BBC Bitesize - Chemistry

Episode 7 – The periodic table

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

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

SUNAYANA: And this is Bitesize Chemistry. This is the seventh episode in an eight-part series on atomic structure and the periodic table. In this episode, we're going to look at the development of the periodic table to the one we have today, how the table arranges the elements in increasing atomic number and by their chemical properties.

TULELA: And we'll define periods and groups.

SUNAYANA: The rows and columns in the table.

TULELA: And as always, we'll round it off with a quick quiz and summary of all the most important facts. Ready with your pen and paper to make notes?

SUNAYANA: And hit pause and rewind when you need to, to have a little more time to let those facts really sink in.

TULELA: In previous episodes, we've looked at the subatomic family of particles that make up the atom. The proton and neutron in the nucleus and those electrons orbiting around in their energy shells.

SUNAYANA: But even before these particles were discovered, scientists of the time tried to arrange the elements into some kind of order by their atomic weight and properties. And it took about a hundred years of refining this order before the we got to the periodic table that you see today.

TULELA: And this table is based on one made by a Russian scientist, Dimitri Mendeleev. Time for some background info. Let's fire up our Bitesize banter buddy, NNICK. Hi, NNICK. Can you tell us more about how Mendeleev's idea led to the modern periodic table?

NNICK: Mendeleev wrote the names of the elements onto cards and arranged them in order of the lightest to the heaviest. Then he made groups based on their physical and chemical properties. About 50 elements were known at the time, and here's the clever bit: Mendeleev left gaps in his table for elements yet to be discovered. He was even able to predict their properties. Pretty smart for a human.

TULELA: Thanks, NNICK.

SUNAYANA: So let's just summarise Mendeleev's table. He arranged elements in order of increasing atomic weight. The horizontal rows are called periods. The vertical columns are called groups, and elements in the same group have similar properties to each other. But, I mean, he wasn't the first scientist to arrange the elements in a list, nor the first to arrange them with similar properties, so what makes him the so-called 'Father of the periodic table?'

TULELA: That is because of what was not in his original table. Mendeleev's brilliance comes from what he left out - the gaps in his table that NNICK mentioned. Unlike previous attempts from Dalton and Newlands who arranged in atomic weight and did not leave gaps, those gaps that Mendeleev left were placeholders for elements that hadn't been discovered at the time. He's like saying 'Hey, I predict that one day we will discover an element with these properties which will slot nicely in this gap' and based on where that gap is in my table, I predict what its properties will be.

SUNAYANA: That's a great way to show how science works. Make a prediction - or hypothesis - and later, when the evidence backs that up, the science progresses.

TULELA: And that's exactly what happened. For example, one of the gaps in Mendeleev's table is associated with an element with an atomic weight of around 68. An element that hadn't been discovered. But Mendeleev predicted its properties, that it would be a solid metal at room temperature and that its melting point was likely to be quite low. A few years later, the previously unknown metallic element gallium was discovered precisely with those properties and that gap was filled.

SUNAYANA: And what's even more amazing is that some of the elements he predicted weren't discovered until many years after he died.

TULELA: All hail Dimitri Mendeleev – the 'Father of the periodic table'.

SUNAYANA: Yes, however although his table arranged the atoms by their atomic weight he did also swap around some elements because of their properties as that made them fit better. This insight eventually was shown to be correct when the existence of isotopes was discovered.

TULELA: Remember, isotopes of an element are different forms of the same element. So, same number of protons but different number of neutrons – have a listen to episode 4 for a quick refresh.

SUNAYANA: Not accounting for isotopes would have led to a few elements ending up in the wrong columns, like iodine and tellurium. Tellurium has a greater atomic weight than iodine but one fewer proton so would have been placed after iodine on Newland's and Dalton's tables instead of before as in the modern table. So instead of arranging by atomic weight, which is the number of protons plus neutrons, the modern periodic table arranges the elements by atomic number.

TULELA: Just the number of protons.

SUNAYANA: Let's look a little bit more detail at the table itself. It might be useful if you have a copy of one in front of you or one on your classroom wall.

TULELA: Either way, make sure you find the one issued by your exam board if you look it up online.

SUNAYANA: You'll see that as we go from left to right across the table, the atomic number increases by one and these horizonal rows are called periods, and the period that each element belongs to represents the number of electron shells that the atom has.

TULELA: So for example, the second row down – or period 2 – is lithium, beryllium, boron, carbon, nitrogen, oxygen, fluorine and neon and each of these elements has two electron shells.

SUNAYANA: And as we go down the vertical columns, the groups, the elements all have the same number of electrons in their outer-shell.

TULELA: So in group 1 (ignoring hydrogen for the moment) we have lithium, sodium, potassium and so on – all have one outer-shell electron.

SUNAYANA: Whereas group 7, fluorine, chlorine, bromine, iodine all have seven.

TULELA: And group 0, the far-right column with helium, neon, argon and krypton have a complete outer-shell.

SUNAYANA: Elements in the same group have similar properties. For example, in group 1 (that group with lithium, sodium etc.) are all called alkali metals with relatively low melting points and can all be cut with a knife.

TULELA: You'll see that between group 2 and group 3 there's a gap where there's a block of elements with similar properties and these are called transition metals.

SUNAYANA: Time for a quick quiz. Write your answers down, here goes. I'll give you an element and you tell me what period and group it's in on the table and therefore how many electron shells it has and how many electrons in its outer shell. It would help if you've got a periodic table in front of you.

TULELA: Go for it.

SUNAYANA: Nitrogen.

TULELA: The answer is period 2. Group 5. Two shells. Five electrons in the outer shell.

SUNAYANA: Sodium.

TULELA: That answer is period 3, group 1. So three shells and one electron in the outer shell.

SUNAYANA: And, argon.

TULELA: That's period 3. Group 0. So three shells, but a full complete eight electrons in the outer shell.

SUNAYANA: Nicely done!

TULELA: Thanks, Sunayana. Time for a re-cap.

SUNAYANA: The periodic table developed when the early chemists attempted to list the known elements into some kind of order.

TULELA: The early periodic table was arranged by atomic weight and the properties of the elements. Mendeleev added to this by rearranging the order of some and leaving gaps where he predicted unknown elements would be found.

SUNAYANA: His table is the basis of the one we use today, although we order by atomic number not weight.

TULELA: The rows are the different periods and defines how many electron shells there are in the atom.

SUNAYANA: The columns are the groups and define how many electrons there are in the outer shell.

TULELA: Elements in the same group have similar chemical properties. In the next episode, there'll be more on the periodic table, specifically group 1, 7 and 0.

SUNAYANA: I'm Dr Sunayana Bhargava.

TULELA: And I'm Tulela Pea.

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