# BBC Bitesize - Chemistry

# Episode 5 – Metallic bonding

**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.

**SUNAYANA:** This is the fifth episode in an eight-part series on bonding, structure and properties. In this episode, we're going to look at metallic bonding and properties of metals.

**TULELA:** And specifically how metal atoms are bonded together and how this relates to their structure and properties and how we can mix metals together to make alloys which have other really useful properties.

**SUNAYANA:** As always, it might be handy to write some notes or diagrams along the way, so hit pause when you need to. Don't worry, we'll still wait for you to hit play again.

**TULELA:** In previous episodes of this series, we've looked at the other two types of bonding we need to know about.

**SUNAYANA:** If you need a quick refresh, listen back to those episodes whenever you like.

**TULELA:** In this episode, we're looking at metals and how these elements are bonded.

**SUNAYANA:** We're all so familiar with them on a daily basis, from the jewellery that you are wearing, the electric wires charging your phone.

**TULELA:** Or the cutlery you use to make and eat your food.

**SUNAYANA:** But what, in terms of chemistry, makes a metal a metal? Grab a pen to make some notes. Time to bond with our own metallic maestro NNICK! Hi NNICK, easy question this time, what makes a metal a metal?

**NNICK:** Oh I love these. I don't know, what makes a metal a metal?

**SUNAYANA:** No, it's not a joke, I really want to know.

**NNICK:** Oh OK. What makes a metal a metal?

*SONG*

**NNICK:** Do you react to form positive ions?

**ELEMENT:** Yes I do.

**NNICK:** Then you're a metal. [ELECTRIC GUITAR]

**NNICK:** Do you react to form positive ions?

**ELEMENT:** No I don't.

**NNICK:** Then you're not a metal. [FLUTE]

**NNICK:** Are you found to the left and towards the bottom of the periodic table [LOW VOICE]?

**ELEMENT:** Yes I am.

**NNICK:** Then you're a metal. [ELECTRIC GUITAR]

**NNICK:** Are you found towards the right and top of the periodic table [HIGH VOICE]?

**ELEMENT:** Yes I am.

**NNICK:** Then you're not a metal. [FLUTE]

**NNICK:** Are you one of the majority of elements?

**ELEMENT:** Yes I am.

**NNICK:** Then you're a metal. [ELECTRIC GUITAR]

**NNICK:** Are you a non-metal?

**ELEMENT:** Yes I am.

**NNICK:** Then you're not a metal.

**TULELA:** Thanks, NNICK. So metal atoms form positive ions when they lose their outer shell electrons and this gives a clue as to how they are bonded together.

**SUNAYANA:** Metals consist of giant structures in which the positive ions are tightly packed together in a regular pattern and where the outer shell electrons are free to move around.

**TULELA:** They are delocalised?

**SUNAYANA:** Indeed they are - and these delocalised electrons are free to move through the whole structure.

**TULELA:** There are strong electrostatic forces of attraction between the positive ions and the negative sea of delocalised electrons.

**SUNAYANA:** And this sharing of delocalised electrons is the metallic bonding that holds the atoms strongly together within the structure. I like to imagine this to be like a busy restaurant where the tables are the positive metal ions, and the waiters are the delocalised electrons moving in between the tables keeping everyone happy and the restaurant together.

**TULELA:** I love the way your brain works.

**SUNAYANA:** So, a metallic bond occurs because of those delocalised electrons moving freely around the metal ions. And they are responsible for the electrical and thermal conductivity of the metal.

**TULELA:** Aha, yes! If we recall that the definition of electricity is simply the flow of charge. And we can see that since those delocalised electrons do just that, they carry the electrical charge through the metal and so all metals are good electrical conductors.

**SUNAYANA:** They are also good conductors of heat for exactly the same reason - those delocalised electrons transfer thermal energy very easily.

**TULELA:** And because metallic bonds are generally strong due to the electrostatic attraction between the positive metal ions and the sea of negative electrons, most metals have high boiling and melting points.

**SUNAYANA:** Sounds like all metals have really amazingly strong properties. But if you just give me your copper bracelet for a moment.

**TULELA:** Really? OK.

**SUNAYANA:** I can do this really easy.

**TULELA:** Hey, don’t bend it.

**SUNAYANA:** It's OK, I can bend it back. There you go.

**TULELA:** Thanks.

**SUNAYANA:** Pure metals are malleable, they can be easily deformed and bent because since the ions are all the same size, the layers of ions in the structure – those identical regular arrangements – can easily slide over each other. It's a bit like bending a pack of cards where each layer slides past each other. That means that pure metals aren't strong enough for particular uses.

**TULELA:** And that's why we combine metals together to form alloys.

**SUNAYANA:** Right. People has been doing this for thousands of years. For example, bronze is an alloy of copper and tin, and its discovery marked the beginning of the Bronze Age which saw the replacement of pure copper tools and weapons with more durable and harder bronze ones.

**TULELA:** And what's happening on an atomic level in alloys is that there are atoms of different sizes mixed together – and the structure is no longer regular like a pure metal. The different size atoms distort the layers and so greater forces are needed for those layers to slide over each other.

**SUNAYANA:** And so alloys are harder than pure metals – although they have all those other metallic properties – they conduct electricity and heat well because of the metallic bonding in their structure.

**TULELA:** And you can see some diagrams of the structures of pure metals and alloys on the Bitesize website.

**SUNAYANA:** Quick refresher quiz – three questions, 5 seconds each, write your answers down.

**TULELA:** Question 1: what type of bonding is present in metals?

**SUNAYANA:** It's not a trick question – the answer is simply metallic bonding.

**TULELA:** Question 2: what is the key characteristic of metallic bonding that allows metals to conduct electricity?

**SUNAYANA:** Answer – those delocalised free moving electrons – remember those restaurant waiters.

**TULELA:** And question 3: copper is used in wires because one of its properties is that is it malleable. Why does it have that property?

**SUNAYANA:** It's those layers of same-sized ions being able to slide over each other easily, like bending a pack of cards.

**TULELA:** How did you do? Don't answer because we can't hear you but if you need any more on metallic bonding or other topics in chemistry head over to the Bitesize website. Summary time, Sunayana?

**SUNAYANA:** You bet. Metals consist of giant structures of tightly packed positive ions in regular patterns and delocalised electrons.

**TULELA:** The negative electrons are free to move through the structure and give rise to strong metallic bonds.

**SUNAYANA:** Metals are good conductors of electricity and heat.

**TULELA:** Most metals also have high melting and boiling points.

**SUNAYANA:** Pure metals tend to bend easily because of their structure of regular layers of same size ions.

**TULELA:** Other metals are mixed to make alloys which are harder.

**SUNAYANA:** In the next episode, we'll be looking at some different identities of giant structures of carbon which are called allotropes.

**TULELA:** Bring it on.

**SUNAYANA:** To hear more, search 'Chemistry' on BBC Sounds.