Chem1311Ch7Ep1 Transcript

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

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In today's episode.

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We will learn the reason why a quantum model of the atom is necessary.

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And we will learn the meaning behind the quantum numbers in Schrodinger's equation.

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Most people recognize this model of the atom.

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It shows the subatomic particles where they should be.

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And it shows the electron flying in nice understandable orbits.

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But unfortunately, it is fantasy.

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That is not what electrons do.

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So how do electrons move?

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That's not even known.

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The planetary model that gives everyone such a warm, fuzzy feeling fails to account for the fact that electrons have both wave and particle properties.

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But why only electrons?

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Why not other subatomic particles like neutrons and protons?

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The answer is that they are too large.

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The wavelength is inversely proportional to the mass; and they just have too much mass.

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Any particle larger than the electron

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Is too massive to have a measurable wavelength.

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So how did they figure out that there was a problem with the planetary model?

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If an element is pumped full of energy by either heating it or running an electric current through it.

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Its electrons will absorb some of that energy.

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Later they will release it in the form of light.

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If that emitted light is then passed through a prism.

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It will produce a spectrum.

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But not an ordinary one.

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The emission spectrum of a given element will only show certain wavelengths because only certain quantities of energy are permitted, and all others are not.

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That's where the name Quantum comes from.

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Emission Spectra are unique to the element, like fingerprints.

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Here in this slide, we have some examples of emission Spectra for various elements.

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In 1913

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Niels Bohr proposed the first quantum model of the atom.

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Which still considered the electrons to move in orbits.

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He viewed the allowed energies as reflecting some allowed orbits, whose circumference would have to be an exact multiple of the wavelength of the electron.

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Thus, his model stated that the electron can only have certain specific energy values.

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And that light is emitted as an electron moves from an energy level to a lower one.

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Both statements are still correct.

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But the orbit thing had to go.

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How electrons move is not merely unknown.

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But it is unknowable, according to Heisenberg's uncertainty principle.

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That's the real Heisenberg, not the cartoon you are familiar with.

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The allowed energy levels can be visualized as uneven spaced steps, each step described by Schrodinger's equation and the observed light emissions were the energy released when the electron moved down to a random lower energy level.

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Because the energy depends on the frequency.

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The different energies result in a different color of light emission.

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Since frequency and wavelength are linked.

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Schrodinger was better able to describe the atom by taking a mathematical approach which allowed him to account for both the particle and wave nature of the electron.

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Schrodinger's Wave equation allowed him to describe the energy of the electron and the probability of finding it in a given volume of space around the nucleus.

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He named this volume of space orbitals.

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Schrodinger's equation, however, can only be solved exactly for a one-electron atom, and it yields approximate solutions for more complex systems, since it does not account for electron-electron interaction.

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Schrodinger's wave function is a function of four numbers called quantum numbers, whose symbols are n, l, m_l and m_s.

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The first number is the principal quantum number, its symbol is n.

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This quantum number is allowed values that are positive integers.

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1,2,3,4, and so on.

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The principal quantum number n describes the distance of the electron from the nucleus and thus the size of the orbital.

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Remember, an orbital is the three-dimensional space inhabited by an electron or by an electron pair.

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The larger the value of n, the larger the orbital.

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These orbitals overlap, of course.

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The second quantum number is the angular momentum quantum number.

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And its symbol is l.

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Values permitted to l are integers from zero all the way to n - 1.

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So if the value of n is 1,

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L can only be 0.

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If the value of n is 2.

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L can only be zero or one.

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If the value of n is 3.

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Then l can be zero, one or two.

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A quirky thing to notice.

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Is that whatever the value of n is, will be the number of values that l can have.

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So then so if n is equal to 4, l can have four values.

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0,1,2 or 3

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For clarity, the values of l, the angular momentum quantum number values, are also assigned a letter.

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L is equal to 0 is called an “s” orbital.

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L is equal to 1, is called a “p” orbital.

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L is equal to two is called a “d” orbital.

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L is equal to three, is called an “f” orbital.

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And the letters are assigned alphabetical thereafter.

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So l is equal to four is a “g” orbital.

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And l is equal to five.

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Is an h orbital, and so on.

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The angular momentum quantum number describes the shape of the orbital, with different values representing different shapes.

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The third quantum number is the magnetic quantum number.

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And its symbol is m_l.

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For a given value of l.

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m_l will be an integer between -l & l.

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So if l is equal to 0.

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m_l can only be 0.

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If l is equal to 1 then m_l can be –1, 0 or 1.

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If l is equal to two, then m_l can be –2, -1, 0, 1, or 2.

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If l is equal to three, then m_l can be –3, -2, -1, 0, 1, 2, or 3.

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If l is equal to four, then m_l can be –4, -3, -2, -1, 0, 1, 2, 3, or 4.

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Another quirky thing to notice is that the number of values that m_l can have is always odd.

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How odd!.

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Pun intended.

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The value of m_l describes the orientation of the orbital in three-dimensional space.

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Which way it’s pointing basically.

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The 4th Quantum number is the spin quantum number, and its symbol is m_s.

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There are only two directions an electron can spin.

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Clockwise, represented by an arrow pointing up or a value of + ½,

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Or counterclockwise, represented by an arrow pointing down or a value of -½.

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The arrow thing refers to the magnetic field created by the spinning charge.

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This table summarizes the information on the four quantum numbers.

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Study it before next time.

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And that's all there is, there isn't any more.