<BrianQ> well, speaking of hydrogen atoms....
<_Frank_> lets do H2 atoms instead
<doos> He
<BrianQ> um... that would be a molecule... two H atoms
<doos> nanana
<BrianQ> He would be an atom, though....
<_Frank_> one for doos and one for me
<BrianQ> but H, one atom consisting of one electron in some quantum "state"
<BrianQ> in particular we seek out the "energy eigenstates"
<BrianQ> and we've learned that transitions from lower to higher energy states can be done by absorbing a photon of exactly the correct wavelength (frequency, energy)
<BrianQ> and transitions from higher to lower energy states can be done by emitting a photon of exactly the correct wavelength (frequency, energy)
<BrianQ> Going back to the states themselves, they are represented by quantum numbers... what are the symbols and names for these quantum numbers?
<doos> n, principle
<BrianQ> yes, that's one
<doos> s ..
<BrianQ> nope
<doos> p ..
<BrianQ> nope
<doos> heh
<_Frank_> l angular
<BrianQ> yes, thats another
<_Frank_> m quantum
<doos> m .. momentumn
<BrianQ> m is magnetic
<doos> oh yes
<_Frank_> which?
<doos> m
<BrianQ> pretty good... n L m, principle, (orbital) angular (momentum), and magnetic
<_Frank_> is it a capital L...I have it down as a miniscule
<BrianQ> ok, now how many possible states can have the same value for n (which are positive integer values from 1,2,3...)
<_Frank_> 2
<BrianQ> no...
<doos> n+1
<BrianQ> nope...
<_Frank_> n-1
<doos> n +- 1?
<BrianQ> nope
<BrianQ> n^2
<BrianQ> n squared.
<BrianQ> for a given quantum number n, what values can L take on?
<doos> n +- 1
<_Frank_> -l to +L in integer steps
<_Frank_> -L that should be
<BrianQ> yes, sort of Doos,... thats how many values... Frank, that is the m values
<_Frank_> ah sorry
<doos> for n=1 .. 3
<BrianQ> The L values can go from 1 to n-1 in integer steps
<BrianQ> no, for n=1 only one, L=0
<_Frank_> my notes say from 0 to n-1 in integer steps

<BrianQ> oops, the L values can only go from zero 0 to n-1 in integer steps
<BrianQ> so your notes are correct.
<_Frank_> phew
<doos> so 3?
<BrianQ> for n=2, can have two values, L = 0,1
<BrianQ> and so on...
<BrianQ> Then, as Frank stated in a mangled sort of way.. for a given L there are values
<BrianQ> of m that go from -L to L in integer steps
<BrianQ> now getting to something that Doos was bringing up... sometimes the values of the L quantum numbers
<BrianQ> are represented by letters.
<BrianQ> This is tricky, because there seems no rhyme or reason for the letters chosen...
<BrianQ> you only get good at knowing them through constant practice
<BrianQ> Possible L values are 0, 1, 2, 3, etc.... each number is represented by a letter
<doos> s p d f
<BrianQ> yes
<doos> woohoo
<_Frank_> good guess
<doos> heh
<BrianQ> s = 0, p = 1, d = 2, f = 3, and then the maker-uppers got a bit bored so that...
<BrianQ> g = 4, h = 5, ... and you get the picture.
<_Frank_> makers up should have been shot
<_Frank_> what a mad system
<BrianQ> yep, it seems so now, but they had some reason way back when the notation was first devised....
<BrianQ> at first they didn't know they were describing quantum numbers
<BrianQ> So an energy eigenstate of the electron in a hydrogen atom might be written as nL and then we also need m.
<BrianQ> several states might have the same n and L ... now it is our task to figure out how many...
<BrianQ> ground state of hydrogen is 1s (this is the nL notation using the s=0 spectroscopic notation)
<BrianQ> how many states can have quantum numbers 1s?
<doos> 1
<BrianQ> yes, good guess ;)
<doos> heh
<BrianQ> what is the m value for that state?
<doos> 1/2 1 or -1/2?
<_Frank_> _1
<DragonStek> -1 TO 1
<BrianQ> no... and no...
<BrianQ> zero
<_Frank_> 0 and 1
<BrianQ> m = 0
<doos> -0 to +0
<BrianQ> no... m can only be zero, because L is zero...
<BrianQ> yes Doos
<BrianQ> minus to plus zero :)
<doos> I was thinking of spin
<BrianQ> so.. only one 1s state and this is the ground state of hydrogen...
<BrianQ> ok, well, that we introduce next... but still your answers above would've been wrong
<BrianQ> :)

