CHEMISTRY (XI)

Chapter 5
Atomic Structure
Short Questions

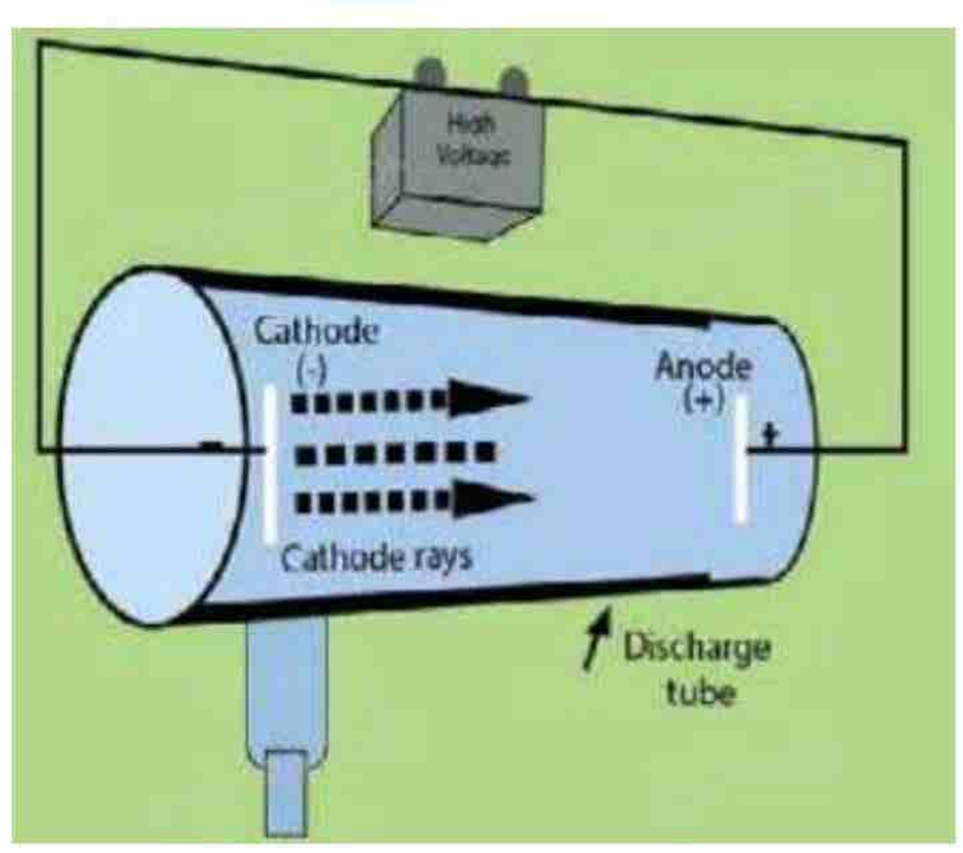
1. Name the fundamental particles of atom.

Ans: The fundamental particles of atom are electron, proton and neutron.

2. How cathode rays (electrons) were discovered?

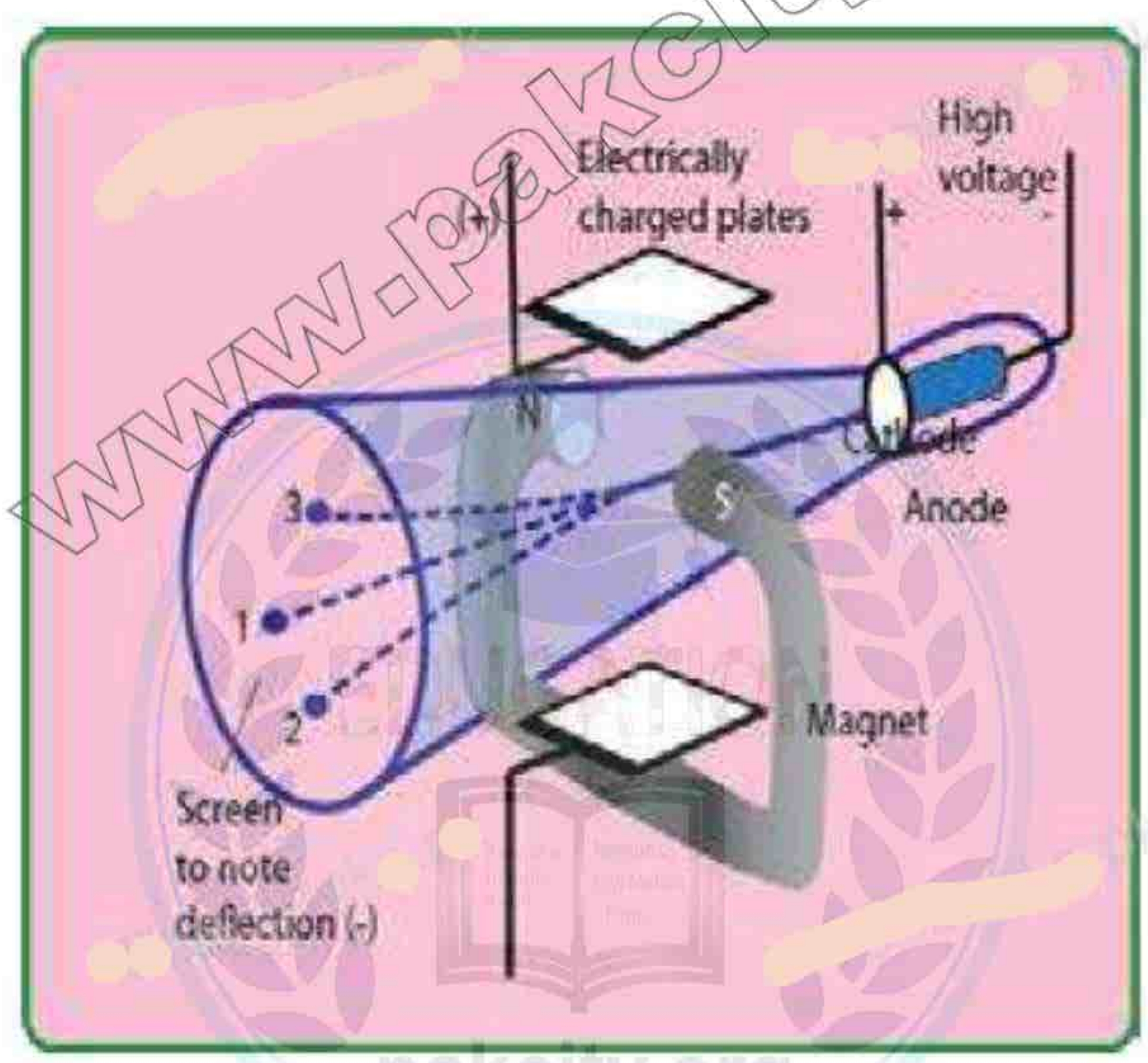
Ans: A gas discharge tube is fitted with two metallic electrodes acting as cathode and anode. The tube is filled with a gas, air or vapours of a substance at any desired pressure. The electrodes are connected to a source of high voltage. The tube is attached to a vacuum pump by means of a small side tube so that the conduction of electricity may be studied at any value of low pressure

It is observed that current does not flow through the gas at ordinary pressure even at high voltage of 5000 volts. When the pressure inside the tube is reduced and a high voltage of 5000-10000 volts is applied, then an electric discharge takes place through the gas producing a uniform glow inside the tube. When the pressure is reduced further to about 0.01 torr, the original glow disappears. Some rays are produced which create fluorescence on the glass wall opposite to the cathode. These rays are called cathode rays.



3. How was it proved that cathode rays are negatively charged particles? OR How the bending of the cathode rays in the electric and magnetic field prove that they are negatively charged?

Ans: Cathode rays are negatively charged. In 1895, J. Perrin showed that when the cathode rays passed between the poles of the magnet, the path of the negatively charged particles was curved downward to point 2 by the magnetic field. In 1897, J. Thomson established their electric charge by the application of electric field, the cathode ray particles were deflected upwards (towards the positive plate) to point 3. Thomson found that by carefully controlling the charge on the plates when the plates and the magnet were both around the tube, he could make the cathode rays strike the tube at point 1 again. He was able to cancel the effect of the magnetic field by applying an electric field that tended to bend the path of the cathode rays in the opposite direction.

