hello and welcome to the class of solving problem in modern physics i will start this session by telling a brief history about the modern physics this is very interesting

so this starts with the early 20th century when black body radiation was observed

so if you heat a body and you observe the radiation coming from that body with the frequency at different temperature then you observe a spectrum now if you want to explain that observation then classical mechanics was completely failed

so to explain that max planck observed that the oscillator present on the wall do not have the continuous energy but they have the quantized energy

so they can absorb or emit only quantize energy and that was the foundation of quantization or the modern physics and that was followed by the photoelectric effect

so in photoelectric effect if you sign a light on a metal surface which has a work function phi then the photoelectron start to emit now there was few observation of this simple experiment that put question mark on age old classical mechanics the observation was like if you sign the light of different frequencies then the kinetic energy of these photoelectron continuously increases with the frequency of incident light and there was no delay as soon as you sign the light then photoelectron start to emit and the total energy of incident photon is equal to the work function which is the minimum energy required to emit the electron to the metal surface plus the extra energy is used as the kinetic energy of electrons and this is a famous einstein photoelectric equation now this observation was not able to explain by the electromagnetic radiation as a wave nature of light

so the albert einstein explained this based on the quanta of light is photon

so photon is shining on the surface and then it is being absorbed in its process and then it is emitting the photoelectrons for that albert einstein bought nobel prize in 1921 this was followed by the wave nature of party

so in photoelectric effect we have seen the particle nature of light now that was followed by the wave nature of particle

so if we have suppose electron and we accelerate that electron at a particular voltage then this electron can be represented by a wave which has wavelength lambda is equal to planck constant divided by the momentum and the momentum can be calculated from the accelerated voltage now that is this explanation this wave nature of the particle was used to explain the atomic stability and including the quantization of different orbitals and stationary states now if you look at this wave nature of the incident particle that was proved by the diffraction of electron beam and this is defected in the same way as the x-ray deflected from the crystal and it follows the refraction law which is a back slope which is 2 d sine theta is equal to and lambda where d is the enterprise spacing and theta is the angle of the incident electron beam or the x-rays now if you see the chronological order of this development

so this is very interesting

so max planck in 1900 first proposed that the quantization of energy

so the harmonic oscillator the oscillator that is present on the wall of this black body can absorb or emit the quantized light or the discrete line now followed that albert einstein in 1905 proposed the photoelectric effect and for that he got a nobel prize in 1921 after that boards proposed after considering the quantization of energy both proposed as atomic model in 1911 and there was another uh content effect which proved the existence of particle nature of light in 1923 in same year in 1923 the wave nature of particle was proposed by dee broglie and that was in 1927 proved by diversion and german experiment which was interference pattern of electron beam from the crystal

so let us see few problems based on this photoelectric effect and bohr's model okay let us take few problems

so in problem one it said that in the historical experiment to determine plants constant a metal surface was irradiated with the light of different wavelengths the emitted photoelectrons energy were measured by applying a stopping potential the relevant data for the wavelength lambda of incident light and this corresponding stopping potential are given below given that velocity of light c is 3 tends to power 8 meter per second and charge on electron e is 1.6 raised to power minus 19 coulomb

so we have to calculate plans constant in the unit of joule second and in the table it is given the different wavelength of 0.3 micrometer and the right hand side corresponding stopping potential v is three volt and second one is point four micrometer and the stopping potential is one volt and point five micrometer and the corresponding potential reduced to point four volt

so you can see as we are increasing the incident wavelength then the stopping potential is also reducing

so the solution is like we know the equation sc by lambda is equal to work function phi plus kinetic energy

so we know that the kinetic energy if we rearrange that

so kinetic energy will be sc by lambda minus phi

so we can say equation one

so we can take any two values

so we are taking uh uh the first value which is incident wavelength is point three micrometer and the sloping potential is two volt

so you insert these values

so we have left hand side the kinetic energy of that electron will be two multiplied by one point six raised to the power minus 19 that will be equal to planck's constant h that we have to calculate multiplied by the velocity of light which is three times the power eight divided by the incident wavelength which is point three micrometer

so point three tends to power minus six meter minus five

so the one function is not given

so we can say this is equation 2

so the next value we can take corresponding to 0.4 micrometer and the sloping potential is 1 volt

so the energy corresponding to that will be one point zero multiplied by one point six tends to power minus 19 will be equal to h into three times to power eight divided by point four tends to power minus six minus five