<doos> I know
<BrianQ> ok now... next up... what are possible L values for n=2?
<BrianQ> tick tock...
<doos> 0, 1 ,2
<BrianQ> one digit too many
<_Frank_> 0 and 1
<BrianQ> yes frank
<BrianQ> so... for n=2 there can be nL states corresponding to 2s and to 2p, yes do we see that?
<doos> yes
<_Frank_> yes
<BrianQ> Now how many states can have quantum numbers represented by 2s and how many can have quantum numbers represented by 2p?
<doos> 3 and 3?
<BrianQ> 1 and 3, actually
<doos> ok
<BrianQ> s corresponds to L =?
<_Frank_> -0
<doos> 0
<BrianQ> and there is only one allowed m, m=0
<BrianQ> so 2s has only the m=0 state...
<BrianQ> p corresponds to L=?
<_Frank_> 1
<doos> -1 0 1
<_Frank_> yes doos
<BrianQ> yes Frank, and then as Doos points out, possible m values are -1, 0, 1
<BrianQ> so 2p has three states, m = -1, 0, 1
<_Frank_> these letters don't half confuse it all
<BrianQ> hah!
<BrianQ> next up... n=3 ... what are the possible nL's? how many states in each nL?
<doos> s p d
<doos> so 1 3 and 5
<_Frank_> 5, -2 -1 0 +1 +2
<BrianQ> yes
<BrianQ> 3s has one state
<BrianQ> 3p has three states
<BrianQ> 3d has five states
<BrianQ> and so n=4?
<doos> 4s, 4p, 4d, 4f
<_Frank_> 7states
<doos> 1, 3, 5 , 7
<BrianQ> 7 states for the 4f, yes, and yes Doos
<BrianQ> now the n values are sometimes called "shells" and the L values are sometimes called "subshells"
<BrianQ> so how many states are in the 4f subshell?
<doos> 7
<BrianQ> yes
<BrianQ> and how many states are in the 4 shell?
<doos> 16
<doos> u 4
<doos> +h
<BrianQ> yes... n =4 and n^2 = n*n = 16... or...
<BrianQ> 1+3+5+7 = 16
<BrianQ> interesting how that works out.
<_Frank_> does that continue to work out as we get higher?

<BrianQ> always, yes indeed
<BrianQ> Let's try it for n = 5... what are the possible subshells and how many states in each subshell
<doos> 5 and 25 then
<_Frank_> 1,3,5,7,9 and 25in total
<doos> yes
<BrianQ> yes... but let's read the question closely.... "what are the possible shells?" using correct notation
<BrianQ> um... "possible subshells"
<doos> 5s 5p 5 d 5f 5g
<BrianQ> yes..
<_Frank_> he's so smart with these letters
<doos> heh
<BrianQ> that is correct even in notation... except that space with the "d" ;)
<doos> yes
<BrianQ> and 1+3+5+7 +9 = 25
<BrianQ> and n^2=25
<_Frank_> very tidy
<BrianQ> so the relation still holds... and it continues on and on
<BrianQ> now... we have to tack on another phenomenon that was discovered about electrons...
<doos> spin!
<BrianQ> yep
<_Frank_> he's been swatting
<doos> I was
<_Frank_> swotting
<_Frank_> bastid
<BrianQ> This was discovered experimentally and then explained theoretically by Stern and Gerlach back in the '20s
<BrianQ> and it is truly one of the landmarks of 20th century physics experiments...
<BrianQ> There are a lot of "classic" physics experiments first performed at the turn of the 20th century..
<BrianQ> so classic, they just go by the name of the persons who did them...
<doos> their wifes?
<BrianQ> like for example, Thomson's e/m ratio expt, or Millikan's oil drop expt.
<BrianQ> and so there is the classic Stern-Gerlach spin expt.
<BrianQ> Unlike the other expts... there still is no simple undergraduate lab setup to perform the Stern-Gerlach expt.
<BrianQ> This one is still difficult to do today, so I think it is amazing they did it in the '20s
<BrianQ> And better yet, they came up with the theory based on the newly developed quantum mechanics
<BrianQ> What is so interesting is that "spin" is a purely quantum mechanical property, there is no classical analogy
<BrianQ> "position" and "speed" of an electron in quantum mechanics have classical analogies, but "spin" of an electron does not.
<BrianQ> In fact, all quantum mechanical particles have some type of spin, which is indicated by a quantum number S
<_Frank_> by spin do we mean that the electron rotates (spins) as it orbits the nucleus
<BrianQ> all electrons, no matter where they are or what they are doing have spin S = 1/2
<BrianQ> no, we do not... an electron as far as we can determine is a point object... you cannot rotate a point object

