BBC Bitesize - Chemistry

Episode 4 – Redox reactions

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 chemical changes. In this episode, we're going to look at processes known as redox reactions.

TULELA: Red-uction, which is the loss of oxygen.

SUNAYANA: And Ox-idation, which is the gain of oxygen.

TULELA: And we'll look at how carbon can be used to extract pure metals from some metal oxides.

SUNAYANA: And we'll have a quiz and summary of the main facts.

TULELA: Great, let's go.

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 wait for you to hit play again!

TULELA: And also hit rewind if you need to go over some of those key facts. And remember to head over to BBC Bitesize on the web for more useful information and diagrams.

SUNAYANA: Before we get into the details of the reaction between metals and oxygen, let's get some background on why these reactions are relevant and important in the real world.

TULELA: Time for an overview from our AI chat-bot NNICK. Hi NNICK – can you tell us about the relevance of the reaction between metals and oxygen please?

NNICK: Ooh, I know the answer to this one! Pick me, pick me! Oh I see, you already picked me…

Many metals react with oxygen to make metal oxides. How enthusiastically metals react with oxygen depends on their reactivity. For example, magnesium is pretty keen, but gold can't really be bothered. If the iron in your steel infrastructure reacts with oxygen and water it forms an iron oxide called rust. In summary, it's like that old song…

SONG

You shouldn't let that oxygen settle – on your metal.

Otherwise it's no surprise – your metal may oxidise.

If building an infrastructure out of steel has appeal,
You won't, I trust, want it to rust – and crumble into dust.

To protect your treasured metal creation from oxidation,
You'd need, I'd say, to find a way – to keep oxygen at bay.

Try coating, painting, galvanising and lubricating – or electroplating.
And as advised your metal prized, will stay unoxidised.

SUNAYANA: Thanks NNICK! So if something, in this case a metal, gains oxygen it is oxidised. A good example of this is iron. Take an iron nail and leave it in damp air for a while and it will rust. That rust is iron oxide. The iron has gained oxygen so it has been oxidised.

TULELA: Because iron rusts – or oxidises – so easily is the reason why pure iron is rarely found on Earth, but mostly in iron ores – those iron oxide compounds.

SUNAYANA: And why iron doesn't rust in space, because of the lack of oxygen!

TULELA: You had to get that astronomy fact in there, didn't you!

SUNAYANA: Always! But keeping on with that same idea is the reason why most metals are also found in the Earth's crust as ores rather than in their pure metal form – because they oxidise easily.

TULELA: These ores are mainly oxide compounds, like iron oxide. But some are carbonates like calcium carbonate.

SUNAYANA: And an ore is simply a rock that contains enough of a metal to make it worth extracting that metal for profit.

TULELA: In episode 2 we looked at the idea of a reactivity series that lists metals in order of their reactivity. Have a listen back to that if you need a quick refresh. We saw that metals higher in the series are more reactive and metals lower in the series are less reactive.

SUNAYANA: In terms of oxidation this means that those higher in a series – like potassium, sodium and aluminium – oxidise much more easily than those lower like copper. So they form oxides, or corrode, much faster than those lower down.

TULELA: And the metals at the very bottom of the reactivity series – silver, gold and platinum – are all found in their pure form as they are so unreactive, they are resistant to oxidation.

SUNAYANA: So if you're lucky to find some pure gold or silver then your job's done. But if you want to extract a pure metal from one that does oxidise easily then you've got a little bit more work to do.

TULELA: This extra work is to remove the oxygen from the metal compound. And that's the opposite of oxidation and is called reduction.

SUNAYANA: So oxidation is the gain of oxygen, and reduction is the loss of oxygen. And one way to reduce an oxidised metal is by using carbon – but only if the metal is below carbon in the reactivity series. That's because carbon can only take away oxygen from metals less reactive than itself.

TULELA: That's important to remember. If a metal is more reactive than carbon – ie higher in the reactivity series, then we need to use electrolysis to reduce it from its oxide. And we'll talk about that in episode 7 of this series. For now, let's think about metals that are less reactive than carbon.

SUNAYANA: Let's keep with our iron oxide example and extract pure iron. Iron oxide, in this case Fe_2O_3 is added into a blast furnace – basically a huge and very hot container – to which is added carbon in the form of coke.

TULELA: And that coke is the carbon-based fuel – not the drink!

SUNAYANA: Absolutely. Because iron is lower in the reactivity series than carbon, the carbon reduces the iron ore to produce iron and carbon dioxide. You can find a diagram showing this and descriptions of intermediate steps in the process on the BBC Bitesize website.

TULELA: Hang on, Sunayana. If the iron oxide has been reduced by carbon and the product is iron and carbon dioxide, then has the carbon been oxidised?

SUNAYANA: Exactly! The carbon has gained oxygen which is the definition of oxidation. And this shows that every time a reduction reaction happens, an oxidation reaction also happens. Hence redox. You can't have one without the other.

TULELA: Noted!

How about a quick redox quiz for our lovely podcast listening friends?

SUNAYANA: You took the words out of my mouth. Three questions, five seconds for you to ponder. Hit pause if you need extra time to write your wonderful answers down.

TULELA: I'm sure they'll ace it. Question 1. Why is iron found in ores rather than as an uncombined element in the earth?

SUNAYANA: Because iron oxidises easily in air and moisture to form iron oxide – or rust.

TULELA: Question 2. Why can we use carbon to get pure iron from its ore?

SUNAYANA: Carbon is higher in the reactivity series than iron and so can reduce its ore by removing the oxygen.

TULELA: And question 3. Why can we find pure gold on earth?

SUNAYANA: Because it doesn't oxidise to form ores as it is so unreactive.

TULELA: Hope you got those! A lump of gold if you did, but you have to find it yourselves.

SUNAYANA: And a rusty nail if you didn't, which you can turn back to pure iron if you have a blast furnace handy.

SUNAYANA: Time for a summary, Tulela?

TULELA: Summarise away, Sunayana.

SUNAYANA: When something gains oxygen in a reaction it is oxidised.

TULELA: And when metal oxides lose oxygen they are reduced.

SUNAYANA: We can use carbon to reduce metal oxides only if the metal is less reactive than carbon in the reactivity series.

TULELA: In this case the metal oxide is reduced whilst the carbon is oxidised.

SUNAYANA: Oxidation and reduction always take place at the same time hence these are called redox reactions.

TULELA: In the next episode we'll have more on oxidation and reduction but this time in terms of the exchange of electrons!

SUNAYANA: Exciting! See you then.

TULELA: Bye!