Condensed Matter Physics
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Lecture - 10
The Free Electron Theory of Metals – Electrical Conductivity – Worked Examples

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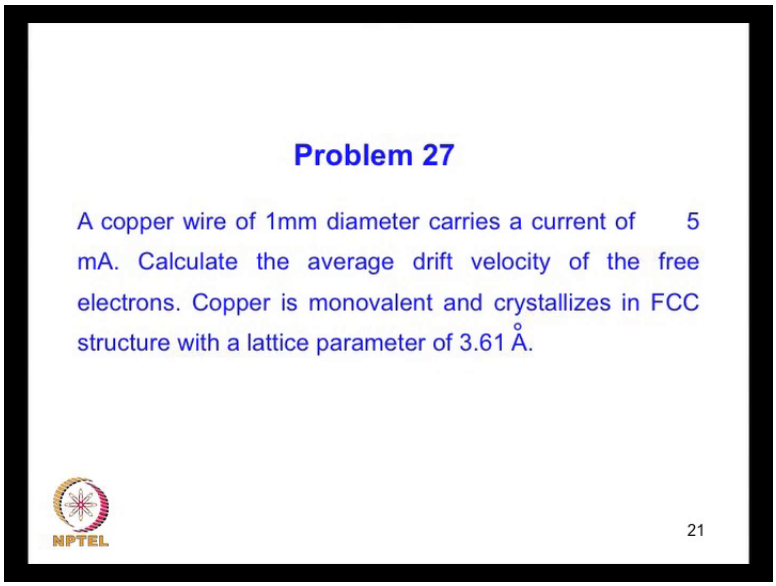

Next we go on to the problem regarding the conduction electrons in copper - in a copper wire. We are told that it has a diameter of one

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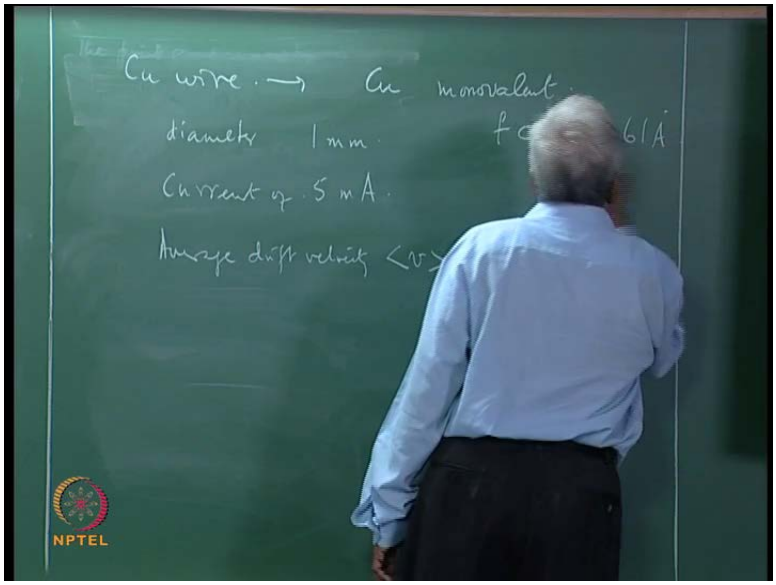

1 millimeter, and it carries the current of 5 milliamps. Now we are ask to calculate the average drift velocity. We are given the copper is monovalent, elemental copper is monovalent; and crystallizes in a face centered cubic structure with a lattice parameter of 3.61 Angstrom. These are the data given.

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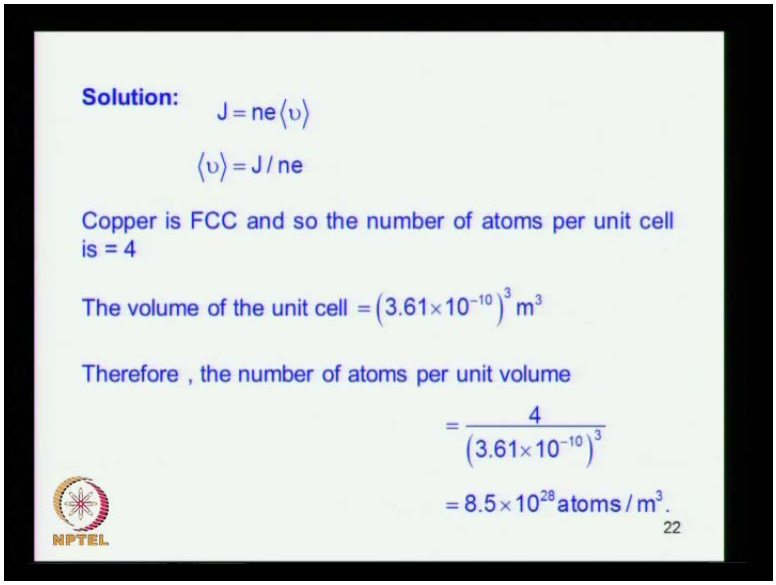