so that we can say as equation three

so we can subtract two minus three then we will have one point six times two power minus nineteen is equal to h into three tends to power eight divided by ten to power minus seven and in the bracket we will have 1 by 3 minus 1 by 4 and then if we uh solve that then we will have h is equal to 12 into 10 to the power -7 into 1.6 and to power minus 19 divided by three point zero raised to power eight

so with that we will have the h is equal to six point four tends to power minus thirty four joule into second go to the problem uh two

so it says that the electric field at a point associated with the light wave is e is equal to 100 volt per meter and sine 3.0 tends to power 15 second inverse and then time and it is multiplied by another sine function and in the bracket it is giving 6.0 times to power 15 second inverse and then time

so these are the angular frequencies given in the question now if this light

falls on the metal surface having a work function of 2.
0 electron volt what will be the maximum kinetic energy of photoelectrons
  so what we have to do we since there are two angular frequencies
  so corresponding to that there will be two frequencies
  so since the question it is asking about the maximum kinetic energy
  so we have to consider the highest frequency that can sign on the surface
  so let us rearrange that electric field vector that is given for the incident
light
  so e is equal to 100 sine okay and then in the bracket two uh quantities okay
  so let us arrange it
  so we know that two sine a sine b is equal to cos a plus b minus cos a minus b
  so if you use that then it will be 100 multiplied by 1 by 2 and then cos 9 10
to the power 15 t minus cos 3 tends to power 15 t
  so we have the two angular frequencies omega 1 and omega 2
  so omega 1 is 9.
0 x to power 15 and omega 2 is 3 times the power 15
  so from there we can calculate what is the maximum frequency
  so that will be maximum will be omega by 2 pi and that is corresponding to 9
into 10 to the power 15 okay
  so the maximum frequency will be 9 2 times power 15 in mult divided by 2 and
then 3.
14
  so that is the maximum frequency
  so we have to calculate the maximum kinetic energy
  so we know the formula h nu is equal to kinetic energy plus work function
  so kinetic energy will be h nu minus or function
  so put all these values the value of uh bank constant and the frequencies that
is given okay and then it is in electron mode
  so we have divided the whole number h nu divided by 1.
6 as to power minus 19 to convert that into electron volt and then we have the
maximum kinetic energy will be 5.
93 minus 2 that will be 3.
93 electron volt
  so this is the maximum kinetic energy of photoelectron emitting from the metal
surface let's go to the problem 3 which is we say that find the maximum
magnitude of the linear momentum of a photoelectron emitted when the light of
wavelength 400 nanometer falls on the metal surface having a work function of 2.
5 electrode volt
  so we have to calculate the linear momentum of the electron
  so the same equation sc by lambda is equal to kinetic energy plus work function
  so we know that the kinetic energy of the photoelectron which may be
represented in the term of linear momentum
  so p square divided by 2m
  so the kinetic energy which is p square by 2 m that will be sc by lambda minus
5
  so we can say that this is equation 1 to put all these values the values of
planck's constant speed of light and the incident wavelength which is 400
nanometer
  so we converted into the that into meter and then 2.
5 is about function
  so we convert that also into joule
  so uh p square by 2m will be 0.
97 tends to power minus 19
  so p will be the under root of this value multiplied by 2 m where m is the mass

