BBC Bitesize - Chemistry

Episode 5 – Redox in terms of electrons

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. This is the fifth episode in an eight-part series on chemical changes.

SUNAYANA: In this episode, we're going to look at redox reactions in terms of the gain or loss of electrons. And we'll be saying "oil rig" over and over again. Because "oil rig" is a nice way to remember which is which.

TULELA: We'll be looking at ionic equations in these displacement reactions.

SUNAYANA: We'll be chatting about the use of half-equations to help us determine which of the substances involved are oxidised or reduced.

In the previous episode we looked at redox reactions – those in which oxidation and reduction was occurring – from the point of view of gain or loss of oxygen. Have a listen to that episode if you need a refresh.

TULELA: We defined oxidation as a gain of oxygen, and a reduction as the loss of oxygen. In many cases, we can indeed explain a reaction in terms of the change in oxygen content. But sometimes, especially when oxygen isn't involved in the reaction, an explanation is needed in terms of electrons. Time to call our AI know-it-all for some background. Hi NNICK! Can you tell us why it's useful to explain oxidation and reduction in terms of electron transfer please?

NNICK: Hmm – this sounds like a case for… Detective Inspector NNICK! I've gathered you here because you are all suspects in the case of missing oxygen.

CROWD: What?

NNICK: Yes. Last evening, magnesium was oxidised after reacting with chlorine to form magnesium chloride.

CROWD: [Gasps] No!

NNICK: And the question I put to you all, whoever you are, is – if magnesium was oxidised, where is the oxygen? One of you must have hidden it.

CROWD: No!

NNICK: What do you have to say for yourselves? Yes, you at the back with the squeaky voice.

SUSPECT: Oxidation is loss of electrons.

CROWD: [Gasps] What?

SUSPECT: Yes – magnesium lost electrons and was oxidised. While chlorine gained electrons and was reduced.

NNICK: So you're saying that electron transfer is a useful way to understand oxidation, especially in cases like this where there's no oxygen involved?

SUSPECT: Yes.

NNICK: Right, well, then you are all free to go.

CROWD: Hurray!

TULELA: Thanks NNICK. So if a substance loses electrons in a chemical reaction, then it has been oxidised. And if it gains electrons it has been reduced.

SUNAYANA: And this is where "Oil Rig" is a good way to remember – because "Oil Rig" O-I-L R-I-G stands for Oxidation Is Loss. Reduction is Gain. But only use "Oil Rig" when we are talking about electron loss and gain, NOT about oxygen.

TULELA: Got ya! OIL RIG only for loss and gain of electrons not oxygen!

SUNAYANA: Hi NNICK – can you give a summary about "oil rig"?

NNICK: Oil rig [**CHORUS:** O-I-L]. Oxidation is loss [**CHORUS:** of electrons]. Oil rig [**CHORUS:** R-I-G]. Reduction is gain [**CHORUS:** of electrons]. Oil rig.

SUNAYANA: Thanks NNICK – nice singing!

TULELA: Let's have an example to illustrate this. How about describing the reaction between magnesium and copper sulfate solution in which the magnesium displaces the copper from the sulfate solution and we're left with magnesium sulfate and copper.

SUNAYANA: So this is one of those displacement reactions that we talked about in episode 2 of this series – where a more reactive element displaces a less reactive one from a solution of its compound.

TULELA: Right – we start with the magnesium which is neutral. And end with magnesium sulfate. So in this case the magnesium has lost two electrons, becoming a magnesium 2+ ion in order to bond with the sulfate.

SUNAYANA: O-I-L – oxidation is loss of electrons.

TULELA: So the magnesium has been oxidised. And the copper, which was originally an ion in the sulfate solution has been displaced from the solution by gaining two electrons to become neutral copper.

SUNAYANA: R-I-G – reduction is gain of electrons.

TULELA: So the copper ions have been reduced. Maybe our dear podcast listening friends might want to try one which we can work through.

SUNAYANA: How about the reaction between aluminium and iron oxide which produces aluminium oxide and iron? Press pause whilst you think about what has been oxidised and what has been reduced in terms of electron transfer. But remember to press play again or we'll be waiting for ages.

