BBC Bitesize - Chemistry

Episode 6 – Distillation and chromatography

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. In episode six of this eight-part series on atomic structure and the periodic table, we're going to look at more physical separation processes. In the previous episode we looked at filtration and crystallisation, which we use to separate mixtures of solids and liquids.

SUNAYANA: And in this episode, we'll be looking at separating a liquid or many different liquids out of a solution using….

TULELA: Distillation and chromatography.

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.

First up, distillation. There are two types – simple distillation and fractional distillation.

TULELA: Both types rely on the fact that every pure substance has its own unique boiling point – for example, pure water boils at 100 degrees Celsius. So let's start with simple distillation because it's erm… simple.

SUNAYANA: If we want to separate out a liquid from a solution then we can so long as the boiling points of the components are quite different. Let's say we have a solution of sea water, we use simple distillation. In this case, that salt in the sea water has a much, much higher boiling point than the water. Pure water boils at a 100 degrees Celsius and the salt boils at 1,465 degrees Celsius.

TULELA: And that's important to remember – simple distillation relies on very different boiling points of the individual pure components in the solution.

In the last episode, we talked about separating salt from water by crystallisation where we were interested in collecting the salt rather than the pure water which simply evaporated into the air. Have a

listen to that episode if you need a quick recap. This time, we're interested in purifying and collecting the water itself.

SUNAYANA: In this case, the sea water is heated in a flask. As the temperature rises, pure water evaporates and is trapped in a condensing column.

TULELA: Usually a tube surrounded by a cooling jacket or cold water flow.

SUNAYANA: Where it cools and condenses back into the pure liquid water and is collected drop by drop into a beaker, leaving the salt behind in the flask. Simple distillation. Simple. But only useful if we have a solution with substances with very different boiling points. If we want to separate mixtures of liquids with similar boiling points we need a different method, which is duh-duh-duh…

TULELA: Fractional distillation.

SUNAYANA: Let's say we have a complex mixture. In this case, we need to use a fractionating column which is cooler towards the top than the bottom. This makes sure that only the pure liquid with a boiling point lower than the temperature at the top of the column will rise to the very top of the column before condensing. The different temperatures along the fractionating column…

TULELA: Cooler at the top, hotter at the bottom…

SUNAYANA: Mean that even if more than one liquid evaporates, the ones with higher boiling points condense lower in the column so just drip back into the flask again.

TULELA: When the first liquid has been collected, we raise the temperature until the next one reaches the top – and in this way, we can collect each of the different pure liquids one at a time. Have a look over at the Bitesize website for some diagrams of both simple distillation and fractionating columns.

SUNAYANA: A really good example of the use of fractional distillation is the process that goes into oil refineries to separate crude oil into its useful parts.

TULELA: Time for an overview from our AI chat bot, NNICK. Grab a pen and paper to take notes.

SUNAYANA: Hi, NNICK. Can you give us an overview of how crude oil is separated using fractional distillation?

NNICK: Heated crude oil is put into a tall fractionating column which has a cool top and a hot bottom.

The fractions leaving the column, from top to bottom, are from (HIGH VOICE) lightest to (LOW VOICE) heaviest:

(HIGHEST VOICE) Liquified petroleum gases, petrol, kerosene, diesel, heavy fuel oil, (LOWEST VOICE) and bitumen.

'How do you remember all this NNICK?' you ask. Well, by using cutting edge semiconductor technology. But as humans are embarrassingly bad at remembering things, you might be better off with a mnemonic like this: Lazy Penguins Keep Drinking Hot Beverage.

PENGUINS: L-L-L-Lazy

NNICK: L-L-L-Liquefied petroleum gases

PENGUINS: P-P-P-Penguins

NNICK: P-P-P-Petrol

PENGUINS: K-K-K-Keep

NNICK: K-K-K-Kerosene

PENGUINS: D-D-D-Drinking

NNICK: D-D-D-Diesel

PENGUINS: H-H-H-Hot

NNICK: H-H-H-Heavy fuel oil

PENGUINS: B-B-B-Beverage

NNICK: B-B-B-Bitumen

TULELA: Thanks, NNICK and the penguins. So let's summarise distillation. Simple distillation – where the components have very different boiling points. And fractional distillation – where the mixture is more complex and where boiling points are not very different.

SUNAYANA: The final physical separation method that we might use in chemistry is chromatography. And this is used if we want to separate out a mixture of a soluble substance, such as food colouring or inks and identify what are the pure chemicals that it's made from.

TULELA: Unlike distillation, which uses different boiling points to allow separation, chromatography relies on how far the separate liquids can move – and in chromatography, there are two phases involved. The stationary phase, which is a piece of chromatography paper which is similar to filter paper. And the mobile phase which is a liquid, for example water, that moves through the stationary phase.

SUNAYANA: In paper chromatography we draw a pencil line across the chromatography paper, the stationary phase, a couple of centimetres from one end and add a spot of our unknown substance onto the pencil line. We dip the bottom of the chromatography paper into the water, the mobile phase. And we'll see that the water will start to move up the chromatography paper and when it gets to the pencil line it will carry the spot with it as it travels up the paper.

TULELA: But because the different substances in our spot have different solubilities they will travel at different rates, and so the individual chemicals will separate out forming their own unique spot at different distances from the pencil baseline on the paper.

SUNAYANA: If you do this with food colouring or inks, they will be different colours. And if you see only one spot on the filter paper, then you know you've had a pure substance there all along.

TULELA: A nice way to imagine chromatography to make it more memorable is to think of it as if you have a team of three sprint runners lining up at the starting line. Each has different coloured trainers on and each colour has a different stickiness to the track. Blue is very sticky so that runner will not be able to run very fast, red is medium stickiness so that runner will get further, and yellow trainers are super-whizz new ones with very little stickiness so that runner will get furthest in the same time. And once again, with distillation and chromatography we are physically separating pure chemicals without producing anything that wasn't already there in the first place. And you can visit the BBC Bitesize website for more information on chromatography.

So, lots of info there, Sunayana, so let's have a quiz to get those facts to stick.

SUNAYANA: Yes, please.

TULELA: Three questions, five seconds – no prizes. So grab that pen and write your answers down. Here we go. Question 1. How does the temperature in a fractionating column change from bottom to top?

SUNAYANA: It's hotter at the bottom and cooler at the top.

TULELA: Question 2. I have a liquid mixture of two substances. One with a boiling point of 100 degrees (which must be water) and the other with a boiling point of 2000 degrees. Which method can I use to separate them?

SUNAYANA: Simple distillation is what we need, because the boiling points are very, very different.

TULELA: And question 3. In chromatography, what are the names of the two phases and give an example of each.

SUNAYANA: We have the stationary phase, for example chromatography paper, and the mobile phase, for example water.

TULELA: End of podcast summary time – let's go.

SUNAYANA: Right, to physically separate liquids from mixtures we can use distillation and chromatography.

TULELA: Distillation make uses of the fact that pure substances in a mixture have unique and different boiling points.

SUNAYANA: We use simple distillation where the components in the mixture have very different boiling points.

TULELA: And fractional distillation for more complex mixtures where individual boiling points are not too different.

SUNAYANA: Chromatography has a mobile phase to carry an unknown solution across a stationary phase.

TULELA: On the next episode, we'll be looking at the development of the periodic table in a little bit more detail.

SUNAYANA: I'm Dr Sunayana Bhargava.

TULELA: And I'm Tulela Pea.

SUNAYANA: And this is Bitesize Chemistry. To hear more, search Bitesize Chemistry on BBC Sounds.

TULELA: Bye then!

SUNAYANA: See ya.