of electron which is 9.
1 as to power minus 31
 so the momentum of this photoelectron emitted will be 4.
2 times the power minus 25 kilogram meter per second okay
 so let's go to the problem 4 which says that find the maximum kinetic energy of the photoelectrons ejected when the light of wavelength 250 350 nanometer it's incident on a cesium surface the work function of the cesium is 1.
9 electron volt
 so the wavelength that is shining on the surface is 350 nanometer and the work function of that metal is 1.
9 electron volt
 so we have to calculate what is the maximum kinetic energy
 so we know that sc by lambda is equal to kinetic energy plus what function of that metal
 so the kinetic energy is you can just rearrange that
 so it will be sc by lambda minus pi
 so you can rearrange that okay and then sc by lambda you can also convert that into electron volt by dividing 1.
6 into 10 to the power minus 19 the kinetic energy of this maximum kinetic energy of the photoelectron will be 1.
65 electron volt now the next question says that a monochromatic light source of intensity 5 milli watt emits 8 into 10 to power 15 photons per second this light ejects photoelectrons from a metal surface the stopping potential for this setup is 2 volt calculate the work function of the metal
 so the light which is shining on the surface is given which is which has five milli watt okay and the number of photons per second is 8 into 10 to power 15
 so we can calculate what is the energy of the single photon if you divide this total energy okay divide by the number of total photons
 so the energy of the incident photon will be 5 10 to power -3 okay which is what divided by 8 into 10 to the power 15
 so we have 6.
25 x to power minus 19 which is joule per second
 so we have now sc by lambda is equal to work function plus kinetic energy and the work function will be sc by lambda minus kinetic energy
 so sc by lambda that is the the photon the energy we have already calculated is point two five s to power minus nineteen minus two into one point six times to power minus nineteen
 so five will be three point zero uh five times the power minus nineteen and you can convert that into electron volt
 so that will be 1.
906 electron volt now the next question says that the uv light of wavelength 450 nanometer and intensity 2 watt per centimeter square was sine on a metal surface calculate the amount of current flows in the outer circuit due to the photoelectrons emitted from the metal surface having an area of 2 centimeter square considering only 5 percent of the incident photon produces photoelectrons consider the energy of the photon is more than the work function of metal and the efficiency to collect the photoelectrons is 100
 so the last line says that the efficiency of the collection that means we are in the saturation regime to collect these electrons to the collector plate
 so let us see
 so systemic in the schematic diagram you can see that there is a emitter plate where 450 nanometer photons is being signed and then electrons are empty but only five percent of these uh incident photon is converted into the electrons
 so we have to calculate what is the amount of current flowing in the outer

circuit

so incident wavelength is 450 nanometer and the intensity is 2 watt per centimeter square

so we can convert that

so number of photons what is the number of photons

so we can divide the intensity divided by the energy of the single photon

so that will be

so first we have to calculate the energy of single photon which will be sc by lambda

so that will be six 6.

63 ten super minus thirty four multiply by three point zero times to power eight and then the incident wavelength is 450 nanometer okay

so the number of photons will be two and then you divide that number the enriching the energy of single photos then finally you will see 45.

24 as to power 17 photons per second per centimeter square

so this is the number of photons shining on the surface continuously now the next uh line says that only five percent of this incident photon is able to convert to the photoelectrons

so the number of photoelectrons will be five percent of the total incident photons

so that will be 45 into 45.

24 10 to the power 17 into 5 by 100

so that will be 2.

263 into 10 to power 17 photoelectrons

so the amount of current corresponding to that number flows in the outer circuit will be the number multiplied by the charge

so that will be 2.

263 times to power 17 multiplied by 1.

6 raised to power minus 19

so that will be 36 milli ampere

so the next problem which says that the light is being shined on a metal surface and photoelectrons are emitted when wavelength of incident light is 532 nanometer then the stopping potential of photoelectron is 0.

5 volt however when the incident wavelength it changes to a new value then the stopping potential is increased to 1.

2 volt now we have to calculate what is the wavelength of that change line

so you can see in uh in diagram

so the wavelength of 532 nanometer and unknown wavelength is being signed and the kinetic energy the potential that you are applying to stop these photoelectrons is given corresponding to 532 nanometer which is 0.

5 electron volt and the lambda lambda corresponding to lambda it is given 1.

2 volt

so the energy corresponding to that will be 0.

5 electron volt and corresponding to unknown wavelength it will be 1.

2 electron volt

so we have to calculate the wavelength

so we know that corresponding to one wavelength this will be sc by lambda 1 that will be equal to 5 plus kinetic energy 1 and the kinetic energy 1 is given 0.

5 electron volt and corresponding to lambda 2 it will be sc by lambda 2 which will be equal to 5 plus kinetic energy 2 and corresponding to that kinetic energy 2 is given which is 1.

2 electron volt and as we know that phi what function is the property of the material it will not change with the different wavelength

so using equation one

so we know that sc by lambda this is 532 nanometer is equal to 5 plus uh the kinetic energy which is 0.

5 electron volt

so from there rearrange it we can calculate what is the work function

so which is 2.

9 x to power minus 19 now we know the word function of the method now in the equation using equation 2

so we know that sc by lambda c by lambda 2 is equal to 5 plus 1.

2 electron volt which is the kinetic energy corresponding to lambda 2 now if you put all these values and then rearrange for the unknown lambda 2 then we can calculate lambda 2 will be 4.

