hello students welcome to this lecture on problem solving session on atomic structure in you must have gone through the videos where we discussed the theory of atomic structure we discussed several models of atom and now in this class we would revise our content of this chapter and then we'll see that how important insights we are getting and we will do this revision in by the help of some selected problems

so let us start the first problem here concerns the charge and mass of the sub-atomic particle if you remember we realized we understood that the atomic model has the following structure it has the core the nucleus which is at the core the nucleus com is composed of neutrons which are neutral and protons which are positively charged and surrounding this nucleus electrons go around in different orbits

so this is the uh picture of atom that we have in our mind and now we also know what are the charge what are the mass of these sub atomic particles like electron or proton or neutron the first question asks calculate the mass and charge of one mole of electrons

so we know that mass of one electron is is given over here nine point one one into ten to the power minus thirty 31 kg and this is this as one mole of electron

so therefore the total mass of one mole of electron m equals six point zero two three into ten to the power twenty three which is because there are one in one mole of electrons you have this many number of electrons and each electron has the mass of nine point one one into ten to the power minus thirty one ah kilogram

so therefore the mass of one mole of electron comes out to be five point four eight into ten to the power minus seven kilogram now this is the total mass of one mole of electron let us find out what is the charge of one mole of electron and to do that we would again see we have one mole of electron

so six point zero two three into ten to the power twenty three and we have now multiply the charge of this electron which is you remember know that it is a negatively charged particle

so therefore minus 1.
602 into 10 to the power minus 19 the unit is coulomb now when you have ah when you do this

so this minus sign should remind you that this is the electron is a negatively charged particle and when you do this number crunching you would get one important number ninety six thousand four hundred eighty five coulomb which is also has a a common name which is known as one faraday you would use this in when you learn more about electrochemistry

so the one mole

so the charge on one mole of electron is one faraday or or this ah number that you are having

so this is the first question now let us look at the second question the second question tells find the total number and the total mass of protons in 34 milligrams of ammonia

so let us call this a and we look at the second problem here the total number of protons and the total mass of protons in 34 milligram of ammonia

so if you ammonia has one nitrogen atom and three hydrogen atoms

so therefore its atomic mass is ah 17 gram

so 17 gram of ammonia

so this is this excuse me this is a molecule

so therefore this is a molecular mass of ammonia 17 gram of ammonia contains 1 mole of ammonia molecules 6.

023 into 10 to the power 23 number of ah ammonia molecules because this is its molecular mass
so now it says we do not have we have 34 milligrams
so let us find out how many molecules of ammonia will be there in 34 milligram of ammonia
so to get this you will see 6.
023 into 10 to the power 23 divided by 17 which is now gram
so therefore i am expressing it in terms of milligram and in 34 milligram will have this many number of ammonia molecules and if you solve it it should turn out to be
so this many number of ammonia molecules are present in 34 milligram of ammonia but the question asked how many number of protons are there now let us look at one molecule of ammonia in one molecule of ammonia nitrogen atom will have seven protons hide each hydrogen will have one proton
so there therefore together one molecule of ammonia has 10 protons but in our sample of 34 milligram of ammonia we have this many number of protons
so therefore 34 milligram of ammonia would have this number multiplied by 10
so which is 1.
2046 into 10 to the power 22 number of protons now these many number of protons are present in 34 milligram of ammonia we understood what is this uh the first bit of this the second bit says what is the total mass of proton but we know what is the mass of one proton
so this is given here
so therefore the total mass of protons in this sample you would have 1.
2046 into 10 to the power 22 these many number of protons multiply that with 1.
672 into 10 to the power minus 27 kilograms and if you solve this you would come about you will get something about 20.
1 milligram
so you see that in 34 milligram of ammonia we have 20.
1 milligram of protons
so the remaining mass is contributed by the neutrons because you know that in in an atom the electrons have very little mass
so therefore approximate mass in atomic unit it is ah zero
so the proton and neutrons contribute to the mass of the ah nucleus
so therefore the ah 20 milligram of mass is coming from proton and the remaining mass will come from the neutrons okay
so let us look at the next question the next question concerns about the atomic mass and atomic number now when we are discussing this chapter you say we represented an atom in this particular form where x where x would be the symbol of the atom z is is its number of protons atomic number and a is its atomic mass or mass number
so this question the first bit asks the atom that we have is 26 56 find out how many neutrons and protons are there
so when you see z is 26 z is that atomic number which is also the number of protons
so number of protons
so you immediately know by looking at this value
so number of protons are 26 but it's charge that means number of protons are greater than number of electrons
so this is what we have n e equals np plus 1 because this is an anion with an unit 1 unit of negative charge it also tells the ion contains 11.
1 percent more neutrons than the electrons
so that means number of neutrons is 11.
1 percent more than number of electrons to do write that i can write simply if i

