

[Music] [Music] [Music] 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 6.023×10^{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 6.023×10^{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 1.2046×10^{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 1.2046×10^{-22} these many number of protons multiply that with 1.672×10^{-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 an atom the electrons have very little mass

So therefore approximate mass in atomic unit it is almost zero

So the proton and neutrons contribute to the mass of the atom nucleus

So therefore the 34 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 ${}_Z^A X$ where X would be the symbol of the atom Z 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 its mass number is 56. the mass number is number of protons plus number of neutrons

So since 26 is the number of protons

So therefore number of neutrons is $56 - 26 = 30$ number of neutrons is 30.

So we got this question this has 26 number of protons and 30 number of neutrons now let us look at another question which also uses the similar concept this says that you have an iron whose mass number is 37

So let us write down

So the A is 37 that's it possesses one unit of negative charge when an atom has one unit of negative charge we call it an anion and it happens because it has got one electron extra than what it has as the number of protons

So therefore number of electron in this atom is number of proton plus one then only charge of minus one occurs if you have a cation or positive charge that means number of protons are greater than number of electrons

So this is what we have $n_e = n_p + 1$ 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 one number of electron then if I have one number of electron the number of neutrons is 1.111 because this is 11.1 percent almost greater than the number of electrons

So therefore this value is the number of neutrons now atomic mass is given 37 how do I get this atomic mass if I must almost add n number of neutrons to number of protons that means $n_p + n_n = 37$ but I know $n_p = n_e - 1$ and $n_n = 1.111 n_e$

So this is equal to thirty seven

So this minus one goes the other side

So I have and 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 $Z = 17$ and $Z = 17$ means we know that this is chlorine the species is chlorine and what is number of neutrons number of neutrons is $A - Z$ 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 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 questions us find the symbol of the iron the symbol of the iron is here this is Z this is A and this is the number of charges almost present in this small 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 they are related to the energy of this uh 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 ν 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 ν which is the frequency can also be expressed in terms of the wavelength λ by $\frac{c}{\lambda}$ where c is the speed of light it can also be expressed in terms of wave numbers $\bar{\nu}$ a $\frac{1}{\lambda}$

So here $\bar{\nu}$ is simply $\frac{1}{\lambda}$ 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 ν 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 λ 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 $E = \frac{hc}{\lambda}$ this one now i have two constants to uh worry about six is the planck's constant multiplied by three into ten to the power eight 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 doesn't 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 τ is 2 into 10 to the power minus 10 second but we know τ is close related to the frequency

So therefore frequency is $\frac{1}{\tau}$ which is 0.5 into 10 to the power 10 second inverse or hertz this is the frequency now the question ask wavelength but we know that ν is $\frac{c}{\lambda}$

So therefore λ is $\frac{c}{\nu}$

So to get this

So 3 into 10 to the power 8 meter second inverse that is the speed of light divided by the frequency which is now 0.5 into 10 to the power 10 second inverse

So you see that the unit that would come out will be in the unit of meter and this comes out to be 0.06 meter of course if you want you have here λ you can also convert it to $\bar{\nu}$ because this is one simply one over λ and then you will get the ah number in the units of meter inverse which is the wave number

So the point that you should ah remember here is that there are various ways to express ah a wave either through its wavelength or time period or a wave number but they are all interconvertible and they correspond to one ah energy ah associated with one energy which is given by if we multiply them with the planck's constant h okay now let us look

at another question this question concerns photoelectric effect if you remember the discussion that we had on photoelectric effect is that if we irradiate some light onto a metal surface then light when you have light of frequency ν is used then the energy associated with this light is given by $E = h\nu$ and when you shine this light on a 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 experimentally observe them

So every metal we understood that is associated with its characteristic value of work function which is ϕ_0 which whose energy can also be converted to the frequency ν_0 through flux constant now if I am irradiating a light with a new frequency the metal has what function of ϕ_0 after compensating the metal with its work function whatever energy remaining will be used as the kinetic energy of the ejected electron So that means the energy associated with ϕ_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 4.10×10^{-7} meter it strikes on the metal surface and the work function of the metal 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/λ

So you see that we are often using the multiplication of these two constant hc 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 result of this product hc in an eV 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 4.07×10^{-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 an electron volt

So we have 4.07×10^{-19} divided by 1.602×10^{-19} this is in the unit of electron volt which should come out to be an 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 ϕ_0 given here the remaining energy will be converted as the kinetic energy of the electron So kinetic energy of the electron is $E - \phi_0$ which is 0.97 electron volt because ϕ_0 is 2.13 and this is 3.10 volt

So this is the third bit ask what is the velocity of the electron

So this is kinetic energy

So this is kinetic energy can be written as $\frac{1}{2}mv^2$ which is 0.97 an electron volt now we can express it in terms of an joules unit

So this kinetic energy $\frac{1}{2}mv^2$ is given here

So therefore v^2 is $2/m$ what is m m is the mass of the ejected electron

So 9.11×10^{-31} ah forgive me this has to be divided not multiplied two into zero point nine seven one point six zero two ten to the power minus nineteen ah joule divided by this is 9.11×10^{-31} joule per kg