So we know that the current density J is n e v.

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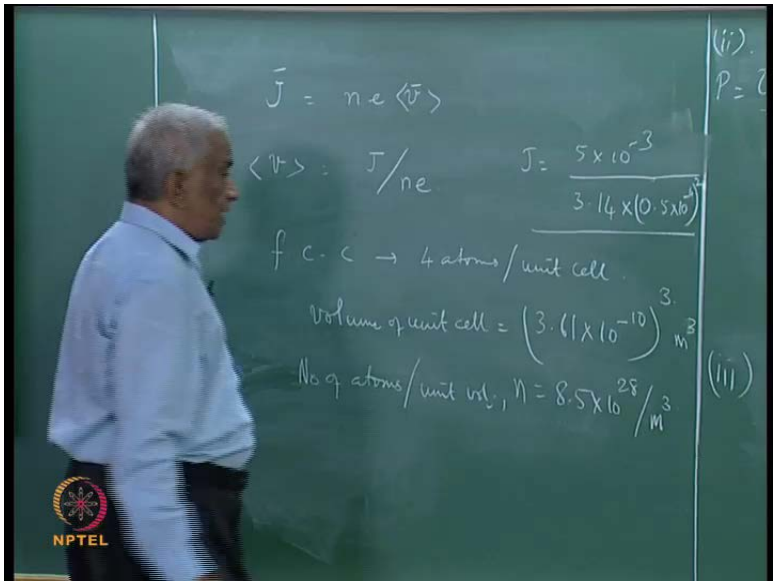

Therefore, the magnitude average drift velocity is just the magnitude of the current density by n e. Now J is of course we are told that it has 5 milliamps current in a diameter of one millimeter, so it is 3.5 into 0.5 into 10 to the power minus 4 square, that is the diameter, that is the radius, so that gives the value of the current density. We also know from the fact that it has the unit cell, which is face centered cubic, therefore there are four atoms per unit cell.

In the unit cell volume can be calculated from the given lattice parameter, which is 3.61 into 10 to the power of minus ten cube that is the volume in meter cube. Therefore, we can calculate the numbers, since there are four atoms in the unit cell, so what is the number of the atoms per unit cell number of atoms per unit volume that is what we call as n and that turns out to be 8.5 into 10 to the power 28 per meter cube. And since copper is monovalent, this is the number of, this is n equal to this, the number of electrons is just equal to this.

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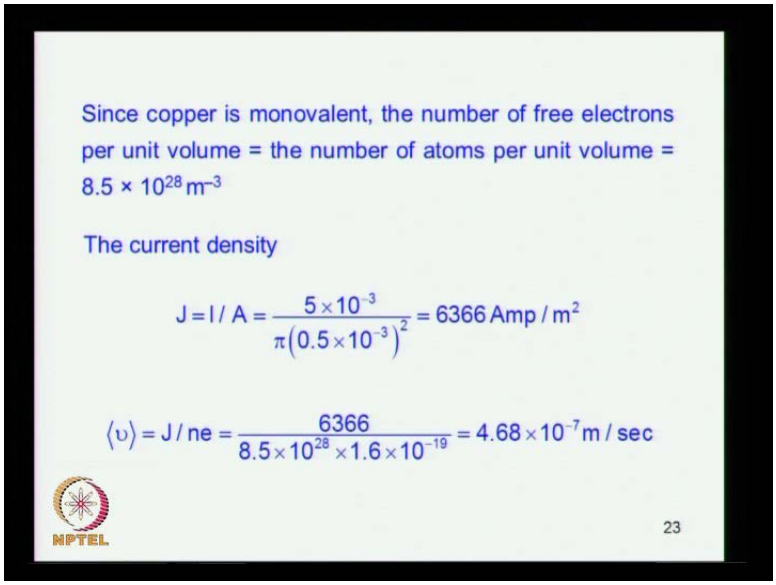

Therefore we have the current density, we have this know the electron charge, so we can readily calculate the drift velocity which turns out to be the average drift velocity by substitution in this as the value of 4.68.

