BBC Bitesize - Chemistry

Episode 2 – Properties of ionic compounds

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 second episode in an eight-part series on bonding, structure and properties. In this episode, we're going to look at properties of ionic compounds and how we can represent the structure of ionic compounds with different diagrams and the advantages and disadvantages of each.

TULELA: Remember to have a pen and paper handy to take notes and draw diagrams along the way. Let's do it.

SUNAYANA: On the previous episode, we looked at how ionic bonding occurs between metals and non-metals to form ionic compounds.

TULELA: Quick recap, the metals in group 1 or group 2 of the periodic table donate their outer shell electrons to non-metals in groups 6 or 7. The metals become positively charged ions and the non-metals negatively charged ions.

SUNAYANA: And the electrostatic force of attraction between these oppositely charged ions is ionic bonding.

TULELA: And we looked at how we could represent this in a dot and cross diagram showing the transfer of the outer shell electron from the metal to the non-metal.

SUNAYANA: OK. Let's now look at why that dot and cross diagram doesn't give us the full story. It only shows the bonds and transfer of electrons between two or three ions and in two dimensions. In the real 3D world, ionic compounds are formed in giant lattices built of lots of ions where the forces act in all directions of the lattice.

TULELA: If you imagine, for example, our old favourite table salt sodium chloride – NaCl – just one grain may contain about one quintillion sodium and chloride ions. That's one with 18 zeros after it. Each sodium ion in the lattice is bonded to a chloride ion above, below, to its left, to its right, behind and in front. And the same is true for each chloride ion – they're bonded to a sodium ion in all directions. You can think of this lattice as a regular repeating ordered pattern of those ions.

SUNAYANA: You'd need a pretty large sheet of paper to draw one quintillion dot and cross diagrams in a three-dimensional lattice.

TULELA: You're right about that. It can be tricky to draw exactly what an ionic compound looks like, but we can use different models to help us.

SUNAYANA: Models in science are a convenient way for us to imagine sometimes complex ideas and each model has its advantages and disadvantages, but taken together they aid our understanding. So, let's have a look at what models we can use to describe ionic compounds.

TULELA: We've looked at the dot and crosses diagrams already and seen that they're good for showing how electrons transfer from the metal atom to the non-metals. However, they don't tell us anything about the size of the atoms nor how they are arranged in the lattice.

SUNAYANA: We can also represent the compound in two dimensions by showing what atoms are in the compound and how the ions of these atoms are connected. And also to give an idea of the relative size of the ions.

TULELA: Let's take the example of sodium chloride. Grab that pen and paper and draw along. **I**f you have a couple of different size coins, say a 10p and a 5p, first draw around the 10 pence coin.

SUNAYANA: Representing the chloride ion.

TULELA: On a blank page and then next to it draw a five pence coin.

SUNAYANA: Representing the smaller sodium ion.

TULELA: Make sure that the two circles you've drawn touch each other but don't overlap, and alternate these across the sheet. Then, on the next row down, start with the 5p and alternate again with the 10p and so on. Eventually, you'll build up a two-dimension space filling model of the lattice.

SUNAYANA: Pretty useful as it shows how the ions are arranged in one layer of the lattice. But it doesn't show how all the other layers fit together.

TULELA: For that, we need to venture into – de-de-de-de de-de-de-de – the third dimension.

SUNAYANA: **I**t's not that mysterious, Tulela. A 3D space filling model is a bit trickier to imagine, but there are some great diagrams on the BBC Bitesize chemistry webpages.

TULELA: We can also make 3-dimensional structures using balls and sticks, where the balls represent the ions and the sticks represent the bonds. We can draw these on paper but again this has a limitation of trying to represent something in 3D on a flat 2D page – or, we can create them in our wonderful 3D world using plastic model kits or computer models.

SUNAYANA: In each case, they are helpful to visualise the structure as we can rotate them to look around the lattice and get a much better idea of the shape of the ionic compound.

TULELA: But they are also misleading as the sticks make it look as though there's a lot of space between the ions when, in reality, there isn't. The forces between the ions are in all directions, not just along the length of the sticks keeping the balls together.

SUNAYANA: So, there are various models to help us visualise the structure of that giant ionic compound lattice.

TULELA: In which strong electrostatic forces of attraction act in all directions between the oppositely charged ions.

SUNAYANA: And it's that very structure and the bonding that helps to explain the physical properties of ionic compounds.

TULELA: If we look at melting and boiling points first. Since those electrostatic forces between the ions are strong, it takes a lot of energy to overcome them, and so ionic compounds have high melting and boiling points.

SUNAYANA: For example, sodium chloride melts at just over 800 degrees Celsius and boils at around 1400 degrees Celsius.

TULELA: When it's a solid, the ions in the lattice are held together by that same strong force, and so the solid compound cannot conduct electricity, since electricity is simply the flow of charged particles from one place to another. Ions can't flow when it's a solid.

SUNAYANA: However, if we melt the solid, or dissolve it in water, in this state as a liquid those ions separate and are all free to move. So in this state, an ionic compound can conduct electricity as charge can now flow.

TULELA: You know Sunayana, we haven't heard from our AI chatbot NNICK this episode. I think we need to give him something to do... Hi NNICK, can you give us a quick multiple-choice quiz based on the structure of ionic compound lattices? And do write down your answers, dear podcast listening friends, as we go along.

NNICK: It's the ionic bonding multiple choice quiz. Question 1: Are ionic bonds held together by: a) glue b) string c) hopes, dreams and wishful thinking d) electrostatic forces, or e) intermolecular forces.

TULELA: That would be electrostatic forces.

NNICK: Question 2: The dot and cross ionic bonding diagram is limited because: a) it gives no information about bonding b) it does not show the 3D shape of the molecule or c) Yes.

SUNAYANA: Answer B – it doesn't show the 3D shape of the compound.

NNICK: Question 3: True or false? When ionic compounds are dissolved in water they cannot conduct electricity. a) true b) false c) none of the above. Hmm, that's a tricky one.

SUNAYANA: False – ionic compounds can and do conduct electricity in water – and there'll be more on this in series 3.

NNICK: That's the end of the quiz.

SUNAYANA: Thanks, NNICK. Quick summary of ionic compound structures, Tulela?

TULELA: Indeed. Ionic compounds have a giant ionic lattice structure.

SUNAYANA: The ions are held together by strong electrostatic forces of attraction.

TULELA: We can visualise the structure in 2-dimensional drawings as well as 3-dimensional models. Each model has advantages and disadvantages.

SUNAYANA: And the structure and bonding in ionic compounds explains their high melting points and whether it conducts electricity if solid or liquid.

TULELA: 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.

SUNAYANA: Bye.