Worksheet 1: Significant Figures in Science

No science can proceed very far without resorting to quantitative observation[s]. This is a big part of **the** Scientific Method:

Step 1: Observation

Step 2: Data Gathering

Generate a law or laws from the data – means of prediction

Step 3: Hypothesize

Step 4: Test Hypothesis[es] by Experiment

Step 5: Prove Hypothesis[es] to make Theory

That means that scientists must make measurements. To fulfill the requirements of the Scientific Method, there are an unlimited number of experimental techniques or experimental methodologies that may be used. Quantifying data through measurements is one such methodology. Quantification usually means reading numbers from some sort of measuring device.

There must be some way to limit the number of meaningful digits (significant figures) that may be obtained in an experimentally determined quantity.

Significant figures are critical when reporting scientific data because they give the reader an idea of how well you actually measure[d] and/or report[ed] your data.

Significant Figures' Rules

http://www.usca.edu/chemistry/genchem/sigfig.htm

1) ALL non-zero numbers (1,2,3,4,5,6,7,8,9) are ALWAYS significant.

2) ALL zeroes between non-zero numbers are ALWAYS significant.

3) ALL zeroes which are SIMULTANEOUSLY to the right of the decimal point AND at the end of the number are ALWAYS significant.

4) ALL zeroes which are to the left of a written decimal point and are in a number >= 10 are ALWAYS significant.

A helpful way to check rules 3 and 4 is to write the number in scientific notation. If you can/must get rid of the zeroes, then they are NOT significant.

Examples: How many significant figures are present in the following numbers?

Number	# Significant Figures	Rule(s)
54,356	5	1
3.142	4	1
750.04	5	1,2,4
0.00006 (= $6 * 10^{-5}$)	1	1,4
6.6000	5	1,3
606.060	6	1,2,3,4
8,000,000 (= $8 * 10^{+6}$)	1	1
30.0 (= $3.00 * 10^{+1}$)	3	1,3,4

SIGNIFICANT FIGURES - Mathematical Operations

http://www.usca.edu/chemistry/genchem/sigfig2.htm

ADDITION AND SUBTRACTION

When adding or subtracting numbers, count the NUMBER OF DECIMAL PLACES to determine the number of significant figures. The answer cannot CONTAIN MORE PLACES AFTER THE DECIMAL POINT THAN THE SMALLEST NUMBER OF DECIMAL PLACES in the numbers being added or subtracted.

Example: *Note: There are 4 significant figures in the answer.*

23.112233	(6 places after the decimal point
1.3324	(4 places after the decimal point)
+ 0.25	(2 places after the decimal point)
24.694633	(on calculator
24.69	(rounded to 2 places in the answer)

MULTIPLICATION AND DIVISION

When multiplying or dividing numbers, count the NUMBER OF SIGNIFICANT FIGURES. The answer cannot CONTAIN MORE SIGNIFICANT FIGURES THAN THE NUMBER BEING MULTIPLIED OR DIVIDED with the LEAST NUMBER OF SIGNIFICANT FIGURES.

Example: *Note: There are 5 significant figures in the answer.*

23.123123	(8 significant figures)
x 1.3344	(5 significant figures)
30.855495	(on calculator)
30.855	(rounded to 5 significant figures; and 3 places)

Significant Figures in the Laboratory

Masses should always be recorded to as many places after the decimal point as are read off the balance: NEVER round data! Calculation of mass by difference using a tare should be reported to this same number of places.

10 mL Graduate cylinders should be read to the nearest 0.01 mL. 25 mL and 100 mL graduate cylinders should be read to the nearest 0.1 mL.

Rules for Rounding Whole Numbers

http://mathatube.com/rounding-rules-for-rounding.html

1) If the number you are rounding is followed by 5, 6, 7, 8, or 9, round the number up. Example: 38 rounded to the nearest ten is 40.

2) If the number you are rounding is followed by 0, 1, 2, 3, or 4, round the number down. Example: 33 rounded to the nearest ten is 30.

To round a number to a particular place, look at the digit to its right. If it is 5 or more, round up. If it is 4 or less, round down.

Number Rounding Examples

Round 53 to the nearest 10. Look at the one's position. It's a "3". Round down to 50.

Round 368 to the nearest 100. Look at the ten's position. It's a "6". Round up to 400.

Note that all of the numbers to the right of the place you are rounding to become zeros. When rounding a number, you first need to ask: what are you rounding it to? Numbers can be rounded to the nearest ten, the nearest hundred, the nearest thousand, and so on.

