Laboratory Manual to Accompany Chemistry A World of Choices

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to accompany

Chemistry
A World of Choices

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Preface

To voyage into the world of chemistry requires the development of a new vocabulary that deals with many things unseen and certainly many concepts never before encountered. To facilitate the understanding of this new world, a laboratory experience can prove extremely useful.

In this laboratory manual for **Chemistry: A World of Choices**, the student is provided with the opportunity to gain some first-hand experience with the chemical and physical properties of a variety of substances and to employ a number of the chemist's methodologies in the systematic approach to the study of matter. The experiments are fairly short, generally ranging from one to two hours. The normal format for the lab period will consist of a discussion session, and then the experiment. During the experiment the instructor will be available to answer any questions that may arise concerning equipment, chemicals, or the techniques being employed in the experiment.

A number of the experiments will involve the identification of unknowns by a variety of methods. At the end of the period, your instructor may ask you to turn in a brief report of the identity of the unknown. At the end of each experiment is a set of questions that pertain to what you did in lab, the theory of some of the principles you studied, and practical calculations related to the lab and corresponding lecture material. These questions should be answered at home in your lab manual. Show all your work when answering mathematical questions. Please write neatly and legibly. The question pages should be torn out of you lab manual, stapled at the upper left-hand corner, and turned in to the instructor on the next meeting of your lab. All possible effort will be made to return them to you by the following lab meeting.

The performance of any experiment is always rooted in a clear understanding of the theory and the technique. It is therefore important that the student prepare for the experiment before entering the lab. Much less time will then be spent by the student trying to puzzle through the experiment at the bench top, or making needless errors based on a lack of a clear understanding. Each experiment has been tested many times for ease of operation and, with proper preparation, the student should find them both interesting and informative.

Safety

The following is a guide to provide you with a safe and enjoyable lab experience.

1. Eye protection (eye glasses, safety glasses, goggles, or face shields) must be worn by all students when working in the laboratory.

2. Do not eat or drink in the laboratory.

3. Do not taste any chemical.

4. Clothing, purses, books, briefcases, or backpacks should not be placed on the floor next to your work area. In an emergency, these may provide an obstacle course to a safe exit. Instead, place these items out of the way next to the wall or on your bench top.

5. Bare feet, sandals, and open toed shoes are prohibited in the laboratory. To avoid chemical burns, wear old, non-synthetic clothing. For maximum protection, wear a lab coat or apron while in the lab.

6. Long hair should be tied back or pinned up, so it will not fall into chemicals or flames.

7. If an accident occurs in the laboratory, report it to the instructor immediately.

8. If you should have skin contact with any chemical, wash it off with water at the sink immediately.

9. If you spill a large amount of corrosive chemical on your skin, you may need to use the lab safety shower. Make sure you know its location in the lab. If the chemical has gotten into your eyes, the eye-wash fountain may be used to rinse out the chemical. Know the location of the eye-wash fountain.

10. You should be aware of the location of the fire extinguishers. If a large fire occurs, direct the extinguisher's discharge at the base of the flames.

11. If you spill any chemical, solid or liquid, be sure to clean it up immediately so that another student does not come into contact with it, and perhaps be injured.

12. Before leaving the laboratory, make sure your equipment and chemicals are put away. Wipe off the desk top with a damp paper towel. Finally, wash your hands with soap and water.

13. Never perform an unauthorized experiment.

14. When observing a chemical reaction in a test tube, beaker, or flask, always observe from the side of the container. You never know if the contents may suddenly be ejected like a geyser. This is especially true if you are heating the reaction mixture.

15. Never point the open end of a test tube at yourself or another person.

16. If you have heated any glassware, be cautious when it is handled. Hot and cold glass looks exactly the same.

17. When inserting glass tubing into a stopper, lubricate the tubing with water or glycerol, wrap the tubing with a towel, and hold the end of the tubing about 1 cm from its end. Insert the tubing with a twisting motion while continuing to keep your hand close to the stopper.

18. Take only small, necessary quantities of **stock chemicals** (large bottles of chemicals that are used by the entire class). Never return any chemical back to its stock bottle from one of your containers.

19. If you want to smell a substance, do not hold it directly to your nose; instead, hold the container a few centimeters away and use your hand to fan the vapors to you. This procedure is referred to as **wafting**.

20. Avoid handling more than one **reagent** (another name for a chemical used in an experiment) bottle at a time, so that you do not interchange their stoppers by mistake. Make sure you read the labels on reagent bottles carefully. Mixing the wrong chemicals may be dangerous.

