units time=15 min.

TEST 19

1. IT IS DESIRED TO PREPARE A SOLUTION OF $BaCl_2$ IN 465 ML OF WATER SUCH THAT THE MOLE FRACTION OF $BaCl_2$ IS EQUAL TO 0.0056 . HOW MANY GRAMS OF $BaCl_2$ ARE REQUIRED?

2. CALCULATE THE NUMBER OF MOLES OF $Cd(NO_3)_2$ IN 90.9 ML OF 0.796 M $Cd(NO_3)_2$.

3. A SOLUTION IS PREPARED BY DISSOLVING 52.50 G OF $Ni(NO_3)_2$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. THE DENSITY OF THE SOLUTION IS 1.059 G/ML. CALCULATE THE WEIGHT PERCENT OF WATER IN THIS SOLUTION.

4. CALCULATE THE MOLALITY OF $NaClO_3$ IN A SOLUTION CONTAINING 16.00 GRAMS OF WATER IN 5.04 GRAMS OF $NaClO_3$.

TEST 19

1. 3.03E+01

2. 7.24E-02

3. 9.50E+01

4. 2.96E+00

Unit Test on Concentration Units time=15 min.

TEST 20

1. FIND THE MOLARITY OF A SOLUTION PREPARED BY DISSOLVING 3.07 G OF Na_2CO_3 IN A TOTAL OF 358 ML OF SOLUTION.

2. THE DENSITY OF 71.2 PERCENT $BaCl_2$ SOLUTION IS 1.171 G/ML. WHAT WEIGHT AND WHAT VOLUME OF THIS SOLUTION WILL CONTAIN 72 GRAMS OF $BaCl_2$?

3. IF A SOLUTION OF DENSITY 1.265 G/ML IS PREPARED BY DISSOLVING 15.5 G OF KIO_3 IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION, WHAT WOULD BE THE MOLALITY OF KIO_3 IN THE SOLUTION?

4. A SOLUTION IS PREPARED BY DISSOLVING 128.10 GRAMS OF $NaClO_3$ IN ENOUGH WATER TO FORM 1 LITER OF SOLUTION. THE DENSITY OF THE SOLUTION IS 1.12 G/ML. CALCULATE THE MOLE FRACTION OF WATER IN THIS SOLUTION.

TEST 20

1. 8.10E-02

2. 101.13 G, 86.35 ML

3. 5.79E-02

4. 9.79E-01