BBC Bitesize – Chemistry

Episode 1 – The pH scale

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 first episode in an eight-part series on chemical changes.

SUNAYANA: In this episode, we'll be looking at what makes an acid an acid, and an alkali an alkali.

TULELA: As well as the pH scale, strength and concentration of acids.

SUNAYANA: We'll place acids, alkalis and neutral solutions on the pH scale.

TULELA: Going from 0 to 14 real quick!

SUNAYANA: And as always, we're aided by our AI chatbot with attitude, NNICK.

NNICK: Oh I love chemistry, I adore it! Divine chemistry!

TULELA: Feel free to hit pause along the way where you need to write things down and draw some diagrams, or rewind to listen again so that those key facts stick.

SUNAYANA: Acids and alkalis are everywhere around us – for example, there's hydrochloric acid in our stomachs, and we put acid in the form of vinegar on our chips. Tulela, can you think of any other examples?

TULELA: Yeah, there are some alkalis in the cleaning products we use in our kitchen.

SUNAYANA: But what makes an acid an acid and what makes an alkali an alkali?

TULELA: A good definition is that acids are simply substances that generate hydrogen ions when dissolved in an aqueous solution, ie water.

SUNAYANA: Let's unpack that a bit – if a chemical contains hydrogen, which can be released as ions in water, then it is an acid.

TULELA: So for example when hydrogen chloride – or HCl – is added to water, that's the aqueous solution, it dissolves and the bonds between the hydrogen and chlorine break down and the hydrogen ions H-plus are formed. That means they dissociate, and so the solution is acidic.

SUNAYANA: So an acid is a substance that produce hydrogen ions when placed in aqueous solution.

TULELA: Other examples are H_2SO_4 or sulfuric acid, and HNO_3 or nitric acid. These are all examples of strong acids because the bonds in the molecules break up completely to produce a high concentration of hydrogen ions in the solution. Some acids, like ethanoic acid, are weaker because the hydrogen ions only partially break away in water.

SUNAYANA: So the difference between a strong and weak acid depends on the extent of how they ionise, or break apart, to produce hydrogen ions in water. Those that completely ionise or dissociate are strong. Those which are only partially ionised are weaker.

TULELA: Imagine in a netball game in which I was a strong player – quite effective at passing the ball. Let's say I was the chlorine in hydrochloric acid and the ball is the hydrogen that I was good at always getting rid of. I was like the strong acid which fully release its H-plus ions away in the water.

SUNAYANA: Well if I was a weak player, more like ethanoic acid, then I wasn't that good at passing, making me a weak acid which mostly just holds onto those H-plus ions and releases fewer of them in the water.

TULELA: Let go of that ball, Sunayana!

SUNAYANA: So strong acids are completely ionised, which means the H-plus ions completely break away in water – and weaker acids only partially ionise. That's acids. What about alkalis?

TULELA: Alkalis are substances that produce hydroxide ions – or OH minus ions – when dissolved in water.

SUNAYANA: So for example, when sodium hydroxide NaOH is dissolved in water, the bonds between the positive sodium ion and the negative hydroxide OH minus ion break away from each other.

TULELA: And so sodium hydroxide is an alkali. As is potassium hydroxide as both of these chemicals dissolve in water and produce hydroxide ions.

So quick recap: acids produce hydrogen ions in water. Alkalis produce hydroxide ions in water.

SUNAYANA: Stronger acids are those where the hydrogen ions dissociate more fully. Weaker acids are those where the hydrogen ions only partially dissociate in water.

TULELA: Sunayana, time for an acid test?

SUNAYANA: Ready, go for it.

TULELA: OK, I've got five food and drink substances here – a cola drink, a jar of peanut butter, mushrooms, a bottle of tap water and a grapefruit and I want you to guess where to place them from most acidic to most alkaline. Have a think for yourselves dear podcast listening friend – maybe hit pause before Sunayana gives the answer… 3,2,1…

TULELA: So that list again – a cola drink, a jar of peanut butter, mushrooms, a bottle of tap water and a grapefruit. Sunayana, over to you.

SUNAYANA: What if I told you that it was going from acidic to alkaline: cola, grapefruit, peanut butter, tap water, mushrooms.

TULELA: I'm amazed by your talents, Sunayana!

SUNAYANA: No need to be.

TULELA: And that's right! Because we know that we can measure how acidic or alkaline a substance is.

