

## Precision, Accuracy and the Rules for Significant Digits (SD's)

***NOTE: The rules only apply to measurements!!!***

1. Precision
  - a. Relates directly to the actual measuring device used
  - b. Refers to closeness of repeated measurements
2. Accuracy
  - a. Also relates directly to the actual measuring device used
  - b. Refers to how close a measurement or average is to an expected value
3. Precision and accuracy are often confused
  - a. But, they are *not* the same
  - b. Measuring instruments are tested to make sure they are both accurate and precise to a certain *practical* extent
    - i. The higher the accuracy and precision, the higher the cost
    - ii. This means that any measuring device is built to a degree of *uncertainty*
    - iii. Measurements can only have the certain digit(s) plus one uncertain digit
      1. For example, a meter stick might have only centimeter marks
      2. You can have a measurement of 23.2 cm
        - a. The "23" is exact (certain- from the marks on the stick)
        - b. The ".2" is estimated (uncertain)
4. Nonzero numbers in a measurement are always significant
  - a. **14.232** g = 5 SD's
  - b. **3.11** g = 3 SD's
  - c. **244.6** g = 4 SD's
5. Leading zeroes in a measurement are *never* significant
  - a. 0.000**45** m = 2 SD's
  - b. 0.0**113** m = 3 SD's
  - c. 0.0000000000000**72** m = 2 SD's
6. Confined zeroes in a measurement are *always* significant
  - a. **2.075** mL = 4 SD's
  - b. **6007** mL = 4 SD's
  - c. 0.0**3007** mL = 4 SD's
7. *Trailing* zeroes in a measurement are significant *if*
  - a. There is an overbar
    - i. **36,00̄** km = 5 SD's
    - ii. **40, 0̄00** km = 3 SD's
    - iii. **6̄0** km = 2 SD's

- b. There is a decimal point
  - i. 0.0**10** L = 2 SD's
  - ii. 0.00**1200** L = 4 SD's
  - iii. 0.**10300** L = 5 SD's

8. Mathematical operations

a. Multiplication/Division- Answer has same number of SD's as fewest in problem

i.  $6.038 \text{ m} \times 2.57 \text{ m} = 15.51766 \text{ m}^2$  *Correct answer = 15.5 m<sup>2</sup>*  
 (4 SD's) (3 SD's) (3 SD's)

ii.  $(0.006 \text{ cm})(0.060 \text{ cm})(0.600 \text{ cm}) = 0.000216 \text{ cm}^3$  Answer = **0.0002 cm<sup>3</sup>**

b. Addition/Subtraction – Line up decimal points; add/subtract; round answer to the greatest *uncertain* place value.

i.  $347\text{g} + 2.03\text{g} + 23.6\text{g} = 372.63\text{g}$

ii. Correct answer is **373 g**, from...

347. ← This number has the greatest *uncertain* place value (*ones*)

2.03

+ 23.6

**372.63** ← So, this number must be rounded to the *ones* place.

iii. Likewise,  $23000 + 2300 + 230 = 48530 = 49000$  (rounded to greatest uncertain value, *thousands*)

iv. Subtract 340.1 g from 4563.07 g. Answer= 4223.0 g (Greatest uncertain place value is the *tenths* place)

c. Exact numbers

i. Includes counted numbers, defined numbers, simple fractions, and ratios.

ii. Examples

1. The formula for finding the perimeter (P) of a square is  $P = 4s$

a. What is the perimeter of a square that is 5.2 m on a side?

i.  $P = 4(5.2 \text{ m}) = 20.8 \text{ m}$

ii. Correct answer= **21 m**, because the *measured* part of the problem (5.2 m) only has 2 SD's. The 4 is *not* considered because it is a counted number.

2. There are 1.8 Fahrenheit degrees for every 1 Celsius degree. How many Fahrenheit degrees would there be for **212** measured Celsius degrees?

a.  $212 \text{ C}^0 \times 1.8 \text{ F}^0 / 1 \text{ C}^0 = 381.6 \text{ F}^0$

b. Correct answer = **382 F<sup>0</sup>** (3 SD's, because the measurement of 212 C<sup>0</sup> has 3)

3. The formula for the area of a triangle is  $A = \frac{1}{2}bh$ . What would be the area of a triangle where  $b = 4.2 \text{ mm}$ , and  $h = 12.04 \text{ mm}$ ?

a.  $A = \frac{1}{2}(4.2 \text{ mm})(12.04 \text{ mm}) = 25.284 \text{ mm}^2$

b. Correct answer = **25** mm<sup>2</sup>

4. There is a *defined* relationship between the inch and the centimeter:  
2.54 cm = 1 inch. What is the equivalent of **35.6** centimeters in inches?

a.  $35.6 \text{ cm} \times \frac{1 \text{ in}}{2.54 \text{ cm}} = 14.015748 \text{ in}$

b. Correct answer is **14.0** cm (3 SD's)

- d. Significant digits for *measurements* written in scientific notation

- i. *Only* significant digits are written

1.  $3 \times 10^{-4}$  mL has 1 SD

2.  $3.0 \times 10^{-4}$  mL has 2 SD's

3.  $3.100 \times 10^{-4}$  mL has 4 SD's

4.  $1.345900 \times 10^{19}$  Km has 7 SD's

- ii. Multiply/Divide

1. Same rule as before

a.  $(2.03 \times 10^{-6} \text{ m})(18.006 \times 10^{11} \text{ m}) = 3.66 \times 10^6 \text{ m}^2$

b. But,  $5(3.660 \times 10^3 \text{ m}) = 1.830 \times 10^4 \text{ m}$

2. Best to use calculator in "SCI" mode and round to correct SD's

- iii. Scientific notation is the preferred format for...

1. Large measurements and numbers

a.  $9.3 \times 10^9 \text{ mi}$ , rather than 9300000000 mi

b.  $6.02 \times 10^{23}$  atoms/mol

2. Small measurements and numbers

a.  $9.0 \times 10^{-5} \text{ m}$ , rather than 0.000090 m

b. 1 mm =  $1 \times 10^{-6}$  km