MATH Primer Addendum/Addition Fall 2016

This addendum has been developed in response to concerns from faculty regarding MATH skills of a clinical or basic science origin. It is to be completed just as the traditional MATH Primer is to be completed. Both are quizzable, both are testable.

Section Nulla A: Multiplying and Dividing Fractions

As with anything in the quantitative sciences, one deals with numbers. In some cases, one deals with the multiplication and division of fractions. A fraction is defined as a mathematical expression representing the division of one whole number by another. It's usually written as two numbers separated by a **horizontal or a diagonal** line, **fractions** are also used to indicate a part of a whole number or a ratio between two numbers (http://www.dictionary.com/browse/fraction):

$\frac{1}{2}$ = 1 ÷ 2 = 1 divided by 2 = one half = 0.5

1/2 = 1 ÷ 2 = 1 divided by 2 = one half = 0.5

Note that, in both graphics, at right, the fraction is on the far left and the decimal form (more later) is on the far right.

When multiplying fractions, here's a helpful mnemonic as you negotiate your way through this topic.

♫ "Multiplying fractions: no big problem,
Top times top over bottom times bottom.
"And don't forget to simplify,
Before it's time to say goodbye" ♫

https://www.mathsisfun.com/fractions_multiplication.html

Multiplying fractions is not like solving a ratio, although the two are sort of related. When multiplying a fraction, the top numbers (numerators) are multiplied together and the bottom numbers (denominators) are multiplied together to make a new fraction:

Example:

$$\frac{1}{2} \times \frac{2}{5}$$

Step 1. Multiply the top numbers:

$$\frac{1}{2} \times \frac{2}{5} = \frac{1 \times 2}{} = \frac{2}{}$$

Step 2. Multiply the bottom numbers:

$$\frac{1}{2} \times \frac{2}{5} = \frac{1 \times 2}{2 \times 5} = \frac{2}{10}$$

Step 3. Simplify the fraction :

$$\frac{2}{10} = \frac{1}{5}$$

https://www.mathsisfun.com/fractions_multiplication.html

Each step is carefully explained and illustrated in the graphic at right.

Remember, though, that when you make a new fraction that you must reduce (simplify) it to its lowest common denominator.

In the case of the example, both numerator and denominator are divisible by 2, reducing two tenths to one fifth.

It's not always this simple and may require you to review your multiplication tables if you don't want to go through 7 or 8 simplification steps.

Here's another example for you to study.

Another Example

$$\frac{1}{3} \times \frac{9}{16}$$

https://www.mathsisfun.com/fractions_multiplication.html

Step 1. Multiply the top numbers:

$$\frac{1}{3} \times \frac{9}{16} = \frac{1 \times 9}{} = \frac{9}{}$$

Step 2. Multiply the bottom numbers:

$$\frac{1}{3} \times \frac{9}{16} = \frac{1 \times 9}{3 \times 16} = \frac{9}{48}$$

Step 3. Simplify the fraction:

$$\frac{9}{48} = \frac{3}{16}$$

Note that the final fraction was simplified by dividing numerator and denominator by 3.

Example:

$$\frac{2}{3} \times 5$$

https://www.mathsisfun.com/fractions_multiplication.html

Make 5 into $\frac{5}{1}$:

$$\frac{2}{3} \times \frac{5}{1}$$

Now just go ahead as normal.

Multiply tops and bottoms:

$$\frac{2}{3} \times \frac{5}{1} = \frac{2 \times 5}{3 \times 1} = \frac{10}{3}$$

$$\text{Answer} = \frac{10}{3}$$

The fraction is already as simple as it can be.

There are other forms that fractions can take, as well. For example, if one chooses to multiply a fraction times a whole number (a "non-fraction" number), you can easily accomplish this as follows:

Note that "5" can be written as "5 over 1" without changing its value, i.e., this is an equivalent statement. Did you note that the new fraction (the answer) is as simple as it can get?)

You can also think of a whole number as just being a "top number", as in the example at bottom right. Did you observe that the initial answer was simplified by dividing the numerator and denominator by 3? Good!

Example:

$$3 \times \frac{2}{9}$$

https://www.mathsisfun.com/fractions_multiplication.html

Multiply tops and bottoms:

$$\frac{3}{} \times \frac{2}{9} = \frac{3 \times 2}{9} = \frac{6}{9}$$

Simplify:

$$\frac{6}{9} = \frac{2}{3}$$

Questions/Problems

Write out the fractions from the words:

1. two fifths **2. three seventeenths** **3. four fifths**

4. one fifth **5. seven tenths** **6. two fifteenths**

7. nine forty sevenths **8. three tenths**

9. fifteen sixteenths **10. five eighths** **11. nine elevenths**

12. thirteen sixteenths **13. nineteen twenty thirds**

14. thirty one forty sevenths **15. Nineteen fifty sevenths**

Multiply the fractions from above as follows:

16. #1 times #10 **17. #3 times #7** **18. #2 times #9**

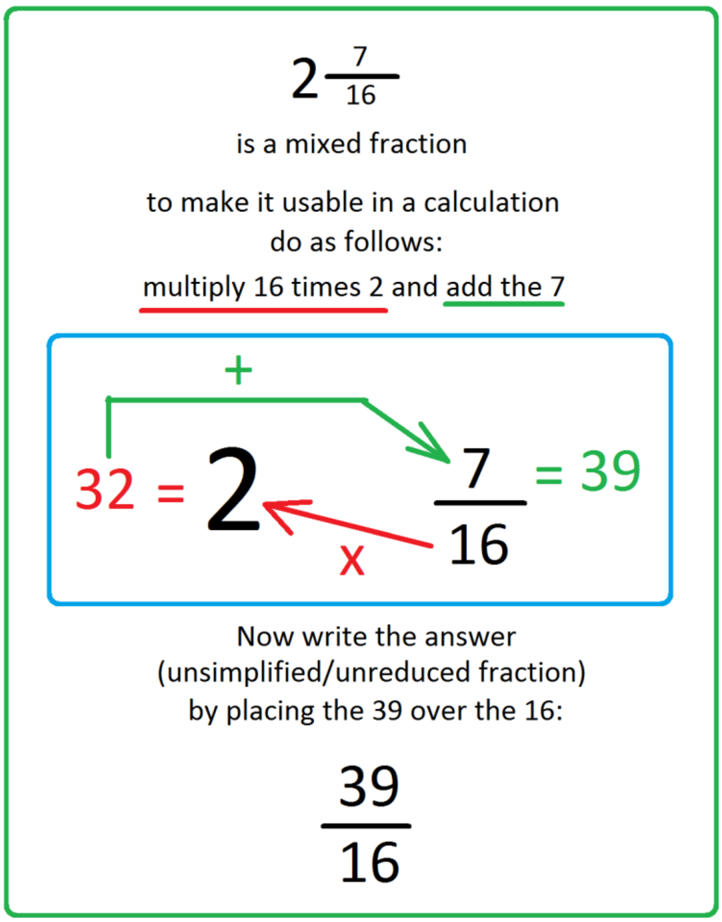
19. #4 times #13 **20. #5 times # 15** **21. #9 times #11**

22. #6 times #12 **23. #7 times #13** **24. #11 times #11**

25. #14 times #15

How might you go about multiplying mixed fractions? First you must "unsimplify" the complex fraction to an improper fraction as in the example in the graphic at right.

Another way of stating this is to multiply the denominator by the whole number and, then, add the numerator to the product and, finally, write your sum over the original denominator.



Convert both to improper fractions

$$1\ {}^{1}/_{2} \times 2\ {}^{1}/_{5} = {}^{3}/_{2} \times {}^{11}/_{5}$$

Multiply the fractions (multiply the top numbers, multiply bottom numbers):

$${}^{3}/_{2} \times {}^{11}/_{5} = {}^{(3 \times 11)}/_{(2 \times 5)} = {}^{33}/_{10}$$

Convert to a mixed number

$${}^{33}/_{10} = \mathbf{3\ {}^{3}/_{10}}$$

If you are clever you can do it all in one line like this:

$$1\ {}^{1}/_{2} \times 2\ {}^{1}/_{5} = {}^{3}/_{2} \times {}^{11}/_{5} = {}^{33}/_{10} = \mathbf{3\ {}^{3}/_{10}}$$

https://www.mathsisfun.com/mixed-fractions-multiply.html

Let's look at an example where we'll multiply one and a half by two and one fifth:

Questions/Problems

Multiply the following fractions

26. one and six sevenths by two and three fifths

27. three and one fourths by two and seven ninths

28. one fifth by four and two elevenths

29. two and one fourth by seven and five twenty thirds

30. four and three sevenths by one and two ninths

31. one and two thirds by two and three fourths

32. three and four fifths by four and five sixths

33. four and five sixths by five and six sevenths

34. eight and nine tenths by eleven and twelve thirteenths

35. seven and eight ninths by thirteen and fourteen fifteenths

36. ten and eleven fifteenths by fourteen and fifteen nineteenths

37. one and three fifths by seven and four ninths

38. two and three elevenths by five and two thirteenths

39. one hundred forty two and five sixteenths by thirty seven and nine fourteenths

40. sixty six and six sixty fifths by twenty two and two twenty firsts

♫ "Dividing fractions, as easy as pie,
Flip the second fraction, then multiply.
And don't forget to simplify,
Before it's time to say goodbye" ♫

We've pretty much beaten fraction multiplication to death, now, and we need to take a look at dividing fractions. Division is just fast subtraction … with fractions, it's more akin to multiplication of the reciprocal, making it fast addition. As we begin to think about this topic, here's a mnemonic to help you remember how to divide fractions:

Another way to remember is:

"leave me, change me, turn me over"

https://www.mathsisfun.com/fractions_division.html

If you don't like that one, here's another:

Either way, dividing fractions, as long as one remembers the rules (just like in multiplying fractions, there are rules, too!), is very doable, e.g., at right.

Example:

$$\frac{1}{2} \div \frac{1}{6}$$

https://www.mathsisfun.com/fractions_division.html

Step 1. Turn the second fraction upside down (it becomes a **reciprocal**):

$$\frac{1}{6} \text{ becomes } \frac{6}{1}$$

Step 2. Multiply the first fraction by that **reciprocal**:

(multiply tops …)

$$\frac{1}{2} \times \frac{6}{1} = \frac{1 \times 6}{2 \times 1} = \frac{6}{2}$$

(… multiply bottoms)

Step 3. Simplify the fraction:

$$\frac{6}{2} = 3$$

Another way fraction dividing may be presented is as follows:

$$\frac{\frac{3}{5}}{\frac{4}{7}} \quad \begin{matrix}\text{Fraction 1}\\ \text{Divided by}\\ \text{Fraction 2}\end{matrix} \quad \frac{3}{5} \div \frac{4}{7} \rightarrow \frac{3}{5} \times \frac{7}{4} = \frac{21}{20} = 1\frac{1}{20}$$

Now that you know that dividing fractions is really a form of multiplication, here are some problems for you to work out to help you learn this operation.

Questions/Problems

Divide the following fractions

41 – 50: Fraction statements in Questions 16-25

Section Nulla B: Solving Ratios (Proportionalities)

One of the most common operations that students and professionals carry out in their day-to-day lives is that of solving proportions (or proportionalities). Solving proportions is simply a matter of stating the ratios as fractions, setting the two fractions equal to each other, cross-multiplying, and solving the resulting equation. This is a way in which to determine proper medication dosages in health care and to determine proper solute to solvent ratios in Biology and in Chemistry.

- **Find the unknown value in the proportion: $2 : x = 3 : 9$.**

$$2 : x = 3 : 9$$

First, I convert the colon-based odds-notation ratios to fractional form:

$$\frac{2}{x} = \frac{3}{9}$$

Then I solve the proportion:

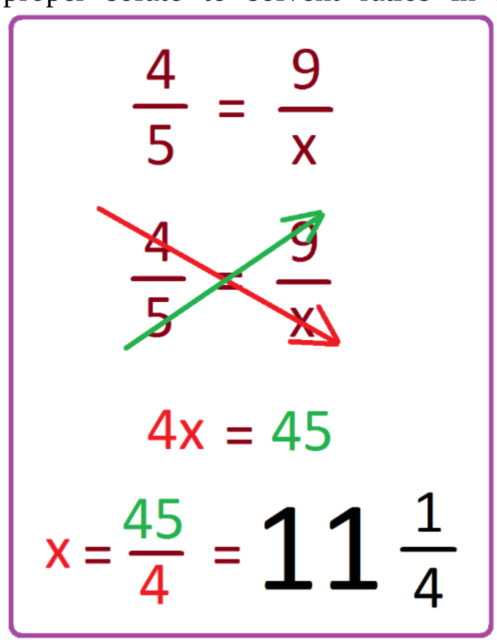
$$\frac{2}{x} = \frac{3}{9}$$

$$9(2) = x(3)$$

$$18 = 3x$$

$$\mathbf{6 = x}$$

www.purplemath.com/modules/ratio4.htm



Here's an example of a ratio/proportion and how to solve it:

The proportion, above, is read as "two is to x, as three is to nine" – set up the fraction based on that statement, then solve for "x".