PAUSE

TULELA: Ah, there you are. We started with iron (or Fe) as a positive ion bonded to oxygen in the compound iron oxide and finished with neutral iron – so the iron ions have gained electrons…

SUNAYANA: R-I-G – reduction is gain of electrons.

TULELA: …and have been reduced. And so the aluminium which started as neutral but ended up losing electrons to form a positive aluminium ion in aluminium oxide and so…

SUNAYANA: O-I-L – oxidation is loss of electrons.

TULELA: …aluminium has been oxidised.

TULELA: Sometimes in these redox reactions it's useful to look at what's happening at the oxidation and reduction parts individually. And this is where this idea of half-equations come in.

SUNAYANA: The oxidation half-equation represents the reaction that involves the loss of electrons. And it shows the atom or ion that has been oxidized, the electrons lost, and the products formed.

TULELA: The reduction half-equation represents the reaction that involves the gain of electrons. And it shows the atom or ion that has been reduced, the electrons gained, and the products formed. It's important to ensure that the number of electrons lost in the oxidation half-equation equals the number of electrons gained in the reduction half-equation to maintain charge neutrality.

SUNAYANA: So let's go back to our example from earlier with the reaction between magnesium and copper sulfate. For the oxidation half-equation we concentrate only on the magnesium as this is what has been oxidised to magnesium 2 plus ion. And our half-equation would be written as Mg (for magnesium) goes to Mg 2 plus, to show that it's become an ion, plus 2 e minus showing the two electrons that have been lost.

TULELA: And in the reduction half-equation, we concentrate on only on the copper. This started off as copper ion which were reduced by gaining electrons to become neutral copper. And so we'd write this half equation as Cu (for copper) 2 plus, as it was an ion in the sulfate, plus 2 e minus (those two electrons) goes to Cu.

SUNAYANA: If you didn't quite follow that, you can rewind and relisten or find it written down on the Bitesize website. Remember, half-equations show only the relevant atom or ion which either lose electrons in the oxidation half-equation or gain electrons in the reduction half-equation.

TULELA: If we do want to include all the ions in an equation – and sometimes that's also useful to check whether all the charged balance out nicely – we use an ionic equation.

SUNAYANA: In an ionic equation, we combine the two half-equations but don't include anything else that hasn't lost or gained an electron. And these are called spectator ions.

TULELA: So remember the difference. Ionic equations show all the ions that change in terms of their charge in a reaction. And half-equations show what is happening to one atom or ion, whether it is being oxidised or reduced.

SUNAYANA: How about an electron transfer-based redox quiz, Tulela? Three questions, five seconds each, press pause and write down the answers.

TULELA: Question 1. In terms of electron transfers, what is meant by oxidation?

SUNAYANA: O-I-L – oxidation is loss of electrons.

TULELA: Question 2. In a reaction between copper sulfate and magnesium, why have the copper ions been reduced to copper atoms?

SUNAYANA: Because magnesium is more reactive, copper has been displaced. The copper ions have each gained two electrons and are now neutral. R-I-G – reduction is gain of electrons.

TULELA: And question 3. In an oxidation half-equation an atom has lost two electrons to form an ion. How many electrons have been gained in the reduction half-equation of the same reaction?

SUNAYANA: That would be two. Electrons lost in one half-equation will always balance out electrons gained in the other half-equation.

TULELA: Time for a summary, Sunayana?

SUNAYANA: We can define redox reactions in terms of electron transfers.

TULELA: Oxidation is the loss of electrons.

SUNAYANA: Reduction is the gain of electrons.

TULELA: These can be shown in half-equations. The oxidation half showing the atom or ion which has lost electrons and so has been oxidised.

SUNAYANA: And the reduction half, showing the atom or ion that has gained electrons and so has been reduced.

TULELA: Ionic equations show all the ions that are changing but miss out on any so-called spectator ions that don't change.

SUNAYANA: You can listen on BBC Sounds for other episodes in this series as well as many more Bitesize podcasts.

TULELA: Thanks for listening!

SUNAYANA: Bye!

NNICK: Oil rig [**CHORUS:** O-I-L]. Oxidation is loss [**CHORUS:** of electrons]. Oil rig [**CHORUS:** R-I-G]. Reduction is gain [**CHORUS:** of electrons]. Oil rig.