<_Frank_> so not like side on a pool ball
<doos> question
<BrianQ> nope... spin like on a cue ball, at the values for maximum size of electrons, would violate relativity
<BrianQ> yes Doos?
<doos> but is is visually often presented as a spinning around an axes .. right?
<BrianQ> yes, but it is a false analogy
<doos> ok
<_Frank_> can you give us a better analogy then please
<BrianQ> um... no, because it is purely quantum mechanic, and my perceptions don't live in that world
<doos> abstract thinking required?
<BrianQ> When you have to do the math, yes.
<_Frank_> so it's called spin but doesn't and we can't visualise it
<_Frank_> groan
<BrianQ> When you want to give people a picture to hold in their head, you explain it like the earth spinning on its axis.
<_Frank_> ok
<doos> but that isn't really happening .. sweet
<_Frank_> bit like the hidden symmetry
<BrianQ> yep, a bit like that... a truth hidden in the math, but sometimes you want a half-truth to provide a visual picture
<_Frank_> I thought it was the church that taught faith
<BrianQ> no faith needed... do the math and if it agrees with repeated observation... that is science
<_Frank_> what was the experiment they did?
<BrianQ> philosophy maybe in trying to picture what the math is "telling us"
<BrianQ> but not religion
<BrianQ> I'll get there Frank ;)
<_Frank_> ok I'll be good
<BrianQ> but we should first note that all subatomic particles have spin, which repeating myself, goes by the quantum number S
<BrianQ> all electrons everywhere have spin S = 1/2 (half-integer spin)
<BrianQ> photons have spin S=0 (integer spin)
<BrianQ> other types of particles have S= 3/2 or 5/2 (half-integer spins) or S = 1 or 2 (integer spins)
<BrianQ> particles with half-integer spins behave differently from those with integer spins
<BrianQ> and, as mentioned, electrons have half integer spin
<BrianQ> So, we pay attention to the rule for half integer spin particles... called the Pauli exclusion principle.
<doos> no two particles can be in the same state?
<BrianQ> that says half-integer spin particles can never have exactly the same set of quantum numbers... yes Doos, you phrase it another way.
<BrianQ> Next up... along with the quantum number S, all electrons have another quantum number called ms (really m subscript s, but boring to keep trying to write that)
<BrianQ> for electrons, S = 1/2 always and ms can equal +1/2 or -1/2
<BrianQ> In a way, if you just think about isolated electrons, they can exist in two possible spin states ... one that has S=1/2,ms=1/2 and another that has S=1/2,ms=-1/2
<BrianQ> um... I should qualify that a bit...
<BrianQ> Those are the "eigenstates" of spin, you can have linear combinations of those two "eigenstates"
<BrianQ> They are sort of like the energy eigenstates, which we also call stationary states... they are states where the ms eigenvalue

doesn't change... but anyways.
<BrianQ> Particle spins interact with magnetic fields
<BrianQ> and Stern and Gerlach created some magnetic fields and sent beams of electrons through them to discover spin and spin behavior.
<BrianQ> What is interesting is that the mathematics that describes electron spin and magnetic fields is exactly the same mathematics that describes light polarization
<BrianQ> Two unrelated physical phenomena governed by exactly the same math.
<BrianQ> So all the mysteries that surround polarization, they surround the electron spin as well... how can you go from one polarization to another... how can you go from one spin to another... all the same math
<BrianQ> Anyways, though, what it means for us is pretty simple... electrons have two eigenstates of spin...
<BrianQ> We might as well not drag around S=1/2 because every electron shares that quantum number
<BrianQ> (even though in the textbooks and in working problems, you always DO drag it around)
<BrianQ> and concentrate on the ms quantum number... we have to add that to our collection of eigenvalues that describe the hydrogen atom...
<BrianQ> oops... I mean quantum numbers that describe the electron in the hydrogen atom
<BrianQ> So, what are the full suite of quantum numbers for an electron in the hydrogen atom?
<doos> 1s m=0, ms=1/2
<BrianQ> um...
<_Frank_> n, L, m, ms
<BrianQ> yes, that would describe one possible ground state... but I'm just looking for the symbols used
<BrianQ> yes Frank!
<BrianQ> those
<doos> that's the only groundstate, right?
<BrianQ> and so, we have to go back to our original line of questioning... how many possible states are there now in the 1s subshell, and in the n=1 shell?
<doos> 1s
<doos> m=0
<_Frank_> 0
<doos> ms=1/2 or ms =-1/2
<BrianQ> no Doos, there are two ground states.... one with ms=1/2 and one with ms=-1/2
<doos> heh
<BrianQ> yes... Doos you got there first...
<BrianQ> So, two ground states
<doos> see it now
<BrianQ> two states in the 1s subshell and two in the n=1 shell
<BrianQ> now for the n=2 shell... how many states in each subshell and how many in the shell?
<doos> 2s 2p
<doos> m=-1, 0, 1
<BrianQ> yes, how many states in each of those subshells, and how many in the shell?
<BrianQ> not quite
<doos> ms=-1/2, 1/2
<doos> oh wait
<BrianQ> let's start off listing everything...
<_Frank_> m=-1, -1/2, 0 1/2, 1
<doos> 2s 2p