12 as to power minus 7 meter or 412 nano meter

so let's see the next question

so we say that the metal surface is illuminated by light of two different wavelengths 248 nanometer and three 110 nanometer the maximum speed of the photoelectrons corresponding to these wavelengths are v1 and v2 respectively if the ratio of v1 and v2 is 3 is to 1 and sc is equal to 1240 electron volt nanometer then the work function of the metal is nearly

so in diagram it is clearly as demonstrated that two wavelength three one zero nanometer and two fourteen and forty eight nanometer is shining and the electrons are emitted corresponding to that now if their velocity because their kinetic energy is will be different because the wavelength is shining is different

so if we consider their velocity v 1 and v 2 then their ratio is given and the word function uh is unknown

so we have to calculate that

so it is given that as c is equal to the the h nu is equal to work function plus kinetic energy and you can say sc by lambda 1 is equal to our function plus the kinetic energy 1 corresponding to lambda wavelength lambda 1 corresponding to wavelength lambda 2 it will be sc by lambda 2 is equal to 5 plus kinetic energy two now we can uh also say that kinetic energy one is equal to one by two and v one square and kinetic energy two is equal to one by two m v two square where m is the mass of electron and v1 and v2 are the velocity of electron corresponding to lambda 1 and lambda 2 wavelength that is shining on the ammeter plane

so for that we can write as c by lambda 1 minus phi is equal to 1 by 2 m v 1 square and s c by lambda 2 minus phi is equal to 1 by 2 m v 2 square

so we can divide 5 by 6 and then we will have v1 square divided by v2 square is equal to sc by lambda 1 minus 5 divided by sc by lambda 2 minus 5 now we have given have the ratio v1 by v2 which is 3 is to 1

so the square of that will be 9

so we will have 9 is equal to sc by lambda 1 minus 5 divided by sc by lambda 2 minus 5 and if you rearrange that we will have the value of 5 okay after converting to electron volt

so the number can be divided into divided by 1.

6 raised to power minus 19

so 5 will be 3.

88 electron volt for that matter let us see this uh problem

so it is say that in a photoelectric experiment the collector plate is at 2 volt with respect to the ammeter plate made of copper which has a wall function 4.

5 electron volt diameter is illuminated by a source of monochromatic light of wavelength 200 nanometer find the minimum and maximum kinetic energy of

photoelectrons reaching the connector plane

so we have a photon which is shining a 200 nanometer and the electron is being uh emitted and then we have the collector okay that is at 2 volt with respect to the emitter plate

so 5 we have 4.
5 electron volt and the wavelength which is given ah 200 nanometer

so sc by lambda is equal to kinetic energy plus what function

so that we can rearrange it and then we have kinetic energy is equal to you put the values of planck constant and velocity of light and the incident radiation which is 200 nanometer and the work function is given 4.
5 electron volt

so we can convert that into joule

so that will be four point five into one point six cents to power minus nineteen

so the kinetic energy will be two point seven four five into ten to power minus nineteen

so we can convert that into electron volt

so that will be two point seven four five ten to power minus nineteen divided by one point six times two power minus nineteen and that will be one point seven electron volt

so the electrons that are emitting from the emitter plate with a kinetic energy 1.
7 electron volt but the minimum energy will be corresponding uh to those electron which are just emitting from the metal surface and they are being accelerated by the relative potential applied between that

so that is equivalent to the applied potential between the uh emitter and the collector

so that will be two electron volt because two volt is being applied

so the minimum energy will be two electron volt however the maximum energy will be uh the voltage applied plus the kinetic energy that electron is having that are being emitted from the metal surface which is 1.
7 electron volt

so the applied voltage corresponding energy and the energy of emitted electron if you sum then we will have the maximum energy of photoelectron that is being emitted

so it will be 2.
0 plus 1.
7 that will be 3.
7 electron volt okay

so let us take the next problem it says that when a metal plate is exposed to a monochromatic beam of light of wavelength 400 nanometer a negative potential of 1.
1 volt is needed to stop the find the threshold wavelength for the metal

so it is asking about the work function of the material as corresponding wavelength

so you can see in the diagram

so 400 nanometer light is being signed and the electron is being emitted from diameter and to stop to reach this electron to the collector a voltage of 1.
1 volt was applied

so this will be the kinetic energy of the photoelectron

so we see that the lambda given is 400 nanometer and the kinetic energy is 1.
1 electron volt

so as per the equation sc by lambda is equal to kinetic energy plus what function

so we have sc by lambda is equal to kinetic energy plus what function we can replace by a wavelength which is lambda 0
 so that will be sc by lambda 0
 so that is a lambda 0 corresponding wavelength which is equivalent to the work function
 so we can rewrite it as c by lambda 0 is equal to s c by lambda minus kinetic energy this we can say equation 1.

