Tutorial 1

MATHEMATICAL SKILLS

To a mathematician math is an end in itself; to the chemist and chemistry student it is a means to an end: a tool. Little in chemistry can be studied and understood without the aid of mathematics. Since math will be an important tool for you it is best if you learn to use this tool efficiently.

Efficiency at doing anything comes through practice; you learn to do something by doing it. The problems in this Tutorial are for your practice. You should do these problems over and over until you can do them automatically. Then when the time comes to use these skills in a chemistry problem you can pay attention to the principle illustrated by the problem and not get lost in the use of math.

If you have to spend what seems like an extraordinary amount of time on these problems, then, definitely, you need to practice and the time spent will repay you many times over during the semester. It may even make the difference between doing well and dropping out.

The two math skills covered in this Tutorial are: (1) exponential arithmetic and (2) significant figures.

EXPONENTIAL ARITHMETIC: The basics are given in Appendix A, section A.1, pp 1012-1014, of your lecture text.

SIGNIFICANT FIGURES: This topic is discussed in your lecture text, pp 20-24; a further treatment is given below. You will be penalized in the laboratory and in your 1310 lecture for misuse of significant figures. It is well worth your time and effort to master this topic.

ADDITION AND SUBTRACTION WITH SIGNIFICANT FIGURES: When measured quantities are added or subtracted, the absolute uncertainty of the result must be equal to the largest absolute uncertainty among the quantities used in the operation. In plain English, perform the addition or subtraction, then round off the result to the same number of decimal places as there are in the measured quantity with the smallest number of decimal places.

EXAMPLES: The underlined zeros in these examples are added for ease of lining up the columns; they are not significant.

Add: 415.5 + 3.63 + 0.328   Subtract: 15.33 – 4.129

$$
\begin{array}{r}
415.5\underline{00} \\
+\ \ 3.63\underline{0} \\
+\ \ 0.328 \\
\hline
419.458\ \rightarrow\ 419.5
\end{array}
$$

(round to nearest tenth)

$$
\begin{array}{r}
15.33\underline{0} \\
-\ \ 4.129 \\
\hline
11.201\ \rightarrow\ 11.20
\end{array}
$$

(round to nearest hundredth)

<u>MULTIPLICATION AND DIVISION WITH SIGNIFICANT FIGURES</u>: When measured quantities are multiplied or divided, the relative uncertainty of the result must be equal to the largest relative uncertainty among the quantities used in the operation. In plain English, perform the multiplication or division, then round off the result so that it contains the same number of significant digits as the quantity with the smallest number of significant digits.

<u>EXAMPLE</u>:

Multiply: 101.3 cm x 11.9 cm x 7.6 cm = 9161.572 cm^3 (calculator result)

$$= 9.2 \ x \ 10^3 \ cm^3$$

(round to two significant figures)

<u>EXAMPLE</u>:

Divide: 160.3 g ÷ 9.2 x 10^3 cm^3 = 0.0174239 g/cm^3 (calculator result)

$$= 1.7 \ x \ 10^{-2} \ g/cm^3$$

(round to two significant figures)

CALCULATORS AND CALCULATIONS: All scientific calculators allow you to enter numbers in standard notation (up to the display limit) and exponential notation. Likewise, they can display calculational results in either notation. More importantly, calculators are programmed to perform multi-step calculations according to the rules of math. Therefore, it is critical that numbers, operators, and other functions are entered in a manner that is consistent with those rules. The best way to avoid common 'calculator errors' is to carefully read the directions that accompany your calculator. Doing so will almost certainly eliminate the frustration other students have experienced when they couldn't successfully execute a multi-step calculation in lab or worse yet, on a quiz or test, because they didn't know how to use their calculators. Lastly, calculators are not programmed to display results with the proper number of significant digits – maybe someday.

REMEMBER THE TWO DIFFERENT RULES FOR SIGNIFICANT FIGURES:

(1) ADDITION AND SUBTRACTION: THE SMALLEST NUMBER OF DECIMAL PLACES

(2) MULTIPLICATION AND DIVISION: THE SMALLEST NUMBER OF SIGNIGICANT DIGITS

1)   Write each of the following numbers in Scientific Notation:

   a)   2500   b)   0.00119   c)   0.0101
   d)   107,000   e)   0.000001   f) 456×10^5
   g) 0.035×10^2 h) 18.45×10^{-8} i) 135×10^{-3}
   j) 0.00998×10^4 k) 1558×10^{-4} l) 0.0008×10^{-4}

2)   Write each of the following numbers in expanded form:

   a) 2.45×10^3 b) 18.56×10^{-6} c) 3.67×10^{-5}
   d) 55.56×10^{-8} e) 0.0056×10^6 f) 0.00032×10^{-3}
   g) 0.00123×10^{-6} h) 0.000843×10^{12} i) 1557×10^{-5}

3)   Carry out the following multiplications. Write your answer in Scientific Notation. Follow the
     rules of significant figures.

