BBC Bitesize - Chemistry

Episode 6 – Electrolysis of molten solutions

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TULELA: And I'm Tulela Pea, a science communicator and podcaster.

SUNAYANA: And this is Bitesize Chemistry.

TULELA: And this is Bitesize Chemistry. This is episode six in an eight-part series on chemical changes. In this episode, we're going to look at electrolysis of molten solutions.

SUNAYANA: We'll define what electrolysis is, on what molten compounds it can be used and what's going on in terms of oxidation and reduction of the ions involved.

TULELA: As always it might be handy to write down some notes or diagrams along the way. So hit pause where you need to. Don't worry, we'll wait for you to hit play again!

SUNAYANA: And remember to head over to BBC Bitesize on the web for more useful information and diagrams.

TULELA: OK, we're going to be spending the next three episodes getting to know electrolysis so that by the end of the series electrolysis will be your new best friend.

SUNAYANA: No one will replace you, Tulela.

TULELA: Aw, that's nice. In episode 5 we looked at oxidation and reduction from the point of view of electron transfers in a reaction. And this is also very relevant to electrolysis. If you need a quick refresh of that, have a relisten to that episode and you'll be fully up to speed.

SUNAYANA: Before we welcome electrolysis into our lives, let's get some background on what it is and why it's useful. Hi NNICK! Can you give us a brief introduction to electrolysis please?

NNICK: Electrolysis involves the decomposition of electrolytes – ionic compounds or solutions – into their constituent elements, or ions.

Imagine a molten ionic compound containing positive and negative ions. An electric current is passed through it using a pair of electrodes. Because the compound is molten, its ions are free to move.

Let's represent a negative ion, or anion, with this sound [BOING]

And let's represent a positive ion, or cation, with this sound [MIAOW]

If I go all the way over to one side [GOES LEFT]:

[MISERABLE VOICE] I'm the negative electrode, or cathode. And positive ions are attracted to me. [LOTS OF MIAOWS] I give them electrons and they are reduced. [MIAOW?]

And if I go over to the other side [GOES RIGHT]:

[HAPPY VOICE] I'm the positive electrode, or anode, and negative ions are attracted to me. [LOTS OF BOINGS]. They give me electrons and are oxidised. [BOING?]

Of course, all this is going on simultaneously, which would be more like this: [CACOPHONY OF BOINGS AND MIAOWS]

SUNAYANA: Thanks NNICK. So electrolysis is the process where an ionic substance is broken down using electricity. In fact, the word electrolysis comes from 'electron' meaning 'from electricity' and 'lysis' meaning 'to split'. So literally means 'to split using electricity'.

TULELA: Nice trivia, Sunayana.

SUNAYANA: That ionic substance is called an electrolyte and can be a molten substance…

TULELA: …remembering that a molten ionic compound is simply one that is melted into its liquid state.

SUNAYANA: Or an aqueous solution – that is, one where an ionic compound has been dissolved in water.

TULELA: The compounds have to be in this liquid form so that the ions are free to move and carry the charge. And in this episode we're looking at the first type – molten.

SUNAYANA: Electrolysis also involves two electrodes – the positive anode and the negative cathode. You can remember which is which if you don't PANIC! Because PANIC, P-A-N-I-C, stands for "Positive Anode, Negative Is Cathode". And when these are connected to a power supply, an electric current flows from one to the other through the electrolyte.

TULELA: The negatively charged ions in the electrolyte are attracted to the positive anode where they lose their electrons. And so they are oxidised.

SUNAYANA: Remember "OIL RIG" from the previous episode. O-I-L stands for oxidation is loss of electrons.

TULELA: And the positive ions in the electrolyte are attracted to the negative cathode. Here, they gain electrons and are reduced.

SUNAYANA: R-I-G. Reduction is gain of electrons.

TULELA: And as the ions lose or gain electrons, they form the uncharged substance and are discharged from the electrolyte.

SUNAYANA: So the main thing to remember is that the negative ions flow to the positive electrode, the anode. And the positive ions flow to the negative electrode, the cathode. Remember that and you'll have no problem.

TULELA: And another good tip to remember is that electrolysis only works on ionic compounds and not covalently bonded ones. As, if you remember, the vast majority of covalent compounds don't conduct electricity but ionic ones do.

