

Laboratory Manual

General Chemistry I Honors

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Calculations in the Chemistry Laboratory

The Unit Basis Method

Experience with numerical problems is extremely important in your study of chemistry, for it gives you practice in thinking problems through and deepens your understanding of the principles involved. However, if you just go through the mechanical steps of solution, giving no thought to the meaning of what you are doing, you may actually impair your understanding of the principles. In the following pages, you will learn a simple method of approaching problems—the “Unit Basis Method”—that is founded on clear thinking and is applicable not only to chemistry but also to other sciences and to “everyday problems.” In fact, you have undoubtedly used this method many times already, for example when shopping. If you diligently use the “Unit Basis” in your chemistry problems, you will be thoroughly satisfied with the results.

One important principle underlies the discussion that follows. In the types of problems considered, numbers are meaningless in themselves; ***only numbers associated with units have a meaning. Therefore, only numbers associated with units are used in calculations.***

The “Unit Basis Method” in Everyday Problems

First, we shall apply the Unit Basis Method to some very simple everyday problems. The advantages of doing this are the following: (1) all the terms are familiar, and (2) the problems are so simple that you can focus your attention on **the method alone.**

Consider the following example:

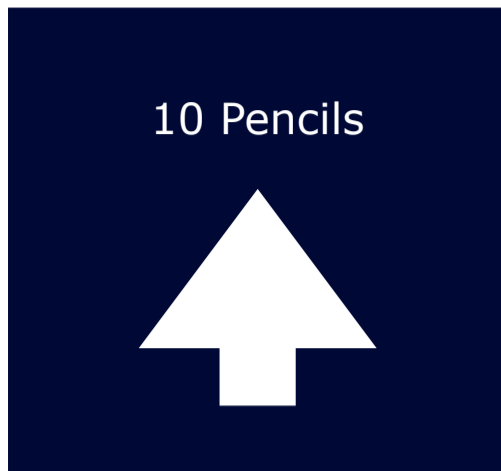
Problem 1

The cost of 8 pencils is 40 cents. How many cents do 10 pencils cost?

Solution

- **Step 1:** Start by setting up the question (Q) in a form that clearly shows what is given in the problem (the “data”) and what you must find out (the “unknown”). It is helpful to use the same format each time; a convenient one is shown below:

(Q):



This query is given in the problem (number with units).



In these expressions, the "=" stands for "equivalent to".



The "?" stands for the number (+units) to be found.

- **Step 2:** To answer the Q shown in step 1. You need to find a link between the data and the unknown. In this example the link is given in the text of the problem itself:

Link:

$$40 \text{ cents} = 8 \text{ pencils}$$

- **Step 3:** The link may be rewritten in the form of two Unit Basis

$$\frac{40 \text{ cents}}{8 \text{ pencils}} = \frac{5.0 \text{ cents}}{1 \text{ pencil}} = \text{number of cents necessary to buy 1 pencil}$$
$$\frac{8 \text{ pencils}}{40 \text{ cents}} = \frac{0.2 \text{ pencils}}{1 \text{ cent}} = \text{number of pencils purchased with 1 cent}$$

Note that the meaning of a Unit Basis Fraction (UBF) is the same whether the division has been carried out or not:

$$\frac{40 \text{ cents}}{8 \text{ pencils}} = \frac{5.0 \text{ cents}}{1 \text{ pencil}} = \text{number of cents necessary to buy 1 pencil}$$

- each of those Unit Base Fractions tell you the cost of 1 pencil.

- **Step 4:** Next examine the meanings of the two UBFs and select the UBF needed to answer the question Q. In this example, you want to find the number of cents necessary to buy 10 pencils. So you need the UBF that gives "the number of cents necessary to buy one pencil" Once you know how many cents are needed to buy 1 pencil, it is easy to find how many are needed to buy 10 pencils—or 25 or 54, or any desired number of pencils:

The answer is expressed in "cents." This is the correct unit as shown in the set-up of the question in Step 1.

Solve and Check Units

$$10 \cancel{\text{pencils}} \times \frac{5.0 \text{ cents}}{1 \cancel{\text{pencil}}} = 50 \text{ cents}$$

Note: In solving problems of this type, the units are treated as arithmetical quantities and can be cancelled.

