Calculations Using Scientific Notation

Scientific notation is the expression of numbers in a form that easily handles very large or small numbers. For example, the number of carbon atoms in 12 grams of carbon is approximately 602214090000000000000000. Written in scientific notation, this same number is 6.0221409×10^{23} which is shown on most calculators as 6.0221409e+23. The decimal point has been moved 23 places to the left, so the power of 10 is +23. In Science-1A, we do not need this much accuracy and will approximate this number by 6.02×10^{23} .

Similarly small numbers are written in an analogous manner. The size of a helium atom is about 0.000000000140 meters which is written as $1.40\times10^{-10}\,\text{meters}$. This is shown on most calculators as 1.40e-10. The decimal point has been moved 10 places to the right in order to write 1.40, so the power of 10 is then -10.

You will need to know how to enter and interpret numbers in scientific notation on your calculator or calculator app. Test yourself with the following:

$$500=5\times10^{2}=5.00\times10^{2}=5.0\times10^{2}=5.00000\times10^{2}$$

$$5005=5.005\times10^{3}=5.0050\times10^{3}=5.00500\times10^{3}$$

$$10000000=1\times10^{7}=10^{7}=1.0\times10^{7}=1.0000\times10^{7}=1.0000000000\times10^{7}$$

$$1.000=1\times10^{0}=10^{0}=1.0\times10^{0}=1.0000\times10^{0}=1.00000000000\times10^{0}$$

$$10=1\times10^{1}=10^{1}=10.00=1.0\times10^{1}=1.0000\times10^{1}=1.00000000000\times10^{1}$$

$$0.10=10^{-1}=1.0\times10^{-1}=1.00000\times10^{-1}$$

$$0.00001=10^{-5}=1.0\times10^{-5}=1.0000\times10^{-5}$$

$$0.0002=2\times10^{-4}=2.0\times10^{-4}=2.00000000\times10^{-4}$$

Usually we use a special set of abbreviations for certain powers of 10 when used with measurement units. They are:

$$10^{12}=\text{T}\quad 10^{9}=\text{G}\quad 10^{6}=\text{M}\quad 10^{3}=\text{k}\quad 10^{-2}=\text{c}\quad 10^{-3}=\text{m}\quad 10^{-6}=\mu\quad 10^{-9}=\text{n}\quad 10^{-12}=\text{p}\quad 10^{-15}=\text{f}$$

Here, the Greek letter μ is pronounced “mu”.

Here are examples of this usage with the unit of length, the meter, abbreviated as m:

$$34\,\text{km}=34\times10^{3}\,\text{m}=34000\,\text{m}\qquad 5\,\text{mm}=5\times10^{-3}\,\text{m}=0.005\,\text{m}\qquad 2.3\,\mu\text{m}=2.3\times10^{-6}\,\text{m}=0.0000023\,\text{m}$$

$$140\,\text{pm}=140\times10^{-12}\,\text{m}=1.40\times10^{-10}\,\text{m}=0.000000000140\,\text{m}\qquad 125\,\text{cm}=125\times10^{-2}\,\text{m}=1.25\,\text{m}$$

You may have noticed other examples when looking at computer specifications:

GHz clock speed, TByte of disk storage, Gbits/s of network speed

Remember that inverting a power of 10 changes the sign of the power number: $\frac{1}{10^{4}}=10^{-4}$ $\quad \frac{1}{2\times10^{-6}}=0.5\times10^{6}$

and that multiplying powers of 10 adds the power numbers: $10^{5}\times10^{7}=10^{12}$ $\quad (2\times10^{-5})\times(3\times10^{5})=6\times10^{0}=6$

Check yourself by doing the following calculations in your head or with a calculator or calculator app. Remember that on most calculators entry of scientific notation involves the EE key. For example, entering $3x10^5$ might be done with the keys **3 EE 5** and $3x10^{-5}$ might be done with the keys **3 EE +/- 5** .

1. $(2\times10^{10})\times(3\times10^{4})=$

2. $\dfrac{3\times10^{10}}{2\times10^{4}}=$

3. $\dfrac{(3.00\times10^{8})\times(5.5\times10^{3})}{1.1\times10^{-3}}=$

4. $(3\times10^{4})^{3}=(3\times10^{4})\times(3\times10^{4})\times(3\times10^{4})=$

5. $\dfrac{1}{2\times10^{5}}=$

6. $\dfrac{6}{2.00\times10^{-5}}=$

Units can be manipulated like numbers, including cancellation of identical numerator and denominator units.
Study the following:

$$\text{speed}\times\text{time}=\text{distance}: \quad (5\,\text{m/s})\times(20\,\text{s})=100\,\frac{\text{m}}{\text{s}}\times\text{s}=100\,\text{m}$$

Failure to write the units of this answer is an error. You need to write "100 m", not merely "100".

$$\text{pi}\times\text{radius squared}=\text{area}: \quad \pi\times(1.5\times10^{3}\,\text{m})^{2}=3.14\times(2.25\times10^{6}\,\text{m}^{2})=7.065\times10^{6}\,\text{m}^{2}$$

$$\frac{\text{mass}}{\text{volume}}=\text{density}: \quad \frac{(5\,\text{kg})}{(2\,\text{m}^{3})}=2.5\,\text{kg/m}^{3}=2.5\,\frac{\text{kg}}{\text{m}^{3}}$$

$$\text{ratio of densities}=\text{dimensionless number}: \quad \frac{4.4\times10^{2}\,\text{kg/m}^{3}}{4.0\times10^{1}\,\text{kg/m}^{3}}=1.1\times10^{1}=11$$

This last example has no units in its correct answer.

Check yourself with the following calculations and be sure to write the units of the final answer:

5. $v=\dfrac{\pi\times(4\times10^{4}\,\text{m})^{3}}{(100\,\text{s})\times\pi\times(4\times10^{2}\,\text{m})^{2}}=$

In the following, N is a unit of force.

6. $F=\dfrac{\left(6.67\times10^{-11}\,\dfrac{\text{N}\cdot\text{m}^{2}}{\text{kg}^{2}}\right)\times(5.97\times10^{24}\,\text{kg})\times(7.35\times10^{22}\,\text{kg})}{(3.84\times10^{8}\,\text{m})^{2}}=$