BBC Bitesize - Chemistry

Episode 4 – Isotopes

TULELA: I'm Tulela Pea, a science communicator and podcaster.

SUNAYANA: And I'm Dr Sunayana Bhargava, scientist and poet.

TULELA: And this is Bitesize Chemistry. And this is Bitesize Chemistry.

SUNAYANA: This is the fourth episode in an eight-part series on atomic structure and the periodic table. We'll be looking at what makes isotopes of an element different…

TULELA: …Neutrons.

SUNAYANA: Spoilers! And how and why isotopes are useful in everyday life.

TULELA: And how this relates to the relative atomic mass of an atom.

SUNAYANA: And NNICK, our AI with attitude will help us along the way.

TULELA: Feel free to hit pause along the way when you need to write things down and draw some diagrams, or rewind to listen again so that those key facts stick.

In the last episode, we looked at how atoms are made up from neutrons, protons and electrons.

SUNAYANA: We defined the atomic number, which is the number of protons in the atom.

TULELA: And atomic mass – the total number of protons and neutrons in the atom. And now come along isotopes. We need to know about them to work out the relative atomic mass of an element. Isotopes are defined as a different form of the same element, so same number of protons but a different number of neutrons.

SUNAYANA: And therefore, all isotopes of the same element have the same atomic number but different mass number.

TULELA: NNICK, can you give us some lowdown on isotopes please?

NNICK: The most sensible, mature and adult way to remember it is like this:

SINGER: Please welcome my dear friends the three isotopes of hydrogen! [APPLAUSE]

How many protons have you got?

ISOTOPES: (together) One.

SINGER: How many electrons have you got?

ISOTOPES: (together) One.

SINGER: How many neutrons have you got?

ISOTOPE 1: Two.

ISOTOPE 2: Nought.

ISOTOPE 3: One.

TULELA: Thanks, NNICK. So why should we care so much about isotopes? How do we use them in the real world and what good is knowing whether an element is one isotope or another?

SUNAYANA: Understanding isotopes is essential in various scientific fields, not just chemistry. In my own subject – astrophysics – one example is that different isotopes are involved in the explosion of stars called supernovas. And in archaeology, isotopes of carbon are used to estimate how long ago a once-living organism died.

TULELA: I also know that isotopes have various applications in medicine, such as in cancer treatment and medical imaging.

SUNAYANA: It's important to remember that although isotopes of the same element have different atomic masses, they are still the same element. They all still share the same chemical properties, but they will have different physical properties, like hardness or boiling point.

TULELA: OK, so what about chlorine? That comes in two stable isotopes, chlorine-35 and chlorine-37. And I'll give you a clue that chlorine's atomic number is 17. Hit that pause button for the glory of working it our yourselves, in 5,4,3,2,1.

SUNAYANA: OK…atomic number 17 must mean that there are 17 protons and therefore 17 electrons. And because the mass number is 35, to work out the number of neutrons we subtract atomic number from the mass number…. 35 minus 17. 18 neutrons.

TULELA: Correct. And similarly chlorine-37. Atomic number 17, so 17 protons, 17 electrons and the number of neutrons must be 37 minus 17 equalling 20.

SUNAYANA: In the previous episode, when we talked about atomic and mass number of an atom, we said that these are usually written alongside the element's symbol with the mass number above the symbol and the atomic number below the symbol.

TULELA: So for example, helium is He, its atomic number is 2 which is written below the symbol and its mass number is 4 which is written above the symbol.

SUNAYANA: However, the idea of isotopes makes this just a little bit more complex.

TULELA: But only a little, I promise.

SUNAYANA: Because elements have isotopes with different masses, we now need to talk about the relative atomic mass of the element, and this takes account of all the isotopes and is given by the symbol capital A with a little r by its side.

TULELA: Ahhh, that's so sweet. It's easy if an element has only one isotope, because then its relative atomic mass is the same as the mass number.

SUNAYANA: But if an element has more than one isotope then it's relative atomic mass...

TULELA: ...capital A tiny r...

SUNAYANA: ...is the average of the mass numbers of all the different isotopes, taking into account how abundant each isotope is.

TULELA: So this might not be a whole number when you look at that element in the periodic table.

SUNAYANA: Sometimes, that number might be rounded off to one decimal place.

TULELA: So for example, chlorine has two isotopes: chlorine 35 and chlorine 37. The abundance of chlorine 35 is 75% and the abundance of chlorine 37 is 25%. In other words, in every 100 chlorine atoms, 75 atoms have a mass number of 35, and 25 atoms have a mass number of 37. So to find the relative atomic mass of chlorine.

SUNAYANA: Capital A tiny r.

TULELA: We multiply 35 by 0.75.

SUNAYANA: The 75%.

TULELA: And add that to 37 multiplied by 0.25.

SUNAYANA: The 25%, and we get 35.5 to one decimal place and that's what you'll see if you look for chlorine in the periodic table. So the relative atomic mass considers all the isotopes of an element. It is different to the mass number of a specific isotope.

TULELA: Just remember to take into account all the relative abundances of each isotope and average them over.

SUNAYANA: Here's another example you can have a go at. Bromine has two stable isotopes bromine 79 and bromine 81. Bromine 79 has an abundance of around 51%.

TULELA: That means that if you take all the bromine in the universe, 51% of that will be the isotope with mass 79.

SUNAYANA: And bromine 81 isotope has an abundance of around 49%.

TULELA: 49% of all the bromine in the universe has a mass of 81.

SUNAYANA: Use that information to calculate the relative atomic mass of bromine. Hit pause now if you want to do this yourself. OK. Hey, Tulela, how is your mental arithmetic?

TULELA: I think I'll do this on my calculator, thanks. So 51% is 0.51 and 49% is 0.49 so it'll be… 0.51 times 79 plus 0.49 times 81 is 80.0 when we round it off to one decimal place.

SUNAYANA: Correct! If you didn't get that answer, then don't worry – have another go.

TULELA: Quick recap time. Let's go.

SUNAYANA: Isotopes of the same element have the same number of protons but a different number of neutrons.

TULELA: And so a different mass number.

SUNAYANA: Isotopes of the same element have the same chemical properties but different physical ones – like boiling point.

TULELA: The relative atomic mass of an atom takes into account the abundance of each of the isotopes of the element.

SUNAYANA: And the relative atomic mass is shown by the symbol.

BOTH: Capital A tiny r.

TULELA: In the next episode in this series, we'll be looking at physical separation processes: filtration, evaporation and crystallisation …

SUNAYANA: Across the nation?

TULELA: Across the universe, if you want. I'm Tulela Pea.

SUNAYANA: And I'm Dr Sunayana Bhargava.

TULELA: And this is Bitesize Chemistry. To hear more, search Bitesize Chemistry on BBC Sounds. Thanks for listening! Bye.

SUNAYANA: Bye!