Chem 1311Ch3Ep3Transcript

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Hello and welcome to the third episode of mass relationships and chemical reactions.

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Previously, in mass relationships and chemical reactions.

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We learned to calculate molecular and formula masses.

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And we practiced using the equation-based method to solve composition stoichiometry problems.

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In today's episode.

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We will further practice our problem-solving skills in stoichiometry problems.

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We will learn.

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To calculate percent composition from a chemical formula.

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And we will learn to derive empirical and molecular formulas from a compound's percent composition.

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Let's start with another stochiometric problem, this one.

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About cobalt (III) sulfite.

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There's our formula.

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The ask is how many oxygen atoms?

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Because it is atoms, we will use Avogadro's number.

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Times 9.

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Because there are nine oxygen atoms in the formula.

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The given quantity has units of grams of cobalt 3 sulfite.

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So we use the molar mass.

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From the periodic table.

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To solve, we enter the given quantity in the 1st frame.

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And our conversion factor.

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In the 2nd frame.

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Oh, I forgot to.

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Change Avogadro's number for its value. There.

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And the final answer is 6.479 * 10 to the 23rd atoms of oxygen.

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Of course, you can ask more than one stoichiometry question from a given compound.

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Why waste a good compound when you have it right here?

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So let's say we're interested in grams of cobalt instead of atoms of oxygen, and let's get a bigger sample.

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OK.

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This time the ask is grams of cobalt.

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We will use the molar mass from the periodic table.

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And the given quantity has units of grams of.

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Cobalt (III) sulfite.

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And so we will also use the molar mass from the periodic table.

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To solve, we place the given quantity in the 1st frame.

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And the conversion factor in the 2nd frame.

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The final answer is 23.7 grams of cobalt.

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To three significant digits.

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Here's another interesting example.

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The ask is the mass of phosphate.

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We will need the molar mass from the periodic table.

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For just the phosphate.

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The given quantity has units of moles of iron.

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To solve, we enter the given quantity in the 1st frame.

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And the conversion factor in the 2nd frame.

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The final answer is 364 grams of phosphate.

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All of today's.

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Examples required the calculation of molar masses.

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Be sure that you understand where these values are coming from.

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There is another video with problem solving examples you should view to help understand the topic.

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For any questions, please follow the office hours or discussion links in canvas.

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This is a mass spectrometer.

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Like its name implies, it can determine the mass of atoms accurately enough to distinguish isotopes of the same element.

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Which I think is amazing.

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The way it works is as follows.

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A gas sample is injected into the mass spec and passed through an electron beam.

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This uniformly charges the atoms.

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The charged atoms.

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Are then accelerated by passing them through an electric field.

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After that.

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They are deflected by a magnetic field.

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Larger atoms are deflected less, and lighter items are deflected more.

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So when they hit the detector in different locations, that location represents their masses.

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It's brilliantly simple.

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It is also possible to know.

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With accuracy, what percent of the population in the sample has each mass by simply comparing the relative sizes of the signals for each one of the weighted particles.

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That way, determining the percent composition of a compound.

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Can be done easily by digesting it.

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Vaporizing it.

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And injecting it into a mass spec.

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The result will be a percent composition.

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For that compound.

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Percent composition is a big deal because it can be the first step in determining a chemical formula for an unknown compound.

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And also it can be used to determine the amount of an element of interest in a given compound.

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The percent composition of a compound can be determined by using this formula.

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We will apply this formula to ethyl alcohol or ethanol, whose molecular model is here.

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It looks kind of like.

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A dog, at least to me.

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See his little leg raised he's peeing.

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The percent carbon.

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Is 2 times the molar mass of carbon.

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Divided by the molar mass of ethanol.

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The percent hydrogen will be 6 times the molar mass of hydrogen.

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Divided by the molar mass of ethanol times 100.

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And the percent oxygen is the molar mass of oxygen.

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Divided by the molar mass of ethanol times 100.

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If you're curious and you add the percentages of all the components, it should be very close to 100%.