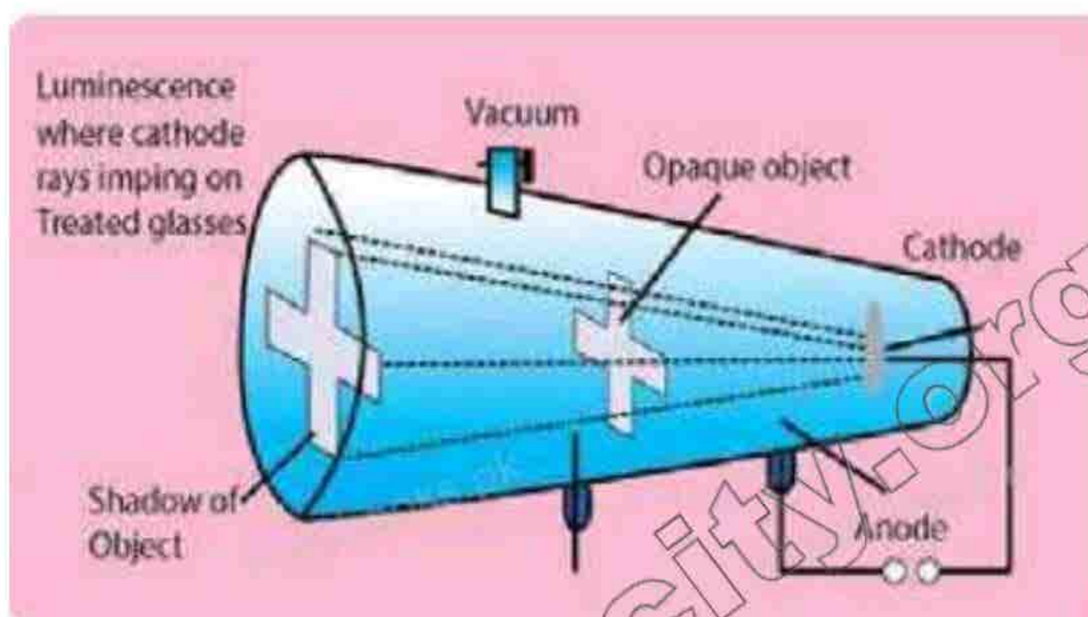


4. What type of fluorescence is shown by cathode rays?

Ans: They produce a greenish fluorescence on striking the walls of the glass tube. These rays also produce fluorescence in rare earths and minerals. When placed in the path of these rays, alumina glows red and tin stone yellow.

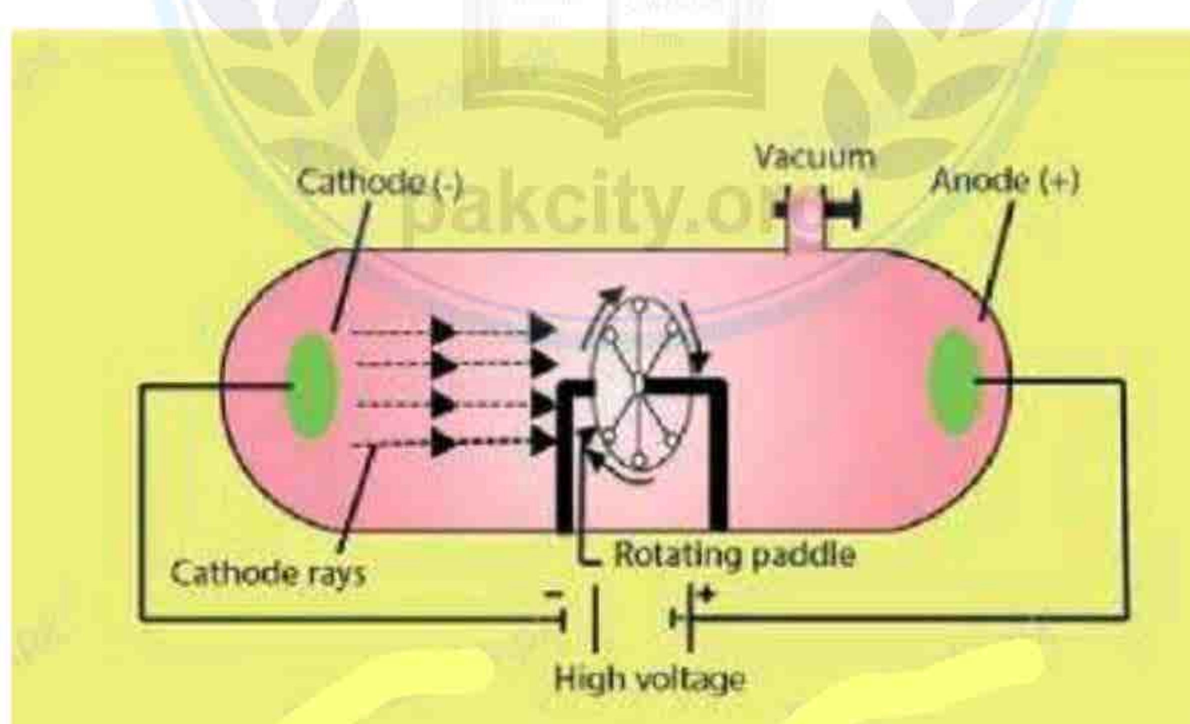
5. Which observations prove that cathode rays cast shadow?

Ans: Cathode rays cast a shadow when an opaque object is placed in their path. This proves that they travel in straight line perpendicular to the surface of cathode.



6. Which observations prove that cathode rays have momentum? Or Prove that cathode rays have momentum.

Ans: These rays can drive a small paddle wheel placed in their path. This shows that these rays possess momentum. From this observation, it is inferred that cathode rays are not rays but material particles having a definite mass and velocity.



7. Why is it necessary to decrease the pressure in the discharge tube to get the cathode rays?

Ans: The pressure in discharge tube is decreased to allow the cathode to move freely from cathode towards opposite wall. Hence, possibility of collisions between rays and the gas molecules are minimized.

8. Whichever gas is used in the discharge tube the nature of the cathode rays remains the same. Why?

Ans: All the gases have atoms and molecules having electrons in the outermost shell. Due to high voltage these electrons become free. They are repelled by the cathode and attracted towards the anode. That is why, they are called cathode rays as they are always electrons and nature of electrons is same no matter which gas is used in the discharge tube experiment.

9. Why e/m value of the cathode rays is just equal to that of electron?

Ans: Cathode rays are actually electrons and the nature of electrons remains the same irrespective of the substance used in the discharge tube. So, e/m value of cathode rays is also called e/m value of electron.

10. Why the positive rays are also called canal rays? Give reason.

Ans: Positive rays after passing through the perforated cathode produce a glow on the wall opposite to the anode. Since these rays pass through the canals or the holes of cathode, they are called canal rays.

11. What is the reason for the production of positive rays?

Ans: These positive rays are produced, when high speed cathode rays (electrons) strike the molecules of a gas enclosed in the discharge tube. They knock out electrons from the gas molecules and positive ions are produced, which start moving towards the cathode.

$$M+e^{-} \rightarrow M^{+}+2e^{-}$$

12. The e/m values of positive rays for different gases are different, but those for cathode rays the e/m values are same. Justify it.

Ans: The nature of particles of positive rays depends upon the nature of the gas as every gas has its own atomic mass. As the mass is different so e/m values of positive rays for different gases are different. Cathode rays are simply electrons, so the e/m value of cathode rays remains the same no matter which gas is used in the experiment.

13. The e/m value of positive rays obtained from the hydrogen gas is 1836 times less than that of cathode rays. Justify it.

Ans: The e/m value for the positive rays is always smaller than that of electrons and depends upon the nature of the gas used in the discharge tube. Heavier the gas, smaller is the e/m value. When hydrogen gas is used in the discharge tube, the e/m value is found to be the maximum in comparison to any other gas because the value of 'm' is the lowest for the positive particle obtained from the hydrogen gas. Hence, the positive particle obtained from hydrogen gas is the lightest among all the positive particles. The mass of a proton is 1836 times more than that of an electron.

14. Which particles are formed by the decay of free neutron?

Ans:

Free neutron decays into a proton ${}^{1}_{+}P$ with the emission of an electron ${}^{0}_{-1}e$ and a neutrino ${}^{0}_{0}n$.

$$ {}^{1}_{0}n \rightarrow {}^{1}_{+1}P + {}^{0}_{-1}e + {}^{0}_{0}n $$

15. How the slow neutrons prove to be more effective than fast neutrons?

Ans: When the travelling neutrons have energy below 1 eV then they are called slow neutrons.

They are more effective in fission processes. Slow neutrons hit the copper metal and gamma radiations are emitted giving a new isotope of copper i.e. Cu (66) which is again radioactive.

