

## How big is the nanoscale?

### Education in Chemistry

January 2018

[rsc.li/EiC118-preciouswater](http://rsc.li/EiC118-preciouswater)

### Mathematics in science, ages 14–16

The purpose of this set of exercises is to immerse pupils in the mathematics of the measurement of materials on a very small scale.

**Exercise 1:** Draw lines to match up the measurement described with the appropriate value and unit. *This could also be organised as a card sort activity.*

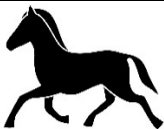




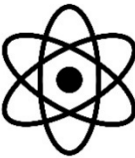

Height of an average sized horse	16 hands
Width of a strand of DNA	2.5 nanometres
Height of a Scots pine tree	20 metres
Average height of an adult female	160cm
Width of an E string on an acoustic guitar	0.254mm
Atomic radius of calcium	231 pm
Thickness of a piece of paper	100 microns

**Exercise 2:** Skim read the article 'Precious Water'. List below all the measurements given in the article and what they are describing.

This exercise is intended to guide pupils to read information carefully and get used to associating figures with units and the factor they are related to.

- ✓ 416,000 km of mains water pipes in the UK
- ✓ 5-100 nm, width of the membranes in Reynolds ultra-filtration system
- ✓ 18,000 litres of clean water an hour produced by Reynolds's existing system
- ✓ 5 litres of water a day, the average needed by one person
- ✓ 12 hours a day, the running time for one box
- ✓ 216,000 litres of water per day that could be supplied by one box
- ✓ 150–200 nm thickness of active layer in the CSMCRI system
- ✓ 35 micrometers, thickness of the supporting layer in the CSMCRI system
- ✓ 40,000–50,000 litres of clean water a day produced by the CSMCRI system during the Latur drought in 2016
- ✓ 15nm is the pore size in membranes in nanofiltration systems

**Exercise 3:** Below is a table with the measurements considered earlier. For the first two the measurements have been converted into metres and into nanometres. Study these conversions carefully. Can you spot the pattern? Using this pattern, fill in the blanks giving the conversions.

		In metres	In nm
	16 hands	1.63	$1.63 \times 10^9$
 <small>Redline/vector/Shutterstock.com</small>	0.254 mm	0.000254	254000 or $2.54 \times 10^5$
	2.5 nm	$2.5 \times 10^{-9}$	2.5
	20 m	20	$2 \times 10^{10}$
	160 cm	1.6	$1.6 \times 10^9$
	231 pm	$2.31 \times 10^{-10}$	23.1 or $2.31 \times 10^1$
 <small>Art work/Shutterstock.com</small>	100 microns	$1 \times 10^{-4}$	100000 or $1 \times 10^5$

#### Exercise 4: Considering relative size

You will need: a pack of icon cards and a roll of toilet paper.

1. Roll out the toilet paper so you have 12 sheets in total.
2. Mark up each sheet with a power of ten scale in nanometres,  $\times 10^1$  nm,  $\times 10^2$  nm etc.
3. Place each icon card in the right place on your toilet paper scale.
4. Use reference materials (books, the internet) to find out the measurements of some things you consider very small, convert these measurements to nanometres and put the cards on the scale.