21. Always pour concentrated acids and bases **into** water when diluting them. The reverse procedure can lead to a violent boiling and splattering of the acid or base solution.

22. When disposing of liquid chemicals in the sink, flush them with large quantities of water.

23. Do not dispose of matches, paper or solid chemicals in the troughs or sink. Discard them instead into a waste bucket.

24. Dispose of any broken glassware in the container designated for broken glass.

25. Always come to lab prepared. Read the experiment before you come to lab so that you have a general idea of what you will be during the lab period.

An Introduction to the Use of a Scientific Calculator

I. OBJECTIVES:

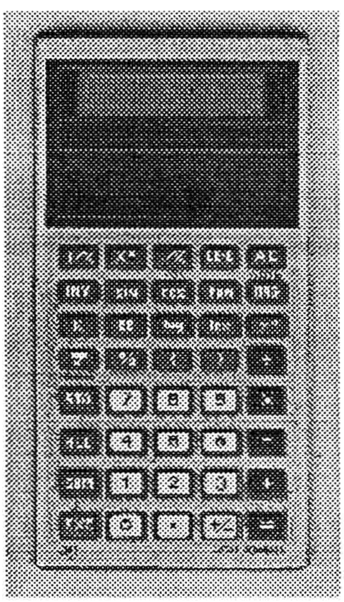
A. To understand the general functioning of a calculator.

B. To learn to use the following calculator keys: parentheses, change sign, exponential, reciprocal, square, square root, cube, and cube root.

C. To apply the use of these keys to the solution of some math problems.

II. DISCUSSION:

Most types of calculators accept the entry of numbers in what is called the Algebraic Operating System (AOS). A few types use the Reverse Polish Notation System. This discussion will focus on the AOS calculators. Typical calculator layouts, and their important keys are shown below.



The operations listed above the keys can be accessed by first pressing the inverse (IVN), SHIFT, or 2ndF key.

A. The Order of Common Operations:

When you enter a series of numbers and operations into your calculator, they are performed in a particular order. For the more common operations, the order from highest to lowest priority is:

1. Parenthesis
2. Exponentiation
3. Multiplication/Division
4. Addition/Subtraction

Try the following two calculations:

[4] [+] [6] [x] [2] [=]

[2] [x] [6] [+] [4] [=]

Note that in each case the answer displayed was 16. Your calculator did the multiplication operation first to give 12, and then added the 4 to give 16. If you wish it to perform the addition first and then multiply by 2, you can use the parenthesis keys.

B. The Parenthesis Keys:

By placing a set of parentheses around an operation, the calculator will perform the operation within the parentheses before it performs any other operations. Key in the following set of numbers and operations:

[(] [4] [+] [6] [)] [x] [2] [=]

The calculator now performed the addition within the parenthesis first to give 10, and then multiplied it by 2 to give 20.

If you wish to multiply two sets of numbers within parentheses, you must supply the calculator with the times sign; it will not automatically multiply them together. Thus, if you wish to perform the following calculation:

$(5 + 2)\ (2 + 3) =$

you would have to key in:

[(] [5] [+] [2] [)] [x] [(] [2] [+] [3] [)] [=]

in order to get the answer of 35. Try it with and without the use of the times key.

In complex calculations involving a number of operations in a numerator and a denominator, place additional parentheses around the entire numerator and the entire denominator. Try the following calculation:

$$\frac{(5 + 4) + (6 \times 3)}{(6 + 8/2) \times 4} =$$

This would be keyed in as:

Keys	Displayed
((5 + 4)	9
+ (6 x 3)) ÷	27
((6 + 8 ÷ 2) x 4)	40
=	0.675

C. Sign Change:

By pressing the +/- key after a number has been displayed, its sign becomes negative. If the +/- key is pressed a second time, the sign becomes positive again. Try pressing:

6 +/-

Notice that -6 is displayed.

This also works in calculations. Try this calculation:

$$\frac{-5 \times 2}{-8} =$$

by pressing:

Keys	Display
5 +/- x 2 ÷	-10
8 +/-	-8
=	1.25

D. Entering Exponential Numbers:

Most calculators display the coefficient of an exponential number first, followed by a space, and finally the exponent. Thus, 4.62×10^8 would be displayed as 4.62 08. The value 9.03×10^{-16} would be displayed as 9.03 -16. The key entry for these two numbers would be:

4 • 6 2 EXP 8

9 • 0 3 EXP 1 6 +/-

Multiplication and division of exponential numbers involves the entry of the first number, then the x or ÷ key, the second number, and then the = key. Try this calculation:

$$\frac{4.62 \times 10^{-8}}{1.87 \times 10^{-6}} =$$

Key this in as: **Display**

[4] [•] [6] [2] [EXP] [8] [+/-] **4.62 -08**

[÷] [1] [•] [8] [7] [EXP] [6] [+/-] **1.87 -06**

[=] **2.4706 -02**

E. The Reciprocal Key:

Once a value is displayed, its reciprocal may be generated by pressing the reciprocal key (1/x). If you key in 56, and then press 1/x, its reciprocal, 0.017857 will be displayed.

