



CHEMISTRY

JEE (MAIN AND ADVANCED) CHEMISTRY

ATOMIC STRUCTURE

Problems

1. How many protons and neutrons are there in one atom of



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2. Calculate the number of electrons which will together weigh one gram.



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3. An ion with mass number 37 possesses one unit of negative charge. If the ion contains 11.1 % more neutrons than the electrons, write its symbol.



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4. The wavelength of a blue light is $4800\text{\AA}$. Calculate the frequency and wave number of this light.



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5. The Vividh Bharati station of All India Radio, Delhi broadcasts on a frequency of 1.368 kHz. Calculate the wavelength of the electromagnetic radiation emitted by the transmitter. Which part of the electromagnetic spectrum does it belong to?



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6. How many photons of light with a wavelength of 4000 pm are necessary to provide one joule of energy?



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7. How does the colour of an iron rod change during heating?

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8. The threshold frequency of a metal is $1.11 \times 10^{16} \text{ Hz}$.

What is the maximum kinetic energy of the photo electron produced by applying a light of $15\text{\AA}$ on the metal?

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9. What is the ratio between the energies of two types of radiation whose wavelengths are $6000\text{\AA}$ and $2000\text{\AA}$ respectively.

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10. A 100 watt bulb emits monochromatic light of wavelength 400 nm . Calculate the number of photons emitted per second by the bulb.



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11. The work function of a metal is 4.2eV. If the radiation of 2000Å falls on the metal, find the kinetic energy of the metal



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12. Iodine molecule dissociates into atoms after absorbing light of 4500Å. If one quantum of radiation is absorbed by each molecule, calculate the kinetic energy of iodine atoms.
Bond energy of I_2 is 240 kJ mol^{-1}



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13. A near U.V. photon of 300 nm is absorbed by a gas then reemitted as two photons. If the wave length of one photon is 700 nm, find out the wave length of second photon.



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14. Calculate the wave number and wave length of H_β line in the Balmer series of hydrogen emission spectrum.



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15. Calculate the wave number of the first spectral line in the lyman series of He^+ spectrum.



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16. Hydrogen atoms are de-excited from N shell. Illustrate the spectral lines obtained in the emission



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17. The radius of the fourth orbit in hydrogen atom is 0.85 nm. Calculate the velocity of the electron in this orbit.



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18. Why does the transition from $n=3$ to $n=1$ gives a spectral triplet?



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19. What is the ratio of the radii of the 3rd orbits of He^+ and Li^{2+} ?



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20. The ionisation energy of He^+ is $19.6 \times 10^{-18} \text{ J atom}^{-1}$. Calculate the energy of first stationary state of Li^{2+} ion.



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21. How many time the normal electrons of hydrogen atom revolve round the nucleus in one sec? velocity of the electron



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22. What is the circumference of the second orbit of hydrogen atom?



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23. What is the length of the minor axes in the L shell of hydrogen atom?



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24. Calculate the wave length of an electron moving with a velocity of $2.05 \times 10^7 \text{ m s}^{-1}$.



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25. If the kinetic energy of an electron is $4.55 \times 10^{-25} \text{ J}$, find its wavelength (Planck's constant, $h = 6.6 \times 10^{-34} \text{ kg m}^2 \text{ s}^{-1}$, $m = 9.1 \times 10^{-31} \text{ kg}$).



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26. Find the momentum of a particle whose de Broglie wavelength is $1 \text{ \AA}$.



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27. If the radius of first orbit in hydrogen atom is $x\text{\AA}$, calculate the de Broglie wave length of electron in the third orbit.



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28. When would the wavelength associated with an electron become equal to that with proton? (Mass of electron $= 9.1095 \times 10^{-31} \text{ kg}$, Mass of proton $= 1.6725 \times 10^{-27} \text{ kg}$)



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29. Find the number of waves made by a Bohr electron in one complete revolution in the 3^{rd} orbit.

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30. A golf ball has a mass 40g and a speed of 45ms^{-1} . If the speed can be measured with an accuracy of 2% , calculate the uncertainty in position.

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31. The uncertainty in the position and velocity of a particle are 10^{-10}m and $5.25 \times 10^{-24}\text{ms}^{-1}$. What is the mass of the particle? (Value of Planck's constant is $6.6 \times 10^{-34}\text{Js}$)

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32. Calculate the wavelength of an electron that has been accelerated in a particle accelerator through a potential difference of 100 million volts.



