BBC Bitesize - Chemistry

Episode 4 – Properties of giant covalent 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 fourth episode in an eight-part series on bonding, structure and properties.

TULELA: On this episode, we’ll look at the structures of large covalently bonded structures, such as polythene.

SUNAYANA: And diamond.

TULELA: Looking at the strength of the different bonds involved and how they relate to the properties of those substances. Remember to have a pen and paper handy to take notes and draw diagrams along the way. Let’s do it.

Quick reminder that in the previous episode, we looked at simple covalently bonded molecules, where electrons are shared between a fixed number of atoms to complete their respective outer shell. Simple molecules such as hydrogen, oxygen, water and methane are bonded that way.

However, simple molecular structures aren’t the only compounds held together by covalent bonds – giant molecular structures are as well.

SUNAYANA: In these giant structures, all the atoms in the substance are held together by strong covalent bonds. Before we get into the nitty gritty, NNICK can you give us an overview of these giant structures?

NNICK: Whilst simple covalently bonded structures are teeny tiny, other covalently bonded substances have molecules that are comparatively very large. Huge. Enormous. For example, polymers.

The forces between large polymer molecules are stronger than those between small molecules, so polymers have relatively higher melting points.

Giant covalent structures, on the other hand, can be comparatively gargantuan. Humungous. Prodigious. Jumbo. King size. Voluminous. Really big. They contain many, many, many, many atoms, each joined to adjacent atoms by covalent bonds.

SONG

It's big
It's enormous
It's a long polymer molecule
Whose atoms are bonded with covalent strength

It's immense
It's gigantic
It's a long polymer molecule
A chain that's many thousands of atoms in length

It's even bigger
It's colossal
It's a giant covalent structure
With a melting point which seems to be exceedingly high

It's gargantuan
It's humungous
It's a giant covalent structure
To which the word molecule doesn't apply

TULELA: Thanks, NNICK. So in a giant covalent structure all the atoms are bonded strongly together and this makes the structure very strong. A nice analogy is to picture a spider weaving a strong complex web with each thread representing a covalent bond. And where the threads intersect corresponds to where the atoms are in the structure. Breaking a single thread, the covalent bond, won't affect the overall strength of the web, just as breaking one bond in a giant covalent structure doesn't weaken the entire structure.

SUNAYANA: That's a nice way to think about them, Tulela, unless you don't like spiders. And unlike the links in a spider web, the individual covalent bonds are very strong. And since those covalent bonds are strong, we find that most giant covalent structures have very high melting and boiling points as a lot of energy is needed to break those bonds.

TULELA: And most giant covalent structures have no charged particles that are free to move and so this means that most cannot conduct electricity.

SUNAYANA: Although one exception to this is graphite which is a particular giant structure of carbon and we'll look at why this is in episode 6 of the series.

TULELA: Let's stay with carbon for the moment as it's a very good example of how it forms different giant structures. For example, graphite as you've mentioned Sunayana, is where each carbon atom is covalently bonded to three others and this creates sheets of carbon atoms arranged in hexagons.

SUNAYANA: In a diamond, each carbon atom is bonded to four others in a very rigid lattice - a tetrahedral arrangement.

TULELA: And one other example that it's useful to know is silicon dioxide which is also called silica. This is a compound found in sand with many repeating patterns of silicon and oxygen atoms linked together by covalent bonds in a regular arrangement forming a giant structure.

SUNAYANA: You can see diagrams of all of these structures on the Bitesize website.

TULELA: Hey Sunayana, I bought you a present. It's a giant covalently bonded structure.

SUNAYANA: Ooh, a polythene bag. What's inside? You haven't bought me… a diamond?

TULELA: Not quite.

SUNAYANA: There's nothing inside it, Tulela.

TULELA: I know, that's the present. A polythene bag – a perfect example of a giant covalent structure.

SUNAYANA: As is a diamond.

TULELA: And a polythene bag is also an example of a polymer, which is a very long chain molecule made up of lots of repeating units called monomer.

SUNAYANA: And in the case of polyethene (also known as polythene) the monomer that is repeated is ethene, which has the formula C_2H_4. We can show this in a diagram of a long chain of repeating carbon and hydrogen atoms, which is the polymer, or we can just show the bit that repeats.

TULELA: Again, visit the Bitesize website for useful diagrams of this.

SUNAYANA: When I think about polymers and monomers, I imagine a necklace made of identical beads. Each bead represents a monomer, and the entire necklace is the polymer. Just as you can extend the necklace by adding more beads, polymers can grow by adding more monomers in a repetitive fashion.

TULELA: The intermolecular forces between polymer molecules are strong compared to the intermolecular forces between small molecules. And this is why polymers have higher melting and boiling points than simple covalent compounds, but lower melting and boiling points than giant covalent structures.

SUNAYANA: Polyethene is just one kind of polymer and there are loads of others but let's look at why polymers are so important in chemistry.

TULELA: First up, because some polymers are man-made different types of man-made polymers are tailored to have a wide range of specific properties depending on what we want to use them for. We've seen that they can be very strong but many of them are also lightweight and resistant to corrosion which is useful in industries such as building cars and planes. And the production of polymers can be cost-effective, especially for large-scale manufacturing.

SUNAYANA: Sounds too good to be true. What about their disadvantages we should be aware of?

TULELA: Absolutely. There's a concern about how biodegradable or recyclable they are.

SUNAYANA: As with all substances in chemistry, it sounds like it's good to know more about the properties and how the substance is actually used in the real world to understand more about its potential good and bad sides.

TULELA: Quiz time! Here's three giant structure questions for you to have a go at. We'll give you 5 seconds on each.

SUNAYANA: Or you can pause after each question and take as long as you like.

TULELA: Question 1: What type of giant covalent structure is formed by each carbon atom bonding to four other carbon atoms in a tetrahedral arrangement?

SUNAYANA: That'll be my diamond.

TULELA: I guess it will be. Question 2: Why does a diamond have a high melting point and hardness?

SUNAYANA: It has a giant covalent structure with strong bonds.

TULELA: And question 3: In the formation of a polymer, what is the name of the small, repeating unit that links together to create the polymer chain?

SUNAYANA: That'll be a monomer.

TULELA: And how did you do? Don't write in as there are no prizes, just the self-satisfaction and glory of being right.

SUNAYANA: Final summary of giant covalent structures, Tulela?

TULELA: Yep. You start.

SUNAYANA: OK. Giant covalent substances are very large structures where molecules are linked by covalent bonds.

TULELA: The strength of the bonds throughout the structures mean that they tend to have high melting and boiling points.

SUNAYANA: But most don't conduct electricity as there are no freely moving charged particles.

TULELA: Silicon dioxide is an example as are two forms of giant carbon structures which are graphite and - go on, Sunayana...

SUNAYANA: Diamond.

TULELA: And polymers are large structure covalent compounds where chains of monomers are linked together by those strong covalent bonds.

SUNAYANA: More about covalent bonding can be found on the Bitesize website and there's more Chemistry and combined science topics in other episodes in this series.

TULELA: In the next episode, we'll look at the final type of bonds that we need to know about – metallic.

SUNAYANA: Thanks for listening to me, Sunayana

TULELA: And me, Tulela. Bye.