So you know joule per kg will be meter square second inverse square

So therefore v is the square root of this

So joule per kg I can write as meter square second ah as to the second to the minus 2 and therefore v will be obtained by taking the square root of this and when you do this you will get 5.84×10^6 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 6000 close to 6000 kilometer per second

So that's quite quite a fast electron there all right

So we proceed to the next question the next question concerns the hydrogen atoms energy levels

So if you remember we discussed the hydrogen atom emission problem through Bohr's

model and then we also saw that bose model 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 that they are quantized

So we have the n where n is the quantum number that goes from 1 to larger numbers

So energy of the n th 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 one the next one is n equals two n equals three n equals four 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 2.

So this transition is happening

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

So it is asking what is the wavelength 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 the ah atomic z is one for hydrogen atom n is 4 now

So this is my 2.18×10^{-18} by 4^2 this is in the unit of joules what is the energy of second level eq n equals 2 this is again simple 10^{-18} over 2^2 again the unit of joule

So when it happen uh this ah the jump happens what is the energy of the ah emission the emission energy is given by $e_{\text{final}} - e_{\text{initial}}$

So that we would get to 10^{-18} minus 18 one by 4 minus one by 16

So [Music] 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 4.087×10^{-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 ah indicates that

So now corresponding to this energy what is the wavelength

So λ we know ah we sorry we know uh energy is $e = hc / \lambda$

So therefore λ is hc / e again we have to deal with the multiplication of the two constant divided by 4.087×10^{-19} joule which should come out to be in the unit of nanometer it is 486.3 nanometer which is 10^{-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 4 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 uh detached from the uh 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 $1/n^2$ or $1/n^2$ 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 zero because n goes very large and what is the e_{initial} e_{initial} is simply e_4

So the ionization energy what would uh how much you would do to ionize this electron from n equals four you have to give the energy corresponding to this e_4

So you can see $0 - e_4$ that would be simply the ionization energy would be 2.18

divided by ah 16 into 10^{-18} joule which will turn out to be 1.36×10^{-18}

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 the electron okay

So let us ah 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 z is greater than one but still the system has one electron

So now let us look at this 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 ah recall what is ah 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 ionized 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 1 here

So this is simply into 4 this this is the uh 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 eight point seven two into ten to one minus eighteen joules to ionize this electron

So therefore the energy required is this ah quantity shown here okay

So the next question that we are 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 depressed hypothesis

So depressed 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 λ is given by h by p or h by $m v$

So if you 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 10 to the power minus 31 ah kilogram 3 into 10 to the power minus 25 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 seven point three nine into ten to the power minus twenty eight with the unit of kilogram meter ah second in ah a 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 de Broglie wavelength which is given by $\lambda = \frac{h}{p}$ and h is 6.626×10^{-34} divided by the momentum and when you do this you would find 0.897×10^{-6} meter which is about 897 nanometer

So this is the de Broglie wavelength

So that means an electron whose kinetic energy is 3×10^{-25} joules is also a wave and corresponding wavelength is 897 nm. Now in this question we will discuss about the solutions of the atomic model that we had after doing quantum mechanical solution. We realize that the states of hydrogen atom or and then we can generalize to other hydrogen like systems. States of this system depend on different quantum numbers.

So the four quantum numbers we discussed in our class they are the principal quantum number which goes from which is denoted by n which goes from one to three and higher values for each principal quantum number n we have associated a azimuthal quantum number which is denoted by l and the value of l goes from 0 to $n-1$.

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 $-l$ to $+l$ in the step of one and apart from these three quantum numbers we also have the electron which has a spin and we denote the electron spin with this spin quantum number as m_s equals $+\frac{1}{2}$ or m_s equals $-\frac{1}{2}$ 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 $n-1$ and in this case zero one two three

So these four are called sub shells

So these are the four sub shells that we have now for each value of l we have m_l values $2l+1$ number of m_l values suppose l equals zero

So therefore since l is zero its $2l+1$ is one

So therefore one possible value of m_l exist and that value of m_l is zero and this one we call as an orbital

So I have got one orbital

So since n equals four l equals zero m_l equals zero

So this orbital is four s orbital similarly when I go to l equals one I have $2l+1$ plus one that means three number of m_l values

So m_l goes from -1 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 $2, 1, 0, -1, -2$ plus minus two plus minus one zero

So therefore five orbitals in this sub shell and l equals 3 I have m_l value going from $3, 2, 1, 0, -1, -2, -3$ plus minus 3 plus minus 2 plus minus 1 0

So therefore 7 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 seven orbitals

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

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

So this number of orbitals of course goes as n^2

So if n is four

So we have n^2 number of orbitals or by 16 orbitals and if number of subshells is also given as n because it goes from zero to $n-1$

So therefore for if principal quantum number n is given

So you have n number of sub shell you have n^2 number of orbitals and you know that each orbital can have two electrons