$$^{65}_{29}Cu + ^{1}_{0}n \rightarrow ^{66}_{29}Cu + h\nu(\gamma - raditions)$$

$$^{66}_{29}Cu \rightarrow ^{66}_{30}Zn + ^{0}_{-1}e \text{ (electron)}$$

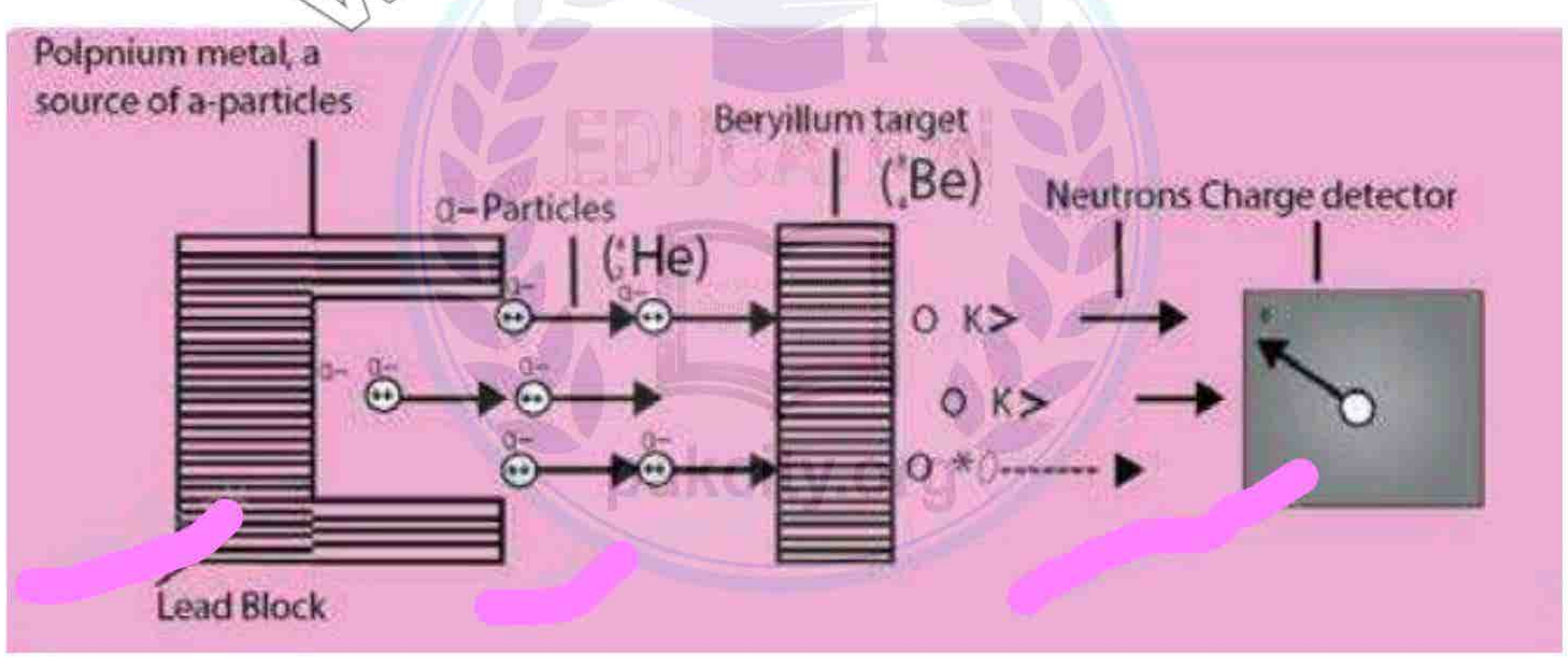
16. How neutron was discovered?

Ans: Chadwick discovered neutron in 1932 and was awarded Nobel Prize in Physics in 1935. A stream of α-particles produced from a polonium source was directed at beryllium ($^{9}_{4}Be$) target. It was noticed that some penetrating radiations were produced. These radiations were called neutrons because the charge detector showed them to be neutral.

$$^{4}_{2}He + ^{9}_{4}Be \rightarrow ^{12}_{6}C + ^{1}_{0}n$$

(α-particle)

Actually α-particles and the nuclei of Beryllium are re-arranged and extra neutron is emitted.



17. Give properties of Neutron.

Ans: Some properties of neutron are as follows:

1. Neutrons cannot ionize gases.

2. Neutrons are highly penetrating particles.

3. They can expel high speed protons from paraffin, water, paper and cellulose.

4. When neutrons travel with an energy of 1.2 Mev (Mega electron volt 10^6), they are called fast neutrons but with energy below 1ev they are called slow neutrons.

18. How did Rutherford's model of an atom proved the existence of nucleus of the atom?

Ans: A beam of α-particles was directed onto a gold foil of 0.00004 cm thickness as target through a pin-hole in lead plate. A photographic plate or a screen coated with zinc sulphide was used as a detector. Whenever, an α-particle struck the screen, flash of light was produced at that point. It was observed that most of the particles went through the foil undeflected. Some were deflected at fairly large angles, and a few were deflected backward. Rutherford proposed that the rebounding particles must have collided with the central heavy portion of the atom which he called as nucleus.

19. What are the defects of Rutherford's model of atom?

Ans: Following are the defects in Rutherford's model of atom:

(i) It is based on the laws of the motion and the gravitation. These laws are not for the charged bodies like electrons.

(ii) The revolving electron should emit the energy continuously and by producing a spiral path it should ultimately fall into the nucleus. But actually the atoms don't do that.

(iii) The atom should give continuous spectra but actually line spectra are obtained.

20. What does Planck's quantum theory say? Mention main points.

Ans: According to Planck's theory, energy travels in a discontinuous manner and it is composed of large number of tiny discrete units called quanta. The main points of his theory are:

(i) Energy is not emitted or absorbed continuously. Rather, it is emitted or absorbed in a discontinuous manner and in the form of wave packets. Each wave packet or quantum is associated with a definite amount of energy. In case of light, the quantum of energy is often called photon.

(ii) The amount of energy associated with a quantum of radiation is proportional to the frequency of the radiation.

$$E \propto v$$
$$E = hv$$

Where 'h' is a constant known as Planck's constant and its value is 6.626×10^{-34} Js. Frequency (v) has the units of cycles s^{-1} or Hz. (1 Hz = 1 cycle s^{-1})

21. Define frequency.

Ans: Frequency is the number of waves passing through a point per second. The SI unit of frequency is hertz (Hz).

22. Define wavelength.

Ans: Wavelength is the distance between the two adjacent crests or troughs and expressed in °A, nm or pm. (1 °A $=10^{-10}$ m, 1 nm = 10^{-9}m, 1 pm=10^{-12}m)

23. Define wave number.

Ans: Wave number ($\bar{v}$) is the number of waves per unit length and is reciprocal to wavelength. It is usually measured in units of m^{-1} or cm^{-1}.

$$\bar{v} = 1/\lambda$$

24. How the energy of the photon can be calculated from the measurement of the frequency, wavelength or wave number of the photon?

Ans: According to Planck's theory, the energy depends upon the frequency, wavelength and wave number of photons as in the equations

$$E = hv$$

$$E = hc/\lambda$$

$$\bar{v} = 1/\lambda$$

$$E = hc\bar{v}$$

We need two constants for this i.e., 'c' and 'h'

25. How do you justify that the distances between adjacent orbits of Hydrogen atom go on increasing from lower to the higher orbits?

Ans: From equation of radius for hydrogen atom

$$r = 0.529\ \text{Å} \times n^2$$

where $n = 1 \quad r_1 = 0.529 \times (1)^2 = 0.529\ \text{Å}$

$n = 2 \qquad r_2 = 0.529 \times (2)^2 = 2.11\ \text{Å}$

$n = 3 \qquad r_3 = 0.529 \times (3)^2 = 4.75\ \text{Å}$

$n = 4 \qquad r_4 = 0.529 \times (4)^2 = 8.4\ \text{Å}$

From the above data it is clear that distance gaps go on increasing from lower to higher orbits. Therefore,

$r_2 - r_1 < r_3 - r_2 < r_4 - r_3 <$ ....so on.

The second orbit is four times away from the nucleus than first orbit, third orbit is nine times away and similarly fourth orbit is sixteen times away.

26. How do you prove that the energy associated with the electron which is revolving around the nucleus of H-atom is negative?

The work done is the potential energy of electron, so

Ans: Work done = $E_{potential} = -\frac{Ze^2}{4\pi\varepsilon_0 r}$

The total energy (E) of the electron is:

So, **E=Ekinetic + Epotential**

$$= \frac{1}{2}mv^2 - \frac{Ze^2}{4\pi\varepsilon_0 r} \quad \ldots\ldots \quad \ldots\ldots\ldots\ldots \quad (1)$$

Now, we want to eliminate the factor of **velocity from** equation (1). So, from equation (2) substitute the value of mv^2

Since $mv^2 = \frac{Ze^2}{4\pi\epsilon_0 r}$ .... (2)

$$E = \frac{Ze^2}{8\pi\epsilon_0 r} - \frac{Ze^2}{4\pi\epsilon_0 r}$$

Simplifying it, $E = -\frac{Ze^2}{8\pi\epsilon_0 r}$ .... (3)

27. How do you come to know that the velocities of electrons in higher orbitsare less than those in lower orbits of hydrogen atom?

Ans: According to Bohr's proposals, the centrifugal force of the electron is equal to the force of attraction between nucleus and electron.

$$\frac{mv^2}{r} = \frac{Ze^2}{4\pi\epsilon_0 r^2}$$

Rearranging it,

$$r = \frac{Ze^2}{4\pi \in_0 mv^2}$$

According to equation, the radius of a moving electron is inversely proportional to the square of its velocity. Electron should move faster nearer to the nucleus in an orbit of smaller radius. It also tells that if hydrogen atom has many possible orbits, then the promotion of electron to higher orbits makes it move with less velocity.

28. Energy of an electron is inversely proportional to 'n^2' but energy of higher orbits is always greater than those of the lower orbits. Why?

Ans: The formula for the energy of an electron revolving in any orbit is given by the equation:

$$E_n = -2.178 \times 10^{-18} \left[\frac{1}{n^2}\right] J$$

This equation gives the energy associated with electron in the n^{th} orbit of hydrogen atom. Its negative value shows that greater the value of n greater the energy of electron.