While the image at upper right shows the final "cross multiplying product", it doesn't walk you through the sequence. Here's a graphic with a different example that originated as 4 : 5 = 9 : x, that will, at left.

Keep in mind that "x" can be anywhere in the ratio/proportion – one still cross multiplies to solve for "x", i.e., the solution.

On the following page are problems for you to work through as you learn this operation.

Problems/Questions

Solve the proportionalities – you'll have to use your calculator in many cases. Report the results in FRACTIONS, however!

51. x : 5 = 4 : 9

52. 3 : x = 2 : 5

53. 5 : 6 = x : 7

54. 7 : 8 = 9 ; x

55. x : 8 = 5 : 6

56. 10 : x = 4 : 11

57. 5 : 7 = x : 13

58. 9 : 23 = 15 : x

59. x : 2 = 3 : 5

60. 9 : x = 2 : 7

61. 11 : 25 = x : 3

62. 13 : 29 = 23 : x

63. x : 2 = 3 : 7

64. 6 : x = 3 : 14

65. 8 : 9 = x : 31

66. 4 : 5 = 19 : x

67. x : ½ = ¾ : 2/5

68. ¼ : x = ¾ : 7/8

69. 1/3 : 2/7 = x : 4/9

70. 4/5 : 9/10 = 7/8 : x

71. 6 : 7 = 17 : x

72. x : 19 = 21 : 33

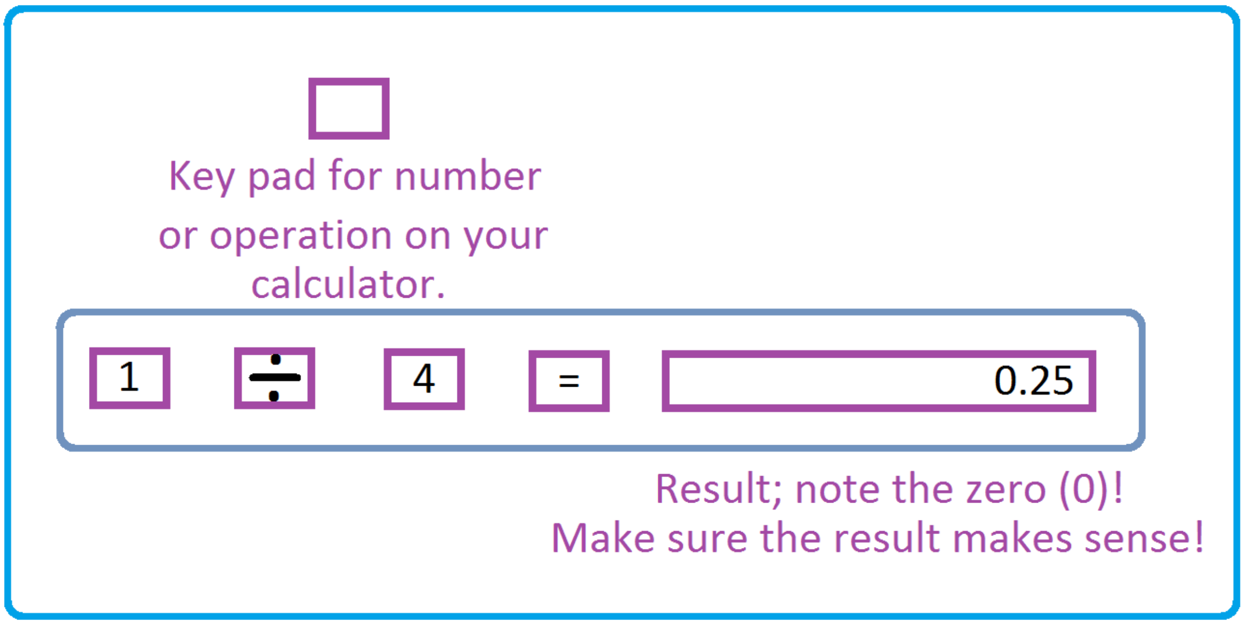
73. 1 : x = 19 : 21

74. 0 : 1 = x : 354

75. 1 : 1 = 3 : x

Section Nulla C: Converting Fractions to Decimal Values

While fractions are useful in numerous ways in health care and science, in most cases in Chemistry, Biology and Physics, fractions are not helpful. In that case, one must have the skills to convert fractions to decimals AND they must make sense! For example if you simply punch in 1 ÷ 4 for one fourth and you obtain 1.73, you must know that it's wrong! And that it's really 0.25! This is a HUGE critical thinking thing! Just because you punch a series of numbers into your calculator does not guarantee that the calculation will be correct. THINK whilst you're doing fraction to decimal conversions!



For now, we're gonna focus only on the conversion of a fraction to a decimal without worrying about significant figures (that's coming up later). It's as simple as:

Problems/Questions

Convert the following fractions to decimal form – if you're "up" on your fractions, you'll see that there are some you won't need a calculator for. Remember: just because you have a calculator, you don't have to use it – it may be faster and more efficient to use your brain.

76. ¼

77. 1/8

78. ½

79. ¾

80. 1

81. 3/2

82. 14/15

83. 20/25

84. 15/16 **85. 19/32**

If you can complete this operation, then you can run it backwards to convert a decimal to a fraction.

Section Nulla D: Roman Numerals

In human anatomy, we use the first 12 Roman Numerals to label the 12 pairs of cranial nerves (I – XII); in pharmacy, Roman Numerals are used in script writing and reading, hence, it's important to be able to maneuver your way through Roman Numerals – besides, how would you know which Super Bowl it is if you couldn't read Roman Numerals???

Roman Numerals are defined as any of the letters representing numbers in the Roman numerical system: I = 1, V = 5, X = 10, L = 50, C = 100, D = 500, M = 1,000. In this system, a letter placed after another of greater value adds (thus XVI or xvi is 16), whereas a letter placed before another of greater value subtracts (thus XC or xc is 90).

Note in the table, below, some of the peculiarities of the Roman numbering system, e.g., look what happens at 9 (IX), 40 (XL), 90 (XC). 1000 is M, by the way; also, lower case is used as much as upper case.

www.roman-numerals.org/chart100.html

1	I	**21**	XXI	**41**	XLI	**61**	LXI	**81**	LXXXI
2	II	**22**	XXII	**42**	XLII	**62**	LXII	**82**	LXXXII
3	III	**23**	XXIII	**43**	XLIII	**63**	LXIII	**83**	LXXXIII
4	IV	**24**	XXIV	**44**	XLIV	**64**	LXIV	**84**	LXXXIV
5	V	**25**	XXV	**45**	XLV	**65**	LXV	**85**	LXXXV
6	VI	**26**	XXVI	**46**	XLVI	**66**	LXVI	**86**	LXXXVI
7	VII	**27**	XXVII	**47**	XLVII	**67**	LXVII	**87**	LXXXVII
8	VIII	**28**	XXVIII	**48**	XLVIII	**68**	LXVIII	**88**	LXXXVIII
9	IX	**29**	XXIX	**49**	XLIX	**69**	LXIX	**89**	LXXXIX
10	X	**30**	XXX	**50**	L	**70**	LXX	**90**	XC
11	XI	**31**	XXXI	**51**	LI	**71**	LXXI	**91**	XCI
12	XII	**32**	XXXII	**52**	LII	**72**	LXXII	**92**	XCII
13	XIII	**33**	XXXIII	**53**	LIII	**73**	LXXIII	**93**	XCIII
14	XIV	**34**	XXXIV	**54**	LIV	**74**	LXXIV	**94**	XCIV
15	XV	**35**	XXXV	**55**	LV	**75**	LXXV	**95**	XCV
16	XVI	**36**	XXXVI	**56**	LVI	**76**	LXXVI	**96**	XCVI
17	XVII	**37**	XXXVII	**57**	LVII	**77**	LXXVII	**97**	XCVII
18	XVIII	**38**	XXXVIII	**58**	LVIII	**78**	LXXVIII	**98**	XCVIII
19	XIX	**39**	XXXIX	**59**	LIX	**79**	LXXIX	**99**	XCIX
20	XX	**40**	XL	**60**	LX	**80**	LXXX	**100**	C

Problems/Questions

86. Write the current year in Roman Numerals.

87. Write the year of your birth in Roman Numerals.

88. A prescription has been presented to you to take to your pharmacist. On it it says "tab iv". How many tablets are you supposed to get?

89. Cranial nerve VIII is the acoustic nerve (or auditory nerve or vestibulocochlear nerve). What number is it using Arabic numbers?

90. XXXVI times XIII equals what using Arabic numbers?

91. What Super Bowl just played back in February? Which one is coming next February?

92. A prescription has been written for you: ASA gr x po qhs. How many grains of aspririn are you supposed to take by mouth at night? Answer using Arabic numbers.

93. A prescription for your patient reads "morphine sulfate gr vii IM prn pain". How many grains of morphine sulfate are you going to give to your patient intra-muscularly when they're in pain? Answer using Arabic numbers.

94. A prescription has been written for you as follows: atorvastatin, 10 mg po qhs, disp tab XC. How many tablets will be dispensed in the bottle? Answer using Arabic numbers.

95. Write out the Roman Numerals for the 12 pairs of cranial nerves – match them against the Arabic numbers.

96. A significant piece of federal law is called Title IX – how would you spell IX using words?

97. Cranial nerves III, IV and VI regulate eye movement – what are they in Arabic numbers?

98. You've been given an order to dose a patient with ASA gr iii now. If 1 gr of ASA is 65 mg, how many mg are you to administer?

99. How many mg ASA are you to take in #92?

100. Write out the course number for this course in Roman Numerals.

Thus ends the Addendum for Fall 2016 and commences the traditional MATH Primer on a following web page (linked at another location).

Mathematics for Chemistry: A Primer

When studying any field of the physical sciences, one inevitably runs into the necessity of using some mathematics to understand that field. Chemistry is one of those fields that requires the utilization of some fairly simple concepts of mathematics.

The areas of mathematics that are the most applicable to a beginning college chemistry course are typically taught to students in Intermediate Algebra and Trigonometry or in Pre-Calculus Mathematics courses. Actually, if one has completed (and retained and used regularly) appropriate instruction through high school Algebra II and Geometry, one can easily complete General Chemistry I and II with little mathematical difficulty.

However, if one did not take (or use routinely) that sort of instruction (or retained the knowledge) and matriculated only the barest of mathematics minimums for their pre-requisite courses, General Chemistry courses can be a regular nightmare.

The goal of this short monologue is to refresh your mathematics memories or to upgrade your mathematics toolbox so that you may more comfortably and confidently complete General Chemistry and go on to the course[s] for which General Chemistry is [are] a pre-requisite course[s].

I. Simple Algebra

In all likelihood, you remember some sort of algebraic equation of the form:

$$2x = 4$$

Where "x" is the variable that we don't know and it doesn't matter if it's an "x" or a "p" or a "t" – it's just something for which we need a temporary identity so that we can solve for it. The simplest way to solve this equation is to go back into our bags of high school algebra tricks and remember that whatever we do to one side of the equation, we have to do to the other side of the equation as we isolate "x" to determine its value. In this case, let's divide both sides of the equation by 2 and see what happens:

$$2x = 4$$

$$\frac{2}{2}x = \frac{4}{2}$$

$$x = 2$$

As you can see, we solved fairly quickly for “x” and it’s equal to 2.

In a slightly different variation of this form of simple algebraic equation, let’s take the following equation and solve for “x”:

$$\frac{3}{x} = 1$$

$$Let's\ multiply\ \ both\ sides\ by\ x$$

$$(x)\frac{3}{x} = 1(x)$$

$$3 = x$$

By multiplying both sides by “x”, we managed to isolate “x” by itself and solve the problem all at once.

There are other variations on this theme, e.g., how would we go about solving the following equation?

$$4 = 3x + 1$$

Remember that whatever we do to one side of the equation, we have to do to the other side of the equation. So, let’s subtract 1 from each side of the equation:

$$4 - 1 = 3x + 1 - 1$$

$$3 = 3x$$

Now, let's divide both sides by 3 and solve for "x":

$$\frac{3}{3} = \frac{3x}{3}$$

$$1 = x$$

What about solving for "x" in the following equation?

$$6 = 2x - 5$$

Let's just jump right to it and see how it comes out:

$$6 = 2x - 5$$

$$5 + 6 = 2x - 5 + 5$$

$$11 = 2x$$

$$\frac{11}{2} = \frac{2x}{2}$$

$$5.5 = x$$

Do you see how we added 5 to each side, then divided each side by 2 to isolate and solve for "x"? Good!