 so put all these values of plans constant and the velocity of light and the incident radiation wavelength which is 400 nanometer minus 1.
1 which is the stopping potential and multiplied by 1.
6 raised to power minus 19 to convert that into joule
 so we will have sc by lambda will be equal to 3.
21 into 10 to power minus 19
 so the lambda not lambda 0 that will be you rearrange for the value of sc then we will have lambda 0 will be equal to 620 nanometer okay let us take next problem
 so it says a beam of 450 nanometer light is incident on a metal surface having a work function of 2.
0 electron volt and placed in a magnetic field b considering that energetic electrons are emitted only perpendicular to the magnetic field and are banned in circular r of radius 20 centimeter find the value of magnetic field b
 so in this question it is given that the plate where the electrons are emitted the magnetic field are perpendicular to that and all the electrons are emitted perpendicular to the magnetic field
 so under these assumptions
 so let us start
 so the wavelength of incident light is 450 nanometer
 so as per the equation sc by lambda is equal to kinetic energy plus work function and the work function is 2.
0 electron volt
 so we put these values
 so it will be six point six three times to power minus 34 the planck's constant multiplied by velocity of light which is three point zero times to power eight divided by 450 nanometer
 so that in the meter it will be 450 times the power minus 9 meter will be equal to kinetic energy
 so kinetic energy of electron will be 1 by 2 m mass of electron v velocity of light
 so 1 by 2 mv square plus work function which is 2.
0 into 1.
6 tends to power minus 19
 so 1 by 2 mv square if you rearrange
 so 1 by 2 mb square will be 1.
22 to power minus 19
 so from here we can calculate the value of mv
 so if you multiply both sides by m and then 2 will go on the other side
 so the mv will be two into nine point one tends to power minus thirty one into one point two two times to power minus nineteen
 so mv will be four point six seven tens to power minus twenty five kilogram meter per second
 so we can say this equation one
 so from here now since you can see this uh schematic diagram
 so this is a plate and 450 nanometer radiation is shining on this plate and

this electron is emitted
 so this is step one
 so the electron is emitted with the velocity v and mass is m and the magnetic field b is applied perpendicular
 so that is in the direction two
 so the force on this electron will be in the direction three
 so that will force the electron to bend and the banding radius is given 20 centimeter
 so if we equate that forces
 so we know that the radius will be mv divided by qb where q is the charge on the electron and v is the magnetic field
 so from here magnetic field we can rearrange
 so b will be mv divided by qr
 so mv we have already calculated
 so it is 4.
67 x to power minus 25 divided by q that is charge on the electron
 so it is 1.
6 times to power minus 19 and r is given and that meter it will be point two
 so from here b is equal to one point four six tends to power minus five x
 so in the next problem it is mentioned that the electric field associated with a light wave is given by e is equal to e0 sine in the bracket one point five seven tens to power seven meter inverse in the bracket close the next packet it is given x minus c t
 so find the sloping potential when this light is used in an experiment on photoelectric effect with the emitter having a verb function of 1.
9 electron volt
 so we start
 so we have this question it is given uh omega
 so omega in this question is 1.
57 10 to the power 7 multiplied by c where c is the velocity of light
 so from here we can calculate frequency
 so frequency will be omega by 2 pi
 so it is 1.
57 x to the power 7 multiplied by 3.
0 tends to power 8 divided by 2 into pi which is 3.
14
 so that will be in hertz
 so what function is giving 1.
9 electron volt
 so as per the equation h nu is equal to kinetic energy plus for function
 so the kinetic energy of electron
 so we can write it kinetic energy and e l e that stands for electron will be equal to h nu minus five
 so you put all these values
 so h will be six point six three times two power minus thirty four into one point five seven tends to power seven into 3 10 to power 8 divided by 2 into 3.
14 into 1.
6 times the power minus 19
 so we have converted that term into electron volt as the work function is already given in the electron word
 so we have work function is 1.
9 electron volt
 so the kinetic energy will be 3.
107 minus 1.

