Standard form

This statement appears in an exam question:

A nucleus of an atom has a radius of 1.0×10^{-15} m

The value **1.0×10^{-15}** is in **standard form**, and many students struggle to handle numbers expressed like this. Another way of writing the same value would be:

0.000 000 000 000 001

…and many students would try to do this to use the number in a calculation. Often, the problem is that they aren't sure how to put numbers in standard form into their calculator.

How would you enter the value

1×10^{-15}

into this scientific calculator?

Obviously, you start with the number 1

This is the part where many students will start to go wrong – by hitting the 'multiply' key on the calculator.

No – wrong move!

The key you need is this one – the x10ˣ key. That's how it's labelled on this model of calculator – but other makes sometimes have 'EXP' or 'EE' for this function – you have to know how to do it on your own calculator.

Now there's a second place where many go wrong – the radius of the nucleus is 1 x 10 to the MINUS 15 – and many students will press the 'subtract' key on the calculator. It's wrong.

The one we need for the negative exponent (ten to the <u>minus</u> fifteen) is this key up here – usually shown as a 'minus sign' in brackets.

If you've managed those two obstacles, the rest is plain sailing, just type in the fifteen for the exponent (power of ten).

Worked example:

So, now we're ready to tackle this question:

An atom has a radius of 1.0 x 10^{-10} m. A nucleus has a radius of 1.0 x 10^{-15} m

Calculate the ratio of the radius of the atom to the radius of the nucleus.

One student's attempt (shown in the examiner's report published after this question was included in an exam paper) used this method:

0.000 000 000 1 ÷ 0.000 000 000 000 001

= **100 000 : 1**

The examiner commented: *"The candidate sets out their calculation, with a conversion from standard form to decimal, accurately achieving the correct answer"*

So – this student gained the two marks. But you can probably see how it's a risky strategy – it's very easy indeed to lose count of all those zeroes and to miss one or add an extra one.

Try it now, yourself, using your scientific calculator and keeping the values in standard form.

1 x 10^{-10} ÷ 1 x 10^{-15} = 100 000 – so the ratio is **100 000 : 1**

Questions:

Q1: The Earth is 1.5 x 10^{8} km from the Sun.

It takes light 500 s to reach the Earth from the Sun.

Calculate the speed of light in km/s. (3 marks)

Q2: The relative atomic mass of carbon is 12. Avogadro's constant is 6.02 x 10^{23} mol^{-1}

Calculate the number of atoms in 3g of carbon. (4 marks)

For more information on using calculators in examinations please visit: https://www.jcq.org.uk/wp-content/uploads/2023/08/FAQs-%E2%80%93-Using-Calculators_FINAL.pdf

Mark schemes:

Q1: Substitution $\frac{1.5 \times 10^8}{500}$ 1 mark

Evaluation: 3×10^5 1 mark

Units consistent with answer i.e 3×10^5 **km/s** or 3×10^8 **m/s** 1 mark

Q2: 1 mole of a substance contains Avogadro's constant number of particles. 1 mark

1 mole of carbon is 12g; so 3g of carbon is 0.25 moles 1 mark

Number of atoms in 3g of carbon = $6.02 \times 10^{23} \times 0.25$ 1 mark

= $\mathbf{1.51 \times 10^{23}}$ 1 mark