PHYSICS

BOOKS - HC VERMA PHYSICS (HINGLISH)

BOHR'S MODEL AND PHYSICS OF THE ATOM

Examples

1. Calculate the energy of a $He^{+} ion$ in its first excited state solution

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2. Calculate the wavelength of radiation emitted when He^{+} makes a transition from the state $n = 3$ to the state $n = 2$

A. $16400nm$

B. $164.0nm$

C. $1.64nm$

D. $0.164nm$

Answer: B

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3. The excititation energy of a hydrogen -like ion in its first excitedstate is $40.8eV$ Find the energy needed to remain the electron from the ion

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Worked Out Examples

1. Find the ratio of Li^{++} ions in its ground state assuming Bohr 's model to be vaild

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2. A particular hydrogen like rediation of frequency $2.467 \times 10^{15} Hs$ when it makes transition from $n = 3 \rightarrow n = 1$,What will be the frequency of the raditation emitted in a transion from $n = 3 \rightarrow n = 1$?

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3. Calculate the two highest wavelength of the radiation emitted when hydrogen atoms make transition from higher state to $n = 2$

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4. What is the wavelength of the radiation emitted to the electron in a hydrogen atom junps from $n = 1 \rightarrow n = 2$?

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5. (a)Find the wavelength of the radiation required to excited the electron is Li^{++} from the first to the third Bohr orbit (b) How many speciral are obseved in the emission apactrum of the above excited system?

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6. Find the wavelength present in the radiation emitted when hydrogen atoms emitted to $n = 3$ states return to their ground state

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7. How many different wavelength may be observed in the spectrum from a hydrogen sample if the atoms excited to states with principal quantum number n?

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8. Monnohramatic radition of wavelength λ is incident on a hydrogen sample in ground state hydrogen atoms obserb a frection of light and subsequently and radition of six different wavelength .Find the value of λ

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9. The energy needed to detach the electron of a hydrogen like ion in ground state is a system(a) what is the wavelength of the radiation emitted when the electron jumps from the first excited state to the

ground state? (b) What is the radius of the orbit for this atom?

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10. A hydrogen sample is prepored in a particular state A photon of energy $2.55eV$ gel obserbed into the sample to take some of the electron ti a farther excited state B find the quantum numbers of the state A and B

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11. (a) Find the maximum wavelength $\lambda_{90})$ of light which can ionize a hydrogen atom in its ground (b) light of wavelength λ_0 is inclined on ahydrogen atom which is in its first excited state find the kinrtic energy of the electron coming out

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12. Derive an expression for the magnetic field at the site of the necleas in a hydrogen atom due to the circular motion of the electron Assume that the atom is in its ground state and the answer in lerms of fandmental constants

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13. A lithioum atom has electron Assume the following simple picture of the atom Two electron move close to the nucleas making up a spherical cloud in a circular orbit Bohr's model can be used for the motiobn of this third electron but$n = 1$ state are not andiable is it calculate the ionzation energy of lithium in ground state using the above picture

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14. A particle known as mu mean has a charge equal to that of no electron and mass 208times the mass of the electron B moves in a circular orbit around a nucleus of charge $+3e$ Take the mass of the nucles to be infinite Assuming that the bohr's model is applicable to this system (a)drive an eqression for the radius of the nth Bohr orbit (b) find the value of a for which the redius of the orbit it approninately the same as that at the first bohr for a hydrogen atom (c) find the wavelength of the radiation emitted when the u - mean jump from the orbit to the first orbit

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15. Find the wavelength in a hydrogen spectirm between the range $500nm \rightarrow 700nm$

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16. A beem of ultraviolet radius hacking wavelength between $100nm \text{ and } 200nm$ is inclined on a sample of atomic hydrogen gos Assuming that the atoms are in ground state which wavelength will have low intensity in the transnilled been? If the energy of a photon is equal to the ground state it haslarge probobility of being observed by on atom in the ground state

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17. A neutron moving with a speed v makes a head-on collision with a hydrogen in ground state kept at rest which inelastic collision will be take place is (assume that mass of photon is nearly equal to the mass of neutron)

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18. Light corresponding in the transition $n = 4 \rightarrow n = 2$in hydrogen atoms falls an cesium metal (work function $= 1.9eV$) Find the maximum kinetic energy of the photoelectrons emitted

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19. A small particle of mass m move in such a way the potential energy $U = \frac{1}{2}m^2\omega^2r^2$ when a is a constant and r is the distance of the particle from the origin Assuming Bohr's model of quantization of angular momentum and circular orbits , show that radius of the nth allowed orbit is proportional to in

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Short Answer

1. How many wavelength are emitted by atomic hydrogen in visible range $(380nm - 780nm)$? In the range $50nm \rightarrow 100nm$?