have ah one number of electron then if i have one number of electron the number of neutrons is one point one one one because this is eleven point one percent uh greater than ah the number of electrons
so therefore this value is the number of neutrons now atomic mass is given thirty seven how do i get this atomic mass if i mus ah
so ah add n number of neutrons to number of protons that means n p plus n n is 37 but i know np is n e minus 1 and nn is 1.
111 n e
so this is equal to 37
so this minus 1 goes the other side
so i have therefore number of electrons becomes 38 divided by 2.
111 which is if you do it you will get 18.

so that means it has got 18 number of electrons
so what is the number of protons number of proton is one less than number of electron
so therefore number of proton is 17 and if number of proton is 17
so that is that means this is z is 17 and z 17 means we know that this is chlorine ah the species is chlorine and what is number of neutrons number of neutrons is a minus z which is equivalent to 20
so therefore the z is 17 a is 37 this is the atomic number this is the mass number and the the atom that use by looking at z you know that this is chlorine but this is not just chlorine this is actually chloride ion because you have one negative charge
so the question sends us find the symbol of the ion the symbol of the iron is here this is z this is a and this is the number of charges ah present in this molecule atom ok
so we go ahead and we look at the next question the next question concerns about the wavelength wave number frequency and time period and how of a wave and how their related to the energy of this wave
so we saw that interaction of radiation with matter we talked about photon photon has both a wave like nature and a particle like nature and what is the energy of the photon
so the expressions that are useful in this discussion are summarized here
so we say we we discussed that if if we have a radiation with frequency nu then the energy associated with that radiation is e given by h nu where h is the planck's constant which is a universal constant nu which is the frequency can also be expressed in terms of the wavelength c by lambda where c is the speed of light it can also be expressed in terms of wave numbers nu bar a c into nu bar
so here nu bar is simply 1 over lambda and this is also it can be expressed in terms of the period of this way
so let us look at this question the question says the first one find the energy of the photon which corresponds to the light of frequency 3.
10 to the power 15 hertz
so we see that the question gives us nu equals 3 into 10 to the power 15 hertz which is also second inverse
so what is the energy
so we know that e is simply h nu where h is the planck's constant 6.
626 into 10 to the power minus 34 joule into second and multiply that with the frequency which is 3 into 10 to the power 15 hertz is second inverse
so when you do this multiplication you will get 19.
88 into 10 to the power minus 19 joules
so this many joules is the energy corresponding to this ah photon of course you can convert this ah into other units such as electron volt ah now this is the