Example: look at the number 2,827:

2,827 rounded to the nearest ten is 2,830

2,827 rounded to the nearest hundred is 2,800

2,827 rounded to the nearest thousand is 3,000

Practice Problems

1) The measurement, 206 cm, has how many significant (measured) digits?

2) The measurement, 206.0 ^{o}C, has how many significant digits?

3) The measurement, 0.00206 g, has how many significant digits?

4) The measurement, 0.0020600 mole, has how many significant digits?

5) The measurement, 2.060 x 10^{-3} coulombs, has how many significant digits?

6) The measurement, 20600 molecules, has how many significant digits?

7) Add the following three numbers and report your answer using significant figures:
   2.5 cm + 0.50 cm + 0.055 cm = ?

8) Subtract the following numbers and report your answer using significant figures:
   416 g - 210 g = ?

9) Multiply the following three numbers and report your answer to the correct number of significant figures: 0.020 cm x 50 cm x 11.1 cm = ?

10) Divide the following numbers and report your answer to the correct number of significant figures and units: 0.530 g / 0.1010 mL = ?

11) How many significant figures are in the number 720?

12) 3.461728 + 14.91 + 0.980001 + 5.2631

13) 23.1 + 4.77 + 125.39 + 3.581

14) 22.101 - 0.9307

15) 0.04216 - 0.0004134

16) 564,321 - 264,321

State the number of significant digits in each measurement.

17) **2804 m**

18) **2.84 km**

19) **5.029 m**

20) **0.003068 m**

21) **4.6×10^{5} m**

22) **4.06×10^{-5} m**

23) **750 m**

24) **75 m**

25) **75,000 m**

Solve the following problems and report answers with appropriate number of significant digits.

26) **6.201 cm + 7.4 cm + 0.68 cm +12.0 cm =**

27) **1.6 km + 1.62 m +1200 cm =**

28) **8.264 g - 7.8 g =**

29) **10.4168 m - 6.0 m =**

30) **12.00 kg +15.001 kg=**

31) **1.31 cm x 2.3 cm =**

32) **5.7621 m x 6.201 m =**

33) **20.2 cm ÷ 7.41 s =**

34) **40.002 g ÷ 13.000005 g =**

35) Calculate the answers to the appropriate number of significant figures:

32.567	246.24	658.0
135.0	238.278	23.5478
+ 1.4567	+ 98.3	+ 1345.29

36) Calculate the answers to the appropriate number of significant figures.

a) 23.7 x 3.8 = _____

b) 45.76 x 0.25 = _____

c) 81.04 g x0.010 = _____

d) 6.47 x 64.5 = _____

e) 43.678 x 64.1 = _____

f) 1.678 / 0.42 = _____

g) 28.367 / 3.74 = _____

h) 4278 / 1.006 = _____

37) Re-write the quantity 827,000,000,000,000 picoseconds to show:

a) 1 sig. fig. _____

b) 2 sig. figs. _____

c) 3 sig. figs. _____

d) 4 sig. figs. _____

e) 5 sig. figs. _____

38) Rewrite the quantity 0.0031904 kg to show:

a) 1 sig. fig. _____

b) 2 sig. figs. _____

c) 3 sig. figs. _____

39) Round each of the following to 3 significant figures:

a) 16.8477 L _____

b) 5.6732 _____

c) 0.14986 L _____

d) 861.85 _____

e) 4.203×10^4 km _____

f) 5.0981×10^{-3} _____

g) 0.00318756 m _____

h) 0.09025011 _____

40) Perform the following calculations and report the results with the correct number of significant figure and proper units.

$$\begin{array}{r} 0.0677 \\ 48.1 \\ +82.7655 \\ \hline \end{array}$$

$$\begin{array}{r} 43.8316 \\ -\ 29.5706 \\ \hline \end{array}$$

$$\frac{8506 \times 0.02}{6.524}$$

$$0.0222 \times 0.7000 \times 8.702$$

Perform all operations on a calculator and write the answers with the correct number of significant figures. These problems are good for practicing putting numbers in your calculator correctly!

