Chemistry 11

Uncertain Quantities and Significant Figures

Uncertainty:

Most often when we measure something it is not exact. When we count a small number of things, such as apples in a bag, we can be sure our results are exact. However, when we try to measure something, such as mass, there is always some uncertainty in our results. We usually assume that all of the digits in a measurement are certain except the last one.

E.g. If we measure a length of time with a stopwatch to be 39.43s, we assume that the 3, 9, and 4 are certain, while the 3 is uncertain.

Significant Digits:

Whenever we record a measurement in Chemistry, we will include all of the digits that are certain plus the first uncertain digit. These are called the significant digits or significant figures ('sig figs') in a measurement. It is not always as straightforward as it sounds so there are some important rules for counting and using significant figures:

1. Digits that are non-zero always count as significant figures.
2. Leading zeros are not significant. E.g. In 0.0012, the three leading zeros simply show the position of the decimal point and are not significant.
3. "Captive" zeros always count. E.g. In 1.005, the zeros are significant.
4. "Trailing" zeros that are at the end of a number only count if there is a decimal point in the number. E.g. 100 has only one significant figure, but 1.00 has three. If you wrote 100. it would have three sig figs as well (but we don't do this). To show the number 100 with three sig figs you would have to use scientific notation: 1.00×10^2. If you wrote 100.0, it would have four sig figs!
5. 'Defined' numbers or counted numbers, such as 2 apples, 1 dozen, or 1000g = 1kg, are considered to be perfect and have infinite sig figs.

Doing Calculations With Sig Figs:

A. When adding or subtracting numbers, round off the answer to the least number of decimal places found in the calculation:

E.g. 112.008 + 34.2 = 146.208
= 146.2

B. When multiplying or dividing numbers that have different numbers of sig figs, do the math first, and then round the answer off to the least number of sig figs found in the calculation:

E.g. 112.008 x 34.2 = 3830.6736
= 3830

2.6 Significant Figures

Once you make a mathematical computation, you can use significant figures to standardize the precision of your answer.*

Rules for counting significant digits

1) All non-zero numbers are significant.
2) Zeros are significant only when they are in the middle of a number, or at the end of a number that includes a decimal point.

* A number is only as precise as the number of significant digits (*s.d.*).

1.01 (*3 s.d.*) 2.020 (*4 s.d.*) 0.013 (*2 s.d.*)
200 (*1 s.d.*) 2.00×10^2 (*3 s.d.*) 200. (***exact***)

Addition and Subtraction

1) Line up decimal points in the following form:

```
 2500        35.689
+13.5       -25.3
```

2) Draw a line to the right of the last significant digit in each number.

```
 25|00       35.689|
+13.5|      -25.3|
```

3) Pick the line farthest to the left and extend. Disregard the other lines.

```
 25|00       35.6|89
+  |13.5    -25.3|
   |             |
```

4) Add or subtract.

```
 25|00       35.6|89
+  |13.5    -25.3|
 2500        10.3|89
```

5) If the first digit to the right of the line falls between 0 and 4, discard it. If the first digit to the right of the line falls between 5 and 9, discard it and round up the number to the left (add one). Where necessary, fill spaces from line to decimal point with zeros.

```
 25|00       35.6|89
+  |13.5    -25.3|
 2500        10.4
```

Multiplication and Division

1) Count the number of significant digits (*s.d.*) in each number. Your answer will have the same number of significant digits as the least precise number, so remember this number.

```
  2.000 (4 s.d.)          27 (2 s.d.)
× 3.11  (3 s.d.) ←        3. (exact)
```

2) Multiply or divide.

```
  2000          27
× 3.11          -- = 9
 6.220          3.
```

3) Starting from the left, count the significant digits. Draw a line after the last one.

```
  2.000         27
× 3.11          -- = 9.0|
 6.22|0         3.
```

4) If the first digit to the right of the line falls between 0 and 4, discard it. If the first digit to the right of the line falls between 5 and 9, discard it and round up the number to the left (add one). Where necessary, fill spaces from line to decimal point with zeros.

```
  2.000         27
× 3.11          -- = 9.0
  6.22          3.
```