Now you try some, showing all of your work on a separate piece of paper:

1. 3 x = 9

2. 5 x = 15

3. 5 x = 25

4. 6 x = 36

5. 2.5 x = 10

6. 16 x = 96

7. 21 x = 84

8. 19 x = 76

9. 32 x = 64

10. 100 x = 10,500

11. 6 = 3 x + 4

12. 15 = 5 x – 6

13. 22 = 4 x + 3

14. 5 = 2 x + 7

15. 10 = 3 x – 16

16. 24 = 6 x – 8

17. 92 = 13 x – 42

18. 132 = 15 x – 44

19. 2 x + 5 = 13

20. 16 x – 32 = 5

21. 45 x – 3 = 6

22. 18 x + 24 = 42

II. Simple Exponents

Exponents are one of math's way of telling us to multiply something by itself so many times, e.g.:

$$4^2 \textit{ says to multiply } 4 \textit{ by itself twice}:$$

$$4 \bullet 4 = 16$$

$$\therefore 4^2 = 16$$

We would express this as "four squared equals 16". If we had:

$$5^5, \textit{we'd multiply } 5 \textit{ by itself } 5 \textit{ times}:$$

$$5 * 5 * 5 * 5 * 5 = 3125$$

Exponents can also be fractions (or expressed as decimals), and these tell us something different, e.g.,

$$25^{\frac{1}{2}} = 25^{0.5} = \sqrt{25} = 5$$

Or, e.g.,

$$8^{\frac{1}{3}} = 8^{0.3333} = \sqrt[3]{8} = 2$$

The former is called the square root (of 25) and the latter is called the cubed root (of 8) in the former's case, we wanted to know what we had to multiply by itself twice (that's the "2") to get 25 and in the case of the latter what we had to multiply by itself 3 times (that's the "3") to get 8.

Another way of looking at this is as follows:

$$x^{\frac{1}{n}} = \sqrt[n]{x}$$

We can also use exponents as follows:

$$2^{-3} = \frac{1}{2^3} = \frac{1}{8} = 0.125$$

Now you try some, showing all of your work on a separate piece of paper:

23. $4^2 = x$
24. $6^2 = x$
25. $9^2 = x$
26. $11^2 = x$
27. $13^2 = x$
28. $22^2 = x$
29. $12^2 = x$
30. $18^2 = x$

31. $3^4 = x$ 32. $6^4 = x$ 33. $8^4 = x$ 34. $23^4 = x$

35. $3^6 = x$ 36. $7^6 = x$ 37. $9^{0.5} = x$ 38. $81^{0.5} = x$

39. $64^{0.5} = x$ 40. $27^{0.3333} = x$ 41. $64^{0.3333} = x$ 42. $125^{0.3333} = x$

43. $216^{0.3333} = x$ 44. $343^{0.3333} = x$ 45. $1^{0.3333} = x$ 46. $12363.59^{0} = x$

47. $9^{-2} = x$ 48. $16^{-2} = x$ 49. $25^{-2} = x$ 50. $36^{-2} = x$

51. $27^{-3} = x$ 52. $64^{-3} = x$ 53. $125^{-3} = x$ 54. $216^{-3} = x$

III. Compound Exponents

If we have an equation of the general form:

$$\left(x^{n}\right)\left(x^{m}\right)$$

We can re-write it as:

$$x^{n+m}$$

I.e., you add the exponents. If we have an equation of the general form:

$$\left(x^{n}\right)^{m}, this\ equals\ x^{nm}$$

I.e., you multiply the exponents. If you've an equation of the general form:

$$\frac{x^{n}}{x^{m}}, this\ equals\ x^{n-m}$$

If you've an equation of the form:

$$\left(x^{n}\right)\left(y^{n}\right), this\ equals\ \left(xy\right)^{n}\ if\ and\ only\ if\ n=n$$

If you've an equation of the form:

$$\frac{x^{n}}{y^{n}}, this\ equals\ \left(\frac{x}{y}\right)^{n}$$

Calculators have made exponents much easier to perform in most cases – likewise, calculators have made them more difficult … if you don't know how to use your calculator to evaluate exponents. Make sure you read your calculator instruction manual.

Now you try some, showing all of your work on a separate piece of paper:

55. $(4^2)(4^2) = x$

56. $(5^2)(5^2) = x$

57. $(8^2)(8^2) = x$

58. $(9^2)(9^2) = x$

59. $(10^2)(10^2) = x$

60. $(12^2)(12^2) = x$

61. $(10^2)^2 = x$

62. $(10^2)^4 = x$

63. $(8^2)^6 = x$

64. $(4^2)^2 = x$

65. $(5^2)^7 = x$

66. $(2^2)^9 = x$

67. $(8)^{2/3} = x$

68. $(27)^{2/3} = x$

69. $(64)^{2/3} = x$

70. $(125)^{2/3} = x$

71. $(216)^{2/3} = x$

72. $(343)^{2/3} = x$

IV. Scientific Notation

Scientific notation is a way of using exponents and numbers that allow us to work with very small or very large numbers in a comfortable manner. Scientific notation is used wherever numbers are expressed as the product of a NON-exponential term and an exponential term:

$$M \times 10^{n}$$

Where M is a number between 1 and 10, but never equals 10. A number in scientific notation is written with a decimal to the right of the first non-zero digit in the number (called the standard position). The "n" to which the 10 is raised may be positive (+) or negative (-): if "n" is positive, the decimal goes to the right of standard position; if "n" is negative, the decimal goes to the left of the standard position, i.e., when written out of scientific notation for both.

Examples follow:

Standard position -- note decimal location	$6.85*10^3$
Standard position -- note decimal location	$7.63*10^5$
Original position -- note decimal location	6850.
Original position -- note decimal location	763000.
Standard position -- note decimal location	$5.36*10^{-3}$
Standard position -- note decimal location	$3.1416*10^{-1}$
Original position -- note decimal location	0.00536
Original position -- note decimal location	0.31416

As with any sort of exponent, remember that any number raised to the zero power still equals one.

To reiterate: a number is said to be written in scientific notation when it is written as a number that is between 1 and 10 (but not equal to 10) times 10 raised to some power, e.g.,

$$0.000025498 \quad \textit{is not in scientific notation, but}$$
$$2.5498 * 10^{-5} \ \textit{IS in scientific notation}$$

Note that the number to which the 10 is raised tells you how many zeroes are taken up by the 10 and the sign in front of the power tells you which way to go when you count the zeroes, i.e., a negative sign says to put the zeroes in front of the number and a positive sign says to put the numbers behind the number:

$$1{,}257{,}634{,}888{,}972 \ \textit{is not in scientific notation, but}$$
$$1.258 * 10^{12} \ \textit{IS in scientific notation}$$

Note that the bottom number has been rounded – in my courses, 4 digits (zeroes not included) used in problem sets are close enough for learning the material – note that in lab, you must record ALL numbers as they are data – rounding comes when you calculate. Note that when re-writing our original number from scientific notation, the first three "zeroes" will remove the decimal from the format followed by 9 zeroes.

Now you try some, showing all of your work on a separate piece of paper:

Write the following numbers in scientific notation:

73. 0.00254 74. 0.000006487 75. 0.0000000000001548

76. 0.025 77. 0.00002026 78. 0.00000000058246

79. 0.2 80. 0.00035687 81. 0.000000026713

Write the following numbers in non-scientific notation:

82. $1*10^5$ 83. $1*10^9$ 84. $1.25*10^3$ 85. $1.658*10^4$

86. $5.632*10^5$ 87. $4.7258*10^{14}$ 88. $2.543*10^{-4}$ 89. $5.8954*10^{-2}$

90. $2.6713852*10^{-5}$ 91. $2.3548*10^{-5}$ 92. $5.3975*10^{-1}$ 93. $6.325*10^{-3}$

V. Applications of Scientific Notation

Just as with other exponents, we can use scientific notation in similar ways – and some of them can save you from using a calculator and cutting right to the bottom line!

Let's start with a generic form of equations for multiplying, then move to the specific:

$$(M * 10^{x})(N * 10^{y}) = (M * N)(10^{x+y})$$

$$(1 * 10^{4})(1 * 10^{12}) = (1 * 1)(10^{4+12}) = 1 * 10^{16}$$

Now, let’s move into the generic to the specific for dividing in scientific notation:

$$\frac{(M * 10^{x})}{(N * 10^{y})} = \left(\frac{M}{N}\right)(10^{x-y})$$

$$\frac{(3 * 10^{5})}{(5 * 10^{-6})} = \left(\frac{3}{5}\right)(10^{5--6}) = (0.6)(10^{11}) = 6 * 10^{10}$$

Now you try some, showing all of your work on a separate piece of paper:

94. Question 82 divided by question 91

95. Question 86 times question 85

96. Question 83 times question 87

97. Question 84 divided by question 88

98. Question 85 divided by question 86

99. Question 86 times question 93

100. Question 87 divided by Question 87

101. Question 88 divided by question 91

102. Question 88 divided by question 82

103. Question 89 times question 83

VI. Using the Quadratic Formula

There are times in Chemistry when one has to solve equations that aren't as easily solved as a linear equation, e.g., y = m x + b. These equations are more complicated and are called quadratic equations. They are of the form (the highest power of the unknown in these equations is 2, BTW):

$$t^2 - 6t + 8 = 0$$

$$or$$

$$at^2 + bt + c = 0$$

Where a = 1, b = 6, and c = 8 in the example. These equations have more than one answer, mathematically. Chemically, we're really interested in the positive solutions as negative concentrations, for example, mean nothing useful. To solve these equations, we must use the quadratic formula:

$$t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Let's solve our example, above, using the quadratic formula:

$$t = \frac{-(-6) \pm \sqrt{(-6)^2 - (4)(1)(8)}}{2(1)}$$

$$t = \frac{6 \pm \sqrt{36 - 32}}{2}$$

$$t = \frac{6 \pm \sqrt{4}}{2} = \frac{6 \pm 2}{2}$$

$$t = \frac{6 + 2}{2} \ OR \ t = \frac{6 - 2}{2}$$

$$So, \ t \ equals \ 4 \ and \ 2$$

In this case, there are 2 positive solutions. Note that the portion of the quadratic formula under the root radical sign is called the discriminant. The value of the discriminant (b^2-4ac) can help you in determining how many real roots to the equation there are: 1) if the value of the discriminant is zero, there is only one real double root; 2) if the value of the discriminant is positive, there are two real double roots; 3) if the value of the discriminant is negative, there are no real roots.

Second Example:

For equations in the form

$$aq^2 + bq + c,$$

use of the quadratic formula may be more useful in the long run

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

e.g.,

$$2x^2 + 8x - 10$$

$$a = 2$$

$$b = 8$$

$$c = -10$$

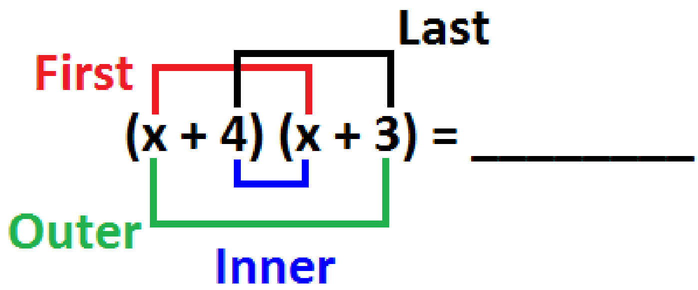
$$x = \frac{-8 \pm \sqrt{8^2 - (4)(2)(-10)}}{2 * 2} = \frac{-8 \pm \sqrt{64 + 80}}{4} = \frac{-8 \pm \sqrt{144}}{4} = \frac{-8 \pm 12}{4}$$

$$x = \frac{-8 + 12}{4} = 1 \text{ and } x = \frac{-8 - 12}{4} = -5$$

Alternative to the Quadratic Formula: FOIL Method

In elementary algebra, ***FOIL*** is a mnemonic for the standard method of multiplying two binomials—hence the method may be referred to as the **FOIL method**. The word *FOIL* is an acronym for the four terms of the product:

First ("first" terms of each binomial are multiplied together); **O**uter ("outside" terms are multiplied—that is, the first term of the first binomial and the second term of the second); **I**nner ("inside" terms are multiplied—second term of the first binomial and first term of the second); **L**ast ("last" terms of each binomial are multiplied). FOIL is used to multiply binomials together.