Thinking out a problem using the Unit Basis Method will take a little extra time until you get accustomed to it. However, it is really the best way to solve the problem. Incidentally, you may be interested to know that this method is the way scientists solve their own problems. A major advantage of the Unit Basis is that you can check your final answer for the correct units. Remember units are a wonderful built-in check of your reasoning.

Summary Outline of the Unit Basis Method

- **Step 1:** Rewrite the question to show the data and the unknown.
- **Step 2:** Find the link
- **Step 3:** From the link work out the desired Unit Basis Fraction
- **Step 4:** Use the Unit Basis Fraction to solve the problem. Check that the answer thus obtained has the desired units.

The same Unit Basis Method employed in the previous "money- pencils" problem can be used for problems involving systems of measurements. We will begin with some very simple examples:

Problem 2

The length of a football field is 100 yards. What is the length of the field, expressed in feet?

- **Step 1:** Question

$$100 \text{ yards} = ? \text{ feet}$$

- **Step 2:** Link: 1 yard = 3 feet

Note that in this example the link is not given in the problem itself you are supposed to know it or to find it in a conversion table.

Step 3: UBFs:

$$\frac{1 \text{ yd}}{3 \text{ ft}} = \frac{0.33 \text{ yd}}{1 \text{ ft}} = \text{number of yards in 1 foot}$$

$$\frac{3 \text{ ft}}{1 \text{ yd}} = \text{number of feet in 1 yard}$$

Step 4: Solve and check: You want to find how many feet are in 100 yd. Thus, the UBF you need is the one that gives the “no. of ft in one yd”, that is $\frac{3 \text{ ft}}{1 \text{ yd}}$.

$$100 \text{ yd} \times \frac{3 \text{ ft}}{1 \text{ yd}} = 300 \text{ ft (no. of ft in 100 yd)}$$

- No. of yd.
- Check answer: the unit is ft, as indicated in the question.
 - UBF giving no. of ft in 1 yd.

In problems 1 and 2, the solutions required **only one link** and therefore only one Unit Basis Fraction. You can further develop this approach by solving problems that involve two (or more) links and therefore **two** (or more) Unit Basis Fractions. This extension of the Unit Basis Method is illustrated by some relatively simple problems involving everyday conversions of lengths.

Problem 3

- **Step 1:** 100 yds = ? inches

To solve this problem, you can first convert yards to feet, and then convert feet to inches.

To convert yards to feet, you need a link between these units (1 yd = 3 ft) and to convert feet to inches, you need a link between these units (1 ft = 12 in). So, you really have two Q's.

- QI: 100 yds = ? feet

You have already answered this question in problem 2. The answer was 300 feet.

- QII: 300 ft = ? inches

- **Step 2:** Link for QII: 1 ft = 12 in

- **Step 3:** UBF's from above link:

$$\frac{12 \text{ in}}{1 \text{ ft}} \text{ no of inches in 1 ft. and } \frac{1 \text{ ft}}{12 \text{ in}} = \frac{0.833 \text{ ft}}{\text{in}} = \text{no. of ft in 1 inch}$$

- **Step 4:** Solve and check units:

$$300 \text{ ft} \times \frac{12 \text{ in}}{1 \text{ ft}} = 3600 \text{ in}$$

Once you understand the method, you can solve the problem more rapidly by combining the successive conversions in one step. Also, after a little practice you will quickly recognize the UBF required to solve the problem, so you need not right the other one. Here is a streamlined solution of problem 3:

- **Step 1:** Q: 100 yd = ? in

- **Step 2:** Links: 100 yd = ? ft = ? in

$$1 \text{ yd} = 3 \text{ ft and } 1 \text{ ft} = 12 \text{ in}$$

- **Step 3:** UBFs:

$$\frac{3 \text{ ft}}{1 \text{ yd}} \text{ and } \frac{12 \text{ in}}{1 \text{ ft}}$$

- **Step 4:** Solve and check:

$$100 \text{ yd} \times \frac{3 \text{ ft}}{1 \text{ yd}} \times \frac{12 \text{ in}}{1 \text{ ft}} = 3600 \text{ in}$$

The preceding examples illustrate that the key to the unit method is to have the necessary link or links. Where do you obtain the relationship that lets you write the desired link?

1. Sometimes you may recall the relationship from your general knowledge
2. Sometimes you may need to look it up in a table of conversions for other reference sources
3. Sometimes you have to work it out for yourself

You will soon find that searching for the links is an effective way to review what you are learning about chemistry.