first bit of the uh question the second if the photon has wavelength of 0.
5
so in this question instead of giving new the problem gives us the wavelength which is lambda 0.
5 angstrom we know that one angstrom is 10 to the power minus 10 meter
so therefore this i can express in terms of ah meter unit and this is 5 5 into 10 to the power minus 11 meter now what will be the energy energy is simply e hc by lambda this one now i have two constants to ah worry about six is planck's constant multiplied by 3 into 10 to the power 8 ah joule second meter second inverse joule second is the unit of planck's constant meter per second is the unit of the speed of light and divided by the wavelength of the radiation which is given in the unit of meter second second inverse cancel out meter meter cancel out and i am left with joules which is actually the correct unit of energy
so i can see this uh if you if you do the numbers you would get 3.
976 into 10 to the power minus 15 ah joules
so this is the energy up
so if we know the if we know the frequency or the wavelength of the light or a photon we can convert them to energy or vice ah the other way around also
so now let us look at the second question the second question does not ask to convert them to energy but it asks if that is find the well wavelength of the photon whose period is ah 2 into 10 to the power minus 10 second
so the time period tau is 2 into 10 to the power minus 10 second but we know tau is close related to the frequency
so therefore frequency is 1 over tau which is 0.
5 into 10 to the power 10 second inverse or hertz this is the frequency now the question asked wavelength you know that nu is c by lambda and this comes out to be 0.
06 meter of course if you want you have here lambda you can also convert it to nu bar because this is one simply 1 over lambda and then you will get the number in the units of meter inverse which is the wave number
so the point that you should remember here is that there are various ways to express ah a a wave either through its wavelength or time period or a wave number but they are all interconvertible and they correspond to one energy ah associated with one energy which is given by if we multiply them with the planck's constant h ah now let us look at ah another ah question this question concerns photoelectric effect if you remember the discussion that we had on photoelectric effect is that if we irradiate some ah light onto onto a metal surface then light when you have light of frequency nu is used then the energy associated with this light is given by e as h nu and when you shine this light on metal surface then at some point of time you would see that the metal would start losing electrons and that you can of course when you connect them to a circuit then you can ah experimentally observe them
so every metal we understood that is associated with its characteristic value of work function which is phi zero uh which whose energy can also be converted to the frequency uh through flanks constant now if i am irradiating ah a light with h new frequency the metal has watt function of i zero after compensating the metal with its what function whatever energy remaining will be used as the kinetic energy of the ejected electron
so that means the energy associated with phi 0 plus the kinetic energy of the electron will be equal to the energy of the radiation that we are using
so this is about the photoelectric effect let us look at the question the question says that we have a photon of wavelength 4 4 into 10 to the power minus 7 meter

so therefore lambda is given 4 into 10 to the power minus ah 7 meter it strikes on the metal surface and the work function of the metal is give phi 0 is given as 2.
13 electron volt and we have to calculate the energy of the photon kinetic energy of the emission and the velocity of the electron
so first let us look at the first bit the energy of the photon
so energy of the photon e is hc by lambda
so you see that we are often using the multiplication of these two constant hc 10 to the power minus 34 into 3 into 10 to the power 8 joule second meter second inverse
so it is a good idea to actually remember the the result of this product hc in ah joule a meter unit
so that you can directly use them and you will be faster to solve problems
so this is this is the energy we already have used such an expression when i do this i would get 4.
07 into 10 to the power minus 19 joule but this is better if we can convert this energy into in from units of joules to the units of electron how do we do we know that one electron volt is this many joules if given here
so to convert it to ah electron volt
so we have 4.
07 into 10 to the power minus 19 divided by 1.
602 into 10 to the power minus 19 this is in in the unit of electron volt which should come out to be 3.
10 electron volt this is the energy associated with the photon that we are giving now looking at the second bit we see it is asking what is the kinetic energy of the emission
so this much light energy we are giving through the light the work function is phi 0 given here the remaining energy will be converted as the kinetic energy of the electron
so kinetic energy of the electron is e minus phi 0 which is 0.
97 electron volt because phi 0 is 2.
13 and this is 3.
10 volt
so this is the third bit ask what is the velocity of the photoelectron
so this is kinetic energy
so this is kinetic energy can be written as half m v square which is 0.
97 ah electron volt now we can ah express it in terms of ah joules unit
so this kinetic energy half mv square is is given here
so therefore v square is 2 into m what is m m is the ejected the mass of the ejected electron
so 9.
11 into 10 to the power minus 31 ah forgive me this has to be divided not multiplied 2 into nine seven one point six zero two ten to the power minus nineteen ah joule divided by this is nine point one one into ten to the power minus thirty one joule per kg
so you know joule per kg will be ah meter square ah second inverse ah square
so therefore v is the square root of this
so joule per kg i can write as meter square second as to the second to the minus two and therefore v will be obtained by taking the square root of this and when you do this you will get five point eight four into ten to the power six meters per second
so this is the speed with which this ejected electron will go out and come look at this speed which is about 6 000 close to 6000 kilometer uh per second
so that's quite uh quite a fast electron there all right