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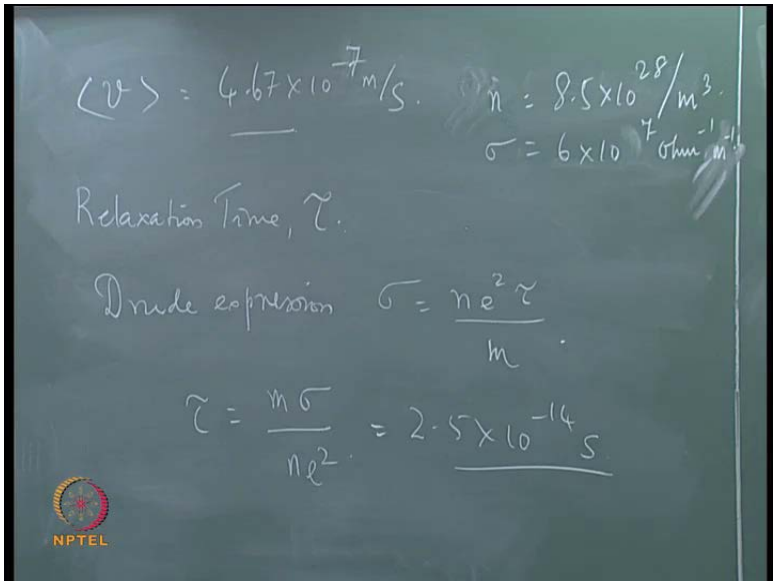

We will take the data for a common metal a general metal.

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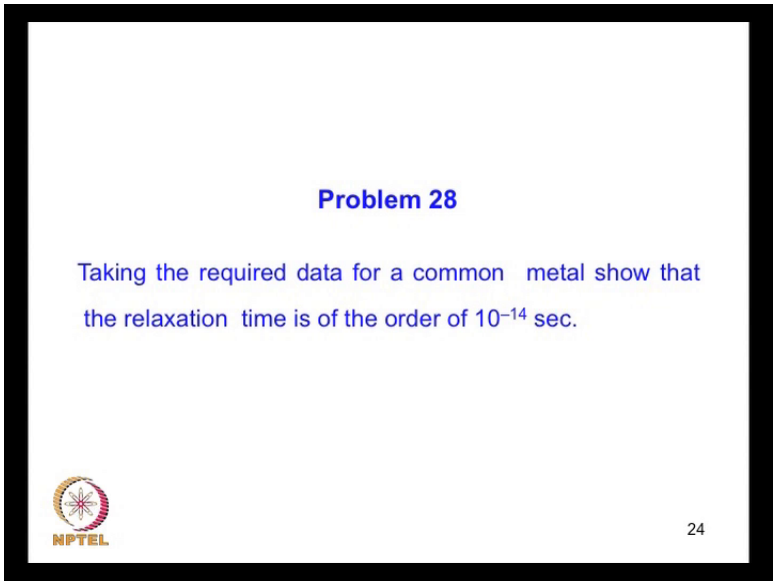

So and we are ask to prove calculate the relaxation time time tau from Drude expression for the electrical conductivity, where tau is the relaxation time, so tau is inverting this and sigma n e square.

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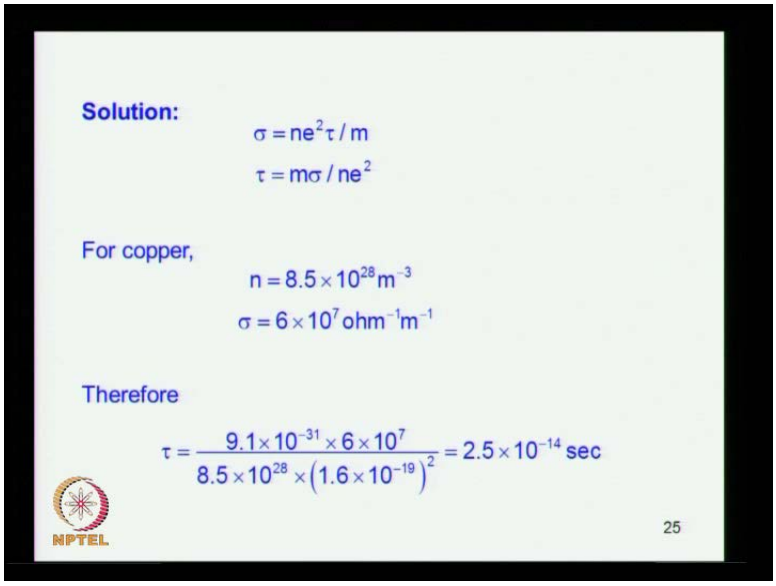