29. The energy difference between adjacent levels goes on decreasing sharply. Why?

Ans: Substituting the values of n as 1, 2, 3, 4, 5, etc. in equation, we get the energy associated with an electron revolving in 1^{st}, 2^{nd}, 3^{rd}, 4^{th} and 5^{th} orbits of H-atoms.

$$E_1 = -\frac{1313.31}{1^2} = -1313.31 kJmol^{-1}$$

$$E_2 = -\frac{1313.31}{2^2} = -328.32 kJmol^{-1}$$

$$E_3 = -\frac{1313.31}{3^2} = -145.92 kJmol^{-1}$$

$$E_4 = -\frac{1313.31}{4^2} = -82.08\,kJmol^{-1}$$

$$E_5 = -\frac{1313.31}{5^2} = -52.53\,kJmol^{-1}$$

$$E_\infty = -\frac{1313.31}{\infty^2} = 0\,kJmol^{-1}\ (\text{electron is free from the nucleus})$$

$$E_2 - E_1 = (-328.32) - (-1313.31) = 984.99\ kJmol^{-1}$$

$$E_3 - E_2 = (-145.92) - (-328.32) = 182.40\ kJmol^{-1}$$

$$E_4 - E_3 = (-82.08) - (-145.92) = 63.84\ kJmol^{-1}$$

The data obtained above proves that

$$E_2 - E_1 > E_3 - E_2 > E_4 - E_3$$

Energy difference between lower orbits is greater and energy difference between higher orbits is lower.

30. How Bohr's model of H-atom can help us to justify the ionization potentialof H-atom?

Ans: Substituting the values of n as 1, 2, 3, 4, 5, etc. in equation we get the energy associated with an electron revolving in various orbits of hydrogen atom.

$$E_1 = -\frac{1313.31}{1^2} = -1313.31\,kJmol^{-1}$$

$$E_\infty = -\frac{1313.31}{\infty^2} = 0\,kJmol^{-1}\ (\text{electron is free from the nucleus})$$

$$E_2 - E_1 = (-328.32) - (-1313.31) = 984.99\ kJmol^{-1}$$

The energy difference between first and infinite levels of energy is calculated as:

$$E_\infty - E_1 = 0 - (-1313.31) = 1313.31\ kJmol^{-1}$$

1313.31 $kJmol^{-1}$ is the ionization energy of hydrogen. This value is the same as determined experimentally.

31. What are the defects of Bohr's model of atom?

Ans: Following are the defects of Bohr's model of atom:

1. Bohr's theory can successfully explain the origin of the spectrum of H-atom and ions like He^{+1}, Li^{+2} and Be^{+3}, etc. These are all one electron systems. But this theory is not able to explain the origin of the spectrum of multi-electrons or poly-electrons system like He, Li and Be etc.

2. When the spectrum of hydrogen gas is observed by means of a high resolving power spectrometer, the individual spectral lines are replaced by several very fine lines. The Hα line in the Balmer series is found to consist of five - component lines. This is called fine structure or multiple structure. The appearance of several lines in a single line suggests that only one quantum number is not sufficient to explain the origin of various spectral lines.

3. Bohr suggested circular orbits of electrons around the nucleus of hydrogen atom, but researches have shown that the motion of electron is not in a single plane, but takes place in three dimensional space. The atomic model is not flat.

4. When the excited atoms of hydrogen (which give an emission line spectrum) are placed in a magnetic field, its spectral lines are further split up into closely spaced lines. This type of splitting of spectral lines is called Zeeman effect. So, if the source which is producing the Na – spectrum is placed in a weak magnetic field, it causes the splitting of two lines of Na into component lines.

Similarly, when the excited hydrogen atoms are placed in an electrical field, then similar splitting of spectral lines takes place which is called "Stark effect". Bohr's theory does not explain either Zeeman or Stark effect.

32. What is Zeeman effect and Stark effect?

Ans: When the excited atoms of hydrogen (which give an emission line spectrum) are placed in a magnetic field, its spectral lines are further split up into closely spaced lines. This type of splitting of spectral lines is called Zeeman effect. Similarly, when the excited hydrogen atoms are placed in an electrical field, then similar splittingof spectral lines takes place which is called “Stark effect”.

33. What are the names of the spectral series in hydrogen spectrum?

Ans: These spectral lines of hydrogen spectrum can be classified into five groups called spectral series. These series are named after their discoverers as:

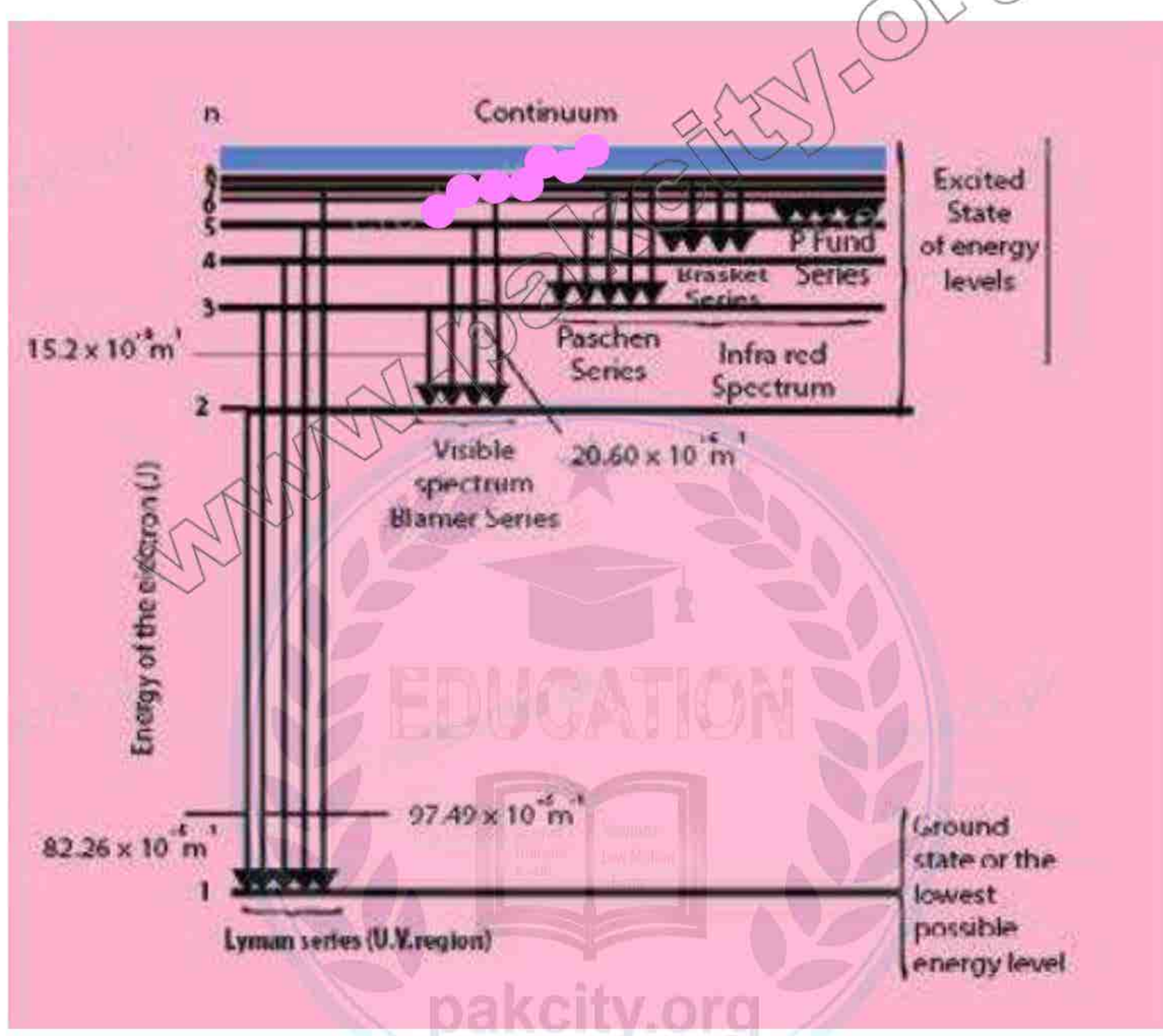
(i) Lyman series (U.V region)

(ii) Balmer series (visible region)

(iii) Paschen series (LR region)

(iv) Brackett series (I.R region)

(v) Pfund series (I.R region)



34. Define spectrum.

Ans: A visual display or dispersion of the components of white light, when it is passed through a prism is called a spectrum.

35. What is continuous spectrum?

Ans: In this type of spectrum, the boundary line between the colours cannot be marked. The colours diffuse into each other. One colour merges into another without any dark space. The best example of continuous spectrum is rainbow. It is obtained from the light emitted by the sun or incandescent (electric light) solids. It is the characteristic of matter in bulk.

36. What is line or atomic spectrum?

Ans: When an element or its compound is volatilized on a flame and the light emitted is seen through a spectrometer, we see distinct lines separated by dark spaces. This type of spectrum is called line spectrum or atomic spectrum.