F + O + I + L

$$x * x = x^2$$

$$x * 3 = 3x$$

$$4 * x = 4x$$

$$4 * 3 = 12$$

$$(x + 4)(x + 3) = x^2 + (3x + 4x) + 12 = x^2 + 7x + 12$$

$2x^2 + 8x - 10$

$(2x \quad\quad)(x \quad\quad)$ Start factoring

$10 = 10 * 1$ ← Obviously won't work

$10 = 2 * 5$ ← Best Choice

$(2x - 2)(x + 5)$ Finish up

$x = 1$ or $x = -5$

REVERSE FOIL is used to factor polynomials with an exponential power not greater than 2:

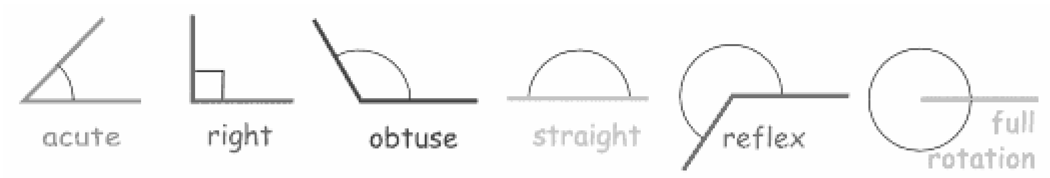
Now you try some, by solving the following equations using the quadratic formula (or FOIL method, as long as you can do BOTH methods!), showing all of your work on a separate piece of paper:

104. $2x^2 - 8x + 3 = 0$	105. $3x^2 - 8x + 5 = 0$	106. $x^2 + 3x - 1 = 0$
107. $3x^2 - 8x + 2 = 0$	108. $x^2 - 12x + 35 = 0$	109. $x^2 - 3x + 2 = 0$
110. $3x^2 - 7x - 3 = 0$	111. $x^2 - 13x + 3 = 0$	112. $x^2 + 18x + 12 = 0$
113. $2x^2 - 5x + 1 = 0$	114. $2x^2 + x - 1 = 0$	115. $x^2 - x + 1 = 0$
116. $x^2 - 18x + 56 = 0$	117. $32x^2 - 4x + 21 = 0$	118. $12x^2 + 29x - 11 = 0$

119. $x^2 - 12x - 20 = 0$ 120. $6x^2 - x - 5 = 0$ 121. $2x^2 + 5x - 3 = 0$

122. $x^2 + 3x - 1 = 0$ 123. $4x^2 + 6x + 1 = 0$ 124. $2x^2 - 6x + 5 = 0$

125. $x^2 + 6x + 9 = 0$



VII.

Plane Geometry and Trigonometric Functions of Right Triangles

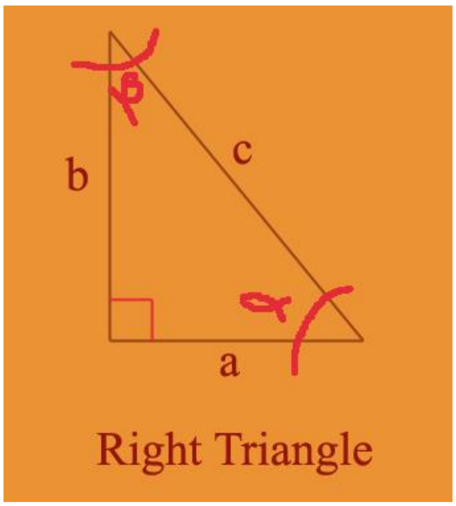
Plane geometry is all about shapes like lines, circles and triangles ... shapes that can be drawn on a flat surface called a **Plane** (like an endless piece of paper). A **Right Triangle** is a triangle that has one of its three angles equal to 90 degrees. All angles in a triangle add up to 180 degrees.

Angle Types

Triangle Terminology

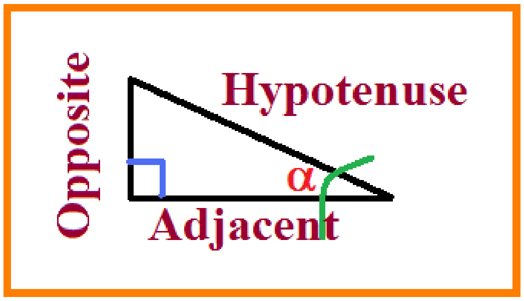
Remember that when working with triangles (any triangle) that the sums of the angles must equal 180°. When working with a right triangle, remember that the square angle is 90° and the other two angles must equal 90°:

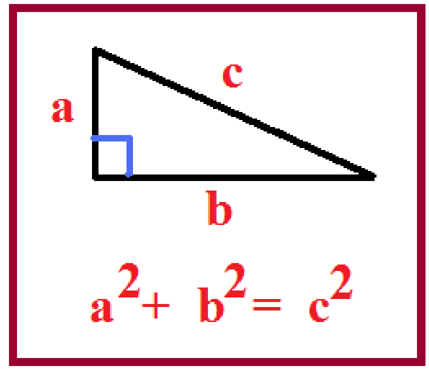
Note the square angle on the lower left – that's the 90° angle. Angle alpha (α) on the lower right of the triangle and angle beta (β) on the upper left of the triangle must each be of a magnitude to summate to 90°. Note that the triangle has three sides: one side of length "a", one side of length "b" ands the hypotenuse of length "c" – the hypotenuse is the longest side of a right triangle.



Remember that one can determine the length of one side of a right triangle (using the diagram, above, as the classic example) if the other two lengths are known by utilizing the Pythagorean theorem:

$$a^2 + b^2 = c^2$$





We can also take advantage of related concepts to determine actual angles by knowing the lengths of the sides involved with the angles and using a table of values or a calculator. The three functions we're most interested in are sine, (sin), cosine (cos) and tangent (tan). To see how we can obtain these values, let's use our classic triangle, above, to define these terms:

$$\sin \alpha = \frac{side\ b\ length}{side\ c\ length} = \frac{side\ length\ opposite\ the\ angle}{hypotenuse\ length}$$

$$\cos \alpha = \frac{side\ a\ length}{side\ c\ length} = \frac{side\ length\ adjacent\ to\ the\ angle}{hypotenuse\ length}$$

$$\tan \alpha = \frac{side\ b\ length}{side\ a\ length} = \frac{side\ length\ opposite\ the\ angle}{side\ length\ adjacent\ to\ the\ angle}$$

If we have a right triangle of a = 2 length units, b = 4 length units, can we determine the length of side c AND can we determine the sin and cos of angles α and β? The answer is yes, and here are the solutions (we're still using our classic triangle above):

$$Part\ 1$$

$$a^2 + b^2 = c^2$$

$$\therefore\ 2^2 + 4^2 = c^2 = 20$$

$$c = \sqrt{20} = 4.472$$

$$Part\ 2a$$

$$\sin\ \alpha = \frac{opposite}{hypotenuse} = \frac{4}{4.472} = 0.8945$$

$$\cos\ \alpha = \frac{adjacent}{hypotenuse} = \frac{2}{4.472} = 0.4472$$

$$inv\ \sin\ 0.8945\ = 63.44^{\circ}$$

$$inv\ \cos\ 0.4472\ = 63.44^{\circ}$$

"inv sin" and "inv cos" are calculator key strokes (on some calculators it's "2nd") – knowing the sin and/or cos of an angle, we can use that to determine the angle, itself – and calculators, BTW, are a far cry from hand calculating these values using tables or by using a slide rule (aka "slip-stick").

$$Part\ 2b$$

$$\sin\ \beta = \frac{opposite}{hypotenuse} = \frac{2}{4.472} = 0.4472$$

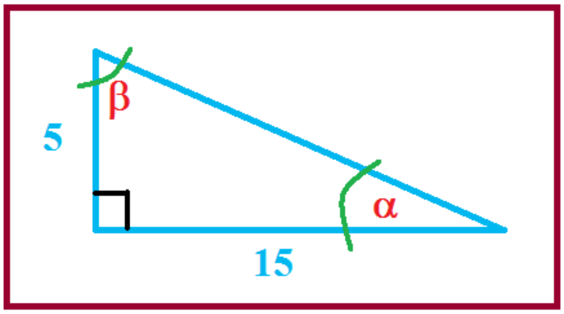
$$\cos\ \beta = \frac{adjacent}{hypotenuse} = \frac{4}{4.472} = 0.8945$$

$$inv\ \sin\ 0.4472\ = 26.56^{\circ}$$

$$inv\ \cos\ 0.8945\ = 26.56^{\circ}$$

We could have simply subtracted the first angle measurement from 90 to obtain its measurement – did you notice that the two angles, when summed, equal 90°? Good!

Triangle Example



$$\text{Hypotenuse length :}$$

$$c^2 = a^2 + b^2$$

$$c^2 = 5^2 + 15^2 = 250$$

$$\therefore c = 15.811 \text{ length units}$$

$$\text{Angle Measurements}$$

$$\sin \alpha = \frac{o}{h} = \frac{a}{c} = \frac{5}{15.811} = 0.316$$

$$\text{inv} \sin 0.316 = 18.44^\circ = \alpha$$

$$\beta = 90 - \alpha$$

$$\beta = 90 - 18.44 = 71.56^\circ$$

A useful mnemonic to help you remember how to determine sin, cos, and tan is soh-cah-toa, where s = sin, o = opposite side length, h = hypotenuse, c = cos, a = adjacent side length and t = tan. I learned this mnemonic in high school geometry and have carried it around for 40 years and use it regularly in my daily life.

Now you try some using the classic right triangle, above,
showing all of your work (including drawing the triangle for each question) on a separate piece of paper:

Determine the side length missing:

126. a = 1, b = 3 , c=?

127. a = ?, b = 4, c = 9

128. a = 2, b = ?, c = 6

129. a = 1, b = 3, c = ?

130. a = 3, b = ?, c = 9

131. a = 2, b = 4, c = ?

132. a = ?, b = 3, c = 12

133. a = 4, b = 6, c = ?

134. a = 5, b = ?, c = 15

135. a = ?, b = 4, c = 13

For each of the above problems (126-135), determine the sin and cos of both α and β (these are questions 136-145).

For each of these questions (136-145) determine the angle measurements you calculated sin and cos for (these are questions 146-155).

VIII. Rules of Logarithms

There are two bases of logarithms that chemists use: natural (or Naperian-based) logarithms abbreviated ln and the base 10 logarithms abbreviated log. Naperian-based logarithms have as their base 2.71828 – you can find this by keying "1" in most calculators, then keying "2^{nd}" followed by "ln". There is no real rule that I know of in using one form over the other – as they are related by the following: 2.303 * log will get you ln. Historically, chemists and physicists have used what fit their purposes for simplicity, hence, you'll see both formats used.

There are four properties of logarithms that are necessary to comprehend their use in Chemistry:

$$\log (x\,y) = \log x + \log y \qquad \ln (x\,y) = \ln x + \ln y$$

$$\log \frac{x}{y} = \log x - \log y \qquad \ln \frac{x}{y} = \ln x - \ln y$$

$$\log x^y = y \log x \qquad \ln x^y = y \ln x$$

$$\log \sqrt[y]{x} = \frac{\log x}{y} \qquad \ln \sqrt[y]{x} = \frac{\ln x}{y}$$

These rules are equally as applicable for base 10 logs, as well. Simply replace "ln" with "log". Let's solve an example:

$$\ln \sqrt{3x+2}$$

$$\ln \sqrt{3x+2} = \ln (3x+2)^{\frac{1}{2}} = \frac{1}{2} \ln (3x+2)$$

Logarithms are used throughout chemistry to determine values that are important with acid-base balance (pH, pK's, Henderson-Hasselbach) and with radioactive decay. They are also used to determine equilibrium constants and thermodynamic data, all of which are taught across General Chemistry I and II. As a result it is of great importance that you can manipulate logarithms as you study your Chemistry material and work the problems, e.g.,

> A patient's arterial blood sample was analyzed in your lab. The pH of the sample was 7.4. The bicarbonate ion concentration was 0.022N. The first pK for carbonic acid is 6.357. What is the concentration of the carbonic acid in the patient's blood?

Forget that you haven't studied some of these concepts – it's the application of the equation using logs that we need to focus on:

$$pH = pK_a + \log \frac{[HCO_3^-]}{[H_2CO_3]} \text{ is the Henderson – Hasselbach equation}$$

$$pH - pK_a = \log \frac{[HCO_3^-]}{[H_2CO_3]} = \log [HCO_3^-] - \log [H_2CO_3]$$

$$pH - pK_a - \log [HCO_3^-] = -\log [H_2CO_3]$$

$$7.4 - 6.357 + 1.658 = -\log [H_2CO_3]$$

$$2.701 = -\log [H_2CO_3]$$

$$-2.701 = \log [H_2CO_3]$$

$$anti - \log -2.701 = [H_2CO_3] = 0.001991\ N = 1.991 * 10^{-3}\ N = 1.991\ mN$$

This concept is of immeasurable value in Human Physiology and Nutrition and across Biochemistry.

We also use logs for nuclear decay of radio-isotopes, e.g.,

> Cobalt-60 has a half-life of 5.26 years. If 1.25 g of ^{60}Co was allowed to decay, how much would be present after one half-life?

$$\ln \frac{A}{A_\circ} = -k\, t_{\frac{1}{2}}$$

$$\ln \frac{A}{1.25} = -\frac{\ln 2}{t_{\frac{1}{2}}} * t_{\frac{1}{2}} = \ln 2 = 0.693$$

$$\ln A - \ln 1.25 = -0.693$$

$$\ln A - 0.2231 = -0.693$$

$$\ln A = -0.693 + 0.2231 = -0.4699$$

$$A = anti - \ln -0.4699 = 0.625\ g\ left$$

$$\frac{0.625\ g}{1.25\ g} * 100 = 50\%\ remaining$$

This equation using natural logs is important across general chemistry and in a portion of introductory organic chemistry – it has become more important since BSN-prepared RN's in NV are being required more and more to educate various groups on WMD's and they need to comprehend radionuclide decay as it pertains to health care.