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33. A microscope using suitable photons is employed to locate an electron in an atom within a distance of $0.1\text{\AA}$. What is the uncertainty involved in the measurement of its velocity?



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34. Comment on the applicability of the following concepts on moving particles :

(a) de Broglie's wave nature (b) Heisenberg's uncertainty



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35. Calculate the radial distance between two peaks in the radial probability of 2s orbital.



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36. How many peaks and nodes are present in the radial probability curve of 3s-orbital?



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37. s-Orbitals have no direction. Comment.



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38. How many nodal planes and nodal regions are present for 3p orbital?



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39. How many unpaired electrons are present in each of the following ground state atoms :
a) O and b) As



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40. What is the maximum number of electrons that can be present in the M shell.



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41. Write the electronic configurations of the following ions:

a) H^- , b) Na^+ and c) S^{2-}



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42. What is the total number of orbitals present in the shell with the principal quantum number, $n = 3$



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43. What is the lowest value of "n" that allows 'g' orbitals to exist?



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44. How many unpaired electrons are present in ferrous ion? Calculate its net spin and magnetic moment.



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45. Which noble gas has same number of electrons both in ultimate and penultimate shells?



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46. Among cuprous and cupric, which has more stable configuration? Why?



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47. $Cu(g) \xrightarrow{+e^-} Cu^+(g)$. Write the set of quantum numbers for the electron released in this process.



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Exercise 111

1. Write notes on the discovery of electron, proton and neutron



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2. What is the ratio of the mass of an electron to the mass of a proton?



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3. What are the three sub-atomic particles?



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4. What is atomic number? Write its significance.



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5. What is the difference between mass number and atomic mass?



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6. Write on the α – ray scattering experiment.



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7. What are the defects of nuclear model of atom.



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8. Calculate the number of protons, neutrons and electrons respectively in ${}^{14}_7\text{N}^{3-}$



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9. What is the mass of one mole electrons in kg?



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10. An isotope of ${}_{50}^A\text{Sn}$ contains 68 neutrons. What will be its mass number?



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11. The nucleus of an element contains 17 protons and 18 neutrons. What is its (a) atomic number and (b) mass number? Write the complete symbol for the element.



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12. What is the relationship between the atoms of strontium,

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13. The ratio between the neutrons present in carbon atom and silicon atoms with mass numbers 12 and 28 is

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Exercise 112

1. What are wave length, wave number and frequency? Write the relationship between them.



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2. Which has the higher frequency, infrared light or ultraviolet light? Which has the greater energy?



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3. What is the wave length of ultra violet light of $\nu = 5.5 \times 10^{15} \text{ s}^{-1}$?



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4. Write the ratio of velocity of red and violet radiations.



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5. What is the frequency of microwave with a wave length of 4.33×10^{-3} m?



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6. Calculate the wavelength, wave number and frequency of photon which has energy equal to 3 eV.



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7. Blackbody Radiation is



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8. Write the postulates of Planck's theory.



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9. What is the wave length in nanometers of radiation that has energy content $1.0 \times 100^3 kJmol^{-1}$? In which region of the electromagnetic spectrum this radiation is found.



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10. Discuss the photoelectric effect. Mention the condition for the photoelectric effect.



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11. Write the main difference in the views of Planck and Einstein, regarding the electromagnetic radiation

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12. The threshold wave length (λ_0) of sodium metal is $6500\text{\AA}$. If uv light of wave length $360\text{\AA}$ is used, what will be the kinetic energy of the photoelectron?

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13. The minimum energy required for the photo emission of electrons from the surface of a metal is $4.95 \times 10^{-19} J$.

Calculate the critical frequency and the corresponding wave length of the photon required to eject the electron.



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Exercise 1 1 4

1. What is spectrum? How is it taken?



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2. What are : (a) absorption (b) emission (c) line and (d) band spectra.



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3. Discuss various spectral lines in the hydrogen emission.

Write the equation useful for characterisation of spectral lines.



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4. What is the shortest wave length line (in nanometers) in Lyman series of the hydrogen spectrum?



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5. Calculate the longest wave length spectral line in the Paschen series of hydrogen emission spectrum



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6. Give the main postulates of Bohr's model of an atom.