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It will sometimes be a little bit off because of rounding, but that is fine.

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Next, we will follow the same process to determine the percent composition of phosphoric acid.

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Pause the video.

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Write down your answer and then come right back.

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Welcome back.

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The first thing to do is to determine the molar mass of phosphoric acid.

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Then you can use each of the elements’ mass contributions divided by the molar mass of the phosphoric acid.

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And multiply it times 100.

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Because of the rounding, the percentages don't add to exactly 100%.

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But that is fine.

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If you're more of a visual person, you can also use a diagram to organize the molar masses.

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You need to calculate your percent compositions similarly to the way we figure out unit conversions for stoichiometry problems.

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Here we have shown each element mass contribution as well as the molar mass for the entire compound.

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Using these values, we can calculate that the compound is 65.13% copper.

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32.80%.

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And 2.07% hydrogen.

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Easy peasy.

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A little more complicated, is to start with a percent composition and derive an empirical formula.

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This diagram shows the three basic steps and what each one of them accomplishes.

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The first step.

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Is dividing grams by the elements' molar mass

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What this does is it converts the quantity to moles.

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The second step.

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Dividing by the smallest number of moles turns the values into more ratios.

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And the third step.

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Gives the actual number in the empirical formula.

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Let's try an example.

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To derive the empirical formula of ascorbic acid.

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We will start with its percent composition.

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As it's given in this example problem.

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40.92% carbon.

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4.58% hydrogen.

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And 54.50% oxygen.

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We need to have those quantities in grams and by assuming that we have exactly 100 grams of ascorbic acid, we can treat the percentages as masses.

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Why? How do I justify this, you ask?

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Because this way I do less math.

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That's really the only reason.

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The first step, as mentioned earlier, involves dividing each mass by the elements molar mass to obtain the number of moles in this 100 and.

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101 within this 100 gram imaginary sample.

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The second step is to divide the number of moles of each element by the lesser one of them.

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In this case 3.406.

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The moles of oxygen.

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This gives us the mole ratios in the formula relative to one another.

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The 3rd and final step is to verify that all the ratios are whole numbers because chemical formulas require integers.

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Subscripts are never decimals.

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If the value is.

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Close to an integer, like in this case.

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Then rounding it off is no problem.

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But if the value is not close to an integer, then it becomes necessary to multiply all the ratios, not just the offending one, by a prime number.

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The same prime number, in order to get all integers.

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In theory, any prime number is likely to be the one, but in practice you will find that either 2 or3 does the job every time.

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If the decimal part of the offending ratio is .33 or .66, multiplying all the ratios by 3 will take care of the problem.

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But if the decimal part of the offending ratio is .5 or very close to .5.

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Then multiplying all the ratios by 2 will solve the problem.

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In the case of ascorbic acid, we multiply all the ratios by 3 to get $C_3H_4O_3$ as the empirical formula.

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Molecular formulas are always a multiple of the empirical formula, but for that more information is needed.

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In most cases, that information is the molecular mass.

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Let's try another example.

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This compound is 30.46% nitrogen.

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And 69.54% oxygen.

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We will come back to this molecular mass information after we have the empirical formula.

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We again assume that we have a 100 gram sample and we proceed to convert the masses to moles.

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By dividing each one by the elements' molar mass.

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To get the number of moles of each element in our 100 gram sample.

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The next step is to divide both values by the smaller one.

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Which results in the following mole ratios.

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In this case, they are already integers, so there is no need to multiply by either two or three.

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This is fine the way it is.

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So our empirical formula is NO_2.

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The molecular formula is always a multiple of the empirical formula.

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But that leaves us with many possibilities.

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Is it times 1? times 2? Times3? or times 52? We don't know.

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And the only way to know that is by comparing the molar masses.

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To the molar mass of the compound.

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We are told that our molar mass is between 90 grams and 95 grams.

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So as we calculate the molar masses of our suspects.

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We can see.

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That N_20_4.

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It's a winner having a mass of 92.02.

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And this is what it looks like.

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And that's all there is.

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There isn't anymore.