so we proceed to the uh next question the next question concerns the hydrogen atoms energy levels

so if you remember we discussed uh the hydrogen atom emission problem through bohr's model and then we also saw that bose model ah has some certain limitations and then exact treatment of quantum mechanical treatment of hydrogen atom gave us ah proper results which is given over here which tells that the hydrogen atoms energy levels are discrete ah the the the quantized

so we have the n where n is the quantum number that goes from one to ah larger numbers

so energy of the nth ah state of hydrogen atom is given by this expression which is here is a constant multiplied by z square divided by n square where z is the atomic number of the system and n is the quantum number or the state

so the ground state i here n equals 1 the next one is n equals 2 n equals 3 n equals 4 and

so on

so forth until very large number of n

so now for let us look at the question what it tells itself what is the wavelength of the light emitted when the electron in a hydrogen atom undergoes transition from an energy level with n equals four to an energy level of n equals two

so the electron goes from n equals four to n equals two

so this transition is happening

so we see that when electron jumps from a higher orbit to lower bit it will emit some ah energy

so it is asking what is the wavelength uh of that energy that the electron will emit

so to answer that we have to first know what is the energy of the fourth orbit

so this is very easy we simply have to take this constant multiply it ah atomic z is one for hydrogen atom n is four now

so this is my two point one eight into ten to the power minus eighteen one by four square this is in the unit of joules what is the energy of second level eq n equals two this is again simple ten to the power minus eighteen one over two square again the unit of joule

so when it happen ah this ah the jump happens what is the energy of the ah emission the emission energy is given by e final minus e initial

so that you would get to 10 to the power minus 18 1 by 4 minus 1 by 16

so when you do this this will come out to be 3 divided by 16 and when you multiply this number you would get this as minus 4.

087 into 10 to the power minus 19

so this is in the units of joules

so this is this many joules

so this is the emission energy what is this minus sign doing here this simply says that this is the the energy that is being emitted not not observed

so this minus sign indicates that

so now corresponding to this energy what is the wavelength

so lambda we know ah we sorry we know uh energy is e by hc e equals hc by lambda

so therefore lambda is hc by e again we have to deal with the multiplication of the two constant divided by 4.

087 into 10 to the power minus 19 joule which should come out to be in the unit of nanometer it is 486.

3 nanometer which is 10 to the power minus 9 meter

so this is the wavelength that the electron will emit when it jumps from n equals 4 to n equals 2.