Measurement and Scientific Notation

To measure means to determine the size (magnitude) of anything by comparing it to some accepted reference standard. Thus, **all measurements are relative**, and they all depend on the standard used as the reference unit. For this reason, **a measured value must always be expressed by a number accompanied by the appropriate unit or units.**

There are three important aspects involved with measurements:

1. A suitable measuring instrument
2. An accepted standard of reference that can serve as the basis for the "marking off" (calibration) of the measuring instrument.
3. A conventionally accepted and uniform way to report a measured value so that it will convey the necessary information clearly and do so in a convenient form.

Significant Figures

How "good" is a measurement? Almost all numbers used in a science come directly or indirectly from some measurement, so "good science" depends to a very large extent on "good measurement." There are two somewhat distinct aspects to how good a measured value is.

One aspect is called **precision** and refers to how closely repeated measurements of the same quantity agree with one another when carried out under very much the same conditions. Precision is, in a sense, the reproducibility of the measured values.

The other aspect is called **accuracy** and refers to how close a certain measured value comes to the “true value”—that is, to the officially accepted value. (Of course, the “true value” itself is never really known, except within certain limits.) The accuracy of a measurement depends to a large extent on the sensitivity of the instrument used, the **sensitivity** being the ability of the instrument to detect and measure even very minute differences of the quantity being measured.

Scientific measurements are never performed only once; they are always repeated—often many times. The various results are then compared and averaged, discarding those values that happened to be too “far off” from the average. At the end, the final result is reported in such a way as to give some indication of its precision. In simple chemical problems, the precision of a measured value is often indicated by the number of significant figures used in expressing the value.

What Are Significant Figures?

First let us review briefly the official meaning of some common terms:

- A number is an expression of quantity.
- A digit or figure is any one of the characters (0, 1, 2, ...9) used to write numbers
- A **significant figure** is a meaningful digit in a number. It stands for its value in its specific place: for example, in the number 243, the 2 stands for “2 hundredths” and 4 stands for “4 tens” and the 3 stands for “3 ones”. The three digits in the number 243 are all significant—that is, the number 243 has three significant figures.

The general rule about reporting numerical values obtained from measurements or calculations is:

Give as many significant figures as to include only one uncertain digit the last one at the right.

This means that all the digits must be “sure” except the last one at the right which is a “best guess.” When you need to round off a number to the correct significant figures follow this rule: (1) non-significant figures amounting to less than five at the “right most” non-significant digit is counted as “zero,” and (2) non-significant figures amounting to five or more at the right most non-significant digit are counted as a “one” to be added to the last significant digit.

Problem 4

Round off the following numbers so that each has only three significant figures:

A. 1.0632

B. 0.42468

Solution

A. $1.0632 = 1.06$ (right most dropped digit is less than 5)

B. $0.42468 = 4.425$ (right most dropped digit is more than 5)

Digits to be dropped are counted as "zero" digits to be dropped are counted as "1" to be added to last significant digit

The examples in Problem 4 illustrate that the digits "0" can be used in two different ways. At times it represents a significant figure: for example, the mass of sample may be reported at 16.50 grams, meaning that it is closer to 16.50 than to 16.49 or 16.51. In this case, "0" in the number 16.50 is significant, and the number therefore has four significant figures. Similarly, the number 10.50 also has four significant figures, two of which are zeros. At other times the digit "0" may be used as a decimal place marker. For example, the mass of a sample may be reported as 0.068 gram. Here neither of the two digits "0" is significant; each "0" merely serves to indicate that the 6 means "6 hundredths" and that the 8 means "8 thousandths" of a gram. The value 0.068 gram, therefore, has only two significant figures—the 6 and the 8. (Often people drop the digit "0" before the decimal. For example, the value 0.068 gram may be reported as ".068" gram; this practice is not recommended in chemistry).

