Worksheet 1 - Calculations

Significant Figures - the number of significant figures (sig. fig.) is a measure of the degree of uncertainty in a measurement. There is experimental uncertainty in the last significant figure of a measurement. The rules for sig. fig. are given in Chapter 1.5. All non-zero numbers are significant. Zeros between numbers are significant. Zeros to the left of numbers are not significant. Zeros to the right of numbers may be significant (in presence of a decimal point).

1. Express each of the following numbers in scientific notation and decide the number of significant figures:

<table>
<thead>
<tr>
<th>Number</th>
<th>Scientific notation</th>
<th>sig.fig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>409.10</td>
<td>4.0910 x 10^2</td>
<td>5</td>
</tr>
<tr>
<td>4091.00</td>
<td>4.09100 x 10^3</td>
<td>6</td>
</tr>
<tr>
<td>0.004091</td>
<td>4.091 x 10^-3</td>
<td>4</td>
</tr>
<tr>
<td>308,000</td>
<td>3.08 x 10^5</td>
<td>3</td>
</tr>
<tr>
<td>30,860</td>
<td>3.0860 x 10^4</td>
<td>5</td>
</tr>
<tr>
<td>0.00056030</td>
<td>5.6030 x 10^-4</td>
<td>5</td>
</tr>
</tbody>
</table>

Calculations with significant figures - In multiplication or division, the number of sig. fig. in the answer has only as many sig. fig. as the factor with the smallest number of sig. fig.

\[
(0.46307)(0.0805) = 0.004016430
\]

(63.54)(0.052)(2.809)

2 sig. fig. - limiting factor

which rounds to .0040 or 4.0 x 10^-3 (2 sig. fig.)

In addition and subtraction, the answer should be reported to the same number of decimal places as the term with the least number of decimal places.

\[
37.598 - 36.76 = 0.838
\]

2 decimal places - limiting factor

which rounds to 0.84 or 8.4 x 10^-1

Do addition and subtraction first. When rounding, numbers ≥ 5 are rounded up. Do not round until the end of the calculations.
2. Do the following calculations and express the answers to the correct number of sig. fig.

\[
\begin{align*}
\text{3 dec. places} & \quad \frac{29.837 - 29.241}{32.064} = \frac{0.596}{32.064} = 0.0185875... = 1.86 \times 10^{-2} \\
\text{5 sig. fig} & \quad \frac{752.12 + 26.3}{760.00} = \frac{778.42}{760.00} = 1.0242368... = 1.024 \quad 4 \text{ sig. fig}
\end{align*}
\]

**Dimensional Analysis** - This technique can be used to change units \((K \rightarrow ^\circ C)\) and also as an aid in solving problems, by carefully keeping track of units. SI Units and conversion factors are listed in Appendix 6 (A26) in the textbook. A table of metric to English conversion factors is on page 16 of the textbook.

*A certain process yields \(4.85 \times 10^2 \text{ g}\) of a chemical product per second.*

*How many kilograms will be produced in five days of continuous reaction?*

Start with what you know on the left and what you are trying to find on the right.

\[
\frac{4.85 \times 10^2 \text{ g}}{s} = \quad \text{ ___ kg}
\]

Then find **conversion factors**, which allow you to change your units.

\[
\frac{4.85 \times 10^2 \text{ g}}{s} \quad \frac{60 \text{ s}}{\text{ min}} \quad \frac{60 \text{ min}}{\text{ h}} \quad \frac{24 \text{ h}}{\text{ day}} \quad \frac{1 \text{ kg}}{10^3 \text{ g}} = 20.95200 \text{ kg}
\]

Finally, determine the number of sig. fig. The first term has 3 sig. fig. All of the other factors are definitions, and have \(\infty\) sig. fig. So, the answer will be limited to 3 sig. fig., \(21.0 \text{ kg}\).

In the **conversion factors** the value of the numerator and denominator are the same; 60 seconds = 1 minute, 24 hours = 1 day. The final conversion unit illustrates the use of **metric prefixes**; 1000 grams = 1 kilogram. It is important to know these commonly used prefixes.