now let us look at the second bit it says how much of energy is required to ionize hydrogen atom if the electron occupies n equals four level
so that means my electron is here to begin with and i am ionizing it what does it mean when i ionize we i actually remove this electron from from one finite value of n to a very very large value of n or i can say the final state has n equals infinite that is the state of ionization where the electron is completely detached from the the nucleus
so therefore n is n goes very high and infinite
so e in finite or when n is very large you would see that this 1 over n square or 1 over in n square will make this term go zero
so therefore the final state here for for ionization the final state energy is simply 0
so which is given here this is the ionization limit whose that means the electron is now called a free electron it is not associated with any more any nucleus
so its energy is 0 because n goes very large and what is the e initial e initial is simply e4
so the ionization energy what would how much you would do to ionize this electron from n equals 4 you have to give the energy corresponding to this e4
so you can see 0 minus e4 that would be simply the ionization energy would be 2.
18 divided by ah 16 into 10 to the power minus 18 joule which will turn out to be 1.
36 into 10 to the power minus 19 joule
so this is the ionization energy simply the energy of that particular orbit from which you are ionizing the electron ok
so let us look at the next question the next question is something similar we discussed hydrogen atom the advantage of using quantum mechanical model ah instead of boards model is that we can use this expression even for hydrogen like system that means when i when we go to hydrogen like system hydrogen like system means when z is not necessarily one is z is greater than one but still the system has one electron
so now let us look at this ah question it tells you what is the energy required to do this following process what is the process it starts with h e plus if you recall what is helium
so helium has got two electrons and its nucleus has two protons and two neutrons
so this is helium with two electrons how do i get helium plus this reactant is helium plus i will get this when i remove ionize one electron
so therefore the helium plus ah is given here this is my helium plus with the nucleus which has z equals two and one electron
so this is a hydrogen like system now the what is the reaction the reaction is i am taking removing this one electron that is there in h e plus
so that i simply have the ah h e 2 plus plus a free electron
so this electron has been ionized
so now what what do we how much of energy do i need to carry out this ionization
so to do that i already know to carry out this ionization i need to know what is the energy of this state what is the energy of the state
so this is h e plus with z equals two
so the energy of the starting state is given by this relation minus two point one eight ten to the power minus eighteen here z is the nuclear charge which is two
so therefore multiply it with four and n since the system exists in this ground

state
so n equals one here
so this is simply into four this this is the ah energy that of the reactant
so this would turn out to be 8.
72 into 10 to the power minus 18 joules
so this is the energy of h e plus when i remove this electron to ionize this electron i must give this energy this is this negative sign indicates that this in system h e plus is a stable system
so i must give 8.
72 into 10 to power minus 18 joules to ionize this electron
so therefore the energy required is this ah quantity shown here okay
so the next question that we are going to discuss ah concerns the debroise hypothesis you remember ah to describe ah the blackbody radiation or photoelectric effect we said that ah light which was popularly known as a wave also has particle like nature but deep roy suggested that not only a traditional wave has a particle like nature but conventional particle also has a wave like nature
so the wave particle duality became complete when we have gibros hypothesis
so deprives hypothesis says that if you have a particle whose mass is m and moving with a speed of v
so its momentum is given by m v
so corresponding to the wavelength corresponding to this particle lambda is given by h by p or h by m v
so if we know the mass and velocity of a particle then we can cut know its corresponding debroise wavelength
so this is this question concerns that
so the mass of electron we know its kinetic energy is given by this energy calculate its wavelength
so we know that kinetic energy is v square divided by 2 m which p is is the momentum
so this is given as 3 into 10 to the power minus 25 joules
so therefore p square is 2 into mass of electron 9.
11 into ten to the power minus thirty one ah kilogram three into ten to the power minus twenty five joule multiplied by joule ah kilogram ah
so therefore i will get p as the square root of this quantity and the p that would come out to be is 7.
39 into 10 to the power minus 28 with the unit of kilogram meter ah second in ah second inverse
so now i got the momentum of this particle from the kinetic energy if i know the kinetic energy i got the momentum because i already know the mass of this particle now i got the momentum but what i need now is the deploy wavelength which is given by h by p and h is 6.
626 into divided by the momentum and when you do this you would find get eight nine seven into ten to the power minus six meter which is about eight hundred ninety seven ah nano meter
so this is the de bruy's wavelength
so that means an electron whose kinetic energy is 3 into 10 to the power minus 25 joules is also a wave and corresponding wavelength is 897 ah nanometer now in this question we will discuss about the solutions of ah the atomic model that we had after doing quantum mechanical solution we realized that the ah states of hydrogen atom or ah and then we can generalize to ah other hydrogen like systems states of this system depend on different quantum numbers
so the four quantum numbers we discussed in in our class they are the principal quantum number which goes from which is denoted by n which goes from one to

three and and higher values for each principal quantum number n we have associated ah a zimuthal quantum number which is denoted by l and the value of l goes from 0 to 0 1 2 to n minus 1.