Common-Sense Rules About the Use of Significant Figures. Assume that you have just carried out three independent measurements of the thickness of a bone sliver. The three measured values, as read on the instrument used, are as follows: 0.253 cm, 0.255 cm, 0.252 cm. The average thickness is then calculated as:

$$\text{average value} = \frac{(0.253 + 0.255 + 0.252)}{3} \text{ cm} = \frac{0.760}{3} \text{ cm} = 0.253333\dots\text{cm}$$

Notice, that the number 3 in the denominator of the above fraction is an exact number (three measurements, no more or less) so you can think of it as 3.00... with as many zeros as you wish. For simplicity, an exact number is written

without any decimals, keeping in mind that the other number(s) in the calculation are those which determine the number of significant figures in the answer. How many significant figures does the answer have in this example? From the division you can get just about as many digits as you wish, since 0.760 is not exactly divisible by 3. Where should you stop? Clearly the final answer cannot be any better than the initial measured values, each of which had only three significant figures. In this example therefore, you should express your answer with three significant figures—that is, 0.253 cm. (In this number, the “0” plays the role of a place marker, the 2 and the 5 are sure figures, and the last digit, 3, is a best guess.)

As a useful general guideline, the result of a multiplication or division should not be reported with more significant figures than any of the values entered in the calculation.

How about adding or subtracting values? In this case use the following example as a guideline:

Experiment 1

- Mass of beaker + sample: 21.836g
- Mass of empty beaker: $\frac{-20.612 \text{ g}}{?} = 1.224 \text{ g}$ (both measured on a sensitive analytical balance)

Both starting values have the same number of digits (three) after the decimal point. The answer also has the same number of digits (three) after the decimal point.

Experiment 2

- Mass of beaker + sample: 21.836 g (measured on a sensitive analytical balance)
- Mass of empty beaker: $\frac{-20.6 \text{ g}}{?} = 1.236 \text{ g}$ (measured on a technical balance)
- Mass of sample: =1.2g (correct no. of significant figures)

Numbers in Exponential Form

Nature offers many examples of extremely tiny, and many examples of extremely huge, and countless examples of the in-between. The diameter of a polio virus sphere is about 0.000002 of an inch or 0.000000006 m; an average person is about 5 ½ to 6 feet tall- a little less than 2 m; the distance from the earth and the moon is 240,000 miles or 390,000,000 m. Length is not the only property that shows such a spectacular range of values. The electrical driving force that triggers lightning during the storm is a million times greater than that require to operate a lightbulb, and this in turn is a million times greater than the nerve impulse that causes the blink of an eye.

To handle the fantastic range of values that nature presents, we have developed some special expressions. In common language, we refer to the "order of magnitude" of things, where "one order of magnitude" indicates a ten-fold increase or decrease in size.

In scientific work, very large and very small numbers are expressed in a conventional shorthand way, called exponential form, which is based on the use of powers of ten.

Positive Powers of 10. Table 1 list some examples of positive powers of 10. As you see, is a shorthand way to write 100 and is a shorthand way to write 1,000. A number such as and is called a positive power of 10. In such a number, 10 is called the base and the superscript (2 or 3 in our examples) is called the exponent. In every power, when the exponent has no sign, it is understood to have a (+) sign: ($10^2 = 10^{+2}$ and $10^3 = 10^{+3}$).

Table 1: Some Positive Powers of 10

Number	Positive Powers of 10
One	$1 = 1 \times 10^0$
Ten	$10 = 1 \times 10^1$
One-hundred	$100 = 1 \times 10^2$
One-thousand	$1000 = 1 \times 10^3$
Ten-thousand	$10000 = 1 \times 10^4$
One-hundred-thousand	$100000 = 1 \times 10^5$
One-million	$1000000 = 1 \times 10^6$

A change from a power of ten to the next higher power means a ten-fold increase in value, that is, an increase "by one order of magnitude"

The exponent of a **positive** power of 10 tells you how many zeros you must add to the right of the digit 1 to express the number in the usual “longhand” form, so is a 1 followed by 9 zeros, that is 1,000,000,000. In order to convert a “longhand” number, which is a multiple of 10 such as 100,000, to an exponential form, you may simply count the zeros that follow the digit 1. In 100,000 there are 5 zeros so 5 will be the exponent: $100,000 = 10^5$.

You can also calculate this conversion another way. Look again at 100,000 as your example. Where is the decimal point in this number? It is not written out explicitly, but it is understood to be at the right of the last digit. So, 100,000 is really 100,000., isn't it? To go from 100,000 to 1, you must move the decimal point to the **left**, (100000.0). More specifically, you must move the decimal point 5 places to the left, and this tells you that +5 is the exponent in the power of 10. That is: $100000 = 10^{+5} = 10^5$.