So we take the data of copper which we already found just now as 8.5 into 10 to the power 28 meter cube. And for copper the number of electrons per unit volume and the conductivity is, so

using these values, we can readily calculate the relaxation time as 2.5 into 10 to the fourteen sec. So this is the average time in which the electronic system the electron relax back in an electric field.

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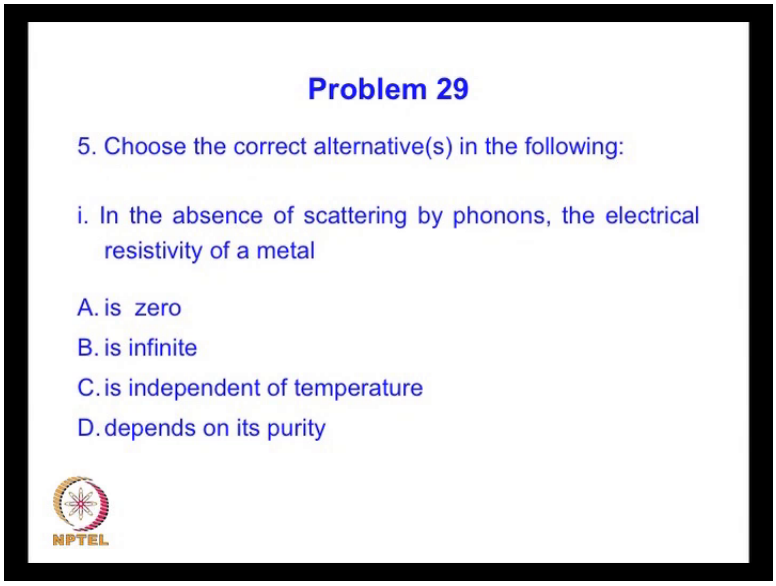

In the next question, we are given a set of correct alternatives answers then we are ask to choose the correct alternative, there may be more than one correct alternative.

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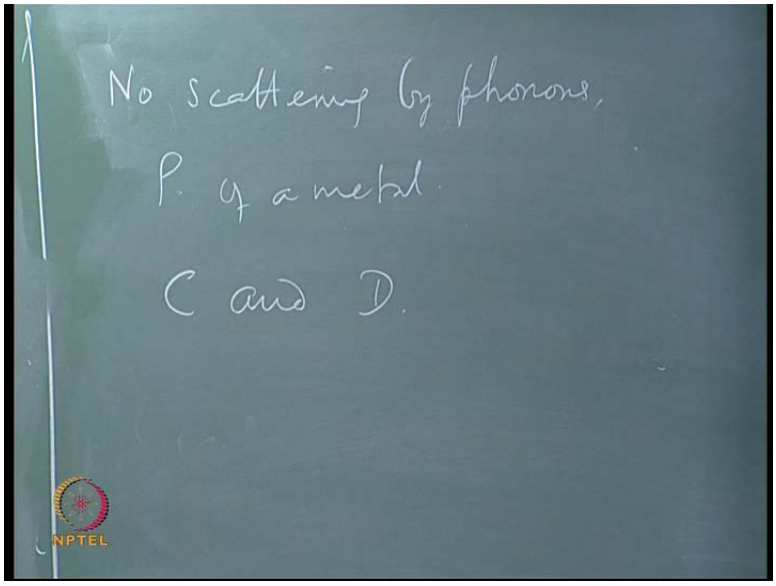

So when there is no scattering by phonons, we are told this statement is the electrical resistivity rho of a metal is it 0, is it infinite or is it independent of temperature and does it depends on its purity. Obviously C and D are the correct alternatives.