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2. The excited energy of a He^{+} ion is the same as the ground state energy of hydrogen is it always true that one of the energies of any hydrogen like ion will bethe same as the ground state energy of a hydrogen atom?

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3. Which wavelength will be emitting by a sample of atomic hydrogen gas (in ground state) if electron of energy $12.5eV$ collide with the atoms of the gas?

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4. What while radiation is passed through a sample of hydrogen gas at room temperature , absorption lines are observed in lyman series only Explain

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5. Balmer series was observed and analysed before the other series .Can you suggest a reason for such an order?

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6. What will be the energy corresponding to the first excited state of a hydrogen atom if the potential energy of the atom is taken to be $10eV$ when the electron is widely separated from the proton ? Can be still write $E_0 - E_1/n^2$, or , $r_n = a_0 n^2$?

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7. The differece is the frequency of series limit of lyman series and balmar series is equal to the frequency of the first line of the lyman series Explain

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8. The numeriecal value of ionization in eV equals the inoization potential in volts .Does the equally hold if thesequantities are inasured in some other units?

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9. We havestimulated and spontaneous emission.Do we also have stimulated absorption and spontaneous obsorption?

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10. An atom is in its excited state ,Does the probalility of its coming to ground state depend on whether the radiation is alreasdy pressent or not? If you does it also depends on the wavelength of the radiation pressent?

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Objective 1

1. The minimum orbital angular momentum of the electron in a hydrogen atom is

A. h

B. $h/2$

C. $h/2\pi$

D. h/λ

Answer: C

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2. Three photons coming from excited atoms hydrogen sample are pickedup .There energies are $12.1eV, 10.2eV \text{ and } 1.9eV$ these photons must come from

A. a simple atom

B. two atoms

C. three atoms

D. either two atoms or three atoms

Answer: D

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3. Suppose the electron in a hydrogen atom makes transition from $n = 3 \rightarrow n = 2 \in 10^{-8}s$ The order of the torque acting on the electon in this period, using the relation between torque and angular momentum as discussed in the chapter on rotational machanics is

A. $10^{-34}Nm$

B. $10^{-24}Nm$

C. $10^{-42}Nm$

D. $10^{-8}Nm$

Answer: B

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4. In which of the following transition will the wavelength be minimum ?

A. $n = 5 \rightarrow n = 4$

B. $n = 4 \rightarrow n = 3$

C. $n = 3 \rightarrow n = 2$

D. $n = 2 \rightarrow n = 1$

Answer: D

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5. In which of the following system will theratio of the first orbit$(n = 1)$ be maximum ?

A. Hydrogen atom

B. Deuterium atom

C. single ionized helium

D. Doubly ionized lithium

Answer: D

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6. In which of the following system will the wavelength corresponding to $n = 2 \rightarrow n = 1$be

minimum ?

A. Hydrogen atom

B. Deuterium atom

C. single ionized helium

D. Doubly ionized lithium

Answer: D

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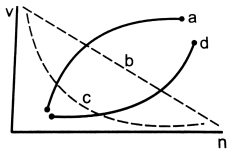
7. Which of the following curve may represent the speed of the electron in a hydrogen atom as a

function of the principal quantum number n?