SUNAYANA: And we're talking about the pH scale, of course.

TULELA: Spot on! Hi NNICK – can you give us a quick summary of the pH scale?

NNICK: The pH scale, hmm, I've got it somewhere, I'll check my RAM. [BLEAT] Yes he's fine. Let's see – P P P P P P … pH.

A summary of the pH Scale. The pH Scale is a series of numbers which indicate how acidic or alkaline a substance is. It ranges from 0 to 14, where 0 is very acidic and 14 is very alkaline. The middle value, pH 7, shows a substance is neutral. In pH, the H is upper case and stands for hydrogen. The p is lower case and nobody really knows what it stands for. Though it could be thought of as power. So pH could be thought of as "power of hydrogen". This is not to be confused with the "power of love". Whatever that is. It's not that being a hyperintelligent electronic algorithm I shun love exactly... I simply don't have the time for it darling. But I am open to offers.

TULELA: Thanks NNICK!

SUNAYANA: So pH …

TULELA: little p, big H

SUNAYANA: Measures how acidic or alkaline a solution is from 0 to 14.

TULELA: So pure water, that's pH 7 and neutral. Below 7, the more acidic…

SUNAYANA: …and above 7, the more alkaline. And you may well have seen small strips of coloured paper and dipped it in a solution and it watched it change colour.

TULELA: That's universal indicator paper. The colours from yellow to red indicate a solution is acidic with pH below 7. So red indicates a strong acid – pH 1 or 2. Whereas the colours blue to violet indicate an alkaline solution with pH above 7 and a green colour indicates a solution is neutral at pH 7.

SUNAYANA: Let's look at what's actually going on with those hydrogen ions to make those numbers go up and down.

TULELA: You might want to grab a pen and paper for this bit. You remember that we talked about acids being able to release Hydrogen H-plus ions. Well, the more concentrated those H-plus ions are in the aqueous solution

SUNAYANA: …the water…

TULELA: …the lower the pH. Every time we multiply the number of Hydrogen ions by 10 – making it more concentrated by a factor of 10 – we reduce the pH by 1.

SUNAYANA: So that it becomes more acidic.

TULELA: And every time we decrease the number of hydrogen ions by a factor of 10, by diluting it – we increase the pH by 1.

SUNAYANA: It becomes less acidic.

TULELA: So, increase the concentration by a factor of 10, decrease the pH by 1.

SUNAYANA: And decrease the concentration by a factor of 10, increase the pH by 1.

SUNAYANA: Tulela, have you ever been stung by a bee?

TULELA: Yeah, it's not very nice.

SUNAYANA: So bee stings are around pH 5, so slightly acidic and some people claim that if you rub on an alkali cream you can relieve some of the pain. Although it's not really the acid causing the stinging pain, adding an alkali to an acid is a good example of a neutralisation reaction.

TULELA: In those neutralisation reactions where we add an acid to an alkali, the hydrogen ions…

SUNAYANA: …the H-pluses from the acid…

TULELA: …combine with the hydroxide ions…

SUNAYANA: …the OH-minus from the alkali…

TULELA: …to produce water –

SUNAYANA: H_2O!

SUNAYANA: So a quick summary of acids and alkalis, Tulela?

TULELA: You bet.

SUNAYANA: Acids produce positive hydrogen ions (H-plus) in aqueous solution.

TULELA: Alkalis produce hydroxide ions (OH-minus) in aqueous solution.

SUNAYANA: Strong acids are those where the hydrogen ions completely dissociate.

TULELA: In weaker acids H-plus ions partially dissociate.

SUNAYANA: The pH…

TOGETHER: …little p, big H!

SUNAYANA: The pH scale from 0 to 14 measures how acidic or alkaline a solution is.

TULELA: pH 7 is neutral and the lower the number below 7 the more acidic.

SUNAYANA: The higher the number above 7 the more alkaline.

TULELA: If we increase the concentration of hydrogen ions by a factor of 10 we reduce the pH by 1, making it more acidic.

SUNAYANA: And if we dilute the concentration of hydrogen ions by a factor of 10 we increase the pH by 1, making it more alkaline.

TULELA: And in neutralisation reactions between acids and alkalis, the hydrogen ions from the acid combine with the hydroxide ions from the alkali to produce water.

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

TULELA: Thanks for listening!

TOGETHER: Little p, big H!