Anti-log's and anti-lns are either 2^{nd} functions or "inv" functions on most calculators, BTW.

With that bit of an overview, let's have you do some of the simpler manipulations with log's and lns, showing all of your work on a separate piece of paper:

156. Determine the log and ln of (2/3)

157. Determine the log and ln of (2^3)

158. Determine the log and ln of 24

159. Determine the log and ln of (√(2/3))

160. Determine the log and ln of 0.6

161. Determine the log and ln of 2.655

Solve the following, showing all of your work:

162. 1.35 = (log (x/0.25))

163. 2.643 = (log (1.25/x))

164. 0.65 = (ln (x/0.35))

165. 0.0025 = (ln (1.25/x))

166. 17.35 = (log (2.5x/3.5))

167. 6.3567 = (ln(3.5/2.4x))

168. 6.455 = (log(0.035/x))

169. 7.835 = (ln(2.65x/3.45))

170. 4.653 = (ln(0.25/3.55y))

Before we leave logarithms, there is one other detail that most people forget about logs. That detail is that if your calculator won't let you determine logs of a number with the power of 10 being above 100, you have to do it another way, e.g., $2*10^{100}$. Remember that the log of $1*10^{100}$ is 100 – your calculator will calculate the log of 2 = 0.301, hence the log of $2*10^{100}$ is 100.301 and the antilog 100.301 is the antilog of 100 times the antilog of 0.301 or $2*10^{100}$. Only rarely does this happen, any more – it's pretty common more in CHEM 122 because of some of the thermodynamics that are studied there.

IX. Graphing

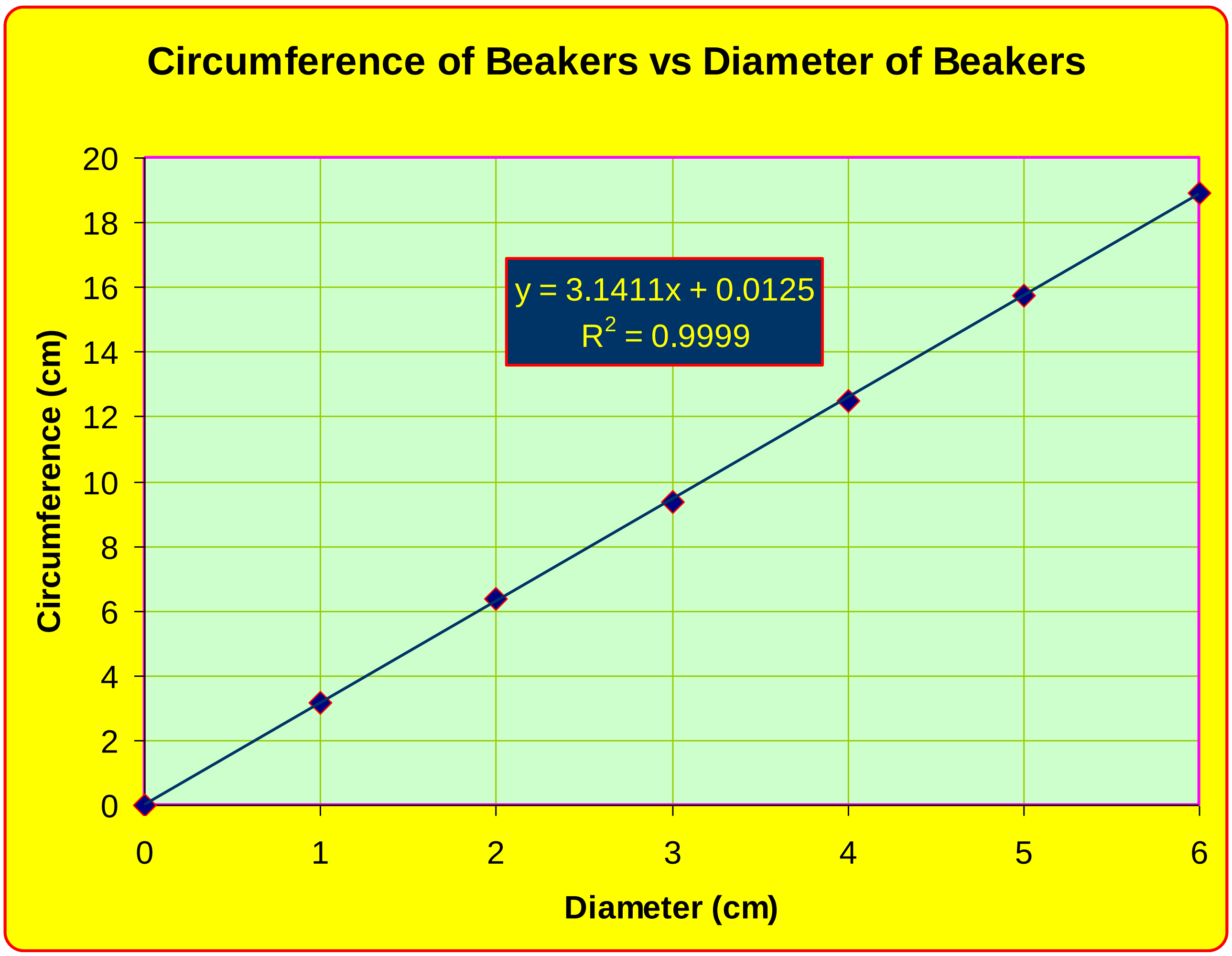
Scientists are notorious for graphing data – it tells us about relationships between drugs and blood vessels, between drugs and uterine hyperactivity, students' ages and recorded grades, whether pre-requisite courses are working as planned, ad nauseum. Graphing is a way to study whether or not something is dependent upon (the dependent variable) something (the independent variable) else. The former is plotted on the y or vertical axis and the latter on the horizontal or x axis.

For example if we were to have obtained the following data:

Beaker Data	
Circumference (cm)	Diameter (cm)
0	0
3.17	1
6.37	2

9.38	3
12.50	4
15.73	5
18.90	6

How would you plot it? Circumference depends on the diameter, hence Circumference would go on the y axis and Diameter would go on the x axis:



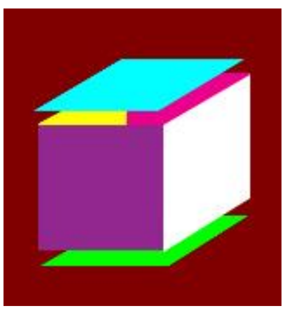
Note that the units for the measurements are in parentheses on each axis and that each axis is clearly labeled. In this example, the data is pretty good as denoted by an R^2 of virtually unity – note, too, the equation of the line that Excel puts into the plot when you queue for that. This equation is in the form of a straight line and note that the slope is almost perfect for pi (π; 3.141596). Note, too, that the data does NOT go dot-to-dot – the curve put in by Excel is a trend line and fits a best fit for linear regression. Note also that I expect students to use Excel or QuattroPro or Lotus or the equivalent for graphing – no pencil and paper graphing for Chemistry data turn-in. Keep in mind that the more data that you have to plot, the better the curve will look and the more accurate and/or precise your data will be.

Now you try a graph of your own using the date, below, showing your plot printed out on a separate piece of paper for turn-in (don't forget to include the trend line and the correlation):

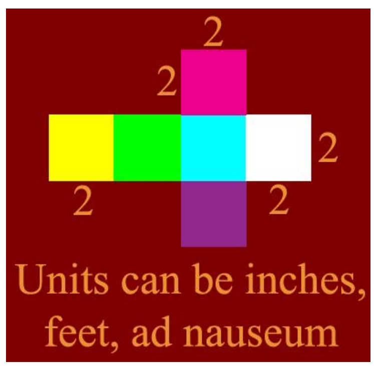
Question # 171. Beaker Data	
Circumference (cm)	Diameter (cm)
0	0
3.17	2
6.37	4
9.38	6
12.50	8
15.73	10
18.90	12

X. Surface Area

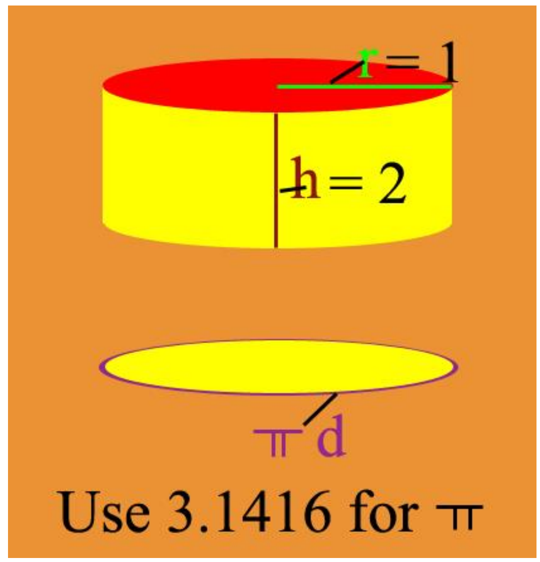
Surface area is another concept that is quite useful in Chemistry, Physics and Health Care fields. The units of surface area are square distance, e.g., square feet, square meters. The surface area of a solid is the sum of all the areas on the outside of the solid.



Cubes and other three-dimensional objects which have all corners at 90 degrees to each other are referred to as "prisms". The surface area of a prism is equal to the sum of all the areas of the faces of the prisms, e.g.:



In other words, since the area of each face is length times width (l * w), then it follows that the surface are of a cubic prism is equal to 6 * l * w, or 6 faces times each face's surface area (left partially "exploded" cube and right "opened" or "unfolded" cube, above, respectively). Were this a rectangular prism, then the surface area (SA) would equal twice the SA of the ends (two of them that are squares, more or less) plus 4 times the SA of the long sides. Top and bottom of the rectangular or: (2 * l * w) + (4 * l* w) which accounts for the surface area of all 6 sides of the rectangular prism. For our example, above, right, the surface area (using inches as the units) of the cube is (6 * 2 * 2) = 24 square inches = 24 sq in = 24 in^2.



What about determining the surface area (SA) of a cylinder? At first glance, this might seem a bit challenging: there are three surfaces, two of which are circles and their area is easy to determine: πr^2. Since there are two of these faces, their cumulative SA is $2\pi r^2$. What do we do about the height of the cylinder, though? While it's bent, most people wouldn't recognize it as an easy shape to figure out. If you were, though, to take a prune juice can, cut out the top and bottom, then cut parallel to the wall of the prune juice can, you'd soon see that it's in the shape of a rectangle. And, the top and bottom edges are fairly easy to determine: they're the circumference of the circle! From High School geometry, remember that the circumference (C) of a circle equals $2\pi r$; remember, too, that 2r (twice the radius) is the diameter of the circle. Hence, the length of one side of the rectangular is πd. The edge of the rectangular that was left when you cut through the can wall is the height (h) of the rectangular. The area of the rectangular, now, is $h\pi d$. Knowing these three areas, we can now determine the surface area of a cylinder: $2\pi r^2 + h\pi d$:

The SA of the cylinder depicted above is, then,

$$SA = 2\pi r^2 + h\pi d = 2\pi(1)^2 + (2)\ \pi(2)$$

$$SA = 2\pi\ (1 + 2) = 6\pi = 18.85\ in^2,$$

if we use inches as the base unit of measure.

A bit more easily, we can determine the SA of a sphere by using the following, easy-to-memorize, formula: SA = $4\pi r^2$. Hence if we had a sphere with a radius of 4 inches, the SA of the sphere would be: SA = $4\pi 4^2$ = $4^3 \pi$ = 201 in^2.

Now that we've done squares and circles, so to speak, let's take a look at determining the SA of a pyramid that has a square base, i.e., a 5-faced pyramid. This is really quite straight-forward, as you learned in high school geometry how to determine the area of an isosceles and equilateral triangle: Area = ½ times the base times the height = A = ½*b*h. You already know how to determine the area of a square, as well: A = l * w. It follows, then, that with 4 of these triangles, you simply add up the areas of each of the 4 triangles and the area of the base to determine the SA of the pyramid. What, though, does one do when the pyramid is reported as base measurements and the overall height measurement?

One must determine the slant distance of the pyramid using the Pythagorean theorem (and the diagram of the square pyramid on the right).

