Basics in Inorganic Chemistry
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Lecture – 03
Properties of Elements (Size, IA, EA and EN)

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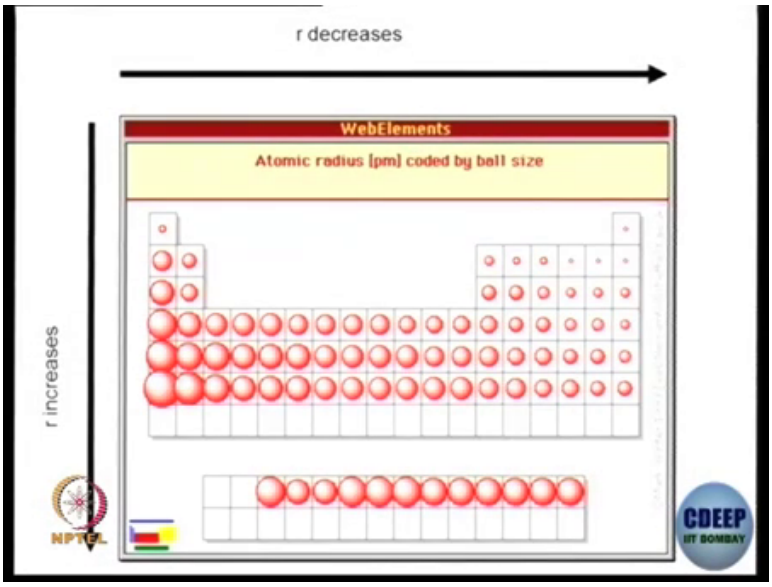

Now let us look at the periodic table how the periodic trends are and how can you explain very simply by what we understand. So, far is just Z star by Z star mainly we would like to look at the periodic trend. So, what do we have learned so far from left to right Z star increases, why Z star increases that is because the electrons are getting incorporated in the same outer sphere electron one by one.

So, it is 2 2s 1 2s 2 2 p 1 2 p 2 2 p 3 2 p 4 2 p 5 2 p 6. Same two cell to cell number principle cell two the electrons are getting incorporated one by one right and therefore those electrons

are not capable of neutralizing the positive charge at the nucleus. So, the shielding is going to be very less, shielding towards the outer sphere electron shielding of the nuclear charge what is the outer sphere electron is going to be very less.

And therefore this effective nuclear charge will be very high. Since the effective nuclear charge is very high the outer sphere electron or the electrons will overall all the electrons will be zoomed in or pulled in very effectively towards the nucleus and therefore size will be decreasing considerately.

If you see from here lithium beryllium boron carbon nitrogen oxygen fluorine neon size is decreasing considerably this is a representative data. On the other hand if you look from top to bottom you see the size is increasing, why it is increasing? Because from walking from 1s to 2s 2 3 s 2 4 s 2 5 s every time you are increasing a new cell completely new cell. Of course, new cell means your size is going to increase by default.

More so with electrons from going for let us say 3 s to 4 s more and more electrons are going to get accumulated, those inner electrons are going to neutralize the nuclear charge effectively. And therefore effective nuclear charge is not increasing dramatically right. It is almost remained constant from top to bottom it is the change is very little ok. Effective nuclear charge remain almost constant and the principle cell is increasing and therefore you have no control in size; size is going to increase since the principle cell is increasing.

From left to right, it is the same principle cell where electrons are getting in again and again. The penetration of these electrons or the neutralization of this electron neutralization of positive charge by these electrons are not that much and therefore the effective nuclear charge increasing and pulling in the electrons or overall size will be decreasing from left to right from top to bottom size is going to dramatically increase.

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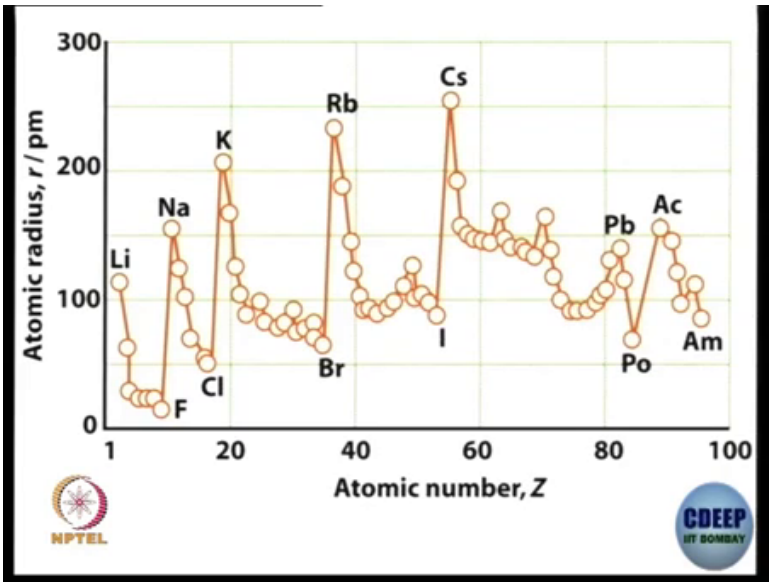

