Chem 1311Ch7Ep3 Transcript

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Hello and welcome to the third episode of Theory and the electronic structure of atoms.

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Previously, in theory and the electron extract structure of atoms.

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We applied the hotel analogy to obtain a better grasp of the relationship between orbitals and electrons.

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As well as the four quantum numbers.

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And we don't talk about the 5g subshell.

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In today's episode.

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We will consider how the shape of an orbital is determined.

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We will define Pauli’s exclusion principle.

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And we will learn to different shapes that result from the various values of l.

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We will practice answering several common problems and questions concerning quantum numbers.

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An orbital is a probability calculation.

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It shows the area where the electron pair is likely to be and is sometimes referred to as an electron cloud because the graphic plot reminds someone.

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Of a cloud.

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Not important.

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If we measure the distance from the nucleus outwardly, we will notice that as we move further from the nucleus, the density of the cloud changes.

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That means that an electron is not equally likely to be anywhere within the orbital, but will have areas of the orbital where it is more likely to be than others.

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If we look at the probability along this line.

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We will notice that there is 0 probability of the electron being in the nucleus and a very low probability of being right adjacent to it.

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The probability of the electron rapidly rises at the distance to the nucleus increases.

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Until it reaches a maximum probability.

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If we continue to move even further from the nucleus, the probability of the electron drops rapidly.

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But it does not ever reach 0.

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That means that an electron in one of the atoms at the tip of my pencil.

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Could very well be across the room.

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It's just not very likely.

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So to determine the size of an orbital.

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Because humans like to measure things.

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There's an arbitrary number.

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90% of the electron density.

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Has been arbitrarily chosen to be the size of the orbital.

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With this definition in mind.

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This diagram shows the relative sizes of the 1 S, 2 S and 3 S subshells.

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Notice that the “s” orbitals will have a spherical shape around the nucleus.

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Remember that “s”,

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The value of l for the subshell, determines the shape.

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And the shape is spherical.

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The “p” subshell has three different orbitals which have different orientations, but the same basic shape.

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A “p” orbital is shaped as two spheres with the nucleus between them.

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The two lobes of the orbital don't touch because an electron can pass from 1 lobe to the other without passing through the space between them.

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That is freaky.

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The “d” subshells show 5 orbitals having different orientations.

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One of them looks a little bit different.

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The lobes are pear shaped with the narrow ends pointing toward the nucleus.

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The “f” subshell has lobes similar to a “d” subshell, but has 8 instead of four, and they do not all lie in the same plane.

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Here's a typical question that looks way harder than it is.

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n is the floor number.

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l is the room number.

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And m_l is the bed number.

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A subshell is a room.

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So the number of answers will be equal to the number of beds in that 4d room.

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The rooms or subshells have five orbitals or beds.

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Therefore, this question will have 5 answers.

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4d specifies that this room or subshell is in the 4th floor.

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And therefore, all the beds will be in the 4th floor, so n is equal to 4, for all five answers.

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d is the room number, and it corresponds to a value of two.

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Because you may remember, s is equal to 0, p is equal to 1, d is equal to two, f is equal to three, and so on.

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So l will be 2 for all five beds.

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m_l is the bed number and the values for m_l range from negative l.

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That's negative 2, to positive l, that's two.

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So negative two to positive 2.

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And done.

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A quick reminder.

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p subshells have 3 orbitals.

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d subshells have 5 orbitals.

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Let's consider.

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What is the total number of orbitals associated with the principal quantum number 3?

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Or if you prefer.

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The total number of beds in the third floor.

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The third shell or floor has three subshells of rooms.

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3s, 3p and 3d.

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3s has one orbital.

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3p has three orbitals.

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And 3d has five orbitals.

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That is 9 total.

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So it wasn't that hard now.

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According to Schrodinger, all electrons in an atom have a unique wavefunction.

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For the wavefunction to be unique, it must have a unique set of quantum numbers.

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That is why Pauli's exclusion principle states that no two electrons in an atom can have the same set of quantum numbers.

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A quick reminder of some definitions.

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A shell (think floor) consists of all the electrons in one atom having the same principal quantum number.

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A subshell (think room) consists of all the electrons with the same value for n and l.

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And an orbital consists of all the electrons with the same value of n, l and m_l.

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Describe the shape of the “s” and “p” and ‘d” orbitals.

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Mmmmh... No. You describe it.

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OK, this one looks more fun.

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Remember that each shell or energy level.

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The floor.

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Has as many subshells.

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As it as its value.

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That means that the 1st floor only has one room and it would have to be an s subshell, so no 1P exists.