This illustration may look like a lot of unnecessary work; you had arrived at the same answer more quickly by counting the zeros! True, for this very simple example, but there are cases where “counting the zeros” does not work, whereas the “move- the- decimal- point” method works for every number.

Negative Powers of 10. Table 2 lists some negative powers of ten. As you see, is a shorthand way of writing 0.01; a number such as is called a negative power of 10. Notice that a negative power of 10 is equal to 1 divided by the corresponding positive power of 10^{-7} . For example: equals $\frac{1}{10^{-2}}$

This illustrates a general rule: **When a power of 10 is transferred from the numerator to the denominator, or vice versa, the sign of the exponent is changed.**

Table 2: Some Negative Powers of 10

Number	Negative Powers of 10
One-tenth	$0.1 = 1 \times 10^{-1}$
One-hundredth	$0.01 = 1 \times 10^{-2}$
One-thousandth	$0.001 = 1 \times 10^{-3}$
One-ten-thousandth	$0.0001 = 1 \times 10^{-4}$
One-hundredth-thousandth	$0.00001 = 1 \times 10^{-5}$
One-millionth	$0.000001 = 1 \times 10^{-6}$

How can you quickly express a small number, for example 0.0000001, as a (negative) power of 10? To go from 0.0000001 to 1 you must move the decimal point **to the right** (0.0000001). More specifically, you must move the decimal point 7 places to the **right**, so -7 (minus 7) is the exponent. That is 0.0000001 equals 10^{-7} .

Writing Any Number in Exponential Form. To express any number in a **standard exponential form**, you need to write it as a product of two factors. One is a **digit factor**, consisting of a number with just **one digit** at the left of the decimal point. The other is an **exponential factor** which is an appropriate power of 10.

Here is what you do for the example of a large number such as 2460000. (Assume this number to have four significant figures.) First, write the decimal point where it is understood to be (2460000.). Then move the decimal point to the left, until only **one digit**, 2, remains at the left of the decimal point (2.460000.). This gives you 2.460 (a number between 1 and 10) as the digit factor. (Four digits have been retained since the given number has four significant figures; the other zeros were "place markers" and were dropped.) The digit factor must now be multiplied by an appropriate power of 10. What is this power? You have moved the decimal point six places to the left. Therefore, the exponent of the power of 10 is $(+)$ 6, that is, simply 6. Thus, 10^{+6} or 10^6 is the desired exponential factor.

Here is a quick way to summarize the entire process:

$$2460000 = (2460000.) = 2.46 \times 10^6$$

2.46 is the digit factor and 10^6 is the exponential factor

Similarly, you can express a very small number, such as, 0.000000729, as the product of a "digit factor" and of an "exponential factor." In this case, the exponential factor is a **negative** power of 10.

$$0.000000729 = (0.000000729) = 7.29 \times 10^{-7}$$

7.29 is the digit factor and 10^{-7} is the exponential factor

In general: Any number can be expressed in **standard exponential form** as the product of a digit factor (a number with just one digit to the left of the decimal point) and an **exponential factor** (a power of 10 having a whole number exponent, either positive or negative.)

Problem 5

Write the following ordinary numbers in the standard exponential form. Assume each number to have four significant figures:

A. 4256.

B. 0.00005291

C. 260000000

Solution

$$A. 4256 = (4256.) = 4.256 \times 10^3$$

$$B. 0.00005291 = (0.00005291) = 5.291 \times 10^{-5}$$

$$C. 260000000 = (260000000.) = 2.600 \times 10^8$$

Problem 6

Convert the following numbers from standard exponential form to ordinary "longhand" form. (Keep in mind that large "longhand" numbers are not written in scientific form and usually do not have the correct number of significant figures.)

$$A. 5 \times 10^{10}$$

$$B. 4.58 \times 10^{-4}$$

$$C. 1.65 \times 10^0$$

$$D. 6.02 \times 10^{23}$$

Solution

A. 50,000,000,000

B. 0.000458

C. 1.65

D. 602,000,000,000,000,000,000,000

Problem 7

Convert the following non-standard exponential numbers to the standard exponential form:

A. 42.6×10^3

B. 259×10^0

C. 62.7×10^{-4}

Solution

A. In this and similar problems, first rewrite the given digit factor so that it is expressed in standard exponential form with just one digit before the decimal point.