9 electron volt
 so the kinetic energy will be 1.
207 electron volt
 so this is the kinetic energy
 so the stopping potential that need to be stopped for this electron will be 1.
207 volt
 so you can see in schematic
 so the radiation is shining on the plate and the electron are emitted and reaching to the plate
 so we can apply a negative potential okay to stop this electron and since this is a electron of maximum kinetic energy
 so the voltage the sloping potential can be calculated now let us see the next problem
 so in the next problem it says that in arrangement which is shown in the figure y is one millimeter d is 0.
24 millimeter and capital d which is the distance between this range and thus source is 1.
2 meter the work function of the material uh of ammeter is two point zero two point two electron volt now find the stopping potential we needed to stop the photo current okay
 so now we can see that how how to proceed
 so we know that what is the fringe width
 so fringe weight is given from one side it is one millimeter
 so the total width will be twice of that
 so it will be two millimeter now d is given
 so what is g small d d is the zero point two four millimeter and phi is given which is two point two electron volt and capital d is one point two meter where all the symbols have their usual meaning
 so we can see that y okay
 so that which is the width of range that will be lambda capital d divided by small d
 so lambda wavelength will be y small d divided by the capital d
 so you put all these values okay and then like 2 into 10 to power minus 3 into four times to power minus three divided by one point two meter
 so where we will have the lambda will be four into ten to power minus seven meter
 so if this is a wavelength then the energy corresponding to that will be as c divided by lambda
 so we can easily calculate that and it will be 3.
105 electron volt
 so stopping potential will be e v naught is equal to 3.
105 minus 2.
2
 so that will be equal to 0.
905 volt now the next question says that a small small piece of caesium metal with a wall function 1.
9 electron volt is kept at a distance of 20 centimeter from a large metal plate having a charge density of 1.
0 to power minus 9 coulomb per meter square on the surface facing the cesium piece a monochromatic light of wavelength 400 nanometer is incident on the cesium piece find the minimum and maximum kinetic energy of photoelectrons reaching the large metal plate neglect any charge in electric field due to the small piece of cesium per percent
 so this is a very interesting question

so here the charge density rho is given which is 1 10 to the power minus 9 coulomb per meter square one function of the metal is given 1.

9 electron volt and incident wavelength is 400 nanometer and the spacing is 20 centimeter which is 0.

2 meter

so the electric potential due to the charge plate will be v is equal to e into d

so electric field will be e will be sigma by epsilon naught

so that is a charge density okay divided by epsilon naught

so if you put the value of e there then v will be sigma by epsilon naught into d d is the spacing

so you put that values

so 1 into 10 to the power minus 9 and then divide into 20 divided by 8 into 8

8.

85 times to power minus 12 divided by 100 because that is in centimeter

so we will be 22.

7 volt

so from there sc by lambda is equal to 5 plus kinetic energy

so we know that if you rearrange it

so kinetic energy will be sc by lambda minus phi

so you put all these values of constants okay and phi is already given

so we will have the kinetic energy is 1.

205 okay

so this kinetic energy of this electron is very very small in contrast in comparison to the voltage between the plate

so minimum kinetic energy because the electron is being emitted from the cesium surface okay and then they will accelerate towards the other plate

so if the any electron is just emitting from the surface

so it will be accelerated with a voltage that is between the uh cesium and the other plate and that is 22.

7 electron volt

so the minimum kinetic energy of the photoelectron will be the voltage between that

so that will be 22.

7 electron volt and the maximum kinetic energy we will just add the kinetic energy of an electron plus the accelerating voltage that is exist between the plates

so we will have the maximum kinetic energy will be 22.

7 plus 1.

205 electron volt

so the maximum kinetic energy will be 23.

905 electron volt and the minimum kinetic energy will be 22.

7 electron volt okay let us take next problem it says a light beam of wavelength 400 nanometer is incident on a metal plate of wall function 2.

2 electron volt a particular electron absorbs a photon and makes collision before coming out of matter assuming that 10 percent of the energy is lost to the metal in each collision find the minimum number of collision by the electron before it becomes unable to come out of the metal

so here we have a metal surface which has a work function of 2.

2 electron volt and a 400 nanometer uh wavelength is shining on the metal surface and the electron before coming out it is making number of collision and in one collision it is losing 10 percent of its energy

so we have to calculate how much energy is remaining after the collision and when this energy is less than the work function of this material then this

electron will be unable to come out from the metal surface

so wavelength given is 400 nanometer and work function is 2.

2 electron volt

so we have to calculate the energy corresponding to the photon

so this is sc by lambda which will be 6.

63 tends to power minus 34 into 3 times to power 8 divided by 400 10 to the power minus 9 divided by 1.

6 10 to the power -19

so that will be equal to 3.