   a) $2.4 \times 10^4 \ \times \ 36.77 \times 10^{-7} \ \times \ 1.33 \times 10^{12} \ =$
   b) $0.00445 \times 10^{-7} \ \times \ 1.558 \times 10^5 \ \times \ 0.135 \times 10^2 \ =$
   c) $9.556 \times 10^4 \ \times \ 18.3 \times 10^{10} \ \times \ 2.59 \times 10^{-6} \ =$
   d) $10.55 \times 10^4 \ \times \ 0.000335 \times 10^6 \ \times \ 14 \ =$
   e) $3.66 \times 10^6 \ \times \ 2.778 \times 10^{-7} \ \times \ 8.993 \times 10^{-10} \ \times \ 3.578 \times 10^8 \ =$
   f) $135 \ \times \ 246 \ \times \ 0.000556 \ \times \ 0.0998 \ \times \ 155 \ =$

4)   Carry out the following additions. Write your answers in Scientific Notation. Follow the
     rules of significant figures.

   a) $12.160 \ + \ 3.12 \ =$
   b) $0.005763 \ + \ 0.0251 \ =$
   c) $29.63 \ + \ 24.798 \ + 1.263 \ =$
   d) $1.927 \ + \ 0.876 \ + \ 0.00392 \ =$
   e) $12.6 \ + \ 193.8 \ + \ 0.937 \ =$
   f) $(1.70 \times 10^{12}) \ + \ (7.9 \times 10^{11}) \ =$
   g) $(12.6 \times 10^{10}) \ + \ (1.07 \times 10^{12}) \ =$
   h) $(2.37 \times 10^{-6}) \ + \ (2.37 \times 10^{-7}) \ =$

5) Carry out the following divisions. Write your answers in Scientific Notation. Follow the rules of significant figures.

a) $\dfrac{8.445 \times 10^5}{9.445 \times 10^2}$ =

b) $\dfrac{0.00345 \times 10^7}{3.556 \times 10^5}$ =

c) $\dfrac{7.884 \times 10^{-7}}{0.994 \times 10^3}$ =

d) $\dfrac{5.67 \times 10^4}{18.4 \times 10^{-8}}$ =

e) $\dfrac{18.4 \times 10^{-9}}{2.66 \times 10^5}$ =

f) $\dfrac{0.00033 \times 10^5}{185 \times 10^7}$ =

g) $\dfrac{185 \times 10^{-5}}{0.000333 \times 10^7}$ =

h) $\dfrac{3.689 \times 10^{-5}}{0.937 \times 10^8}$ =

i) $\dfrac{9.57 \times 10^{-2}}{8.35 \times 10^3}$ =

6) Carry out the following operations. Write your answers in Scientific Notation. Follow the rules of significant figures.

a) $\dfrac{3.56 \times 10^2 \ \times \ 5.920 \times 10^{-9} \ \times \ 15}{196 \ \times \ 3.67 \times 10^{-6} \ \times \ 5.56 \times 10^4}$ =

b) $\dfrac{0.00558 \times 10^{-6} \ \times \ 135 \times 10^3 \ \times \ 2.56 \times 10^4}{6.02 \times 10^{23} \ \times \ 34 \ \times \ 2.85 \times 10^{-8} \ \times \ 255}$ =

c) $\dfrac{8888 \ \times \ 6.32 \times 10^{12} \ \times \ 3 \ \times \ 5.66 \times 10^{-8}}{25 \ \times \ 67.3 \times 10^5 \ \times \ 0.000455 \times 10^{-10}}$ =

Answers to Problems

1. a) 2.500×10^3 b) 1.19×10^{-3} c) 1.01×10^{-2}
   d) 1.07000×10^5 e) 1×10^{-6} f) 4.56×10^7
   g) 3.5×10^0 h) 1.845×10^{-7} i) 1.35×10^{-1}
   j) 9.98×10^1 k) 1.558×10^{-1} l) 8×10^{-8}

2. a) 2450   b) 0.00001856   c) 0.0000367
   d) 0.0000005556   e) 5600   f) 0.00000032
   g) 0.00000000123   h) 843,000,000   i) 0.01557

3. a) 1.2×10^{11} b) 9.36×10^{-4} c) 4.53×10^{10}
   d) 4.9×10^8 e) 3.27×10^{-1} f) 2.86×10^2

4. a) 1.528×10^1 b) 3.09×10^{-2} c) 5.569×10^1
   d) 2.807×10^0 e) 2.073×10^2 f) 2.49×10^{12}
   g) 1.20×10^{12} h) 2.61×10^{-6}

5. a) 8.941×10^2 b) 9.70×10^{-2} c) 7.93×10^{-10}
   d) 3.08×10^{11} e) 6.92×10^{-14} f) 1.8×10^{-8}
   g) 5.56×10^{-7} h) 3.94×10^{-13} i) 1.15×10^{-5}

6. a) 7.9×10^{-7} b) 1.3×10^{-19} c) 1×10^{15}