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7. Derive expressions for the following:

(a) radius of hydrogen atom and (b) energy of hydrogen electron



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8. How are different spectral lines explained by Bohr's theory?



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9. How the atomic model suggested by Bohr explains the stability of atom ?



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10. What are the failures of Bohr's model of atom ?



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11. How is Sommerfeld's extension to Bohr's model of atom explains fine structure of spectral lines?



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12. Calculate the energy associated with the first orbit of He^+ . What is the radius of this orbit?



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13. The ionisation energy of hydrogen atom is 13.6 eV. What will be the ionisation energy of He^+ and Li^{2+} ions?



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14. How many spectral lines can be obtained during the de-excitation of electron of hydrogen from 'O' shell to the most stable state ?



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15. Calculate the energy required to remove an electron completely from $n = 2$ orbit. What is the longest wave length of light that can be used to cause this transition?



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16. An atom emits energy by a $4 \rightarrow 2$ transition. What other transitions must also be present in order to reach the ground state?



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17. What is the energy difference between the $n=2$ and $n=3$ levels for the hydrogen atom?

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Exercise 1 1 5

1. Explain the significance of de Broglie's concept.

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2. Derive de Broglie's equation.

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3. State Heisenberg's uncertainly principle.

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4. Calculate the momentum of a particle which has a de Broglie wave length of 0.1 mm.



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5. The wave length of a moving body of mass one-tenth of a milligram is $3.312 \times 10^{-29} m$. Calculate its kinetic energy.



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6. A proton is moving with kinetic energy 5×10^{-27} . What is the wavelength of de Broglie wave associated with it?
(Mass of proton = $1.66 \times 10^{-27} kg$, $h = 6.6 \times 10^{-34} Js$)



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7. What is the wave length of electron wave in the first orbit of hydrogen atom?



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8. How many waves are present in N shell o hydrogen atom ?



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9. The uncertainty in the momentum of a particle is $2.2 \times 10^4 \text{ g cms}^{-1}$. With what accuracy can its position be determined ?



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10. It is not possible to determine precisely both the position and the momentum or velocity) of a small moving particle (e.g. electron , proton, etc)

The uncertainty in position and velocity of a particle are $10^{-10}m$ and $5.27 \times 10^{-24}ms^{-1}$ respectively, Calculate the mass of the particle. ($h = 6.625 \times 10^{-34}J - s$)



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11. Calculate the wave length of atomic electron revolving in the third shell of hydrogen atom.



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12. Heisenberg's uncertainty principle cannot be applied to stationary electron. Why?



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13. Calculate the uncertainty in the velocity of an electron, if the uncertainty in position is 100 pm.



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Exercise 116

1. Write the Schrodinger wave equation and explain each term in it.



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2. Explain the significance of Ψ^2 .



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3. Draw the radial probability curves of s, p and d orbitals.



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4. Draw the shapes of s, p and d orbitals.



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5. What is the difference between an orbit and orbital ?



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Exercise 117

1. What are quantum numbers ?



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2. How are quantum numbers useful to designate orbitals?



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3. Write the permissible combinations of quantum numbers is M shell.



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4. Describe the nI^x method of electronic con-figuration using Pauli's and Auf-bau principles.



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5. State and explain Hunds's rule of maximum multiplicity.



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6. How is the stability of atoms and ions determined?



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7. Explain the magnetic behaviour of atoms, ions and molecules. How is the magnetic moment calculated?



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8. What are the possible values of l and m for an electron with $n = 3$?



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9. Give the set of quantum numbers that describe an electron in 3p orbital



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10. Write the configuration of Ni^{2+} . How many unpaired electrons are there in the ion?



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11. Explain why chromium has only one electron in its 4s subshell?



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12. Predict the magnetic moment of Co^{3+} and Cu^{2+} ions.



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13. Give the electronic configuration, the number of unpaired electrons and the type of magnetic behaviour of the following:

a) Se^{2-} , b) Mn^{2+} , c) Fe^{3+} and d) Ni



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Questions For Descriptive Answers

1. Calculate their specific charges of fundamental particles.



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2. How are number of fundamental particles calculated from atomic and mass numbers ?



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3. How are the characteristics of wave inter-related?