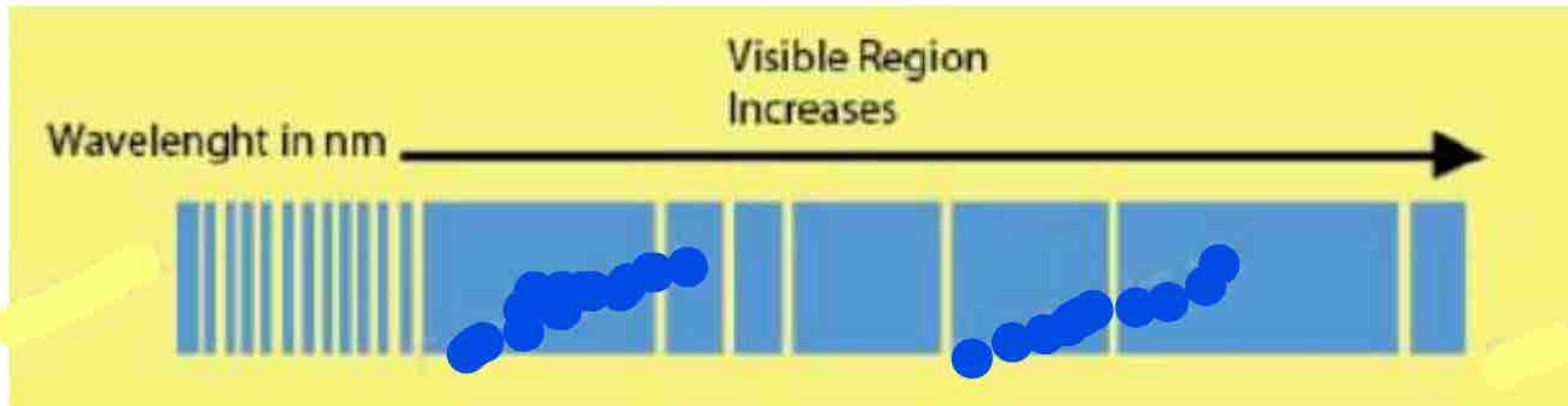
37. What are the features/characteristics of line spectrum?

Ans: Following are the features of line spectrum:

1. This is characteristic of an atom.

2. The number of lines and the distance between them depends upon the element volatilized. For example, line spectrum of sodium contains two yellow-coloured lines separated by a definite distance. Similarly, the spectrum of hydrogen consists of a number of lines of different colours having different distances from each other. It has also been observed that distances between the lines for the hydrogen spectrum decrease with the decrease in wavelength and the spectrum becomes continuous after a certain value of wavelength.

3. Atomic spectrum can also be observed when elements in gaseous state are heated at high temperature or subjected to an electric discharge.



Atomic spectrum of hydrogen

38. Name the two types of atomic spectrum.

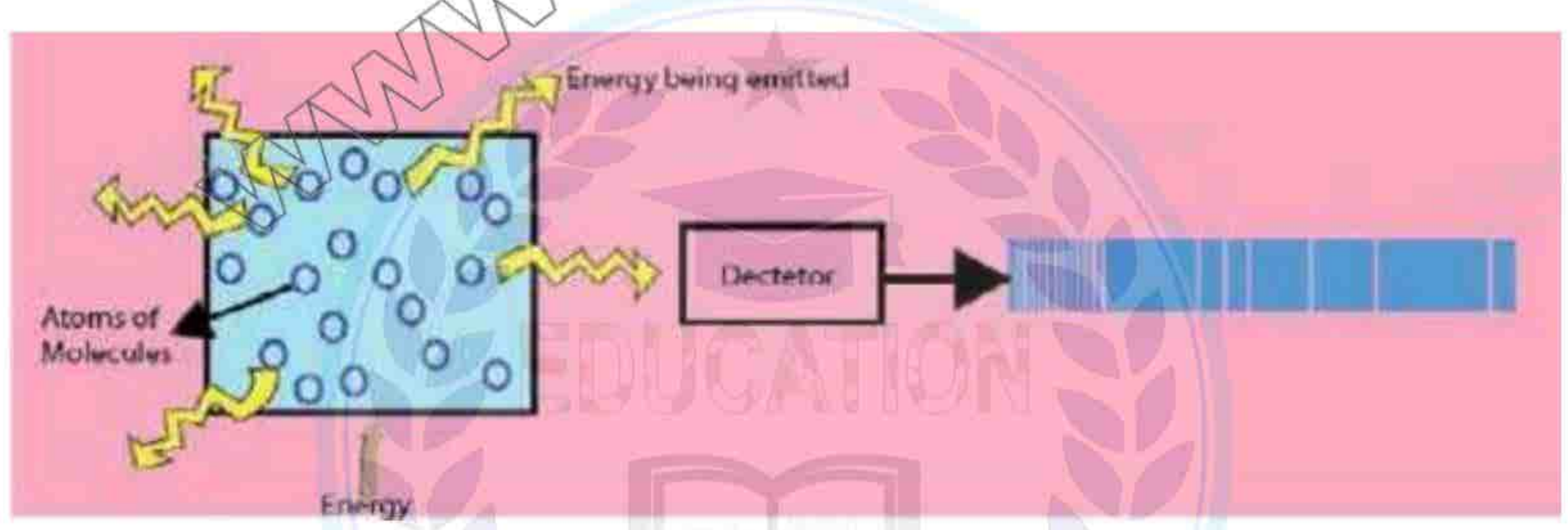
Ans: There are two types of atomic spectrum:

(i) Atomic emission spectrum

(ii) Atomic absorption spectrum

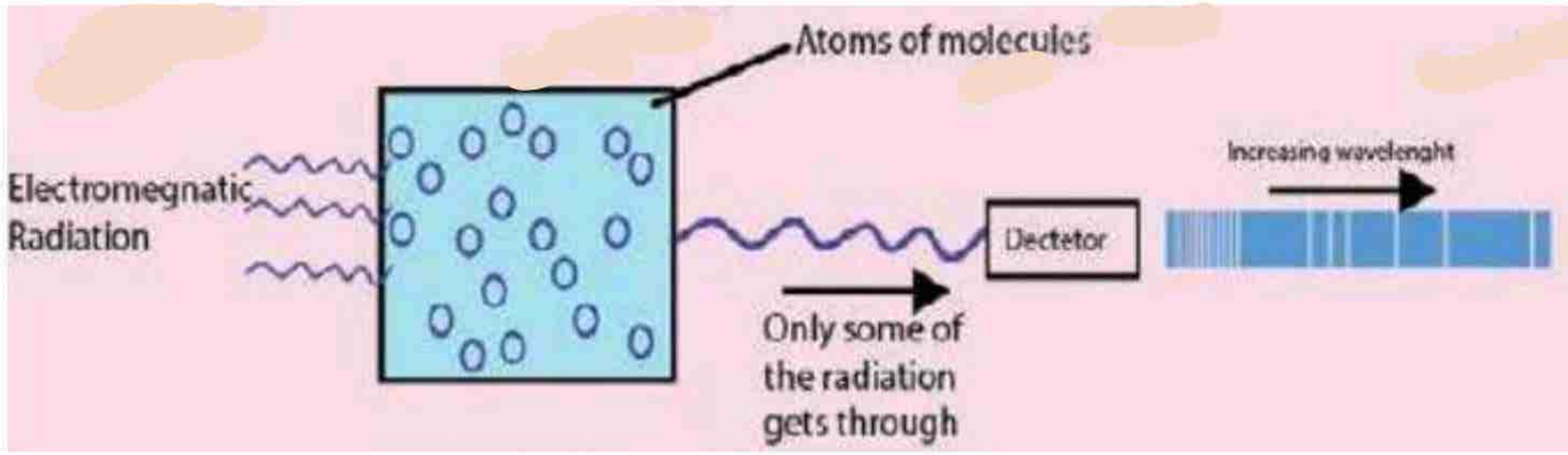
39. What is atomic emission spectrum?

Ans: When solids are volatilized or elements in their gaseous states are heated to high temperature or subjected to an electrical discharge, radiations of certain wavelengths are emitted. The spectrum of this radiation contained bright lines against a dark background. This is called atomic emission spectrum.



40. What is atomic absorption spectrum?

Ans: When a beam of white light is passed through a gaseous sample of an element, the element absorbs certain wavelengths while the rest of wavelengths pass through it. The spectrum of this radiation is called an atomic absorption spectrum. The wavelengths of the radiation that have been absorbed by the element appear as dark lines and the background is bright.