This function can be useful if you have calculated a value which you now wish to divide into another number. For example, if you have calculated the value 637.9 and it is displayed on your calculator, you may wish to divide it into another number, e.g., 2628. If 637.9 is converted to its reciprocal, it can then be multiplied by 2628. Try the following steps to make this calculation:

Display

[6] [3] [7] [•] [9] [1/x] **1.5676 -03**

[x] [2] [6] [2] [8] [=] **4.1198**

F. The Square and Square Root Keys:

By pressing the square key (x^2), whatever is in the calculator's display is squared. Thus, if you key in:

[8] [2] [x^2]

yields the square of 82, i.e., 6.7240×10^3.

By pressing the square root key (√), whatever is in the calculator's display is converted to the square root. Thus the calculation:

$$\frac{15}{\sqrt{6}} =$$

would be performed by the following key entries:

Key entries	Display
[1] [5] [÷]	15
[6] [√]	2.4495
[=]	6.1237

G. The Cube and Cube Root:

Your calculator may have a cube (x^3) and cube root ($^3\sqrt{\ }$) keys. These keys function just like the square and square root keys described above. Other calculators are designed to calculate the value of a number raised to any power, or to calculate any root. Normally, cubes and cube roots are the only ones used in chemistry. The y^x key is used to calculate the cube of a number. For example, to determine:

$$5^3 =$$

key as follows:

Key entries	Display
[5] [y^x] [3] [=]	125

To take the cube root of a number, use the SHIFT, INV, or 2ndF key in conjunction with the y^x key. Thus, to determine:

$$\frac{\sqrt[3]{26}}{8} =$$

key as follows:

Key entries	Display
[2] [6] [INV] [y^x] [3] [÷]	2.962496
[8] [=]	0.370312

Name:______________________ **Section:**________________

Review Problems for the Scientific Calculator

1. By using your calculator, find the answers to the following problems:

a. $16 + 9 \times 7 =$

b. $12 - 8 \div 5 =$

c. $14 - 18 \times -17 =$

d. $\dfrac{16.9 + 21.8}{17.6} =$

e. $\dfrac{21.6 - 37.8}{-62.6} =$

f. $\dfrac{(12.67 + 18.95)(31.33 - 17.41)}{10.99\,(38.61 - 25.62)} =$

2. By using your calculator, find the answers to the following problems:

a. $(6.17 \times 10^{4})(8.92 \times 10^{8}) =$

b. $(9.22 \times 10^{8})(3.70 \times 10^{-5}) =$

c. $(5.63 \times 10^{-4})(9.67 \times 10^{2}) =$

d. $(3.14 \times 10^{-12})(7.75 \times 10^{-4}) =$

e. $\dfrac{4.48 \times 10^{12}}{8.62 \times 10^{5}} =$

f. $\dfrac{6.97 \times 10^{7}}{7.66 \times 10^{10}} =$

g. $\dfrac{2.71 \times 10^{8}}{9.62 \times 10^{-3}} =$

h. $\dfrac{4.11 \times 10^{-9}}{8.97 \times 10^{5}} =$

3. Find the reciprocal of the following numbers:

a. 12

b. 318.66

c. 0.0715

d. 8.07×10^{5}

e. 5.41×10^{-3}

4. Enter 196 into your calculator. By use of the 1/x key, divide it into 12.4 .

5. Find the square of the following numbers:

a. 87

b. 6.91

c. 0.00275

d. 9.70×10^{3}

e. 6.13×10^{-2}

6. Take the square root of the following numbers:

a. 19.6

b. 129

c. 0.00628

d. 4.24×10^{12}

e. 8.62×10^{-6}

7. Find the cube of the following numbers:

a. 26.76

b. 0.298

c. 2.57×10^{8}

d. 6.33×10^{-5}

8. The speed of light is 2.9979×10^8 meters/second. The nearest star outside the solar system is 4.3 light-years away. How long would it take (in years) to travel to this star, if you drove a Volkswagen "Bug" at 75 miles per hour? Show how you would set up this problem.