so therefore once we define n we have an upper limit of l again for each value of azimuthal quantum number we have associated m l or the magnetic quantum number which goes from minus l to plus l in the step of one and apart from ah these three quantum numbers we also have the electron which which has a spin and we denote the electron spin with the spin quantum number as ms equals plus half or ms equals minus half signifying the up spin of the electron or down spin of the electron this particular question concerns about this quantum number for example this question asks what are how many sub shells are associated with n equals four

so to answer the first bit

so we know that we got this question that n equals four

so therefore the principal quantum number n is given n equals four and we know for n equals four l goes from zero to n minus one and in this case zero one two three

so these four are called sub shells

so these are the four ah subshells that we have now for each value of l we have ml values two l plus one number of ml values suppose l equals zero

so therefore since l is zero 2 l plus 1 is 1

so therefore one possible value of m l exists and that value of m l is 0 and this one we call as an orbital

so i have got one orbital

so since n equals 4 l equals 0 ml equals 0

so this orbital is 4 s orbital similarly when i go to l equals 1 i have 2 l plus 1 that means 3 number of ml values

so m l goes from minus one to zero plus one

so therefore i have three orbitals in this subshell

so this can be four p and for l equals two i have m l equals plus minus 2 plus minus 1 0

so therefore 5 orbitals in this sub shell and l equals 3 i have ml value going from plus minus 3 plus minus two plus minus one zero

so therefore seven seven orbitals

so one orbital for l equals zero l equals one we have three orbitals l equals two we have five orbitals l equals three we have ah seven orbitals

so together we have got ah one plus three plus five plus seven that is ah sixteen orbitals

so we have got four sub shells we have got sixteen orbitals

so this number of orbitals of course goes as n square

so if n is 4

so we have n square number of ah or by 16 orbitals and if number of subshells is also given as n because it goes from zero to n minus one

so therefore for if principal quantum number n is given

so you have n number of sub shell you have in square number of orbitals and you know that each orbital can have two electrons

so therefore number of electrons will be two n square in this case it is thirty two

so how is that hap possible because each orbital can contain two electron over here similarly i can fill fourteen electrons here 10 electrons here

so if i ful fill all the 16 orbitals i can fill with 32 electrons out of them you see that in each orbital one electron has spin m s equals plus r the other one has m s equals minus half

so one is alpha spin another is bit spin and that is happening in each orbital
so since i have 16 orbitals
so therefore i have 16 number of electrons that can have m s equals plus half and 16 the remaining 16 electrons will have m s equals minus r this is this concerns the second bit of this question the second bit of the question tells how many electrons are there ah in in this sub cells having m s value of minus half for n equals four
so you see that for n equals four we have four sub shell 16 orbitals and 32 electrons out of them 16 or exactly half of these electrons can have m s equals minus half ah the remaining half will have m s equals plus up
so in this way you actually ah what you should learn in this problem is that every elect each electron in this in this case has a specific identity it has an identity with respect to the principal quantum number in this case n is four for all these thirty two electrons they can have one of these four sub shells zero one two three four s four p four d four f orbital ah sub shells and in each case four p four s will have one orbital four p will have four p x four p y four p z four d will have five orbitals four f will have seven orbitals and if i fill all the electrons i can fill 32 electrons out of which 16 will be up spin or the alpha spin ms equals plus half the remaining 16 will have betas electron which will have ms equals minus up
so this question concerns about the quantum number of the ah quantum numbers of an electron now after learning about this orbitals we started to know how to ah we can ah arrange this electrons in in different orbitals
so this question concerns that
so it says that an atom of an element ah atom of an element contains 29 electrons and 35 neutrons
so this shows that this at this is not an ion this is an atom
so therefore number of electrons is equal to number of protons
so it asks deduce the number of protons
so therefore we already know
so if it is an atom and not an ion
so it has 29 electrons
so therefore the number of protons is going to be 29
so if we know number of protons is 29 that means z is 29
so we know which atom we are talking about ah that is this is ah copper and it asks the find out the electronic configuration of this element
so this is ah kappa
so this is 29 it's z value a value is the mass number is 29 plus 35 that will be ah 64.
ah we will have to find out the electronic configuration for this to do this electronic configuration you remember that ah we have to see the you have to arrange the orbitals in their increasing order and we get this increasing order by taking n plus l value
so we have one s then will fail two s then will fill two p then will fail three s then will fill three p then four s then three d four p
so this diagram uh i am sure you are familiar with now this is the increasing order of n plus l that is given here
so let us write down 1s 2s 2p 3s 3s 3p
so after 3p i will not write 3d rather i'll write 4s because 4s will have n plus l uh
so four s has n plus l four three d has n plus l five
so therefore ah this way
so let us try to fill the electrons from lower
so one s can have two electrons