1 electron volt

so after collision the first collision the energy loss is 10 percent

so 0.

31 electron volt energy will be lost after the first collision

so how much energy remains after the first collision

so the energy remains is 3.

1 electron volt minus 0.

31 electron volt

so that will be equal to 2.

79 electron volt

so this is the energy remaining after the first collision now when the electron is ready to do second collision and again it will lose is ten percent

so that will be ten percent of two point seven nine that is remaining energy will be zero point two seven nine

so after second collision the energy remaining with the electron will be 2.

79 minus 0.

279

so that will be 2.

511 electron volt which is after second collision after third collision energy loss will be two point five one one the ten percent of that will be zero point two five one one electron volt

so the energy remains after third collision is two point two five nine nine electron volt now the energy loss after the fourth collision is two point two five nine nine at the ten percent of that that will be uh two zero point two two five nine nine electron volt

so the energy remains after fourth collision is 2.

033 electron volt

so the energy of an electron after the fourth collision is 2.

033

so and that energy is less than the work function of the metal

so after fourth collision

so the v the question ask the minimum number of collision

so after fourth collision the electron will not be able to come out if the electron is even at the surface now let us take uh some question from the boards model

so now we have the question says a hydrogen atom in ground state absorbed a photon of ultraviolet radiation of wavelength 50 nanometer assuming that that the entire photon energy is taken up by the electron with what kinetic energy will the electron be exactly

so we have a positive center and the electron is revolving in the ground state and 50 nanometer radiation is absorbed by this electron

so what is the energy of photon

so energy of photon will be sc by lambda you put all these values and divide this number by one point six times the power minus 19 to convert that into electron volt

so you will have 24.
84 electron volt
so that is the energy of this incident photo now energy required to remove this electron
so what we are doing we are going from n is equal to one orbit to n square and n is equal to infinite
so the energy for that we know it is 13.
6 electron volt that is ionization energy of hydrogen atom
so the kinetic energy of electron
so whatever the energy of incident photon that is 24.
84 minus the energy required to remove this electron that is 13.
6 electron volt
so if you uh subtract that we will have the kinetic energy 11.
24 electron volt now the next question says a beam of light having wavelength distributed uniformly between 450 nanometer to 550 nanometer passes through a sample of hydrogen gas which wavelength will have the least intensity in the transmitted beam
so what is the question
so there is a leg chamber is filled with the hydrogen and that continuous spectrum for 450 to 550 nanometer is passed through that now they are asking that which wavelength will be uh less or will be least in the transmitted
so the wavelength that will be a list in the transmitted will be the wavelength that is being absorbed by this hydrogen atom but we know that hydrogen atom can only absorb the energy which is corresponding to the transition of the uh like from n is equal to two to three three to four or four to five
so it is say now since this energy is in the visible region 450 nanometer to 550 nanometer and that is we know that the transition is coming from and three n is equal to three times equal to two or n is equal to four to n is equal to two or n is equal to phi is equal to n is equal to two
so let us see what will be the energy corresponding to this radiation and then we can see which wavelength will be absorbed
so the radiation in the range of we know that 450 nanometer to 550 nanometer
so the corresponding energy to 450 nanometer will be 2.
75 electron volt because as c if you put the value of sc
so which is uh one two four zero electron volt into nanometer divided by 450 nanometer
so we will have 2.
75 electron volt for 550 nanometer
so we can similarly calculate
so that will be 2.
26 electron volt
so this is the total range of the radiation that we are getting or shining on the hydrogen gas
so the light comes under the visible region as already mentioned
so transition from the n is equal to two two three four and 5
so we can calculate the energy corresponding to these transitions
so if the transition is from 2 to 3 then we will have 13.
6 electron volt and then multiply by 1 by n is equal to 2 square
so that will be 1 by 4 minus and is equal to 3 square
so as that will be 1 by 9
so total will be 1.
9 electron volt similarly corresponding to 2 to 4 we will have like 13.
6 and into 1 by 4 minus 1 by 16
so that value will be 2.