41. How wave number of photons is calculated for Lyman series?

First line $n_1 = 1$ (lower orbit), $n_2 = 2$ (higher orbit)

$$\bar{v} = 1.09678\ 10^7\left[\frac{1}{1^2}-\frac{1}{2^2}\right]\ 82.26x10^5m^{-1}$$

Second line $n_1 = 1$ $n_2 = 3$

$$\bar{v} = 1.09678\ 10^7\left[\frac{1}{1^2}-\frac{1}{3^2}\right]\ 97.49x10^5m^{-1}$$

Limiting line $n_1 = 1$ $n_2 = \infty$

$$\bar{v} = 1.09678\ 10^7\left[\frac{1}{1^2}-\frac{1}{\infty^2}\right]\ 109.678x10^5m^{-1}$$

Ans:

42. How wave number of photons is calculated for Balmer series?

Ans:

First line $n_1 = 2$, $n_2 = 3$

$$\bar{v} = 1.09678\ 10^7\left[\frac{1}{2^2}-\frac{1}{3^2}\right]\ 15.234x10^5m^{-1}$$

Second line $n_1 = 2$ $n_2 = 4$

$$\bar{\nu} = 1.09678\ 10^7 \left[\frac{1}{2^2} - \frac{1}{4^2}\right]\ 20.566\times10^5 m^{-1}$$

Third line $n_1 = 2$ $n_2 = 5$

$$\bar{\nu} = 1.09678\ 10^7 \left[\frac{1}{2^2} - \frac{1}{5^2}\right]\ 23.00\times10^5 m^{-1}$$

Limiting line $n_1 = 2$ $n_2 = \infty$

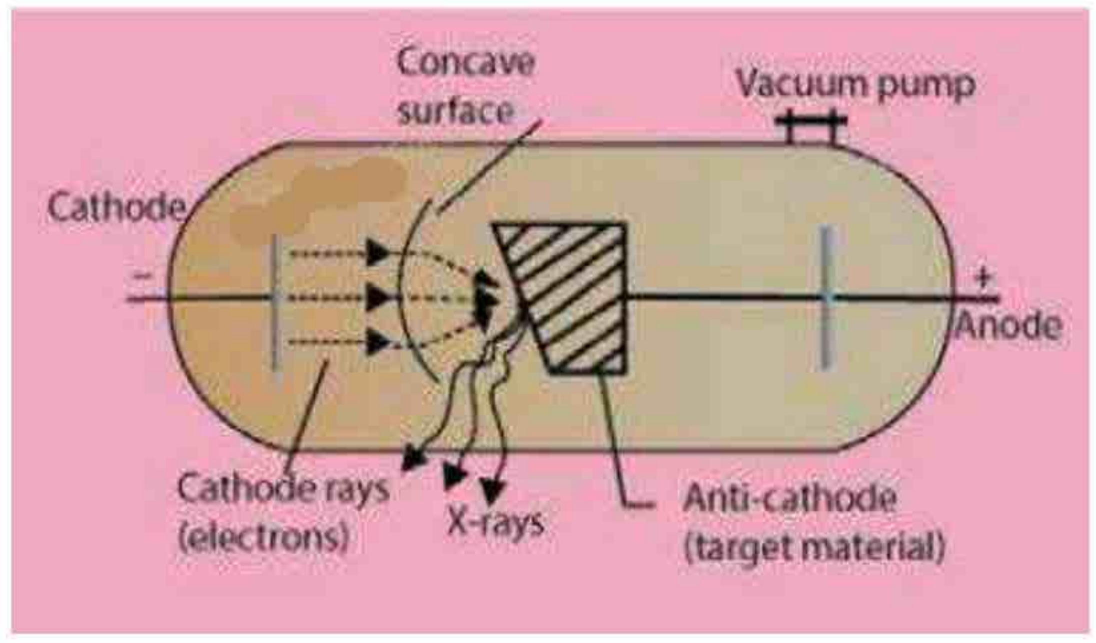
$$\bar{\nu} = 1.09678\ 10^7 \left[\frac{1}{2^2} - \frac{1}{\infty^2}\right]\ 27.421\times10^5 m^{-1}$$

43. How are the X-ray series generated?

Ans: The X-rays are passed through a slit in platinum plate and then emerged through aluminum window. This is thrown on a crystal of $K_4[Fe(CN)_6]$, which analyzes the X-ray beam. The rays are diffracted from the crystal and are obtained in the form of line spectrum of X-rays. This is allowed to fall on photographic plate. This line spectrum is the characteristic of target material used. This characteristic X-rays spectrum has discrete spectral lines. These are grouped into K-series, L-series and M-series, etc. Each series has various lines as K_α, K_β, L_α, L_β, M_α, M_β etc.

44. On what factors the wavelength of X-rays depends?

Ans: The wavelength of X-rays produced depends upon the nature of the target metal. Every metal has its own characteristic X-rays.



45. Detail out the work of Moseley on X-rays.

Ans: A systematic and comprehensive study of X-rays was undertaken by Moseley in 1913-1914. His research covered a range of wavelengths 0.04 - 8 A. He employed thirty-eight different elements from Aluminium to Gold as target in X-rays tube. Moseley was able to draw the following important conclusions from a detailed analysis of the spectral lines which he obtained.

(i) The spectral lines could be classified into two distinct groups. One of shorter wavelengths are identified by K-series and the other of comparatively longer wavelengths are identified by L-series.

(ii) If the target element is of higher atomic number the wavelength of X-rays becomes shorter.

(iii) A very simple relationship was found between the frequency (v) of a particular line of X-rays and the atomic number Z of the element emitting it.

$$\sqrt{v} = a(Z-b)$$

Here 'a' and 'b' are the constants characteristic of the metal under consideration. This linear equation is known as Moseley's Law. 'a' is proportionality constant and 'b' is called screening constant of the metals.

46. State Moseley's law.

Ans: This law states that the frequency of a spectral line in X-ray spectrum varies as the square of atomic number of an element emitting it. This law convinces us that it is the atomic number and not the atomic mass of the element which determines its characteristic properties, both physical and chemical. If value of $\sqrt{v}$ for K-series are plotted against Z, then a straight line is obtained.

$$\sqrt{v} = a(Z-b)$$

47. Write about importance of Moseley's law.

Ans: Following are the points of importance of Moseley's law:

(i) Moseley arranged K and Ar, Ni and Co in a proper way in Mendeleev's periodic table.

(ii) This law has led to the discovery of many new elements like Tc(43), Pr(59), Rh(45).

(iii) The atomic numbers of rare earths have been determined by this law.

48. What is meant by dual particle nature of matter?

Ans: According to de-Broglie, all matter particles in motion have a dual character. It means that electrons, protons, neutrons, atoms and molecules possess the characteristics of both the material particle and a wave. This is called wave-particle duality in matter. de-Broglie derived a mathematical equation which relates the wavelength (ʎ) of the electron to the momentum of electron.

$$\lambda = \frac{h}{mv}$$

where

ʎ = de-Broglie's wavelength

m = mass of the particle

v = velocity of electron

According to this equation, the wavelength associated with an electron is inversely proportional to its momentum (mv). This equation is called de-Broglie's equation.

49. Prove that macroscopic bodies don't have waves.

Ans: If we imagine a proton moving in a straight line with the velocity of 2.188x10^6 ms^{-1} its wavelength will be 1836 times smaller than that of electron. Similarly, an α-particle moving with the same velocity should have a wavelength 7344 times smaller as compared to thatof electron. Now, consider a stone of mass one gram moving with a velocity of 10 ms^{-1}then its wavelength will be:

$$\lambda = \frac{6.626\times10^{-34}\,Js}{10^{-3}kg\times10ms^{-1}}$$

$$= 6.626\times10^{-30}\,m$$

This wavelength is so small, that it cannot be measured by any conceivable method. It means that heavy material particles have waves associated with them, but they cannot be captured and we say that the macroscopic bodies don't have the waves.

50. Prove that microscopic bodies can have waves in measurable range.

Ans: Consider an electron which is moving with a velocity of 2.188x10^6 ms^{-1} in the first orbit of Bohr's model of hydrogen atom. Then, wavelength associated with it can be calculated as:

$$h = 6.626 \times 10^{-34}\ Js$$

$$m_e = 9.108 \times 10^{-31}\ kg$$

$$\lambda = \frac{6.626 \times 10\text{-}34\ Js}{9.108 \times 10^{-31}\ kg \times 2.188 \times 10^{6}\ ms^{-1}}$$

Since ($J= kg\ m^2\ s^{-2}$)

λ = 0.33 nm (10^9 m= 1nm)
λ= 0.33 nm

This value of wavelength (λ) of electron while moving in the first orbit of H-atom is comparable to the wavelength of X-rays and can be measured.

51. What is line spectrum of hydrogen and how it differs from continuousspectrum?

Ans: Hydrogen spectrum is an important example of atomic spectrum. The spectrum of hydrogen consists of a number of lines of different colours having different distances from each other. It has also been observed that distances between the lines for the hydrogen spectrum decrease with the decrease in wavelength and the spectrum becomes continuous after a certain value of wavelength

52. How Bohr's model justifies the H-spectra?

Ans: Lyman and Balmer discovered spectra of hydrogen in 1887. They did know the reasons for their line. In 1913, Bohr's equation of wave number gives us the values of wave numbers as were measured by Lyman, Balmer, Paschen, Bracket and Pfund. So, Bohr's model can explain the spectrum of hydrogen.

53. Heisenberg's uncertainty principle has no relation with Bohr's atomicmodel. Justify it.

Ans: Since the electron has wave nature having elliptical paths so the simultaneous determination of position and momentum is not possible. But Bohr's model does not accommodate the wave nature of electron. He proposes fixed orbits. It means that Bohr's model is very simple as compared to Heisenberg's uncertainty principle.

54. State Heisenberg's uncertainty principle.

Ans: It states that certainty in the determination of momentum introduces uncertainty in the determination of position and vice versa.