So, this is the atomic number versus you know atomic radius plot which you can justify from top from left to right you see size increases and then size lithium to sodium, lithium, sodium, potassium, rubidium, cesium you see size increases, dramatically left to right size decreases right.

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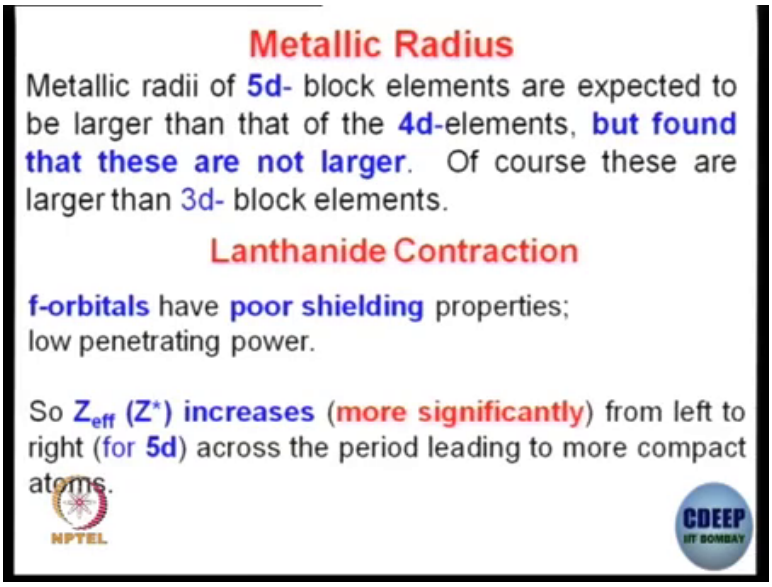

Of course these are something this is something you do understand, that is metallic radii of 5d block elements are expected to be larger than that of 4d. So, 4d to 5d you should have if you look from know go down from 4d to 5d, 5d we should be having as you discussed should be having larger size right. Larger size compared to 4d of course, compared to 3 d.

But in reality what we find that these are not larger, 5d elements are not larger compared to 4d. Which is kind of contradicting in the last slide whatever we were trying to discuss, why is that? This is mainly due to the fact that 4 f is coming into the picture right. So, since 4 f is not almost very least penetrating or have the very little ability to neutralize the positive charge. What will happen then overall you see the (Refer Time 05:44) of 4 f is little.

So, the Z star is going to get more and more, because the neutralization or the shielding is not effective and therefore although 4d to 5d you see a principle cell increases Z star also

increases. And therefore you will be able to construct or you know you will be able to mitigate that effect of the increase effect of increasing this atomic size by the Z star.

So, overall you see the size of 4d and 5d will remain same or similar. So, once again all though 4d to 5d one of the cell is increasing. But at this point you are bringing in the f orbital's, f orbital's being less or least penetrating. Now Z star or the effective nuclear charge is going to be much more felt at this point penetration of f electrons are less and therefore shielding is going to be less Z star is going to be much more effective.

And what we will see is although the cell principle cell is increasing due to the increased Z star they the size will remain constant 4d and 5d elements will have similar size overall. This is what is called lanthanide contraction. So, f orbital's are poor shielding properties low penetrating power right, that is what we tried to say. So Z effective that means Z star increases more see left to right for 5d across the period leading to more compact atoms ok.