A. a

B. b

C. c

D. d

Answer: C

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8. As one considers orbits with higher value of n in a hydrogen atom, the electron potential energy of the atom

A. decreases

B. increases

C. remain the same

D. does not increases

Answer: B

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9. The enrgy of an atom (or ion) in the ground state is $-54.4eV$ .If may be

A. Hydrogen

B. deuterium

C. He^{+}

D. Li^{++}

Answer: C

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10. The radius of the shoetest orbit in a one electron system is $18 \pm$ if may be

A. Hydrogen

B. deuterium

C. He^{+}

D. Li^{++}

Answer: D

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11. A hydrogen atom in ground state absorbs $10.2eV$ of energy .The orbital angular momentum of the electron is increases by

A. $1.05 \times 10^{-34} Js$

B. $2.11 \times 10^{-34} Js$

C. $3.16 \times 10^{-34} Js$

D. $4.22 \times 10^{-34} Js$

Answer: A

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12. Which of the following parameters are the same for all hydrogen like atoms and ions in their ground state?

A. Radius of the orbit

B. Speed of the electron

C. Energy of the atom

D. Orbital angular momentum of the electron

Answer: D

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13. In a inser tube all the photons

A. have same wavelength

B. have same energy

C. move in same direction

D. move with same speed

Answer: D

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Objective 2

1. In a laboratory experiment on emission from atomic hydrogen in a discharge tube only a small number of lines are observed whereas a large number of lines are pressent in the hydrogen spectrum of a star .This is because in a laboratory

A. the amount of hydrogen taken is smaller than that pressent in the star

B. the temperature of hydrogen is much smaller than that of the star

C. the pressure of hydrogen is much smaller than that of the star

D. the gravitational pull is much smaller than that of the star

Answer: B

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2. An electron with kinetic energy $5eV$ is incident on a hydrogen atom in its ground state.The collision

A. must be elastic

B. may be partially elastic

C. must be completely inelastic

D. may be completely inelastic

Answer: A

3. Which of the following products in a hydrogen atom are independent of the principal quantum number n? The symbols have theirusual meanings

A. un

B. Er

C. E pi

D. ur

Answer: A::B

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4. Let A_(0) be the area enclined by the orbit in a hydrogen atom .The graph of in (A_0 / A_1) againest in(pi)

A. will pass through the origin

B. will be a straigth line with slope 4

C. will be a monotonically increasing nonlinear curve

D. will be a circle

Answer: A::B

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5. Ionzation energy of a hydrogen like A is greater than that of another hydrogen like ion Let r, u, E and L repreasent the radius of the orbit, speed of the electron energy of the atom and orbital angular momentum of the electron respectively, in ground state

A. $r_A > r_B$

B. $u_A > u_B$

C. $E_A > E_B$

D. $L_A > l_B$

Answer: B

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6. When a photon stimulates the emission of another photon the two photon have

A. same energy

B. same direction

C. same phase

D. same wavelength

Answer: A::B::C::D

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Exercises

1. The bohrradius is given by $a_0 = \frac{\varepsilon_0 h^2}{\pi m e^2}$ verify that the KHS has dimesions of length

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2. Find the wavelength of the radiation by hydrogen in the transition (a)

$n = 3 \rightarrow n = 2, n = 5 \rightarrow n = 4$ and $n = 10 \rightarrow n = 9$

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3. Calculate the smaller wavelength of radiation that may be emitted by (a) hydrogen (b)He^{+} and (c) Li^{++}

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4. Evalute Rydberg constant by putting the value of the fundamental constants in its expression

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5. Find the binding energy of a hydrogen atom in the state$n = 2$

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6. Find the radius and energy of a He^{++} ion in the states (a) $n = 1, (b)n = 4$ and $©n = 4$ is

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7. A hydrogen atom emits ultraviolet of wavelength $102.5nm$ what are the quantum number of the state involved in the transition?

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8. Find the first excitation potential of He^{+} ion (a)Find the ionization potential of Li^{++} ion

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9. A group of hydrogen atom are prepered in $n = 4$ states list the wavelength that are emitted as the atoms make transition and return to $n = 2$ states

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10. A positive ion having just one electron ejects it if a photon of wavelength 228Å or less is absorbed by it. Identify the ion

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11. Find the maximum calculate force can act on the electron due to the nucleus in a hydrogen atom

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12. A hydrogen atom in a having a binding of $0.85eV$ makes transition to a state with excited energy

$10.2eV$(a) identify the quantum number n of theupper and the lower energy state involved in the transition (b) Find the wavelength of the emitted radiation

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13. Whenever a photon is emitted by hydrogen in balmer series it is followed by another in lyman series what wavelength does this latter photon correspond to?