The Pythagorean Theorem simply says that the sum of the squares of the legs of a right triangle equal the square of the hypotenuse, hence, to solve for "c" in the diagram, we do the following:

$$c^2 = h^2 + \left(\frac{l}{2}\right)^2$$

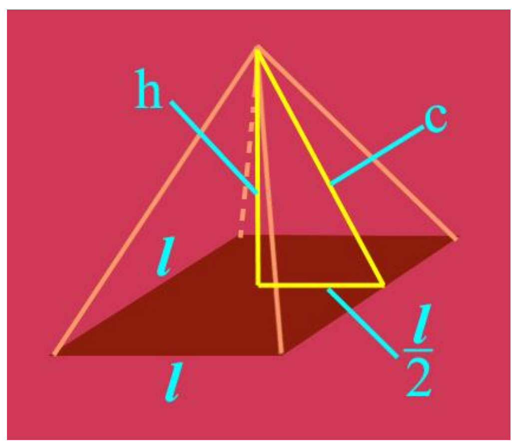
$$if\ \ h = 3\,cm\ and\ \frac{l}{2} = 1.5\,cm\,,$$

$$then\ :$$

$$c^2 = 3^2 + 1.5^2 = 11.25$$

$$and\ \ c = \sqrt{11.25} = 3.354\ \ cm$$

$$= slant\ \ length\ \ of\ \ pyramid$$



Now that we know the slant length, we can calculate the SA of this pyramid:

$$l = 3, hence\ l^2 = 9\,cm^2 = square\ base\ area$$

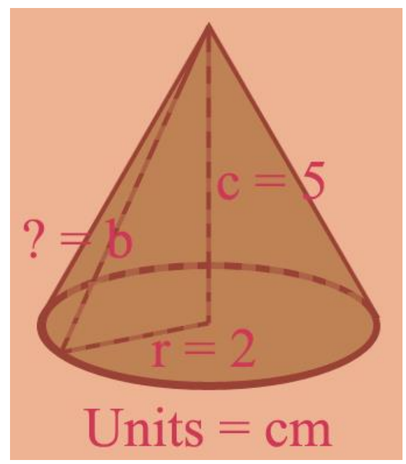
$$\frac{1}{2} l * c = Area\ of\ one\ triangular\ \ face$$

$$Hence\ , 4 * \frac{1}{2} l * c = Area\ of\ all\ 4\ triangular\ \ faces$$

$$\therefore 4 * 1.5 * 3.354 = 20.125\ cm^2 = SA\ of\ the\ 4\ faces$$

$$20.125\ cm^2 + 9\,cm^2 = 29.125\ cm^2 = Pyramid\ \ SA$$

Let's now bring together all that we've looked at in this section by learning how to determine the SA of a cone – this brings in triangular trigonometry/geometry and circular geometry that we've already played with to some extent. And let's use the diagram at right as we work it through:



A cone still has triangles in it – and they are right triangles: Δrbc in the diagram fits this criteria. We have to first calculate "b" just as we did the slant length in the square pyramid. "b" equals the $\sqrt{29}$ = 5.385 cm. Do you see how I got that?

SA = SA of circular base + SA of the cone surface, itself, or:

$SA = \pi r^2 + \pi rb$

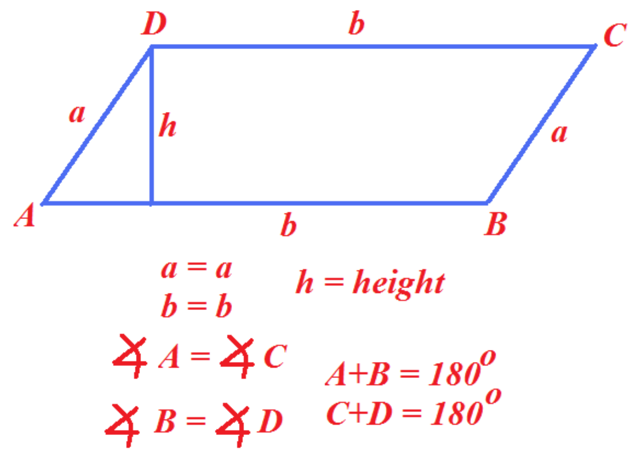
$SA = \pi (2)^2 + \pi (2) (5.385)$

$SA = 4\pi + 10.8\pi$

$SA = 14.8\pi$

$SA = 46.5\ cm^2$

Surface Area of Parallelograms

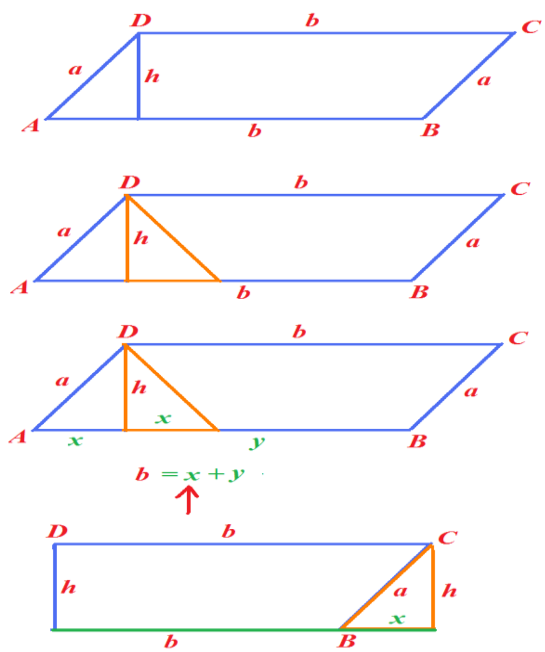


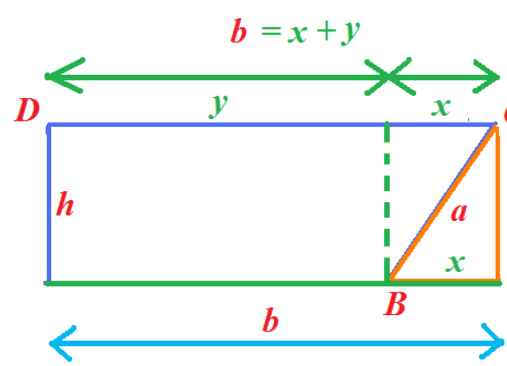
A parallelogram is a quadrilateral with opposite sides parallel (and therefore opposite angles equal). A parallelogram of base (b) and height (h) has an area (A):

Area = b h = ab sin ∠A = ab sin ∠B

Example (Lower Left and Right)

2 Ways to Determine Area without Trig Functions (sin, cos, tan)



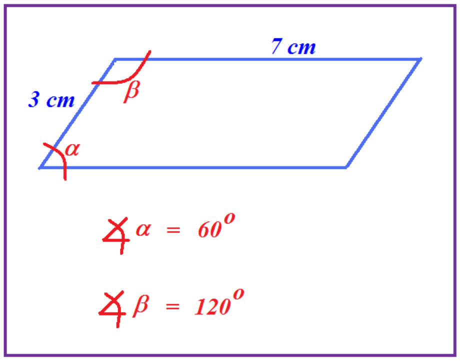


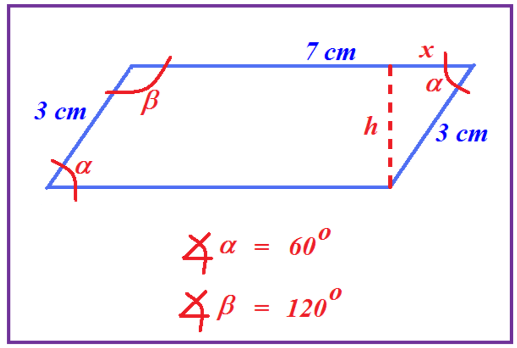
1) **b** * h

2) (**x** + y) h,

using variables, only. If, though, "a" is known and "h" is unknown, then trig functions (sin, cos, tan – even Pythagorean Theorem) are necessary. See following example.

Note in graphic that the triangle on the right side of the parallelogram contains 2 side lengths that are unknown: 1 equation with 2 unknowns. Note also that we know ∠α: one equation with one unknown.





To Determine h : use sin or cos

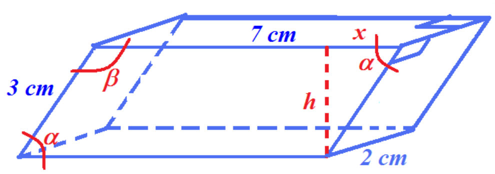
$$\sin \alpha = \frac{h}{3\,cm} = \frac{opposite}{hypotenuse} \qquad \cos \alpha = \frac{x}{3\,cm} = \frac{adjacent}{hypotenuse}$$

$$\sin 60 = \frac{h}{3\,cm} \qquad \cos 60 = \frac{x}{3\,cm}$$

$$3 \sin 60 = h \qquad 3 \cos 60 = x$$

$$2.598 \ cm = h \qquad 1.5 \ cm = x$$

How to Calculate SA of a Parallelogram Prism



To Determine the Area of The Parallelog ram

2.598 cm = h 1.5 cm = x

$$A = b * h$$

$$A = (7\ cm) * (2.598\ cm)$$

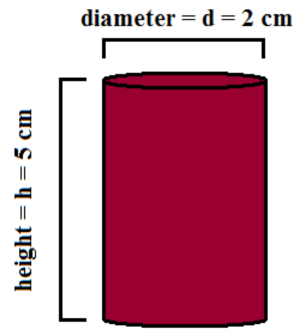
$$A = 18.186\ cm^2$$

Using previous example with 3 dimensions thrown in, now, h = 2.598 cm. Note the 2 square angles in upper right of prism. Area of one parallelogram = 18.186 cm^2; Area of two parallelogram faces = (2) * (18.186 cm^2) = 36.372 cm^2; Area of two rectangular ends = 2 *l * w = (2) * (2 cm) * (3 cm) = 12 cm^2

Area of two rectangular faces = 2 * l * w = (2) * (7 cm) * (2 cm) = 28 cm; SA of prism = The Sum of The Last Three Calculations:

(36.372 cm^2) + (12 cm^2) + (28 cm^2) = 76.372 cm^2

Cylinder and Sphere Volume Determinations



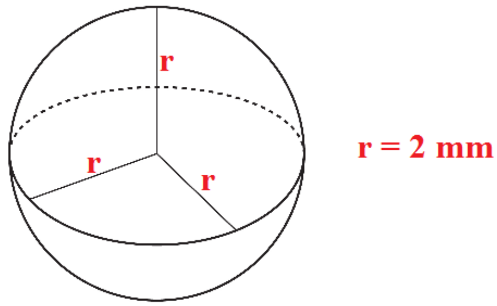
$$\text{Volume of a Cylinder} = V = \pi r^2 h$$
$$V = \pi (1\text{cm})^2 (5\text{ cm})$$
$$V = 15.708\text{ cm}^3 = 15.708\text{ cc}$$

Surface Area of A Sphere

We can determine the SA of a sphere by using the following, easy-to-memorize, formula:

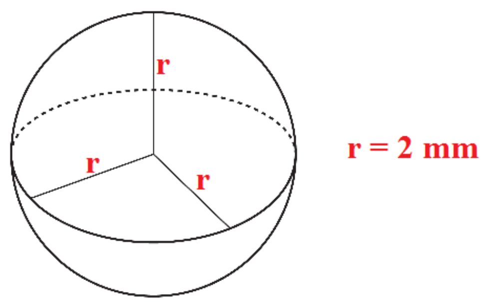
SA = $4\pi r^2$.

$$SA = 4\pi r^2$$
$$SA = (4)(3.141596)(2\text{ mm})^2$$
$$SA = 50.265\text{ mm}^2$$



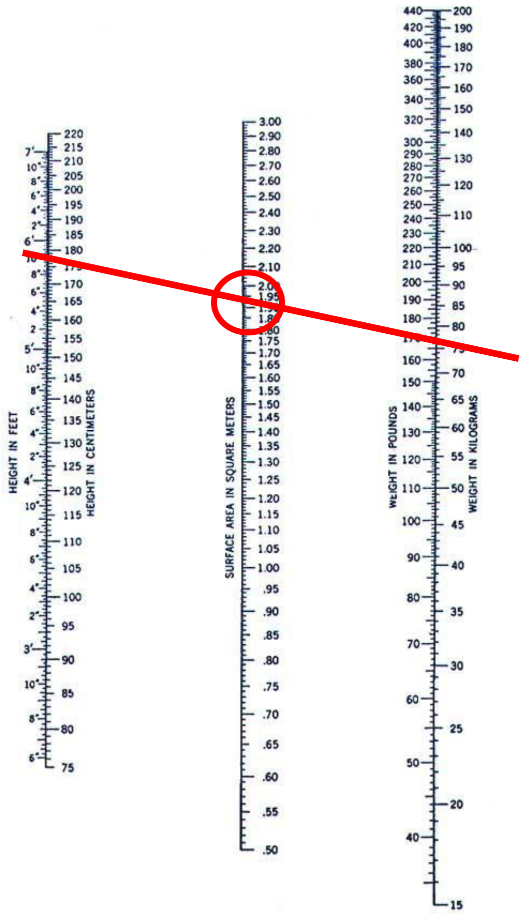
Volume of A Sphere

$$\text{Volume of a Sphere} = V = \frac{4}{3}\pi r^3$$
$$V = \frac{4}{3}\pi (2\text{ mm})^3$$
$$V = \frac{4}{3}\pi (8\text{ mm}^3)$$
$$V = 33.510\text{ mm}^3$$



Why are we spending time on this topic? Many of you are looking eagerly ahead to a career in health care. There are times that you'll have to determine the SA of the human body to calculate a drug dosage, e.g., some chemotherapy agent doses are determined by a patient's body surface area, e.g,. 5-FU, 400 to 600 mg/m^2; for a 70", 170 lb patient, the SA = 1.95 m^2 – remember to watch your metric values as even a small change in measurement impacts the dosage of very toxic drugs. This gets very messy, very quickly … except there is a very nice nomogram that allows you to do this very easily (figure, following page).