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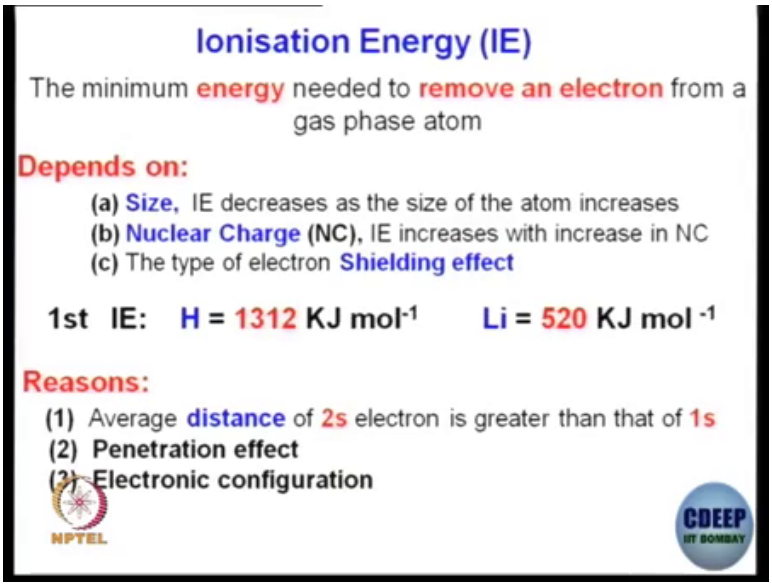

What about ionization energy what do we have seen. So, far from left to right in the periodic table we see that size is decreasing right and from top to bottom size is increasing. What is the ionization energy? Ionization energy is the minimum energy that is required to remove an electron from a gas phase atom right. If the size from left to right is increase decreasing and you have really strong attraction between nucleus and your outer sphere electron, I think removing electron is going to be very difficult right.

So, effectively what we will see that ionization energy will increase from left to right, ionization energy will increase dramatically from left to right from top to bottom it will be much easier to remove the electron. That means, ionization energy will be less, because from top to bottom size is getting higher and higher and therefore removing electron will be very easy.

So, the ionization energy depends on size nuclear charge and the shielding effect ok. Let us take an example first time ionization energy for hydrogen is this much 1312 lithium, which is 1s 2 2s 1 these this 1s electron removal will cost you 1312 kilo Joule per mole lithium 2s electron removal will same 2s 1 electron removal will cost you 520 kilo Joule per mole.

So, 1 s electron removal is costing much more compared to 2s electron, why is that? Of course, 1s is smaller in size 2s is bigger. So, the you know distance of 2s electron is greater than of you know 1s electron penetration effect you have to consider electronic configuration you have to consider.

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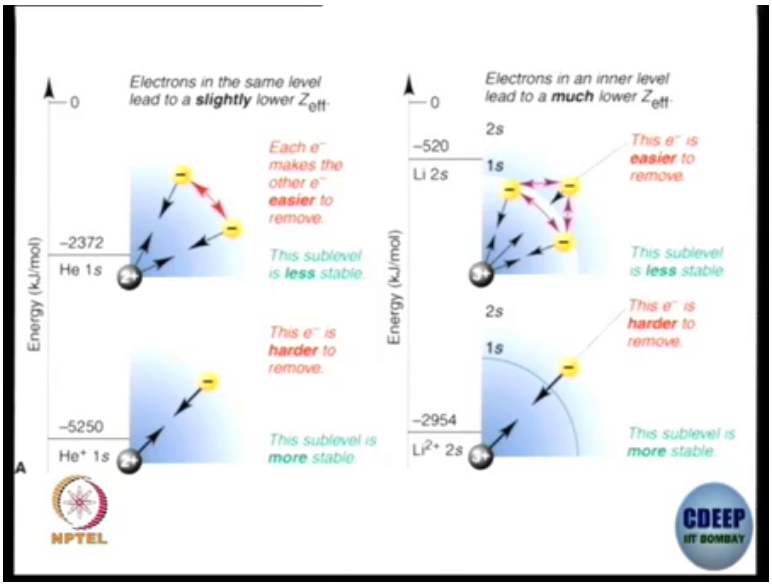

Let us look at this one for example you have helium, helium you have 1s 2 electron this two electrons will be repelling each other considerably right. And therefore removal of the first electron that is the first ionization energy will be much easier right. It is a two plus charge two

electron removal of first electron is easier, once you remove the first electron you have something like this situation where two plus positive charge it is attracting one electron.

So, that you know two positive charge attracting one electron, if you want to remove this electron from this system it is going to cost you much more and for that there is no repulsive energy. If you look at lithium; lithium you have 1s 2 2s 1 this three electrons are repelling each other very strongly. As you can see now this electron being outer sphere it is easy to remove compared to let us say you if you have let us lithium 3 plus with lithium 3 like 3 proton with lithium 2 plus.