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The second floor has two subshells and they would have to be “s” and “p”.

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So 2s is righteous.

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But 2d is fake.

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The third floor would have 3 subshells.

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“s”, “p”, and “d”

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So 3p and 3d are fine.

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Finally, the 4th floor has four subshells.

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“s”, “p”, “d”, and “f”.

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So “f” is fine, but 4g is a poser.

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So many questions!

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OK, pause the video.

00:12:27

Write down your answers, and then come right back.

00:12:33

Welcome back.

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Let's address each question, shall we?

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The first two questions deal with general properties of quantum numbers and are just a matter of having a good memory...

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What was I just saying?

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Oh yes, the answers.

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The principal quantum number n defines a shell.

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And the angular momentum quantum number, l defines a subshell.

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The next question asks for possible values for an electron in the second shell.

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Think floor.

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In the second floor, there are two subshells.

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“s” and “p”.

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So the possible values for l.

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Are zero and one.

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If l is 0 then m_l can only be 0 because there's only one orbital in an “s” subshell.

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And if it is one, it can be –1, 0, or 1 because there are three orbitals in a “p” subshell.

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For the next question, we are now considering an electron in the third shell or floor.

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There are three subshells in the third level.

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“s,” ”p,” and ”d”

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The values of l for the subshells are going to be 0, 1, and 2.

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An “s” subshell has only one orbital, so 0.

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A “p” subshell has three orbitals.

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-1, 0, and 1.

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And a “d” subshell has five orbitals.

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-2, -1, 0, 1, and 2.

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4 quantum numbers for three sets of electrons. Cool.

00:15:14

Pause the video.

00:15:15

Write down your answers and then come right back.

00:15:21

Welcome back.

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Let's start with a.

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There is only one orbital in an “s” subshell, so we can only have two electrons.

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n and l were given to us, so we don't have to figure those out. There's only one orbital.

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So m_l has to be 0.

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And the two electrons have to spin in opposite direction.

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So m_s has to be ½.

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Or -½.

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b) refers to a p subshell, which means 3 orbitals.

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And therefore 6 electrons.

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6 answers.

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Once again, the values for n and l were given to us, so we don't have to figure those out.

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m_l can be –1, 0 or 1.

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And each of those orbitals holds 2 electrons with opposite spins.

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If you're wondering why I listed first all the positive values for the spin quantum number

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and then all the negative values for the spin quantum number.

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It's not because I'm quirky.

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Though I am.

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It actually has to do with a rule we haven't learned (spoiler).

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c) refers to a “d” subshell, which means 5 orbitals and therefore 10 electrons.

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10 answers.

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Once again, the question gives us the values of n and l.

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And m_l can have values from –2 to +2.

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Each orbital will hold 2 electrons spinning in opposite directions.

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And here are the combinations.

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Here we have two more fun questions to ponder.

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Pause the video.

00:18:08

Write down your answer.

00:18:10

And then come right back.

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Welcome back.

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Let's go to work on the first question.

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The number of electrons that fit in a subshell is twice the number of orbitals, because each orbital can hold 2 electrons.

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Remember, orbitals are beds.

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“s” subshells have one orbital, so just two electrons.

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“d" subshells have five orbitals, so 10 electrons.

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“p” subshells have three orbitals, so six electrons.

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Finally, ”f” subshells have 7 orbitals.

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So 14 electrons.

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This one too.

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The next question is great.

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Let's start by collecting data.

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This should be enough.

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Each different shell will have a different number of subshells and orbitals, so let's count.

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The first shell has one orbital.

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The second shell has one “s” and 3 “p” orbitals. The third shell has a 1 s.

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Has 3 ”p” and 5 “d” orbitals.

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The 4th Shell has one “s” orbital 3 “p” orbitals and 5 ”d” orbitals and seven “f” orbitals.

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The 5th Shell has 1 “s” orbital.

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3 “p” orbitals, 5 “d” d orbitals, 7 “f” orbitals and 9 ”g “ orbitals.

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For a total of 25.

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To get the number of electrons, we simply multiply times two and done.

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OK, so this is not the answer.

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This is the data.

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Now we need to find a mathematical relation between n.

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And the number of electrons.

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Watch this.

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It appears.

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That the total number of orbitals is the square of n.

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See, one square is 1. 2, square is 4.

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Three Square is 9, four square is 16 and five square is 25.

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This is going somewhere.

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That means.

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That the number.

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Of electrons is going to be twice.

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n square.

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And that is the answer we seek.

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See your next episode.

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Because that's all there is. There isn't any more.