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Hello and welcome to the fifth episode of Chemistry the study of change.

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Previously in chemistry the study of change.

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We used the density formula to calculate density, mass or volume.

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We also learned to convert numbers from standard notation to scientific notation and back.

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And we learned to do arithmetic with numbers in scientific notation.

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In today's episode.

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We're going to learn why significant digits are important.

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We will learn to determine the correct number of significant digits when reading or writing a measurement.

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We will learn where to round calculations based on measurements.

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We will learn where to round calculations based on measurements.

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And we will apply significant digits to unit conversions.

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Significant digits is the way we express the confidence that we have on a measurement.

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The more significant digits, the more confidence we have in it.

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This degree of confidence will depend on the instrument you use to record the measurement.

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Only measurements have uncertainty.

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Some quantities you will be dealing with are known exactly, and they are considered to have an infinite number of significant digits.

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The rules we will learn about significant digits will not apply to exact numbers.

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The significant digits rules we will be learning

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Apply only to measurements because an intrinsic amount of uncertainty is present in all measurements.

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Exact numbers, on the other hand, are quantities that are counted rather than measured, or they are definitions, which are numbers arbitrarily chosen.

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And as previously mentioned, they have an infinite number of significant digits.

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All measuring instruments have limitations and these limitations are the source of the uncertainty.

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We follow different rules for recording a measurement with the correct number of significant digits depending on whether the measuring instrument is analog or digital.

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Let's start with the analogs.

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For Analog Devices, the measurements will be recorded to 1 decimal place further than the smallest hash marks.

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The last significant digit will be the user's best estimate.

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For example, when you see this graduated cylinder which has hash marks that are one milliliter apart.

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The measurement would be recorded to the 10th of a milliliter.

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One place further than the smallest hash marks, which are one milliliter apart.

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This example should therefore be recorded as 36.4 milliliters.

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With the .4 being our best estimate of how far above the 36 milliliter hashmark the liquid is.

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For the same reason.

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The length of this object should be recorded.

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As six point. 33 centimeters. Because the,... because the hash marks are one 10th of a centimeter apart.

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The second three in this better bit is estimated.

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Even if the object is exactly on the hash mark, the final digit must still be estimated.

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In this case, it is recorded as a 0 because it is right on the hash mark.

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The second zero is estimated.

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Digital devices don't have any hash marks and therefore it is not possible to estimate an extra digit.

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We must simply record what we see, including any zeros.

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To read the number of significant digits in a measurement.

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You must follow the four simple rules I'm about to give you.

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Any non 0 digit.

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Is significant, without any exceptions whatsoever.

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So this measurement has four significant digits.

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Embedded zeros.

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Those between two non zeros are always significant.

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So this measurement has three significant digits.

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Our third rule, leading zeros, which are those found to the left of the first non-zero digit are never significant.

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So this number has only one significant digit.

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And finally.

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Trailing zeros are only significant if the measurement has an explicit decimal point.

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Because of this, this example has only one significant digit.

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But this example has three significant digits because the trailing 0 is significant.

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Well, let's practice applying these rules now.

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Determine the number of significant digits in each of the measurements provided.

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Pause the video and write down your answers.

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Then we can go over them.

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Hey, welcome back.

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Let's check out those answers.

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This first example has three significant digits because all the digits are non zeros.

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This one also has three because the embedded zeros are significant.

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This one has also three because the leading 0 is not significant.

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This example has two significant digits for the same reason.

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The leading zeros are not significant.

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This example has four significant digits because trailing zeros are significant if.

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The measurement has an explicit decimal point.

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Notice that for numbers in scientific notation only the pre-exponential factor can have significant digits.

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And 7000 has one significant digit the way it's written. However, let's take this chance to show how you would write 7000.

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To have 1,2, 3 or 4 significant digits. If you notice scientific notation provides the answer.

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And this illustrates.

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Why sometimes it is necessary to write down a number in scientific notation?

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If you must do arithmetic with a measurement that you took, you must make sure that the answer has the correct number of significant digits.

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In most cases this will require rounding.

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This must be done because if you have measurements that have a low number of significant digits, your answer should also reflect that small number of significant digits.

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There are two sets of rules for rounding with significant digits, depending on whether you will be adding and subtracting, or you will be multiplying and dividing.

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If you must do both, then you will have to round twice because they are fundamentally different.

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The sum should be rounded to the place furthest to the right, where both numbers have a significant digit.

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In this example, we see that both addends have a significant digit, one place after the decimal.

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Therefore the answer is rounded to one place after the decimal.

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In the second example.

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Both numbers have a significant digit two places after the decimal.

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Therefore, the answer must be rounded to the second place after the decimal.

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If there is no one place where both numbers have a significant digit, then you were round.

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To the place.

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Further to the right, where the larger measurement.

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Has a significant digit.

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Here's an example.

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In this example, the answer should be rounded to the second place after the decimal.

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Because 1.25, the larger number, has a significant digit two places after the decimal.

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The rule for multiplication and division is very different.

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Emphasis on very.

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The result of a multiplication or division should be rounded so that it has the same number of significant digits.

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As the factor that has the fewer significant digits.

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So in this example.

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The measurement having the fewer significant digits has three.

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And so must the product.

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In the second example.

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The measurement with the fewer significant digits has only two.

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And so must the product.

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This is the third time I say it in this episode.

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Exact numbers like counted objects or definitions (such as 12 inches in a foot or three feet in a yard) have an infinite number of significant digits.

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I said it three times for emphasis.

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It's not like OCD or anything.

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OK, well here's a practical application.

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Calculate the average length in centimeters.

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Don't forget to round your answers.

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That's kind of the point of this exercise.

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Now pause the video for a bit and write down your answer.

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Welcome back.

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Here is my official answer.

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Do not be outraged.

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I will explain myself.

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You will notice that we did not round to one significant digit, even though we did divide by three.

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The reason for that is that threes had exact number.

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We counted 3 measurements.

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We did not measure it.

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But you may notice that we also did not round to 6.67.

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Even though all three of our.

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Addends had three significant digits.

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That is because we added the measurements, and the answer was rounded to two places after the decimal.

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Then we divided a four significant digit number by an exact number.

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And therefore our answer had to have four significant digits.

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Now here is a little more practice.

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Pause the video and write down your answers and then come back and check.

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Welcome back.

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The first example was rounded to one place after the decimal.

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The second example was rounded to two places after the decimal.

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The third example was rounded so that it would have three significant digits.

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The fourth example was rounded, so it would have.

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Also three significant digits.

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And the 5th and final example was rounded to two places after the decimal.

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Two terms that are often confused are accuracy and precision.

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They are not synonymous.

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Accuracy refers to the closeness of your measurement’s average to the accepted value.

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And precision refers to the closeness of your measurements to each other.

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This diagram illustrates the difference.

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You can see now.

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Clearly that.

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Precision is not necessarily the same as the accuracy.

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Precision only requires that the measurements be close to each other, whereas accuracy requires that they also be close to the true value.

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And that's all there is.

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There isn't anymore.