They are going to attract these three protons are going to attract this one remaining electron very effectively. This energy where this is 520 this is you can see for the third electron removal it is going to be 2954 kilo Joule per mole right. That is quite a lot. So the first electron removal is easy second is difficult third is even further more difficult in the first cases you see of course, there is repulsive energy and the electrons are outer sphere. So, you will have much easier situation to deal with.

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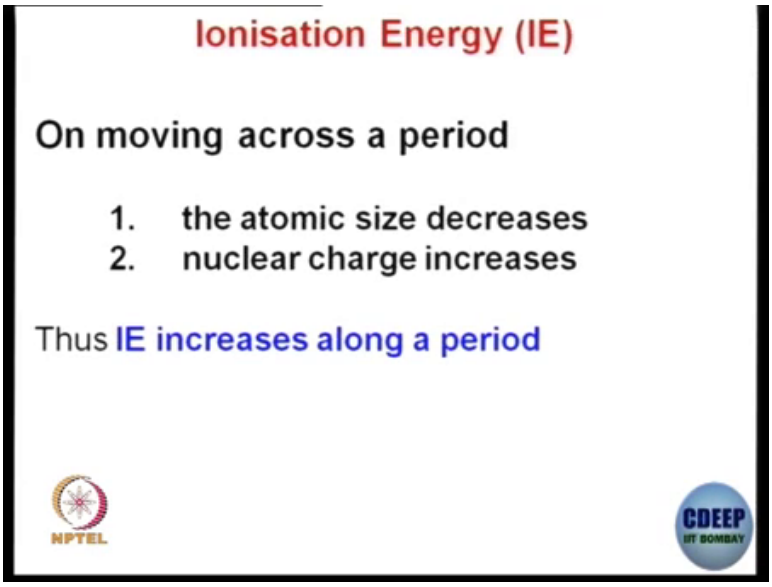

As I was trying to say on moving across a period ok, from left to right if you are trying to go the atomic size is decreasing, nuclear charge is increasing and therefore ionization energy increases along a period. As it is getting smaller nuclear charge is getting increased and then therefore ionization energy increases along a period ok.

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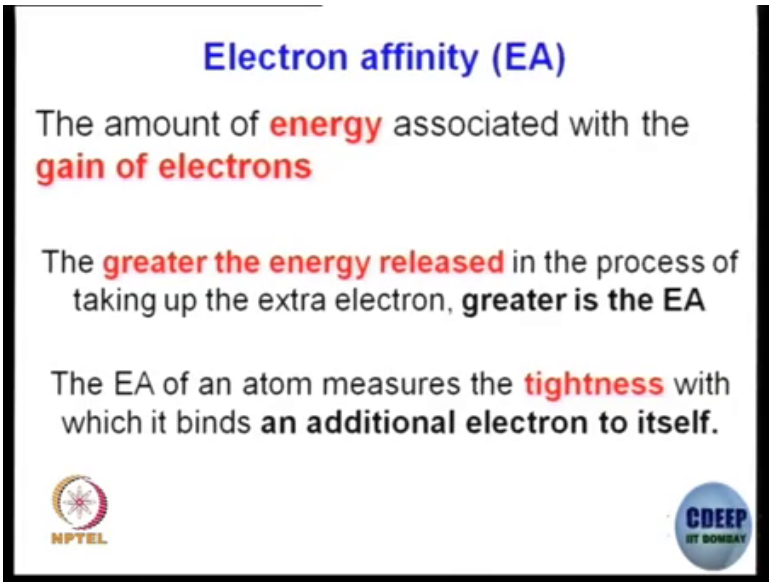

And from top to bottom same ionization energy you will have lesser and lesser ionization energy as you go from top to bottom. Electron affinity what is electron affinity first of all, electron affinity is means affinity means what love for it right. If you want to have you know another electron what is the gain in energy, the amount of energy associated with the gain of electron. You want to take one electron one atom wants to take one more electron what is the energy gain that is what is electron affinity.

As you can understand the greater the energy release in the process of taking up this extra electron your ionization energy or electron affinity is going to be greater. More energy released means electron affinity is greater. Now you see from left to right your size is decreasing your attraction between the nucleus and electron are quite high. If you want to put one more electron; electron affinity; affinity is going to be very high right.

You can since the attraction of nucleus towards outer sphere electron is very high, want to put one more electron in the outer sphere electron they are going to take it or the you know system is going to allow it quite easily the energy will be released quite a lot right.