<doos> 1 an 3
<_Frank_> so 5 in total
<doos> 4
<BrianQ> 2s had 1, and 2p had 3 but now each of those can have two possible ms values
<doos> plus the spins
<doos> yes
<BrianQ> so the number of states in the 2s doubles... the number in the 2p doubles... and the number in the n=2 shell doubles
<BrianQ> the introduction of spin double the number of states in a given subshell and in a given shell
<BrianQ> So... how many states are in any s subshell?
<_Frank_> 2n^2
<doos> 1 + 2
<BrianQ> 2
<BrianQ> s means L=0, which has only m=0, but which can have ms=1/2 or -1/2
<BrianQ> Frank... 2n^2 is how many states are in any given shell n
<doos> you cant count m=0 as 1?
<BrianQ> ??
<_Frank_> yes I was thinking that....it was shell not subshell
<BrianQ> what do you mean
<doos> BrianQ, m=0 is one state .. no?
<BrianQ> A state is defined by all of its quantum numbers
<doos> oh ok ..
<doos> yes see it now
<BrianQ> state defined by (n, L, m, ms)
<BrianQ> for 1s shell there are two states (1,0,0,1/2) and (1,0,0,-1/2)
<doos> yes
<BrianQ> for 2s subshell there are two possible states (2,0,0,1/2) and (2,0,0,-1/2)
<BrianQ> For 2p subshell, how many possible states?
<_Frank_> 6
<doos> 4
<BrianQ> Frank is correct
<doos> (2,1,-1,1/2) to (2,1,1,-1/2)
<doos> that makes 6 indeed
<doos> did I get that right?
<_Frank_> you said above the introduction of spin doubles the number of states
<_Frank_> so I just doubled the results we got from the calculations without ms
<BrianQ> all the states are (2,1,0,1/2), (2,1,0,-1/2), (2,1,1,1/2), (2,1,1,1/2), (2,1,-1,1/2), (2,1,-1,-1/2)... six states
<_Frank_> I think ther'd be six of those bracket sets doos
<_Frank_> yes
<BrianQ> or... the way Frank did it
<doos> yes range from -1 to 1 in the 3rd
<BrianQ> And the periodic table is arranged by shells and subshells... Meendelev (sp?) hit upon the shell subshell arrangment before quantum mechanics defined it
<doos> Mendelev
<BrianQ> yeah, ok
<BrianQ> let's look at a periodic table...
<BrianQ> can you pull that up in another browser window?
<_Frank_> yes
<doos> have it
<_Frank_> got it