SUNAYANA: You know what I also find is useful? Examples. Real-life examples always bring the science to life and help me remember the facts.

TULELA: How about the electrolysis of lead bromide?

SUNAYANA: Music to my ears.

TULELA: Lead bromide it is then. Its chemical formula is $PbBr_2$. And we can use electrolysis to separate the lead and the bromine out.

SUNAYANA: We heat the solid compound in a container for heating hot substances called a crucible until it melts and then insert two carbon electrodes into the now molten electrolyte. We attach the electrodes to a power supply to allow a current to pass from one electrode to the other through the liquid electrolyte.

TULELA: And why do we choose carbon for our electrodes?

SUNAYANA: Carbon is chosen because it has a high melting point and doesn't react with the reactants or products during electrolysis.

TULELA: So let's look at what we see at those electrodes. Anode first.

SUNAYANA: At the positive anode we see bubbles of reddish-brown gas. This is the bromine vapour which has been produced as the bromide negative ions lose electrons – they are oxidised. O-I-L. Oxidation is loss.

TULELA: And at the negative cathode we see silvery liquid metal forming. This is the lead which is produced as the positive lead ions in the electrolyte gain electrons – they are reduced. R-I-G. Reduction is gain.

SUNAYANA: So in general the metal is formed at the cathode, the negative electrode, because that is where the positive metal ions are attracted. And the non-metal element is formed at the anode, the positive electrode, where the negative non-metal ions are attracted.

TULELA: How about you dear podcast listening friends try one for yourselves? And we'll walk you through the answer together. Let's go with the electrolysis of molten zinc chloride – and you identify what is the product at the anode and cathode. Press pause whilst you have a think. Write your answer down and we'll be back as soon as you press play again.

SUNAYANA: But do hit play or we'll miss you!

TULELA: So, zinc chloride was our molten substance. It's an ionic compound so we can use electrolysis to separate it. Once we've added in two electrodes and connected a power supply, what will we find at the anode and cathode?

SUNAYANA: The negative chloride ions will be attracted to the positive anode, where bubbles of chlorine gas will form. The chlorine ions have lost their electrons and so have been oxidised.

TULELA: And the positive zinc ions will be attracted to the negative cathode where zinc metal will form. The zinc ions have gained electrons so have been reduced. Hope you got both correct!

SUNAYANA: You may be asked to write half-equations describing these redox changes – and there's a reminder on the previous episode as well as on the Bitesize website.

TULELA: Quiz time for electrolysis of molten compounds, anyone?

SUNAYANA: Yes please!

TULELA: OK, usual rules, three questions, five seconds each – no prizes or we'll run out of budget. Remember to write your answers down. Here we go.

SUNAYANA: Question 1. What are the names and electric charges of the two electrodes used in electrolysis?

TULELA: That'll be the positive anode and the negative cathode.

SUNAYANA: Question 2. A molten solution of aluminium oxide is used as an electrolyte. What elements will be formed at the anode and cathode?

TULELA: The metal always forms at the cathode so in this case aluminium. And so oxygen gas will form at the anode.

SUNAYANA: And question 3. In that same electrolysis, what has been oxidised and reduced?

TULELA: Aluminium has been reduced as it has gained electrons, and oxygen has been oxidised because it has lost electrons.

SUNAYANA: Fab – you all did brilliantly. But any problems, have a look over at the Bitesize website for more.

TULELA: Quick summary before we end this episode off, Sunayana?

SUNAYANA: Let's blitz it, Tulela.

TULELA: Electrolysis is a process of splitting ionic compounds by passing electricity through them.

SUNAYANA: The liquid is called the electrolyte, and the electrodes are the anode…

TULELA: …which is positive…

SUNAYANA: …and cathode…

TULELA: …which is negative.

SUNAYANA: The metal ions in the electrolyte are reduced to form metal atoms at the cathode.

TULELA: The non-metal ions in the electrolyte are oxidised to form non-metal atoms at the anode.

SUNAYANA: And remember that electrolysis only works on ionic compounds and not covalent ones.

TULELA: In the next episode we'll look at more electrolysis, and how we use it to extract pure metals from their ores, specifically aluminium. And in episode 8 we'll look at electrolysis of aqueous solutions – that is those dissolved in water.

SUNAYANA: Can't wait!

TULELA: Bye!

SUNAYANA: Thanks for listening!