55 electron volt and corresponding to the final transition that is e2 minus t5
so that will be 13.
6 multiplied by 1 by 4 and minus 1 by 25
so that this value will be 2.
856 electron volt
so we can see from all this energy the transition from t2 to 4 comes in the range of the radiation that we have we have we are signing on the hydrogen gas
so the wavelength corresponding to that okay
so what will be the wavelength corresponding to that
so the wavelength will be one two four zero electron volt nanometer divided by two point uh five five nanometer that is energy corresponding to e2 e4 transition
so we will have the wavelength exactly will be 486 nanometer
so if you are signing from left side the radiation of a float spectrum okay uh the 486 nanometer wavelength will be absent in the transmitted beam because that is being absorbed and the hydrogen is reaching from e n is equal to 2 to n is equal to 4 state now the next question says suppose a monochromatic x-ray beam of wavelength 100 picometer is sent through a young double slit okay and the interference pattern is observed on a photographic plate place 40 centimeter away from the seat what would be the separation between the slit
so that successive maxima on the screen are separated by a distance of 0.
1 millimeter
so this is a kind of arrangement
so we have small d okay is the the spacing between the slit and d is the the capital d the spacing between the slit and the screen and the lambda this is incident wavelength is 100 picometer
so we know that distance between the successive maxima that is represented by beta will be this lambda capital d by small d
so d small d will be lambda capital d by beta
so you put all these values and then we will have d is 4 into 10 to the power minus 7 meter or 400 nanometer now the next question says that the electric current from the target to the filament in an x-ray tube operating at 40 kilowatt is 10 milli ampere assume that on an average one percent of the total kinetic energy of electrons hitting the target are converted into x-ray what is the total power emitted as x-ray
so if we see uh in this diagram
so the electron is being accelerated okay and they are targeted on a particular metal to emit the axial
so we will have the cut characteristic as well as continuous axis and it is saying that uh like one percent of the total kinetic energy of this electron which are being accelerated at 40 kilowatt is converted into axis
so what will be the power
so we know that what is the accelerating voltage to this electron is 30 kilo volt and what is the current is 30 milliampere
so we know that current is the number of charge and then uh a number of charged particles and the charge on the single particle
so the n will be i current divided by the charge
so it will be zero ten to power minus three okay divided by uh one point six tends to power minus nineteen
so it will be zero point six two five ten to power seventeen photoelectrons per second
so kinetic energy of one electron is one point six tends to power minus nineteen into forty raised to power three because it is kilo volt
so that will be six point four tends to power minus 15

so the total kinetic energy will be 0.
625 into 6.
4 times to power minus 15 into 10 to power 17
 so that will be 4.
0 raised to power two joule power emitted by x ray as we are saying actually it is only one percent
 so this will be a four tends to power two into one divided by hundred
 so the total power emitted as an x-ray is 4 volt okay
 so let us take next problem
 so next problem says an xa tube operates at 40 kilo volt suppose the electron converts 70 percent of its energy into photon at each collision find the lowest three wavelengths emit from the tube neglect the energy impacted to the atom with which electron collides hello okay let us take the next problem and it says an axillary tube operates at 40 kilo volt suppose the electron converts 70 percent of its energy into a photon at each collision find the lowest three wavelengths emitted from the tube neglect the energy impacted to the atom with which electron collides
 so the question suggests we have to neglect the collision energy between electron and atom and we have to calculate three wavelengths okay and cube is operated at 40 kilovolt
 so voltage at which the tube is being operated is 40 kilo volt
 so that will be 40 times to power 3 volt
 so energy utilized suppose in the first collision
 so energy utilize is 70 percent of it
 so 70 divided by 100 into 40 okay and tends to power 3
 so it will be 28 into 10 to power 3
 so that is the energy being utilized
 so what will be the wavelength corresponding to that
 so the wavelength corresponding to that will be sc by e and we know that the value of sc is 1240 electron volt into nanometer divided by 28 to power 3 that is the energy utilized to convert into x-ray
 so the wavelength of the first x-ray will be 44 pico meter for other wavelengths
 so now we know that what is the energy uh left
 so e will be 70 of the leftover energy
 so it will be 70 percent and then 40 minus 28 okay
 so 28 is energy left after that
 so now we have the energy is 84 times to power 2 now the wavelength corresponding to that we can calculate in the same manner
 so it will be sc divided by e it will be 1240 electron volt nanometer divided by 84 tends to power 2
 so we will have the wavelength is 148 equal meter now for third wavelength now again it is 70 of leftover
 so it will be 12 minus 8.
4 into 10 to power 3
 so we will have 25.
2 into 10 to power 2.
 now the wavelength corresponding to that will be 1240 electron volt nanometer divided by 25.
2 s to power 2
 so the wavelength third wavelength will be 493 picometer
 so with that this is the end of the lecture and thank you very much for your attention