so i can i already gave two electrons to them
so two s and two p can have ah two s can have two electrons two p can have six electrons
so together now if i count i have already used ten electrons now let us look at three s and 3 p
so i if i fill 3 s 2 3 p 6 i am done with 18 electrons i am left with 11 more because i have got 29 electrons to fill
so i have 4 s i give 2 electrons i have three d i have
so after giving two electrons i am done with twenty electrons
so therefore i am left with nine electrons let me fill this ah four into two eight and one over here
so this configuration turns out as four s two three d nine but there is a problem with this configuration is that this shell this structure four s is fully filled but three d nine is just next to ah fully filled
so if we can we know that half filled and fulfilled ah shells are the most stable one
so they can have an internal arrangement
so that you have four race one and three d ten such that this is half filled therefore stability provides stability this is fully filled
so therefore this also provides stability
so therefore with twenty nine electron you have four s one three d ten electronic configuration at the valence ah and then you have this core orbitals which are which are given here
so this is the electronic configuration of this element now the next question concerns the orbital ah shapes or in particular it wants to find out what how many nodes are there in this orbitals
so you remember when we have different l values as methyl counter number
so we have s orbital or p orbital or d orbital we know s orbital is spherically symmetric is simply a sphere
so 1s is a sphere 2 s is also a sphere but 2s has got a radial node
so how do i define 2s 2s is one sphere within another sphere and in between the two spheres there is a node that means you will not find electron during that region and this is what is given in this contour diagram
so where in for the 2s orbital you see the there is electron distribution at the center and after that there is a gap where there is because there is a node and again electrons are ah can be found here
so this is about the radial node when you talk about two p orbital ah we know that p orbitals have one angular node you see this is two p y you can see that in x z plane there is a node
so there is a lobe above x z plane there is a low below x z plane but not on the x z plane
so there is a plane planar node for two p and similarly for three d orbitals or any d orbitals you have got two planes along which the nodes are there
so there are two angular nodes for d orbitals one angular node for p orbital and no angular node for s orbitals now the ah a number of radial nodes is given by n minus l minus 1 and number of angular nodes is simply given by l and total number of nodes when you add them up you will get n minus 1.
the question asked arrange the following orbitals in increasing order of radial nodes angular nodes and total nodes let us write down this 1s the orbitals 1 is 2s2p 3s 3p 3d and find out the number of angular nodes
so since this is s orbital angular node is zero again s orbital angular node is zero p orbital angular node is one s orbital angular node is zero p orbital angular node is 1 d orbital angular node is 2 just by looking at whether spd i am assigning angular nodes what about the radial nodes the radial nodes 1s is

the lowest s orbital
so therefore there is no node two s is the ah second ah s orbital
so therefore it has got one node two p is the lowest p orbital
so therefore it has got no node three s is the third s orbital
so therefore it has got two nodes because i am n minus l minus one
so three p will have one node three d is the lowest d orbital
so therefore it has got no radial node now the total number of nodes is obtained when we just ah add them up
so when i do this 0 1 1 2 2 2.