<BrianQ> The rows correspond to shells... how many states can you have for n=1 shell?
<doos> 2
<BrianQ> yes
<BrianQ> and how many atoms in the top row?
<doos> 2
<BrianQ> yes, H and He
<BrianQ> how many states can you have in the n=2 shell?
<doos> 6
<BrianQ> and how many atoms in the second row of the periodic table?
<_Frank_> 6...though I count eight in the row
<doos> 8
<BrianQ> oops, sorry, you can have 8 in the n=2 shell
<doos> 1s and 1p
<BrianQ> 2n^2
<doos> that adds to n=2 shells
<BrianQ> n=2... so 8 states
<_Frank_> but without ms the n=2 shell had only 3 states
<BrianQ> oo, you guys are confusing yourselves and me... confusing shells with subshells
<doos> the also have the 1s shells
<doos> (not the 1p)
<BrianQ> n=2 does not have 1 in front
<BrianQ> it has 2s and 2p subshells
<_Frank_> so £ +2
<_Frank_> sorry 3 + 2
<BrianQ> 2s has two possible states, and 2p has 6 possible states
<BrianQ> so eight total
<_Frank_> ah ok 6 + 2
<doos> ok
<BrianQ> if you do it that way
<_Frank_> or 22^2
<BrianQ> or 2n^2 = 2*2^2 = 2*4 = 8 if you do it that way
<_Frank_> 2X2^2
<BrianQ> yes
<BrianQ> so... how many states in n=2 shell? and how many atoms in second row?
<BrianQ> eight
<BrianQ> how many states in n=3 shell, and how many atoms in third row?
<doos> 27
<_Frank_> 18
<doos> but counting 8
<_Frank_> 2X3^2
<_Frank_> =18
<BrianQ> whew... that periodic table is making me dizzy as I move my cursor across it
<_Frank_> but don't count 18 till 4th row
<doos> me to
<doos> I was doing n*n^2
<doos> oh well
<doos> blond day again
<Guest> hello
<_Frank_> I did 2*n^2
<BrianQ> anyways... we'll connect the shells and subshells to the periodic table more fully next time
<BrianQ> so... let's review... how many states in a shell n?
<BrianQ> 2 times n squared

<BrianQ> so... how many states in a given shell?
<doos> 2n^2
<BrianQ> yes
<BrianQ> and how many states in the s subshell?
<_Frank_> 2
<doos> 2
<BrianQ> yes
<BrianQ> and how many states in the p subshell?
<_Frank_> 8
<doos> 6
<doos> no 6
<BrianQ> Doos is correct
<BrianQ> how many states in the d subshell?
<doos> 10
<BrianQ> yes
<BrianQ> how many in the f subshell?
<doos> 14?
<BrianQ> yes
<_Frank_> what am I missing?
<_Frank_> how are these being calculated?
<doos> 7 states times the 2 spins
<doos> -5 to 5
<BrianQ> n = 1 shell has 1s subshell and 1s has two states
<doos> that is only for the f shell .. you need to add the s,p and d's to that for the total
<_Frank_> so we double the number for subshells and use 2*n^2 for the shells
<BrianQ> n=2 shell has 2s and 2p subshells, 2s has two states and 2p has 6 states, so n=2 has eight states
<doos> n=4 has 32 states .. 4f is just one of the 4 subshells
<BrianQ> n=3 shell has 3s and 3p and 3d subshells, 3s has two states, 3p has 6 states, 3d has 10 states and so total is 18 for n=3
<BrianQ> and on it goes ... and so homework for next time is how to arrange these shells, subshells, and number of states in a convenient manner...
<doos> I like this
<BrianQ> of course, that is what is done with the periodic table...
<_Frank_> I do too...but I'm getting confused with states and subshels
<BrianQ> states... shells and subshells
<BrianQ> So give you until next time to carefully re-read and link this chat
<doos> frank in n=2, there can be 8 electrons .. all must have a different "state"
<BrianQ> hopefully someone will make the magic happen :)
<doos> we will Brian
<_Frank_> I've just re-read it and I think I have it
<_Frank_> but will read it all through again before next week
<BrianQ> As for me... I'm not confused... until I start to listen to you guys...
<DragonStek> hehe
<doos> heh, sorry
<BrianQ> hehehe
<_Frank_> lol
<_Frank_> could be worse
<doos> maybe we should rename these chats
<Crystal> I spend my time like that :)
<_Frank_> Tim could have been here from the start
<_Frank_> :)
<DragonStek> i could be guessing lol

<doos> the gueesing games
<_Frank_> oh another questioner always adds to the confusion
<_Frank_> good stuff Brian...thanks again
<_Frank_> great chat
<_Frank_> something to think about when I'm supposed to be studying
<Crystal> thanks Brian; thankfully my are running real late.
<DragonStek> thanks brian will reread
<BrianQ> yep, but now it is time for me to go :(
<Crystal> yes, many times :)
<Guest20682> bye bye B
<BrianQ> ciao everyone
<Crystal> have a great evening
<doos> ok Brian, thanks again
<DragonStek> night
<_Frank_> bye Brian...thanks
* BrianQ has quit IRC ("Java user signed off")