3. Fill in the missing information in the following chart.

<table>
<thead>
<tr>
<th>Metric prefix</th>
<th>Symbol</th>
<th>Exponent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mega</td>
<td>M</td>
<td>(10^6)</td>
</tr>
<tr>
<td>nano</td>
<td>n</td>
<td>(10^{-9})</td>
</tr>
<tr>
<td>deci</td>
<td>d</td>
<td>(10^{-1})</td>
</tr>
<tr>
<td>micro</td>
<td>(\mu)</td>
<td>(10^{-6})</td>
</tr>
<tr>
<td>pico</td>
<td>p</td>
<td>(10^{-12})</td>
</tr>
<tr>
<td>kilo</td>
<td>k</td>
<td>(10^3)</td>
</tr>
<tr>
<td>milli</td>
<td>m</td>
<td>(10^{-3})</td>
</tr>
<tr>
<td>centi</td>
<td>(\text{c})</td>
<td>(10^{-2})</td>
</tr>
</tbody>
</table>
4. A volume of 520. cm³ is equivalent to:

\[ 520 \text{ ml} \times \frac{1 \text{ dl}}{5.20 \text{ ml}} \times \frac{1 \text{ L}}{520 \text{ L}} = \frac{520 \text{ ml} \times 1 \text{ dl}}{10 \text{ ml}} \times \frac{1 \text{ L}}{10 \text{ dl}} = 5.20 \text{ dl} \times \frac{1 \text{ L}}{10 \text{ dl}} = 0.520 \text{ L} \]

5. Make the following conversions (Express your answer in scientific notation.)

a. 0.0024 km to nm

\[ 0.0024 \text{ km} \times \frac{1000 \text{ m}}{1 \text{ km}} \times \frac{1 \text{ mm}}{10^{-3} \text{ m}} = 2.4 \times 10^9 \text{ nm} \]

b. 3.5 g/dm³ to mg/mm³

\[ \frac{3.5 \text{ g}}{\text{dm}^3} \times \frac{1000 \text{ mg}}{1 \text{ g}} \times \left( \frac{10 \text{ dm}}{1 \text{ m}} \right)^3 \times \left( \frac{1 \text{ m}}{1000 \text{ mm}} \right)^3 = 3.5 \times 10^{-3} \text{ mg/mm}^3 \]

c. 95 yards to cm (3 feet in a yard; 2.54 cm in 1 inch)

\[ 95 \text{ yd} \times \frac{3 \text{ ft}}{1 \text{ yd}} \times \frac{12 \text{ in}}{1 \text{ ft}} \times \frac{2.54 \text{ cm}}{1 \text{ in}} = 8686.8 \text{ cm} = 8.7 \times 10^3 \text{ cm} \]

6. You feel a bit feverish and take your temperature with a lab thermometer, marked in degrees kelvin. It reads 310 K. What is your Fahrenheit temperature? [Remember (°F) = 1.8 °C + 32° and K = °C + 273]

\[ 310 \text{ K} - 273 = 37 \text{ °C} \quad (37 \text{ °C}) \times 1.8 + 32 = 98.6 \text{ °F} \quad \text{not feverish} \]

Work on the following problems, paying attention to sig. fig.

7. Write down your height. Convert it to meters (m.)

\[ \frac{5}{\text{ ft}} \times \frac{7}{\text{ in}} = 67 \text{ in} \times \frac{2.54 \text{ cm}}{1 \text{ in}} \times \frac{1 \text{ m}}{100 \text{ cm}} = 1.7 \text{ m} \]

8. A child's sandbox is 4.0 ft. wide, 4.0 ft. long and 9.0 in. deep. If there are, on the average, 55 grains of sand per mm², how many grains of sand are there in the sandbox?

\[ 4.0 \text{ ft} \times 12 \text{ in} = 48 \text{ in} \]

\[ 48 \text{ in} \times 48 \text{ in} \times 9.0 \text{ in} = 20736 \text{ in}^3 \quad \text{(all 2 sig figs)} \]

\[ 20736 \text{ in}^3 \times \left( \frac{2.54 \text{ cm}}{1 \text{ in}} \right)^3 = 3.39802 \ldots \times 10^5 \text{ cm}^3 \]

\[ 3.39802 \ldots \times 10^5 \text{ cm}^3 \times \left( \frac{10 \text{ mm}}{1 \text{ cm}} \right)^3 = 3.39802 \ldots \times 10^8 \text{ mm}^3 \]

\[ 3.39802 \ldots \times 10^8 \text{ mm}^3 \times \frac{55 \text{ grains}}{\text{ mm}^3} = 1.89689 \ldots \times 10^{10} \text{ grains} \]

1.9 x 10¹⁰ grains of sand (2 sig figs)