Full sources are http://www.bioscience.org/atlases/clinical/nomogram/nomoadul.htm and **Boothby WM, Sandiford RB. Boston Med Surg J 1921, 185, 337.** For a more in-depth treatment of another way to determine SA of infants and children, see http://www.ispub.com/ostia/index.php?xmlFilePath=journals/ija/vol2n2/bsa.xml**.**



The problem set for this section follows:

NOTE of CAUTION: When dimensions are given as "l" and "w" and "h", "l" goes with the longest edge and "w" values go with the shortest edge and "h" values are for height. It helps to draw and label a rough diagram similar to the above diagrams as you work the problems.

Determine the surface areas of the following on a separate piece of paper for turn-in:

172. Rectangular prism with square ends; "l" = 10 cm; "w" = 2 cm

173. Cube with "l" of 5 mm

174. Rectangular prism with square ends; "l" = 10 cm; "w" = 2 cm

175. Cube of "l" = 6 nm

176. Cube of "l" = 2 km

177. Rectangular prism with square ends; "l" = 3 cm; "w" = 1 cm

178. Cylinder with "h" = 4"; "d" = 2"

179. Cylinder with "h" = 7 cm' "d" = 4 cm

180. Cylinder with "h" = 8 ft; "d" = 1 ft

181. Cylinder with "h" = 1 mile; "d" = 10 ft

182. Cylinder of "h" = 30"; "d" = 0.5"

183. Cylinder of "h" = 250 nm; "d" = 10 nm

184. Sphere of "r" = 10"

185. Sphere of "r" = 5 cm

186. Sphere of “r” = 200 nm

187. Sphere of “r” = 40 ft

188. Sphere of “r” = 10 cm

189. 3/8 sphere of “r” = 45 ft

190. A square pyramid of “h” = 4”; “l” = 2”

191. A square pyramid of “h” = 12ft; “l” = 6ft

192. A square pyramid of “h” = 3 m; “l” = 1 m

193. A square pyramid of “h” = 10 cm; “l” = 2 cm

194. A cone of “r” = 4”; “h” = 12”

195. A cone of “r” = 25 cm; “h” = 100 cm

196. A cone of “r” = 25 nm; “h” = 175 nm

197. A cone of “r” = 2 mi; “h” = 4 mi

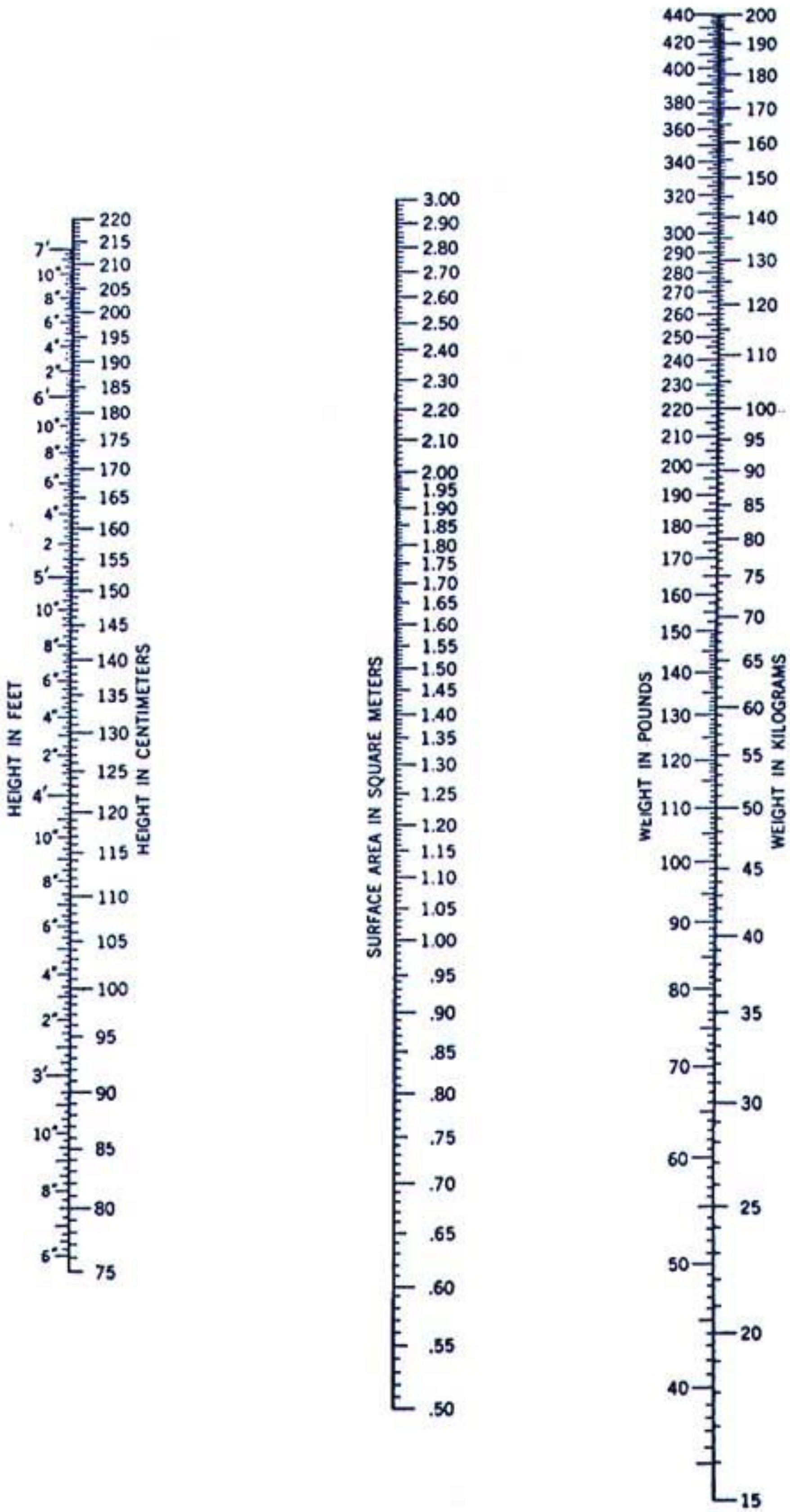
For the remaining problems, use the nomogram on the following page.

198. A person is 5’ 10” tall and weighs 170 lbs. What is their SA?

199. A person is 5’ 4” tall and weighs 125 lbs. What is their SA?

200. A person is 5’ 10” tall and weighs 200 lbs. What is their SA?

Using a nomogram for SA determination of a human:


HEIGHT IN FEET
HEIGHT IN CENTIMETERS
SURFACE AREA IN SQUARE METERS
WEIGHT IN POUNDS
WEIGHT IN KILOGRAMS

XI. Units of Measure

Base quantities are fundamental quantities of measurement. They number 4:

- Mass,
- Length,
- Time and
- Temperature.

MASS

The base unit of MASS is the kilogram (kg). The most commonly used units are the gram (g), milligram (mg) and microgram (μg):

- 1 kg = 1000 g;
- 1 g = 1000 mg;
- 1 mg = 1000 μg.
-

Other unit conversions necessary to manipulate through the American system and the SI are:

- 1 grain (gr) = 60-65 mg (depending on the manufacturer),
- 1 pound = 454 g and
- 1 kg = 2.2 pounds.

The table, below, summarizes common metric equivalencies:

1 kg = 1000 g
1 g = 1000 mg
1 mg = 1000 μg = 1000 mcg (in older literature)

There are common measures of mass, as well. These measures are summarized, below, in tables:

American (Avoirdupois)		Apothecaries'		Other
1 ton = 2000 lbs		1 lb = 12 oz = 5760 grains		1 grain = 65 mg (some bottles will say 60 mg)
1 lb = 16 oz		1 oz = 8 drams = 480 grains		1 lb = 454 g
1 oz = 16 drams		1 dram = 60 grains		1 kg = 2.2 lbs
1 dram = 27.343 grains				

LENGTH

Length is a physical quantity that describes how far an object extends in some direction. It is the distance between two points. The basic unit of length is the meter.

- 1 meter (m) = 100 centimeters (cm).
- 1 cm = 10 millimeters (mm).
- 1 m = 1000 mm.

The common measures of length in science are from the SI ("metric") system. These measures are summarized, below, in the tables:

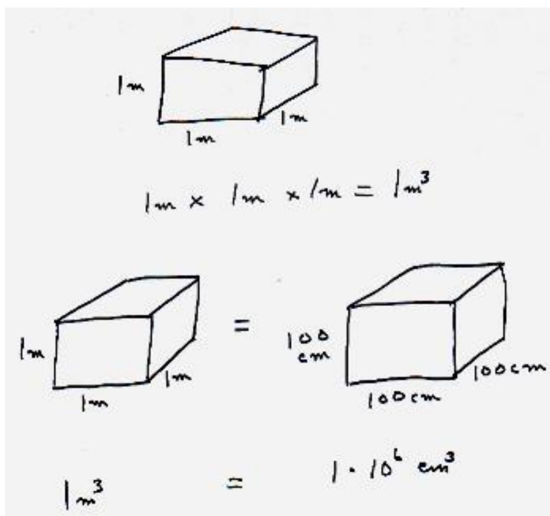
SI (Metric) System		American System
1 km = 1000 m		1 mile = 5280 ft = 1760 yards
1 m = 100 cm		1 yard = 3 feet
1 cm = 10 mm		1 foot = 12"
1 m = 39.37"		1" = 2.54 cm

Volume is derived from length. It is defined as the space an object occupies and is described by length units. Remember that for a cube, the volume is equal to the cube of the length of one side.

The formulas for the volume of a cylinder and sphere are in the table, below:

Cylinder volume	Sphere volume
$V = \pi r^2 h$	$V = 4/3 \pi r^3$

The basic unit of volume is the cubic meter (m^3). 1 m^3 is equal to 1,000,000 cm^3. Since the cubic meter is very large and cumbersome, volume is based upon the density of water: 1 gram of water occupies a volume of 1 milliliter (mL). Given that 1 cubic centimeter (cc) of water is very close to 1 mL, the mL is used. The graphic, below, illustrates this volume discussion:



1 m^3 is equivalent to $1*10^6$ cm^3. One cm^3 (cc) of water at approximately 4°C is about 1 gram. This volume, then, is equivalent to 1 mL. So, the mL is used; the μL is also used as necessary: 1000 μL = 1 mL. To reiterate:

1 m^3 = 1000 L (liters)
1 L = 1000 mL
1 mL = 1000 μL

Other common equivalencies are summarized in the tables, below:

American		Other
1 gallon = 4 quarts		1 quart = 946 mL
1 quart = 2 pints		1 tsp = 5 mL
1 pint = 16 oz		NOT the eating tsp! The one you get from the pharmacist!

Metric prefixes are used regularly to describe units. Some of these units are tabulated below with their abbreviations and values:

M = mega = 1,000,000 = 10^6	k = kilo = 1000 = 10^3
d = deci = 0.1 = 10^{-1}	c = centi = 0.01 = 10^{-2}
m = milli = 0.001 = 10^{-3}	μ = micro = 0.000001 = 10^{-6}
n = nano = 0.000000001 = 10^{-9}	p = pico = 0.000000000001 = 10^{-12}

TIME

Time is a measure of how long events last. The SI unit of time is the second.

TEMPERATURE

Temperature (degrees in the F and C scales) is used to describe the hotness or coldness of an object. The SI unit of temperature is the Kelvin -- NOT "degrees" Kelvin! The table, below summarizes important temperatures between all 3 temperature scales:

Event	° F	° C	K
Water boils	212	100	373
Body temperature	98.6	37	310
Room temperature	68	20	293
Water freezes	32	0	273
Equivalent point	**-40**	**-40**	*********

The equations to manipulate between F, C and K are as follow:

$$^{\circ}C = \frac{5}{9}(^{\circ}F - 32)$$

$$^{\circ}F = (\frac{9}{5}{}^{\circ}C) + 32$$

$$K = {}^{\circ}C + 273.15$$

VARIATIONS IN BODY TEMPERATURES

On average, we awaken with a body temperature of around 36.1° C. Our temperature measures around 37.2° C before we go to bed, on average. As a general rule, temperatures 3.5° C above 37° C lead to bodily function interference. Body temperatures above 41.1° C can result in convulsions and can cause permanent brain damage.