So therefore number of electrons will be $2n^2$ in this case it is thirty two

So how is that possible because each orbital can contain two electron over here similarly I can fill fourteen electrons here six ten electrons here

So if I full fill all the sixteen orbitals I can fill with thirty two electrons out of them you see that in each orbital one electron has spin m_s equals $+\frac{1}{2}$ the other one has m_s equals $-\frac{1}{2}$

So one is alpha spin another is beta 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 half this is this concerns the second bit of this question the second bit of the question tells how many electrons are there in in this sub shells having m_s value of minus half for n equals four

So you see that for n equals four we have four sub shells 16 orbitals and thirty two electrons out of them sixteen or exactly half of this electrons can have m_s equals minus half and the remaining half will have m_s equals plus up

So in this way you actually have what you should learn in this problem is that every 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 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 thirty two electrons out of which sixteen will be up spin or the alpha spin m_s equals plus half the remaining 16 will have beta electron which will have m_s equals minus up

So this question concerns about the quantum number of the electron now after learning about this orbitals we started to know how to arrange these electrons in in different orbitals

So this question concerns that

So it says that an atom of an element contains 29 electrons and 35 neutrons

So this shows that 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 that is this is copper and it asks the find out the electronic configuration of this element

So this is copper

So this is 29 its Z value a value is the mass number is 29 plus 35 that will be 64. we will have to find out the electronic configuration for this to do this electronic configuration you remember that we have to see the you have to arrange the orbitals in their increasing order and we get this increasing order by taking $n + 1$ value

So you have 1s then we'll fill 2s then we'll fill 2p then we'll fill 3s then we'll fill 3p then 4s then 3d 4p

So this diagram I am sure you are familiar with now this is the increasing order of $n + 1$ that is given here

So let us write down 1s 2s 2p 3s 3p

So after 3p I will not write 3d rather I'll write 4s because 4s will have $n + 1$

So 4s has $n + 1 = 4$ 3d has $n + 1 = 5$

So therefore in this way

So let us try to fill the electrons from lower

So one s can have two electrons

So I can already give two electrons to them

So two s and two p can have 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 three p

So if I fill three s two three p six I am done with eighteen electrons I am left with 11 more because I have got 29 electrons to fill

So I have 4s I give 2 electrons I have 3d I have

So after giving 2 electrons I am done with 20 electrons

So therefore I am left with nine electrons let me fill this 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 4s is fully filled but 3d 9 is just

next to a half filled

So if we can know that half filled and fully filled shells are the most stable one

So they can have an internal arrangement

So that you have four s one and three d ten such that this is half filled therefore stable provides stability this is fully filled

So therefore this also provides stability

So therefore with twenty nine electron you have $4s^1 3d^{10}$ electronic configuration at the valence shell and then you have this core orbitals which are given here

So this is the electronic configuration of this element now the next question concerns the orbital shapes or in particular it wants to find out what how many nodes are there in these orbitals

So remember when we have different l values as magnetic quantum numbers

So we have s orbital or p orbital or d orbital we know s orbital is spherically symmetric is simply a sphere

So one s is a sphere two s is also a sphere but two s 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 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 can be found here

So this is about the radial node when we talk about two p orbitals 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 lobe 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 number of radial nodes is given by $n - 1 - l$ and number of angular nodes is simply given by l and total number of nodes when you add them up you will get $n - 1$. the question asked arrange the following orbitals in increasing order of radial nodes angular nodes and total nodes let us write down this 1 as the orbital 1s 2s 2p 3s 3p 3d and find out the number of angular nodes

So since this is s orbital angular node is 0 again s orbital angular node is 0 p orbital angular node is 1 s orbital angular node is 0 p orbital angular node is 1 d orbital angular node is 2 just by looking at whether s p d 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 2s is the second 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 $n - 1 - l$

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 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 1 nodes 3s 3p 3d have both two all two nodes each

So because number of nodes total number of nodes is depend given by $n - 1$

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 dependent only on n angular node depend on only an l and radial nodes depend on both n and l 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 distribution of the wave function corresponding to this the this diagram corresponds to 1s orbital this diagram corresponds to 2s orbital of hydrogen atom what 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 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 distance between the electron and nucleus is also finite

So therefore two s electrons are 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 nuclear charge

So we have the nucleus which has a lot of protons and that provides a positive charge environment at the center and this positive charge of the nucleus contributes to hold 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 experience an electron will experience the nuclear charge is given by this effective nuclear charge roughly when you are the electron is further and further away from the nucleus of course it is going to experience less of the 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 a way further away from the nucleus compared to 4d because even if both have same principle quantum number 4 they have two different azimuthal quantum numbers

So therefore 4f which is more diffused will experience less of the nuclear charge

So therefore for this nuclear charge will be greater than 4f and if I compare three d and three p the argument is again same three d orbital has $l = 2$ which is more diffused compared to the three p orbitals whose $l = 1$ 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 charge 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 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

So if the number of positive charges are number of protons are greater in a particular nucleus and the number of electrons is in the same orbital in this case both in the same 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 are attracting these electrons

So this is how we 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 text books 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 like 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