CHM 4, PAL – Significant figures   Student name:

Part A: Scientific Notation

Scientists often deal with really large numbers such as the distance light travels in 1 year (9,540,000,000,000,000 m) and really small numbers such as the mass of a proton (0.00000000000000000000000000167 kg. It wouldn't take more than a few of these numbers before you'd grow tired of counting zeros and would be looking for a short cut. Luckily, *scientific notation* helps us deal with really large and really small numbers by writing them in an abbreviated form.

1) The diameter of the sun is equal to 1,390,000 km. This number is written as 1.39×10^{6} km in scientific notation. Type both numbers into your calculator to prove to yourself that they are equivalent.

2) Working in your PAL team, use the example in the previous question to come up with a generalizable statement that describes how numbers greater than "1" are turned into scientific notation.

3) The mean diameter of a carbon atom is equal to 0.00000013 mm. In scientific notation, this same number is written as 1.3×10^{-7} mm. Type both numbers into your calculator to prove to yourself that they are equivalent.

4) Working in your PAL team, use the example in the previous question to come up with a generalizable statement that describes how numbers less than "1" are turned into scientific notation.

5) Write the following measurements in scientific notation:

   0.00000000000000000000000000167 kg =

   9,540,000,000,000,000 m =

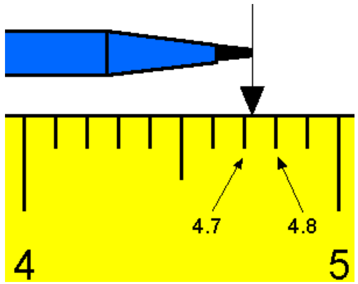
6) Change the following measurements from scientific notation back to their original long form.

   5.70×10^{-8} =

   8.4×10^{11} =

Part B: Significant figures

7) All measurements have a limited number of significant figures associated with them. As an example use the ruler below to measure the length of the pencil in centimeters.



Length of pencil = ___________ cm

8) Go around your PAL team and compare your answers. What digits does everyone agree on? [These are our "certain digits"] What digit is there some disagreement on? [This is our "estimated digit"]

9) Since we are only allowed one "estimated digit", what is wrong with reporting the length of the pencil as 4.732 cm?

10) Imagine the ruler only had been marked with "4" and "5" and did not have the tenths placed marked. How would that have changed your answer?

When using someone else's measurement it is important to understand how many significant figures it has. Table 1 shows a series of measurements, each identified with how many of the digits count as significant figures.

Table 1:

Measurement	Significant Figures
1.8335 ml	5
97,531.82 gal	7
1.003 L	4
80.0102 kg	6

11) Based on the first two examples in Table 1, what is the general rule for whether to count "non-zero digits" as significant?

12) Based on the last two examples in Table 1, what is the general rule for whether to count "zeros sandwiched between other numbers" as significant?

Now, let's look at "zeros" that are at the start or end of a measurement (i.e. they are not sandwiched between two other numbers). Some of these "zeros" are place holders (as in Table 2) and some of them are actual, measured values and are NOT place holders (as in Table 3)

Table 2:

Measurement	Significant Figures
2400 ml	2
3,000,000 ml	1
0.00065	2

Table 3:

Measurement	Significant Figures
25.0 ml	3
3.0000 ml	5

13) How can you tell the difference between the "zeros" in Table 2 (place holders) and Table 3 (non-place holders)?

14) Based on Table 2, what is the general rule for whether to count, "zeros that are place holders" as significant?

15) Based on Table 3, what is the general rule for whether to count, "zeros that are non-place holders" as significant?

16) In summarizing your rules from questions 11-15 above, what are the only digits that are not considered to be significant?

17) Determine the number of significant figures in each of the following measurements.

Measurement	Significant Figures
4530 kg	
0.00070 sec	
8.01000 miles	
501.040 cm	
56,004,000 lb	

Part C: Significant figures in calculations (multiplying and dividing)

We must follow different rules depending on whether we are adding/subtracting or multiplying/dividing our measurements. Let's start by looking at a calculation involving just multiplication and division.

18) Perform the following calculation and *write down everything your calculator gives you*.

$$\frac{(105.982\,\text{mm})(3.6\,\text{mm})}{16.030\,\text{mm}} =$$

Our answer can only have as many **significant figures** as the measurement we used with the least number of significant figures. In the above calculation, label the number of significant figures in each of the 3 measurements. Based on the smallest number of significant figures, go back to the answer your calculator gave you and round off your calculation to the correct number of significant figures. [See page 17 of your textbook if you need help with rounding.]

Report the answers to the following calculations using the correct significant figures. Be sure to use scientific notation as needed to avoid "ambiguous zeros". Check your answers with your PAL team.

19) (105 in)(56 in) =

20) $\frac{\left(1.5 \times 10^{5}\ \text{mm}^{2}\right)}{\left(2.056 \times 10^{-6}\ \text{mm}\right)} =$

Part D: Significant figures in calculations (adding and subtracting)

21) Perform the following calculation and *write down everything your calculator gives you*.

(1.7 mm) + (915.49 mm) + (89 mm) =

Our answer can only have as many **decimal places** as the measurement we used with the least number of decimal places. In the above calculation, label the number of decimal places in each of the 3 measurements. Based on the smallest number of decimal places, go back to the answer your calculator gave you and round off your calculation to the correct number of decimal places.

Report the answers to the following calculations using the correct significant figures. Be sure to use scientific notation as needed to avoid "ambiguous zeros". Check your answers with your PAL team.

22) 45.9 + 87 – 32.5 =

23) Determine the formula mass (in amu) of lead(IV) hydrogen carbonate.