So, the greater energy will be removed, that electron affinity of an atom measures that tightness with which it binds an additional electrons to itself. So, it is a neutral condition from there you want to put one more electron to it and what the love what is what type of interaction you are going to have with the existing system that is what your electron affinity right.

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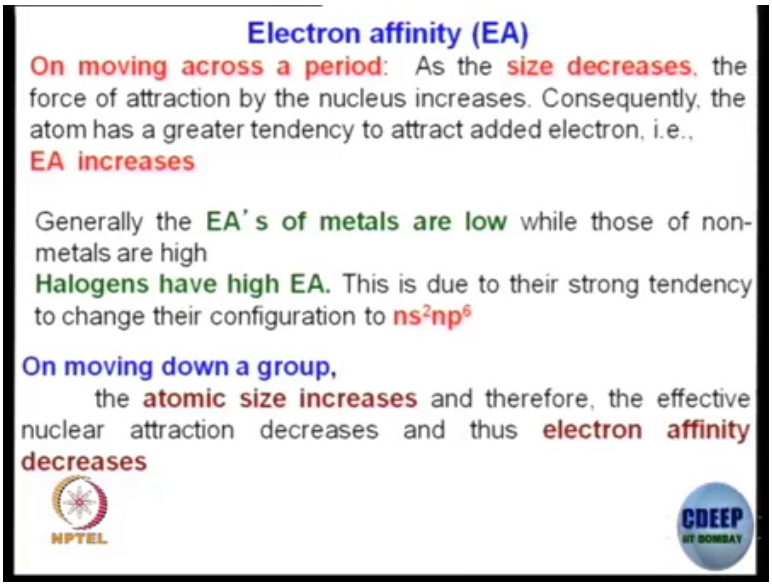

On moving across a period which I try to discuss and the size decreases ok, size is getting smaller and smaller the force of attraction by the nucleus increases right. So, force of attraction increases from left to right, consequently the atom has a greater tendency to attract

the added electron that is electron affinity increases, from left to right your electron affinity going to increase.

You might will generalize in it in a different way the electron affinities of metals are low while those of non metals are high, same thing from left side electron affinity is low as you go to the left to right your electron affinity is going to be quite high. This is where you see halogens have highest electron affinity and therefore they would like to take up the electronic configuration of ns 2 np 6 right.

So, on moving down a group well a size is very much increasing right. It is becoming more and more bigger and bigger from top to bottom sorry some from if you are moving from top to the bottom in the periodic table. Then size is going to be bigger they cannot hold on to their own electron they want to release, the electron pretty easily how come they will take up more electron from outside. It is not possible for them to really pick up more electron from outside they will be more happy to release electron than taking up kind of right.

So therefore, energy release during the process of adding electron from top to bottom will be less. So, it is going to be a less favourable process. So, the electron affinity will be less from top to bottom.

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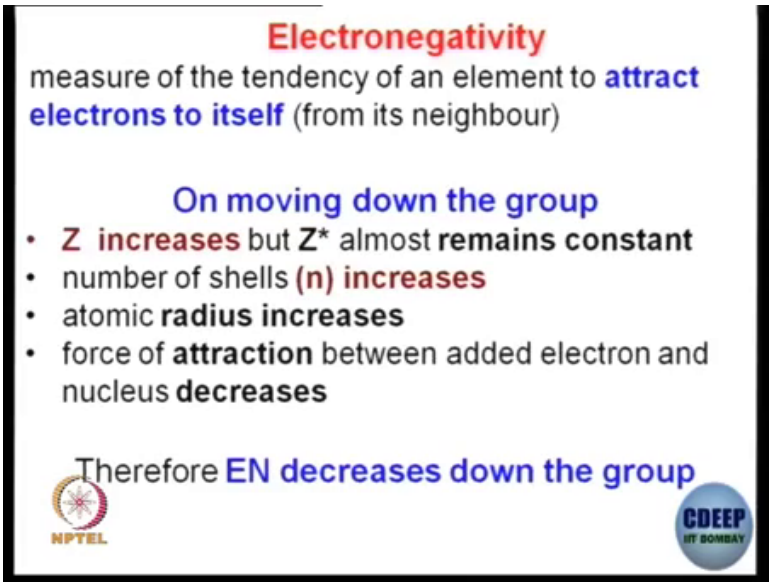

Now, electronegativity that is another very important phenomenon or they are an another important topic in the periodic table discussion. So, what is electronegativity? Electronegativity is simply the measurement or measure of the tendency of an electron to attract electrons to itself.