Variations below "normal" body temperature are summarized, below, in the table:

Temperature or temperature range	Variation -- body response
37° C	Normal
35-36° C	Shivering
33-35° C	Memory loss
30-32° C	Loss of muscle control
28-30° C	Irrational behavior
~28.5° C	Pale, cold, irregular heart beat
26.7° C	Loss of consciousness, shallow respirations

DENSITY

Density is the ratio of an object's mass to its volume, i.e.,

$$\rho = \frac{mass}{volume} = \frac{grams}{mL} = \frac{g}{mL}$$

Heaviness is NOT equal to denseness, e.g., 1 pound of mercury equals one pound of water equals one pound of feathers. BUT! 1 pound of mercury occupies 1/13.6 of the volume that is occupied by water.

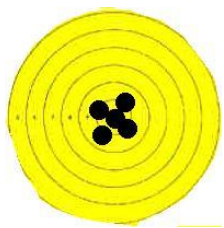
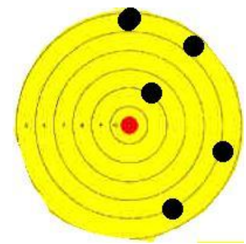
SPECIFIC GRAVITY -- SP.G.

In simplest terms, the Sp.G. is equal to the ratio of the density (ρ) of one liquid to the density (ρ) of water, for our purposes, e.g., the density of mercury (Hg) is 13.6 g/mL and that of water is 1 g/mL. The Sp.G. of Hg is 13.6 and is UNITLESS. This means that Hg is 13.6 times more dense than water.

Clinically, the normal range of urinary Sp.G. is 1.005 to 1.040. If the Sp.G. is less than this range, the urine is very dilute and more like water. Conversely, if the Sp.G. is greater than this range, then the urine is really concentrated and unlike water.

ACCURACY AND PRECISION

Accuracy is how close a value is to known values. Precision is within test agreement. The table, below, illustrates the concepts of accuracy, precision and deviations from both:

			
Precise, Accurate -- great	Precise, Inaccurate -- repair instrument; avoidable	Imprecise, Accurate -- Train person; accident	Imprecise, Inaccurate -- Hire new person; sad

Problem Set

201. Convert 0.5 mi to cm.

202. Convert 4 lbs to kg.

203. Convert 3 oz to microliters.

204. Convert 4” to meters.

205. Convert 0.25 qt to liters.

206. Convert 3 L to oz.

207. Convert 4 gallons to mL.

208. Convert 3 km to miles.

209. Convert 5 grams to micrograms.

210. Convert 32 oz to liters.

211. Convert 30 mL to oz, qt, L, gal.

212. Convert 16 oz to kg, lb, tons, g.

213. Convert 25.4 cm to inches, m, km, Mm.

214. Convert 32°F to °C.

215. Convert -40°F to °C.

216. Convert 99°F to °C.

217. Convert 158°F to °C.

218. Convert 210°F to °C.

219. Convert 325°F to °C.

220. Convert 39°F to °C.

221. Convert 40°F to °C.

222. Convert 3°F to °C.

223. Convert 58°F to °C.

224. Convert 65°F to °C.

225. Convert 72°F to °C.

226. Convert 82°F to °C.

227. Convert -65°F to °C.

228. Convert 5°F to °C.

229. Convert 320°F to °C.

230. Convert 10°F to °C.

231. Convert 6°F to °C.

232. Convert 105°F to °C.

233. Convert -83°F to °C.

234. No problem, here.

235. Convert 54°F to °C.

236. Convert -32°F to °C.

237. Convert -100°F to °C.

238. Convert -23°F to °C.

239. Convert -96°F to °C.

240. Convert -232°F to °C.

241. Convert -3°F to °C.

242. Convert -2°F to °C.

243. Convert 168°F to °C.

244. Convert 112°F to °C.

245. Convert 132°F to °C.

246. Convert 232°F to °C.

247. Convert 332°F to °C.

248. Convert -132°F to °C.

249. Convert -332°F to °C.

250. Convert 432°F to °C.

251-287. Convert your responses to Questions 214-250 to Kelvins.

288. No question, here.

289. Convert -40°C to °F.

290. Convert -60°C to °F.

291. Convert -80°C to °F.

292. Convert -100°C to °F.

293. Convert -30°C to °F.

294. Convert -20°C to °F.

295. Convert -10°C to °F.

296. Convert 0°C to °F.

297. Convert 10°C to °F.

298. Convert 20°C to °F.

299. Convert 30°C to °F.

300. Convert 40°C to °F.

301. Convert 50°C to °F.

302. Convert 60°C to °F.

303. Convert 70°C to °F.

304. Convert 80°C to °F.

305. Convert 90°C to °F.

306. Convert 100°C to °F.

307. Convert 110°C to °F.

308. Convert 120°C to °F.

309. Convert 130°C to °F.

310. Convert 140°C to °F.

311. Convert 45°C to °F.

312. Convert 37°C to °F.

313. Convert 65°C to °F.

314. Convert -75°C to °F.

315. Convert 75°C to °F.

316. Convert 85°C to °F.

317. Convert 95°C to °F.

318. Convert 105°C to °F.

319. Convert 125°C to °F.

320. Convert 135°C to °F.

321. Convert 145°C to °F.

322. Convert 155°C to °F.

323-356. Convert Questions 289-322 to Kelvins.

Using dimensional analysis (factor labeling) that you've learned thus far in the Math Primer and in your MATH pore-requisite courses, solve the following problems.

357. An acre is 43,560 sq ft. How large is this in square meters?

358. Convert 40 miles per hour to meters per second.

359. A gallon is 231 cubic inches and a liter is 1000 cubic cm. How many liters are there in a gallon?

360. A furlong is 220 yards and a fortnight is 14 days. If a snail moves at 2 meters per hour, what is this in furlongs per fortnight?

361. A cell membrane is 70 angstrom (Å) units thick. If 1 Å is $1x10^{-10}$ m, what is the membrane thickness in inches?

362. Convert 10 meters per second to feet per second.

363. Convert 3.5 hours to milliseconds (ms).

364. In most of the world, land is measured in hectares (1 hectare = 10,000 sq meters). If a farm is 100 hectares in area, how large is this in acres (1 acre = 43,560 sq ft)?

365. If the capillaries of an average adult were unwound and spread out end-to-end, they would extend to a length of more than 40,000 miles. If you are 1.75 meters tall, how many times would the capillary length equal your height?

366. John-Bob regularly buys 18 gallons of gas, but the gas station has installed new pumps that dispense gasoline in units of liters. How many liters of gas should he ask for?

367. The density of metal Hg is 13.6 grams per cubic cm. What is the density in kg per cubic meter?

368. Using your results from question #367, how many kg of Hg would be required to fill a 0.25 L container?

369. What is the density, in kg per cubic meter, of a sphere with a radius 10 cm and a mass of 10 kg?

370. Using your density result from Question #369, if a second sphere had that same density with a radius of 20 cm, what is its mass?

371. The Earth has a mass of $6*10^{24}$ kg and a volume of $1.1*10^{21}$ cubic meters. What is the Earth's average density?

372. On the average, the human heart beats 70 times a minute (pulse rate). On the average, how many times does the heat beat in an 85-year lifetime?

373. The inner and outer diameters of a thick-walled spherical metal shell are 18.5 and 24.6 cm, respectively. What is the volume occupied by the shell, itself?

374. Convert 1.4 m to cm.

375. Convert 2800 mm to m.

376. Convert 185 mL to liters.

377. Convert 18 g to kg.

378. Convert 10 sq yds to sq meters.

379. Convert 100 miles to inches.

380. Convert 20 feet per second to mph.

381. Convert 1 cubic mile to cubic meters.

382. Convert 40 mph to cm per second.

383. Convert 25 liters to cubic decimeters.

384. Express 275 mL in liters.

385. Express 18 mm in m.

386. Express 1.5 kg in mg.

387. Express 100 cc's in cubic meters.

388. Express 150 km/h in m/s.

389. Express 450 g as kg.

390. Express 650 mL as L.

391. Express 75 mg as kg.

392. Express 40 mph as ft/sec.

393. An automobile travelling at 55 mph is moving at how many kmph?

394. What is the height of a 5'6" person in meters?

395. Five gallons of gasoline is equivalent to how many liters?

396. If a gallon of gas is $2.059 at the pump, how much does the preceding gasoline (from Question 395) cost?

397. If a liter of gasoline is $1.189 at the pump, how much does the preceding gasoline (from Question 395) cost?

398. How many ounces of wine are in a 750 mL bottle?

399. The membrane of a red blood cell is 90 Å thick. What is its thickness in inches?

400. What is the mass in grams of a quarter pound hamburger?

401. The velocity of sound at 0°C in dry air is 1089 ft per second. What is this velocity in cm/sec?

402. Using your solution to Question 401, what is the velocity of sound in mph?

403. The radius of a Cu atom is 128 pm. What is its radius in nm?

404. The radius of a Ba atom is $2.22*10^{-10}$ m. What is its radius in Å?

405. A small hole in the wing of the space shuttle requires a 36.8 cm^2 patch. What is the patch's area in km^2?

406. Using your results from Question 405, if the patching material costs NASA $4.35 per square inch, what is the cost of this patch?

407. Anton van Leeuwenhoek, a 17^{th} century pioneer in the use of the microscope, described the micro-organisms he saw from his teeth scrapings as "animalcules" whose length was "25 thousandths of an inch". How long were the animalcules in meters?

408. Using your response to Question #407, how long were the animalcules in cm?

409. Using your response to Question #407, how long were the animalcules in nm?

410. To the alchemists, gold was the material representation of purity. It is a very soft metal that can be hammered into extremely thin sheets. If a 1.10 gram piece of gold (ρ = 19.32 g/cc) is hammered into a sheet whose area is 40.0 sq ft, what is the average thickness of the sheet in mm?

411. A cylindrical tube 13.0 cm high and 1.5 cm in diameter is used to collect blood samples. How many cubic decimeters of blood can it hold?

412. Nifedipine is a medication that is administered intra-venously (IV) to patients who are suffering from angina. The usual dosage is 5 μg/kg body weight IV. Your patient weighs 235 lbs. What dosage will you administer to relieve his/her suffering?

413. Bretylium is a medication that is administered IV to patients to rapidly reduce hypertension. The usual dosage is 5 mg/kg body weight over a 10 minute period. Your patient weighs 187 lbs. What dosage will you administer to relieve his/her suffering?

414. Using your response to Question 413, how many mg bretylium will you administer per minute on average?

415. Tranxene is a medication given by mouth (po) to induce sedation and/or hypnosis. The usual dosage is 7.5 mg twice a day (bid). While it is available in 3.75 and 7.5 mg tablets, the pharmacy where you work does not have those dosages – only the 15 mg tablets. How many tablets will you have to give for one dose?

416. Diazepam is rather useful medication. It is used to treat withdrawal symptoms (DT's) following alcohol withdrawal. It is given parenterally and comes in a vial at a concentration of 5 mg/mL. If the attending physician orders that 10 mg be given, how many mL of the medication must you draw up in a syringe?

417. You have a 30 kg canine patient that has been admitted into the veterinary CCU under your care. You observe on the telemetry monitor that the patient is throwing premature ventricular contractions every other beat (bigeminy). CCU SOP is to administer lidocaine, 1.5 mg/kg body weight bolus, followed by a maintenance dose of 60 µg/kg/min for 36 hours. 1 mL equals 20 drops per your IV infusion pump directions. You have a 5 mL vial that contains 20 mg/mL lidocaine. The infusion rate is set at 2 mL per minute. How much Lidocaine is in the 5 mL vial?

418. Using the information from Question 417, how much lidocaine do you need to prepare for the 36 hour infusion?

419. Using the information from Question 418, do you have enough lidocaine to fulfill the infusion orders?

420. Using the information from Question 417, how much does your patient weight in lbs?

421. Using the information in Question 417, with how much Lidocaine will you bolus the patient?

422. Express 25 m as cm.

423. Griseofulvin (Grisactin) is dispensed for oral consumption in children at a dosage of 7.25 mg/kg body weight/day. One of your patients presents with Trichophyton infection that requires the use of Grisactin. The patient weights 35 lbs. How much Grisactin should the patient receive on a daily basis?

424. Using your response to Question 423, if the dose of Grisactin is to be given in 3 equally divided doses throughout the day, how much is one dose?

425. Using your response to Question 423, if the dose of Grisactin is to be given in 4 equally divided doses throughout the day, how much is one dose?

XII. Conclusion and Assignments

You now have enough mathematics tools, coupled with what you'll be learning in class and lab, to successfully complete CHEM 121, 122 and 220.

XIII. References

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