9. The Ideal Gas Law states:

$$PV = nRT$$

If $P = 1.69 \times 10^2$, $V = 19.8$, $n = 26.2$, and $R = 0.0821$, what is the value of T? Show your setup.

10. The density of a substance is defined as:

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

What is the volume, in cm^3, of a piece of aluminum that weights 29.6 g. The density of aluminum is 2.70 g/cm^3. Show your setup.

Laboratory Equipment and Techniques

I. OBJECTIVES:

A. To recognize the components of the Bunsen burner and to learn how they can be adjusted to control the type of flame produced.

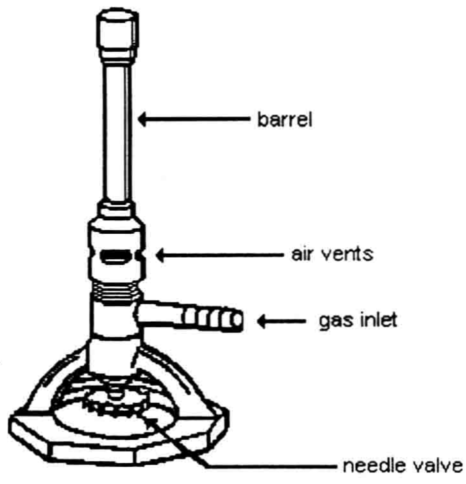
B. To become familiar with common laboratory equipment.

C. To learn how to make measurements of mass and volume.

II. DISCUSSION:

A. The Bunsen Burner:

The most common heating device in the laboratory is the Bunsen burner. A typical Bunsen burner is pictured below.



The function of the four components listed above are as follows:

1. **Needle valve**: by turning this you can control the amount of methane gas going into the burner.

2. **Gas inlet**: gas enters the burner via this inlet.

3. **Air vents**: air enters the burner via these vents.

4. **Barrel**: by rotating this you can control the amount of air going into the burner. Turning the barrel counterclockwise increases the amount of air.

The Bunsen burner used in most labs employs natural gas (primarily methane) as its fuel. The amount of fuel and air that are combined can affect the type of flame that is produced. A properly adjusted flame should consist of a total flame height of about 8 - 10 cm and two cones of combustion. A larger, light blue cone and a smaller, darker blue cone. At the top of this smaller, inner cone is the hottest point of the flame. When glassware needs to be heated very vigorously, it should be held at the top of this inner cone of flame. If the flame is too large or small, it may be adjusted by turning the needle valve.

A poorly adjusted flame sometimes has too much fuel and not enough air. This is termed a **fuel-rich flame** and is characterized by being yellow or orange in color and of relatively low temperature. By turning the barrel of the burner, more air can be admitted into the gas mixture and a blue flame obtained.

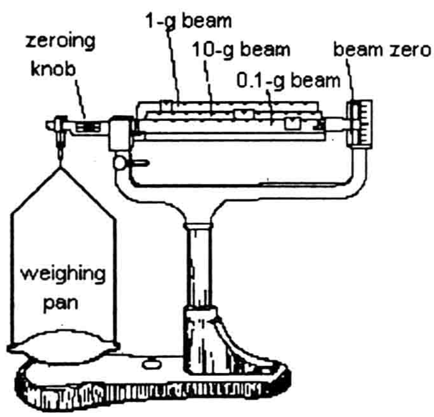
B. Heating Samples of Chemicals:

Frequently we will want to heat a chemical in a test tube to cause it to undergo a chemical change. The test tube, never more than one-third full, should **not** be held in one's hand, but rather a test tube clamp or a buret clamp should be used. Put the clamp near the top of the test tube, incline the tube at about a 45° angle, and heat near the bottom of the tube. Remember to make sure that the tube is not pointed at yourself nor anyone near you.

C. Measuring Mass:

1. Two different kinds of balances for making mass measurements are frequently used in the lab.

a. The Multiple Beam Mechanical Balance (Centigram Balance):



With all the riders on the beams set to zero, the beam zero needle should read zero. If it doesn't, the zeroing knob is turned until the needle points to zero. The object to be weighed is placed on the pan and the beam riders moved rightward into the indentations (always start with the heaviest rider first before moving the lighter ones). When the beam reads zero, add up the weights of the riders to obtain the weight of the object. The precision generally obtained with these balances is ± 0.01 g or 0.001 g, depending on the divisions on the smallest beam. Therefore, a measurement made with a balance whose smallest rider can be read to 0.01 g, should have two digits to the right of the decimal point, even if one or both of them are zeros. Likewise, a measurement made with a balance whose smallest rider can be read to 0.001 g, should have three digits to the right of the decimal point, even if one, two, or all three of them are zeros.