So, the atom is going to attract electron to itself right. When the atom is going to attract electron to itself, when it can hold it is own electron tightly right. So, you are going to attract electron towards yourself, if you can attract if you can keep your own electron very strongly right. So, once again if you walk from left to right in the periodic table what happened your size decreases, so your attraction is quite good.

So, from the neighbour you can really take up the electron quite or you know you can attract the neighbour's electron quite effectively. So, left to right in the periodic table your electron

affinity is going to be high from top to bottom you cannot even hold your own electron, how can you attract from the neighbours.

So, electron negativity will be less or becoming less from top to bottom right. On moving down the group that is what I am trying to discuss Z increases, but Z star almost remained constant, number of cells increases, atomic radius increases force of attraction between electron and nucleus decreases and therefore electronegativity decreases down the group.

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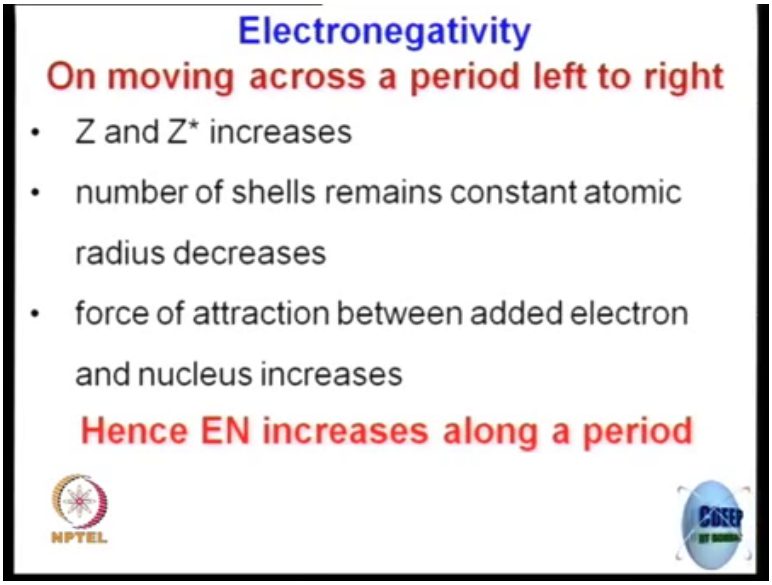

Or moving across a periodic table from left to right what is happening Z and Z star increases that is true, number of cells remains constant, atomic radius decreases, atomic radius becoming smaller and smaller. Force of attraction between added electron and nucleus increases and therefore electronegativity increases along a period.

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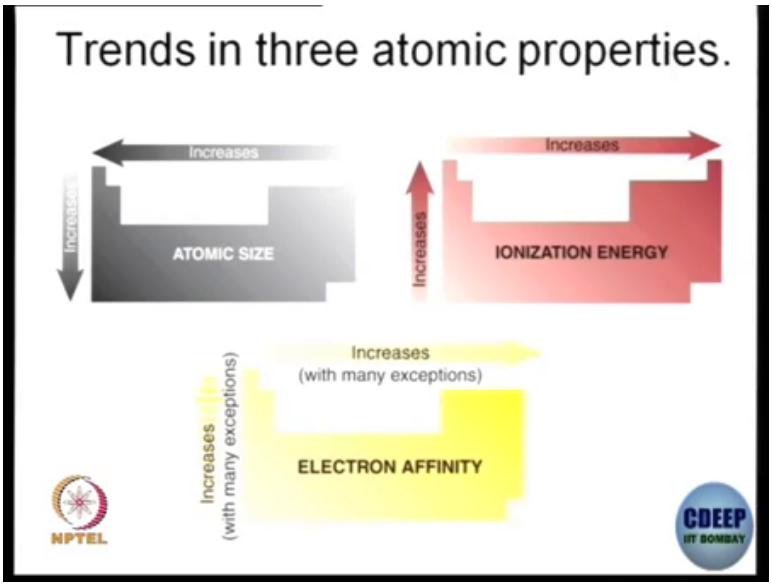

So, this is the trends in three atomic properties atomic size as I was saying from left to right. It is decreases from top to bottom it is increases for ionization energy ionization energy is going to be increasing from left to right and going to be decreasing from top to bottom. Electron affinity it is going to be increasing from left to right, electron affinity from top to bottom is again going to be decreasing. So, that is all for today.