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14. A hydrogen atom in state $n = 6$ makes two successive transition and reaches the ground state in the first transition a photon of $1.13eV$ is emitted (a) Find the energy of the photon emitted in the second transition (b) what is the value of n in the intermediate state?

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15. What is the energy of a hydrogen atom in the first excited state if the potential energy is taken to be zero in the ground state?

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16. A hot gas emites radition of wavelength $46.0nm, 82.8nm$ and $103.5nm$ only Assume that the atoms have only two excited state and the difference between consecutive energy levels decrease as energy is increased Taking the energy of the higest energy state to be zero find the energies of the ground state and the first excited state

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17. A gas of hydrogen like ions is prepared in a particular excited state A. if emit photons having

wavelength equal to the wavelength of the first line of the lyman series together with photons of five other wavelength identify the gas and find the principal quantum number of the state A

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18. Find the maximum angular speed of the electron of a hydrogen atoms in a statoonary orbit

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19. A spectroscopic instrument can resolve two nearly wavelength λ and $\lambda + \Delta\lambda$ if $\lambda/\Delta\lambda$ is smaller

than 8000 This is used to study the spectral lines of the balmer series of hydrogen Approximately how many lines will be resolved by the instrument?

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20. Suppose in certine condition only those transition are allowed to hydrogen atoms in which the principal quantum number a changes by2 (a) Find the smaller wavelength emitted by hydrogen (b) list the wavelength emitted by hydrogen in the visible range $(380nm \to 780nm)$

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21. According to maxwell's theiory of electrodnamics, an electron going in a circle should emit redastion of frequency equal to the frequency of revolution what should be the wavelength of the radiation emitted by a hydrogen atom in ground state if this rule is followed?

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22. The evrage kinetic energy of molecules in a gas at temperature T is $1.5KT$ find the temperature at which the average kinetic energy of the molecules of hydrogen equals the binding energy of its atoms will

hydrogen remain in molecles form at this temperature ? Take $h = 8.62 \times 10^{-6} eVK^{-1}$

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23. Find the temperature at which the everage thermal kinetic energy is equal to the energy needed to take a hydrogen atom from its ground state $n = 3$ state hydrogen can now emit rod light of wavelength $653.1nm$because of maxwellan distribution of speeds a hydrogen sample emits red light at temperature much lower than that obtained from this problem Asuume that hydrogen that hydrogen molecules dissociate into atoms

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24. Avarage lifetime of a hydrogen atom excited to $n = 2$ state $10^{-6}s$ find the number of revolutions madfe by the electron on the avarage before it jump to the ground state

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25. calculate the magnetic dipolemoment corresponding to the motion of the electron in the ground state of a hydrogen atom

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26. Show that the ratio of the magnitic dipole moment to the angular momentum$(1 = \mu r)$ is a universal constant for hydrogen atom and ions find the value

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27. A beam of light having wavelength distributed uniformly between $450nm \to 550nm$ passes through a sample of hydrogen gas which wavelength will have the least intensity in the transition beam?

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28. Radiation coming from transition $n = 2 \rightarrow n = 1$ of hydrogen atoms falls on helium in $n = 1 \text{ and } n = 2$ state what are the possible transition of helium ions as they absorb energy from the radiation?

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29. A hydrogen atom in ground state obsebe a photon of ultraviolet radition of wavelength $50nm$ Assuming that the entire photon energy is taken up by the electron with what kinetic energy will the up

by the electron with what kinetic energy will the electron be ejected?

