Significant Digits

When are Digits Significant?

- Non-zero digits are always significant. Thus, 22 has two significant digits, and 22.3 has three significant digits.
- With zeroes, the situation is more complicated:
  1. Zeroes placed before other digits are not significant; 0.046 has two significant digits.
  2. Zeroes placed between other digits are always significant; 4009 kg has four significant digits.
  3. Zeroes placed after other digits but behind a decimal point are significant; 7.90 has three significant digits.
  4. Zeroes at the end of a number are significant only if they are behind a decimal point as in (c). Otherwise, it is impossible to tell if they are significant. For example, in the number 8200, it is not clear if the zeroes are significant or not. The number of significant digits in 8200 is at least two, but could be three or four. To avoid uncertainty, use scientific notation to place significant zeroes behind a decimal point:

8.200×10^3 has 4 sig figs 8.20×10^3 has 3 sig figs 8.2×10^3 has 2 sig figs

Significant Digits in Multiplication, Division, Trig. functions, etc.

- In a calculation involving multiplication, division, trigonometric functions, etc., the number of significant digits in an answer should **equal the least number of significant digits** in any one of the numbers being multiplied, divided etc.
  - Multiplying 0.097 m^{-1} (two significant digits) and 4.73 m (three significant digits), the answer should have two significant digits.
- Keep One Extra Digit in Intermediate Answers
  - When doing multi-step calculations, *keep at least one more significant digit in intermediate results* than needed in your final answer.
- For instance, if a final answer requires two significant digits, then carry at least three significant digits in calculations. If you round-off all your intermediate answers to only two digits, you are discarding the information contained in the third digit, and as a result the *second* digit in your final answer might be incorrect. (This phenomenon is known as "round-off error.")

The Two Greatest Sins Regarding Significant Digits

- Writing more digits in an answer (intermediate or final) than justified by the number of digits in the data.
- Rounding-off, say, to two digits in an intermediate answer, and then writing three digits in the final answer.

Scientific Notation:

- Only one number before the decimal
- Positive exponents are large numbers (4.5×10^6 is 4500000)
- Negative exponents are small numbers (4.5×10^{-6} is 0.0000045)
- Entering on your scientific calculator:
  - Punch the number (the digit number) into your calculator.
  - **Push the EE or EXP button. Do NOT use the x (times) or 10^x button!!**
  - Enter the exponent number. Use the +/- button to change its sign.
  - Voila! Treat this number normally in all subsequent calculations.
  - To check yourself, multiply 6.0×10^5 times 4.0×10^3 on your calculator. Your answer should be 2.4×10^9.

CHEMISTRY : MEASUREMENT PRACTICE

A. How many significant digits are in each of the following numbers?

1837	
3.14145×10^4	
6005	
0.08206	
0.000014	
149356	
8.7300	
0.00743	
302400	
8.732	
14.000	
19.7342	

205.8	
1900	
1200.43	
6000	
632	
14.163000	
14.000	
302400.00	
0.0019872	
20000	
426.1	
60.0	

SCIENTIFIC NOTATION

B. Convert the following numbers into or out of scientific notation:

142.63	
1,500,000	
0.00336	
1.63×10^7	
3.11×10^{-4}	
0.00125	
86,400	
1.01×10^6	
9.81×10^1	
0.000000000000144	
4,663,310.56	

C. Round each of the following numbers to four significant digits.

6.16782	
6.19648	
0.0019872	
3.14145×10^4	
213.25	
14.163000	
90210	
234.4	
1200.43	
0.0022475	
14.16300	
0.02315	
13.462	
135.69	
152.00	
395.55	

D. Add or subtract as indicated and state the answer with the correct number of significant digits.

85.26 cm + 4.6 cm	
1.07 m + 0.607 m	
186.4 g - 57.83 g	
60.08 s - 12.2 s	
4,285.75 - 520.1 - 386.255	
72.60 m + 0.0950 m	

E. Multiply or divide as indicated and state the answer with the correct number of significant digits.

(5.5 m) (4.22 m)	
(0.0167 km) (8.525 km)	
2.6 kg ÷ 9.42 m^3	
0.632 m ÷ 3.8 s	
(8.95) (9.162)/(4.25) (6.3)	
0.0045 mm^2 ÷ 0.90 mm	

F. Evaluate the following with answers expressed to proper number of significant digits.

$4.22 \times 10^5 + 3.11 \times 10^7 + 6.003 \times 10^6$	
$(9.11 \times 10^{-28})(6.02 \times 10^{23})$	
$2.160 \times 10^3 + 6.2000 \times 10^4 + 5.2 \times 10^1$	
$\frac{8.4x10^7}{2.1x10^4}$	
$\frac{8.4x10^{-7}}{2.1x10^4}$	
$\frac{8.4x10^7}{2.1x10^{-4}}$	
$\frac{8.4x10^{-7}}{2.1x10^{-4}}$	
$\frac{6.02x10^{23}}{9.11x10^{28}}$	