41) $\dfrac{(3.4617 \times 10^{2})(5.61 \times 10^{-4})}{(9.87 \times 10^{5})(3.1)(1.171 \times 10^{4})} =$

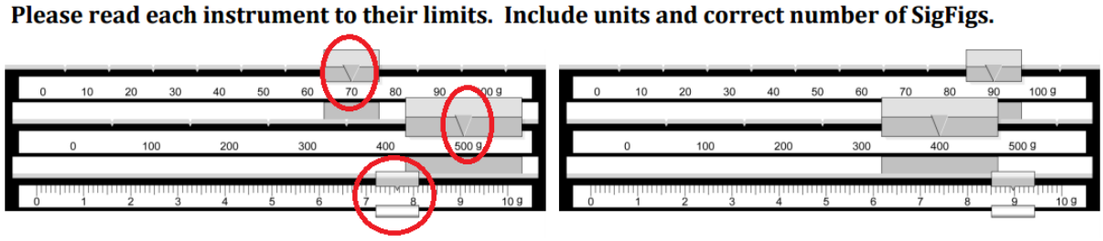
42) $\dfrac{(3.52164 \times 10^{2})(3.1741 \times 10^{5})}{(8.22 \times 10^{7})(4.65217 \times 10^{-3})(9.711 \times 10^{4})} =$

43) $\dfrac{(1.8741 \times 10^{11})}{(5.6 \times 10^{4})(2.173 \times 10^{8})} =$

44) $\dfrac{(1.745 \times 10^{-2})(9.51 \times 10^{-7})}{(16.21)(9.346 \times 10^{-10})} =$

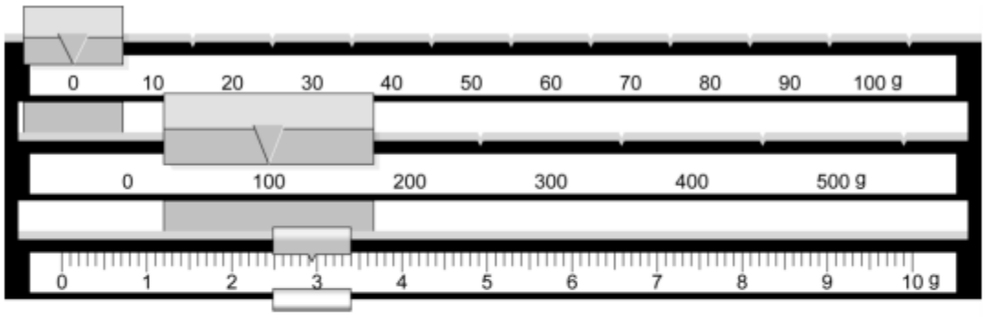
Reading Instruments With Significant Figures

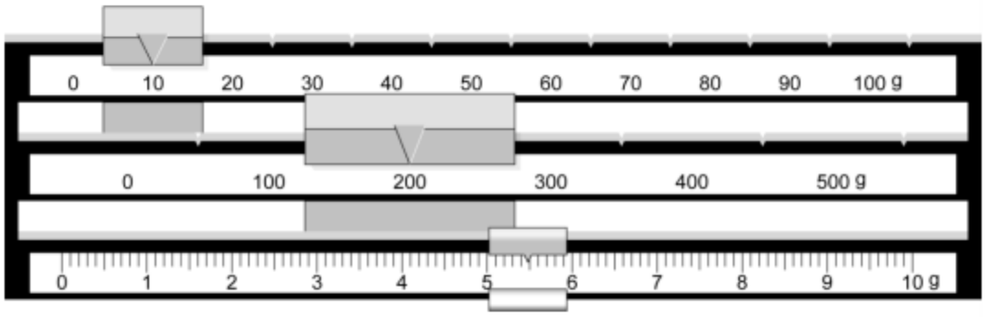
Please read each instrument to their limits. Include units and correct number of SigFigs.

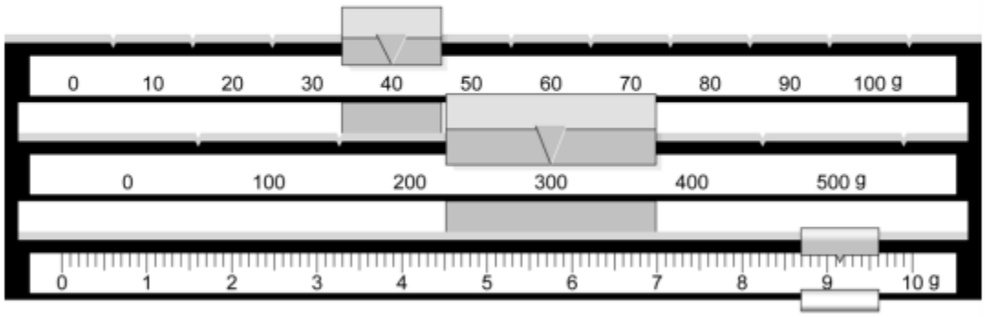


The above graphic is of an old school triple beam balance. The left one reads 500+70+7.66 = 577.66 grams.