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30. A parallel beam of light of wavelength $100nm$ passes through a sample of atomic hydrogengas in ground state (a)Assume that when a photon suppose some of its energy to a hydrogen atom the rest of the energy appears as another photon moving in the same direction as the incident photon Neglecting the light emitted by the excited hydrogen ato in the direction of the incident beam, ? (b) A radiation detector is placed near the gas to detect radiation

coming perpenducular to the incident beam find the wevelength of radiation that may be detected by the detector

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31. A beam of momechromatic light of wavelength λ ejectes photonelectrons from a cesium $(\phi = 1.9eV)$ these photonelectron from a radius are made to ceslum with hydrogen atoms in ground state find the maximum value of λ for which (a) hydrogen atoms may be ionised (b) hydrogen may get excited from the ground state to the first excited state and (c) the excited hydrogen atoms may emit visible light

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32. Electron are emited from an electron gun at almost zero velocity and are accelerated by an electric field E through a distance of $1.0m$ The electron are now scatteared by an atomic hydrogen sample in ground state what should be the minimum value of E so that red light of wavelength $656.5nm$ may be emitted by the hydrogen?

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33. A neutron having kinetic energy $12.5eV$ collides with a hydrogen atom at rest negect the difference in mass between the neutron and the hydrogen atom and assume that the neutron does not leave its of motion find the posible kinetic energy of the neutron after the event

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34. a hydrogen atom moving at speed v collides with another hydrogen atom kept at rest .Find the minimum value of u for which one of the atoms may

get ionized the mass of a hydrogen atom $= 1.67 \times 10^{-27} kg$

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35. A neutron moving with a speed u strikes a hydrogen atom in ground state in ground toward it with the same speed Find the minimum speed of the neutron for which ineleastic (completely or perially) collision may take place .The mass of neutron = mass of hydrogen $= 1.67 \times 10^{-27} kg$

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36. When a photon is emited by a hydrogen atom , the photon carries a momentum with it (a) calculate the momentum carreied by the photon when a hydrogen atom emits light of wavelength $656.3nm$(b) with what speed does the atoms recoil during this transition? Take the mass of the hydrogen atom $= 1.67 \times 10^{-27} kg$ (c) Find the kinetic energy of recoil of the atom

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37. When a photon is emitted from an atom , the atom recils The kinetic energy of recoils and the

energy of the photon come from the difference in energy between the state involved in the transition suppose a hydrogen atom change its state from $n = 3 \rightarrow n = 2$ calculate the fractional change in the wavelength of light emitted , due to the recoil

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38. The light emitted in the transition $n = 3 \rightarrow n = 2$ in hydrogen is called H_0 light .Find the maximum work fonction a metel one have so that H_0 light can emit photoelectrons from it

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39. Light from balmer series of hydrogen is able to eject photoelectron from a metal what can be the maximum work function of the metal?

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40. Radiation from hydrogen discharge tube falls on a cesium plate find the maximum possible kinetic energy of the photeelectron work function of cesium is $1.9ev$

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41. A filter transition only the radiationof wavelength greater than 440 nm. Radiation from a hydrogen discharge tube goes through such a filter and is incident on a metel of work function 2.0eV . Find the stopping potential which can stop the photoelectrons.

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42. The earth revolves round the sun due to gravitatinal attraction. Suppose that the sun and the earth are point particle with their existing masses and that Bhor's quantization rule for angular

monentum is valid in the case of gravitation (a) Calculate the minimum radius the earth can have for its orbit. (b) What is the value of the principle quantum number n for the present radius ? Mass of the earth = 6.0×10^{24} kg, mass of the sun = 2.0×10^{30} kg, earth-sun distance = $1.5 \times 10^{11} m$.

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43. Consider a neutrom and an electron bound to each other due to gravitational force. Assuming Bohr's quantization rule angular momentum to be valid in this case, derive an expression for the energy of the neutron-electron system.

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44. A uniform magnetic field B exists in a region. An electrons projected perpendicular to the field goes in a circle. Assuming Bohr's quantization rule for angular momentum, calculate (a) the smallest possible radius of the electrons (b) the radius of the nth orbit and (c) the minimum possible speed of the electron.

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45. Suppose in an imginary world the angular momentum is quantized to be even integral multiples of $h/2\pi$. What is the longest possible wavelenght emitted by hydrogen atoms in visible range in such a world according to Bohr's model?

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46. Consider an excited hydrogen atom in state n moving with a velocity $v(v << c)$. It emits a photon in the direction of its motion and changes its state to a lower state m. Apply momentum and energy conservation principle to calculate the

frequency v of the emitted radiation, compare this with the frequency v_0 emitted if the atom were at rest.

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