so you see 0 for 1s 2s and 2p both have one nodes 3s 3p 3d have both two all two nodes each
so because number of nodes total number of nodes is depend given by n minus one
so three s three p three d have same value of n that is three
so therefore total number of nodes is two
so total number of nodes depend on only on n angular node depend on only an l and radial nodes depend on both n and l ah let us look at the next question this question concerns the effective nuclear charge the if you remember
so we discussed this is the square of the wave function or the probability ah distribution of the wave function corresponding to ah this the ah this diagram corresponds to one s orbital this diagram corresponds to two s orbital a hydrogen atom what do we see here we see here that the probability of finding electron in 1s orbital vanishes very quickly you can see this is beyond 0. 2 nanometer you have ah almost zero probability but when you look at two s orbitals you see that the probability of finding the electron even at larger value larger ah distance between the electron and nucleus is also finite
so therefore two s electrons are ah found further from the nucleus and one s electrons are formed closer to the nucleus now this question asked among the following pairs of orbitals which orbital will experience the larger effective nuclear charge now what is effective nucleation
so we have the nucleus which has ah gut protons and that provides a positive charge environment at the center and this positive charge of the nucleus contrib ah holds together the electrons that are around around this now if you have more and more number of electrons added to a fixed amount of positive charge of course you would see that the electrons will start experiencing less of this nuclear charge or less of this positive charge because there are many electrons which are competing with each other for the same source of positive charge
so therefore when you have more number of electrons not all electrons will experience the nuclear charge to the same extent this to the extent to which they will exp an electron will expect experience ah the nuclear charge is given by this effective nuclear chain roughly when you are the electron is further and further away from the nucleus of course it is going to experience less of the new if nuclear charge
so therefore this effective nuclear charge becomes smaller when the electron is found further from the nucleus
so now let us compare 1s and 2s of course 2s electron is found further than the nucleus compared to 1s electron since 1s orbital is closer to the nucleus
so therefore the effective nuclear charge of 1s will be greater than the effective nuclear charge of the 2s orbital now the other question is 4d and 4f the argument goes again in the same direction for f electron is more diffused that means it goes away further away from the the nucleus compared to 4 d because even if both have same principle quantum number 4 they have 2 different ah azimuthal quantum number l
so therefore 4 f which is more diffused will will experience less of the

nuclear charge
so therefore for this nuclear charge will be greater than four f and if i compare three d and three p the argument is again same three d orbital has l equals two which is more diffused compared to the three p orbitals whose l equals one and remember we are doing this only when the n values are the principal quantum number is the same
so comparing 3p and 3d then i see that 3p will have experience more nuclear charge effective nuclear chance than 3d of course now we can similarly say that in this case we kept the nuclear charge same and we said that we compared different orbitals but suppose if i say aluminum and silicon both have valence electrons in three p
so which electron will experience more nuclear charge is it aluminum or ah or is it in silicon
so that case you have to pay attention to what is the number of positive charges in the aluminum and silicon nucleus nuclei
so if the number of positive charges or number of protons are greater in a particular nucleus and the number of electro the electron is in the same orbital in this case both in the same p ah or p orbitals with same principle quantum number
so in that case the greater the positive charge greater will be the effective nuclear charge because now more number of positive charge attack are attracting these electrons
so this is how we ah do this effective nuclear charge
so in this lecture we revise the concept of the chapter atomic structure through a number of problems of course you in your textbooks you have many more problems but i try to cover all those important concepts that you would need to recall before you can solve all other problems i hope you you like this these problems and you would continue to solve other problems based on the inputs that we had in this lecture thank you for your attention you