Suppose that Δx is the uncertainty in the measurement of the position and Δp is the uncertainty in the measurement of momentum of an electron, then the mathematical expression is:

$$\Delta x \Delta p \geq \frac{h}{4\pi}$$

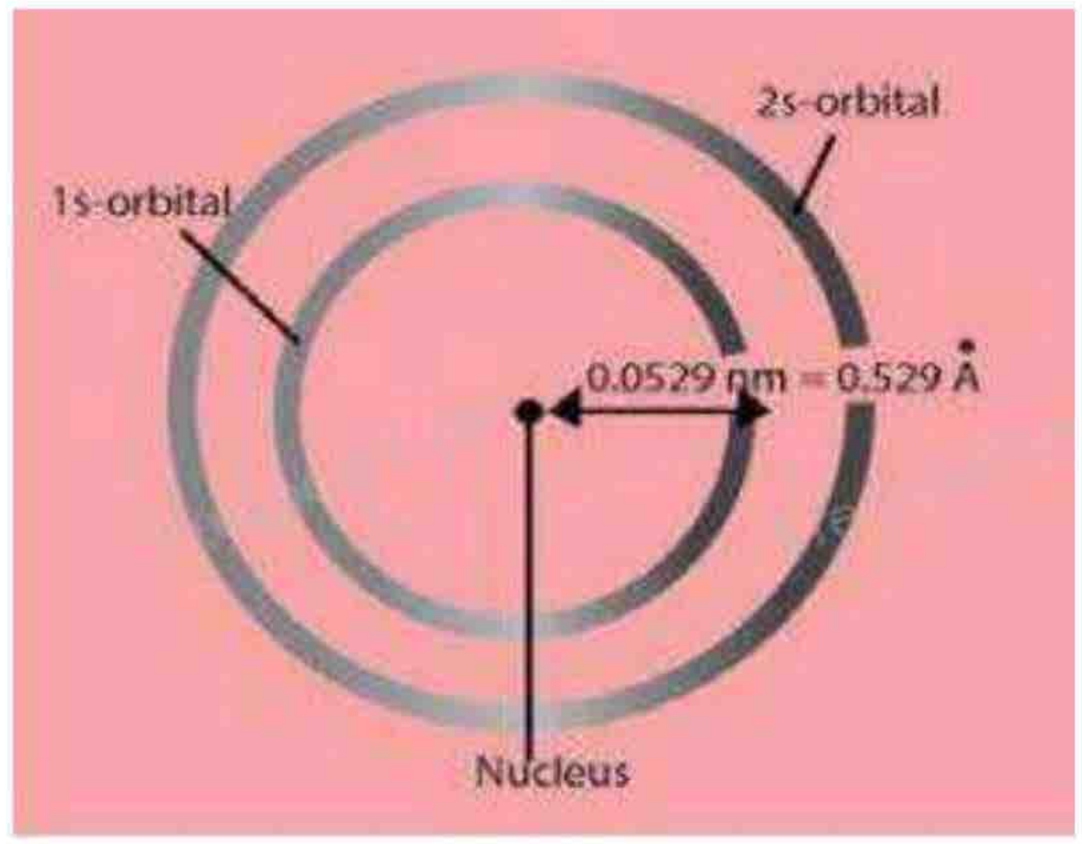
This relationship is called uncertainty principle. This equation shows that if Δx is small then Δp will be large and vice versa. So, if one quantity is measured accurately then the other becomes less accurate. It is applicable to microscopic bodies.

55. How Compton Effect helps to study uncertainty principle?

Ans: Compton's effect helps us understand the uncertainty principle. Suppose, we need to determine the position of an electron. Visible light cannot help us because the wavelength of visible light is millions time large as compared to the diameter of electron. We have touse X-rays which have very short wavelength as compared to that of visible light. When thisphoton of X-rays strikes an electron, the momentum of electron is expected to change. Uncertainty of momentum will appear due to change of velocity of electron. Smaller the wavelength of X-rays greater will be the energy of the photon. Hence, the collision of X-rays with electron will bring about the greater uncertainty in momentum. So, an effort to determine the exact position of electron has rendered its momentum uncertain. When we use the photons of longer wavelength to avoid the change of momentum, the determination of the position of electron becomes impossible.

56. Define orbital.

Ans: The volume of space in which there is 95% chance of finding an electron is called atomic orbital. The term orbital should not be confused with the term orbit as used in the Bohr's theory. The orbital can be regarded as a spread of charge surrounding the nucleus. This is often called the "electron cloud".



57. Define quantum numbers.

Ans: Quantum numbers are the sets of numerical values which give the acceptable solutions to Schrodinger wave equation for hydrogen atom. An electron in an atom is completely described by its four quantum numbers:

(1) Principal quantum number (n)

(2) Azimuthal quantum number (*l*)

(3) Magnetic quantum number (m)

(4) Spin quantum number (s)

58. What is the function of principal quantum number?

Ans: Principal quantum number gives information about:

1. Energy of electron
2. Distance of electron from the nucleus
3. Radius of orbit

59. What is the function of azimuthal quantum number?

Ans: Azimuthal quantum number (l) gives us information about the orbitals present in an orbit.

l=0 s-orbital

l=1 p-orbital

l=2 d-orbital

l=3 f-orbital

60. Calculate the number of electrons in s, p, d and f sub-shells from theformula.

Ans: The formula is 2(2l+1)

For s-orbital 2(2×0+1) = 2 electrons

For p-orbital 2(2×1+1) = 6 electrons

For d-orbital 2(2×2+1) = 10 electrons

For f-orbital 2(2×3+1) = 14 electrons

61. The magnetic quantum number gives orientation of orbital in space. Justify it.

Ans: The value of m gives us the information of degeneracy of orbitals in space. It tells us the number of different ways in which a given s, p, d or f-subshell can be arranged along x, y and z-axes in the presence of a magnetic field. Thus, different values of 'm' for a given value of '**l**', represent the total number of different space orientations for a subshell. In case of s-subshell l= 0, so, m = 0. It implies that s-subshell of any energy level has only one space orientation and can be arranged in space only in one way along x, y and z-axes. So, s-subshell is not sub-divided into any other orbital. The shape of s' orbital is such that the probability of finding the electron in all the directions from the nucleus is the same. It is spherical and symmetrical orbital.

62. Define Hund's rule.

Ans: This rule is concerned with the distribution of electrons in degenerate orbitals. These orbitals may be atomic or molecular. It states that:

If degenerate orbitals are available and more than one electrons are to be placed in them then place them in separate orbitals with the same spin rather than putting them in the same orbital with opposite spins.

63. State Pauli's exclusion principle.

Ans: According to Pauli's exclusion principle:

No two electrons in an atom can have the same set of four quantum numbers.

64. What is n+l rule?

Ans: To determine the energy position of an electron we take the sum of principal and azimuthal quantum number. Greater the value of n+l means greater the energy of electron.

65. What is the function of spin quantum number?

Ans: An electron while moving in an orbital around the nucleus also rotates or spins about its own axis either in a clockwise or anti-clockwise direction. This is also called self-rotation. Clockwise motion is shown as +1/2 and anti-clockwise as -1/2. This is explained by spin quantum number.

66. Calculate mass of an electron when $e/m=1.7588 \times 10^{11} CKg^{-1}$ OR Calculate mass of an electron from its e/m value.

Ans:

Charge of electron$=1.602 \times 10^{-19}$ C

e/m of electron$=1.7588 \times 10^{11}$ Ckg^{-1}

Mass of electron$= 1.6022 \times 10^{-19} C / 1.7588 \times 10^{11} Ckg^{-1}$

Mass of electron$=9.1095 \times 10^{-31}$Kg

67. How do you come to know that velocities of electrons in higher orbitsare less than those in lower orbits of hydrogen atom?

Ans: According to Bohr's proposal, the centrifugal force of the electron is equal to the force of attraction between nucleus and electron.

$$mv^2 = \frac{Ze^2}{4\pi \epsilon_0 r}$$

Rearranging

$$r = \frac{Ze^2}{4\pi \epsilon_0 mv^2}$$

The factors are Z,4,π, ε_o and m are constant, so

$$r \alpha \frac{1}{v^2}$$

According to this equation, radius and velocities are inverse to each other. Greater the velocity of the moving electron smaller is the radius.

68. Write down electronic configuration of Fe (26) and Br (35) (Electronic configuration of the complete list at the end of chapter should be done)

Ans:

Fe (26)

$1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$

Br(35)

$1s^2 2s^2 2p^6 3s^2 3p^6\ 3d^{10} 4s^2 4p^5$

69. Write down electronic configuration of P(15) and Cu(29).

Ans:

P(15)

$1s^2\ 2s^2 2p^6 3s^2 3p^3$

Cu (29)

$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$

70. Write down electronic configuration of Cr (24).

Ans:

Cr (24)

$1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$

71. Calculate the number of electrons in s, p, d and f-sub-shells from theformula and write separately.

Ans: Following is the formula for calculating the number of electrons in s,p,d,f 2(2l+1)

For s-sub-shell=2(2l +1)=2(2(0)+1)=2(0+1)=2(1)=2 electrons

f or p-subshell=(2l+1)=2(2(1)+1)=2(2+1)=2(3)=6 electrons

f or d-subshell=2(2l+1)=2(2(2)+1) =2(4+1)=2(5)=10 electrons

f or f-subshell= 2(2l+1)= 2(2(3)+1)= 2(6+1)= 2(7)= 14 electrons

72. The e/m value for positive rays obtained from hydrogen gas is 1836times less than that of cathode rays. Justify it.

Ans: e/m ratio depends directly on 'e' and inversely on 'm'. e/m ratio of positive rays obtained from hydrogen has less value than that of cathode rays, because the mass of electron is 1836 times smaller than the mass of proton (H^+) positive particle.