45) What's the mass on the right triple beam balance? Show your work in the space below:





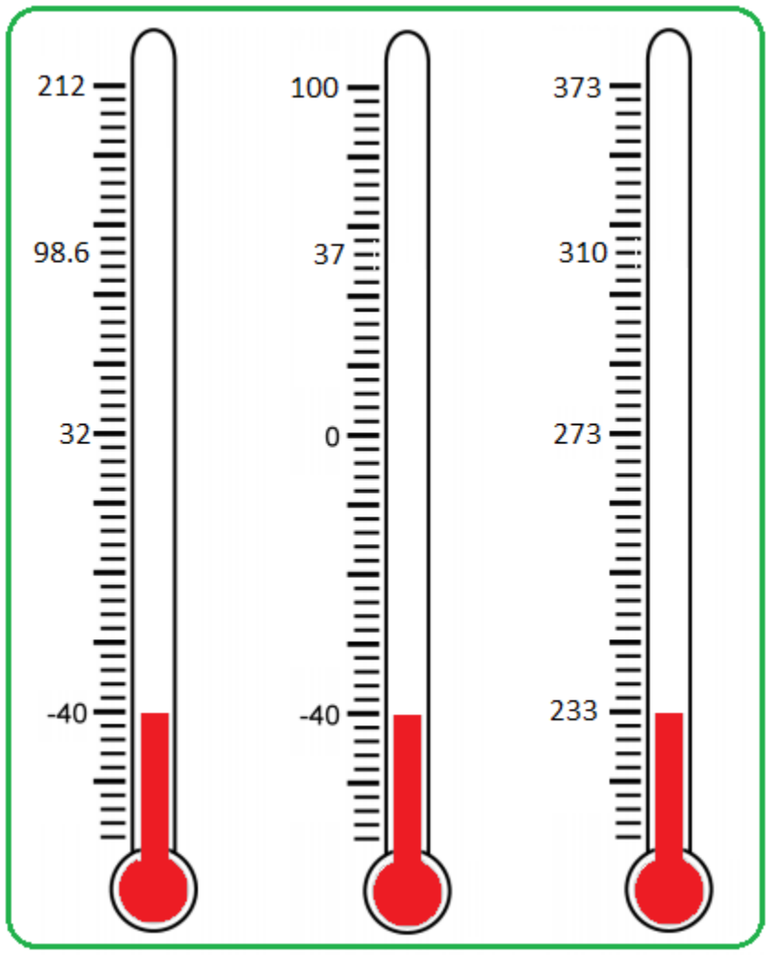


46 top) Determine the mass represented on the top triple beam balance.

47 middle) Determine the mass represented on the triple beam balance.

48 bottom) Determine the mass represented on the triple beam balance.

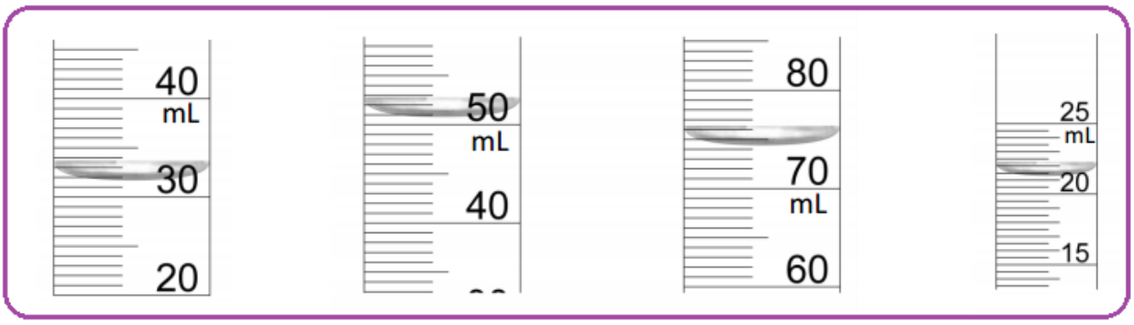
49) Identify the following using the following graphic:



A) Label the temperature scales correctly on the picture.

B) Indicate the significance of each numerical value on each scale in the space, below.

C) Using your Celsius and Fahrenheit scales, show how you might derive the conversion formula from °C to °F (or *vice versa*) if you couldn't remember the actual formula – explain your thinking – don't just regurgitate the formula – demonstrate some critical thinking.



50) Using the diagram above, determine the correct volume to the correct number of sig figs – using the <u>bottom of the meniscus</u> – for each measurement, above. What is a meniscus? Use your own words to define what a meniscus is.