$$42.6 = 4.26 \times 10^1$$

The resulting number is then multiplied by the original exponential factor to give the entire number. Thus:

$$42.6 \times 10^3 = (4.26 \times 10^1) \times 10^3 \text{ (collect the exponential factors)}$$

$$= 4.26 \times (10^1 \times 10^3)$$

$$= 4.26 \times 10^{(1+3)} \text{ (to multiply the exponential factors, add the exponents (each with its sign))}$$

$$= 4.26 \times 10^4$$

$$B. 259 \times 10^0 = (2.59 \times 10^2) \times 10^0 = 2.59 \times 10^{(2+0)} = 2.59 \times 10^2$$

$$C. 62.7 \times 10^{-4} = (6.27 \times 10^1) \times 10^{-4} = 6.27 \times 10^{(1-4)} = 6.27 \times 10^{-3}$$

Scientific Notation. A measured value, when expressed in a standard exponential form and with the correct number of significant figures, is commonly said to be in "scientific notation." Scientific notation is the conventional way to express numbers in science. It is useful because it lets you see at a glance which figures in the number you can "trust," and it is convenient because the exponential form makes both large and small numbers easy to handle.

Doing Arithmetic With Numbers in Scientific Notation

Addition and Subtraction

Numbers with the same exponential factor may be added and subtracted directly:

Examples

$$\begin{array}{r} \text{A. } 6.02 \times 10^{23} \\ + 3.01 \times 10^{23} \\ \hline = 9.03 \times 10^{23} \end{array}$$

The digit factors are added. The exponential factor is unchanged. The answer is in standard exponential form, so no further work is needed.

$$\begin{array}{r} \text{B. } 6.02 \times 10^{23} \\ + 5.92 \times 10^{23} \\ \hline = 11.94 \times 10^{23} \end{array}$$

The first answer must be put in standard exponential form.

$$= 1.19 \times 10^{24}$$

Numbers that have different—but not too different—exponential factors must be converted to the same exponential form before adding or subtracting. If the exponential factors of the numbers are very different, the smaller number(s) are ignored. As a general rule, in adding and subtracting, neglect all numbers whose exponent is smaller than the largest exponent by 3 units or more.

Examples

exponents differ by one unit

$$\text{A. } 1.03 \times 10^{-2} + 6.35 \times 10^{-1} = ?$$

the smaller number is converted and then added.

$$\begin{array}{r} 0.013 \times 10^{-1} \\ + 6.35 \times 10^{-1} \\ \hline = 6.453 \times 10^{-1} \end{array}$$

this first answer is rounded off to two decimal figures because one of the numbers added only had two decimal figures.

$$= 6.45 \times 10^{-1}$$

Exponents differ by 12 units

$$B. 8.95 \times 10^{-3} + 6.20 \times 10^{-15} = 8.95 \times 10^{-3}$$

$$C. 8.95 \times 10^{-3} + 6.20 \times 10^{-15}$$

The smaller number is neglected.

Exponents differ by 4 units

$$D. 1.5 \times 10^2 - 3.7 \times 10^{-2} = 1.5 \times 10^2$$

The smaller number is neglected.

Multiplication

To multiply numbers written in standard exponential form, follow a stepwise procedure as illustrated by the following example.

$$(6.3 \times 10^3) \times (3.4 \times 10^7) = ?$$

- **Step 1:** Collect all digit factors together and all exponential factors together:

$$(6.3 \times 3.4) \times (10^3 \times 10^7) = ?$$

- **Step 2:** Multiply the digit factors as usual; multiply the exponential factors by adding the exponents, if necessary; rearrange the number to standard scientific notation:

$$(21.42) \times (10^{(3+7)}) = 21.42 \times 10^{10} = 2.1 \times 10^{11}$$

Here is another example:

$$(1.3 \times 10^{-5}) \times (9.45 \times 10^4) = ?$$

$$(1.3 \times 10^{-5}) \times (9.45 \times 10^4) = [12.285] \times [10^{(-5+4)}] = ?$$

$$12.285 \times 10^{-1} = 1.2 \times 10^0 = 1.2$$

Division

The procedure is outlined in the following example.