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4. Electromagnetic waves differ from matter waves in many respect. Substantiate.



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5. How energy density in black body radiation depends upon temperature?



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6. What is the longest wavelength line in Paschen series for hydrogen?



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7. Define isotopic number. Calculate the isotopic numbers of hydrogen-3 and chlorine-37



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8. A bulb emits light of wavelength $4500\text{\AA}$. The bulb is rated as 150 watt and 8 % of the energy is emitted as light. How many photons are emitted per sec?



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9. The work function for Cesium atom is 1.9 eV . Calculate the threshold frequency of the radiation . If the Cesium element is irradiated with a wavelength of 500 nm , calculate the kinetic energy of the ejected photoelectron .



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10. What is the minimum energy of photons which causes photoelectric effect with platinum metal? The threshold

frequency of the metal platinum is $1.3 \times 10^{15} \text{s}^{-1}$.



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11. The energy of the electron in the first Bohr orbit of H is -2.18×10^{-11} erg. Calculate the charge of electron.



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12. Why the total energy of atomic electron is negative ?



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13. Calculate the wave number for the longest wavelength transition in the Balmer series of atomic hydrogen emission

spectrum.



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14. The wavelength of a certain line in Balmer series is 4341 angstroms. To what value of 'n' does this transition correspond ? ($R = 109678 \text{ cm}^{-1}$).



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15. A spectral triplet is obtained for the electronic transition from $n = 3$ to $n=1$. Why?



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16. What transition in the hydrogen emission spectrum have the same wavelength as Balmer transition, $n=4$ to $n=2$ of He^+ spectrum ?



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17. Calculate the wave length of an electron moving with a velocity of $2.05 \times 10^7 \text{ms}^{-1}$.



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18. The kinetic energy of an electron is $4.55 \times 10^{-28} \text{kJ}$. Calculate the de Broglie's wavelength.



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19. Calculate the product of uncertainties of displacement and velocity of a moving electron.



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20. What is the maximum number of emission lines observed when the excited electron of hydrogen atom in $n = 6$ drops to the ground state?



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21. How many waves will be made by a Bohr electron in one complete revolution in the 2nd excited state?



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22. Electrons of energy 10.2 and 12.09eV $\rightarrow m^{-1}$ can cause radiations to be emitted from H atoms. Name the spectral line in the Balmer series.



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23. Calculate the wavelength of carbon dioxide molecule whose velocity is 440m s^{-1} .



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24. The mass of an electron is $9.1 \times 10^{-31}\text{kg}$. If its K.E. is $3.0 \times 10^{-25}\text{J}$, calculate its wavelength.



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25. If the circumference of first Bohr orbit is $3.3 \times 10^{-10} \text{ m}$ and if this circumference represents one wavelength, find the velocity of electron revolving in that orbit.

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26. How does the five degenerate d-orbitals split into two groups in the applied field?

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27. $3d_{x^2-y^2}$ and $3d_{xy}$ orbitals both have electron density in the xy-plane. Comment



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28. How is orbital energy diagram useful for predicting the relative energies of orbitals?



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29. Comment on extra stability with parallel spin configuration of electron pairs.



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30. Write the set of quantum numbers for all electrons of oxygen atom.



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31. Velocity of the electron in the 1st Bohr orbit



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32. Write the $(n + l)$ value of one of the atomic electron present in the outermost orbit of ground electronic state of argon



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33. Divalent zinc is diamagnetic, while divalent copper is paramagnetic. Discuss.



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34. Ferric iron is more stable than ferrous iron. Explain.



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35. How many unpaired electrons are present in Ca^{2+} ?

What is its magnetic moment?



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36. Write the configuration of the following elements:

Sc, Cr, Cu, As, Rb, Pd and *Ba*.



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37. Completely filled or half-filled configurations give extra stability. Why?



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38. How many electrons in an atom may have $n = 4$ and $m_s = +\frac{1}{2}$?



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39. 24th electron of chromium enters in 3d-subshell. Discuss.



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40. Chromium atom has six unpaired electrons. Substantiate.



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41. The first element that acquires $3d^{10}$ configuration is copper. Substantiate.



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42. Find out the net electronic spin of divalent nickel cation.



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43. If an element with $Z = 118$ is discovered, what ground state electron configuration do you think it will have?



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