73. Hydrogen atom and He^+ are mono-electronic systems, but the size of the He^+ is much smaller than H-atom why?

Ans: It is because the atomic number (number of protons) is higher in Helium and lesser in hydrogen. Radius or size of atom or ion depends inversely on its atomic number.

According to Bohr's atomic model,

$$r = 0.529\ \text{Å}\ \frac{n^2}{z}$$

For H-atom,	For He^+,
$r = 0.529\ \text{Å}\ \frac{1^2}{1}$	$r = 0.529\ \text{Å}\ \frac{1^2}{2}$
$r = 0.529\ \text{Å}$	$r = 0.26\ \text{Å}$

74. Do you think that the size of Li^{+2} is even smaller than He^+? Justify with calculations.

Ans:

The size of Li^{+2} is even smaller than He^+ because Li^{2+} has three protons in the nucleus. It has only one electron. Therefore, nucleus will have greater force of attraction for electron and pull it towards itself.

According to Bohr's atomic model,

$$r = 0.529\ \text{Å}\ \frac{n^2}{z}$$

For Li^{2+},	For He^{+},
$r = 0.529\ \text{Å}\ \frac{1^2}{3}$	$r = 0.529\ \text{Å}\ \frac{1^2}{2}$
$r = 0.176\ \text{Å}$	$r = 0.26\ \text{Å}$

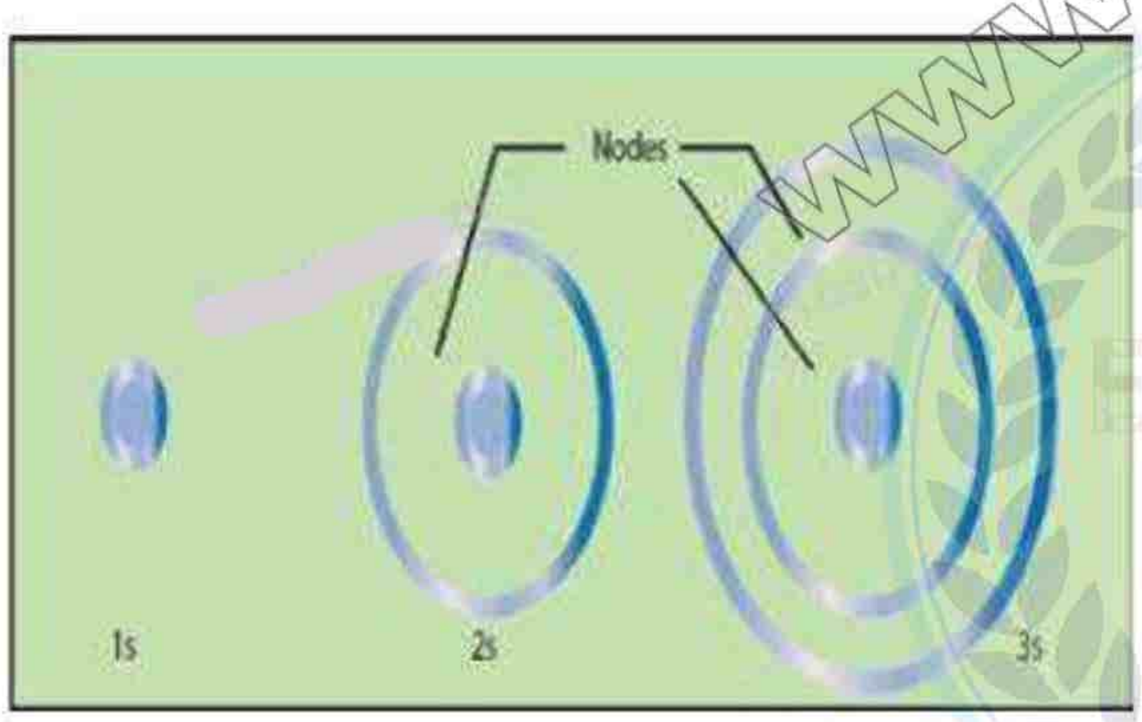
75. How does the Bohr's model justify the Moseley's equation?

Ans: According to Bohr's atomic model, energy is released in the form of radiations when electrons are de-excited from higher energy levels to lower ones. During the production of X-Rays the same process occurs in the ionized anode's atom, as a result of which X-Rays are produced. Electrons of higher shells fall into K or L or M-shell and produce K-Series or L-Series or M-Series X-Rays.

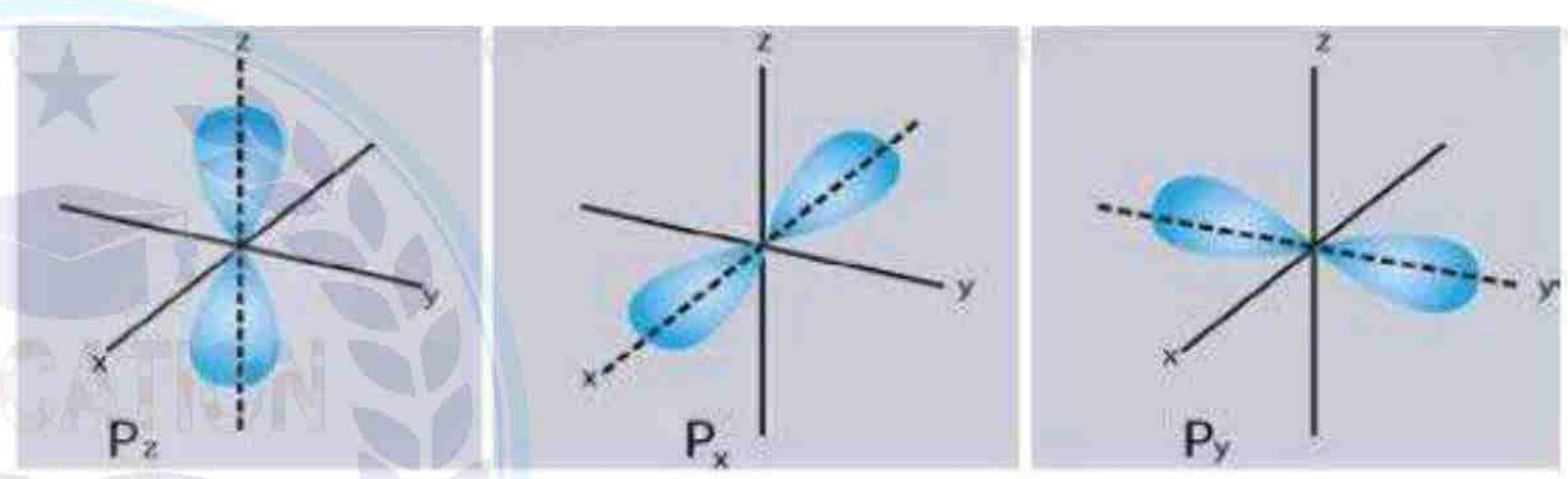
76. Draw the shapes of s, p and d sub-shells.

Ans:

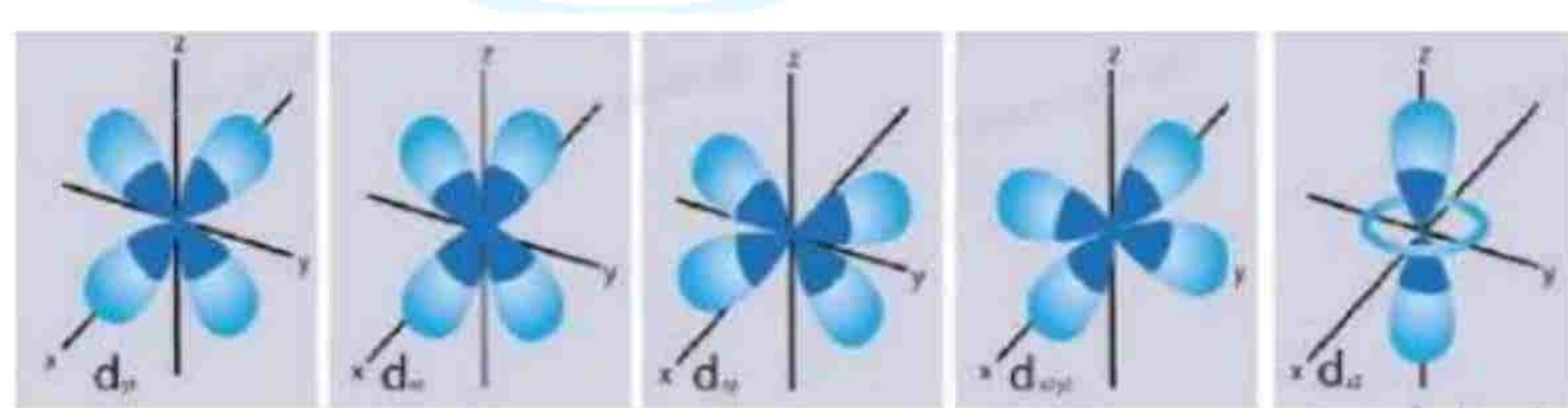
s-subshell



p-Sub-shell



d-Sub-shell



77. Define node.

Ans: The probability of finding the electron is zero between two orbitals. This place is called nodal plane or nodal surface.