- **Step 1:** Collect digit factors and exponential factors separately:

$$\frac{4.2 \times 10^8}{2.1 \times 10^5} = ?$$

- **Step 2:** Carry out the indicated operations:

$$2.0 \times 10^{(8-5)} = 2.0 \times 10^3$$

To divide an exponential factor by another, subtract the exponents

Answer is already in standard form

Here is another example:

$$\frac{3.2 \times 10^{-6}}{4.6 \times 10^2} = \frac{3.2}{4.6} \times \frac{10^{-6}}{10^2} = ?$$

$$= 0.6956... \times 10^{(-6-2)} = 0.6956... \times 10^{-8} = 7.0 \times 10^{-9}$$

Powers

To raise a number written in exponential form to a power, raise both the digit factor in the exponential factor to the desired power independently; here are two worked-out examples:

Positive Powers

$$(2.3 \times 10^3)^2 = ?$$

$$(2.3)^2 \times (10^3)^2 = (2.3) \times (2.3) \times 10^{(3 \times 2)} = 5.29 \times 10^6 = 5.3 \times 10^6$$

To raise an exponential factor to a power, multiply the exponent by the power.

Negative Powers

$$(2.3 \times 10^3)^{-2} = ?$$

$$\left(2.3\right)^{-2} \times \left(10^3\right)^{-2} = \frac{1}{(2.3)^2} \times 10^{-6} = \frac{1}{(2.3) \times (2.3)} \times 10^{-6} = ?$$

$$= \frac{1}{(2.3)^{-2} \times 10^{-6}}$$

$$= \frac{1}{5.29} \times 10^{-6} = 0.189 \times 10^{-6} = 1.9 \times 10^{-7}$$

Experiment One: Which Antacid Is Most Effective?

Pre-Lab Questions, Experiment Data Tables, and Post-Lab Analysis are available for Word Document download via [Google Drive: Experiment One Word Document Download](#). Make a copy of the document in a personal Google Drive account or download the document in order to edit.

Pre-Lab Questions

1. To what class of compounds do antacids belong? Why is NaCl not a good antacid?
2. If 13.0 g of antacid A have neutralized 40 mL of 0.56 M HCl, while 6.00 g of antacid B have neutralized 25 mL of the same acid solution, then which of the two acids has the greater neutralizing power? Justify answer with calculations.
3. After taking an antacid, the pH of your stomach solution will:
 - E. Increase
 - F. Decrease
 - G. Stay the same
4. Suppose an antacid has the formula $B(OH)_2$ where B is a dipositive metal ion. If your stomach acid is HCl, write a chemical equation that describes what happens after the antacid reaches the stomach.
5. What is the difference between acid neutralizers and acid blockers?

Introduction

There are different antacids marketed today, and they range in price from cheap to semi-expensive. The efficacy of each one is not dependent on price but rather on the active ingredients as well as each person's bodily response to the antacid. Independent of these two factors and to answer the effectiveness question, we can determine the acid neutralizing power of different antacids and rank each accordingly.

Background

Antacids are among the most heavily advertised pharmaceutical products: Brand A "consumes forty-five times its own weight in stomach acid." Brand B "coats your stomach with a pink, soothing lining." Brand C "spells R-E-L-I-E-F." In drugstores, the antacids' section often takes up a complete set of shelves. There you can see bottles with liquids, jars with powders, and boxes with tablets. Some preparations are pink, some green, and some white. Some are plain, and some are mint or orange flavored. If you needed to buy an antacid, which one would you choose? Which of the advertising claims would you most believe?

This is one case where you can, with little effort, really "check the claim." At least, you can do so regarding the neutralizing power of the antacid. First, however, you need to think about what an antacid really does.

The gastric juices present in your stomach are acidic and contain a carefully controlled amount of hydrochloric acid, HCl. Sometimes, likely due to poor eating or stress, our body reacts. Typically, this reaction causes more than the usual amount of acid to be produced in the stomach and hyperacidity results. (Hyperacidity means "too much acidity.") This is what some people call "acid indigestion."

What is the most immediate way to counteract hyperacidity? Just add enough of an appropriate base to neutralize the excess stomach acid. This is exactly what antacids are intended to do. How well they do it is what we need to find out.

Purpose

The purpose of this work is to determine the neutralizing capacity of various commercially available antacids, and in doing so help people in making informed decisions as to which antacid to use.